NEW GEOCHEMICAL MAP OF KAZAKHSTAN FOLD AREA.

E. V. Plyushchev, I. V. Glukhan, V. V. Shatov

The map covers the unique ore province of Kazakhstan bordering on China. In fold systems, median masses and epi-Hercynian platform cover of this area, thousands of ore occurrences are found, which include some major deposits of tungsten, molybdenum, tin, uranium, lead, zinc, copper, gold, phosphorus, fluorine, beryllium and other economic minerals.

Based on bedrock sampling using special techniques and the analysis of many hundred thousands of samples for a wide range of microelements, the geochemical specialization of geological bodies of formational levels was determined.

In addition to the mass-scale approximate quantitative spectral analysis, a complex of quantitative determinations by composite samples (about 5 thou. samples) was carried out.

The polyelemental geochemical map was compiled on the 1:1 500 000 geological base. On this scale, various maps of geological content were compiled for the Kazakhstan fold area, which enlarges substantially the opportunity of data interpretation in geological, metallogenic and environmental aspects. The legend explains principles and methodology of distinguishing and classification of microelement associations, showing geochemical cross-sections of type geochemical provinces.

These studies resulted in definition of regional geochemical zonation and geochemical demarcation of territories and in establishing interrelationship between geochemical background of geological bodies and ore presence. Two geochemical blocks are recognized within the limits of the fold area, i.e. a) essentially simatic (eastern) one, and b) essentially sialic (western) one. At the junction of these geoblocks, there lie provinces of litho-chalcophylic specialization with typical copper-molybdenum, tungsten-gold, fluorine-polymetallic, lead-rare earths and similar deposits of "mixed" ores. The western geoblock contains main geochemical provinces of rare earth specialization with ore deposits of tungsten, tin, molybdenum, uranium, fluorine and other lithophylic elements. The eastern geoblock is known for the predominance of massive copper sulfide, lead-zinc and gold deposits.

In geological sense proper, the geochemical map is in accord with main plate tectonics conceptions, testifying to inherited nature of chalco-lithophylic specialization of protocontinental blocks, and chalco-siderophylic specialization of protooceanic blocks, the latter acquiring rare earth - rare metal specialization only during superimposed processes of cratonization.

Environmentally, the geochemical map characterizes

microelemental composition of substratum in zone of hypergenesis-environs of human habitation.

Unlike other similar maps, the polyelemental map of the Kazakhstan fold area characterizes not only anomalous geochemical field, but also background geochemical field of geological bodies, whose composition, structure and age are known; this makes it possible to bring to light the history of geochemical resources formation in one of the central fragments of the Central-Asiatic fold belt.

THE USE OF MACROCOMPONENT WATER COMPOSITION FOR THE SEARCH OF ORES NOT EXPOSED TO THE SURFACE

A.M.Plyusnin

The Buryat Institute of Geology of the RAS SD, Russia

Carbon dioxide is known to take a great role in the formation of the various types of hydrothermal deposits. Carbonate is widely developed in several facies of regional, fractured and periveined metasomatosis and in the mineral associations of ore bodies. The main carbonate minerals are calcite, ankerite and dolomite.

The formation of macrocomponent water composition is directly connected with the process of rock weathering. The speed of carbonate solubility under exogenetic conditions is several tens of times higher than the speed of the solubility of other rock-forming minerals. When carbonates are being solved, waters are mainly enriched in alkaline-earth elements and in hydrocarbonation. The sufficient increase of water mineralization is often connected not with the disintegration of the main rock complexes, but with the solubility of the carbonate minerals of the rocks changed periore. The absolute contents of water acrocomposition depend on rock weathering intensity, that is why the waters of the various intensity of waterchange are difficult to compare. The relations among macrocomponents are more informative which depend on the composition of weathering rocks. The following relations, as Ca/HCO_3, Na/HCO_3 and $(Ca+Mg)/(Na+K)$ are significant and can be used in the wide interval of water mineralization. Limitations are made by achieving equilibrium relative to calcium carbonate.

More contrastingly carbonatization can be exposed among intrusive rocks. Researches are carried out in one of the ore regions. The formation of periore metasomatites and carbonate minerals is connected with the final stages of forming hydrothermal mineralization. This process covers the sufficient areas of the ore region, as a rule, in the peripheral part of ore fields.

The relations' range of the elements under investigation is three orders. The manifestations of the known native gold-ore mineralization, the contact of the Paleozoic and Mesozoic ages intrusives and some objects of buried placer gold are marked out contrastingly.

THE POSSIBILITIES OF THE EXPLORATION OF THE PRECIOUS METALS' MINERALIZATION BY A HYDROGEOCHEMICAL METHOD

A.M.PLYUSNIN, E.M. TATIYANKINA

The deposits of low sulphide and moderate sulphide goldquartzy formations are shown by the conrtrasting streams of gold dispersion. Gold content in water reaches 0,n mkg/l. Gold migrates in the form of complex compounds with different ligands, in the form of colloids and in the composition of microsuspension. The migration forms determined are distinguished by stability in solution.

The mineralization of platinum and palladium connected with sulphide copper and nickel mineralization is marked out by platinum content to 0,15 mkg/l and palladium content to 0,016 mkg/l in the hydrogeochemical field. For all that practically the whole platinum is transported in microsuspension composition. The main part of palladium is present in the form of true solutions.

The mechanism of precious metals delivery into solution under various sulphides oxidation has sufficient differences which influence on their migration power. Precious metals possess the greastest migration power in the form of true solutions under the oxidation of galenite, chalcopyrite and arsenopyrite.

APPLICATION OF SCINTILLATION EMISSION SPECTRAL ANALYSIS IN GEOCHEMISTRY

PROKOPCHUK S.I, MEKHANOSHIN A.S.

The scintillation emission spectral analysis is based on counting and measuring the spectral line scintillations of the elements to be studied. This method is productive, when the elements are concentrated in separate grains and irregularly distributed within the sample, i.e. when they are found as a nugget or as different minerals. Such parameters of the detected scintillations as quantity, amplitude, duration and the area are used as analytical signals. The scintillation amplitudes and the distribution histograms allow the particles within the size range from 1 to 30 mkm to be estimated. The detection of the compound particles, containing two or more elements, provides the information on the presence of corresponding minerals in the samples. The simultaneous detection of gold and silver line scintillations is particularly significant in this case. Their quantity and values determine the silver concentration in the gold particles within the sample. The analysis accuracy depends mainly on the size particle, the form of element occurrence within rocks, the weight of the material to be analyzed, and is checked by the reference samples. The analytical weight is 0,5 gramm. The relative standard deviation is 0.2-0.3.

Such elements as gold (0.01 ppm), silver (0.01), arsenic (1-20), platinum (0,1), palladium (0,005), rhodium, iridium, ruthenium and osmium (0,01-0,1) are analyzed by scintillation method, Institute of Geochemistry in Irkutsk.

Scintillation emission analysis is mainly applied in different geochemical methods of prospecting, i.e. prospecting and survey from the secondary haloes and from stream sediments. The ore zones may be outlined from the primary haloes within sulfide occurrences in the massifs of the basic and ultrabasic rocks. This method may be used for prospecting the native platinoid deposits within the platinum placers if the massif type, which is associated with platinum mineralization, is not evident. When the platinum and palladium contents in the rocks are higher than the clarke concentration, the ratio between these elements is used for a massif to be identified. Using this method the form of platinoid occurrence within the rock and uniformity of platinoid particle distribution may be determined and the samples may be preliminarily selected for techniques of a high precision. The method is appropriate for granulometric analysis, the study of references samples and assessment of the gold grade.

The platinoid contents were determined in nearly all rocks from large basic and ultrabasic complexes of the Eastern Sayan, the Baikal region and Northern Mongolia. The prevalence of palladium over platinum is typical for the gabbroids. Platinoids are observed in the rocks with the increased sulfide concentrations. Platinum is predominant in the massifs with abundant ultrabasic rocks.

Study of platinoids, silver and gold geochemistry in the gabbro-peridotite massifs of the Sharyzhalgai protrusion of the Siberian Platform indicates the increased

concentrations of the above elements as opposed to the clarke ones. The direct relation between the noble metal concentrations and sulfur content in the rock is evident in cross-sections. Tenfold excess of platinum concentrations over palladium and similar contents of gold and silver are also observed in the gabroids. The method of sulfide solution enables determination of platinum occurrence as a nugget and the palladium one as different compounds, as it almost completely goes into solution.

Simplicity, high productivity, low price of analyses, make the scintillation method favoured in prospecting, particularly when preliminary data are needed to be obtained within a short time.

ABSTRACT

of the paper by M.S. Rafailovich
Geochemical Models of Gold Deposits in Kazakhstan

. The paper describes geochemical models of gold-sulphide-
quartz and gold-sulphide ore formations with a characteristic
of geological structure, elemental composition, correlation
links, specificity of the geochemical field and endogenic
zoning of reference deposits. The main geologic and geochemical
criteria of local prediction and estimation of standard ore
objects are considered.

The method of constructing and the structure of geochemical
model for the deposit of gold-sulphide-quartz formation are
characterized in detail. The model was oriented towards dis-
covering large objects of high vertical extent (up to 1.0-1.5 km).
Root, intermediate, front-line and frontal zones are identified
upwards. The frontal and front-line zones are of utmost interest:
the first one indicates blind mineralization and the second one
concentrates the main volume of rich ores and accounting re-
sources of noble metal. These zones have specific features:
the composition of ore-controlling intrusions are variegated,
morphological types of ores are varied (veins, stockworks,
silicification and sulphide mineralization zones, mineralized
breccii); increased sulfidity (up to 10-20%); several gene-
rations and structural-texturing varieties of productive
quartz; unusual peri-ore metasomatites (beresites, in some
objects - propylites, argillizites); complex paragenesis and
telescoping of geochemical associations (gold-and-arsenic and
gold-antimony-polymetallic prevail); fine-dispersed and free
forms of free gold; decreased standard of gold (more frequently
800-900); various generations and crystallographic forms of
pyrites (up to 3-5); high ultimate role of sial components
(up to 40-80% of arsenic, antimony, lead, bismuth, tellurium,
barium); close relations and broad spectrum of mutually corre-
lative elements (up to 8-10); low ratios of arsenic and anti-
mony (below 30); differentiated geochemical field with uneven,
frequently zonal distribution of gold and associated rocks and

overlap of peri-ore aureoles.

Ores with average and low gold concentrations dominate
in the intermediate and root zones. The diagnostic characte-
ristics of these zones: simple forms of intrusions (single
dikes) and ore bodies (single quartz veins or aggregates of
small veins of aureole type); thick quartz of one or two
generations; reduced character of metasomatic processes
(slightly expressed beresitization prevails); high-standard
free gold (900-990); gold-bearing pyrite of one or two
crystallographic forms (more frequently cubes); high femic
quality of ores (gold, silver, copper, cobalt); increased
concentrations of arsenic and low-mobile sialic components
(molybdenum, tungsten); low content of antimony; high values
of arsenic-antimony ratio (up to 200 and more); correlation
of gold with arsenic, bismuth and tungsten.

The generalized model of vertical zoning of the deposits
under consideration (upwards): nickel - tungsten - chromium -
cobalt - bismuth - arsenic I, gold I - copper, zinc - lead -
silver - gold II - antimony - arsenic II - barium, mercury.
The last seven elements are indicators of the frontal and
front-line zones.

GEOCHEMICAL MAPPING AND DATA BASES AT THE GEOLOGICAL SURVEY OF FINLAND

SALMINEN, R and TARVAINEN, T.

The Geochemistry Department of the Geological Survey of Finland acquires and manages geochemical data from glacial and post-glacial deposits, lake sediments, stream sediments (mainly organic), stream water, ground water, and bedrock. Most of the data are published and available to both Finnish and foreign researchers and are stored in a relational data base called ALKEMIA.

In addition to geochemical data, ALKEMIA also contains interactive programmes for retrieving data from the data base and programmes for statistical analysis and map drawing. Geologists at the Geological Survey can thus easily produce geochemical maps from the ALKEMIA data base themselves. The data are delivered to clients outside the Survey as hardcopys in the form of maps, in digital form on diskettes, in image processing data files, published Atlases, microcomputer versions of Atlases, or as maps produced and interpreted according to client's requirements.

Maps with different symbols and colour surface anomaly maps can be produced by the map graphics programmes included in the ALKEMIA-package. Line data such as borders and shore lines can also be superimposed on the anomaly maps. On anomaly maps spot valves and coloured surfaces can also be presented together on the same map.

Till

Reconnaissance scale till sampling (1 sample/300 km^2) were carried out in 1984. Altogether 1057 samples throughout the whole country were collected from the basal till, the sampling depth being on average 0.7 m. Abundances of 43 elements were determined from the <0.06 mm fraction and total concentrations (determined mainly by NAA and by ICP-AES after $HF + H_3BO_3$ leach) are available from Al, As, Au, Ba, Be, Ca, Co, Cr, Cs, Cu, Fe, K, La, Li, Lu, Mg, Mo, Na, Ni, P, Pd, Rb, S, Sb, Sc, Si, Sm, Sr, Ta, Th, Ti, U, V, W, Y, Yb, Zn, and Zr. Aqua regia soluble abundances of Al, Au, Ba, Ca, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Na, Ni, P, Sc, Sr, Th, Ti, V, Y, Zn, and Zr were determined by ICP-AES, and the results were published in the beginning of 1993 (Geochemical Atlas of Finland, Part 2, Till).

Regional scale till sampling (sampling density 1 sample/4 km^2) was completed in 1991, the total amount of samples collected being about 80 000. The sampling depth was 1.5 - 2.5 metres and the samples represent composites of 3-5 subsamples. The <0.06 mm fraction was assayed by hot aqua regia and concentration of about 30 elements were determined by ICP-AES. The data are published as 1:400 000 map sheets and the analytical results for Al, Au, Ba, Ca, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Ni, P, Sc, Sr, Th, Ti, V, Y, Zn, and Zr, which all exceed their respective detection limits are included in the publishing program. Gold was analyzed from southern and central Finland from the composites of four original samples, thus representing a sampling density of 1 sample/16 km^2, from northern Finland every sample was analyzed for Au. Chemical analysis is continuing and will be completed before the end of 1993. A report describing the methods used in detail will be published at some stage during 1993.

Lake sediments

Regional scale sampling of lake sediments (sampling density 1 sample/5 km^2) was carried out between 1973-1984 from the Finnish Lake District. Resampling in restricted areas has also been undertaken in order to monitor heavy metal concentrations. The area sampled is 80 000 km^2 and the total number of samples amounts to 16 058.

The sample is a bulk sample from the uppermost 10 cm layer of sediment, which contains 10-50 % organic matter on average. The samples were first dried at 80°C, then ashed at 500°C and digested in 6 M HCl. The concentrations of Cu, Zn, Ni, Co, Pb, Mo, Mn and Fe were determined by the atomic absorption method. Uranium concentrations were determined by the NAA-method from the ashed sample. Element abundances are given as ppm in dry matter.

Stream sediments and stream water

At the regional scale stream sediment samples, both minerogenic (grain size < 0.170 mm) and organic were collected during 1971-1983 in Lapland and Central Finland. However, because the regional till geochemical mapping was producing more useful data the regional stream sediment programme was curtailed, although the data and samples have been stored and are available for scientific purposes.

At the reconnaissance scale (1 sample/300 km^2) organic stream sediments were sampled in August 1990 from the whole country. Sampling material consisted of the topmost fine grained organic rich layer of sediments from the bed of streams having catchment area of 30-40 km^2. Samples represent composites of 3-5 subsamples. Samples were dried at 70°C, homogenized and digested by a microwave assisted nitric acid (65 %) method (EPA 3051). The abundances of Ca, Mg, Sr, Ba, Na, K, Li, Fe, Mn, Al, Ti, V, Zn, Cu, Ni, Cr, Co, Pb, Cd, Mo, As, Be, B, Sb, Bi, Tl, Se, Ag, and U were determined by ICP-MS and ICP-AES.

Along with the organic stream sediments, stream water samples were also collected. The same elements were analysed as those from sediment samples using filtered (0.45 μm) samples. In addition pH, electric conductivity (EC), colour index, $KMnO_4$-consumption (COD), HCO_3, SO_4, Cl, F, SiO_2, and NO_3 were determined from the untreated sample.

A part of the samples were passed to National Public Health Institute, where some microbiological determinations were made from sediment and water samples.

The results of both sediment and water samples will be published in 1994 (Geochemical Atlas of Finland, Part 3, Environmental Geochemistry).

Ground waters

Hydrogeochemical mapping was carried out *at the reconnaissance scale* (1 sample/50 km^2) during 1978-1982. Natural springs, drilled wells and dug wells were sampled. Temperature, pH, electric conductance, dissolved O_2, and CO_2 were measured at each sampling site. In the laboratory pH, EC, colour index, COD, alkalinity (HCO_3), SO_4, Cl, F, SiO_2, and NO_3 were measured from untreated samples. From the filtered (0.45 μm) samples the Ca-, Mg-, Na-, Fe-, Mn-, Zn-, Cu-, Ni-, Pb-, Cd- and U-concentrations were measured. The results were published in 1990 (Geochemical Atlas of Finland, Part 1, Hydrogeochemical Mapping of Groundwaters)

Ground water has been sampled *at the regional scale* in conjunction with 1:20 000 scale mapping of Quaternary deposits. In addition to the previously mentioned elements Sr, Ba, Li, Ti, V, Al, Cr, Co, Mo, As, Be, B, Sb, Bi, Tl, Se, and Ag have also determined, using ICP-MS method. These results are published as part of the explanatory texts to the maps.

Other scales of geochemical studies

At the local scale (sampling density 4-40 samples/km^2) and *detailed scale* (sampling density more than 100 samples/km^2) geochemical data from till and bedrock are collected in accordance with exploration and environmental requirements. These data are usually not published separately, but rather within final reports relating to the area of interest.

GEOCHEMICAL INDICATORS OF ORE GOLD COLUMNS PROSPECTING, EXEMPLIFIED BY ONE OF THE KUZNETSKY ALATAU DEPOSITS

SANINA N.B., AKHMADULIN F.A.

The majority of the investigators consider the structural factor to be the principal in ore column formation and distribution. The study of mineralization features, exemplified by one of the deposits in the Kuznetsky Alatau, indicated the significance of mineralogical-geochemical features of the ore columns under local forecast.

The deposit under consideration (Central part of the Kuznetsky Alatau) is gold-quartz formation with low sulfide contents, located in the volcanogenic sequence of PR_3 age.

The commercial gold concentrations are mainly observed in ore columns i.e. quartz lenses (thickness - 0.5-1.5 m, extension - up to 100 m).

The metasomatites of berisite-listvenite formation with pyrite occur in the exocontacts of the quartz veins. The mineralization with low sulfide contents were formed in two stages. The ores of the early pyrite stage, containing quartz with pyrite, arsenopyrite, to some extent chalcopyrite are widely distributed. The ores of the second (polymetallic) stage mainly contain quartz with pyrite, sphalerite, galenite.

The spatial disconnection of mineral associations both of the single stage and different ones and telescoped zone occurrences are common to sulfide mineralization of the deposit.

The pyrite from the near-ore metasomatites is marked by low Au (up to 0.5 ppm) and Ag (up to 10 ppm) concentrations and high (up to 2.00 %) Ni, V and, in some cases, Co contents.

There is a tendency to direct correlation of Ni and V contents in the near-ore pyrites as the ore column is approached. The concentrations of these elements are 2-10 times higher as opposed to the ore pyrites.

The sulfides of the pyrite stage (pyrite, chalcopyrite, arsenopyrite) are characterized by high Ni, Co, V contents, as compared to the minerals of the polymetallic stage, and significant increase of Cu, Zn, Pb contents as the ore column is approached.

Arsenopyrite mainly concentrates gold in ore columns, composed of the parageneses of the pyrite stage (up to 10 ppm).

The sulfides of the polymetallic stage are marked by maximum Au (up to 50 ppm), Ag (up to 30 ppm), Cu, Pb, Zn (up to 2%) contents. Gold mainly occurs in the pyrites and arsenopyrites. Sphalerite possesses lower Au concentrations, nevertheless it is the second sulfide (after pyrite), widely distributed on the deposit. Sphalerite is marked by low Fe (up to 6 mass%) and significantly high Cd concentrations (up to 1,5 mass%). The heightened Au contents (up to 10 ppm) are mainly observed in the low-ferriferrous (up to 3%) and medium-ferriferrous (up to 4.5%) varieties.

Quartz of the pyrite stage possesses Au and Hg contents

which are 2-3 times higher as opposed to the polymetallic
one. It is fine-grained in the aggregates. The direct Au and
Hg correlation is evident for the quartz of the pyrite
stage.

The concentrations of Ag, Cu, Pb, Zn, Sb (V, Co, Ni)
are constant (without significant fluctuations) on the whole
range for the geochemical anomalies of the barren locations.
The ore columns are associated with clear positive-negative
Au, Ag, Cu, Zn, As, Bi anomalies: element concentrations are
high (contrast coefficient - up to 100) near the veins, in
the range between 1.0-10 m the removal of the elements is
observed (up to the background), then the element
concentrations increase (contrast coefficient - 10-50).

Thus, the positive-negative distribution pattern of the
elements near the veins, increased Ni, V contents in pyrites
from the near-ore metasomatites, Au and Hg direct
correlation in the near-ore pyrites, Ni , Co and V
concentration increase in the sulfides of the pyrite stage;
low Fe contents in the sphalerites; increased Au and Hg
contents in the quartz and their direct correlation; fine-
grained quartz are the indicators of the ore column
occurrences. The revealed geochemical indicators of the ore
columns allow more precise assessment of the deposit deep
horizons and edges, where the direct structural and
mineralogical features are not available.

ECOOGICAL-GEOCHEMICAL MAPPING, EXEMPLIFIED BY ONE SITE ALONG THE WESTERN BAIKAL COAST

SANINA N.B., FILLIPOVA L.A.

Geochemical mapping is one of the methods, using for the environment control. Geochemical mapping of the western Olkhon region (Western Baikal coast), carried out systematically (i.e. annual sampling on reference sites), indicated the significance of mapping of the secondary geochemical settings, aimed at assessment of anthropogenic pollution of the environment.

Comprehensive mapping is made from the lithogeochemical, hydrogeochemical and biogeochemical stream sediments as well as the dispersion haloes at 1:50 000-1:25 000 scales with sampling interval in 100 m for the bedrocks. The overflood sediments were mapped at 1: 50 000 scale (with the profiles in 500 m and sampling range in 100m).They were sampled from the valley of the Kuchelga River , which is the main water reservoir in the region.

1 mm fraction was obtained from the stream sediments and overflood sediments (300 gram) using the mesh sieve. The optimal fraction size was determined using the investigations, concerning the element distribution in the stream and overflood sediments in 0.25; 0.25-0.5; 0.5-1.0; 1mm fractions.

The samples were analyzed for 26 elements by semi-quantitative optic spectral analysis. The element concentrations, determined using this method are compatible, with the contents, obtained via quantitative spectral analysis. The greatest difference (decrease of element concentrations, obtained via quantitative method) is observed for Pb, Zn (in 2 times) and for Ag (in 4 times).

The contents of the rest elements are the most compatible (difference in decimal and hundredth quotas of %) . It indicates the reliability of the data, obtained by semi-quantitaive optic-spectral analysis.

The analysis results were processed on the computer via the method of multi-dimensional fields, resulting in compiling geochemical maps, which indicate distribution pattern of the chemical elements and the associations in the region under survey.

The average background concentrations of the chemical elements were determined as the median values of the statistical distributions for all massifs and all survey types. The background concentrations of the majority of the elements for all samples (bedrocks, alluvium, delluvium, plants) are in 1.5-5 times, in some cases, in 10 times (larch ash) lower than the clarke concentrations.

The geochemical map of the western Olkhon region, compiled from the stream sediments indicates that the background associations of chemical elements and those,which are lower than the background level, are significant here (not considering the Kuchelga River valley). The Y,La,Pb,Zn,Ni/1-2* and Li,Ga/1-3 geochemical associations (contrast coefficient of rest elements - 1),is typical for the major part of the area. The anomalies with the heightened REE (Y, La) concentrations (contrast coefficient - 2-20) as well as Li and Ag anomalies are common to the

north-western part of the region. The "rare earth " associations evidently results from the granitoids, distributed here.

Mapping of the overflood sediments, sampled from the Kuchelga River valley, indicated anomaly existences in the vicinity of Chernorud settlement and river mouth (where it falls into the Muhkor bay). The concentrations of a number of elements are on the background level or lower beyond the settlement (against the current).

The anomalous Mo, V, Cr, Mn, La, Y concentrations are clearly observed within the settlement. P and Li anomalies are observed within the settlement near the eastern valley edge (contrast coefficient - 2-10). The whole valley is marked by the increased Be, Cu concentrations. The maximum Ag and B concentrations (contrast coefficients is up to 3) are observed in the lower part of the settlement (along the Kuchelga river current). The removal of Ga and Co is observed within the settlement. Their concentrations beyond the settlement and near the river mouth are high (contrast coefficient - 3). The polyelement P, Mo, Cr, Ag, Be, B, Ge, La, Y, Li anomalies (contrast coefficient - 3-7) are observed in the river mouth. The increased Y, La, Li, Ag concentrations in the overflood sediments result from the bedrock influence, while the anomalies of the rest of the elements and their attachment to the settlement and river mouth is associated with soil pollution and migration of the elements, transported mainly by the rivers and ground waters and accumulated at the place of the discharge into the Mukhor bay.

Thus, geochemical maps, compiled from the stream sediments and overflood ones enable the element distribution to be evaluated, and the areas, affecting by the pollution, to be recognized. The geochemical mapping is the expressive method, which provides reliable information.

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*Contrast coefficient indicates ratio of the average element concentration to the background content.

A METHOD FOR SEPARATING ANTHROPOGENIC AND NATURAL ANOMALIES IN ENVIRONMENTAL GEOCHEMISTRY

SELINUS, O.S.

Environmental geochemistry has during the last decade gained an ever increasing interest. Geochemical mapping as well as more detailed environmental geochemical investigations have been carried out in several countries . A number of different methods have been used. The most common method in geochemical mapping has been inorganic stream sediments because of the institutions carrying out the mapping have a mineral exploration background.

In Sweden however, the geochemical mapping is carried out with other methods especially developed for environmental research, namely plant roots and mosses from streams (reflecting the bioavailable metal contents in natural waters), till samples and bedrock samples. These three sample types form an integrated strategy in environmental research, as well as in geochemical exploration.

One problem in geochemical mapping is however to distinguish the natural background from anthropogenic anomalies. This has so far mostly been done by using additional sample types and by sampling different horizons in eg soil profiles. This is however both expensive and time consuming. Therefore we are developing statistical methodologies for this purpose. The method used is PLS (partial least square regression analysis). PLS performs a simultaneous and interdependent Principal Component Analysis decomposition in both X- and Y-matrices, in such a way that the information in the Y-matrix is used directly a a guide for optimal decomposition of the X-matrix, and then performs regression of Y. The advantage of PLS is that it gives optimal prediction ability in a strict statistical sense.

Bedrock samples from as many different lithologies as possible in the mapping area are analyzed. These analyses (Y-matrix) are used together with well known stream data or soil data (X-matrix) as a test set. By finding the regression relationships by means of PLS between these two data sets it is possible to develop multivariate geochemical models based on the different bedrock types for the stream data. This step is called calibration. These models are then used for predicting unknown geochemical samples and estimating the Y-variable values in these new samples. In that respect we get information on how much of the metal contents of each geochemical sample is derived from different bedrock types. By computing the residuals we also receive information on the anthropogenic impact on the samples.

Examples of "natural" and "anthropogenic" maps derived from one single geochemical sample type will be presented. It will also be discussed more in detail the strategy, the statistical methods, as well as the importance of normalization, variance, validation, outliers and other factors of importance for the modelling work.

Geochemical Exploration in southern Sinai, Egypt

I. M. Shalaby, Z. M. El Alfi, H. Bekheit & E. H. El Mahallawy
Geological Survey of Egypt, 3 Salah Salem St., Abbasyia, Cairo, Egypt.

The Egyptian Geological Survey carried out intensive geological exploration programmes in the Eastern Desert and Sinai. Dry stream sediments samples and bedrock samples were the media for analyses. This presentation consentares the bed-rock sampling carried out in the southern Sinai.

The area under investigation covers about 11.000 Km2. Bed-rock samples were collected from all the rock units outcropping in the area. These rocks are igneous and metamorphic units of Late Proterozoic age. Density of samppling was 1-2 samples per Km2, totalling to nearly 10.000 samples. These samples were analysed spectrographically for 20 elements. Elements that show enhanced results are Cu, As, Pb, Zn, Ni, Cr, Mn and Ti. The values of these elements are plotted (in symbol form) on five sheets, complemented by a sample location map. Compairaing these geochemical maps with the geological map, the following results are obtained: the area of Cu anomaly (1000-3000 ppm) coinsides with the metavolcanic-metasedimentary rocks. Significant overlap with the As (100-200 ppm) anomaly area is clear.

This zone proved to be a potential area for polymetallic sulfides and gold mineralization. Follow up geochemical prospection indicated the presence of gossans, alteration zones & quartz veins with gold values from 0.3 to 3 ppm.

A Mn anomaly (2000-4000 ppm) overlaps with the Pb (200-300 ppm) and Zn (200-300 ppm) anomalies. This could represent hydrothermal mineralization.

Titanium did not show significant anomalies. High values of Cr (800-1000 ppm) and Ni (100-200 ppm) are related to the ultrabasic rocks.

This concluded that geochemical exploration is a good tool for mineral prospection, even in arid desert terraine.

EGYPTIAN GEOLOGICAL SURVEY AND MINING AUTHORITY

Geologist / Geochemist
IBRAHIM M. SHALABY
Head of Mining Sector

3 Salah Salem St., Abbasslya
Cairo - Egypt
Tlx. 22695 GEOSU UN

Tel. : Office 829662
Home 3950933
Fax. : 820128

LOCAL METALLOGENIC ANALYSIS OF THE IRTYSH AREA
OF RUDNYI ALTAI BASED ON GEOCHEMICAL DATA.

V. V. Shatov

Large-scale geochemical study was carried out within the central part of the Irtysh area of Rudnyi Altai, which is characterized by pyrite deposits and ore shows differing in composition and condition of manifestation (Nikolaevsk, Rulikhinsk, Talovsk, Pokrovsk, Verkhubinsk, Irtysh, Berezovo, Novoberezovsk, etc.).

Geochemical sampling of bedrock was undertaken with 750x500 m spacing, the intervals becoming closer (to 250x100 m) in the areas of strong hydrothermal-metasomatic alteration. In areas covered by loose deposits, sampling of core from shallow and deep boreholes was carried out. During the entire period of study a total of 4 thou. geochemical samples were taken in an area of 1200 sq. km. The results of roentgenospectral analysis of microelements in selected samples served as a basis for constructing polyelemental geochemical map on 1:50 000 scale.

For interpretation of date on the same scale as geochemical sampling, the mapping of hydrothermally altered rocks was undertaken, which made it possible to compile, for the area, the map of regional metasomatic zonation on 1:50 000 scale. As a result, it has been found that pyrite deposits of the area are controlled by zones of alteration of three regional metasomatic formations, i.e. 1) volcanogenic albitophyre-beresite one related to evolution of submarine and island-arc volcanogenic structures of Middle Devonian - Lower Carboniferous age; 2) tectonogenic propylite-cericitolite one, which is manifested in northeastern block of the Irtysh zone of crush, noted for intensification of tectonic movements and amagmatic hydrothermal activity during Middle-Late Proterozoic; 3) plutonogenic feldspatholite-scarn-propylite one, resulting from the process of emplacement of granitoid intrusions of Zmeinogorsk complex (Middle-Late Carboniferous). According to combination of the above formations, the pyrite deposits are divided into three formational-genetic type, which differ not only in the composition of wallrock metasomatites and the position in regional metasomatic zonation, but also in the position in anomalous geochemical fields. These are: 1) volcanogenic ("Nikolaevsky") type proper; 2) volcanogenic-tectonic ("Irtysh") type; and 3) volcanogenic-plutonogenic ("Talovsk-Rulukhinsk") type.

The ore deposits of the "Nikolaevsk" type are associated with narrow stratiform (by their position in layered cross-section of Middle Devonian - Lower Carboniferous rocks) aureoles of beresite-argillisite alterations in central zones of albitophyre-beresite regionally metasomatic formation. In anomalous geochemical fields

they are controlled by linear, complexly differentiated anomalies of Cu, Pb, Zn, Ag, Ba, characterized, like hydrothermalites of central zones of albitophyre-beresite formations, by transverse asymmetric zonal pattern (from lying side of volcanic structures to hanging side): Cu Zn -> Cu Pb Ag -> Ba Ag. Deposits of the "Irtysh" type are confined to the ares noted for combination of hydrothermal alterations of central zones of propylite-cericitolite and albitophyre-beresite formations. Ore bodies are contained in cericitolites and chlorite-carbonate metasomatites of precipitation stage, being controlled by narrow extended anomalies of complex composition, i. e. Pb Zn Ba Ag Cu Co Ni Mo. Ore deposits of the "Talovsk-Rulikhinsk" type are situated within contact aureoles of granitoids of the Zmeinogorsk complex, where they can be recognized by the occurrence of contact skarn-propylite-secondary quartzite alteration combined with hydrothermalites of central zones of albitophyre-beresite formation, to which complexly shaped contrasting Cu Zn Co V Pb Ni Ag anomalies are associated.

With due consideration of the above regularities, a large-scale predictive demarcation on the petrographic-geochemical basis was undertaken. Such demarcation, being a new one in the study area, helped to distinguish regions promising for pyrite mineralization of different formational-genetic types.

GEOCHEMICAL METHODS OF HIDDEN MINERALS PROSPECTING

S.L.Shimanovich, L.I.Matveyeva, T.Ye.Kolosova

Institute of Geology, Geochemistry and Geophysics of the
Belarus Academy of Sciences, Zhodinskaja, 7, Minsk,220600

Geochemical methods permit to reveal hidden uncustomary minerals in non-prospective at first sight sedimentary strata within Belarus. A peculiarity of sedimentary deposits of the studied region is their facies nonuniformity and step-type behaviour, with are due to the diversity of palaeogeographical conditions of sedimentation. The study of both solid and liquid (pore solutions) phases of sedimentary rocks to discover ore mineralization made feasible geochemical methods of mineral prospecting.

1. Geochemical method,where minor elements of sandy Anthropogene formations are considered to be evidences of prospecting for titanium or zircon mineralization.This method involves the investigation of minor elements in sandy deposits,the study of minerals in some specific size fractions with subsequent recognition of anomalies relative to the background contents and genetically related minerals confine to the deeper horizons.

The territory of Belarus is a unique example of glacial areas, where mechanical differentiation of sediments and accordingly, of the mineral composition occured involving rocks of the glaciation centres, transition and local materials coming from the original moraine, on the one hand,and taken directly from rocks of the sedimentary cover washed by water streams, on the other hand. This process caused high concentrations of heavy minerals. It was established that Anthropogene deposits show a stable association of allothigenic minerals: garnets, amphiboles, ilmenite, to a lesser degree-zircon, rutile, disthene, sillimanite, etc. Being concentrated in heavy fractions, these minerals are an inexhaustible source of many rare components, which can be extracted by force differentiation and dressing of minerals. To detect these components the following method is proposed.

Based on spectral analysis of 900 samples of sandy formations from the south of Belarus, areas with various element contents determined palaeolevels have been distinguished.Schematic maps showing a series. of minor elements and a general map of geochemical zonation have been compiled and show three areas with contrast anomalous contents of minor elements, especially in the more ancient deposits. The location of the revealed anomalies depends on their tectonic position.(at the intersection of rupture disturbances) and

on the proximity to the crystalline basement, which is involved there in the most intense neotectonic upwarping.

2. Geochemical peculiarities of pore waters are evidences of ore mineralization. This method is based on hydrogeochemical indicators of pore solutions and on their comparison with the background contents, on the interrelation with underground waters and enclosing rocks with regard to geological and lithologic-facies conditions.

On a basis of empirical generalizations and computer-aided thermodynamic calculations it was shown that the accumulation of high concentrations of Zn, Cu, Pb, Fe, Al in pore waters of sedimentary basins is a regular geochemical consequence of their diagenetic and catagenetic metamorphism in sedimentary rocks. This metamorphism is accompanied by the transition of considerable amounts of ore elements from rocks to pore waters. A phenomenon of ore elements accumulation in pore solutions is of regional occurence, especially in structures including halogenic formations.

In the other case, geochemical peculiarities of pore solutions made possible the determination of the genesis and formation conditions of dawsonite mineralization in the south of Belarus (Zaozerje area). The background and anomalous contents of chemical elements, paragenetic associations and correlations between individual elements, which define the type of ore mineralization, have been studied. The nature and spatial distribution of secondary alkaline solutions confined to zones of mixed underground waters of continental and marine genesis have been determined. The degree of mobility and a concentration range of aluminum (from 0,3 to 57 mg/l), as well as the migration forms of alluminum among which dominant are AlOH$^-$ (from 0,7 to 72%) and AlO$_2$ (from 12 to 99%) have been established. This permits to conclude that dawsonite mineralization of the studied region is of epigenetic nature and is firstly due to the facies sedimentation conditions, composition and structure of rocks (alumina concentration, degree of dispersion, sodium exchange complex, organic material presence in a section), palaeotemperature regime, as well as to the interaction between solution and enclosing rocks.

The above examples of geochemical methods of analogies and detection of anomalous concentrations of ore elements can be used as prospecting ones in sedimentary strata.

GEOMATHEMATICAL RE-INTERPRETATION OF LITHE - AND PEDOCHEMICAL MAPPING IN LATERITIC ENVIRONMENTS - CASE STUDIES IN THE TIN FIELDS OF NIGERIA/WEST AFRICA.

A.SIAD, G.MATHEIS, A.UTKE & D.KUESTER
Techn. Univ. Berlin/Appl. Geochemistry

Thick accumulations of lateritic covers limit the occurences of easily detectable exploration targets in the tropics considerably. The most successful way to establish the badly needed geological and mineral inventories is the regional application of geochemical mapping exercises. Although chemical weathering progresses very fast in the tropic environments, extensive leaching of the primary constituents is mainly restricted to the major elements Mg, Ca, Na, K and partly Si; most of the lithologically determined trace elements, however, retain the contrasts of their primary concentration levels during weathering processes. Consequently, geochemical dispersion patterns detected from clay - and hydroxid-rich fractions of lateritic covers reflect the concealed bedrock composition adequately and seve as the primary sample media in such surveys.

The Nigerian tin province is known for both Sn-Ta-beating pegmatites and Sn-Nb-mineralized ring compleses. Orientation studies of lithoand pedochemical surveys were centered around the late Proterozoic rare-metal pegmatite fields of Egbe and Wamba in the humid tropics of central Nigeria; the most critical pathfinder elements are Rb, Li, Cs, F in combination with the element ratios like K/Rb, Rb/Sr and Mg/Li.

Multivariate statistical analysis of the two areal data sets were carried out in order to enhance the rare-metal fingerprints in the geochemical soil data by a combination of regression and factor analysis to obtain potential exploration targets. In a second approach, training samples for rare-metal mineralization and the main rock units in the study area were used to discriminate the ore target from the background and to classify the buried parent rocks. Subsets of six variables for Egbe area (Li, Rb, Cs, Mn, V and Ba) and of five variables for Wamba area (Li, Rb, Mn, V, Mg/Li) were found to give the best results. The linear discriminant functions compiled with these training samples were used to relate unknown soil samples to either target or background sites; overall recognition rates of 96.58g and 97g were found for the Egbe and Wamba areas, respectively.

In a second approach, the concealed rock units were classified on the basis of their geochemical parameters Ba, Cr, Mn, Ni, Ti, V, Zn. In the Egbe area, the first discriminant function in soil (Ba, Mn) differentiated spessartine-gnerss, mica-schist and gnersses from amphibolites and so-called Older Granites, while the second distriminant function in soil (Ni, Cr) separated mafic from acidic units; an overall recognition rate of 94g wag achieved. All the areas, where rare-metal targets are plotting, coincide with either spessartine-gneiss or mica-schist distributions according to traditional geological mapping.

ENVIRONMENTAL GEOCHEMISTRY IN ECONOMIC DEVELOPMENT PLANNING

FREDERIC R. SIEGEL and MARIA L. SLABODA, Department of Geology,
The George Washington University, Washington, D.C. 20052 USA
DANIEL J. STANLEY, Smithsonian Institution, MEDIBA, Washington, D.C. 20560

Geochemists-geologists working in the environmental realm have multiple missions. The primary mission, but one not often realized, is to work with environmental assessment teams as development planning is initiated so as to predict potential geochemical (pollution) problems that could occur, and alter the development plan or establish an alternative one so that the problems are obviated. Prevention should be practiced so that coping after the fact does not result. The cost of prevention will depress the economic benefit/cost factor for a project, but during the life of the development it will preserve capital investment and maximize benefits. The second mission, and one in which most geochemists are presently involved, is to try to resolve newly identified or suddenly high profile short-term or long-term contamination problems before they impact maximally on the living ecosystem. This would involve discovering the source or sources of the contamination, establishing a time-space framework for the pollution, and identifying the physical, chemical and biological processes active in the mobilization, dispersion, deposition, concentration and bioavailability of one or more than one contaminant. A third mission, and one in which more environmental geochemists are becoming involved as part of research teams, is the remediation that might be called for in light of the practical and future impacts on the environment. This requires a thorough evaluation of the remediation process(es) and of the projected use of products derived therefrom.

Case study results which illustrate the multiple mission responsibilities of the environmental geochemist are given from lagoons and lakes in Egypt. These lagoons and lakes have been and are being developed for aquaculture using waste discharge (of sewage, agricultural and industrial origin) as a nutrient source, have been reclaimed in part for agriculture, and have been irrigated with waste waters. Heavy metals in the waste discharge (e.g. Hg, Pb, Zn, Cu, Cr, Sn) can present a long-term health risk if they are bioaccumulated first in the food products (fish, vegetables or fruits, and grazing food animals) and then by the human consumer. Any remediation plan that includes bioremediation must take into consideration how and where heavy metal-bearing vegetation remediates are to be used or disposed of lest the heavy metals reenter an atmospheric, hydrospheric, or food pool for recycling to the living ecosystem.

INVESTIGATIONS OF THE CHIM ELECTROGEOCHEMICAL EXPLORATION

METHOD: PRINCIPLES AND PROCESSES

DAVID B. SMITH, DONALD B. HOOVER, REINHARD W. LEINZ, RICHARD

F. SANZOLONE

The CHIM electrogeochemical exploration method, developed in the former Soviet Union over twenty years ago, is claimed to be a means of collecting ions emanating from ore deposits concealed by thick cover. CHIM is an acronym for the Russian phrase "chastichnoe izvlechenniye mettalov", which means "partial extraction of metals". The limited English-language literature on CHIM cites case histories in which concealed mineral deposits have been found through several hundred meters of barren cover in a variety of geologic settings. A modification of the CHIM method has been developed by Chinese geoscientists and is currently being used for mineral exploration in that country.

The method is based on the premise that an applied electric field will draw ions from the surrounding soil into specially designed collector electrodes where they accumulate in an electrolyte, typically 2N to 4N nitric acid. The solution is then recovered and analyzed for ions of interest. Because only ions mobile in an electric field are collected, a CHIM sample is, in effect, an in-situ partial extraction of the soil near the electrode.

The U.S. Geological Survey has been conducting studies of the CHIM method since 1989 in an attempt to understand the physicochemical processes involved and to answer some pertinent questions not addressed in the available Russian and Chinese literature. Field tests have been conducted at three locations in the western United States: 1) the Kokomo Mine near Central City, Colorado; 2) the Cross Mine near Nederland, Colorado; and 3) Johnson Camp, Arizona. The Colorado sites both consist of gold-bearing base metal veins concealed by shallow cover (3 meters of colluvial material at Kokomo, 10-12 meters of alluvium at Cross). The mineralization at Johnson Camp consists of metasomatic replacement deposits containing primarily copper and zinc covered by basin-fill material varying from approximately 10 meters to 100 meters in thickness.

Our tests have shown that geochemical anomaly patterns generated by the CHIM method are repeatable over time and are generally correlative with underlying ore occurrences. We have observed, however, that the magnitudes of the anomalies vary depending on factors such as soil moisture.   In addition, the CHIM anomalies are generally narrower and show higher contrast (anomaly-to-background ratio) than those produced through conventional soil geochemical surveys.

Our research has also indicated that the cumbersome conventional CHIM equipment can be replaced with a simplified set-up. The large current generator used in conventional CHIM

work can be replaced by individual batteries at each electrode. The battery method (termed APLOCHIM) produces currents of a few tens of milliamperes, whereas the conventional CHIM technique produces currents of a few hundreds of milliamperes. We have shown, however, that similar quantities of ions are collected even with an order of magnitude decrease in current. This observation has led to our current investigation of the role of diffusion in the CHIM technique. Preliminary results indicate that the applied electric field may play only a secondary role in causing ions to move into the collector electrodes. Recent experiments show that diffusion is a major, if not the predominant, mechanism by which the ions are moved. The ions are formed as a result of in-situ leaching of soil by acid diffusing out of the electrodes. Resulting concentration gradients cause the diffusion of leached ions into the electrodes. At both the Kokomo and Cross Mines, simple diffusion tests have produced geochemical patterns that are similar to both CHIM and APLOCHIM.

At all three of our test sites, we have shown that the geochemical patterns produced by the CHIM technique can be approximately duplicated by the application of an appropriate weak partial extraction of soil. The types of partial extractions that have given patterns similar to CHIM are: 0.1N hydrochloric acid, 2.5% acetic acid, and an enzyme leach.

GOLD INDICATIONS IN EAST GREENLAND IN THE LIGHT OF CURRENT MODELS FOR GOLD MINERALISATION IN THE CALEDONIAN OROGEN

AGNETE STEENFELT AND PETER R.SIMPSON

Reconnaissance geochemical surveys and new geological base mapping in North-East Greenland indicate the presence of gold mineralisation and have been used to compare its setting with gold mineralisation elsewhere in the Caledonian orogen, including Scotland, Ireland, Newfoundland and Nova Scotia.

Gold mineralisation has been recognised in the Archaean of the fiord zone of southern North-East Greenland in quartz veins associated with greenstones and also in siliceous gneisses which are possibly metamorphosed equivalents of auriferous quartz-pebble conglomerate. Veins and disseminations of gold are also located in younger rocks along a north/south decollement/thrust zone separating Middle Proterozoic high grade metasediments and Upper Proterozoic low-grade metasediments in the Eleonore Bay Supergroup (EBS) and also along a north/south oriented fault separating Caledonian and post-Caledonian rocks. Gold bearing polymetallic veins and stockworks are also associated with Caledonian, Devonian and Tertiary caldera complexes.

The occurrence and distribution of EBS rocks appear from the reconnaissance geochemical data to be the most important common factor in many of the gold mineralised localities noted in rocks younger than Archaean, however. This many be indicative that EBS rocks have benefitted from some enrichment in gold and its pathfinders relative to clarke levels during their formation, mainly by reworking of gold mineralisation from Archaean rocks in the area and transport and further concentration and enrichment, together with sedimentary gold pathfinders such as As and Sb, within the glacigenic tillites and turbiditic sandstones and siltstones which are interleaved with shallow water dolomitic shale and carbonate-rich platform sequences of the EBS. The enrichment in As and Sb in the late Proterozoic to middle Palaezoic sedimentary successions hosting Caledonian gold mineralised structures appear be a common feature during the Caledonian orogeny. However, the general absence of volcanic rocks in the East Greenland sequence is indicative that these rocks most probably did not benefit from juvenile additions of and enrichment of gold by hydrothermal activity during their formation, unlike other regions within the Caledonian orogen further to the south such as the Upper Dalradian of Sheltland and the Scottish Mainland where contemporaneous volcanics related to a back are tensional environment are recognized (e.g. the Dunrossness spilites of the Clift Hills Division; Middle Dalradian to lower Upper Dalradian, Shetland and their presumed equivalents the Fayvallich Lavas of the Scottish Mainland). On the other hand the regional geochemical data for the Dalradian rocks of Shetland and the Scottish Mainland clearly indicate that they do not benefit by being sourced from the weathering of a potentially favourable hinerland with granite-greenstone terrain hosting gold-mineralisation such as the EBS of East Greenland but are partly sourced from the barren Moine pelites and psammites with no potential for gold.

The gold mineralising systems in East Greenland are generally focussed in the vicinity of major fault zones which extend over hundreds of kms, especially where they intersect EBS rocks (such as Western Fault Zone and Main post-Devonian fault zone) and also in the vicinity of late Caledonian or Devonian granitic intrusions. This

situation is similar to the setting of gold mineralisation in other parts of the Caledonian orogen, such as at Lagalochan, Cononish and Comrie in the Scottish Highlands. The models developed for these other gold prospects emphasize the existence of a sedimentary (turbiditic) reservoir enriched in Au, As, Sb and other pathfinder elements, later intrusion of granitic magma and contemporaneous development of major fault zones.

Hence, although the gold and gold pathfinder enrichment processes in the sedimentary sequences differ along the strike direction of the Caledonian Orogen during the Late Proterozoic to early Palaeozoic, there are common features in the later processes which have lead to known gold mineralisation. The gold indications in East Greenland, therefore, justify further study to determine whether they are locally sufficiently enriched for economic exploitation.

GEOCHEMICAL LANDSCAPES OF THE ENDEMIC NIDUS
IN ZABAIKALYE

T.T. Tajsaev

Buryat Teachers' Training Institute, Ulan-Ude, Russia

On the Early Cretaceous period black shales of the Vitim high-
land cryogenic steppe within the Zaza bazin limits Mo, F, Sr &
Li surplus and J & Co lack entail domestic animals endemic di-
seases, such as goitre, fluoris and molybdenum & lithium toxico-
pathy. Black shale strata is composed of argillites, coaly & bi-
tuminous shales and marls interlaid with sandstone, phosphorite
& gypsum. Clayey minerals are presented by montmorillonite, hyd-
romica & palygorskite. In the Zaza bazin during the Early Creta-
ceous period there have been landscapes of dry savanna with nu-
merous temporary lakes surrounded by low mountains. Conditions
have been oxydative with neutral & alkaline class waters. Marls
& dolomites have been settled and sapropelic mud has been accu-
mulated in the lakes periodically getting dry. Siderite & marca-
site presence in shales testifies to reducing conditions in lakes.
Sedimentation in the basin has been accompanied by trachybasalt
flow. Volcano thermal springs have enriched Fe, Al, Ti, P, S &
Cl sediments and in rare elements. Mo, F, Sr, Li, V, U & Cu have
been concentrated on sorptive, alkaline, reducing, sulphide &
evaporative barriers in lakes. Black shales are enriched in these
elements.

Heavy north-western winds dominated in the basins of the cold
ice-aged semi-deserts and steppes. Hollows of outblowing and sal-
ting them are connected with deflation of black shales.

Meadow-black earth steppes of hilly low-mountain relief are
attributed to Ca^{2+} - Na^+ class and the landscapes of drainless
basins - to Na^+ - Ca^{2+} - SO_4^{2-} - Cl^- class. F, Mo, Li, Sr, U and
V high concentrations have found themselves in animal organisms
from salty water, solonchak and meadow herbage of the basin.
Steppe salting is connected with the active cryogenic weathering
of black shales, with freezing out and the evaporative concent-
ration of easily soluble salts and rare elements.

Domestic animals endemic diseases are known in other basins
of the rigion.

DISCRIMINATION OF IRON OXIDEX USING GEOCHEMICAL, MINERALOGICAL AND SATELITE THEMATIC MAPPER DATA: A PRELIMINARY STUDY.

Vairinho,M**; Muge,F.H.*; Sousa,A.J*; Pina,P*

This study sums up research aimed at developing a method of mineral prospecting where the discrimination of iron oxides related to the surficial expression of mineralized areas and hydrothermal alteration takes an important role. The ability to map the surficial distribution of iron oxides species is potentially a source of significant information.

The immediate goal was to differentiate and map ferric oxide species: this was based on an initial test over some previously geochemical-mineralogical caracterized gossans and other iron concentrations in a mediterranean mainly carbonate environment.

This test involves the application of a technique for identifying and mapping hematitic and goethitic, ferric oxides on a Thematic Mapper data. This technique is based on the use of Direct Principal Component Analysis at two selected input ratios, chosen because they permit the higlighting or separation of hematite, goethite and vegetation. The correlated and uncorrelated information between these two input bands is supposed to be separated so it can be possible to distinguish the iron oxide species (hematite-goetite) information from that related to vegetation. Once the relative positions of hematite, goethite and vegetation are established in ration space is possible to infer from the directions of the resulting eigenvectors whether a material is displayed as low or, high digital numbers on the resulting images.

The investigation will be carried out within the Ossa Morena Zone in Alentejo, South of Portugal, at Moura-Ficalho area. This area contains Zn--Pb (+Cu) sulphide mineralization with variable amounts of minor metals (Sb,As,Ag) hosted in Cambrian dolomites. The oxidation of some of the sulfide deposits in the region has led to significant gossan development,

* Instituto Superior Tecnico - Centro de Valorização de Recursos Minerais
** Direcção Geral de Geologia e Minas

during which enrichement reached economic values (Preguiça, Vila Ruiva). But others iron oxide concentrations are known in the area, some have unknown origin and others are steril. The aim of present investigation is to complement already existing geochemical and mineralogical data with information obtained from Thematic Mapper Data.

MODEL FOR PROCESSING MECHANICAL AND CHEMICAL-MECHANICAL AREOLAS DURING GEOCHEMICAL SAMPLING

VALLS ALVAREZ, R.A.

A geomathematic model for processing mechanical and chemical-mechanical areolas during geochemical research is proposed. This method allow us the direct determination of the beginning (Ro) and the end (R) of the anomalies. The method also allow us to avoid the more or less complex statistic procedures, and to make the calculation by independent basins, which means it can be done without the totality of the data from the area under study.

The method consists in the following steps:

a- determination of the macrobasin of denudation,

b- determination of the area of denudation of each sampling point,

c- determination of the informative element(s) in the area,

d- decomposition of the river basin in "profiles".

e- reduction of the local variation of the data,

f- calculation of the medium (Me) of the informative element(s) for each macrobasin.

g- substraction of Me to each smoothed value in the basin,

h- obtaining the productivity (Pi) of each sampling point,

i- graphical or numerical determination of the beginning (Ro) and end (R) of the anomalies (see Table 1) and outlining the perspective area, and

j- calculation of the resources (Q) of the anomalies in category P, and proposing an order of priority for their verification.

As you can see in Table 1, the beginning of the anomaly will be determinate by the first value of productivity that will sensibly differ from zero, while the end will correspond to the point after which the values will tend to zero again.

Table 1.- Geomathematic modelling of the profile #1. The informative element in the area is the lead (Pb) and its medium value in this basin is of 40 p.p.m.

N	Sample	Pb, ppm.	Xs	Xs - Me	Area	Pi	R-positions
1	22	40	40	0	725	0	
2	21	30	30	0	700	0	
3	20	90	50	10	580	5 800	Ro
4	19	100	143	103	621	63 963	
5	18	300	267	227	630	143 010	
6	17	400	253	213	800	197 440	
7	16	60	163	123	962	120 726	R
8	15	30	37	0	5 801	0	
9	14	20	20	0	60 565	0	

$Xs = (X_{-1} + X_i + X_{+1}) / 3$

$Pi = (Xs - Me) \times Area$

The proposed method can be successfully used for studying any kind of mechanical and chemico-mechanical aureoles, such as stream sediments, panning sampling and other similar aureoles, in order to locate the ore body.

GEOCHEMICAL METHOD FOR TALC PROSPECTING IN THE ESCAMBRAY METAMORPHIC MASSIF

VALLS ALVAREZ, R.A. , NUNEZ, F.

The prospection of talc deposits is mainly based on direct field observations, while geochemical methods are considered inefficient or of a limited effectiveness. This paper demonstrates the effectiveness of soil sampling for the prospection of talc, based on a real study done in the Escambray Metamorphic Massif in Central Cuba.

Between 1981 and 1984, a wide complex of geological, geophysical and geochemical methods were carried out by the Enterprise Santa Clara for talc prospecting. Within them, and because of a recommendation of the czechoslovakian specialist Guenadi Burt of the Centre of Geological Investigations from Havana, soil samples were taken with a net of 20 x 100 m., at a depth of more than 0,2 m., and with a weight of 200 - 300 g.

Common geochemical methods of interpretation didn't help to locate anything knew, an even failed to locate old talc outcrops directly over the surface, which seemed to confirm the idea of the ineffectiveness of geochemical methods in this case. Therefore, I developed a new geomathematic model for the interpretation of the data which I named "**correlational coefficients**" (C.C.) Basically it consists in the following procedures:

a- selection of a statistical sample on each geological formation in the area under study, including the ore,

b- detection and further exclusion of "*hurricane*" data,

c- selection of the informative elements,

d- determination of their law of distribution,

e- calculation of their binary correlation,

f- determination of the typical correlational coefficients for each geological formation (see Table 1), and

g- finally, the selection of the C.C. which will revels **only** the formation which contents the talc ores, and the determination of its range of importance, by comparing the correlational coefficients showed in Table 1.

Table 1.- Correlational coefficients for the geological formations in the area under study.

Fm. *Loma Quivicán*	Fm. *Loma Quivicán alterada*	*Complejo metaintrusivo* (which contents the talc ores)
Cr x Cu x Ni	Cr x Ni	Cr x Ni x Co
Cr x Cu x Ni x Co (?)	(Cr x Ni)/Cu	Ba x Cu
		(Cr x Ni x Co)/(Ba x Cu)
		Co / Ba

In our case, the C.C. selected because of its superior performance was (Cr x Ni x Co)/(Ba x Cu). Any result in the 10^1 range an over (up to 10^9) will indicate the presence of a talc perspective zone whiting the *Complejo metaintrusivo*. The use of this C.C. in the area under study not only located all the old outcrops, but also indicated the existence of other blind bodies in the area, which were later reached by surface-mining works, increasing in several thousands of tons the original resources of the area.

I should add that the developed model of the **correlational coefficients** can be equal successfully used for prospecting other kinds of metallic and non-metallic ores in different geological environments.

METAL POLLUTION HISTORY IN NORTHEAST ESTONIA, RECORDED BY LAKE SEDIMENTS

VARVAS, M.

The biggest industrial region in Estonia lies in the northeast part of the country. Up to the beginning of this century the human activity and its influence to the ecosystems in the given area were rather modest. It was a territory with the sparse population, except its northernmost part near the Gulf of Finland and there were not any industrial centers. Due the mining and processing of oil-shale since 1916 the situation in this region was changed. The most dramatical raise in human impact took part after a World War II as a result of rapid increase of mining activity and ejection of several powerful thermal power plants, based on oil-shale. As a consequence a large amount of alkaline fly ash, containing elevated levels of several metals and other compounds, was emitted to the atmosphere and deposited then in the environment. Several lakes are influenced by the discharge of mining waters with high mineralization and chemical composition different from natural surface waters. Mining waters are also carrying to the lakes a large amount of suspended matter, causing dramatic increase of sedimentation rates.

During the recent study the bottom sediments of several lakes and ponds nearby the NE Estonian industrial area were investigated by their metal composition. Among them were the closed lakes, influenced only by the atmospheric fallout as well as throughflowing water bodies, some of them are influenced by the discharging mining waters. Samples from the uppermost section of bottom sediments (50-60 cm) were obtained using a piston corer and by in situ freezing technique. Both Neutron Activation method and Atomic Adsorption Spectrometry were used for metal analysis. In many cases sediment layers were dated using Pb-210 method. Content of organic matter (LOI) was also determined.

