GEOCHEMICAL EXPLORATION IN AN AREA WITH ARTISANAL GOLD MINING IN PERU

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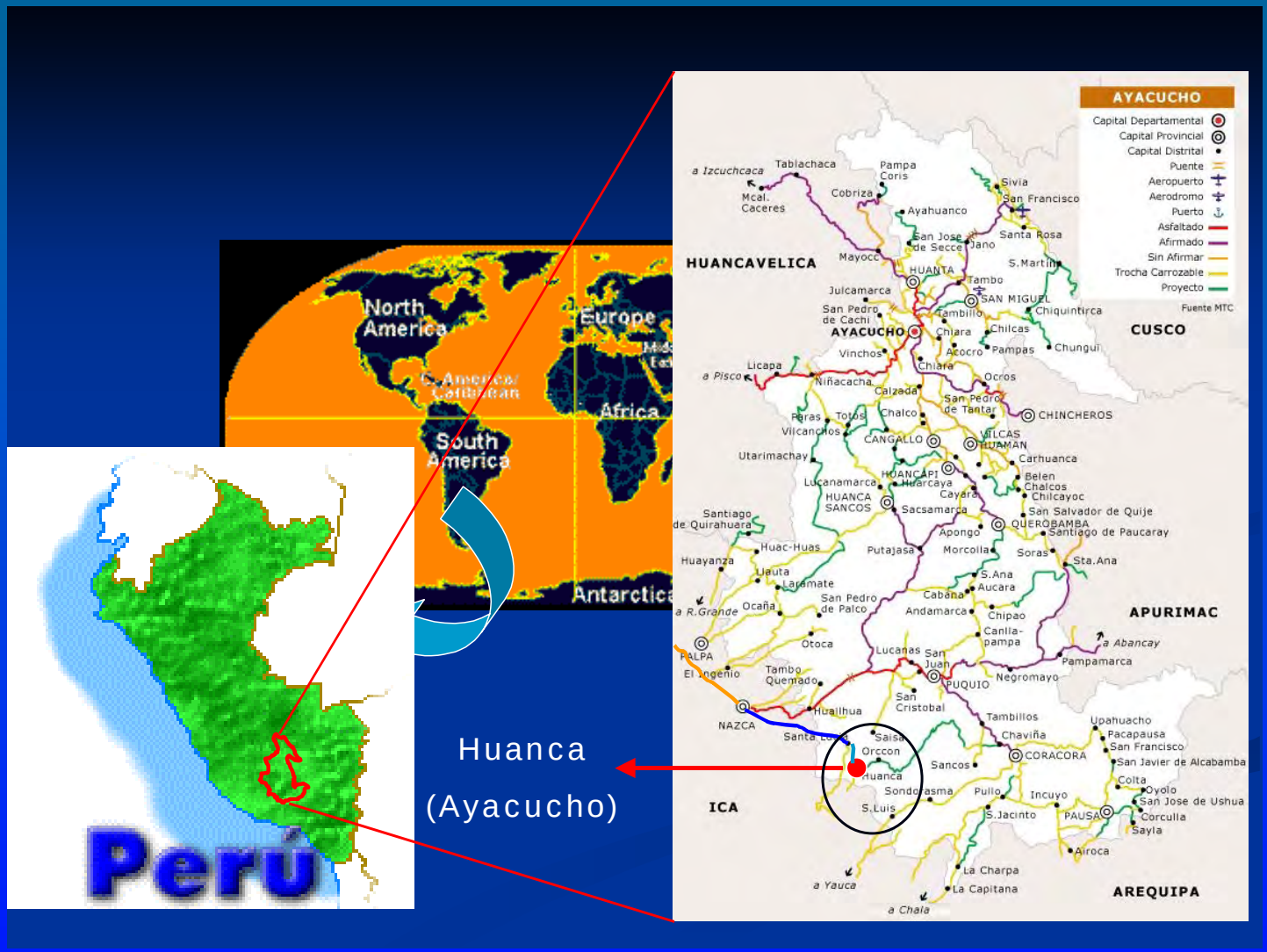
LOCATION



Huanca settlement, in Ayacucho Department, is located 590 km south-eastern of Lima.

CHARACTERISTICS OF THE SITE

Population of Huanca village is estimated in 1,200 inhabitants, which participate in the artisanal extractive operations for gold recovery without any type of health protection in the manipulation of mercury.

