^{210}Pb-derived chronology in sediment cores evidencing the anthropogenic occupation history at Corumbataí River basin, Brazil

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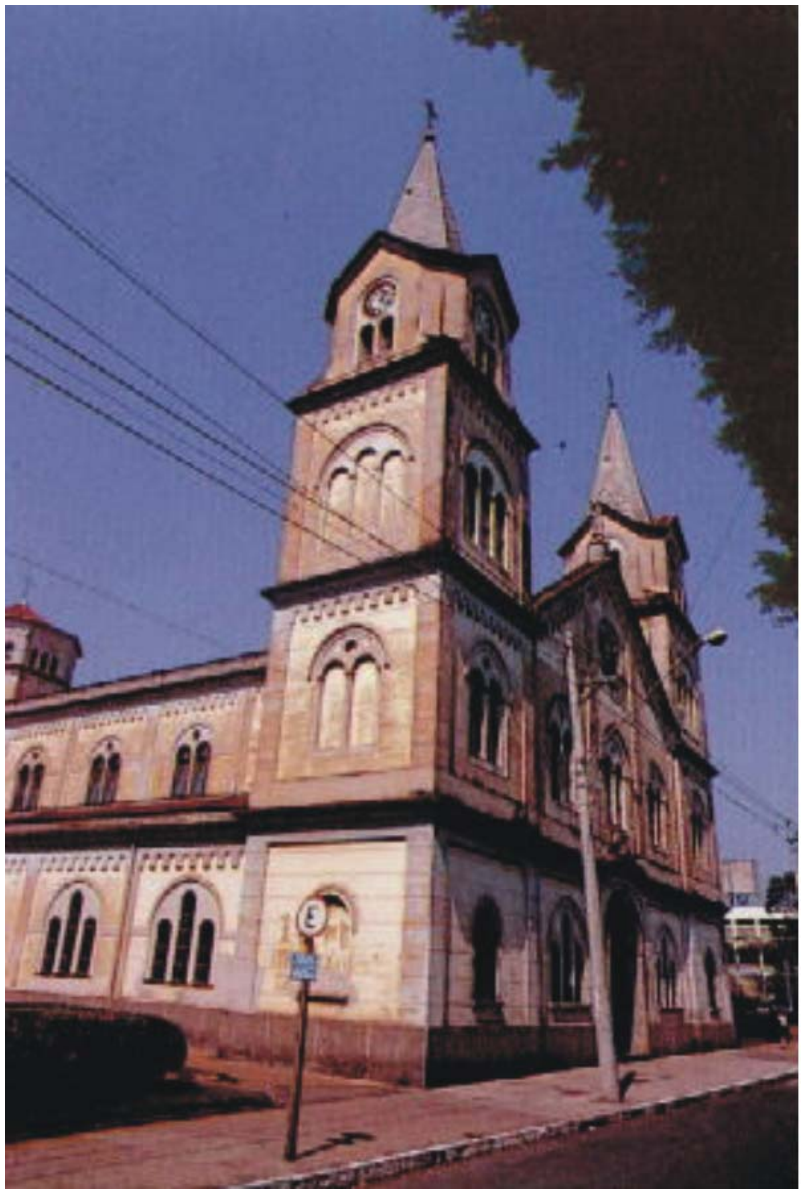
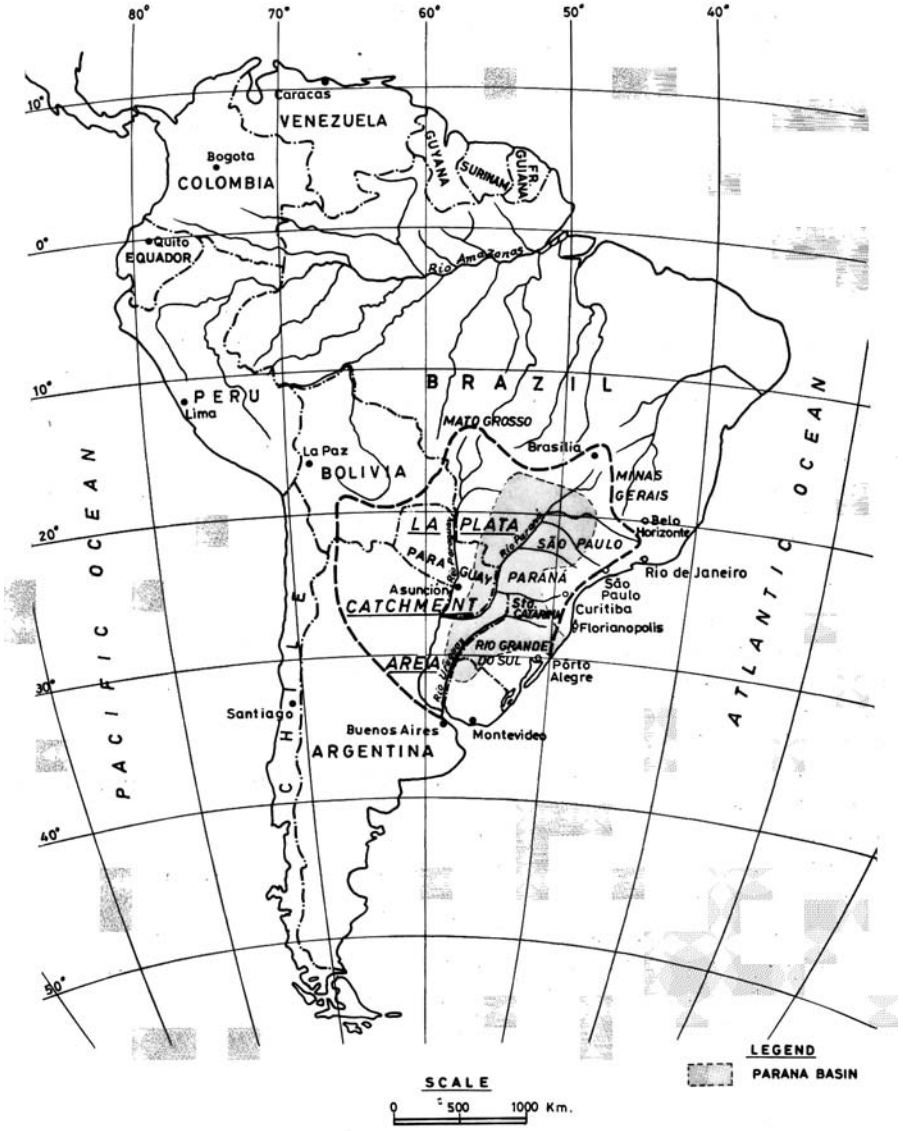
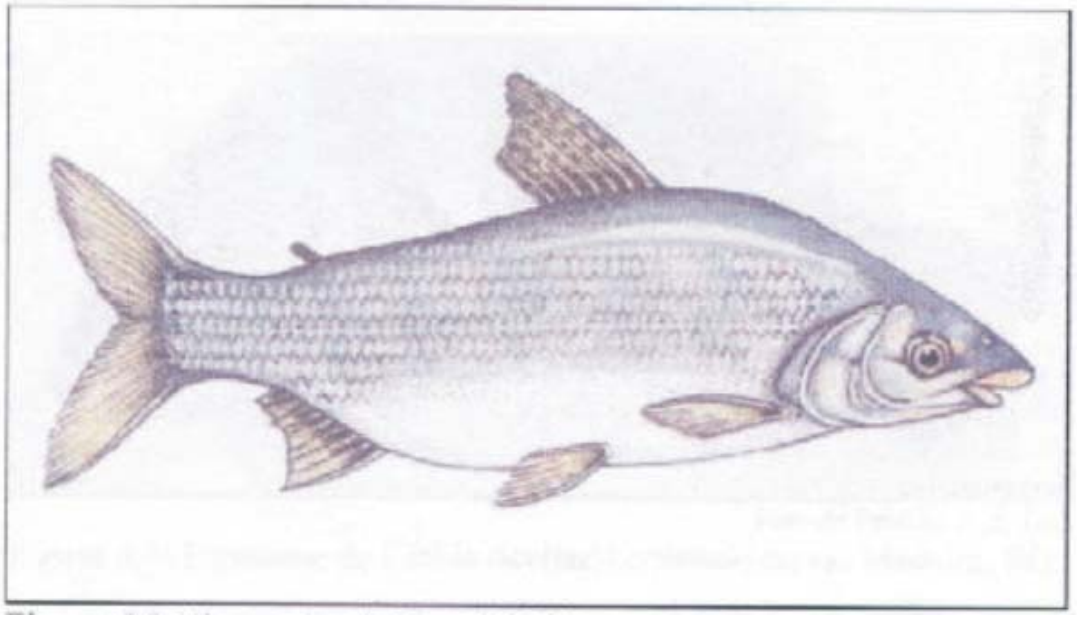
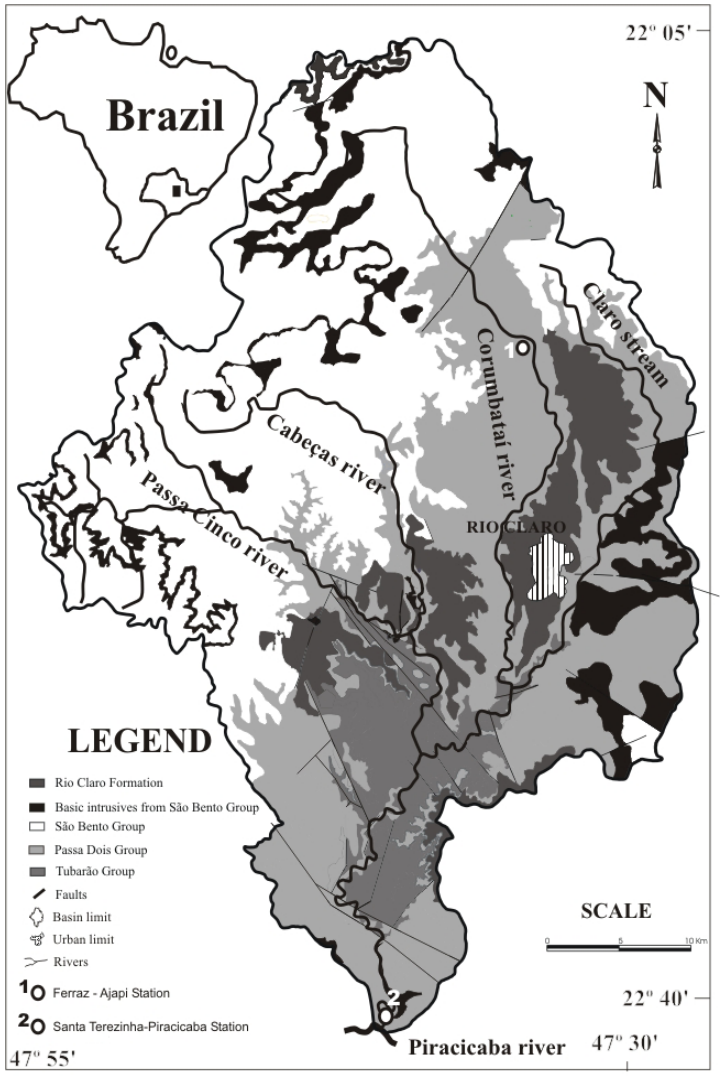
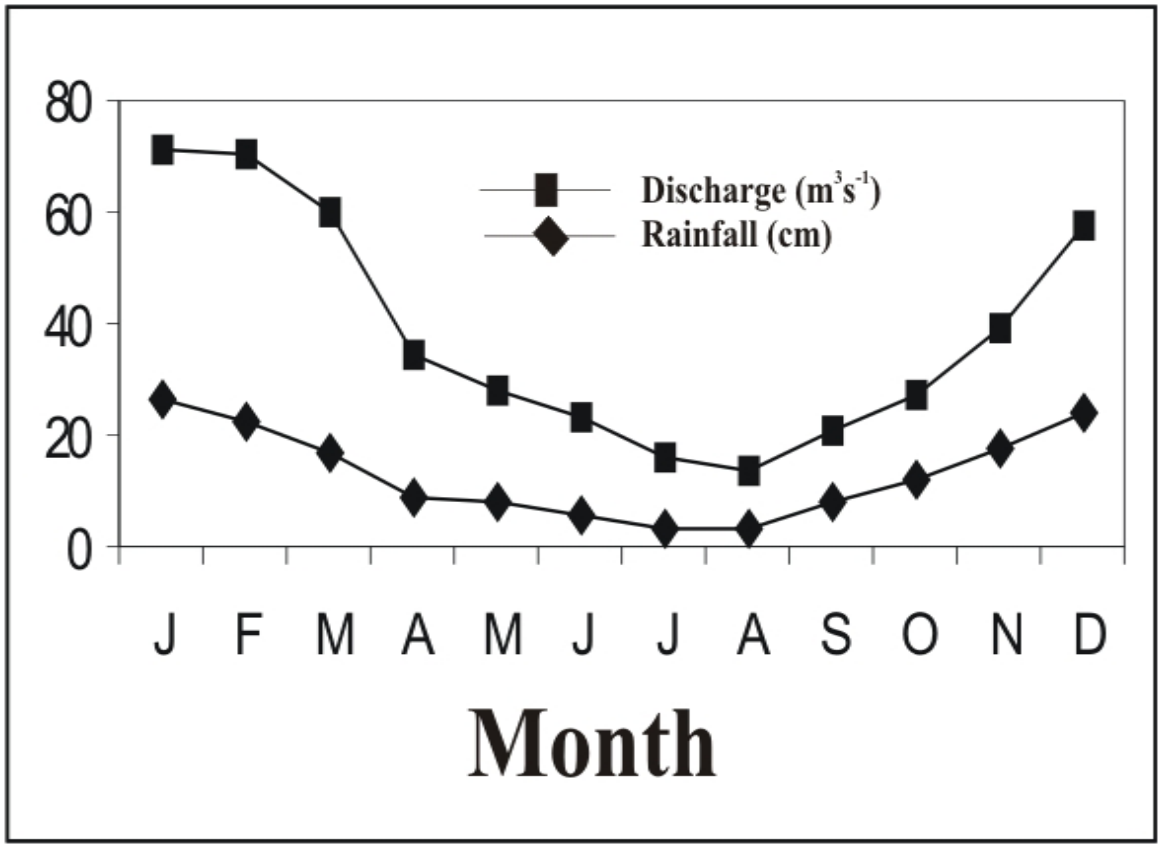
Fundação Universidade Federal de Rondônia-UNIR

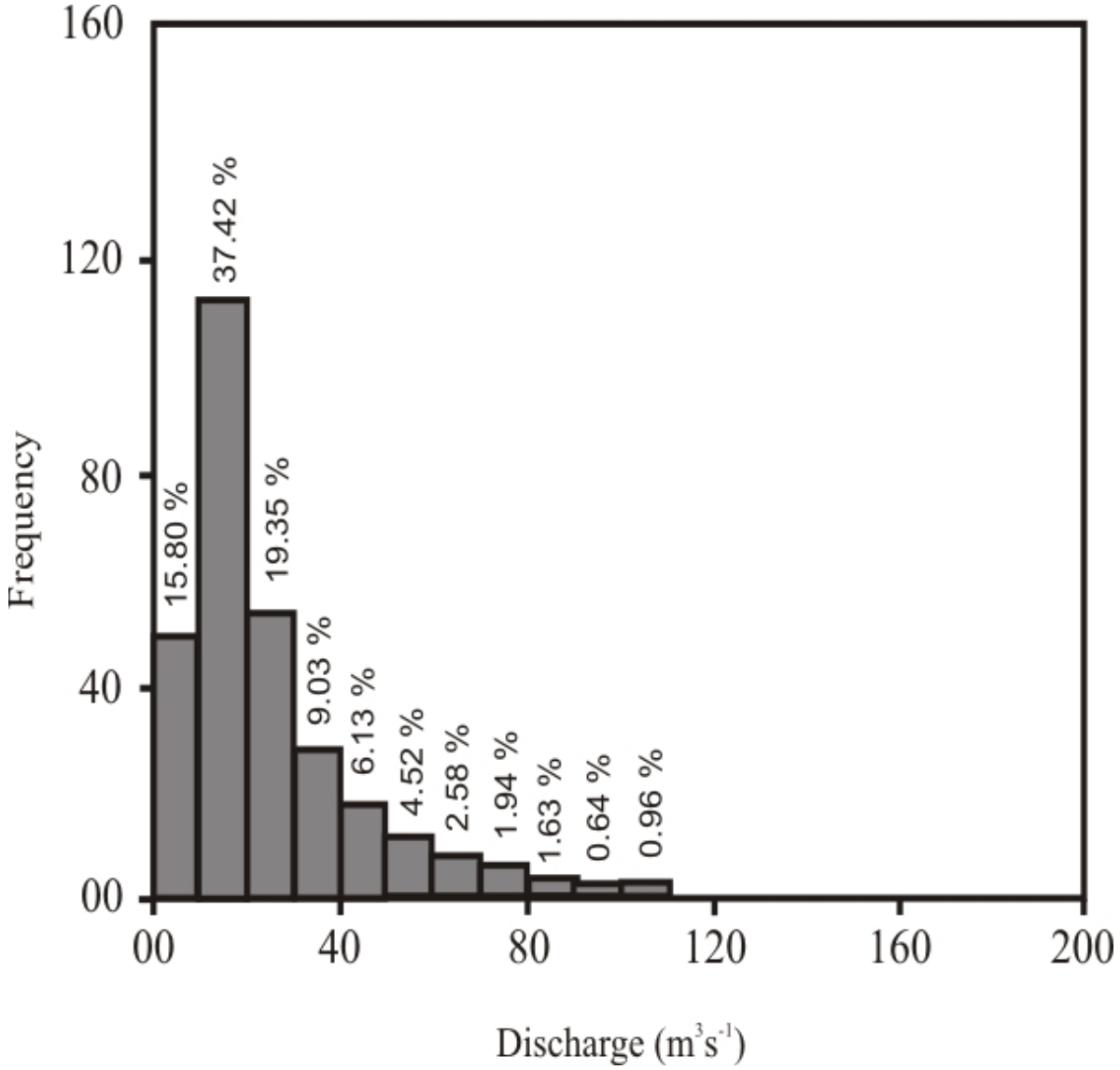


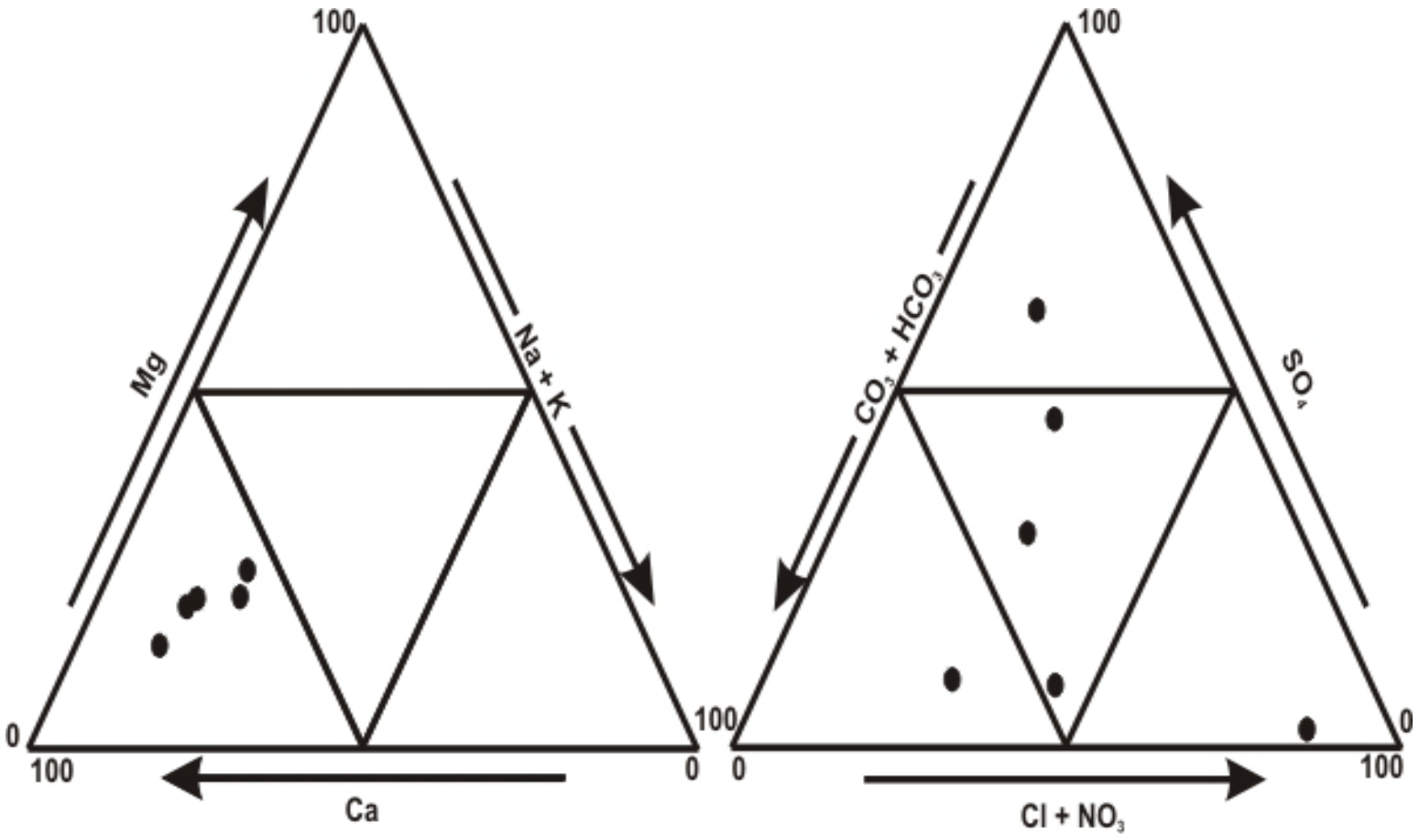

80°
70°
60°
50°
40°
10°
0°
10°
20°
30°
40°
50°
Caracas
VENEZUELA
Bogota
COLOMBIA
GUYANA
SURINAM
FR. GUIANA
Quito
EQUADOR
Rio Amazonas
PERU
Lima
BRAZIL
MATO GROSSO
Brasilia
La Paz
BOLIVIA
MINAS GERAIS
Belo Horizonte
LA PLATA
SÃO PAULO
Rio de Janeiro
PARA
GUAY
PARANÁ
Asuncion
São Paulo
CATCHMENT
Curitiba
Florianopolis
RIO GRANDE DO SUL
AREA
Porto Alegre
Santiago
Buenos Aires
Montevideo
ARGENTINA
CHILE
PACIFIC OCEAN
ATLANTIC OCEAN
LEGEND
PARANA BASIN
SCALE
0
500
1000 Km.

