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Geochemical exploration in the Montseny Mountains (NE Spain)

by X. FONT *, M. VILADEVALL *, A. CASAS * y R. VAQUER **

* Dpto. de Prospección Geológica y Geofísica. Fac. de Geología. Universidad de Barcelona.
** Dpto. de Petrología y Geoquímica. Fac. de Geología. Universidad de Barcelona.

ABSTRACT

A five year program of systematic multi-element geochemical exploration of the Catalonian Coastal Ranges has been initiated by the Geological Survey of Autonomic Government of Catalonia (Generalitat de Catalunya) and the Department of Geological and Geophysical Exploration (University of Barcelona). This paper reports the first stage results of this regional survey, covering an area of 530 km² in the Montseny Mountains, NE of Barcelona (Spain).

Stream sediments for metals and stream waters for fluoride were chosen because of the regional characteristics. Four target areas for future tactic survey were recognized after the prospect. The most important is a 40 km² zone in the Canoves-Vilamajor area, with high base metal values accompanied by Cd, Ni, Co, As and Sb anomalies.

Keywords: Catalanides. Geochemical exploration. Stream sediments. Base metal anomalies. Principal Component Analysis.

RESUMEN

En el marco de un convenio entre el Servei Geològic de la Generalitat de Catalunya y el Departamento de Prospección Geológica y Geofísica (Universidad de Barcelona), se ha emprendido un programa de exploración geoquímica multielemental en fase estratégica de las Cadenas Costeras Catalanas. El presente artículo da cuenta de los primeros resultados de esta exploración de carácter regional. La primera zona estudiada, cubriendo una extensión de 530 km², corresponde al Macizo del Montseny (NE de Barcelona).

Debido a las características fisiográficas de este macizo y en base a anteriores estudios de carácter local, se consideraron como idóneas la prospección de sedimentos aluviales para determinar los metales base e indicadores y la prospección hidrogeoquímica para determinar el flúor. Como resultado de esta campaña se han reconocido cuatro áreas con interés potencial para futuras prospecciones de carácter táctico, destacando una franja de unos 40 km² en la zona Cánoves-Vilamajor con valores anómalos de los metales base acompañados por Cd, Ni, Co, As y Sb.

INTRODUCTION

After the exploration of mineralisations in the NE of the Iberic Peninsula made during the period 1976-1980 (Viladevall, 1980), two main regions for further strategic multi-element geochemical exploration were defined: the Pyrinean and the Catalonian Coastal Ranges. This work was to be done in cooperation with the Geological Survey of the Autonomic Government of Catalonia, and began in 1981 (Font et al., 1983).

The previous stage of the program was a methodologic search in a reduced area of the region and as a result we found that stream sediments and waters were the best materials for prospecting in such a basis.

The first stage has been made in the Montseny Mountains, NE of Barcelona, covering an area of about 530 km². The results of this study are presented here.

GEOLOGICAL AND MINERALOGICAL FEATURES

Montseny Mountains comprise the Cambro-Ordovician (gneisses, micaschists, marbles, slates and shales), the Silurian-Devonian (shales, black shales, limestones and cherts) and the Carboniferous (shales, greywackes and cherts)

metamorphosed to medium-grade and intruded by granitic and porphiritic rocks of granodioritic to monzonitic-granitic composition and late Hercynian age (Viladevall, 1975; Casas, 1979; Julivert and Martínez, 1980).

Triassic sediments cover the SW border and are built up of conglomerates, sandstones and clays of Buntsandstein facies.

The Cenozoic contain marls, clay and sandstone in the NW and SE, filling up the Ebro and Valles depressions limited by NNE-SSW (IGME, 1976).

Three main types of mineralisations can be distinguished (Font, 1983):

1) Magnetite-pyrrhotite or magnetite-sphalerite-scheelite (galena-chalcopyrite) skarns in the Cambro-Ordovician limestones.
2) Large F-Ba (Pb-Zn) veins and Pb-Zn (Ba) small veins associated to E-W faults.
3) Many veinlets of Ba trending NW-SE and NE-SW, and some veins of Cu, direction N-S.

