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Metallogenic and tectonic characteristics of the paleozoic ophiolitic belt of the southern Chile coastal Cordillera

By JOSE FRUTOS J. and GUILLERMO ALFARO H., Concepción*)

With 7 figures

Zusammenfassung

Das kristalline Grundgebirge der Küstenkordillere Süd-chiles zeigt in tektonischer, geochemischer und metallogenetischer Hinsicht viele Ähnlichkeiten mit den bekannten, klassischen Ophiolithkomplexen, wie z.B. Cypern, Oman, Apenninen und Magallanes. Bemerkenswert sind Rodingite und stark serpentinisierte ultrabasische Gesteine, u.a. Wehrlite, Harzburgite sowie Dunite. Außerdem treten Basalte mit Pillow-Strukturen, vulkanoklastische Sedimente tholeiitischer Zusammensetzung (Grünschiefer) und Metapelite (Grauschiefer) auf. Von metallogenetischer Bedeutung ist die Anwesenheit von podiformen Chromit in Serpentiniten, von gebänderten Eisenerzen (BIF-Typ), stratiformen Mn-Oxid-Lagen in Metacherts und Quarziten sowie polymetallischen, massiven Sulfidschichten in Grünschiefern.

Das metamorphe Grundgebirge wird aufgrund seiner tektonischen, petrographischen, geochemischen und metallogenetischen Gegebenheiten als Ophiolithkomplex des »back arc«-Typs angesehen, der im Zusammenhang mit einem paläozoischen Inselbogen gebildet wurde.

Abstract

The comparison of the tectonic, geochemical, and metallogenic information of the Crystalline Paleozoic Basement of the South Coast Range of Chile, with those classical ophiolites complexes like Cyprus, Oman, the Apennines, Magellean, etc., allows to find many similarities between them: ultramafic rocks, mainly wherlites, harzburgites and dunites with strong serpentinization, and rodingites; tholeiitic basalts with pillow structures; volcano-clastic sediments (»green schists«) of tholeiitic composition and meta-pelites (»grey schists«).

From a metallogenitic point of view, the frame is completed by podiform chromites: occurrences associated to the serpentinizing banded iron formations, stratiform manganese oxides (mainly pyrolusite) associated to meta-cherts and quartzites, and polymetallic massive sulphide horizons interbedded with green schists.

It is proposed that this sequence, based on its tectonic, petrographical, geochemical and metallogenetical characteristics, corresponds to an ophiolite back arc complex associated to an island arc developed during the Paleozoic.

Resumen

Al comparar las características tectónicas, geoquímicas y metalogenéticas del Basamento Cristalino Paleozoico de la Cordillera de la Costa del sur de Chile, con complejos ofiolíticos clásicos como Chipre, Omán, Los Apeninos, Magallanes, etc., se encuentran muchas similaridades entre ellos: rocas ultramáficas, principalmente wehrlitas, harzburgitas y dunitas, con fuerte serpentinización, y rodingitas; basaltos con estructura de almohadilla; sedimentos volcano-clásticos (»esquistos verdes«) de composición tholeiítica y metapelitas (»esquistos grises«).

Desde el punto de vista metalogénico, el cuadro se completa con la ocurrencia de cromita podiforme asociada a serpentinitas; formaciones de hierro bandeado (BIF); óxidos de manganeso estratiformes asociados a meta-cherts y cuarcitas, y sulfuros masivos polimetálicos intercalados con esquistos verdes.

Se propone que esta secuencia, basado en sus características tectónicas, petrográficas, geoquímicas y metalogénicas, corresponde a un complejo ofiolítico tipo »back arc« asociado a un arco de islas desarrollado durante el Paleozoico.

Краткое содержание

На основании тектонических, геохимических и металлогенических исследований кристаллиновых пород из массивов прибрежных Кордильер юга Чиле установили в них много общего с известными классическими офиолитовыми комплексами, как напр.: на Кипре, в Омане, Апеннинах итд. Особенно бросаются в глаза Родингиты и сильно серпентизированные ультрабазические породы, как-то верлиты, гарцбургиты и дуниты. Кроме того отмечаются базальты в виде подушечных лав, вулканокластические седименты толеиитного состава – зеленый сланец – и метапелиты – серый сланец –. Металлогенетически важным является присутствие линз хро-

*) Authors' address: Dr. J. FRUTOS and Dr. G. ALFARO, Departamento de Geociencias, Universidad de Concepción, Casilla 3-C, Concepción Chile.

митов в серпентинитах, полосчатых железных руд – тип BIF –, стратиформных прослоек из окислов марганца в метакремнистом сланце – metacherts – и кварцитах, с также полиметаллические массивные слои сульфидов в зеленом сланце.
На основании тектонических, петрографических, геохимических и металлогенических характеристик эти метаморфные породы рассматривают, как офиолитовый комплекс типа «тыловой дуги» – back arc –, образовавшийся одновременно с островной дугой в палеозое.

Introduction

The denomination »ophiolite« or »ophiolite complex« (from the Greek »*ophi*«: serpent) has had different connotations since its use in the geologic language. The term was used probably for the first time by Brongniart (1821) describing an association of ultrabasic rocks, gabbros, diabases-spilites and cherts of tertiary age that appears in the Apennines, and which were redefined by Steinmann (1927), who explained them from a magmatic evolution point of view as a peridotite-gabbro-dykes and pyroxenitic-diabase-spilite complex, culminating with copper veins cutting the gabbro, the diabase-spilite and the associated sediments. Steinmann (op. cit.) emphasized the association between ophiolites and the abyssal sediments (cherts, radiolarites and red clays) where they are intercalated. In that form the well known »Steinmann Trinity«, formed by serpentinites, diabase-spilites and cherts, was defined.

In 1972, under the auspices of the Geological Society of America (Penrose Conference, Anonymous, 1972), it was agreed to use the term »ophiolite« for the igneous mafic and ultramafic rocks assemblage, in a similar form to the original sense given by the European authors (Brongniart, 1821; Steinmann, 1927, etc.). According to the Penrose Conference, a complete ophiolitic sequence is made up of (from the base): ultramafic complex, gabbric complex, dyke complex in »sheets« (sheeted dykes), mafic volcanic complex, usually with pillow-lavas. The associated sedimentary rocks are mainly cherts, slates and limestones. Chromite podiform bodies in dunites and felsic intrusive and/or effusive rocks, are also commonly present.