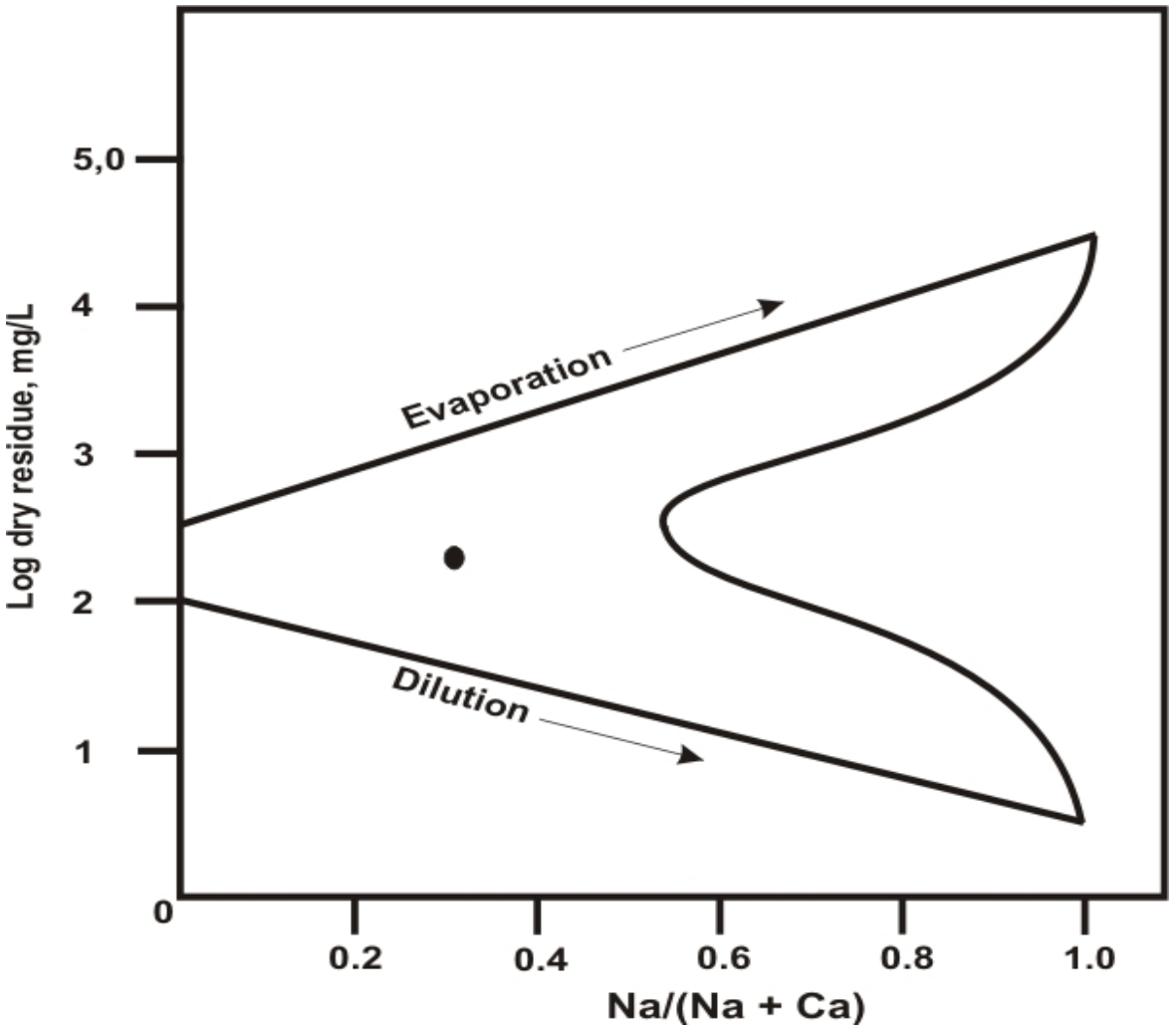


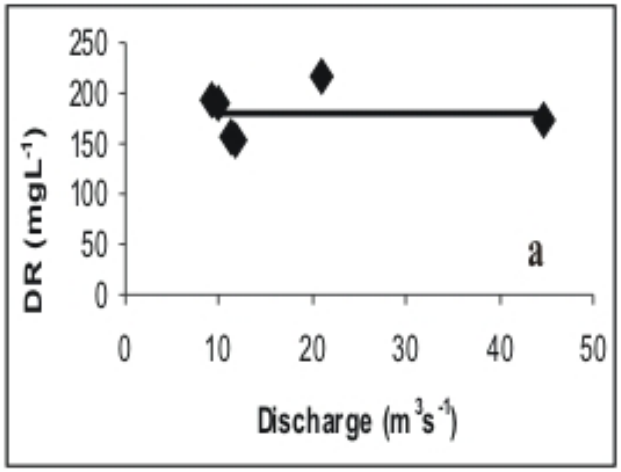

22° 05'
N
Brazil
Claro stream
Corumbataí river
1
Cabeças river
Passa Cinco river
RIO CLARO
LEGEND
Rio Claro Formation
Basic intrusives from São Bento Group
São Bento Group
Passa Dois Group
Tubarão Group
Faults
Basin limit
Urban limit
Rivers
1 Ferraz - Ajapi Station
2 Santa Terezinha-Piracicaba Station
SCALE
0 5 10 Km
22° 40'
2
Piracicaba river
47° 55'
47° 30'

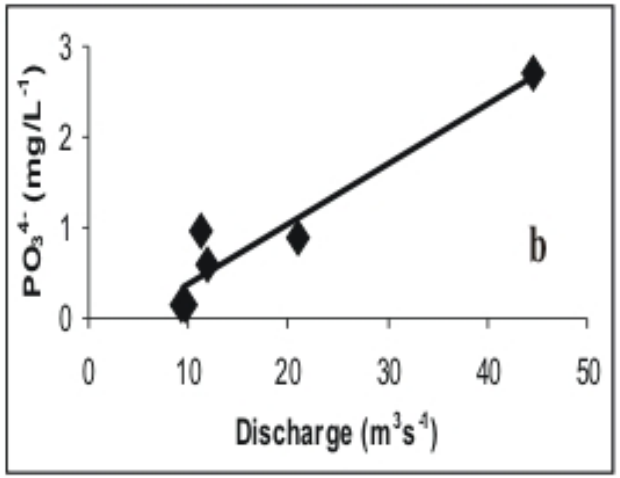

80
60
40
20
0
Discharge (m3s-1)
Rainfall (cm)
J F M A M J J A S O N D
Month

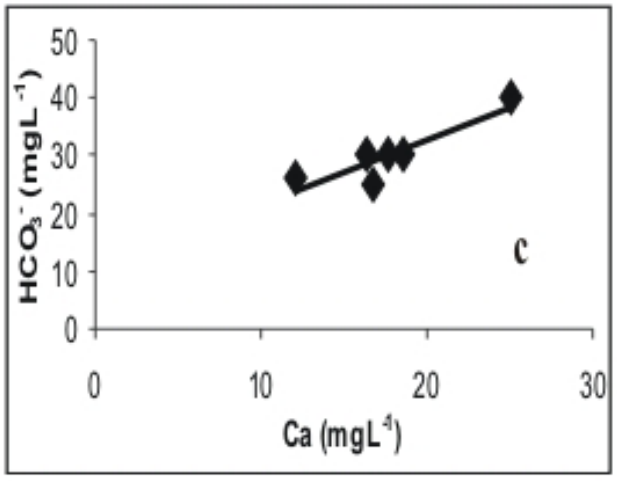

160
120
80
40
00
Frequency
15.80 %
37.42 %
19.35 %
9.03 %
6.13 %
4.52 %
2.58 %
1.94 %
1.63 %
0.64 %
0.96 %
00
40
80
120
160
200
Discharge (m3s-1)

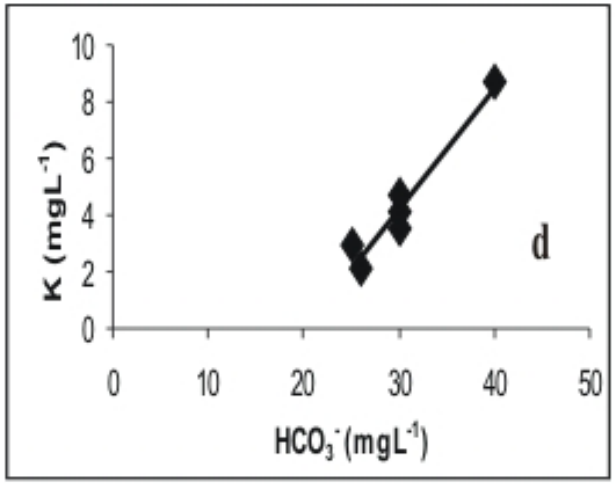

100
Mg
Na + K
0
100
100
0
Ca
100
$CO_3 + HCO_3$
SO_4
0
100
0
$Cl + NO_3$

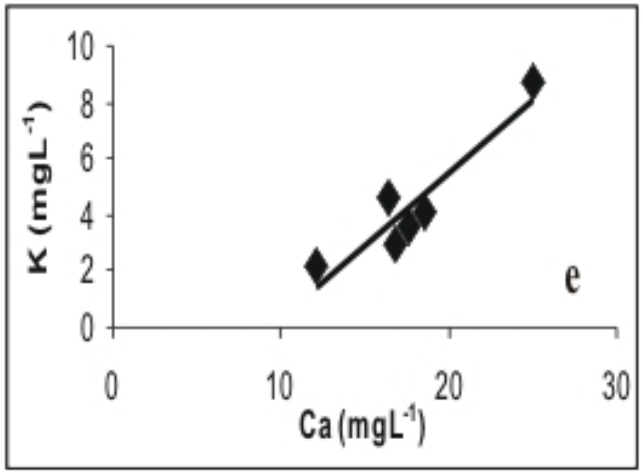

5,0
4
3
2
1
0
Log dry residue, mg/L
Evaporation
Dilution
0.2
0.4
0.6
0.8
1.0
Na/(Na + Ca)

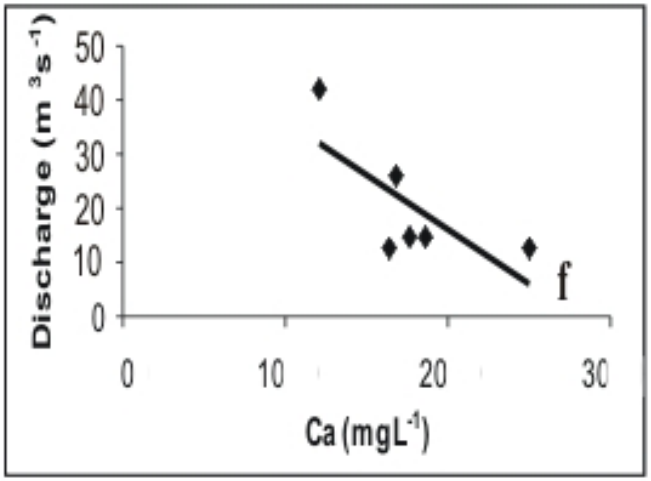

DR (mgL-1)
250
200
150
100
50
0
0
10
20
30
40
50
Discharge (m3s-1)
a

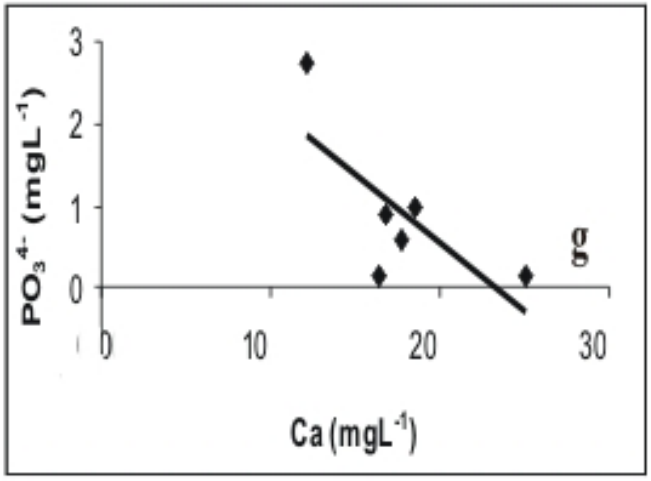

PO43- (mg/L-1)
3
2
1
0
0
10
20
30
40
50
Discharge (m3s-1)
b

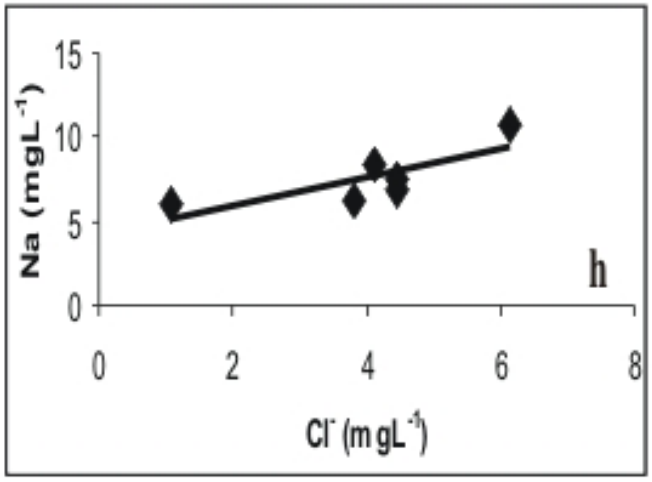

HCO3- (mgL-1)
50
40
30
20
10
0
0
10
20
30
Ca (mgL-1)
c


K (mgL-1)
10
8
6
4
2
0
0
10
20
30
40
50
HCO3- (mgL-1)
d


K (mgL-1)
Ca (mgL-1)
e


Discharge (m 3s-1)
Ca (mgL-1)
f

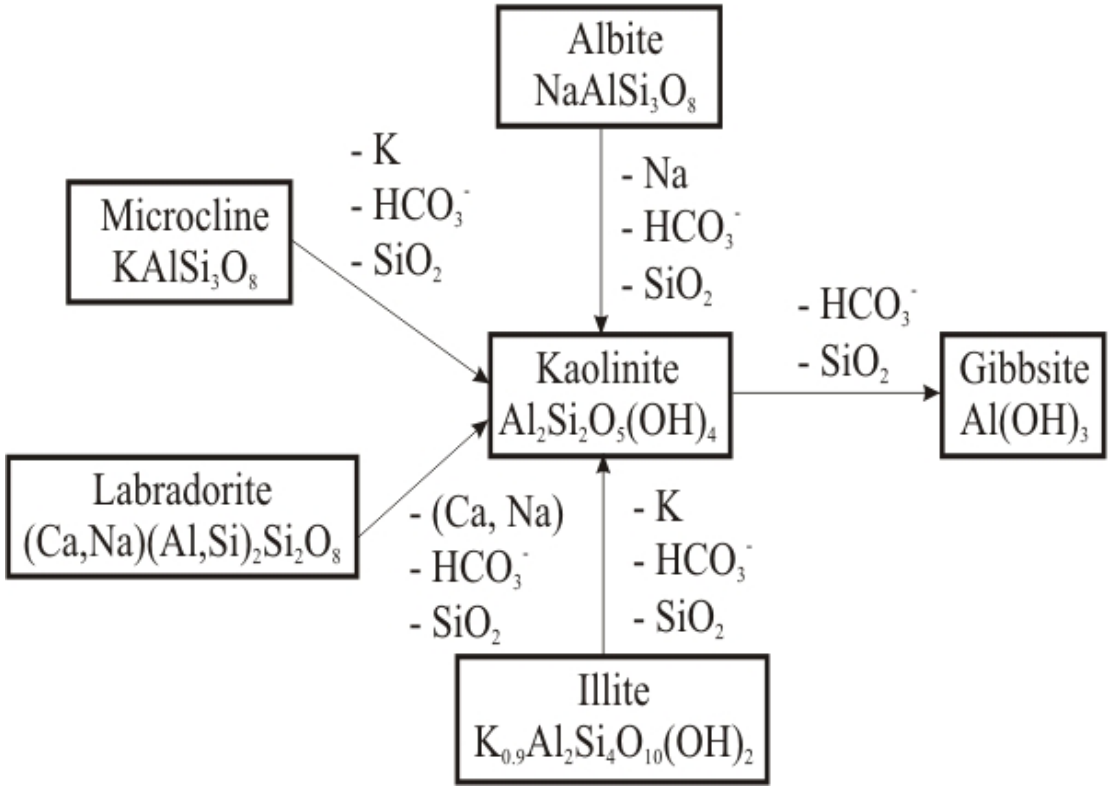

PO43- (mgL-1)
Ca (mgL-1)
g

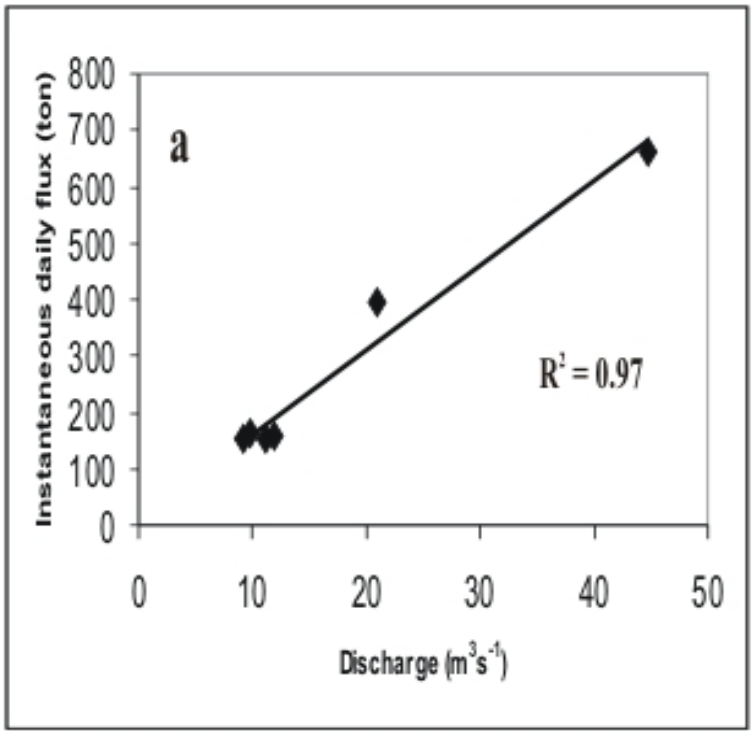

Na (mgL-1)
Cl- (mgL-1)
h

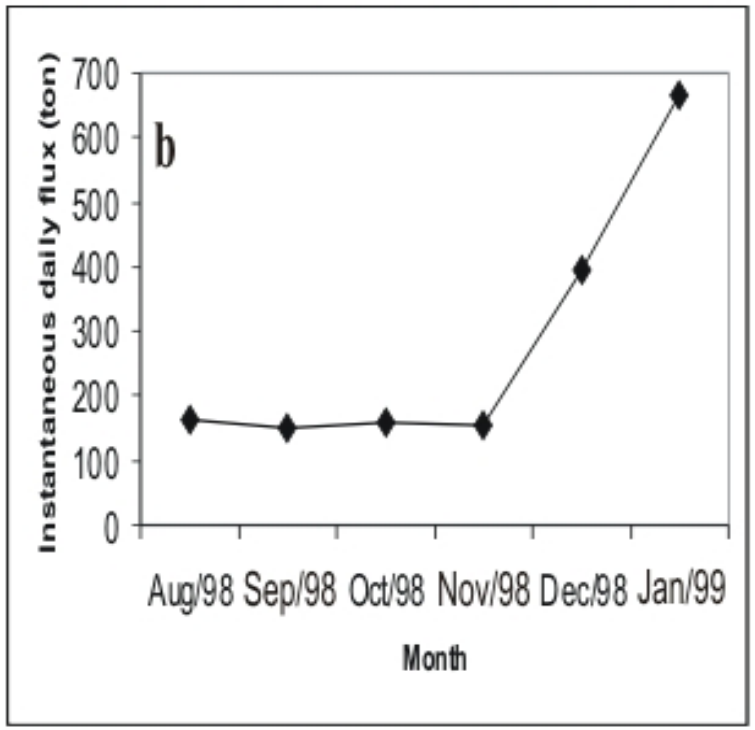
Dissolution: Calcite - $CaCO_3 \longrightarrow Ca^{2+}$ and HCO_3^-

