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PROJECT 276
Paleozoic of the Tethys

The Hercynian ore deposits from the Catalonian Coastal Ranges

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ABSTRACT

Many mineralizations, showings and geochemical anomalies have been found in the Hercynian of the Catalonian Coastal Ranges during the last ten years. Many of them are enclosed in the Paleozoic sediments and volcanics and display pre-metamorphic syngenetic characteristics. The lower Carboniferous manganese and base metal deposits appear to be formed from hydrothermal fluids springing up in the sea floor through active fractures controlling the filling of the basins in a extensional geotectonic setting. Although less evidence and more controversy is available, similar ore forming processes could have taken place in older Paleozoic times. The deformation and metamorphism have not played an important remobilization role, and most epigenetic deposits of Hercynian age are related to the hydrothermal cells induced by the post-metamorphic granitic intrusives.

Key words: Sedex. Base metals. Metallogeny. Hercynian. Carboniferous. Extensional tectonics.

RESUMEN

Numerosas mineralizaciones, indicios o anomalías geoquímicas, han sido localizadas durante los últimos años en el Hercínico de las Cordilleras Costeras Catalanas. Muchos de ellos se localizan en metasedimentos o metavulcanitas y evidencian características singenéticas pre-metamórficas. Diversas mineralizaciones de manganeso y metales base en el Carbonífero Inferior se depositaron por el vertido de soluciones hidrotermales en un fondo submarino, a través de fracturas sinsedimentarias que controlaban a su vez la morfología de la cuenca, en un contexto geodinámico de extensión. Aunque con reservas, similares procesos metalogenéticos habrían actuado en el Paleozoico Inferior del área. La deformación y el metamorfismo regional hercínicos no han actuado en este sector como un importante reconcentrador de menas, y la mayor parte de indicios epigenéticos de edad tardihercínica están relacionados a las células hidrotermales inducidas por las intrusiones graníticas post-metamórficas.

Palabras clave: Sedex. Metales-base. Metalogenia. Hercínico. Carbonífero. Tectónica extensional.

INTRODUCTION

The Hercynian materials of the Catalonian Coastal Ranges (CCR) are constituted by Paleozoic metasediments and metavolcanics and post-metamorphic granitic intrusives. They are outcropping, often in limited surfaces, inside ranging NE-SW horst structures generated by the Neogene tectonics. The age, as well as the metamorphic grade of the Paleozoic series, decreases from the northern to southern outcrops, the lower Paleozoic and high metamorphic grade generally being found in the Montseny and Guilleries Massifs, whilst the anchimetamorphic Carboniferous predominates in the Priorat-Serra de Prades outcrops (Fig. 1).

A distinction will be made in the following pages between pre-Carboniferous and Carboniferous according to the available data on the geology and ore deposits. These are more scarce and contradictory in the first