The idea that an ophiolite complex represents simatic materials of the oceanic crust and the upper mantle, is greatly accepted at the present time. This hypothesis has been supported by a great number of plate tectonic research, accomplished during the last years. However, it still exists a strong scientific discussion regarding its formation and emplacing mechanism, being this problem also valid for the formation of the modern ophiolites. The lack of information about the processes occurring in the recent oceanic bottoms, yielded to the use of a wrong »reverse« actualism, since it means the use of geologically old ophiolitic complexes to explain what is happening nowadays, and not the contrary.

Anyway, we debt to Aubouin (1965) one of the best ophiolitic complex description concerning its tectonic role and structural position: the ophiolites are characteristically present in the initial stage of a geosynclinal system, as an emission of ophiolitic (simatic) magma through fissures in the ocean crust, forming a belt subparallel to the back-arc basin over the external slope of the eugeanticlinal ridge (volcanic arc) (Aubouin, 1965).

The central-meridional Andes paleozoic geosynclinal system: general considerations.

The Central-Meridional Andes is developed as a complete cycle between the Cambrian and the Upper Permian – Lower Triassic as shown by Mégard (1978); Marocco et al. (1971), Borrello (1969), Audebaud et al. (1973), Aubouin et al. (1973), Frutos & Tobar (1973) and Frutos (1985). From a paleogeographic point of view it is possible to distinguish: (Fig. 1).

a) An Eugeosynclinal Realm (mainly located in the Chilean territory, western Perú and the extreme west of Argentine) which is characterized by the predominance of granitic batholitic rocks (zone of evolution of the magmatic arc), basic meta-volcanic rock sequences and ultramafic complexes (ophiolitic belt) and flysch sequences in the eugeosynclinal basin. In some areas of the westernmost border of the arc, metamorphic mélange and meta-volcanic tholeiitic rocks of blue schists to green schist facies, (interpreted as oceanic crust accretion in paleosubduction zones) were studied (Hervé et al. 1976; Godoy, 1979). In this form we think that a Paleozoic subduction zone trended, to the west, parallel to the arc and partly near and sub-parallel to the actual coast line.

b) A Miogeosynclinal Realm, (located mainly in the Bolivian and Argentinian territory) which is characterized by the absolute predominance of thick marine series and the subordinated character or the absence of volcanism and intrusive magmatism. These unmetamorphozed units are not affected by the tectonic superimposition of the Andean Mesozoic – Cenozoic system, which is located later principally over the before mentioned eugeosynclinal paleozoic realm that forms its basement.

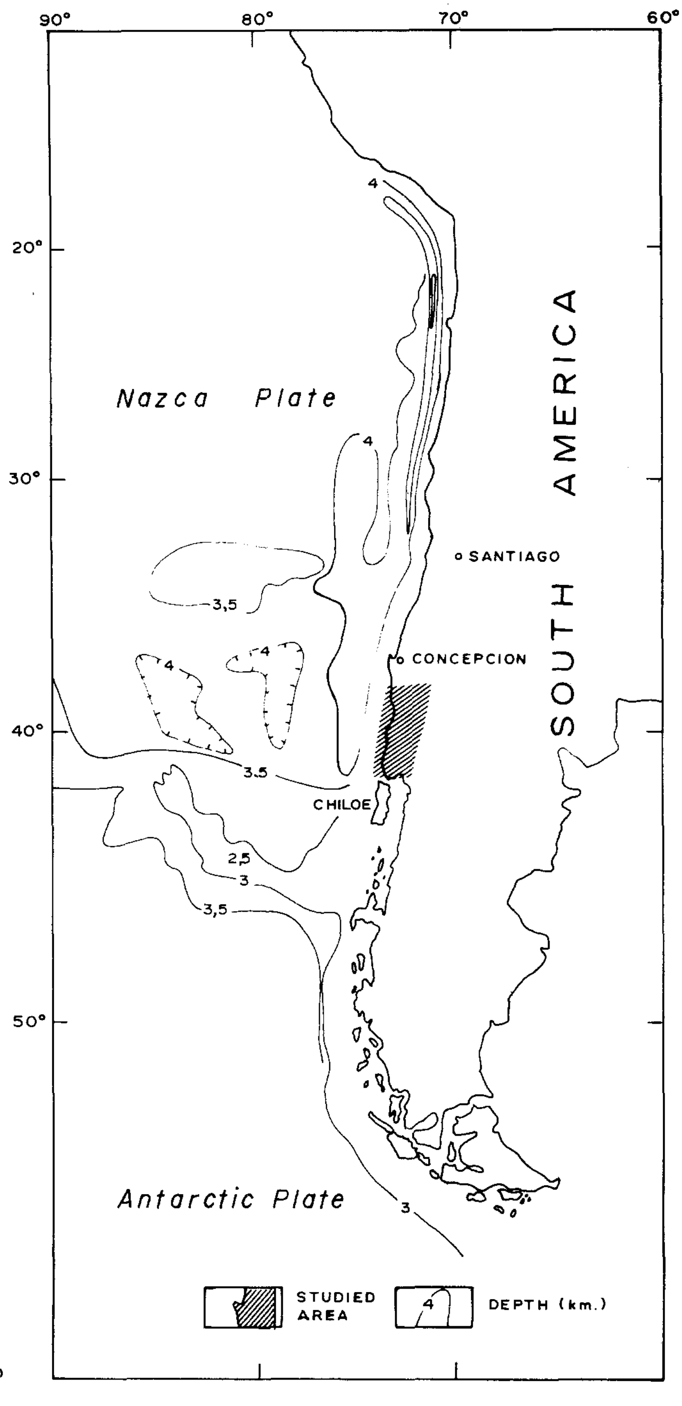


Fig. 1. Location map

The eugeosynclinal and the miogeosynclinal basins appear separated by a sub-positive ridge, partially emmerged, partly coinciding with the Macizo de Arequipa-Dorsal of the Sierras Pampeanas-Dorsal Patagónica line, which can be defined, following Aubouin's (1965) terminology, as the miogeanticlinal ridge of the Andean Paleozoic Geosyncline (Frutos, 1985).

As a synthesis of the geologic-tectonic characteristics of this large area, which is extended from the Province of Arauco (37°S) until the Darwin Cordillera in Magallanes (50°S), we can say it is formed mainly by marine series of meta-grauwackes and tholeiitic basalts with pillow structures, in a proximal position, interfingering to the east with flyschoid and pelitic sequences lying in a more distal or external position.

