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CALDERAS DEL PALEOZOICO SUPERIOR – TRIASICO INFERIOR Y MINERALIZACION ASOCIADA EN LA CORDILLERA DE DOMEYKO, NORTE DE CHILE

LATE PALAEOZOIC – EARLY TRIASSIC CALDERAS AND RELATED MINERALIZATION IN THE CORDILLERA DE DOMEYKO, NORTHERN CHILE

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The Cordillera de Domeyko at 24° South latitude consists largely of extensive exposures of Late Paleozoic - Early Triassic volcanic rocks and associated intrusions of batholithic size. They form part of a magmatic belt extending for more than 4,000 km from Neuquen (Argentina) to Peru and Bolivia. Ignimbrite flow sheets and intermediate lava flows are interbedded with lagoonal (paralic) fossiliferous sediments of Carboniferous - Permian age (OSORIO and RIVANO, 1985). The granitoids and the volcanic - sedimentary suite intrude or unconformably cover Ordovician granitoids and Devonian to Early Carboniferous marine sediments (DAVIDSON et al., 1981; MPODOZIS et al., 1983), and southeast of Imilac they underlie transgressive late Triassic fossiliferous sedimentary sequences (HAYAMI et al., 1977).

The igneous rocks of the area, here defined as Imilac Volcanic Field (IVF), consist of: 1) Silicic to mesosilicic volcanic rocks and 2) Epizonal granitic to granodioritic plutons which are mostly exposed in the axis of the Imilac and Almeida Ranges, or as conspicous arcuate plutons at the more deeply eroded Mariposas Range. Volcanic as well as plutonic rocks in the IVF crop out in two NNE elongate horsts some 100 km long, separated by post late Cretaceous grabens at present occupied by the Punta Negra, Imilac and Atacama salars. Late Tertiary NW and NE high angle reverse faults cross cut the Almeida Range, being the site of geothermal and volcanic activity (i.e. Guanaqueros, Alto del Inca and Punta Colorada Faults). The western Imilac–Mariposas horst is also truncated along its eastern edge by a deep 800 km long fault zone, undergoing cataclistic and mylonitic deformation (Ballenato Fault zone), partly synmagmatic.

A composite granitic–granodioritic batholith 18 x 60 km wide extends northward within the western parts of the IVF (Imilac and Mariposas Ranges) and as isolated plutons in the eastern part of the IVF (Almeida Range). Intrusive radiometric ages (K-Ar mineral ages and Rb-Sr whole rock isochrons) range from 290 to 217 Ma, overlapping with those of volcanic rocks. Most contacts between batholithic and Imilac volcanics are gentle, although tonalitic bodies (Cerro Negro) clearly cut the volcanic pile in the western flank of Almeida Range.

The batholithic core rocks are flanked on both sides by at least 2,000 meters of massive rhyolites, breccias, andesitic flows, ignimbrites, rhyolite porphyries, volcanoclastic and chemical sediments. This volcanogenic synchronical cover may be correlated with extensive exposures of silicic to mesosilicic volcanic rocks, some of them in the form of ash flow tuffs, which outcrop throughout the Main Andean Range of Atacama and Antofagasta Regions (La Tabla, Sierra San Juan, Agua Dulce, Cas and El Bordo Fms.).

The occurrence of such thick sequences of rhyolitic ash flow tuffs, and its distribution closely related to large, granitic plutons, suggest that the volcanic units are the principal eruptive material of various caldera like volcanic structures and the plutons their eroded roots.

The existance of three calderas has been inferred (Fig. 1): Imilac, Mariposas and Guanaqueros calderas. Additional calderas may have existed in areas now occuppied by batholithic rocks and/or at present covered by meso–cenozoic formations.

