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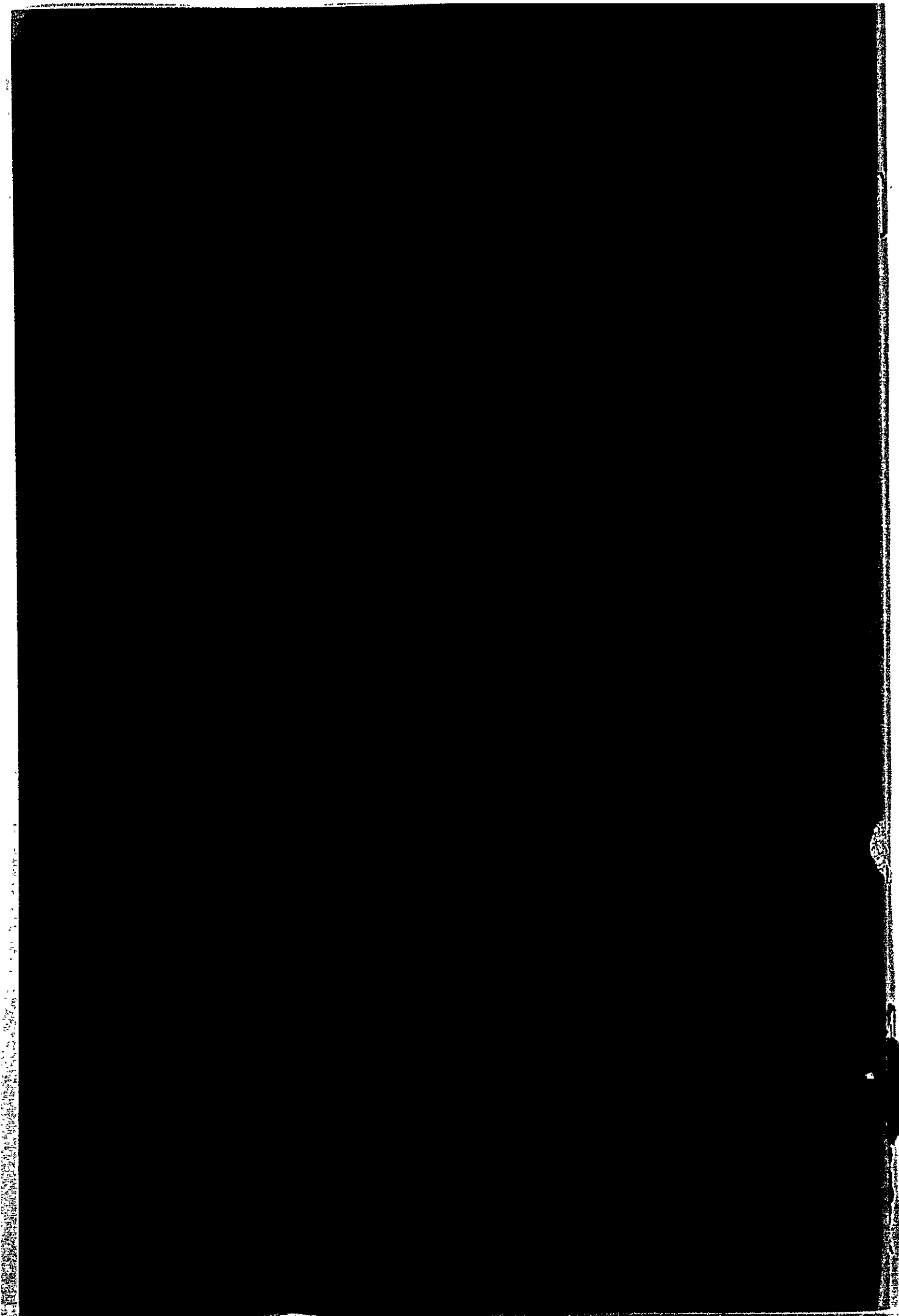
アルゼンティン共和国
ネウケン州北部地熱開発計画調査
(第1、2年次)
中間報告書(付図集)

1983年11月

国際協力事業団

鉱計資

83-115



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Fig. 8 - 1 第3次調査計画案
Proposed working plan of the third phase survey

1. 総 説

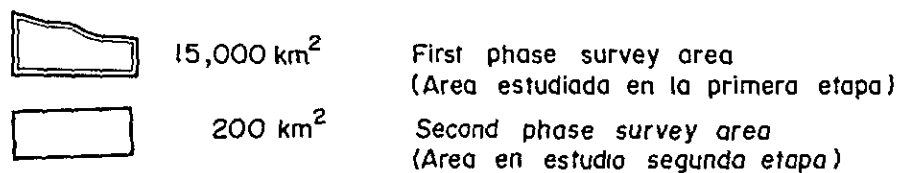
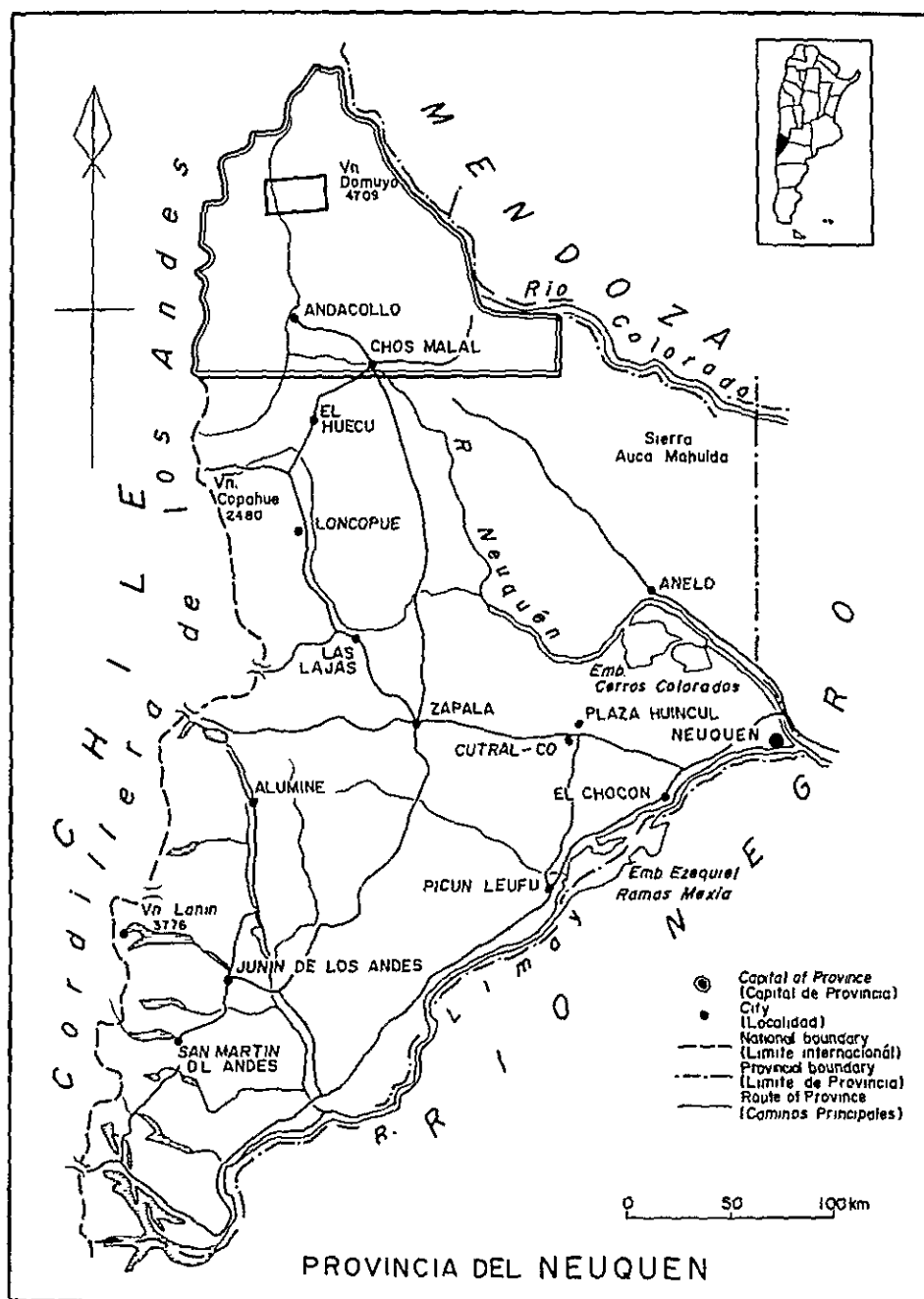


Fig.1-1 Location map of the survey areas

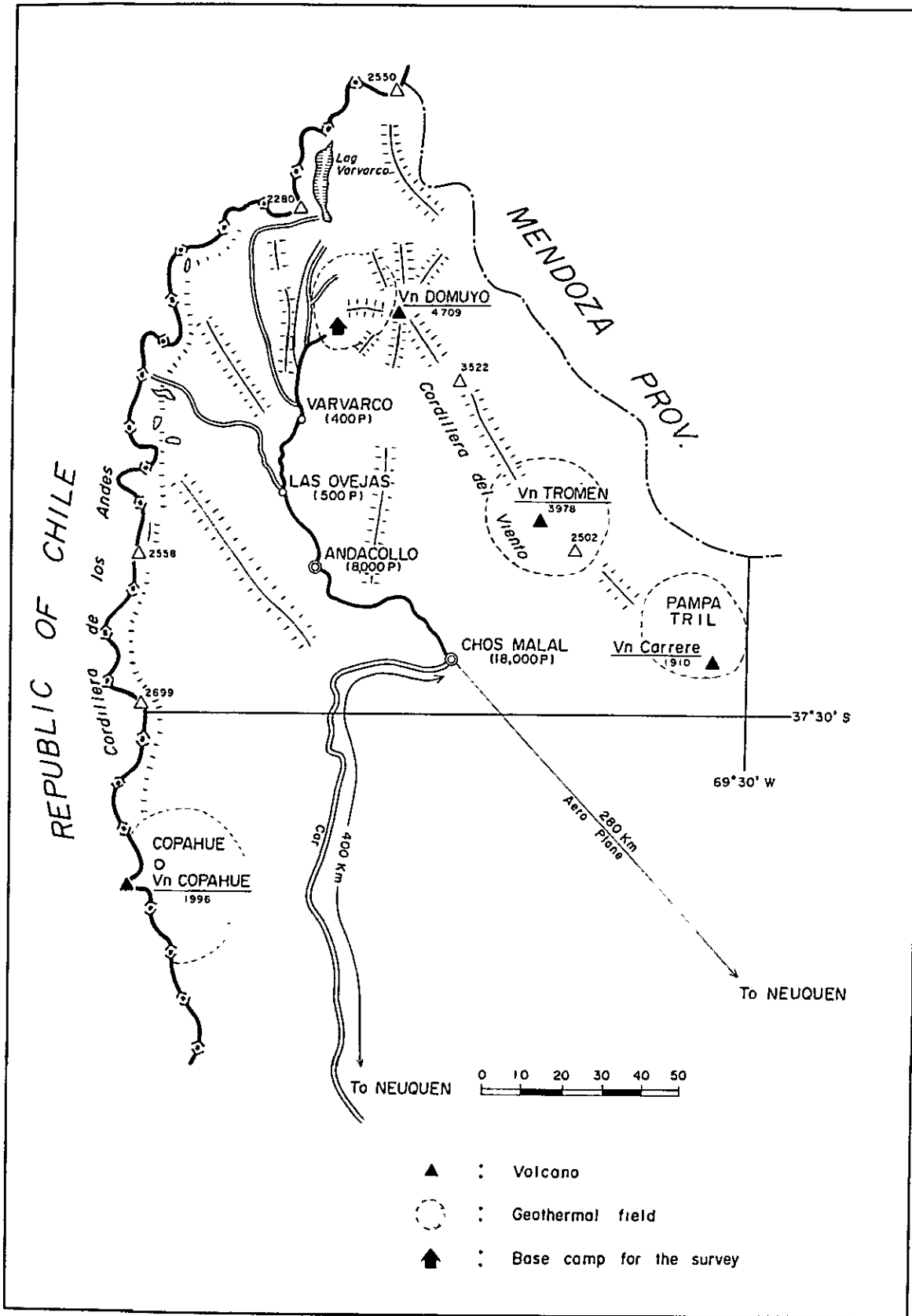
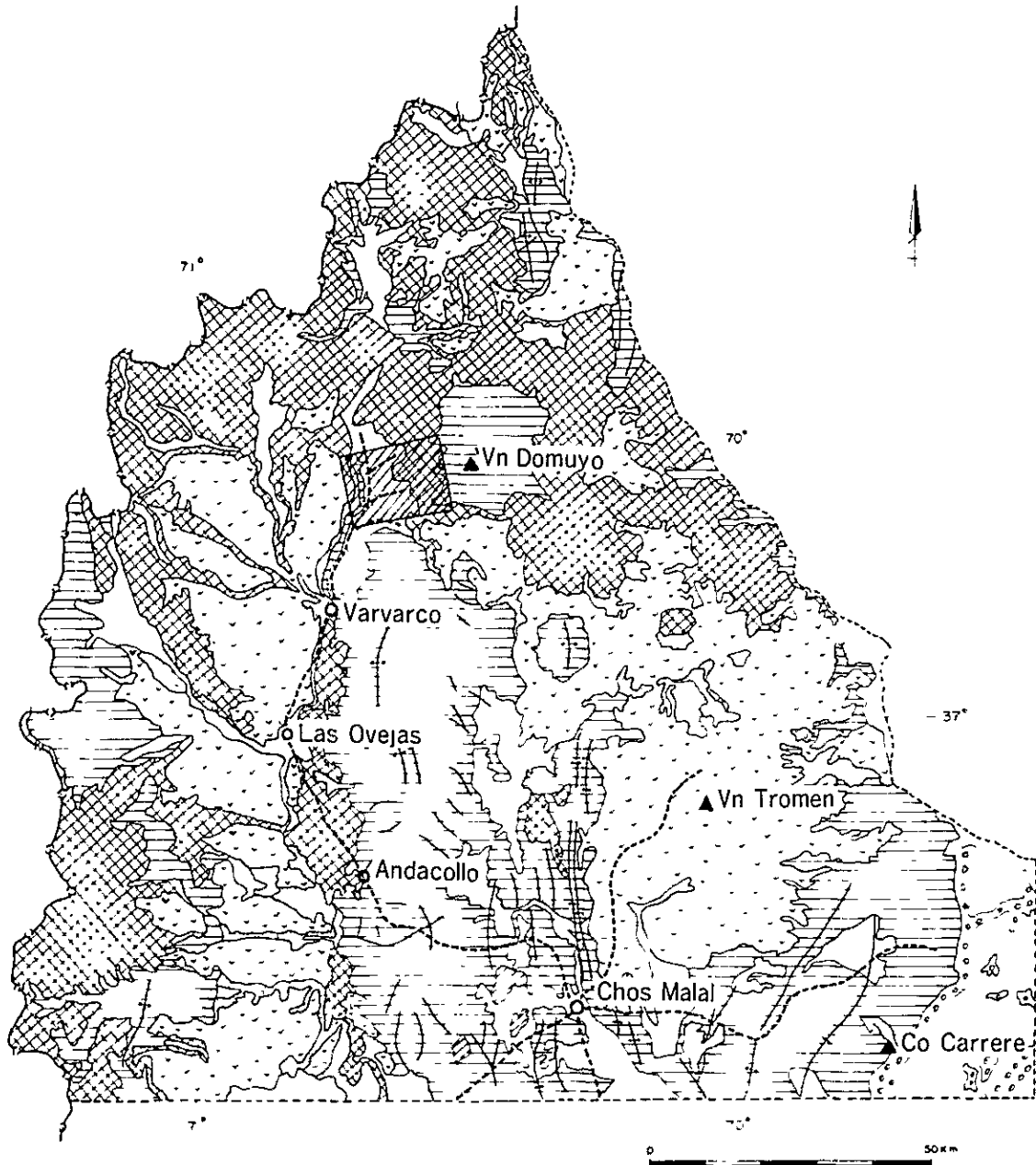


Fig.1-2 Explanatory map of northern parts of the Province of Neuquen

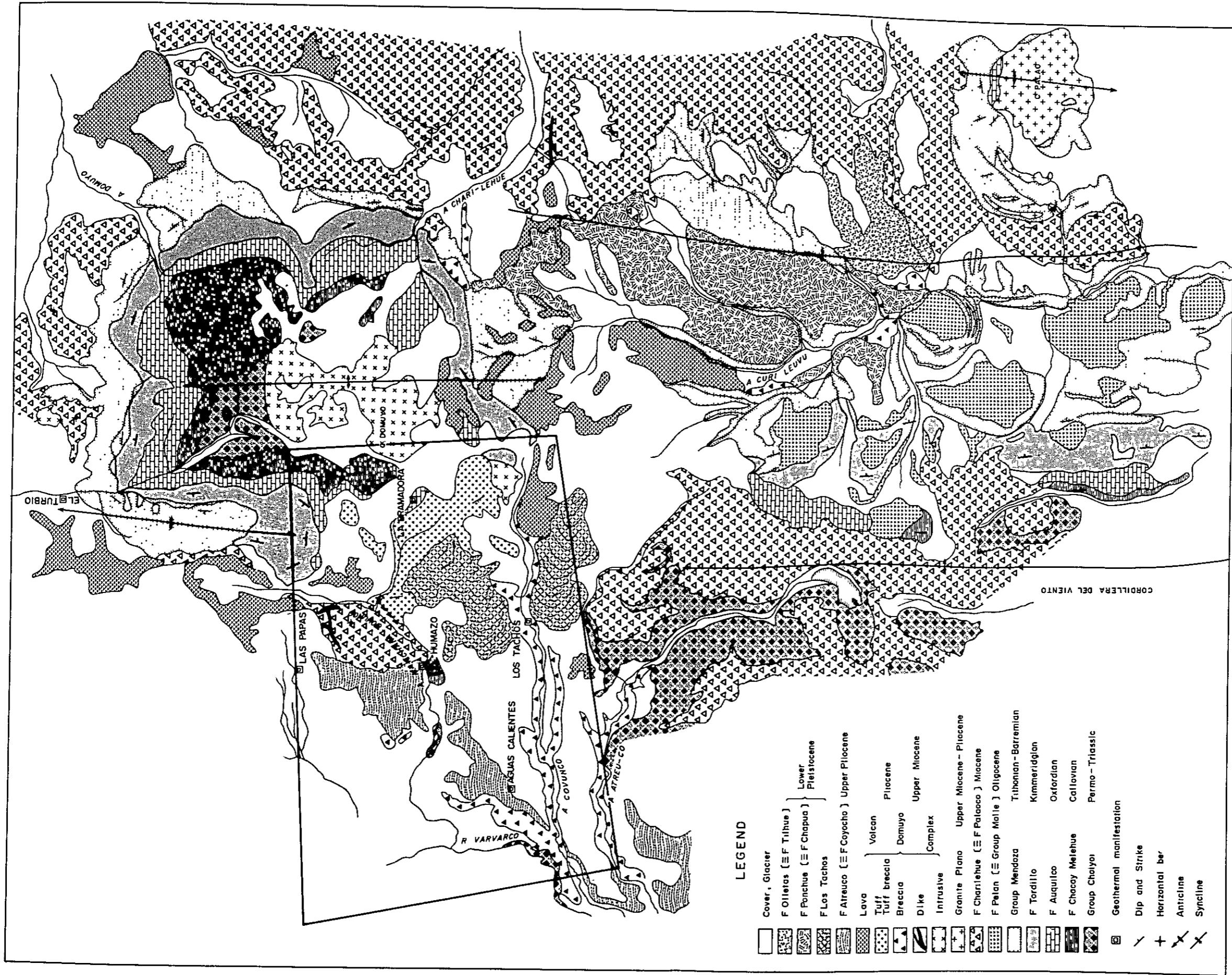
2. 第1次調査(広域調査)の概要



REGEND

Quaternary	□	Aluvium	▨	Folding axes
	▨	Andesite, Basalt	—	Road
	▨	Andesite, Basalt, Rhyolite	◊	Selected area 200 km ²
Tertiary	□	Andesite (volcanics, pyroclastics)	○	Village
	▨	Andesite, Dacite		
pre-Tertiary	▨	Basement		

Fig.2-1 Geological interpretation map of Landsat image



LEGEND

- Cover, Glacier
- ▨ F Olletas (≡ F Tilhue) } Lower Pleistocene
- ▩ F Panchue (≡ F Chapua) } Lower Pleistocene
- ▧ F Los Tachos
- ▦ F Atreuco (≡ F Coyochto) Upper Pliocene
- ▥ Lava
- ▤ Tuff breccia } Volcan
- ▣ Breccia } Pliocene
- ▢ Diike } Upper Miocene
- Intrusive } Complex
- Granite Plano Upper Miocene - Pliocene
- ▧ F Charihue (≡ F Palaco) Miocene
- ▦ F Pelan (≡ Group Malle) Oligocene
- ▥ Group Mendoza Tithonian - Barremian
- ▤ F Tordillo Kimmeridgian
- ▣ F Auquileo Oxfordian
- ▢ F Chacoy Melehue Cretaceous
- Group Chalyoi Permo - Triassic
- ⊕ Geothermal manifestation
- ↘ Dip and Strike
- Horizontal bar
- + Anticline
- ⋈ Syncline



Fig.2-2 Regional geological map

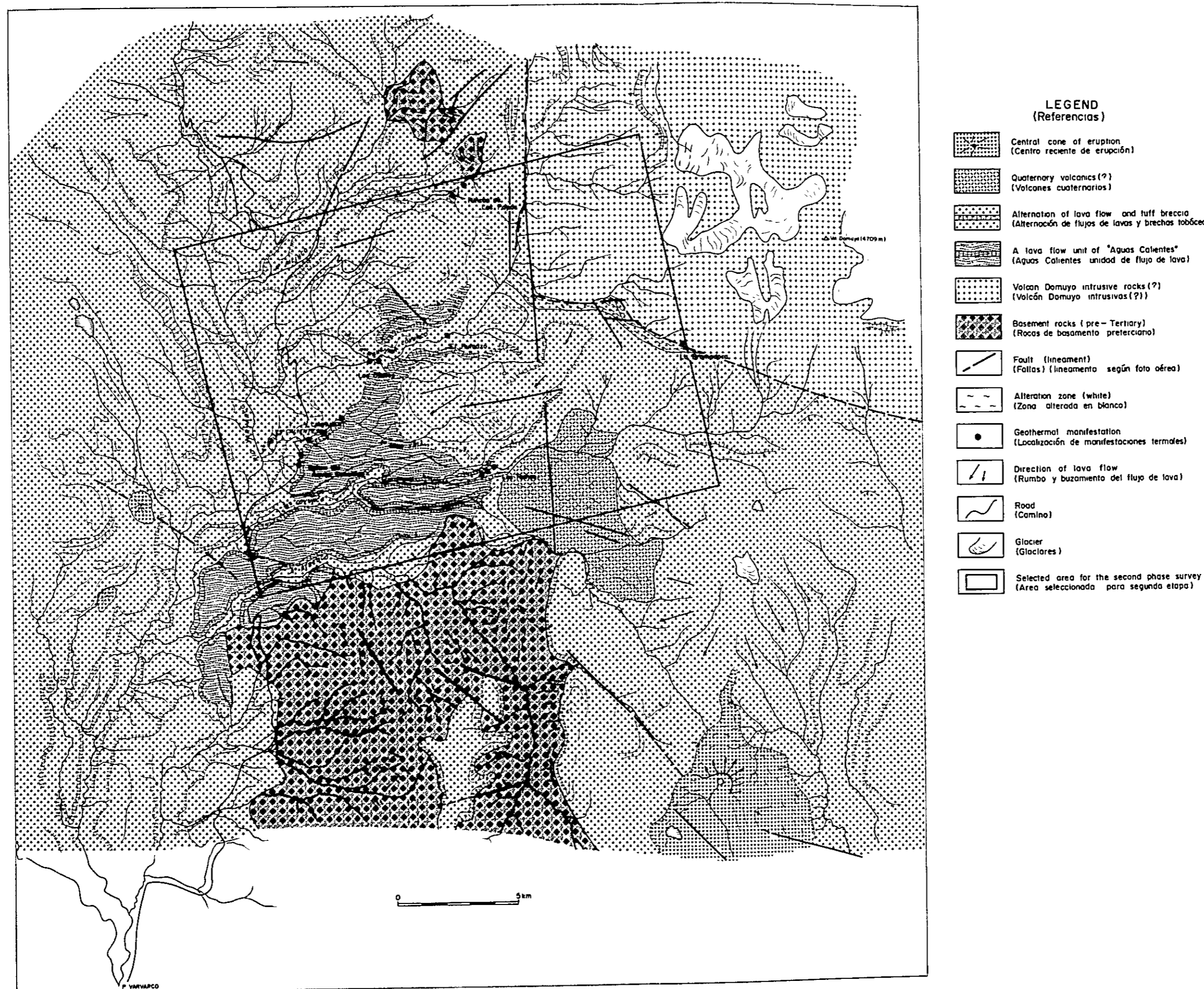
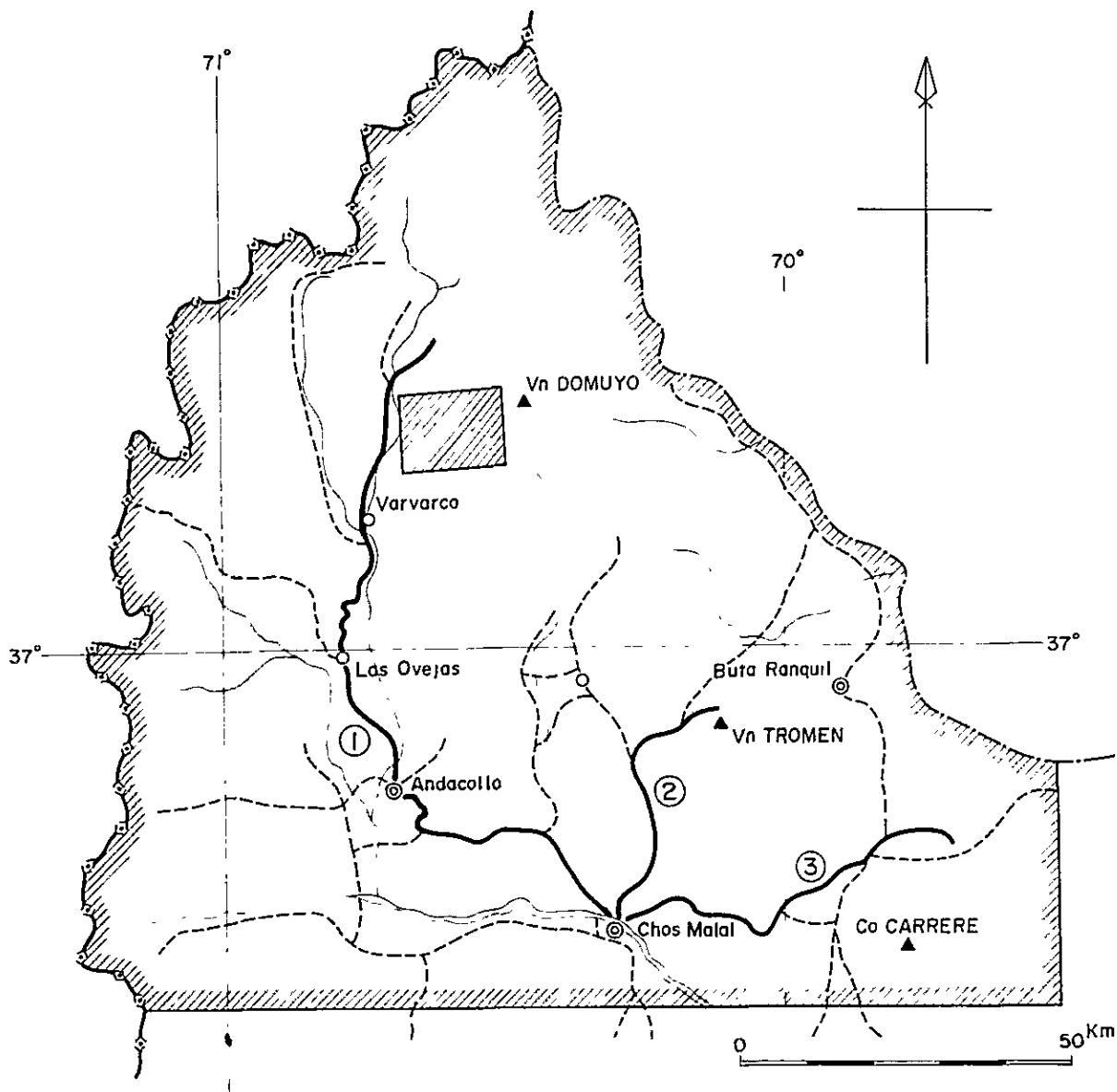


Fig.2-3 Geological interpretation map of aerial photographs



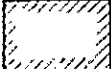



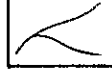
- 
 First phase survey area : 15,000Km²
 (Limite del area de 15,000Km²)
- 
 Second phase survey area : 200Km²
 (Area seleccionada de 200Km²)
- 
 Routes of reconnaissance geological survey
 (Rutas de reconocimiento efectuadas)
- 
 Roads
 (Rutas y accesos a la zona)
- 
 Rivers
 (Detalle de drenaje)

