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BE-10 EN LAVAS DE LA ZONA VOLCANICA ANDINA MERIDIONAL (35°40°S): EVIDENCIAS PARA LA SUBDUCCION DE SEDIMENTOS

BE-10 IN LAVAS FROM THE ANDEAN SOUTHERN VOLCANIC ZONE (35°40°S): EVIDENCE FOR SEDIMENT SUBDUCTION

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Be-10 has been measured in 8 volcanic rocks from historic eruptions in the Chilean Andes (35-40°S latitude). Volcanoes of the Andean Southern Volcanic Zone lie ~90- 120 km. above a slab dipping to the east at 15-30° (Barazangi and Isacks, 1976). Calc-alkaline lavas from this region are primarily high-alumina basalt with minor andesite, dacite and rhyolite. An overview of the geochemistry of the lavas from the Southern Volcanic Zone (Harmon et al ., 1984; Hickey et al 1984) indicates that these lavas have isotopic and trace element characteristics similar to those of intraoceanic island arcs, and that they show negligible effects resulting from ascent through relatively thin (35-40 km) continental crust.

Be-10 was measured in these lavas because it is an excellent tracer of sediment subduction in island arcs. Be-10 is a cosmogenic isotope formed by spallation reactions in the upper atmosphere. It is transfered via rain and snow to the earth's surface, where it is strongly partitioned into sediments and soils (Valette-Silver et al , 1985). The half-life for Be-10 is short, only 1.5 x 10^6 years (Yiou and Raisbeck, 1972). As a result of its surficial source and strong affinity for sediments, Be-10 concentrations are high in oceanic sediments, averaging 5 x 10^9 atoms/gram (Raisbeck et al, 1981), and are quite low, 1 x 10^6, in mid-ocean ridge and oceanic island basalts (Tera et al , 1985). Hence, even a small sediment signature in island arc magmas could be quite pronounced. As a consequence of its short half-life, Be-10 monitors sediment subduction only if it is approximately contemporaneous with magma generation. Because cosmogenic Be-10 is almost completely decayed to B after 10 my, ancient sediment recycling would impose no Be-10 anomaly on modern arc lavas.

Be-10 is measured by Accelerator Mass Spectromety using an isotope dilution technique. Be is extracted from ~5 g of volcanic rock, from which all weathered surfaces have been carefully removed. Multiple analysis of in-house standards indicate an uncertainty of ± 12.4 °/o (1 sigma) for these low concentration samples.

Be-10 concentrations in island arc volcanics span two orders of magnitude (Tera et al , 1985). Lavas from the Sunda, Mariana and Halmahera arcs contain less than 1 x 10^6 atoms/gram, and are indistinguishable from mid-ocean ridge and oceanic island basalts. Samples from Peru and Japan are characterized by values generally less than 1 x 10^6 atoms/gram, but each arc has a few lavas which contain 1 - 10 x 10^6 atoms/gram. Volcanics from the Aleutian and Central American arcs consistently have high Be-10 concentrations, 2-15 and 1-24 x 10^6 atoms/gram, respectively.

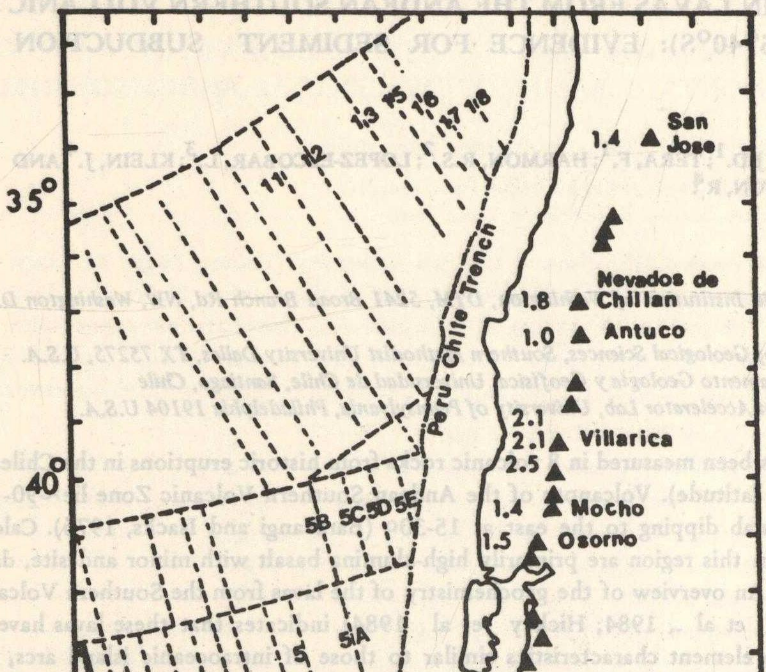

Fig.1. Map of the Chilean Margin. Position of the Chile Rise (heavy solid line), fracture zones (heavy dashed lines) and magnetic anomalies (light dashed lines) from Herron et al, 1981. Triangles represent Cenozoic volcanoes; numbers adjacent to volcanoes indicate Be-10 concentrations in millons of atoms/gram.

Fig.1. Mapa del margen Chileno. La posición de la Dorsal de Chile (línea gruesa), de las zonas de fractura (líneas segmentadas) y de las anomalías magnéticas (líneas delgadas segmentadas) según Herron et al, 1981. Los triángulos representan los volcanes cenozoicos; los números adyacentes a los volcanes indican las concentraciones de Be-10 en millones de átomos por gramo.