In all lakes, close to the industrial areas the lithological and chemical composition of the uppermost sediment intervals (10-20 cm) was changed remarkeably. Elevation of metal concentrations are syncronous with decreasing of LOI as a result of the deposition of fly ash. Beginning of these processes was dated with Pb-210 as the beginning of the 50-ies, when the consumption of oil-shale as a fuel in power plants increased rapidly. In all lakes especially in closed ones the correlations between most metals as well as LOI were extremly high (r=0.80-0.95), which is also reflect to the common source of metals. In lakes and ponds, distant from big atmospheric pollution point sources but affected by discharging mining waters the distribution pattern of metals in their sediments was somewhere different. For example, remarkable decrease of Cu and Zn in sediment layers, affected by mining waters, was correspond with increase of Hg and Pb. It is found that last two metals exist in elevated concentrations in Estonian oil-shales.

STABLE ISOTOPE GEOCHEMISTRY OF LOS AZUFRES GEOTHERMAL SYSTEM, MEXICO

VERMA, M.P., BARRAGAN, R.M.. PORTUGAL, E.

It presents a systematic stable isotope geochemical studies of Los Azufres geothermal system, a second highly developed geothermal field in Mexico. The first isotopic (δD and $\delta^{18}O$) composition of the fluid from natural manifestations and exploratory drilled wells were determined in early 1980s. Since then a continuous monitoring of isotopes of hydrogen, oxygen and carbon in various species of the geothermal fluids has been carried out in order to characterize and evaluate effect of exploitation on the geothermal reservoir parameters.

The chemical and isotopic compositions of natural manifestations and drilled wells demonstrate the evidence of non-existence of direct infiltration of meteoric water in the deep reservoir. Although the natural manifestations in the region of south-east of the field has very low concentration of dissolved salts and present an isotopic shift in oxygen with that of deep reservoir fluids. This may be considered as a possible recharge zone in the south-east of the field. The meteoric waters (i.e. diluted cold natural springs) in the main field fall on the world meteoric line, but they are lighter than that of the region of the south-east of the field. It can be explained as an elevation effect, as the main field is about 500 m higher than the south-east region.

The main processes, identified in formation of natural manifestations, are heating of local meteoric water with reservoir vapor, mixing of local meteoric water with a component of deep reservoir fluid, and mixing of local meteoric water with highly evaporated surface water and a component of reservoir fluid.

The reservoir of Los Azufres geothermal system is a unique featured. The upper part of the reservoir contains vapor dominated region which is consequence of a process of steam upflow and partial condensation. The behavior of chemical and isotopic species in geothermal fluid with elevation of production zone of the drilled wells supports this hypothesis as concentration of volatiles increases with elevation whereas the non-volatiles shows opposite behavior. A one-dimensional stratification model of the reservoir is proposed using Rayleigh fractionation equation to comprehend the physical-chemical processes existing the reservoir.

GEOCHEMICAL ATLAS OF SLOVAKIA-
- COMPLEX GEOCHEMICAL MAPPING

Kemil Vrana
Dionyz Stur Institute of Geology

Project is aimed at the compilation of a geochemical atlas made of maps of single chemical elements and radioactivity in the territory of Slovak ropublic in 1:1,000,000 scake. The investigated elements are Al, As, Ba, Be, Ca, Ce, Co, Cd, Cs, Cr, Cu, Fe, Ga, Hg, K, L, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Rb, Sb, Se, Sn, Sr, Tl, V, W, Y, Zn and Zr in rocks, stream sediments, groundwates, soils and forest hiomass. The evaluation includes also the total radioactivity of the territory and their partial element concentration (K, U, Th). The second goal is the compilation or association maps of anomalous concentration of ecologically significent elements (namely Cd, Hg, Cr, Mn, Sb, As, Cs, Tl) in 1:200,000 scale. The set of selected elements will be to a certain extent modified for single sampled media. THe projoct is under reslization during 1991- 1995 (including the complete termination and map printing of the atlas and single association maps). Research is made beside the coordinating institution (D. Stur Institute of Geology also by further institutions acting in geological and natural science research.

Obtained data will be digitalized and processed by computers. The hardware and software bosc is realized in cooperation of D.Stur Institute of Geology with Geofond Bratislava.

The significant output of this project will be hence a geochemical database. The processed data will be included into explanations to the Geochemical atlas (report) as two independant parts (stream sediments and groudwaters) where also the other analytical results will be collected (lithogoochemcial and biogeochemical results).

LAND APPLICATION OF WASTE WATER AT RANGER URANIUM MINE, ALLIGATOR RIVERS REGION, NORTHERN TERRITORY, AUSTRALIA

ROGER WATTERS

In 1984, discussion commenced regarding the environmentally benign methods which might be used to dispose of an excess of waste water accumulated at the Ranger uranium mine in the Alligator Rivers Region of the Northern Territory, Australia.

The expressed fears were mainly concerning uranium and its radioactive decay products, especially radium-226.

The idea of land application, ie spray irrigation, of the excess water was mooted and supported by consideration of applied geochemical principles, including fixation by sesquioxides in soils and sediments. Predictions of the likely outcomes and subsequent lack of environmental detriment were made.

After several years of operation of the system, monitoring data from soils, seepage and the associated biota have indicated that the original predictions were correct and that no significant detriment was attributable to the irrigation process.

Iron Oxide Dissolution Patterns - Implications for Geochemical Samples Containing Relict Iron Oxides

J.J. Xie and A.C. Dunlop
Department of Applied Geology
University of New South Wales
P. O. Box 1
Kensington
New South Wales
AUSTRALIA 2033
Tel: (02) 697 4265
Fax: (02) 313 8883

Extended Abstract

Considerable attention has long been paid to geochemical patterns related to the surface absorption processes on recently precipitated Fe oxides in sample media from a range of secondary environments. In many parts of Australia with long weathering histories Fe oxides may have experienced several cycles of chemical and mechanical reworking. The role of element retention in such relict Fe oxides is of significance in recognition of geochemical patterns related to mineralisation in various surfacial sample media particularly lags. Such considerations have played a role in gossan interpretation. These are often dominated by sulphide oxidation and the stability of oxidised minerals in relation factors such as pH. In this investigation, geochemical patterns in laboratory transformed Fe oxides are reported which are in part, similar to transformation through which Fe oxides may go during aging, chemical and mechanical reworking on ancient erosion surfaces.

Goethite has been prepared in the laboratory with the incorporation of Cu, Pb and Zn in varying proportions (1, 3, 5 and 25 millimole $M/(M + Fe)$ ratios). Samples of these synthetic goethites have been transformed to dominant maghemite and hematite assemblages by heating in reducing and oxidising conditions at 650 °C for 2.5 hours. The size, morphology and crystallinity of these samples have been evaluated by XRD and TEM studies. Naturally occurring leached surface gossans derived from VMS pyritic sulphides composed of varying proportions of goethite and hematite have been similarly transformed by heating. The character of original and transformed assemblages have been evaluated by polished section, SEM, electron probe and XRD studies. Both synthetic and naturally occurring Fe oxides samples have been subjected to 6 M HCl dissolution after periods up to 200 hours at 20 °C.

Dissolution curves for synthetic Fe oxides are prepared by plotting metal released against time and Cu, Pb and Zn released against Fe at different stages of dissolution. These can allow some inferences to be made about dissolution of metals within the Fe oxide crystals. Distinctive dissolution curves are produced for goethite, hematite and maghemite which vary in relation to the degree of Cu, Pb and Zn incorporation. Maghemite is much more readily decomposed than goethite and hematite. The dissolution curves for goethite and hematite generally have a positive curve suggesting particularly that Cu, Pb and Zn are concentrated on the periphery of the crystals. Goethite dissolution shows a greater tendency to a linear pattern suggesting a more uniform element distribution throughout the crystals. In contrast, Zn at low concentrations (1 millimole M/(M + Fe) ratio) for goethite, hematite and maghemite shows negative curve suggesting depletion on the margins of crystals. Generally, during dissolution of goethite less Cu is extracted than Zn and Pb.

Dissolution patterns for untreated gossan samples and those samples transformed to hematite and maghemite dominant assemblages are comparable to the trends observed in the synthetic Fe oxides. Differences in dissolution curves between gossan samples are largely attributed to differences in initial mineralogical and bulk chemical composition. Constant high Pb extraction patterns are apparently related to the presence of discrete Pb minerals rather than substitution in the lattice of Fe oxides.

The results of evaluation of differing dissolution curves for the various Fe oxide as reflecting a tendency of trace element retention may explain in part element distribution in coarse lag style samples in the vicinity of sulphide mineralisation for several sites in central New South Wales. Here patterns of trace element retention in Fe oxides as reflected by dissolution curves are of greater importance than present surface adsorption processes in determining metal content of these Fe oxide rich samples. In this regard explanation is offered to the consistent development of enhanced Cu levels in non-magnetic lag samples dominated by goethite and hematite as compared to magnetic dominated by maghemite and hematite. Examination of a wider range of element distributions together with spatial patterns in magnetic and non magnetic fractions of lag samples suggest that they reflect not only different patterns of element retention related to Fe oxide mineralogy, but also subtle relict primary and oxidation controlled signatures. These signatures may be enhanced by appropriate choice of sample type and a clearer perception of element retention characteristics of various Fe oxides in these sample types.

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APPLICATION OF TANDEM MASS SPECTROMETRY IN STUDYING THE DISTRIBUTION OF HOPANOIDS IN RECENT AND ANCIENT SEDIMENTS

YU, SHU-CHING[1]; LIU, CHIN-TOU[1]; OUNG, JUNG-NAN[2]; SHIEA, JENTAIE[1]

[1] Dept. of Chemistry,Natl. Sun Yat-sen Univ., Kaohsiung, Taiwan
[2] Inst. of Marine Geology,Natl. Sun Yat-sen Univ., Kaohsiung, Taiwan

Hopanoids are types of pentacyclic hydrocarbon which were detected in most recent and ancient sediments and fossil fuels. The information gained from distribution and types of these compounds in the samples has been proved to be very useful in assisting oil exploration.

Traditionally, the analysis of such compounds are performed with gas chromatography/mass spectrometry (GC/MS). However, the technique is limited by its resolution in detecting trace of complex mixture. Recently, the development of tandem mass spectrometry (MS/MS) has made such analysis become possible. We have studied the distribution and composition of hopanoids in recent cyanobacterial mat and ancient sediments with GC/MS and GC/MS/MS. Although the samples were collected from different area-Baffin Bay, Texas and Southern Taiwan, large quantity of unusual C28 hopanes were detected in both sediments. The electron impact (EI) and daughter ion mass spectra of the compounds show some degree of difference. The results from Multiple Reaction Monitoring (MRM) show there are three isomers in the ancient sediment. The presence of C28 hopane in the cyanobacterial mat implies that the the bacteria may be the original source for these compounds. Under the effects of diagenesis, and catagenesis, the original C28 hopane from bacteria may be converted to its structural and steric isomers in the sediments.

A QUANTITATIVE APPROACH TO GOLD SIGNAL EVOLUTION IN DIFFERENT LATERITIC CONTEXTS

ZEEGERS H. and FREYSSINET Ph.

An understanding of the geochemical environment is essential for the efficient application of a geochemical survey. Although the combination of geological, geomorphological and environmental conditions, and thus the geochemical response, is unique to any region, many similarities can nevertheless be defined in the pedogenic and paleoclimatic processes of geochemical dispersion, particularly in tropical environments (Butt and Zeegers, 1992).

The aim of the present study was to determine some of these models through a quantitative approach to the gold signal evolution in lateritic profiles from different paleoclimatic zones. The comparison of variations in gold concentration at selected sites was based on a mass balance calculation of the gold, using the average gold content in the saprolite horizon as the reference and estimating the evolution of concentration in the overlying horizons in terms of residual enrichment or absolute gain or loss.

The sites were selected according to their pedogenic and paleoclimatic situation (Table 1) and range from an ancient laterite profile exposed to contrasted tropical conditions, as at Kangaba in Mali, to a truncated laterite profile covered by a recent soil horizon in equilibrium with existing equatorial conditions, as at Yaou in French Guyana. The other selected sites represent intermediate conditions under which the laterite has been progressively degraded first to a nodular horizon (latosol) and then to a stone line - a nodular horizon representing an old lferricrete and an overlying clay horizon formed under rainforest conditions.

The global evolution of the gold signal from the saprolite to the surface was determined by estimating the gold mass balance for the two main horizons generally sampled in a geochemical soil survey: the actual surface soil (H1) and the laterite or its degraded horizon (H2).

In ancient laterite profiles (Kangaba), the gold is strongly leached from the top of the profile. Where the laterite has been degraded to a latosol, the gold mass balance is less negative (Posse deposit), and may even be positive (Mborguéné, Ity). Thus the surface soils showing the highest gold accumulation are in equatorial climates (Yaou), those with the least gold accumulation,(because of intense leaching and thus a poor gold signal) are in contrasted tropical climates, and those where gold tends to be enriched at the surface form under wetter conditions.

The stone-line profiles of Gabon represent the most advanced stage of laterite degradation under an equatorial climate. The gold mass balance reflects the pedogenic evolution of the profile. In the nodular horizon (H2) derived from the laterite the gold is strongly negative as in the laterite. In the surface clay horizon (H1) that develops under equatorial forest conditions, the gold grades show an enrichment of about 60% compared with the nodular horizon (H2).

Variations in surface physico-chemical conditions between the contrasted tropical climate soils and those from an equatorial climate determine the mobility of gold and thus its gold mass balance at the tops of the profiles. Equatorial forest conditions seem to be less oxidizing with the result that the gold stock is preserved during pedogenesis and gold becomes truly enriched in the surface horizon. In contrast, in the savannah environment undergoing laterization, gold is highly remobilized at the top of the profile.

The conclusion from this comparative study of the gold mass balance in different laterite contexts, is that the potential of a soil geochemical gold anomaly and the possible evolution of gold grade with depth to the saprolite horizon can be assessed from a detailed knowledge of pedological environment.

Table 1: Principal characteristics of the studied sites.

	Kangaba (South Mali)	Posse (Bahia st., Brazil)	Mborguene (Cameroun)	Ity Mine (Ivory C.)	Dondo Mobi (Gabon)	Yaou (F. Guiana)
Climate	Contrasted tropical	Humid tropical	Humid tropical	Humid tropical	Equatorial	Equatorial
Annual rainfall (mm/y)	900	1800	1800	2000	2500	2500
Profile	Complete	Complete	Complete	Complete	Complete	Truncated
Surafce	ferricrete	latosol	latosol	latosol	stone line	feralitic soil
Gold mass balance (%) H1 (top horizon - soil)		-30			-10	+64
H2 (ferricrete and nodular horizon)	-73	-11	+37	+47	-72	-
references	BRGM (1984) unpl. report; Freyssinet (1991)	Porto (1991)	BRGM (1986) unpl. report; Freyssinet et al (1989);	Vitali (1964); S.M.I. (1992) unpl. report.	Lecomle and Colin (1989); Colin et al (1993)	BRGM-BHP-UTAH (1991) unpl. report; Freyssinet (1993)

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THE APPLICATION OF ANALYSES OF ULTRA-FINE GRAIN-SIZED GOLD TO EXPLORATION

Zhou, X. and Nichol, I.

Geochemical exploration for gold in many parts of the world has focused attention on obtaining a representative sample in the first instance, having regard to the very low concentrations of gold present, together with the relatively erratic distribution of gold. This objective has been achieved variously by collecting large samples, concentrating the gold into small sub-samples (heavy mineral concentrates) or analysing very large samples. These approaches have proven effective and contributed to the discovery of significant deposits throughout the world. However, a number of weaknesses of these approaches have been identified, which together with their relatively high cost, raises the question as to whether technically more reliable and cost-effective methods can be developed.

A very interesting approach has been developed in China involving stream sediments and soils for use in reconnaissance and detailed scale exploration and led to the discovery of several major deposits. The procedure is based on the occurrence of significant but low order concentrations of homogeneously distributed micron- to submicron-sized gold in soils and stream sediments associated with mineralization. For example, in reconnaissance scale exploration low level Au anomalies, delineated by a 2-4 ppb threshold, have led to the discovery of some significant deposits. A key feature of the approach has been focusing attention on the recognition of patterns and less attention on single erratic high values attributable to the nugget effect.

The essential components of the approach rely on (a) the presence of ultra-fine grain-sized gold, (b) concentrations of ultra-fine grain-sized gold spatially related to mineralization, and (c) an ultra-sensitive analytical procedure capable of giving adequate precision at the sub ppb level.

Canada has been a major producer of gold for many years, and interest in exploration for gold deposits in areas of favourable geology has similarly attracted attention for an extended period, and for the last fifteen years geochemical techniques have been one of the major exploration approaches. The procedures adopted have contributed to the discovery of some major deposits but weaknesses in the techniques have been recognized. Hence, the question arose as to whether the Chinese approach of adopting an ultra-sensitive analytical procedure had

a wider application for identifying low-order gold anomalies, attributable to ultra-fine grain-sized gold particles and thereby detecting mineralization that would be overlooked by conventional procedures.

In the first instance fourteen soil samples from the Carlin area of Nevada, and thereby expected to contain micron sized gold particles and known to contain sub-ppb to 10 ppb Au, were sieved to minus 177 μm (80 mesh), pulverized to minus 75 μm (200 mesh) and then homogenized. The samples were analysed in triplicate by nine methods or laboratories. The precision achieved by the different methods or laboratories varied in the range $\pm$50 to $\pm$120 % at the 95 % confidence level. An interesting feature that emerged was the existence of consistent variations in concentration of gold reported by different laboratories. Despite the differences in absolute concentration of gold quoted by various laboratories the same relative differences were indicated amongst samples, indicating that several of the laboratories involved would detect the same geochemical pattern. A further unexplained point of interest was the divergence from accepted values of results for some of the Chinese Reference Materials reported by some of the laboratories.

With regard to the grain size of gold within samples significant proportions of ultra-fine grain-sized gold have been recorded in glacial till by previous workers. In the present investigation it has been confirmed that, within the minus 63 μm fraction, a significant proportion occurs in the minus 2 μm fractions. The minus 2 μm fraction consistently contains the highest absolute gold concentration within the overall minus 63 μm fraction but not always the highest proportion of gold due to varying mechanical composition of the samples.

Microscopic, scanning electron microscope and X-ray diffraction investigations have indicated the different fractions of the minus 63 μm fraction to have different mineralogy which may account for the varying distribution of gold within samples.

On the above basis it can be concluded that there is an analytical capability of providing the necessary precision at low levels of concentration and that significant proportions of ultra-fine grain-sized gold occur in till samples. Currently work is in progress to see whether superior dispersal trains associated with mineralization can be detected by adopting an ultra-sensitive analytical method capable of determining low-order gold concentrations attributable to ultra-fine grain-sized gold particles, relative to dispersal trains displayed by conventional methods.

DISTRIBUTION OF AU IN DIFFERENT TILL SHEETS, BEARDMORE-GERALDTON, ONTARIO, CANADA

ZHOU, XIAODONG, NICHOL, IAN

A study of gold distribution in different till sheets has been conducted in the Beardmore-Geraldton area, Ontario, where gold exploration has been long hindered by the glacial overburden and the nugget effect. A more sensitive analytical method, which is compatible to the Chemical-Spectral method adopted widely in China, has been used in this study.

As part of the orientation survey, a series of 14 soil samples (~75 μm dry sieved), collected along the Carlin Trend, Nevada, were sent to different laboratories in Canada and China for triplicate Au analysis. Among these laboratories, precision varies from $\pm$ 50 % to $\pm$ 140 %. Results from different laboratories also show a consistent shift in absolute values for each sample giving similar variation patterns in the mean values of all 14 Carlin samples. This feature has been reproduced in different rounds of tests done by the same laboratories. Variation in precision given by different laboratories is probably due to different extraction procedure adopted by these laboratories. Au that occurs in quartz and/or bound in organic material and/or adsorbed on clay or Fe-Mn oxides, might affect the efficiency of each extraction procedures. Based on these results, a 30 g FA/DCP method with a detection limit of 0.5 ppb is selected for the study.

Four weathered till samples from the Beardmore-Geraldton area were selected to study Au distribution among seven size fractions broken down from the -63 μm fraction. Preliminary results displayed a bimodal distribution pattern. Au appears to be concentrated naturally in both the coarsest fraction (-63+45 μm) and the finest fractions (-11+2 μm; -2+0.1 μm). Furthermore, Au concentrations in the -2+0.1 μm fractions are always the highest, although the proportion of total Au in the fraction is not necessarily high, due to the variation in sample texture. Microscopic and SEM examination and XRD analysis of these fractions reveal a mineralogical and phase differentiation that is probably related to the Au distribution in the surface environment within the area. Among all the samples, the population in the coarse fraction is attributable to micron- to submicron-sized gold that is included in quartz and, to lesser extent, that associated with oxidized sulphide. In contrast the population in the finest fractions is caused by gold adsorbed on chlorite and/or Fe-Mn oxides. Bacteria may also occur in the micron- to submicron-sized fractions of some of these samples, and may have absorbed gold in the surficial environment.

Surficial till samples collected from two transects across greenstone belts within the Beardmore-Geraldton area, covered by either local till sheets or exotic till sheets, were also analyzed to define the regional distribution of gold. Along the transect where exotic till sheets overlie local tills, samples from two rotasonic drill holes were selected to determine the vertical variation of gold with respect to type of till and secondary / supergene effects. Surficial till samples collected at 100 × 20 grids in the Onaman River area in the region were analyzed in order to determine the distribution of gold on a local scale.

It has been confirmed that micron- to submicron-sized gold occurs widely in surficial environments in glaciated terrain. This study provides priliminary results for the possibility of adopting methods of defining low-level gold anomalies for gold exploration in areas of glacial overburden.

GEOCHEMICAL EXPLORATION OF ORE DEPOSITS BY THE MOBILE FORMS OF CHEMICAL ELEMENTS

ZHOVINSKY RDW. YA.

Traditional geochemical methods gave slight effect for the exploration of deep-seated blind ore deposits. Their improvement should be directed to the use of new methodological ways and first of all to the use of mobile forms of chemical elements.

Such an approach to the decision of this problem made possible to establish that above blind deep-seated deposits covered with thick series of sedimentary rocks local geochemical anomalies of superposed haloes of metals may form and even of such an active element as fluorine.

The difficulty consists in detecting of anomalies above ore deposits because the anomalies of similar type may be also formed above zones of tectonic faults and tectonic activization, locations of unloading of abyssal underground waters, zones of ore body margins alterations, technogenic pollution and other cases. First of all, anomalies related to ore objects are difficult for detection because of small contrasts in contents of elements in superposed haloes in comparison to background ones.

The conditions of their formation and contrast are caused by a set of reasons: concentration and forms of presence of indicator element in mineral phase of studied sample and contacting solution, matter composition of strata (soil), composition of contacting waters, physical-chemical conditions of formation of dispersion halo, special features of kinetics and dynamics of sorption-desorption process and its thermodynamic direction in natural system rock (mineral) – water.

Superposed dispersion halo above ore deposit is formed on account of coming of the element from ore body and its sorption by surface deposits (soils). The task consists in the detecting of its amount during desorption process by obtaining water extract and detecting in it of quantity of indicator element. The value adequate to the sorbed amount may be detected by determination of duration of water extraction that makes possible to establish with the most precesion the amount of the element sorbed by the rock (soil) before.

The duration of water extraction is established by special study of kinetics and dynamics of sorption-desorption process.

That is why during geochemical exploration by the mobile forms of chemical elements it is necessary in conditions of definite geochemical landscape to carry out preliminary study of kinetics of the process of element desorption for the most correct measurement of water extraction duration.

The technology of the method of geochemical exploration by superposed dispersion haloes consists in sampling of soil (subsoil), obtaining of water extract, measurement of element content in it and compiling according to the data obtained of the map of distribution of mobile form of the element.

Physical – chemical methods of relative contrasting (2-4-fold) of contents of indicator elements which came from ore object have been also worked out.

Geochemical method of exploration by superposed haloes has been widely confirmed by the exploration of deposits of fluorite, polymetallic and rare-metal mineralization, mineral waters and some other deposits.

GEOLOGICAL-GEICHEMICAL PATTERN OF GOLD-SULFIDE DEPOSITS IN THE TECTONIC-MAGMATIC STRUCTURES OF CENTRAL TYPE

ZORINA L.D.

The gold-sulfide deposits of the Darasun ore-magmatic system (Trans-Baikal area) are considered. They are the series of quartz-sulfide veins and mineralization zones in the fractures of north-eastern and north-western trends. The ore bodies mainly occur in the small intrusions of the porphyry rocks of intermediate-acid composition (diorite porphyrites, granodiorite-porphyries, felsite-porphyries etc.). They are paragenetically associated with these rocks. The porphyry rocks are the representatives of the differentiated associations (from basic rocks to acid volcano-plutonic ones), which are enriched in potassium.

The model of ore-magmatic system is developed on the basis of the genetic type formula, proposed by Ovchinikov (1988), and involves 12 major points. These are characteristics of deep origin of the geological process, responsible for ore formation (A); geodynamic settings (B); geological process, giving rise to ore formation (C); sources of ore substance (D); ore-forming solution (E); energy of ore process (F); parameters of ore-forming solutions(G); medium (H) and mechanism (I) of ore deposition; zonation (J); interaction with the host rocks (K) and physical-chemical conditions of ore deposition (L).

A. Study of Sr, Pb, S isotopes indicates that the primary melts and ore-bearing fluids were formed due to interaction of the partially depleted upper mantle ($^{87}Sr/^{86}Sr = 0.7050 - 0.7080$) and the deeper non-depleted mantle ($^{87}Sr/^{86}Sr = 0.7130$).

B. The geodynamic setting is associated with the reconstructed Benef paleozone for the early Mesozoic, made by M.I.Kuzmin, along the southern margin of the Trans-Baikal microplate.

C. The sources of fluids, involving the incoherent and ore components, are probable the mantle melts of the latitic composition ($^{87}Sr/^{86}Sr$ in latites is 0.7050, in the pre-ore propilites - 0.7044, in syn-ore carbonates - 0.7046). The mantle and crustal melts can be mixed (combination of the latitic and calc-alkaline magmas derivatives in the space, hybrid rock occurrences, significant variations in concentrations of a number of elements of the iron family).

D. The sources of ore substance, in addition to the upper mantle and intermediate chambers in the crust, are the country gabbroids, which contain 4 ppm of gold.

E. The analysis of the fluid inclusions show that the sources of ore-forming solution are the magmatic waters and gaseous fluids.

F. The sources of energy of ore process is heat energy of the Earth as convective flows (Pospelov, 1973). The deposit were formed within the time range 175 + 5 - 111 + 5 Ma (Rb-Sr method)

G. The explosive phenomena and tourmaline occurrences on early stage of ore process under $400^{o}C$ indicate that the ore-forming solution was initially gaseous but under 350-$320^{o}C$ it liquefied. The liquid dissolved substance contains main ore components as haloid and sulphur compounds. B, S,

CO_2 are significant among the dissolved gases.

H. The hosting medium is alumosilicates.

J. The mechanism of ore deposition is fissure metasomatism, in addition to convective substance transfer and complicated movement of the solution in the porous medium. The ore deposition occur under the conditions of temperature lowering with a discrete deposition of ore components under appropriate temperatures. It results in the successive change in the stages of ore deposition process: tourmaline (430-320°C), pyrite (390-275°C), polymetallic (315-230°C), sulphosalt (300-200°C), sulphoantimonite (270-170°C), post-ore quartz-carbonate (120-75°C). The stage pattern in time correlates with the zonation in space. This fact results in the telescoped complex gold deposits with Ag, As, Pb, Zn, Cu, Bi, Sb as the accessory elements.

I. The zonation pattern is typical of the considered deposits. It is evident on magmatic and ore stages as well as on different hierarchical levels. The concentric mineralogical-geochemical zonation, which correlates with temperature and age, is also common. The complex ores and geochemical fields with the intensive concentrations of ore components are observed in the centers of ore columns, ore bodies and deposits.

K. When ore solutions interact with the host rocks, the pre-ore propylites and syn-ore listvenites-beresites are formed.

L. The ore deposition occurs in two stages (considering the data on fluid inclusions). The solutions are boiled away, the chloride brines, which extract and accumulate ore components, are formed during the first stage (metasomatites and associations of tourmaline and pyrite stages are generated) due to pressure decrease in the thermal field of granodiorite-porphyry intrusion. The deposition of productive associations of the polymetallic and sulphosalt stages, which results from the supply of weakly mineralized vadose waters and their mixture with the brines, occurs within the second step. The boundary parameters of ore deposition are: temperature - 430-75°C, pressure - 1420-60 bars, salt concentrations - 44-2 mass % equal to NaCl.

List of authors from countries and districts outside China

AUSTRALIA
Aubrey, M.
Beck, R.W.
Butt, Charles
Butt, Fay
Cohen, David
Dunlop, A.C.
Gray, D.J.
Lintern, Melvyn J.
Lintern, Suzie
Moort, Van, J.C.
Pwa, A.
Watters, Roger Allan
Xie, Jian Jiao

BELARUS
Anoshko, Ya.I.
Brezgunov, V.S.
Generalova, V.A.
Kolnenkov, V.P.
Kolosova, T. Ye.
Kuznetsov, V.A.
Lukashev, Valentine
Matveyeva, L.I.
Nikitin, A.B.
Onoshko, M.P.
Petukhova, N. N.
Rjabova, L.N.
Romanov, S.L.
Shimanovich, S. L.
Zhukhovitskaya, A.L.

BRAZIL
Angelica, Romulo
Costa, Marcondes

CANADA
Barefoot, R.R.
Blok, H.
Carignan, Jacque
Caughlin, B.L.
Chen, Zhongxing
Darnley, Joan
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Nichol, Ian   Queen's Uni., Kingston, Ont. K7L 3N6, Canada, 33, 189, 191
Nikitin, A.B.   Inst. of Geochem. & Geophy., Acad. Sci. of Belarus, Zhodinskaya Str.7, 220600 Minsk, Belarus, 139
Nilsson, B.   Geol. Survey of Finland, Betonimiehenkuja 4, Espoo SF-02150, Finland, 60
Norblad, G.   Geol. Survey of Finland, Betonimiehenkuja 4, Espoo SF-02150, Finland, 60
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Nunez, F.   5475 Rosedale St., Apt 401, Montreal, Quebec H4V 2H8, Canada, 179
Onoshko, M.P.   Inst. of Geochem. & Geophy., Acad. Sci. of Belarus, Zhodinskaya Str.7, 220600 Minsk, Belarus, 103, 139
Ossenkopf, P.   Sachsisches landesamt Fur Umwelt & Geol., Halsbrucker St. 31A, D-09599 Freiberg, Germany, 137
Palchen, Werner Sachsisches landesamt Fur Umwelt & Geol., Halsbrucker St. 31A, D-09599 Freiberg, Germany, 137
Pampura, V.D.   Inst. of Geoche., P.O. Box 4019, Irkutsk-33 664033, Russia, 62, 76
Perry, Bruce   Dept. of Geol., Uni. of Toronto, 22 Russell St. (ESC), Toronto, Ont. M5S 3B1, Canada, 138
Petukhova, N. N. Inst. of Geochem. & Geophy., Acad. Sci. of Belarus, Zhodinskaya Str.7, 220600 Minsk, Belarus, 139, 142
Peuraniemi, Vesa Dept. of Geol., Uni. of Oulu, Linnanmaa, 90570 Oulu, Finland, 1, 2, 145
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Pinto, M.   ABO Akademi Uni., Dept. of Geol., SF-20500 ABO, Finland, 42
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Plyushchev, E.V. Geol. Research Inst. (VSEGEI) St. Petersburg, Sredny Prospect 74, 199026, Russia, 148
Plyusnin, A. M.   Buryat Geol. Inst., Siberian Div. of the Russian Acad. of Sci., Sakhyanova Str. 6, 670042 Ulan-Ude, 42 Russia, 150
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Portugal, E.   Geotermia, Inst. de Invest. Elec., Apdo. Post. 475, Internado Palmira S/N, Palmira Cuernavaca 62000, Mexico, 181
Prokofev, V.Yu.   Inst. of Geoche., P.O. Box 4019, Irkutsk-33 664033, Russia, 54
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Rafailovich, M.S Kazakh Rese. Inst. of Min. Resour, "Kazrudgeologia", K.Marx St.105, Alma-Ata 480033, Kazakhstan, R., 155
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Rank, G.   Sachsisches landesamt Fur Umwelt & Geol., Halsbrucker St. 31A, D-09599 Freiberg, Germany, 137
Rjabova, L.N.   Inst. of Geochem. & Geophy., Acad. Sci. of Belarus, Zhodinskaya Str.7, 220600 Minsk, Belarus, 139
Rodriguez, Simon Ministry Energy & Mines, IGCP, Piso 5, Torre Oeste, Parque Central, Caracas D.F., Venezuela, 6
Romanov, S.L.   Inst. of Geochem. & Geophy., Acad. Sci. of Belarus, Zhodinskaya Str.7, 220600 Minsk, Belarus, 142
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PART II

Abstracts from China

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ABUNDANCE OF 37 ELEMENTS, SPATIAL STRUCTURE AND ORE POTENTIAL OF SHAOGUAN DISTRICT, NORTH GUANGDONG, CHINA.

Bao Zhenyu
(China University of Geosciences, Wuhan)

Bedrock samples from more than 1,000 sites in an area of 4,292 sq.km of Shaoguan District, North Guangdong have been taken and analyzed for 37 elements. The data set was processed in the light of the theory and methods proposed by Professor Yu Congwen (1985, 1987) which is composed of Kolmogolov -Smirnov normality test followed by eliminating of post-stage superimposition. The abundances of 37 elements in different strata and various granitoids were thus obtained. It is found that the regional background is better represented by the primary concentration which is defined as abundance. The ratio between the average concentration and the abundance for a given geological object is called by the author the intensity coefficient of post-stage superimposition, which possess very important implication in revealing the ore potential of the geological bodies.

By means of data processing and geostatistics, the spacial distriburion of 37 elelments in study area is mapped. The boundaries of geochemical anomalies are viewed as self - organizing dissipation structures, where extensive exchanges of energy and mass occur. At the boundaries, there are sharp compositional and heat gradients. According to this brand new criteria, 21 target areas were delineated and a detailed discussion on ore potential for each target was given.

SOME FEATURES AND APPLICATION OF GEOCHEMICAL EXPLORATION FOR OLD GOLD DEPOSITS

CHANG XILIN
(Geology Department of No.2 Division, Gold Headquarters, the Chinese People's Armed Police Army)

Geochemical exploration for gold deposits refers to apply geochemical exploration approaches to prospect gold deposits. Because of the special characteristics of gold deposits the approaches have achieved significant results and are applied widely.

I. Features of gold deposits:

1. Genetic models complexity of gold deposits.

2. Extensive nature of geological setting that host gold deposits.

3. It is difficult for recognizing gold mineralization, especially microscopic disseminated type gold deposits, because the super-fine particles (n-0.0n um) gold can be seen neither by naked-eye nor microscope, even gold particles can not be panned out using nature heavy concentrate or artificial heavy concentrate.

4. Gold mineralization is commonly hard to form obvious geophysical anomaly.

II. Features of geochemical exploration for gold deposits.

1. Direct method for prospecting ore deposits

Comparing with geophysical approach, the geochmical approach is a direct method. Gold mineralization can be found rapidly if it exists in a favorable ore-forming structure unit.

2. Speciality for selecting target

Unlike prospecting for base metals, selecting gold prospecting targets in an area which shows no gold mineralization must be based on gold or other related elements anomaly obtained from 1:200000 and 1:500000 regional geochemical exploration. Otherwise, the work is in vain.

3. Sampling representativity

Since gold distribution in nature is extremely heteropic, sampling representative and subsampling representativity of trace gold become the key of the approach.

4. Variety of sampling material.

5. It is a direct approach to study the changing features of gold content. The statistic results over hundred thousands square kilometres of drainage sediment survey in the main gold ore-forming belts of China suggest that all large and middle gold deposits can cause Au geochemical anomaly. Gold anomaly with larger dimensions is caused by industrial ore deposits, in which gold content is higher than industrial cutoff grade.

III. Application of geochemical exploration for gold ore deposits.

A COMPARISON AMONG THE METHODS FOR DELINEATION OF GEOCHEMICAL BACKGROUND AND ANOMALY

CHEN MING AND WU XISHENG
(Changchun University of Geology, P.R.C)

Delineation of geochemical background and anomaly (DGBA) is an important step, or roblem, in geochemical prospecting. Though the prospectors have been working on it for a long time, it hasn't been solved satisfactorily.

There are many methods for you to choose, but it's still a great problem. Which way should taken?

Several methods (x+s, x+2s, Moving average, EDA and Universal Kriging) were applied to delineate the regional background and anomaly (sedimentary) in a known area in the eastern part of Jilin Province. The effects of each method are different from the others.

In order to tell which known method is the best, the author advanced a new criterion to evaluate DGBA methods. The criterion can be illustrated shortly as follows:

(1) Six situations may be met: (a), True anomaly; (b), Pseudo-anomaly; (c), Loosed anomaly; (d), True background; (e), Pseudo-background; (f), Loosed background. Their area are STA, SPA, SLA, STB, SPB and SLB.

(2) We hope that SPA, SLA, SPB and SLB=> 0 which is impossible now because no such 4 methods have been invented. Assume that sampling and sample analysis are qualified, and

$$SLB=SPA$$

$$SLA=SPB$$

(3) According to (1) and (2), we can reach

2

$$E1 = \frac{SPA}{(STA+SPA)} \quad 100\% \qquad E2 = \frac{SLA}{(STA+SLA)} \quad 100\%$$

(4) E1 and E2 are both relative-errors. A big E1 means the failure of follow-up for anomalies; A big E2 means that mineral occurrences or mineralized points will "slip through the net".

(5) According to the E1 and E2 values of each method in a known area, we can select the best one to apply in an unknown area.

(6) The two errors even can help you to choose one method among the ways in your economic situation.

The E1-E2 chart in the study area see the figure following. Clearly, Universal Kriging is the best one.

A PROSPECTING GEOCHEMICAL ANALYSIS METHOD FOR OIL AND GAS EXPLORATIO---ADSORPTION WIRE/GC/MS ANALYSIS SYSTEM.

Chen Wei and Feng Xiaoshuang
(Geochemical Exploration Center, Bureau of Petroleum Geology, MGMR)

Although various geophysical and geochemical methods areintroduced nowadays into oil and gas exploration, the primarygeochemical method detecting the permeated hydrocarbons is still effectively used in exploration. Nevertheless, the conventionalgeochemical method has serveral defects, i.e. the range ofdetectable hydrocarbon is narrow and the surface pollution tends todistort the analytical results. Furthermore, this kind ofconventional method has some difficulties in detecting tracesamples. Therefore its further application is limited because ofthese shortcommings.

In 1983, Professor R.W.Klusman, K.J.Voorhees et al havedeveloped a new technique based on accumulation and analysis oftrace hydrocarbons in soilgas which is called K-V Fingerprinttechnique. They employed active carbon (charcoal) to collect gasesand desorption by pyrolysis, the trace gases is then directlyanalyzed by mass spectrometer. The MS spectrum obtained was actedas a fingerprint spectrum. By comparing the characteristic patternsthey are able to conclude the evaluation of geochemicalexploration.

Because the trace hydrocarbons released from pyrolysis aredirectly introduced into the MS, it makes the MS spectrum ratherconfusing and the real fingerprint indexes were not easily beextracted. In this paper, we utilized active carbon to concentrategases, and after pyrolysis the mixtures were analyzed by GC/MS.

GEOCHEMICAL PROGNOSTIC MAP FOR ORE-FORMING SERIES OF GOLD DEPOSITS

CHEN YONGQING
(Changchun University of Earth Sciences)

Ore-forming series is an idea that different types of mineralization distribute regularly under a key control factor. Three key control factors and their associated gold deposits are described below:

1. If sedimentary strata is the key control factor, the geochemical anomalies of ore elements are planar.
2. If fractures or faults are the key control factor, the geochemical anomalies and associated deposits are linear.
3. If intrusives are the key control factor, the geochemical anomalies and associated deposits are annular.

In the western part of Shandong province, gold ore-forming series are best presented in a 1:200,000 scale map where two series of gold deposits have been identified:
1, Au-Cu ore-forming series which is characterized by association of Au with mesothermal elements such as Cu, Pb and Zn.
2, Au-Ag ore-forming series which is characterized by association of Au with epithermal elements such as Ag and Sb.

GEOCHEMISTRY IN COMPREHENSIVE INFORMATION GOLD ORE-FORMING SERIES PROGNOSIS

CHEN YONGQING
(Changchun University of Earth Sciences)

Comprehensive information ore-forming series prognosis is Prof. Wang Shicheng's improvement on comprehensive information mineral resource prognosis. Its basic idea is mainly manifested as follows: (a) Under guidance of ore-forming series theory, the mineralization series of known ore-forming series is studied by the principles and methods of comprehensive information mineral resource prognosis; (b) Comprehensive information ore-forming series prospecting model and its mineralization series prognostic model is established by the connection and transformation of prospecting information between the known ore-forming series and their mineralization series. (c) The goal of ore-forming series prognosis among unknown mineralization series will be realized by mineralization series prognostic model of known ore-forming series.

Geochemical information is the key to the realization of comprehensive information gold ore-forming series prognosis. Ore-forming series of different types are of different characteristics of element mineralization. Syngenetic ore-forming series are of mineralization characteristics of macroelements (Fe, Al, Mn, P and B etc.) which are of high abundance in the crust. Epigenetic ore-forming series are of mineralization characteristics of microelements (Cu, Pb, Zn, Ag and Au etc.) which are of low abundance in the crust.

Mineralization series can be classified three types on controlling factors;
(a) Strata mineralization series.

The geochemical anomalies of ore-forming elements are controlled by the rock beds and are of plane shape;

(b) Fracture mineralization series.

The geochemical anomalies of ore-forming elements are controlled by the fracture and are of linear shape;

(c) Intrusive body mineralization series.

The geochemical anomalies of ore-forming elements are controlled by intrusive body and are of circular shape around intrusive body and elements zoning as well as concentration zoning. Ore-forming series are of the geochemical characteristics of multi-distribution of elements anomalies association in space.

The above regularities are manifested in this paper by 1:200000 comprehensive information gold ore-forming series prognosis in West of Shandong Province. Gold ore-forming series are classified two types on ore-forming elements association in this area:

(a) Au-Cu ore-forming series;

(b) Au-Ag ore-forming series.

The former has association anomalies of middle temperature elements (Cu, Pb and Zn) related to multi-mineralization of gold; The latter has association anomalies of low temperature elements (Ag-Sb) related to multi-mineralization of gold.

Conclusion: plane, linear and circular geochemical anomalies show favorable geological background of ore-forming. The element association anomalies related to multi-mineralization of gold is anomalies of gold deposits. Therefore, the area of distribution of elements association anomalies related to multi-mineralization of gold is the targets of prospecting for ore-forming series of gold.

GEOCHEMICAL CHARACTER AND PROSPECTING MARKS OF FRACTURE ALTERATION TYPE GOLD DEPOSIT IN XIAO GIAPU, HUBEI PROVINCE

CHENG CONGLUN

1. Geological Character of the Deposit

The mining district is located in the western section of Fe, Cu and gold metallogenetic belt in the fold zone of the lower Yangtze Platform. The fracture alteration zone to control the deposit is positioned at the southern margin of TeiShan complex and along with axial part of Xiao Giapu anticline, which is 4,500 m long East to West and 1,000 m wide North to South and the dip is 50-80 degrees towards the North.

The orebodies are vein and lens-like and no clear boundaries with wall rocks and quartzdiorite; single orebody length is between 4-215 m, the extension in the dip direction is 22-110 m; the average grade of gold is 4.1 g/t.

The ores are gold-bearing pyrite, limonite, metamorphic siltstone and breccia. The minerals are imonite, baryte, clay, quartz, native copper, galena and chalcopytite. The

wall rock alterations are pyrite-sericite-quartzification, silicification, carbonatization and barytization etc.

2. Geochemical Character:

(1) We have studied the element distribution character of the main stratigraphy in the district. For example, after the alteration of siliceous original rock of the middle Triassic second section, Au enrichment could be up to 26 times and Ag 2, Cu 9, W 1.8, Mo 2.7, Cr 1.3, Sr 3.5, Ba 1.47 and S 36.

(2) The elements distribution character in the ores:

The gold content in limonite is 1.28 g/t and Ag 25.82g/t; in gold-bearing siliceous rock Au 39.7 g/t, Ag 19.24×10^{-6}, Cu 150×10^{-6}, Pb $2,250 \times 10^{-6}$, Zn $2,-250 \times 10^{-6}$ and As $1,580 \times 10^{-6}$; in gold-bearing porphyritic quartz diorite Au 45 g/t, Ag 50.6×10^{-6}, Cu 230×10^{-6}, Pb $1,570 \times 10^{-6}$, Zn $5,690 \times 10^{-6}$ and As $1,300 \times 10^{-6}$.

(3). The elements distribution character in minerals:

The gold content in minerals carrying Au and Ag is in sequence: limonite>quartz> clay (mineral)>barite>galena; Ag content in sequence is quartz>clay(mineral)>barite> arsenopyrite> galena.

(4). The elements correlation in rocks and ores:

In the wall rocks of the deposit the elements having positive correlation with Au are:

As(0.68)>Ag(0.59)>Te(0.58)>Pb(0.31); in the ores they are As>Ag>F>SiO_2>Cu>S; for negative correlation Pb>Zn.

(5). We have studied geochemical character of quartz diorite related to metallogeny and concluded that after alteration of original rock Au, Ag, Cu, Mo and S would be brought in the rock and Pb, Zn, Ba and Sr brought out.

3. Geochemical Anomaly Character of the Mining District

(1) Secondary geochemical anomalies: There are Au, Ag, As and Sb anomalies over gold mineralization zone; Au, Pb, Zn, Mo and As anomalies over Pb and Zn mineralization; Ni, Co, Mn, Bi, Cu, Mo, Pb, Zn and Ba anomalies over the iron orebodies and Fe mineralization.

(2) Primary geochemical anomalies: At the top of the orebody there are Au, Ag and As inner zone anomalies and Pb and Zn middle ones; at the middle part of the orebody there are mainly Au and Ag inner ones and Cu and Pb middle ones; at the tail there are W inner and Cu, Pb and Au external anomalies.

4. Geochemical Prospecting Marks:

(1) Directly outline Au orebody and mineralization by Au, As and Sb(Ag) anomalies;

(2) Indicate Au mineralization by positive correlation between Au and Cu and S and negative ones between Au and Pb and Zn.

(3) Recognize denudation of the orebody by Au, Ag and As inner anomalies of the top halo and W anomaly of the tail halo;

(4) Recognize the wall rocks by positive correlation coefficient between Au and As>Ag> Te>Pb.

(5) Indicate the alternated mineralization by Au, Mo,Ag, Zn, Ba, S, Sr, As, K and H_2O^+ high conductivity.

DISTRIBUTION OF PRECIOUS METALS IN KALATONGKE COPPER-NICKEL DEPOSITS

CHENG HANGXIN
*(Institute of Geophysical and Geochemical Exploration
Langfang, Hebei, 102849 R. P. China)*

The precious metals Ir, Rh, Pt, Pd and Au in rock samples from 3 economic ore rock bodies and 14 evaluated rock bodies are discussed in this paper. Concentration of those elements is shown in the table below:

Concentration of precious metals in copper-nickel deposits, KALATONGKE
(ppb)

	Ir	Rh	Pt	Pd	Au	Pd	Pd/Pd+Pt
Y_1	4.9	4.1	38.0	18.5	49.5	114.9	0.33
Y_2	3.1	2.3	8.2	4.0	2.3	19.9	0.33
Y_3	1.5	1.4	4.0	2.9	0.9	10.7	0.42
A_{m16-1}	2.1	1.8	5.1	4.1	1.3	14.4	0.44
G_9	1.4	2.3	4.3	2.8	0.7	11.5	0.39

The available evidence suggests that total concentration of precious metals can be used in defining two stages of Cu-Ni mineralization-magmatic segregation. During stage one, immiscible Ni sulfide liquids segregated out of the silicate belts in situ. In the second stage, formated injection NI sulfide orebodies in basic-ultrabasic bodies formed at greater depths. The indicative value of ΣPt in the latter is over 10 times greater than in the former.

Y_1, Y_2 and Y_3 deposits exhibit the same element chondritic standard curve distribution model, which indicates that these three deposits have the same magmatic genetic model. At the same time, there are two Cu-Ni mineralization stages in Y_1 - the magmatic segregation and injection stages - but only one mineralization stage in Y_2 and Y_3, because the concentration of SPt in Y_1 is higher than in Y_2 and Y_3.

The same distribution model has been discovered in two out of the 14 evaluated bodies. These two hidden bodies, Am_{16-1} and G_9 therefore, are likely to contain Cu-Ni mineralizations.

GEOCHEMICAL EVALUATION FOR ORE POTENTIAL OF BASIC ROCK BODIES IN EXPLORATING COPPER-NICKEL DEPOSITS

CHENG HANGXIN AND LI YINGGUI
*(Institute of Geophysical and Geochemical Exploration
Langfang, Hebei 102849 P.R. China)*

During 1985-1990, geochemical characteristics of one exposed and two concealed copper-nickel deposits were studied systematically in northwest China's Xinjiang province. The aims of this project were to establish the qualitative and quantitative

geochemical criteria of this type of deposit, and to evaluate the ore-bearing potential of basic-ultrabasic bodies in the ore-bearing belt.

Effective indicator elements of the studied deposits are I, Hg, F, Ba, B, As, Mo, Ag, Cr, Co, Cu and Ni. Primary halos of these elements indicate greater migratory distances lengthwise than traditional views suggest. The migratory distances in meters were : Ba - 750; B - 700; As - 550; Mo - 750; Ag - 750; Cr - 737; Co - 437; Cu - 437; and Ni - 437 in the hidden Y_2 rock body. Individually they were in meters : Ba - 614; B - 500; As - 571; Mo - 614; Ag - 600; Cr - 485; Co - 158; Cu - 142; Ni - 142 in the hidden Y_3 rock body. The former measured 160 metres from surface to rock body, the latter 200 meters. Therefore, primary halos of associated elements B, Ba, and As, and at times Ag and Mo, indicate a mineralization body below the surface.

Analysis of element distribution in sulfide phase indicates that S, Cu and Co are particularly helpful in assessing the mineralization potential of the ore body. In nickel-copper-bearing rock bodies, S>0.1%. In non-ore bodies, S<0.06%. Mineralization probability of S - 4.5×10^{-3}; Cu - 1.9×10^{-2}; Ni - 7.0×10^{-2} and Co - 1.3×10^{-5} in economic rock bodies; S- 1.5×10^{-10}; Cu- 3.3×10^{-10}; Ni- 1.8×10^{-5} and Co - 1.0×10^{-10} in non-ore bodies; the product of association these elements is 3.08 in mineralization bodies; 0.00 in non-ore bodies.

The research of multiplicative halos of Cr and Ag suggest that such halos can be used in locating Cu-Ni ore bodies. CrxAg>30 indicates dimension of the mineralization; CrxAg>100 shows cutoff grade ranges; CrxAg>300 can be used in defining economic Cu-Ni ore bodies in basic-ultrabasic magmatic bodies.

We have used these geochemical criteria to analyse 22 rock bodies. We determined that 3 of the 22 represented potential mineralization bodies. One of these 3 proved to be an economic Ni mineralization. The other two have yet to be drilled.

A DISCUSSION ON THE POTENTIAL APPLICATION OF FRACTAL THEORY IN PETROLEUM GEOCHEMICAL EXPLORATION

CHENG JIANPING
(China University of Geosciences, Wuhan)

A general account of fractal theory is given in this paper. The author considers that the fractal models such as DLA and KCA model are highly desirable to improve the theoretical foundation of petroleum geochemical exploration.

REGIONAL GAMMA-RAY FIELD IN NORTH-WEST CHINA

CUI ZHENSHENG AND WU WENXIU

The total area in the north-western part of China is about 3.8 million km^2. This region includes Shaanxi, Qinghai, Gansu and Shanxi provinces, Xinjiang and Ningxia autonomous regions and a large part of Inner Mongolia autonomous region. Up to date (1991) an area of about 1.6 million km^2 was surveyed by airbore, vehiclebore and ground radiometric methods (total count measurement). The dosimetric unit in this case is nc/(kg.h) (1 uR/h=0.285nc/(kg.h)). Solid radium sources were used for this

work. The correction method using comparative coefficient was used so as to reduce the data collected from above mentioned three methods to standard exposure level 1 meter above ground.

It should be noted that the regional γ-ray exposure rate contour (isoline) map also be named regional γ-ray field map. In general situation this map reflects comprehensive effect distribution. The mean value of regional background in North-west China is 2.25 nc/(kg.h). The basic data of γ-ray fields are illustrated in table 1.

Tab 1. Statistical table for classification of γ-ray fields in North-West China

Interval of field value [nc/(kg.h)]	<=1.5	1.5--2.3	2.3--3.1	3.1--3.9	3.9--4.6	>4.6
Field value level	lower	low	normal	less high	high	higher
Area (%)	10.4	46.2	32.2	8	2.4	0.84

Summary:

1. Regional γ-ray fields reflect the difference between different earth structure units and unconformity in each unit.

2. Regional fields reflect regional distribution for various lithological rock, but they also reflect the difference in each lithological rock. At the same time they also reflect the difference between geological bodies of various geological periods and their evolution character.

3. Low γ-ray field distribution character would generally be measured in the regional fault fields by basic rock or perbasic rock. But the fault fields by acidic rock or alkaline rock characterized high r-ray fields.

4. The γ-ray field distribution and uranium ore deposits (or ore occurences) distribution are closely correlated tightly.

It should be noted that in the γ-ray fields about 70% ore-body deposits are discovered nearby high fields, less high fields or in them. In interpreting γ-spectrometric data, it is found that the regional γ-ray field distribution reflects the regional uranium source condition and the separation of uranium from thorium reflects the genesis of uranium ore deposits. In general speaking uranium deposits genetically had been nearby high γ-ray fields and the less high γ-ray fields are characterized relative enough uranium region.

Research of regional γ-ray fields is very useful for estimation of regional radioactivity, geological work, finding uranium deposits, potassium soil deposits and other metallic deposits .

ROCK GEOCHEMISTRY OF DONGPING GOLD DEPOSIT, HEBEI

DAI BAORUN
(North-East Institute of Technology, Qinhuangdao)

A brief description of the geology of Dongping gold deposit is given. The main strata of the deposit are composed of metamorphic rocks of Shonggan Group, in which Au content is 32.1 ppb, 10 times higher than the crustal abundance, and therefore the group is assumed to be the source bed of the gold deposit. The wall rock of ore bodies is alkaline monzonite with $SiO_2=67.18\%$ and $Na_2O+K_2O>11\%$. The REE Ce/Nd ratio in monzonite is 7.67 and it is very close to that of basement metamorphic rocks (7.79) and granite (8.85), and so is the Sm/Nb ratio, indicating that the monzonite is of autochthonous origin. Gold mineralization occurs basically in the altered monzonite with which secondary anomalies are closely associated.

A RESEARCH ON GEOELECTROCHEMICAL EXTRACTION METHOD FOR GOLD EXPLORATION

DENG TAOSHEN AND XIE QINGLIN
(Guilin College of Geology, Guilin)

A number of experiment work was carried out both in door and in the field. By model experiments, the authors have confirmed that electrochemical dissolution of Au from a mixture of sulfides does occur which is caused by the difference in electrode potential and could be the mechanism responsible for the formation of ionic halo around the buried ore bodies.

In the field experiment, both high and low power excitation are compared in the same deposit, and the results show that both are applicable. Favorite results have been obtained over quartz veins, altered rocks and gold-bearing placers. The usual shapes of geoelectrochemical anomalies are double peaked or multiple peaked.

Five factors leading to false anomalies are discussed and the way to distinguish false anomalies from true anomalies is noted.

Regional Geochemical Mapping in North Xingjiang, China

DU PEIXUAN
Geophysical and Geochemical Prospecting Party, Shaanxi

A large research exploration project----"Integrated Application of Geology, Geophysics and Geochemistry to Accelerate the Evaluation of Mineral Resources in Xingjiang " initiated in 1985 which was coded as "National Project 305."

The strategy used in this project is to cover the whole North Xinjing rapidly with low density and very low density geochemical regional survey integrated geological , geophysical and geochemical follow-up works were then focused in the regional geochemical anomalies delineated.

Stream sediment survey, and lag material survey were used. About five hundred fifty thousand km^2 were covered from 1985-1992, more than 3,000 multi-element geochemical anomalies were discovered. After follow-up studies of about a hundred of them, about 20 medium and large economic deposits were found, including gold, copper, copper-nickel, tin, lead-zinc and mercury deposit.

ORE-FORMING AND HALO-FORMING PROCESSES OF GOLD DEPOSITS IN XIAOQINGLING AND A PREDICTION SYSTEM FOR THE REGION

FANG WEIXUAN
(North-West Bureau of Geological Exploration, CNNC)

As one of the most productive gold districts, the Xiaoqingling gold belt is located at the northern margin of the North China Platform where the types of mineralization are auriferous quartz veins and potassium metasomatic rocks hosted in Taihua Group of Archean age. The amphibolite and hornblendite in the Archean Taihua Group, aged 2,800Ma-2,500Ma, contains 4.2 ppb and 9.2 ppb of Au respectively, which is considered the primary source of the gold deposits in the area. Paleozoic and Mesozoic felsic magmatic activities are extensive throughout the entire district which could be the source of Ag, Bi, W, Mo and F in the primary halos around the gold ore bodies. S, H, O isotopes data show that S may come from the Archean rocks and H_2O from a mixture of metamorphic, magmatic and precipitation origin.

Geochemical investigation has shown that Au was remobilized by several geothermal events during progressive metamorphism 2,300Ma-1,000Ma ago. The highest concentration of Au in mineralization solution is estimated to be 6,500 ppb at the inception of sodium-replacement alteration. The alkaline and reducing Au-rich solution moved upward under the tectonic forces to a shallow oxidizing place where it was unloaded to form Au-pyrite-quartz veins. The fineness of gold is more than 90,000 and the pyrite is always rich in Co and Ni. The second phase of gold mineralization was motivated by Caledonian Movement when the remelting of the Archean rocks had led to the formation of gold deposits in altered rocks. The latest stage of mineralization show itself by the formation of fluorite, carbonates and individual Mo ore bodies near the pre-existed Au ore.

According to the above described understanding of the ore forming processes, a geological-geochemical prediction system was designed which was composed of three parts: regional assessment subsystem(1:200,000), large scale (1:10,000 or more) qualitative prediction subsystem and large scale quantitative prediction subsystem. More than 10 target areas have been located by the system. Six of them have been drilled or trenched and 4 targets were reported to occur commercial ore bodies.

RELATIONSHIP BETWEEN HELIUM ANOMALY AND GEOTHERMAL FIELDS IN JIANGSU

FEI FUAN AND FANG GUOYING

During the courses of oil and gas prospecting, a series of NE-trending geothermal fields have been found in Jiangsu. The drilling wells in the geothermal field have hot water at a moderate temperature about $50^{\circ}C$.

From North to South, they are Yancheng, Dafeng, Xiaohai, Dongtai, Tainan, Diduo, Daiyao, Taizhou and Weigang of Zhenjiang.

The natural gas samples from drilling wells in geothermal fields contain high concentrations of helium and CO_2. He concentration varies from 1.34% to 0.0089%, worthy of commercial exploitation.

A He-rich field has also been found in Neogene Yancheng Fm of Huangqiao. Its He isotopic ratios: $^3He/^4He$ from 3.71 to 6.42×10^{-6}, R/Ra from 2.65 to 4.58, reflecting mainly mantle-derived, and the associated high concentration CO_2 has $\Delta^{13}C_{co_2}$ from -3.82 to -8.09%, reflecting an inorganic origin, mainly mantle-derived. Besides, the natural gas samples from both sides of geothermal fields also contain a certain amount of He, with $^3He/^4He = 0.6-0.95 \times 10^{-6}$, R/Ra =0.43-0.67, reflecting crust-derived.

No geothermal field has been found in crust-derived He area. Thus, it is clear that only the mantle-derived He anomaly can be regarded as an indicator for discovering geothermal fields.

In addition, by studying geothermal field of this area, the distributions of three zones-geothermal abnormal zone, mantle derived He anomaly zone and active fault zone, coincide with one another.