Fig.2-4 Map of the survey areas and routes of reconnaissance geological survey

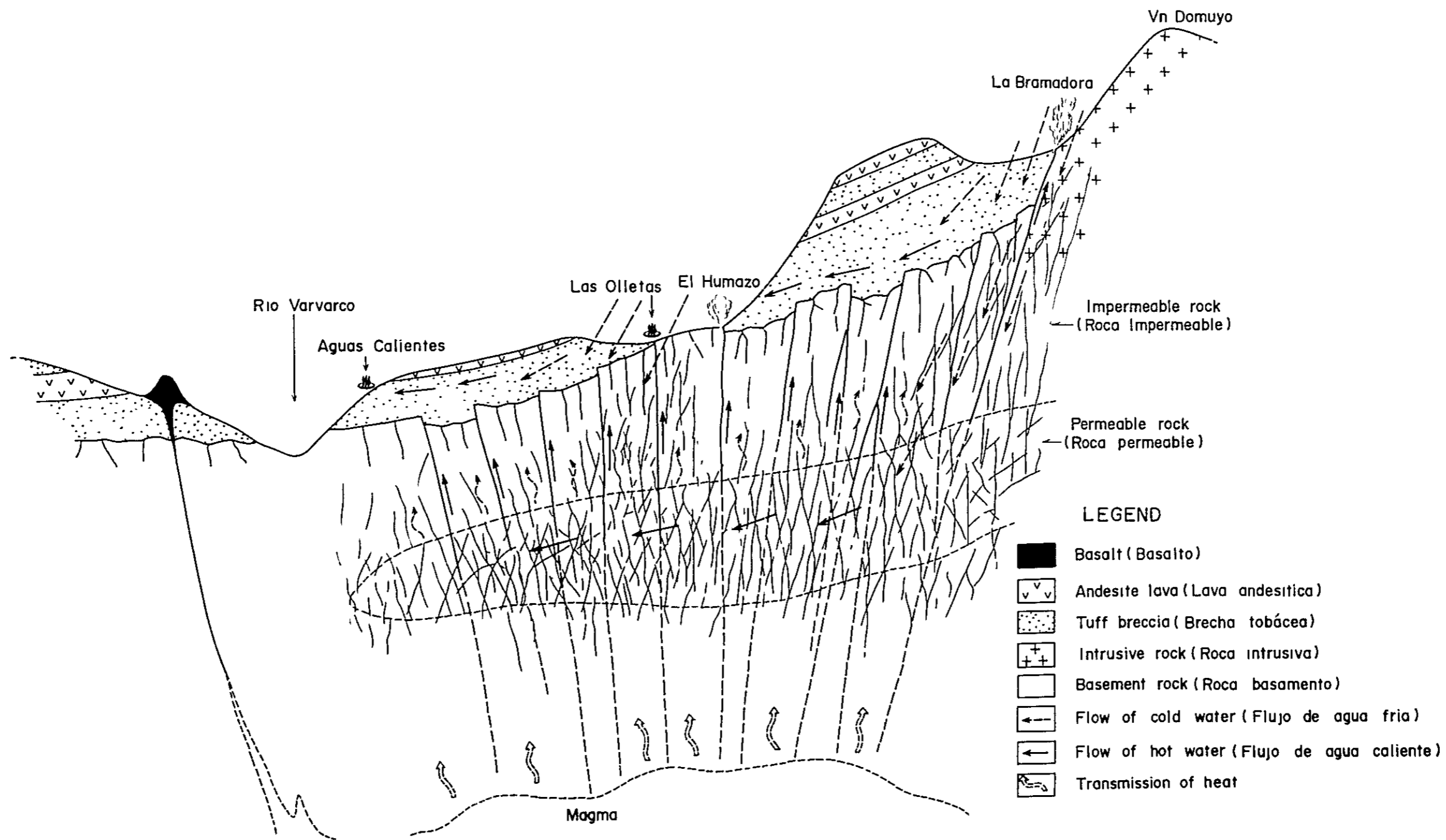


Fig.2-5 Schematic profile of geology and geothermal system

3. 調査地域の地質

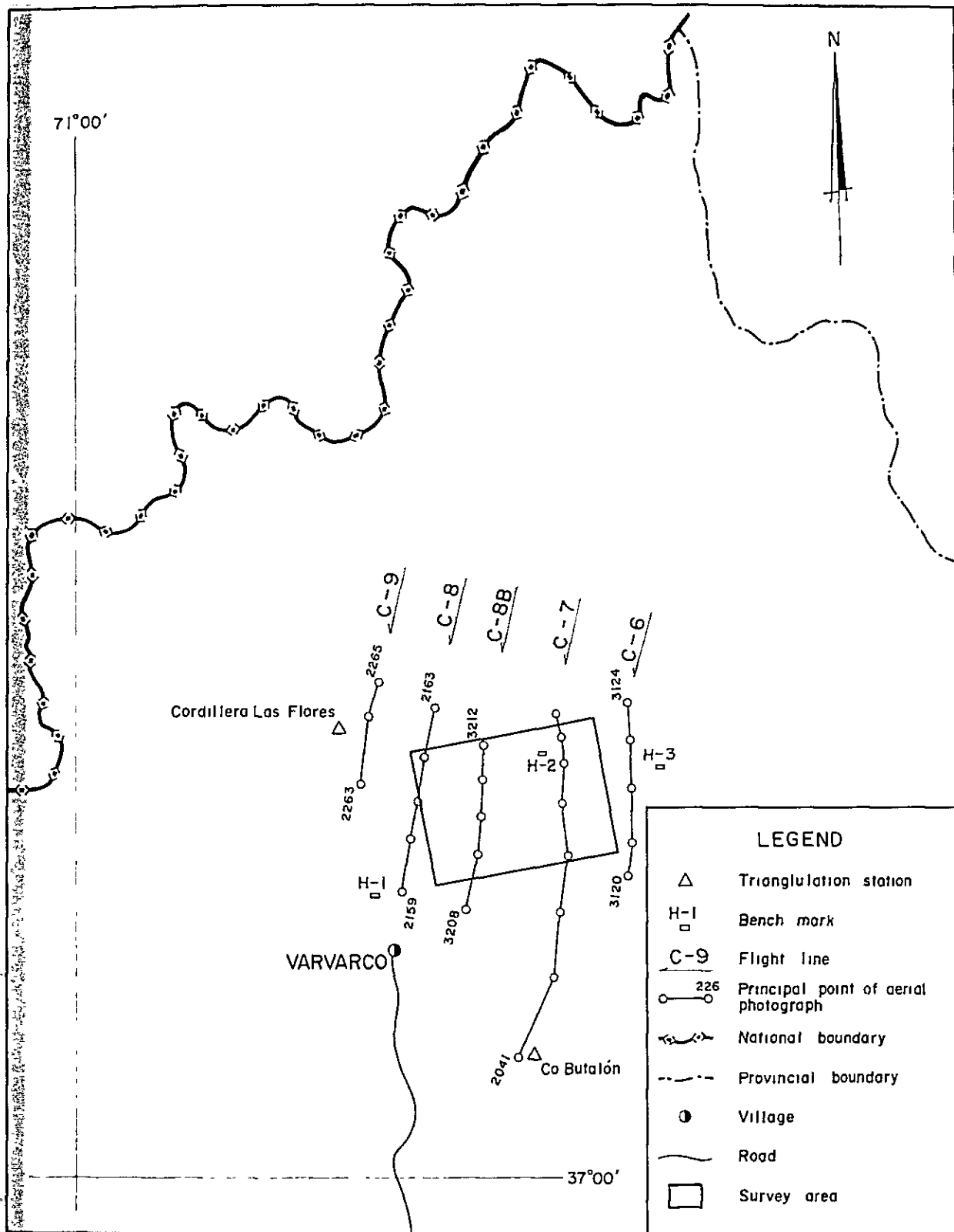


Fig.3-1 Principal points of aerial photographs and topographic standard points

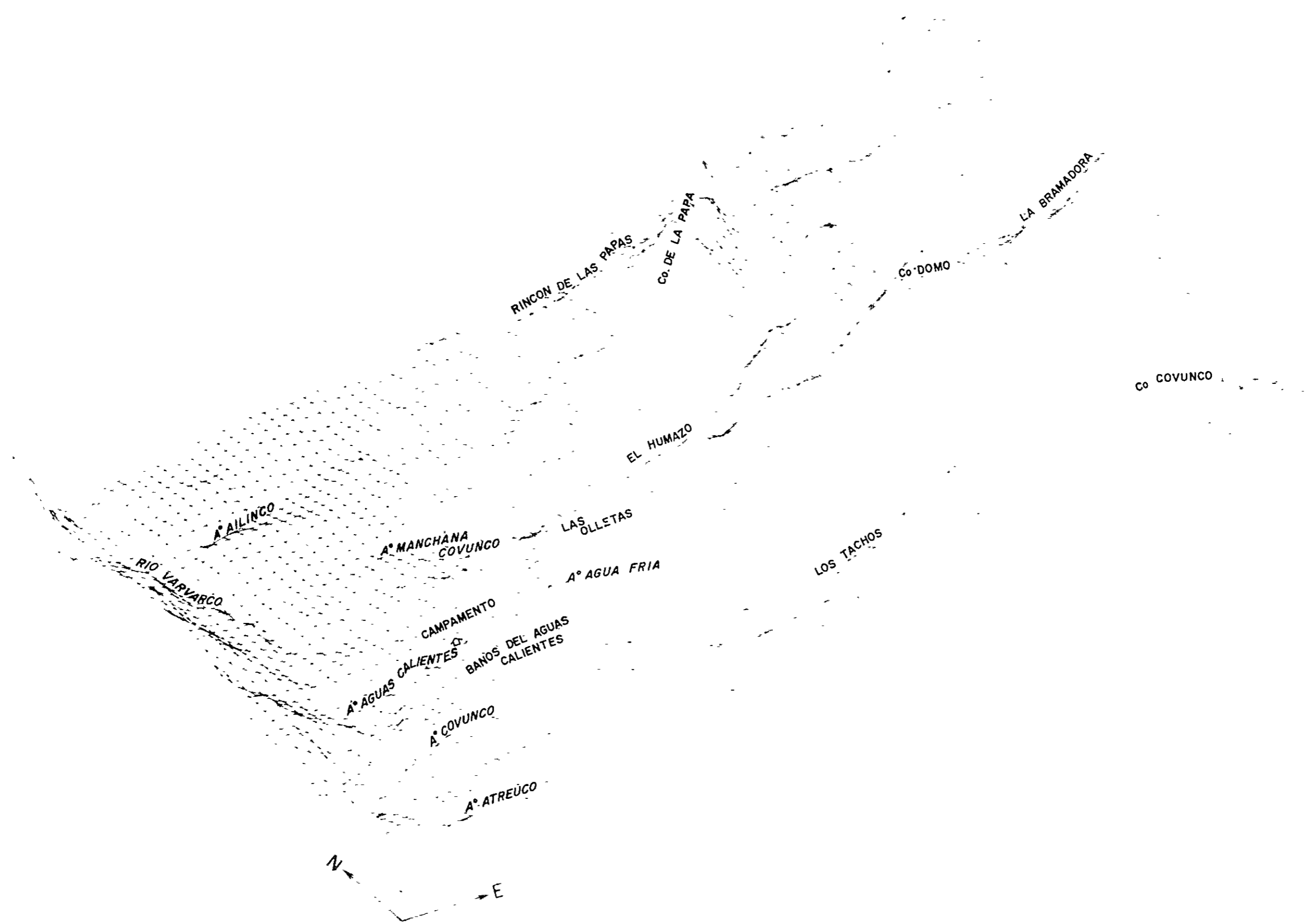


Fig.3-2 Bird's-eye view map of the survey area

Age	Formation	Geological Column	Thickness	Lithology	Remarks
Quaternary	Holocene			Sand, Gravel (Terrace) Glacial deposits	
	Pleistocene	Volcanics of Co Domo 	200 m 1200 m+	Rhyolite lava, Partially pumiceous Decite lava (including Peritic layers) Dacitic tuff breccia	FT Age: 011 ± 002 029 ± 007 055 ± 010 Distribution Southern half of the survey area
Tertiary - Quaternary	Pliocene - Pleistocene	Acidic Pyroclastics F Sierra de Flores F Atreuco 	200 m 1000 m	Pumiceous tuff Andesitic volcanic breccia Andesite (dike) Welded tuff Andesitic tuff breccia (Scoria tuff) Andesite lava	FT Age: 011 ± 003 Distribution Northern half of the survey area
	Pliocene - Miocene	andesite 	100 m 500 m	Andesite lava Granodiorite - porphy (intrusive) Andesitic tuff breccia	Locality Co Domo and Los Tachos
Jurassic	Malm	F Tardito 	100 m 450 m	Dacitic tuff, Sandy tuff (thin beds) Limestone, Calcareous siltstone Red ~ green sandstone, shale	Locality La Bramadora
		F Auquico 	100 m 500 m	White mudstone, green sandstone Limestone Gypsum beds	Locality La Bramadora
	Dogger	F Chacoy Melehue 	550 m 1000m+	Black mudstone Andesitic tuff breccia Black mudstone Andesite lava Andesitic lapilli tuff Red sandstone (thickness 1-2 cm) Basalt lava Basaltic lapilli tuff ~ andesitic tuff	Locality El Humazo La Bramadora Rincón de Las Papas
	Basement			Pelitic hornfels, Psammitic hornfels Basic hornfels (Partially sandy) Pelitic schist, Psammitic schist Granite, apite Granodiorite (including xenoliths of silticified rock) Basalt (dyke)	K-Ar Age: 227 ± 16 259 ± 13 Locality El Humazo Rincón de Las Papas Locality Rio Varvarco A° Atreuco, A° Covunco A° Manchana Covunco

Fig.3-3 Geological columnar section of the survey area

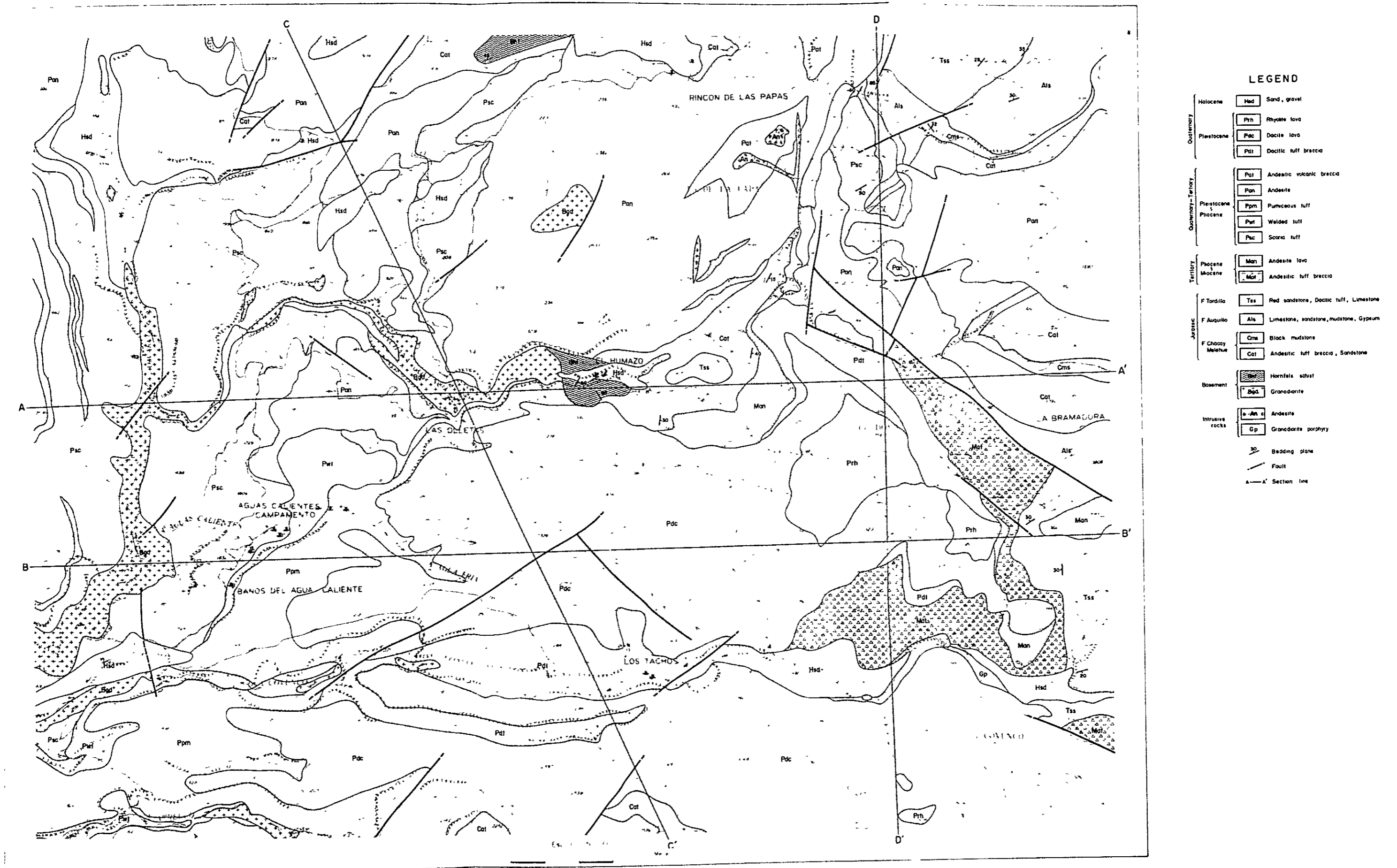


Fig.3-4 Geological map of the survey area

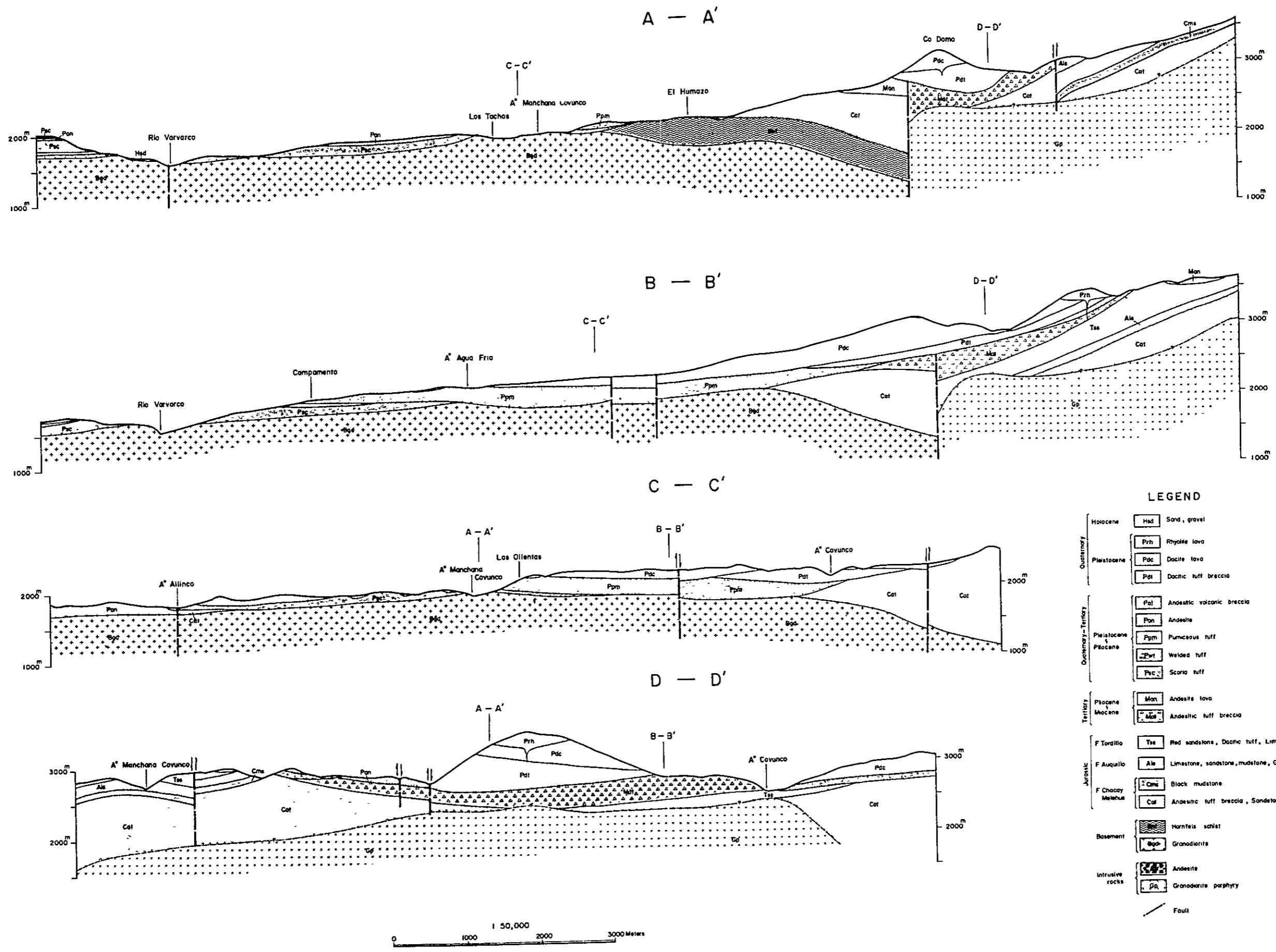
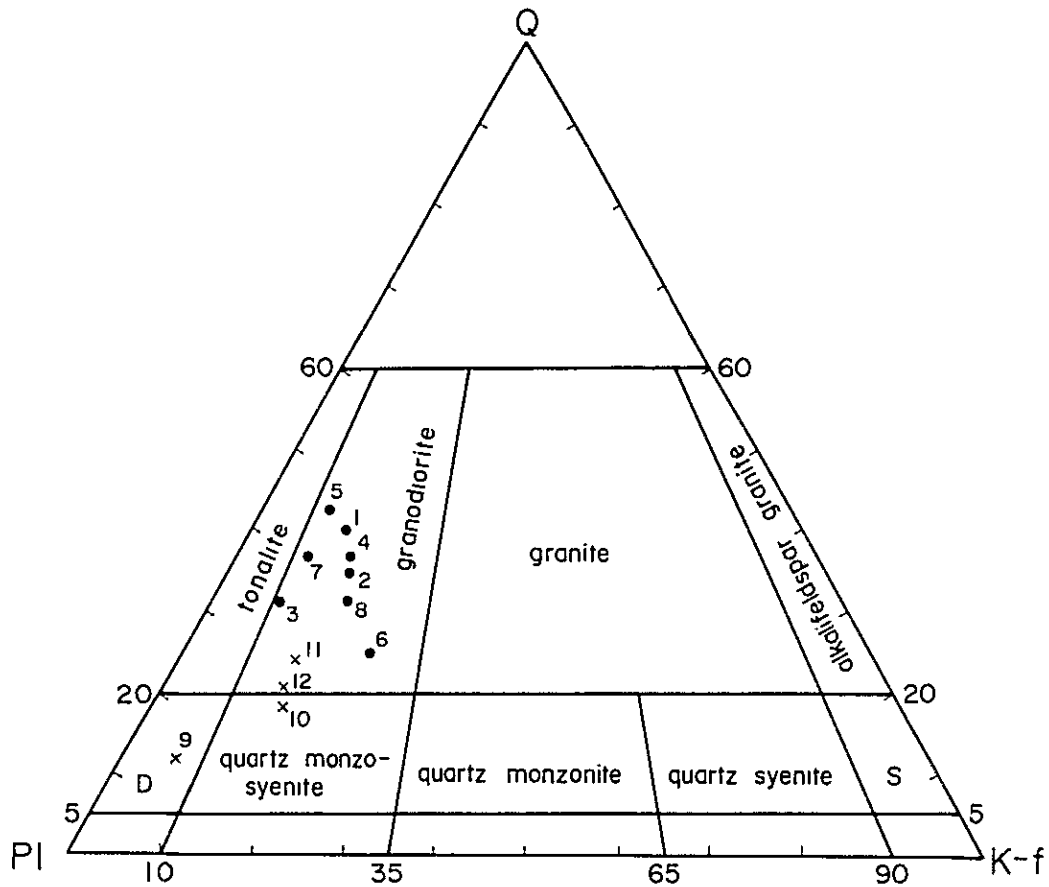


Fig.3-5 Geological cross-sections



- | | | | |
|--------------------|---|------------|---------------|
| Varvarco intrusive | { | 1 : F-1 | 5 : TM-11 |
| | | 2 : F-26 | 6 : TM-16 |
| | | 3 : F-42-2 | 7 : TM-27 |
| | | 4 : TM-8 | 8 : 83-2-12-5 |
| Domuyo complex | { | 9 : F-14 | 10 : TM-12 |
| | | 11 : TM-48 | 12 : TM-20 |

D : quartz diorite etc

S : alkalfeldspar-quartz syenite

Fig.3-6 Modal diagram of quartz - potash feldspar plagioclase

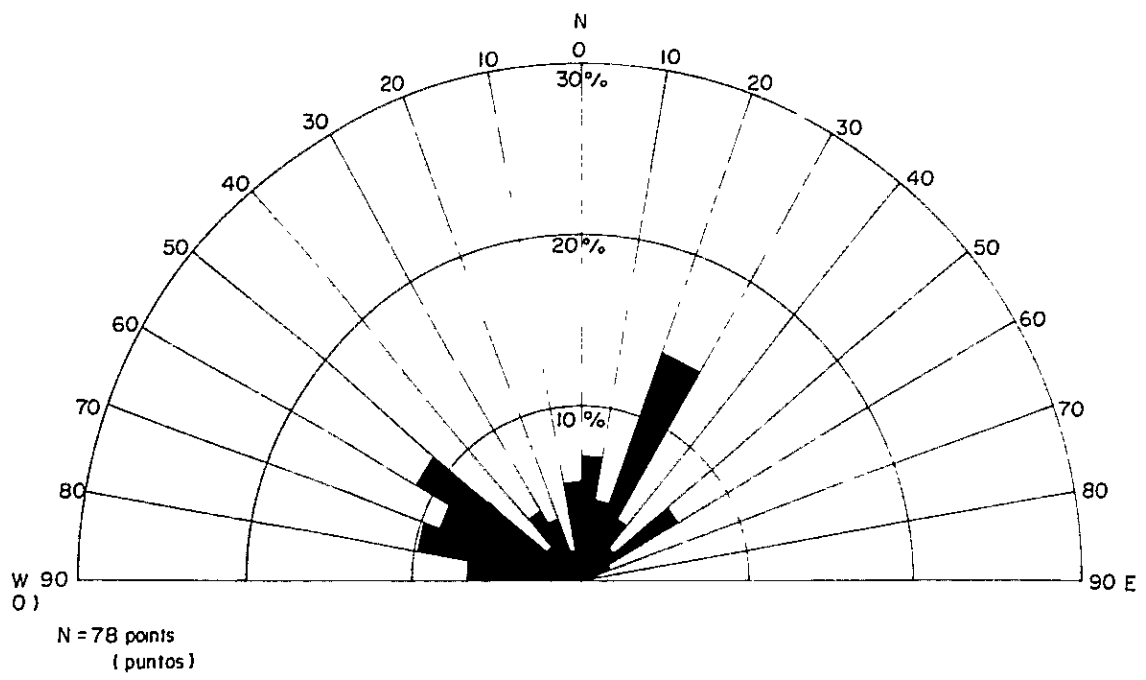
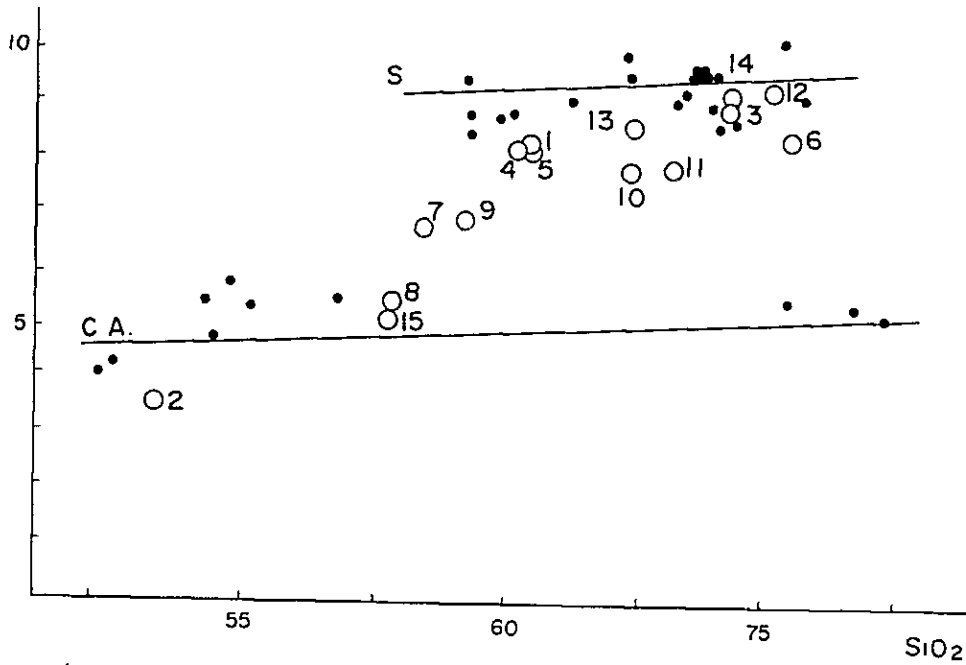


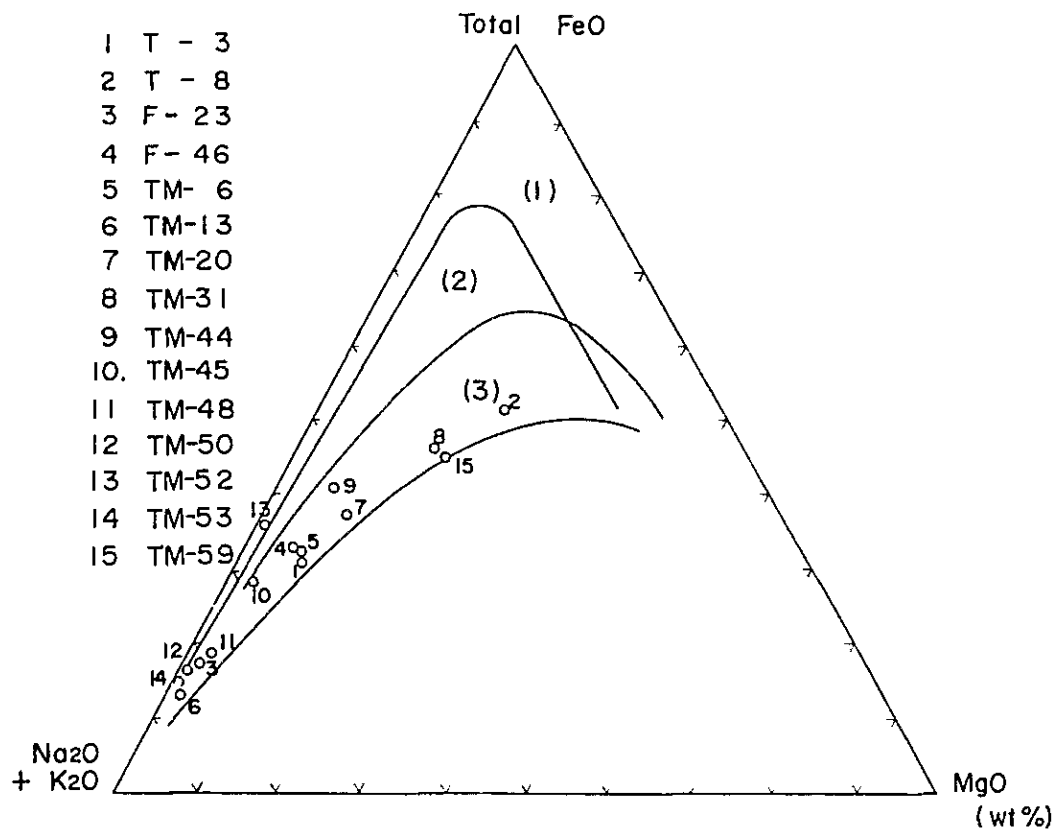
Fig.3-7 Rose diagram of joints in granodiorite



}	1	F-3	9	TM-44	S	Shoshonitic series (Serie shoshonitica)
	2	F-8	10	TM-45	C A	Calc-alkaline series (Serie calc-alkalina)
	3	F-23	11	TM-48		
	4	F-46	12	TM-50		
	5	TM-6	13	TM-52		
	6	TM-13	14	TM-53		
	7	TM-20	15	TM-69		
	8	TM-31				

• Brousse, Pesco (1982)

Fig.3-8 Alkali - silica diagram of younger volcanic rocks



- (1) Chemical variation in rocks of Skaergaard intrusion
- (2) Chemical variation in tholeiitic volcanics of Izu-Hakone area, Japan
- (3) Chemical variation in calc-alkaline volcanics of Izu-Hakone area, Japan