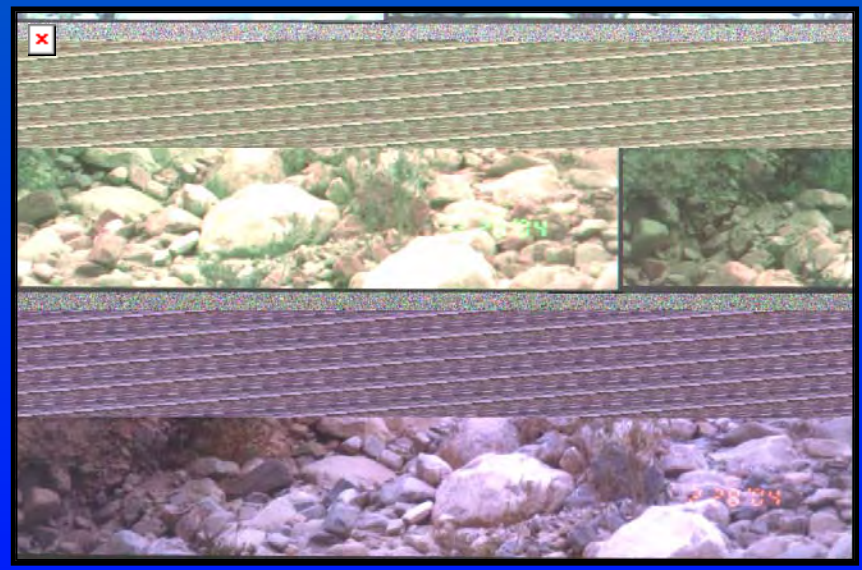
Artisanal gold mining is the main economical activity of the area and generates an important socio-economical impact in the employment creation (both direct and indirect).

CLIMATOLOGY

- *The area is located at a height of 750/800 metres above sea level, in a typical coastal sub-tropical climate.*
- *Average temperature fluctuates between 22ºC and 24ºC in summer and between 15ºC and 20ºC in winter.*
- *Relative humidity ranges from 50 to 70%. The zone is characterized by scarce precipitations along the year.*
- *1mm/month is the maximum precipitation registered in the rainfall station of Otapara, located in the Acarí river catchment, at 400 metres above sea level.*

GEOLOGY

- *Materials correspond to igneous intrusive rocks differ in composition from tonalites, to diorites and granodiorites, with granular texture, and zoned plagioclases with alteration rings and solids inclusions of hornblende.*
- *Recent alluvial, eluvia and colluvial deposits are abundant.*



Main structures are related to the tectonic movements of the andine cycle.

GEOMORPHOLOGY AND HYDROLOGY

- *The area is included in an erosion surface, which is dissected by the bed of the Acarí river, with an average wide of 300 m, developing agricultural areas in some zones.*
- *Acarí River is the main source of water for the area. Flow ranges from 500 l/s in dry months to 20,000/40,000 l/s in rainy periods.*
- *Water is used for domestic and agricultural applications.*
- *Piezometric level in the area is 10 m and groundwater is used for industrial operations.*

GOLD MINERALIZATION

- *Mineralization is banded or brecciated and it presents in veins, lenticular bodies and disseminations of pyrite.*
- *Veins are of regular length with auriferous pyrite in milky quartz.*
- *Paragenesis is constituted by auriferous pyrite, chalcopyrite, galene, sphalerite and malachite, in a gangue of quartz and calcite.*
- *The mineralization has a tectonic control related to fracture systems of N-20/25-W and N-50/60-W trend in La Costa Batholite.*

ARTISANAL MINING

Artisanal mining explotes gold veins with lengths from 1 to 10 cm and gold grade from 1 to 80 oz/ton.

These veins have low interest for medium to big scale mine companies but they have enough interest for artisanal mining because of the easy and low cost of operations.

OPERATIONS ASSOCIATED TO ARTISANAL MINING

- *Manual selection of the high-grade ore*
- *Grinding*
- *Amalgamation of ore with mercury*
- *Burn of the amalgamate in conventional furnaces at home.*
- *Collecting of ore for treatment in the cyanidation plants of the mining companies*

Burning of amalgamate in conventional furnaces at home

OLD TAILING PONDS

CURRENT TAILING DAM LOCATED IN THE LEFT MARGIN OF THE ACARÍ RIVER

SOIL SAMPLING IN HUANCA SETLEMENT

A random soil sampling (C1 to C9) has been made in Huanca settlement, in the area where the manual metallurgical operations are located.