The results above reflect that both He from geothermal fields and the abnormal geothermal source are from the upper-mantle-derived magma. Their origins are closely related to each other.

All of them are located in the area with shallow Moho depth about 27 km and adjacent to two recently active deep faults. The volatile gasses continue degassing from deep magma and going upward through the fault zones. Besides, there are good overlying reservoir-cap associations for accumulation. Thus, the He-rich and geothermal fields can be formed.

AN EVOLUTION MODEL OF SURFACE GEOCHEMICAL ANOMALIES OVER OIL AND GAS TRAPS

FEI QI, RUAN TIANJIAN
(China University of Geosciences, Wuhan)

Based on the general theory of vertical microseepage and a number of data sets from urface geochemical survey over oil and gas fields, the following 4 major types of surface geochemical anomaly patterns could be distinguished. 1, Single ring type: appears over those oil traps where structure is relatively simple and oil and gas is trapped at the center part of the structural high. 2, Apical type: the surface pattern is

expressed by a denser distribution of high values above the oil and gas pool. 3, Linear and strip with semi-ring type: oil and gas is trapped along a fault, which leads to a large displacement from the vertical projection of the oil pool. 4, Offset double or ulti-ring type: appears over those traps where structure is complex or lithology of the caprock changes dramatically. The commercial traps are usually localized in the inner ring. All the above ring types with commercial oil and oil and gas pools are expressed by halo anomalies of multi-geochemical indicators, which is suggestive of some mechanism of the vertical microseepage for oil and gas. An evolution model with four stages of the halo anomalies is proposed. According to this model, the authors have succeeded in predictions of commercial oil and gas pools, which were confirmed by the discoveries of a major gas field and western Yuan Cheng oil field in Ordos basin.

APPLICATION OF STATISTICAL PARAMETERS IN DONGPING GOLD DEPOSIT

FENG KEWU AND WANG YUJUAN
(North-East Institute of Technology, Qinhuangdao)

One hundred and fifty rock samples from the wall rock of 5 veins (vein No. 1, 2, 3, 22 and 70) in the study deposit were taken and analyzed for 10 elements (Cu, Mo, Pb, Zn, Ag, Bi, Sb, Hg, As, and Au). The mean and standard deviation for each element was calculated from the data set. The results show as follows:

1, The mean and deviation of Au, Mo, Bi, Ag, Sb for veins No.1, 3 and 70 is equal, indicating that the mineralization could be stable and homogeneous for the three veins. Because the vein No.1 is the well-known rich ore body, the other two veins are inferred to be of the most promising.

2, Both the mean and the deviation of Cu, Mo, Pb, Zn and Bi are high for vein No.2, indicating that the mineralization probably be inhomogeneous and rich ore shoots may exist.

3, Factor analysis shows that the first principal factor for veins No.1, 2, 3 and 70 are pomposed of Au, Cu, Pb, Sb and As.

4, The mean and deviation of Au of vein No.22 is greater than that of vein No.1 and 3, and the first factor is composed of Au, Ag, Pb, Cu and Mo, indicating a deep degree of erosion, hence further exploration is meaningless.

GEOCHEMICAL ANOMALY CHARACTER AND ITS PROSPECTING APPLICATION OF JILONGSHAN GOLD-COPPER DEPOSIT IN NORTHERN HUBEI PROVINCE

FU ZHIZHONG AND LI LANGTIAN

Jilongshan gold-copper deposit is located in iron and copper metallogenic belt of lower and middle reaches of the Yangtze River or at mineralization zone of Jiurui

subouterropped structure NWW - magma. It is a large gold deposit belonging to Skarn gold-copper deposit.

Jilongshan intrusion is mainly granodiorite-porphyry which is the mother rock of gold-copper mineralization. Its petrochemical composition compared with similar rocks in China is: $K_2O+ Na_2O$ and K_2O/Na_2O high, SiO_2 and $SiO_2/(K_2O+Na_2O)$ low, while Au/Ag and Te/Au compared with that of mother intrusions of gold deposits in rest of the world are all high. Average contents of trace elements in magmatic rock compared with Vinogradov values of the same type of rocks reveal Au, As, Mo and Te with more than 5 times ratio; and Cu, Pb, Ag, Sb, Co and V with 2-5 times ratio; there are W, Cl, Ni and F to be lower than its Vinogradov value respectively.

From stable isotope data it is indicated that the magma of Jilongshan intrusion was derived from upper mantle or lower crust.

Jilongshan gold-copper orebodies occurred mainly in Skarn rock of contact zone around granodiorite porphyry. Geological and analytical data of different rocks and minerals and their multielement R factor analysis revealed four major mineralization stages. For gold-copper deposit the main mineralization stage is: (1) copper-gold-silver sulfide stage, major elements are Cu, Au and Ag and their minerals are chalcopyrite, bornite, silver-contained native gold, native gold and electrum etc. and forming temperature is 280-330°C and pH value is 5.6. (2) gold-arsenic-tellurium sulfide stage, major elements are Au, Pb, As, Te and Mn and their minerals are native gold, galena, pyrite, eilite, arsenblende, stromite and petzite compound, temperature 150-220°C, pH 6.3. It is indicated from stable isotope data in the orebody that hydrothermal solution belong to magmatic type as same as the intrusive body.

Primary halo is well developed in gold-copper orebody and around the orebody there are well developed Au, Cu, Ag, Te and Pb and Co etc. internal, intermediate and external halos. Au, Cu, Ag, As and Te internal zones are near orehalos. Sn intermediate and internal zones are only presented in central part of the orebody.

(Au+Cu)/Ag value increases from front halo--> the top--> the middle--> the tail of the orebody--> to tail halo while Ag/Cu value in reverse. And the correlation coefficient of Au with Ag changed from positive to no correlation at all.

The indicator element combination of soil survey is basically the same as primary halo and only the enrichment coefficients of the elements are different.

The indicator elements of stream sediment survey are Au, Cu, As, Pb and Zn. There is no correlation among the anomalous elements. Au anomalous area is 3.75 km^2 that is as 3.12 times large as the area of metallogenic intrusion. The average Au content in anomaly is 16.37 mg/t. The expression of normalized area metal quantity would indicate the mineralization type of this mining district.

In different prospecting stages, geochemical anomalies in this district outlined the targets for test drilling and indicated the occurrence of gold ores. Primary anomaly in

borehole in particular can indicate the deep blind ores. The result is very successful by test drilling.

GEOCHEMICAL CHARACTER OF GOLD DEPOSIT IN MURU GOLD BELT, SHANGONG

GENG XIANHU and LI HUE

Muru gold belt is one of the most important gold belts in the eastern Shandong peninsula. there are several gold mines with large and medium sizes which are mainly quartz vein type gold deposits controlled by structure strictly. Most gold deposits occurred in Kunyu gnanite and others in Jiandong Group.

On the basis of introduction of gold metallogenic and geological characters of this belt, this paper summarized geochemical characters of the gold deposits in Muru gold belt in priority.

Besides Au there are Ag, Cu, Pb, Zn, As, Sb, Mo and Bi concentrated in gold deposits of this belt. The contents of these elements in the gold deposits are generally n-nx10 times higher than their Clark values. In these gold deposits, Jinqiengding gold mine has the highest contents of Ag, Au, Cu, Pb, Zn and Hg and Donggezhuang gold mine with the highest As and Sb, Jinneushan gold mine with Bi high and Sanjia gold mine with relatively higher Mn than other mines. We summarized typical element combinations of major gold deposits in this area.

The wall rock alterations of gold deposits in the area are silicification, sericitization, pyritization and potashilazation which possess certain zonation. In the course of alteration the brought-in elements are Si, K, Au, Ag, Cu, Pb, Zn, As, Sb, Bi, Mo and Hg etc., and the brought-out or mobilized ones are Fe, Mn, Mg, Ca and Na.

The gold deposits in this area possess a distinct geochemical zoning in vertical direction and Jinqingding, Denggezhuang and Sangia gold deposits have a great generality, i.e. As, Sb and Hg commonly concentrated at the top or the front of the orebodies, while Bi, Mo and Mn at the bottom or tail halo of them. From the top to the bottom of the orebodies the ratios of Sb/Bi, PbxZn/BixMo, Ag/Au and PbxZn/AuxAg have a decreasing tendency. In pyrite some trace elements also possess vertical variable regulations. Therefore, we summarized a series of geochemical marks to search for blind ores and recognize erosion level of gold deposits. These marks have successfully been used in deep exploration and prediction.

A NEW TECHNIQUE FOR EVALUATING GOLD ANOMALIES

GONG MEILING
(North-West Institute of Geology, CNNC, Xi'an)

In the light of geochemistry of gold and geology of gold deposits the author carried out a large number of experiment which has led to the following scheme for evaluating gold anomalies.

1, At the sites to be evaluated additional samples are taken, each weight about 1 kg.

2, The samples are grounded to -80 mesh and a 100g fraction is further pulverized to -200 mesh (primary sample).

3, The remaining -80 mesh fraction is subjected to heavy liquid separation.

4, 40% heavy fraction is pulverized to -200 mesh (heavy fraction).

5, The light fraction is used to separate quartz concentrates, from which Au content in its fluid inclusion is determined (detection limit being 0.1×10^{-9}).

6, Both primary sample and heavy fraction are analyzed for multiple elements: Au, Ag, Pb, Zn, Cu, As, Sb, Bi and Hg.

7, The elements are ranked according to the descending order of their correlation coefficients respected to $Au(r_{Au})$.

8, The discrimination criteria

For significant anomalies are: (a) The number of elements with $r_{Au} > 0.5$ is equal to or more than 3, (b) The ranking of elements is similar in the primary sample and heavy fraction, (c) Au content in quartz fluid inclusion is $>3 \times 10^{-9}$, (d) Au in heavy fraction is more than two times Au in the primary sample.

For nonsignificant anomalies are: (a) No element correlates well with Au in primary sample, (b) The ranking of elements is different in primary sample and heavy fraction, (c) Au content in quartz fluid inclusion is $<1 \times 10^{-9}$, (d) Au in heavy fraction is less than Au in primary sample.

For anomalies with by-product gold only: (a) The ranking of elements is similar in primary sample and heavy fraction, (b) good correlations exist between elements except Au, (c) Au content in quartz fluid inclusion is $>1 \times 10^{-9}$.

A number of anomalies have been evaluated by the procedure and the results are encouraging.

HYDROCARBON STRUCTURAL ANOMALOUS FIELD AND ITS SIGNIFICANCE OVER OIL AND GAS DEPOSITS

GONG WEIQI

With the wide application of high precision gas chromatography, mass spectrometry and spectrographic technique to geochemical prospecting for oil and gas, it is possible

for us to observe the full view of trace light hydrocarbons (C_1 - C_5) which present a dynamic variation in near surface soil, water and gas materials.

Studying the geochemical data of light hydrocrbons in some areas, it was discovered that there is a stable line structural characteristic between the constituents of various hydrocarbons in near surface sediment over or on the edge of oil and gas fields. In surface geochemical samples, many constituents of hydrocarbons as a vector in Ojilid multi-dimensional space gather closely together and are similar to the constituents of oil or gas samples. These hydrocarbon constituents of surface geochemical samples differ obviously from that of background samples out of oil or gas fields. The geochemical anomalous field determined by the former is situated directly over oil and gas field and indicates more definitely the outline of oil and gas deposits. The geochemical anomaly appears as a halo or apical and massive anomalous mode.

In order to differentiate the word "concentration anomaly" used in the traditional geochemical prospecting, the author proposed the word "structural anomaly" in present paper. The two types of anomalies as indicated above express respectively two aspects of variation of hydrocarbons migrated from depth to the surface in quantity (concentration) and quality (construction). But concentration anomaly does not usually exist over oil and gas field.

The sufficient and essential conditions of differentiating the structural anomalous patterns indicating oil and gas deposit are as follows:

1. The origins of the surface structural anomalous hydrocarbons and that of the hydrocarbon constituents in the oil reservoir (original constituent structures) must be similar. The threshold can be determined by many statistical discriminating methods.

2. The structural anomalous patterns must be structures or comprehensive structures of most hydrocarbon constituents or main characteristic constituents.

There is an example of BNG oil field. Samples were collected on the edge of and out of the oil field and five kinds of hydrocarbon structures were analyzed respectively. By comparison, we found that the five kinds of hydrocarbons over and on the edge of the oil field change linearly in the same pattern particularly with stable F1 factor combinations, while the five kinds of hydrocarbons out of the oil field have no correlation except for aromatic hydrocarbons and cycloalkanes, which are independent factors to dispersed structures. The data of 158 samples in the study area were treated by cluster analysis and 36 samples gather together with source rock samples with similarity level 0.91. It is found that the 36 sampling sites of structure anomalies with similar origin are located over the oil field or around it. But the anomalies determined by total hydrocarbon concentrations (Fig.b) are dispersed, and could not indicate the position of the oil deposit.

The possible mechanism of the similar original structures are also discussed in this paper.

The author realized that hydrocarbon anomalous field of structure original exists. This breaks through the old concept that only hydrocarbon concentration anomalies are used in oil and gas geochemical exploration. All of these will greatly increase the geochemical efficiency in oil and gas exploration.

CHARACTERISTICS OF PEDOGEOCHEMISTRY AND THEIR SIGNIFICANCE IN GRICULTURE AND ENVIRONMENT IN CHINA

GONG ZITONG AND HUANG BIAO
(Institute of Soil Science, Academia Sinica, Nanjing, 210008, China)

By soil geochemistry the whole territory of China is divided into four main regions. This paper discussed states of some available trace elements in each region from the view of plant growth and human health.

1. Saline soil region   It is distributed in the inland arid area of the western China, including the northern Tibet Plateau which occupies 29% of the whole land in China, the soil is rich in salts that is mainly chlorides and sulfates, alkaline in reaction, as well as the clay minerals in soil are mainly hydromicas. In this region, 70% of the soil are high and very high in the content of water soluble boron and high in the content of water soluble fluorine, while more than 80% of the soil is deficient in available Zn and Mn, and 50% in available Fe.

2. Carbonate soil region   It extends from the southwestward Inner Mongolia Plateau to the Qinghai-Tibet Plateau which occupies 23% of the whole territory of China, $CaCO_3$ and $MgCO_3$ contents in soils may be up to 10-20% and the clay minerals in soils are mainly hydromicas and vermiculite. The soda saline soils in depression have high contents of water soluble fluorine. It is estimated that 80% soils in the region lack available Zn, Mn and Mo, and the content of water soluble Se is also deficient.

3. Siallitic soil region   It expands from northeast to southwest in a band-shape, covering an area of 30% of the whole territory of China. The soil in the region is neutral. Compared with the two soil regions above, the soil is deficient in available Zn and Mn decrease, but the area is deficient in available B, Mn and Se increase.

4. Ferrallitic soil region   It lies in the vast area south of the Yangtze River which occupies 18% of the total land area in China, the soils are acid and the clay minerals in soils are mainly kaolinite and gibbsite. The soils are so rich in Fe, Al and Mn that toxicities of Al and Mn occur in some of the soils. The 90% of the soils are deficient in available B, Mo and F.

On the basis of the characteristics of pedogeochemistry in China, plant and rational application of fertilizer to soil types will be of great significance in raising the yield and quality of agricultural products as well as improving the health of human and domestic animals.

APPLICATION OF MULTIVARIATE STATISTICAL ANALYSIS TO KANGSHAN GOLD FIELD

GUO RUIDONG AND ZHANG FAWANG
Gold Headquarters, Ministry of Metallurgical Industry, Beijing, China

In this paper , an application of multivariate statistical analysis to the geochemical data obtained in Kangshan gold field, Henan Province, is given. In an effort to bring out an integrated analysis and research result, the main points run as follows:

1. Multivariate Statistical Analysis
Multi-elements analytical results are picked from 325 rock geochemical samples involving Au, Ag, Cu,Pb, Zn, As, Mo, Bi, Co, Ni, Mn, etc. obtained from six gold-bearing (mineralized) veins of various types at different sections of this gold field to conduct cluster analysis, regression analysis and factor analysis. The results show as follows:

A. Diversity in the time-space distribution and imputation of characteristic elements stretching from east to west of the field, with east part predominantly of Au, Cu, and Ag, west part, of Ag and Pb, while the middle, of Au, Ag, Pb, Zn, Cu, and Bi.

B. In the gold field, variation of stages for gold mineralisation is shown as extending from east to west, with Au mineralization predominant in the east,polymetallic and Au mineralization prevailing in the middle, and Pb and Zn mineralization predominant in the west.

C. All the regression coefficients of elements Cu are greater than zero, whereas those of element Pb less than zero, indicating that Au and Cu are closely correlated, while Au and Pb are not. Occurrence of chalcopyrite is propitious for gold mineralization.

D. A negative correlative relationship exists between Co, Ni and Au contained in the auriferous polymetallic quartz veins. Strata of the Taihua Group with low content of Co and Ni are the favorable country rocks for gold mineralization in this district.

E. Au constitutes an associated product in the auriferous lead and zinc ore veins in the west of the gold field, which has at least three metallogenetic phases: polymetallic sulfide phase with Pb, Ag, Cu, Zn and Mn; major metallogenetic phase of lead mineralzation with Pb, As, Co and Ni; mineralization phase with sole and minor Au content.

Au contained in gold veins of polymetallic quartz vein-type in the middle of the field has got various sources, but is predominantly of polymetallic mineralization phase with Cu, Pb, Zn and Ag.

Au and Cu occur as paragenetic in the alteration-made fractured rock-type gold veins in the east of the field, belonging to coeval product.

2. Moving Average Result For Au Anomaly at scale 1:10,000
After using PC-1500 microcomputer to conduct moving average treatment on a grid of 100x200 m^2 in connection with the study of primary (secondary) haloes collected from Kangshan Gold Field of an area 27 km^2 (1:10,000), four concentration centres of Au anomaly are found to have suppressed the disturbance and influence of

noise due to the low sensitivity of gold analysis, thus magnifying geochemical prospecting information.

3. Geological And Geochemical Information And Their Interpretation

Based on the multivariate statistical analysis and integrated geological and geochemical time-space data of the gold field, it is believed that

A. gold mineralization in this gold field is multiphase and multiperiod in origin, and it can be, at least, divided into three metallogenetic phases superimposed with each other;

B. an elevation of gold mineralizations outcropped in this field is characterized by displaying a landscape high in the west and low in the east, and thus one may infer that, vertically, the ascending sequence of gold mineralization phases for this gold field run as (1) --> (2)--> (3), which further provides the study of geochemical vertical zoning with evidence;

C. Au mineralization phase varies with different types of gold veins present, and what is more, spatially (horizontally or vertically) has different distribution features, however, various types of auriferous (mineralized) gold veins at different sections are all possessed with a general character--Au and Cu being closely correlated;

D. the middle and east segments of the gold field are proved to be favorable for gold-prospecting, while the west and southwest part of it is promising for prospecting lead and zinc deposits;

E. there exist some striking differences in terms of hydrothermal activities at different sections in this district, indicating the regularities governing time-space distribution and imputation of trace elements. Varied geochemical indices should be carefully selected in the geological interpretation and evaluation of primary (secondary) halo anomalies picked up at various sections of this gold field.

THE SUPERGENE GEOCHEMICAL BEHAVIOR OF GOLD IN GOSSANS AND DSCUSSION OF ITS AFFECTING FACTORS

GUO YINGJIE
*Institute of Geophysical and Geochemical Exploration,
Langfang, Hebei 102849, P.R, China*

During 1986--1988, gold in the gossans over different kinds of ore deposits in the middle-ower reach of Yangtze River was studied systematically. The results are shown as follows:

1. Gold enriches highly in gossans. The gold content ranges from 0.1--19.37 g/T. The gold average accumulation coefficient is 7.72. It has been found by statistics that the percentage of samples whose gold contents are above the Au cut-off grade in gossan is higher than that in the primary orebody below.

2. Along the strike of the ore zone, the gold content, which is much higher than that in the ore below, changes greatly. However, the changing tendency of the gold in the gossan is almost the same as that in the ore. It can be inferred that although the gold in ore has migrated and enriched in the supergene process, the gold distribution in gossan has inherited to some extent that in the orebody below. In other words, when the gold

distribution in gossans is known, the gold-bearing properties of the orebody are also known roughly.

In the vertical exploratory profiles perpendicular to the stride of the ore zone, there are two Au concentration belts--the near surface belt and the belt in the absolute elevation of 90--50m. Generally speaking, the gold content in other belts is less than 1 g/t. The result of R factoranalysis has shown two Au factors which may be correlated with the two Au concentration belts. It is possible for R factor analysis to be used not only to reveal the gold supergene enrichment, but also to understand the variation of the supergene conditions.

3. The experiment has proved that the major form of Au is the native Au (89.30%). The gold migrates mainly as the forms of complex ions, colloid absorption and the colloids.

4. The pH value of gossan ranges from 6.11 to 7.99, while that of the primary sulphide ore is less than 2. In addition, the pH value of gossan is in inverse proportion to its gold content. It can be inferred that the most favorable conditions for gold supergene enrichment are weakly acid, neutral and weakly alkaline (especially the weakly acid conditions).

5. Using meteorological, hydrogeological and tectonic information, we have found that: (1) Gold distribution in gossan is close related to ground water. When the deep ground water goes upward through the orebodies and wallrocks, it will become acid water with a much higher ion content of SO_4^{2-}, Au and other metals. As the acid water enters the alkaline environment in the oxidation zone, its front is neutralized and a new environment which is favorable for Au supergene enrichment appears. When the acid ground water moves downward, the Au in the orebodies and wallrocks will partly dissolve. Due to this annual downward migration of ground water, Au concentration belts form in the gossans. (2) Since Quaternary time, neotectonic movements have caused the crust to go up and down again and again. As the crust moves upward and the weather drys, the supergene migration of gold is affected in four different ways.

GEOCHEMICAL RESEARCH OF REE AND TRACE ELEMENTS IN KIMBERLITES

GUO YINGJIE AND SHAO YUE
*Institute of Geophysical and Geochemical Exploration,
Langfang, Hebei 102849, P.R. China*

The REE and trace elements in kimberlites were studied experimentally by Shao Yue and Liu Jimin (1985). On the basis of their research, we, from 1988 to 1990, did a systematic geochemical research on REE and trace elements in 27 kimberlite pipes which distribute in Guizhou, Shandong, Liaoning, Henan and Heilongjiang Provinces. The main goal is (1) to inspect the previous results; (2) to do further research on distributory law of REE and trace elements in kimberlites. Our research includes the comparison of the contents of REE and trace elements in different kimberlites; the normalized REE curves of different kimberlites; the geochemical behavior of REE and

trace elements in the process of the weathering and magma evolution of kimberlies; evaluation of diamond-bearing properties of kimberlites. In addition, the geochemical behavior of REE and trace elements in the process of hydrothermal alteration has been studied.

In comparison with the former research, some advances and more accurate results have been achieved in our research.

1. Kimberlites are rich in REE , especially the LREE. $REE is more than 300 ppm in the diamond-bearing kimberlites and less than 150 ppm in the nondiamond-bearing kimberlites.

2. The degree of the fractionation between LREE and HREE is related to the diamond-bearing properties. In diamond-bearing kimberlites, $\Sigma LREE/\Sigma HREE>12$, $(La/Yb)N>40$, $(La/Sm)N>4$ and $\Sigma(La-Sm)/\Sigma REE>25\%$. In non-diamond kimberlites, $\Sigma LREE/\Sigma HREE<10$, $(La/Yb)N<30$, $(La/Sm)N<4$ and $\Sigma(La-Sm)/\Sigma REE<25\%$. It has been found in the kimberlites that the more the diamonds, the higher the LREE content. The ration $\Sigma LREE/\Sigma HREE$ is more than 15 in the kimberlites which are rich in diamonds.

3. The kimberlites contain higher Cr, Ni, Ti besides Zr, Nb and Se. There is no or little Nb in the non-diamond kimberlites.

4. the REE contents in the kimberlites which form in different stages, but locate in the same tectonic belt, are obviously different. The REE content of the late kimberlite is more than that of the early kimberlite. On the contrary, $\Sigma(La-Nd)/\Sigma REE$ of the late kimberlite is less than that of the early one. It can be inferred that with the evolution of the kimberlite magma, its REE content varies regularly.

5. Compared with the primary kimberlite, the weathered one has a higher REE content, but the altered one (carbonatization) has much lower not only the REE content (especially the LREE content), but also the ratios of $\Sigma LREE/\Sigma HREE$, $(La/Yb)N$, La/Sm, Ce/Yb, etc. Therefore, taking the representative samples is the key to study the kimberlites.

6. The As, Sb, Hg and diamond contents are higher at the top (or upper part) of the kimberlites, but decrease with the increasing depth of the kimberlites. The result of the discriminant analysis using the three variations---(CrxNi), Nb and (AsxSbxHg) could act as the indicator by which the diamond-bearing properties of the kimberlites can be evaluated.

It has been found that the Shuangyashan kimberlite does not contain any diamonds.

RESEARCH AND APPLICATION OF ELECTRICAL EXTRACTION METHODS IN GEOCHEMICAL EXPLORATION

GUO YINGJIE, WU ZONGHUA, JIN YIANGFEN
Institute of Geophysical and Geochemical Exploration,

In this article, we will introduce two kinds of electrical extraction methods--hydroelectrical and soil electrical which are quite different in some respects from previous methods.

HYDROELECTRICAL EXTRACTION METHOD (HEEM)

The sampling device is a plastic bar with two removeable graphite rods, each of which is wrapped in polyurethane foam. Its power supply, connected to electrodes by wires, consists of a 45 V battery and an adjustable electric resistance by which the electric current can be changed freely.

For sampling, both electrodes are immersed in the well water with the battery on the ground. Twenty minutes later, the device is taken out, the absorbents are removed, wrung by hand and put in the sample bag separately. The samples are submitted to the lab for analysis of Au, Ag, Cu and Pb by atomic absorption spectrometry.

Some experiments have been done to determine the most suitable electric current value, time and distance between the two electrodes. The results show the high content of Au, Ag, Cu and Pb in both absorbents and run counter to the accepted idea that the longer the time and higher the current value, the higher the amount of metal in the absorbents. It may be inferred that the reaction on the electrode surfaces is complicated and the metal ions exist in the form of complex ions and colloids carrying the positive or negative charges.

An experimental survey using HEEM has been carried out within a 45 km^2 area in the famous Au metallogenic province in the eastern part of Shandong Province.

Distinct Au, Ag, Cu and Pb anomalies were discovered not only over and adjacent to the known Dayingezhuang primary gold deposit, but also in previously unknown areas. The distribution of Au anomalies coming from the anode absorbents coincides much better with the known deposit than those coming from the cathode absorbents. According to the anomalies, some promising areas for further Au exploration have been revealed.

SOIL ELECTRICAL EXTRACTION METHOD (SEEM)

SEEM is a technique used in camping sites. Soil samples are taken at a depth of 20-50 cm at each site, sieved to-20 mesh in the field and dried in the air. 400-500 g soil is placed in a 500 ml beaker and 300-400 ml water is added. Then, beat the solution with a glass rod to mix them evenly. Plunge the two electrodes vertically into the solution and switch on the electric power for 5 minutes. Finally, take the electrodes out, remove the absorbents, clean them with water and put them in the sample bag separately. With our special equipment, 40 soil samples can be done in only 5 minutes.

Some experiments have been made with the fixed potential difference between the two electrodes (100 V). The results show that Au and Ag reach their highest level in 5

minutes; as for Cu and Pb, the longer the time, the higher the content; the Zn content shows little change between 5 to 80 minutes.

SEEM is used in some traverses over known gold deposits and the promising Au region in Shandong Province. Some Au, Ag, Cu, Pb anomalies, although weak, have been distinctly identified over and adjacent to the gold deposit.

In a word, HEEM and SEEM are effective, time-saving and economical in geochemical exploration for metallic deposits, especially gold deposits. Although SEEM will require improvement in many respects, it is a promising technique expected to replace the traditional, bulky, time-consuming geo-electrical extraction method developed by the former Soviet Union.

METHOD AND RESULT OF ENVIRONMENTAL GEOCHEMICAL SOIL INVESTIGATION IN WEINAN REGION

HAN XIDING
(The Geophysical and Geochemical Exploration Team of Shaanxi)

To meet the need of city development, an environmental geochemical investigation was performed in Weinan city and surrounding area, totaled 1700 km^2. The regional geochemical background was determined. Pollution areas were delineated, and the environment quality was evaluated. The result is useful for land planning.

The soil beneath plough depth was sampled. The sample8 density was 4/km^2, and four samples taken in a 1Km^2 cell were comprised a composite sample for analysis. During crushing and grinding, contamination was carefully prevented. Sixteen elements were quantitatively analyzed, which include Cu, Pb, Zn, Ag, Bi, As, Sb, Hg, Se, Cr, Ni, Co, Mo, Sr, Cd and F.

Statistic methods were used to determine background, and anomalous high values were excluded during computation. The distribution patterns of 16 elements obtained by this investigation was similar to those othe world-wide and the Shaanxi Province, demonstrating that the result is reliable. Compared to the word-wide and Shaanxi value for normal soil, the concentration of Hg, Pb, Ag, Mo and Bi is slightly higher. For other elements, no distinct difference was observed. The overall environmental quality is rather good.

To evaluate the pollution and the industrial influence more exactly, the area with different background has been distinguished and geochemical grading has been established. The statistic values of element concentrations between adjacent area must be distinctly different, and overlap of successive grades must be less than 50 percent. Altogether, 3-6 areas and 2-3 grades have been distinguished for 16 elements respectively.

In evaluating geochemical quality, all parameters were taken into consideration quantitatively. For all 16 elements, single-factor evaluation has been made, and multi-factor analysis has been used for poisonous elements Hg, As, Pb, Bi, Ag, Cd and Cr.

In summary, 19 pollution areas have been recognized. Among these are 4 weakly-polluted areas, 1 moderately-polluted, 10 heavily-polluted, 4 seriously-polluted. These areas are in general distributed along the railway and clustered around the towns and mines. The pollution is obviously an industrial origin.

REGIONAL GEOCHEMICAL DATA PROCESSING OF LUHUO-QIANNING GEOANTICLINE LINE, SICHUAN PROVINCE

HE DERUN

The research area is located in the fold system of Songpan-Ganzi. Most of the rocks outcropped most belong to the Traffic, Xikang formation partly the upper Permian, and the intermediate to felsitic intrusion. The proportions of them are: sandstone 52%; slate 32%, carbonates 9%, mafic volcanics 2%; intermediate intrusions 1% and felsitic intrusions 4%. The regional faults are mainly two groups: NNW and new NW. Placer gold was main mining predict in the past; then the mercury, stadium (multimetals), and iron-copper of SK type (associated with gold). There are many gold occurrences, but no one has economic interest.

In the end of 1980's, a geochemical exploration survey of stream sediments was carried out in this district with a sampling density of 1-2 per km^2; resulting in 65 gold anomalies in the area of 4,992 km^2. After drilling, a fine gold deposit of disseminated type was discovered. There are also a group of gold anomalies with Au, As, Hg and Sb (Bi) which need to be investigated. It is obvious that there is a great potential for gold in this area.

In the data processing, we first classified statistical units which were irregular drainage areas with 10-20 km^2. Then, performed R-type fuzzy cluster analysis with 38 controlled units which had been known as gold deposits and with 330 drainage areas respectively. Based on the obtained variable spectra maps which are very similar to the known deposits, we determined Au, As, Sb, Bi, HgxAs, HgxSb, AsxSb, AsxBi and AuxAsxSb as the nine best-statistical variables. We used these variables to conduct R-type factor analysis for the 330 drainage units and 65 gold anomalies. The results indicated: if we take gold anomalies as statistical standard, some important information might be lost in searching for fine disseminated gold; using drainage units as statistical standard, it would not only enhance the information for fine disseminated gold, but also obtain some more important information which was not easily recognized before geochemical prospecting. Finally, combined the result of factor analysis with geological information of regional mineralization, we found 6 promising regions. One of them is as for fine disseminated gold deposit; three are for fine disseminated gold and for SK type of gold deposits; one is for fine disseminated gold deposit and for quartz-vein type gold deposit; and the last one is for quartz vein gold and placer gold. When we take the value of perpendicular factor F1 of the 330 drainage units as the importance for gold, 145 drainage units which have different importances in prospecting will be determined. A class unit is 5 (F1>3); B is 10 (3>F1>2); C is 28 units (2>F1=1) and D is 102 units (1>F1>0). In these 145 units, there are 25 drainage units in which the prospecting information is in a rather implicit way, two of them in B class, four in C class and nineteen in D class. These results indicated where and how we can do the further exploration work in this district, and also determined the targets for further prospecting. In recent years, after further geological investigation in Gaodingshan drainage unit, we have found three gold ore bodies which contain gold from 4.55 g/t to

10.15 g/t. So it is proved again that the predictions of data processing in this district are successful.

COMPUTER SIMULATION ON DRAINAGE SYSTEM FOR GEOCHEMICAL EXPLORATION

HOU ZUNZE, LIN CUNSHAN AND XU ZHENBANG

Analysis of drainage system is significant in geochemical exploration. Especially in regional survey, geochemical samples are usually collected along the drainage. Based on the contents of elements on sampling sites, geochemical anomalies can be found and the anomalous sources are then located. Computer simulation on drainage system can be used to quantitatively analyze migration and distribution of elements in the drainage. The paper describes concepts and properties of drainage system, design of simulation models and operation of the models. Two-dimensional drainage networks are successfully created. Preliminary application of the simulation in geochemistry is made.

A drainage is a network composed of flow links which originated from several water sources. A topological relationship exists among the flow links. Each link is assigned a magnitude according to a certain regulation. Water flow depends on the topography, tectonic, and rock types etc.. A simulation model of random walk based on main probability weight is established. Factors of both determinate and indeterminate are taken into account to set up the main probability weight which guides the most possible direction the random walk will take. An algorithm of self evading random walk is incorporated to generate the moving track of the water flow point. Processing of confluence among the flow lines is then performed, and drainage network is finally formed. With the method, some two-dimensional drainage networks are constructed which are then used to analyze and calculate the transported quantity of chemical elements under ideal condition. Such calculation becomes easier while information about the components of the drainage network has been obtained and stored in the computer.

Theory of the simulation on drainage system is under improvement, which involves determination of the main probability weight, simultaneous random walk of multiple points and mutual influence of the points.

BACKGROUND, ANOMALY AND ANOMALY OF ORE

HUA FULIN

The technical key to distinguish anomalies related to mineralizations and anomalies not related to mineralizations is to choose one mark or anomaly parameter, which is influenced slightly by background field and other factors of anomalies not related to mineralizations but

possesses the function of indication for mineral exploration, as its effective criteria.

In the past, it was often stressed on "high, large and overall" (i.e. high intensity of anomalies, large anomalous area and good association of elements) as the geochemical anomalies being evaluated. It was, of course, made some results of mineral exploration obviously according to such diagnostic marks, but most of them are outcrop minerals or near surface mines.

In fact, the experiences of anomaly follow up in recent years indicate that "weak, small and unitary" anomalies (i.e. weak intensity, small areas and unitary element) is the identification marking to search for some buried ore or hidden deposit.

The essential property of geochemical anomalies can be understood well to study the characteristic marks of anomalies related to mineralization from the probability distribution composition model of geochemical data in anomalous region.

The mixed distribution of triple (or multiple) constructions is statistical probability distribution feature of anomalies related to mineralizations. This is a very important distributional feature of anomalies related to mineralizations, which possess the connotation of generality and basis to compare relying for the "high, large and overall" and "weak, small and unitary" anomalies related to mineralizations. It is the summary of all kinds of feature of geochemical anomalies related to mineralizations. The statistical distribution characteristic of anomalies not related to mineralizations is unitary distribution model.

There are three value regional sections, generally for the accumulative frequency distribution curve; The first, is the background distribution which indicates the geochemical distribution feature of non-alteration and not-normal-mineralization geological formation, the middle is the signs of the dispersed distribution feature of the minerals in host wall rock and the last section is the marks of the distribution feature of enriched mineralization in the formation of magmatic deposit of near deposit space. Both of the middle and the last sections are anomalous distribution, only the later one is the distribution of anomalies related to mineralizations which usually shows no difference with the composition of the occult mineral.

LEAD ISOTOPES AS A SIGNATURE OF GEOCHEMICAL ANOMALIES FORGOLD EXPLORATION IN WEST HAINAN, CHINA

HUANG BIN
(Guilin Institute of Geology and Mineral Resources, CNNC, Guilin)

In order to determine reference value of Pb isotopes for gold exploration in the study area, Pb isotopic ratios and Pb contents have been measured for typical profile samples from ore bodies in Baoban and Tuwaishan deposits. The study gold deposits are hosted in middle-upper Proterozoic Baoban Group which is composed of migmatite and extends over an area of about 30 km along the hanging wall of Gezhen fault. The study deposits have common initial Pb isotopic ratio ($^{206}Pb/^{204}Pb=18.683$), but show distinctive variations in individual deposit. The Pb isotopic values are more homogeneous in ore bodies and auriferous altered rocks than that

in the migmatite wall rocks. Especially the richest ore forms the VI orebody of Baoban deposit which has the lowest and most homogeneous $^{206}Pb/^{204}Pb$ ratio. This feature suggests that in this migmatite area it is possible to distinguish ore from barren wall rock and rich ore shoots from noncommercial minerlization by their distinctive Pb isotopic ratios.

A lower initial Pb isotopic ration ($^{206}Pb/^{204}Pb=18.5380$ was detected in two other deposits, Beiniu and Erjia, which occur in the same migmatite and controlled by the same fault. Therefore, it is proposed that two metallogenic phases may have taken place whose ages, being 85Ma and 170Ma respectively, can be calculated from Pb growth model of Cumming and Richard.

In order to confirm the feasibility of evaluating geochemical anomalies by Pb isotopic signatures the Pb isotopic ratios of B horizon soil samples from both significant and nonsignificant anomalies are compared to the reference value. The results have shown that the Pb isotopic ratios in significant anomalies are consistent with the reference value while the signatures of nonsignificant anomalies are heterogeneous and rather different from the reference.

Six unknown anomalies have been evaluated by this criteria, of which 5 were negative. One anomaly presents the same signature as those of Beiniu ore deposit, which may indicate the existence of underlying ore bodies close to the fracture zone of Gezhen fault. The local geologists are planning to drill the target.

CORRESPONDENCE CLUSTER ANALYSIS AND ITS APPLICATION IN EXPLORATION GEOCHEMISTRY

JI HONGJIN
(Changchun University of Earth Sciences)

Correspondence analysis and cluster analysis are two well-known multivariable methods for data processing among geochemical explorationists. In this paper ,an attempt is made to combine correspondence analysis with cluster analysis which is called by the author correspondence cluster analysis. Let X be an N by M matrix which is the original data set. After applying correspondence analysis to matrix X, we can obtain the coordi nates of n individuals and m variables in the p-dimensional factor space which is expressed in terms of a matrix Z with order of (n+m) by p. When Q-mode cluster analysis is applied to matrix Z, a dendrogram of correspondence cluster analysis is obtained, by which the individuals,the variables as well as their corresponding relationships are completely shown. This procedure has been used to some practical data set, and the results show some interesting features of the method:1, a better classification capability2, a combined function of both Q-mode and R-mode cluster analysis3, a wider application field

A GEOCHEMICAL MODEL FOR THE FANGNIUGOU PYRITE-POLYMETALLICDEPOSIT, JILIN

HUANG XUNDE, PIAO SHOUCHENG, LIU SHUTIAN, ZHANG XIAOMIN AND
LIAN CHANGYUN
(Changchun University of Geosciences, Changchun, China)

The deposit occurs in the contact zone of volcanic sedimentary rocks and granite intrusives. In the primary halos, ore-forming elements such as Pb, Zn, Ag, Cd and Mn present positive (increased) values whereas lithophile elements such as Cr, Sr and V have (negative) depleted values. The vertical and horizontal zonations of the primary halos are similar to the typical zoning of thermal deposits. The ration Ag/Bi and PbxZnxAgxBa/CuxBi increase from deep to shallow which can be use as an indicator of the erosion degree of the ore bodies.

The elemental association in pyrite and the REE patterns are used as the genetic indicators of the study deposit. According to the genetic model established in the research, a prediction is made that under the igneous rock there could be another contact zone hosting blind ore bodies.

PROSPECTING FOR BLIND OREBODIES WITH NEW GEOCHEMCIAL TECHNIQUES A TYPICAL CASE HISTORY.

Huang Shujun
(Institute of Geology for Mineral Resources, CNNC, China)

To develop new field in prospecting for blind and buried oreswith geochemical techniques over more than ten years a test surveyhas been carried out with such new geochemical methods as thermalreleased Hg in soil, halogen, electric conductivity and pH technique. The investigation shows that these geochemicaltechniques are cost effective. In following a case history the discovery of blind ores with these new geochemical techniques inTianwei area, Yizhang county, Hunan province is illustrated.

1. A GENERAL OUTLINE OF GEOLOGY.
The landscape condition of the survey area Tianwei belongs to low mountain and hill country. The middle part of it is covered byrice field with thick overburden representing alluvium anddeluvium; while the periphery is occupied by low mountains andhills with thin overburden representing elluvium and slope wash,with rocks outcroped somewhere. The stratigraphy in the areasurveyed from old to young represents limestone of Qiziqiaoformation of middle Devonian series, argillaceous banded limestone of Yutianqiao and limestone, dolomitic limestone of Xikuangshan formation of upper Devonian series, sandstone and granulite ofJurassic system. The fracture in the area is more or lessdeveloped and it is divided into three groups, with those in NNEdirection as the main and others in both NW and nearly SNdirections as subsidiary. No igneous rocks are outcropped in thearea. Weak Pb-Zn mineralization and Fe-Mn mineraliztion areobserved locally, and so far all discoveries have been blindorebodies probably of stratabound type.

2. THE CHARACTERISTICS OF GEOCHEMICAL ANOMALIES DELINEATED BY NEW GEOCHEMICAL TECHNIQUES.
A test survey was carried out in the area (4 sq. kilometers)with network 200mx40m

using thermal released Hg in soil, halogen, electric conductivity and pH technique. As a result four integratedanomaly belts, with stress on Hg anomalies, were located with anomalies of thermo released Hg in soil, and secondary halo of F.

The integrated anomaly belt No.1, located in the south-east cornerof the area near Tianwei, is composed of No.1 Hg, F, I and electric conductivity anomalies. They coincide with each other well. Thesize of anomaly is larger, with 200 to 600m in width and 1000m inlength. The anomaly is still open to the south-west direction, probably it extends further. The peak values of the anomalies: Hg 19.8×10^{-9}, F 1600×10^{-6}, I 21×10^{-6}.

The underlying country rocks are mainly limestone and dolomiticlimestone of Qiziqiao formation, which is one of the horizonsfavourable for ore occurence. Judjing from the above mentionedgeochemical anomalies in combination with geological setting it isinterpreted that the anomaly is caused by blind ores and "is one ofthe most potential anomalies in this area, and therefore, isrecommended to be examined by drilling."

The integrated anomaly belt No.2, located in the central part ofthe area suveyed, in composed of N0.2 Hg, F, I, electricconductivity and pH anomalies, the axis of which is in NE-SWdirection. The Hg anomaly exhibits irregular and banded, with 100mto 400m wide, and more than 3000m long. In most cases more than twocomponent anomalies are observed in addition to Hg anomaly. Allcomponent anomalies coincide well enough. Peak values of theanomalies: Hg 19.2×10^{-9} F 1300×10^{-6}. I 19.5×10^{-6}.. Theanomalies are distributed mainly over the rice field, with unknowngeological condition, it is interpreted, however, that theunderlying country rocks are mainly those of Qiziqiao formation.Judjing from topographic and geomorphic features there is probablya NNE-SW fault along the axis of the anomaly belt. Therefore it isinterpreted that the present integrated anomaly belt is probablydue to a ore-bearing fracture, especially near the south-west partof Lijiatang village the concentration centers of Hg, F, I,electric conductivity and pH anomalies coinside better, and withhigh intensity. So it is considered that the anomaly "is one of themost potential anomalies in this area, especially the Lijiatangvillage is the most favourable for ore occurrence, and, therefore,is recommended to be examined by drilling." The integrated anomalybelts No.3 and No.4 because of low intensity of all componentanomalies, small size and poor coincidence, are considered asinsignificant for prospecting.

3. EXAMINATION BY DRILLING.

1) The results of examination of the No.1 integrated anomaly belt.

Some Pb-Zn blind orebodies in several horizons were discoveredby the 206th NM geological team in boreholes drilled alongexploration line No.16 in 1984). The orebodies are veinand stratoid, occurring in fracture and faulted zones in limestoneand dolomitic limestone of Qiziqiao formation, and the thickness oforebodies is tending to be enlarged gradually to the depth, buttheir extensions to the depth still remained to be uncontrolled. Later some discoveries also have been made in boreholes drilledalong line No.10 and line No.24 outside the south-west part of thearea surveyed. From the figure 3, it is seen that Hg, F, Ianomalies are delineated at the front and upper wall of the Pb-Zn blind ore bodies. Undoubtedly the integrated anomaly belt No.1seems to be the front and upper wall haloes of the Pb-Zn blindorebodies. Now the exploration work continues to be done at present time, and a sizable Pb-Zn deposit is , therefore, expected.

2) The results of examination of integrated anmomaly belt No.2.

In recent years the 206th team has realized a drilling programin the south_west part

or Lijiatang village, where Hg, F, I,electric conductivity and pH multicomponent anomalies coincide, asa result a multilayer Ag orebody was discovered along lines No.21,23, 25 and 33. The Ag orebody represents vein in figulation,filling up the interlayer fracture zone of Qiziqiao formation, withthe orebody enlarged into the depth gradually, but its extension tothe depth, however, still remained to be uncontrolled.

From fig.4 it is seen that distinct Hg, F, I, electric conductivityand pH anomalies are observed at the front and upper wall of the Agorebody; the anomaly No.1 on the rightside of the profile might becaused by other noises. Undoubtedly the present integrated anomalybelt is just the reflection of the front and upper wall haloes ofthe Ag blind orebody group. Now the exploration continues to bedone, and therefore a sizable Ag deposit is expected.

4) Conclusion.

The prospecting practice indicates that these new geochemicaltechniques, such as thermoreleased Hg in soil, halogen (mainly Fand I), electric conductivity and pH, are cost-effective techniquesin prospecting for blind and buried orebodies. Their wideapplication should be envisaged.

The author is indebted to the following individuals who tookpart in the survey: Li Shuiming, Zeng Yongcao and Jia Guoxiang.

A DISCUSSION ON GEOCHEMISTRY OF ORE-FORMING PROCESSES IN MEIJIAO AREA, GUANGDONG

HUANG YAOHUA
(Team 940, Guangdong Bureau of Geological Exploration, CNNC)

Meijiao area is mainly an upper-Jurassic volcanic basin in the Yongan-Meixian Depression. As a part of the SW Fujian-NE Guangdong metallogenetic belt, the study area is structurally located at the intersection region of two major fold belts. The ore-forming processes are contemporaneous with intensive and widespread volcanic, intrusive and structural activities.

Geochemical investigations have shown that the Sinian strata, which is abundant in volcanic clastics, and the Jurassic formations are enriched in Cu, Pb, Zn, Cr, Ni, Co, Au, W, Sn and Mo, and felsic intrusives are to some extent enriched in Cu, Mo, Au, and Ag and W of volcanic and intrusive hydrothermal origin. The association of elements are similar for different types of deposits which are characterized by vertical and horizontal zoning.

Stream sediment survey has shown that the anomalies are basically controlled by faults and intrusives, and show no close relation with sedimentary strata. The association of elements in stream sediments are essentially the same as those in ore deposits, which presents a regional zonation from inner Ag and Cu zone to outer Cu and Au. It is typical for the structural framework and geochemical feature of a fault-depression basin. According to an integrated analysis of the known deposits in the area, it is understood that the primary sources of metals are the deep-seated felsic intrusives which provide heat and driving forces for ore-forming fluids. From upper

level to deep position, the zonation of the ore deposits is Sb, Ag (vein type), Cu, Pb, Zn (vein type), Cu, Au, Mo (porphyrytic and vein type), and the accompanying element zonation is Sb, Ag, As, Hg, Cu, Pb, Zn -- Cu, Pb, Zn, Ag, Sb, Au -- Cu, Au, Mo, Co, Pb, Zn, Ag.

It is argued that the most favorable prospecting areas for Cu, Au and Mo deposits are at the rim and the periphery of the J3 volcanic basin.

A PRELIMINARY MODEL EXPERIMENT ON RN MIGRATION THROUGH POROUS MEDIUM

JIA WENYI, GE JUNWEI, WU QIFAN AND TANG HONG
(Chengdu College of Geology)

The purpose of the experiment is to study whether or not diffusion is the only mechanism for radon transport in the air and through porous medium. The experiment has been carried out on 1-D model and 3-D model repeatedly. All the models are sealed to avoid convection and built in the lab to prevent any influence from the climate condition so that the experiments are repeatable.

The 1-D models are composed of a set of tubes (4-8cm i.d. and about 8m in length) which is filled with testing material (air, clay, sand or gravel) and placed vertically or horizontally. Uranium ore is used as the radon source which is put at the bottom or the middle of the model tube. The 3-D models are a set of containers (1.2m*1.0m*1.0m) filled with testing material with radon source at the bottom center.

The key to success of the experiments is the radon sampling and determining technique. The traditional emanation and track etch measurement are inapplicable because these methods either have low sensitivity or will alter the experimental condition. Electrostatic alpha-card and ionization chamber alpha-cup, developed recently by the authors, was used satisfactory.

Some preliminary results have shown that (1) despite its high density, radon can migrate upward at a high speed which can not be explained by diffusion. (2) the remains of radon after 5 times of its half-life (T=3.8 days) is much higher than that calculated from theory. The authors infer that some long half-life daughters of radon may accompany the migration of radon in soiled particles.

The fact that radon as well as its long half-life daughters can migrate upward quickly even in the air explains why geochemical methods such as alpha-cup, alpha-card, and gamma-ray spectrometry of radiometries can be used to obtain deep geologic information.

PRELIMINARY MODEL EXPERIMENTAL STUDY OF RADON TRANSPORT

JIA WENYI, GE JUNWEI, WU QIFAN AND TANG HONG
(Chengdu College of Geology)

The study of radon transport, which started at the beginning of the century, has brought a renewed interest of many geochemists in the 90s because the research on the moving process of elements is the basis of geochemical exploration. The investigations, made on the mechanism of transport at home and abroad, focus on the influence of temperature, pressure and groundwater exerted upon the transport on the basis of diffusion theory. But we don't know whether the mechanism of radon transport is diffusion without the influence, which is the fundamental of the study and should be studied through the experiment on the indoor models.

Two types of experimental models have been built, one-dimensional model and three-dimensional model. The models are indoor to reduce the influence of temperature and climate and to repeat the experiments easily. They are sealed up to avoid the convection.

(1) The one-dimensional model is consisted of a group of about 8 m high columns filled with air, water, clay, sand and gravel respectively. The air model is the main. They are set vertically or horizontally. Radon source can be put in the bottom or middle of the columns. The purpose of setting up one-dimensional models is to observe the ability and law of radon transport vertically and horizontally.

(2) The three-dimensional model is used to observe the distribution law of radon in the three-dimensional space. It is filled with sand, and radon source is buried in the bottom of the model. The size of the model is 1.2x1.0x1.0m.

The key to the model experiments is the observation method. The methods detecting radon in the past were emanation measurement and track etch measurement mainly. Both of them can not be used in the model experiments. The reason is as follows:

(1) Emanation method is a kind of dynamic measurement, which is used to detect radon by pumping air and it would destroy the dynamic balance of radon.

(2) Track etch method has low sensitivity and a very long experimental period. It is very inconvennient though it is a sort of static measurement.

In recent years, we have developed electrostatic alpha-card method and ionization chamber alpha-cup method. Both of them are integrating methods of detecting radon. They have lots of characteristics, such as high sensitivity, static measurement and short experimental periods. Therefore, we select them as the main observing methods in the experiments.

Some initial experimental results has been gained from the model experiments.

(1) Although radon has the largest weight among the gas, and its density is about seven times as large as the air, it can migrate upward very fast and efficiently even in the sealed model. The diffusion process doesn't play a noticeable role in the movement of radon in the experiments.

(2) The longest half-life radon is T=3.8 day, but the density remained in the model after 5T is much larger than the theory. Thus, we infer that the long half-life daughters of radon can move upward with radon similarly. It has shown that some soiled radioactive elements can participate in the movement automatically in the air space.

The initial experiments have shown that radon and its daughters can migrate upward strongly by themselves in the air space, which could explain why geochemical

methods, such as alpha-cup, alpha-card and gamma-ray spectrometry of radiometries, can get deep geological information.

FOLLOW-UP FOR A HYDROGEOCHEMICAL ANOMALY: A CASE HISTORY OF PROSPECTINCG CONCEALED GOLD MINERALIZATION

JIANG RUIJIN, REN TIANXIANG, MA SHENGMINGH AND WANG MINGQI
*(Institute of Geophysical and Geochemical Exploration,
Langfang, Hebei, People's Republic of China)*

Follow-up work was carried out in a composite hydrogeochemical anomaly area near Changbai Town in south Jilin Province so as to evaluate the mineral potential of the studied area. Based on the characteristics of regional geology, structural geology and the results of remote sensing and surface observation, detailed investigation area was selected in the hydrogeochemical anomaly area. Several targets for concealed ore exploration were delineated through lithogechemical survey, mercurometric survey and geochemical soil survey. The sequel drilling at one of the target areas and the geochemical study of the drillcore confirmed a concealed gold mineralization at the depth of 600 meters below the surface. The procedures and main results of the follow-up work are described below:

1. At the southern end of the hydrogeochemical anomaly area, rock samples were collected along a profile across the bedrock crops of the main stratigraphic units of the studied area in order to investigate the geochemical characteristics and mineral potential of different fault zone and stratum. A composite lithogeochemical anomaly of As, Sb, F, I, Ag, Cu, Zn, etc. was found at a fault zone between the Ordovician limestone and the Permian sandstone and shales. The peak values of As and Sb are 193ppm and 7.9ppm respectively with a anomalous width of more than 200m; strong anomalies of mineralisers such as F and I appear at the middle part of the fractured zone with peak values of 15800ppm and 5ppm respectively. Weak anomalies of Cu, Pb, Zn and Au appear on both sides of the fractured zone. It is deduced that the fractured zone has experienced relatively strong hydrothermal activity and may be as regional ore fluid channelway of the area. The sandstone of the hanging wall and the limestone of the bottom wall may be the possible host rock of the unknown mineralizations in the studied area.

2. In an area where ore-controlling structure and host rocks may exist, a detailed investigation area was selected. The main bedrocks cropped there are Ordovician limestone and Permian sandstone which are locally covered with Cenozoic basalt. Mercurometric survey and routine geochemical soil survey were used to delineate target areas for further prospecting. The extension trend of ore-controlling structures can be clearly delineated by mercury anomalies in soil gas and soil. Five composite geochemical soil anomalies were found in the detailed survey area. The main anomalous elements is a series of front elements and mineraliser elements such as As, Sb, F, Hg, B and I and has formed high-intensity anomalies with well-coresponded concentration centers. Au and Bi formed weak but conspicuous anomalies that coresponded to those of other elements. Most geochemical anomalies in the area are located on the conjunction part of the regional ore-controlling structures (high-angle

fault with NNW trend) with secondary structure. Carbonatization and fertilization can be found at the surface of the anomalous area. In view of the geochemical anomalies of the surface and mineraliser elements and the favorable geological conditions, we infer that there may be gold or polymetallic mineralizations at depth of the surface anomalies.

3. According to the above inference, drilling was carried out to confirm the No.1 geochemical soil anomaly at the northern part of the studied area. Two multi-element anomaly belts have been identified in the drillcore: the upper anomaly belt is composed of strong anomalies of As, Sb and Hg and weak anomaly of Au, which has a typical characteristics of front element combination of gold deposits; in compa-rison with the upper belt, the lower belt, appeared at a depth of about 600m below the surface, consists of much stronger anomalies of As, Hg, Au and Sb which have peak values of 7,682ppm, 3,450ppm 46ppm respectively. The thickness of anomalous strata with more than 0.1g/t Au is up to 50 meters and has thus formed a relatively large scale gold mineralized zone. Gold concentration of the mineralized zone significantly increases with depth and maximum value of 1.5g/t Au has been found in a sample collected from the bottom of the drillcore. It is expected, therefore, that the mineralized zone discovered in the drillcore is approaching the main ore body.

On the basis of geology and geochemistry study on the mineralized body, it has been known that the mineralization is hosted within the Ordovician carbonous limestone interlayered with thin shales and strong silification has developed in the mineralized rocks. Main metallic minerals include pyrite and arsenopyrite. It is deduced that the gold grain size in mineralized rocks is extrafine because no native gold particles have been observed with naked-eyes and microscope. Therefore, it is concluded that the mineralized zone discovered in the drillcore may be the upper mineralization of a gold ore body and there is a favorable potential for Carlin-type deposit at the depth of the studied area.

A TENTATIVE IDEA ON COMPILATION SHEET FOR REGIONAL METALLIZATION RATE OF ELEMENT

JIANG ZHI
(Gold Headquarters, MMI, P.O.Box 1604, Beijing, Postal Code:100012, China)

According to statistical geochemistry, regional metallization rate, e, of element is a ratio of metallization quantity of element in certain region to its total, which can be written as follows:

$$e = \int_{\zeta > B} \zeta f(\zeta) d\zeta \Big/ \int_{\zeta > 0} \zeta f(\zeta) d\zeta$$

Where, $f(\zeta)$ is a probability density function for element content, ζ; B is the cut-off grade of the element. According to which, the metallization rate in certain mini-region was calculated with the formula under known cut-off grade and probability density function obtained generally from geochemical surveys. For instance, there are 100

composite samples per 1 km^2 sufficient enough to obtain the function that is small enough for mini-region in the geochemical map on a scale of 1:2,000,000. It is equal to a composite sample per 4 km^2 in the regional geochemical reconnaissance in China.

There are two methods for calculating value of e with a computer: I) calculating the e value in each check in a map; II) calculating the e value by moving average in a map. In this way, isopleth maps of the regional metallization rate of the element used to metallogenetic prognosis is made with the rate, e, of each mini-region.

HE METHOD FOR SOIL GAS RN-HG COMBINED MEASUREMENT AND ITS APPLICATION

JIN YANGFEN, WU ZONGHUA AND GUO YINGJIE
Institute of Geophysical and Geochemical Exploration,
Langfang, Hebel 102849, P.R. China

The method for soil gas Rn-Hg combined measurement (MSGRHCM) is a time-saving and on-the-spot method developed by the authors several years ago. Since 1987, MSGRHCM has been used in the exploration for gold and petroleum in Zhejiang, Shandong and Xinjiang Provinces, respectively. Compared with the individual Rn and Hg measurement, this method can highly improve the work efficiency and the comparability of geochemical data. At the same time, the method can also improve the reliability of the data and the survey effect. In addition, it has also been applied in locating concealed fractures in engineering geology and studying the tectonic problem of the distribution of deep fractures.

The equipment used in the field includes an FD-3017 Rn detector, a Hg vapormeter, Hg gold-wire trapper tubes, RaA trapper disks, a soil gas sampler, an RaA standard, saturated mercury vapor and micro-injectors etc. The operating procedure can be simply described as follows: make a hole (50-70 cm deep) -- -- pump out the residual air in the hole -- -- connect the tubes and put the trapper disk in -- -- take the soil gas sample -- -- gather RaA by adding a high negative voltage-- -- remove the tube-- -- remove the disk and measure RaA. The goldwire trapper tubes are then taken back to the camping base for analysis.

Our research has proved that MSGRHCM is most effective not only in the exploration for gold and petroleum, but also in distinguishing and sorting larges cale Au anomalies found in the 1/200,000 regional geochemical exploration project. With the help of other geological and integrated indexes, this method can be used to indicate promising mineralizations. Generally, in transported overburden, the fact that soil gas Rn and Hg anomalies coincide with stream sediment Au anomalies demonstrates the existence of a gold mineralization below their intercrossing section. The single Rn, Hg anomaly can reveal concealed fractures, while the single Au anomaly can reveal the contamination from cities or mineralization upstream. Additionally, this method can also be used to carry out integrated gas survey over a large area of transported overburden.