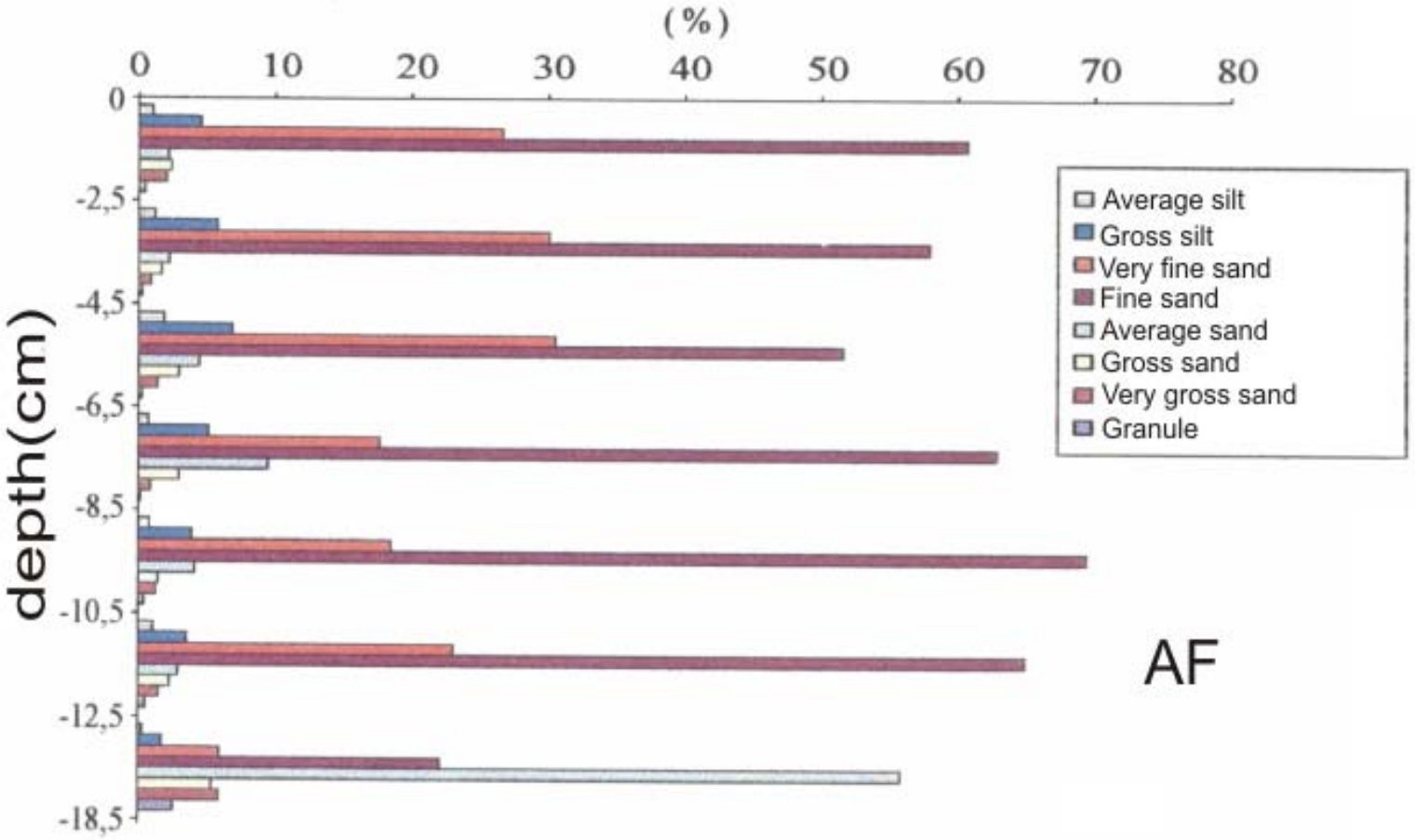
Dolomite - $CaMg(CO_3)_2 \longrightarrow Ca^{2+}, Mg^{2+}$ and HCO_3^-

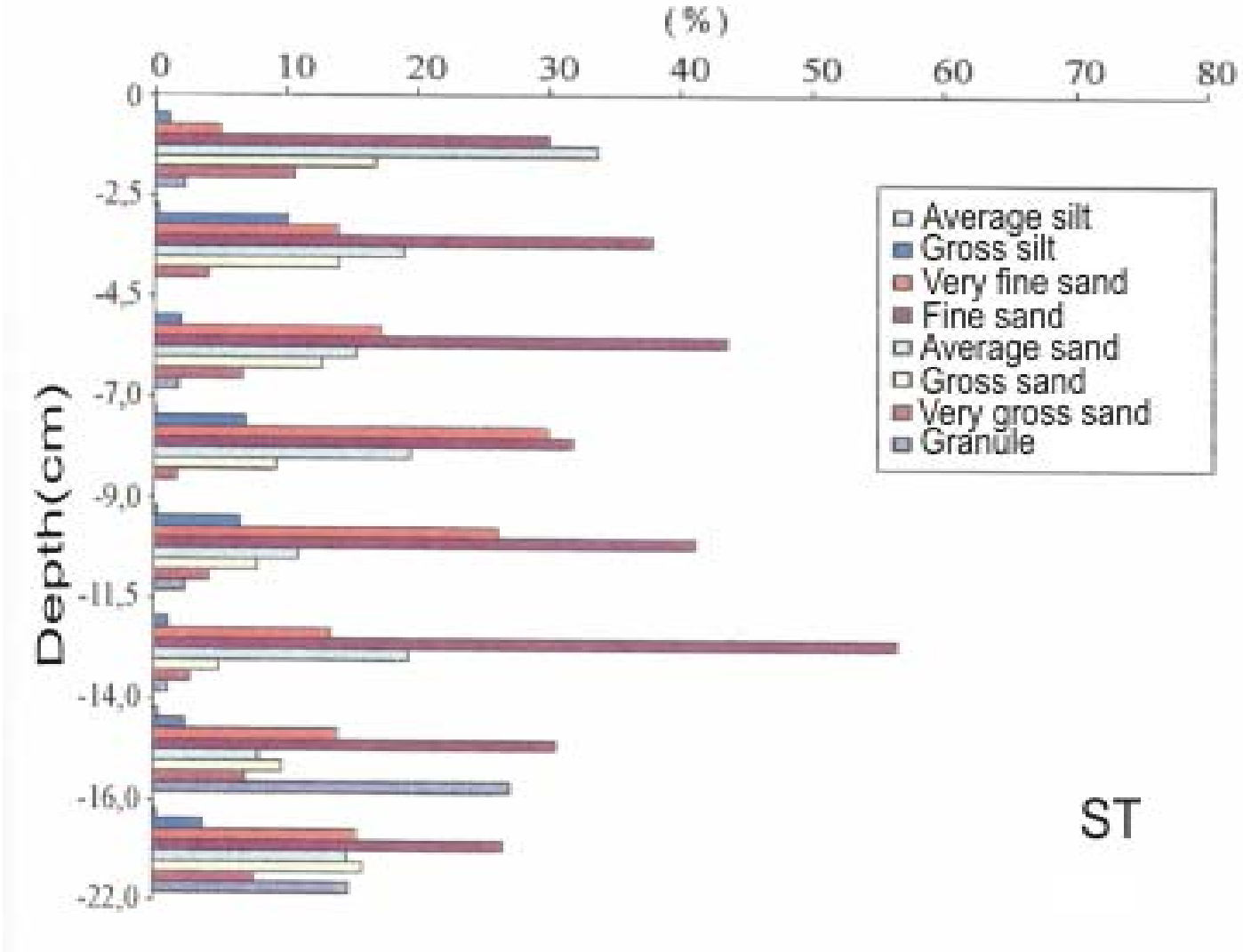
Hydrolysis: Augite - $Ca(Mg)Si_2O_6 \longrightarrow Ca(Mg)^{2+}$, HCO_3^- and SiO_2

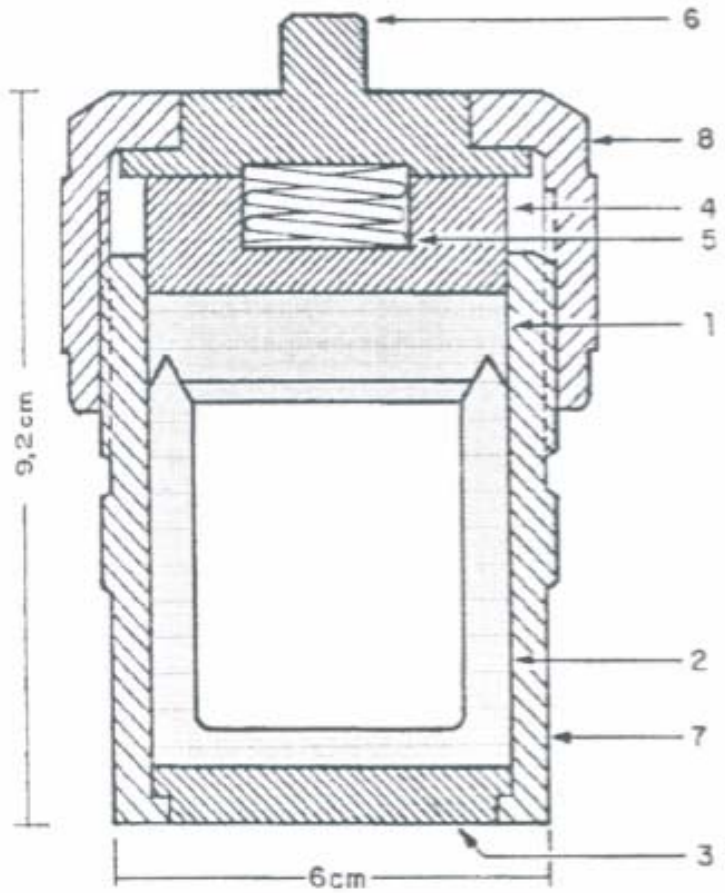



a
Instantaneous daily flux (ton)
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
Discharge (m^3s^{-1})
$R^2 = 0.97$


b
Instantaneous daily flux (ton)
700
600
500
400
300
200
100
0
Aug/98
Sep/98
Oct/98
Nov/98
Dec/98
Jan/99
Month


(%)
0
10
20
30
40
50
60
70
80
depth(cm)
0
-2,5
-4,5
-6,5
-8,5
-10,5
-12,5
-18,5
Average silt
Gross silt
Very fine sand
Fine sand
Average sand
Gross sand
Very gross sand
Granule
AF


(%)
0
10
20
30
40
50
60
70
80
0
-2.5
-4.5
-7.0
-9.0
-11.5
-14.0
-16.0
-22.0
Depth(cm)
Average silt
Gross silt
Very fine sand
Fine sand
Average sand
Gross sand
Very gross sand
Granule
ST



1 - Teflon cover

2 - Teflon cilinder and base

3 - Metallic base

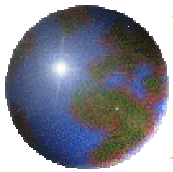
4 - Protecting cover

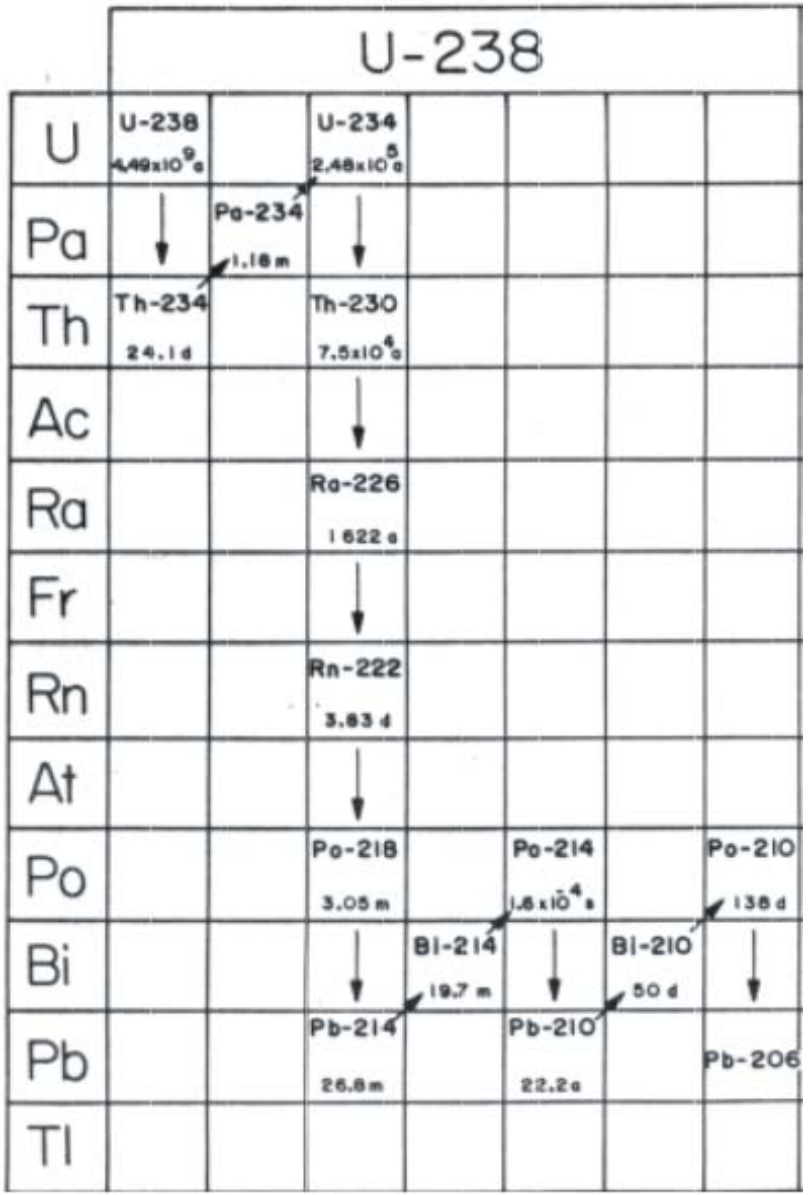
5 - Wire

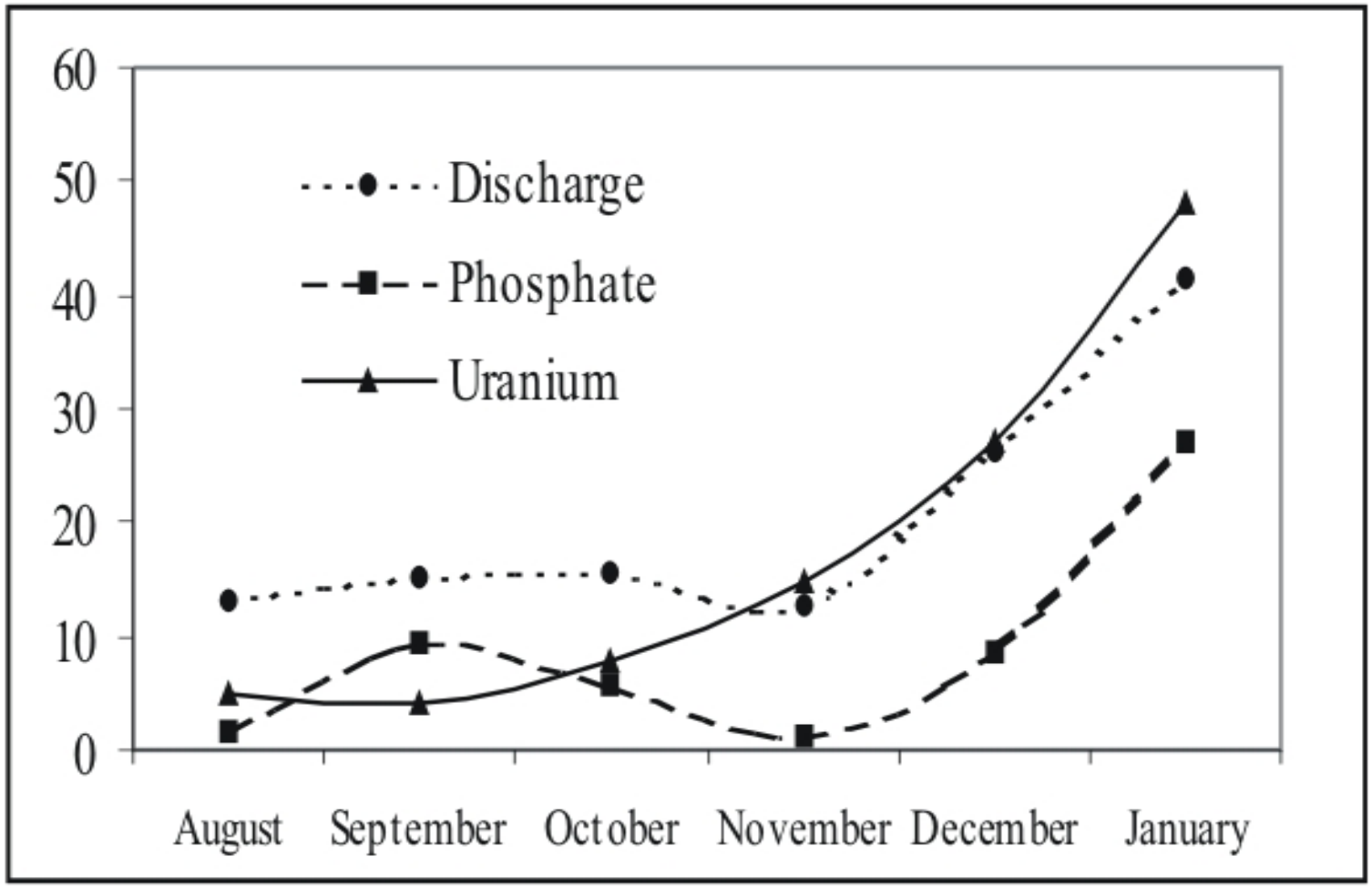
6 - Metallic cover

7 - Metallic body

8 - Metallic cover




U-238
U
U-238
4.49x10^9 a
U-234
2.48x10^5 a
Pa
Pa-234
1.18 m
Th
Th-234
24.1 d
Th-230
7.5x10^4 a
Ac
Ra
Ra-226
1622 a
Fr
Rn
Rn-222
3.83 d
At
Po
Po-218
3.05 m
Po-214
1.6x10^-4 s
Po-210
138 d
Bi
Bi-214
19.7 m
Bi-210
5.0 d
Pb
Pb-214
26.8 m
Pb-210
22.2 a
Pb-206
Tl