Fig.3-9 MgO - total FeO - (Na₂O + K₂O) diagram of younger volcanic rocks

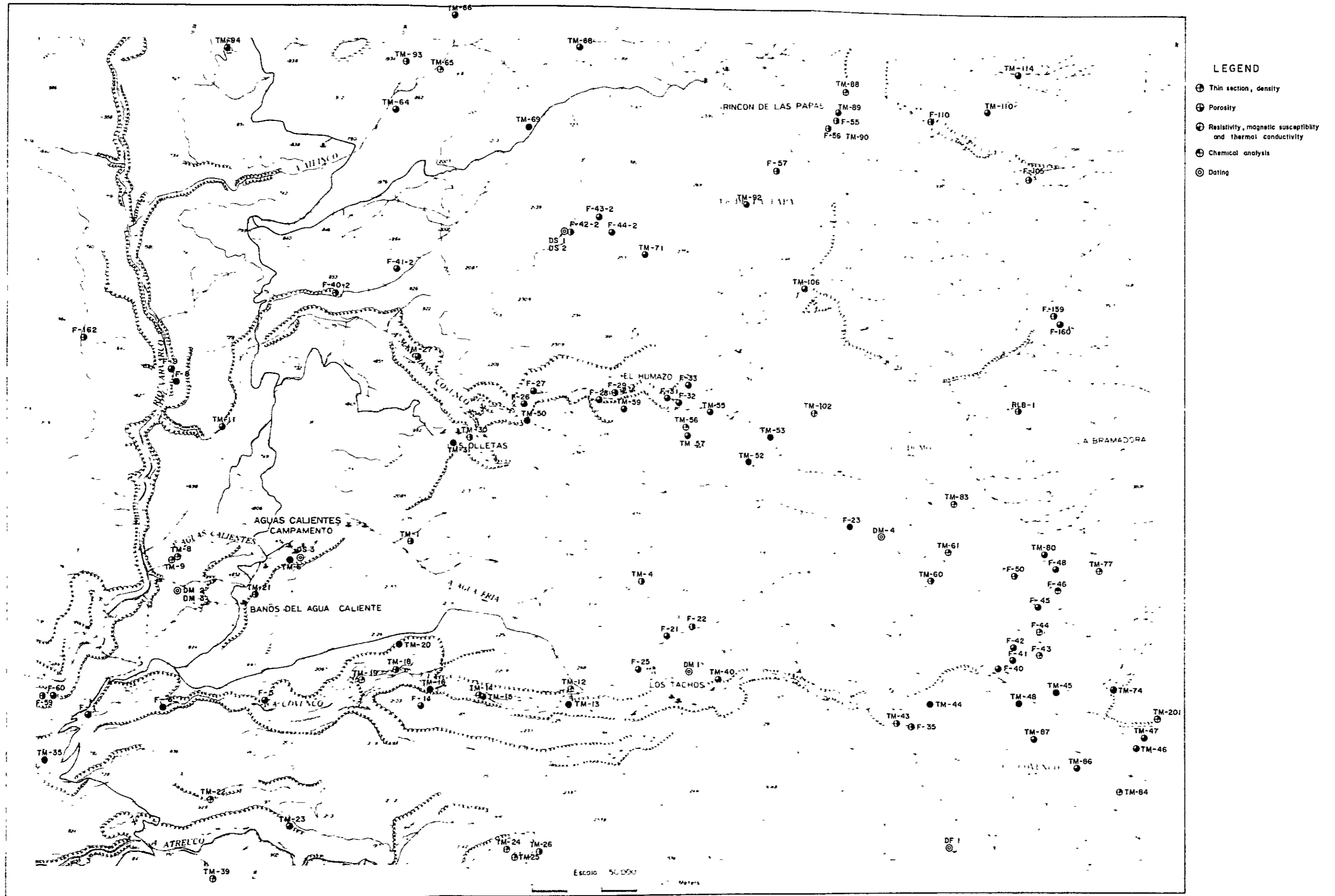
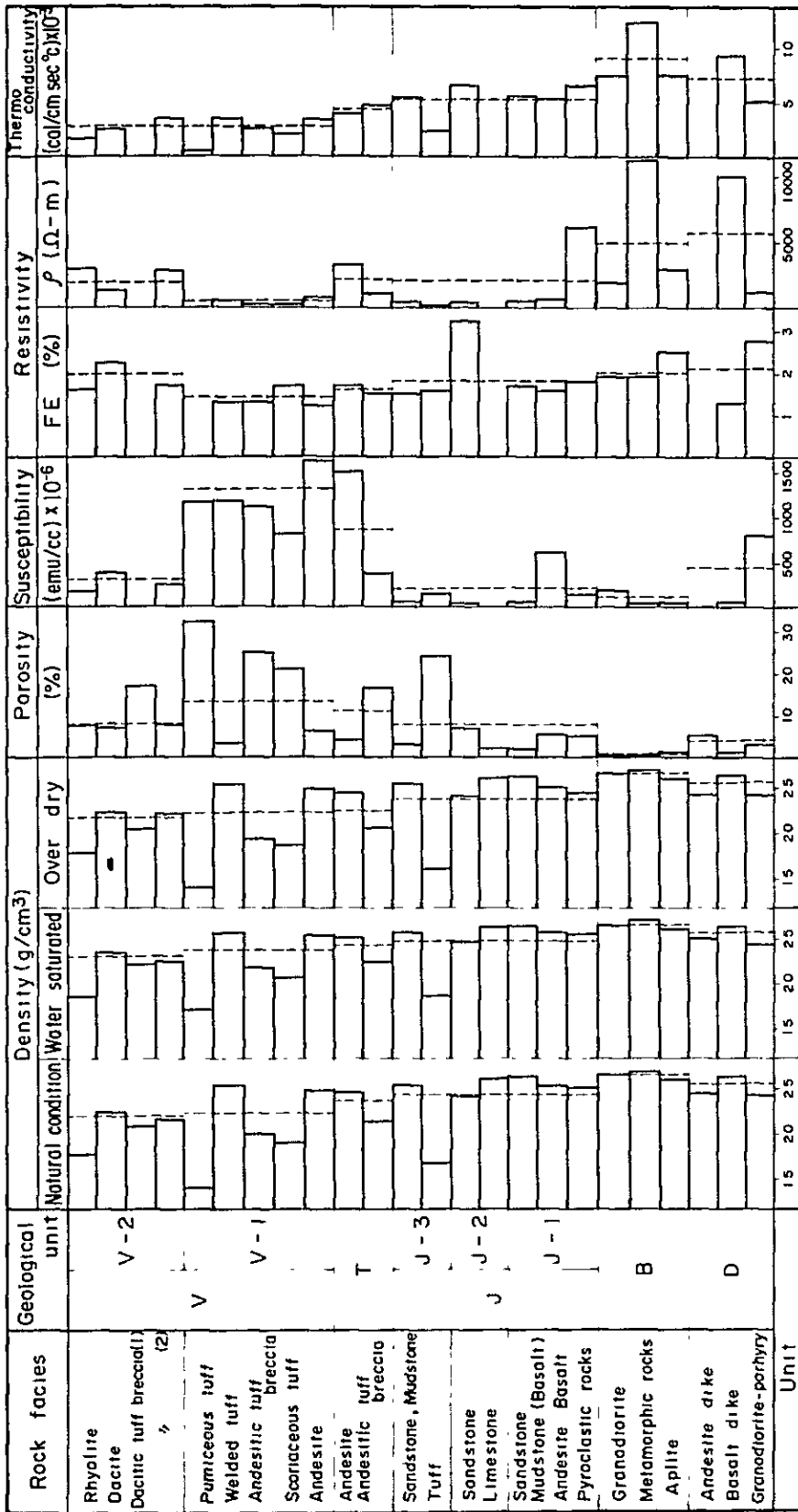


Fig.3-10 Location map of rock sampling



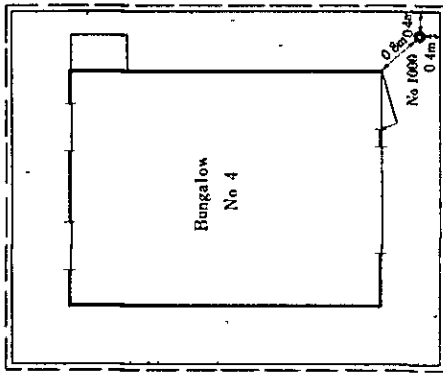
Mean value of rock facies, - - - Mean value of geological unit

V Quaternary - Tertiary
 V-2 Pleistocene, Volcanics of Co Domo
 V-1 Pleistocene - Pliocene, Tertiary, Pliocene - Miocene, Andesite
 Acidic Pyroclastics J Jurassic, Dogger - Malm,
 Sierra de Flores Formation J-3 Tordillo Formation
 Atreuco Formation J-2 Auquico Formation
 J-1 Chacay Melehue Formation

B Basement
 D Dike rock etc

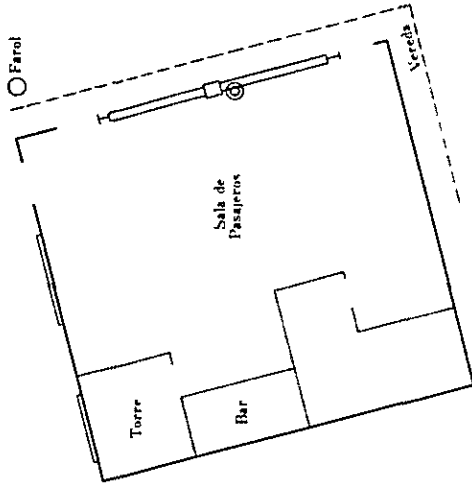
Fig.3-11 Physical properties of rocks

4. 調査地域の地質構造



CAMPAMENTO

(b) Base station
(No.1000)



NEQUEN AEROPUERTO

a Reference station
No.9310 68

- A : Eyepiece
- B : Dial
- C : Long Level
- D : Cross Level
- E : Arrestment Knob
- F : Counter
- G : Thermometer
- H : Light Switch

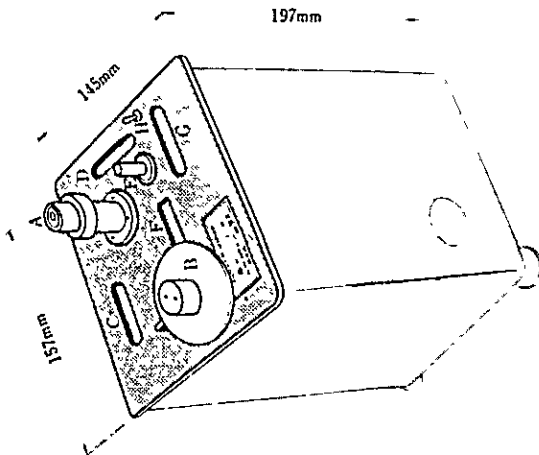


Fig.4-1 LaCoste & Romberg gravity
meter Model - G

Fig.4-2 Sketches of reference station(a)
and base station(b)

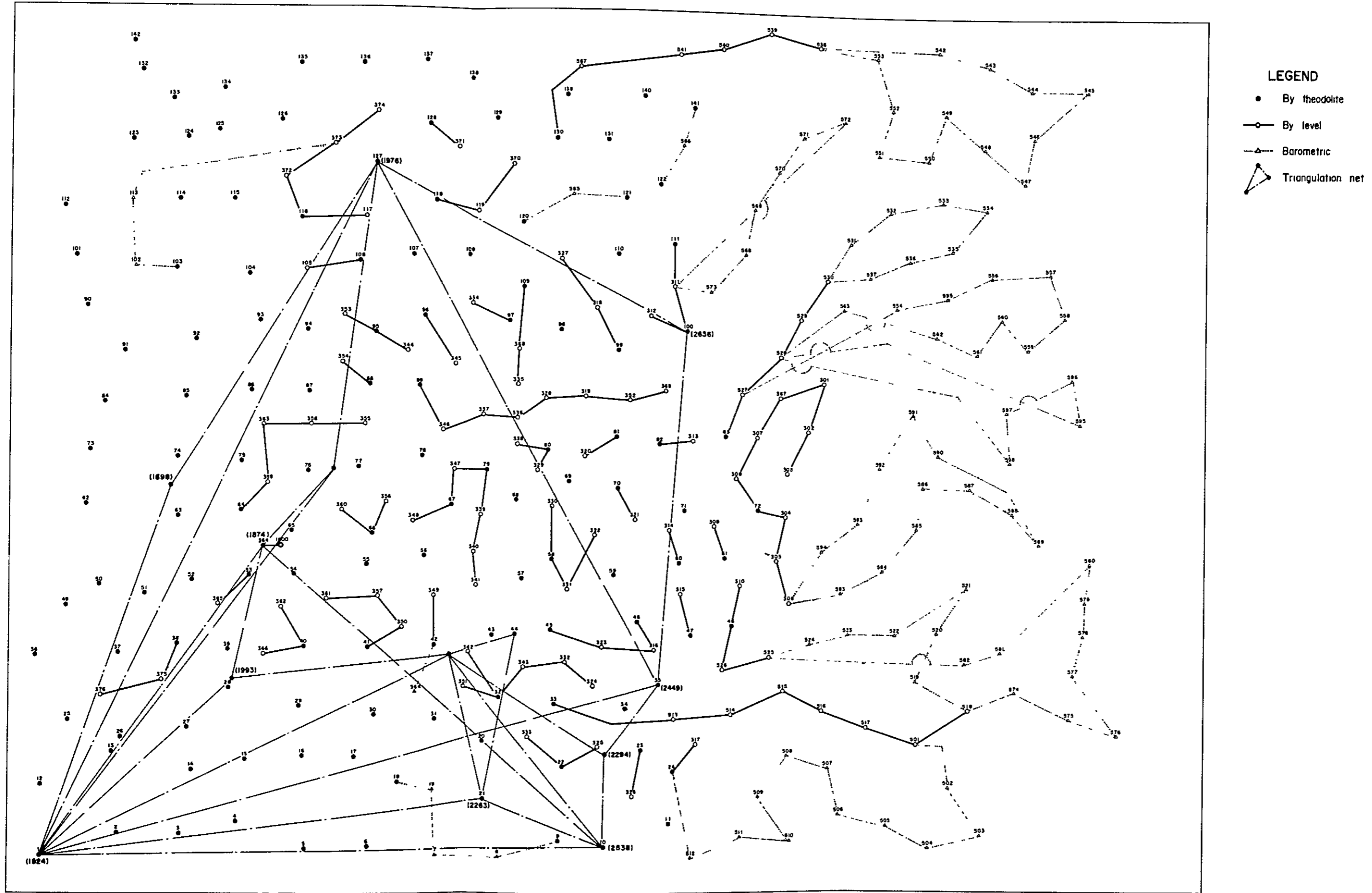


Fig.4-3 Network of leveling

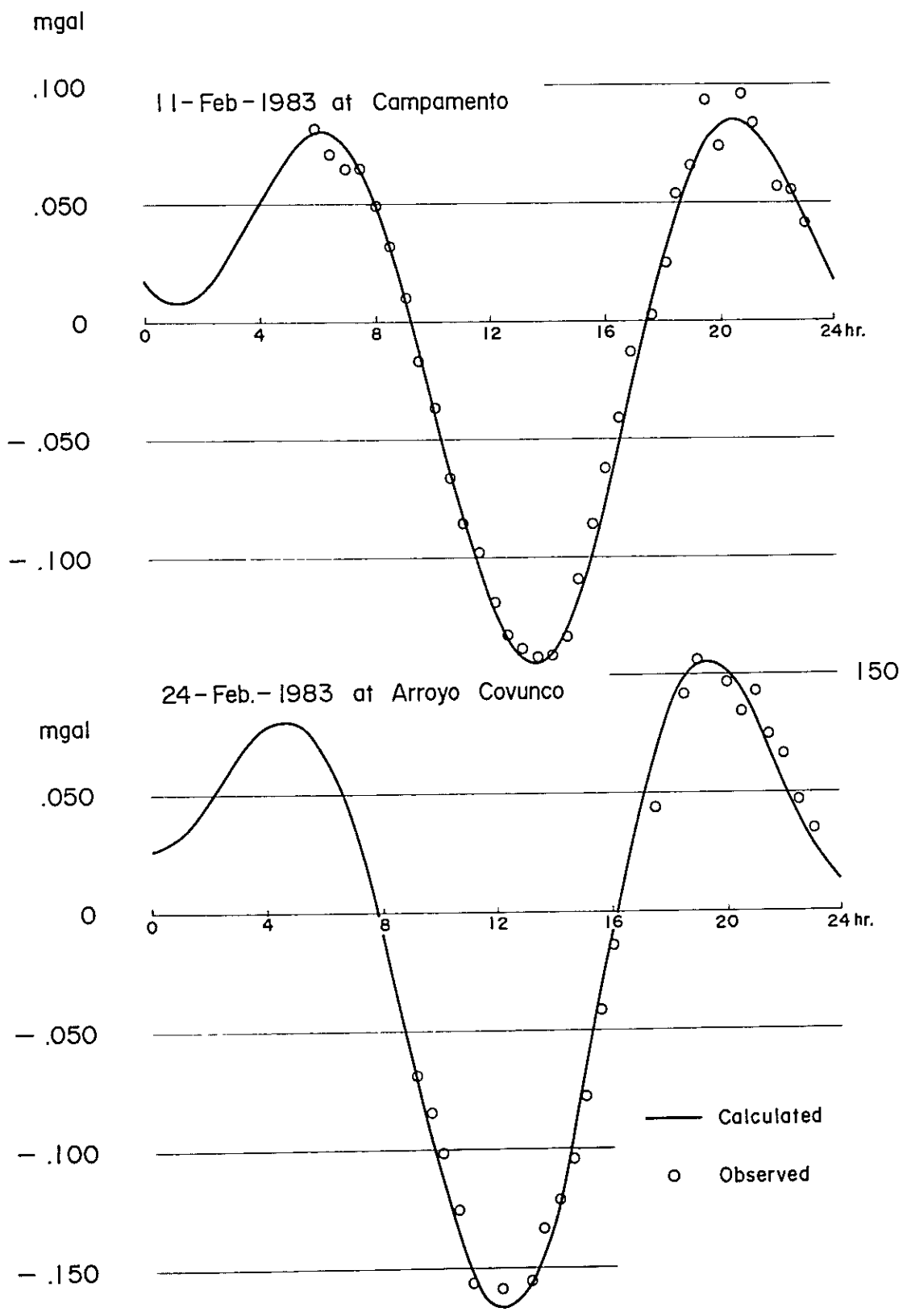
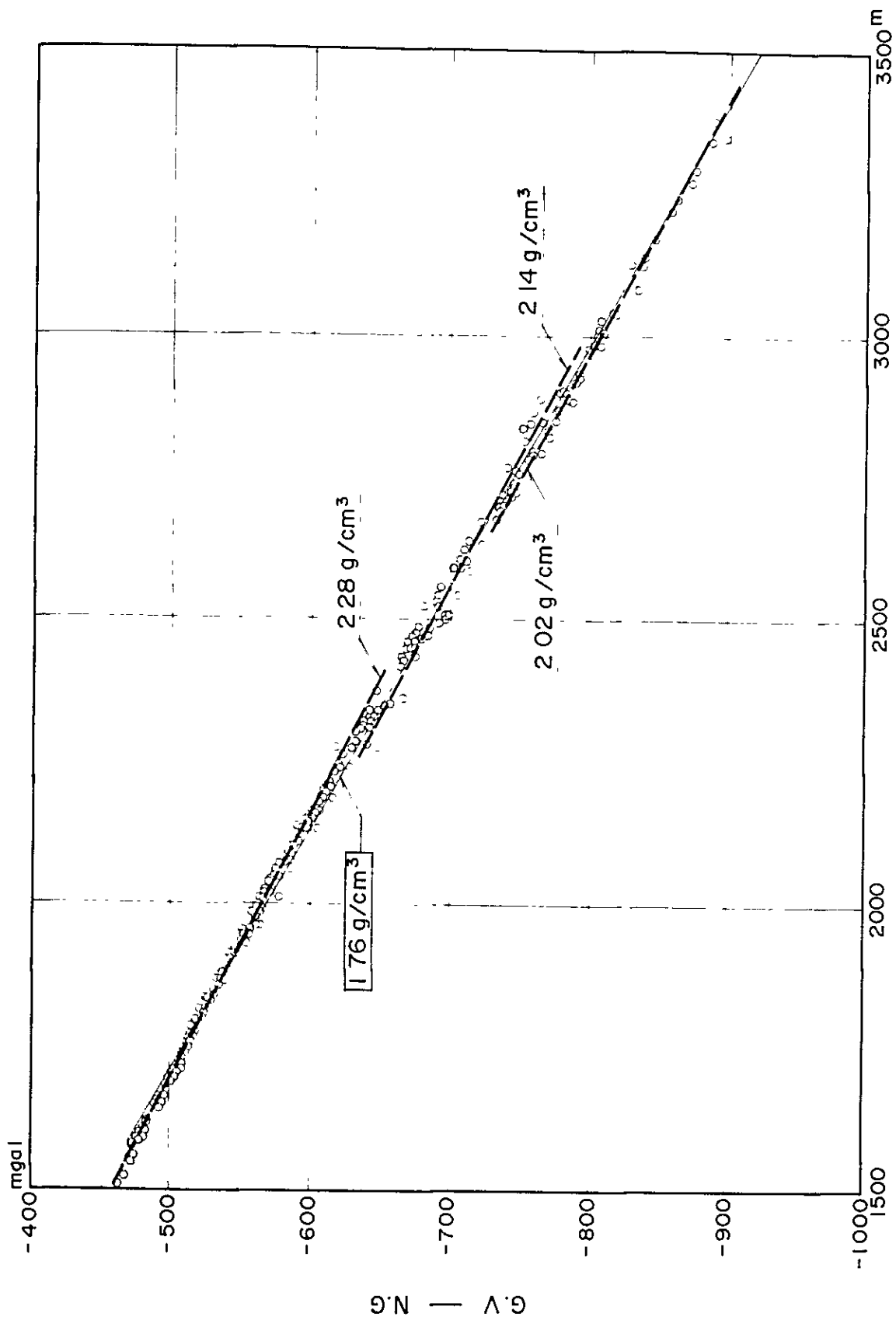


Fig.4-4 Observations of diurnal gravity variation



ELEVATION (A.S.L.)

Fig.4-5 Relation between gravity and altitude

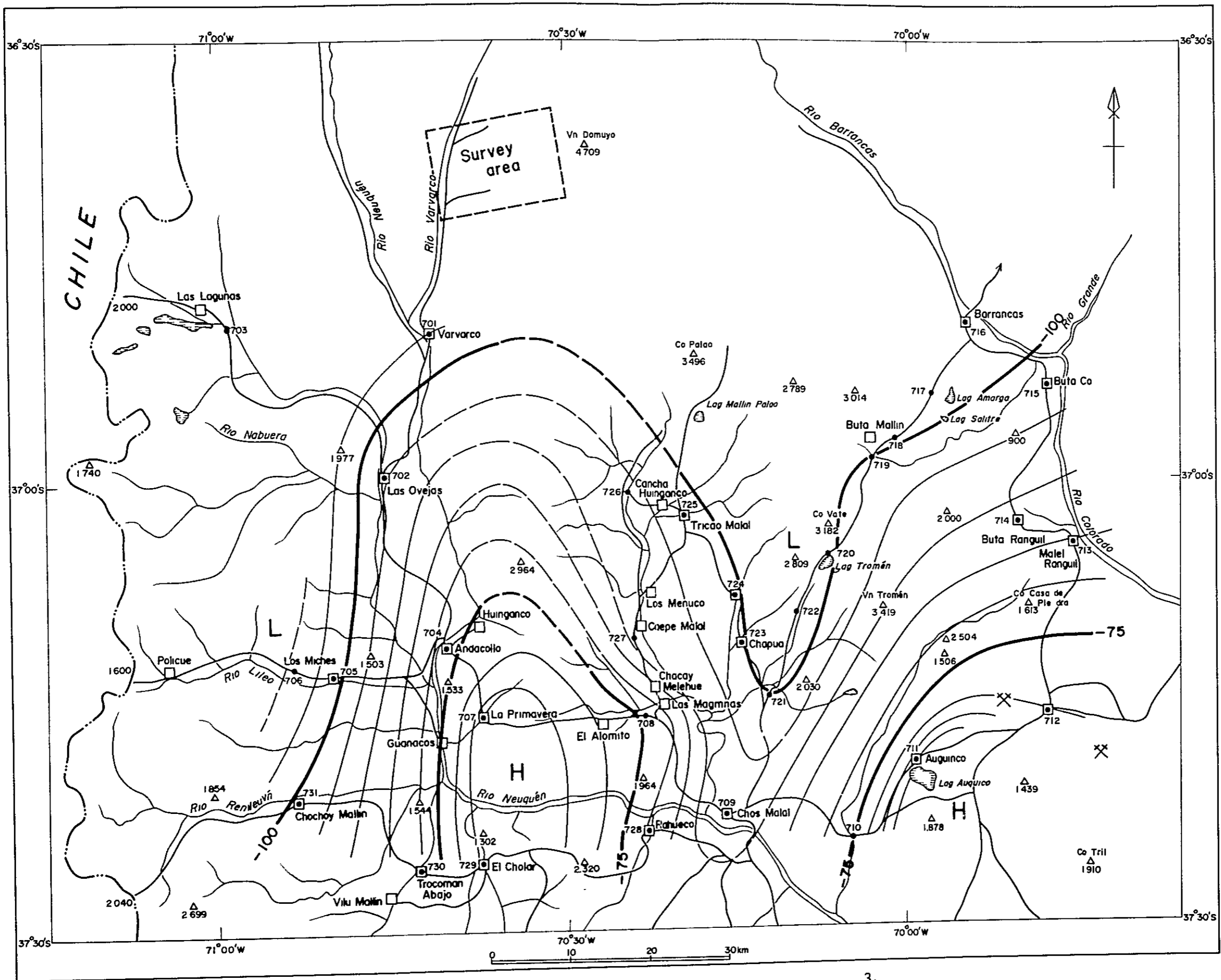


Fig.4-6 Regional Bouguer anomaly map ($\rho = 2.30 \text{ g/cm}^3$)

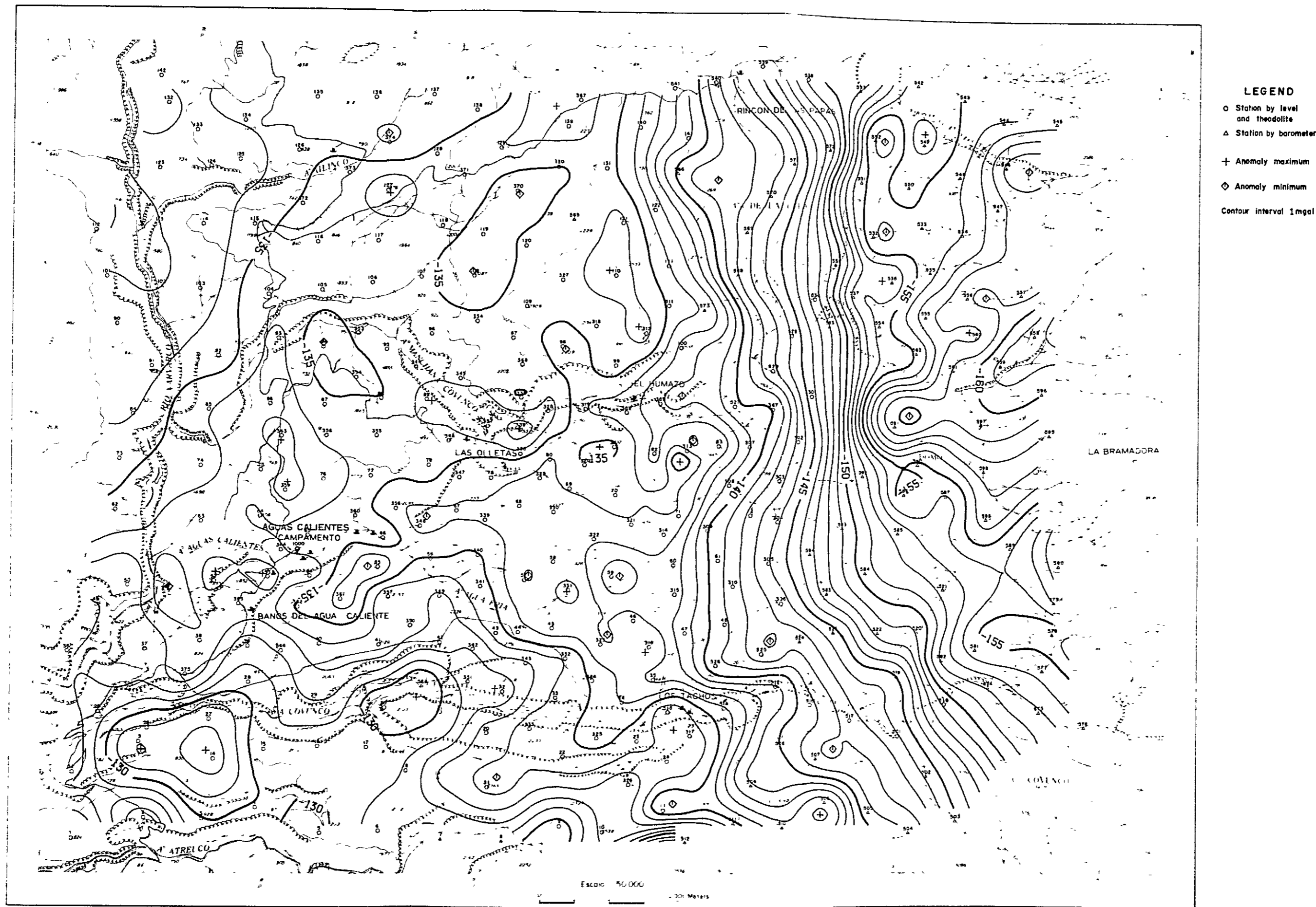
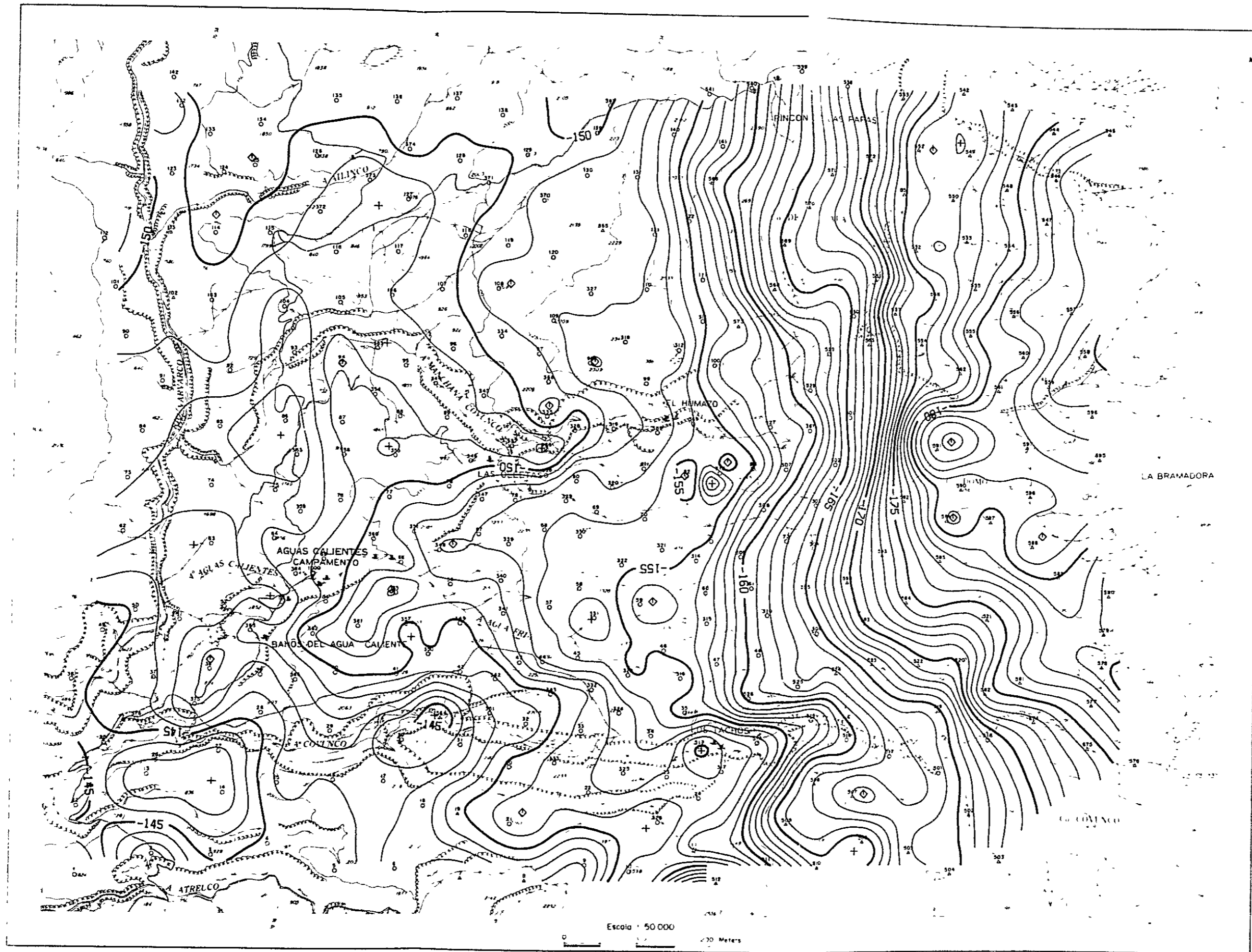