MERCURY IN WATER: AN OPTIMUM IMMEDIATE GEOCHEMICAL WARNING INDEX OF AN EARTHQUAKE

JIN YANGFEN1, WU ZONGHUA1, WEI JIAZHEN2 AND SHEN CHUNSHENG2

(1) Institute of Geophysical and Geochemical Exploration, Langfang, Hebei 102849, P.R. China
(2) Center of Analysis and Prediction, State Bureau of Seismology

During the period of 1984-1986, experimental researches on the possibility of applying mercurometric survey to earthquake prediction were carried out in China. The artificial simulation of earthquakes, the characteristics of mercury anomalies over faulted zones and near hot springs, and the data on variation in mercury contents of water before and after an earthquake all show that the application of mercury to earthquake prediction has good prospects. Up to now, mercury in water from more than 40 earthquake observation wells has been used to perform earthquake monitoring and prediction in China. It can be seen from the data available on quite a few earthquake cases that water mercury anomalies generally appear before seismic activity and, compared with such indexes as water radon, have advantages of high anomaly intensity, sharp contrast, easy recognition, the quickest response to the signs of an earthquake and the best sensitivity, thus serving as an optimum immediate geochemical warning index of an earthquake.

From quite a few earthquake cases, data of two earthquake cases obtained in eight observation wells were selected to illustrate characteristics of pre-earthquake and post-earthquake mercury anomalies in water near the earthquake region. For the same earthquake, water mercury anomalies appeared simultaneously at several observation wells before the earthquake; earthquakes usually took place several days to one month after the falling or disappearance of anomalies and relatively seldom occurred in the anomalous period; the intensity, duration and sizes of water mercury anomalies were evidently related to the intensity of earthquake, and anomalies are generally zigzag with abrupt variations in shape. It is expected that mercury will be more extensively and effectively used in earthquake prediction.

NEUTRON ACTIVATION ANALYSIS: AN EFFECTIVE TECHNIQUE FOR ANALYSIS OF GEOCHEMICAL SAMPLES

LI GUODONG, JIA WENYI, ZHOU RONGSHENG
(Chengdu College of Geology)

Minor reactors (SLOWPOKE) are now available in a number of provinces in China which made neutron activation analysis (NAA) applicable in geochemical exploration. The authors took the advantage of relatively concentrated distribution of reactors in Changdu area and began to develop this technique early in the 60's. In 1990, an extensive replacement and innovation took place to the NAA lab in the College. A PC controlled new gamma-ray spectrometry system has been constructed, and associated software improved. The technology of NAA has come to a maturity after 3 decade's development. It is now capable of determining Na,Mg,Al,K,Sc,Ti,V,Mn,Fe,Co, Ni,Zn,As,Br,Rb,Sr,Sb,Cs,Ba,La,Ce,Nd,Sm,Eu,Tb,Yb,Lu,Hf,Ta,Au,Ag,Th and U for rock, soil and sediment samples at varies detection limits from 0.0n ppm to 0.n ppm

without chemical pre-concentration. For vegetable samples and organic matter, the detection limits can be one order of magnitude lower. With chemical separation and concentration ,the method can virtually cover almost all the elements in the periodic table with atomic number greater than 10.

Tens of thousands analytical data have been produced for our clients at a reasonable price since the establishment of the new system. This analytical technique will play more and more important part in geochemical exploration and geological research in general.

IDEAL MODEL OF PRIMARY SUPERIMPOSED HALO IN HYDROTHERMAL GOLD DEPOSIT

LI HUI, LI FUGUO AND WANG ZHINONG

On the basis of geochemical characters of multiple stages of gold metallogeny and halo forming, the paper summarized ideal model of superimposed halo in gold deposit and concluded five criteria for looking for blind ores and recognizing the erosion level of gold deposit by using superimposed halo.

1. Studying metallogenic stages and the mineral and element combinations of each stage for gold deposit. We understood that the gold deposit and its halo were due to superposition of two stages mineralization i.e., quartz-pyrite and gold-multi metal sulfide.

2. The basic characteristics of gold metallogeny and halo forming are: (1) the gold orebody (halo) formed in single stage exhibits distinct geochemical positive axial zoning, in which the diagnostic elements of the front halo are Hg, Sb, As, (F, I, B, Ba and Pb) and the tail elements are Bi, Mo, Mn, Co, Ni and Sn etc.. All of these elements would appear not at every deposit; (2) the paternoster orebodies formed at the same stage will have general front and tail halos and each orebody in the paternoster system will have its own front and tail halos also; (3) the orebodies formed at different stages will have their own front and tail halos; (4) the original zoning of the formed orebody will not be destroyed when it is superimposed by a post stage formed orebody which make the elements in the orebody and halo mobilize and transform.

3. We summarized four ideal models of primary superposition halo for gold deposit: (1) a complete superposition model of metallogeny at single or at two stages, i.e. a normal positive vertical (axial) zoning; (2) partial superposition of two orebodies formed at two stages in metallogeny, as a result the front and tail halos are superimposed separately that means the area in axial direction would be increased and the superimposed section of front and tail halos also be increased; (3) for paternoster orebodies, the front halo of the bottom orebody superimposed at the tail halo of the upper orebody; (4) the superposition between the earlier stage paternoster orebodies and the later stage orebodies that resulted in more length of the front and tail halos in axial direction and more large area of coexisting range for the two.

4. Five criteria of superposition halo of gold deposit for looking for blind gold are: (1) when Au is anomalous or $n.10^{-1}$ g/t only, while Hg, As, Sb, F, Ba and I elements

appear to have strong anomalies as front halo, then it indicated there would be a blind ore in the depth; (2) if Au is only $n.10^{-1}$ g/t and Bi, Mo, Ni, Mn and Sn strong anomalies exist as tail halo then there is no interest in the depth; (3) reverse zoning criterion i.e., Hg, Sb and As anomalies appear at the bottom position of the section map indicated there would be a new blind ore or more extension of the orebody in the depth; (4) coexisting criterion, i.e. the diagnostic elements of front and tail halos are coexisting it will indicate another enrichment level in the depth or more extension of the orebody; (5) reverse criterion, i.e. when the vertical geochemical parameters of a gold orebody are calculated if the increase and decrease of the parameters are continuing to appear for more than three levels but a sudden reverse at the fourth level, then it indicate more extension of the ores or a new blind ore in the depth.

SUPERGENE GEOCHEMICAL CHARACTERISTICS OF THE HIGH AND COLD LAKE AREA IN EAST QINGHAI-TIBET PLATEAU WITH GEOCHEMICAL DATA OF TIN-POLYMETALLIC ORE DEPOSIT IN CUOMOLONG, SICHUAN

LI HONGXIANG
(Geophysical and Geochemical Prospecting Party, Bureau of Geology and Mineral Resources of Sichuan Province)

In this area elevations of the land surface are 4,500--5,100 m above sealevel. The yearly average temperatures are 0-6°C. There are many lakes in it. The types of loose sediments on the land surface are varied.

The distribution of elements in eluvial-slope layer is largely controlled by the distribution of elements in the subjacent mother rocks and ore bodies. The order of principal element activity in weathering and residual crust upon the granite is Na > K > Ca > Si > Al > Mn > P > Ti > Mg > Fe. In the crust of this area Pb, Li, Mo and Cu are accumulated, but Zn, Bi, Be and B are leached. K, Na, Si and many ore forming elements in the ore skarn are accumulated in weathering and residual crust upon it, but Ca and Mg are leached.

Correlation between concentrations of elements in the lacustrine deposits and in that the near littoral soils is positive. However, the concentration of element in the lacustrine deposits is slightly higher. The lakes can pirate ore forming matters in its catchment basin. Order of effect of various lakes to pirate elements conforms approximately to the order of average enrichment intensity of elements in lacustrine deposits, and this effect increases as area of lake increases.

The change of concentration of elements in the drainage sediments reveals the sources and multistage of element migration. The order of anomaly persistence for principal ore forming elements is in km

Sn, W	Cu, Zn	Mo, Bi	Pb
--------- >	---------- >	------------ >	------ .
5.2-4.7	4.1-4.0	2.3-1.2	0.7

The order of accumulation effect of elements in gray heavy sands of river is

Sn	B	W	Bi	Pb	Mo	Li	Cu	Zn	Ag
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2025	327	158	6	-20	-35	-37	-37	-60	-72

The geochemical anomalies reveal information of crop and blind deposits.

$$\frac{\Sigma Cuo}{\Sigma Cu}, \frac{CxCu}{\Sigma Cu}$$

in various loose layers increase as the distance from these layers to ore body increases, and as the grain size of sediments decreases, and as the acidity of theirs environment increases. They also reveal that in this area physical weathering is principal with chemical weathering to some extent.

RESEARCH OF GOLD-SEARCHING METHOD BY APPLYING HYDRARGYRUM COMPOUND

LI JIAN
(Institute for Geology & Mineral Resources, First Geoexploration Bureau)

By applying the law that different hydrargyrum compounds have different fixed heat-releasing temperature, and by adopting the method that heat-releasing are conducted at different stage, primary halo samples of rock or ore vein could be tested. The feature that the percentage of hydrargyrum compounds varies in geological bodies could suggest the ore-bearing section, and infer the concealed ore bodies .Thus, it is a economical, fast and effective ore-exploring method.

The Institute of Geology & Mineral Resources of the First Geo-Exploration Bureau, MMI began in 1986 the research of gold- searching method by applying hydrargyrum compounds. From 1988 to 1992, testing research about the ore-exploring mechanism by applying hydrargyrum compounds and the infering of concealed ore bodies had been completed .A obvious ore-exploring result was achieved.

The main results are as follows:

1. The easy-to-populorized testing method by applying hydrargyrum compounds has been tested and perfected.

2. The changing situation of hydrargyrum compounds in the surface environment has been basically obtained.

3. At the Niuxinshan gold deposit in Kuancheng County of Hebei Province, the anolies of hydrargyrum compounds on the upper section of the five known main vein-bearing concealed ore bodies have been made.

4. There exists concealed ore bodies between the line No. 24 to line No.40 of Nandaxian gold mine in Jianchang County of Liaoning Province. The drilling engineering confirmed that fact, namely, there is a prospect reserves of 3 tons industrial ore body under the depth of the area.

5. The drilling engineering also confirmed the infered fact that in No.102 vein of Shihu gold deposit in Lingshou County of Hebei Province some section possibly contains ore while some section contains ore in less possibility. Besides, the ascertained ore laying direction is the similar with that of the infered result.

It is estimated that popularization and application of the gold-searching method by applying hydrargyrum compounds will contribute a economical and effective method for infering the exact ore- bearing section in ore field. in ore field.

ESTABLISHMENT OF DATABASE SYSTEM FOR GEOCHEMICAL EXPLORATION IN LIAONING PROVINCE

LI SHUYU
(Computing Center of Liaoning Bureau of Geology and Mineral Resources, Shengyang)

Storage structure of grid data

The Hierachic Index Direct Access Method is used for data access. One standardized map-sheet represents a logic store unit with an index list. The base file structure of the database in all provinces is based on analytical elements. One logic store unit is made up by a map-sheet at scale 1:200,000.
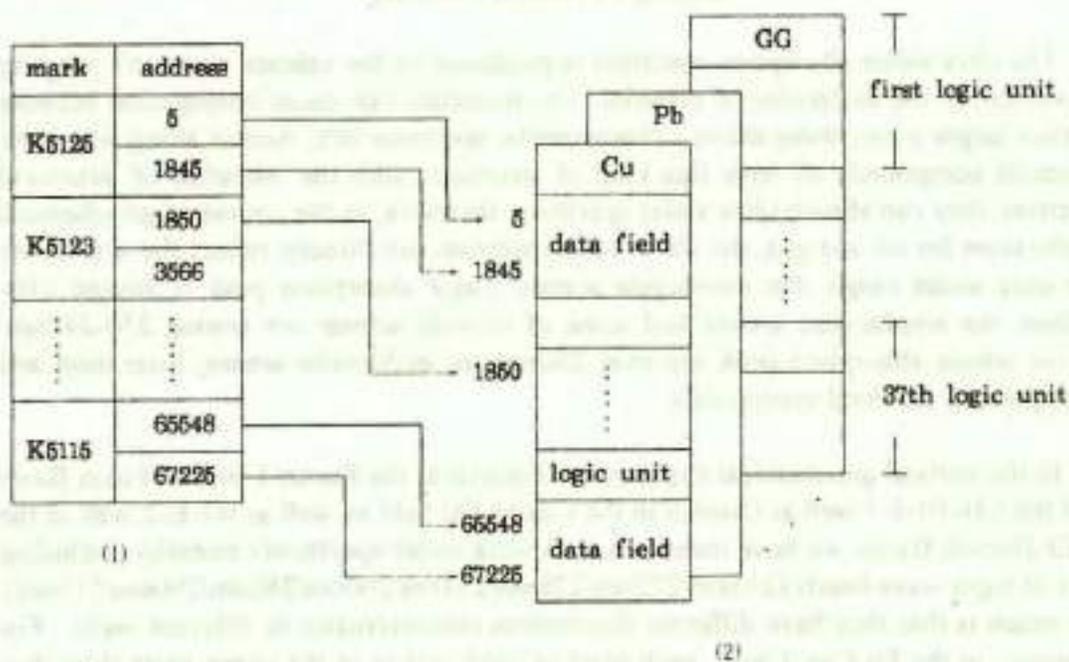
Sketch map of structure of database
(1) file of index list   (2) file of databse

Storage structure of non-grid data

To store non-grid data, coordinates of samples are required.

The sample analytical data are stored in database in accordance to the coordinate of samples. While the data are stored, the chained list will be established and the pointer index is to be built up simutanously.

Storage structure of sectional line

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The Hierachic Index Sequential Access Method is used in this structure. One logic store unit represents a sectional line and a database file is made up by one surveying area. The index list consists of many logic units. Each logic unit can be divided into parameter field and data field. The attributes of data field are described by parameter field which is of start coordinate, point spacing, number of points etc. The sample analytical data are stored into data field based on the order of point coordinate.

Because the relationship between the data has been established in the database, the data in these three storage structures can be retrieved. While the linear chained list was built up by value, the batch data processing can be achieved by the storage structures presented in this paper.

THE INSTRUCTIVE SIGNIFICANCE OF ULTRA VIOLET SPECTRUM FOR OIL AND GAS IN VERTICAL GEOCHEMICAL EXPLORATION

LI WENQING, YANG GUIFANG AND ZHU QINGJIE
(Daqing Petroleum Institute)

The ultra violet absorption spectrum is produced by the valence electron's jumping movement in the molecules of material. The materials can cause conjugation because of their larger p key, there exists a characteristic spectrum belt. Arenas along with their chemical compounds all have this kind of structure; with the vibration of structural electron, they can absorb ultra violet spectrum; therefore, in the course of geochemical exploration for oil and gas, the ultra violet spectrum can directly reflect the arenas. At the ultra violet range, the monocycle arenes' major absorption peak is among 210-230nm, the amphicyclic arenes' and some of tricyclic arenes' are among 250-280nm. Those whose absorption peak are over 280nm are multicyclic arenes, heteratom and their perssad chemical compounds.

In the vertical geochemical exploration research at the Fucan-1 well in Fuxin Basin and the LH-10-1-1 well at Qianhai in the Liaohe Oil field as well as the E-2 well in the E-Er-Duo-Si Basin, we have measured each ultra violet spectrum's intensity, including that of eight wave bands (215nm/222nm/228nm/254nm/260nm/280nm/290nm/310nm), the result is that they have different distribution characteristics in different wells. For example, in the Fu-Can-1 well, each band of ultra violets at the upper parts (less than 1100m) shows high value, against with the low value at the lower part; and the maximum value can add up to 3,225 (luminous intensity unit). But in the LH-10-1-1 well, each band of ultra violets has lower value at the upper part (<1,900m) against with the higher value at the lower part (>19,900m); in this well the 216nm can add up to 2,530 (luminous intensity unit). The high value of each band of ultra violet in E--2 well are mainly concentrated in the well's middle part (1,000-1,500m), and its higher intensity value can be over 1,000 (luminous intensity unit). Although the distribution of ultra violets in all these wells is very different, yet it has the common characteristics for the oil and gas instructions. It is also said that there is a better oil and gas display in the higher intensity parts of each band. Meanwhile, at the shallow part (50-150m) filled with water, and also for the arenes being easily dissolved in water, each band of the ultra violets can also be displayed clearly; therefore, it can be regarded as the frontier indicator of the pools.

In the same well, each band of ultra violet spectrum has better corresponding net relations (coefficient >0.8). In the course of vertical hydrocarbon migration, the monocycle or dicyclic arenes indicated by the low band of ultra violet has the appearances that it migrates ahead of the multicycles; this is correspondent with what the methane mitigates ahead of the acidolysis hydrocarbon. But it is not completely correspondent with the distribution of acidolysis hydrocarbon. The overlapping layer of the two's higher intensity is a more helpful area for finding oil and gas; for example, at the middle part (1,000-1,500m) of E--1 well and the low part (2,600-3,000m) of the LH--1--1 well, the better displaying of oil and gas is just the higher value overlapping ranges of acidolysis hydrocarbon with ultra violet spectrum.

Through the analysis with Q--type clusters and Q--type fctors for each band of ultra violet in each well, the result shows that the higher intensity value layers of the ultra violet in the wells, the closer relations to the loess of the shallow layer (10-100m). In the geochemical exploration at the surface, we should collect the samples of loess with a selected method, until getting some more important information of the wells' deep part, and this has more significance to raise the success rate in the exploration of oil and gas.

Analysis of the Disturbance of Soil pH Value on Electric Conductivity Anomaly

Li Xian

The soil eletric conductivity is a new rapid, convenient, economical and effective exploring method. Oxidation-reduction increases the concentrations of negative and positive ions in soil over the orebody to form electric conductivity anomaly.

Normally, electric conductivity anomaly over orebody is affected by ions SO_4^{2-}, HCO_3^-, Cl^-, F^-, K^+, Na^+, Ca^{+2}, Mg^{+2}. But OH^- and H^+ effect electric conductivity greatly. In the condition of lower concentration, the effect of same concentration H^+ on solution electric conductivity is 5 times as many as that of K^+, 7 times of Na^+, 5 times of Cl^-; the effect of OH^- is 3 times greater than of K^+, 4 times of Na^+, 3 times of Cl^+. So, pH value anomaly can affect electric conductionary immediately. We found in our works that pH value had positive interrelations with electric conductivity, and the in terelated coefficient is considerably great.

Commonly, the orebody has a less effect on pH value, but surface pollutions greatly affect it, such as pesticide, chemical ferticizer and some waste materials of industry and agricalture. Therefore, in intrepretation of electric conductivity anomaly, the effect of pH value on eletric conductivity must be eliminated corrected.

Curve of electric conducivity vs pH value was given by the experiment, as the diagram shown.The diagram showed that there is distinct changing regularity in different sections of pH value, so, would be corrected on the basis of pH value sections.

Following are corrected formulas in different pH value sections:
when 5 < pH < 6,   when 8 < pH < 9
when 4 < pH < 5   when 9 < pH <10
(NiñB: is corrected value is original observed value, pH is original value)
When pH < 4 and pH > 10 , pH value greatly affect electric conductivity, its value is far in excess of the effect of hidden orebody on soil electric conductivity. But this case is less met in the practical work, If any , it is explained as disturbances, and such data should be rejected. Using the above method , the data collected in the perphery of Houxi gold deposit has been corrected and the corrected anomaly has been interpreted, which has achieved remarkable result.

THREE-DIMENSIONAL GEOCHEMICAL SURVEY IN OIL/GAS EXPLORATION

LI XIAOMENG

Substances from oil and gas reservoirs in the depth of earth migrate toward surface through complicated diffusion processes. As a result, they form a characteristic geochemical field which is restricted by those factors, namely the properties of oil/gas accumulation, the geological environment of surroundings and the intersticial condition of crust surface etc. For the purpose of effective use of the information obtained from the geochemical field, methods based on high-technique and multi-direction approach should be used for the research.

The China Petroleum and Natural Gas Corporation has recently conducted a relatively large scale preliminary experiment and fruitful results were obtained. In this paper, results and knowledge of the study are introduced in the following titles:

1) The rules of variation of geochemical field over oil/gas accumulation in horizontal and vertical directions.

2) The serial techniques for three-dimensional geochemical survey conducted on land, on sea and in air.

3) The serial survey techniques for hydrocarbons occurred in different state.

4) Results of three-dimensional geochemical exploration at different stage of oil/gas exploration.

5) Conclusion.

FOLLOW- UP TO GOLD SOURCE IN GEOCHEMICALEXPLORATION.

Li Xingguo and Meng Qingru
(Geophysical team of No.1 Bureau of Geological Exploration, MMI)

The paper introduced a quick follow_up method to gold source forregional stream sediment survey. It is a technique based on theanalysis for the anomaly source and compilation of the anomaly source distribution map to conduct quick follow-up the goldanomaly. Also it is a new tool for further study of regionalgeochemical exploration data.

1.Analysis of Gold Anomaly Source

It is indicated by test at 5 gold deposits that the dispersionrange of gold drainage system is very large, generally more than 1Km sometimes up to 2-3 Km. Therefore, it may produce a "anomalychain" consisted of several sampling points, in which only thefirst anomaly point at the upper stream of the drainage sustem isclose to anomaly source and the rest of the anomaly points isproduced by feeding of gold-contained material from the upperstream; it is discovered by field examination that (1) the distribution area of most gold sources is only a small proportionof the whole anomaly i.e, a large anomaly is only caused by a smallsource; (2) the concentration center of the anomaly is not orseldom the gold source which may be possible to locate at theposition of weak anomaly or on the margin of the concentrationcenter, moreover the strike is reverse; (3) several gold anomaliesmay be caused by one source, otherwise a gold anomaly may be causedby more than two sources; (4) the gold anomaly without anyconcentration center may be possibly caused a definite source. All the above indicated the diversity and complexity of the goldanomaly. Thus, simpiy based on the intensity of anomaly or itsconcentration center to layout the survey grid and profile forexamination it will waste the man and capital resources.

2. Technique of Quick Follow-up to Gold Source

In the basis of the analysis of anomaly source the sourcedistribution map can be compilated which includes:(1) drainagesystem, (2) sample point, (3) data of anomaly point, (4) selectedanomaly point closed to the source, (5) mark the drainage divide,(6) plotting the line along with the anomaly points closed to thesources. As a result, enclosing area by the line and drainagedivide will be the source distribution map. Obviously the sourcemap will be much smaller than the area of the anomaly itself. Thus,it offers a definite target to follow-up the gold source. We suggested the field operation method for the follow-up. It isessentially to collect large sample at the anomaly site closed tothe source and in the valley between drainage divide, samplespacing 100-200 m. The source location will be a place between new appeared anomaly point close to source and disappeared anomalypoint; if we can find the new anomaly points closed to the sourcein several valleys, the strike of the source could be determined.Buried source body of the anomaly could be exposed by small surfaceengineering.

In order to make the follow-up method be more reliable andusefull we suggested to collect large stream sediment sample, eachweights 10Kg. After washing keep 200g "heavy component sample".This kind of sample can not only concentrate gold grain, goldcontained heavy minerals,sulfides EM minerals and magneticminerals, but can also increase the intensity and accuracy of ananomaly to be assaied, i.e. using "gold grain effect" forprospecting. Mean while it can be used to distinguish theinteresting anomaly from no interesting ones. We tested at theknown deposit that the anomaly intensity of "heavy componentsample" could increase several times or even a hundred times ascompared with that of conventional sample, but for the nointeresting anomaly the intensities of the two are not different.

THERMODYNAMIC AND KINETIC CHARACTERISTICS OF DIAGENESIS IN FLUVIAL SANDBODIES AND ITS THEORETICAL SIGNIFICANCE TO OIL AND GAS EXPLORATION

LI YANFANG AND LI GUOHUI

(Department of Exploration, Daqing Petroleum Institute, Anda, Heilongjiang, China, 151400)

Diagenesis of fluvial sandbodies and its consequences of preminary porosity reduction, secondary porosity occurrence as well as extinction of both of them closely relate to the thermodynamic and kinetic activities of minerals. The detail investigation of these properties is certainly significant to discuss the mechanisms of precipitation and dissolution of minerals in different diagenetic stages, and therefore to grasp the formation and evolution of porosity in sandbodies.

The Fuyu and Yangdachengzi formations on Songliao basin were once formed on dry and moderate dry climate environment which are dominated with terrigenous fluvial deposits. The sandbodies develop widely in forms of strips and lens that are greatly cut by mudstones and have poorly lateral continuty. A single sandbody is thin in thickness and has low porosity and permeability which possesses poorly physical properties.

The petrographic study reveals that the fluvial sandbodies are middle to fine lithic feldspar sandstones and feldspathic to lithic sandstones which are composed by quartz, feldspar and fragments. The unstable minerals are high in composition, and together with low composition maturity and fabric maturation.

Observations of many thin sections and impregnated thin sections as well as diagenetic examinations verify that the main diagenetic events are authigenic quartz and authigenic feldspar overgrowth, carbonate and anhydrite precipitation and replacement, together with clay minerals transformation and etc.

In all these diagenetic events, the precipitation and dissolution of minerals are main causes that reduce the preminary porosity and increase the secondary porosity. The precipitation and dissolution of different minerals were not only controlled by the thermodynamic and kinetic activities of minerals, but also related to the properties of fluid in sandstones. In different diagenetic stages, because of the difference of the thermodynamic and kinetic activities of minerals, the sequence of mineral occurence is obviously periodic, and as a result, it must be carved with diagenetic evidences in fabric.

The purpose of using thermodynamic and kinetic principles to discuss precipitation and dissolution of minerals is to recognize the sequence of minerals in fabric, and to predict the chemical diagenesis theoretically. The practical applications prove that based on the observation of thin sections, we can reveal the diagenetic sequence, the chemical reactive patterns and the controlling diagenetic factors of minerals by the combinations of the thermodynamic and kinetic principles and the useful limit probability analysis, difference matrix analysis, priority deposit index analysis, entropy analysis, substitutility analysis and optimum decomposition analysis in markov process

as well as by combination between sedimentary faces and diagenetic facies through R factor analysis. All these aspects are meaningful and practicable to understand the formation and evolution of porosity, together with to determine the relative time of migration of oil and gas, and to predict the favorable porosity zone as well.

GEOCHEMICAL EXPLORATION FOR COPPER-NICKEL

LI YINGGUI, YU XUEDONG AND CHENG HANGXIN
Institute of Geophysical and Geochemical Exploration
Langfang, Hebei 102849 P.R. China

Geochemical anomaly characteristics of a copper-nickel deposit and geochemical exploration methods for such deposits are described in this paper. The studied deposit, located in an arid-semiarid area of West China, is associated with basic-ultrabasic magmatic bodies. We have reached the following conclusions-- on the basis of our research.

1. The element zoning sequence of the studied deposit is I, Hg, F--B, Ba, As, Mo--Ag_1, Cr--Co, Ag_2, Cu and Ni, similar to the sequence of hydrothemal deposit. Effective indicator elements can be divided into four groups: below-ore elements (Cu, Ni and Co), short range elements (Ag and Cr), above-ore elements (As, B, Ba, Mo), long range elements (I, Hg and F). Because of different erosion levels the magmatic (ore) bodies have different anomaly element associations and distribution patterns. Below-ore elements are spatially associated with magmatic (ore) bodies and form primary halos with conspicuous concentration zones around ore bodies at the middle-lower parts of the magmatic bodies. Short range indicator elements form high-contrast anomalies at the middle-upper parts of the magmatic bodies. Above-ore elements form upper annular halos which envelop the magmatic body and its main anomalies of other elements. On the surface of the ore-bearing blind magmatic body with greater depth, some volatile elements such as I, Hg and F form long range dispersion upper halos which can indicate blind ore deposit at a depth of more than 600 meters. Therefore, multi-element primary halos can be found in Cu-Ni sulfide deposits.

2. According to further geochemical study, it has been found that multiplication halos of short range elements as well as multiplicative values of above-ore elements and below-ore elements ratio can be used not only in evaluating the relative level of ore deposits but also in fast evaluating geochemical anomalies and predicting the location of blind ore deposits. As for Cu-Ni deposits, AsxBxBa/CuxNixCo ratio is more than 10 over the ore-bearing magmatic body, from <10 to>0.1 in the upper parts of the body, from<0.1 to>0.01 in the middle-upper parts of the middle-bottom of the body. The product of short range elements Cr and Ag can been used to identify the range of mineralization. Successful results have been achieved in mineral prospecting with these parameters.

3. Based on petrochemical and mineralogical characteristics, frequency distribution pattern of trace elements and elements distribution in sulfide phase, some geochemical qualitative and quantitative criterion for evaluating the mineralization potential of

basic-ultrabsic bodies have been established and successful applies in the geochemical exploration at a Cu-Ni ineralization zone.

4. Geochemical orientation survey in a mineralization zone with an area of 5,600 km^2, it is shown that a "surficial" sampling technique within a 1x1 or 0.5x0.5 km^2 unit is as effective as the routine sampling technique of 1 : 25,000 or 10,000 scale. In arid and semiarid Gobi areas where stream sediment is not well developed, small-scale hydrogeochemical survey accompanied with hydroelectrochemical survey is economical and can quickly delineate prospecting targets. Radon and mercury in soil gas can be used effectively to trace the extension of ore-controlling faults. As accessory methods to routine geochemical prospecting, rock and soil mercury survey, conductivity and geoeletrochemical survey can be used to delineate not only the exposed mineralized magmatic bodies but also the concealed ore bodies which can not be discovered by routine geochemical methods.

The key problems in geochemical exploration for Cu-Ni deposits are to prospect concealed magmatic bodies, evaluate the mineral potential of the magmatic bodies and deduce the possible location of mineralization. In order to resolve the three technical problems mentioned above a series of methods have been proposed in this paper.

AMMONIUM VANADATE TITRIMETRIC METHOD DETERMINATION OF TRACE GOLD IN MINERALS AND ROCKS BY A NEW SENSITIVE VANADATE-AURIC REAGENT II

LI YUCHENG
Laboratory of Analytical Chemistry, P.O.Box 63, Shaoguan, Guandong, 512026, P.R.China

A new sensitive oxidation-reduction indicator of Vanadate-Auric Reagent II (VAR-II) has been synthesized by the author. In acidic agueous solution VAR-II can be oxidized (E0=0.85) by V(v), Au(III), Ce(IV), Cr(VI) and Mn(VII) ions and the violetred colour can be observed. The VAR-II with colour-changing sensitivity of about 10-15g vanadate/ml. VAR-II has been applied successfully to the ammonium vanadate titrimetric method determination of Au (0.000001-200×10^{-6}) in minerals and rocks. The sample (10-20g) was dissolved in a mixture of aqua regia and phosphoric acid. Acidic solution was diluted to 100 ml and sucked off 5 ml. Au^{3+} of 5 ml was concentrated by the use of polyurethane foam (1x1x1cm). At 15% concentration of H_2SO_4-H_3PO_4, Au^{3+} of polyurethane foam was reduced to AuI by potassium iodine. AuI came into acidic solution. Acidic solution transfers into triangular bottle of 50 ml. The excess amount of I- and other low-valent elements are oxidized by sodium nitrite, while the AuI of I⁻ is not oxidized. The excess amount of sodium nitrite is destroyed by urea. At 11-13% concentration of H_2SO_4-H_3PO_4, two drops 0.2% VAR-II are added. AuI of I⁻ is titrated by standardized ammonium vanadate solution (T=0.000003-100 ug Au/ml) and the end-point is judged by a violet-red color apparent.

$$Au^{3+}+3I^-=AuI+I_2$$

$$2AuI+2VO_3^-+8H^+=2Au^++I_2+2VO^{2+}+4H_2O$$
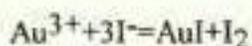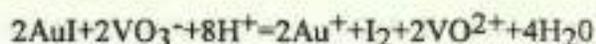
The detection limit is 0.2 pg Au/5ml. The relative standard error for the five determination 0.03ng Au are 6.7%.

THE APPLICATION OF RARE GASES AND LIGHT HYDROCARBONS IN GEOCHEMICAL EXPLORATION AND RESEARCH ON GAS RESERVOIR

LIAO YONGSHENG

Helium and argon in oil and gas reservoir are produced either from the decay of uranium, thorium and potassium in the crust or from the degasification of the mantle, they are cumulated together with hydrocarbons and the compositions of oil and gas reservoir. If there is an important source of helium, such as helium-bearing gas reservoir, fault or cleavage system, which rovides abysmally large quantity of helium to the local soils and, hence, one can easily determine the presence of gas reservoir or fault/cleavage system. The features of helium in soils over Caoqiao oilfield are: Aureoles are presented on the boundary of the oilfield by which one can sum up some features and rules for the helium and hydrocarbons anomalies over the oil-water boundary and fracture system. There are eight kinds of combination mode that can be obtained by them, which are valuable in differentiation of oil/gas or non-oil/gas reservoir. In the structural area of compressive trapping, the abundance of helium and argon varies as negative correlation but in the area of extending and opening structure, they behave as positive correlation.

Among different types of gas reservoir in Jiyang depression, the natural gas occurred in tertiary volcanic rock area of Gaoqin. Yuhuangmiao has an order higher helium abundance and $^3He/^4He$ ratio, two or three folds higher $^{40}Ar/^{36}Ar$ ratio and contrary one half lower argon abundance in comparison to that of the non-volcanic rock area. The gas from high carbon dioxide contained reservoir ($CO_2 > 65\%$) in Pingfonghuan and Xinyang volcanic rock area which contain several times higher helium abundance and $^3He/^4He$ ratio than gases from Gaoqin and Yuhuangmiao areas. According to the calculated result of the helium isotope ratio, there are 20 to 32% of helium in the gases from Pingfanghuang and Yangxin areas are of mantal-magmatic genesis.

THE PRIMARY ANOMALY AND HALO-FORMING MECHANISM OF CAIJIAYING Pb-Zn-Ag DEPOSIT

LIU CHONGMIN AND XU WAISHENG
Institute of Geophysical and Geochemical Exploration, Ministry of Geology and Mineral Resources, Langfang, Hebei 102849, P.R. China

The deposit occurs in the Caijiaying fault block in the central part of the anteclise of Inner Mongolia, in the northern edge of North China platform. Yanshannian subvolcanic veins, faults and cracks are well developed in the deposit, and strong

sericitization and chlortization are observed in the ore zone. The group of lodes occurs in the hornblend-plagioclase granulates of Archean Hongqiying formation. The ore composition is very complex. It is a large size magmatic hydrothermal polymetallic deposit.

The results, based on the study of strata, ore and gangue minerals around the deposit, show that Pb, Zn and Ag (Au) are the major ore-forming elements and As, Sb, Hg, B, In, Cd, Cu, Co and I are the accompanying elements. Among these elements, Hg, As, Sb, I and B are the long-range indicator elements, Cu, Co, B, In and Cd are the short-range indicator elements and Pb, Zn and Ag (Au) are the ore elements.

The indicator elements are well developed in the deposit. The anomalies of ore-forming elements are large and strong and their concentration centers coincide with ore bodies. The front indicator elements have longer distances of horizontal dispersion and their concentration centers are in front of the ore bodies. The anomalies of near-ore indicator elements are small and weak. These anomalies occur mainly in ore bodies. The vertical primary zoning sequence (from lower to upper) is I-B-Sb-Hg-As-Ag-Pb-In-Zn-Cd-Bi-Co-Mn-Cu.

The zoning index (AsxSbxBxPb/CuxBixCoxZn) decreases gradually from bottom to upper: nx1,000, above the ore bodies; nx100, at the top and middle part of the ore bodies; nx10 at the middle and lower part of the ore bodies; and nx1 under the ore bodies. The zoning index can be used to assess anomalies and denudation levels of the ore bodies.

The geochemical model of the deposit was established according to the features of primary anomalies and the ore-forming geochemical and geological factors. The geochemical assessment of the mineralized zone II was made using the established model and new ore bodies were found.

The genesis of the deposit was proposed by analyzing the origin of ore-forming and halo-forming material, matallogenetic epoch, temperature, pressure, matallogenetic conditions such as the nature of hydrothermal solution, redox potential and so forth with an integration of geological controls of halo-formation. First, the ore-bearing hydrothermal solution moved upward and extracted Pb, Zn and Ag and other elements from the adjoining rocks and then migrated to the places where the ore bodies were formed. Ore-forming elements in hydrothermal solution precipitated with the change of the geological environment. In the meantime, the active components in the ore-bearing hydrothermal solution kept migrating to the country rooks by infiltration diffusion and the primary halos surrounding ore bodies formed.

EFFECT OF ELECTROGEOCHEMICAL EXPLORATION FOR BURIED AND BLIND DEPOSITS

LIU JIMIN, LIU ZHANYUAN AND CHENG ZHIZHONG
Institute of Geophysical and Geochemical Exploration, MGMR, Langfang, Hebei 102849, P.R. China

Electrogeochemical studies in China began in the early 1980's. From then, the electrogeochemical research group of Institute of Geophysical and Geochemical Exploration of MGMR, has been engaged in electrogeochemical exploration. A set of methods, including electro-extraction method (CHIM), metallorganic compound prospecting (MPF), soil conductivity measurement (SCM), has been used. Good results have been obtained in prospecting deposits, especially in prospecting buried deposits, which are uneasy to be found by conventional geophysical and geochemical techniques. Some examples are given.

Example 1: Electrogeochemical exploration for a gold deposit in Xinjiang. Three integrated anomalous belts which stretch from south to north were found. According to the distribution of anomalies and characteristics of geological structure, we deduced that there are three belts of gold mineralization. More than ten gold ore-bodies were discovered by drilling.

Typical geological and electrogeochemical cross-sections:
  (a) The width of the CHIM anomaly is about 200 metres, the peak value of gold anomaly of electro-extraction is 780×10^{-6}. There is also a soil conductivity anomaly in this section. A gold ore-body with gold grade 3 g/t at a depth of 85 to 250 metres has been proven by drilling.
  (b) At another section, with 10 metres-thick overburden, no anomaly was found by conventional soil sampling, but anomalies were discovered by electro-extraction and soil conductivity measurement. Two gold mineralization beds at a depth of 135 metres, with good grade of 3-9.5 g/t were found by drilling.

Example 2: The use of electrogeochemical exploration in a known Cu-Ni deposit in Xinjing. The deposit is under cap rock with a thickness of 400 meters. Remarkable anomalies of Cu, Ni and Cr were discovered by CHIM. The peak value of Cu anomaly is more than $1,000 \times 10^{-6}$.

Example 3: Electrogeochemical exploration for a copper deposit in Shandong. The thickness of transported overburden thickness over the orebody reaches 130 meters. No anomaly was found by soil survey and soil conductivity measurement. But anomalies of Cu and Mo were discovered by electro-extraction survey and metallorganic compound survey. The anomalous curve has the characteristic of "double-peak" and the depression of anomalous curve lies over ore-body.

Example 4: Electrogeochemical exploration for a copper deposit in Shanxi. The deposit occur under 88-meter-thick caprock and about 40-meter-thick loess. An integrated anomaly was discovered by eletrogeochemical survey. Copper ore body was found by follow up.

Example 5: Electrogeochemical exploration experiment at an oil-gas field in Inner Mongolia. Electrogeochemical exploration was firstly used in prospecting for oil and gas field in China. The oil reservoir is under 1,000 meters. The preliminary electrogeochemical experiment shows that there are positive anomalies around the edge of the oil field and the lower values are over the oil field.

ELECTROCHEMICAL PROPERTIES OF SOILS AND STREAM SEDIMENTS AND THEIR SIGNIFICANCE FOR PROSPECTING IN SHILU ORE FIELD, GUANGDONG

LIU KANGHUAI AND TIAN ZHISI
(Guilin College of Geology, Guilin, China)

Shilu ore filed is an important mineral producer in Guangdong province with subtropical climate. Soil and stream sediment samples were taken in an area of 228 km2 and pH, Eh and Ks (conductivity) were determined by special instruments.

Distinct variation is seen in these electrochemical parameters, and their anomalies are spatially related to the distribution of ore deposits in the area. The pH values of soils from skarn type Cu deposits are usually greater than 7.0 (mostly 8.0-9.0) and the Eh are low (mostly <210 mv) while the pH of soils from W-Sn quartz vein type deposits are lower than 6.0 (usually 5.0-4.0) with a relatively high Eh (>225 mv). Soil conductivity is higher above ore deposit (usually Ks>5.5) than in the ordinary area. In stream sediments, only Ks is usable, pH and Eh are erratic.

The variation of surficial electrochemical properties is controlled by the mineral composition, wall rock lithology as well as the grain size of the soil and stream sediments, e.g. low Eh is associated with sulfides, high pH is encountered over carbonate rocks. In Qiguling area, a distinct anomaly with pH>7.0, Eh<210 mv and Ks>5.5 was detected and it was interpreted as an indication of underlying ore deposit. This conclusion has led to a discovery of Pb-Zn ore body by the local people.

TRACE ELEMENTS IN HAIR, NINGCHUAN, JIANGXI

LIU QINGCHENG and PAN NIE
(East China College of Geology, Fuzhou, Jiangxi)

It is widely accepted that trace elements in human hair have environmental implications which is easy to sample and less difficult to be analyzed. A large number of human hair samples were analyzed, and the mean of different elements are reported below: (in ppm)

element	Ca	Cr	Mn	Fe	Co	Ni	Cu	Zn
adults	800	0.72	7.1	65	0.2	1.5	15	145
children	570	1.60	1.37	17.9	0.05	0.96	3.5	129

element	As	Mg	Pb	Cd	Mo	Ge	Se
adults	5.0	75	7.0	3.1	0.43	0.35	0.37
children	3.0	20	5.7	0.88	0.17	0.17	0.32

The factors that influence the trace elements intake are discussed in this paper.

AN INVERSE METHOD FOR INTERPRETING GAS ANOMALIES

LIU QINGCHENG AND YE SHULIN
(East China College of geology)

Radon is continuously produced from uranium deposits to form gaseous halos above the deposits. In the light of gas migrating theory and statistics of some actual observation on uranium deposits, the author proposed an empirical formula for estimating burial depth of the ore body: $h=kX_b/2$ where h refers to the burial depth, k an empirical coefficient, X_b the width of the anomaly curve at half peak.

If the burial depth could be calculated, the grade of the ore can be estimated by another empirical formula: $Q=aSe_{bh}$ where Q refers to the grade, S the area confined by the anomaly curve, a and b two empirical coefficients. The method has been applied to some observed data sets obtained in uranium exploration in Guangxi and Jiangxi. The results are consistent with that by drilling. Further improvement is under way.

ENVIRONMENTAL GEOCHEMISTRY OF TL POLLUTION IN SOUTHWESTERN GUIZHOU PROVINCE, CHINA

LONG JIANGPING1, CHENG HANGXIN2, YAN WEN1 AND TAO YUXIANG1
1--Open Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Academia Sincia, Guiyang 550002, China
2--Institute of Geophysical and Geochemical Exploration, Langfang, Hebei 102849, China

Toxication of the human body caused by Tl pollution because of the exploitation of mercury ores in southwestern Guizhou province of China is an exceptional phenomenon at home and abroad. There have been more than 400 people suffered from the Tl toxication in different degree in this area since 1962, by which a series of clinical reactions, for instance, trichhomadesis, poor appetite, pain of arms and legs, view obstruction, even blind in both eyes and so on are caused.

Tl is a dispersed element. Its clarke is only 0.4 ppm, but this element is highly concentrated in the mercury and gold ores (more than a few hundreds ppm in mercury ores and tens to a hundred ppm in gold ores), and some independent Tl minerals and Tl-bearing sulfides were found, such as Lorandite ($TlAsS_2$), Christite ($TlHgAsS_3$), Imhofite ($Tl_{5.6}As_{15}S_{25.3}$), Pyrite (FeS_2), Cinnabar (HgS), Realgar (AsS), Orpriment (As_2S_3) etc. With the exploitation of mine, Tl-bearing ores moved into supergene environment from primary environment and changed in geochemical state. Under supergene condition, Tl and associated Hg and As come into the circulation of supergene geochemistry and polluted the environment and harmed the human health through water--soil--plant--human body chain (see table):

Tl Contents of Water, Soil and Plant in Polluted Area
in Southwestern Guizhou Province, China

Location	Symptom	Spring water (mg/L)	Soil (mg/kg)	Cabbage (mg/kg)	Kidney beam (mg/kg)

| Tl polluted area | Tl toxication | 0.05-0.1 | >200 | >0.047 | >0.04 |
| Un-polluted area | No | 0.009-0.04 | <10 | <0.025 | <0.02 |

Tl is one of the extremely poisonous elements. It is more poisonous than As. In drinking water, the mineral concentration of Tl toxication is 0.05 mg/L. The average concentration of Tl in river water is 10^{-4}-5×10^{-4} mg/L, but the concentration of Tl in the water from mine pits of this area is more than 10 mg/L. The immersing and leaching experiments of Tl in Tl-bearing ores shows that a lot of Tl in ores moves into the solution under supergene condition (pH 4-6, immersed time: six months) and results in high enrichment of Tl in immersing solution (3.3-67 mg/L). From the experiments above, it can be concluded that Tl minerals and Tl-bearing minerals in ores are easily solubilized into water and transported in surface water in the supergene weathering process. This geochemical process brings about large scale Tl pollution and regional Tl toxication.

PRIMARY GEOCHEMICAL ANOMALY CHARACTERS OF DAHISHAN GOLD DEPOSIT, INNER MONGOLIA, CHINA

LU HUNXIU[1] AND GU YINGQUN[2]
1--No.6 Gold Prospecting Team, Gold Headquarters.
2--No.1 Gold General Team, Gold headquarters.

Dahishan gold deposit is situated in the Aohan-Jincanggoulia-Beizifu gold mineralized zone on the northern margin of North China platform. In these years, we have made a breakthrough in gold prospecting in this district, where there were some gold occurrences before our work.

1. Geochemical Characters

The deposit is typically controlled by the trinity of strata-tectonics-magmatite. The wall rocks of ore preserving, a set of gneissold rocks rich in amphibole, are contained characteristically abundant of Au, Ag, Pb, Sb and W. It is indicated that the first concentration of the elements is resulted from metahydrothermal slution during regional metamorphism. The migmatizing of the strata around the ore bodies becomes strengthened. So these elements and Fe, Mg are removed, K, Na immigrated and Ni, Co, V, Mn etc. are changed weakly. Among the magmatite bodies, the late Variscan granite is main one, which rich in Sb, Bi, W, Ni, Cd, Co etc, indicating the heredity of the high-grade elements in the strata. The Yanshanian magmatite bodies rich in Au, Ag, Pb, Zn etc, which are closely related to the mineralization.

2. Geochemical Anomaly Characters

The ore bodies occur in the altered fractural zones along the outer contact zone between the strata and the magmatite bodies. There are obvious anomalies of Au, Ag, As, Sb, Hg, Bi, Pb, Zn, Cu, Cd, Mn and Mo over the ore bodies. Co, V and W are the outer zone anomalies.

1). Anomaly Shape: across the section vertical to the ore body, the zoning of anomaly concentration of Au, Ag, As, Sb, Hg, Pb, Zn, Cu, Cd is obvious. The middle-inner zones are distributed around the ore body. The outer zone correspond to the altered fractured zone approximately. Mn, Bi, Co, V and Mo occur as the outer zone anomalies, which correspond to the inner zone anomalies of Au approximately. Mn, Bi and Co occur as the inner zone anomalies in the lower and the tail of the ore body, and W is a large scale anomaly only here.

2). Group and Zoning of Elements: there are the middle-inner zone anomaly group of As, Sb, Hg, Cd and Cu at the top of the ore body, the middle-inner zone anomaly group of Au, Ag, As, Sb, Hg, Cd and Cu in the upper, the middle-inner zone anomaly group of Au, Ag, Pb, Zn, Cu, Cd, As, Sb and Hg in the middle, the middle-inner zone anomaly group of Au, Ag, Pb, Zn, As and Mn in the lower, only the middle-inner zone anomaly group of Mo and Bi in the tail.

The zoning sequence of the elements calculated from the upper to lower is Cd-Sb-Cu-Hg-Ag-Au-As-Pb-Bi-V-Mn-W-Co-Mo.

3). Correlation of the Elements: Au-Ag is only closely correlated within the ore body; Sb-As, Ag-Cu are correlated beyond the ore body, correlated weakly within it.

Sb-Mo, Au-W, Au-As are correlated weakly within the ore body.

4). Ration of the Elements: (As. Sb. 103)/(W. Mo), (Pb. Zn)/(W. Mo) are less than 1,000 beyond the ore body, greater than 1,000 within it, less than 100 below it. (Pb. Zn)/(Au. Ag. 104) is less than 10 beyond the ore body, 10-20 within it, greater than 20 at its rear.

3. Predicting of the Mineralization

From the primary geochemical characters, we have developed the geochemical index to evaluate erosion depth of the deposit and the deep predicting. We carry out prediction for the erosion degree and the deep mineralization of the deposit.

RESEARCH ON INTEGRATED GEOCHEMICAL PROSPECTING FOR OIL AND GAS IN THE INLAND BASINS OF THE SOUTHERN CHINA

LUAN JISHEN, JIA GUOXIAN AND CHEN YUANRONG
(Guilin Institute of Geology and Mineral Resources, CNNC, Guilin)

There are numerous small-medium sized sedimentary basins in southern China where geochemical prospecting for oil and gas has not been widely conducted because of the complexity of the tectonics, the variability and smallness of the trap structures and the diversity of the landscape.

A series of experimental work on the applicability and optimizing the methodology of geochemical exploration for oil and gas have been carried out by combined efforts of the authors and the oil companies responsible for exploration in these areas. The results lead to the following conclusions: 1. successful application of geochemical prospecting for oil and gas should be based on a reasonable selection of technique for field work, including sampling density, depth and layer and processing (grain size, weight and material to be sent to analytical lab.), which has to be optimized individually for each study basin; 2. combination of organic and inorganic indicators can not only increase success possibility but also enhance the theoretical basis; 3. the geochemical patterns over oil and gas pools are characterized by the following zonation: Hg anomaly at apical position (inner zone), hydrocarbons anomaly to form bay-shaped middle zone and other inorganic indicators distributed in the periphery to form so called outer zone; 4. integration of geochemical data with geological and geophysical information may greatly increase discovery rate for oil and gas accumulations.

The above described methodology has led to the discovery of one oil field and two oil-gas pools in the region. it has now been implemented in 14 prospects in 7 basins and 12 wells have been drilled at the composite anomalies, of which 7 flew commercial oil, 3 had oil-gas shows. The overall success rate is more than 75%.

THE PRESENT STATUS, PITFALLS AND THE FUTURE OF GEOELECTROCHEMICAL PROSPECTING FOR HIDDEN ORES

LUO XIANRONG
(Guilin College of Geology, Guilin, China)

It is reported that in China there are more than 50 organizations involved in the research and application of geoelectrochemical prospecting for Cu, Pb, Zn, Au, Ag, W, Sn, As, Sb and Co in areas with thick overburden of loess, elluvum, gobi, fluvial and flesh rocks. This method is useful for exploration of hydrothermal, stratabound, sedimentary and volcanic sedimentary ore deposits. A number of success case histories were reported where hidden ores were found. Numerous experiments have shown that distinct anomalies are detected by this technique while no indications of other conventional geochemical methods.

However, there are no consensus about the theoretical background of the method. Research on mass-time curve is far from satisfactory. The instrumentation and the analytical technique should be standardized so that the results can be correlated nationwide. Investigation of the factors that influence the geoelectrochemical anomalies should be strengthened. It is hoped that this new technique would be extensively applied in difficult areas.

GEOELECTROCHEMICAL METHOD IN PROSPECTING FOR HIDDEN GOLD DEPOSITS

LUO XIANRONG AND YANG XIAO
(Guilin College of Geology, Guilin)

A number of auriferous areas have been chosen for testing geoelectrochemical method which is based on ionic migration under artificial electric field. In the nature, gold ores are surrounded by an ionic halo, when an electricfield, which is established by a pair of electrodes driven into the overburden, is applied, the ions are accelerated towards the electrodes according to their polarity. The authors have been investigating this method since the 80's. Three success case histories are documented in this paper. 1, In Hami gold deposit, Xinjiang, where the overburden is composed of arid residual soil with thickness of 10-15 m, two anomaly belts were delineated with Au intensity of 0.25 ppm. The anomaly is drilled which resulted in the discovery of a 4.5 m thick hidden ore body at 215 m below the surface. 2, In Fanchi gold deposit, Shanxi, where the overburden is composed of loess, two 0.66-1.2 ppb anomalies were discovered against a background of 0.3 ppb. 3, In Chuncheng, Hebei, where the overburden is composed of eluvium with a thickness of 10 m, geoelectrochemical anomalies with 0.4 ppb Au were found at the fracture zones.

GEOCHEMICAL CHARACTER AND METALLOGENIC ANALYSIS OF SIDAOGOU GOLD DEPOSIT IN LIAONING PROVINCE

MA MINTAO, ZHENG CHAO, YANG HONGYING AND SHI CHENG

The Sidaogou gold deposit is located in the southern margin of Yin Kou - Kuan Dian old uplift of Liaoning east anteclise and in the pressed fractures with 2 km width at the western side of Yalujiang River fault. The orebodies occurred grouply and the mineralization zones are various in length and width; the shape of single orebody is complicated and however most orebodies are lens, veins and irregular. The primary halo of single orebody is generally superimposed by the anomalies of grouped orebodies.

Based on the study of geochemical backgrounds of the crustal, regional and mining areas, it is indicated that if Au, Bi, W, etc. as metallogenic and associated elements are concentrated continuously, it is beneficial to gold metallogeny; the trends of most element variations of the regional and ore district geochemical backgrounds compared with that of the crustal background are the same which indicated a long periodicity of gold mineralization and the continuity of different geochemical backgrounds; the associated element As in the mining area is concentrated obviously as compared with that of the regional background. The specialty of the mining background is shown by Sb and Pb dispersions.

By using cluster and factor analyses of systematic sampling of typical orebody combined with geological observation, we concluded that V, Ti, Cu and Zn of the mining area were multimetallic of magmatic element combination; Au, Bi, As, Co and Ni combination represents the main mineralization and shows a close relationship between gold mineralization, Bi and pyritization (taking As, Co and Ni as examples); negative correlation of Mo and Hg represents the indications of the head and tail halos of the orebody, and a combination of Sb, Ag and Pb indicated geochemical anomalies near the orebody.

Analyzing the assay results of the 20 indicator elements of individual orebodies of two vein groups in the eastern and western mining areas and after removing the noise of exotic orebody (or mineralization) halo in the ore veins, we calculated and summarized the axial zonation model of primary halo of the orebody in this mining area:

Ti - Cu - Sb	--- As - Bi - Ag - Au ---	Co - V - Pb
Head halo	Middle	Tail halo

According to Q type cluster and factor analyses of the assay data of some surrounding rock samples, occurrences and various lithologies and veins and geological observation, we believed that the gold mineralization in this mining district was not lithologically specialized, i.e. there is no lithological control for mineralization. However, the common mineralization in graphitic schist could reflect geological fact of interesting gold mineralization at the structural weak sections of schistolization and graphitization created by structural activities.

Studying the factor analysis of systematic sampling and geological observation over a typical structural section, we concluded that before ductile shear deformation of the district the existed structure controlled the main gold orebody; as the increase of breakage in rocks the components of Na_2O_3, Al_2O_3, TiO_2 and MnO of major element components in rocks will be increased; while SiO_2, FeO, K_2O, P_2O_5 and CO_2 will be decreased; however MgO, Fe_2O_3 and H_2O have no significant change.

SEARCH FOR GOLD WITH CAR-BORNE GAMMA-RAY SPECTROMERY

MA ZONGXIANG, LIU TENGYAO AND ZHANG PENG
(Beijing Research Institute of Uranium Geology)

Basic rock and intermediate-basic rock, in which the clark value of gold is much higher than in acidic rock is the main source rock of gold. On the contrary, background concentrations of radioactive elements (U, Th and k) in both basic and intermediate-basic rock are much less than in acidic one. The gold source bodies can be indirectly and quickly determined according to the ranges of basic and acidic rocks which are outlined with the distributions of U, Th and K in a region investigated with car-borne spectrometric method.

Gold in geological body can activate and migrate at a high temperature and in a strong oxidization environment and precipitate in intermediate-low temperature and low pressure reduction environment. After the mother rocks underwent movement for many times, gold activated repeatedly, migrated and enriched at last formed ores in local favorable geological environment. During a series of geological movements and surficial geochemical actions in geological bodies related to gold metallogenisis, the distributions of radioactive elements experienced some changes. Among these elements, much more active uranium, much less active potassium and not active thorium will be separated and differentiated in different degrees in different areas. The characteristics of U, Th and K and their comprehensive parameters distribution in the areas to a certain extent can reflect the geological environment caused by the relevant geological structure actions. So the relations between spectral parameters and gold deposit environment can be found and the areas favourable for gold can be delineated on the same distribution of the spectral parameters through interpretation of data from car-bonre spectrometry which are appropriately processed with computer.

We carried out a regional survey in some areas ($49,000km^2$) located in the north of Hebei province, North China with car-borne spectrometric method and collected a number of data. After processing, analysis and interpretation of the data, the gamma-ray spectral parameters related to the geological environment with gold deposit have been found. U, Th and K parameters are used to research the distribution of rich gold source; $\delta k/k$ reflecting geological structural actions; $\delta th/Threg$ for thermal movement actions; K^2/U and Ki/K for potassium increment variation; (Ki-kreg) and (Ki-Korig) for potassium decrement variation in fault and fissure belts. Comparing with known geological information, geophysical data and distribution of gold deposit, we come to following conclusions:

1. There is a spatial relation between regional distribution of radioactive elements in the investigation region and gold concentration in geological bodies. In general old genesis (or migmatite) and granite areas with slightly low uranium, slightly high thorium and high potassium are rich gold source ones.

2. Overlap areas among belts of high value parameters or gradient belts of these parameters: Ki/Kr, δth/Threg, K^2/U, (Ki-Kreg), (Ki-Korig) and Moho gradient belts and geological fault belts within gold source areas in the region are enrichment ones of gold deposits (or gold occurrences). Gold favourable areas were outlined and the target ones were predicted based on the parameters mentioned above. Through investigation and examination with carborne spectrometry, some areas within investigating region. They are porphyritic granite massif in which gold concentration (9.6×10^{-9}) is 4 or 5 times as high as background one in the region, migatite granite massif with 5 times (10.4×10^{-9}) and hornblende anorthosite massif with 4 times (8.8×10^{-9}).

GEOCHEMICAL EXPLORATION AS SYSTEMATIC ENGINEERING: A REVIEW

MENG XIANWEI AND CHEN YONGQING
(Changchun College of Geology)

Geochemical exploration is virtually a matter of systematic searching for ore bodies through regional mapping to detailed survey. Geochemical anomalies of different scale and stage nest together in space and time to form a geochemical system. The authors emphasize the following points in dealing with geochemical systems:

1. Geochemical systems are primarily based on geochemical framework of the study area.

2. Geochemical systems are composed of several subsystems which are interrelated.

3. Tectonic and structural background is the backbone for most geochemical systems.

4. Geological units are the confining factor for the geochemical systems.

5. Integration with geological and geophysical data is an indispensable procedure in researching into geochemical systems.

STUDIES ON MIGRATION MODE OF GOLD IN MAOPAI GOLD DEPOSIT, JIANGXI

Peng Renyong
(College of Geology of East China, 344000)

1. Geological Aspects

Maopai gold deposit exists in the migmatites and metamorphics of Zhou Tan Group in Sinian. The ore-forming is divided into two stages. The mineral fluids of first stage mainly from midhigh temperature metamorphic hydrothermal produced by migmatitism in late Caledonian. In the second stage, gold mineralization was controlled by the tectonic-magma activity in late Yanshan movement in Mesozoic, and ore fluids came from postmagmatic hydrothermal.