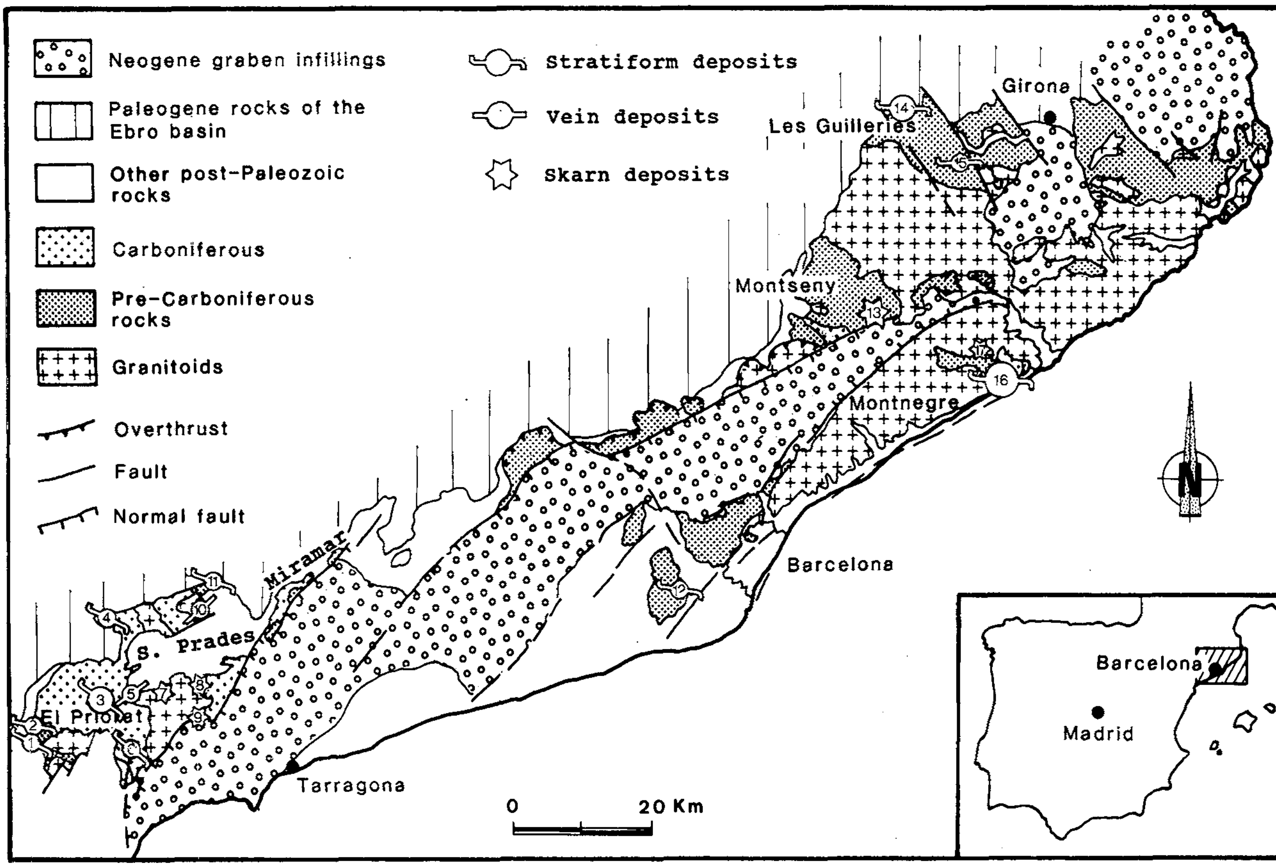

Figure 1.- Distribution of hercynian ore showings into Catalonian Coastal Ranges: 1) Pb-Zn bearing prehercynian series from El Molar; 2) Mn bearing tournaisian sedex (Priorat); 3) Cu-Zn-Pb-Ag bearing namurian sedex (Alforja); 4) Cu-Pb-Zn bearing namurian sedex (Ulldemolins); 5) Cu-Sn bearing late-hercynian vein (Alforja); 6) Pb-Zn bearing visean sedex (L'Argentera); 7) Cu-Zn-Ag-Au bearing skarn (Alforja); 8) Zn-Pb-Ag-Au-Sn bearing skarn (La Selva del Camp); 9) Cu-Zn-Fe bearing skarn (Les Borges del Camp); 10) W-(Pb-Zn-Mo-Bi-Ag) bearing veins (Poblet); 11) Cu bearing LLandoverian sedex (Poblet); 12) P-Fe bearing silurian sedex (Gavà); 13) W-Cu-Pb-Zn-Sn bearing skarn (Gualba); 14) Sant Martí Sacalm cambrian with Pb-Zn-W ores; 15) Sant Julià de LLor with Pb-Zn-Cu ores; 16) Fe silurian ores (Malgrat); 17) Cu bearing skarn (Orsavinyà). Geology slightly modified after Julivert *et al.* (1987).

case, mainly due to the higher deformation and metamorphism and to the availability of representative exposures.

PRE-CARBONIFEROUS

The pre-Carboniferous of the CCR have been synthetically described by Julivert *et al.* (1987). The series display such significant differences from those of adjacent Hercynian provinces,that they have moved these authors to propose a facial Mediterranean province.

Most of the lower Paleozoic sediments outcrop in the Guilleries and Montseny Massifs and are constituted of a leucocratic gneiss overlain by a thick pile of schists and fine grained sandstones with carbonates, amphibolites and silicates interbedded in its lower part. The ensemble is deformed and affected by the Hercynian metamorphism of medium to high grade. These lithologies can be broadly correlated with the Canavelles and Jujols series (Cavet, 1957), and other ones described as Cambro-Ordovician in the Eastern Pyrenees (Ayora and Casas,1986; Carreras and Santanach,1983). The age of the whole series is unknown, they are overlain by fossiliferous Caradoc-Asghill and are traditionally considered as the most ancient sediments in the CCR.

The lower part is the most interesting one from the ore mineralization point of view (fig. 2). A conspicuous horizon of carbonates overlies the basal gneiss of Sant Martí Sacalm (Guilleries) and encloses metric sized masses of calcosilicates. Pyrrhotite, sphalerite and magnetite, with minor amounts of fluorite, galena, chalcopyrite and scheelite, can be found disseminated in the calcosilicates. The ores occupy interstitial positions among undeformed hedenbergite crystals of metasomatic aspect (skarn). However, Gimeno and Viladevall (1983) describe millimetric size bands of scheelite enclosed in the calcosilicates and in the contiguous carbonate. The bands are affected by the main Hercynian folding and consequently interpreted as a mineralization syngenetic to the carbonate formation.

The carbonates from Sant Julià de Llor (Guilleries), located in a similar stratigraphic setting, bear disseminations of idiomorphic and undeformed crystals of galena, associated to quartz and ankerite. They are attributed (Gimeno and Viladevall, 1983) to sedimentary-diagenetic ores lately recrystallized by the nearby intrusion of an Hercynian granite. According to the former authors the ores have been lately reconcentrated in karstic cavities.

Several ore showings and geochemical anomalies are also found in the same stratigraphic position, though more than 60 km in the Guilleries Massif, as well as in Breda area, in the southern Montseny. Gimeno and Viladevall (1983) attribute the whole ensemble of mineralizations to the establishment of the Cambrian platform beneath an active volcanic paleorelief. The gneiss and amphibolites are the lithological representation of a volcanic event whose exhalative activity probably supplied the metals into the basin. The lack of reliable stratigraphic markers, the deformation and metamorphic grade, as well as the exposure conditions do not allow progress in the detailed reconstruction of the paleogeography of the basin.

From the regional point of view, syngenetic ore deposits can also be found in a comparable lithological and structural setting in the Cambro-Ordovician from the eastern Pyrenees (Ayora and Casas, 1986,87).