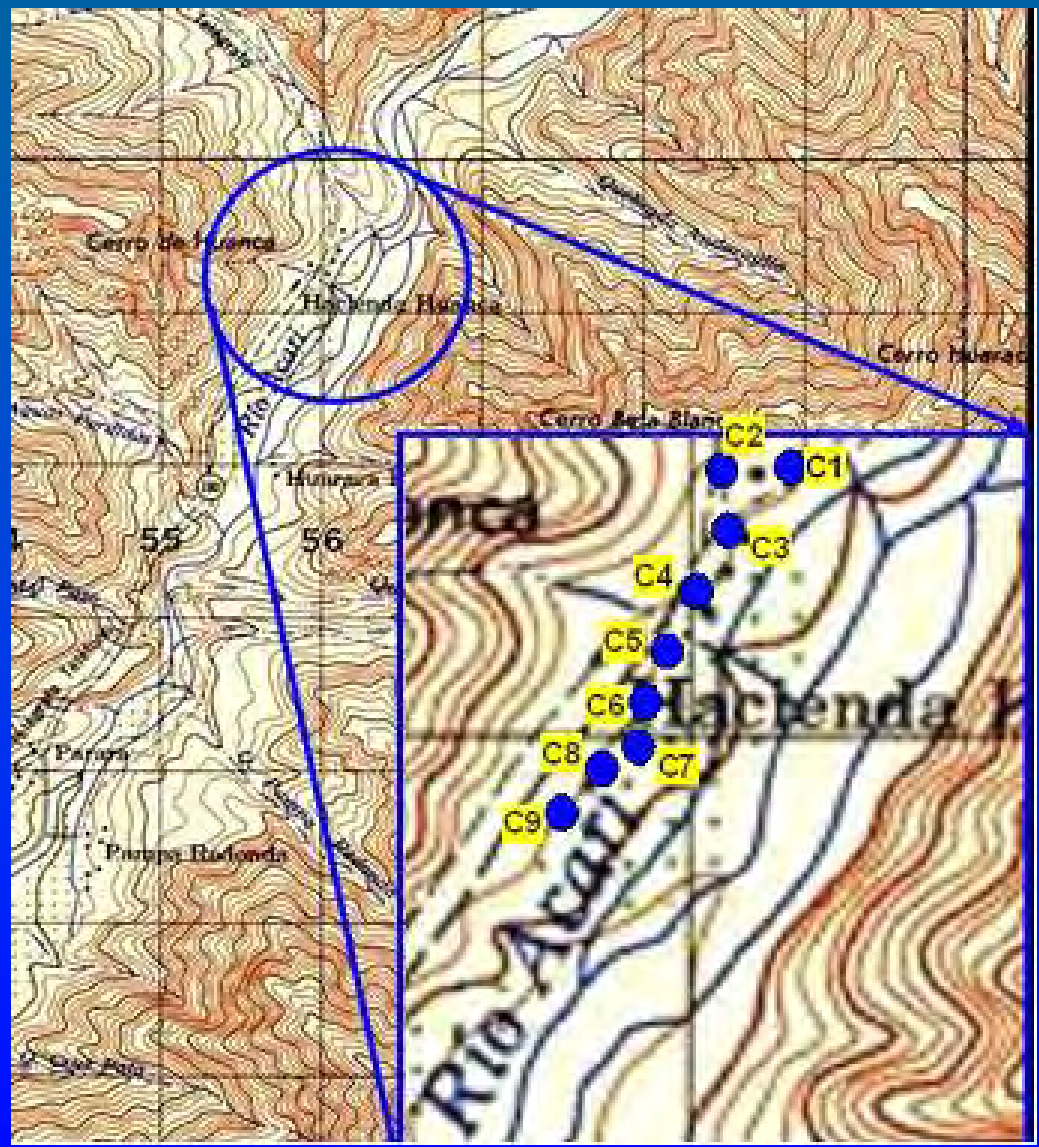
For sampling design it has been taking in consideration incidences occurred in the area such as Hg spills during the commercialisation operations, tailing ponds, the burn of the amalgamate in conventional furnaces, etc.

Samples have been collected at depths of 5 cm.