2. Research on Migration Mode of Gold

Gold element has very strong complexiation relation in the hydrothermal system, it can take shape stably complex anion with varid of ligand in the hydrothermal which can be migrated by gold complex mode. In acid solution of higher temperature, a lot of experiments reveal that gold has high solubility in the hydrothermal system while chlorides exist. Henley (1983) measured that in the range of 300-500C and with chlorides, water of dehydration reaction (metamorphic hydrothermal can bring gold from wall rocks into shear belts or faults during metamorphism. In the first stage, the inclusion composition of Maopai gold deposit shows that its homogenization temperature of the ore-forming fluids is in the range of 290-370C. There exist pure CO_2 gas and liquid inclusious, its composition is rich in k^+, $k^+>Na^+$, SO_4^{2-} and is slight higher than other; Salinity equals to 6.5-10.5 WT% NaCl; Fluids are slight acid, i.e PH=5.4, Eh=-0.43V, gfo_2=-3a1

Based on the field investigation and indoor research, we suppose that the migration mode of gold of first stage is mainly in the form of $M^+(AuCl_4^-)$, $m^+(AuCl_4^-)$.

According to the result of inclusion composition of mineralizied luids in the second stage, the hornogenization temperature is in the range of 260-320C. The inclusion are rich in Na^+, $Na^+>k^+$, CO_2+CH_4(gas) and Cl^- being little high. Sulfur had been dissolved in the water solution, so the gas facies of inclusion relativly reduced the amoun of sulfur and carbon dioxide. The value of gfo2 of ore fluids equals to -34.6, the value of pH equals to 5.97. They reveal that sulfur of reduction hold a dominant position and have been dissolved sult-atomic group. Combining with macroexamination evidence, i.e the association of the second stage is polymetallic sulphide-natural gold-Quaid, we assume that the migratiol mode of gold of late stage was mainly in the form of $Au(Hs)_2^-$. The process are :

$Au(Hs)_2^- + M^+ --- Ms + Au + 2H^+$
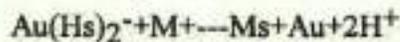
The code of M^+ --- is taken place of Fe_3^+, Fe_2^+, Pb_2^+, Zn_2^+, Cu_2^+ and so on.

The code of Ms replaced pyrite, chalocopyrite, galeno, sphalerite.

BASIC FEATUERS OF GEOCHEMICAL LANDSCAPE IN JILIN PROVINCE

PIAO QINGLONG, GUO WENXIU AND LIU SHUJIE
The 5th Geological Institute, BGMR, Jilin

The landscape of Jilin as a whole shows an obviously horizontal latitude zonation. But in southeast Changba mountain and its peripheral shows a vertical zonation. The terrain can be subdivided into eight subzones: the tundra subzone in the upper truncated volcano cone and birch forest zone in the base of the shield batholith, mixed coniferous and broadleaf forest subzone in the middle-low mountain area between Tonghua and Yianbian, deciduous broadleaf forest subzone in the low mountain and hill area between Liaoyuan and Jilin city, sparse forest and grassland subzone between Siping and Yushu, plain meadow grassland subzone between Changling and Zhenlai, and dry grassland subzone in Tongsheng hill area. The last five subzones show horizontal latitude zonation and are main geochemical landscape in Jilin Province; the first three (minor landscape zone) show vertical terrain zonation.

Marked geochemical zonation can be also observed in Jinlin province:

From southeast to northwest Jinlin, many indices, including water dynamics in rocks and oils, migration forms of elements in water, acidity of different media, typical elements and ions in different terrain and the types of elements with migration parameter in water >10 and mobility parameters in media >2, show a regular change. The changes of typical elements and ions, for example, are that H^+ occupies first place and HCO_3, organic acid and Fe come second in tundra subzone; HCO^-_3 first and Fe^{2+}, Mn^{2+}, SiO_2 second in forest subzone; HCO^-_3, Na^+ first and OH^-, SiO_2 second in forest and grassland subzone; Ca^{2+} and Na^+ first in grassland subterrain, in which first is Na followed by Ca^{2+}, SO_4^{2-} and HCO_3^- in meadow grassland areas, and in dry grassland area Ca^{2+} comes first followed by Mg^{2+}, HCO^-_3.

DISPERSION PATTERNS OF ANAMALIES RELATED TO MINERALIZATION OF 1:200,000 STREAM SEDIMENT SURVEY IN JILIN

PIAO QINGLONG AND GUO WENXIU
The Fifth Geological Survey, BGMR, Jilin

To select and rank geochemical anomalies found by 1:200,000 stream sediment survey and study surficial geochemical characteristics of typical ore deposits in Jilin, we studied 16 regional geochemical anomalies relevant to typical ore deposits, including anomalies related to the five key deposits (fields), and found dispersion patterns of the anomalies related to mineralization were:

1. The anomalies related to mineralizations are characterized by polyelemental anomaly association comprising ore-forming and main accompanying elements relevant to mineralization, and which the anomalies surrounding the known mines (fields) constitute the main part of the anomalies; around the main anomalies are circular satellite anomalies of most halo-forming elements.

2. The main anomalies related to mineralization are generally coincided with orefield occurrence.

3. The main anomalies generally have large anomaly area, similar anomaly shape, marked concentration gradient and center.

4. The concentrated centers comprising the main anomalies are generally located in the center of the orefields or point to the main deposits in an orefield.

5. The anomalies related to mineralization exhibit a markedly horizontal zonation.

6. The endozones of the anomalies are generally coincided with the central section of orefields or the sites where main deposits occur; the mesozones of the anomalies are basically coincided with orefield distribution; the exozones of the anomalies are in accordance with outer area affected by mineralization related to ore-forming.

Cu ABUNDANCE OF THE MESOZOIC STRATA AND SANDSTONE-TPYE Cu MINERALIZATION IN THE MESOZOIC MID-YUNNAN BASIN, YUNNAN, CHINA

QIN DEXIAN AND MENG QING
(Department of Geology, Kunming Institute of Technology)

The Mid-Yunnan Basin is located in the western margin of the Sichuan-Yunnan geoanticline, which can be divided into two parts:eastern paleoland and western tectonic belt. The eastern part, composed of volcanosedimentart metamorphic rocks of Dahongshang Group and Kunyang Group, is a well known Cu geochemical province while the western part is composed of Mesozoic fluvio-lacustrine clastic sediments with 10,000 meters thick. The sandstone Cu deposits mainly occur in the Cretaceous Matoushan Formation which form a half-annular belt around the western margin of the paleoland. Based on a large collection of Cu concentration data from the Mesozoic strata, the author conducted a series of Kolmogorov-Smirnov normality test confirming that the Cu concentrations in various sections possess mixed populations of multi-mode distribution. After statistical separation of the mixture populations, the mean of single normal population with the highest frequency is taken as the abundance of the strata, and the ratio between the mean of the total data set and the abundance is called the coefficient of superimposed mineralization intensity. The results indicate that:

1. The Cu abundances of the regional Mesozoic strata increase from lower to upper, namely 14.2 ppm for T_3,18.7 ppm for J_2 19.8 ppm J_3, 20.8ppm for K_1, 21.5 ppm for K_2.

2. The Cu abundances of the strata surrounding mining areas are distinctly higher than that in the same stratigraphic layers far away from the deposits. For example, Cu concentration in K_2 is 83 ppm around Mouding Copper deposit. The Cu source is believed to be the Cu-rich paleo-land to the east, which explains why the Cu deposits are distributed mainly in the Cretaceous Series at the eastern margin of the basin.

3. Lithologically, the Cu deposits are concentrated in the sandstone rather than in the mudstone. The fact that the Cu abundance in sandstone is lower than that in the mudstone suggest that Cu may have migrated from the hanging and/or foot wall of mudstone into porous sandstone during mineralization. In the foot wall of the purplish mudstone in Mouding Deposit a negative (depletion) Cu anomaly has been detected which can serve as an evidence of Cu being carried away.

GEOLOGY AND GEOCHEMISTRY OF THE STRATABOUND LEAD-ZINC DEPOSITS IN MIDDLE-YUNNAN, CHINA

QIN DEXIAN

(Kunming Institute of Technology)

The middle-Yunnan area is located at the intersection of Sichuan-Yunnan geoanticline, East Yunnan platform folding belt and South-East Yunnan fold belt, where lead-zinc

deposits and occurrences are abundant but geological research is poorly conducted. Supported by a fund from the National Natural Science Foundation the author investigated the geology and geochemistry of the deposits by means of field work and laboratory analysis.

The Pb-Zn deposits are controlled by the combination of strata and structure. 9 predominant horizons can be recognized namely: middle-late Proterozoic Kunyang group, upper Sinian Doushantou Formation, Sinian-Cambrian Yufuchun Formation, middle Cambrian Shuanglogtan Formation, mid-Devonian Qujing Formation, lower Carboniferous Datang Formation, lower Permian Maokou Formation, lower Triassic Feixianguan Formation and upper Triassic Shezhi Formation. And 3 major controlling structures are Tanglang-Yimen fault, Puduhe-Dianchi fault and Xiaojiang fault. The mineralization belts are distributed successively from west to east with the age of the ore controlling strata changing from older to younger. According to Tu Guangzhi's classification scheme(1984) for Pb-Zn deposits, ore deposits in the northern part of middle Yunnan belong to sedimentary-reformed type (type I), those in the southern part belong to epigenic type (type II) and superimposed type (typ III).

Based on observation along 8 profiles and analysis of 436 samples for samples for trace elements, the geological history and asssociation of chemical elements are discussed. Type I and type II usually occur in geologically instable areas and are rich in Sn, Bi, Ag while type III in stable areas and contains no Sn and Bi.63 pyrite samples were analyzed for S isotopes, the data is indicative of sedimentary reduction origin. This is consistent with the fact that pyrite laminations are often seen in carbonaceous strata. 52 galena samples have been analyzed for Pb isotope composition. As far as a single deposit of type I ± is concerned, the Pb isotope data seems to follow single stage model. The model age of the ore is consistent with that of the ore-bearing strata indicating that the Pb may have come from the sedimentary rocks. For type II and III, the Pb isotope data show a multiple source and multistage origin. Fluid inclusion study has shown that the ore forming temperatures are within $100^{o}C$-$210^{o}C$ and it is higher for type II and III than that for type I.

THE GOCHEMICAL CHARACTERISTICS AND INDICATORS FOR EXPLORATION IN   DONGKENG GOLD DEPOSIT,WEST OF GANGDONG PROVINCE

REN LINZI

Dongkeng golden deposit is located in Xinyi country,the west of the Wuchan-Sihui fault zone. It is controlled by Datanding structure, the ore bodies occurred in a silication shear zone along the structure. The host rocks are a series of shallow metamorphic rocks (yunkai Formation) which contain quartz-mica or mica-quantz schists, mica quartzites, and striped migmatites are overlain and eye migmatites are underlain. The average content of gold is 7.67 ppb in the shallow metamorphic rocks . The ore bodies with averge grade of 3.1~15.25g/t are found in the shape of bed or vein.

The deposit is composed of gold-bearing quartz veins, ore minerals are pyrites and magnetic pyrites. Alteration can be observed near the ore bodies, including silication, pyrition, chloritcation and sericitization.

The halo elements of deposit consist of Pb-As-Sb-Au, Cu-Bi, W, Mo. Au, Cu, Bi and Sb are at the front hole of bodies and W, Mo, As, Pb, Zn at the trail holes. The content of W, Sb. Au, Zn, Cu, Bi, As decrease as the depth of the ore bodies increase.

1.The indicators for differentiating mineralized bodies(ore bodies)
(1)mineralized bodies: As x Bi x Cu/Au>2.5, Mo x 10/Au<2.
(2)unmineralized bodies: As x Bi x Cu/Au<2.5, Mo x 10/Au>2.

2.The indicators for deciding the erosion degree of bodies
(1)middle to upper parts of ore bodies:

Au x 10^3/Pb>0.03, Au x 10^3/Zn>0.015, Au x 10^3/As>0.1,

Au x Bi x Cu x 10^3/Asx Pb x Zn>0.03, Au x 10^3/W x Mo>0.1, Bi x Cu/W x Mo>4.
(2)The trail parts of ore bodies:

Au x 10^3/Pb<0.01, Au x 10^3/Zn < 0.01, Au x 10^3/As<0.002,

Au x Bi x Cu x 10^3/ As x Pb x Zn<0.0001, Au x 10^3/W x Mo<0.05, Bi x Cu/W x Mo<1

After investigating the surrounding area, the four promising anomalous areas have been found. The erosion degree of bodies is moderate in Dongkeng deposit.

DETERMINATION OF TRACE SELENIUM IN GEOLOGICAL MATERIALS BY HYDRIDE GENERATION-ATOMIC FLUORESCENCE SPECTROMETRY

REN PING, ZHANG QIN AND ZHANG JINMAO

Institute of Geophysical & Geochemical Exploration Langfang, Hebei 102849 P.R.China

Hydride generation-atomic fluroscence spectrometry (HGAFS) is a new trace analytical technique. This technique is based on determination of volatile hydride or metal vapour formed from the elements to be determined in the solution by atomic fluroscence spectrometry. HGAFS is characterized by high sensitivity, good precision, few interferences as well as its simplicity and rapidity, and it is becoming a more promising and effective technique for determination of Hg, As, Sb, Bi, Se, Te, Ge, Sn and Pb. A method is developed for determination of trace Se by HGAFS after seperation and concentration using baking process. The sample was mixed with active carbon, covered by mixture flux (MgO-Na_2CO_3) and baked at 800°C. After this, the baked mixture was dissoved in water. Then the aqueous solution was acidified by hydrochloricacid and analyzed by HGAFS using special hollow-cathod lamp (HCL) as exciting source. The characteristics of this method are low detection limit, good precision and rapidity.

The authors also have systematically optimized seperation and concentration conditions, instrumental working parameters, relative experimental conditions, and especially studied the interferences of more than 30 elements to Se. Under the optimum conditions selected, the detection limit of this method is 0.01 ug/g, dynamic liner range is 0.00ug/ml-0.3ug/ml. The relative standard deviations (RSD) are 10.0% and 6.3%, when the levels of Se in samples are 0.036ug/g and 0.089ug/g,respectively.

This method has been applied to analyze 26 geochemical reference samples (GSR1-6,GSSI-8,GSD1-12) and a fairly good agreement is obtained between our determinations and the recommended data.

VOLCANIC-TYPE GOLD MINERALIIZATION DISCOVERED WITH DETAILED GEOCHEMICAL EXPLORATION IN MALUGOU

REN TIANXIANG, MA SHENGMING, WANG MINGQI AND JIANG RUIJIN

Institute of Geophysical and Geochemical Exploration, Langfang, Hebei 102849, People's Republic of China

A hydrogeochemical anomaly composed of As and Sb was discovered in an orientation hydrogeochemical survey in Malugou, southern Jilin province. According to the known geology and mineralization materials and remote sensing study, it was considered that the metallogenic conditions were favorable in the hydrogechemically anomalous area. Several types of alteration such as kaolinization and alunituzation can be found locally and two sets of faults with NW trends have developed in this area. A small outcrop of a granodiorite-porphyry body was found through surface investigation. Therefore, it is inferred that this area has a potential for gold and poly-metals exploration and follow-up for the hydrogeochemical anomaly has been carried out. Stream sediment survey, heavey-mineral survey, soil survey and rock survey were sequentially conducted so as to identify the target and delineate the mineralization belts.

Stream sediment survey was carried out in an area of 45 square kilometers. Multi-element anomalies of Au, As, Sb, Ag, Bi, Pb, Mo and Zn were found in the studied area. The strongest anomalies are composed of Au, As and Sb with maximum values of 0.217ppm, 179.4ppm and 7.48ppm respectively. The maximum concentration coefficients for Au, As and Sb are 217,18 and 15, and it is thus indicated that the main mineralization type in the area may be gold mineralization.

Heavey mineral survey was conducted in the geochemical anomalies of stream sediment in order to investigate the surficial gold occurrences, trace the source of gold mineralization and determine the area for futher detailed exploration. Samples were collected from the present-day alluvium and proluvium. In addition to the accessory minerals in neutral-and acidic volcanic rocks, pyrite, cinnabar and native gold have also been discovered in the heavey minerals, which can be considered as an evidence of sulfide mineralization in the studied area. The presence of native gold may presage the existence of primary gold mineralization and indicate that the mineralized body has been denuded to the surface. Based on the distribution and occurrences of the native gold in heavy minerals, the possible location of gold mineralization was determined and an area of 1.5 square kilometers for futher detailed work was delineated.

Soil survey was used as a detailed surved method, and rock samples was also collected in some streams where bedrock outcroped. Two composite anomaly belts of Au, As, Sb, Ag and Hg have been found and three multi-element concentration centers have been identified in the two belts. The element combination of No.1 and 2 anomalies is Au+As+Sb+Ag+Hg which is similar to the element combination of the upper silification zone of volcanics-hosted epithermal gold deposit. The element combination

of No.3 anomaly is As+Sb+Mo+(Au)+(Pb). The anomalies of As and Sb were just located in the center of the ringlike Mo anomaly to the geological conditions and rock alterations of the area, it is deduced that the No.3 anomaly may be related to a concealed magmatic body.The peak value of gold in rocks is 0.11g/t and corresponds to No.1 soil anomaly.

The main companying elements of gold include As, Hg and Sb. The results of rock survey have further confirmed the existence of primary gold mineralization in the area. Gold mineralization is hosted in the acidic volcanics, and no anomalies of gold and related elements have been found in andesite distribution area.

It can be concluded that the gold mineralization of the area is associated with acidic volcanics, The mineralization types may belong to volcanics-hosted epithermal mineralization or the outer gold mineralization zone associated with porphyry mineralizations.

CHARACTERISTICS OF ELEMENT DISPERSION AND GEOCHEMICAL PROSPECTING FOR CONCEALED ORE DEPOSITS OVERLAIN BY LOESS AND RED EARTH IN EASTERN GANSHU

REN TIANXIANG YANG SHAOPING AND LIU YINGHAN

*Institute of Geophysical and Geochemical Exploration,
Langfang, Hebel 102849, People's Republic of China*

The study area is located in western part of loess plateau of China, where continental semi -arid climate and typical loess ridges and hillocks are developed. Loess, which is 20-80m thick and blankets on Prequaternary formation, was formed by wind in Quaternary. Beneath loess 10--over 100m red fluvial and lake facies clay (red earth), formed in Tertiary, is generally observed and overlied directly on bedrocks. Although gullies and velleys are densely spread and sometimes they are great in depth, most of them reach only to upper red earth and few big rivers have cut into the bottom of red earth or bedrock. Thus, it is very difficult for geological prospecting in the area. In order to study the characteristics and machinism of dispersion of mineralized elements from orebodies into loess and red earth overburden and establish possibly efficient methods for geochemical exploration for the area, one polymetallic-pyrite mine overlied by loess and red earth was chosen in eastern Ganshu. The deposit was located in pyroclastic and marine facies volcanic effusive rock of Koumanzi formation of upper Ordovician. Most of orebodies occur below 50m from top bedrock. The samples of drilling chips, loess and red earth, ground water (wells and springs), vegetable and certain gases were collected. The results showed that Zn,Pb, Cu, Ag, As,Mo,Sb,Hg,S and so forth was able to transport into overburden in different forms, manners and degrees.

(1)Cu,Pb,Zn,Hg,As and so forth in the red earth over mineralized zone show a slighter increase (0.25-0.5 time higher) than that over non-mineralized area. Cu, Pb and Zn in red earth exist mainly in "amorphous" Fe oxides and some exist in Mn oxides.

(2)Near red earth--loess interface (0.5-2m) large amount of calsite was enriched and formed alkaline evaporating geochemical barrier; As, Mo Mn and Hg are strikingly

enriched at the interface and As, Mo contents are highly correlated with the amount of calsite.

(3)CU,Pb,Zn,Mn,Ag,As,Mo,Cr and SO^{2-}_4 exhibit consistant anomalies occurring in phreatic water at the bottom of loess around mineralized zone. These elements came not only from evaporation or other process related to hydrodynamism, but also from leaching of these elements in loess transported from deposit and red earth.

(4) Discontinous anomalies of Ag and Mo occur obviously in surface loess over deposit. Pb and Zn anomalies were observed only in amorphous iron oxides by partial extraction.

(5)Hg,SO_2 and CO_2 in surface loess can clearly indicate mineralized one, especially for mineralized structure zone because of their penetrating power.

In conclusion,hydrogeochemical exploration can be used in a regional survey and gas, partially extraction survey can be used to follow up anomalies in the area.

THE BACKGROUND VALUES OF 39 ELEMENTS IN STREAM SEDIMENTS IN CHINA

Ren Tianxiang Yin Binchuan Liu Ruying and Zhao yuxiang

Nationwide Geochemical Mapping Project in China has been carried out for 12 years on a large scale. Samples collecting and most of samples analyzing have basically finished in inland areas, coastal provinces and about 40 percent of workable area in remote provinces and areas up to now. More than 600 1:200,000 quadrangles or about 4 million square kilometers areas have been covered. Most of the work have been done in mountainous and hilly areas. The geochemical mapping offers good opportunity to gain background values (or abundances) of 39 elements from stream sediment survey in China. The authors used the mean value of every 1:200,000 quadrangle in stream sediment survey to do the statistics of nationwide background values of stream sediment in China. At present, the authors have collected 530 mean values data of 1:200,000 quadrangles. Every mean value is the arithmetic mean value calculated after removing outliers.

The authors took advantages of 530 mean values of 39 elements of 1:200,000 quadrangles for calculating mean values. The method for calculating element background values (or abundances) of nationwide stream sediment is as follows: (a) calculating arithmetic mean values and variations; (b) removing the data, >X+2S or <X-2S from data group (removing outliers, about 2-5% from the total); (c) calculating arithmetic mean values and variations by the rest data after moving outliers. Such mean values is thought as background values (or abundances) of stream sediment in China. Mean, median, maximum, minimum value of 32 elements and compounds, namely Ag, As, Au, B, Ba, Be, Bi, Cd,Co, Cr, Cu, F, Hg, La, Li, Mn, Mo, Nb, Ni, P, Pb, Sb, Sn, Sr, Ti, Th, U, V, W, Y,Zn, Zr,and Fe_2O_3, SiO_2, Al_2O_3, K_2O, Na_2O, CaO and MgO are listed on Table 1. Besides, the mean values of 39 elements in different landscapes are given.

THE REPRESENTATIVITY OF WIDE-SPACED OVERBANK SEDIMENT GEOCHEMICAL SAMPLING

SHEN XIACHU, XIE XUEJING AND YAN MINGCAI
Institute of Geophysical and Geochemical Exploration
Langfang, Hebei 102849, P.R.China

In response to the launching of the Global Geochemical Sampling (a subproject of the IGCP Project 259, International Geochemical Mapping), an orientation study was conducted to develop an optimum wide-spaced geochemical sampling approach in Jiangxi province, Southeast China in 1989~1990. One hundred and twenty-one overbank sediment samples were collected in an area of about $157,000km^2$. The average sampling density was 1 sample / $1,300km^2$. The sampling coverage was 24%. Most of the samples were collected at outflow sites of those drainage basins with an area of $100~500km^2$, including 33 samples from basins with an area of $400~2,000km^2$. Overbank sediment samples were taken from at a depth of 50 to 120 cm. Samples were analyzed quantitatively for 39 elements. The representativity of wide-spaced overbank sediment sampling is discussed from various perspectives in the paper, and the following points are made:

----Sampling at the outflow areas of $400~2,000km^2$ drainage basins can identify the major mineralizations in the basins, and more importantly even the 4 samples with the catchments of $1,000~2,000km^2$ have good representativity of the major mineralizations in the basins.

----Tungsten, Sn, Cu, Pb and Zn in both wide-spaced samples and drainage sediment samples collected at a density of 2 samples / km^2 manifested similar regional geochemical trends.

----The distribution of "3Ni+Cr+V" in wide-spaced samples can distinctly reveal the boundary between the Yangtze paraplatform and the Caledonian fold system in Jiangxi.

----The distributions of W, Sn, Rb and Be coincide with the Yanshan granites which are closely related to the major ore-forming processes in Jiangxi.

PRIMARY HALO CHARACTER OF JINKOULING GOLD-COPPER DEPOSIT, TONGLING, ANHUI

SHI ANSHI AND QIAN YIJIN

Jinkouling skarn type gold-copper deposit is located in NS limb of Tongguanshan anticline.The orbody occurred in the contact zone between Jinkouling quartz diorite and Triassic Qinglong formation limestone.All of the orbodies are blind.Bornite and chalcopurite are main gold-copper contained minerals.

1.By the R type cluster analysis of 230 skarn rock samples we found Au,Ag,Cu and Bi exhibited a close associated relationship which is very useful for prospecting. When primary complex anomalies with Ag¦2.5g/t,Au¦0.5g/t,Cu>0.1% and Bi¦40g/t are detected they will indicate occurrence of the orebody effectively .

2.Feature of primary halo

Primary halo of the orebody distributed regularly and is in a banded form.The hanging wall halo (in intrusive)of the orebody is several to several tens times wider than the

foot wall halo (in limestone).The intrusive overlapped the limestone. Therefore the anomaly in the intrusive is very signficant indication for looking for mineralized contact zone and blind orebodies.

3.Zoning series of primary halo

At this deposit there is a distinct zoning of primary halo. From near to and far of the deposit horizontal zoning is :Au-Bi-Ag-Mo-Co-Zn. Axial zoning form top to bottom is: Mo-Cu-Bi-Au-Ag-Co-Pb-Zn. The study of axial variation for the indicator element showed that the front halos of the orebody against its tail halos are 6.9 times for Cu, 13 times for Ag, 4 times for Bi and 6.8 times for Mo. It is noted that the difference of multiple time ratio index is more obvious. Taking Cu x Ag x Bi x Mo/(Co x Pb x Zn) as an example, the front halo is 43.3 times higher than the tail halo and the orebody halo is 17,000 times higher than the tail halo again.Using multiple time ratio index as a mark we could recognize erosion degrees of the orebody.It could indicate blind orebodies and be more reliable than by single element as indicator.Good results have been obtained using all of the above indexes.

REGIONAL SECONDARY GEOCHEMICAL NEGATIVE ANOMALIES AND THEIR SIGNIFICANCE

SHI CHANGYI
Institute of Geophysical & Geochemical Exploration, MGMR,
Langfang, Hebei 102849, P.R. China

Little research on secondary negative anomalies of regional stream sediment surveys has been done until now.

According to the results of 1:200,000 scale regional stream sediment surveys in Area WJ, WT, QH, and GWN etc., this paper will review the following problems involving regional negative anomalies: distributions of regional negative anomalies, the relation between negative and positive anomalies, geological significance and ore-exploration information of negative anomalies and the relationship between regional negative anomalies and environmental geochemistry.

Two distribution tendencies of regional negative anomalies were observed. Firstly, the negative anomalies mainly distribute annularly outside or around the positive anomalies in the regions in which element concentrations exhibit lower than average background (LAB) values. Secondly, not only is it possible for negative anomalies to occur in the LAB area, but they can also occur annularly outside or around the positive anomalies in the regions of higher than average background values. These differences reflect different geological backgrounds and ore-forming processes.

Negative anomalies appear always to occur in company with positive anomalies. At the same time, one negative anomaly must correspond to at least one positive anomaly. There appears to be a positive correlation between negative and positive anomaly dimensions.

Positive anomalies of Be, Pb, P, W and Sn and negative anomalies of As, B, Co, Cr, Cu, Mn, Ni, Ti and V were observed over granite in Area GWN. The coincidence

position of negative anomalies of Fe_2O_3, MgO, V, Ti, Co, Cr, Cu and Ni and positive anomalies of Sn, W, Mo, Bi and Be is one of the important indicators of granite in Area WJ. Different elements of negative and positive anomalies occuring over granite in the above two regions reflect the differences of geological background.

The distributions of positive and negative composited anomalies of Fe_2O_3, MgO, V, Ti and Co in stream sediment in Area WJ are linear and regular. Positive composited anomalies occur alternating with or inlying with negative composited anomalies in space. Overall, there appear to be 3 linear belts of positive and negative composited anomalies with NEE strike showing no different distribution of belts of basic and ultra-basic volcanic rocks and deep faults.

Anomalies of Au-As-Sb and Cu-Cr-Ni are the important indicator element anomaly associations of Au and Cu deposits in Area QH respectively. The results of positive and negative anomaly models over known deposits show that, in the plane figure, positive anomalies occur over the known deposit and negative anomalies distribute on the peripheries of the positive ones. In the cross-section, negative anomalies occur on both sides of positive anomalies reflecting the known deposit. Moreover, it has been found that evident regional negative gold anomalies exist on the periphery of positive anomaly of Au over AX gold deposit and gold deposits in Area WT. It was suggested by Chaffee et al. (1981) that the coincidence position of positive anomalies of Mo, Pb and Te with negative anomaly of Mn is the optimum ore indicator of Red Mantain Porphry-type Cu deposits in Southern Arizona.

Regional stream sediment survey data is now being used in the study of environmental and agricultural geochemistry. A closer relationship has been found between the lower concentration regions (corresponding to negative anomalies) of certain elements and the lower output regions of certain crops and certain endemic diseases.

PRELIMINARY STUDY ON THE INTERPRETATION OF REGIONAL GEOCHEMICAL DATA

SHI CHANGYI AND XIE XUEJING
Institute of Geophysical & Geochemical Exploration,
Langfang, Hebei 102849, P. R. China

The following three problems in the interpretation of regional geochemical data are discussed: (1) regional dispersions and enrichments of trace elements; (2) the relationships between geochemical features and geological background and mineralizations; (3)anomaly sorting, anomaly evaluation and target selection, on the basis of the data processing results of regional stream sediment survey of 1:200,000. These data derived from two regions, one old metamorphic terrian in Area E and another a Mesozoic volcanic region in Area W, were processed by System RESMA (Rapid Evaluation and Sorting Multielement Anomalies, Xie, 1986).

Regional geochemical distributions of trace elements in Area W were analyzed by Concentration Clarke (KK) replaced with Regional Concentration Coefficient (RCC)

and the results show that mineralizations of Au, Cu, Hg, Sn and REE are most likely to occur. Boxplot comparisons are used to describe the geochemical distribution of Au among geological units in Area E.

The maps of regional distribution of higher than average background values (HAB) of various elements are made from "single element component maps of background surface and anomalies". It's found that the distributions of the composited regional distributions of multielement HAB and anomalies related to Ag are controlled by the basement structures and strata in Area E according to comparing them to the geological background. The HAB and anomalies trenched along NW influenced by structure F_4 and F_5 on the lower half part of the sheet below the boundary of structure F_2, on the contrast, they are controlled by the NE basement structures on the upper half part of the sheet above the boundary.

The regional distributions of higher than average background values of Cu, Cr and Ni and their anomalies coincide respectively in space. Not only do the tendency of their regional distributions show no difference, but their distribution ranges are also similar. The composited maps of HAB and anomalies of Cu-Cr-Ni clearly reflect the metamorphic strata of AW and Mh, where primary rocks are basic volcanic rocks. The regional tectonic framework can be revealed distinctly by the maps.

The distributions of the positive and negative composited anomalies of Fe_2O_3, MgO, V, Ti and Co in stream sediment in Area W are linear and regular. The positive composited anomalies occur alternating with or inlying with the negative composited anomalies in space. Overall, there appear to be 3 linear belts of positive and negative composited anomalies with NEE stike showing no different distribution of basic and ultra-basic volcanic rocks, in addition 3 deep faults in this region are revealed by the belts.

The maps of multielement integrated anomalies (MAV) can provide the distributions and components of the multielement anomalies simply and directly, using them we can rapidly predict the regional metallogenic potential in a region. On the basis of geological background, regional distribution of trace elements, the composited regional distribution of multielement HAB and anomalies and the maps of multielement integrated anomalies with regional geophysical features, prediction of the metallogenic potential and major target selection of the two regions has been successful. Preliminary sorting and evaluation of anomalies in Area E and Area W have been done according to "the multielement anomalies association expression" in System RESMA with consideration of all the data mentioned above (negative anomalies included). We are pleased to note that, after reexamination of 16 anomalies of Au, Hg, Cu, Bi, Sn, W and Sb that were first sorted from 116 integrated multielement anomalies in Area W in 1989-1990, one Cu deposit, two gold deposits, one Hg-Au prospect and 10 mineralizations were discovered.

SYSTEM RESMA-II AND ITS APPLICATION

SHI CHANGYI AND XIE XUEJING

Institute of Geophysical & Geochemical Exploration,
Langfang, Hebei 102849, P. R. China

LIU RUYING AND LI JINSU
Beijing Computer Center of MGMR, Beijing, 100083, P. R. China

The interpretation of geochemical anomalies has been being on the forward position of exploration geochemical study from the birthday of exploration geochemistry until now. Many geochemists at home and abroad attempt to contribute their shares on this aspect. The computerized interpretation system---"Rapid Evaluation and Sorting of Multielement Anomalies" (System RESMA-I) was developed by Xie Xuejing in 1986 in order to process the enormous data of regional geochemistry rapidly and effectively. The aim is to provide various significant information as much as possible for the interpretation. System RESMA-II came from System RESMA-I with some refinements in 1990.

One of the key problems in the evaluation and sorting of regional geochemical anomalies is to distinguish main ore elements from the associated elements and to get a clear understanding of the relationship between ore elements and the associated elements. The aim can be carried out with "the single element anomaly association expression" which is one of the most important substances in System RESMA. The conception of the "degree of coincidence of anomalies" (DOCA) was introduced to get more clear picture of element associations of multielement anomalies and to cut apart the main ore element anomalies that have greater NAP value and occur very near or overlap in space in System RESMA-II. Therefore, it is possible to discriminate different types of important mineralization which can not be seperated if the calculation of DOCA is not made . The problem, that anomalies involving in each other can not be recognized clearly when they occur in System RESMA-I, can be overcome and the problem how to cut apart and decompose the multielement compounded anomalies can be resolved in System RESMA-II. And now we can easily identify the elements which have greater contribution to the main ore element anomalies with the "element association expression".

The multielement integrated anomaly map is a important map in the anomaly sorting and the anomaly evaluation. It can be plotted by calculating the multielement anomalies value (MAV1 and MAV2) in System RESMA-I, but we can not know the real dimension of the anomaly and its component elements just according to the map. And now, the calculation of the "multielement integrated anomaly association expression" can be done in System RESMA-II while the integrated map is plotted. Meanwhile, the interpretation of multielement integrated anomaly map would be more objectively on the basis of the expression in System RESMA-II.

The data of regional stream sediment survey in a region of Eastern China have been processed using System RESMA-II. The results proved that the refinements of System RESMA-I yielded notable effect and System RESMA-II was more functional than System RESMA-I.

A GEOCHEMICAL MODEL OF ORE-FORMING SERIES FOR SHANHU W-Sn ORE FIELD, GUANGXI

SONG ZI'AN
(Guilin College of Geology, Guilin)

The Shanhu W-Sn ore field is hosted in the Devonian strata with granitic intrusives of the late Yanshanian. Around a deep seated igneous body, the types of deposits are changing from deep W-Sn quartz vein to shallow W-Sb quartz vein and quartz breccia vein. Accordingly , a systematical variation in the geochemical parameters is observed:

1. Association of ore minerals and trace elements in the ore minerals changes from complex to simple, e.g. from W, Sn, F, B, Be, As, Cu, Pb, Zn, Ag and Cd to Sb,W,Sr and Ba, and finally to W, Cu and Cl.

2. FeO,Cu,Pb, Zn, Cl and Hg in wolframite increase while MnO, $(Nb,Ta)_2O_5$, Sn, Mo, F and B decrease.

3. W,Cu,Cl and Hg in the altered rocks increase while F, Sn, B and Be decrease.

4. Elemental association in hanging part of the primary halo change from complex to simple, e. g.from W,Sn,F,As,Be B, Cu, Pb, Zn and Ag through Sb, W, As, F and Sr to W,Cl,Cu and Hg,

5. Light REE in the ore increase while heavy REE decrease.

6. The composition of fluid inclusions in quartz changes from enrichment in F^-, SO_4^{2-}, CH_4, K^+ and Mg^{2+} to enriched in Cl^-, Na^+, Ca^{2+} and CO_2.

7. Oxygen isotopoic composition in wolframite becomes heavier and sulfur isotopic composition in sulfides differs from that of meteorites.

8. The variations in H and O isotopic composition of H_2O in fluid inclusions become more significant.

9. Ore-forming temperature changes from hypothermal through mesothermal to epithermal.

All these evidences have led the author to formulate and ore-forming history for the study ore field.

THE APPLICATION OF ELEMENTAL ZONATION IN EVALUATING ORE POTENTIAL OF STREAM SEDIMENT ANOMELIES---WITH REFERENCE TO LAOLING AREA, JILING, CHINA

SUN BAOTIAN
(Jilin Bureau of Geological Exploration, CNNC)

The elemental zonation observed in numerous types of ore deposits are the indicators of the changing physiochemical conditions and fluid compositions during rock-froming and ore-forming processes. It has been a common knowledge that elements in the ore-forming fluids are migrationg in different forms and precipitated under varies conditions,thus lead to the formation of zonation around ore bodies. Therefore, the zonation is a common phenomenon in almost all types of deposits.

In the past, geochemists tend to emphasize the zonation in terms of the composition and their spatial variation but neglected the importance of their correlation. In fact, the spatial variation in correlation between elements could be one of the most important

expressions of zonation which could be used to estimate the erosion degree, a piece of helpful information for evaluating ore potentials.

In Laoling area, eastern Jilin, stream sediment survey revealed a large number of Au, Ag, As and Sb anomalies. It has been confirmed by field observation that these anomalies are related to the ultrafine-grained disseminated Au mineralization in the dolomitic carbonates of middle Proterozic rift sedimentary series and, to a large extent, controlled by the zonation and erosion degrees of the associated ores. The author has discovered that stream sediment anomalies over deep blind Au ores are characterized by distinct anomalies of As, Sb, Ag, Hg and their close association, which, according to S.B.Grigorlian's proposal, are the frontal elements in primary halos, whereas anomalies of so-called rear elements such as Co, Ni, Sn and Mo are less developed and poorly correlated. If the Au ores is shallow or has subjected to a certain degree of erosion, the stream sediment anomalies are not only composed of As,Sb, Ag and Hg, but also Au, Cu, Pb and Zn, and display a complex close correlation between these elements. Based on the above criteria, the author has evaluated ore potentials for numerous stream sediment anomalies in the study area.

THE OPTIMUM SAMPLING LAYOUT FOR THE 1:50,000 STREAM SEDIMENT GEOCHMICAL SURVEY

Sun Zhenyong
(Liaoning Bureau of Geology and Mineral Resources,Shenyang)

Much attention was paid to the persistence of anomalies in the stream sediment geochemical survey in the past. In recent years however, this problem has been neglected due to the great advance of the analytical techniques, As a result of low density sampling ($1\sim2$ sites / km^2) in the 1:50,000 stream sediment geochemical survey, there are not enough samples to control persistence of anomaly . According to the decay pattern of anomalies about the stream sediment geochemistry (Hawkes. H.E, 1976), the element content of anomaly can be expressed as:

$$Mea=(Mem-Meb)Am/Aa+Aeb \quad (1)$$

where Mea is the element content of the stream sediment anomaly in the lower reach of the mineralized district, Mem is element content to be denuded matter in the mineralized district,Meb is the element content of the background stream sediment samples, Am is the surface area of the mineralized distrct, and Aa is the catchment area to be located in the upriver of the sampling point.In general, Mem>>Meb,equation (1),the areal productivity of mineralized district (Ps), may be reduced to :

$$Ps=MebxAm \quad Aa(Mea-Meb) \quad (2)$$

If the shape of the confluence basin is a square, we have:

$Aa = L^2 /2$. So that using equation (2) we obtain :

$$Ps (Mea-Meb) L^2/2 \quad (3)$$

where L is the distance between the apex of watershed and sampling point in stream. It is obvious that the areal productivity of mineralized district varies directly as the element content of anomaly for the arbitrary sampling point and as the squares of decay distance of anomalies as well. Therefore the persistence of anomaly has important indicator significance.

1. Anomaly interpretation

(1) The anomaly resulted from analytical error generally has no persistence.

(2) The anomaly formed by the dispersed mineralization has no concentration center.

(3) The concentration gradient of the anomaly that is formed by the secondary enrichment is opposite to the decay pattern of mineralized anomaly.

2. Anomaly assessment

(1)Inferring the scale of mineralized district (Ps).

(2)The denuded degree of orebody can be estimated (by the transverse zoning sequence of the indicator elements).

(3) Deducing the influential range of anomaly to the environmental geochemistry. The persistence of anomaly should be controlled as a key point in the 1:50,000 stream sediment geochemical survey. Appraising anomalies from the decay pattern of anomaly can increase the possibility of success in mineral exploration and enhance ability to solve the problem involving the environmental geochemistry.

In Liaoning, the lenght of the dispersion trains of the main ore-forming elements gold, silver, copper, lead and zinc etc. is generally greater than 800 meters. The length of most first order stream are between 500~1,000 meters and the average lenght is near 800 meters. The optimum sampling layout should therefore be that the sampling interval is 250~300 meters and the average sampling density is 3~4 sites/km^2. If so, at least three sampling sites are distributed within the persistent distance of anomalies.

Application of hydrogeochemistry to prospecting for uranium in Guidong Granite Massif, Northern Guangdong Province

Sun Zhanxue

East China Geological Institute, Fuzhou, Jiangxi 344000

Guidong Granite Massif is located in the contact zone between the south-western limb of the Hunan-Guangdong-Jiangxi Post-Caledonian Uplift which lies in the margin of the Southern China Caledonian Uplift and the Hercynian-Indosinian Geotectogenein the eastern Guangdong Province. It is a composited rock body composed of different rocks formed by multi-period and multi-stage magmatic activities in Yanshanian, and surrounded by Cambrian System mainly composed of sandstones, slates and shales, Ordovician System consisted of sandstones and shales, and Devonian System characterized by sandstones and shales.

In the area, there exist three groups of geological structures:NNW-trending, NNE-trending and NEE-trending faults. The distributions of mineralizations and groundwaters in the area are controlled by the faults. The ore-bearing zones are basically in accord with the groundwater-bearing ones. Faults and fractures are well developed. Topography is strongly intersected, and groundwaters occur widely in the Massif. For the reason, it is suitable to carry out hydrogeochemical prospecting in the area. Researches reveal that the hydrogeochemical prospecting indicators for uranium in the area are as follows.

1. High content of SO_4^{2-} in the groundwater

In the uranium mineralized area, the uranium concentration of groundwater and High content of SO_4^{2-} in the groundwater are the prospecting indicators for Pitchblende-

Chalcedony-Pyrite type uranium mineralization. A lot of hydrochemical composition data show that the SO^{2-}_4 concentration of non-mineralized groundwater is obviously lower than that of mineralized groundwater.

2. High concentration of HCO^-_3 in ground water

The HCO^-_3 concentration of groundwater is in direct proportion to the uranium concentration of groundwater. High content of HCO^-_3 in groundwater is the prospecting indicator for Pitchblende-Calcite type uranium mineralization. In the area, the average HCO^-_3 content of the uranium mineralized groundwater is 53.17mg/L, while that of non-mineralized groundwater is just 19.55mg/L.

3. Low ratio of $^{234}U/^{238}U$ in groundwater

The $^{234}U/^{238}U$ ratio of anomalous groundwater that flows through uranium ore-bodies ranges from 1.0 to 1.6 , while the ratio of non-mineralized groundwater ranges from 3.4 to 4.2. The difference is very clear.

4. High uranium and radon concentration of groundwater

High content of uranium and radon in groundwater is the direct ore indicator for uranium mineralization. In the area, the background values of uranium and radon in groundwater are 6.9×10^{-7} g/L and 370 Bq/L respectively , while the anomalous values of uranium and radon are 1.08×10^{-7} g/L and 1850 Bq/L respectively.

5. High residual ratio of multiple regression

According to the multiple regression analysis of uranium concentration with HCO^-_3, SO^{2-}_4 and other major ions in the groundwater in the area, the prediction value of uranium content (Up)for any groundwater point can be obtained. Assuming that Um is the measured uranium content of groundwater, the residual ratio (R) of multiple regression can be defined as,

$$R=(lgUm-lgUp)/S$$

where, S is residual standard deviation.

Evidences show that the R value of groundwater in the uranium mineralized area is higher than 1.5, and the shorter the distance of groundwater from ore-body is , the higher the R value is. Obviously, it is of good tracing significance. On the basis of the above-mentioned prospecting indicators and local geological conditions, some prospective uranium areas have been obtained. Furthermore, the forecasting prospect for uranium has been proved to be very successful recently by drill work.

PRELIMNINARY RESEARCH OF SURFACE GEOCHEMICAL ANOMALIES
CORRESPONDING TO PETROLEUM RESERVOIRS

SUN ZHONGJUN

Institute of Geophysical and Geochemical Exploration, Langfang, Hebei 102849, China

In local surface geochemical exploration for locating and delineating petroleum reservoirs, it is important that anomalies are in good agreement with petroleum reservoirs. However, typical annular and apical patterns are rarely found. In practice, patchy and offset patterns always occur. Thus ,it is very difficult to define the location and extent of underlying oil gas pool by geochemical methods. The main reason is that the pathways through which hydrocarbons migrate from petroleum reservoirs to the surface are complex, and gaseous hydrocarbons do not migrate upwards strictly vertically, but divergently through joints, faults and fractures. The research shows that the degree of reduction of chimneys over petroleum reservoirs is not affected by complex pathways. The author therefore used the reducing chimney index (R,K) which can be calculated from Delta Carbonate (ΔC) and Oxdizing-reducing Potential for uncertainty in establishing vertical correspondence bewteen surface geochemical anomalies and underlying petroleum reservoirs. Figure 1 shows typical patterns of the reducing index (R,K) K is an apical pattern, R is a halo or annular pattern. Research results show that K exhibits a marked positive relationship with hydrocarbon fluorescence in soil and a slightly negative relationship with $C_1/(C_2+C_3)$ in soil, R presents a marked relation with ration $C_1/(C_2+C_3)$ and no definite relatonship with hydrocarbon fluorescence in soil. It is infered that ration $C_1/(C_2+C_3)$ in soil may indirectly reflect the bacterial oxdization of vertically migrating hydrocarbon. Thus, K indicates the reducing degree of the chimneys formed by vertical migration of hydrocarbons over petroleum reserviors, and R appears to be related to the oxdization of vertically migrating hydrocarbon.Several tests on the reducing chimney index have been done in known oil and gas reservoirs. Table 1 shows some results obtained before 1989.

The results from 10 cases show that the reducing chimney index may be a comprehensive index which strongly reflects characteristics of oxidization-reduction of the chimneys. The index has an inherent anomaly pattern corresponding closely to petroleum reserviors and is little affected by complex faults systems. It may improve or resolve the problem of correspondence between geochemical anomalies and petroleum reserviors. There appears to be a definite relationship between the reduction feature of chimney and a petroleum reservior, therefore, the reducing chimney index provides us a possible means of using surface geochemical data to predict petroleum reservoirs.

INTEGRATED RADIOMETRIC PROSPECTING FOR PETROLEUM IN LUXI DEPRESSION ,KAILU BASIN

SUN ZHONGJUN AND ZHU BINGQIU
*Institute of Geophysical and Geochemical exploration, Langfang,
Hebel 102849, China*

There has been some experimental success in the use of surface radiometrics for hydrocarbon exploration. However, the results of surveys have often been inconsistent with respect to known hydrocarbon pools, which is probably the results of environmental interference (Klusman and Webster, 1981;Siegel, 1983).This problem must be resolved. The purpose of this paper is two-fold: First, to smooth and obviate the effects of environmental variation by the use of integrating radiation detectors; Secondly,to improve the accuracy in the prediction of petroleum potential by using

integrated radiometrics. Therefore, We tested some surface radiometrics in this research as follows: thermoluminescence radiation dosimetry (TLD) , active carbon gas radon survey (Rn) , ground gamma-spectro-metry (U,Th, K and Tc) and polonium survey (Po-210). The study area is located in Luxi depression, Kailu Basin. Three petroliferous traps are verified by drilling. Geologically, the area has fault-block, fault-nose and anticline traps.Topographically,the area is flat grasslands with sand dunes.

The results of factor and cluster analysis showed that: TLD and Rn consist of one factor, which probably indicates a upward migration of radioactive materials around the edges of hydrocarbon accumulations; K and Tc formed another factor and fell in the same cluster as Rn, TLD and Th in 0.45 similarity level. This factor probably shows a   activated migration of near-surface radioelements over hydrocarbon accumulations; U and Po-210 represented an independent factor respectively.

The high and low anomalies are given in figures with the object of delineating integrated petroleum anomaly patterns of radiometric parameters.TLD and Rn present a typical halo pattern. There are four halo anomalies of TLD which are spatially consistent with Rn anomalies in the area, and five producing oil wells fall within three of the anomaly areas. The data of Po-210 provides three halo anomalies reflecting oil traps and three low anomalies caused by sandy samples locating the northeast of the study area. Furthermore, this is testified by two dry wells drilled afterwards. Relatively speaking, the gamma ray spectra provide more complicated results, different patterns and a larger number of anomalies. U is a typical halo, and others show a low anomaly pattern, Six anomalies of U or Th ,five anomalies of K and three anomalies of Tc are delineated. Their anomaly characteristics are somewhat similiar to Po-210. It is clear that the petroleumanomalies indicated by all of the radiometric parameters and soil anomalies showed by U, Th and Po-210 coincide in the area.

On the basis of our study, the following conclusions can be made: a)Integrating radiation methods (TLD and Rn) that can smooth the effect of environment variation and improve detection depth not only indicate a upward migration of radioactive materials around the edges of hydrocarbon accumulations, but also show a activited migration of near-surface radioelements -- the well-known chimney effect. Thus the anomalies delineated using these methods have a good spatial relationship with underlying hydrocarbon pool. b) The shortcomings of surface radiometrics for the prediction of petroleum potential, when petroleum and environment information is mixed up, can be also reduced by the use of integrated radiometrics. Although radioelements have discrepancies in geochemical behavior, they can provide some significant information related to petroleum in some way or other . Therefore, improvements in the accuracy of prediction and success rate are probably anticipated when integrated radiometrics are used.

GEOCHEMICAL METHODS FOR QUANTITATIVE PREDICTION OF MINERAL RESOURCES

TAN GUOPING

Understanding of geological condition and law of ore forming is the base of various scales quantitative prediction of mineral resources and assessment of regional resources. On the base of which establishing ore deposit model of common significance is comprehensive result to geology understanding to assess quantitatively geochemical abnormal, which is objective reflection of various mineralization, can determine not only the resources quantity of some contents, but also the areas of mineralization, which is the key to large scale quantitative predicting.

The study between industrial ore -body index and various geochemical abnormal index of concern is the base of the methods for working out geochemical principle to assess mineral resources. In order to find the regularity of their relationship and work out predicting index of deposits to assess the existed geological abnormals, the concept of ore body must be strictly distinguished from ore deposits. When the principle of resources assessment are worked out, ore deposits are not simple combination of ore bodies, but certain combination of ore bodies and its protogenous halo.

Protogenous halo and ore body are united in space and it's genesis, whose boundary is set by economic index. The ratio between metal quantity of protogenous halo and ore body varies according to the formation type of deposit. Protogenous halo in most deposits has a large reserves. Geochemical index established by composition and structure features should be applied efficiently to assess prospective mineral resources of geochemical abnormal area, which is established on the base of study of model deposits of various genesis. Axial zoning feature of protogenous halo is of the most important, which can be used to assess disintegration level of abnormal. It is the first step for resources prediction that the disintegration level is determined reliably.

QUANTITAIVE TRANSITION OF SECONDARY HALO-PROTOGENOUS HALO AND IT'S APPLICATION IN EVALUATION OF GEOCHEMICAL EXPLORATION ABNORMAL

TAN GUOPING

Soil geochemical exploration is now of the main methods of large scale geochemica lexploration. The main goal of the method is to encircle soil geochemical abnormal (secondary halo).Secondary halo is a kind of hypergene geochemical abnormal which formed in its overlying loose material when ore body or protogenous halo hypergene mechanically slacked or chemically attacked. It can indicate existence of ore body and protogenous halo.

Former USSR scholars have studied the theory of secondary halo-forming in detail.It is direct problem that location, morphology and content of secondary halo can be approximately infered from known location morpholagy and content of protogenous halo.The inversion problem is more important tp calculate location and intensity of protogenous halo from known morphology and intensity of secomdary halo in reality . So morphology and location of ore body can be studied more directly by theory and method of protogenous halo. Good ore prospecting result has been made in attempt of this work in geochemistry. First, to suppose the influence of the other hypergene factors except for topography to element redistribution in each point is the same or resemble under the same landscape geochemical environment. Residual slideroch is not thick(<2m) and each landmarks is close. So we can get the formular herein:a.When topographic slope is equal to 0b.When topographic slope is equal to In formular C(x)

is content of secondary halo of the place x point distance from center of protogenous halo. Mp is linear productivity of protogenous halo, a is disperdsion coefficient, that is half width of halo in 0.6Co level. In specific landscape geochemical conditions,is a constant, Kz is productivity coefficient. In identical area of the same kind of element ,Kz value is a constant, Ka is peristaltic coefficient of halo. It is function of slope a .Z is soil width and Ka Z is distance of secondary halo depast prom protogenous halo, To solve inrecsion problem to get Mp and Ka in formular (1) and (2) , and then to dertermine intensity and location of protogenous halo. Applying the method to evaluation of large scale secondary halo in Tonghua Jilin, a gold mineralized alteration belt has been discovered, and grey predictive model is applied to ascertain possible spatial location of ore bedy.

ON RELATIONSHIP BETWEEN THE REE ABUNDANCE IN THE CRUST AND HUMAN BODY

TAO ZHENGZHANG
(Chengdu College of Geology, Chengdu, China)

By use of logarithmic plotting and regression analysis, the author has compared the abundance of the REE in the crust with that in human blood (plasma & serum) and body. The study has shown that no similarity could be possibly seen. After all,the life processes are fundamentally different from the geological activities, therefore ,the author disagrees Eric Hamilton's view that elemental abundance in human body is surprisingly similar to that in the earth crust except C,H,O,N,Si.

Basic Theory and Methodology of Geochemical Ecospecies Mapping

WAN TE
Institute of Geophysical and Geochemical Exploration Ministry of Geology and Mineral ResourcesLangfang, Hebei 102849, P.R.C.

JIN YINLONG[1], WANG PEISHAN[2] AND GENG GUANYI[2]
1--China Academy of Preventive Medicine, Beijing
2--Tianjin Medical College, Tianjin

The Project supported by the National Natural Science Foundation of China (NSFS) geochemical ecospecies mapping is the methodology of studying the health and disease conditions in regional biological phenomena.It belongs to the applied basic research.The nominated"geochemical ecospecies mapping"is to,from the point of view of synecology of population of animal and plant, upon of multielement distribution map,combining the data of non-infectious epidemiology survey,establish the correlation between the elements associated disease model, growth pattern (include ecotyp, population or organism growth form)and water-soil geochemical anomaly, to harmonize the cause and effect relation through pattern classification, pattern analysis and pattern recognition, and to study the similarity degree of diseases (such as similarity coefficient of species)with comparative law and method of analogy,so as to exploring and investigating the geographical distribution and epidemiological

characteristics of diseases of unknown pathogeny and so far as possible to give a rational explanation to geochemical ecology.Pursuing geochemical ecospecies mapping,by means of geographic mapping.series maps,dynamic map and regional ecology contrast,we are able to locate the boundary of hyperendemic domain of major diseases,such as endemic disease,puplic nulsance,cancer and some chronic diseases and also being capable of finding out the nutritional,physiological and clinical significance of trace elements in pathogeny investigation.Our destination is to adopt cheap and effective chemoprophlaxis without side-effects just in accordance to the actiology,and to improve the China's social health organization and service.

Over a long period of time,China academic circle has dedicated to thoretical and methodological preparation,hoping to apply the achievements relevant to geographical distribution (regional geochemical exploration)of element content in broad areas,to provide important basic data for agriculture,forestry,animal husbandry and endemic affairs.Nowadays the mechanisms of in vivo and in vitro biotransformation of trace element are still remain in a stage of obscurity,we are willing to probe a train of thought, being suited to China's national condition and present speciality, trying to find out the probable co-relation between trace element and disease. The basic concept of geochemical ecology regards:

(1)Essential elements in organism are comparatively stable,both deficiency and overdosing will induce physiological variation of body tissue. Any one kind of trace element cannot be synthesized by body tissue. Biological phenomena can only exist through the functions of assimilation, dessimilation and retention during metabolism. Health and disease, evolution and degeneration, normal and abnormal are maintained by getting rid of the stale and taking in the fresh,especially the later. Without the leading role of refreshing,no change of disease will happen. Therefore, the distribution and content of trace element in environment are closely connected with the amount of ingestion and storage by human beings.

(2)Nowadays,multi-factors theory plays an important role in aetiology.According to the opinion that different factors (elements) can induce different diseases or same factor (element) can induce different diseases in different position, we do our best to harmonize the co-relation between trace element and diseases of unknown pathogeny through geochemical ecospecies mapping, to provide the clue for studying geochemical environmental disease. The major data of geochemical ecospecies mapping include: the survey of national tumor mortality rate from 1973 to 1975 and the gucstionnairs of the incidences of national endemic goitre and endemic cretinism from 1982-1983.

At present, the correlation of the measured criteria of frequency of some diseases (geoecotype) and the value of regional exploration are undergone statistical analysis. Statistical data are continuous distribution document of administrative department of village and town. According to the intimate degrees of co-relation,a minority of major element indexs are piled up to compile the geochemical integrated anomaly map.Consequently, the disease boundarys are delimited on the basis of anomaly pattern,geology and geography. The methodology of delimiting disease area with high incidence and pathogeny investigation are nominated geochemical ecospecies mapping. The significance of practising geochemical ecospecies mapping in China is as follows:

(1) To study nosology with ideal type and ecological landscapes grouping are more confirming to cause and effect sequence than simply in reference of symptoms and signs of disease, furthermore benefitting in pathogeny persveing.

(2) Clinical doctor may select affecting factors from multiple pathogenis factors.

(3) To simplify the physiological, pathological and pharmacological simulation of byperendemic danain, optimize the standardization and working style and promote the scientific development of field study.

(4) To strength the environmental managment of preventive medicine, such as to enhance the manifestation method of disease distribution map.

IDENTIFICATION OF BACKGROUND AND ANOMALY FOR MULTI-ELEMENT GEOCHEMICAL DATA

WANG BAOZHEN

Institute of Geophysical and Geochemical Exploration, Ministry of Geology and Mineral Resouces, Langfang, Hebei 102849,China

Essential in evaluating target element anomalies and finding ore deposits is determining the background and anomalies of multi-element geochemical data. Evaluating target element anomalies using multi-element anomalous areas is a scientific method which works according to geological and geochemical principles, and the inter-relationship of elements. Geochemical data reflects the development of elements in space and time. Decomposing this historical development process allows for new insights into mineral geneses. Different geological genesis result in different combinations of elements, reflecting particular geochemical processes.

Samples taken at the observation site contain such information as the variation of elements and the geochemical actions between the elements in the process of digenesis, mineralization and exogenic actions. R-mode factor analysis is done to the original geochemical data for the purpose of studying the relationship among elements and understanding which elements closely relate to the factors. Each factor can represent a particular geological action. The strength of a geological action in the element distribution process can be inferred from the distribution of factor scores as well as the distribution of a series of closely related elements. Two factors related to Au were found through R-mode factor analysis of geochemical data taken from a district in China. Two associations of elements, closely related to these two factors, represent individual population. In this way, determining the background and anomaly of the individual population bears directly on locating Au deposits.

Multi-element association data are formed using the mean value, or the root mean square value of relative main element contrast. This data are processed before computing the gap statistics. When geological conditions are relatively simple and element distribution is approximately normal or logarithm normal, the data are symmetrically transferred. When, on the other hand, the geological conditions are complex, the data are power transfered. Gap statistics is used to determine the threshold objectively.