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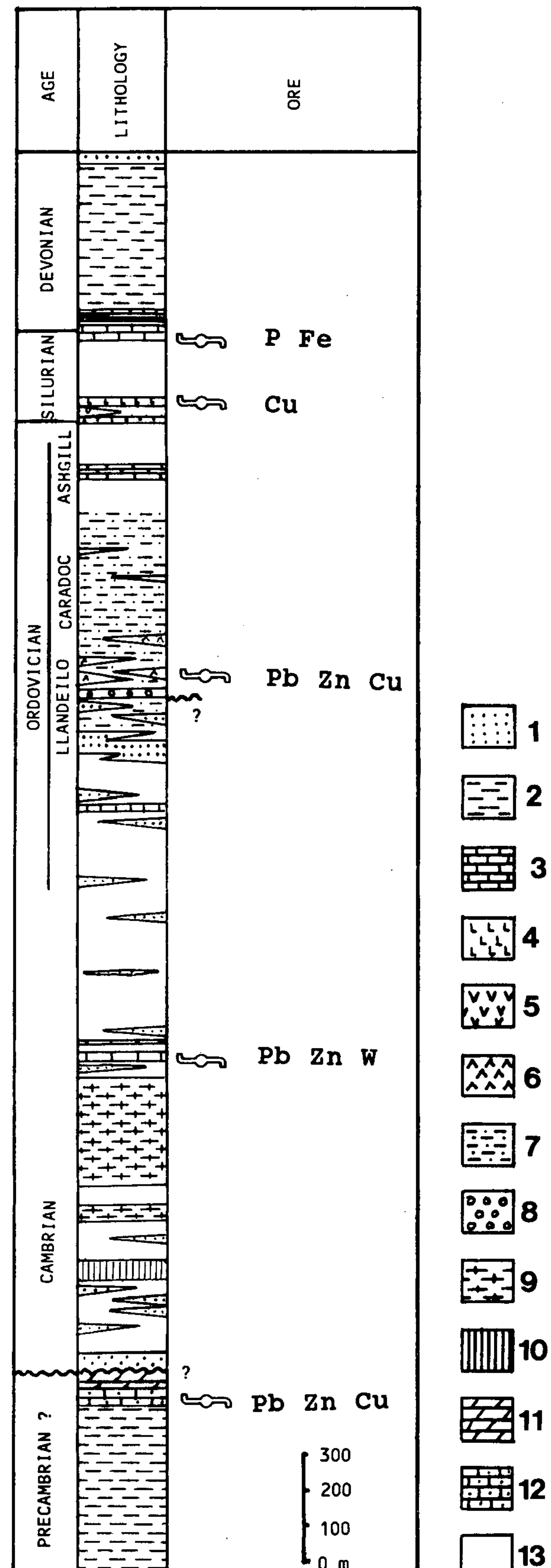


Figure 2.- Distribution of ore showings into the prehercynian series. Geology modified after Julivert *et al.* (1987). Symbols: 1) quartzite; 2) shales and sandstones; 3) limestone; 4) chert; 5) basic volcanics; 6) acidic to intermediate volcanics; 7) greywackes; 8) conglomerates; 9) gneiss; 10) amphibolites; 11) dolostones; 12) chalcarenites; 13) shales

Furthermore, a great number of mineralizations and several large deposits of As-Au and base metals have been also described in the Cambrian series throughout the Hercynian orogen, and especially in the northwestern Mediterranean province (Crouzet and Tollon,1980; Cocozza *et al.*, 1974; Foglierini *et al.*, 1980a,b).

On the other hand, a series made up of shales, sandstones and carbonates is found outcropping in the western Priorat. A several meters thick horizon of scapolite-bearing dolomite constitutes the top of the carbonates. No data are known about the age of these materials, although a quartzite strata lying on the carbonates is very similar to the one in the Serra de Miramar which has been attributed to the lower Cambrian due to ichnofossils. The former series contains pyrrhotite, sphalerite, galena and chalcopyrite disseminated in centimetric thick levels of calcsilicates and black shales (Melgarejo and Ayora, 1989b). They are probably syngenetic sulfides formed in an anoxic sea floor of a near-shore evaporitic environment. The ensemble has been lately affected by the thermal metamorphism induced by a Hercynian granite.

The upper Ordovician mainly outcrops in the northern CCR, in the Gavarres and Guilleries Massifs. It is made up of a siliciclastic series, with a basal mud supported conglomerate, and a large representation of explosive volcanics. The volcanic character is progressively lost towards the top of the sequence where thin limestone layers appear. This series, of Caradoc-Asghill age, are the most ancient dated sediments in the CCR and the Pyrenees. Julivert *et al.* (1987) describe a transitional boundary between the described series and the underlying schists and sandstones attributed to the Cambro-Ordovician, whereas Ferrer (1989) interpret it as an unconformity, similar to that described in the eastern Pyrenees (Santanach,1972).

Several lenses of massive sulfides have been described (Ferrer,1989) interbedded with the volcanics in Sant Martí Sacalm (Guilleries). The deposit is mainly constituted of pyrrhotite and pyrite with sphalerite,galena and chalcopyrite, and seems to laterally give way to small showings richer in galena. Several geochemical anomalies have also been described in calcsilicates and sediments of volcanic affinity of upper Ordovician age in the Gavarres,Guilleries, Montseny massifs as well as in the area surrounding Barcelona (Alcalde,1984; Carmona,1987; Ferrer,1989).

Furthermore, the epigenetic Fe-oxides enclosed in the pre-Caradocian carbonates and schist from Celrà (Gavarres), have been attributed (Ferrer,1989) to an epithermal system also linked to the upper-Ordovician volcanics. Although the outcrops of all these lithologies are spacially close, the Hercynian deformation and the limited exposure prevent the establishing of a definitive morphological and genetic model.

The available data for a paleogeographical reconstruction of the upper Ordovician are still scarce and contradictory. From the calcalkaline chemical trend of the volcanics and their association to the thus considered turbiditic sediments, Julivert *et al.* (1987) propose a compressive-orogenic event for this epoch. They also suggest that the volcanism could be related to the emplacement of acidic igneous intrusives now appearing as the orthogneiss described at the base of the Cambro-Ordovician series. On the other hand, Ferrer (1989) proposes a different geodynamic setting comparable to that described for the upper-Ordovician from southern Sardinia (Gimeno,1989). It is based on extensional tectonics creating a submarine topography of horst and grabens. Although the fractures modelling this topography have not been detected yet, the important changes in thickness and facies of the clastics, as well as the accompanying volcanics suggest their proximity. According to Ferrer (1989) the massive sulfides from Sant Martí Sacalm (Guilleries) were formed from exhalative activity in the basin and are consequently found in the referred proximal facies. The remaining showings and geochemical anomalies from the Montseny and nearby Barcelona could correspond to more distal facies (Plimer, 1978), without important development of volcanics.