The Guanaqueros caldera in the Almeida Range, is the oldest structure. Its existence is inferred from the occurrence of a thick pile of rhyolithic ash flow tuff, lava flows and volcanoclastic sediments (Sierra San Juan Fm.) dipping outward and spatially related to a core of pink granites and red granites and granodiorites (Vizcachas granite). A Late Carboniferous 290 Ma (K-Ar on biotite) minimum age was obtained for the first time in Chile in one ignimbrite flow at the base of the volcanic pile. A severe westerly tilting of the entire area is expected due to the occurrence of early paleozoic rocks on the eastern side of the Almeida Range. Cenozoic reverse faults complicate the geometry of the different units of the caldera.

The Imilac caldera lies in the centre of the IVF. It is nearly circular, has some 25 km in diameter and is flanked on three sides by a complex silicic volcanic pile (Agua Dulce Formation) dipping outward from the batholithic core. The eastern side is deeply eroded and open to the Salar de Imilac area. The Imilac caldera plutonic root largely consist of a central elongate, fine grained high silica Middle Triassic pluton (Imilac monzogranite) that intrudes a Permian plutonic suite of granodiorites, tonalites, monzodiorites and gabbros, probably the core of an older caldera related to other volcanic piles (El Bordo Formation).

The Mariposas caldera, located on the northern end of the IVF, provide a deeper erosional view into a volcano–plutonic suite. At present only a rim of miariolithic granites of alkali feldspar and quartz porphyries intruding middle grained granodiorites, quartz diorites, and monzonites is preserved. Scattered outcrops of volcanic rocks lie of the southern and northern tips of the arcuate Mariposas Range (Agua Dulce Formation).

Available geochemical data show that both plutonic associations are calcalkaline and similar to other subduction related granitoids. While the older Late Carboniferous - Middle Permian low to mesosilicic plutons are metaluminous granitoids and have "I type" affinities (Vizcachas and Imilac granodiorites and gabbros), the younger Late Permian -Early Triassic high silica plutons are normal peraluminous granitoids (Vizcachas pink granites). Preliminary Rb-Sr isotopic results show that both plutonic associations and the related volcanics have initial Sr^{87}/Sr^{86} ratios between 0.7046 and 0.7055 in complete accordance with that assumed in early isotopic work in the Imilac- Monturaqui area (HALPERN, 1978). The younger rocks have the lower initial Sr^{87}/Sr^{86} ratios.

Low initial ratios are indicative of direct mantle derived magmas. Geochemical work indicates that granitic-rhyolitic magmas cannot originate directly in the upper mantle (WYLIE, 1981). Therefore, IVF rocks might have experienced extensive crystal fractionation and some crustal contamination.