60
50
40
30
20
10
0
Discharge
Phosphate
Uranium
August
September
October
November
December
January

^{210}Po MEASUREMENTS

Sample

↓

^{209}Po spike addition

↓

Dissolution with HF, HCl, HNO_3

↓

Evaporation to dryness

↓

Dissolution of dry residue with 8M HCl

↓

Addition of 20% hydroxylamine hydrochloride

+

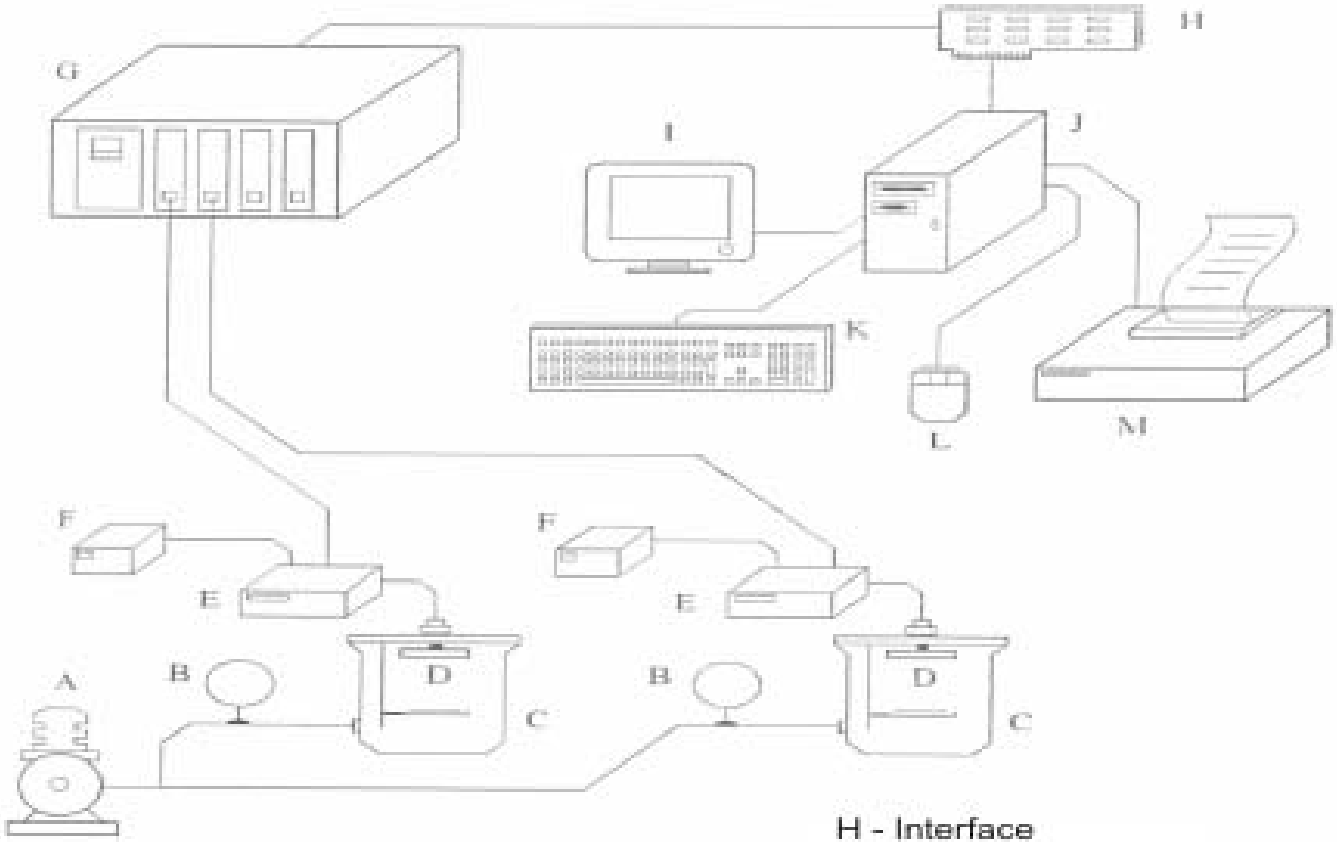
25% sodium citrate solution

↓

Po deposition onto copper disc

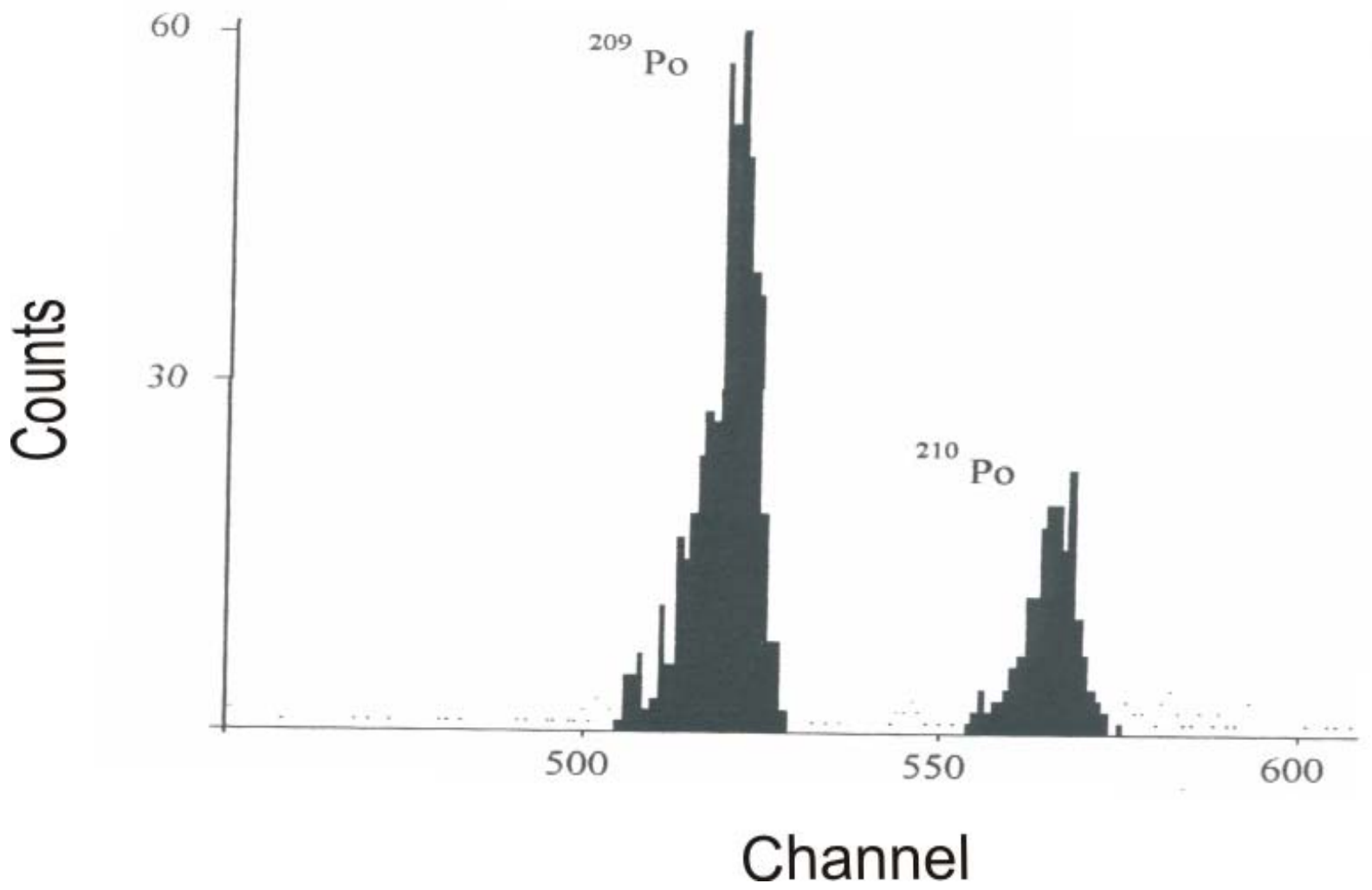
↓

Alpha spectrometry



A - Vacuum pump
B - Vacuum meter
C - Vacuum chamber
D - Surface barrier detector
E - Pre amplifier
F - Power Supply
G - Amplifier

H - Interface
I - Monitor
J - Microcomputer
K - Keyboard
L - Mouse
M - Printer


60
30
Counts
209 Po
210 Po
500
550
600
Channel

U MEASUREMENTS

Dissolution of rock matrix

↓

Addition of ^{232}U spike

↓

Co - precipitation on $Fe(OH)_3$

↓

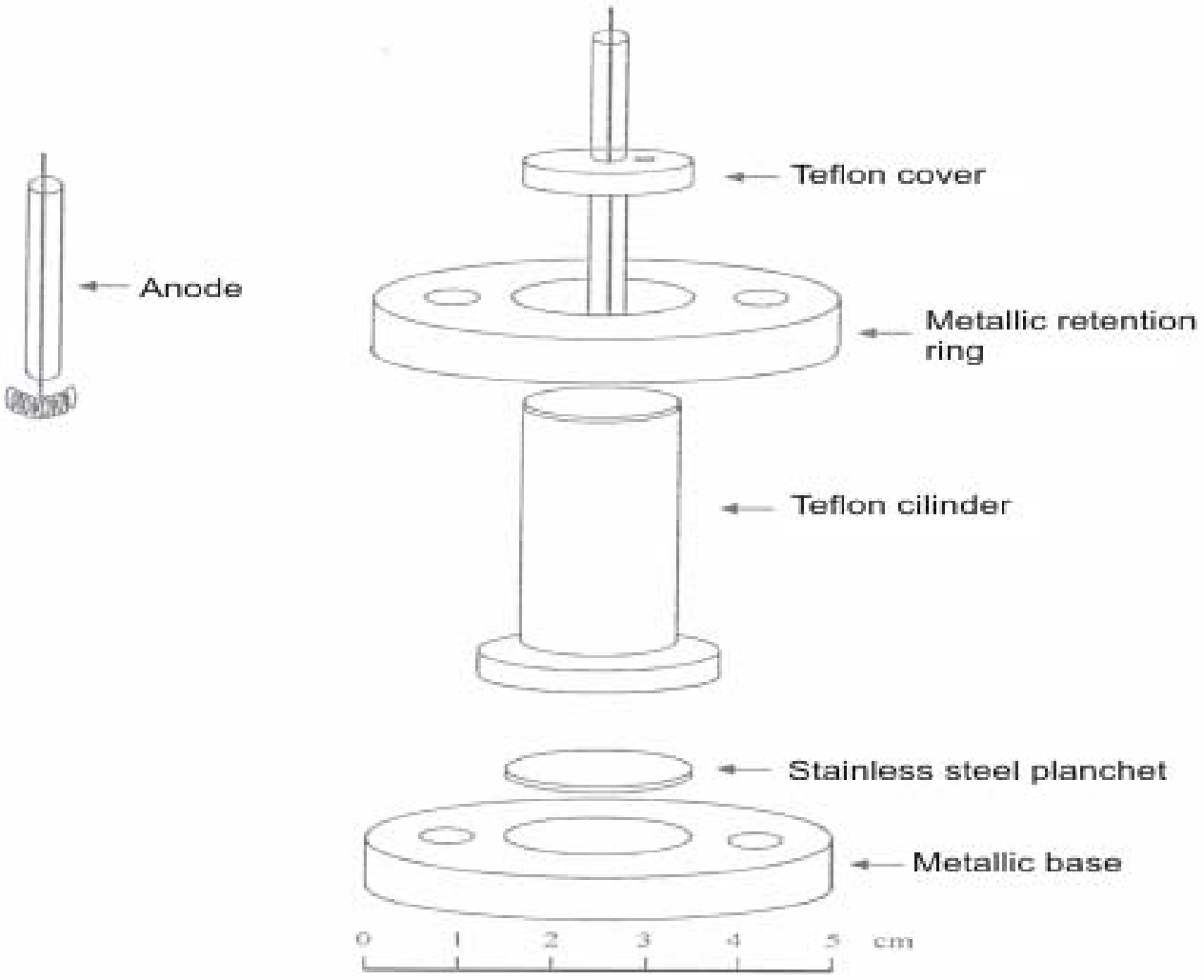
Fe^{3+} extraction (isopropyl ether)

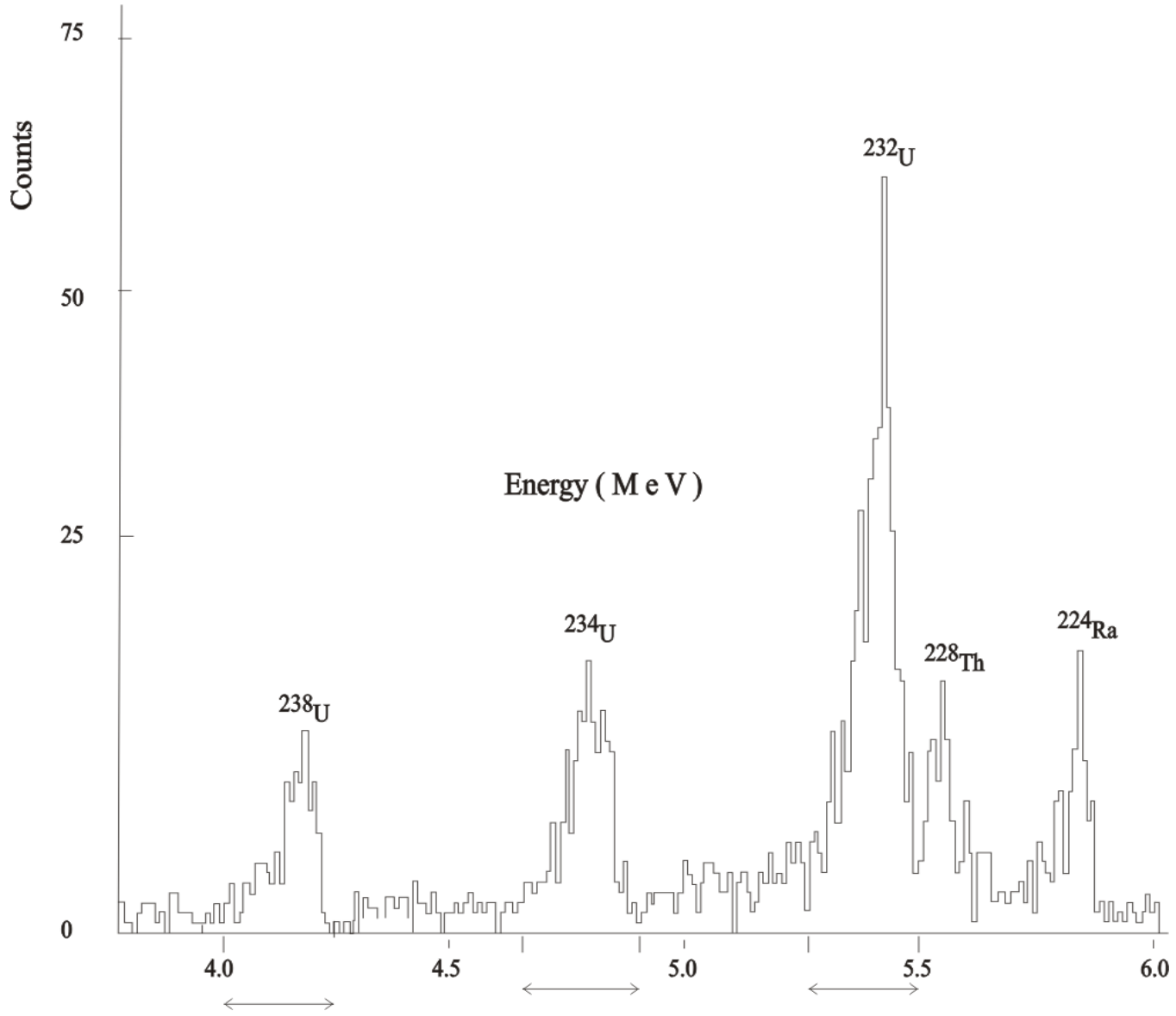
↓

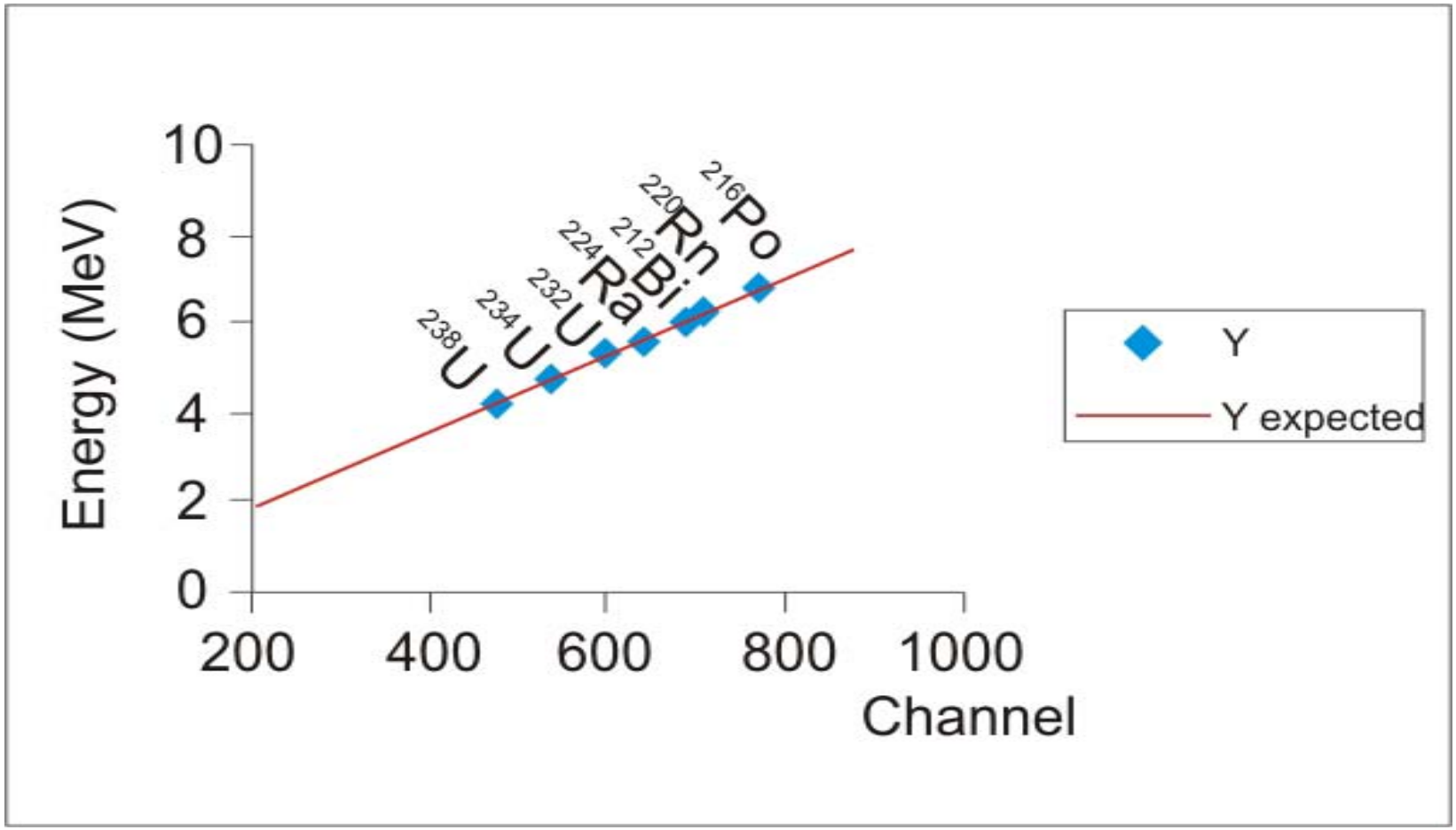
Anion exchange purification

↓

U-fraction	Th-fraction
↓	↓
Electrodeposition	discarded
↓	
300 mA, 3 hr	
↓	
α – spectrometry →	^{238}U content, $^{234}U/^{238}U$ A.R.