Syngenetic ore deposits as well as volcanism are also frequently found in the upper Ordovician from the Pyrenees. Thus, important stratiform Zn(Pb) massive sulfides have been described, whether inside volcanics, such as in Pyerrefitte (Bois *et al*, 1976), or in sedimentary piles with a slight or no volcanic influence, such as in Liat, Pale Rase and Bentaillou (Cardellach, 1977; Pouit, 1978; Guerin, 1981). There is a general agreement on attributing the sulfide lenses, as well as the associated monomineralic sediments (chloritites, cherts, anortitites,...) to submarine exhalative sources close to upper Ordovician active fractures.

Similarly to the Pyrenees, the Silurian is represented by a characteristic facies of graptolite-bearing black shales with chert, basic volcanics and sandstone interbeddings. The upper Silurian and the Devonian are made up of nodular limestones, marls and shales with pelagic and hemipelagic faunas (Julivert *et al.*,1987).

The upper part of the black shales very often contain important disseminations of iron sulfides locally achieving centimetric thick lenses such as in Pineda (Montnegre). However, the most interesting mineralization is located in the Serra de Prades (Melgarejo,1987), where a pyrrhotite-rich horizon rises up to metrical thickness over several kilometers in length and also contain chalcopyrite, sphalerite, galena and silver tellurides.

The sulfide mineralization is thought to be formed from hydrothermal solutions springing up in the Silurian euxinic basins (Carmona and Viladevall,1984; Melgarejo,1987). The presence in the black shales of tuffaceous thin beds and basaltic sills of alkaline chemistry (Julivert *et al.*,1987) points to an extensional-anorogenic regime which can account for the active faulting and the thermal anomaly needed for the hydrothermal activity. Thus, Gimeno (1989) describes sulfides filling vacuolae and stockworks in the basalts from the southern Montseny.

This euxinic environment contrasts with the iron oxide and sulfate mineralizations enclosed in the upper Silurian limestones. Important masses of hematites have been mined in Malgrat (Montnegre) and in minor amounts in Gavà, near Barcelona. The origin of this type of mineralizations is uncertain. Carmona and Viladevall (1984) suggest that the oxides from Malgrat come from the weathering of the preexisting sulfides enclosed in the black shales. On the other hand, stockworks filled up with Fe-Al sulfates and phosphates and associated to an advanced argillitic alteration (alunite-kaolinite) can be observed in the Silurian black shales underlying the oxide lenses of Gavà. The whole structure has been affected by the main Hercynian deformation. Very similar phenomena has been described (Melgarejo, 1987) in the Silurian shales of Serra de Miramar and attributed to an epithermal system linked to the vanishing Silurian hydrothermalism.

CARBONIFEROUS

The Carboniferous is separated from the rest of pre-Carboniferous by a disconformity and perhaps by an unconformity (Julivert *et al.*,1987). A widespread sedimentation of clastics with intraformational breccias, disconformities and sharp changes in facies and thickness characterizes the lower Carboniferous. Intraplate alkali volcanics can be found enclosed throughout the sedimentary pile, being more abundant in the basal part. Thanks to the activity of an extensional tectonics affecting a basement of different ages a submarine topography of rises and grabens were installed in the southern CCR (Priorat, Serra de Prades, Serra de Miramar area) from Tournaisian to Namurian time. The raised areas are characterized by pre-Carboniferous materials overlain by a very condensed sequence of pelagic limestones. On the other hand, the subsident basins are characterized by thick piles of clastic sediments. A more than a thousand meter thick pile of turbiditic sediments (Bouma,1962) disconformably overlies the lower Carboniferous. The age of this series has not been established yet ranging from upper Namurian to Westfalian.