SOIL SAMPLING IN HUANCA SETTLEMENT

Soil samples collected in Huanca setlement:

C1, C2, C3, C4, C5, C6, C7, C8 and C9



AGRICULTURAL LANDS SAMPLING

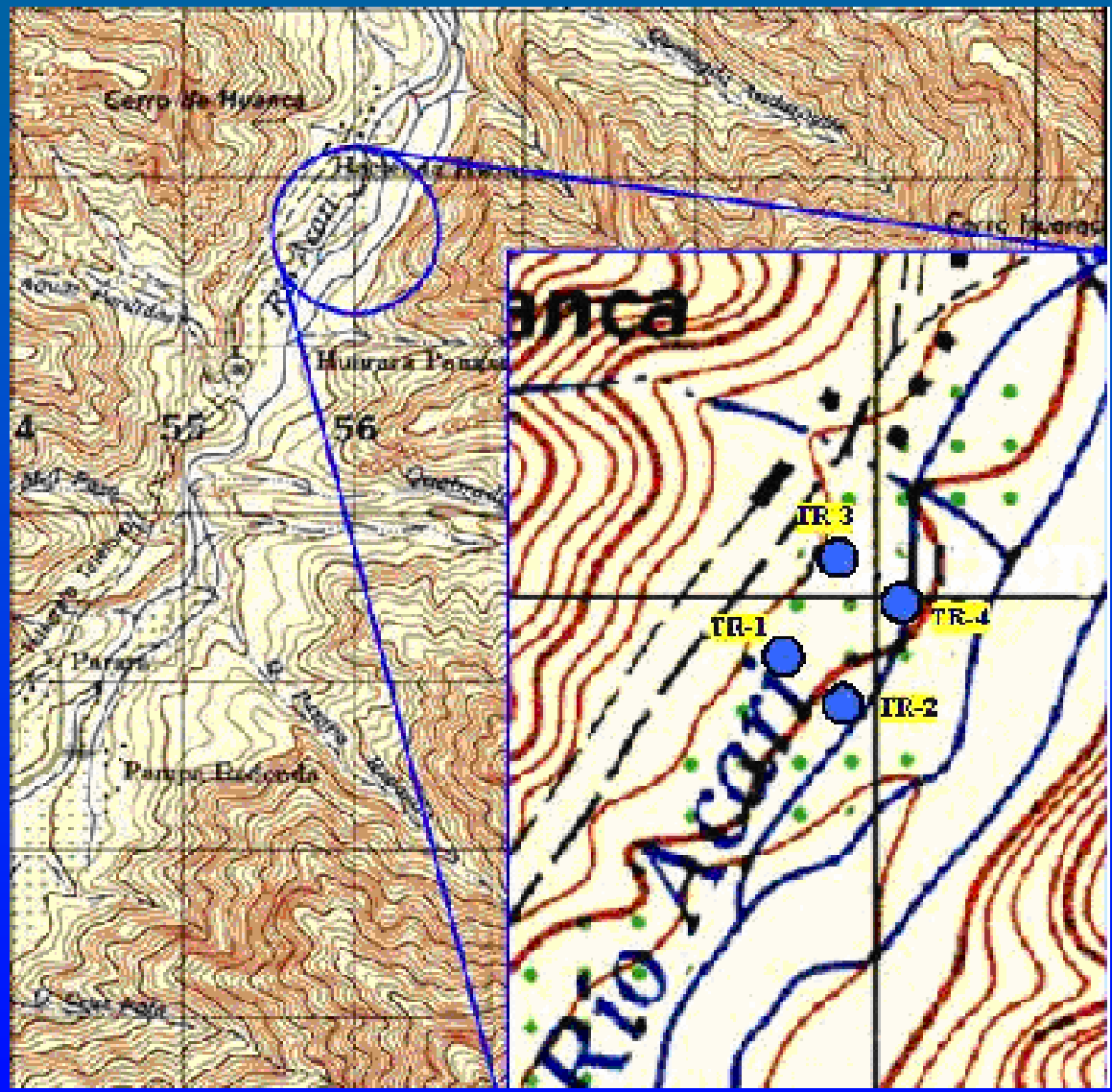
A random soil sampling (TR1 to TR4) has been made in the agricultural lands used by Huanca community, in the right margin of the Acarí River, at 500 m of Huanca settlement.

Samples have been collected at depths of 10 cm with manual tools and their localisation is represented in map.