In comparison with the traditional method of drawing target element anomolous areas, this new method coincides more accurately with the ore deposit area. It reduces target areas for ore deposits. The results have indicated that all known ore deposits are inside multi- element anomalous areas. This method can also be used effectively in areas which have been explored extensively for years without result, despite positive evaluation for gold using the traditional method. For one such site, maps drawn using the new method indicated that despite high Au content, because the site did not coincide with a multi-element anomolous area, no ore body would be found. Thus

identification of background and anomalies for multi-element analysis will be effective both in finding deposits and in reducing costs arising from analytical errors.

ABUNDANCE OF GOLD, GOLD BEARING FORMATION AND APPRAISAL OF GOLD BEARING ABILITY.

Wang Dongbo
(Institute of Geology for Mineral Resources, CNNC, China)

Since "Clark concentration" is often concerned in exploration of gold deposits and appraisal of gold-bearing ability of strata,therefore, the Clark value of gold will directly affect theeffectiveness of appraissal of gold-bearing ability.Although many geochemists (F.W.Clarke et al, 1924; V.M.Goldschmidt, 1954;A.P.Vinogradov, 1962; S.R.Taylor, 1964; Li Tong et al, 1976) have calculated the abundance of elements (including gold) of the crustusing different kinds of method, there are still some vital problems about calculating methods, which are:

1. Without a uniform concept about crust, none of them had calculated the Clark value according to modern structure model ofearth (crust);
2. Neglecting composition of ocean crust and difference betweenlower continental crust and lower ocean crust;
3. Unconsidered the composition shifting of crust with depth;
4. Owing to limitation of analytical accuracy of gold in the past, all Clark values of gold given by above geochemists are much high than real one.

Modern geophysical information have demonstrated that the lowercrust is composed of felsic rocks, not mafic rocks, for thisreason, the abundance of gold in crust undoubtedly will change.

Study shows that abundance of gold in common rocks is about 10 (-9), and the abundance of upper continental crust probably is $1\text{-}1.5 \times 10^{-9}$ (Dai Wentian, 1991), the abundance of gold of majorterrains (South Qinling oorogenic zone, North Qinling orogeniczone, north margin of Yangtze platform, south margin on NorthernChina platform) in Qinling Orogenic zone and neighbouring areavaries from $0.5\text{-}1.1 \times 10^{-9}$ (Zhang Benren et al, 1991).

Both domestic and foreign analysis data indicate that abundanceof gold of different kinds of rock (from ultramafic to felsic)varies from 0.6 to 1.1×10^{-9} (F.T.Flanagan, 1973; Lou Tingchuanet al, 1991; S.Ashihar,1988), which shows that the abundance ofgold in different kinds of rock and terrain is lower than those published in the past. The author thinks it is necessary to correct the abundance of gold in the crust now, $1.0\text{-}1.2 \times 10^{-9}$ is more reasonable gold abundance of upper continental crust.

Geochemists have found that the host rocks of some large gold deposits have lower background of gold, the abundance of "gold-bearing formation" or "bed-source of gold" (regarded in the past)is obviously lower, but they still can be regarded as the bed-source of gold,because of involvement of multi-periodic geological activity, a large part of gold of strata or magmatic rocks had been extracted to form gold deposits

and halo, therefore, the abundanceof gold analysed is only remnant and correspond to inaccessible gold.

The appraisal of gold-bearing ability in strata is a very important procedure in the process of exploration of gold and discrimination of gold-bearing formation. In this paper, it is strongly pointed out that the abundance of gold in strata is not only a discriminating factor, but also the geochemical appraisal crilteria of gold, they are abundance distribution type (Xa-arithmetic mean, Xg-geometric mean), Xg/Xa ratio and variation coefficient, existing form and elemlent combination of gold Instrata. Througth the practice oof appraisal of gold-bearing ability of middle-upper Proterozoic Sub-erathem in the south Qinling Orogenic zone and theoretical analysis, the geochemical indicators which favorabe stata to gold mineralization have are:

1. Higher abundance of gold;
2. Lower Xg/Xa and higher variation coefficient;
3. Multi-modal skew distribution of gold;
4. Higher ratio of accessible gold; and
5. Gold forming special element combination, which is similar to the mineralized element combination in the area.

A STUDY ON SE CONTENT OF SOME CROPS IN CHINA AND THEIR GEOLOGIC BACKGROUNDS

WANG MEIZHU

Based on field investigations of some farm,tea and vegetable gardens in China, 69 samples of parent matters and rocks, 84 samples of soils and 240 samples of corn, tea and radish were taken, and their total Se content was analyzed.The results can be drawn as follows:

Se content in most samples of corn, tea and radish studied is comparatively low, but a few samples exhibit Se enrichment, The statistical results show that Se content in corn, tea and radish are 0.085-0.164, 0.021-0.770 and 0.084-12.154 ug/g respectively, and their geometric means are in order of 0.118, 0.129 and 0.320 ug/g. Frequency distributions of Se abundance of crop samples also show that Se content in 60.15% samples of corn, 51.06% samples of tea and 52.20% samples of radish are lower than their geometric mean respectivly. The results also show that, among three above-mentioned crops, radish has the strongest biological accumulation ability to Se. The Se content ratios of the samples with highest Se content to that with lowest Se content in radish, corn and tea are 1:98, 1:24 and 1:35 respectively .Se content in radish leaf is 2-2.8 times as high as that in its tube.

High Se are almost produced in high Se soil which derived from high Se rocks or parent matters. The Se contents in radish, tea and corn in high Se rock reach as high as 0.996-5.556, 0.422-3.859 and 0.403-2.227 ug/g respectively. The positive correlations are found between Se content in crops (Y-) and that in rocks or parent matters (X-), their linear regression equations are:$Y-=0.0487+0.0659X-$ ($r=0.9948**$ $n=7$) for corn, $Y-=0.0724+0.176X-$

($r=0.9996**,n=9$) for tea, and $Y-=0.0479+0.262X-$ ($r=0.9970**,n=6$) for radish.

In China, the highest Se strata of the parent matters or rocks, on which farm was formed, are siliceous shale and carbonceous siliceous shale of the Permian and Ordovician-Cambrian period. Their Se contents are 20.99 ug/g (n=5) and 69.437 ug/g (n=20) respectively. The secondly high Se strata is ChangXin limestone of the Permian period with Se content as high as 4.11 ug/g. The Se content in soil derived from high Se strata was 9.04 ug/g 9(n=12), however, Se content in most parent matters or rocks in China is as low as 0.5 ug/g, with an average of 0.131 ug/g (n=25), such as granite, tuff, fine arenaceous shale, shallow sea deposit and lecustrine sediments etc.

DISTRIBUTION OF TRACE ELEMENTS IN HETAI GOLD DEPOSITS, WESTERN GUANGDONG, CHINA

WANG MINGQI
Institute of geophysical and geochemical exploration, Langfan, Hebei 102849, China

Hetai gold mine is hosted by precambrian strata comprising quartz schists. Gold orebodies occur in ductile shear zones. Two different types of ores were recognized, but most of economic ore is composed of gold-bearing miltonite (silicified hostrock). Lots of studies on the geology, mineralogy, petrology and geochemistry of Hetai gold mine have been carried out in recent years and geochemical exploration (soil and steam sediment survey) has been playing an important role in detecting Au anomalies and locating gold orebodies. Hundreds of samples from different gold deposits in Hetai district, including bedrock, ore and soil, were collected during 1986-1988. The samples were analyzed for Au by AAs, for Cu, Pb, Zn, Ag, Mo, Ni, Co, B, Be, Ba by ES and for As, Sb, Bi, Hg, Se, Te by AFS.

A marked feature of trace elements in strata for Hetai area is that Au, Cu, As, Ba and V in old units (Pt and precambrian) are much higher than that in young O, S, D and C units. The old gold-rich stratum units could be considered as one of potential origins of gold. Au, Cu, Bi, Te, Ag are highly enriched and Mo, As, Sb, Se show a slight increase in the ore from different deposits. A marked decrease of Cu, Te and Te/Se ratio from Yuenxi (north zone), Gaochun (central zone) to Shangtai deoposit (south zone) may indicate that sulphide mineralization in the north zone is stronger than that in the south zone and because of good correlation between Au and sulphide mineralization, further exploration for potential gold mineralizations or deposits in the area should focus on the north zone. Strong Au, Cu, Ag, Te and weak Bi, As, Sb, Se anomalies occur around the gold orebodies, and Au, Cu, Ag, Te anomalies extend to more than 100m upwards from gold orebodies. Thus, Au, Cu, Ag and Te can be used as indicators to prospect hidden gold mineralizations for lithogeochemical exploration.

The contents of Au, Cu, Ag Te and Te/Se ratio show a great decrease and As Sb show a slight increase downwards from gold orebodies. Au exhibits positive correlations

with Cu, Ag, Te and Bi in gold orebodies. Due to strong weathering, only Au, Cu and Te anomalies were detected in the soil over goldorebodies, and Cu, Te anomalies in soil are much smaller than Au anomalies. Au is a best pathfinder in soil geochemical exploration for gold in the district.

Se AND Te IN SOME GOLD-BEARING SHEAR ZONES OF CHINA

WANG MINGQI
Institute of geophysical and geochemical exploration, Langfan, Hebei 102849, China

Gold deposits in gold-bearing shear zone is very important gold-productive source in China. Among them the biggest ones at date are Hebai gold mine in Guangdong, Zhaoyi gold field in Shandong and Shanggong gold mine in Henan. Gold orebodies in these deposits are hosted by precambrian metamorphic rock and restricted within ductile shear zones. Migmatitic granites often occur near or around gold field. The grains of native gold in ore are fine. The content of Ag is low and Au/Ag ratio is high in native gold.Silicification is weaker compared with gold quartz vein deposits. Main sulphides in ore are pyrite, chalcopyrite, sphalerite and galena.

The samples of ore and non-mineralized wallrock from Zhaoyi, Hebei and shanggong gold mines were collected. Au of the samples was determined by AAS and Se, Te were measured by AFS.Se (0.1-0.42 ppm) is slightly enriched, and Te (1-8ppm) is highly enriched as compared with the wallrock, whose Se and Te show a comparatively small change (0.01-0.05 ppm) and Te/Se ratio is much larger than 1 in the gold ore from different gold mine. Au-Te exhibits a positive correlation in ore.

Se and Te primary halos occur around gold orebodies, coincide with the distribution of Au primary anomalies and extend 50-200m upwards from gold orebodies. Thus, Se and Te are useful pathfinder elements for lithogeochemical exploration of shear zone type gold deposits.To compare with quartz-vein type gold deposits, the samples of ore and host rock were also collected from two gold quartz vein deposits, Hatu gold deposit in Xinjiang and Linglong gold deposit in Shandong. Te/Se ratio, quite different from that in gold-bearing shear zones, is low (less than 1) and Te content is low (less than 1 ppm) in gold quartz vein. Gold quartz veins exhibit geologically on the top of the deposits, and gold-bearing shear zones is low (less than 1) and Te contert is low (less than 1 ppm) in gold quartz vein. Gold-bearing milonite appears in depth in some individual deposits of Zhaoyi gold oreftield. Surprisingly, the distribution of Se, Te and Te/Se ratio in gold-bearing shear zone are much higher than that in gold-quartz vein.
The correlation between the distribution of Te in gold deposits and ore types may suggest that gold-bearing shear zone (Te-Au) mineralizations take place in the bigger depth, therefore, to some economic gold quartz vein deposits in China, much attention should be taken to prospecting for shear zone type gold orebodies in depth.Further researches on the distribution of Se and Te in gold deposits, however, should be done tc understand fully the relationship between Se, Te and Au.

HYDROGEOCHEMISTY OF TWO BASE METAL MINERALIZATIONS IN FOREST BOG AREA, NORTHERN HEILONGJIANG PROVINCE, CHINA

WANG MINGQ[1], REN TIANXIANG[1], LIU YINGHAN[1] AND LIU SHUXING[2]
1 Institute of Geophysical and Geochemcal Exploration, Langfang, Hebei 102849, P. R. China
2 Geophysical Exploration Team, Shuangcheng, Helongjiang, PR China

Forest bog landscape is developed in the upper northeast of china, where middle-low hills comprise the main geomorphology landscape. Bogs are widespread along U-shaped and V-shaped valleys (200m-2000m wide) or at the depression. Generally no obvious water passage is observable in first-order streams. To study the mobility of elements and methodology of 1/200000 regional geochemical mapping in forest bog area, stream water in addition to stream sedment, soil, peat and heavy minerals were sampled from two base metal mineralizations (Pb-Zn-Ag-Mo and porphyry Cu) in 1991. A 400 ml water was collected and preconcentrated by PNA-CdS co-precipitation in the field. Precipitant was filtered and dried. Cu, Pb, Zn, Ag, Mo, Ni, Cr, Co, V, Ti, Mn, Be, Ga and Fe in residual were determined by emission spectrography in the laboratory. At same site, a 200 ml water was collected in acid-rinsed polyethylene bottles for analysing $SO_4^=$, Cl^-, F^-, B^- by ion chromatography, and another 200 ml water was collected and acidified to pH<2 with HCl for analyzing Au by AAS with MIBK extraction. At the same time, pH in the stream water was measured in the field using pocket acidometer. To study the effects of suspensions on the contents of elements in stream water, water was filtered first through fast filter paper and then through 0.45 mm filter film in 1992. The papers and films were analyzed by AAS for Cu, Ag, Pb, Zn, Fe and Mn. The results show that although most of elements in stream water are lower that in general river water in the world, a number of elements are quite mobile, transportable over long distances and form marked anomalies in stream water around the known mineralizations in this landscape. Cu, Pb, Zn, Fe and Mn show no change both in the filter paper and film between background and anomaly water while Ag exhibits a big increase near mineralization. In Duobaoshan porphyry Cu (Mo) deposit, pH in stream water is 5.9-7.2 and increases down the streams. Cu, Ti, Fe, V, $SO_4^=$ showed marked anomalies extending more than 5 km downstream from the deposit while Ga, Zn, Mn showed marked increases and Fe, Co, Ni, Ga, Be, Br, F^- showed slight increases around the polymetallic mineralization. In beilushan area marked Cu, Zn, Fe, Mn and $SO_4^=$anomalies and relatively weak Ni, Co, Be, PB and F^- anomalies occur in stream water around the known mineralization. pH (4.0-5.5) in stream water near the mineralization is much lower than pH (5.7-6.5) in the background water. Cu, Zn and Mn can migrate in stream water at pH<5.5, precipitate at pH>5.5 and form notable anomalies in the peat.

Fe begins to precipitate at about pH=4 and exhibits anomaly in the peat. The results show that, therefore, stream water is a good medium for geochemical exploration for base or even precious metal deposits in the landscape because heavy cover plants prevents clastic matter from being carried down by surface water and water is penetrable to the cover, widespread and easy to be collected.

THE BASIC PRINCIPLES AND METHODS OF COMPREHENSIVE INFORMATION: ORE-FORMING SERIES PROGNOSIS

WANG SHICHENG AND CHEN YONGQING
(Changchun University of Earth Sciences)

The basic principles and-methods of comprehensive information regional metallogenic prognosis are shown in this paper.The basic principles include the principles on metallogeny.geochemistry.geophysics and remote sensing geology. The author think that geochemical information is direct prospecting signation for any mineral deposits.From view of regional integrated evaluation on anomaly,comprehensive information ore-forming series prognosis is,in fact,a integrated quantitative appraisal on geochemical anomaly as well as the geological background in which it occurs by mathematical models,and raises the effect on anomaly estimation.

Geochemical anomaly is divided into regional and local anomaly on its scale.The former may be related to the geological body which favours to form mineral deposits. The latter may be related to the mineral resource body.

The mineral resource body is the product of geological erolution on the base of the favourable ore-foming geological body,and the geological body is the material source of forming mineral resource body.The geochemical anomaly can be also classified into the strata-binding, fracture-binding, intrusive body-binding and ore-binding one on its controlling factor.The main feature of the ore-binding geochemical anomaly is the overlapping anomaly which is controlled by multi-factors(strata.intrusive body and fracture).

The basic methods include compiling the integrated information prognostic map and building up the integrated information prospecting model.The characteristics of multi-stage catchment basin network geochemical anomaly map and its compiling method is narrated in detail in the paper. The authors think that the catchment basin must be used as an unit to study the anomaly distribution of dispersion train(heavy mineral and stream sediment),and that the integrated analysis on two kinds of dispersion trains which come from the same source will give aid to recognize their types of geochemical anomaly.

The establishment of comprehensive information prospecting model must use the geological body or mineral resource body as a unit to connect.trans-form and extract various kinds of ore-forming information under ore-forming series theory's guidance,and eventually the quantitative locating predication of ore-forming series is realized with help of the prospecting model

IODINE VAPOR--A USEFUL INDICATOR FOR GEOCHEMICAL EXPLORATION IN AREAS WITH OVERBURDEN

WANG WEIXI
(Ganshu Bureau of Geological Exploration, CNNC, Lanzhou)

Iodine has long been considered as a pathfinder in geochemical literature. It occurs in soluble complex anion in post-magmatic hydrothermal solutions. Similar to Hg and As, it is volatile in the form of non-ionic vapor. Therefore, iodine can migrate through thick overburden far away from a deposit to form a wide halo which could be detected at the surface.

In 1991,the author made a breakthrough in the iodine vapor detection technique which has a detection limit of 4×10^{-10}g/ml. By use of this instrument, a number of ore deposits with different types of overburden have been tested for their iodine vapor anomalies. Over known Au ore bodies in Jinwozi and Nanjinshan deposit, both are covered by Gobi Desert, iodine vapor anomalies are detected exactly at the surface projection of the ores by iodine vapor detection. In areas covered by thick loess, traditional surface geochemical exploration is also difficult. The well known Cu Deposit of Baiyin is located in such area, whose reserve has nearly exhausted. Along the 8th line of Xiaotieshan ore, Baiyin, a distinct iodine vapor anomaly as wide as 200m with a contrast of 30 has been edlineated just at the surface projection of the ore body where it is buried 30m below. Along the 13th line of the same ore body where it is buried 350m below the surface, no any geological and geochemical indication at the surface has ever been reported, but a clear iodine vapor anomaly has been detected by the iodine vapor sensing.Iodine is also found to associate with oil and gas fields where it can diffuse from the accumulation in the form of organic compound and concen-trate in the soil. So, iodine vapor survey can be a new tool for petroleum geochemical exploration as well.

CHARACTERISTIC RESPONSES OF OIL AND GAS IN GEOCHEMICAL EXPLORATIONIN ORDOS BASIN.

Wang Xifu
(Institute of Exploration and Development of Changqing PetroleumExploration Administration)

Geochemical exploration for oil and gas in Ordos basin has been conducted for years. The main geochemical indicators being used are hydrocarbons which is extracted from cold acid treatment ofsamples. Reconnaissance and exploration survey were conducted overan area of several tens of thousand square kilometers. The characteristic geochemical responses of oil and gas occurred indifferent structural units has been studied, and the intrinsic relationship between distribution of oil and gas and geochemical anomalies has also been diagnosed. Five structural areas are taken as examples and introduced as follows.

1. CHARACTERISTIC GEOCHEMICAL RESPONSES TO THE MIGRATION AND CONCENTRATION OF OIL AND GAS IN YIKEZAOMENG UPLIFT.

Yikezaomeng uplift is located in the northern margin of the basin, the state of up heaving was begun since paleozoic age.Because there was a hydrocarbon generated center in paleozoic groupin Wushengqi area which is neighboring with the southern part ofthe uplift, and, by diagnosis, it is the destination of oil and gasmigration. The outcrop of oil seepage in the northern side of the uplift extends more than a hundred kilometers. This indicates therule of accumulation and loss of oil and gas. It is also provedthat the distribution of oil and gas is controlled by regional tectonic structure zone.

It is found through geochemical exploration that there are threehigh hydrocarbon concentration zones locating from north to southoccurred in this area. They conform with the trend of secondarytectonic structure units, i.e. NWW-SEE. The II high concentrationzone is located over the fault zone in the south flang of Wulangeer Uplift. It has very high intensity of hydrocarbons and the patternof which was exactly coincident with the distribution of Cretaceousoil seepage on the ground. It indicates the result of oil and gasdiffused upwardly through faults. The high concentration zone II(HCZ II) distributes over the arc-shape structure zone in thisarea, in which block structural traps are developed. The objectivestratum of paleozoic group is well preserved and the highconcentration zone which has a length of 230 km. and a width ofsome 40 km., indicates its perspective, and industrial gas flow wasobtained through drilling.

The HCZ III is distributed over a giant nose-like structure.Because of too small survey area was previously laid out, the finalresult can not be obatined yet and further work is necessary.

It can be concluded that the distribution of high concentrationzone of hydrocarbons can reflect the feature of oil and gasdistribution to a certain extent.

2. THE FEATURES OF DISTRIBUTION OF GEOCHEMICAL ANOMALIES OVER THE GAS-BEARING AREA IN ANCIENT CENTRAL UPLIFT AND ITS GEOLOGICAL SIGNIFICANCE.

According to the 9x9 low-pass filtered map and the contour mapof C_1; C_2, C_3 and C^{2+}, the area can be definitely separated into the northern part of low background and the southern part of high background. Factors causing the difference of geochemical field possibly due to only paleozoic group containing the hydrocarbon-bearing strata occurs in the north, but in addition to thehydrocarbon-bearing paleozoic group there are also the superimposed mesozoic group occurs in the south which contains the hydrocarbon-bearing strata as well. It indicates through diagnosis that thepresence of geochemical anomalies are intrinsically correlated withthe paleozoic group gas accumulated area.

(1) There are three main anomalous area related to the northernnatural gas accumulation.

a) Jinbian anomalous area. The eastern and southern margins ofthe area is covered by fine-grain loess. According to the variationof concentration, the eastern and southern boundary can be welldelineated. Despite the western part of the area which is coveredby sand dune, the western boundary can also be delineated by thecharacteristic dense distribution of soil gas hydrocarbon anmalies.

However, the northern boundary is out of the working area. Therange indicates by the upper mentioned boundaries is conformed withthe result of presently known drillings.

b) Dingbian and Zaohuangmiao anomalous area. In these area, theabundance of hydrocarbons is very low and high concentrationappears in saline area. It is considered to be of no significancein delineation of ga-rich area. However, using soil gashydrocarbons as indicators we can see that the Dingbian an dZaohuangmiao areas is the high soil gas hydrocarbons concentrationarea which indicates that they are perspective target areas for gasexploration, the area of which are 7600 and 500 square kilometersrespectively.

(2) The southern part of gas bearing area of the uplift is coveredby loess. After plotting a 9kmx9km moving average map ofhydrocarbons, a regional anomaly with an area of 2500 squarekilometers is discovered near Wuqi. Although in this area thereare several known small oilfield in Triassic and Jurassic systems at shallow, but the cause of their increment of hydrocarbons insurface has already been cancelled as a local factor during the 9x9moving averaging. It is indicated through diagnosis that theregional anomaly is not caused by the shallow seated oilfield andis possibly caused by gas accumulated area of paleozoic group. This conclusion remains to be proved by further exploration work.

4. GEOCHEMICAL INFORMATION OF THE ANCIENT LANDFORM TYPE OILFIELD AREA IN SILURIAN SYSTEM.

(1) Geochemical information exactly reflects the location of regional oil and gas concentration.

In Qingyang district, trend surface analysis has been done forthe hydrocarbons survey data, and the result reveals that the high concentration zone extends from NE to SW. It is generally inconform with the distribution of old river channels of Jurassaicsystem. The rule of oil and gas distribution in this district is generally, oil and gas migrate along the channel upwardly andaccumulate in hills of fossil landscape on both side of the valley.

High concentration zone of hydrocarbons coincides with the oldriver channels and reflects the tracks of regional migration of oiland gas and their locations exactly.

(2) Geochemical anomaly often occurs over the ancient landform typeoilfield and appears as distinct ring_shape anomaly, hence, new oilreservoir can be discovered by using this kind of pattern.

. Taking the survey in Fanjiachuan oilfield area as an example,where three rin-shape anomalies were discovered. The western anomaly is located just over the Fanjiachuan oil reservoir; themiddle and eastern ring_shape anomalies turned out to be twooilfields after drilling.

5. GEOCHEMICAL EXPLORATION IN THE TRIASSIC DELTA, SOUTHERN PART OF THE BASIN-AN AREA OF LITHOGENIC-TYPE OILFIELD DOMAIN.

Oil and gas are distributed in the sand body at the distributary channel and front part of the delta. If the density of sampling grid is appropriate, geochemical anamalies are often occurred overthe oil pool and appear as distinct ring-shape halo and apical anomaly. For example, Tianping and Wangyao oil reservoirs of Ansaioil field is now under exploration and high sampling density geochemical survey reveals local ring-shape halo and apical anomaly which can well control the reservoirs and the enlarged part of the anomaly has further proved by exploring drill to be oil producing.

The previous description of the geochemical characteristics related to different oil and gas bearing units in the basin. Itoffers geological information of different levels and

indicates that geochemical exploration has the prospective future inapplication to oil and gas exploration in basins.

SURFACE GEOCHEMICAL EXPLORATION FOR OIL AND GAS IN ORDOS BASIN: A MAJOR GAS DISCOVERY

WANG XIFU AND YANG XIAOYUAN
(Changqing Bureau of Petroleum Exploration)

FEI QI AND RUAN TIANJIAN
(China University of Geosciences, Wuhan)

Ordos Basin is the second largest sedimentary basin in China, whose central part is characterized by nearly horizontal strata some 4,000 meters thick. In order to evaluate the oil and gas potential, the surface material (mainly sand and loess) of this 30,000 km^2 area was sampled at a depth of 2 m with density of one per km^2 during 1988-1990. The samples were analyzed for C1 and He from vacuum extracted soil gas and for C1-C5 after acid treatment as well as delta carbonate and thermally released Hg. Before the discovery we hit the pay zone in 1988 winter, the authors correctly predicted the existence of natural gas accumulation underneath according to a careful analysis to the geochemical anomaly obtained at that time. The large data set was processed statistically and by low-pass spatial filtration. Based on the geological feature of the entire area, a simple additive model was proposed to explain the multiple suorced anomalies.Three potential areas have been delineated each more than $1000km^2$, one of which has been extensively drilled by Changqing oil Company and turned out to be a large gas field.

APPLICATION OF THE ANALYTICL TECHNIQUE OF DETECTING SINGLE ATOM WITH LASER TO GEOCHEMICAL EXPLORATION FOR GOLD

WANG XUEQIU AND LU YINXIU

*Institute of Geophysical and Geochemical Exploration.
Langfang, Hebei 102849, China*

Hui Qin
*Qinghua University
Beijing 100084, China*

The single atom detection with laser (LSAD) is an ultra-sensitive and selective analytical technique capable of detecting single atom. This technique has been applied successfully in the ultra-trace element analysis.

No applications of LSAD to geology have yet been reported in western countries.

In Russia scientists applied LSAD in determining Ru in sea water to explore for manganese-iron nodules under the ocean and in determining Ir in the formation layers in order to investigate the geological catastrophic event in the period between Cretaceous and Tertiary.

The aim of application of LSAD to geochemical exploration for gold is to determine ultra-trace "gaseous gold" and added gold from mineralization at depth, which can not be determined by conventional analytical methods.

The gold content of surface materials is composed of an original (background) content related to the parent material and an added (anomalous) content from mineralization at depth by some ways of possible transporting process. The added gold occurs in various active forms, and generally much lower concentration than original content. The keys to success are methods which can effectively extract and determine this ultra-trace gold. In this paper, we used Geogas method (gas accumulation extraction method) to capture "gaseous Au", and we also develope a dynamic extraction technique to capture "gaseous Au " in soil and successfully detect this ultra-trace Au by using LSAD.

The preliminary results in a concealed gold deposit are given. The results show that gaesous gold over gold ore body is clearly present in several peaks of anomalies.

GEOCHEMISTRY AND ITS APPLICATION TO PROSPECTING OF LINGLONG GOLD DEPOSIT, SHANDONG PROVINCE

Wang Yanbin
Institute of Geology, Chinese Academy of Geological Science, BaiWanzhuang Rd., BeiJing, 100037, P.R. China.

LingLong gold deposit, located in Zhao Yuan county, Shan Dong Province, is a famous gold productive area. By applying the theory of geochemistry and statistical methods, the geochemical feature of stratigraphy and magmatic rock was investigated. The spatial variation of the elements and element association in the gold deposit were studied and a geochemical anomaly zoning pattern for this deposit has been formulated, and some geochemical prospecting criteria and evalution criteria of blind orebody are given in this paper. The stepwise regression for Au as a function of the other elements from 31-samples in the gold deposit is as follow: $Au=4.793+3.582Ag-1.499 K_2O$. It indicates that Au mineralization is closely associated with Ag and K_2O.

By the studies of R-mode cluster analysis and R-mode factor analysis to the gold deposit samples, the element association of the gold deposit (69-vein) are divided into five group:
Ag-Bi-Pb-Au, Zn-Cu, K_2O-Ha_2O-Al_2O_3, Hg-Sb, As-CaO. It implies gold mineralization process and its element association, and indicates that alkai metasomatism is important in gold mineralization process. The research of geochemical primary halos (69-Vein) shows that the anomaly distribution of element is similar to gold orebody and expands to nearly EW-trending which indicates that structures controlled the gold mineralization. According to the zoning index method proposed by Grigoyan, the veritical zoning sequence of elements in the 160 Line

profile (69-Vein), from the top to middle, is expressed as fallows: Hg-Zn-Cu-Ag-Bi-Pb-Au. Base on this pattern, we can use the zoning coefficient, such as $(Hg \times Zn)/(Au \times Pb)$, to assess the exposure level of the ore body and to evaluate the blind orebody. It was proved by a preliminary test that criteria are feasible.

Study of sulphur, lead isotopes and REE shows that gold mineralization is closely related to the Jiaodong metamorphic rocks and granites. The study of oxygen and hydrogen isotopes indicates that this deposit was magmatic hydrothermal origin deposit.Gold and other elements are transported generally in the form of chlorine complex at higher mineralization temperature, and transported mainly in the form of sulphur complex at low mineralization temperature. Gold is precipitated at temperature $300\ ^{o}C$, pressure 400-600 bar, $logfo_2=-33.66$, $logS_2=-12.88$, and pH=4.0-5.9.

GEOCHEMICAL INFORMATION ON DONGPING GOLD DEPOSIT, CHONGLI,HEBEI

WANG YUJUAN
(North-East Institute of Technology,Qinhuangdao)

A set of 15,351 soil samples were taken and analyzed for Au from a 30 km^2 area in Tongping, Hebei. The data set of Au content in soil samples was grided and contoured. If 2 ppb is taken as the threshold, a 30 km long Au anomaly belt is clearly shown, which extends NW and corresponds well with a known ductile shear zone which has been explained by the local geologists as the pass way of Au from the mantle. If 5 ppb is taken as the threshold, 3 separated anomalies within the shear zone can be delineated which accompany the main ore bodies in the deposit.The 4th polynomial trend surface is similar to the grid contour map, while the residual of the 4th trend surface displays 3 separated anomalies as do the 5 ppb contour in grid contour map. The richest ore is located where the residual is greater than 50 ppb. The map shows that background value differs from anomalies associated with different ore. It is concluded that by comparing contour maps obtained by different methods, more information can be extracted.

THE GEOCHEMICAL ZONATION OF VEIN No.I IN DONGPING GOLD DEPOSIT

WANG YUJUAN
(North-East Institute of Technology, Qinhuangdao)

Vein No.1 is the best investigated and well documented ore body in Dongping gold deposit with a length of more than 1,100m and a vertical mineralization span more than 100m. By sampling at different elevations from underground works, a three dimensional geochemical model was established which can provide useful information about blind ore bodies and erosion degrees.

THE USEFULNESS OF RATIO Au/Ag IN DONGPING GOLD DEPOSIT

WANG YUJUAN
(North-East Institute of Technology, Qinhuangdao)

Ratio Au/Ag in rock samples are the result of exsolution from Au-Ag solid solution, which is sensitive to temperature. Therefore, it can be used as a geothermometer. The high ratio represents high temperature. The mean of ratio Au/Ag over 5 veins in the study deposit is arranged in a descending order as follows:
29.11 (vein No.2),25.84 (vein No.3),18.92 (vein No.1),11.58(vein No. 70),11.44 (vein No.2). According to the distribution of the veins, this may indicate that the temperature decreasse from east to west and from north to south. Vertically, from the sufrace with an elevation of 1,700m to the underground with an elevation of 1,200m, Au/Ag ratios were determined at every 100m interval for vein No.1. The results show that Au/Ag increases 5% for each 100m depth increment. Horizontally, the ratio is increasing towards the center of the veins.

THE ELEMENT ABUNDANCE RELATIONSHIP OF Th, U AND K AND IN SITU GEOCHEMICAL PROSPECTING BY GAMMA-RAY SPECTROSCOPY IN LIWU COPPER DEPOSIT AREA OF SICHUAN PROVINCE

WANG YUNLIANG, HOU XINSHENG AND ZHOU RONGSHENG
(Chengdu College of Geology, Chengdu 610059)

The Liwu copper deposit is in the southeastern flank of the Jianglang dome. The layers of the country rocks belong to Ordovician system (O_2). It is complex for the metallogeny of this copper deposit which was related closely to volcanism. The copper enrichment is ascribed to sedimentation of volcanic debris, submarine eruption of lava, metamorphism and hydrothermal process. Copper was derived from the volcanism and enriched during kinetic metamorphism, but hydrothermal process was the main metallogenetic epoch.Before metamorphism, the abundance relationship of Th,U and K in source rocks petrogenetically associated with two end-member mixing obeys the low of fractional linear function:

$$y=a+bx/C+dx \qquad (1)$$

Where y and x are element (Th, U and K) abundance;a,b,c and d are abundance constants which are equal to the mirror image S transformation of abundances in two rocks:

$$(a,b,c,d)= S\ S\ |x1,y1;x2,y2| \qquad (2)$$

During copper mineralization period, the abundance relationship of Th,U and K in copper-bearing country rocks metallogenetically associated with fractional process of mineralized solution obeys the law of power function:

$$Y=AxR \qquad (3)$$

Where x and y are element (Th,U,and K) abundance, A is phase constant, R is abundance constant which is equal to the H transformation of bulk partition coefficients [D (x,y)] of elements Th, K and U:

$$R=H[D(x,y)] \qquad (4)$$

The surface gamma-ray spectroscopic survey is an effective method of an in-situ geochemical study and prospecting for copper mineralization by measuring Th, U and K. This method could identify the copper mineralization process and the

sedimentation-metamophism, distinguish the country rock with copper mineralization from the similar country rock without those mineralizations.

NEW DEVELOPMENT OF THERMOLUMINESCENCE DOSIMETRY

WANG ZAIMING, QIN DADI, AND ZHUANG GUANGMIN

Radiometric method is one of the rapid high efficient and low cost exploration method for searching petrolleum and gas. It can offer useful information by which geologists can lower the possibility of failure in drilling, shorten the period and decraese the cost of exploration. Thermoluminescence dosimetry is a new radiometric method for oil and gas exploration. It is also a kind of cumulative measuring technique, e. g. to integrate the dose for one to several months, which gives higher sensitivity and signal-to-noise ratio. It can also suppress and/or smoothen several kinds of interference and gives better reproducibility. The method can be applied to the early stage assessment, oil bearing possibility assessment of structure, delineation of oil/gas target area and discovering of non-structural trap type reservoir. The last usage makes it an auxiliary mean for oil and gas prospecting where conventional seismic survey can not be effectively used. In 1985, after the method has obtained its first successful use in Shengping oil field, Daqing, the radiometric survey group of IGGE worked continuously for further test in oil fields and exploration area in east, middle-south and north-west China. In south China, drainage network, salt field beach and reeds-grown marsh are developed. In such landscapes, other kinds of radiometric method are hard to conduct and yield poor result, but thermoluminescence method has gained encourageous result. This paper takes the work in Beitang area of Dagang oil field as an example in order to introduce the result of test and compare it with the known result of 33 drill-holes. It indicates that the rate of comformity in the confirmative side, i.e. the percentage that the oil-producing drill-hole falls within anomaly, is 61.5% and the rate of conformity in the rejective side, i.e. the percentage that the dry-hole or water producing hole falls within the non-anomalous area. reaches 81.3%.

Seven anomalies have been delineated and are interested by geologists. The effectiveness of the method is under proving.

STUDY OF HYDROCARBON GEOCHEMICAL ANOMALY CONSTRUCTION

WANG ZHENPING, LU GUANGYU AND ZHOU SUXIN

(Daqing Petroleum Institute, China)

Geochemical investigation has made known that, all geochemical exploration indexes reflect the information about the existence of oil and gas pool in varying degrees. Full tests show that there are relationships of causes in the geochemical indexes. The relationship of cause reflects the information of oil and gas pool better than the indexes. But, geochemical exploration work, according to a model of "black box",

restricts people to recognizing the cause of geochemical anomaly, and also make people can' t all along attach the importance to the relationship of the indexes.

Based on the geochemical exploration data in an area (including data in well and in ground) and some results of artifical imitated test, this paper discussed the relationship of cause of hydrocarbon geochemical exploration indexes and the regular change of hydrocarbon in the process of geochemical anomaly forming, recognizes that the hydrocarbon geochemical exploration anomaly has some characteristics construction. The understanding has been proved to be correct by the result of geochemical exploration. The discovery provides a new basis for appraisal of anomalies.

UTILIZATION OF THE DISTRIBUTION RULES OF TRACE ELEMENTS IN REGIONAL GEOCHEMISTRY ON THE RESEARCH OF RELATIONSHIPS BETWEEN ENVIRONMENT, LOCAL DISEASES AND HUMAN HEALTH

WANG ZHIGUO

Human being are strictly controlled by environment through-out the long evolution course. The trace elements in food and water come from the earth crust either directly or indirectly, hence there must be an interrelation between element distribution in human body and in crust. Because of regional geochemical process, the abundance of elements varies from place to place and the difference may reflects in human body through diet. When this difference exceeds the limitation of body equilibrium function, it will cause regional difference in health level. The author intends to explain and discuss the distribution of local disease in this paper on the basis of the results of the regional geochemical survey. Besides, the author also tries to study the relationships between environment, local disease and human health.The following titles are involved in the paper:

1)Regional distribution pattern of elements and its variation

2)Distribution of trace elements in human body and the region;

3) Distribution of trace elements in studied region and prediction of the occurrence of local disease, such as stomach cancer,hypoplasia, esophagus cancer, liver and leucocyte disease and ostealgia disease;

4)Conclusion.

GEOCHEMICAL PREDICTION IN NADAXIAN GOLD MINING DISTRICT AND SURROUNDING AREA

WEI FUYOU

The mining area is located in Shanhaiguan anteclise and Archean migmatite and Jurassic andesite are outcropped. In the eastern mining area there is Yengwushan granodiorite and in the western side of the area there is Tengwushan granodiorite and

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in the western side of the area there is Woulunggang granite intrusive. The deposit is controlled by a nearly EW major fault and a secondary NE fault. The deposit belongs to quartz vein gold, however in the contact fracture zone with the intrusive there is alteration gold.

We conducted stream sediment, soil and rock geochemical survey in the mining and surrounding areas. The results of survey and the prediction index are as follows:

1.Stream Sediment Anomaly Prediction

The stream sediment survey with scale of 1: 50,000 delineated several dozens of Au anomalies, including the Nadaxian gold mining area. Over the known deposit Au anomaly is 3,000m long and 1,000m wide associated with As, Sb, Cu, Pb, Zn, Ag etc. anomalies. For the quartz vein gold deposit it is characterized by high Pb anomaly and by high Mo anomaly for the alteration gold deposit. In order to further select the anomalies we took the average value of each anomaly for comparision analysis and concluded:

(1)High gold content points located in peripheral of Yingwushan granite intrusive particularly at the pitching end of the intrusive such as Nadaxian. The Au content in stream sediment is gradually reduced as the distance from the intrusive increases, such as Dunggouling.

(2)At the eastern end of Wolungguang granite intrusive, we found several high Au anomalies which are characterized by high Mo. Through field examination an alteration gold deposit was discovered at the contact fracture zone of the granite. We collected 9 rock samples and the average Au is 4.4 ppm.

2.Prediction of Soil Anomaly

The soil survey with scale of 1:10,000 discovered five mineralization zones including Na daxian known deposit zone. Over the known deposit Au anomaly is n x 100-1000m long and 100-200m wide and Au contents is n x 100-1000 ppb, which associated with As, Sb, Cu, Pb, Zn, Ag and Mo anomalies. At the top of the deposit zone there is Sb>Au (as for the anomaly area, the same as follows),at the middle of the zone Sb=Au, and at the bottom of the zone Sb<Au. Those are the prediction marks to be used for Dunggou prospect zone.

3.Prediction of Rock Anomaly

Na daxian orebodies appeared in a side curtain array. Below pinch-out of the orebody or at the foot wall of the orebody there are some new orebodies. We studied the rock anomalies on the surface and in the adit and drillhole and concluded that at the different parts of the orebody the anomalies were obviously different: at the central part of the orebody there is multi element combination such as high Au, Ag, Mo and Bi; at the top of the orebody high Hg,Sb, Pb and Ag and Pb/Cu>1,A x 100/Cu>1;at the bottom high Cu, Mo, Bi Ni and Co, Pb/Cu=<0.5 and Ag x 100/Cu=<0.3. According to those marks we predicted:

(1)It is middle halo at Shangtun in the western mining district and they are bottom halos between Xiatun and Huashugou. Three test drillholes intersected ores at the location of the middle halo but no orebody was intersected at the location of the bottom halos.

(2)In the eastern mining area, we found 5 anomalies in the underground workings which are all at the footwall of the known deposit and characterized by high Pb and Sb, Pb/Cu>1 and Ag x 100/Cu>1. We predicted there would to be a second enrichment zone. After a test drilling a new deposit was dicovered.

NEW TECHNIQUE ON ANALYSIS OF MERCURY IN SOLID SAMPLES BY DIRECT PYROLYSIS USING A SINGLE WAVE-LENGTH ATOMIC ABSORPTION MERCURY ANALYZER

WEI JINGSHENG

Single wave-length atomic absorption mercury analyzer is most widely used at present in China. Many kinds of this type model have been produced and nearly thousand of which are in used in different geological and geochemical departments and in various fields including mineral and energy resources. The technique is based on direct pyrolysis of pulverized sample and determination of mercury with a single wave-length mercury analyzer. Both the precision, accuracy, speed and cost of the technique are superior to conventional Au-Hg amalgamation (dry method) and chemical dissolution-reduction (wet method) techniques, and reach the level comparable to a sophisticate Zeeman mercury analyzer. The outstanding feature of the technique lies on its ability of preventing from interference which is nearly an order higher than Zeeman model, and this is of significance for the analysis of those organic, sea-bottom sediment and single mineral samples.

A PRELIMINARY STUDY ON THE RELATION OF REGIONAL GEOCHEMISTRY TO AGRICULTURE AND ENDEMIC DISEASES IN HEILONGJIANG PROVINCE, P.R. CHINA

WU XISHENG, CHAI SHELI AND GE XIAOLI
Changchun University of Earth Sciences

1:500,000 regional geochemical reconnaissance data of about 20 elements in Heilongjiang province, from which 15 elements As, Ba, Co, Cr, Cu, Fe_2O_3, Mn,Mo,Ni,Pb,Sr,Ti,U,V and Zn are selected in this study are incorporated into 807 units in which average values of 15 elements are obtained. A preliminary study has been made of the relation between contents of 15 elements in 807 units and prevalences of Keschin-Beck disease (KB) and endemic goitre(EG),and mean outputs of major crops being soybean, wheat, rice, maize and beet in five years. It is considered by the study of environmental geochemistry that KB occured in the environment of rich organic matters and humid acids, and caused by a "conditional fator" which may be some poisons. Factor, progressive regression and correspondence cluster analyses show that KB is related to As, Ba, Pb, etc. in environment, linear regression equation of KB prevalence and As, Ba and Pb contents is

$$KB=0.3470-0.308As+0.0014Ba+0.0394Pb$$

It can be seen from above eqation that a large amount of As existed in environment which reduced the prevalence of KB, and whether As is one of poisonous matters caused KB or not, it needs to be studied further. Endemic goitre is beleived to be caused by I dificiency and toxicity,and Mn, Co,Cu,Zn, etc. in the environment would enhance or reduce the prevailing of KB. Factor, progressive regression and correnspondence analyses indicate that high prevalence of EG is corresponded to high

values of Mo, U, Zn,Pb and Cr,which conmmonly occured in granite exposed area.Linear regression equation between prevalence of KB and contents of Zn, Mo,U,Pb, Cr is EG=1.80+0.021Zn+0.271Mo+0.123U-0.048Pb-0.017Cr in granite is low, and EG took place in the leached conditions, therefore I is low in the environment. It is suggested that enrichment of Zn, Mo, U and dificiency of I caused the prevalence of KB.

It is suggested through the study of the relation between micro-nutrient elements and major crops that :(1) when Mo>1.2 ppb and Co>11.5 ppb, yields of soybean>1,5000 kg x ha^{-1}, and the yields are decreased with contents of Mo and Co, linear regression equations of Mo and Co with outputs of soybean are $Y_{soybean}$=74.6+23.3X_{Mo}, $Y_{soybean}$=35.9+6.3X_{Co} respectively;(2)when Zn>60 ppm, outputs of maize>2850 Kg x ha^{-1}, rice>2550 Kg x ha^{-1}, wheat>1350 kg x ha^{-1}, beet>9000 Kg x ha^{-1}, Outputs of above major crops are reduced with decreasing of Zn content, linear ression eqautions of Zn with crops are Y_{wheat}=44.4+0.98X_{Zn}, Y_{rice}=52.9+3.06X_{Zn}, Y_{beet}=310.6+19.10X_{Zn} respectively.In light of above primary study, suitable planting divisions of major crops in Heilongjiang has been suggested.

A RESEARCH ON THE EVALUATION CRITERIA FOR ANOMALIES FOUND IN PETROLEUM GEOCHEMICAL EXPLORATION IN LANGGU DEPRESSION, DAXIN FAULT ZONE

WU XISHENG AND LI JINGCHAO
Department of Applied Geochemistry, Changchun University of Geosciences

Based on a surface geochemical survey in Langgu depression, the authors proposed a series of descriptive parameters for evaluating anomalies. Each anomaly is given a score which is the sum of subscorces assigned to the form, area, indicator variability and association of the anomaly indicators. The anomalies are ranked by the scores.

In order to eliminate instability and complexity of single indicator under the influence of surface and analytical conditions, the authors proposed a series of combined criteria such as MAD, MAA, MPV, MPR, MPZ, MAV, etc. It is reported in the paper that a 450 km^2 study area with known oil wells was evaluated by use of these criteria and a 62.57% success rate was obtained.

Spatial Extending In Geochemical Exploration

WU XISHEN
(Changchun University of Geology, P.R.C.)

SHEN GUOPING
(Geophysical & Geochemical Team of Anhui Province)

Geochemists had found that the contents of elements nearby orebody vary with certain regular patern. A. Solovof suggested that the content deduces according to the distance of point x to the orebody as Cx=Cmax.EXP(-x)(1)

The authors advance the formula above and reach the universal formulas in 2-& 3-dimensional situations as following

Cx1x2=Cmax.EXP(-x1/k1).EXP(-x2/k2)(2)

Cx1x2x3=Cmax.EXP(-x1/k1).EXP(-x2/k2).EXP(-x3/k3)(3)

where x1,x2 and x3 are the distances between the points to be estimated and the center of the orebody along the three vertical dimensions respectively;1/k1,1/k2 and 1/k3 are the corresponding transporting coefficients in the 3 directions; and formula (2) is a special case of the (3) when x3=0 we can get y=+a1x1+a2x2+a3x3(4)

where a0=1nCmax, a1=-1/k1,a2=-1/k2;a3=-1/k3,y=1n Cx1x2x3 according to (3). The solution of (4) means the predication of the element content at any point rudely, and it becomes possible to evaluate the denudation of orebody.

THE EFFECTS OF SOIL GAS Hg SURVEY OVER SHANGGONG Au DEPOSIT, HENAN PROVINCE

WU ZONGHUA , JIN YANGFEN AND GUO YINGJIE

Institute of Geophysical & Geochemical Exploration,
Langfang, Hebei 102849, P.R.China

Shanggong is located in Luoning County,Henan Province. During 1968-1971, Au anomalies of heavy minerals were found in this area in general exploration for deposits. From 1978 to 1979, the multi-element composite anomalies (especially Au, Ag) were also found in an 1/50,000 stream sediment survey. Two Au-bearing fracture zones were determined by follow-up of the anomalies.

From May to July in 1982, soil gas Hg survey was carried out over and around the two Au-bearing fracture zones. The Hg background value is 10 ng/m3, and the threshold is 20 ng/m3. Three obvious Hg anormaly zones were found. Among them, the first and the second anomaly zones coincide well with the known two Au-bearing fracture zones. The third is unknown before, and no mineralization and wallrock altecation was found on the surface over it. The anomaly follow-up by sampling in the test trenches on line 39 proved that the third Hg anomaly zone is related to Au-bearing fracture zone. Then, soil Au was analyzed in the third Hg anomaly zone. The soil Au anomalies were found to coincide with the three soil gas Hg anomalies. It was proved by the subsequent drilling that the Au reserves in the third Hg anomaly zone are more than

half of that of the large-scale Au deposit. Over the past years, the second larger-scale Au deposit has been found in Shanggong Au anomaly area.

As mentioned above, the effects of different surveys are not bad. But there still exist some problems in evaluating the Au anomalies of the stream sediments i.e., the ore-missing phenomena caused by the blindness of selecting the area for follow-up. Because it is time-consuming and fund-wasting to use the traditional geochemical methods to evaluate the large-scale Au anomalies of the stream sediments, a reasonable procedure for evaluating the Au anomalies found in the stream sediment survey is proposed in this paper. At first, soil gas Hg survey or soil Hg survey was systematically carried out in the area of the stream sediment Au anomalies to figure out the distribution of the fracture zones in the area. Then, soil Au was analyzed in the Hg anomaly zone. Finally, the channel sampling method is used in the strong Au anomaly zone. If this procedure is used with the method of analyzing trace Au on the spot, the number of samples, the amount of analysis, and the blindness in follow-up will be greatly reduced.

VAPOUR GEOCHEMISTRY IN KARST CAVE EXPLORATION

WU ZONGHUA, JIN YIANGFEN AND GUO YINGJIE

*Institute of Geophysical and Geochemical Exploration,
Langfang, Hebei 102849, P.R. China*

One of the outstanding problems in engineering geologic exploration is the location of the concealed karst caves. The problem is particularly severe in reservior area where the geophysical methods widely used for engineering geologic exploration are often difficult in application.

Vapour geochemistry relies on an alternative dispersion medium in which cave-related gases may move as a gaseous phase and, in this case, a porous dry cover may facilitate the development of a detectable near-surface geochemical pattern. The formative mechanism of the vapour geochemical anomalies is demonstrated as follows:

CARBON DIOXIDE
Limestones are generally the surrounding rocks of karst caves. If H_2O and CO_2 are available, they will react with limestones. thus:
$$CaCO_3 + H_2O + CO_2 = Ca(HCO_3)_2$$
$$Ca(HCO_3)_2 = CaCO_3 + CO_2 + H_2O$$
There are sufficient carbon dioxide and water in nature which are available to react with limestones. This would cause the concentration of carbon dioxide in the karst caves. It has been demonstrated from the concentration that karst caves can give rise to significantly anomalous levels of carbon dioxide in soil gas. These near-surface anomalies may indicate the presence of karst caves at depth.
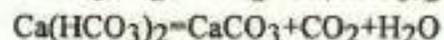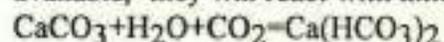
MERCURY

Minor quantities of mercury are often incorporated in limestones. When limestones become the soluble $Ca(HCO_3)_2$ in the supergene process, the mercury released will migrate in oxalate and be adsorbed by soils. For this reason, mercury in the soils on limestones is generally higher than that in limestones. When HgC_2O_4 migrates into the karst caves due to temperature increase and pressure decrease, $HgC_2O_4 \rightarrow Hg + 2CO_2$

By virtue of high vapour pressure of mercury at ambient temperatures, mercury is released to migrate in the vapour phase. These near-surface mercury anomalies in soil gas may serve to indicate the presence of karst caves at depth.

RADON

The earliest reports of the application of radon determinations to cave exploration come from the former Soviet Union(1979). Radon anomalies over karst caves come from the depth of the earth. Radon gets to karst caves via tectonic fractures and continues rising to the surface.

This article introduces the efficiency of the application of soil gas survey for locating concealed karst caves. An experimental soil gas survey for exploring the caves has been carried out in Daliang Reservoior area, Shanxi Province, China. The exploratory grid is generally 150 x 10m and 40 x 2.5m in the anomaly area. The analytical results for Hg, CO_2, Rn show that there are distinct mercury anomalies over karst caves but there is no carbon dioxide and radon anomalies in the reservoir area. Twelve NE-SW lenticular Hg anomalies which are poorly continuous were found. Finally, we arrange five drill holes in the four anomaly areas. It has been found in the four drill holes (Zk22, Zk26, Zk24, Zk25) that fracture zones and karst caves which are 1-9m thick exist in the depths of 25-58m. No fracture zone is found only in drill hole Zk23.

As mentioned above, it has been proved to be effective to apply soil gas survey to locating the concealed karst caves. There will be a bright prospects for the application of this method to the engineering geologic exploration.

APPLICATION OF Hg VAPOR SURVEY TO CANGSHANG Au DEPOSIT, SHANDONG PROVINCE

WU ZONGHUA, JIN YANGFEN AND GUO YINGJIE

Institute of Geophysical and Geochemical Exploration, Langfang Hebei 102849 P.R. China

Cangshang,25 km from Laizhou city in the south,is located on the side of the Laizhou gulf in the northwest of the Jiaodong peninsula. On its north and west is the Bohai Ocean. The altitude varies between 2.2 to 4.3m. Almost all the area is covered by

Quaternary littoral facies which are usually 10m thick (the thickest is 60m.). Only one isolated granite outcrop exists on the north of Cangshang village. It is very difficult to use the traditional geological, geophysical and geochemical surveys for locating the Au orebodies in this area. During 1978-1981, the effects of drilling (8 drill holes) and the 1/10,000 magnetic prospecting were very poor. However, Cangshang, located in the southwestern part of the concealed Sanshandao fracture in which the Sanshandao large-scale Au deposit was found, has been taken a close attention for ages. In order to solve the puzzle, we began the exploration for Au deposits in this area in 1983. At first, soil gas Hg survey was used to trace the concealed fractures. And then, the deep samples were taken in the Hg anomaly area to evaluate the Au-bearing properties.

The working area is 7.5km^2, the sampling grid is 300 x 20m, but 80 x 20m in the Hg anomaly section. The exploratory lines are 1000-2000m long. The Hg background value is 23ng/m^3, the threshold 50ng/m^3 and the highest value more than 1000ng/m^3. Two banding Hg anomalies were found in the area. One, stretching nearly NE-SW, distributes in the porphyroid granodiorite and appears continually from line 267 to line 411. The other, stretching nearly NE-SW, distributes along the contact zone between the prophyroid granodiorite and the metamorphic rock of Jiaodong group. These two anomaly zones intercross at their SW ends; and at their NE ends, there exist silicification belts. It has been assumed that these two anomaly zones are the reflection of the Cangshang major fractures or the SW part of the Sanshandao fracture zone.

Two-meter deep samples were taken on line 351 which exists in the Hg anomaly area and is thinly covered by the Quaternary overburden. The results of the trace-Au site analysis show that the soil gas Hg anomalies coincide well with the Au-bearing altered fracture zone.

In 1984, the electrical prospecting and the soil gas Hg survey were carried out near the intercross-section of the two Hg anomalies. A strong Au mineralization was found by the sampling drill. The subsequent drilling showed that there is a large-scale gold deposit which consists of 32 ore bodies. The orebody No. 1 is the largerst which takes up 98% of the total reserves of the Au deposit. The ore bodies exist deep beneath the major fracture.

Geochemical exploration for Gold in China

XIE XUEJING AND MO XUZHAN
INSTITUTE OF GEOPHYSICAL AND GEOCHEMICAL EXPLORATION

In China, the approach to geochemical exploration for gold has been somewhat different from that adopted in the rest of the world.
Early procedures adopted in the world in the 1960s involved the collection and analyses of heavy mineral concentrates. In the 1970s the direct determination of gold with detection limits of 10-20ppb was preferred. These procedures have all been based on the consideration that gold is distributed in naturally occuring materials mainly as discrete particles. However the poor reproducibility of sampling and gold analysis has remained a serious problem.

Research in the 1970s and 1980s has led to the recognition of the existence of significant proportions of ultrafine gold (<5um) in soil and stream sediment, which gives rise to low order anomalies associated with gold mineralization. On this basis, it was felt that the attention focused on obtaining a representative sample to avoid the "nugget effect" as adopted in the rest of the world was unneccessary.

Accordingly geochemical exploration in China has involved (1) the collection of conventional sized samples, (2) the analysis of the minus 80 mesh (177um) fraction, pulverized to minus 200 mesh (75um) , (3) gold determination by an analytical method with a detection limit of 0.2 ppb. and (4) the delineation of broad pattern of regional anomalies with thresholds in the 2-4ppb range in the case of reconnaissance exploration and the delineation of mineralization target with thresholds in the range of >4-8ppb, in the case of detailed explortion.

A key feature of this approach is that rather than focusing attention on individual highs, which may be erratic due to the nugget effect, it concentrates on the recognition of reproducible anomalious patterns as a whole.

This approach has led to the discovery of hundreds of gold occurrences, many of which are being developed into mines. Several case histories of exploration success are cited The time required from the discovery of a regional anomaly to the preliminary confirmation of industrial grade ore is usually 2-3 years.

Further researchs is aimed at (1) the particle size distribution of discrete gold grains(>5um); (2) the proportion of discrete gold grains to ultrafine gold; (3) the various forms of ultrafine gold. Such researches carried out in different geological and environmental sittings may result in the development of innovative methods for gold exploration in concealed terrains.

UNCONVENTIONAL GEOCHEMICAL EXPLORATION FOR GOLD

XIE XUEJING[1], WANG XUEQIU[1] AND YE SHENGYONG[2]
1. Institute of Geophysical and Geochemical Exploration
Langfang, Hebei 102849, China
2 National Gold Bureau of China
1 North Qingnianhu St., Beijing, China

The conventional geochemical exploration for gold based on the mechanical transport of gold in the surface environments and the determination of total gold in the surface materials have not been very satisfactory for prospecting for buried and blind gold deposits. In this case, new approaches in sampling, analysis and interpretation must be developed in order to be able to successfully explore for gold deposits.

In this paper, we describe our research on various gold forms and migration and transformation of various gold forms, and how to use various gold forms to establish unconventional geochemical exploration, from regional to local exploration for buried and blind gold deposits.

(1). Gold occurs in rocks, soils and stream sediments not only as free coarse particles but also substantial amounts as ultra-fine free gold and as other complex forms in water-soluble phase, clay materials, organic matter, secondary iron and

manganese oxides, carbonates, sulfides and quartz and silicates. The low-concentration anomalies are created by ultra-fine gold and other complex forms of gold.

(2). Gold particle distribution and gold content of different forms vary with the distance from source mineralization. At a blind gold deposit of Shandong, the studies indicated gold particles are big and most of gold occurs in quartz and silicates in ore body. whereas with increase in distance from mineralization gold particle size becomes smaller and smaller, and the ercentage of active forms of gold increase with distance from ore body. At as buried gold deposit covered with well developed soil layers, it is found that there are a great variation in the modes of occurrence of gold with distance from source mineralization, i,e. in horizon C adjacent to mineralization most of gold occurs in quartz and silicates and iron and manganese oxides, in horizon B in clay minerals and in horizon A most of gold in organic matter (humid, humic and fulvic acid).

(3). In regional geochemical exploration for gold, meaningful regional anomalies can be delineated by low threshold value created by ultra-fine gold and complex gold.