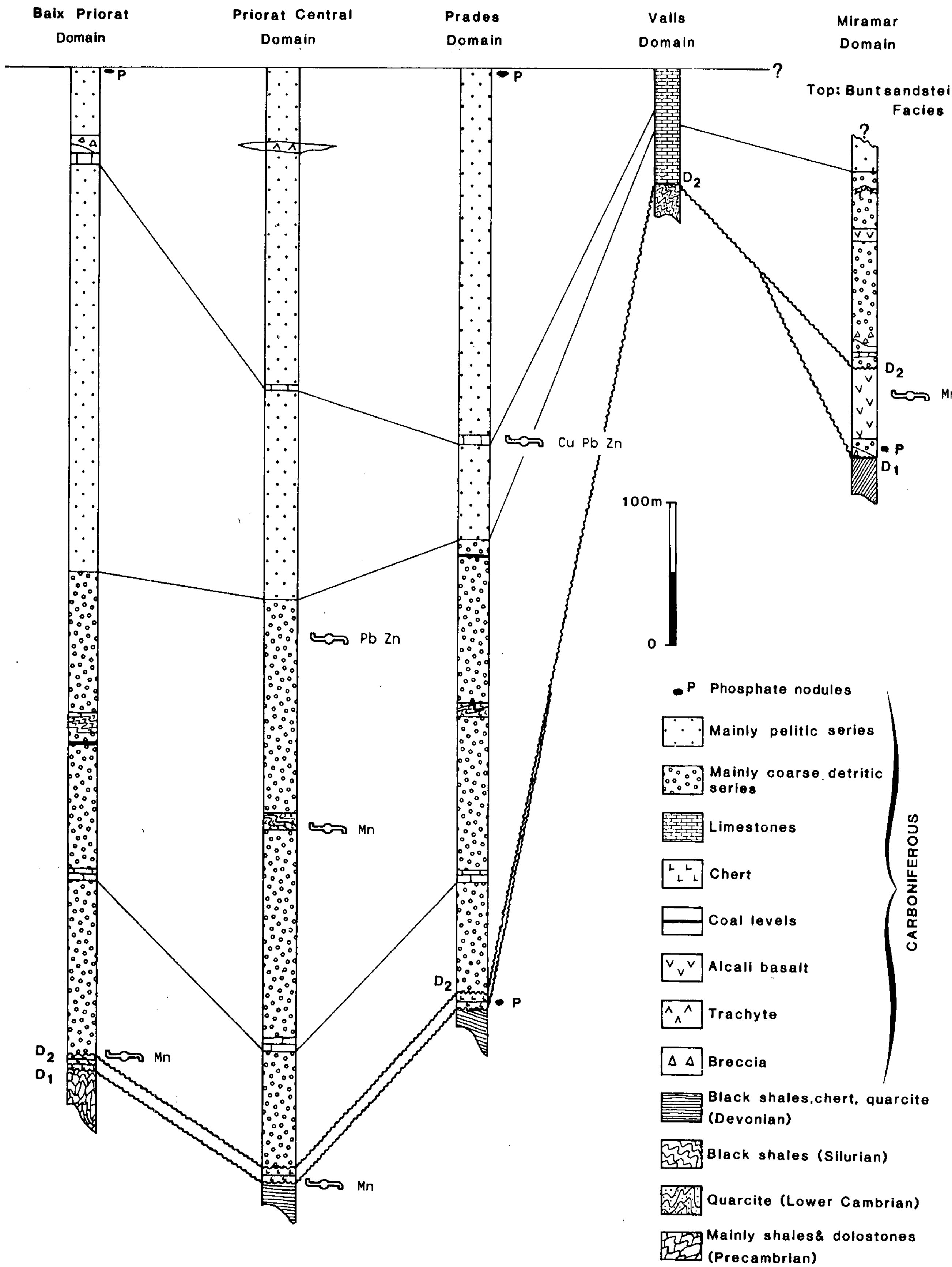
The systematic exploration of the lower Carboniferous has recently lead to the discovery of numerous syngenetic mineralizations (Fig. 3) and the reinterpretation of formerly known ones. The larger outcropping areas, the very low grade of metamorphism and incipient development of the foliation, as well as the amount of available information on the geological setting, allows us to propose an ore deposit genetic model more complete than those suggested for older Paleozoic epochs.

A metric thick horizon of organic matter-bearing chert is conspicuosly found at the base of the Tournaisian from the Priorat. It encloses lenses and nodules of primary rhodochrosite subsequently transformed into Mn-silicates by thermal metamorphism and lately weathered to Mn-oxides that have been occasionally mined (Melgarejo and Ayora, 1989a). Small amounts of base metal sulfides and Ni-Co-As-Sb-Te-W minerals are also found disseminated in the chert.

This type of manganese mineralization in silicic sediments has been described in several points of the western Mediterranean Hercynian belt and there is a general agreement on attributing it to submarine exhalative processes (Crilat,1983; Leyva *et al.*,1986). Furthermore, manganese oxides can also be found as nodules and filling vacuolae of the basalts from Serra de Miramar formed in a shallow sea floor. Because these volcanics are also situated at the base of the Tournaisian Melgarejo and Ayora (1989a) relate them to the manganese mineralization in cherts, the mineralogical differences being due to changes in oxygen activity of the medium.

With the exception of submarine rises, such as those of the southern Serra de Miramar, subsidence and sedimentation are very active during the Visean, as evidenced by the predominance of thick accumulations of coarse clastics over the pelites. The mineralization is characteristically represented throughout the Visean by disseminations of base metal sulfides and monomineralic lithologies (chert, chlorite, epidote, albite,etc.) of reputed exhalative origin (Bernard *et al.*,1982; McLeod and Stanton,1984). Despite the ore supply into the basin the high energy of the sedimentary regime prevents the accumulation of large amounts of ores. Thus, most of the Visean mineralizations are disseminations in sandstones, and a massive sulfide lense found in L'Argentera (Priorat area) displays a channel- like morphology and textures evidencing intensive reworking of the ores (cross bedding, gradded bedding, brecciae,etc.).

More favourable ore forming conditions take place during the Namurian in the Priorat and Serra de Prades area. Whilst the tectonic unstability continues in the



Baix Priorat Domain
Priorat Central Domain
Prades Domain
Valls Domain
Miramar Domain
Top: Buntsandstein Facies
P
D2
D1
Mn
Pb Zn
Cu Pb Zn
100m
0
P Phosphate nodules
Mainly pelitic series
Mainly coarse detritic series
Limestones
Chert
Coal levels
Alcali basalt
Trachyte
Breccia
Black shales, chert, quarcite (Devonian)
Black shales (Silurian)
Quarcite (Lower Cambrian)
Mainly shales& dolostones (Precambrian)
CARBONIFEROUS

margins, fine grained clastics and some carbonates become predominant in the center of the basins. The low energy sedimentary regime allows the exhalative products to accumulate and be preserved in particular points. Thus, the ores form lens-like bodies of centimetric to metric thickness and hectometric extension at L'Alforja. They are interbedded with chert, chamosite, ankerite and other monomineralic sediments. A clear vertical ore zonation can be observed, the base being mainly made up of pyrrhotite, chalcopyrite and Bi-Te-Ag minerals, whereas pyrite, together with sphalerite and galena are more abundant towards the top of the body. The sulfide mass ranges laterally to small lenses of galena, sphalerite, hessite and pyrite. Small deformed veinlets (stockwork), made up of epidote, chlorite, magnetite, chalcopyrite and scheelite, are situated below the main sulfide lens and seem to suggest the feeder channels for the ore forming solutions. The lateral zonation is also evident in the Ulldemolins deposit (Priorat) enclosed in a limestone horizon. The center of the mineralization is constituted by an epidote and quartz mass, with magnetite, chalcopyrite and sphalerite, and gives way to centimetric levels of chamosite with galena,sphalerite and scheelite towards both sides of the central mass. The ore body morphology, host lithologies and internal zonation are characteristic of the deposits generated in the sea floor from exhalative source (Finlow-Bates, 1980; Pouit, 1988).