SAMPLING

The physiographic features of the region (alpine type), with a well-developed drainage system forming small basins, carried us to use stream sediments for metals and stream waters for fluoride on a strategic basis. Soils are scarce and shallow owing to steep slopes, hence they were not used at this stage.

Sampling sites were chosen after an orientation survey performed to determine the length of dispersion trains. The results of which indicates a sampling interval of 400-500 m for sediments and 600-700 m for waters along the streams (Font, 1983). A total of 1069 stream sediments and 790 stream waters were collected covering an area of about 530 km^2 (fig. 1).

Samples were taken from the active stream channel, where posible, and no special attention was paid to seasonal variations of waters because no significant (10-15 %) differences were observed between dry and wet seasons.

ANALYTICAL PROCEDURE

Fluoride in waters

The specific-ion electrode method has been used because of easy operation, high sensitivity (50 ppb in routine measures) and precision (better than 5 % relative).

Samples and standards are mixed 1:1 with TISAB (Total Ion Strength Absorption Buffer) and measurements made under standard calibration procedure between 0,1 and 10 ppm.

Stream sediments

After drying, the minus 80 mesh fraction was used. Sample solution was performed with aqua regia (1 g. sample and 5 ml. of aqua regia), the final volume beeing 25 ml.

AAS flame measurements were made for Pb, Zn, Cu, Fe, Mn, Co, Ni, Cd and Ag with good (better than 5%) analytical precision. Detection limits where satisfactory for all elements except Cd (2 ppm in stream sediments). Standards were corrected for Na, K and Ca (matrix effect).

Evaluation of the sampling error, sample treatment and analysis by flame AAS in duplicate samples gives deviations less than 20 % relative. Most differences can be atributed to sample heterogeneities because physical dispersion seems to be dominant.

Hydride-forming elements As, Sb and Hg were determined by AAS using sodium borohydride as a reductor. Analytical precision is better than 25 % relative at low contents and better than 10 % at high concentrations.

STATISTICAL TREATMENT OF DATA

For statistical purposes four different populations related to main lithologies of the region were considered: slates of low metamorphic grade, granitic rocks, Triassic sandstones and Tertiary marls.

Univariate analysis

Analisys of data distribution was made by constructing the frequency distributions and cumulative curves of the elements following the graphical procedure of Lepeltier (1969). The