Fig.4-7 Bouguer anomaly map ($\rho = 2.30 \text{ g/cm}^3$)



LEGEND
 ○ Station by level and theodolite
 △ Station by barometer
 + Anomaly maximum
 ◇ Anomaly minimum
 Contour interval 1mgal

Fig.4-8 Bouguer anomaly map ($\rho = 2.00 \text{ g/cm}^3$)

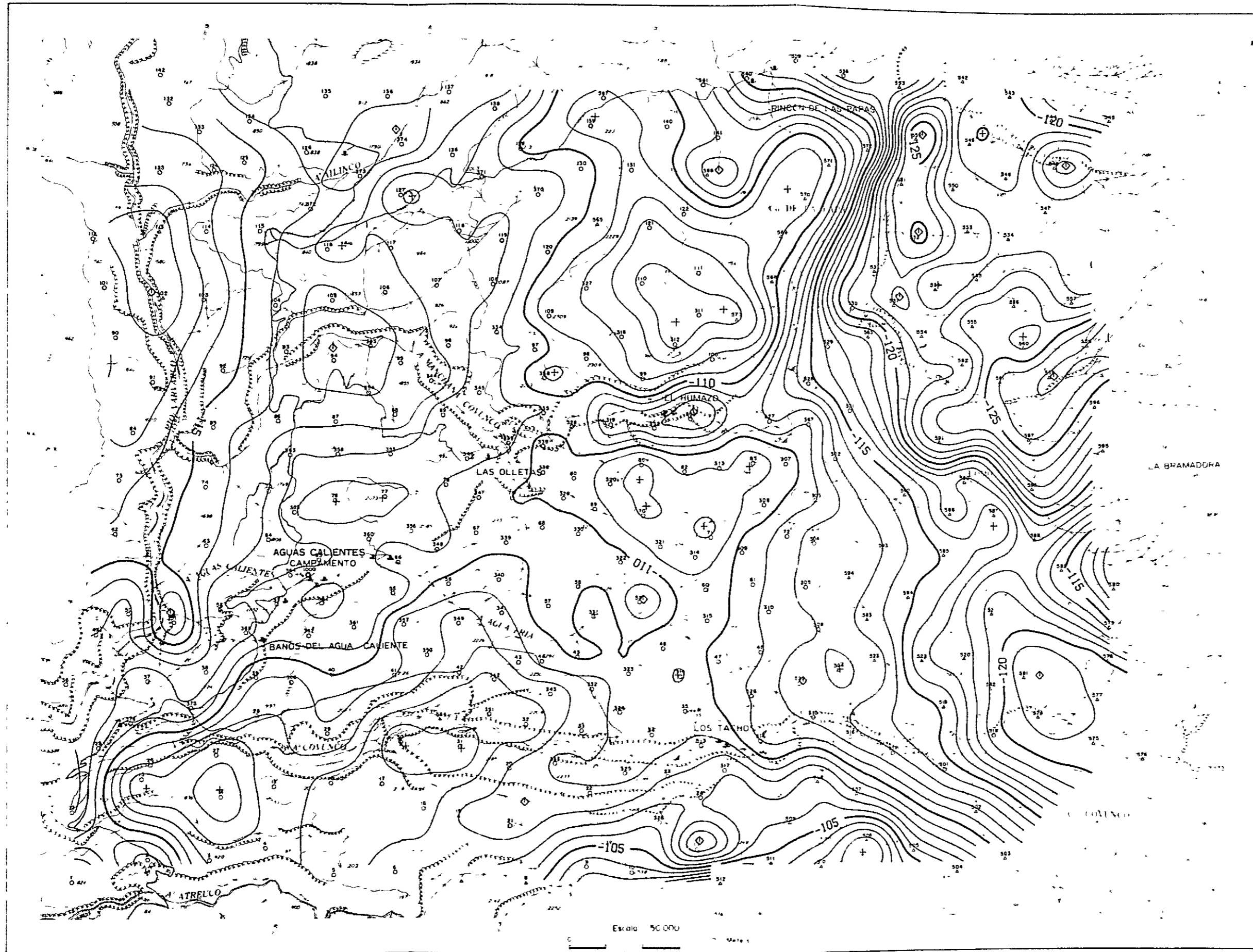


Fig.4-9 Bouguer anomaly map ($\rho = 2.50 \text{ g/cm}^3$)

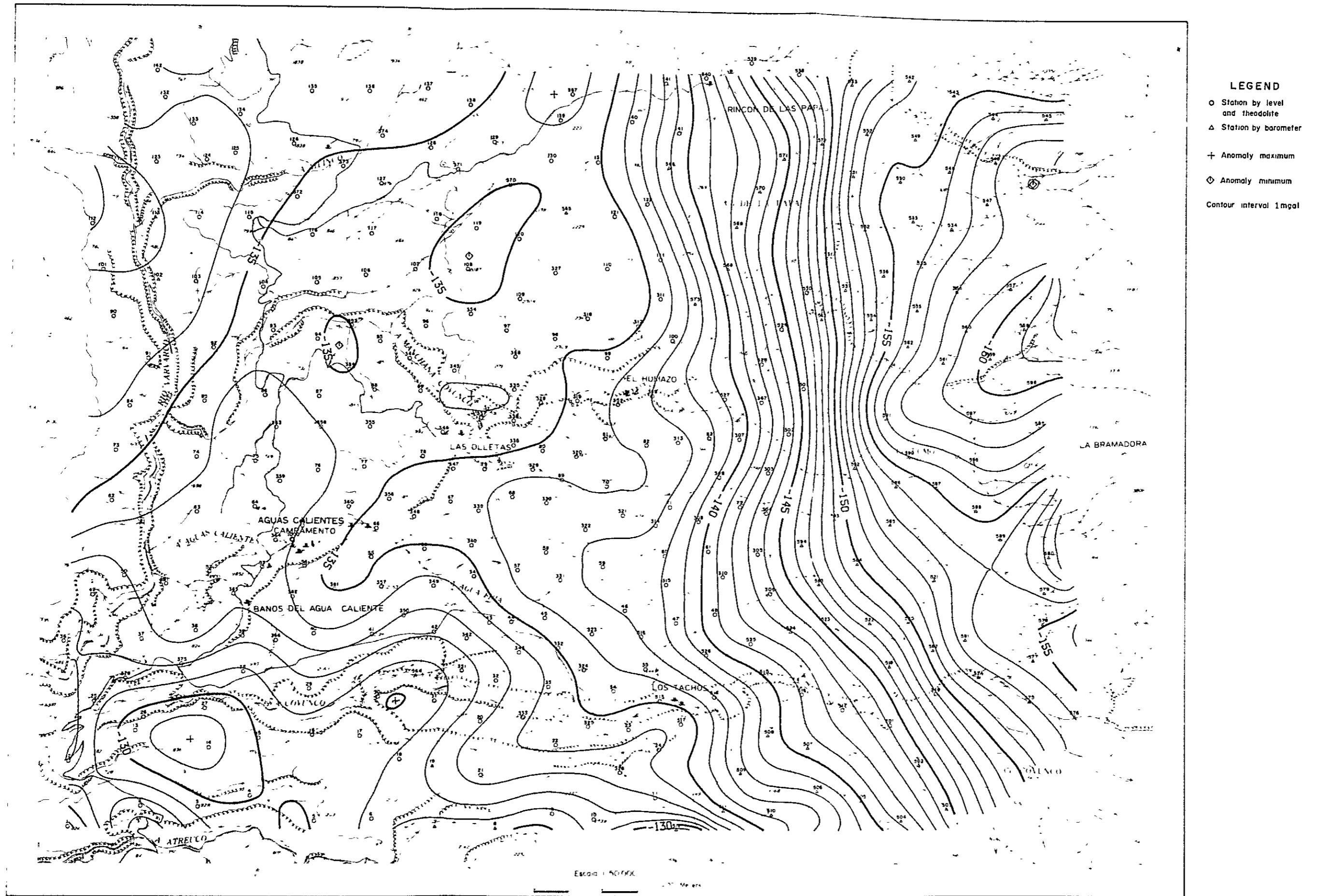


Fig.4-10 Long-wave Bouguer anomaly map ($\rho = 2.30 \text{ g/cm}^3$)

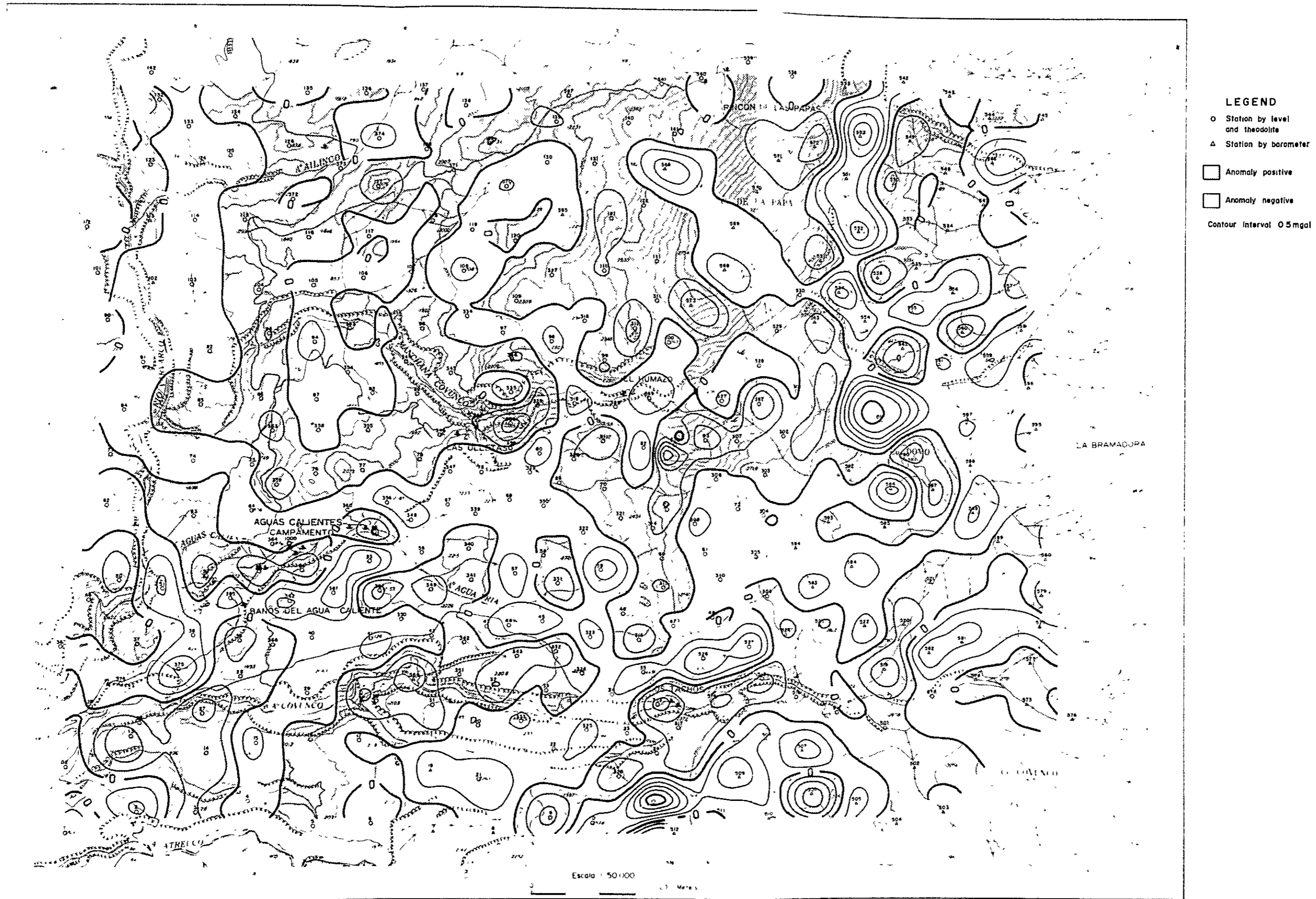


Fig.4-11 Short-wave Bouguer anomaly map ($\rho = 2.30 \text{ g/cm}^3$)

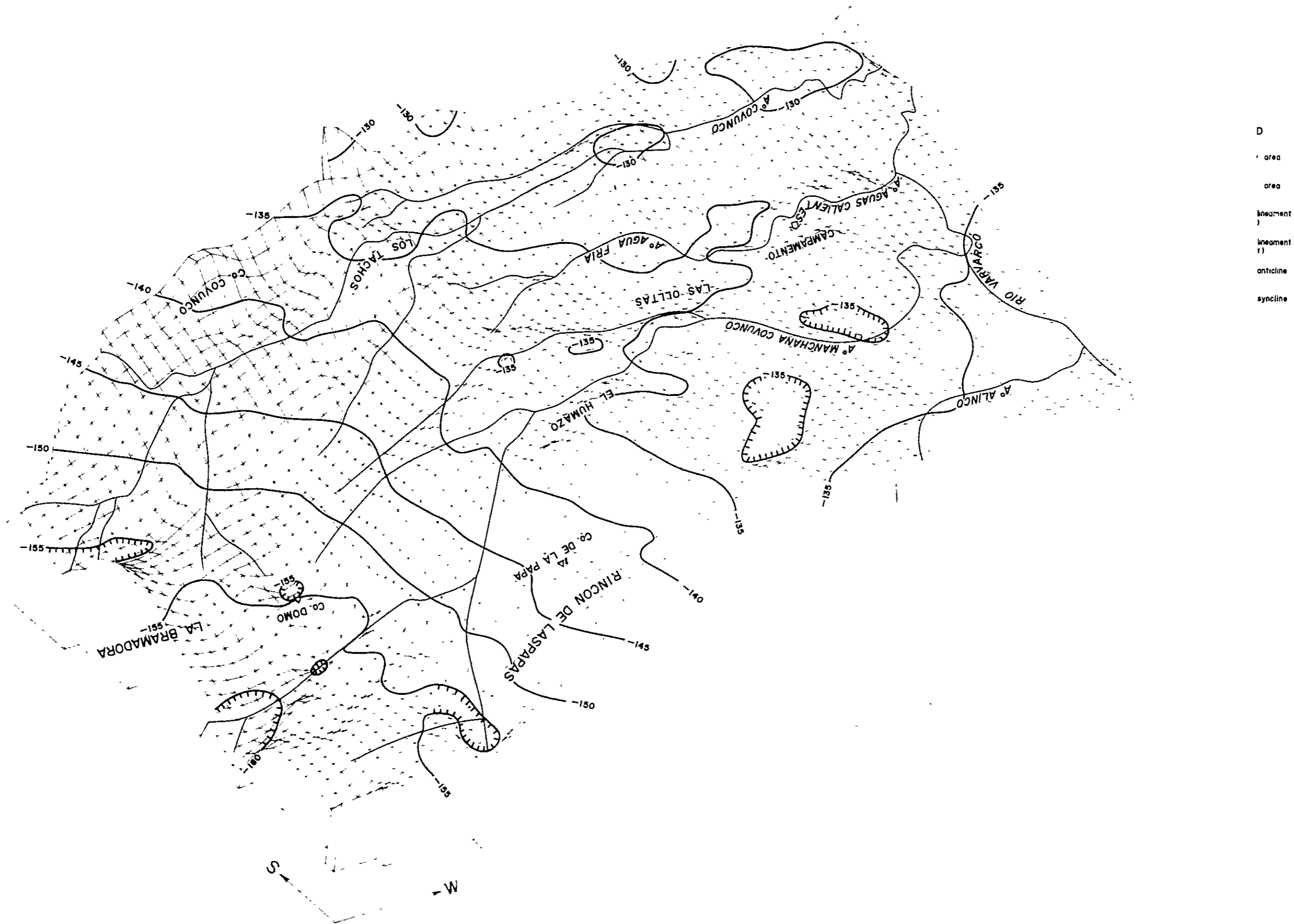
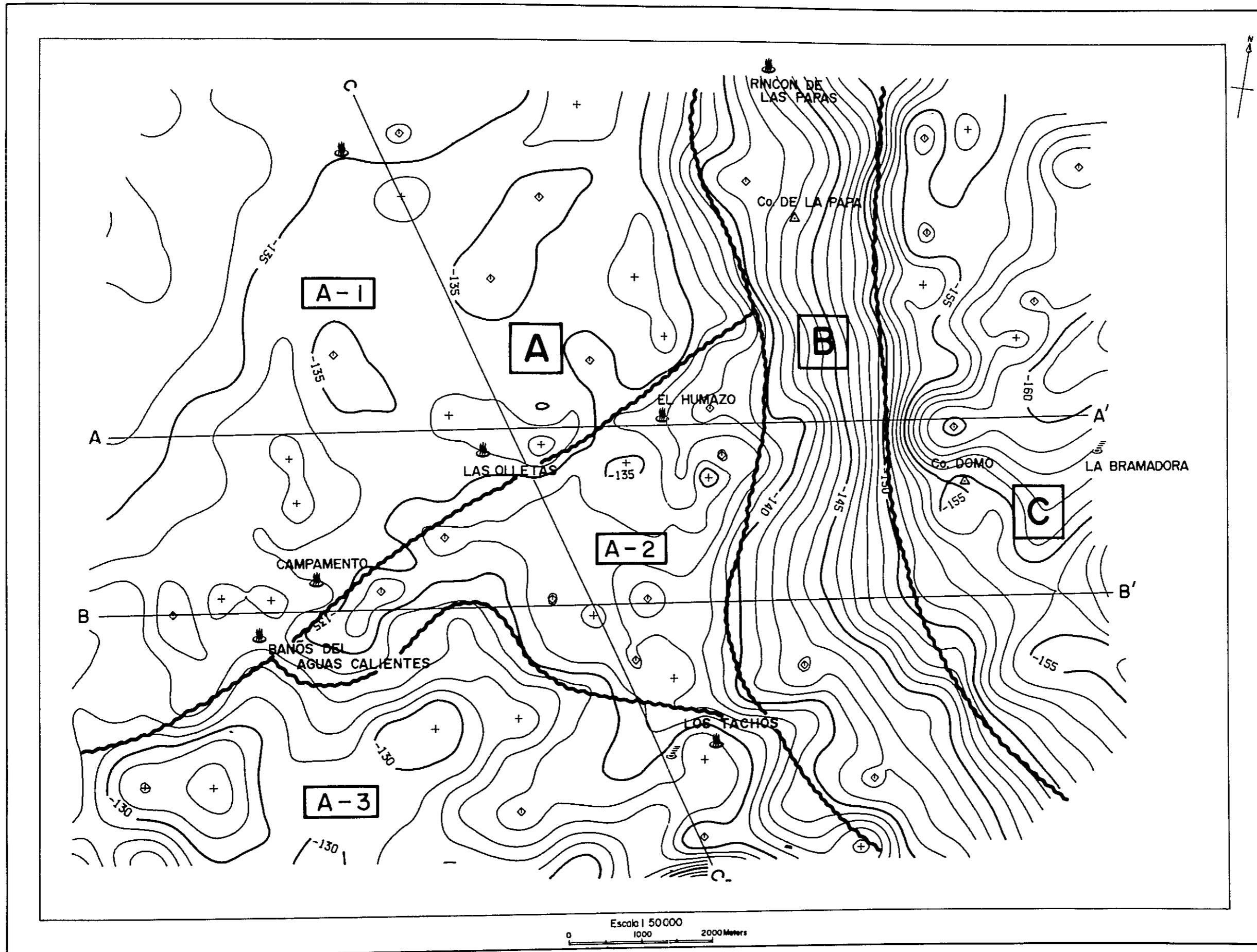


Fig.4-12 Three-dimensional image of Bouguer anomaly map ($\rho = 2.30 \text{ g/cm}^3$)