SAMPLING IN AGRICULTURAL SOILS

Soil samples collected in agricultural soils of Huanca setlement:

TR1, TR2, TR3 and TR4



Hg AND As TOTAL ELEMENTAL CONCENTRATION IN SOILS

- ***Soils in the area affected by mining and smelting operations have pH values ranging from 6.67 to 8.01 units.***
- ***Chemical analysis of soils collected in the area where manual metallurgical operations are located show mercury concentrations between 15.3 mg/kg and 44.2 mg/kg.***
- ***Arsenic reaches concentrations of 48.4 mg/kg at the site of an old manual metallurgical operation, coinciding with maximum concentration of mercury.***

	Sample	pH	Hg (mg.kg-1)	As (mg.kg-1)
Soils in Huanca village	C1	7.03	24	33.4
	C2	7.10	<1	<1
	C3	6.74	44.2	48.4
	C4	6.67	28.9	45.2
	C5	8.01	15.3	<1
	C6	7.70	<1	<1
	C7	7.90	<1	<1
	C8	6.81	<1	<1
	C9	6.99	<1	19.1
Agricultural soils	TR1	7.23	2	15
	TR2	7.41	<1	19
	TR3	6.93	1	19
	TR4	7.08	<1	23

TAILING PONDS

- *Soils around the old manual metallurgical operations are strongly enriched in Hg.*
- *These geochemical anomalies are associated to amalgamation processes, which distribute metallic Hg in soils and vapour Hg in the atmosphere, constituting an important source of pollution for inhabitants of the area and for the environment.*
- *Hg concentrations are distinctly high (up to 44.2 mg/kg,) in proximity to old manual metallurgical operations and informal current tailing ponds.*
- *Hg concentrations in soils decrease as a function of distance from the pollution sources.*