(4). In geochemical exploration for buried and blind gold deposits, selective extraction gold in mobile forms and "gaseous gold" in soils can be effectively applied to exploration for buried and blind gold deposits. The distinct anomalies of gold in water-soluble phase and in iron-manganese oxides, and "gaseous gold" over the blind gold deposit of Shandong have been found. And there are distinct anomalies of gold in organic matter in horizon A over the buried gold deposit of Xinjiang.

ENVIRONMENTAL GEOCHEMISTRY MONITORING NETWORK AND DYNAMIC GEOCHEMICAL MAPS

XIE XUEJING, YAN MINGCAI AND SHEN XIACHU

Institute of Geophysical and Geochemical Exploration
Langfang, Hebei 102849, P.R. China

Changes in the global environment are of increasing concern to the general public.

In 1992 a proposal for an Environmental Geochemical Monitoring Network And Dynamic Geochemical Maps was accepted by the Ministry of Geology and Mineral Resources.

The project is to serve as a pilot study for developing an optimum wide-spaced sampling method for the future layout of the Global Environmetal Geochemistry Monitoring Network; to provide review and a continuous record of environmental geochemical changes in China; and to provide basic information for mineral resource assessment, metallogenesis, global tectonics, agricultural and land use.

In this project flood-plain sediment, believed to be sensitive to environmental changes and highly representative for large areas, was chosen as the sampling medium,

terminating the several-year-long debate about the representativity of sampling media within the International Geochemical Mapping Project of the International Geological Correlation Program (IGCP Project 259). About 600 sampling cells will be established to cover the whole territory of China (96 million km^2). This project therefore is devoted to monitoring environmental geochemical changes in China from an overall point of view whereas in the past environmetal geochemists at home and abroad were mostly devoted to the study of relatively local subjects. The sampling density is one sample / 5,000–10,000 km^2 in the Eastern part of China and one / 20,000–40,000 km^2 in the Western part of China. Within each cell composite flood-plain sediment near-surface samples (at 5–30 cm depth) and deep samples (at 80–120 cm depth) will be collected. Forty to 70 chemical elements and other parameters for mapping the vulnerability of soils, such as pH, Eh, salinity, exchangeable acidity, base saturation, and cation exchange capacity in the samples will be determined and geochemical maps will be generated. The analytical requirements for elements will follow the recommendations of IGCP Project 259.

The same process, including systematic sampling, analysis and map generation will be repeated every 10–20 years. Geochemical maps produced in different periods of time will provide a continuous record of anthrogenic effect on the land surface. This can be used to identify not only pollution hot spots but also to predict the possibility of a large scale chemical time bomb by marking the slow alteration of very large areas. The notion of resampling and reanalysis every 10–20 years in order to generate dynamic geochemical maps and provide a long-term record of environmental geochemical changes is a new one for the field of environmetal geochemistry.

A NEW METHOD FOR QUANTITATIVELY CALCULATING DEPTH OF BURIED ORES BY USING GEOCHEMICAL ANOMALIES

XIE YONG

Institute of Geophysical and Geochemical Explortion, Langfang, Hebei 102849, China

To evaluate the depth of a buried ore using surface geochemical exploration data, the author propose a new method by the thermodynamic principle, together with geochemical process. This method includes:

1) Ore element anomaly method

This method is based on thermodynamic diffusion system, or non-stable thermodynamic system principle, assume the content of element from high to low degree in the primary halo is caused by thermal dissipation action, the author gives an equation: $C_x = C_j e^{-(3h/4b)}$ (C_x----determined content of anomaly, C_j ----maxium value of original anomaly, b----correction coefficient of anomaly, h----buried depth of the top of the ore body).

2) Fluorine anomaly calculation method

This method is based on closed thermodynamic system principle, assume the halo is formed by gas-liquid transfer, the author gives an equation: $h = ((3^{1/2} - b)C_{imax}(1/tga1 + 1/tga2)$ (h----depth of roof of mid-orebody, a1,a2----eigenvalue, C_{imax}----maxium value, b----correction coefficient of anomaly).

The two equations can be used to calculate the depth and altitude of burried ores.

A PRELIMINARY APPLICATION OFáPRINCIPLE OFENTROPY CHANGE IN THERMODYNAMICS FOR   FINDING BLIND ORE DEPOSITS

XIE YONG

A method for finding blind ore deposit has been developed since 1988, which applies   potential heat from the oxidation-reduction reaction of the metallic ore deposit. We have presented field measuring technique and tested it in known blind ore deposits.

The method principle is based on theories of energy change-over in thermochemistry and energy deliver and transposition in thermodynamics. In the course of continual oxidation-reduction reaction for metalic ore deposit, chemical energy changes into heat energy. Thermal deliver and transposition lead to entropy change. If we consider a large system which includes ore deposit circumstances and non-ore surrondings, then the total entropy is equal to the sum of both entropies. For minimal heat change entropy can express as

$$ds = dq/T1 \quad \text{(thermonegative)}$$

$$ds = dq/T2 \quad \text{(thermopositive)}$$

in which s,q and T are entropy, heat and absolute temperature respectively.

Using above-mentioned formula entropies of the stuty disbrict are given. The potential heat (L) equation is
$$L = TS$$
in which f means oxidation-reduction course, S =constant, the unit of L is calorie/gram.
As long as one determines T, potential heat abnormal can obtain.

Through field test it is clear that the potential heat on oxidation zone and reduction zone appear obvious negative and positive abnormal respectively. Based on the model of potential heat abnormal for blind ore deposit, a new thinking finding the deposit has been shown. In this paper an applied example was given.

In this paper thermoposctive process was considered as positive otherwise, negative.

STUDIES OF METHOD OF SEPARATION AND ANALYSIS FOR TRACE GOLD OF VALENCE STATES AND ITS APPLICATIONS

XIONG ZHAOCHUN, PENG ZHUNYING AND ZHOU YINGFUN
Party of No.2 Geology Investigation, Bureau of Geology and

Mineral Resources, Henan, Xuchang, 461000, Henan.

A method of separation and analysis for trace gold of valence states has been studied. The separation of gold on each valence states was carried out using polyether-based polyurethane foam which has selective action of sorption for Au(III) complex anions.

The recovery ratio of Au(III) is 96.3-96.8% at 50-200ng level when concentration of hydrochloric acid is 3-5%, but Au(I) and Au(0) is<5% that is less than error level of analysis for gold, evident characteristic of sorption is quantitative not by polyfoam. After each of them is transformed to Au(III) complex anions, it can be sorbed quantitatively with ployfoam.

Effect of extraction time and concentration of hydrochloric acid has been studied. It was indicated that valence-states and distribution of gold are stabile when extraction time is more than 1h with 3% concentration of hydrochloric acid.

Sorption of Au(III) complex anions is stable and separation of Au(III) and Au(I) is quantitative by polyfoam on selective condition of method even if concentration range of gold is 4-5 orders of magnitude.

The separation of trace valence states gold in soil using polyfoam sorption method has been studied. The added recovery ratio of standard gold of valence states in soil is 92.3% Au(III), 90.8% Au(I) and 98.9% Au(0) which shown stability of gold on each valence states and degree of difficulty for recovery by polyfoam.

The tests show that effect of redundant in soil exists, which leads to reduction of Au(III) and recovery drop of Au(III), see table 1.

Table 1 Effect of recovery Au(III) in soil with redundant .

added gold (ng)	R.(%)		
	Au(III)	Au(I)	Au(0)
500	4.0	6.6	89.4

Results of recovery Au(III) in soil by polyfoam have show an improvement as the preburning of sample (Table 2)

Table 2 Effect of recovery Au(III) in soil by preburning.

added gold (ng)	R.(%)		
	Au(III)	Au(I)	Au(0)
500	92.0	2.7	5.3

Adding mixture of Au(III), Au(I) and Au(0) into soil samples, then recovered separately with polyfoam, it was shown by the experiment: 123. 4% Au(III), 94.6% Au(I) and 86.6% Au(0) at 100 ng magnitude of level.

The recovery of high level of Au(III) owing to oxidization of kAu(III) Au(0) is possible. But, the recovery is of low level of Au(0) relatively. Action of sorption for burning of clay in soil is possible too. Recovery test above is successful, if appraise from angle of ng magnitude of level.

Separations stability for Au(III), Au(I) and Au(0) is (c.v.+-%) 39.9, 38.9 and 30.8 (at<1ng. g-1) respectively.

Result of analysis for standard samples is identical relatively with its analysis phase state.

Distribution of geochemistry for gold in selected area has been studied by this analysis method, and shown in the first test: effect of environmental of oxidizing-reducing in selected area is important. For example, proportion of Au(III) in total gold of residuals is 83.9% for belt of alteration rocks, but Au(III) is 6-12% for sediments in the same area, proportion of Au(III) in other rocks in this area is low too.

Separation dispose of site to Au(III) in geochemical samples is very important, we found that, 82.4% Au(III) reduced to Au(0) in the course of movement and precipitation, and 11.6% Au(III) reduced to Au(I).

Relatively high distribution ratio to Au(III) for total gold in residuals is possible, and reduction rate of Au(III) is relatively slow when grain size of samples is relatively fine.

RAPID DETERMINATION OF GOLD, SILVER AND COPPER IN GEOLOGICAL SAMPLES IN THE FIELD

XUE GUANG

A new field method to determine trace gold, silver, copper in geological samples was developed using goldreagent (4,4'-Bis diethylamino thiobenzophenone-Trinbutly phosphate+Trinoctylamine) through preenrichment and separation with xanthate cotton fiber. It has been found that optimum acidity of enrichment and separation is 5-10% aqua regia for gold; 5-35% perchloric for silver; 4-6% hydrochloric for copper with extraction rate over 98%. It is based on extraction of the color complex of gold-goldreagent, siver-goldreagent, of copper-goldreagent by liquid ball of Tri-n-butyl phosphat+Tri-n octylamine in pH 3.3 buffer solution after preconcentration with xanthated cotton fiber. Detectable limit is $w(Au)/10-5=0.5$, $w(Ag)/10-9=50$, $w(Cu)/10-6=0.1$. Determination can be carried out in no-electricity and no-wind conditions using rapid analysis box.

REMOTE SENSING STUDY ON AU AND ASSOCIATED ELEMENTS BIOGEOCHEMICAL EFFECTS FOR EXPLORING AU DEPOSITS ---A CASE OF MAILY VEGETATION REGIONS IN CHINA

XU RUISONG, LU HUIPING, LI FUCAI, MA YUELIANG AND ZHENG TI
Guangzhou New Technical Institute of Geology, Chinese Academy of Sciences, P.O.Box 1131, Guangzhou, 510640, China.

It is found that the vegetation has been poisoned by Au deposits in Guangdong, Hainan, Xiaoxinganling and Qingling, China. This can be proved by the following facts: Au contents in leaves are 10-2,000 times higher than its vegetable abundance, chlorophyll is 10-30% lower than that of vegetation grown in metamorphic rock, and 10-20% lower than that in granite; Carotenoid is 10-44% lower than the background value; moisture of leaves is 10-20% lower than the normal value; the temperature of leaves surface is 2-3 ^{0}C lower than that of the normal leaves; the cell of leaves are abnormal and broken; the leaf color becomes into yellow or dark green. As a result, there are some abnormality in spectral reflection feature. For example, the spectral reflectance of leaves surface is 5-30% higher than the background value and the spectral wave shape moves towards short wave by 5-15nm. The image gray level of Landsat TM and Airborn Imaging Scanner (AIS) is 10-100% higher than background value. The color of gold deposit is quite different from background color in TM and AIS false color image. The special gold yellow color in false image of Landsat TM and AIS is caused by Au and associated elements poison. Using the results described above, the gold resource information system and detecting experts system have been set up. Using the system, some new gold deposits have successfully been discoverd by multi-information composite analysis, gray system and remote sensing model for Au deposit exploration. It has been shown that the relation between characteristics of ecology and physiology of vegetation, spectral reflectance of leaves surface and remote sensing image based on the multivariate relation analysis. The results indicate that the gray value characteristics of the remote sensing image is positively related to the characteristics of spectral reflectance of leaves surface, Au and Cu contents in leaves as well as the temperature of leaves surface. But it is negatively related to Ag content, pigment, and moisture in vegetable leaves. Eight gold deposits and ten gold mineralization zones are discoverd quickly, economically and accurately in areas covered with vetetation in Guangdong, Hainan, Heilongjiang province and Qinlin region, China.

THE GEOCHEMICAL CONCEPTUAL MODEL OF VOLCANITE-TYPE LEAD-ZINC (SILVER) ORE DEPOSITS IN CHINA

XU WAISHENG AND LIU CHONGMIN

*Institute of Geophysical and Geochemical Exploration,
Ministry of Geology and Mineral Resources. Landfang, Hebel 102849, P.R China*

According to the research results of the characteristics of geochemical primary anomalies in some volcanics-type Pb-Zn-Ag ore deposits in China, the geochemical

conceptual model was established, and the predictive prospecting indicators were summerized.

The volcanic polymetallic deposits were located in the boundary of macrotectonic belt and olcanic basin in China. Ore bodies occurred generally in the core of anticlinel dislocation and are controlled by the secondary fissure. There are metamorphic formations of the Presinian system in the mine field, which was overlaid by the volcanic rock sequence of Jurassic or Cretacic system of Mesozoic era. The volcanic rocks consists of tuff, stuffaceous gravel, clasolite and lava. Magmatite is dominated by acidic rock, and contained many dikes. There were volcanic and subvolcanic rocks.

The country rock of deposits was usually intensely alternated, including silication, sericitization, pyritzation and chloritization. The main metallic minerals consist of galena, sphalerite, pyritite and silver minerals. The mineralization zoning occur vertically from the top to the bottom as follows: lead-zinc-silver, lead-zine, and copper-sulphar (gold). Ore elements and associate elements appear anomalous content in rock, ore and minerals associated with deposits. The content of SiO_2, $Al2O_3$, K_2O and Na_2O generally decrease from the unaltered rock to the altered rock and from poor mineralizations to intensive mineralization, while the content of FeO and MgO increase, the contents of ore elements and associate elements in the country rock are higher than the average contents of the same type of rocks in the surrounding area. The average contents of the ore elements Pb, Zn and Ag (Cu) increase from the ore zone to the country rock around the ore deposits.

The indicator elements associated with the deposit include eighteen elements I, Hg, As, Sb, B and Ba are the front indicator elements, Pb, Zn, Ag, (Au), Cd, Mn (Cu) are the ore body or near-orebody indicator elements and Cu, Bi, Co, Mo (W, Sn) are the tail indicator elements. The

primary anomalies appear linear or combined zone, which were caused by different size veins and echelore orebody, concentration gradient of anomalous elements varied greatly and degraded quickly from orbodies to country rocks. The anomalies of the main ore elements are horizontally large range and high intensity and with clear concentration--zoning and concentration centers. The indicator elements with strong activity and penetrating capability form the circular (zone) anomalies above the buried deposit or the surrounding or deposit. The combination relationships and intensity of different element anomalies reflect different mineralization characteristics and the depth of ore deposit. The vertical element zoning of the volcanics-type ore deposit is (from the top to bottom) I-Hg-As-Sb-Pb-B(Ba)-Ag-Zn-Cd-Mn-Cu(Au)-Bi-Mo-Sn(W); the horizontal zoning is (from the mineralization center to the outward) Cu(Au), W, Bi-Cu, Pb, Zn(Au)-Cd, Mn, Hg, Sb, As and Zn.

In predicting the type of deposit, it is the key to combine geochemical conceptual model with geological characteristics when the model is used to search for this type of concealed deposit.

APPLICATION OF HYBRID METHOD OF MULTIPLE ELEMENT FIELD-PAN KRIGE IN DATA PROCESSING OF LARGE TO MIDDLE SCALE GEOCHEMICAL EXPLORATION

In comparison with the advantages of some kinds of statistical models of space data, the multiple element field Pan Krige hybrid method mentioned in this paper fully utilized the multiple element field method (B. H. Ebgknmoba, 1978) which can classify automatically for space amples with ultra spherical surface and Pan krige method (a geological statistics suggested by D. G. Krige first and then established by G. Matheron) to perform optimizationally no diverging gridded interpolation for irregular distribution data in space and to give the drift components, and to have special function in determining geochemical background and delineating geochemical anomaly.

The hybrid method and its main steps are as follows: (1) automatical classification of ultra spherical surface for the random sample data; (2) Pan Krige analysis respectively for background and all elements data of the samples; (3) automatical classification of ultra spherical surface after contrast transformation from Pan Krige estimated values of the elements to their drift values for the background samples; (4) automatical classification of ultra spherical surface after contrast transformation from Pan Krige estimated values of the elements in all samples to Pan Krige drift values of all elements for the background samples; (5) calculating Pan Krige contrast value of a mineralization element by Pan Krige estimated value of the element in all samples minus Pan Krige drift value of the element in the background samples. The charts given by the above steps in turn are: multiple element field classification; variation function; multiple element background field; multiple element anomaly and main mineralization elements anomaly. They have been calculated and plotted automatically at pc/at, pc/xt and VAX-780 computers and SUN-4 work-station with FORTRAN-77 programme. As an application of the method, the author has completed the training calculations of four steps mentioned above with stream sediment data of Jinchangyu, Eastern Hebei Province (the scale is 1:50,000), and also fulfilled the calculations of 9 elements of the first step and the fifth step at SUN-4 workstation, using the data of 32,287 samples with an area of almost 800 km^2.

The calculation results indicated that the hybrid method had following advantages:

(1) Accurate gridding interpolation to irregular distribution data and perform contour plottin by means of plotter, and also can fill in the gaps of sample better.

(2) According to the variation functions, we can know the variations of elements in all directions, continuities, variation amplitude and the drift influences created by multiple background.

(3) The drift components from the calculations of background samples describe the geochemical background obviously. So we can obtain reasonable anomalies delineated with Pan Krige contrasts, and further predict the mineralization quantitatively.

(4) The calculated normal and abnormal fields of multiple element geochemistry are concentrated visible, simple and contain more information and have great significance.

(5) The hybrid method has wide adaptability and all the multiple element data set is in space; when the grouping is definite, you can have a try.

The author believed that according to the capability to process the spatial multiple element data of different types, sources and scales, this method would be brought into the application softwares of geographic information system (GIS) in the future.

GEOCHEMICAL CHARACTERISTICS AND PREDICTION OF JINCHANGYU GOLD DEPOSIT, HEBEI PROVINCE

XU YUNCHENG AND WANG ZIYING

Jinchangyu gold deposit is located in the intersection of the Southeastern part of Yanshan platform-fold belt, the Eastern end of Malanyu anticline and the Western side of Shanhaiguan uplift. The gold deposit occurs in Archaean metamorphic rocks and is hosted in large shear zones. The schistosity zone of the deposit is distributed regularly. The orebodies are quartz-veins or albite-quartz veins, The host mineral of gold is mainly pyrite.

The geochemical characteristics of the gold deposit were decribed in this paper. A prediction for deep prospecting was made.

1. Characteristics of geochemical anomalies of the gold deposit.
There are more than 15 elements being detected in this gold deposit. According to the feature curves of these elements and the correlated coefficients of gold to these elements in the gold ore, ten elements were selected as the indicators for gold and they are As, Sb, Hg, Au, Ag, Mo, Pb, Bi, Co and Ni. Their concentration coefficients are high and have the characteristic of concentration zonation. In the horizontal direction they can be divided into three zones:

The inner zone: Combination of Au, Ag and Bi, followed by Mo and Hg; their anomalous distributions are narrow and coincide with the surface projection of the gold ore bodies.

The middle zone: Au, Pb and Mo followed by Hg and Sb;

The outer zone: Co and Ni.

The elemental combination of the middle and outer zones has same characteristic for mineralized veins in this area, and the anomalies are wide, most of the anomalies are in banded and lenticular form.

2. The vertical zonation of the gold deposit is (from head to tail): Hg, Sb, As--Mo and Pb--Au, Ag, Bi, Mo, Pb--Co and Ni. Therefore we set up this zonation model for primary halo. It is indicated by the model that the distribution feature of the front indicator elements Hg. Sb and As becomes wider progressively from the head of the orebody to the front of it, and the Hg anomaly is apparent. The anomalies of the tail indicators of the orebody (Co and Ni) also become wide from the orebody itself to its tail. The anomalies of the near ore indicator elements (Au, Ag, Mo, Pb and Bi) have large extension vertically. The widths of the anomalies usually become larger and larger from the tail to the front of the orebody, and these anomalies are superimposed with the head and tail halos.

3. Prediction to the deep prospecting.

(1) In the primary halo anomalies of main ore bodies (NNE) in the south of the mining area, the anomalies of Hg, As and Sb as the front indicator of the orebody were appeared, among them the Hg anomalies were quite developed; and the anomalies of near ore indicators, like Au, Ag, Bi, Mo and Pb are also developed, and the concentration zonation is clear. In addition, there is a superposition of the tail halo elements (Co and Ni), but not developed. According to these anomalies. We interpreted that there might be blind orebodies in the depth of -100m level. After a test drilling, we found thin veins mineralization at the predicted level.

(2) In the southern end of the mining district (the orebody being EW strike) we also did the geochemical prediction and the result indicated that: there were the front halo elements there and the anomalies of near ore elements halos coincided with the anomalies of the tail elements. But the intensities of the anomalies are not very high. In this case we interpreted that there might be a blind orebody extended downward for a barren gap. After another drilling, a vein system thickness being more than 20m and low grade of gold was found at -100m to -150m level.

Except for the two case histories above, other two sections in the northern mining area also were predicted with the same method. The front halo anomaly superimposed with the tailhalo anomaly at the western ore bodies; and the front halo anomaly is significant and the intensity of the anomaly is high, we estimated there might be another orebody under the known ones.

THE GEOLOGICAL HALO OF MINERAL, ASSOCIATION-TRACE ELEMENT OF GOLD DEPOSITS IN GREENSTONE BELT OF JIAODONG AREA, CHINA, AND IT'S IMPLICATION ON FORECASTING BLIND ORES

YANG MINZHI
Tianjin Geological Academy, 42 Youyi Road,
Tianjin, 300061, China

Based on the study of original of mineral association-trace element geochemical halo, the gold deposits related to Archean Greenstone Belt (2,500-3,000 Ma), and Proterozoic Greenstone Belt (2000-2500 Ma) are classified into three types, and they are as follows:
1. Galena-Kustelite-Bonlangenite-Pyrite-hematite-barite-
   cinnabar; Pb-Ag-Sb-Hg-Tl-Ba-Au.
2. Chalcopyrite-sphalenite-pyrite-pyrrhotite-petzite-
   altaite; Cu-Zn-As-Co-Pd-An-Ag-Te.
3. Electrum-Bismmhimite-Caleverite-Molybdenite-
   Scheedlite; Au-Bi-Te-Mo-W-Pd-Pt-Ag.

The main features in the geochemical halo of mineral association-trace element are as follows:
1. The zoning sequence of mineral-element from upper part (0-150m), through middle one (150-250m), to lower one (200-400m) is Pb-Ag-Sb-Ba->Cu--Zn-As-Co-Pb->Au-Bi-Te-Mo.

2. Zoning sequence is overlapped due to different metallogenetic phases and stages.

3. Sequence of alteration replacement with overlapped zoning as Ba-Ge-Tr-Rb-Ga-K-Na->Sr--K-Ni.

4. Structural zoning and original geochemical halo association zoning (from upper to lower) are brittle structure belt (Ba, Pb, Zn, Co)->brittle-ductile shear belt (K, Au, Pd, Co)->duetile-shearing belt.

5. Forecasting blind ores with a comprehensive study of zoning. It's on the basis of host structure- alteration belt->metallogenic stage-element association zoning. According to the forecast, each of the four deposits has a secondary gold enrichment zone,which should have occurred 250m below the first one.However both drifting and drilling work conducted have confirmed the forecast.

ABUNDANCE AND DISTRIBUTION OF CHEMICAL ELEMENTS IN SEDIMENTS FROM THE CONTINENTAL SHELF OF CHINA

YAN MINGCAI[1] AND ZHAO YIYANG[2]
1--Institute of Geophysical and Geochemical Exploration,
Langfang, Hebei 102849, China
2--Institute of Oceanology, Academia Sinica, Qingdao,
Shandong 266071, China

Three hundred and twelve sediment samples were collected from the continental shelf of China and Okinawa Trough. The sample sites distribute evenly in an area of 1,000,000km2. Samples were determined using INAA, XRF, AAS, AFS, POL. The abundances of 62 chemical elements are established and eochemical maps of 54 elements were compiled. For the first time, integrated geochemical basic data for the continental shelf of China and Okinawa Trough were obtained.

The result shows that the abundances and distributions of most elements in shelf sediments have a close inherited relationship with loose sediments of the continent, but the concentrations of some elements in the shelf sediments are slightly lower than in continent ones, owing to the influence by silica--rich relict sediments formed in the last ice age. Most elements enrich in the fine fractions of shelf sediment. In the warm sea region south to northern latitude 32*, it is obvious that the oceanogenic calc--authigenesis becomes stronger with the increase of distance from the sea shore. The elements which are active in hydrothermal processes have a distinct accumulation in the sediments of Okinawa Trough, and it is the reflection of strong neotectonism in this region. Concentrations of Cl, Br and I in sediments of continental shelf are ten times higher than in loose ones of continent. Therefore, it can be deduced that these elements originate mainly from the ocean.

STUDIES ON THE TYPICAL GEOLOGY AND GEOCHEMISTRY AND THE MATERIAL ORIGIN OF A NEW TYPE OF COPPER DEPOSIT

YAN WEN[1], LONG JIANGPING[1], TAO YUXIANG[1], AND FU WEIMING[2]
1-Open Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Academi

a Sinia, Guiyang 550002, China
2-Territory Department of Kunming Engineering College, Kunming 650093, China

Veined copper deposit located in Mesozoic-Neozoic of Lanping-Simao basin (Yunnan province, China) is a new type of copper deposit found recently. Both its regional geological setting and geological and geochemical charcateristics of the deposit are very special. Studies of the regional-geological characteristics show that the Lanping-Simao basin is a depression rift basin evolved from the basement of Hercynian. Veined copper deposits mainly occurred in the red beds of sandstone, and partly in the limestone or marl in Simao basin. Orebodies are all assumed vein-form. The main structure of ores presents explosion-brecciform and block-form. The typical feature of mineral assemblage is mass occurrence of tetrahedrite-tennantite. Travertines are found in the structure of mining area, and present-day sinters can still be seen both inside and outside the mine field.

Studies on geochemistry of trace and rare earth elements indicate that there are succession to a certain extent for these elements from volcanic rocks outside mine area to sedimentary rocks of the mine area and to ores. Ores are typically rich in Bi, Sb, As, Ag, Hg, Cu, Zn, (Au) and seriously deficient in La, Rb, Sr, Ba etc. Country rocks of ore deposits possess REE pattern of northern America shale (NAS), however, the REE patterns of ores, vein minerals and sinters mostly appear approximate pattern of NAS, and partly assume special pattern of richment in MREE.

From the resuls above, the isotope data of S, Pb, C, Sr and high-temperature, high-pressure immerging experiments of various types of strata and rocks possibly supplying the metallogenetic materials, it can be concluded that volcanic rocks are "far source bed of metallogenetic material" of the veined copper deposits in this area, and the Mesozoic sandstone as the host of copper deposits and part of limestone are "near source bed of metallogenetic material". The source of ore-forming materials is mainly from the strata, at the same time, partly from the deep. The principal ways of metallogenesis are explosion-filled and metasomation of continental-phase hydrothermal solution.

METHOD AND RESULT OF GEOCHEMICAL EXPLORATION IN GOBI AND CHARACTERISTICS OF THE FIRST MECURTY ORE BELT IN XINJIANG, CHINA

YANG KE

Shaanxi Geophysical and Geochemical Exploration Institute, China

There are rich mineral resources in the vast expanse of Gobi in Xinjiang. After having completed the first test in Kupu region, we conducted aother geochemical exploration test in Taherbasitao region of northern Xinjiang and applied the stream sediment, gravel and soil survey in the dry middle to low hills, low hills and Gobi respectively. The selected grain sizes were -0.53 to +0.96 mm, -0.53 to +1.63 mm and -0.53 to +0.96 mm respectively and the sampling density was one point per square kilometer. This method effectively gets rid of the disruption caused by eolian sand and strengthens the weak anomalies. Adopting it, we completed the 1:200,000

geochemical exploration of 21 quadrangles totaled 32,448 km^2, discovered and provided two mesoscopic gold mineral evaluation bases and Cu-Pt ore belts as well as a number of Au, Cu, Al, Zn and perlite mineral targets, and found and evaluated the first mecury ore belt in Xinjiang, having made an unprecedented breakthrough in ore-finding.

1 Geological and geochemical characteristics of Taherbasitao-Duanjiadi mecury ore belt

The region is dominated by intermediate to basic volcanic rocks and pyroclastic rocks of the Devonian and the Carboniferous. Folds and faults are developed and the northern Beitashan fault and the southern Zhifang fault control the ore belt. Besides Hg, the anomalous element association in the ore belt includes Sb, As, Au, Ag, Cd and B. Hg distributes along the central part of concentration. Through inspection and evaluation of five anomalies and engineering opening, eight mercury mineralization belts and eight mercury ore bodies have been delineated.

2 Geological and geochemical characteristics of the mercury ore bodies

Anomalous element associations reflecting the mecury ore bodies are Hg--Cu--Ag--Mo--As--Sb and Cu--Ag--Au--Mo--As--Sb. Andesite, dorgalite and rhyolite porphyry filled with granular, lumpy and pellicular cinnabar make up the ore-bearing rocks. Controlled by fold and fault, the mecury bodies have a length of 224 to 460 m, a width of 0.9 to 5.0 m and a Hg content of 0.078 to 2.408 % for individual orebody. Specific ore bodies contain higher gold and silver.

3 Genesis of mercury
3.1 Geochemistry of mercury mineralization

Within the Devonian and Carboniferous strata of the region the concentration clarke is very low while the superimposed strength is very high. All of the faults related to mineralizations are accompanied by acid hypabssal intrusives. Mercury within the strata were accumulated and mineralized by succeeding activation and migration. The geochemistry of mercury mineralization exhibits syngenetically poor and low background as well as epigenetically high to very high superimposition and transformation.

3.2 Metallogenetic epoches of mercury

Three metallogenetic epoches have been distinguished.

The first epoch is characterized by low mercury content and associating Pb, and the main loading reflects Cr, Ni, Co and P of the wall rock constituent.

The second epoch has a largest mercury loading. Except for Zr, Cr and Pb, it is also associated by Y and Nb. Y and Nb anomalies are closely related to the shape of acid intrusives which suggests shows that the mecury mineralization is correlated well with the hydrothermal activity and hypabyssal intrusive rocks.

The third epoch is characterized by lower Hg and associating higher loading Au, Ag, As, B, Sb, Mo and Be, which may reflects a metallogenetic epoch when gold is the predominant element and Hg is the associated element.

It is apparent that the Taherbasitao-Duanjiadi mecury ore belt was found by low-density and coarser-grained geochemical exploration for the first time in Gobi. The practice indicates that this method is rapid, economic and effective for the geochemical exploration in gobi.

ELEMENT OF GOLD DEPOSITS IN GREENSTONE BELT OF JIAODONG AREA, CHINA, AND IT'S IMPLICATION ON FORECASTING BLIND ORES

YANG MINZHI
Tianjin Geological Academy, 42 Youyi Road,
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CHARACTERISTICS OF THE SUPERGENE GEOCHEMISTRY IN AND AROUND ASHELE COPPER DEPOSIT IN XINJIANG

YANG SHAOPING AND REN TIANXIANG
(Institute of Geophysical and Geochemical Exploration,
Langfang. Hebei 102849, People's Republic of China,102849)

ASHELE is located in the middle-low mountain region of the southern margin of the northwest part of ALTUN Moutain in the north of Xinjiang,It is in the frigid temperate zone with continental semiarid climate. Valleys are well developed, and most valleys are coated by the turf horizon . Modern erosion is not very active.

ASHELE deposit, a semi-concealed pyritic type with rich copper, is the largest copper deposit discovered in the area in recent years. Main ore elements are Cu and Zn . The accompaying elements Ag,Pb, Au and Ba also have indussstrial tenor. The major ore bodies are occur under 200m in depth.The alteration zones is partially exposed. The oxidation zone can penetrate downwards to over 100m. The supergene minerals are mainly limonite, azurite, coprocalcite, kaoline, and sericite, and so forth.

To study the characteristics of the geochemical precess and regularity of the elemental migration different media from the orefield and nearby ($263km^2$) rock,soil and stream sediment were sampled, The results show as follows:

1.The formation and development of the calcic horizon engender different impacts on the migration of Cu and Zn in the supergene zone.The effect is very strong when the thickness of the soil horizon is over 2m. Cu and Zn can often coprecipitate with the $CaCO_3$, or be shielded by calcic horizon. The threshold of pH is 8 when calcium eluviating or illuviating.

2.Indicative elements of the copper deposit -- Cu, Zn, Pb, Ag, Au, As, Hg and so forth -- are enriched in the fragments of less than 0.5mm size in the residum, where sulphide is the main occurrenceform of the copper, and crystalline iron form is the main occurrence form of zine.

3.Many elements, for example, Cu, Zn, Pb, Ag, Au, Hg,etc.are enriched in the residum soil in the different geological backgrounds. Relative enrichment degree in the background is higher than that in the anomalours area.

4.The effect of the organic matter is obviously enhanced in the stream sediments, especially in the belts of the valley coated by turf horizon and semiswampy ground. The organic matter fraction of Cu and Zn take up 41% and 33% in these belts. Meanwhile, most indicators elements are also enriched in the fragments of less than 0.5mm size in stream sediments.

HYDROGEOCHEMICAL STUDY IN THICK LOESS OVERBURDEN AREA

YANG SHAOPING, REN TIANXIANG AND LIU YINHAN
*(Institute of Geophysical and Geochemical Exploration,
Langfang 102849, Hebei, People's Republic of China)*

Loess, which is generally 50-150m thick and maximum thickness is up to 280m, distributes in the area of middle reach of the Yellow River in China. Geochemical prospecting in loess area has been considered to be impossible for a long time. To break the traditional view, we tried to use ydrogeochemical survey to explore concealed deposits in this area. The area has temperate semiarid climate, with yearly rainfall of 350-500mm and up to 1,000mm evapotranspiration. Ground water appears mostly at the bottom of loess and few is in the form of fissure water in bedrock. Water table in loess is below 10m and main aquifer is at the bottom of loess and sandy gravel between loess and red earth. Red clay formed aquifuge. Water production and distribution are in connection with the features of underlied aquifuge, thickness of aquifer, the depth of down-cutting and microrelief. Ground water is chiefly supplied from rainfall and establishes relationships with fissure water in bedrock by evaporation and condensation, and dischargs mainly through springs, seepage zone, surficial evaporation and a little by animal activities (wells). A hydrogeochemical orientation study was carried out in Jiaolongzhang polymetallic deposit covered by loess and red earth, Gansu province and Xinzhuang-Yixingzhai quartz vein gold deposits, Shanxi province. Here are the results:

1. Major compositions Ca^{2+} is low, and HCO^{3-}, SO_4^{2-}, Cl^-, Mg^{2+}, K^+ and Na^+ are high in ground water. Low Ca^{2+} is caused by $CaCO_3$ precipitation from high evaporation.

2. Indicator elements are different in different deposits. Cu, Pb, Zn, Ag, Mo and As in phreatic water are increased over mineralized zones, e.g.,in Jiaolongzhang deposit, Cu, Pb and Zn over deposit are ten times higher than that of background area. Major mineralized elements Au and Ag in phreatic water above deposits are also markedly increased in Xinzhuang-Yixingzhai gold deposits. These elements might be transported into ground water by oxidization, hydrolysis, evaporation, capillary and electrochemical diffusion and so forth.

3. Seasonal changes of element contents in ground water are big, and most elements except Mo, Cr and in ground water in rainy season show iregular anomalies associated with deposits. Hydrogeochemical survey, therefore, must be undertaken in the dry season.

4. Mo, Ag, Cr, As, Cu, Pb, Zn and SO_4^{2-}/Cl^- anomalies in water were observed in Jiaolongzhang polymetallic deposit by water survey (1 sample/km^2) and the anomaly area is 9-14km2. The anomalies reflect the known mineralized zone and a new potential copper target.

5. Au, Ag, As, Se, Zn, Sb and SO_4^{2-}/Cl^- exhibit evident anomalies in known gold deposits in Xinzhuang-Yixingzhai mining district by water survey at a density of one sample/3km^2 and Hg anomaly reflects the distribution of major regional faults.Thus, hydrogeochemical survey is an efficient method to mineral exploration in thick loess area and can quickly indicate concealed mineral prospects.

COMPUTER-BASED INTERPRETATION SYSTEM FOR REGIONAL GEOCHEMICAL SURVEYS

YANG ZHUXI, LIN CUNSHAN AND JIA YUHUA

Institute of Geophysical & Geochemical Exploration
Langfang,Hebei 102849,P.R. China

Data from a stream sediment survey in xx quadrangle of 1:200.000 are applied in the paper to investigate distribution and association features of 10 to 20 elements related to gold deposits in the area. Computer programs to evaluate gold anomalies found in regional geochemical exploration are developed.

The system proceeds to three levels of anomaly ranking for regional geochemical exploration, namely, (1) Summary and comparison of geochemical parameters for each element in different geologic units, such as frequency numbers, frequencies, mean, extreme values, and standard deviation of the anomalies which are used to determine mineralization characteristics for different geologic units; (2) Screening out of prospecting targets; and (3) Correlation studies among elements for each sample point in the anomalies, grouping the sample points into classes to define the favorability of each sampling area with respect to mineral prospecting,

Computer data processing and color graphics methods are employed, producing a series of maps with best visual effects to geochemists of interpretation. The maps are:

* Geochemical color maps -- To study the spatial distribution features of each uni-variate concentration.

* Contrast maps --To depress "anomalies" from high background, and to enhance weak anomalies from low background, and act as the comparable maps among different variables.

* Factor scores maps --The combined-variable maps used to analyze correlation among variables and to analyze factors of different genetic origin.

* Shaded (relief) maps --Study of the linear features of geochemical structures.

* Tenary maps -- The three base-color maps representing three elements used to analyze the spatial overlapping of the elements and to locate the most promising area as well as the interference factors.

* Multiversity field maps -- Classification of anomalous points according to correlation features (Eculid's distances) among the variables, capable of decomposing a big anomaly (with an area of e.g., several hundred km2) to determine those parts which are most favorable to mineral prospecting.

Based on data from regional geochemical surveys,criteria for gold prospecting are summarized as follows: In the Lower Proterozoic strata which are considered to be favorable,
(1) The overlapping area of the Au, As and Sb anomalies in Au-As-Sb tenary map. (2) The high score area in Au-As-Sb-factor map. (3) The sample points pertaining to Au-As-Sb-Ag combination in multivariate field map. (4) The area with structural lines stretching along NE and NW in the shaded relief map. (5) A large area of Mn-Fe interferences in Au-Mn-Fe tenary map may be attributed to the absorption effects of the anomalies.

Evaluation has been made on several gold anomalies of large size, and a potential gold mineralization belt in the northwest of the quadrangle has been pointed out. □

RESEARCH AND FORECASTING RESULTS ON GEOCHEMICAL EXPLORATION FOR GOLD (ANTIMONY) IN FUZHUXI AREA, HUNAN PROVINCE

YE QINGSEN

(Institute No.230, Central-south Bureau of
Geological Exploration)

Fuzhuxi is located in Anhua County, Hunan province,China, in which several gold or/and antimony anomalous zones were discovered which spread discontinuously. Fuzhuxi gold-

antimony deposit that has been mined for more than ten years is situated in the area, and new tense situation about Au or/and Sb ore resources will be faced soon in the mine. In order to change this situation, make fully use of Au or/and Sb resources and serve for the mine directly, a research on geochemical exploration for Au and Sb has been carried out.Results of the research is remarkable.

Geological and geochemical features

Fuzhuxi Au-Sb deposit is hosted in the South limb of the Northeastern part of the Xuefeng Mount Complex Anticlines.Outcrop strata are mainly Banxi Group of upper Proterozoic,
Lengjiaxi Group of Middle Proterozoic and some eluviums and sliderocks of Quaternary. Also some granite-porphyry veins and albito-diabase veins can be seen on the surface. Fracturing is well developed but folding is not. Au-Sb ore bodies are hosted in the middle and upper parts of
Madiyi formation of Banxi Group. The lower part is absent in the district. The Au-Sb ineralizations are mainly related to fracture zones with quartz veins and small granite-porphyry intrusions whose occurrences are almost upright. Wallrock underwent intensive hydrothermal alterations among which argillation (bleaching), silification and pyritization are closely concerned with the mineralizations.

It is seen that besides Au and Sb, the ores are rich in the following trace elements: As, Mo, Cu, Hg, W and Ag, by analysing and comparing the contents of trace elements (As, Sb, Bi, Hg.
W, Mo, Ag, Ba, Tl, Cu, Pb, Zn, Be, Co and Ni) in 45 samples of rocks and ores which were collected from different levels in the deposit. Correlation analysis show that there are positive correlations between Au and As, Sb, W, Mo, Ag,Pb, and between Sb and As, Bi, Au, Mo, Ag, Tl, Hg, which corresponds to regularities of contents of the trace elements along profiles in galaxies. It follows that indicator elements prospecting for Au or/and Sb are Au, Sb, As, Mo, W,Hg, Pb, Ag, Tl and Bi, among which Au, Sb, As, Mo, Hg, Bi and W are practical typomorphic indicator elements.

Basically, distribution regularities of the trace elements in soil correspond to correlativities of the trace elements in the rocks and ores above. The soil over fracture zones with quartz veins which are ore-bearing in the deep underground is rich in As, Sb, Au, Hg, W, Mo, etc. The
anomalies, which are distinct and high contrast, of indicator elements such as Au, Sb, As, Mo, etc. in soil along surface profiles under which the ore bodies exist coincide

with ore-bearing fracture zones, which suggests that the anomalies can indicate Au or/and Sb ores. It is important to point out that anomalous dimension of As is large, continuous and 2 times larger than that of ore-bearing fracture zones; especially in the altered rock section As is highly concentrated and the widths of the anomalies are of the order of 80 m. On the contrary, the anomalies of the indicator elements in soil along surface profiles under which the ore bodies don't exist are sawtoothed, discontinuous, low contrast and in disorder.

In summary, it is feasible to use these indicator elements (Au, Sb, As, Mo, Hg, Bi and W) for exploring Au or/ and Sb in the area.

Metallogenic forecast and its results

The forecast for the deeper section of the deposit is conducted by axial zoning of the indicator elements. The rock samples are analysed, which are collected at four levels in the deposit. The statistics suggests that the rising tendency from the upper to the lower of the deposit is obvious about the anomalous concentration of indicator elements of Au, As, Mo, Hg, etc., among which Au is the most obvious. The anomalous contrasts of the indicator elements of Au, Sb, As, Hg, Mo and W are still very high on level -20 m. According to axial zoning of indicator elements by Ophchinikov and Grigorian and the author's experience, it can be deduced that Au and Hg are front elements for Au or/and Sb ores. The anomalies of the front elements on level -20 m indicate that orebodies are hosted below the level. Moreover. It is deduced from a multiplication ratio index, i.e. $(As \times Sb \times Hg)/(Mo \times Bi) \times 1,000$, that it is impossible for the orebodies to thin out on the level. Therefore, it can be inferred that the Au or/and Sb orebodies, especially rich in Au, should be hosted below the level, which is verified by mining. The orebodies in which Au grade is up to 4.4×10 were found on level -60 m. As a result, the crisis trend about Au or/and Sb resources for mining was changed in the mine, and notable economic efficiency was achieved.

Besides, combining with geological conditions, metallogenic forecast are conducted in the sector near the deposit and its periphery by geochemical exploration method known as secondary halo one. In this way, three prospective sectors selected from the whole area are Zhuye Mount, south of the deposit, Yangjiachong and Tianzhuangwan on the periphery of the area.

GEOCHEMICAL VERTICAL ZONATION OF GOLD DEPOSIT AND ITS APPLICATION

YE SHENGYUN AND LI HUI

Hydrothermal gold deposit and its primary halo possess distinct axial zonation (when the orebody has a high angle dip being almost vertical). The study and calculation of the axial zonation in gold prediction have an important and wide application. We used it to obtain a good result for blind gold orebodies in the deep part of the existing mine and the surroundings.

1. We collected and studied geochemical vertical zonations of several dozens of typical gold deposits in China. We summarized the single stage primary geochemical vertical zonation series for China's hydrothermal gold deposits. They are from top to bottom: Hg, Sb, (F, I, B and Ba) and As-Pb, Zn, Ag and Au-Cu-Mo, Bi, Mn, Co, Ni and Sn. Among these anomalies, Hg, Sb (F, I, B and Ba) and As anomalies occurred always at the top of the orebodies or as the front halos, while Mo, Bi, Mn, Co, Ni and Sn occurred generally at the bottom of the orebodies or as the tail halos. However, these anomalies will not always appear for every deposit.

2. Application criteria of vertical zonation

(a) When a zonation of one deposit (or an orebody) is reverse, i.e., Hg, Sb, As,F etc. top element anomalies occurred at the bottom of the zonation vertically. This means there will be blind ores in the depth of the known deposit.

(b) When the surface quartz veins or the gold alteration zones have no enough existing industrial gold grade (<3 g/t), and if Hg, Sb, As, B, F and I anomalies at the top of the zonation series are high intensity, it indicates there will be blind ores in the deep depth.

(c) At the underground mining edit if the above level ores are mined out, it is expected to obtain the tail halos of the above orebody such as Bi, Mo, Mn, Co and Ni strong anomalies. But if the strong Hg, As, Sb, F,B and I anomalies are discovered, then it will indicate another enriched gold mineralization bellow this level.

3. The paper completely reviewed various calculation methods of the zonation and the advantages and disadvantages of every method were compared each other.

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no enough existing industrial gold grade(<3 g/t), and if Hg, Sb, As, B, F and I anomalies at the top of the zonation series are high intensity, it indicates there will be blind ores in the deep depth.(c) At the underground mining edit if the above level ores are mined out, it is expected to obtain the tail halos of the above orebody such as Bi, Mo, Mn, Co and Ni strong anomalies. But if the strong Hg, As, Sb, F, B and I anomalies are discovered, then it will indicate another enriched gold mineralization bellow this level.

3. The paper completely reviewed various calculation methods of the zonation and the advantages and disadvantages of every method were compared each other.

THE GEOCHEMICAL FEATURES OF SHUIKOUSHAN LEAD-ZINC-GOLD ORE FIELD AND ITS ORE-FORMING MODEL

YI HUI
(Team 217, Hunan Bureau of Geological Exploration, CNNC)

The study ore field is located in the northern rim of Nanling fold belt where outcrops of Mesozoic strata are dominant and Cretaceous red layer are distributed in the northern part of the field. The strata are characterized by high concentration of As, Sb and Hg and depletion in Co, Ni, Sr and Ba. Permian Dangzhong Group and Qixia Group are most enriched in sulfophile elements: Cu, Pb, Zn, Ag and Au, which may be related to the mineralization. The ore forming elements show some tendency of concentrating in the NNE compressive faults. Ore bodies usually occur at the intersections of NNE faults with NW and /or NE faults.

The geochemical features of the study deposits are as follows; Laoyaqiao deposit, a gold deposit of endo-explosive breccia type, where Au has close correlation with Pb, Zn, Ag,Co and Ni, and the characteristic ratios are $SiO_2/CaO<5$, $As/Sb<1$ and $Ag/Au<16$; Kangjiawen deposit, a Pb-Zn-Au deposit in silicified breccia, where Au has close correlation with Ag, Pb, Zn, As and Cu, and the characteristic ratios are $SiO_2/CaO>20$, $As/Sb>>1$ and $Ag/Au>20$; Xianrenyan deposit, a gold deposit in fractured breccia, where Au has close correlation with Ag, Cu, Zn, Hg, F and Co, and the characteristic ratios are $As/Sb>>1$ and $Ag/Au<3$. Fluid inclusion study shows that temperatures for different deposits are overlapped indicating that heat may have come from different sources at different stages. S isotope compositions concentrated around the zero position resemble that of meteorite. Pb isotope ratio variation is less than 3.5%, which belongs to common Pb.

The zonations of elements in the halos of study deposits are given. Based on the geochemical data, the author formulated three models for the study deposits, and proposed some criteria for ore prediction and several target areas for further exploration.

PREDICTION AND EVALUATION OF MINERAL RESOURCES IN AKETAS GOLD ANOMALY AREA, XINGJIANG

YU XUEDONG AND LI YINGGGUI
Institute of Geophysical and Geochemical Exploration MGMR
84 Jinguang Road, Langfang, Hebei 102849, P.R. China

Some new ideas and techniques for the rapid evaluation of regional geochemical anomalies (RERGA) have been brought forward by Xie Xuejing, Shao Yue and Zhang Benren etc. in recent years. The feasibility of using mathematical geology method (MGM) for RERGA is discussed in this paper.

The results of evaluation for Aketas gold anomalies using MGM and conventional exploration geochemical method (CEGM), respectively have been compared and indicated that MGM is not only practical and reliable, but also more helpful and effective in locating ore deposits in RERGA.

One of the most important parameters in geochemical prospecting is the indicator element. In CEGM, the indicator elements are determinded by their anomaly range, contents, spatial relationship with ore bodies, etc. In this paper, one of the MGM-cluster analysis is used to determine the indicator elements which are almost the same as those (Au, Ag, As, Sb, Bi, Mo and Hg) determined by CEGM. Therefore, the cluster analysis is not only more rapid and forthright in finding out the indicator elements, but it can also extract some characteristic information of the indicator elements in the ore-forming process.

Whether the threshold is suitable or not could strongly influence the effect of locating ore deposits in the geochemical exploration. Generally, the methods of calculating threshold, such as average value and standard deviation, are semi-quantitative mathematically. In order to determine the threshold more objectively, the rejecting-high-value steady method of Uber estimate location and measure set (RSMUELMS) is used in the anomaly evaluation in this paper. The results have shown that the threshold obtained by RSMUELMS is in better accord with the geological background (especially with that of gold) and can make anomalies more obvious than that demtermined by CEGM. For example, the Au threshold from CEGM is $7.78 \ 10^{-9}$, but that from RSMUELMS is $5.38 \ 10^{-9}$. In the routine geochemcial exploration, the effective associations of indicator elements are determined only according to their characteristics of spatial distribution. But in this paper, the factor analysis is used to determine the associations. The result has shown that the factor analysis can be used not only to determine the effective associations of indicator elements (Au, Ag and Mo in soil and Au, Ag, W, in rocks) but also can extract the information related to the ore-forming process.

The optimum prospecting sector and target of Aketas and its gold prospective resources have been determined by the discriminant analysis and the standard ore-forming estimate method, respectively. The prospecting target has been extended from a small mineralized section only 0.5km long to a 2km belt, and the total gold prospective resource is about 26T. The dilling results have shown that the hidden fractured-alteration-type gold ore bodies are found in the sector, and a more obvious effect for locationg ore bodies has been achieved. Finally, a set of methods and procedures suitable for RERGA has been proposed.

GEOCHEMICAL EXPLORATION FOR BLIND GOLD OREBODIES IN SHIHU GOLD MINE

YUAN TIELIANG

Geology Settings

Shihu gold mine lies to the northwestern limb of Chenzhuang synclinorium of Fuping fold and fault zone (IV), Wutai anteklise (III), Shanxi middle platform uprise (II) of the North China platform (I). The Archean metamorphic rocks of Fuping group are outcropped in this area, which are consisted of biotite plagioclase gneiss, hornblende plagioclase gneiss, leptite and amphibolite stratagraphically along the NW-SE strike with a gentle dip of 20-30 degrees. The deposit occurred in the contact zone of external part between Mapeng intrusive body and the Archean rocks. The fractures in SN-EW and NW directions in the mining area are well developed which are on the anticline folded structure, that provided a favourable condition for gold mineralization and enrichment.

Within the orefield the known gold veins with industrial interest are No.101, No.116 and No.47, the other veins more then 30 also present some weak gold mineralization.

Method Selection

On the basis of trace elements analysis on the known ore bodies in north section of No.101 vein, mercury is selected as a distant indicator for deep blind ore prediction which was conducted over the mercury anomalies by the element axial zonation.

Prediction for Gold Orebodies

1. Considering it is not effective to search for gold ores by conventional soil mercury survey, the method of thermal release mercury was adopted in practice. It has been revealed by a test over the known ore bodies that the gold content in the orebody is related to R which is a rate between high temperature mercury (thermal release temperature above 270 °C) and low temperature mercury (below 270°C).

2. Applying the research result from the above practice on the No.102 vein, a test drilling was carried out on the R-anomalies which sampled from Tc.4-Tc.8 trenches sites. The result proved that there was as gold ore body with grade of 2.82-5.64 g/t and the thickness of 0.6-0.85 meters.

3. Prediction for the south section of No.101 vein is a continued part of the vein, however, the previous geoexploration work ended in failure for finding new ores. For this reason a comprehensive exploration method with geochemistry and geophysics is conducted for new ore finding.

By thermal release mercury analysis on the samples taken from 23 profiles in the trenches on the surface, four R-rate anomalies were obtained. Using the trace element axial zonation and choosing the head and tail halo elements, the formula of the ore body elevation is simulated as follows:

H=38.79 As/Co + 442.84   r=0.7291
LnH=0.0923 Ln(AsxAgxSb/CoxNi)+6.3116   r=0.7533

The existing elevation of the blind ore bodies can be calculated on each R-anomaly. Also, according to the trend of elevation the pitch direction and dip could be determined for the blind ore prediction.

COMPILATION OF REGIONAL GEOCHEMICAL ATLAS OF QINLING-DABASHAN AREA

ZHANG HONG
(Hebei College of Geology)

Qinling-Dabashan area is an important metallogenic province in China. The regional geochemical atlas (scale 1:500,000) of this area has been compiled by a group of geochemists from Henan, Shanxi, Gansu, Sichuan and Hebei province. The compilation is based on a national program of stream sediment survey supported by the Minister of Geology and Mineral Resources, which has produced a series of geochemical maps at a scale of 1:200,000. The compiling area covers 40 quagrangles with an area of 260,000 km2. The atlas is composed of 33 single element maps and some compliment sheets. The procedures and technique of eliminating systematic errors between different sheets and provinces as well as map-sheet make up are discussed in this paper.

Firstly, the analytical raw data for each km^2 sampling unit are subjected to a special treatment called "equivalent geochemical effect treatment" to eliminate the possiblesystematic errors. Then, the data set is processed by conventional statistical methods. The background population and the anomalous population are separated according to the calculated statistical parameters. The final map is in the form of colored mosaic with each 2km by 2km sampling grid as unit. This kind of map can fully preserve initial information and is the most useful product of the compilation.

A PRELIMINARY STUDY ON GEOCHEMICAL EXPLORATION FOR PLATINUM GROUP ELEMENTS

ZHANG HONG, PENG GUIXIAN AND MAO QIAN
(Hebei College of Geology)

It is no doubt that the most reliable way in geochemical exploration for platinum group elements (PGE) is the direct determination of these elements in geochemical samples, although some closely associated elements such as As and Cu are sometimes useful. Pt and Pd are determined by spectrometry after a chemical pre-concentration procedure. The detection limit of the analytical technique is 0.3 ppb for Pt, 0.1 ppb for Pd. Research has been conducted in a number of selected areas in Henan, Yunnan and Shanxi provinces trying to optimize the technique in regional prospecting and detailed follow-up for this particular group of elements. The results are encouraging. By

analyzing Pt and Pd in the storaged sub-samples of stream sediments (samples of a national mapping program) and contouring the data, PGE anomalies can be identified and interpreted. It is interesting to note that the geochemical maps can also provide useful information about some basic geological problems.

Based on the experience acquired in the research, the authors have proposed a rational procedure and technique for further application.

A STUDY FOR THE RECOGNITION OF ANOMALIES ON GEOCHEMICAL HYDROCARBON EXPLORATION

ZHANG LIUPING

The major problems in the recognition of geochemical hydrocarbon anomalies are: (1) how to objectively and accurately separate the anomalies from background, (2) how to distinguish top anomalies from side-moving anomalies controlled by fault, and (3) how to eliminate interferences. The uncertainty in anomalous explanation arising herefrom is a serious obstacle for widely accepting and using geochemical exploration technique. In this paper, the features of hydrocarbon anomalies are analyzed based on micro-migration mechanism, and it is indicated that there are two anomalous populations in most areas which are produced by two mechanisms. In general, one directly reflects oil and gas field, and the other is related to the structure, such as fault. Theoretical study with statistics shows that background, anomaly groups and the boundaries between the two groups are all described by the average value, empirical probability and covariance matrix under the conditions that the background and anomaly groups have normal distribution, and we will get a series of formulas and establish anomaly recognition function. The method designed includes: (1) the method for anomaly recognition with single variable, (2) the method for elimination of regionalbackground interferences, (3) multi-element anomaly recognition method, and (4) multi-element anomaly combination method which offers an approach for recognition of the ring anomalies. The method was applied to the hydrocarbon data in Yangshuiwu region, Hebei Province. The random noise of anomalous distribution was reduced, the interferences from regional background were eliminated, and the uncertainty of interpretation was reduced greatly as the anomaly groups wereseparated. This method was also used in Daxing region of Beijing , Arshan and Jiergalangtu regions, Inner Mongolia Autonomous Region.

DETERMINATION OF COPPER AND LEAD IN GEOLOGICAL MATERIALS BY STRIPPING CHRONOPOTENTIOMETRY

ZHANG QIN AND ZHOU LIYI
Institute of Geophysical and Geochemical Exploration,
Landfang, Hebei 102849, P.R.China

Stripping chronopotentiometry (SC) is a new electroanalytical technique, which is simple and sensitive, and has some interference for determination of trace elements in environmental water, food and biological samples.

In this paper, a method was developed for simultaneous determination of trace copper and lead in geological materials by current oxidating stripping chronopotentiometry (COSC). A sample was digested by mineral acid, then Cu and Pb were directly determined by COSC (t_d=20s, E_d=-0.80V, i=1uA) in the solution of 0.2mol/L HNO_3 and 0.5mg Fe^{3+} and 1.0mol/L NaCl and 0.1mol/L Vc. A model MP--1 Stripping Analyzer was used in this study.

The authors have also systematically optimized instrumental working parameters, experimental conditions, and particularly studied the interferences of more than 40 elements to Cu and Pb. Under the optimum conditions selected, the detection limits for Cu and Pb are 0.24 ug/g and 0.14 ug/g respectively. Dynamic linear ranges are Cu 10-1,000 ng/mL and Pb 2-1,000 ng/mL. The relative standard deviations (RSD) are 2.35% and 3.98% in the levels of Cu 22.3 ug/g and Pb 16.8 ug/g in sample, respectively. 26 geochemical reference materials (GSR1-6, GSS1-8 and GSD1-12) were determined by the method. The results obtained are good agreements with the certified values. COSC can be applied to field analysis. The analytical results of Cu and Pb are listed as follows.

Results for Cu and Pb   (μg/g)

	Cu		Pb			Cu		Pb	
samples	obtained	certified	obtained	Certified	samples	obtained	certified	obtained	Certified
GSR—1	2.5	3.2	30.2	31	GSS—8	20.6	24.3	19.1	21
2	53.9	55.4	11.4	11.3	GSD—1	20.9	21.8	19.9	20.4
3	50.0	48.6	8.1	7.2	2	10.6	10.9	30.9	32.0
4	21.1	19	8.9	7.6	3	171	177	40.9	40
GSS—1	19.8	21.0	94.4	98	6	354	385	88.9	87
2	16.0	16.3	21.3	20.2	7	38.6	38	308	350
3	10.9	11.4	23.3	26	8	5.2	4.1	20.6	21
4	40.9	40.5	58.1	58.5	9	32.3	32.1	19.6	23

GEOCHEMICAL ANOMALIES OF ROCK-FORMING ELEMENTS:IMPORTANT INDICATORS OF BLIND ORE DEPOSITS

ZHANG XIPING
(Beijing Institute of Geology and Mineral Resources, CNNC)

Traditionally, geochemical explorationists rely overwhelmingly on trace elements and ignore major rock-forming elements. It is, however, the major rock-forming elements that dictate the physio-chemical parameters of the ore-forming system to favorite or prevent the precipitation of ore elements. The long-researched wall rock alteration is the results of redistribution of rock-forming elements to form new minerals under changed conditions. A certain portion of wall rock alteration is actually the products of ore forming processes. Wall rock alteration that took place before ore-forming processes may have created a favorable condition for ore precipitation.