- D
- area
- area
- lineament
- lineament
- anticline
- syncline

Fig.4-13 Zoning of Bouguer anomaly map

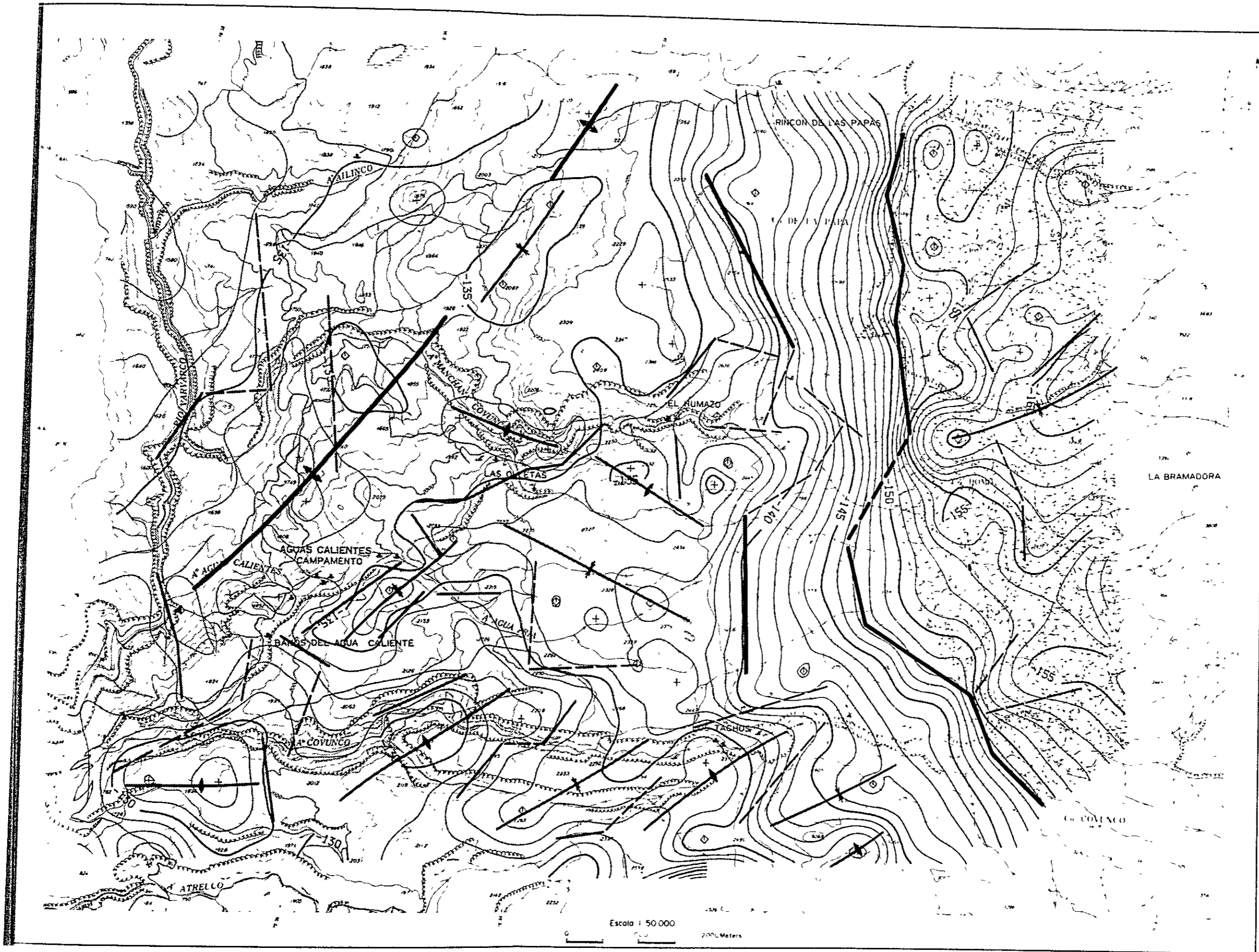


Fig.4-14 Gravimetric interpretation map

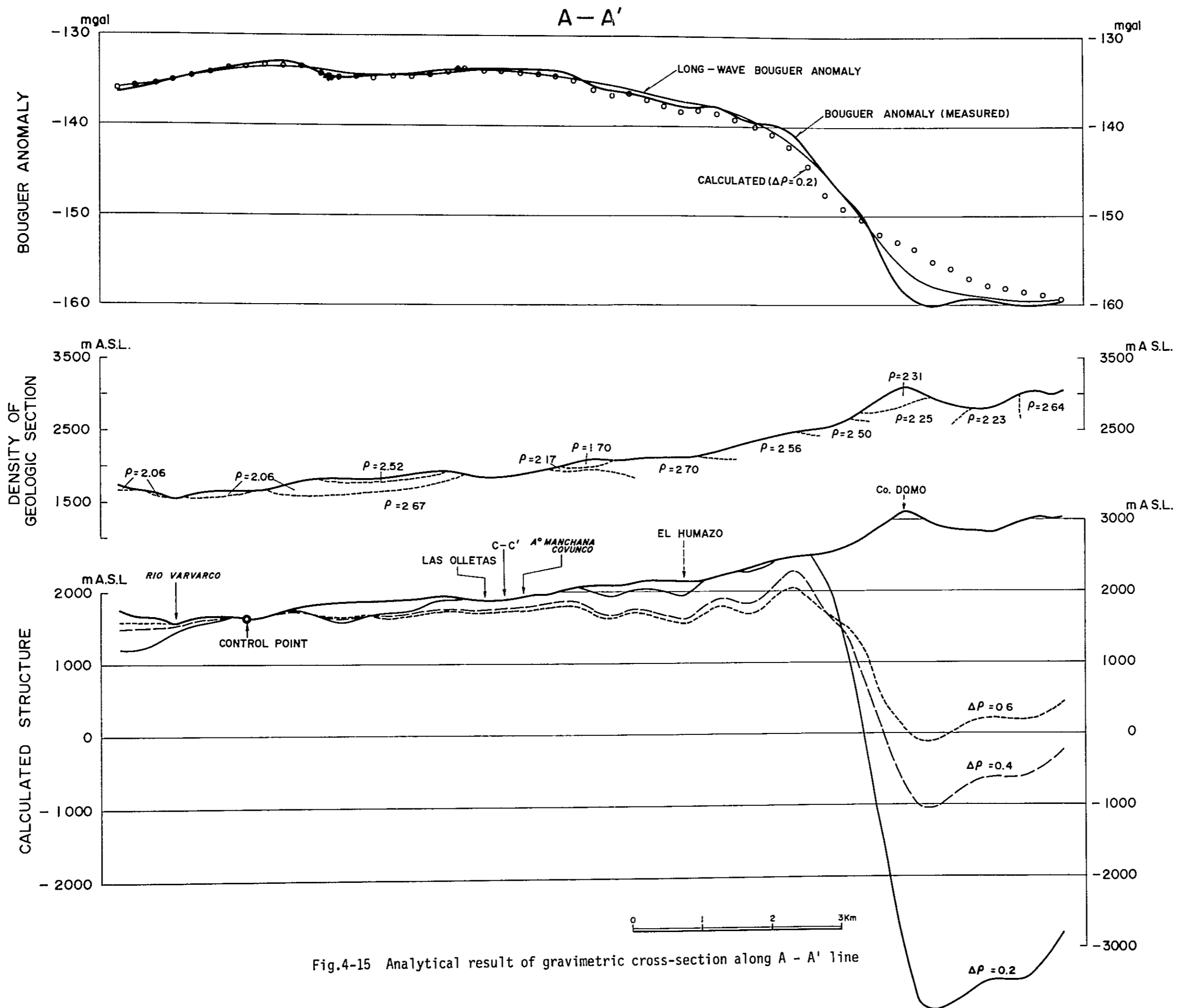


Fig.4-15 Analytical result of gravimetric cross-section along A - A' line

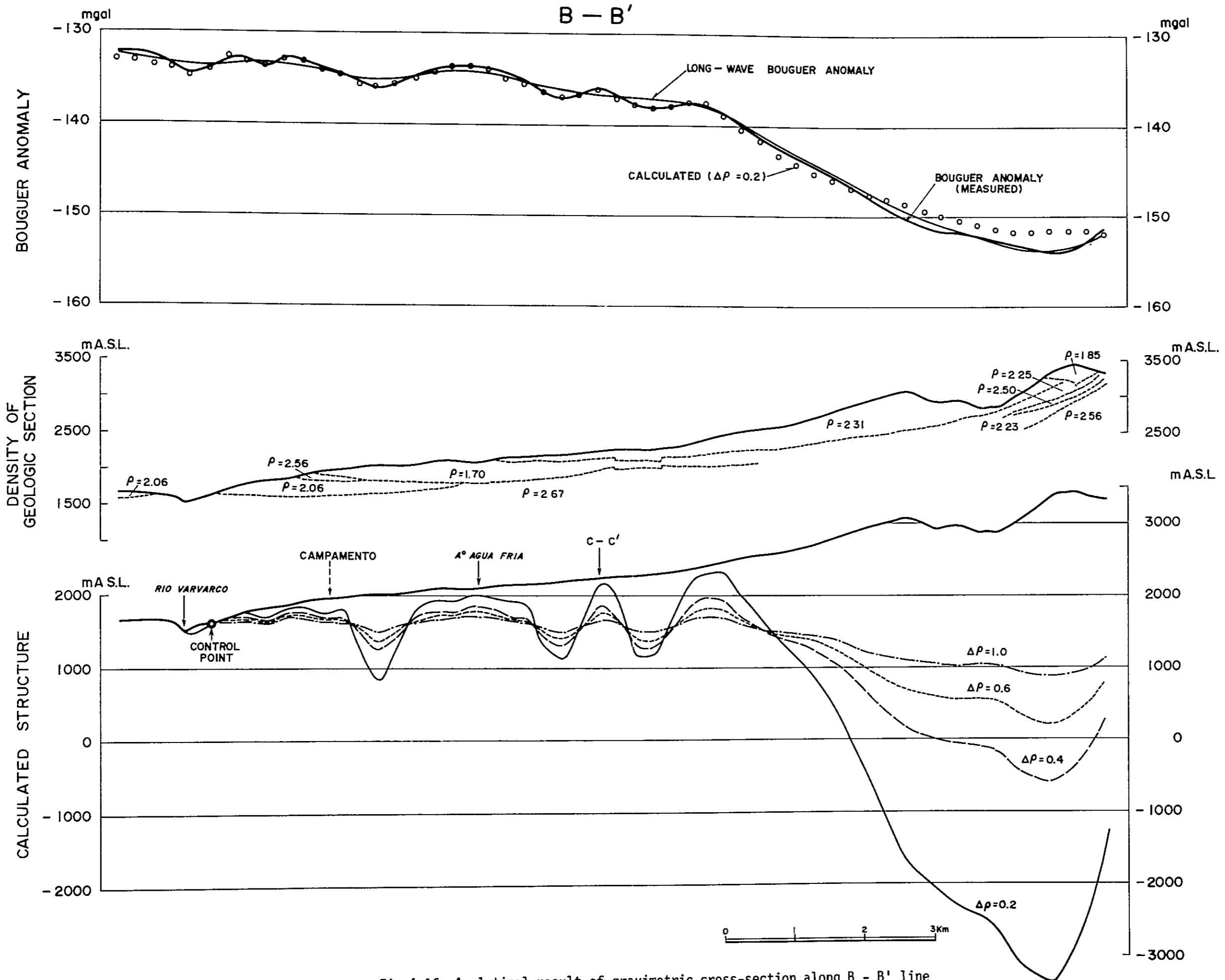


Fig.4-16 Analytical result of gravimetric cross-section along B - B' line

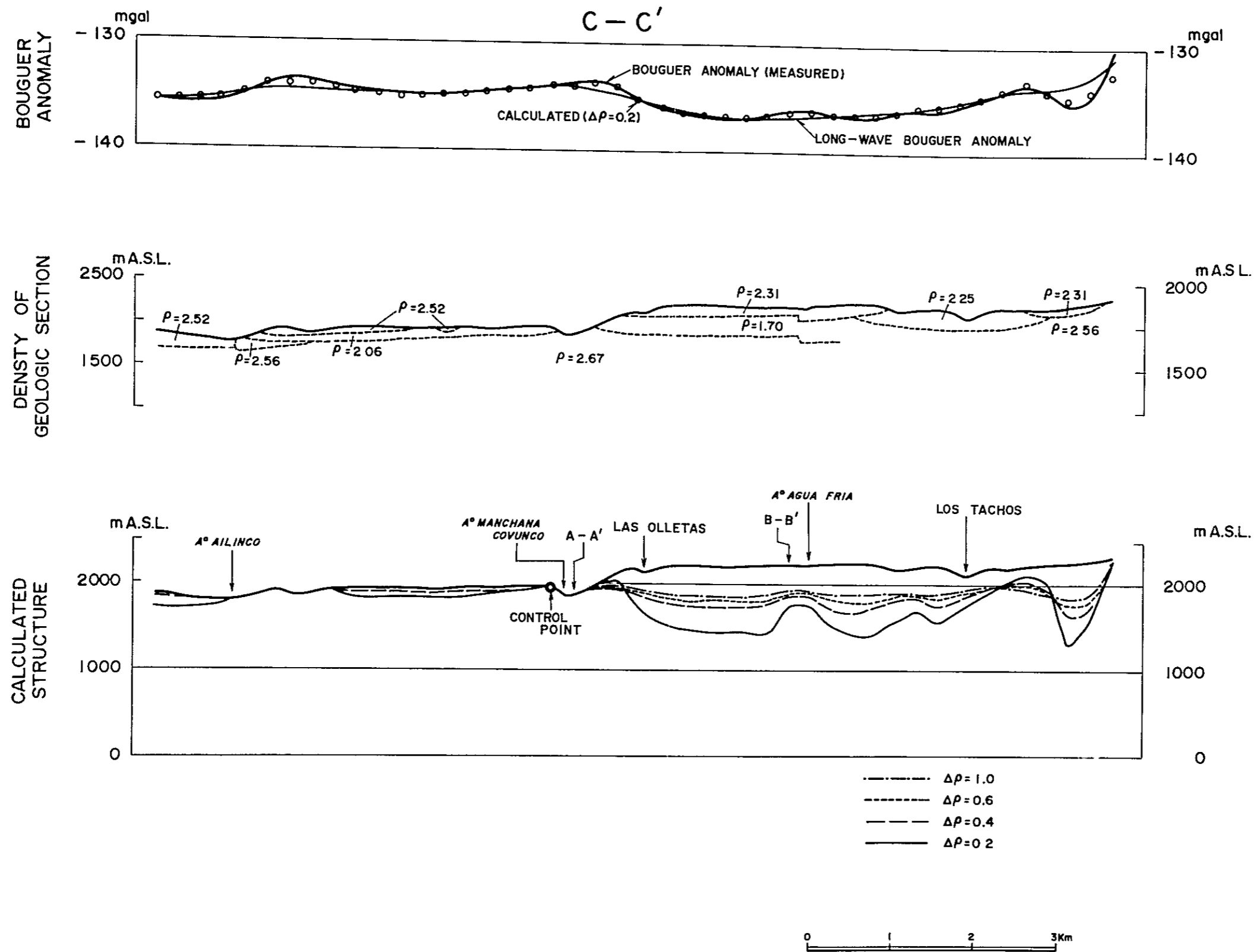


Fig.4-17 Analytical result of gravimetric cross-section along C - C' line

5. 調査地域の熱構造

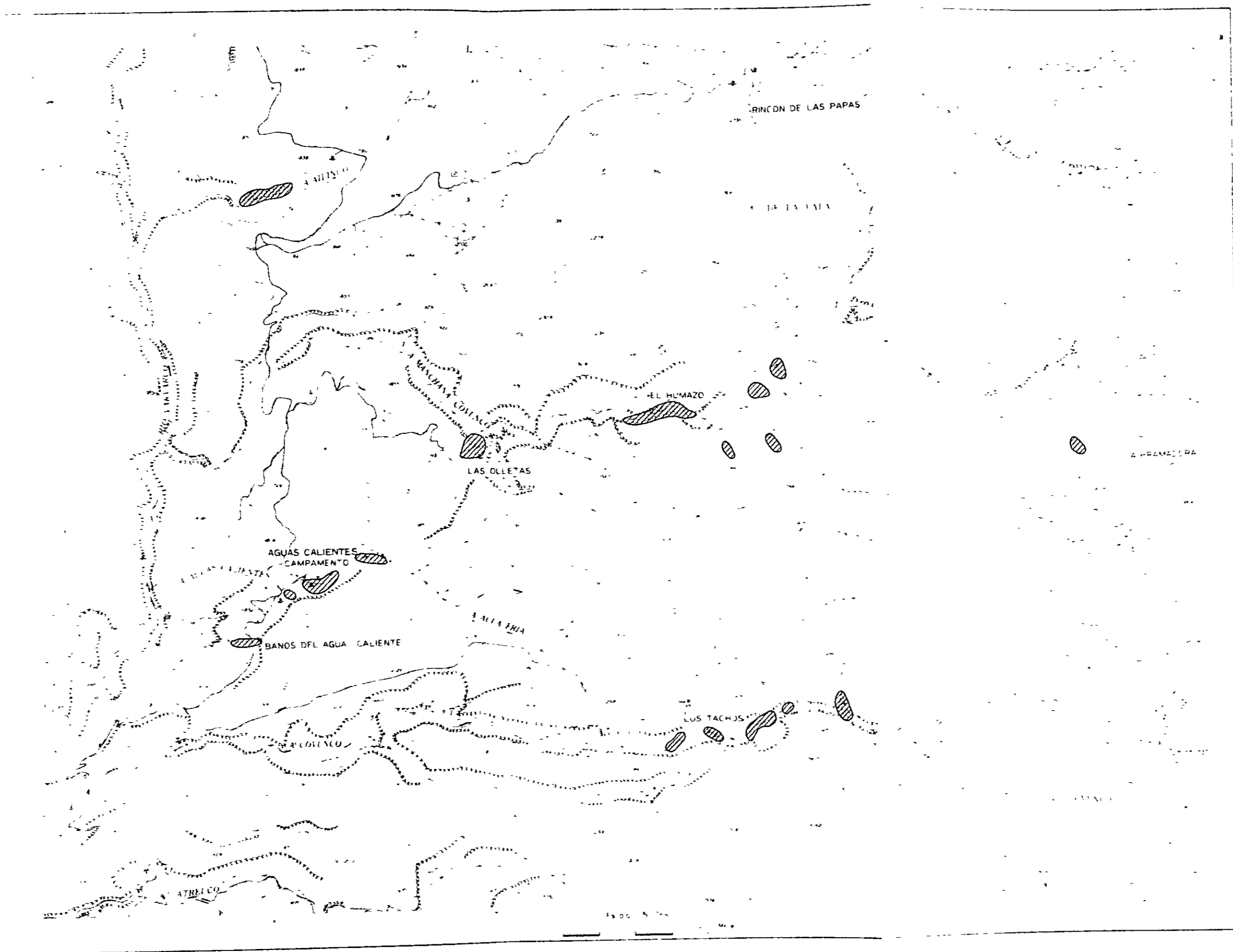


Fig.5-1 Location map of alteration zones

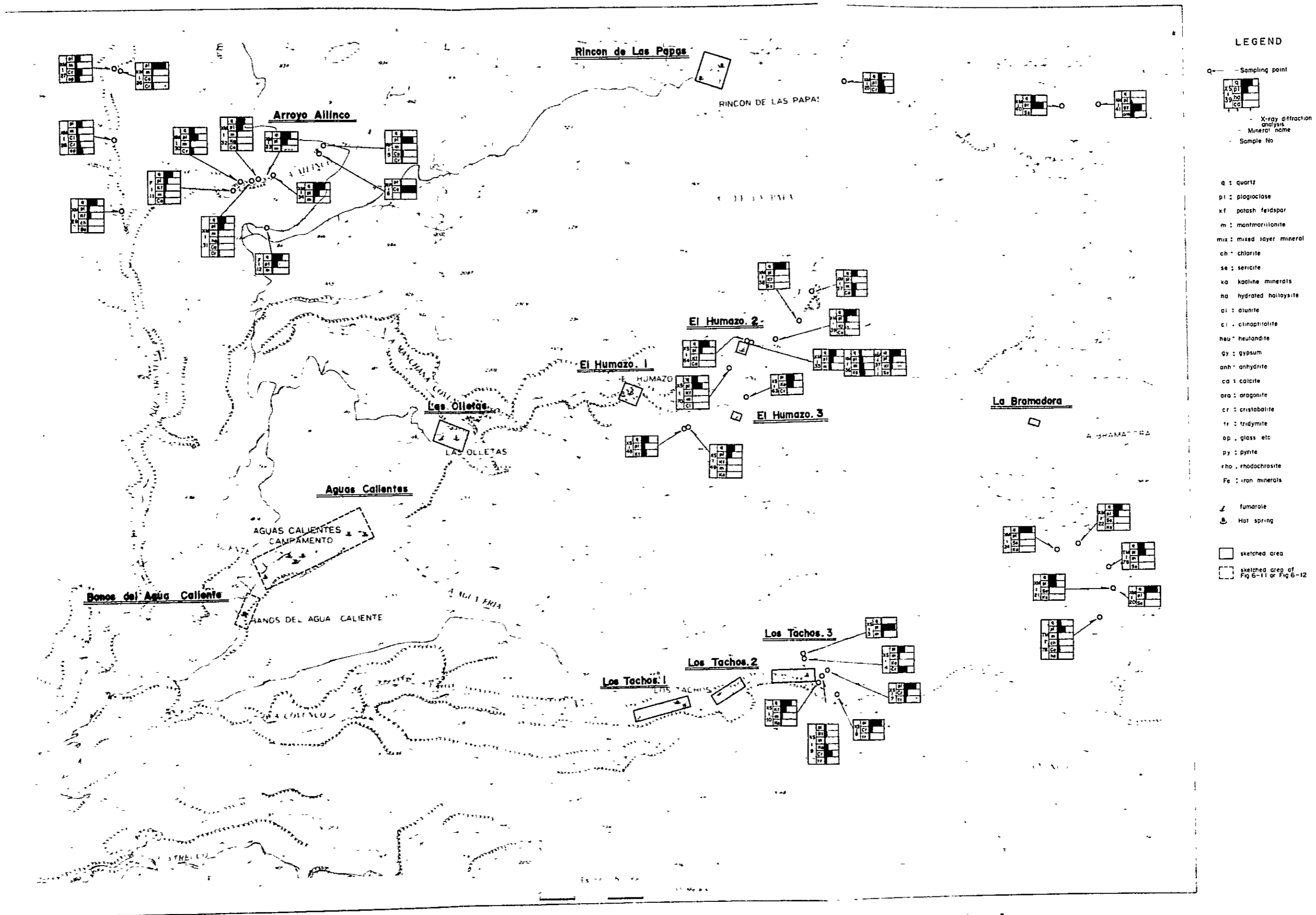


Fig.5-2 Sketched areas of alteration zone and regional distributions of alteration minerals

LEGEND

- Outcrop
 - Cliff of rock
 - Cliff of earth
 - Damp ground
 - Earth slope
 - Talus deposit
 - Hot spring deposit
 - fumarole
 - Hot spring
 - Sampling point
- hst : heulandite
 - gy : gypsum
 - ant : anhydrite
 - ca : calcite
 - arg : aragonite
 - cr : cristobalite
 - tr : tridymite
 - sp : glass etc
 - py : pyrite
 - rha : rhodochrosite
 - Fe : iron minerals
- q : quartz
 - pl : plagioclase
 - fs : feldspar
 - m : montmorillonite
 - mix : mixed layer mineral
 - ch : chlorite
 - se : sericite
 - ka : kaolinite
 - hg : hydrated halloysite
 - al : alunite
 - cl : clinoptilolite



X-ray diffraction
Mineral name
Sample No

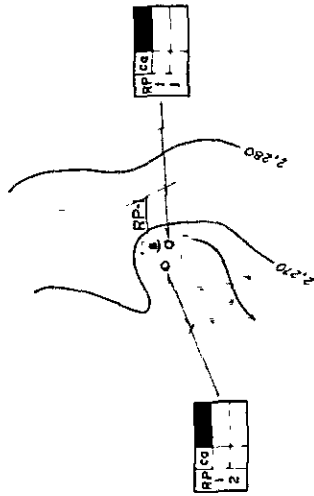
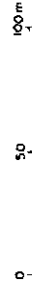
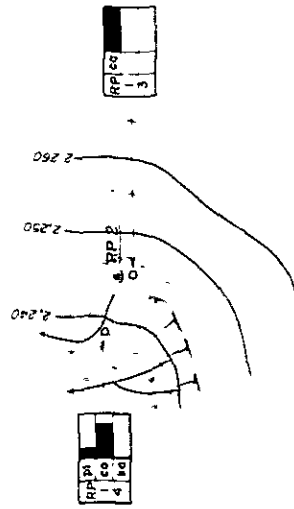


Fig.5-3 Sketch of alteration zone and diagrams of alteration minerals
(1) Rincon de Las Papas

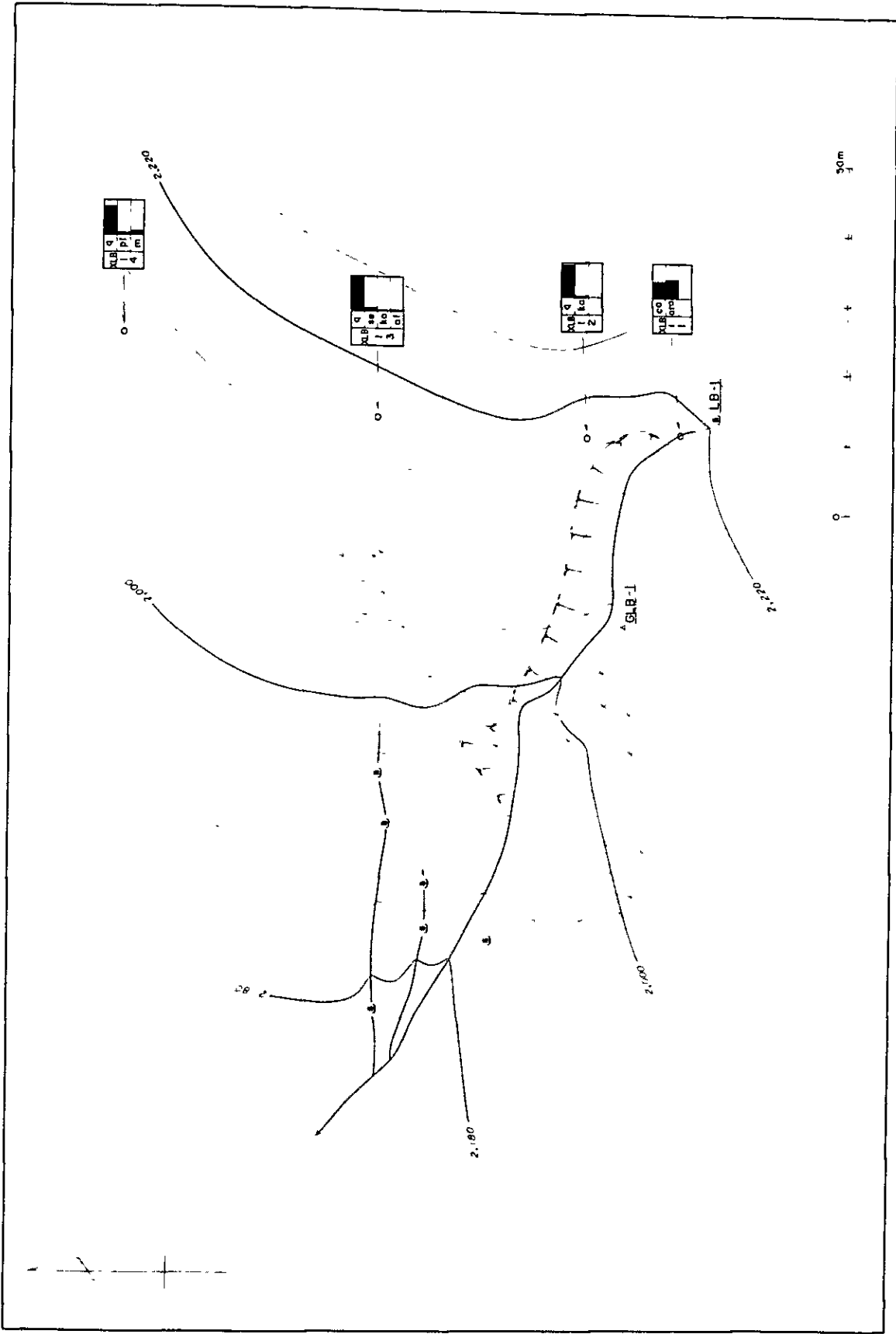


Fig.5-4 Sketch of alteration zone and diagrams of alteration minerals
(2) La Bramadora

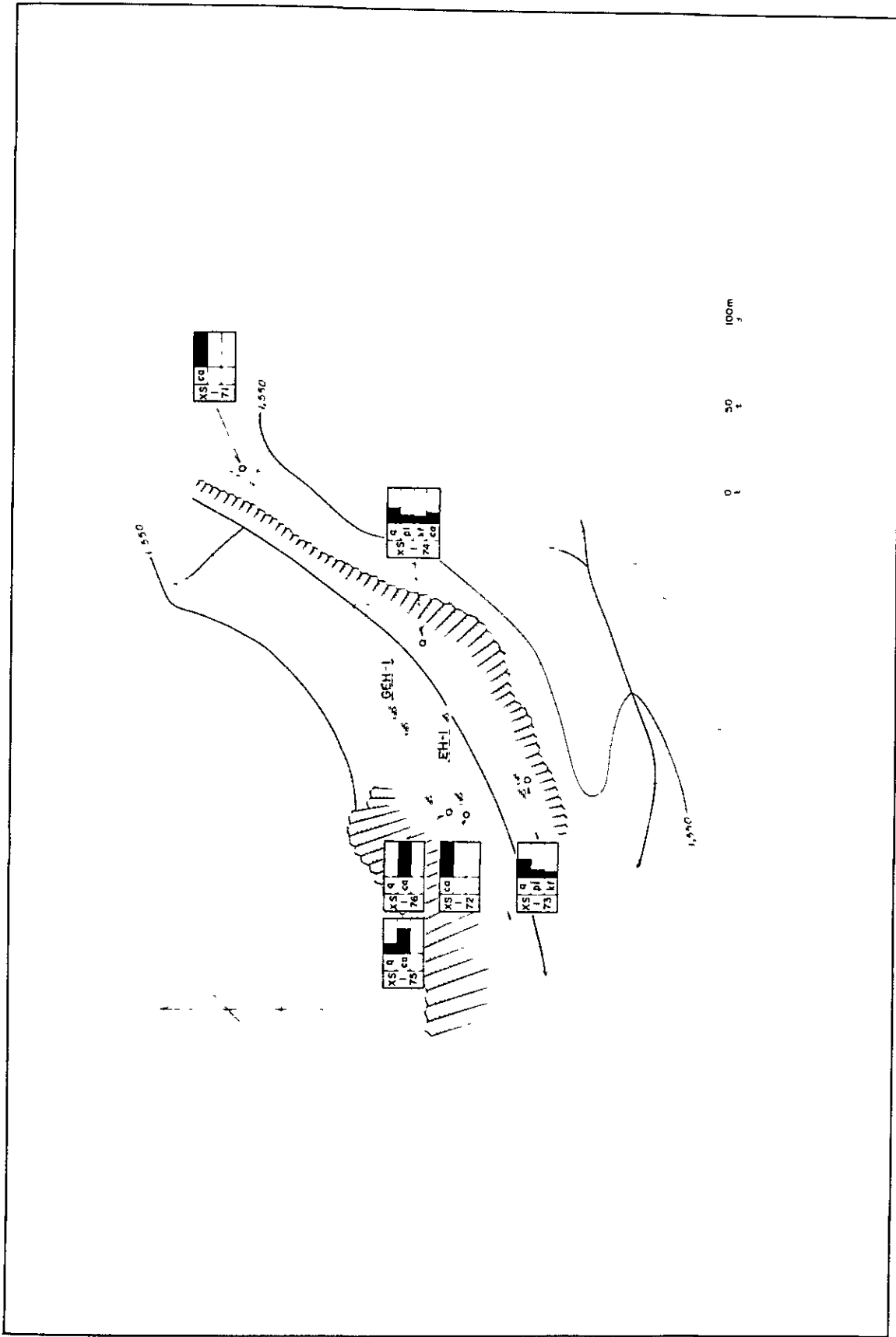


Fig.5-5 Sketch of alteration zone and diagrams of alteration minerals
 (3) El Humazo - 1

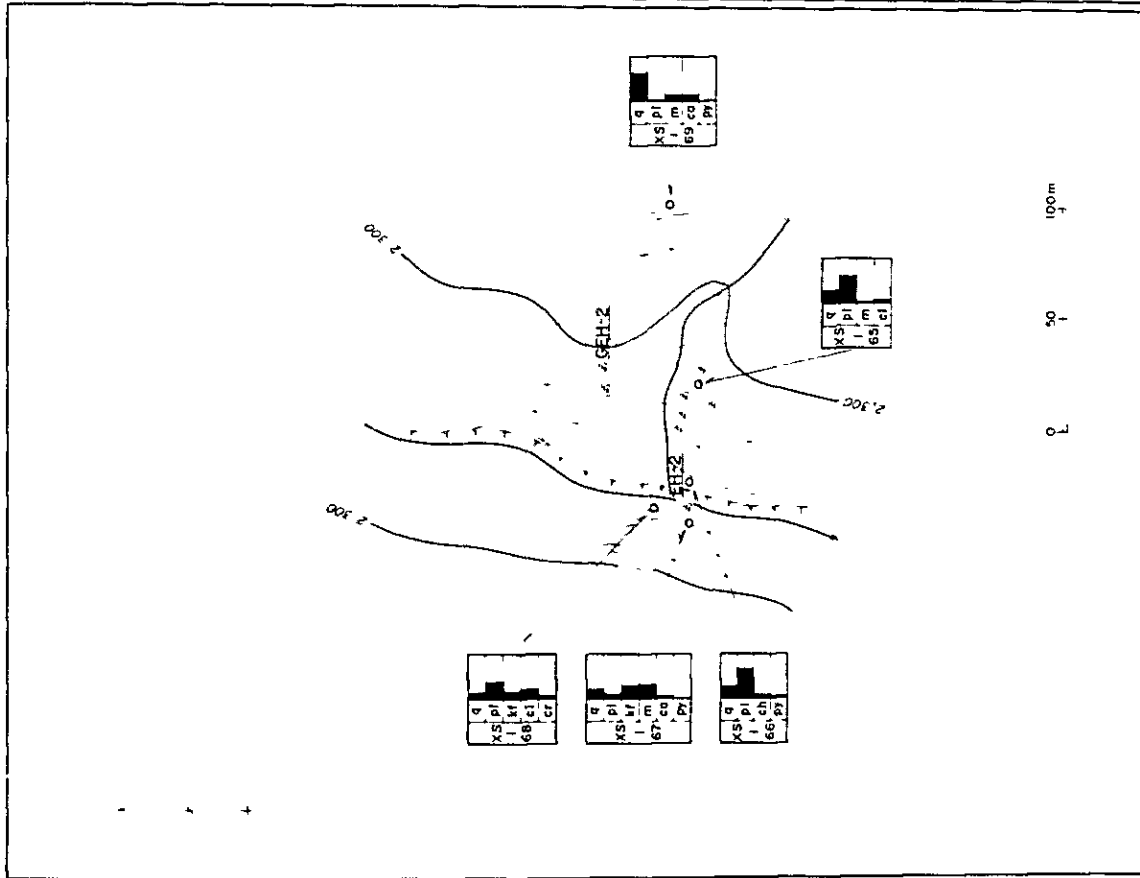


Fig.5-6 Sketch of alteration zone and diagrams of alteration minerals (4) El Humazo - 2

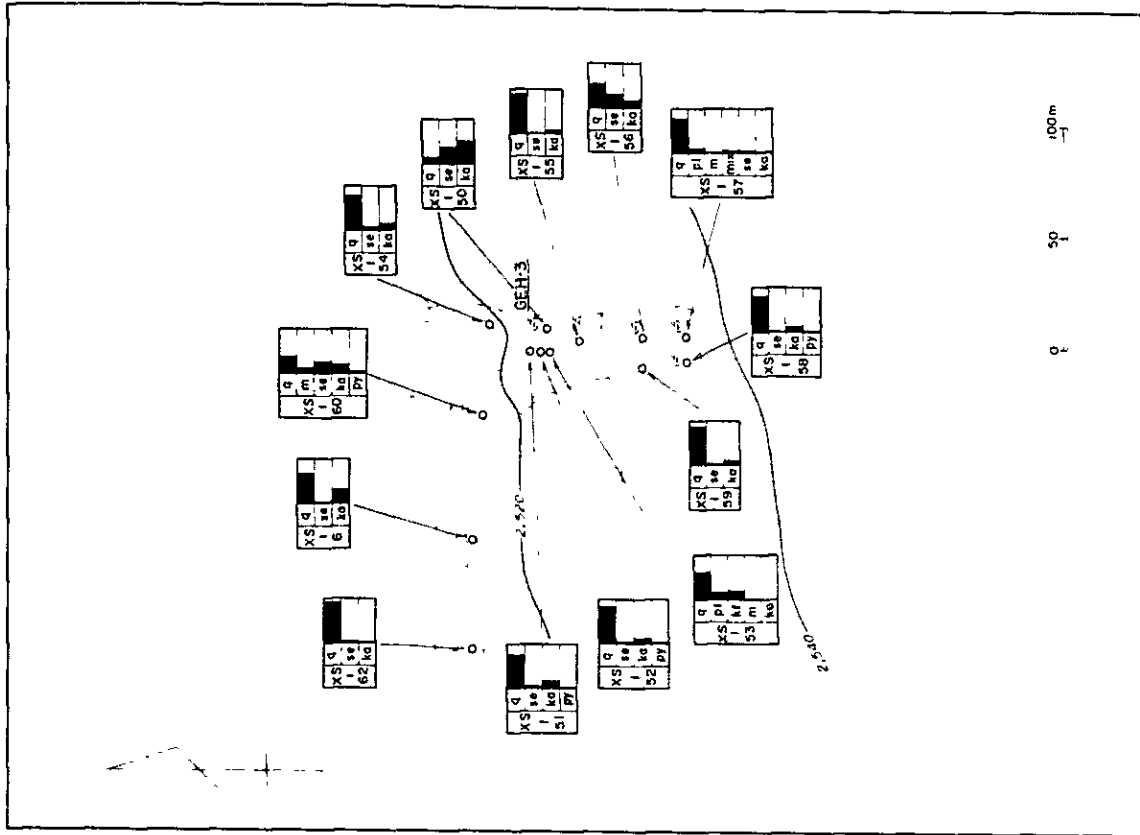


Fig.5-7 Sketch of alteration zone and diagrams of alteration minerals (5) El Humazo - 3

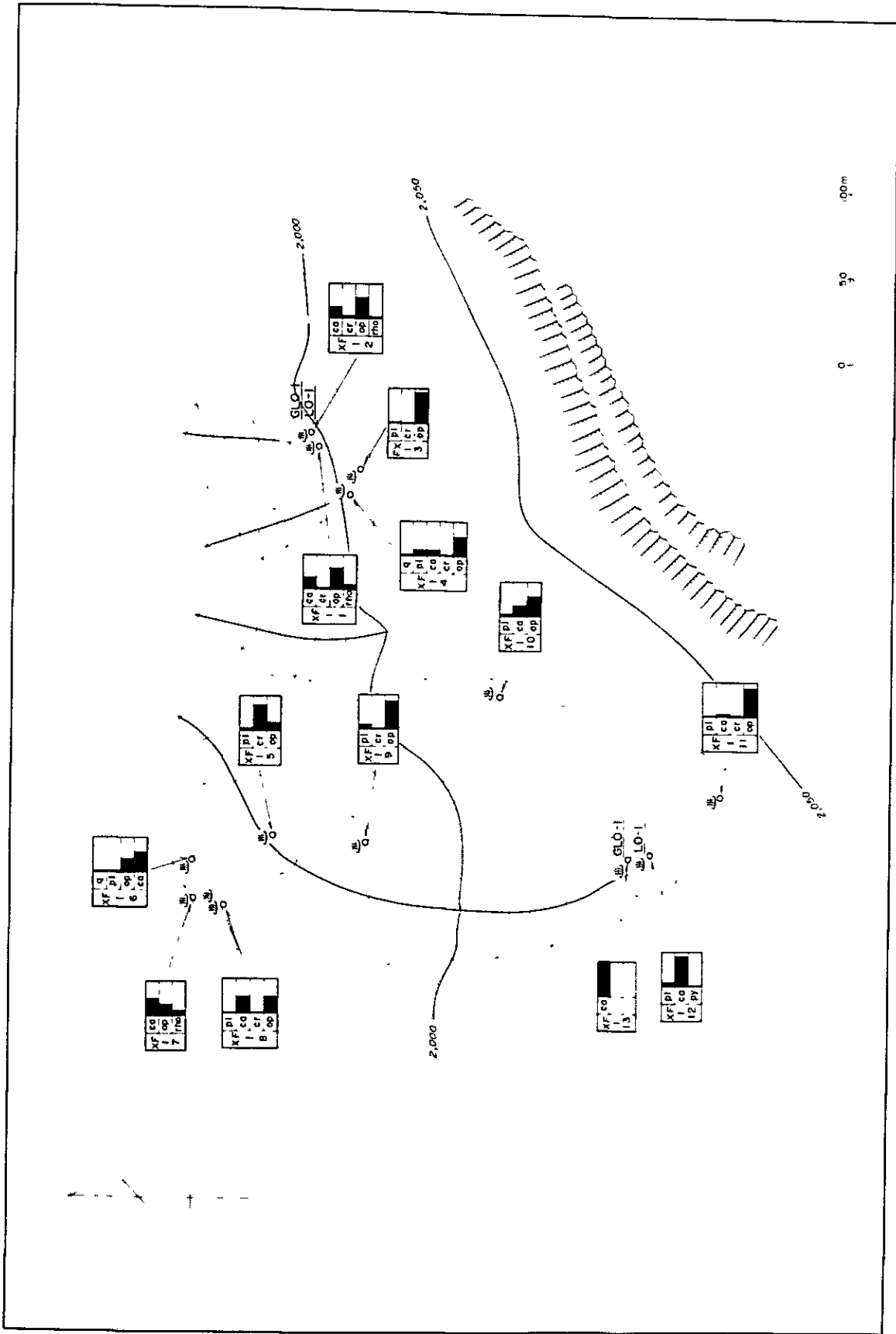


Fig.5-8 Sketch of alteration zone and diagrams of alteration minerals
(6) Las Olletas