An extensive belt of ultramafic rocks, serpentinized peridotites and pillow-lavas intercalated in greenstones (ophiolitic complex) appears mainly in the western part of the Coastal Cordillera Paleozoic System (coastal areas of the Arauco, Cautín and Valdivia Provinces). This belt, affected by a metamorphism not higher than greenschist facies, includes also meta-quarzites and chloritic mica-schists, and represents the most internal or proximal position (tectonically related with the arc) in the Paleozoic System.

To the east follows a weakly metamorphosed subparallel belt of flyschoid sedimentary series which finally grades to a belt of unmetamorphosed clastic sedimentary rocks.

From a geochronologic point of view, all these series seem to correspond to three different cycles, being the older, to the west, the greenstone-ophiolitic belt with a probable Ordovician-Silurian age. The younger rocks appear successively to the east, with a possible Devonian age from the flyschoid belt, and a Carboniferous-Permian age for the clastic sedimentary external belt.

In some regions (Chonos Archipelago, Coastal Zone of Nahuelbuta Cordillera), probably in an outer arc position (GODOY, 1979; OYARZÚN, R., 1985), coinciding with high pressure metamorphism, an oceanic crust accretion belt has been postulated.

However MILLER (1979), who performed regional and structural mapping in the Chonos Archipelago, described a situation somewhat different and completely comparable with what is proposed here for the Arauco-Valdivia Sector. In that area, metasedimentary and metavolcanic rocks of weak to moderate metamorphism of possible Cambro-Ordovician age, lying in the western-most (internal) position (Canal King Formation) were described. Devonian sedimentary series (Potranca Formation) affected by a weak metamorphism succeed to the east, in a more distal or external position, to finish with Carboniferous-Permian clastic sedimentary rocks, without metamorphism (Canal Pérez Sur Formation). MILLER (1979) proposed that all the system corresponds to a typical geosynclinal development.

Even considering or not a possible oceanic crust accretion phenomena, in its internal-most border, the Paleozoic system described presents the characteristic and typical features of a complete geosynclinal development, which includes from the internal zone, the magmatic-volcanic arc (eugeanticlinal ridge) at the summit (and/or external or »back-arc« flank) of which the ophiolitic complex is located; then the eugeosynclinal basin (s.s.) which is limited and separated of the miogeosynclinal basin (Bolivian-North Central Argentine) by the before mentioned miogeanticlinal ridge (FRUTOS, 1985), (subpositive zone of Arequipa-Belén-Sierras Pampeanas and Patagonian Massifs).

The complete Meridional Andes Paleozoic geosynclinal system appears to be affected by the following tectonic events (AUBOUIN et al., 1973; BORRELLO, 1969; HARRINGTON, 1965; FRUTOS & TOBAR, 1975; MILLER, 1979; AUDEBAUD et al., 1973).

- Taconian Orogenesis in the Upper Ordovician (450 m.a.).
- Acadian Orogenesis in the Upper Devonian (350 m.a.)
- Upper Carboniferous Orogenesis (290 m.a., equiv. to the Asturian Orogenesis).
- Appalachian Orogenesis in the Upper Permian (250 m.a.).

It is important to note that the few magmatic-volcanic phenomena occurring in the miogeanticlinal ridge (Arequipa-Belén-Sierras Pampeanas), presents the character of ensialic alignments (partly palingenetic) possibly connected to the south with similar magmatic structures of the Patagonia – Deseado Ridge.

All the Paleozoic (geosynclinal) mobil system emerged in the Upper Paleozoic as a consequence of the Upper Carboniferous and Permian Orogenesis (FRUTOS & TOBAR, 1975; MILLER, 1979) meaning, in the case of most of the eugeosynclinal realm, (Chilean Paleozoic system), a notable phenomenon of accretion to the Gondwanic sialic mass (Fig. 2).

The upper Permian and Lower Triassic correspond to a period characterized by a predominantly continental volcanic-sedimentary development of taphrogenic type. The tendency to peneplanization and the corresponding rhyolitic-keratophyric plateau volcanism, has been very well documented in all the basin (CORVALÁN, 1965; DEDIÓS, 1973; SEGERSTROM, 1959, 1960; SEGERSTROM et al., 1963; FRUTOS and TOBAR, 1975).

The Paleozoic rocks of the Meridional Andes eugeosynclinal realm (mainly in Chile), appear intensively affected and reworked by the geological overprinting produced by the development of the Andean Mesozoic-Cenozoic geosyncline practically in the same geographic place, a phenomenon which does not occur with the Paleozoic system in Argentine, Bolivia and Central-East Perú, where it constituted the substable foreland during that period.

Structures of the studied area

In the Coastal Cordillera, from Concepción (37°S) to Osorno (41°S), many structural measurements