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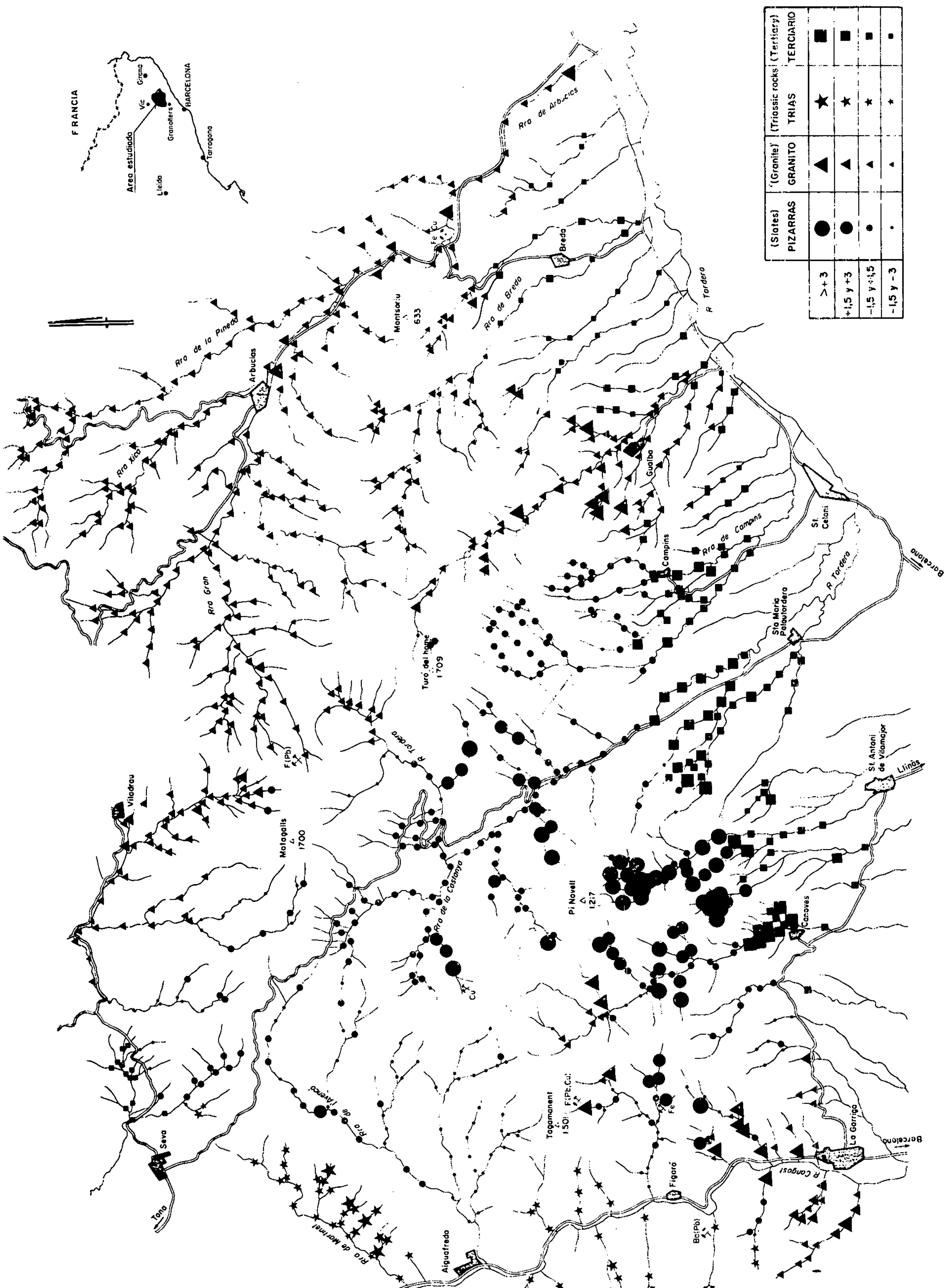
Figure 1. — Principal Components map of factor 1 (Pb - Zn - Cu - Ni - Cd - As). Factor scores are expressed in standard deviations.

Figura 1. — Mapa de los componentes principales del factor 1 (Pb - Zn - Cu - Ni - Cd - As). Las cargas factoriales están expresadas en unidades de desviación estándard.



FRANCIA
Vic
Girona
BARCELONA
Granollers
Tarragona
Lleida
Area estudiada
(Slates) PIZARRAS
(Granite) GRANITO
(Triassic rocks) TRIAS
(Tertiary) TERCIARIO
>+3
+1,5 y +3
-1,5 y +1,5
-1,5 y -3
Rra de Arbucies
Fe Cu
Breda
Rra de Breda
Montsoriu 633
R Tordera
Rra de la Pineda
Arbucias
Rra Xica
Gualba
Campins
Rra de Campins
St. Celoni
Barcelona
Rra Gran
Turó del home 1709
R Tordera
Sta Maria Palautordera
F(Pb)
Viladrau
Matagalls 1700
Pi Novell 1217
Rra de la Costanya
Cu
St. Antoni de Vilamajor
Llinàs
Cànoves
0 1 2 3 4 5Km
Seva
Rra de l'Avenco
Tagamanent 1501
F(Pb.Cu)
Fe
Figaró
La Garriga
R Congost
Tona
Rra de Martinet
Aiguafreda
Bc(Pb)
Vic

Table I. — Statistical parameters of main elements analyzed.