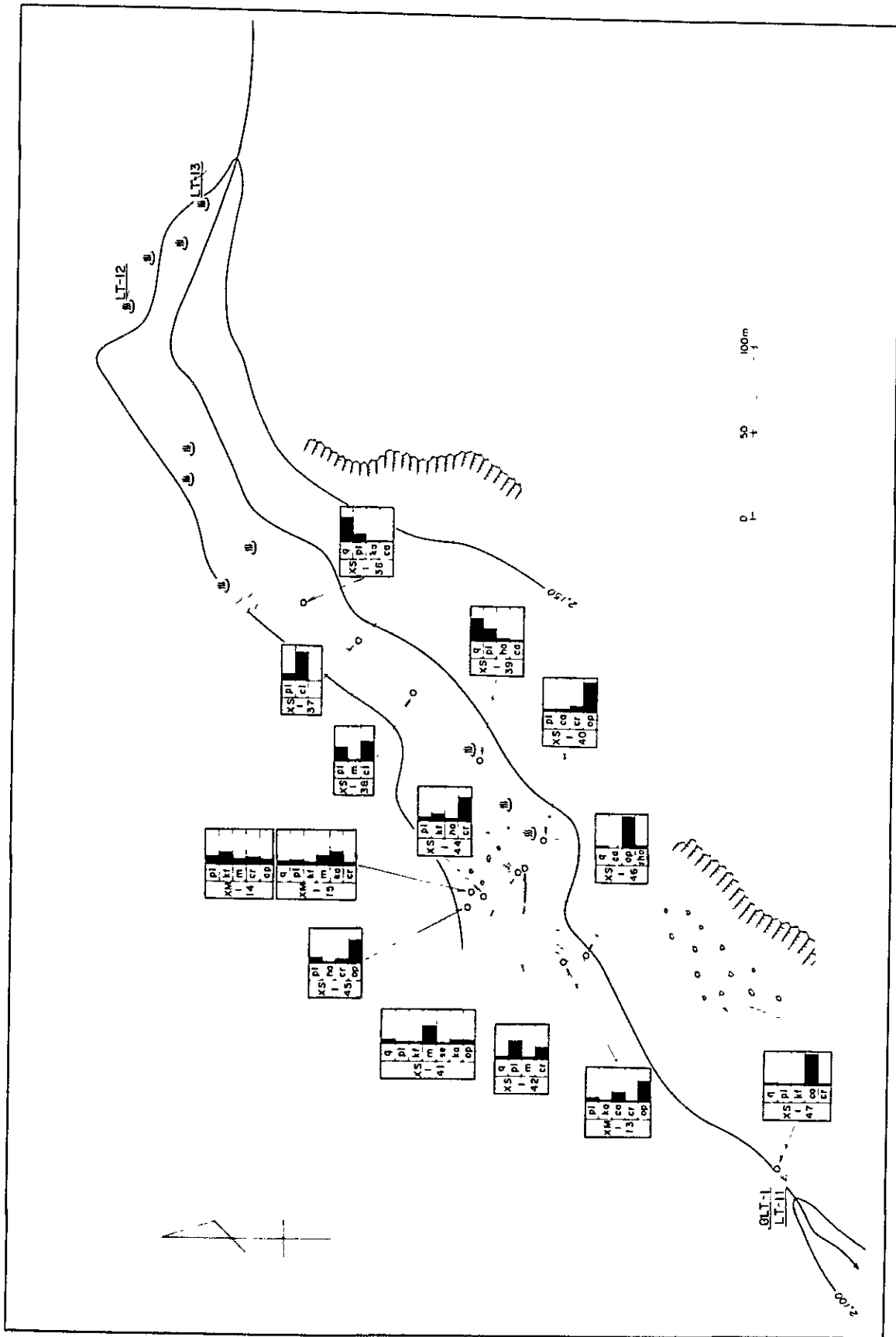


Fig.5-9 Sketch of alteration zone and diagrams of alteration minerals (7) Los Tachos - 1

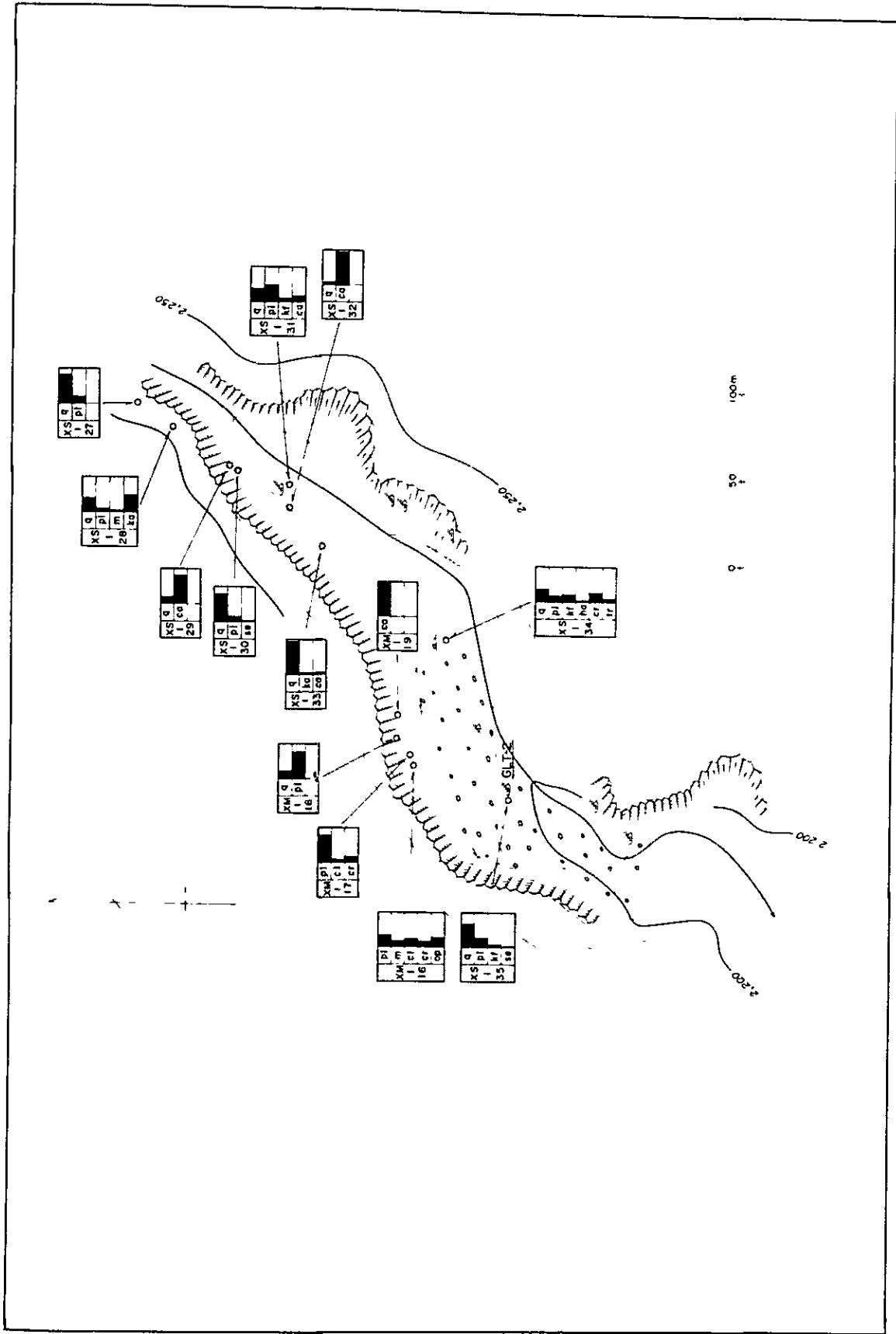


Fig.5-10 Sketch of alteration zone and diagrams of alteration minerals
(8) Los Tachos - 2

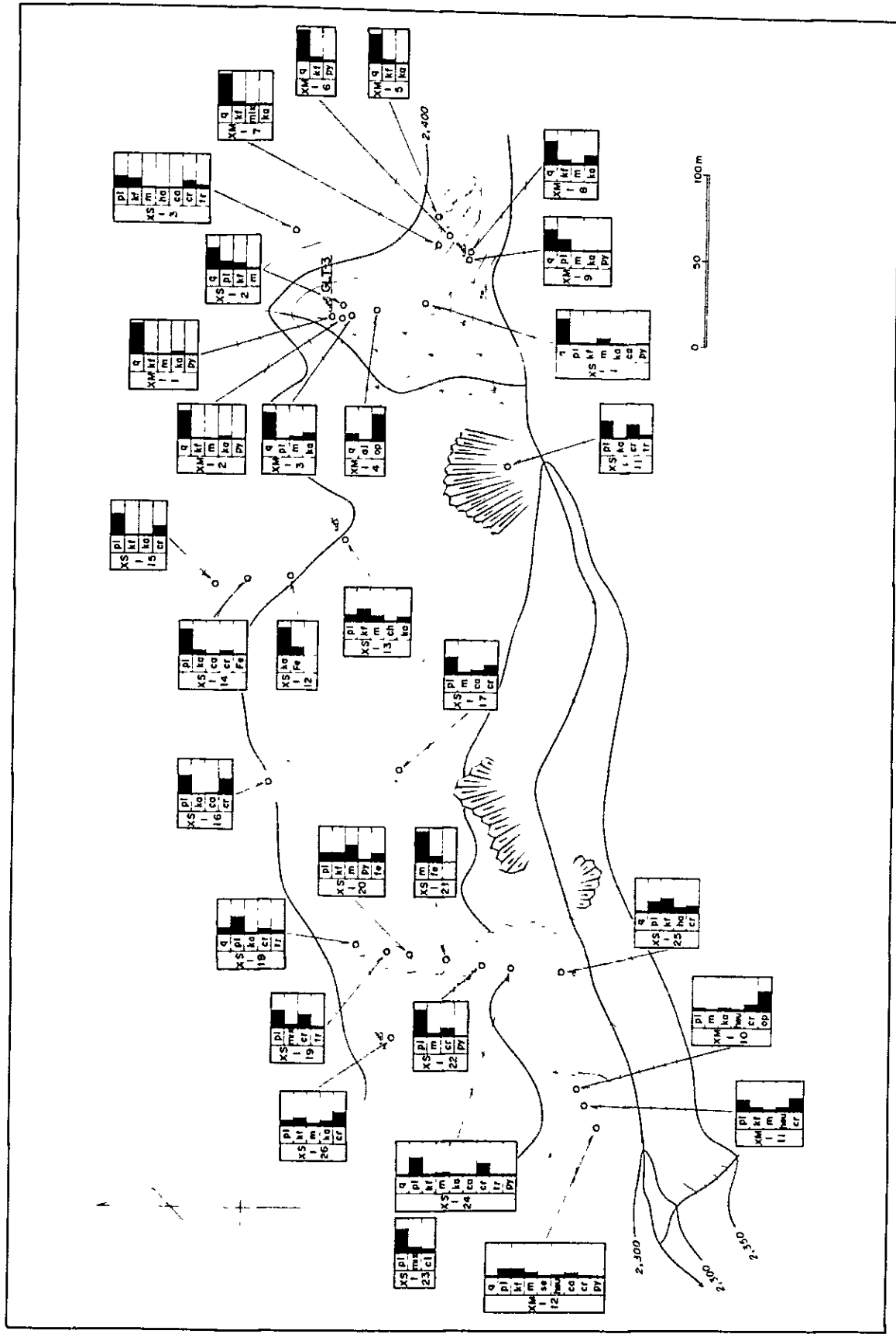
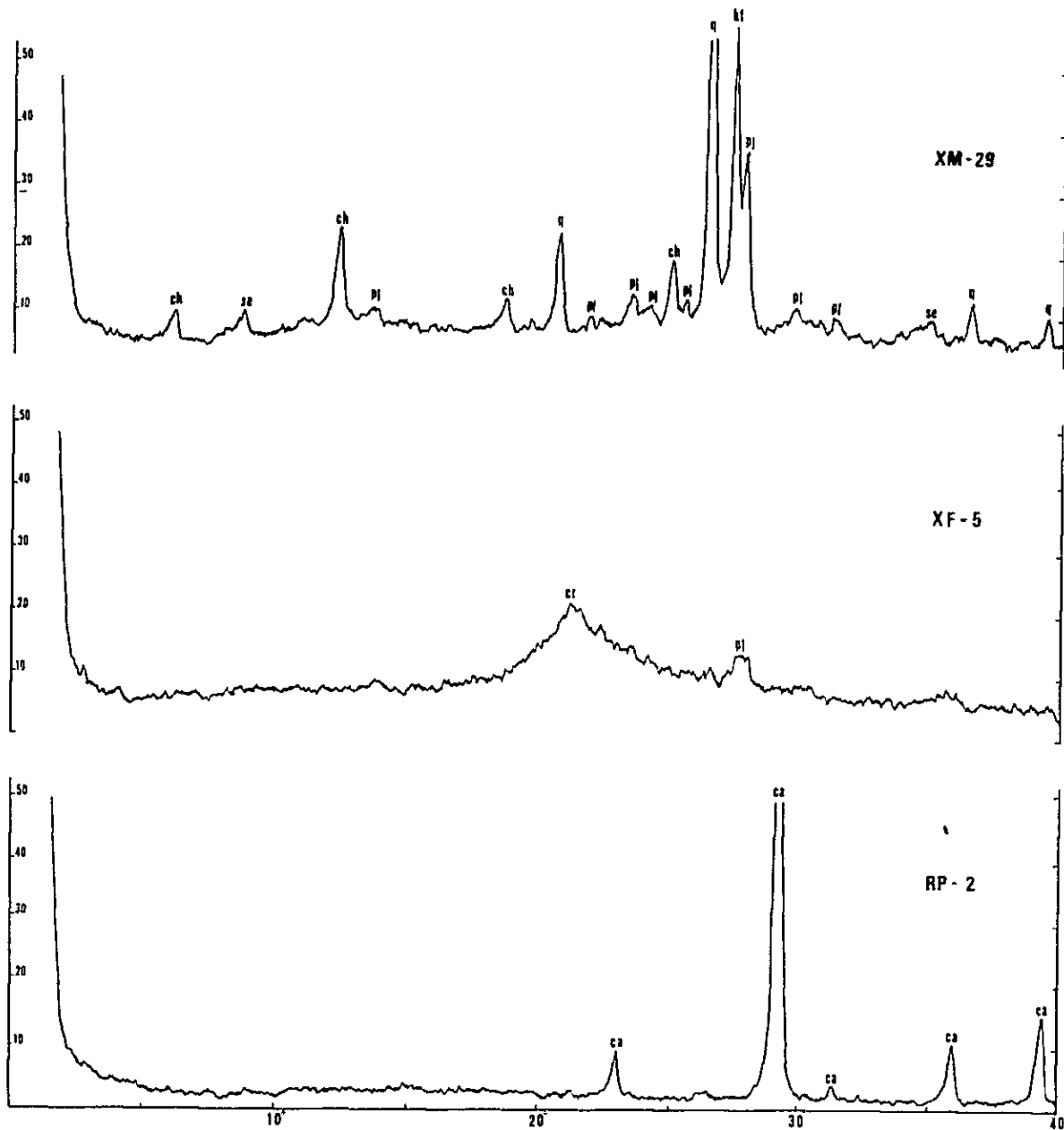


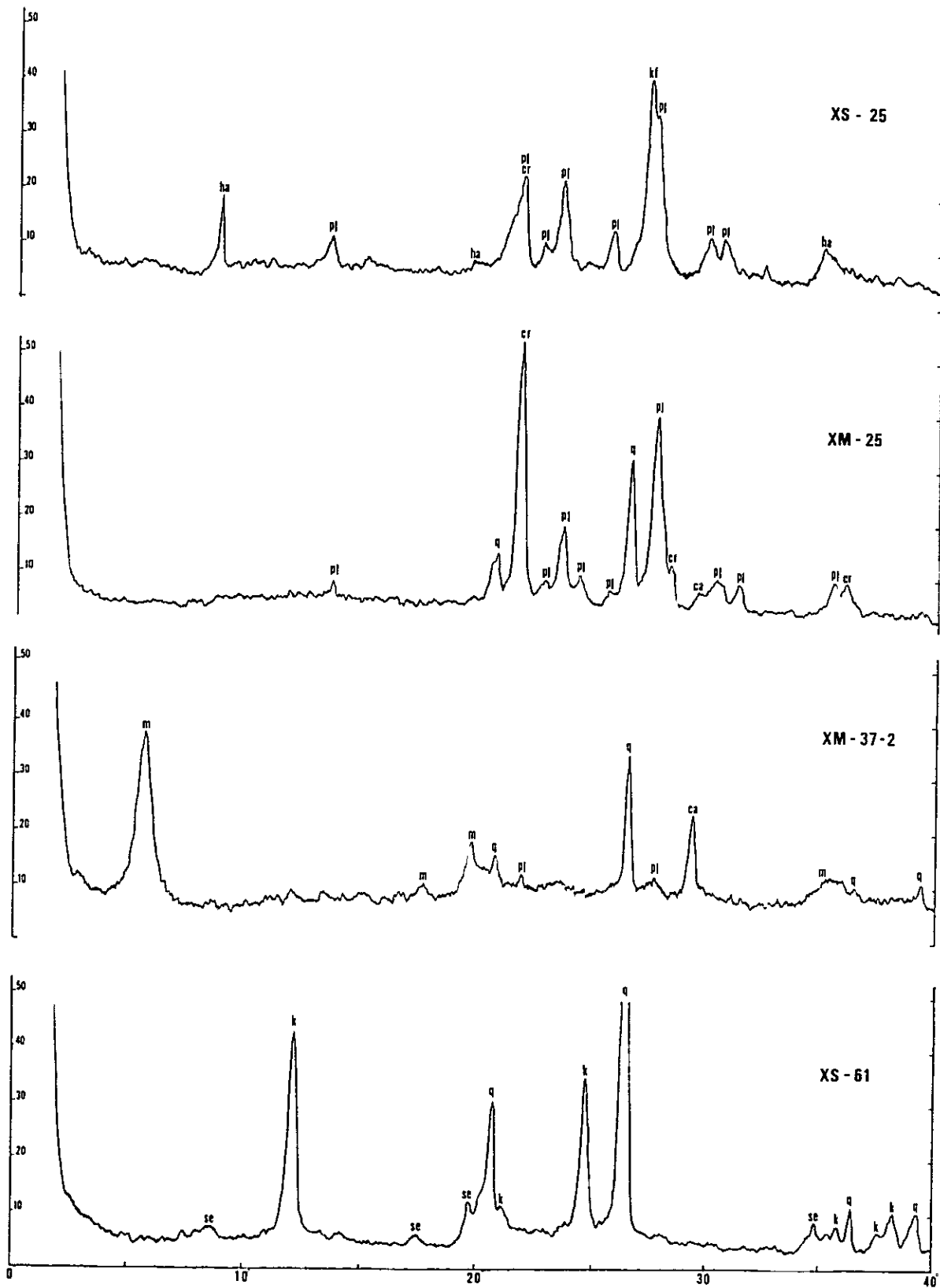
Fig.5-11 Sketch of alteration zone and diagrams of alteration minerals
(9) Los Tachos - 3



LEGEND

- | | |
|-------------------------|---------------------|
| m: montmorillonite | q: quartz |
| ch: chlorite | kf: potash feldspar |
| se: sericite | pl: plagioclase |
| k: kaolinite | ca: calcite |
| ka: hydrated halloysite | cr: cristobalite |

Fig. 5-12 (1) Typical charts of X-ray diffraction analysis



LEGEND

- | | |
|-------------------------|---------------------|
| m: montmorillonite | q: quartz |
| ch: chlorite | kf: potash feldspar |
| se: sericite | pl: plagioclase |
| k: kaolinite | ca: calcite |
| ha: hydrated halloysite | cr: cristobalite |