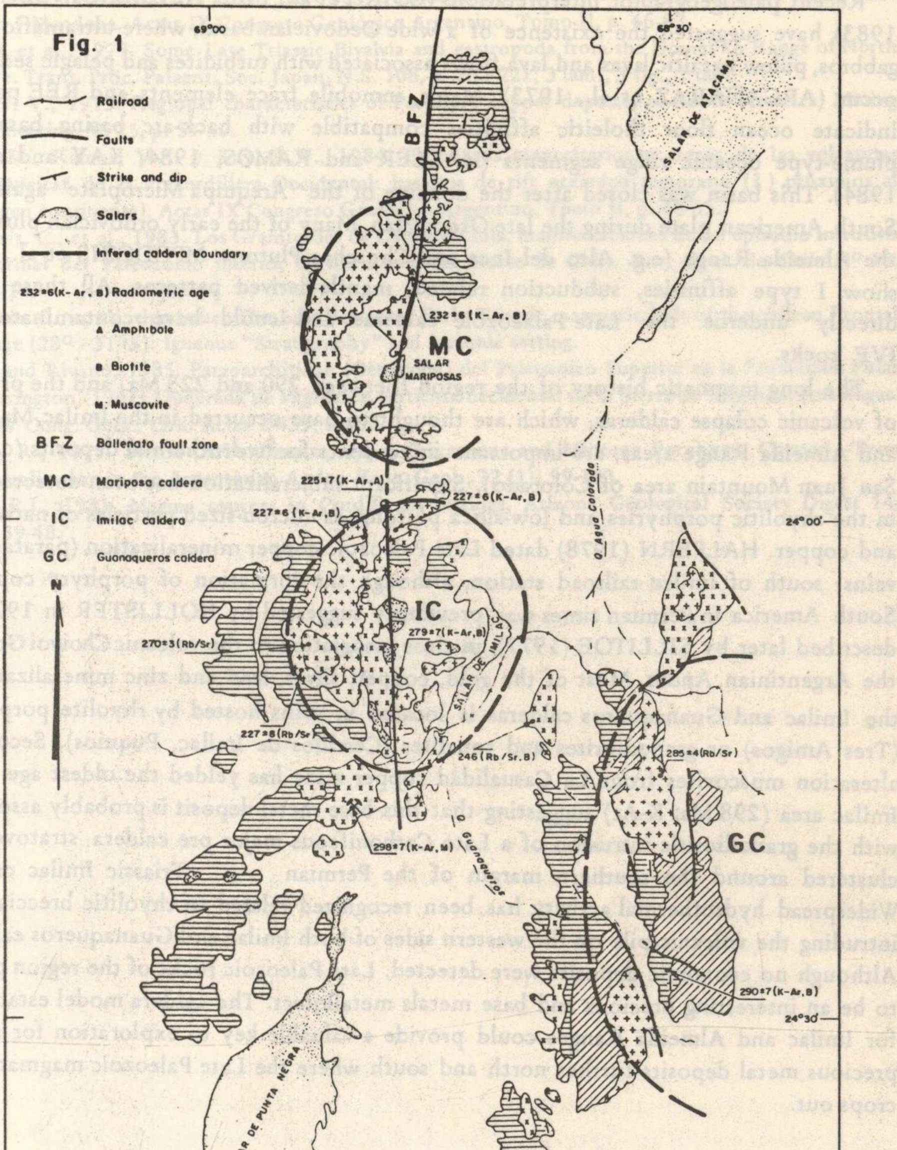

Fig.1. Distribution of Late Paleozoic-Triassic rocks and related Calderas. Domeyko Range, Northerm Chile, (24° S.L.

Fig.1. Distribución de las rocas del Paleozoico Superior-Triásico y Calderas Asociadas en la Cordillera de Domeyko, Norte de Chile, (24° L.S).

Recent paleogeographic interpretations (COIRA et al., 1982; ALLMENDINGER et al., 1983) have suggested the existence of a wide Oedovician basin, where ultramafic rocks, gabbros, pillow basaltic lavas and lava flows associated with turbidites and pelagic sediments occur (ARGAÑARAZ et al., 1973). Major, inmobile trace elements and REE patterns indicate ocean floor tholeitic affinities compatible with back-arc basing basalts or plume-type oceanic ridge segments (HALLER and RAMOS, 1984; KAY and others, 1984). This basin was closed after the docking of the "Arequipa Microplate" against the South American plate during the late Ordovician. Many of the early ordovician plutons in the Almeida Range (e.g. Alto del Inca and Choschas Plutons; MPODOZIS et al., 1983) show I type affinities, subduction related, mantle-derived patterns. All these rocks, directly underlie the Late Palaeozoic calderas and could have contaminated the IVF rocks.