Lavas from the Chilean Southern Volcanic Zone, contain measurable amounts of Be-10, 1-2.5 x 10^6 atoms/gram. Be-10 concentrations are shown on the map in Fig. 1. These preliminary data show no geographic control on Be-10 concentrations. Hence, there is no overall correlation between Be-10 and Sr or 0 isotopes compositions, which tend to

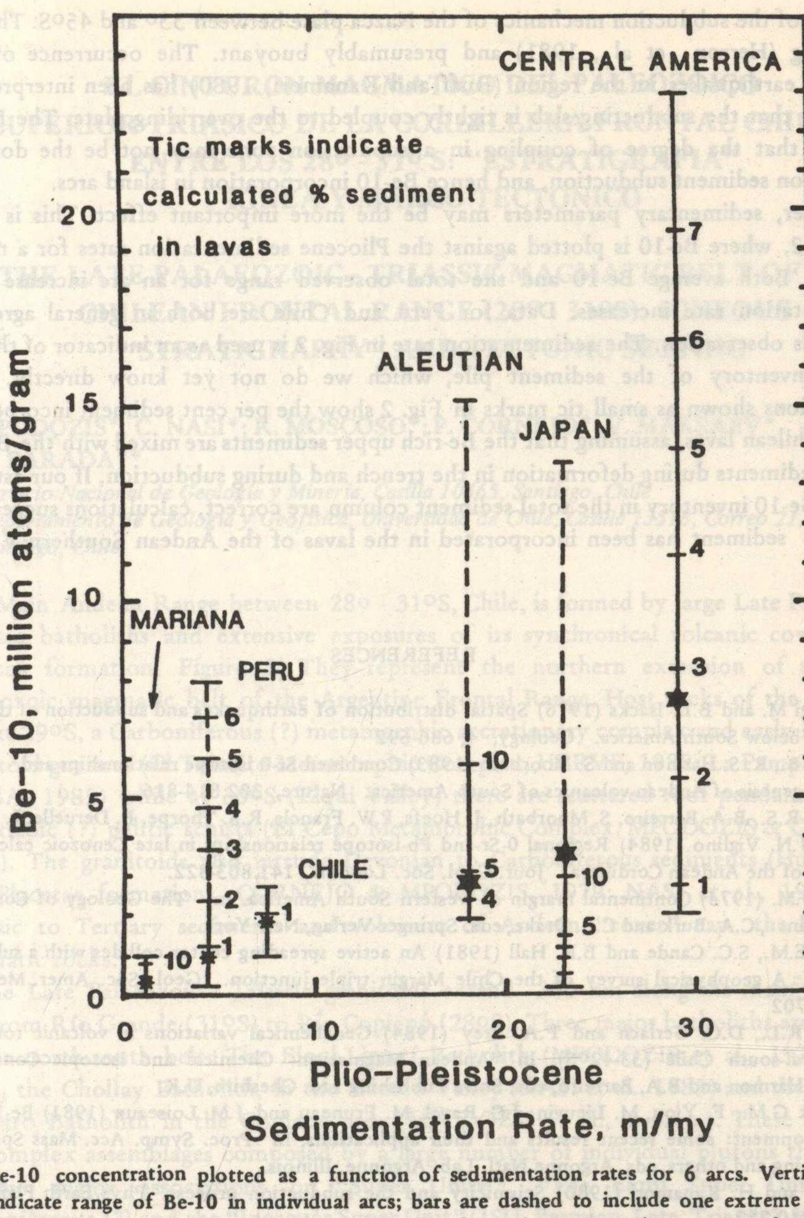

Fig.2. Be-10 concentration plotted as a function of sedimentation rates for 6 arcs. Vertical bars indicate range of Be-10 in individual arcs; bars are dashed to include one extreme value in each of three arcs. Stars represent average value for each arc. Note that average values increase as the sedimentation rate increases.

Fig.2. Concentración de Be-10 graficada versus velocidades de sedimentación para arcos. Las barras verticales indican el rango de Be-10 en arcos individuales; las barras están segmentadas para incluir un valor extremo en cada uno de tres arcos. Las estrellas representan los valores promedios para cada arco. Nótese que los valores promedio aumentan a medida que la velocidad de sedimentación aumenta.

increase southward through the Zone (Deruelle et al, 1983). Note that there is no systematic change in Be-10 concentration as the age of the plate decreases to the south.

Incorporation of Be-10 in lavas of the Southern Volcanic Zone is especially interesting in view of the subduction mechanics of the Nazca plate between 33° and 45°S. The plate is young (Herron et al , 1981) and presumably buoyant. The occurrence of large, shallow earthquakes in the region (Ruff and Kanamori, 1980) has been interpreted to indicate that the subducting slab is tightly coupled to the overriding plate. The Be data suggest that the degree of coupling in a subduction zone may not be the dominant control on sediment subduction, and hence Be-10 incorporation in island arcs.

Rather, sedimentary parameters may be the more important effect. This is shown in Fig. 2, where Be-10 is plotted against the Pliocene sedimentation rates for a number of arcs. Both average Be-10 and the total observed range for an arc increase as the sedimentation rate increases. Data for Peru and Chile are both in general agreement with this observation. The sedimentation rate in Fig. 2 is used as an indicator of the total Be-10 inventory of the sediment pile, which we do not yet know directly. Model calculations shown as small tic marks in Fig. 2 show the per cent sediment incorporation in the Chilean lavas, assuming that the Be-rich upper sediments are mixed with the Be-poor lower sediments during deformation in the trench and during subduction. If our estimates of the Be-10 inventory in the total sediment column are correct, calculations suggest that. 0.5-1.5% sediment has been incorporated in the lavas of the Andean Southern Volcanic Zone.

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