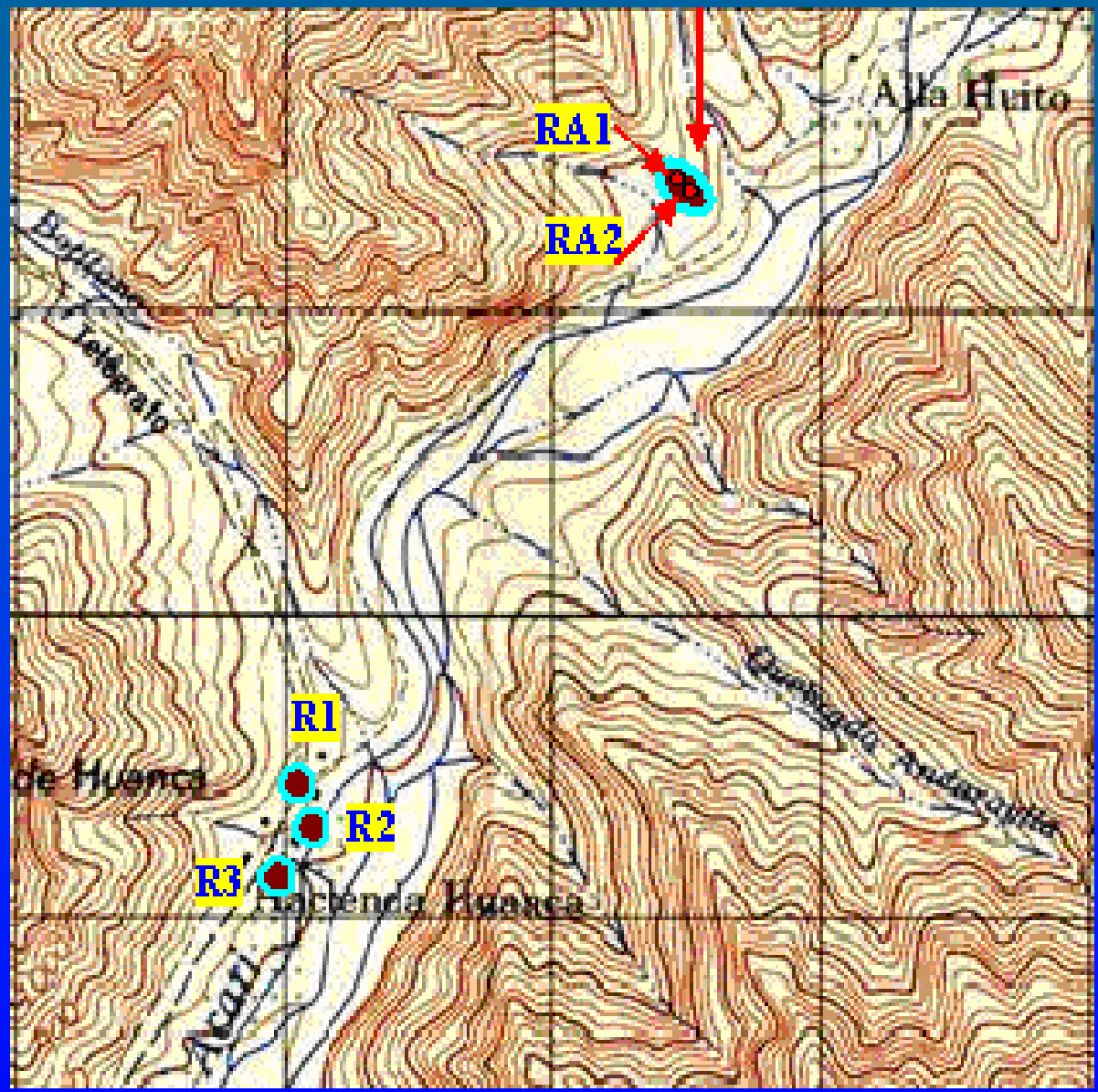
TAILING POND SAMPLING

- ***Two representative samples (RA1 and RA2) of materials stored in a tailing pond abandoned in 1995, and located at a distance of 200 m of the course of Acarí River have been collected at depth of 60 cm.***
- ***Also have been sampled three informal current tailing ponds located in Huanca settlement. . Localisation of samples is represented in the map.***
- ***A portable X-ray fluorescence analyser equipped with three different radioisotope sources (109Cd, 241Am, and 55Fe) has been used for geochemical characterisation of soils and tailing ponds.***

TAILINGS SAMPLING

Samples in old tailing ponds:
RA1 and RA2

Samples in current tailing ponds (Huanca Village):
R1, R2 and R3



Hg AND As TOTAL ELEMENTAL CONCENTRATION IN TAILING

- Soils around the old manual metallurgical operations are strongly enriched in mercury.
- Geochemical anomalies are associated to operations related to amalgamation processes, which distribute metallic mercury in soils and mercury vapour in the atmosphere.
- It must be emphasised that at sites close to the old manual metallurgical operations and the informal current tailing ponds, the concentrations of total mercury reach 44.2 mg/kg.

Hg AND As TOTAL ELEMENTAL CONCENTRATION IN TAILING

	Sample	pH	Hg (mg/kg)	As (mg/kg)
Old tailing pond	RA1	6.93	58	776
	RA2	3.26	104	314
Current tailing ponds	R1	6.83	139	51
	R2	6.97	189	134
	R3	7.28	186	67