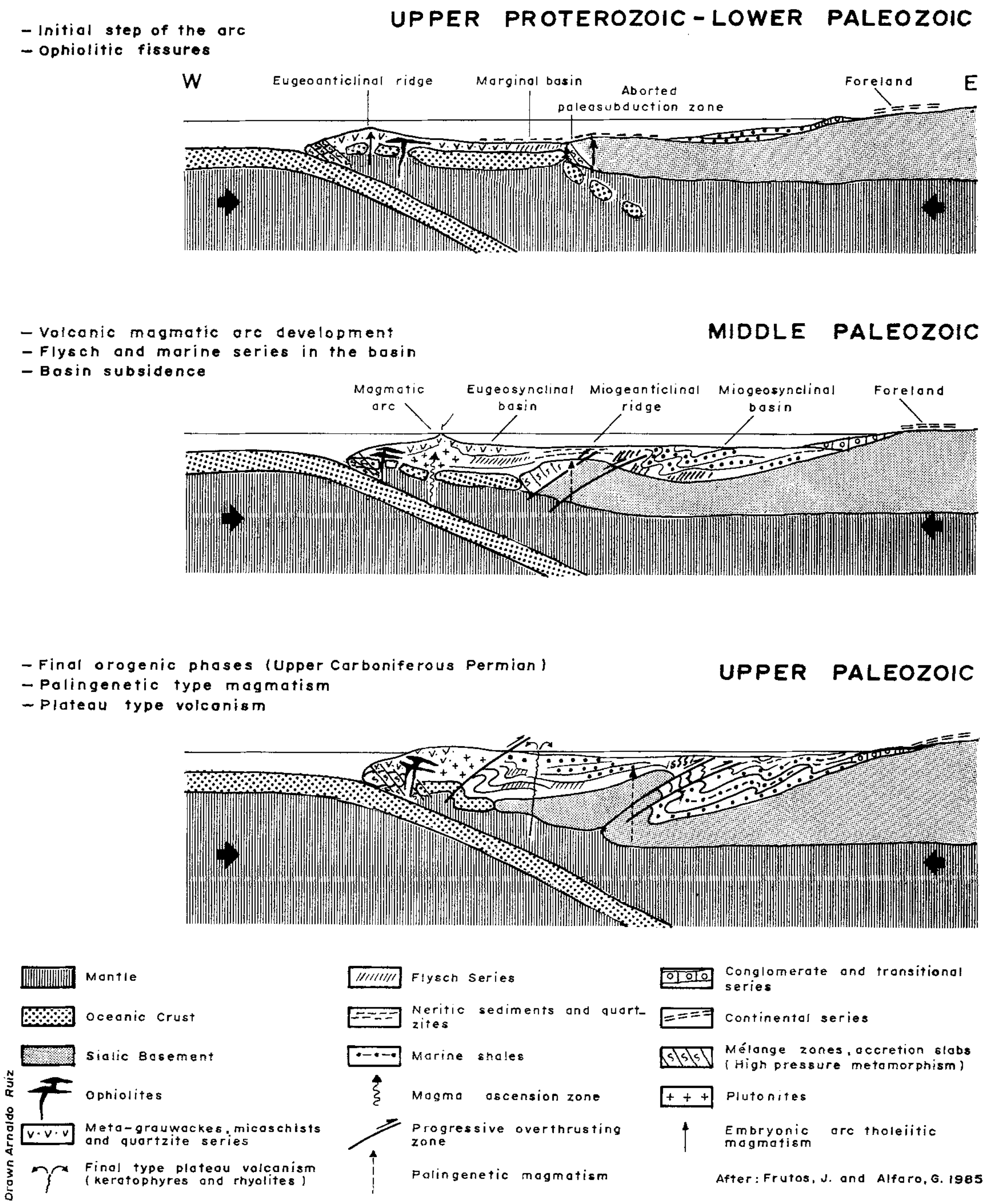
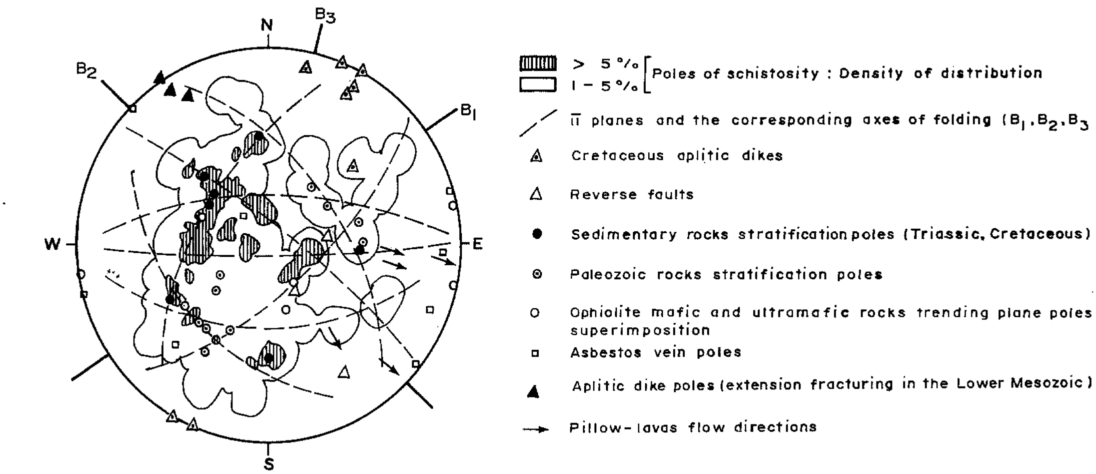
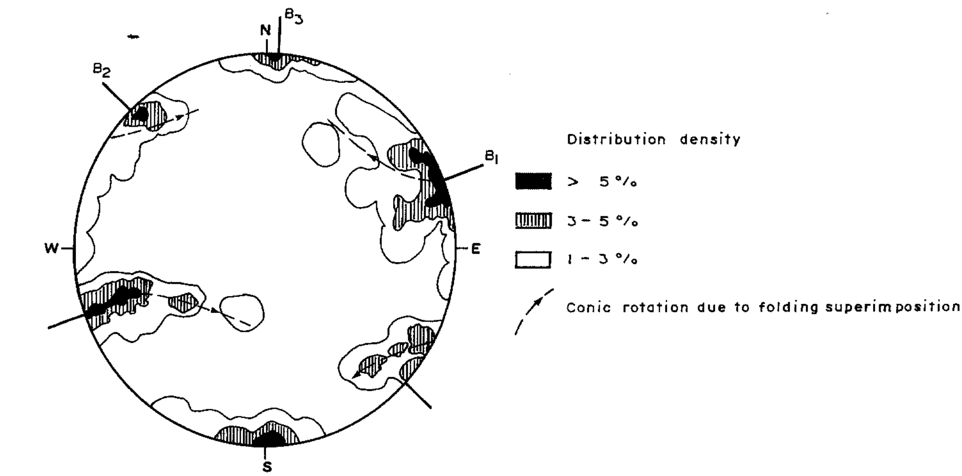


Fig. 2. Schematic tectonic evolution sequence of the paleozoic meridional Andes geosyncline (32°–42° South Latitude)



FOLDING DIAGRAM (SCHMIDT NET) : GREEN SCHISTS QUARTZITES AND MICASCHISTS



AXES OF FOLDING DIAGRAM (SCHMIDT NET) CONSIDERING THE TOTAL AREA

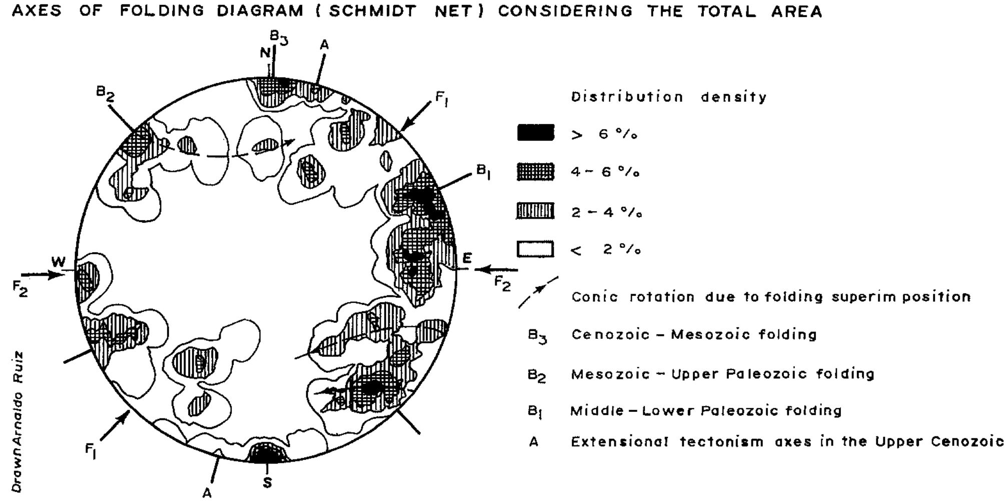


Fig. 3. Analysis of the stratification, fracturing and schistosity (Schmidt Net)

were done whose results have been represented in Schmidt's diagrams (Fig. 3).