Fig. 5-12 (2) Typical charts of X-ray diffraction analysis

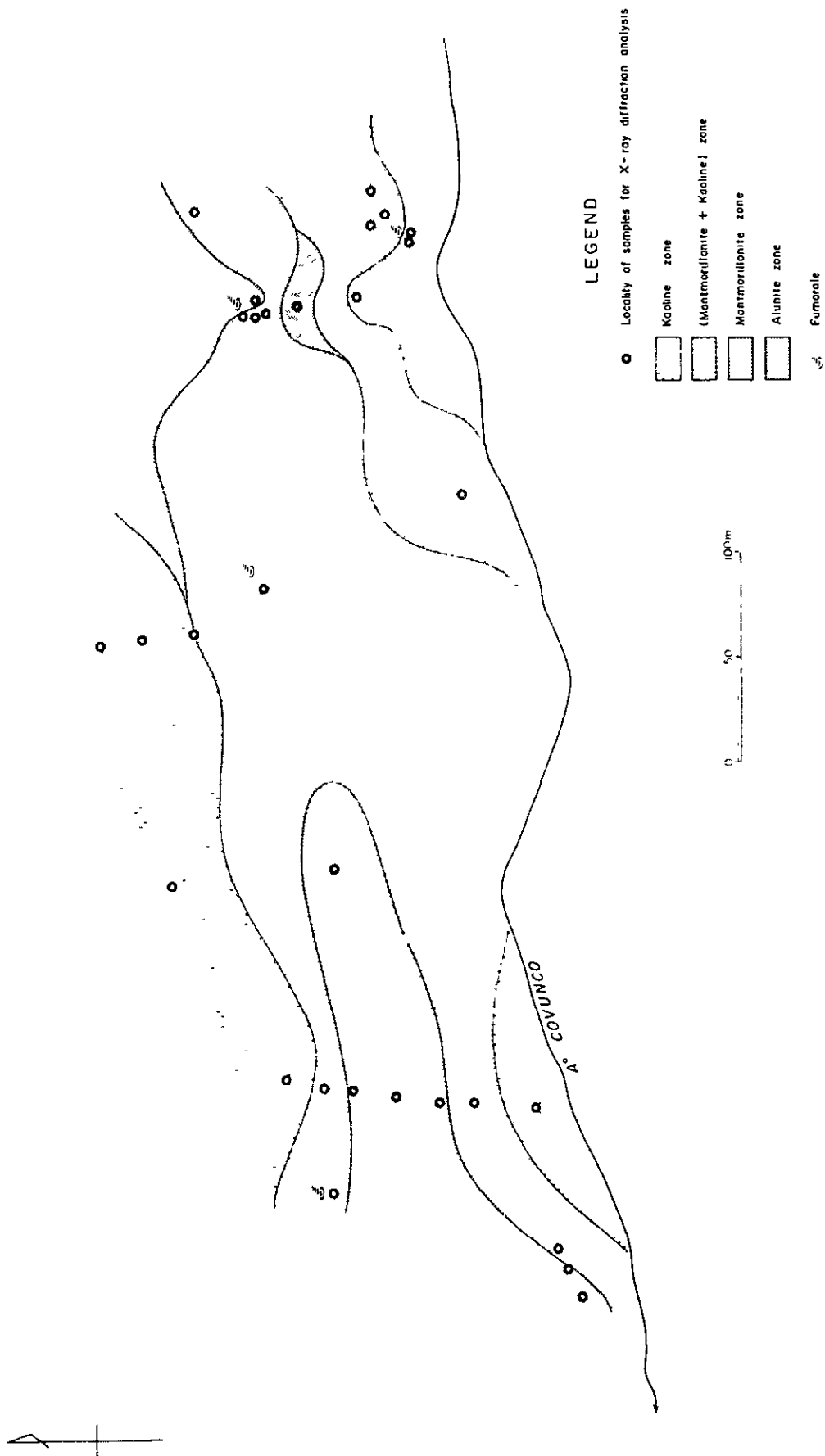


Fig.5-13 Alteration zoning map of Los Tachos - 3

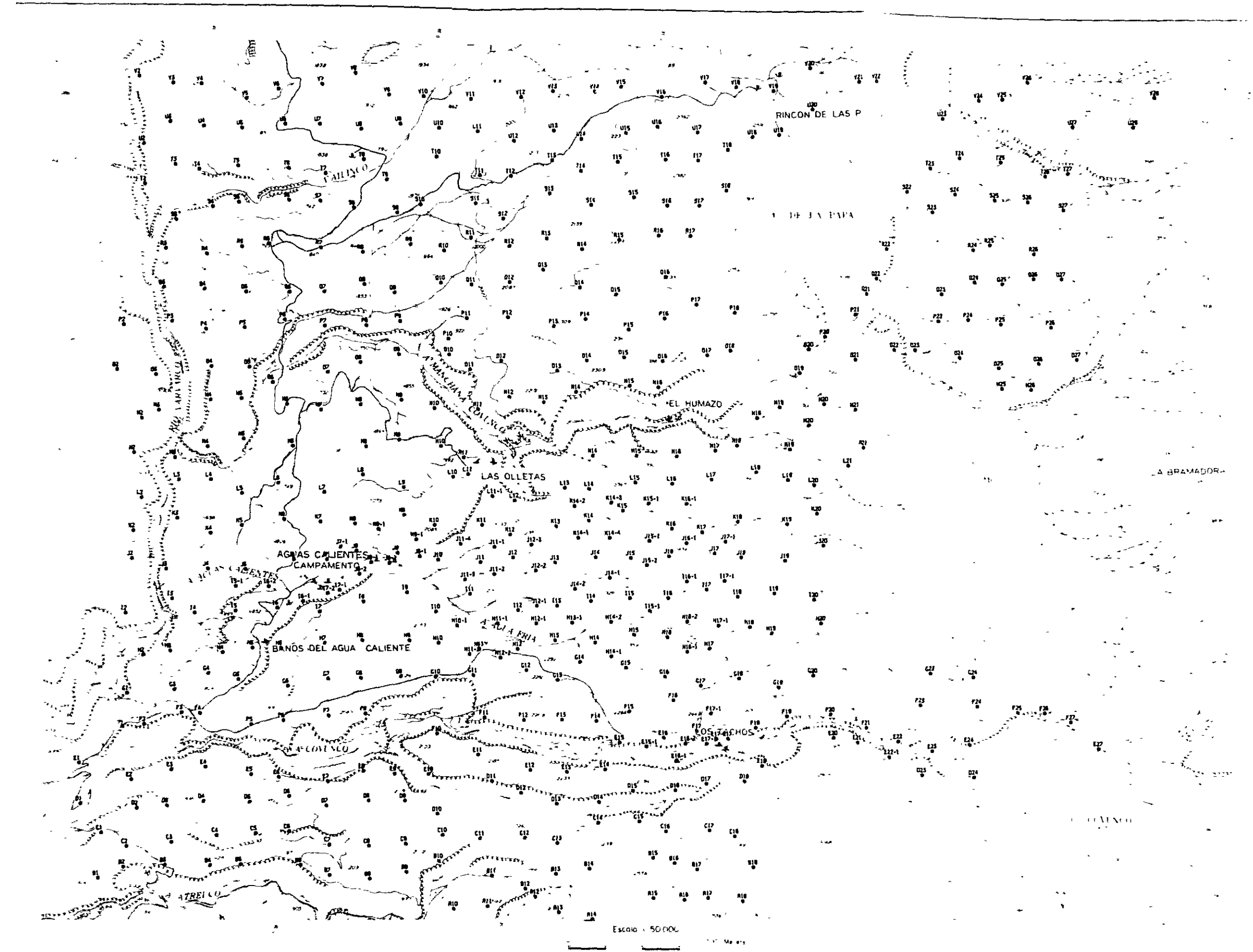


Fig.5-14 Location map of test holes at 1 meter depth

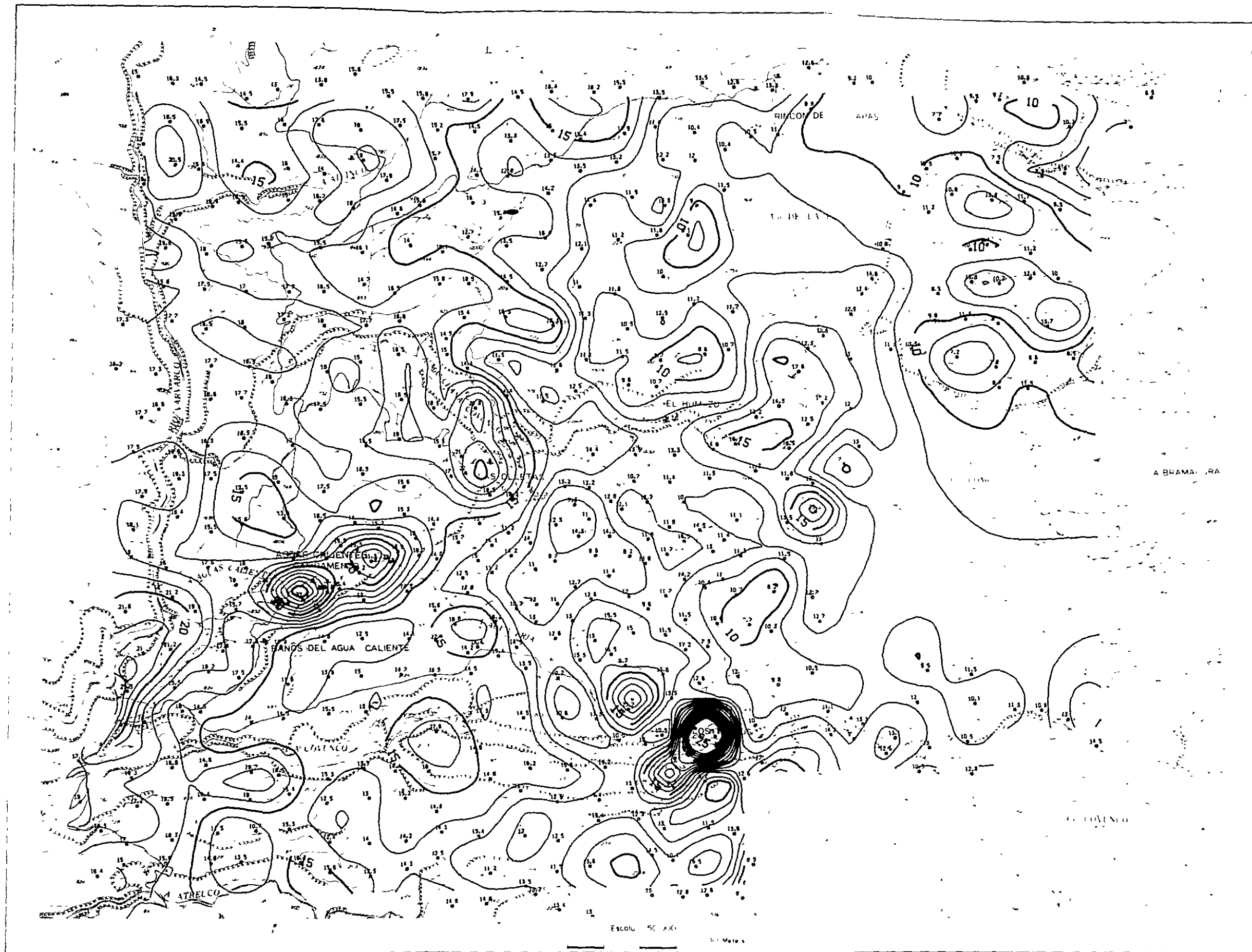


Fig.5-15 Distribution map of ground temperature at 1 meter depth

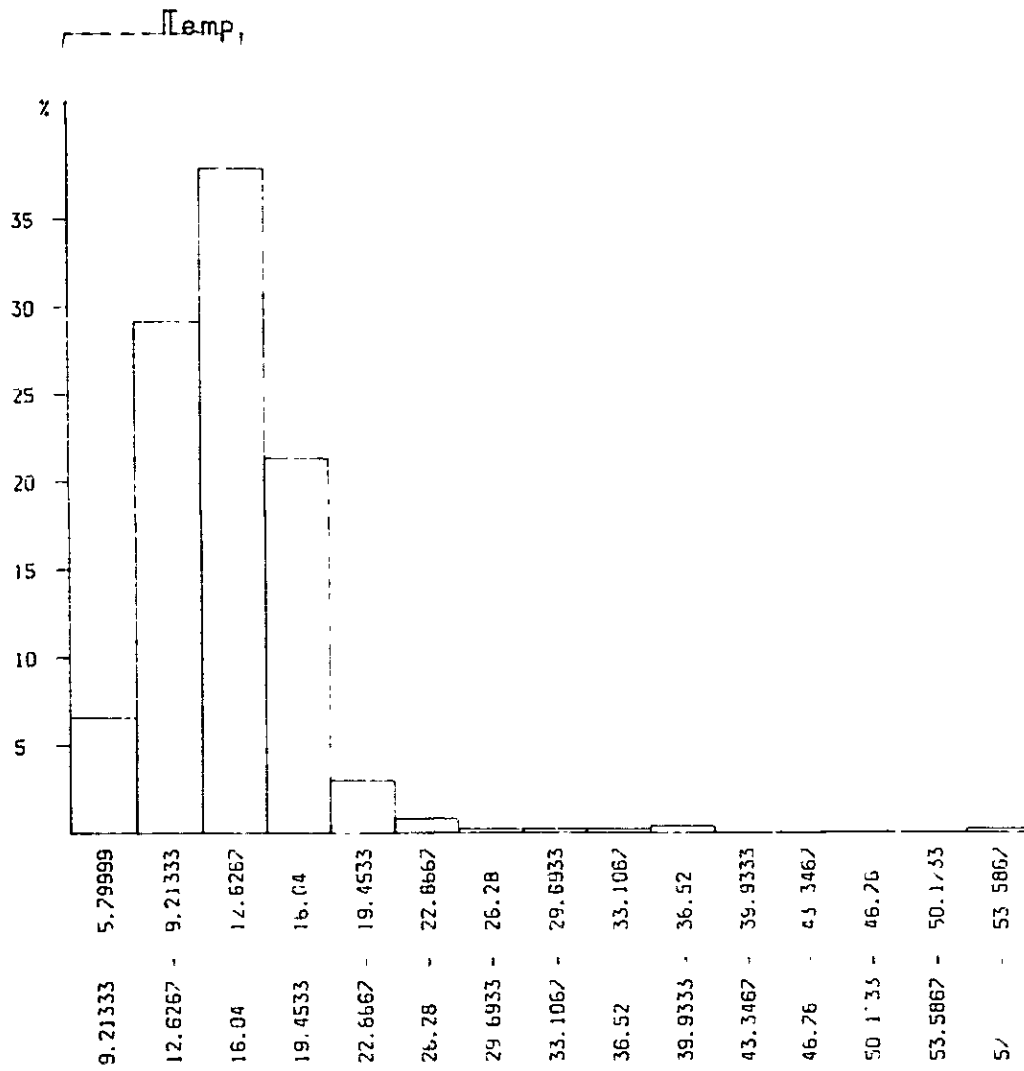


Fig.5-16 Frequency distribution of ground temperature at 1 meter depth

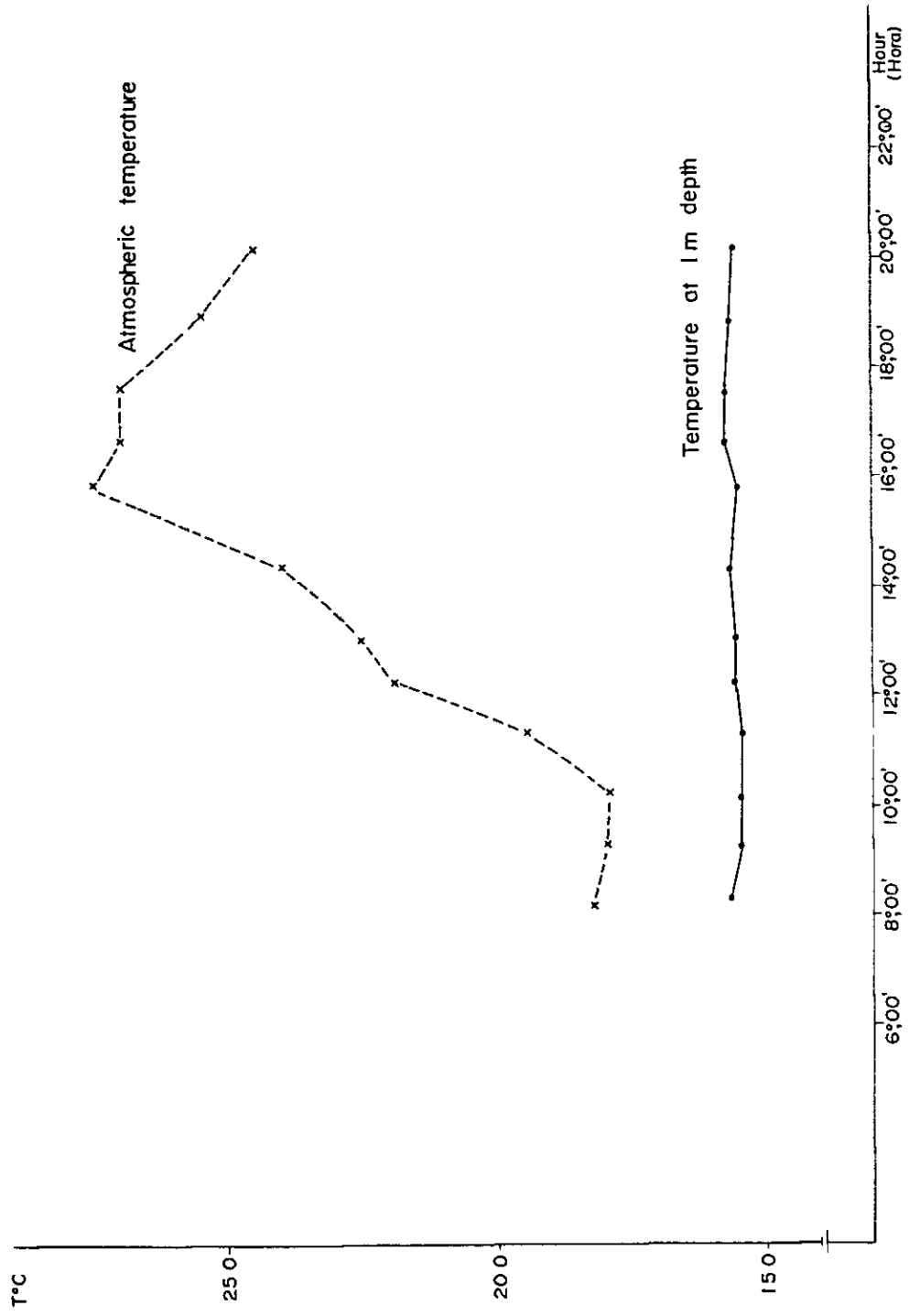


Fig.5-17 Diurnal variation of atmospheric and ground temperatures

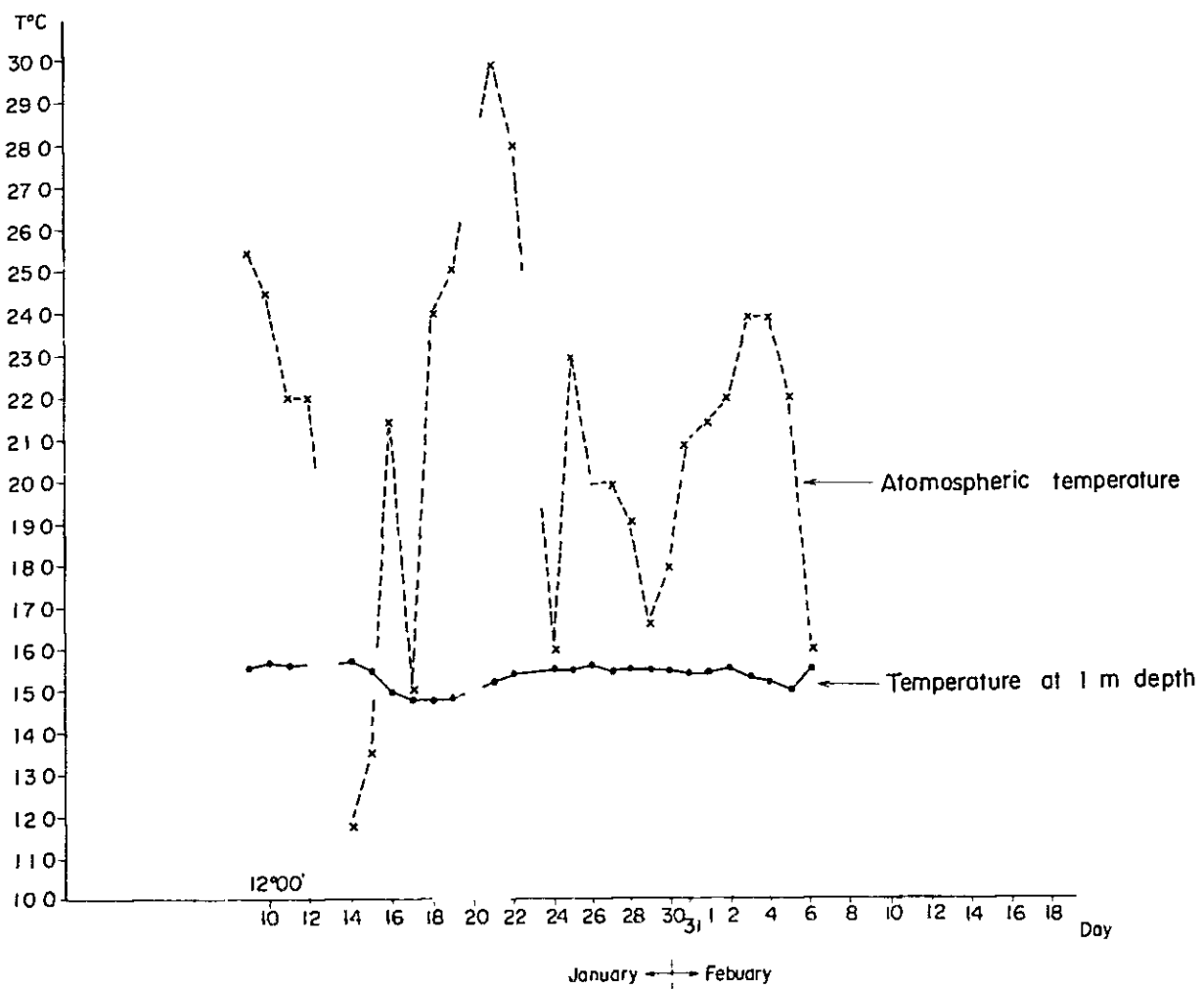


Fig.5-18 Observational results of variation of atmospheric and ground temperatures during period of 1 meter depth survey

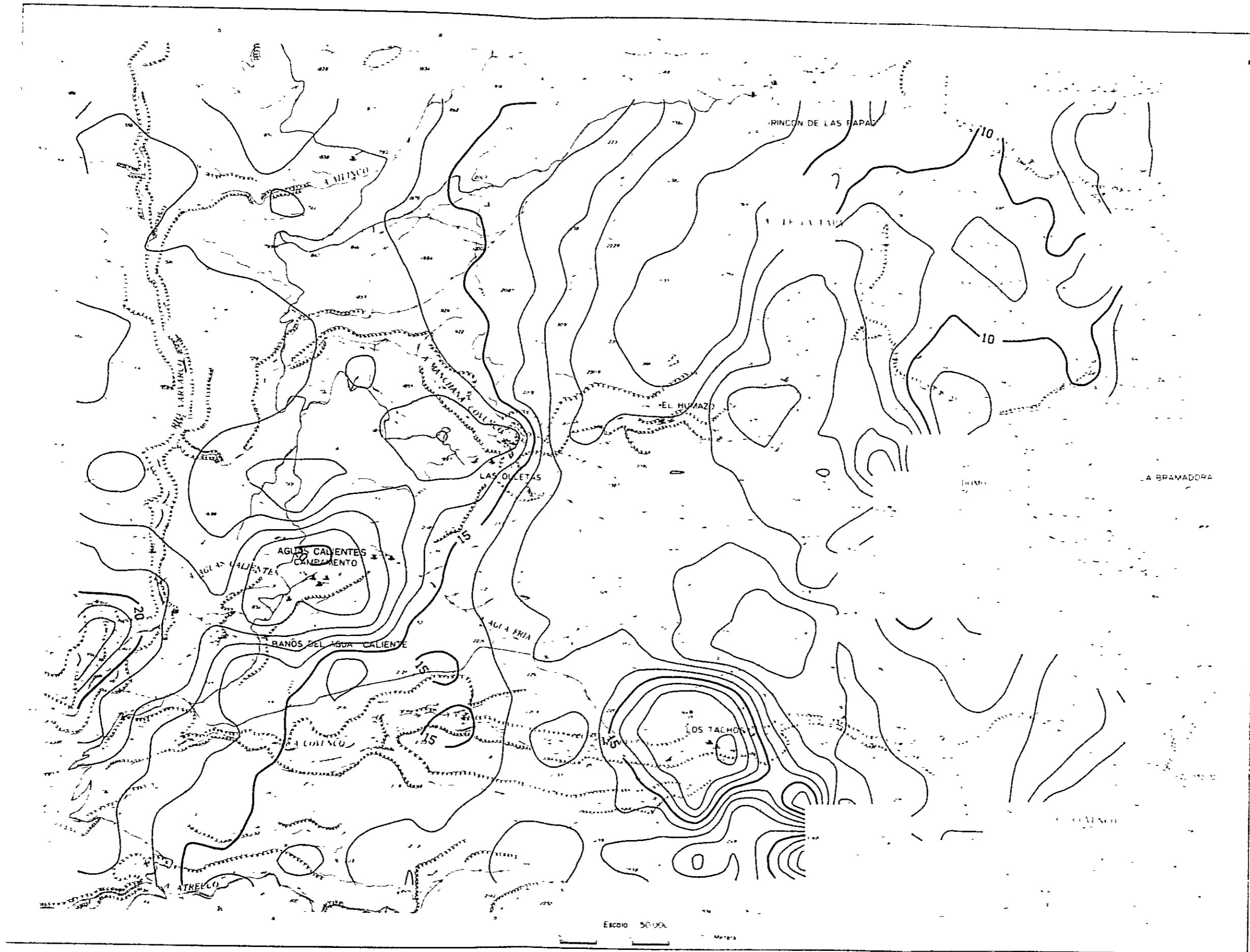


Fig.5-19 Distribution map of ground temperature at 1 meter depth by running average method

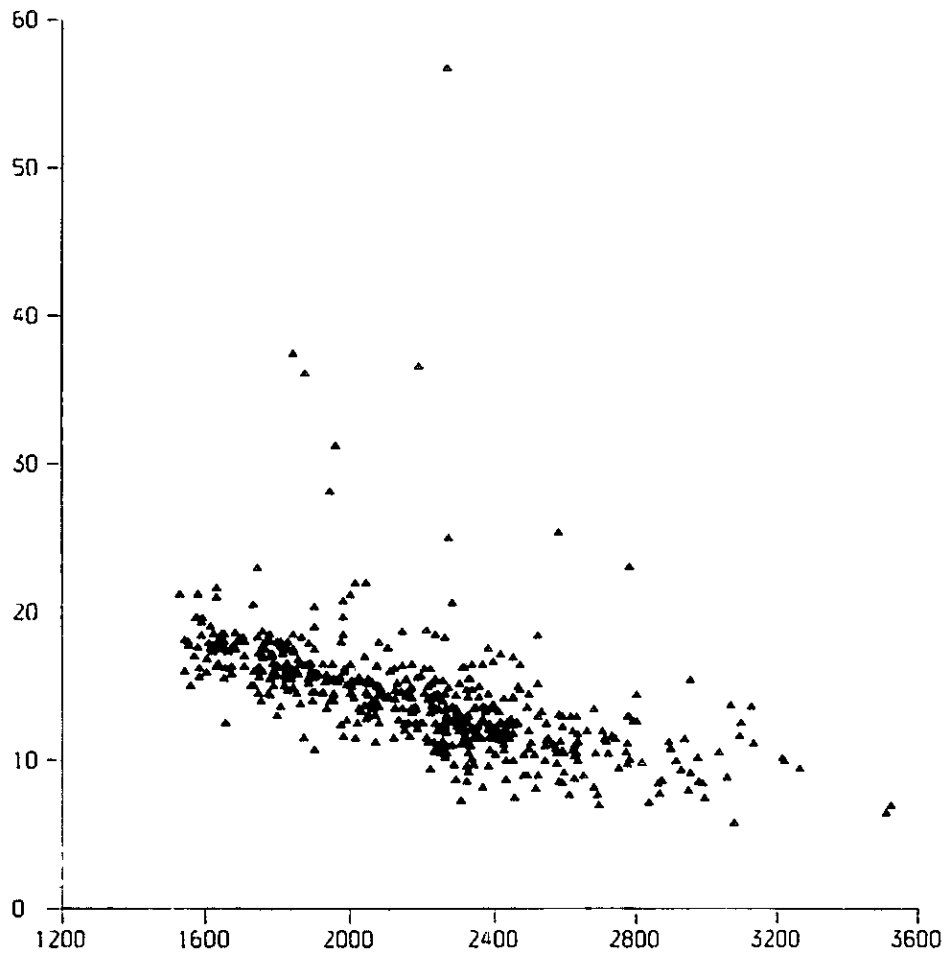


Fig.5-20 Relation between altitude and ground temperature at 1 meter depth

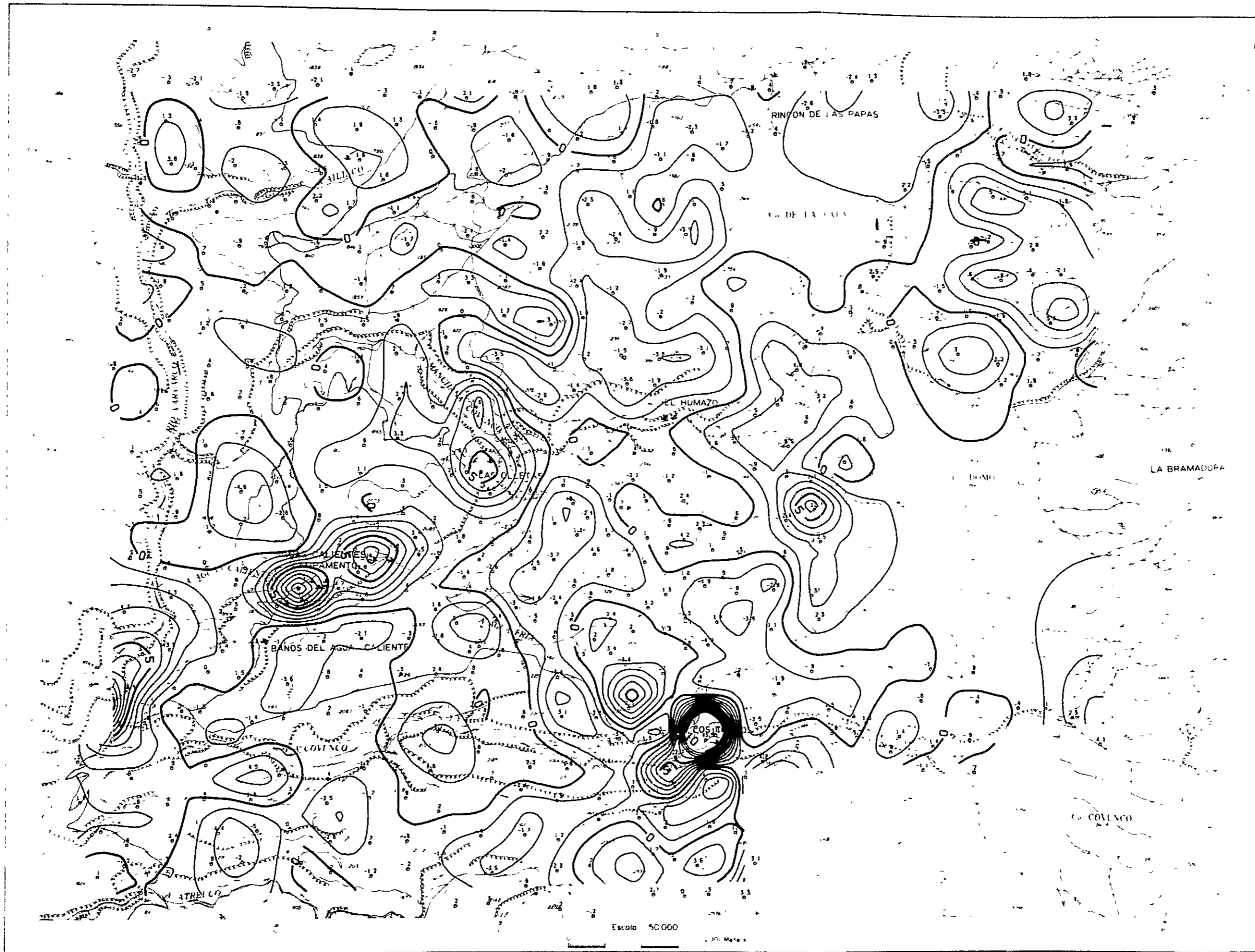


Fig.5-21 Distribution map of residual ground temperature at 1 meter depth (calculated by linear equation)

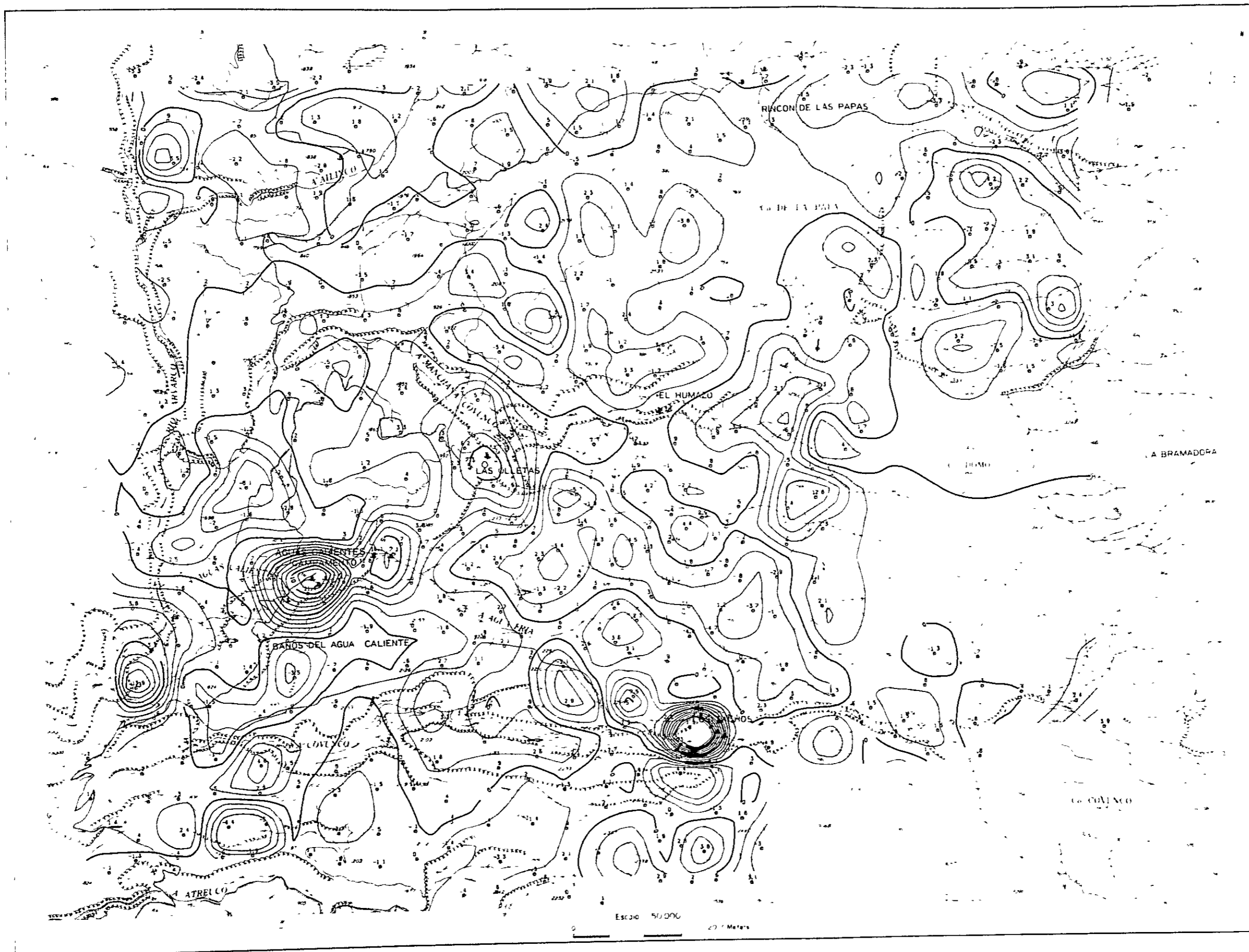


Fig.5-22 Distribution map of residual ground temperature at 1 meter depth (calculated by quadratic equation)