Despite the enormous development of turbidites in the Priorat-Serra de Prades region during the middle-upper Carboniferous, only very scarce disseminations of base metal sulfides have been observed in the Tc terms (Bouma, 1962) at the base of the sequence. The lack of mineralizations in the turbidites is consistent with that expected from these facies traditionally reputed as «negative metallotecte» (Nicolini, 1970).

The paleogeographical and geodynamic setting of the mineralizations enclosed in the lower Carboniferous, their association to monomineralic horizons, and the morphology and zonation of the ore bodies are perfectly coincident with those described as exhalative-sedimentary (Pouit, 1984) or sediment-hosted stratiform massive sulfide deposits (Large, 1983) and with those described as recent mineralizations in the Red Sea floor (Guennoc *et al.*, 1984). The proposed geodynamic and ore forming process are consistent with the Devonian-Dinantian extensional geotectonics suggested for the northwestern Mediterranean province (Spaletta, 1982; Bichot, 1986) and with the arcogenesis (thinning of the Earth crust) proposed as the tectonic setting of the large sediment-hosted massive sulfide deposits of the upper Paleozoic trough (Bauman *et al.*, 1985; Bauman,1986).

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Figure 3.- Distribution of ore showings into the lower carboniferous series. Geology after J.C. Melgarejo, C. Ayora and J. Sanz.

POSTMETAMORPHIC HERCYNIAN DEPOSITS

A calcalkaline suite of plutonic rocks of I-type, ranging in time from diorite to leucogranite, intruded the Paleozoic metasediments developing aureolas of thermal metamorphism (Enrique, 1981). These rocks intruded in epiplutonic to subvolcanic level and are accompanied by a set of dykes of similar composition and porphyritic texture, locally giving breccia structures (Serra, 1987; Serra and Enrique, 1989).

The Hercynian deformation and the metamorphic fluids do not play an important role as ore concentration processes in the CCR. Thus, most of Hercynian epigenetic mineralizations are related to the hydrothermal cells induced by the postmetamorphic granitic intrusions. Two types can be differentiated according to the main morphological criteria: skarns and veins. With the exception of tin, all of the metals constituting the epigenetic mineralizations are also found in the syngenetic ones enclosed in the Paleozoic series, thus displaying an interesting case of ore remobilization and inheritance.

The skarns are spread all through the CCR. They are mainly exoskarns and show no preference for a particular regional carbonate. Thus, calcic and magnesic skarns with scheelite, fluorite, chalcopyrite, molibdenite, sphalerite and galena, are replacing the Cambro-Ordovician carbonates in Gualba (Montseny). Small sulfide-rich hedenbergite skarns are also found developed in the same carbonates at the contact with granitic dykes from the Guilleries massif. Magnetite and chalcopyrite-bearing skarns have developed in the upper Ordovician carbonates from Hortsavinyà (Montnegre), and small skarns with Sn-bearing andradite, sphalerite, chalcopyrite, galena, arsenopyrite, gold and Bi-Te-Ag minerals are found replacing thin strata of Carboniferous limestones in the Serra de Prades-Priorat area (Melgarejo, 1987).

A detailed study of the Hercynian veins from the CCR is still required. Nevertheless a relationship between the ore association and the enclosing or proximal granite type seems to appear from the available data. Thus, several arsenopyrite-pyrrothite-sphalerite-galena-chalcopyrite veins are enclosed or nearby the diorites of Riudecanyes (Priorat area), and various stannite-cassiterite-chalcopyrite quartz veins are related to the tonalites of L'Alforja (Serra de Prades area), all of them associated to an intensive chloritic wall rock alteration (Melgarejo, 1987). The ores of these veins display annealing textures and the accompanying minerals are locally transformed into calcsilicates. These features point to a subsequent thermal metamorphism probably caused by the later intrusives of more acidic composition, such as the leucogranites.

Moreover, numerous scheelite-bearing quartz veins and joints are found in granites throughout the CCR (Enrique, 1982; Viladevall *et al.*, 1984; Tritlla and Cardellach, 1988). Among them the veins from Poblet (Serra de Prades) are the most important ones. They are a system of parallel veins enclosed in Ca-rich granites plotting around an outcrop of alkali granite (Melgarejo and Ayora, 1984). The scheelite is thought to be carried by a hypersaline fluid equilibrated with a granitic magma, and precipitated at about 800 bars and more than 400 ºC, due to the Ca supply of the altered plagioclase of the enclosing rock (Ayora *et al.*, 1986). The Ca-rich enclosing granite and the very low range of the wall rock alteration distinguished the CCR type of scheelite veins from those enclosed in albite-greisen cuppolas from the Hercynian tungsten province (SW England, French Central Massif, Iberian Massif).

Other basement-confined Pb-Zn-Cu veins with quartz, dolomite or calcite gangue have been related (Melgarejo, 1987) to a metallogenetic event associated to the latest Hercynian faulting. Canals (1989) has demonstrated they are formed without influence of igneous source-fluids, and they are described with the rest of post-Hercynian low temperature veins (Cardellach *et al.*, this volume).

REFERENCES

ALCALDE, C. 1984: *Prospección táctica de recursos minerales del área de Cánoves-Sant Pere de Vilamajor (Montseny, Barcelona).* Unpublished graduate Thesis. Univ. de Barcelona. 168 pp.