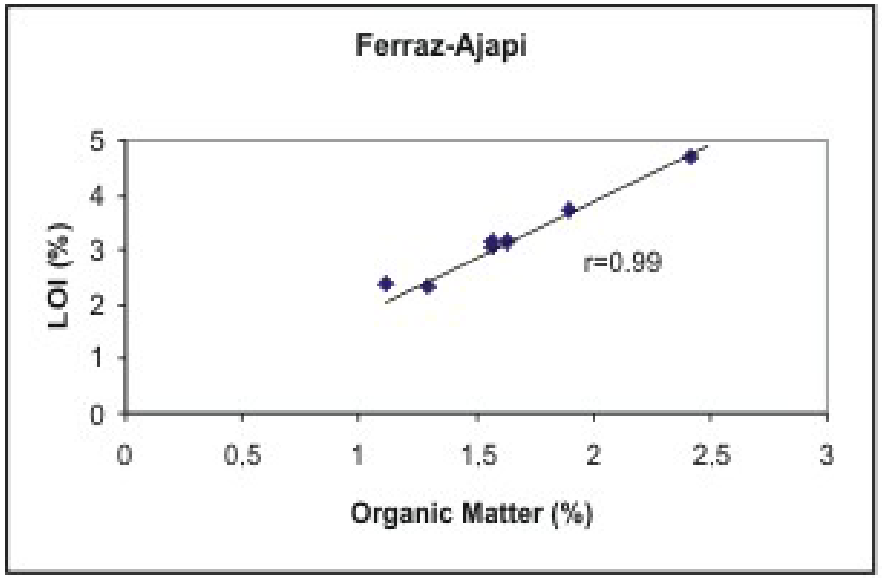

Anode
Teflon cover
Metallic retention ring
Teflon cilinder
Stainless steel planchet
Metallic base
0
1
2
3
4
5
cm

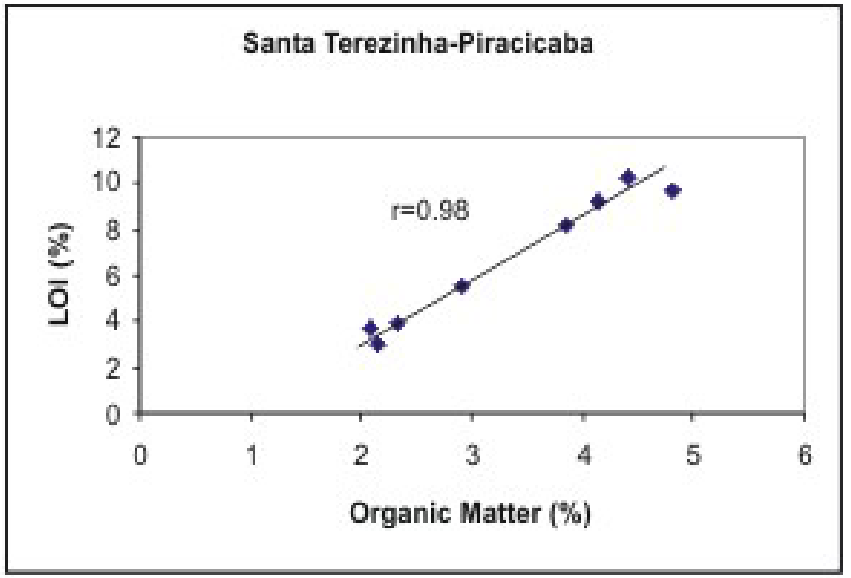

Counts
75
50
25
0
Energy (M e V)
238U
234U
232U
228Th
224Ra
4.0
4.5
5.0
5.5
6.0

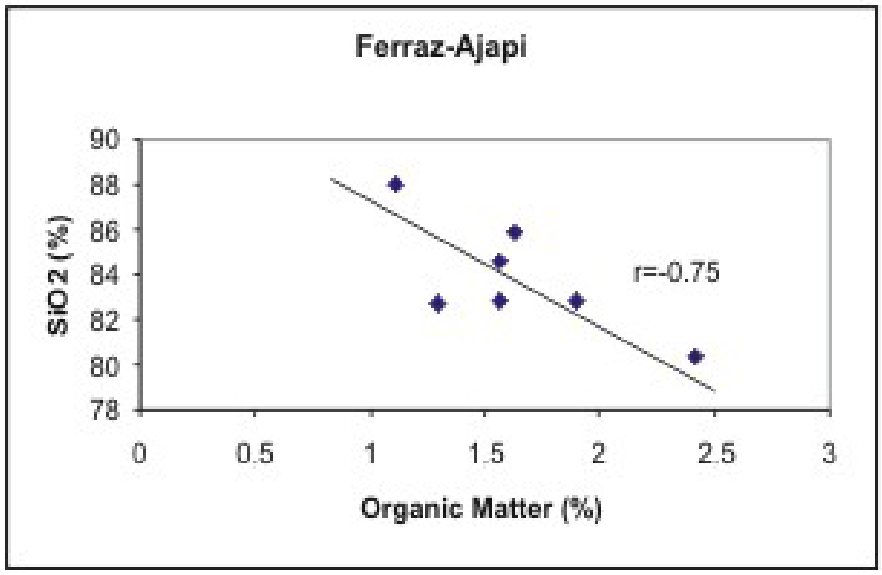

Energy (MeV)
10
8
6
4
2
0
200
400
600
800
1000
Channel
238U
234U
232U
224Ra
212Bi
220Rn
216Po
Y
Y expected

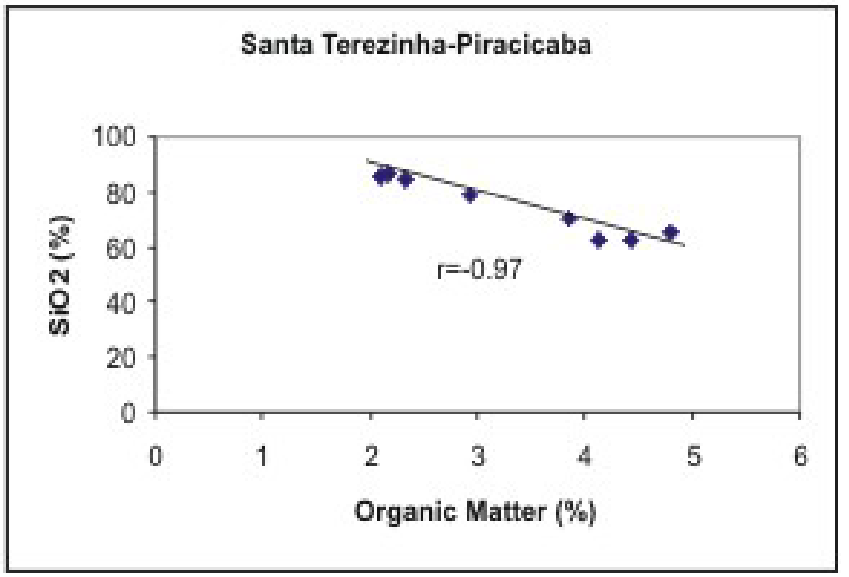
Influence of grain size on radionuclides retention

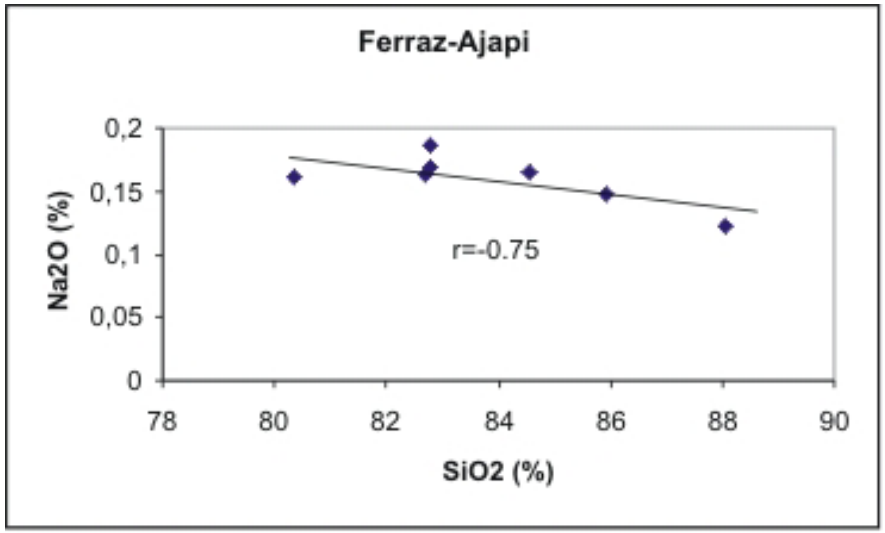
Grain size (mm)	Nuclide	Activity (dpm/g)
< 1	Po-210	1.30±0.10
	U-238	4.22±0.68
0.25-0.125	Po-210	0.80±0.10
	U-238	2.81±0.80
< 0.062	Po-210	3.02±0.24
	U-238	13.58±2.84

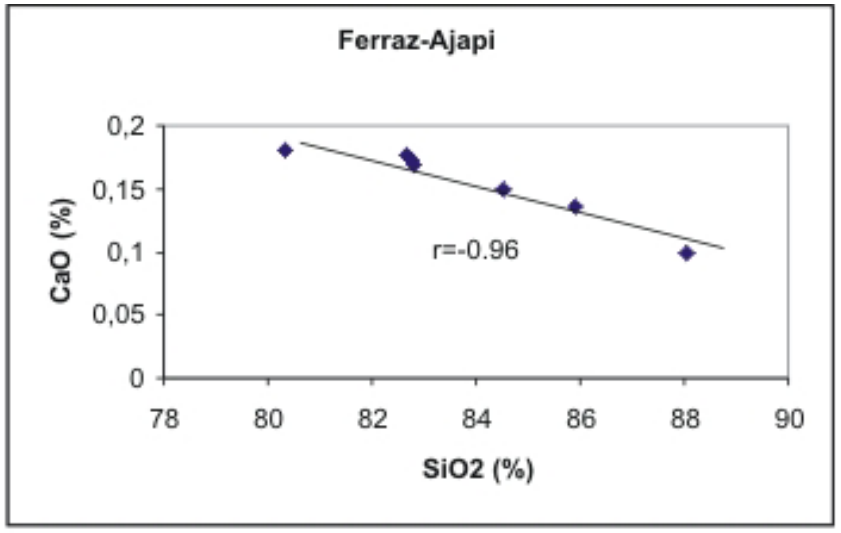

Ferraz-Ajapi
LOI (%)
Organic Matter (%)
r=0.99
0
1
2
3
4
5
0
0,5
1
1,5
2
2,5
3

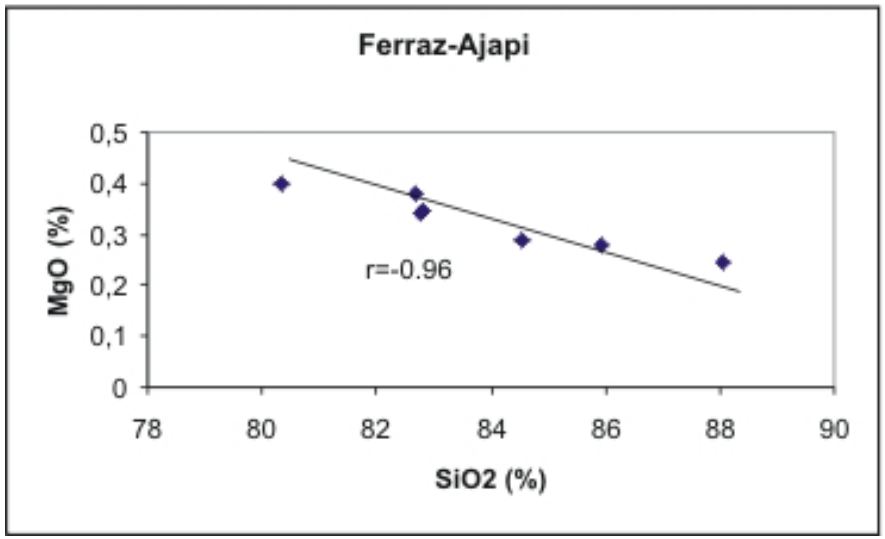

Santa Terezinha-Piracicaba
LOI (%)
Organic Matter (%)
r=0.98
0
2
4
6
8
10
12
0
1
2
3
4
5
6

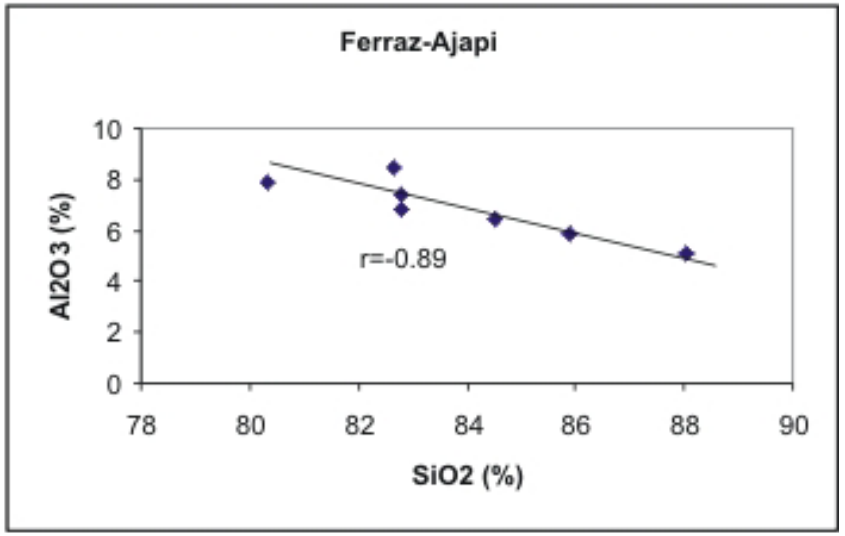

Ferraz-Ajapi
SiO 2 (%)
Organic Matter (%)
r=-0.75
78
80
82
84
86
88
90
0
0.5
1
1.5
2
2.5
3

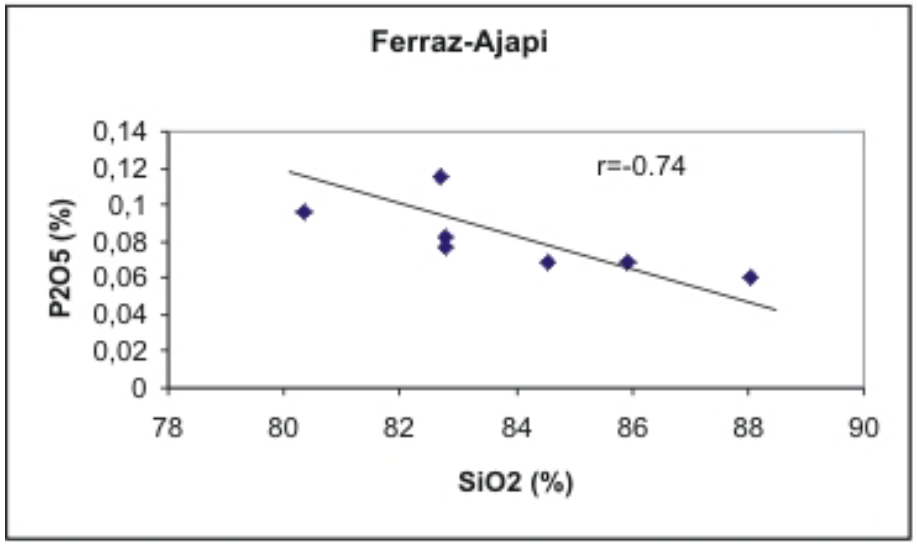

Santa Terezinha-Piracicaba
SiO 2 (%)
Organic Matter (%)
r=-0.97
0
20
40
60
80
100
0
1
2
3
4
5
6

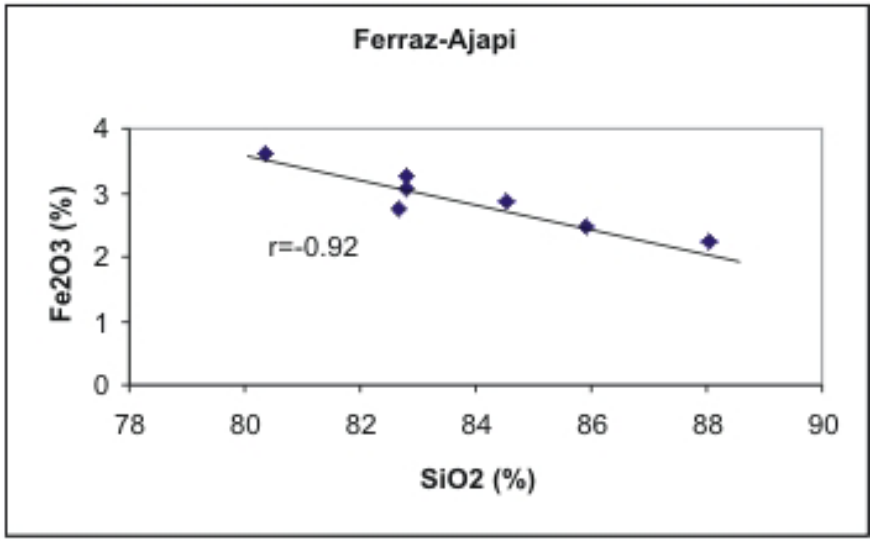

Ferraz-Ajapi
Na2O (%)
0,2
0,15
0,1
0,05
0
r=-0.75
78
80
82
84
86
88
90
SiO2 (%)

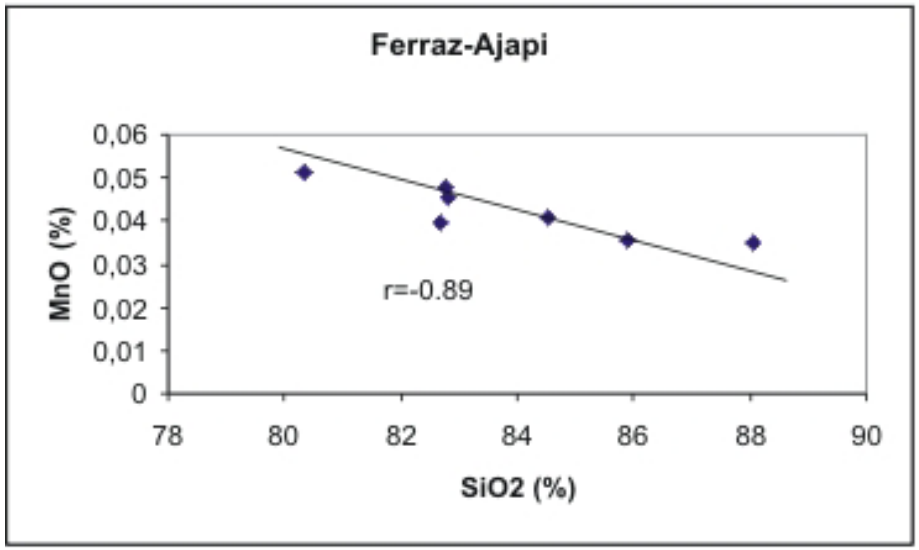

Ferraz-Ajapi
CaO (%)
0,2
0,15
0,1
0,05
0
r=-0.96
78
80
82
84
86
88
90
SiO2 (%)

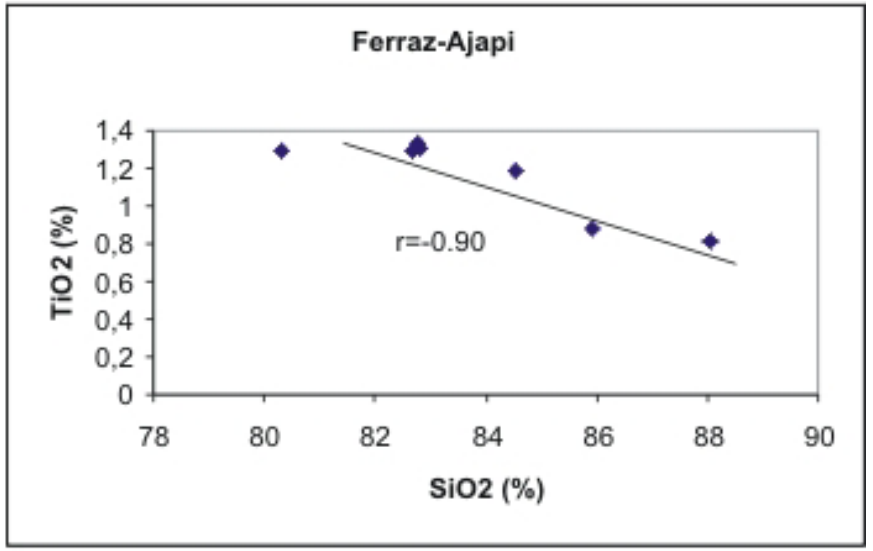

Ferraz-Ajapi
MgO (%)
0,5
0,4
0,3
0,2
0,1
0
r=-0.96
78
80
82
84
86
88
90
SiO2 (%)