WATER SAMPLING IN ACARÍ RIVER

W1: Upstream Dynacor Plant

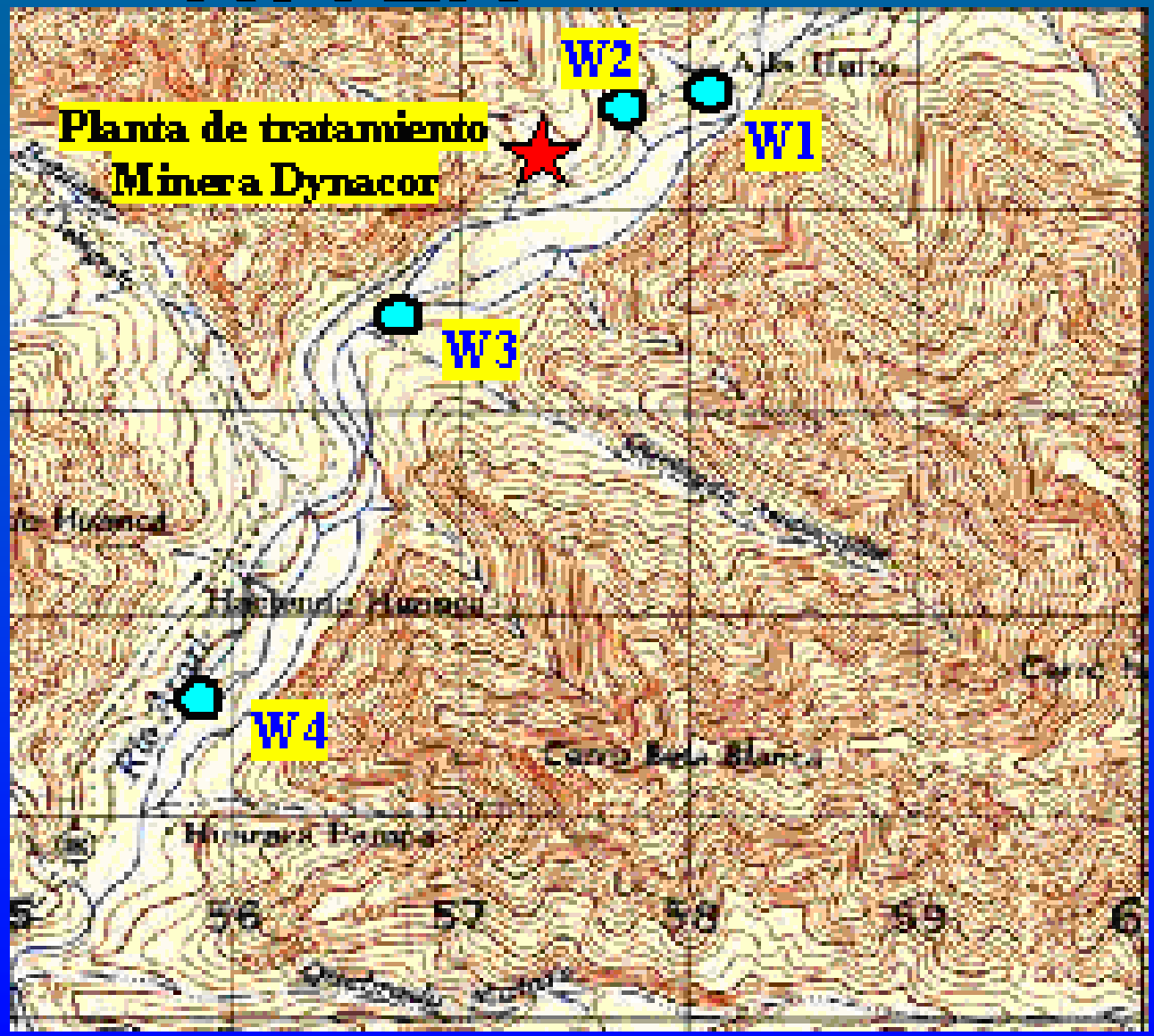
W2:Water Dynacor Plant

W3: Downstream Dynacor Plant

W4: Downstream Huanca village

W5: Upstream Otapara plant

W6: Downstream Otapara plant



WATER ANALYSIS OF ACARÍ RIVER

Sample	As ($\mu g.l^{-1}$)	Au ($\mu g.l^{-1}$)	Ca ($mg.l^{-1}$)	Cl ($mg.l^{-1}$)	Hg ($\mu g.l^{-1}$)	K ($mg.l^{-1}$)	Mg ($mg.l^{-1}$)	Na ($mg.l^{-1}$)
W1	16.5	0.63	86.27	85	<0.1	6.93	16.48	96.66
W2	17.1	0.42	96.66	72	<0.1	6.13	14.08	70.93
W3	7.1	0.37	122.19	88	<0.1	6.39	16.14	92.84
W4	16.2	0.26	119.11	95	<0.1	6.78	18.39	93.09
W5	21.4	0.23	113.05	106	<0.1	6.47	18.35	110.94
W6	6.9	0.15	122.10	143	<0.1	8.02	21.16	144.81

ACARÍ RIVER (UP AND DOWNSTREAM MINE WORKS)

Sample	M2 (upstream mine site)	M3 (downstream mine site)
Conductivity (mS/l)	1.04	1.04
pH	6.8	7.2
TSS (mg/l)	12	8
Sulphates (mg/l)	403.2	361.1
Nitrates (mg/l)	0.73	0.18
Total Cu (mg/l)	<0.01	<0.01
Total Iron (mg/l)	0.02	0.04
Total Cyanide (mg/l)	<0.01	<0.01

CONCLUSIONS

- *The studies accomplished in the Huanca district reveals high mercury concentrations in soils and tailings reaching up to 44.2 mg.kg^{-1} and 189 mg.kg^{-1} respectively.*
- *Soils around ore processing operations are strongly enriched in mercury.*
- *In relation to the amalgamation process, important losses of native mercury to the environment are produced.*
- *Water quality of Acarí River that flows through the area do not present changes important as consequence of the mining and processing operations.*


Thank you very much for your attention