AYORA, C. and CASAS, J. M., 1986: Strata-bound As-Au mineralization in pre-Caradocian rocks froms the Vall de Ribes, Eastern Pyrenees, Spain. *Mineral. Deposita,* 21: 278-287.

AYORA, C. and CASAS, J.M., 1987: Mineralización estratiforme de Pb-Zn-Cu en el Paleozoico de Bassegoda (Pirineo Oriental). *Acta Geol. Hisp.*, 20, 3/4: 233-239.

AYORA, C., GUILHAUMOU, N., TOURAY, J.C. and MELGAREJO, J.C., 1986: Scheelite-bearing quartz veins from Poblet (Catalonian Coastal Ranges): characterization of fluid inclusions and genetic model. *Bull.Minéral,* 110: 603-611.

BAUMAN, L., 1986: Geosynclinal sulphide deposits in the plate tectonics scheme. *In* Wolf, ed.: *Handbook of strata-bound and stratiform ore deposits.* v 14: 185-222. Elsevier Pub. Amsterdam.

BAUMAN, L., LEEDER, O. and WEBER, W., 1985: The position of platform activation (arcogenesis) in plate tectonics and its metallogenetic importance (exemplified by the North Atlantic-West European Lithosferic Area). *In* Wolf, ed.: *Handbook of strata-bound and stratiform ore deposits.* v. 14:409-460. Elsevier Pub. Amsterdam.

BICHOT, F., 1986: *La tectonique distensive carbonifère dans les Pyrénées. Correlations est-canadiennes et ouest- européennes.* Thèse Université de Bordeaux.

BOIS, J.P. *et al.*, 1976: Les minéralisations de Zn (Pb) de l'Anticlinorium de Pierrefitte: un exemple de gisements hidrotermaux et sédimentaires associés au volcanisme dans le Paléozoïque des Pyrénées Centrales. *Bull.B.R.G.M.*, sect.II, 5: 543-567.

BOUMA, A.H., 1962: *Sedimentology of some Flysch deposits. A graphic approach to facies interpretation.* Elsevier Pub. Amsterdam. 168 pp.

CANALS, A., 1989: *Contribució a la gènesi dels filons de baixa temperatura dels Catalànids.* Unpublished Ph. D. Thesis Univ. Barcelona. 268 pp.

CARDELLACH, E., 1977: *Estudio de los sulfuros metálicos del valle del rio Unyola Vall d'Aran, Lleida).* Unpublished Ph. D. Thesis Uni. Barcelona. 171 pp.

CARDELLACH, E., CANALS, A. and TRITLLA, J., 1990: Late and post Hercynian low temperature Ba-(Pb-Zn) veins of the Catalonian Coastal Ranges. *Acta Geologica Hispanica,* 25(1/2): 75-81.

CARMONA, J.M., 1987: *Caracterización geoquímica del tránsito Ordovícico-Silúrico de las Cadenas Costeras Catalanas. Su aplicación en el estudio evolutivo de la cuenca y de los procesos fisico-químicos actuantes en la misma como guía de prospección de recursos minerales.* Unpublished Ph. D. Tesis Univ. Barcelona. 383 pp.

CARMONA, J.M. and VILADEVALL, M., 1984: Morfología y mineralogénesis de las concentraciones de hierro del Macizo Paleozoico del Montnegre, Malgrat-Calella província de Barcelona). *Rev. Inv. Geol.*, 40: 65-86.

CARRERAS, J. and SANTANACH, P., 1983: El Hercínico de los Pirineos. *In* Comba, coord.: *Geología de España. Libro Jubilar J.M. Rios,* v.I:536-550. I.G.M.E. Madrid.

CAVET, P., 1957: Le Paléozoique de la zone axiale des Pyrénées Orientales françaises entre le Rousillon et l'Andorre. *Bull. Serv. Carte Géol. Fr.*, 55, 254:303-518.

COCOZZA, T., JACOBACCI, A., NARDI, R. and SALVADORI, I., 1974: Schema stratigrafico-structurale del Massiccio Sardo-Corso e mineragenesi de la Sardegna. *Mem. Soc. Geol. It.*, XIII: 85-186.

CRILAT, S., 1983: Le Dévonien Supérieur et le Carbonifère Inférieur des Pyrénées et de la Montaigne Noire (Frasnien, Famenien, Tournaisien). *IGCP nº5 Newsletter,* 5: 231-254.

CROUZET, J. and TOLLON, F., 1980: Le gisement stratiforme et filonien de Salsigne, Aude: Au, As, (Ag, Cu, Bi). *26 Congrès International de Géologie,* E8, 54 pp.

ENRIQUE, P., 1981: Late-tectonic granitoids of the Catalonian Coastal Ranges. *In* Julivert, ed.: *Guide to the field trips in the*

Eastern Pyrenees and Catalonian Coastal Ranges. IGCP project n.5: 44-52.

ENRIQUE, P., 1982: Presència de scheelita (CaWO4) a les granodiorites dels Catalànids. *Rev.Inst.Inv.Geol.*, 35:123-126

FERRER, A., 1989: *El volcanismo calcoalcalino del Ordovícico superior de los macizos de Les Guilleries y Les Gavarres (Cadenas Costeras Catalanas, província de Girona) y sus mineralizaciones asociadas: mecanismos eruptivos, metalogenia y propección geoquímica.* Unpublished Ph. D. Thesis. Univ. Barcelona. 660 pp.

FINLOW-BATES, T., 1980: The chemical and physical controls on the genesis of submarine exhalative ore bodies and their implication for formulating exploration concepts. A review. *Geol.Journ.*, D30: 27-39.

FOGLIERINI, F., BERNARD, A. and VERRAES, G., 1980a: Le gisement des Malines (Gard): Zn, Pb. *26 Congrès International de Géologie,* E5, 56 pp.