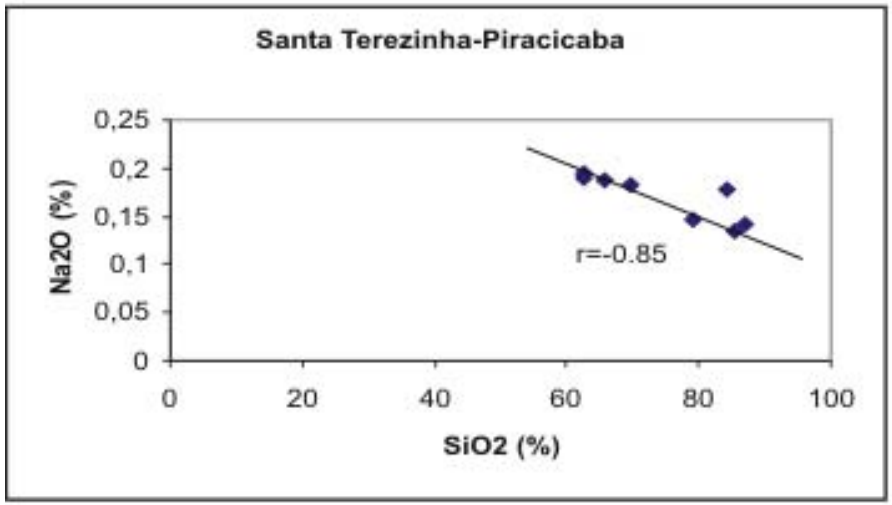

Ferraz-Ajapi
Al2O3 (%)
10
8
6
4
2
0
r=-0.89
78
80
82
84
86
88
90
SiO2 (%)

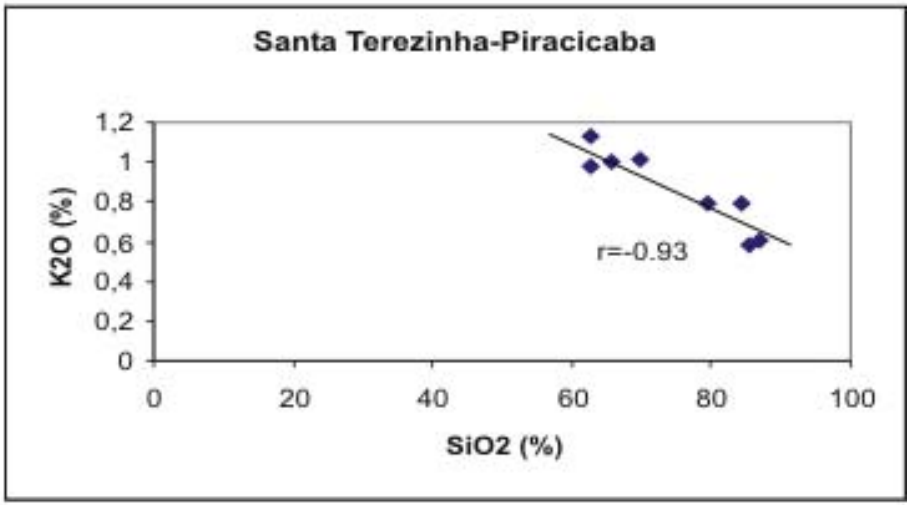

Ferraz-Ajapi
P2O5 (%)
0,14
0,12
0,1
0,08
0,06
0,04
0,02
0
r=-0.74
78
80
82
84
86
88
90
SiO2 (%)

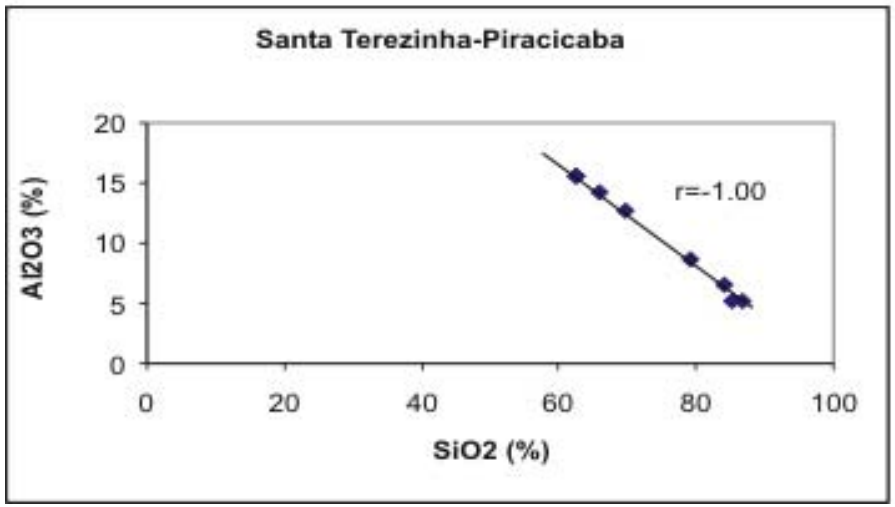

Ferraz-Ajapi
Fe2O3 (%)
4
3
2
1
0
r=-0.92
78
80
82
84
86
88
90
SiO2 (%)

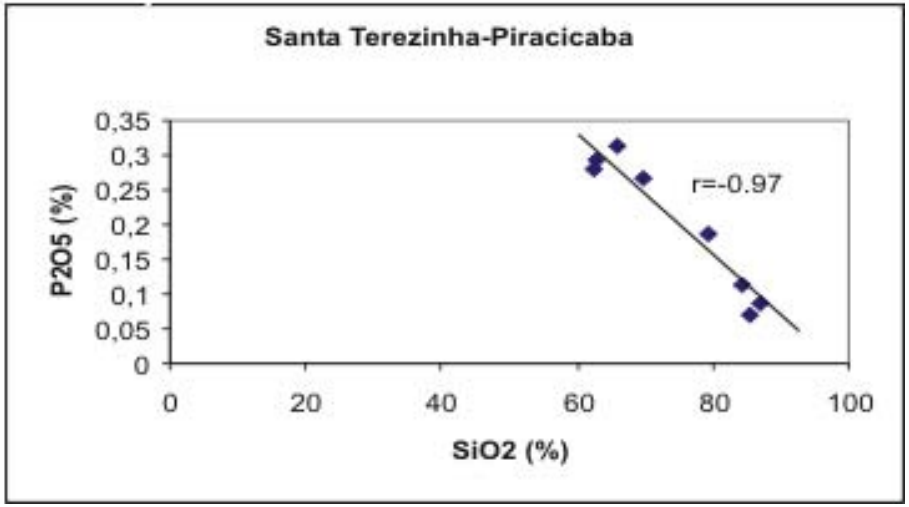

Ferraz-Ajapi
MnO (%)
0,06
0,05
0,04
0,03
0,02
0,01
0
r=-0.89
78
80
82
84
86
88
90
SiO2 (%)

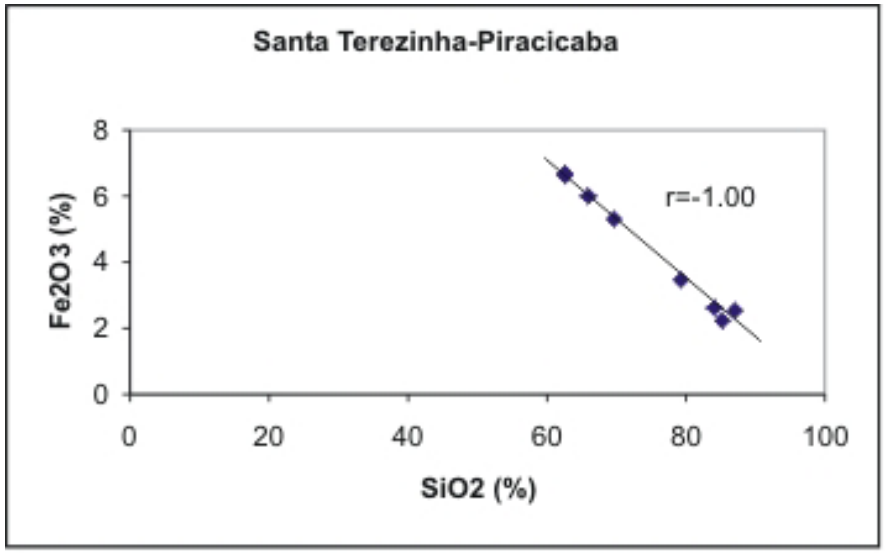

Ferraz-Ajapi
TiO2 (%)
1,4
1,2
1
0,8
0,6
0,4
0,2
0
r=-0.90
78
80
82
84
86
88
90
SiO2 (%)

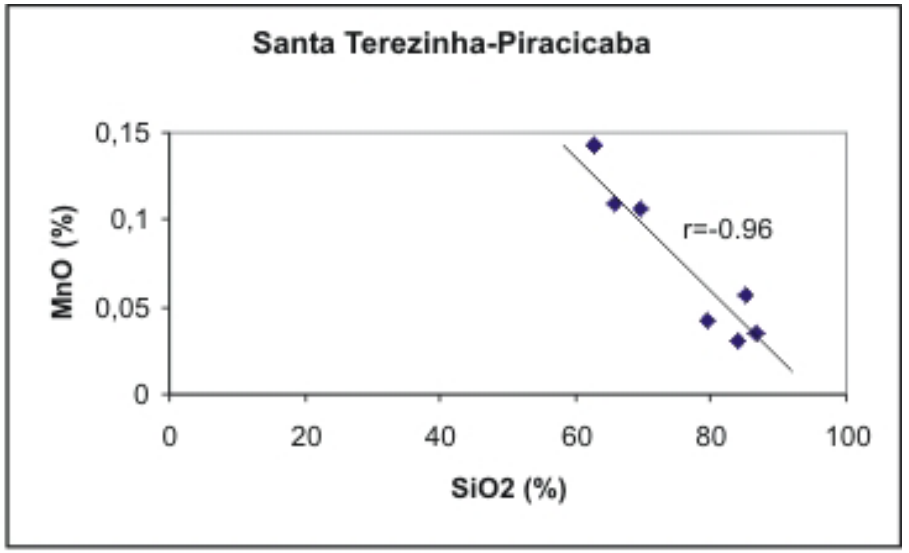

Santa Terezinha-Piracicaba
Na2O (%)
0,25
0,2
0,15
0,1
0,05
0
r=-0.85
0
20
40
60
80
100
SiO2 (%)

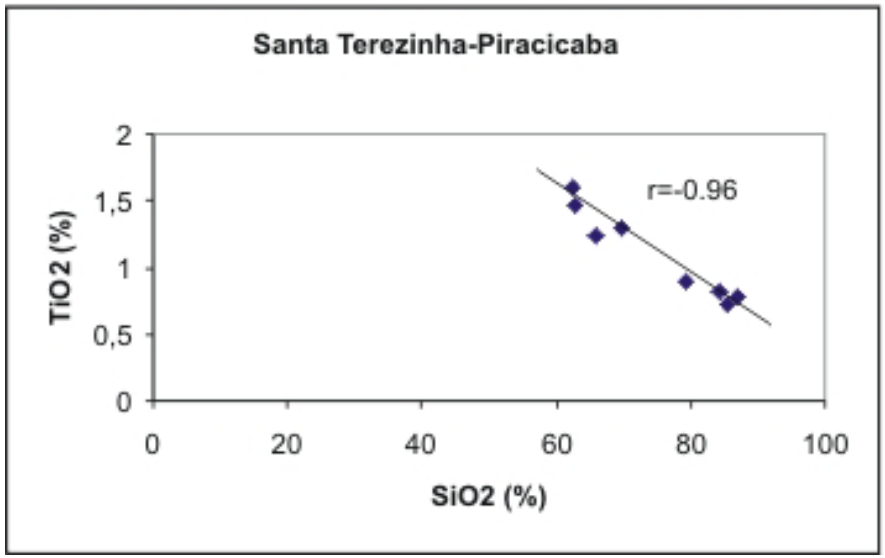

Santa Terezinha-Piracicaba
K2O (%)
1,2
1
0,8
0,6
0,4
0,2
0
r=-0.93
0
20
40
60
80
100
SiO2 (%)

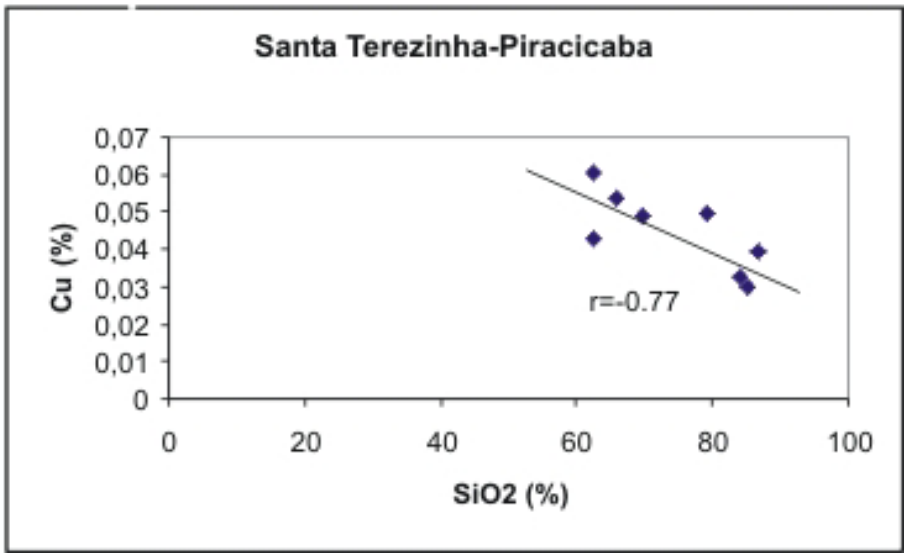

Santa Terezinha-Piracicaba
Al2O3 (%)
20
15
10
5
0
r=-1.00
0
20
40
60
80
100
SiO2 (%)

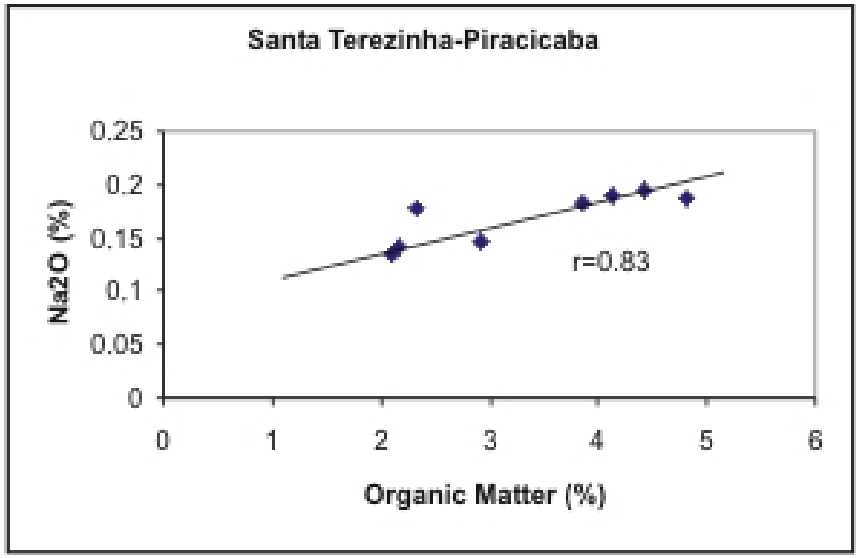

Santa Terezinha-Piracicaba
P2O5 (%)
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
r=-0.97
0
20
40
60
80
100
SiO2 (%)

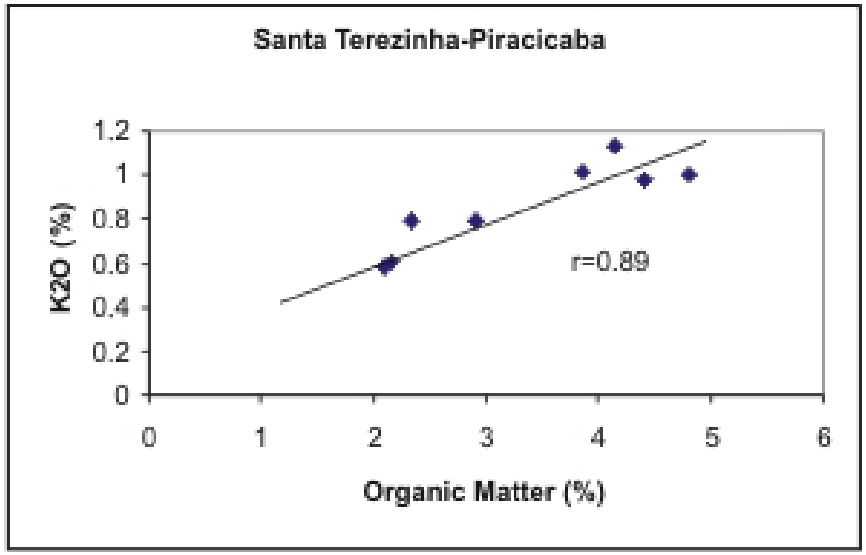

Santa Terezinha-Piracicaba
Fe2O3 (%)
SiO2 (%)
r=-1.00
0
2
4
6
8
0
20
40
60
80
100

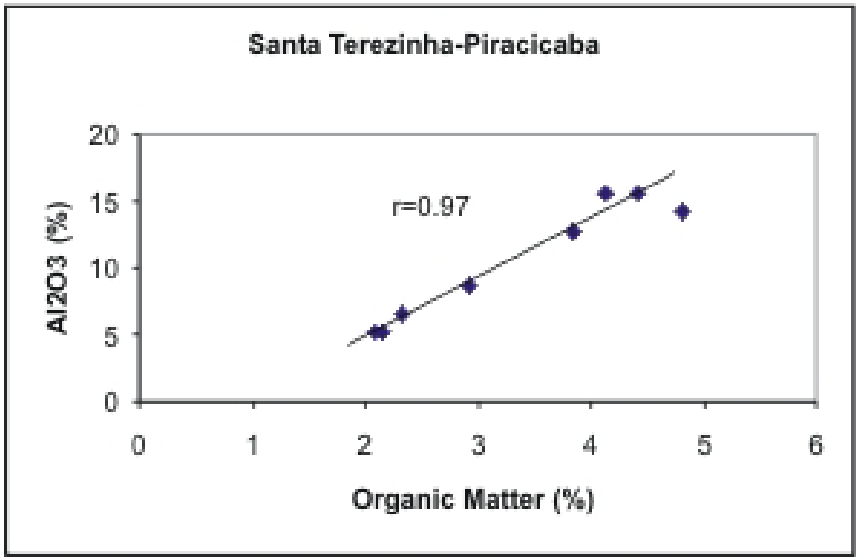

Santa Terezinha-Piracicaba
MnO (%)
SiO2 (%)
r=-0.96
0
0,05
0,1
0,15
0
20
40
60
80
100

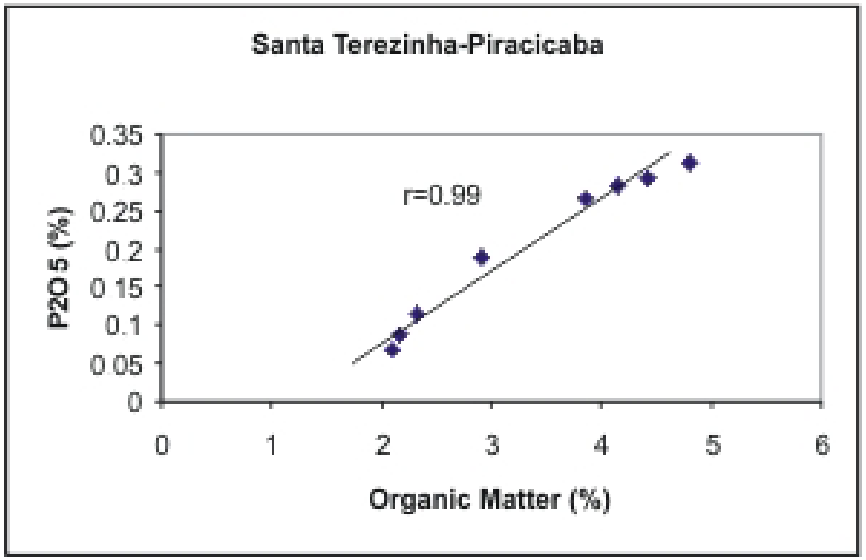

Santa Terezinha-Piracicaba
TiO2 (%)
SiO2 (%)
r=-0.96
0
0,5
1
1,5
2
0
20
40
60
80
100