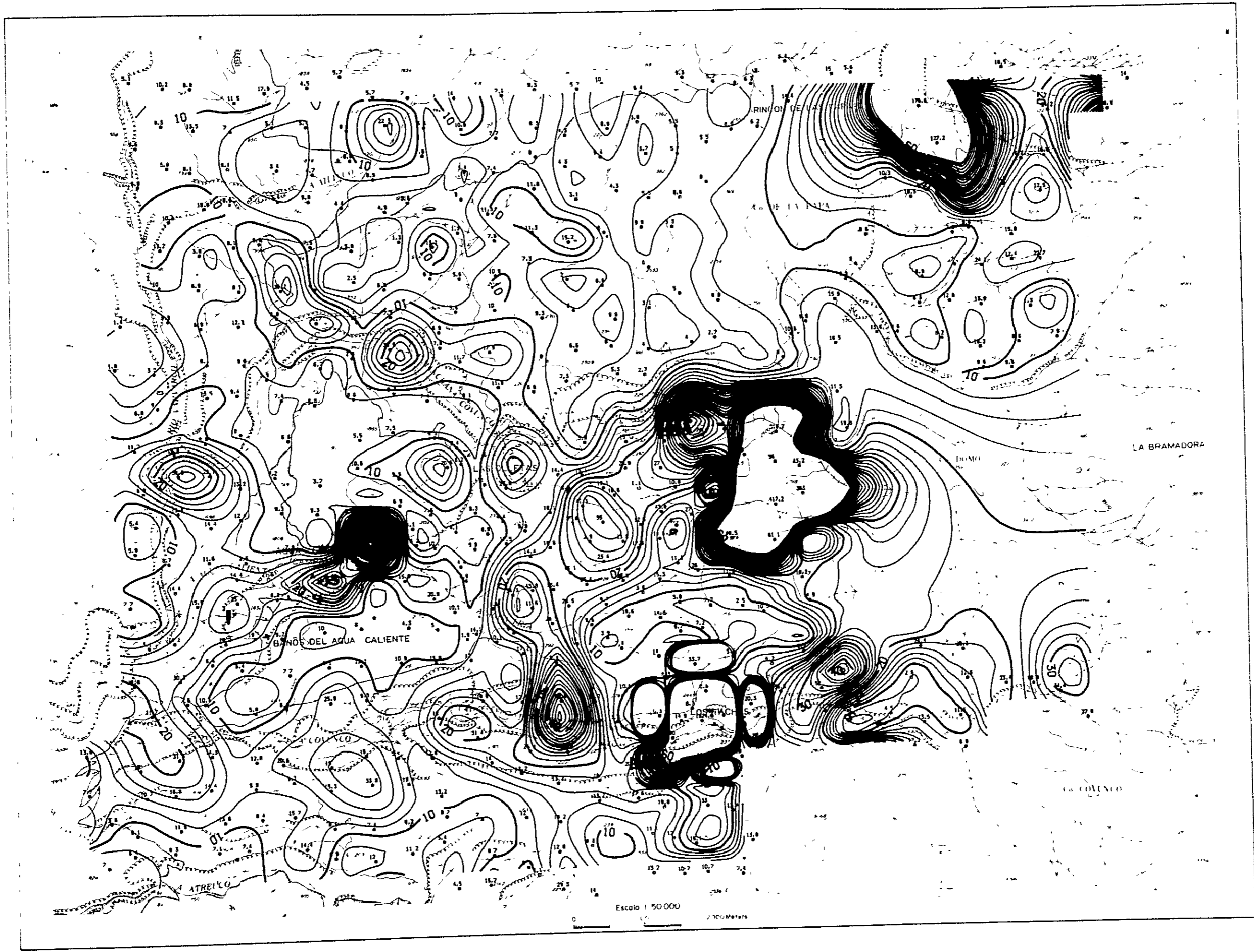


Fig.5-23 Distribution map of Hg - concentration in soil

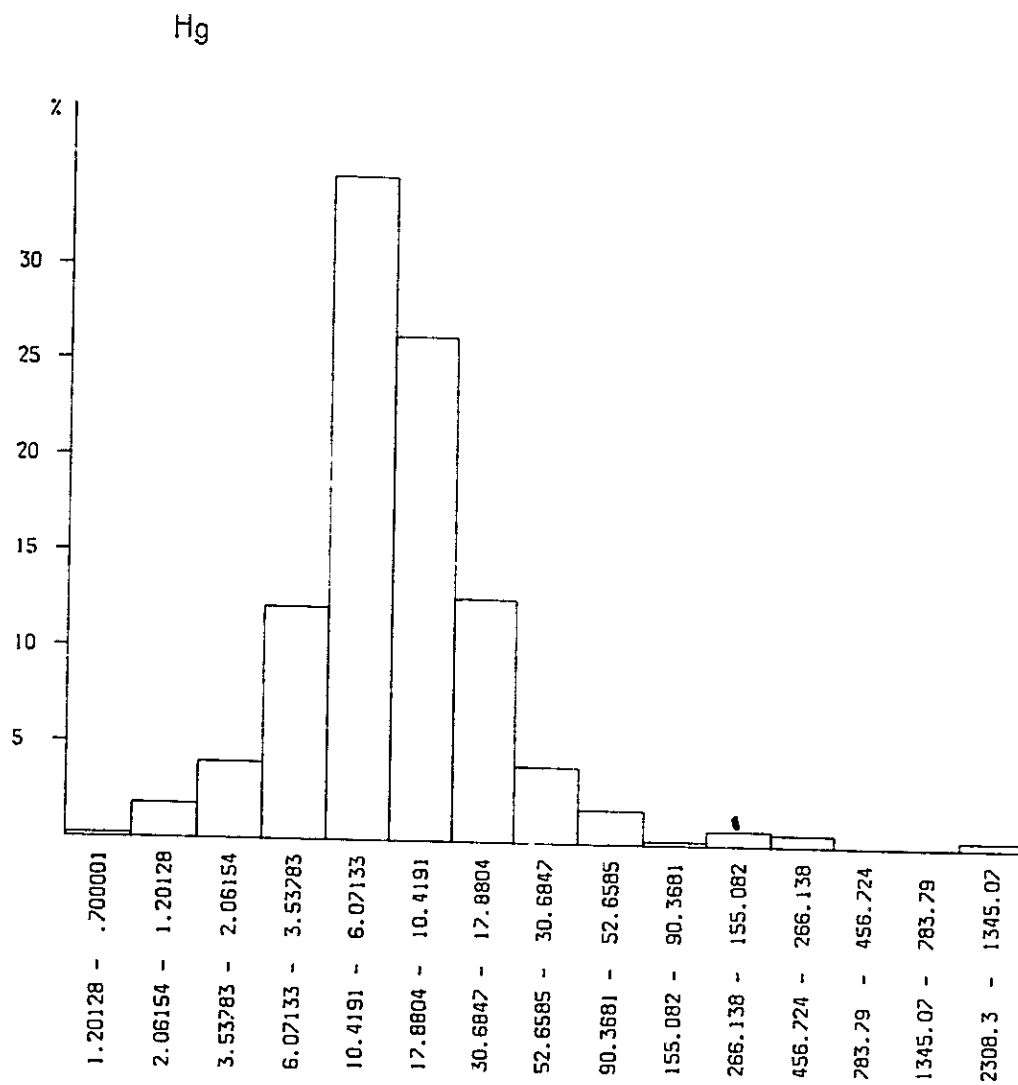


Fig.5-24 Frequency distribution of Hg - concentration in soil

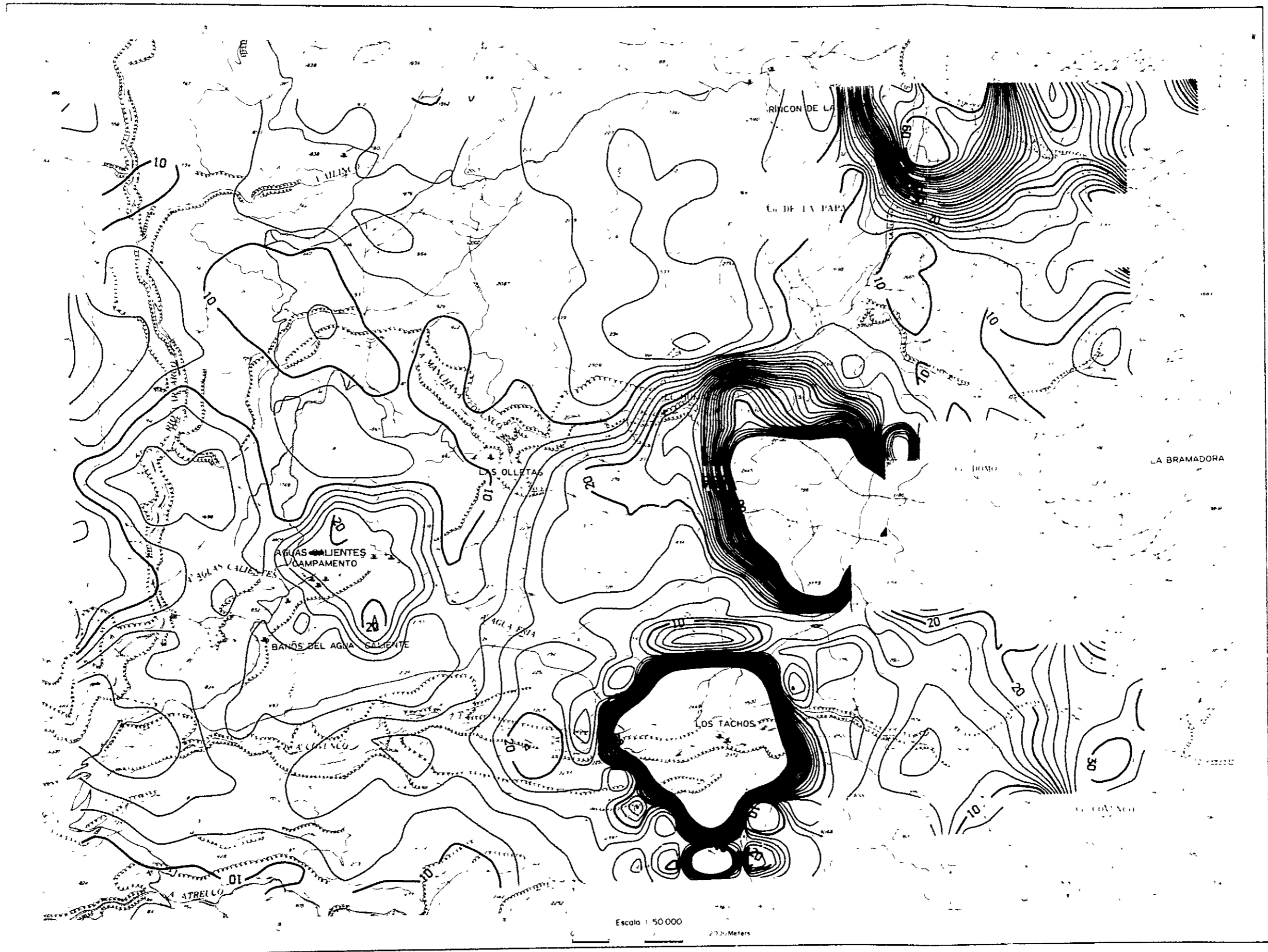


Fig.5-25 Distribution map of Hg - concentration in soil by running average method

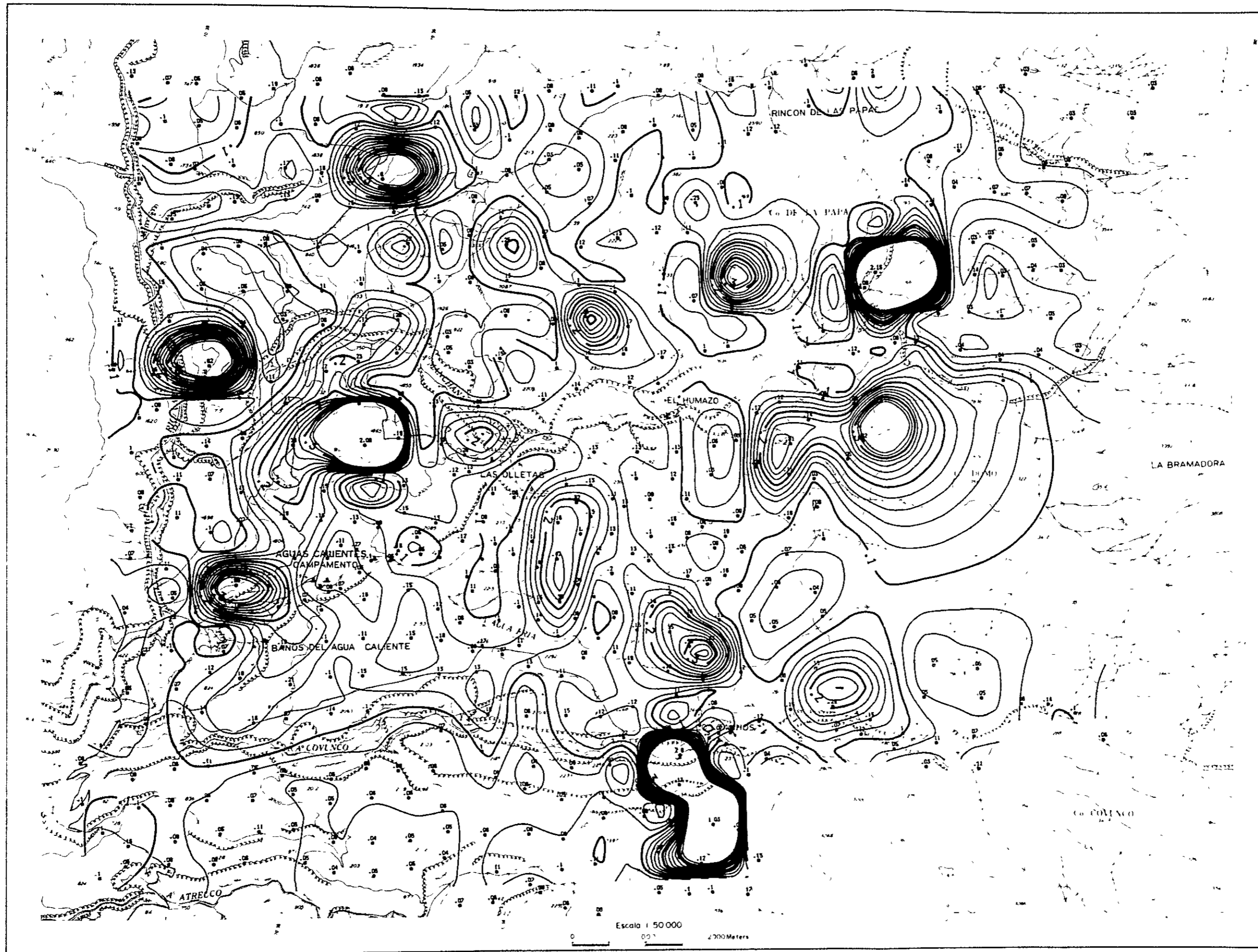


Fig.5-26 Distribution map of CO₂ - concentration in soil-air

C02

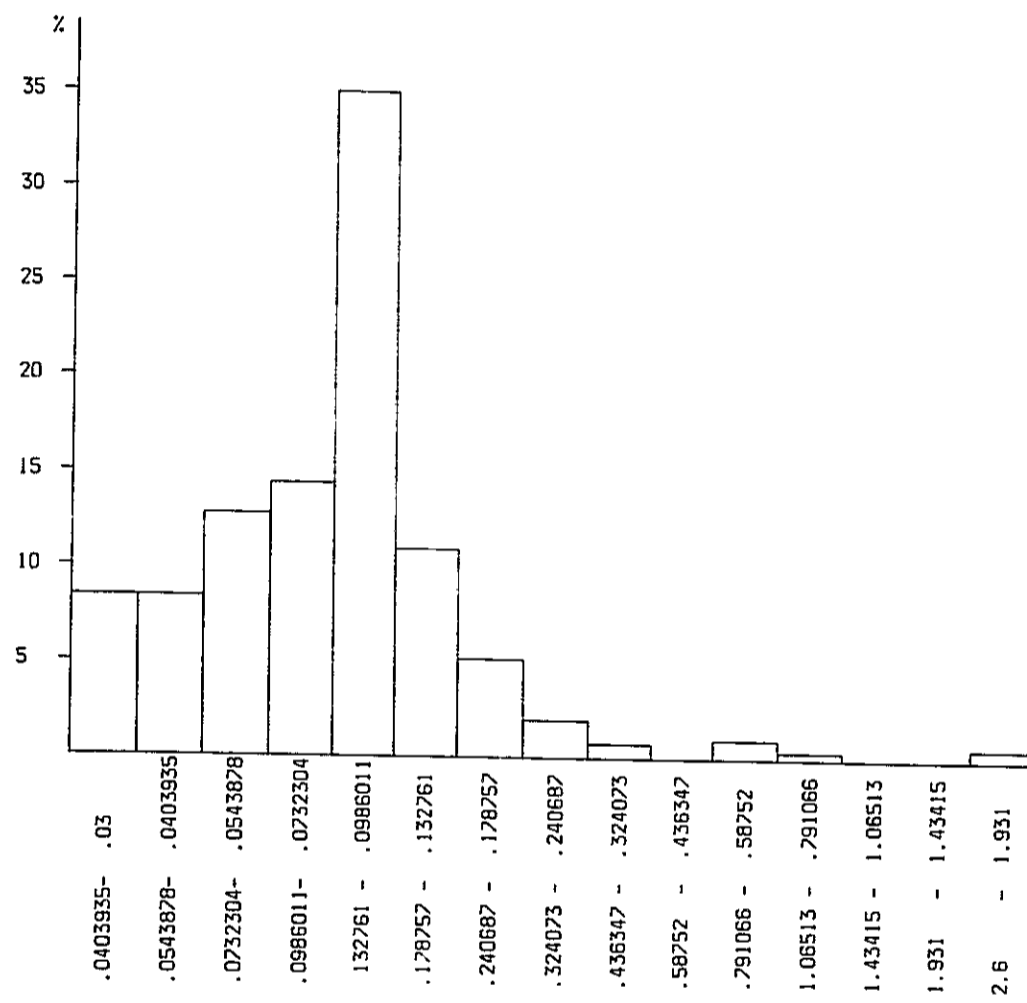


Fig.5-27 Frequency distribution of CO₂ - concentration in soil-air

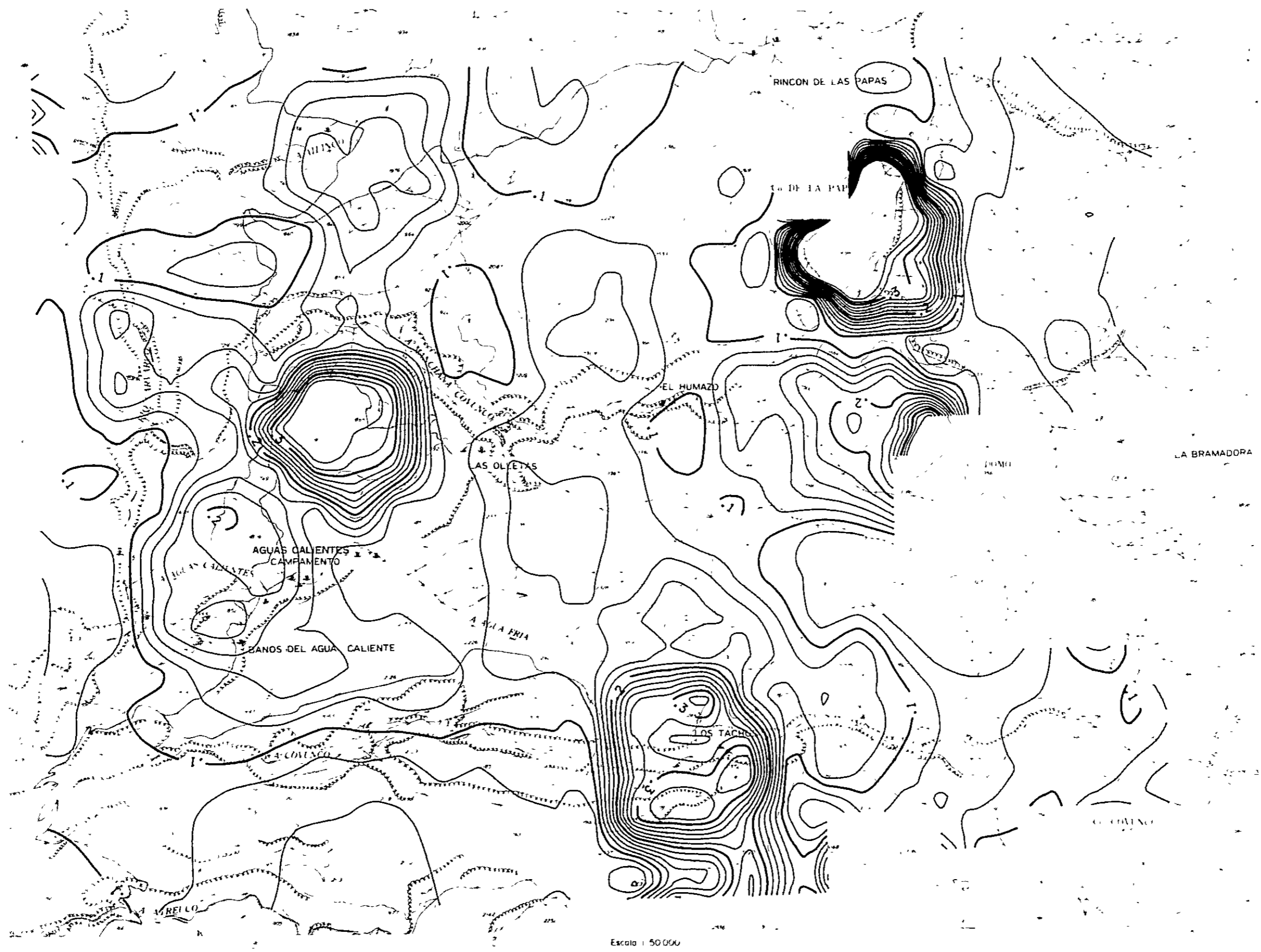


Fig.5-28 Distribution map of CO₂ - concentration in soil-air by running average method

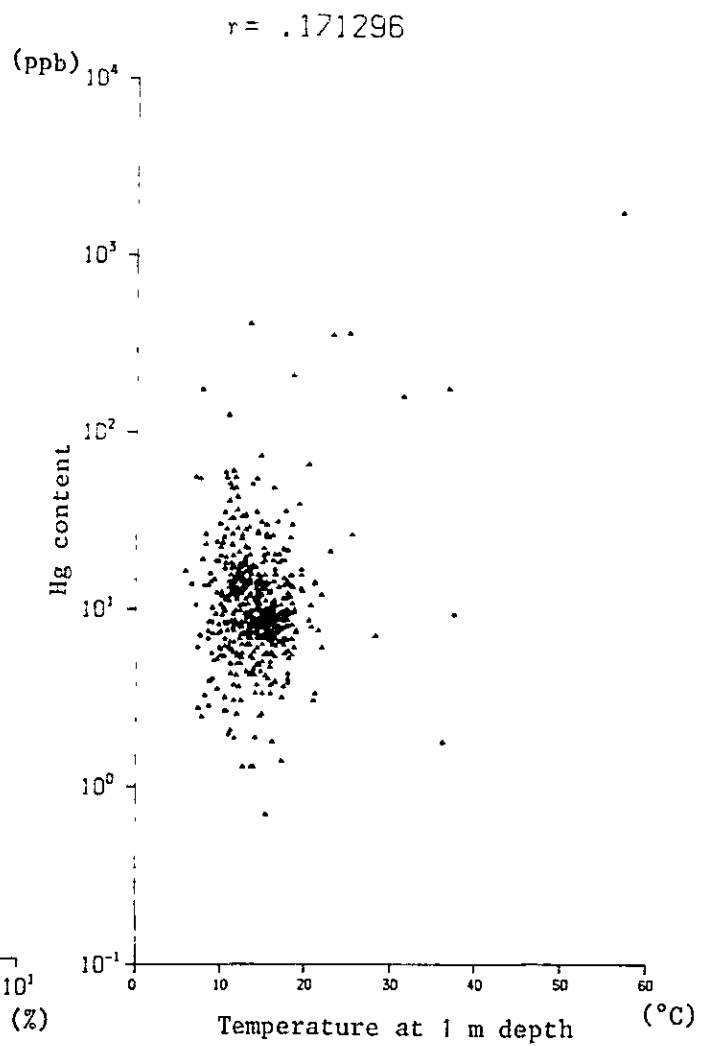
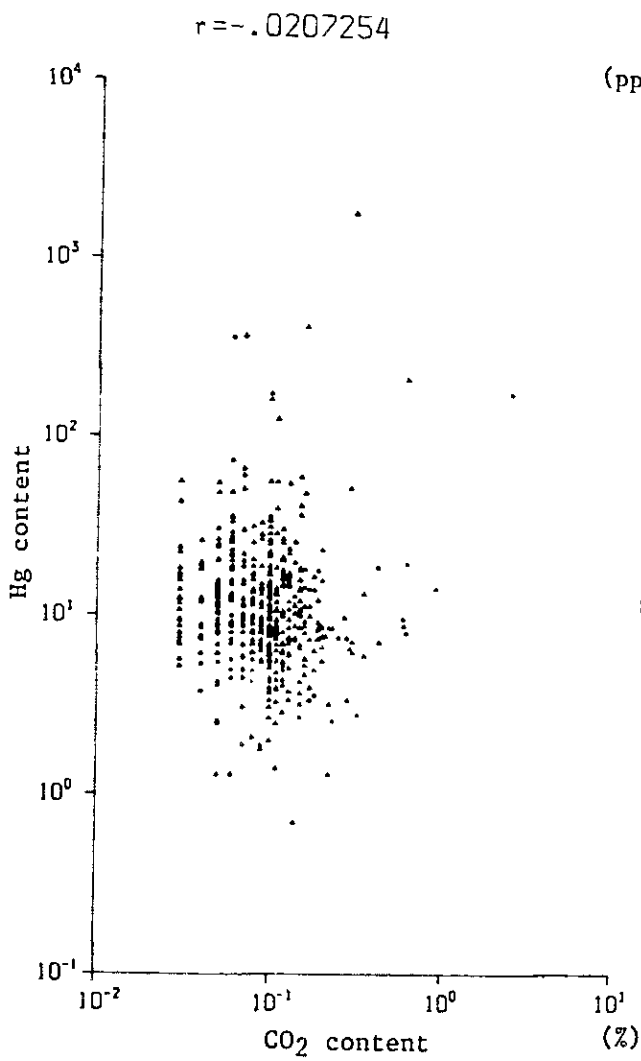
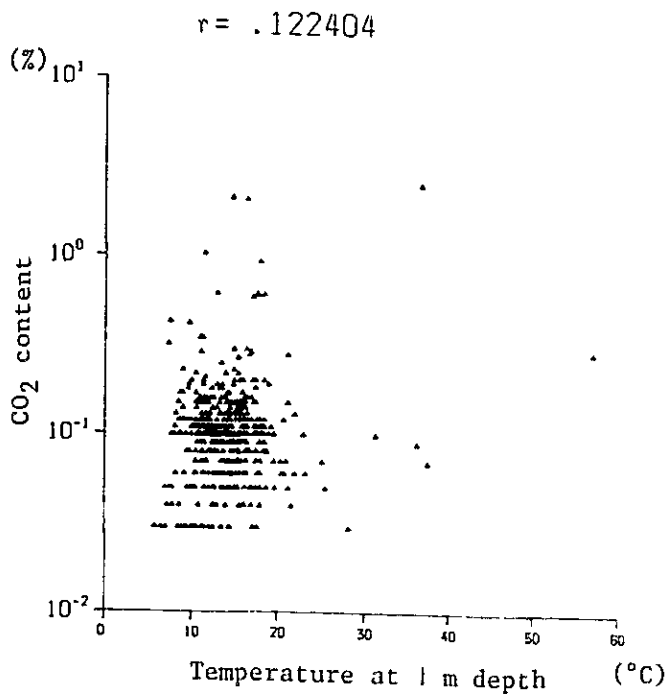


Fig.5-29 Correlations between ground temperature, and Hg and CO₂ - concentrations

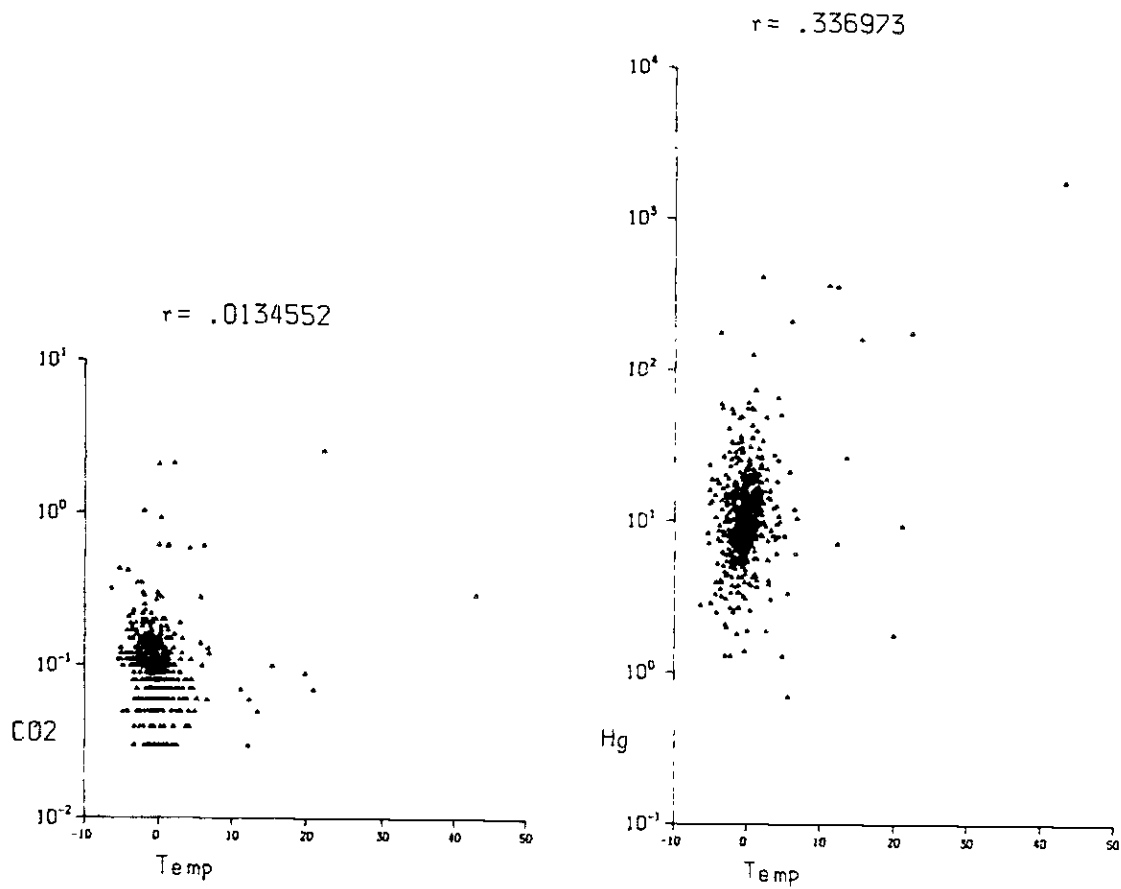


Fig.5-30 Correlations between residual ground temperature, and CO₂ - concentration(1) and Hg - concentration(2)

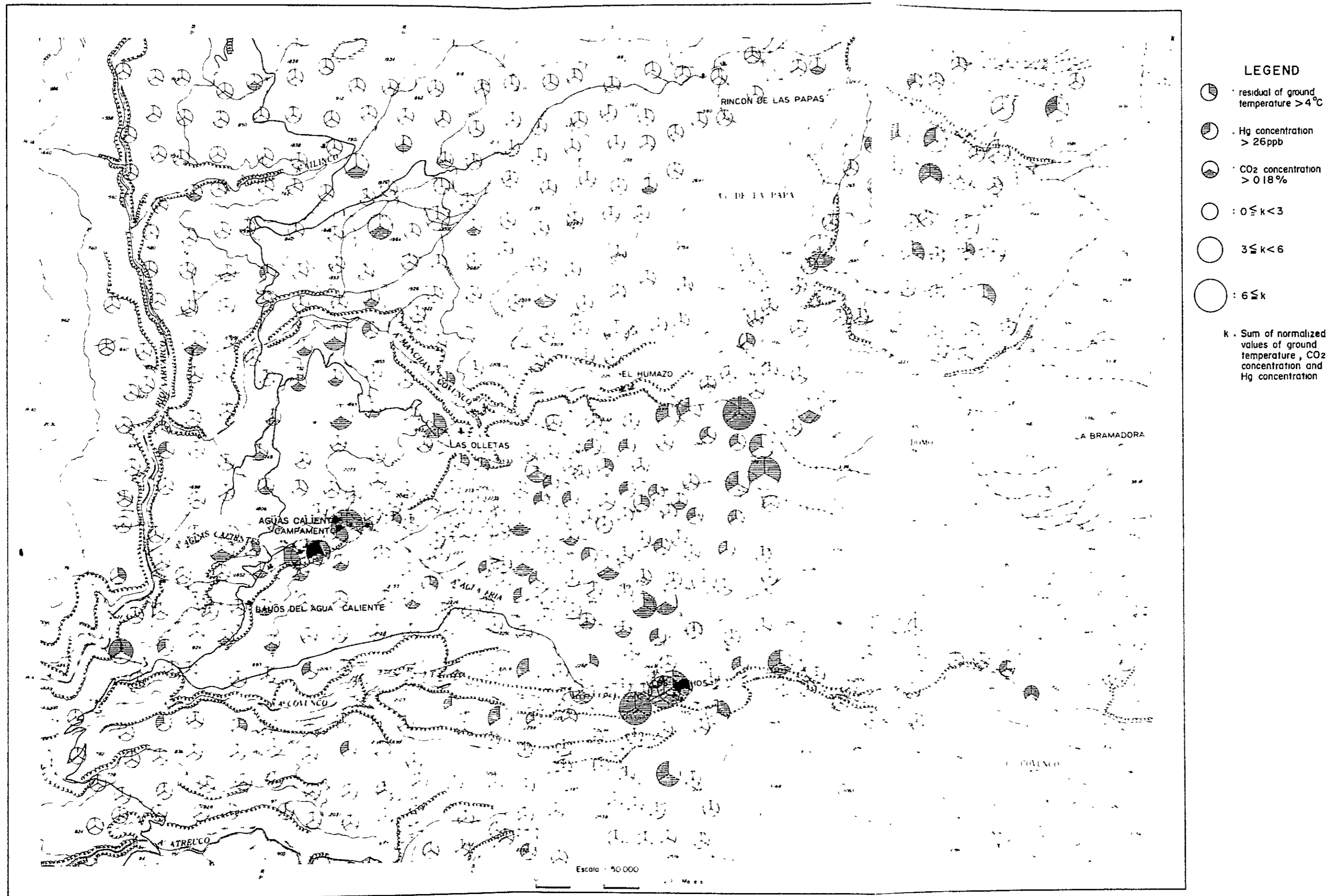


Fig.5-31 Relation map of anomalous values at 1 meter depth survey