Major element anomaly patterns are well developed and best investigated in porphyry Cu deposits and kuroko type deposits where the distribution and quantitative variation of the major elements show close spatial relationship to the extent of mineralization and the rich ore beds. The fact that rock-forming elements control the migration, accumulation and precipitation of ore elements is confirmed by the following observations; the composition of fluid inclusions in both ore minerals and gangue, the theory of transportation in complex ions, the mass exchange between ore fluids and wall rocks and the existence of metasomatic plume at the early stage of ore forming processes in a number of pyrite deposits. Therefore, geochemical anomaly of rock-forming elements is not only a subject of academic interest but a practical indicator in geochemical prospecting, especially in the search for blind ore deposits.

TECTONIC-GEOCHEMICAL FORECASTING IN THE DEPTH OF JIEHE GOLD DEPOSIT

ZHAO LIQING
(Gold Geological Research Institute of MMI, China)

Survey of deposit geology Jiehe gold deposit is a medium-sized alteration-rock type deposit which is located at Jiaoxing ore field in the Jiaodong peninsula and controlled by Wangershan fault which is multiple active one. Its trend is NE, dip NW and dip angle is 30 to 42. There are spray fault at its top or bottom wall. It is in the Linglong granitite in the shallow and in the Guojialing granodiorite in deep. Main orebodies are controlled by master fracture and the position of intersection of master fault and second order fault and its form is vien or lenticular, length of dip is greater than that of trend. Form south to north there are three orebodies which are No.4, No.1 and No.7. No.4 and No.7 orebodies are blind ones, elevation of occurrence of orebody is +50 to -120m and +30 to -200m respectively. Orebody No.1 is exposed at surface, elevation of occurrence is surface (about + 60m) to -450m.

Controlling of shape of fault to gold orebody

Three dimensions coordinate of fault plane, mean grade of orebody, thickness and grade multipled by thickness was counted respectivelly. By means of computer their vertical isogram was plot. At first primary trend surface analysis of the fault plane was done and plot isogram of remanent value of primary tend surface analysis, the isogram reflects variety of the shape of fault plane. Comparing the isogram of remanent value with the isogram of grade multipled by the thickness of orebody, the isogram of mean grade and the isogram of thickness has been studied and demonstrate the occurrence regularity on orebodies and the rich position on mineralization. Ordinate of the isogram is elevation, abscissa is distance along with base line of prospecting (the number of control station is 148). No.4, No.1 and No.7 orebodies is in transition zone in which the fault plane varies from salient to depression or from depression to salient. Of them No.4 and No.1 orebodies are in two sides of salient respectively, and are in the bottom wall of fault plane. No.7 orebody is in the north-eastern side of depression. No.1 orebody has obvious pitch, two plump centers and another center of high grade at -450m level. No.4 and No.7 orebodies have no obvious pitch. It is possible that there is a second enrichment centre along their pitch direction, especially No.7 orebody.

Tectonic-geochemistry

Hydrothermal solution migrated along fault zone, metasomatic adjacent rock, formed orebody (or mineralization), and elements disseminated or concentrated. Dispersion and concentration is controlled by nature and the shape of the fault structure. To forecast position in which orebody probably exist law which elements disseminated and enriched in the fault zone has been studied. To collect geochemical information of boreholes samples that too much money had been spent to get as more as possible we collected accessory samples of boreholes which have been carried out and constituted continuous samples by concentration of gold. The length of samples which have been constituted is generally 3 to 10 metres. 12 element were analysesed. Linear metallo-metrics of each element in all trenches, tunnels and drill holes were calculated. By factor analysis factor leadings of each factor were calculated. By computer vertical isogram of linear metallo-metrics of elements and factor leading of factors in fault zone were plot (draw were omitted). There are different enrichment centres of elements. Below No.4 orebody there are anomalies of Sb, Hg, As which implies existing of another orebody in deep. Anomalies of Cu, As, Hg of No.1 orbody is not closed in deep that implies the orebody still has a stretch. Anomalies of As, Hg, Pb, Ag indicates No.7 orebody would spread along southwestern pitch direction.

Here tectonic-geochemical forecasting has more merits than study of primary halo of profile section. It reflects more extensive information, samples is mainly collected in master fracture alteration zone, constitued and then cost of chemical examination is reduced, effect can be applied to select scientifically position in which borehole would be drilled.

ROCK GEOCHEMICAL SURVEY: ITS THEORY, TECHNOLOGY AND EFFICIENCY

ZHAO LUNSHAN, SHEN YONGLI AND WU YUEBIN
(China University of Geosciences, Beijing)

A 304 km² area in the Mupping-Rushan auriferous belt, eastern Shandong, China, has been covered by bedrock sampling using a new technique called "Target Tracing Prospecting", in which two kinds of rock samples are taken simultaneously during the field work and two sets of indicator elements are used for each set of samples. The advantage of this technique is that it can acquire both information on basic geologic research and prospecting in one field visit. The theory behind the technique is based on the view that there are two geochemical fields which could be dealt with separately. For the study Mupping-Rusan area we have:

1. Normal (or background) field which is determined by sampling the nonnmineralized fresh rocks and using Sr, Zr, V and Ti as the indicators to research into some problems in geology and mineralization in the area.

2. Anomalous field which is observed by sampling the material that have evidence of mineralization or influence of certain mineralization, such as quartz veins, altered rocks, gossans, tectonites and dykes, and using Au, Ag, Pb, Cu, Zn, As, Mo and Co as the indicator elements to investigate the distribution of mineralizatioan in the working area, and delineate prospecting targets.

The distribution of sample sites within a sampling unit is random whereas the sampling units are systematically arranged before field work begins. The entire working area is first divided into sampling units according to the grid of the topographic base map. The sampling density for the 1:50,000 scale are: 1-2 samples/km^2 for the background field and 3-4 samples/km^2 for the anomaly field, thus the overall sampling density is about 4-6 samples per sampling unit. This layout of sampling keeps the distribution of sample sites homogeneous over the entire study area and ensures more complete geological information.

Our experimental work on rock geochemical survey in Mupping-Rusan area has yielded some interesting results which is briefly described below. The regional structure framework and the metamorphism of the study area is well expressed on the maps of geochemical background field, and some indications towards genesis of the granites in the area are also given. On the geochemical map of zirconium, there is a high value zone. Following up in the field, we found that the area where Zr values are higher than 400 ppm are related to a kind of quartzite, the protolith of which is feldspathic sandstone. Therefore, the key bed that dividing the Proterozoic Erathem from Archaeozoic Erathem was found. The geochemical information of Ba and Sr eplenishes the evidence which supports the viewpoint that the genesis of the granites in the working area is migmatization. The migmatization zone with intensive K-alteration is defined by the distribution of the Ba and Sr, which is favorable to Au mineralization and is assumed to be the secondary source of gold mineralization.

25 integrated anomalies were delineated in the study area, of which 7 are associated with known gold deposits whereas other 18 were newly discovered. A computer program, called GA system, is developed and used to evaluate the anomalies. So far four commercial gold ore bodies have been discovered in the anomalies.

IMAGE PROCESSING OF GEOCHEMICAL DATA AND APPLIED EFFECT IN BEISHAN

ZHAO XIGANG

The image processing of the geochemical data has been carried out for the first time in Beishan, Gansu and lot of information of the geochemical data image is obtained. The geochemical data image is easy to integrated with gravity, magnetic, TM and geological data and so on. Interpretive effect is better.

The geochemical data is processed with pre-processing; stereo model; CLUTS and HCF of the image processing; compound processing.

The rich gold rocks and the gold-bearing original rocks are determined, the gold element is considered to be from crust deep because the gold background value of rocks is higher in this region by the statistics of the geochemical data of various rocks from stream sediment survey and rock survey.

According to gradient, intensity and concentration centre of gold geochemical anomaly in the area, radioactive anomaly, gradient zone of gravity and magnetic anomaly, especially the vertical second derivative zero contours of gravity and magnetic data, the colour veins and interpreted structure were determined by TM

image, especially circular and rhombus structure, preferable rocks, alteration (pyritization and silicification) by shallow-yellow compounded image. 18 gold prospective areas have been obtained in 4 gold prospective zones, the gold mineralizations in alteration zones are proved in open-cut. The gold content of 20 trenches is to reach 10 ug/g. The gold ore is interesected in 6 boreholes of T110-(2) mineralization alteration zone.

INTERPRETATION AND EVALUATION OF REGIONAL GEOCHEMICAL ANOMALIES IN THE NORTHERN MARGIN OF NORTH CHINA PLATFORM

ZHAO XIANJUN
(North-East Institute of Technology, Qinhuangdao)

Thousands of square kilometers area in the northern margin of North China platform were covered by stream sediment survey. In interpretation and evaluation of the results of this project, the author formulated a scheme described below: (1) to verify the quality of the raw data by cross check; (2) to classify the anomalies according to their likelihood to possible type of mineralization in the study areas; (3) optimize evaluation criteria by statistical procedure; (4) to assess quantitatively or qualitatively individual anomaly by selected parameters; (5) to estimate erosion degree of the anomalies by vertical zonation.

GEOCHEMICAL METHOD OF SEARCHING FOR IRON AN MANGANESE DEPOSITS

ZHENG TIANYOU

It is necessary to use geochemical method in reconnaissance for searching for iron and manganese deposits. Even though in those deposits without sulfide mineralization geochemical exploration can be used to solve various prospecting problems at different levels such as predicting for ore-bearing possibility of magmatic bodies, prospecting for nonmagnetic iron deposits in overburden areas and reconnaissance for manganese deposits in broad areas.

1. Geochemical Evaluation on Ore-bearing Possibility of Basic Intrusive Bodies
There are two basic conditions for the formation of magmatic deposits: the ore-forming material must be rich and has been concentrated. The magmatic bodies with ore-forming possibility must undergo various metallogenetic and diagenetic geochemical processes, and the products from different geochemical environments must have their distinct geochemical characteristics. So according to certain geochemical characteristics of basic intrusive bodies, some geochemical environments of their formation process can be interpreted, and then the ore possibility of the intrusive can be predicted.

Around a vanadic titanomagnetite deposit, there are a lot of gabbro bodies which are similar to known ore-bearing intrusive bodies in lithology, and it is difficult to discriminate their ore-bearing potential only by geological feature and petrochemical

elements for vegetation's growth including P, K, Fe, Zn and S, particularly K, Zn and P were obviously concentrated in sprouts and tender leaves. Most of these elements are also helpful to human health, Harmful elements for vegetation's growth and human health, such as Hg, Cd, As, Sb, Al and Pb, were greatly concentrated in the ripen leaves. Similar elemental characteristics were discovered in the tea-leaves that were picked from several teagardens in the same growth stage, that is, the high-grade tea-leaves contained more helpful elements such as K, Zn and less harmful elements such as As, Sb, Hg, Ca and Al. It was concluded that the content of nutritive (usually helpful for human health) and harmful (usually toxic for human) elements were greatly related to tea's quality and can be used as useful indicators for tea quality.

It was shown that soil property and its geochemical characteristic which closely related to the bedrock were important factors affecting the growth of tea-tree, the element content in tea-leaves and the quality of tea. Based on the detailed research in several teagardens, it was evident that the physical properties of soil, the contents of P, K, Zn, Mn, Ca, Cu, B, Mo, S and Al, especially their available contents, as well as organic matter and pH, were important geochemical factors to the growth of tea-tree. On the other hand, helpful elements such as K, Zn and P as well as toxic elements such as Hg, Cd, Pb, F and As, were also main factors to affect the quality.

By collecting soil samples over a region of 40 km^2 and analyzing 24 elements, it was studied the relation between element distributions and bed rocks, soil types, human activities in the area. Based on the affecting factors (soil geochemistry, bed rock, soil type, landscape and climate condition), it was preliminarily suggested for the plan about arrangement of tea production and fertilization of teagardens.

THE RELATION BETWEEN SOME ELEMENTS (NUTRITIVE, HELPFUL AN HARMFUL ELEMENTS) AND THE GROWTH AND OUTPUT OF CROPS IN HANGJIAHU PLAIN, ZHEJIANG PROVINCE

ZHOU GUOHUA[1], ZHU LIXIN[1], REN TIANXIANG[1], GU JINQIU[2] AND DU XIONGJIN[2]

1--Institute of Geophysical and Geochemical Exploration, Ministry of Geology and Mineral Resources, Langfang, Hebei 102849, P.R.China
2--Academy of Geophysical and Geochemical Exploration, Zhejiang province

From 1991, based on regional geochemical soil survey, Hangjiahu plain was subdivided into several geochemical districts to particularly investigate the relation between the elements in soil and the growth and yield of crops.

Plant samples including the roots, stems and seeds of oilseed rape crop, the straw, brown rice (unpolished rice) , mulberry leaves, and the roots, stems, bark of hemp were collected and determined. The results showed that concentrations of Mg, Fe, Mn, Cu, Ca and B in oilseed rape crop were the highest in roots, and in general elements such as Na, Ni, Al, Cr, Co, Pb, As, Ti and V had higher contents in roots, whereas the concentrations of K, S and P were higher in stems than in roots. Most trace nutritive

elements particularly Mo, Zn, B and Mn relatively concentrated in seeds. Elements including Mg, K, Ca, Mn, Fe, Mo, S and Cu except for P that enriched in brown rice, obviously concentrated in rice straw. By analyzing hemp's organs, it shown that most elements were abundant in hemp roots, and hemp stems usually had the least amount of elements.

By contrasting the element contents in soils and crop's organs in higher yield fields with lower yield fields, it showed that in Xitang area, some elements in soils such as K, Mg, Mn, Mo and Si as well as the available contents of K, Mn and Si were more abundant in higher yield fields than in lower yield fields. In Qiaosi area, Si and available P, Ca, Zn were higher in higher yield fields. In both areas, P, K, Ca, Mg, S, Fe and Mn in the roots, stems and seeds of oilseed rape crops were more abundant in higher yield fields than that in lower yield fields. In Xitang, in higher rice yield fields some elements including K, Mg and Fe in soil and Mg, P, K, Mn, Fe, Zn, Mo, S and B in straw were more abundant than that in lower yield fields. In Shengshan area, in higher rice yield fields elements including P, K, Ca, Mg, S, Fe, Mn, Cu and Zn in soil and K, Mn, Zn, S, B and Si in straw were richer than that in lower yield fields. In Tongxiang area, elements P, K, Mg, Fe, Cu, Zn, B and Mo and the available contents of P, K, Mg, S, Mn, B and Mo in soils as well as P, K and Mn in mulberry leaves were more abundant in fields where mulberr grows better. All of these proved that the growth and output of crops greatly related to the total and available values of nutritious elements in soils as well as soil properties, organic matter contents, pH. According to crop's demand, threshold and sensitivity for nutritive elements, it was pointed out what kinds of elements were insufficient for the growth of a special crop in certain area. The results can be used to guide agricultural production including crop's planning, fertilizations and managements.

THE CHARACTERISTICS AND SIGNIFICANCES OF MULTI-FORMATION HALOES OF ZHILINGTOU GOLD-SILVER DEPOSITS.

ZHOU JUNFA AND QIAN JANMIN
(The No.7 Geological Party, Zhejiang Province, P.R.C.)

The deposit is situated at the intersection of the Chengcai-Longlu uplift zone (trending NE) and Sanmen-Suichang crustal type fault (trending NW). Peterozoic metamorphic rocks are exposed as a tectonic window and overlied unconformably by upper Jurassic continental clastic rocks in which volcanic intrusive and subvolcanic rocks developed. Different stages of mineralization formed large scale gold- silver deposit of vein type, a small scale pyrite deposit and a copper-rich polymetallic deposit as well as a promising lead-zinc deposit. These deposits can be described using the theory of associated deposits. The multi-formation haloes were found in this mineralized area and halo characteristics and their significance for prospecting are as follows:

1. The results of 1:100,000 -1:200,000 scale stream sediments and heavy minerals surveys delineate multi- element combination anomalies of Au, Ag, Pb, Zn, Mn, Cu,

Sn, Mo, Ni and Co, but the axis of single element anomalies show different trends. Heavy mineral anomalies are characterized by the combination of Au- Ag group -- Pb group -- pyrite, which reflects the combination of occurred deposits in the area.

2. The anomaly revealed in the stream sediment survey was further decomposited into twenty multi-element soil anomalies after conducting a 1:10,000 (100m x 40m sampling grid)soil survey. The combination of major ore elements are: (1) Au-Ag-(pb-Zn), which indicates the vein type gold-silver mineralization; (2) Au, which indicates the dispersion train of the previous mineralization if it is spread along drainages; (3) Pb-Zn-Ag, which indicates the possible occurrence of an industrial lead-zinc deposit if the dimension of anomaly is large enough; (4) Cu-Pb-Zn- (Ag), which indicates the presence of a copper-rich polymetallic deposit. Generally, soil anomalies possess the characteristics of multi-mineralization halo.

3. The features of a multi-formation primary halo are: (1) The primary halo formed by different mineralized formation has different combinations of major ore and associated elements are different. The concentration of major ore-elements differs by 2-3 orders. (2) Elements are disconnected and vertically superimposed or oriented differently (3) Primary haloes of different mineralized formations have their own axial zoning sequence, the ratioes of elements (such as Au/Ag, Ag/Pb) and the index of cumulative multiplication (such as AuxAg/PbxZn). They are distinctly different from each other; (4) They sometimes occur in penetration form and distribute in different geological structures or different parts of the same geological structure.

4. In this area, a small scale pyrite deposit was discovered using geological method in the 1950's. Furthermore, a large scale glod-silver deposit was discovered by studying the deposits complex haloes in the 1960's. The potential of lead-zinc and polymetallic mineralization was confirmed through the study of multi-deposit haloes and multi-formation haloes in the 1980's. Large scale reserves are predicted and new target areas for gold-silver mineralization have been delineated. At present, a follow-up survey for the anomalies in the gold-silver mineralization target areas and prospecting for zinc-lead mineralizations is underway. Satisfactory results have been achieved.

The multi-formation halo is one kind of complex halo formed by the superimposition of haloes of different deposits or ore-bodies. Formation takes place in different stages of the ore-forming process temporally and spatially. It is inherently different from a halo produced by single ore- forming process. Study of the multi-formation halo is of significance especially in omprehensive prospecting and discovering of new deposits.

A NEW PARTIAL DISSOLUTION TECHNIQUE FOR PROSPECTING HIDDEN GOLD DEPOSITS

ZHOU LIYI AND SUN XIAOLING
Institute of Geophysical and Geochemical Exploration, Langfang, Hebei 102849, P.R.China

A new partial dissolution technique was developed for prospecting hidden gold deposits. The technique is based on the selective extraction (or adsorption) of Au by polyurethane foam and can partition gold in geological materials into three fractions:

Fraction 1 water-soluble gold is the most mobile form of occurrence of gold.

When we studied the determination of trace gold by using preconcentration of Au with polyurethane foam, we had found that Au^{3+} in weak acid solution was only adsorbed by the foam, and other forms of gold (i.e. Au^0, Au^{1+} and colloidal Au) were not adsorbed. According to these, we have developed a method for selective extraction and determination of Au^{3+} as follows: 10 grams of the samples are soaked and extracted with 50ml deionized water (acidified with 1% HCl), then put a piece of the foam in extracted solution and extract for a certain time, take the foam out for determination of Au by GFAAS. These portions of gold mainly occur as a form of Au^{3+}.

Fraction 2 is related to stable gold-inorganic complexes and gold-organic acid compounds (fulvic-humic complexes) in geochemical materials. This fraction of gold is a more significant form of dispersion, migration and concentration of occurrence of gold. Gold in this fraction mainly occurs as Au^{1+}.

To extract this fraction of gold, a selective solvent, sodium pyrophosphate, was used. The procedure is as follows: adding $NaOH$-$Na_4P_2O_7$ concentrated solution into the extract solution and residue which were removed out of Au^{3+} by the foam in fraction 1, make the extraction solution equal to 0.1M $NaOH$-0.1M $Na_4P_2O_7$, then shake and extract it for a certain time. After that separate extractant and residue, treat the extractant with aqua regia and determine trace gold by GFAAS after preconcentration with the foam.

Fraction 3 metal-gold (Au^0) is related to native gold particles.

Digest the residue from fraction 2 with aqua regia and determine gold by GFAAS after preconcentration with the foam.

For a comprehensive assessment and quantitative interpretation of the anomalies which are caused by variant forms of occurrence of gold, and an individual sample is taken for determination of total gold. And organic carbon (% DC), DC (CO_2 in alteration carbonate) and $NH4+$ are determined. The concentration of trace gold is described relative to the amount of organic carbon, DC and NH^{4+} by Au/C, Au/DC and Au/NH^{4+}.

An orientation survey for prospecting gold deposits was carried out in the surrounding of a known gold-silver deposit Yindongpo, Henan province and a greenstone belt, Wutai mountain, Shanxi province by using the technique. Results obtained have shown that deep-seated mineralization (up to 250m) and those under thick overburden (10-150m) can be detected. Weak anomaly of gold can be discovered, distinguished and evaluated by using mobile forms of gold (water-soluble,

inorganic complexes and organic acid complexes). Distinct anomalies of DC and NH^{4+} are right over a hidden gold orebody.

A STUDY OF SIMULATION EXPERIMENT ON THE INTENSITY OF VERTICAL MIGRATION

ZHOU SHUXIN WANG ZHENPING AND ZHAO XIGU
Daqing Petroleum Institue, China

Vertical migration involves passage of the material in oil and gas pools through overlying rock layers under the concentration and pressure differences. The cover is the biggest obstacle for vertical migration. Therefore, a special simulation device has been designed to simulate the intensity of vertical migration in mudrock under various conditions.

Results show that a certain amount of gas passes through the mudrock under all conditions. Moreover, amount of gas flow changes regularly with changing conditions. Based on this and geological conditions of forming oil and gas pools, some problems about the vertical migration are further discussed, and the regular pattern of vertical migration and some significant conclusions are obtained.

GAS AND OIL INDICATIVE SIGNIFICANCE OF ACIDOLYSIS HYDROCARBON AND ^C OF VERTICAL SECTION

ZHOU SHUXIN, ZHOU SHENGGUAN, BAO FENG AND JIANG YAOJIAN
(Daqing Petroleum Institute)

The paper is based on the study of vertical profiles of Sheng 501 well and Sheng 69 well of Songliao Basin, E 2 well and Fan 103 well of Ordos Basin and Fu 1 well of Fuxin Basin and LH10-1-1 of Liaohe Basin. It is revealed by way of comparison that acidolysis hydrocarbon is related to ΔC, it can be used as an indicator of underground gas and oil.

The change of characteristics of acidolysis hydrocarbon in vertical section can reflect basically the distribution and migration of underground gas and oil reservoir, and it has been tested by drilling. In Sheng 501 well and Sheng 69 well, acidolysis hydrocarbon, methane and heavy-hydrocarbon appeared evident high values in the middle depth layer (1000-1700m), the highest value of methane is 2898 ul/kg. Under 2600 meters of E 2 well the highest value of methane is 3188.85 ul/kg, the heavy-hydrocanbon 553 ul/kg. These give the important information of underground oil and gas in depth. In the shallow layer (150--400m) of Fan 103 well there are high values of methanes and heavy-hydrocarbons, the highest value of methane is 2400 ul/kg, heavy-hydrocarbon 500 ul/kg, this can help to search for shallow gas in this area. High values of methane and heavy-hydrocarbon concentrate in the middle depth layer (1100--

1250m) in Fu 1 well, the highest value of methane is 55716 ul/kg, the heavy-hydrocarbon 2000 ul/kg, the prospecting result proved that gas-bearing layer is in the middle depth layer in the area.

ΔC is usually considered as a special carbonate that is formed by little hydrocarbon-gases divergent up to near surface from deep gas and oil reservoir and is oxidated. Through preceding the study of geochemical exploratory wells, it has be found that the distribution of ΔC is similar to that of methane and heavy-hydrocarbon, so ΔC can be used as an indicator for oil and gas reservoir. R-tpye cluster analysis and R-type factor analysis have proved that acidoysis hydrocarbon is related to ΔC . The measurement results showed that ΔC values of shallow layer was not higher than that of the deep layer. For example, ΔC value in shallow layer (80--150m) is 6.77%, the deep's (2000m--3000m) ΔC is 2--4%. In Fan 103 well the ΔC average value of surface layer is 2.07%. but deep layer ΔC (1180--1260m) is 5.32%. In all geochemistry exploratory wells, the ΔC high-value zone is often the high-value zone of acidolysis hydrocarbon, this proved that ΔC is relate to oxidizing environment of surface, and intensively influenced by organic-carbon and its evolution.

The application of ΔC in indicating gas and oil in geochemistry exploratory is controversial, the application results in different geochemical exploration wells and in different areas are not the same. If ΔC is combined with acidolysis hydirocarbon, there would be important significance indicator for gas and oil. In the appreciation of gas and oil to Fan 103 well and Fu 1 well, the anomalous values of methane and heavy-hydrocarbon and ΔC were chosen to be an indicator of grade I anomalous zone, the result is evident. In Fan 103 well, the interval of 1180m--1220m is grade I abnormal zone, and the highest value of methane is 2537.35 ul/kg, the heavy-hydrocarbon 446.15 ul/kg, the ΔC 5.32%. In Fu 1 well, the interval of 1100---1260m is grade I anomalous zone, and the highest value of methane is 55716.5 ul/kg, the heavy-hydrocarbon 2327.8 ul/kg, the ΔC 6.47%. The two anomalous zones of those wells are correspond to preferable gas and oil zones.

OVERALL DATA PROCESSING SYSTEM FOR HYDROCHEMICAL PROSPECTING

ZHOU WENBIN
East China Geological Institute, Fuzhou, Jiangxi, China

Hydrogeochemical prospecting is an effective method for exploration of uranium, gold and other ore-deposits. With low cost and high efficiency, it can reduce the size of exploration target areas, thus it is usually applied in regional survey stages. Hydrochemical prospecting has been used in the field of uranium geology in China since the late 1950's and has made great contribution to China's nuclear industry. However, the methods of hydrochemical data anagement and processing are still out of date, resulting in low processing speeds and poor utilization of the prospecting data. In order to change this situation fundamentally, the author has developed an overall data processing system for hydrochemical prospecting for uranium and gold. The system integrates database management with data and graphic processing, and could

improve the quality and speed of hydrochemical data processing. The structure and main functions of the system are briefly introduced below.

1. Database management subsystem

The hydrochemical database management subsystem was programmed in FOXBASE+V 2.10 and has such functions as data input, storage, inquiry, statistics, table forming and printing. In addition, it has data interface capability with hydrochemical data processing subsystems and graphic subsystems.

2. Data processing subsystem

This section consists of a group of programmes in FORTRAN or C, and can process the data stored in the database mentioned above. The major functions of the subsystem include the determination of data distribution patterns, background values and anomaly thresholds, correlation analysis, factor analysis and integrated fuzzy include discrimination and so on. Its other function is to output the calculated results in the form of graphic data files or graphic exchanging files and prepare for graphic processing.

3. Computer graphic subsystem

This subsystem is capable of plotting many kinds of maps and diagrams usually used in hydrogeochemical prospecting, such as actual data map, data distribution diagrams, contour maps and cubic diagram. All the maps can be produced with printer and plotter or by taking a picture from the screen image and processing it into color photograph.

GEOCHEMICAL INDEXES FOR EXPLORATION OF GEOTHERMAL FIELDS AND THEIR EFFECTIVENESS

ZHU BINGQIU AND YU HUI

Institute of Geophysical and Geochemical Exploration, Langfang, Hebei 102849, China

In the past ten years, geochemical studies have been performed in nearly 30 geothermal fields in more than ten provinces or autonomous regions of China such as Tibet and Yunnan. Besides conventional methods such as soil survey and hydrochemical survey, some unconventional geochemical methods have been employed, including geochemical geothermometers, gas survey and radiometric survey. On the basis of comprehensive researches, geochemical indexes for exploration of geothermal fields have been summarized: in geothermal investigation, Hg, As and Sb (Bi) seem to be the optimum indicator elements for delineating geothermal fields; over high-temperature geothermal fields there exist multielement anomalies of W, Sn, Li, Rb, Cs, Be, Hg, As, Sb, Bi, B, Cu, Pb, Zn, Mn, Ni, Co, etc. which show distinct zonation; Na^+, Cl^-, HCO^-_3, CO^{2-}_3 and SO^{2-}_4 can form different hydrochemical types, indicating different sorts of hot waters; in high-temperature hot waters, such minor components as Li, Rb, Cs and HBO_2 are somewhat higher; geochemical geothermometers like SiO_2, Na-K, Na-K-Ca and Na-Li might be used to

estimate temperatures of deep thermal reservoirs; soil gases Hg, Rn, CO_2 and He can reveal structures in geothermal fields; isotopes of H, O, C and S help to find out sources of hot water and properties of heat sources.

The integrated application of these geochemical indexes has yielded obvious geological effects in geothermal field exploration of such areas as Yangbajing, Yangyingxiang and Naquzhen of Tibet, Rehai of Yunnan, Zhangzhou of Fujian, Xiaotangshan of Beijing, Guangzhong of Shanxi and Qinhuangdao of Hebei.

APPLIED RESULTS OF TRACE ELEMENTS IN IMPROVING THE OUTPUT AND QUALITY OF TOBACCO

ZHU LIXIN[1], REN TIANXIANG[1], ZHOU GUOHUA[1], WANG HU[1], HUANG ZHIYE[2] AND HUANG WENXIU[2]

1--Institute of Geophysical and Geochemical Exploration, Ministry of Geology and Mineral Resources, Langfang, Hebei 102849, P.R.China
2--Agricultural University of Henan

From the beginning of 1991, it was carried out to do some experiments of applying trace elements to improve the output and quality of tobacco by Institute of Geophysical and Geochemical Exploration, cooperating with Tobacco Department of Agricultural University of Henan in Xuchang area which is an important area for tobacco production in Henan province. Experiment fields were selected by investigating the soil geochemistry of the cultivated land in which tobacco's growth and quality are good or bad. The results of soil geochemical investigation indicated that the contents of some trace elements, such as Fe, Mn, Cu, Zn, Mo, V, Ni, Co and Sr are insufficient to tobacco's growth in the soil of low production and bad quality. Therefore elements such as Cu, Mn, Mo, Zn, B were selected to fertilize to improve tobacco's output and quality.

The results showed that the botanical parameters of tobacco were improved in certain extent by comparing with the contrast field (not applying trace elements fertilizer) after trace element fertilizers were sprayed on the leaves of tobacco. The output of tobacco was obviously increased by average 27.6 percent per mu (one-fifteenth ha), the highest 57.7 percent. Economic income was also increased by average 159.07 yuan per mu, the highest 323.17 yuan.

The results showed that the grade of tobacco quality was remarkably improved, of which the proportion of first-grade and middle-grade tobacco was increased by 16.9 percent, low-grade was decreased by 17.6 percent.

The chemical composition of high quality tobacco is characteristic of high contents of cartobydrate and nicotine and low element contents of total nitrogen (N) and chlorine (Cl). The experimental results showed that the contents of cartobydrate and nicotine were increased, and the element contents of total N and Co were decreased. The contents of these compositions were approximate to the standard values of good tobacco.

The applied results prove that trace elements are effective to improve the output and quality of tobacco by applying their fertilizers to the cultivated land of tobacco, especially to some areas where the contents of trace elements are insufficient to its growth. If the technique can be used widely in Henan province, the economic benefit will be great.

APPLIED RESULTS OF THE TRACE ELEMENTS IN INCREASING THE OUTPUT OF CROPS

ZHU LIXIN[1], REN TIANXIANG[1], ZHOU GUOHUA[1], WANG HUI[1], ZHANG XIAORAN[2], AND YIN SHUYI[2]

1--Institute of Geophysical and Geochemical Exploration, Ministry of Geology and Mineral Resources, Langfang, Hebei 102849, P.R.China
2--Soil-Fertilizer Station of Agricultural Bureau, Funing county, Hebei province

From 1991, on the basis of studying results of making use of regional geochemical data in agriculture, experiments of applying trace elements, including Zn, Mn, Co, Mo, B to increase the outputs of rice, corn, peanut and apple were carried out in Funing area by Institute of Geophysical and Geochemical Exploration, cooperating with Soil-Fertilizer Station of Agricultural Bureau, Funing county, Hebei province, and excellent results have been obtained.

The fertilizers of elements Zn and Mn were applied to rice in two experiment fields where the contents of elements Zn and Mn are insufficient to rice. The results showed that botanical parameter of the rice, such as the height of plant, the number of higher plant and available spike were improved by comparing them with that of the contrast field's rice (not manuring Zn and Mn fertilizers). After putting Zn and Mn fertilizers on, the output of rice (kg/mu(one-fifteenth ha)) was obviously increased, of which it was increased by 16.9 percent for applying 2 kg Zn-fertilizer per mu, by 14.4 percent for applying 3 kg Zn-fertilizer, and by 7 percent for applying Mn-fertilizer.

The corn was also experimented for applying Zn and Mn fertilizers in two experimental fields where the contents of Zn and Mn are insufficient. The results showed that botanical parameters of the corn, such as the height of plant, the length of corn spike and the number of corn grain per line were improved, the output of corn is remarkedly increased by more than 10 percent per mu, average 16.5, the highest 27 percent.

The peanut was experimented for applying elements Mo and Co in two experimental fields where the contents of Mo and Co are insufficient to its growth. The results showed that the output was increased by average 9 percent per mu, the highest 12 percent.

The apple was experimented for applying elements B and Zn in two fields where the contents of B and Zn are insufficient. The results showed that the output of apple was

obviously increased by average 17 percent per mu and the highest 23.7 percent for applying element B and by 10.7 percent per mu for applying element Zn.

As the results showed above, it is obvious that it is significant to apply trace elements fertilizer to cultivated land where the contents of trace elements are insufficient to crop's growth. Elements such as Zn, Mn, Mo, Co and B are effective on increasing the output of crops.

PRELIMINARY STUDY OF THE RELATION BETWEEN THE TOTAL AND AVAILABLE CONTENTS OF NUTRITIVE TRACE ELEMENTS IN SOIL

ZHU LIXIN[1], WANG HUI[1], ZHOU GUOHUA[1] AND GU JINQIU[2]
1--Institute of Geophysical and Geochemical Exploration, Ministry of Geology and mineral Resources, Langfang, Hebei 102849, P.R.China
2--Academy of Geophysical and Geochemical Exploration, Zhejiang province

According to the difference in natural landscape condition between the south and north part of China, the study of the relation between the total and available contents of nutritive trace elements for crop's growth in soil was carried out in Funing area, Hebei province and Hangjiahu plain area, Zhejiang province. The area of two investigation regions are respectively 450 and 10000 km2. 150 soil samples were collected and analyzed for the total and available contents of nutritive trace elements (Cu, Zn, Fe, Mn, Mo, B) as well as pH and organic matter.

The results showed that the available contents of some elements such as Cu, Zn, Mn, B and Mo (except Fe) have better linear relations respectively with their total contents in different kind of soil. The changing regularities of the total and available contents were the same in the horizontal and vertical direction. It demonstrated that the total contents was an important resource of the available contents.

Another result was that the source and its components that formed soil were basic factors that determined the contents of trace elements in soil. If the difference of the total contents in different soils is not obvious, soil's type, pH and organic matter will be the main factors that affect the available contents of trace elements.

On the basis of consideration for various natural environmental condition of soil, transform coefficients (R) between the total and available contents of Cu, Zn, Mn, Mo and B were alculated for different geographical areas of China. The change of R is vary little in a geographical area. The application of the coefficient was practised in two areas, the result showed that the coefficient was practical and reliable, it can be used in different areas for agricultural geochemical studies.

STUDIES OF ENVIRONMENTAL GEOCHEMISTRY IN HANGJIAHU PLAIN, ZHE JIANG PROVINCE

ZHU LIXIN[1], ZHANG LIANSHENG[1], GU JUNQIU[2], ZHOU GUOHUA [1] AND
WANG CHENG[2]

1--Institute of Geophysical and Geochemical Exploration, Ministry of Geology and
Mineral Resources, Langfang, Hebel 102849, P.R.China
2--Academy of Geophysical and Geochemical Exploration, Zhenjiang province

It was carried out to study on environmental geochemistry in Hangjiahu plain. The result showed that in this region the environmental background values of K, Na, Cu, Zn, Hg, As and Sb were higher, and that of Si, Al, Mn, Mo, S and I lower than the world's average value. Contrasting to Chinese and other provinces elemental background, the content of most element was similar, whereas Hg, Cd and Se were obviously higher.

The distributions of harmful elements in soil were obviously controlled by original soil, nvironment of soil formation and human activities. Some elements which are related to human activities, such as Hg, As, Pb and Cd, were anomalously concentrated in the surface-soil of city and town area. The anomalous properties were related to the history and scale of cities, but the contents of these elements decreased greatly in deep-soil, which proved that the anomalous elements were caused by human activities.

The regional environmental quality was assessed using environmental quality index. The region was divided into several environmental quality districts as follows: I) with the optimum environmental quality (about 4,000km^2); II) with good environmental quality (about 3,000km^2); III) with general environmental quality (about 1,500 km^2); IV) with bad environmental quality (about 500km^2). This divisions basically reflected the different levels of agricultural and industrial production. The soil pollution of harmful elements in urban area should be noticed.

Based on regional environmental assessment, the assessment of environmental quality of city was conducted in Hangzhou city. According to the distribution and pollution index of contanmination elements in soil, the city was divided into four districts of environmental quality as follows: I) with optimum environmental quality; II) with good environmental quality; III) with eneral environmental quality; IV) with bad environmental quality. The elemental concentration and pollution index increased from I to IV, which reflected the changes of environmental quality. By collecting some vegetable samples such as potato, celery and cabbage in different districts of environmental quality and analyzing harmful elements such as Hg, As, Sb, Cd, Cu and Zn in these samples and soil samples, it was shown that the content of these harmful elements were below the standard limited value for vegetables. Soil pollution did not have important influences on humankind health.

Soil, rice and well-water and surface-water samples were collected in Jiashan county with igher morbidity and mortality of large intestine cancer, and analyzed for Se elecment that had possibly a close relation with cancers. The result showed that the available Se that can migrate into biological chain was lower in soil of this districts than others (normal districts for cancer), although the total value of Se was not low.

The content of Se in rice and well and surface water were lower than that of normal areas, corresponding with available Se in soil.

Cancer is a dangerous disease to human health. Its occurrence and distribution are related to several kinds of causes and factors. According to many researches, cancer's distribution was related to lackage of Se. So it can be concluded that lower content of available Se in soil, well and surface water and unpolished rice may be an important environment geochemistry factor for the occurrence of large intestine cancer in Jiashan county.

ASSESSMENT ON THE SUPPLY LEVEL OF NUTRITIVE ELEMENT FOR CROPS IN SOIL IN HANGJIAHU PLAIN, ZHEJIANG PROVINCE

ZHU LIXIN[1], ZHOU GUOHUA[1], GU JINQIU[2], DU XIONGJIN[2] AND REN TIANXIANG

1--Institute of Geophysical and Geochemical Exploration, Ministry of Geology and Mineral Resources, Langfang, Hebei 102849, P.R.China
2--Academy of Geophysical and Geochemical Exploration, Zhejiang Province

On the base of regional geochemical soil survey in Hangjiahu plain, Zhejiang province, it was carried out to investigate geochemical characteristics of the total and available content of nutritive elements in soil. The result showed that total contents of most nutritive elements, except for S and Mo, were more abundant for crops growth in soil by comparison with the average value of Chinese and world's soil, thus there is a great potentialities for agriculture production.

The element distribution was obviously controlled by the original soil, the environment and procedure of soil formation and the human activities. The element content in deep soil (called first environment) was different from that in surface-soil (second environment). According to geochemical distribution pattern the area can be divided into four agricultural geochemical istricts, that is, littoral district of Qiantang River, Tongxiang-Jiashan district, Tai Lake southern district, and western and southern mountainous and hilly district.

The supply level of nutritive elements was different in different soil-type, especially for vailable content of those elements. The result showed that: 1) paddy soil was rich-level in available content for Si, S, Fe, Cu and Zn, sufficient-level for K and Mn, and defficient-level for Mo, B, P; 2) aqult soil was rich-level in available content for P, S, Mn, Fe, Zn, Si, sufficient-level for K and Cu, and defficient-level for B and Mo; 3) solonchak soil was deficient-level in available content for B, Cu, S, P and Mn, especially for K, Zn, Fe, and Mo; 4) yellow and red earth was
rich-level in available content for S and Zn, sufficient-level for Fe, Mo, and Mn, and deficient-level for Si, K, Cu and B.

The regional distribution of nutritive elements in soil varied with the landscape condition and original soil. 1) There are deficient-level in available content for Mn, Cu, Zn, Fe, Si, K and S in coastal plain due to soil with a higher pH and low content of

organic matter, and rich-level for Ca, Na and Mg; 2) There are sufficient-level in available content for Fe, Mn, Cu, Zn, Si and potential dificient-level for K, Mo and B in southern lacustrine plain of Tai Lake; 3) There are rich-level in available content for Fe, Cu, Zn, Si and S, sufficient-level for K and Mn, slightly deficient- level for P, Mo and B in Hydrographic Net plain; 4) There is deficient-level in available content for most nutritive elements except for Mo.

Results of the assessment on supply level of nutritive in soil can be used to guide agricultural production, including cultivated-land distribution for different crops, applying fertilizer to different agricultural districts and soil reclamation.

APPLICATION OF HG AND F ANOMALIES TO DEEP PROSPECTING FOR GOLD DEPOSITS

Zhu Taitian

Hg and F elements are widely used as long-distant indicators in geochemical exploration. The strong dispersion capability of these two elements through overlying rock means that ore bodies over 100 meters below the surface can be identified according to their presence. This paper proposes to describe various features of Hg and F, including anomolous forming mechanisms, and results of deep ore body prospecting predictions.

The gold mine studied lay at an exploration depth of 465m. When the mining work reached a depth of 380m, the Au grade showed clear signs of reduction. Below 470m the ore body was pinched. Clearly it was necessary to determine potential at deeper levels.

Results of a systematic rock geochemistry survey in the adit from the surface to -470m showed Hg and F anomalies in a half-lens shape from the surface down to -100m. From -100m donw to -380m we found the Hg anomaly in a complete lens shape distributed around the main orebodies, No.1, No.2, and No.3, indicating a blind orebody located bellow. According to the shape of the Hg anomaly we predicted the depth of the blind orebody at -510m. Based on studies of lenslike Hg anoamlies at -470m to -650m over the last two years, we predicted another orebody at a depth of 800m.

The F primary dispersion halo above -380m formed a funnel shape with a wide top and narrow bottom. No significant F anomaly existed around the gold veins No.1, No.2, and No.3. Between -470m and -650m the F anomaly was extremely wide and lenticular. This indicated that there might be a large blind ore body. Thus the Hg and F anamolies make roughly the same prediction.

In summary, we used Hg and F anomalies at this deposit to predict the second and third leves of the ore veins. Depths were predicted quantitatively. Test drilling proved all predictions accurate.

VERTICAL DISTRIBUTION CHARACTERISTICS AND INDICATIVE SIGNIFICANCE OF OIL AND GAS GEOCHEMICAL EXPLORATION TARGET IN FU 1 WELL OF FUXIN BASIN, CHINA

ZHUO SHENGGUANG, JIANG YAOJIAN, ZHOU SHUXIN AND YANG GUIFANG
(Daqing Petroleum Institute)

The study of vertical section of oil and gas geochemical exploration in Fu 1 well, using methods of acidolysis adsorption hydrocarbons, heat released carbonate (ΔC), heat released Hg (ΔHg), ultraviolet spectrum, fluorescence spectrum, carbon isotopes of methane, etc. revealed the migrating laws of hydrocarbons and provided a basis for oil and gas evaluation by setting up geochemical exploration vertical section.

Acidolysis adsorption hydrocarbons, such as methane, their vertical distribution, assume characteristics of low value at upper, high value at lower, maximum at central section. The average value in whole well 101 specimen is 6,000 ul/kg. The peak value at central section is 55,716 ul/kg. Methane is one of the most active composition in hydrocarbons. It is effective to indicate oil and gas target. It provides a guidline for seeking oil and gas. The central layer is expected to reserve oil and gas.

Having analysed removing way of hydrocarbons by ratio of i-C_4/n-C_5 and i-C_4/n-C_5, we considered that removing way is mainly infiltration. Only in compact marl bed (1100m--1400m) removing way is diffusion. Through analysis of vertical change of ratio between methane and heavy hydrocarbons,it is considered that the maximum value at central comes from deep gas, and that enrichment is due to separation by compact marl bed.

Distribution of ΔC is similar to methane and ethane, which the high values are in 1100m--1300m, the highest value is 6.47%. R-type cluster and R-type factor analysis have proved that ΔC is related to methane and ethane (correlation coefficient >0.6). Of the three factors situated on the second chief factor axial. It is proved that three of them is related to the cause of formation.

The average value of ΔHg is 12.9×10^{-9}, High value is situated in 900m-1000m. The hihgest value 57.68×10^{-9}. According to the R-type factor analysis, ΔHg possess a characteristic of multiple of formation. ΔHg is not related to acidolysis adsorption hydrocarbons, but is related to ultraviolet and fluorescence.

Ultraviolet spectrum and fluorescence spectrum indicate matters of aromatic hydrocarbon. The study has tested ultraviolet spectrum intensity of eight wave bands and fluorescence spectrum of three wave bands. The high intensity is situated in above 1100m.

According to the results of twelve carbon isotopes of methane (sampling interval is 100 m), methane gas which is situated in lower layer (>1100m) is oil-type gas, and in upper layer is mixed with coal-related gas and oil type gas. On the basis of individual value of carbon isotopic of methane reached -43%-- -46%, the gas in the upper layer came from lower part.

Through Q-type cluster and Q-type factor analysis (22 factors of 101 samples in whole well), the hydrocarbons system at upper is different from lower and at 1100m as their common boundary (oil or oil-gas shows at upper, dry gas shows at lower).

Appreciation of gas and oil in vertical section, chosen the background value of geochemical exploration target plus double variance as lower limit of anomaly, chosen methane, heavy hydrocarbons, ΔC, ultraviolet 216mm and fluorescence as target of anomaly zones. If two targets reached lower limit of anomaly the superimposed position would be as grade I anomaly. And if methane heavy hydrocarbons and ΔC three of them superimposed, the position would be as hopeful gas and oil layer. In view of the above, the 1100m-1120m, 1220m-1260m is hopeful gas and oil position, the 460m--520m is shallow possible gas and oil position. This result is tally with other geological information, and provided theoretical evidence for seeking oil and gas reservoir on this area.

A GEOCHEMICAL MODEL FOR THE FANGNIUGOU PYRITE-POLYMETALLICDEPOSIT, JILIN

HUANG XUNDE, PIAO SHOUCHENG, LIU SHUTIAN, ZHANG XIAOMIN AND LIAN CHANGYUN
(Changchun University of Geosciences, Changchun, China)

The deposit occurs in the contact zone of volcanic sedimentary rocks and granite intrusives. In the primary halos, ore-forming elements such as Pb, Zn, Ag, Cd and Mn present positive (increased) values whereas lithophile elements such as Cr, Sr and V have (negative) depleted values. The vertical and horizontal zonations of the primary halos are similar to the typical zoning of thermal deposits. The ration Ag/Bi and Pb*Zn*Ag*Ba/Cu*Bi increase from deep to shallow which can be use as an indicator of the erosion degree of the ore bodies.

The elemental association in pyrite and the REE patterns are used as the genetic indicators of the study deposit. According to the genetic model established in the research, a prediction is made that under the igneous rock there could be another contact zone hosting blind ore bodies.

PREPARATION OF CERTIFIED REFERENCE MATERIAL FOR VEGETABLE, HUMAN HAIR, SPECTRAL AND GOLD ANALYSIS

YAN MINGCAI, WANG CHUNSHU, CHI QINGHUA AND GU TIEXIN
(Institute of Geophysical and Geochemical Exploration, Langfang, Hebei 102849, China)

Following the stream sediment GSD1--12, soil GSS1--8 and rock GSR1--6 certified reference materials, a number of new geochemical reference materials have been prepared recently.

1. Vegetable certified reference materials, including bush twigs and leaves GSV--1 and GSV--2, poplar leaves GSV--3, tea GSV--4. The values of 51-55 elements have been certified. They are provided for regional environmental exploration and agricultural geochemistry.

2. Human hair certified material GSH--1 is provide for the examination of human health. 39 elements were determined.

3. The standards for spectral analysis comprise two series of silicate (GSES I 1--11) and limestone (GSES II 1--9). GSES I comprises 11 samples with 28 added elements and the base is prepared by synthetic silicate of super--pure reagent roasting 950*C. GSES II comprises 9 amples with 29 added elements and the base is limestone. The certified values are alibrated. They are mainly used to emission spectrometric analysis for trace elements of geological aterials.

4. Certified reference materials of trace ore gold for geochemistry comprise 11 samples and their gold contents vary from 0.5ng/g to 10.0ug/g.

All of the above certified reference materials have been approved by State Bureau of technical Supervision of China and have been used widely.

Geochemical Modeling Based on Factor Analysis and its Application
Jin Jun   Zhou Jufang

This paper presents the purpose, significance and methods of geochemical modeling based on multivariable correlation and factor analysis. Several examples are given of its application in the eastern China.

To set up a geochemical model for a given ore deposit, the deposit is divided into several blocks according to the relative positions to the orebodies, ie. above the ore, beneath the ore, the foot wall, the hanging wall and so on. A number of representative samples are taken from corresponding blocks, analyzed for a large number of elements, and finally, submitted to multivariable correlation and factor analysis. The resulting parameters (regression coefficient, factor scores etc.) are correlated to the geological and geochemical settings, petrology, mineralogy, fluid inclusion compositions, as well as to lithological parameters. The essential relationship between the geochemical data and the ore bodies is expressed in tables and graphs, which form the geochemical model for the study.

The results show that variation in element association is quite sensitive to the relative position of the ore body, which is controlled by structure, the lithology of the country rock, physiochemical conditions and copositions of the ore forming fluids. A set of elements which always shows close association at certain relative positions with regard to the ore bodies is defined as a geochemical factor. Geochemical factors have an advantage over single geochemical parameters in that they are less influenced by absolute concentration (hence analytical errors) and capable of indicating potential superimposition of different mineralization stages, distinguishing commercial ore

bodies from non-significant dispersive mireralization, and detecting the subtle geochemical anomalies of blind ore bodies.

The Application of Multielement Association Mineralization Probability Estimate Values (MPEV) in Evaluation of Geochemical Soil Anomalies

Chen Yuming

(Chinese Institute of Geology and Mineral Resources Information)

Abstract

The area studied, located in Zhaojia–Dajianxi district, Zhuji county, Zhejiang province, was about 70km². The sampling interval for soil samples submitted for spectral analysis was 100m × 20m. Au, Ag, Cu, Pb, Zn, Sn, Mn and V were selected for normal distribution testing. The results show that they are logarithmic normal distribution in each mono-element petrographic area.

Interelement correlation is evaluated in order to characterize elemental associations. Au shows significant correlations with Ag, Pb and Zn, but not with other elements. As an aid to interpretation, R–mode factor analysis with varimax rotation was applied to the data. R–mode factor analysis groups the elements into different multielement associations or factors according to their behaviors. These factors may reflect geological and geochemical features and processes such as mineralization, alteration, mineralogy, lithology and surface weathering. Factor analysis yielded a mineralization factor–factor 2. The elements that load strongly onto factor 2 include Au, Ag, Pb and Zn.

The multielemental association MPEV of Au, Ag, Pb and Zn is calculated in order to evaluate the soil multielemental anomalies and determine the favourable districts of mineralization. The mathematical principle is :

$$F(x) = P(a < x < b) = \int_a^b f(x)dx$$

where $F(x)$ is the probability in case that random variable x is in interval(a, b), $F(x)$ is probability density distribution function. In the case of a normel distribution, the formula to be used is :

$$F(x) = \int_a^b f(x)dx$$

$$= \int_a^b \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-u)^2}{2\sigma^2}} dx$$

$$= \frac{1}{\sigma\sqrt{2\pi}} \int_a^b e^{-\frac{(x-u)^2}{2\sigma^2}} dx$$

where u is the mean value, σ is the standard deviation.

If an element is of normal distribution, the probability of which elemental content is greater than minimum workable grade (c) is:

$$F(x) = P(x > c) = \frac{1}{\sigma\sqrt{2\pi}} \int_c^{+\infty} e^{-\frac{(x-u)^2}{2\sigma^2}} dx$$

$$= 1 - \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^c e^{-\frac{(x-u)^2}{2\sigma^2}} dx$$

let $Z_p = (c-u)/\sigma$

Then $F(x) = 1 - \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Z_p} e^{-\frac{Zp^2}{2}} dZ_p$

In the case of a group of elements, let $Z = \sum_{}^{K} Z_p / \sum_{}^{K+K} \gamma$

Where k is the number of elements, y is the correlation coefficient between every two elements, then

$$F(z) = 1 - F(z) = 1 - \frac{1}{\sqrt{2\pi}} \int_{-\infty}^z e^{-\frac{Z^2}{2}} dz$$

Where F(z) is the multielement association MPEV.

The studied district is divided into 500m × 500m regular grids, the MPEV of a multielement (Au, Ag, Pb and Zn) association in each grid is calculated generating the MPEV contourmap. The application of this technique in Zhaojia−Dajianxi district , which yielded amineralization, proved the effectivness of the method.

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ON THE FEATURES AND GENESIS OF RADIOACTIVE ANOMALIES IN OIL FIELDS*

Li[1]Zhoubo Wang[1]Ping Dai[1]Lijun Zhou[2]Rui Du[2]Shihan

1-Changchun University of Earth Science, Changchun, Jilin, 130026
2-Hebei College of Geology, Shijiazhuang, Hebei, 050031

The study of radioactive anomalies in oil fields has been carried out by well log data and surface radioactive survey to explore the correlation between the surface radioactive anomaly and the underground oil pool. Nine oil pools in Daqing, Liaohe, Huabei and Nanyang oil fields have been investigated. They respectively belong to four types of trap, i.e., anticline trap, fault trap, lithologic trap and buried mountain trap. Radioactive log data (total gamma ray and gamma spectra) have been collected from 310 wells in these oil pools. Supplementary surface radioactive measurements (^{218}Po and gamma spectra) have been done in five oil pools.

A systematic Summary has been made on the features of radioactive anomalies of oil fields in this paper.

The radioactive anomaly on the surface corresponds to the anomalies of different deep layers in the ground. The anomalies are continuous from an oil reservoir to the surface. On the upper part of the same reservoir, the radioactive anomaly will reduce, as the distance between the measurement point and the oil reservoir increase. In the oil pool with multiple reservoirs, the high value anomaly from each layer corresponds to the boundary of its lower oil reservoirs. The surface radioactive anomaly is the comprehensive reflection of the oil reservoirs beneath it. The whole morphologies of the anomalies of different types of oil pools are quite similar, but the anomaly value is related to their oil trap conditions. The oil-water border shows a distinctive anomaly, the fault border exhibits a higher anomaly, while the lithologic border has a weak anomaly. The radioactive anomaly measured in the wells is more stable and clear than that on the surface. The radon anomaly is more obvious than gamma spectra anomalies on the surface. The high value anomaly on the oil field border is characteristic of its radioactive anomaly. Whether the measured anomaly value on the central surface of a pool is higher or lower than the normal field value depends on the surface environment. The shape and strength of the surface radioactive anomaly does not exactly correspond to the buried

depth of the oil pool, but have certain correlation with the scale of it. Normally, big oil pool presents an obvious anomaly, while a small oil pool shows a weak anomaly.

On the basis of previous work and the author's study, new conceptions on the genesis of radioactive anomaly of an oil field have been obtained.

The surface radioactive anomaly above an oil pool is produced by vertical migration of radioactive materials in the ground. According to the abundance of radioactive elements in earth shell and in sedimentary rock and basement, as well as the relation between uranium and oil-generating material in the oil basin, it can be inferred that the main material source of radioactive anomaly in the oil field is source rock in the oil basin. The measurement of radon and gamma spectra, the relation between uranium and organic material, and the geochemical property of uranium and its daughters indicate that the main elements that cause radioacive anomaly of the oil field are uranium and its daughters radium and radon. The fact that the uranium, radium and radon dissolve in water, and the feature that radon gas moves indicate that the carrier of radioactive elements, which migrate vertically, is underground water and gas. The general existence of pores and micro-fractures in the deep, the fact that the width of the throat of pore and micro-fracture is larger than the diameter of uranium and radium ions, and the phenomenon that the water wettability in the cover makes water more penetrative than oil, those provide passage for fluid to move vertically and result in the high value anomaly in the upper layers and on the surface above the border of the oil pool. The overlying strata pressure, the static water pressure, the geothermal and the gas buoyancy cause micro-cycle of fluid transportation in the oil basin, whose direction is upwards vertical in the central part of it. According to Darcy's Low, such dynamics make it possible for deep fluid to penetrate through micro-fractures and pores to the surface. This can also account for all kinds of geochemical anomaly on the surface. The hydrocarbon that penetrates to the surface from the oil pool is oxidized into carbon dioxide and water. On surface, uranium combines carbon dioxide to form dissolvable uranyl carbonate ion, which can be leaked into the ground water. Thus, the ground water table and surface reduction-oxidation condition become main factors of the surface radioactive anomaly in the central upper part of the oil pool. A comprehensive model of radioactive anomaly has been set up on the basis of the conceptions discussed above.

THE PROBLEMS OF SURFICIAL GEOCHEMICAL ENVIRONMENT AND HUMAN HEALTH IN CHINA

LIN NIAGFENG TANG JIE

Changchun University of Earth Sciences

The direction and intensity of surficial geochemical reactions, such as leaching , migrating , concentrating and accumulating etc. ,are controlled by the surficial geochemical environment which is closly related with regional climate.

China has a vast territory which can be classified into three zones ,arid and semi—arid zone, transitional zone and moist zone . Arid and semi— arid zone belongs to the geochemical environment in which the chemical elements are concentrated and accumulated. The local residents over absorbed some elements through drinking water and caused various endemic diseases, such as fluorosis, arsenism ,endemic diarrhoea ($MgSO_4$ over absorption) , Jiashi disease ($MgSO_4$ over , lack of Zn and Se) and endemic joint disease (Sr over) etc. .

The characteristics of moist zone are as follows; The soluable salts and some micro —elements in rock and soil leached out intensively, this caused the lack of some elements, especially lack of Mg,Ca,F,I,Se, Mo,Zn and so on in water. The endemic diseases in this zone is mainly tooth caries and endemic goiter. In some area, the cancer (liver, Stomach ,esophagus) death rate is very high. Besides the low content of Se, Mo,Mg and so forth in water, soil and grain ,the drinking water pollution is also an important reason for various endemic diseases. In the seriously suffered village, the content of humic acid, nitrite ,nitrosolamine in drinking water is very high.

Kaschin—Beck disease and Keshan disease are mainly occurred in the transitional zone, the cause of the disease are complicated and still contending at present ,we believe that those diseases belongs to the bio—geochemical endemic disease. (see fig.)

The endemic disease in China has a characteristic of various kinds, wide distribution and severe harmfulness. The population in disease area is about 0. 3 billion ,the patient is more than 60 million. With the support of the Chinese government, experts engaged in a wide —ranging research on the cause of disease and preventive measures, and have made a large achivement.

The author has conducted research for more than 20 years, and has some good results. Accoding to the research, the cause of endemic disease is very complicated, even for the fluorosis, arsenism and goiter ,the pathogenic rate and the causes of disease (F,As,I) are not in a simple interrelated way . Generally, there are antagonistic factors or coordinate factors in the environment. The causes of cancer is even more complicated, therefore , we ˈ d like to discuss and study the problems between the geochemical environment and human health with foreign scholars.

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