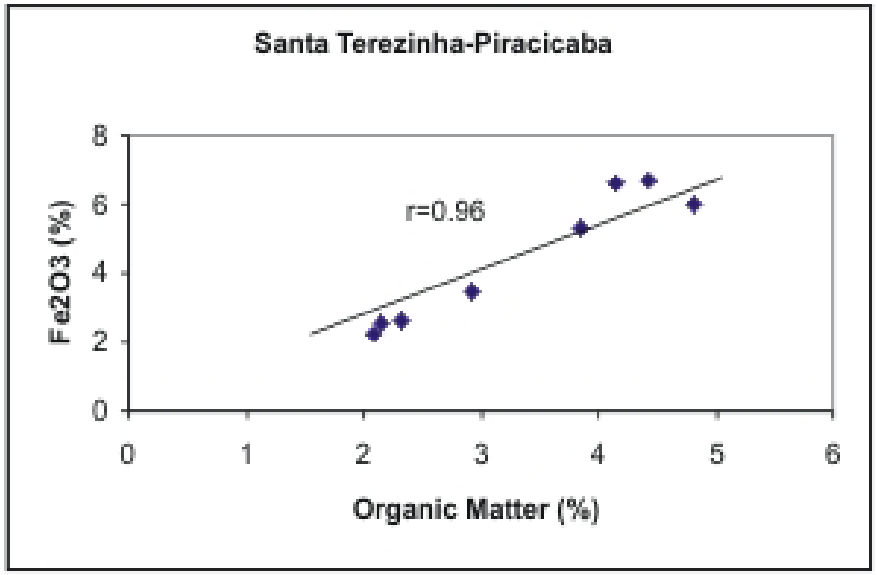

Santa Terezinha-Piracicaba
Cu (%)
SiO2 (%)
r=-0.77
0
0,01
0,02
0,03
0,04
0,05
0,06
0,07
0
20
40
60
80
100

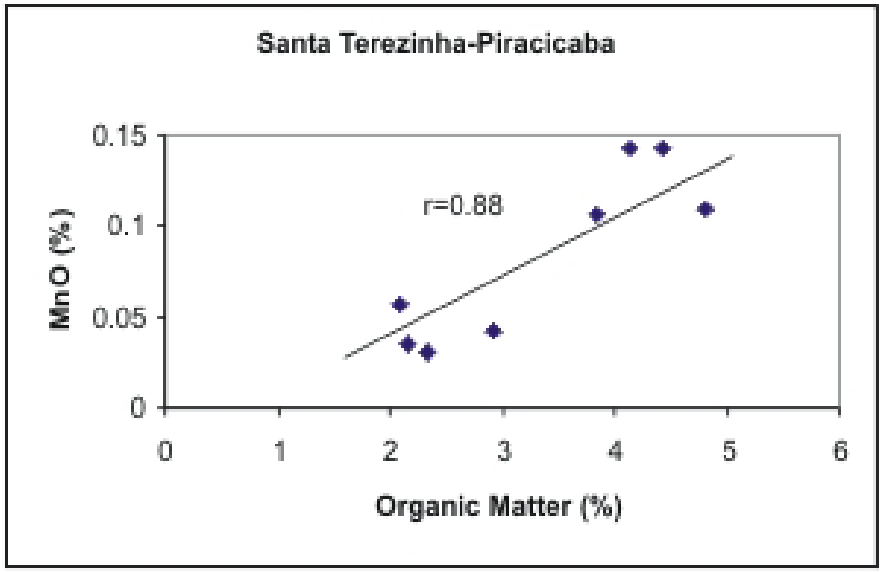

Santa Terezinha-Piracicaba
Na2O (%)
0.25
0.2
0.15
0.1
0.05
0
r=0.83
0
1
2
3
4
5
6
Organic Matter (%)

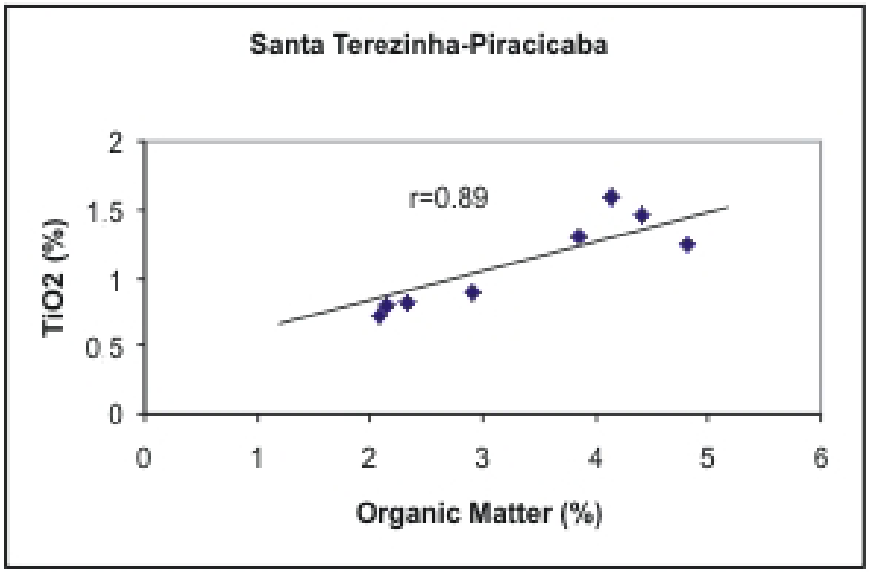

Santa Terezinha-Piracicaba
K2O (%)
1.2
1
0.8
0.6
0.4
0.2
0
r=0.89
0
1
2
3
4
5
6
Organic Matter (%)

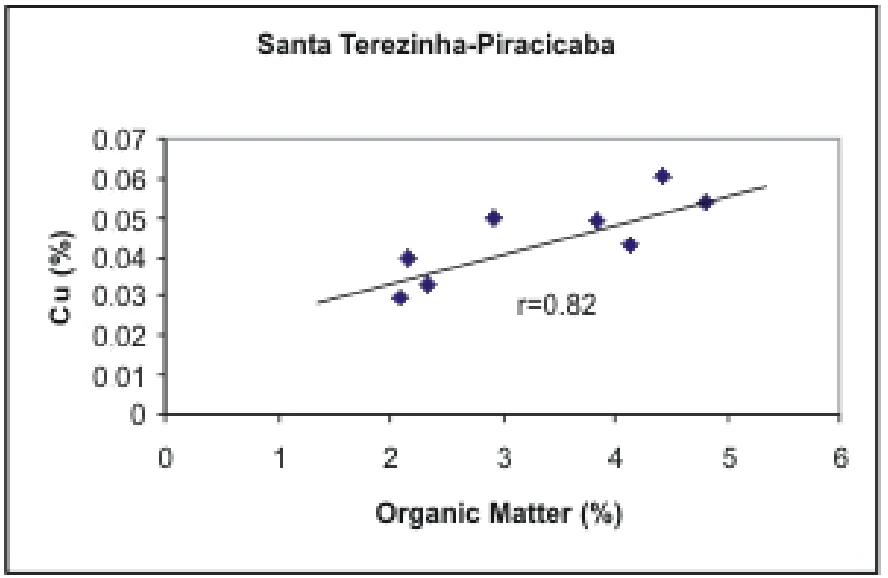

Santa Terezinha-Piracicaba
Al2O3 (%)
20
15
10
5
0
r=0.97
0
1
2
3
4
5
6
Organic Matter (%)

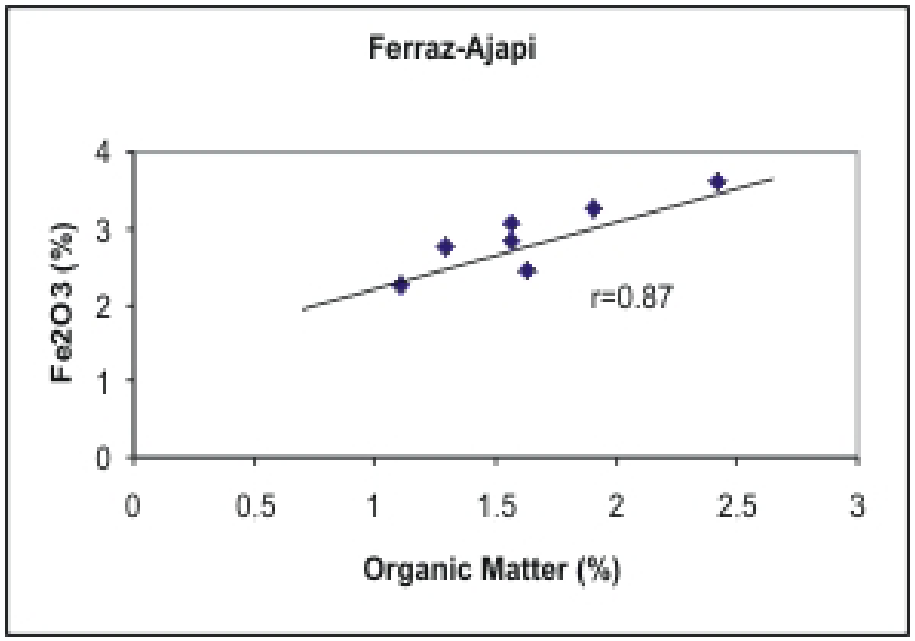

Santa Terezinha-Piracicaba
P2O5 (%)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
r=0.99
0
1
2
3
4
5
6
Organic Matter (%)

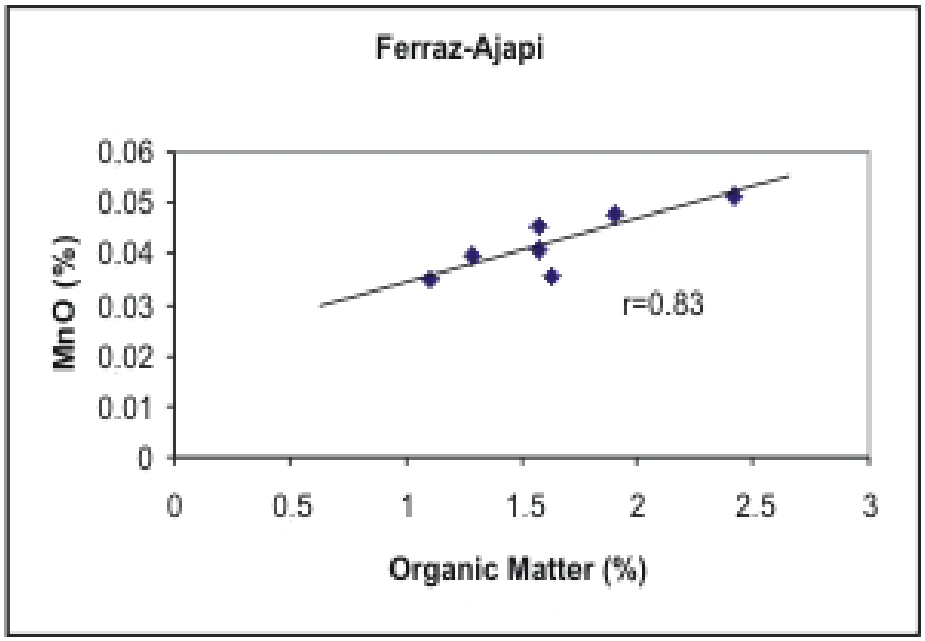

Santa Terezinha-Piracicaba
Fe2O3 (%)
r=0.96
Organic Matter (%)
0
2
4
6
8
0
1
2
3
4
5
6

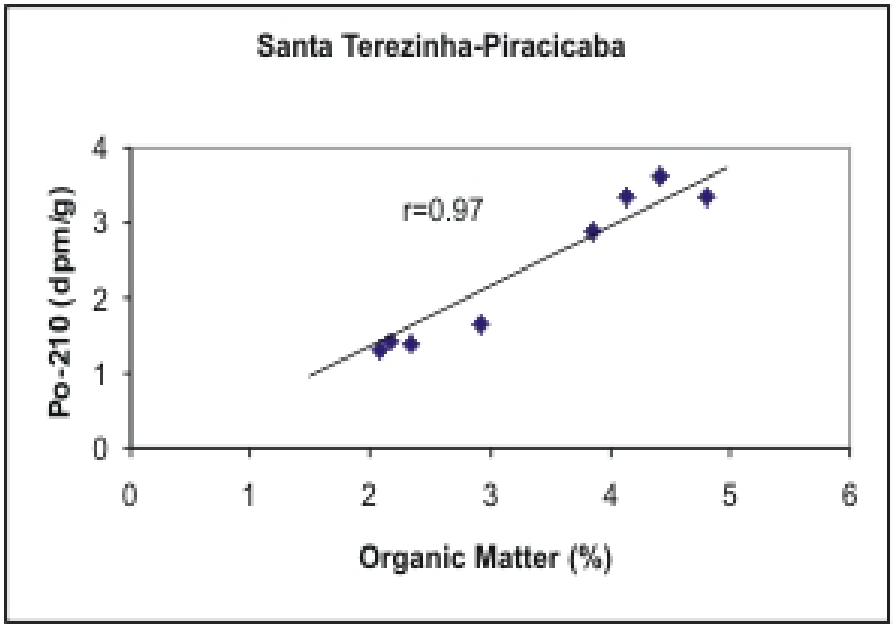

Santa Terezinha-Piracicaba
MnO (%)
r=0.88
Organic Matter (%)
0
0.05
0.1
0.15
0
1
2
3
4
5
6

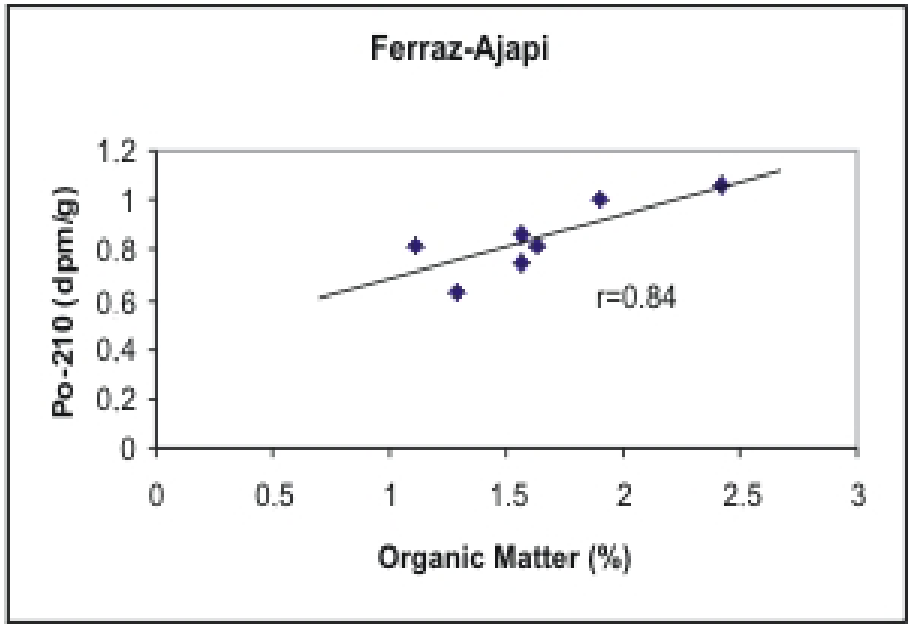

Santa Terezinha-Piracicaba
TiO2 (%)
r=0.89
Organic Matter (%)
0
0 5
1
1.5
2
0
1
2
3
4
5
6

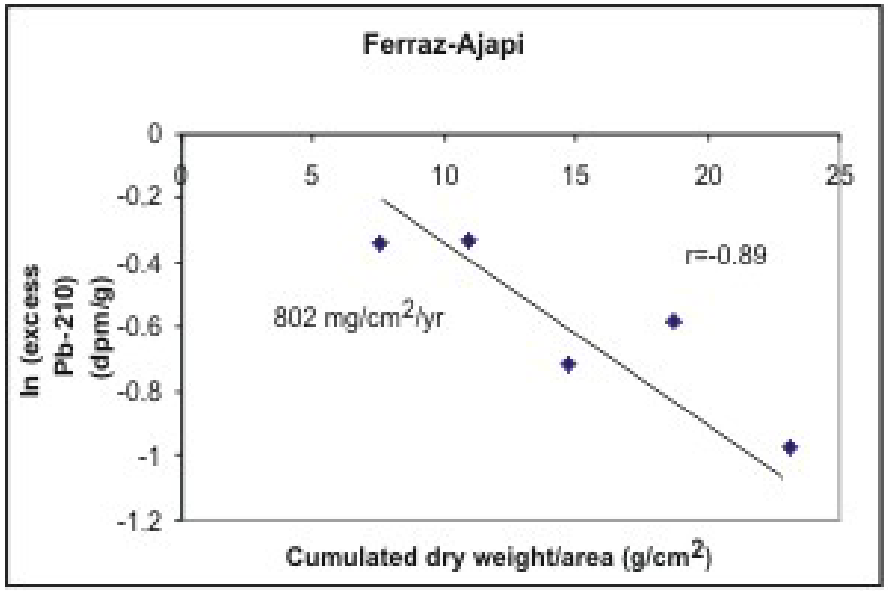

Santa Terezinha-Piracicaba
Cu (%)
r=0.82
Organic Matter (%)
0
0 01
0.02
0.03
0.04
0 05
0.06
0.07
0
1
2
3
4
5
6

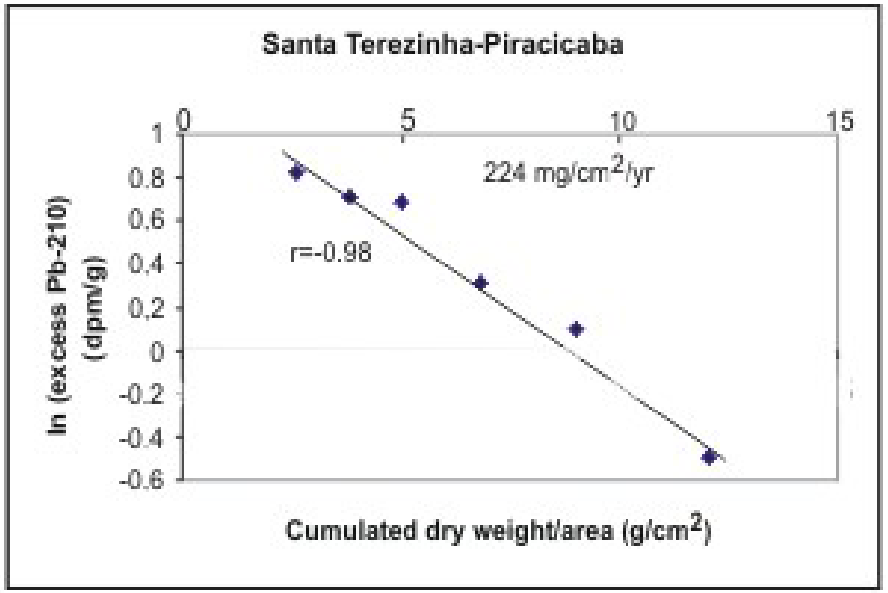

Ferraz-Ajapi
Fe2O3 (%)
Organic Matter (%)
r=0.87
0
1
2
3
4
0
0.5
1
1.5
2
2.5
3

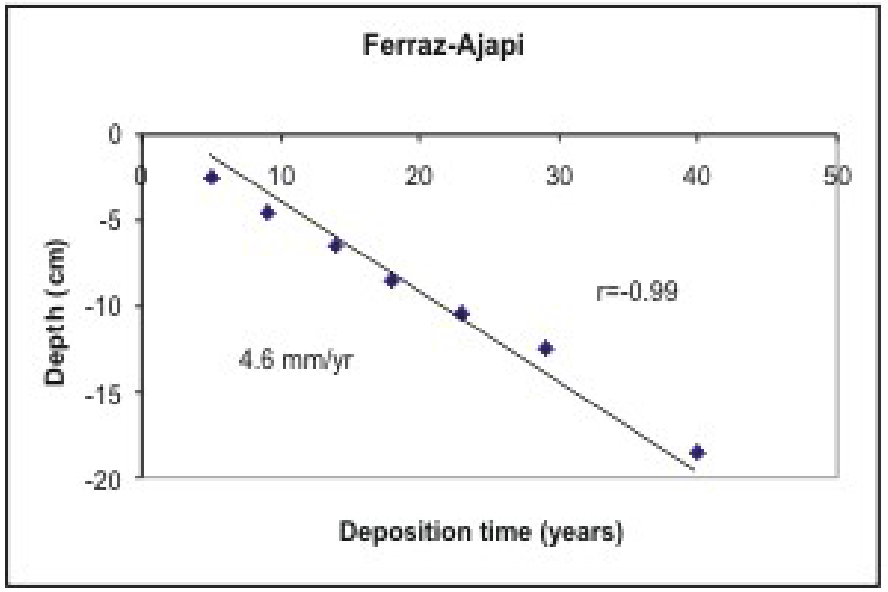

Ferraz-Ajapi
MnO (%)
Organic Matter (%)
r=0.83
0
0.01
0.02
0.03
0.04
0.05
0.06
0
0.5
1
1.5
2
2.5
3