The structural analysis (specially schistosity, stratification, fracture pattern, dykes, faulting and folding) yields interesting results which conjugate well with the other analyzed factors.

As it can be seen from the respective diagrams, the rocks show three different systems of folding that we propose correspond to the following tectonic phases:
a) A phase B_1 with general direction N70°E which represents an incomplete conic rotation due to the effects of the successive folding phases B_2 and B_3. Folding B_1 is found to be exclusively associated to the older Paleozoic rocks and principally associated to the western belt of quartzites and greenschists. For this reason, we think it is the oldest one and it could correspond to the orogenic phases of the Middle Paleozoic (Acadian?). This direction coincides with the measurements done by MILLER (1979) for the predevonian series of Los Chonos (45°S).
b) A phase B_2 with general direction N45°W which also presents some conic rotation due to the tectonic superimposition of B_3 foldings which affect it. The folding B_2 appears affecting the Paleozoic rocks of the greenstone internal belt as well as the flyschoid series of possible Middle-Upper Paleozoic age. Accordingly this folding phase might belong to the orogenic event of the Permian and/or Lower Triassic.
c) A phase B_3 of general direction N5°–10°E, with good concentration in the fold axes distribution and without conic rotation, which affects all the Paleozoic rocks as well as the Triassic and Cretacic ones. It is proposed that it corresponds to the tectonic phases of the Upper Mesozoic-Tertiary (Sub-Hercinic and/or Laramic).

The analysis of the schistosity and stratification, is however, more complicated. Usually the rocks in the Coastal Cordillera are gently dipping towards the E, NE and SE. This fact which was considered by some authors as an argument for the accretionist hypothesis of all what has been defined as Western series is also valid for the Triassic and Cretacic rocks, which are doubtless not a result of accretion. We think that the dipping toward the foreland is mostly the common effect of the continuous tectonic uplift and overthrusting stress tendency toward the foreland of the coastal block due to the »raising« pressure and wedge effect of the oceanic plate subduction. Rocks of the ophiolitic complex (greenstones and Paleozoic pillow-lavas) as well as younger rocks specially the Paleozoic flyschoid series which appear in a more distal position, also presented a generalized dipping toward the E. Analyzing the rotations due to the superimposed foldings and the corresponding π planes, we can observe that the π planes corresponding to the folding phase B_1, are clustering exclusively poles of Paleozoic rocks. The π planes corresponding to the B_2 folding phase involve Paleozoic rocks as well as possible Triassic rocks. The biggest dispersion logically corresponds to groups that correlate with the folding phase B_3, which corresponds to the Mesozoic-Tertiary foldings.

It is worthwhile to emphasize that many asbest veinlets structurally coincide with the tensional fissures produced by the folding phase B_2, the same as part of the aplitic dykes of possible Permian-Lower-Triassic age. The younger aplitic dykes (N100°–110°) coincide with the tensional fracturing produced by the folding phase B_3, which might indicate its Upper Cretaceous-Lower Tertiary age.

The developing of the different types of schistosities in the area are the result of the tectonic superimposition of the already mentioned orogenic phases. A penetrative axial type schistosity well developed in the western belt, generally dipping to the E, ENE and ESE, partly coinciding with a possible relic stratification, is probably produced by the tectonic superimposition of all the orogenic phases including those of the Middle Paleozoic (Taconian? and/or Acadian).

A second important schistosity (mainly of the cleavage type) normally associated to kink-bands and crenulations can be recognized partially affecting the different belts of Paleozoic rocks. It might be the result of the orogenic superimposition from the Upper Paleozoic up to recent (Appalachian and youngers).

Later orogenic events (Mesozoic and Cenozoic) produce mainly gentle superimposed folding with easily observable folds of different spatial orientation (NNE, NS, NNW).

The ophiolite complex of the southern Chile coastal Cordillera.

Based on the analogy with classic ophiolite complexes, the authors propose that important geological units which were defined as the »Western Series« of the crystalline Paleozoic basement of the Coastal Cordillera of South Chile (AQUIRRE et al., 1972; HERVÉ, 1977) correspond to an ophiolite complex with almost all the characteristic elements (Fig. 4). The spatial position of every portion of the complex, as well as the absence of some elements (for example, plagiogranites) is not yet sufficiently clear, due probably to the lack of a detailed geological mapping.