The long magmatic history of the region (between 290 and 225 Ma) and the presence of volcanic colapse calderas, which are thought to have occurred in the Imilac, Mariposas and Almeida Range areas, are important antecedents for hydrothermal deposits (c.f. The San Juan Mountain area of Colorado). Significant mineralization has been detected both in the rhyolitic porphyries and low-silica plutons, as micron-sized particles of native gold and copper. HALPERN (1978) dated Late Paleozoic copper mineralization (paratacamite veins) south of Imilac railroad station, although the formation of porphyry copper in South America in Permian times was previously suggested by HOLLISTER in 1973 and described later by SILLITOE (1977), in close association to the volcanic Choiyoi Group in the Argentinian Andes. Most of the gold, copper, silver, lead and zinc mineralization in the Imilac and Guanaqueros calderas is located in veins hosted by rhyolite porphyries (Tres Amigos) or granodiorites and tonalites (Cerrillos de Imilac, Puquios). Secondary alteration muscovites from La Casualidad copper mine has yelded the oldest age in the Imilac area (298 Ma, K-Ar) suggesting that this base metal deposit is probably associated with the granodioritic intrusion of a Late Carbonifeous major pre caldera stratovolcano clustered around the southern margin of the Permian — Triassic Imilac caldera. Widespread hydrothermal activity has been recognized related to rhyolitic breccia pipes intruding the volcanic pile on the western sides of both Imilac and Guanaqueros calderas. Although no economic deposits were detected. Late Paleozoic rocks of the region proved to be an interesting precious and base metals metallotect. The caldera model established for Imilac and Almeida Ranges could provide a valuable key to exploration for similar precious metal deposits further north and south where the Late Paleozoic magmatic belt crops out.

REFERENCES

Allmendinger, R. et al., 1983. Paleogeography and Andean structural geometry, northwest Argentina. Tectonics, vol. 2, Nº 1, p. 1-16.

Argañaraz, R. et al., 1973. Sobre el hallazgo de serpentinitas en la Puna Argentina. Congr. Geol. Arg. Nº 5, Actas Vol. 1, p. 23-32.

Coira, B. et al., 1982. Tectonic and magmatic evolution of the Andes of Northern Argentine and Chile. Earth Sci. Rev. Vol. 18, p. 303-332.

Davidson, J. et al., 1981. El Paleozoico de Sierra de Almeida, al oeste de Monturaqui, Alta Cordillera de Antofagasta, Chile. Rev. Geol. de Chile Nº 12, p. 3-23, 7 Figs., 2 Fot., 2 Tab.

Halpern, 1978. Geological significance of Rb-Sr isotopic data of northern Chile crystalline rocks of the Andean orogen between latitudes 23º and 27º South Geol. Soc. of Am. Bul., V. 89, p. 522-532.

Haller, M.A. y Ramos, V.A., 1984. Las ofiolitas Famatinianas (Eopaleozoico) de las Provincias de San Juan y Mendoza. Actas IX Congreso Geológico Argentino, Tomo II, p. 66-83.

Hayami, et al., 1977. Some Late Triassic Bivalvia and gastropoda from the Domeyko Range of North Chile. Trans. Proc. Palaent. Soc. Japan, N.S. 108, p. 202-221, 3 lam., 3 fig., 1 tabl.

Hollister, V., 1973. Regional characteristics of Porphyry copper deposits of South America: Mining Engineering, V. 25, p. 51-56.

Kay, S.M.; Ramos, V.A. y Kay, R.W., 1984. Elementos mayoritarios y trazas de las volcanitas ordovícicas de la Precordillera Occidental: basaltos de rift oceánico temprano (?) próximos al margen continental. Actas IX Congreso Geológico Argentino, Tomo II, p. 48-65.

Mpodozis, C., et al., 1983. Los Granitoides de Cerros de Lila, manifestaciones de un episodio intrusivo y termal del Paleozoico inferior en los Andes del Norte de Chile. Rev. Geol. de Chile N° 18, p. 3-14.

Mpodozis, C., et al., this issue. The Late Paleozoic Early Triassic magmatic Belt of the chilean Frontal Range (28° - 31°S): Igneous "Stratigraphy" and tectonic setting.

Osorio and Rivano, 1985. Paraparchitidae (Ostracoda) del Paleozoico Superior en la Formación Pular (Harrington, 1961) Quebrada de Pajonales, vertiente occidental de la Sierra de Almeida, Antofagasta. IV Cong. Geol.. Chil. Actas 1-439, 1-457.

Sillitoe, R., 1977. Permo-Carboniferous, upper Cretaceous and Miocene Porphyry. Copper —Type mineralization in the Argentinian Andes. Econ. Geol., 72 (1): 99-103.

Wyllie, P.J., 1981. Magma sources in Cordilleran settings, Arizona Geological Society Digest 14, pp. 39-48.