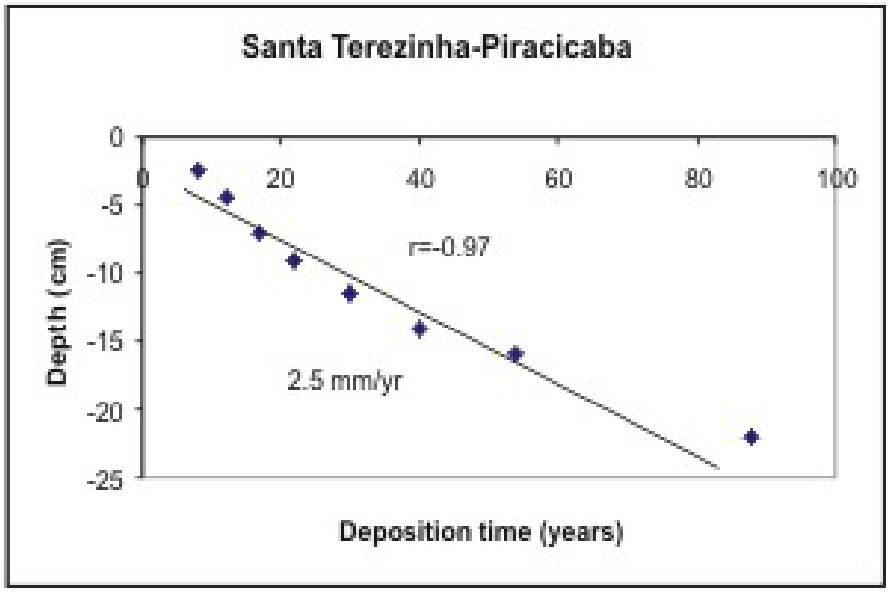

Santa Terezinha-Piracicaba
Po-210 (dpm/g)
Organic Matter (%)
r=0.97
0
1
2
3
4
0
1
2
3
4
5
6

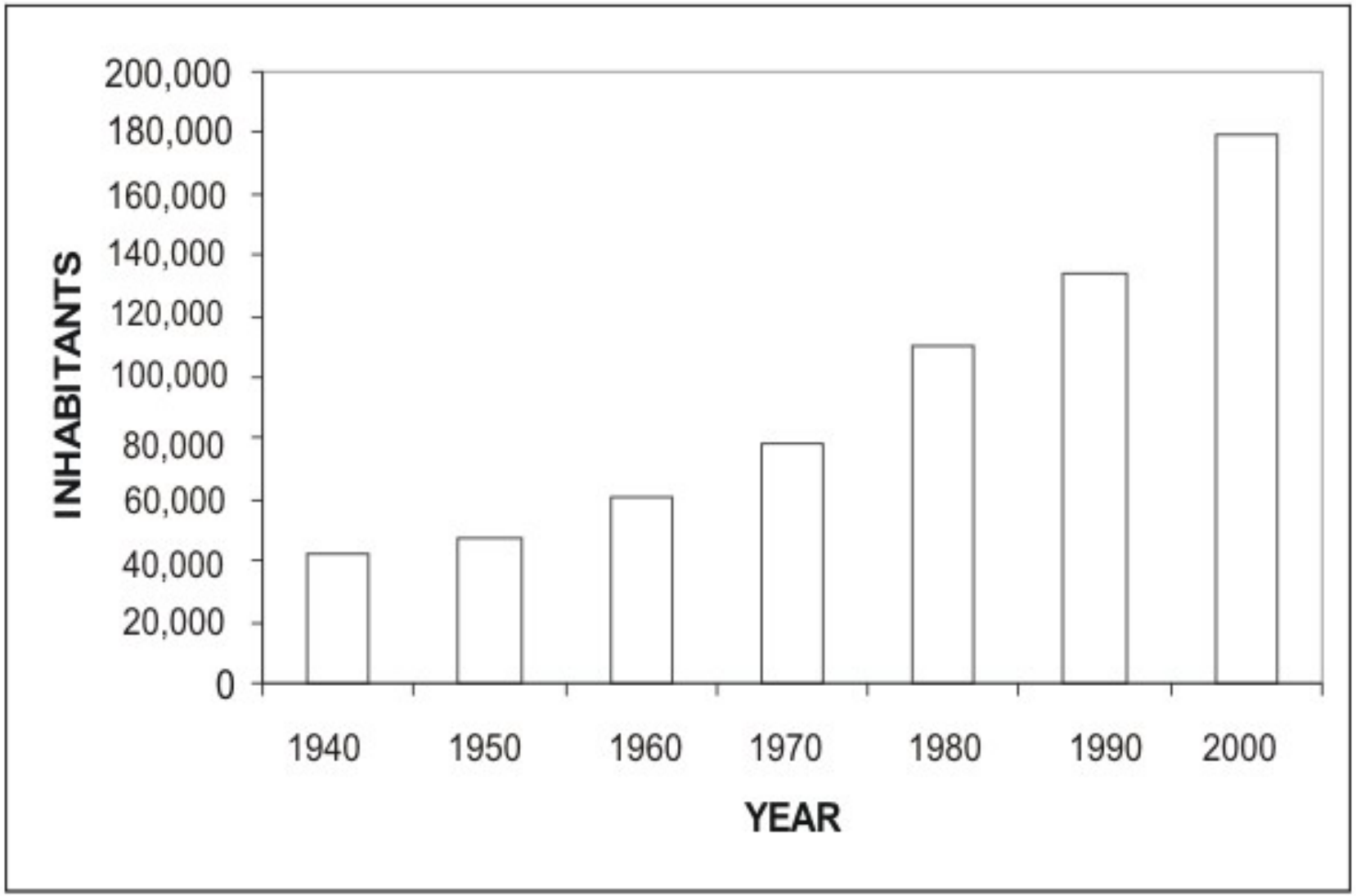

Ferraz-Ajapi
Po-210 (dpm/g)
Organic Matter (%)
r=0.84
0
0.2
0.4
0.6
0.8
1
1.2
0
0.5
1
1.5
2
2.5
3

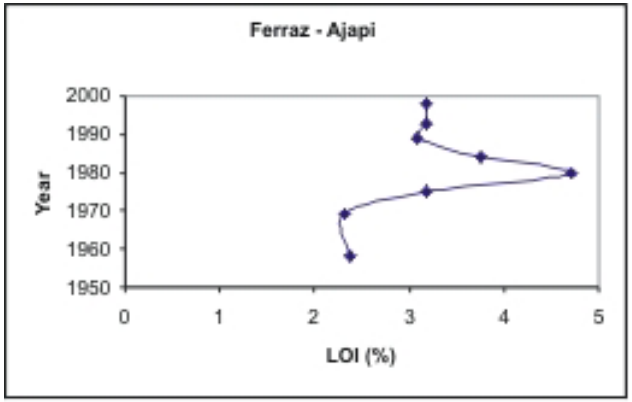

Ferraz-Ajapi
ln (excess Pb-210) (dpm/g)
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
0
5
10
15
20
25
802 mg/cm2/yr
r=-0.89
Cumulated dry weight/area (g/cm2)

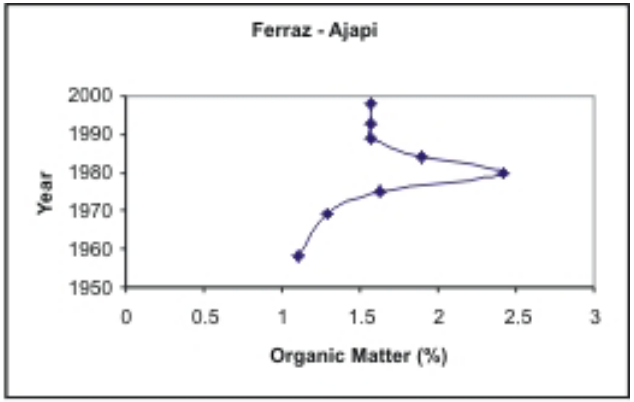

Santa Terezinha-Piracicaba
ln (excess Pb-210) (dpm/g)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
5
10
15
224 mg/cm2/yr
r=-0.98
Cumulated dry weight/area (g/cm2)

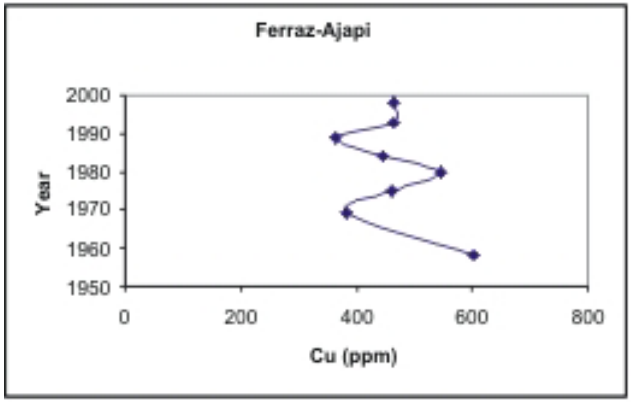

Ferraz-Ajapi
Depth (cm)
0
-5
-10
-15
-20
0
10
20
30
40
50
4.6 mm/yr
r=-0.99
Deposition time (years)

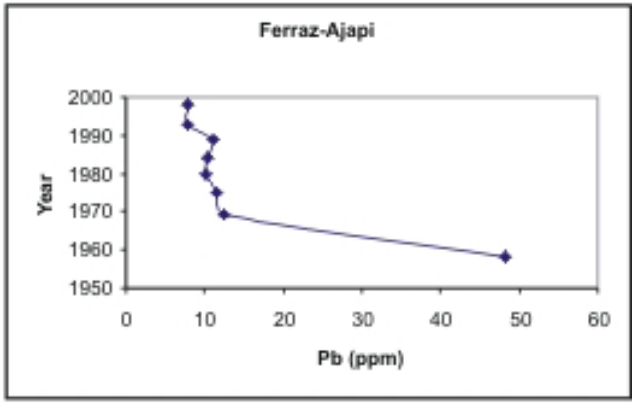

Santa Terezinha-Piracicaba
Depth (cm)
0
-5
-10
-15
-20
-25
0
20
40
60
80
100
r=-0.97
2.5 mm/yr
Deposition time (years)

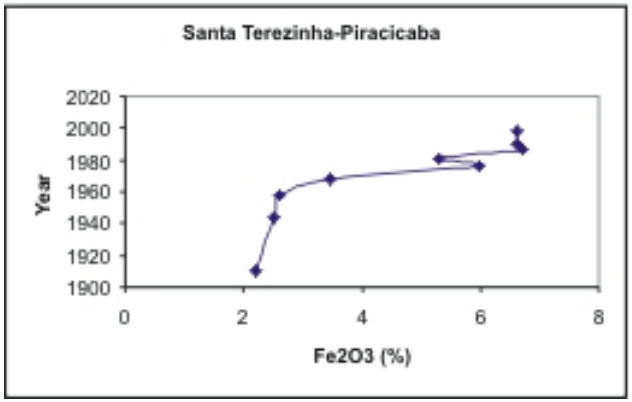

INHABITANTS
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1940
1950
1960
1970
1980
1990
2000
YEAR

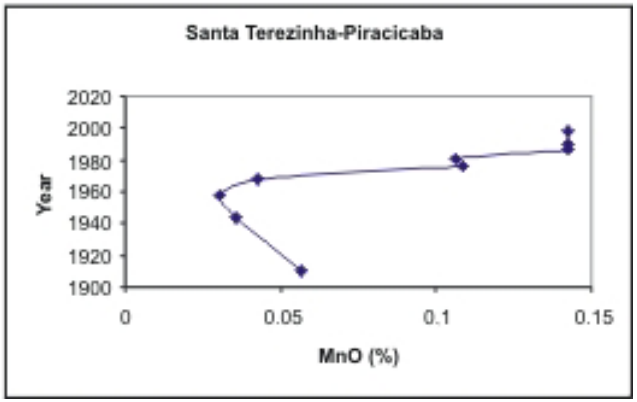

Ferraz - Ajapi
Year
2000
1990
1980
1970
1960
1950
0
1
2
3
4
5
LOI (%)

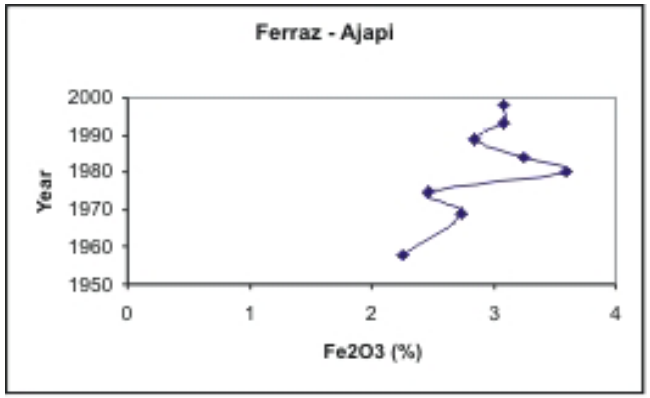

Ferraz - Ajapi
Year
2000
1990
1980
1970
1960
1950
0
0.5
1
1.5
2
2.5
3
Organic Matter (%)

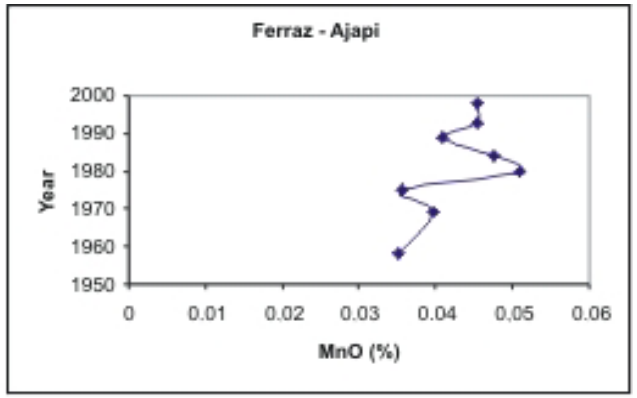

Ferraz-Ajapi
Year
2000
1990
1980
1970
1960
1950
0
200
400
600
800
Cu (ppm)

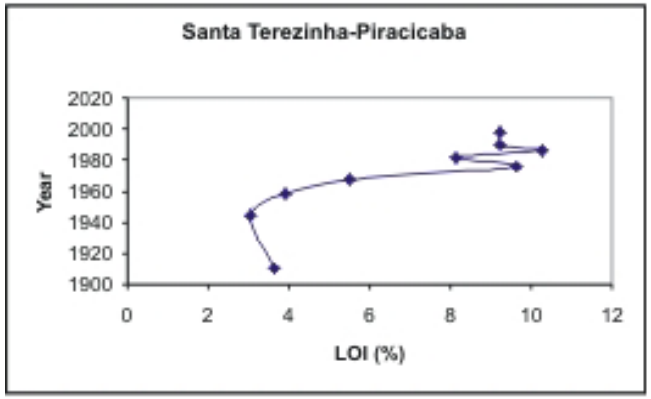

Ferraz-Ajapi
Year
2000
1990
1980
1970
1960
1950
0
10
20
30
40
50
60
Pb (ppm)

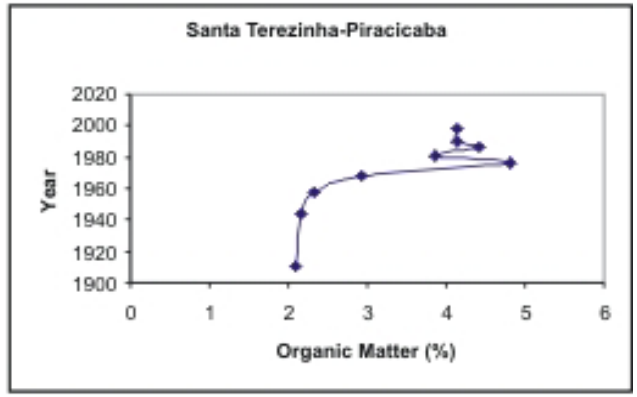

Santa Terezinha-Piracicaba
Year
2020
2000
1980
1960
1940
1920
1900
0
2
4
6
8
Fe2O3 (%)

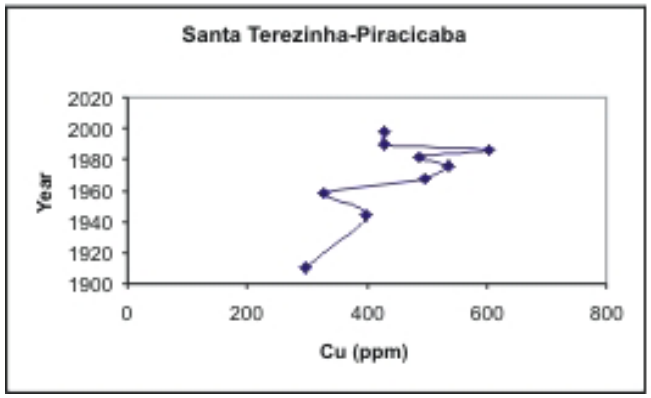

Santa Terezinha-Piracicaba
Year
2020
2000
1980
1960
1940
1920
1900
0
0.05
0.1
0.15
MnO (%)

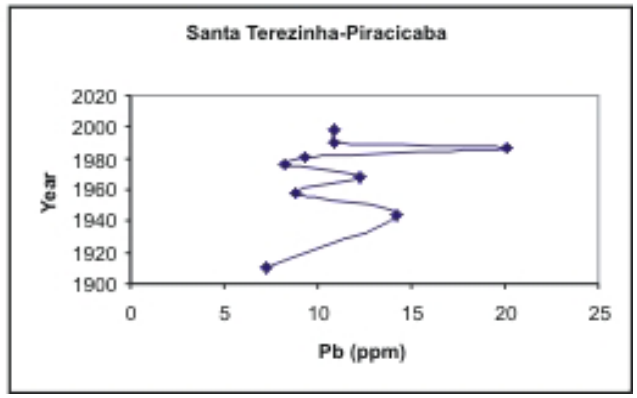

Ferraz - Ajapi
Year
2000
1990
1980
1970
1960
1950
0
1
2
3
4
Fe2O3 (%)


Ferraz - Ajapi
Year
2000
1990
1980
1970
1960
1950
0
0.01
0.02
0.03
0.04
0.05
0.06
MnO (%)


Santa Terezinha-Piracicaba
Year
2020
2000
1980
1960
1940
1920
1900
0
2
4
6
8
10
12
LOI (%)


Santa Terezinha-Piracicaba
Year
2020
2000
1980
1960
1940
1920
1900
0
1
2
3
4
5
6
Organic Matter (%)


Santa Terezinha-Piracicaba
Year
2020
2000
1980
1960
1940
1920
1900
0
200
400
600
800
Cu (ppm)


Santa Terezinha-Piracicaba
Year
2020
2000
1980
1960
1940
1920
1900
0
5
10
15
20
25
Pb (ppm)