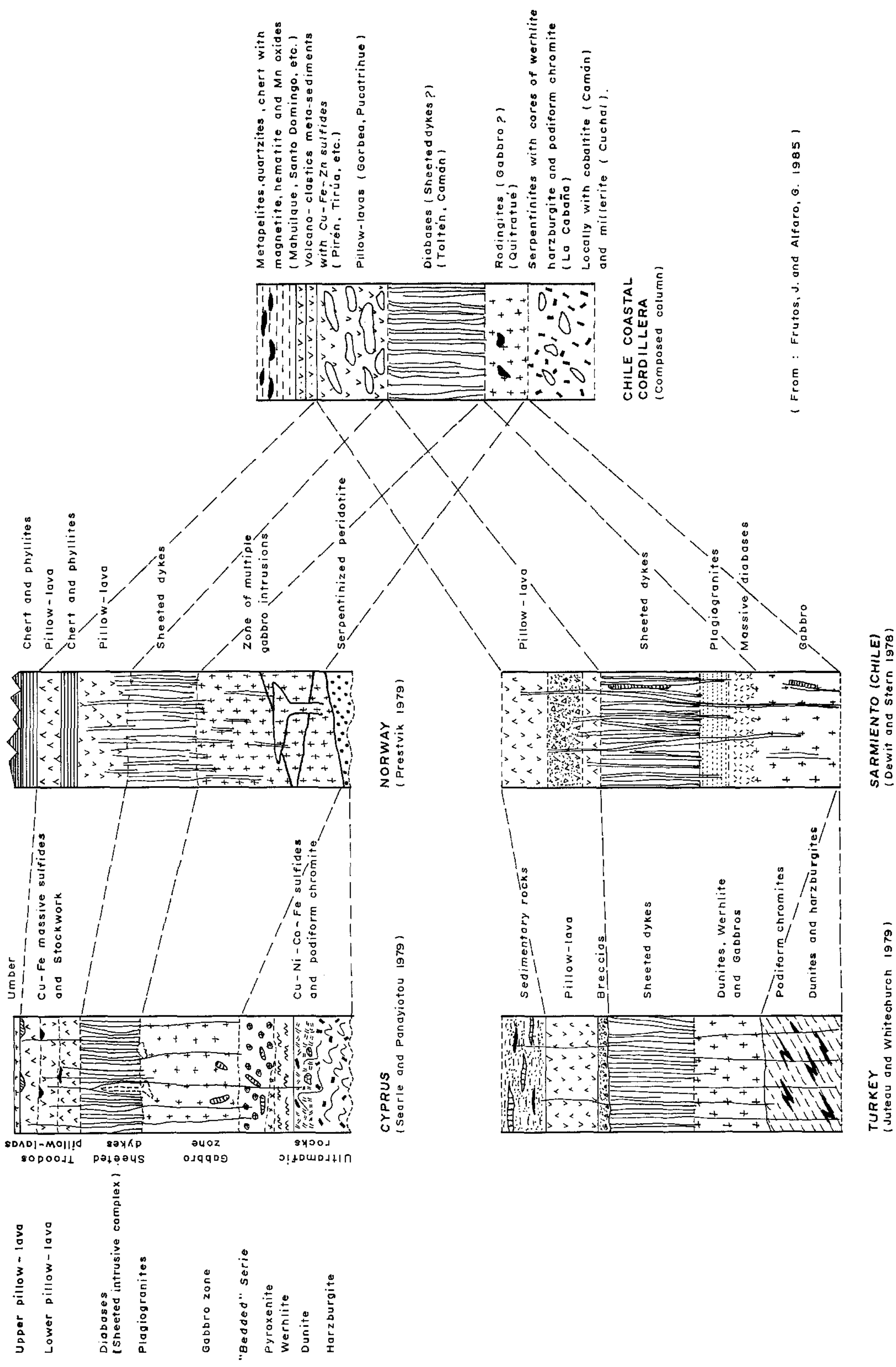


Fig. 4. Comparison with typical ophiolites (arbitrary vertical scale)

HERVÉ et al. (1976) refer to the lithologic sequence of Gorbea, as »non-sequencial ophiolite«.

The ophiolite complex of the Coastal Cordillera of South Chile presents the following units.

1. Ultramafic and Serpentinized Rocks

The presence of ultramafic rocks from South of Arauco Province (38°S) until Llanquihue Province (42°S) had been described by several authors (MUÑOZ-CRISTI, 1931; RUIZ, 1965; ALVAREZ, 1970; ILLIES, 1970; VERGARA, 1970; CONN & PAGE, 1973; MUÑOZ & CONN, 1975; OJEDA, 1976; HERVÉ, 1977; GUZMÁN, 1979; ALVAREZ & RIVERA, 1970; CRUZAT, 1976; ALFARO, 1979, 1980; COLLAO & ALFARO, 1982; OYARZÚN et al. 1984). The rocks correspond mainly to a dunite, with wehrlite nucleus, and possibly harzburgite, generally with intense serpentinization (ALFARO, 1980). Chromite appears as a subordinate mineral in all the ultramafic rocks. Notwithstanding in La Cabaña and Voipire zones, little chromite podiform bodies exist, with banded texture and massive or elongated structures (Fig. 5). The predominant serpentine is antigorite, partly steatitizated. The fact that serpentine veinlets cut chromite crystals indicates that the serpentinization process occurred subsequently to its formation. This fact also explains the formation of an alteration halo in the chromite (ferrichromite and host-chromite formation). In addition to chromite as an accessory mineral of the ultra-mafics, the authors have recognized some little crystals of millerite and cobaltite.

2. Rodingites

The rodingites (AGI definition, 1980) are strongly related with the serpentinites and they could be partly formed as a gabbro metasomation product (although other rocks must not be excluded). The rodingites of Quitratué (GUZMÁN, 1979) are characterized for their fine grain texture containing andradite or grossularite, which can constitute the total of the rocks. Scapolite occurrence is interpreted as a product of alteration of mafic or iron-rich minerals. Rocks similar to those described by GUZMÁN (op. cit.) had been observed in Voipire area and Sierra de Lau-Lau (39°10′ lat. S. 72°40′ long W.). Fig. 5).

3. Dykes in »sheets« (Sheeted Dykes)

Sheeted dykes had been observed by the authors in Sierra de Trapelhué (39°11′ S, 72°41′ W) and in Camán, Valdivia Province. MUÑOZ-CRISTI (1931), HERVÉ et al. (1976), indicated diabase dykes associated to serpentinites of the Gorbea area.

4. Metabasites and Pillow-lavas

ALVAREZ (1970) described metamorphosed mafic rocks in the meridional part of the Nahuelbuta Cordillera, which were later studied in detail by HERVÉ (1976), who associated them to tholeiitic rocks pertaining to the »Western Series« of the Crystalline Paleozoic Basement of the Coastal Cordillera of South Chile (HERVÉ, op. cit.). Near the town of Gorbea, these metabasites present pillow structures (HERVÉ, 1977; ALFARO et al., 1983). Similar to those described in Punta Totora (Coquimbo province) and Punta Lobos (Curicó province) (HERVÉ et al., 1976). In Gorbea, stratigraphically over the metabasites with pillow structure, centimetric layers of manganese minerals, mainly pyrolusite and hollandite, appear intercalated with green schists and quartzites (HELLE et al., 1984). The occurrence of stratiform manganese minerals is more frequent near Valdivia, always associated with quartzites and green schists (ERICKSEN, 1961; DI BIASE & LILLO 1972; ALFARO, 1982). They are interpreted as formed in a distal facies, regarding the volcanic chain as primary genetic center (COLLAO & ALFARO, 1982) and stratigraphically deposited over all before described units (ultramafic and serpentinite rocks, rodingites, sheeted dykes, metabasites and pillow-lavas).