Tabla I. — Parámetros estadísticos de los principales elementos analizados.

		Pb (ppm)	Zn (ppm)	Cu (ppm)	Ni (ppm)	Cd (ppm)	Ag (ppm)	As (ppm)
Granites	range	2-624	15-1125	1-146	2-925	1-140	0,2-5,3	0,03-5,7
	mean	20,6	53,6	8,7	7	1,3	0,35	0,5
	st. dev.	3,75	1,6	2,3	2,1	1,1	1,6	3,1
Slates	range	10-815	18-2350	3-1485	8-138	1-35	0,2-5,3	0,2-120
	mean	74	209	33	36	3,7	1	8,7
	st. dev.	2,6	2,9	1,9	16,8	3,3	1,8	2,6
Triassic	range	8-55	10-108	3-30	8,30	1-2	0,2-3,4	0,3-9,2
	mean	22,6	32,4	10,3	16,6	1,4	0,6	2,7
	st. dev.	1,5	1,5	1,6	5,8	0,5	2,1	1,8
Tertiary	range	10-595	10-975	1-125	3-50	1-5	0,2-2,3	0,2-38,2
	mean	42,4	83	16,3	25	1,9	0,6	4,3
	st. dev.	2	2,2	2,7	14	1,2	1,9	2,6

normal or lognormal character of each element distribution was determined in the four lithologies. Background and threshold values were calculated afterwards (table I).

Four kinds of samples have been considered:

— Background: between x and x+s or x_g and $x_g.s_g$.

— Possible anomaly: bettween x+s and x+2s or $x_g.s_g$ and $x_g.s_g^2$.

— Probable anomaly: between x+2s and x+3s or $x_g.s_g^2$ and $x_g.s_g^3$.

— True anomaly: more than x+3s or than $x_g.s_g^3$.

Bi and Multivariate analysis

Correlation coefficient matrix and Principal Component Analysis have been made for each lithology. Three factors explaining the 65-70 % of total variance were chosen. In each factor or component, loadings higher than 0.4 of the elements were considered significant. The factor or component 1, called «mineralisation component» is common to the four lithologies and comprises the elements association: Pb-Zn-Cu-Ni-Cd-As (fig. 1). This component must be associated to mineralisations of skarn type or complex sulfide type (still unkown in the area).

Component 2 and 3 are of minor importance in this stage of the investigation, only component 2 in slates of low metamorphic grade involving Cu-Ag-Hg were considered. This component is possibly associated to copper veins known in the area, or related to the presence of black shales.

From the results of the statistical treatment of data some interesting points arise:

— Pb and Zn are only significantly correlated in slates of low metamorphic grade. Both elements show no enrichment in Fe and Mn oxides.

— Ag and Pb are not associated in any lithology, having very low correlation coefficients.

— Cu has a fairly good correlation with Ag and Hg only in pelitic paleozoic materials. In the others lithologies, correlate well with Zn, Co, Ni and As.

— Hg shows no general correlation with any element.

CONCLUSIONS

Four main target areas for future tactic survey were recognized (fig. 1):

1) A 40 km² zone of Zn, Pb and Cu high values, acompanied by Cd, Ni, Co, As and Sb anomalies in the SW of the prospect. Rocks are pelites and limestones of Upper Ordovician to Carboniferous age. This geochemical association coincides with the first

factor of Principal Component Analysis, explaining 41 % of total variance.

2) A group of Pb-Zn (Ag) and Co, Ni, Sb and As anomalies with moderate values occur in Triassic deposits at the NW of the Montseny (factors 1 and 2 of this lithology).
3) A conspicuous anomaly of Zn, Cu, Pb and Co at the SE associated with marbles and gneisses (skarn-type mineralisation) of Cambrian age. No statistical treatment could be made in skarns because of the small number of samples (34).
4) A strong anomaly of Hg of the SE and NW without apparent relation to target areas 2) and 3).

There are several scattered anomalies of F in water associated with fluorite-barite veins.

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