FOGLIERINI, F., BEZIAT, P., TOLLON, F. and CHABOD, J.C., 1980b: Le gisement filonien de Noailhac Saint Salvy (Tarn): Zn (Ag,Ge,Pb,Cd). *26 Congrès International de Géologie,* E6, 43 pp.

GIMENO, D., 1989: *Estudio geológico y metalogenético de los materiales de la cuenca paleozoica de la región de Sárrabus (SE de la isla de Cerdeña,Italia). Aplicación de los modelos elaborados en la prospección de recursos minerales en el ámbito del Mediterráneo noroccidental.* Unpublished Ph. D. Thesis Univ. Barcelona. 937 pp.

GIMENO, D. and VILADEVALL, M., 1983: Las mineralizaciones estratiformes en Fe-Zn-Pb-F-Cu(W) y en Pb del Cambro-Ordovícico del macizo de Les Guilleries (Girona). *Rev. Inv.Geol.*, 36: 121-133.

GUENNOC, P., POUIT, G. and NAWAD, Z., 1984: The Red Sea: History and associated mineralizations. In W. Manspeizer, ed.: *Triassic-Jurassic rifting, North America and North Africa* A.A.P.G.,Special Volume. chapter 39,25 pp.

GUERIN, P., 1981: *Les minéralisations zincifères de l'Ordovicien de la région de Liat (Val d'Aran, prov. Lérida, Espagne).* Thèse 3em cycle. Univ. P. et M. Curie. Paris VI. 203 pp.

JULIVERT, M., DURAN, H., GARCÍA LÓPEZ, S., GIL IBARGUCHI, I, TRUYOLS MASSONI, M. and VILLAS, E., 1987: Pre-Carboniferous rocks in the Catalonian Coastal Ranges: volcanism, stratigraphic sequence and fossil content. *In*: W.H. Flugel, F.P. Sassi and P. Grecula ed: *Prevariscan and Variscan events in the Alpine-Mediterranean Mountain belts.* Mineralia slovaca-Monography, 1987. Alfa Bratislava, pp. 313-322

LARGE, D., 1983: Sediment-hosted massive sulphide lead-zinc deposits: an empirical model. *In* D. F. Sangster, ed.: Sediment-hosted stratiform lead-zinc deposits. *Min. Assoc.Canada Short Course.* pp.1-29.

LEYVA, F., MATAS, J. and RUIZ MONTES, M., 1986: El manganeso de la Fuensanta (Lorca, Murcia). Ejemplo de mineralización volcanogénico-sedimentaria en el Paleozoico del Complejo Maláguide (Cordilleras Béticas). *Bol.Geol.Min.*, XCVII-II: 165-193.

MCLEOD, R.L. and STANTON, R.L., 1984: Phyllosilicates and Associated Minerals in Some Paleozoic Stratiform Sulfide Deposits of Southeastern Australia. *Econ. Geol.*, 79, 1: 1-22.

MELGAREJO, J.C., 1987: *Estudi geològic i metal.logenètic del Paleozoic del sector sud de les Cadenes Costeres Catalanes.* Unpublished Ph. D. Thesis. Univ. Barcelona. 646 pp.

MELGAREJO, J.C. and AYORA, C., 1984: Mineralización filoniana de tungsteno en las Cadenas Costeras Catalanas. *Bol. Geol. Min.*, XCVIII: 235-245.

MELGAREJO, J.C. and AYORA, C., 1989a: Mineralización exhalativo-sedimentaria de manganeso en los tramos basales de la serie carbonífera del Priorato-Sierra de Miramar (Cataluña). *Bol.Geol.Min.* (in press).

MELGAREJO, J.C. and AYORA, C., 1989b: Escapolita en metasedimentos pre-carboníferos del Priorato (Cataluña). *Bol.Soc.Esp.Min.* (in press).

NICOLINI, P., 1970: *Gitologie des concentrations minérales stratiformes.* Gauthiers-Villars Ed. 792 pp.

PLIMER, I.R., 1978: Proximal and distal strat-bound ore deposits. *Mineral.Deposita,* 13: 345-353.

POUIT, G., 1978: Les diférents modèles de minéralisations «hydrothermales-sédimentaires» à blende (galène) du Paléozoique des Pyrénées Centrales. *Mineral. Deposita,* 13: 411-421.

POUIT, G., 1984: Les gisements à sulphures massifs exhalatifs-sédimentaires: une mise au point sur leur classification et la methodologie de leur recherche. *Chron.Rech.Min.*, 476: 31-34.

POUIT, G., 1988: Les minéralisations sous-marines actuelles et récentes à sulfures et/au manganèse. Données bibliographiques nouvelles pour les océans Pacifique et Atlantique. *Chron. Rech. Min.*, 490: 17-24.

SERRA, P., 1987: The Alforja Breccia Body (NE Spain) and its origin by explosive phenomena in an epiplutonic magma chamber. Abstract submitted to SIMP Conference on «Granites and their surroundings».

SERRA, P. and ENRIQUE, P., 1989: The late-Hercynian intrusives from Southern Catalonian Coastal Ranges (NE Spain) and their epiplutonic to subvolcanic level of magma emplacement. *SIMP Bull.* (in press).

SPALETTA, C., 1982: Lydite (chert) breccias and conglomerates: a paleogeographic tool for the Dinantian in the circum-Mediterranean area. *IGCP n 5 Newsletter,* 4: 94-96.

TRITLLA, J. and CARDELLACH, E., 1988: Los indicios de W y de Mo en los granitoides del área de Martorell (Prov. de Barcelona). *Bol. Soc. Esp. Min.*, 11-1: 125-133.

VILADEVALL, M., AYORA, C., SAAVEDRA, J. and GARCIA SANCHEZ, 1984: Introducción a la metalogenia del tungsteno del sector NE de la Península Ibérica. *Actas I Congreso Español de Geología,* v.II: 719-728.