In the northern part of the studied region, the distal facies with respect to the volcanic-exhalative centers is represented by the occurrence of banded iron formation, with ferruginous meta-chert layers and thin horizonts of green schists, whose best exposition appears in the Mahuilque-Relún area (ALVAREZ, 1970; VERGARA, 1970; COLLAO et al., 1979; OYARZÚN, 1982). The massive polymetallic sulfides described in the coastal zone between Tirúa and Valdivia (for example Mina Vieja de Tirúa, Casa de Piedra, Pirén, etc.) (VERGARA, 1970; COLLAO & ALFARO, 1982; ALFARO et al., 1984; ALFARO, 1980) are related to a pyroclastic meta-sediment facies of tholeiitic affinity (green schists) alternated with meta-pelites. No direct relationship between the ophiolite members (sheeted dykes, ultramafic rocks or meta-volcanic rocks with pillow-lavas) and the massive sulfide occurrences has been observed, which makes them morphologically and genetically more similar to the Besshi type deposits of Japan (ALFARO et al., 1983). This similarity coincides with some geochemical characteristics of these sulfides, as high values of Co (until 0.6%) and relatively low contents of Au (lower than 0.8 ppm).

The geochemical analyses carried out in these rocks (green schists) present characteristics which permit to interpret them as accreted ocean bottom

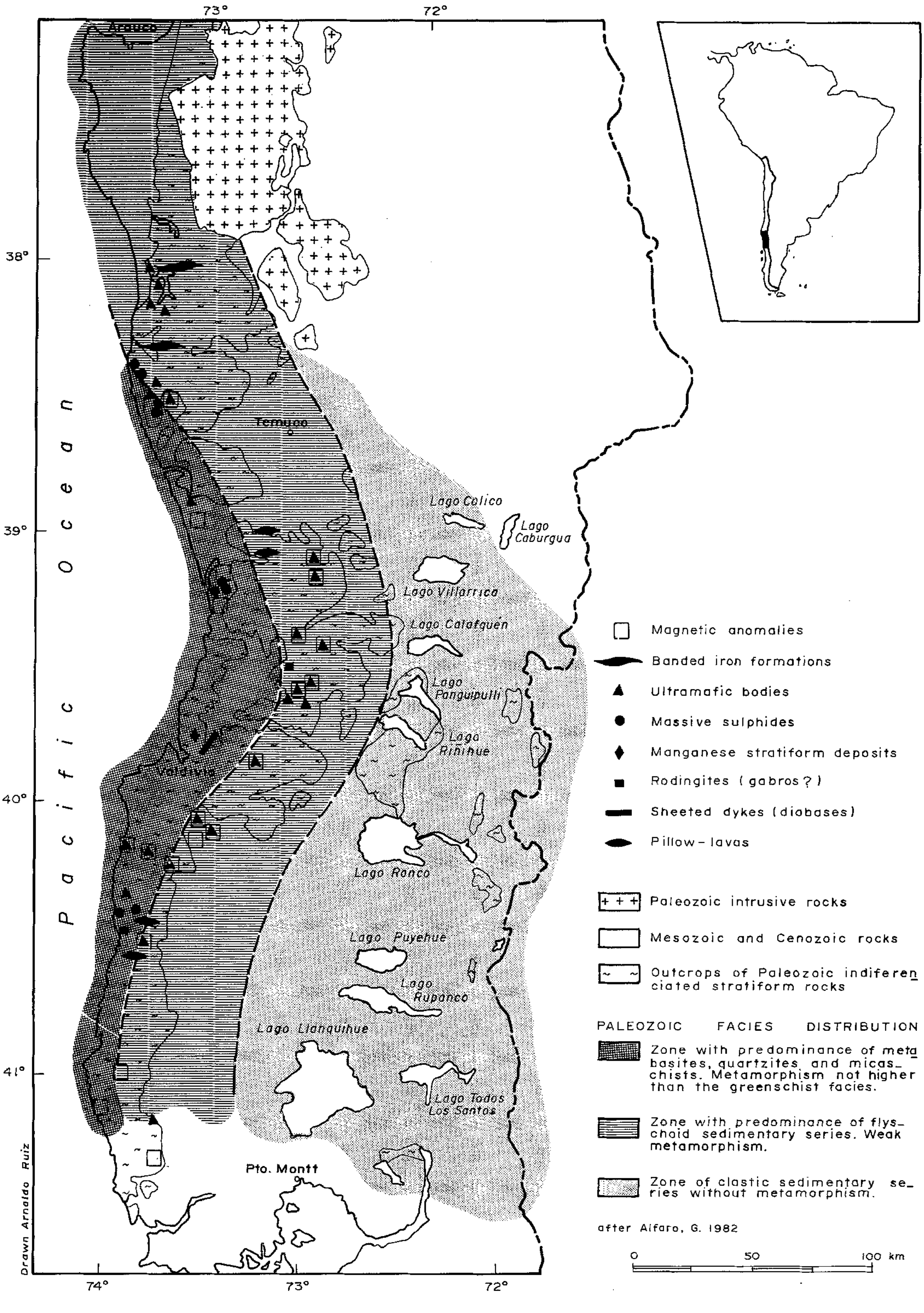


Fig. 5. Geologic – metallogenic characteristics in the southern Chile coastal Cordillera

basalts (HERVÉ et al., 1976; GODOY, 1979; OYARZÚN, 1982) as well as tholeiitic basalts associated to an incipient development of an island arc (FRUTOS & TOBAR, 1975; COLLAO & ALFARO, 1982; ALFARO et al., 1983) (Fig. 6). However, it is important to note, (without considering theoretic petrological arguments), that the field geology characteristics, the stratification, the relatively moderate metamorphism, and the alternancy of quartzites, micaschists and meta-grauwackes, which in many localities can be observed by many kilometers (even to the most distal disposition interfingering with the flyschoid series), favour the idea of an eugeosynclinal realm, in which the tholeiites described coincide with the early development of an island arc in whose »back arc« active marginal basin, the ophiolite belt was formed.

Furthermore analyzing the massive sulfide stratiform mineralization as it has been pointed out by ALFARO (1985) using the FeS contents in sphalerite for the sphalerite-pyrite-pyrrhotite association in equilibrium, the obtained pressure of 2.4 kbar (interpreted as the metamorphism pressure of the involved series), is relatively low and would not support the accretion hypothesis for those rocks. (Fig. 7).

The geologic-metallogenic model proposed in this work permits to predict the possible existence of new mineral resources of the same type we have described here, north and south of the studied region, where the ophiolitic belt elongates with similar characteristics.

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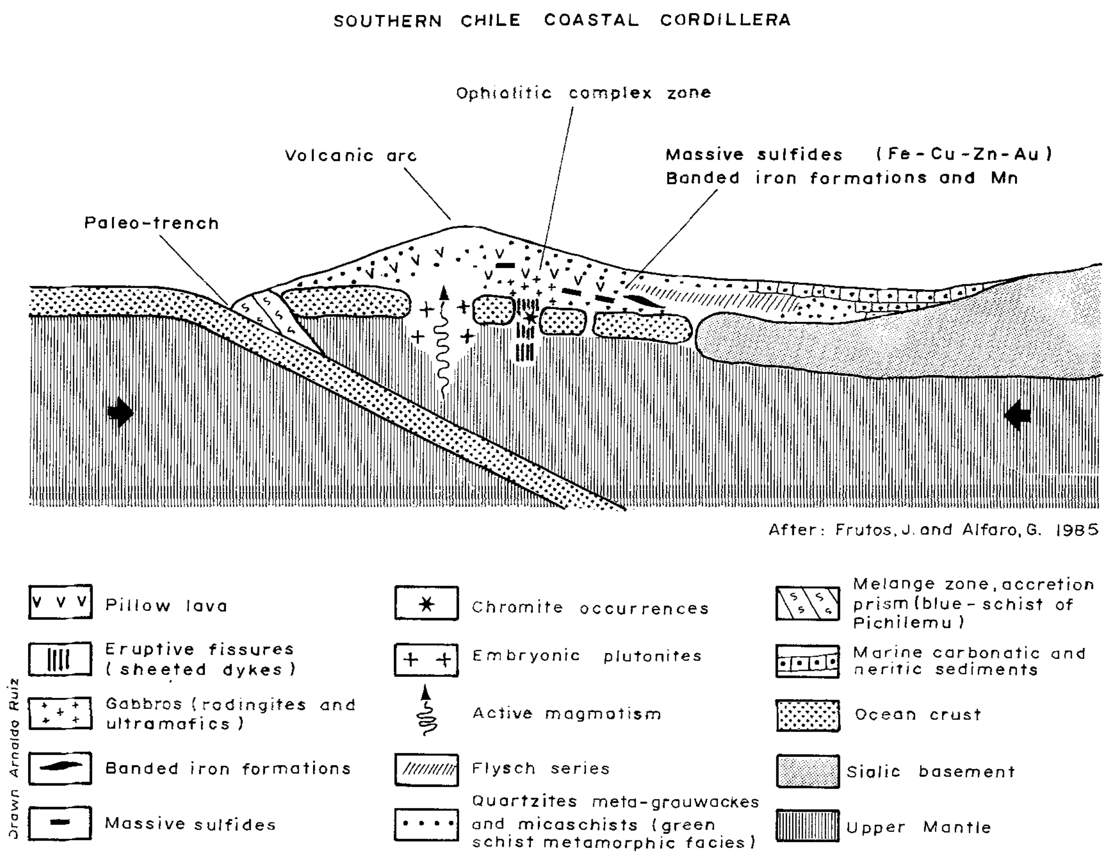

Fig. 6. Metallogenic scheme of the paleozoic eugeosynclinal realm (38°–42° South Latitude)

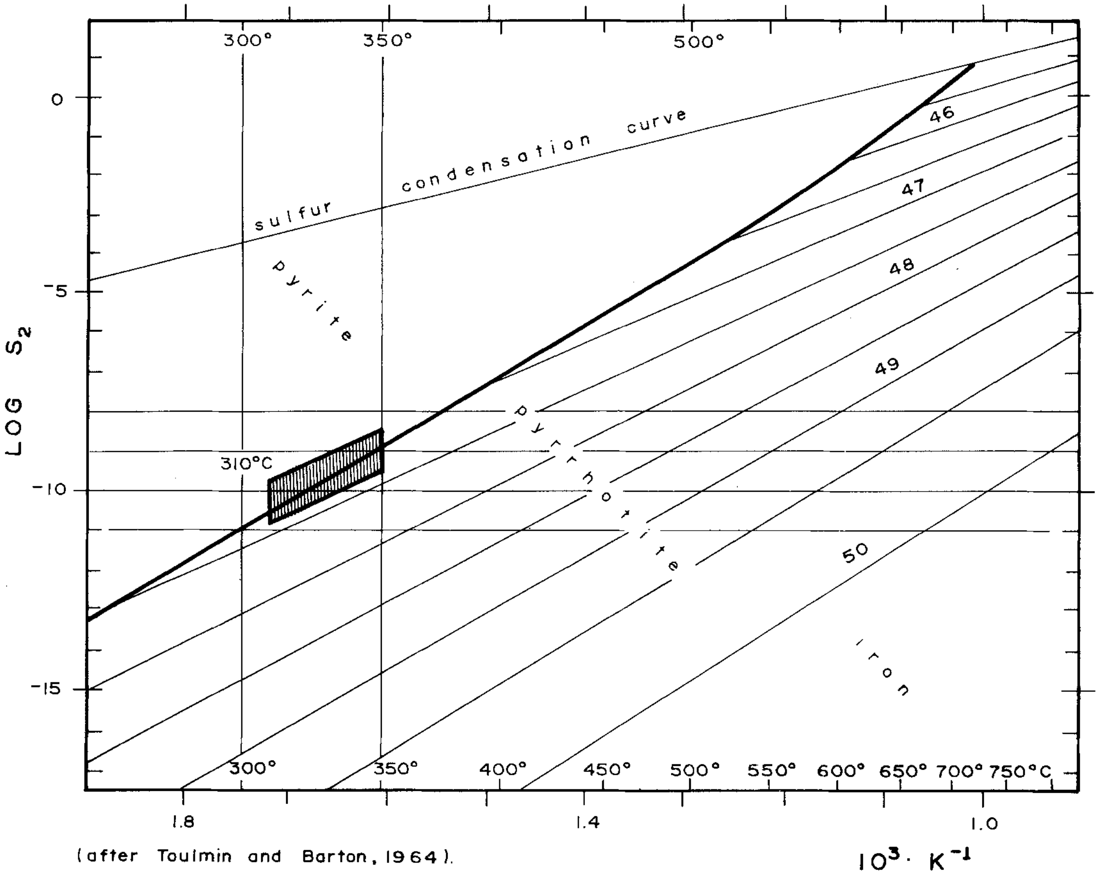

Fig. 7. Activity of S_2 – temperature diagram showing the composition of pyrrhotite in atom percent iron. The shaded area is the activity of S_2 (Alfaro, 1984)

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