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NEOGENE VOLCANISM IN THE CENTRAL CHILEAN ANDES (26°-28° S)

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Four or five large volcanic centers, from Doña Ines in the northe to Jotabeche in the south, define a mid-late Miocene volcanic front between 26° and 28° S. This volcanic front lies approximately 50-75 km westward of the locus of Quaternary volcanism. The following is a preliminary outline of the geology, age, geochemistry and petrology of part of the volcanism along this Neogene volcanic front, followed by a discussion of the implications of the results for Andean magmagenesis and tectonics.

Volcan Copiapo is perhaps the largest volcanic complex along the front with more than a dozen discernable vents. Argon/argon geochronology indicates that volcanism persisted at Volcan Copiapo for almost 5 Ma. The oldest units (14-12 Ma) outcrop around the margins of the complex. Final volcanic activity (10-8.6 Ma) was focussed near the composite cone Azufre. Azufre fills a preexisting caldera formed in a moderate eruption during which pyroclastic flows were emplaced to the north-northeast, northwest and southeast. These pyroclastic flows were strongly channeled by existing volcanic cones and, at most, traveled some 15 km from the caldera. These characteristics, plus the absence of extensive airfall deposits accompanying the ignimbrite, suggest that the pyroclastic flows are genrated by a mechanism other than by collapse of a Plinian column (Fisher and Schmincke, 1984). This caldera-producing eruption capped important explosive activity at Volcan Copiapo. Eruption of lava, infilling of the caldera and construction of the Azufre cone dominated final volcanic activity.

During final effusive volcanic activity at Volcan Copiapo, an explosive eruption of unusually large magnitude occured at Volcan Maricunga, Copiapo's northern neighbor. Evidence for this eruption consists of scattered outcrops of ignimbrite some 10-50 km nortwest, west and southwest of Volcan Maricunga. This ignimbrite, referred to as the San Andres ignimbrite, has been dated at 9.2-9.4 Ma (Clark and others, 1967; original values have been adjusted for newer decay constants). The San Andres ignimbrite is non-welded, generally slightly lithified and unusually fine-grained and well-sorted compared to a majority of pyroclastic flow deposits. The outcrops are from 80-100 m thick, represent a single cooling unit and possibly a single flow unit. The presence of discontinuos breccia horizons 30 km from the vent and ubiquitous fossil fumaroles suggests deposition from a highly-fluidized, probably high velocity, pyroclastic flow which originated from collapse of high Plinian eruptive column (Sparks and others, 1978).

The eruption producing the San Andres ignimbrite was unusual, not only for its large magnitude, but also because the disrupted magma was whyolitic, not intermediate, in

composition. In addition, through a vertical section, the San Andres ignimbrite exhibits prominent compositional zonation in certain elements, such as Ba, Mg, Sr and Zr. Other elements, such as Si, Ti and Al, show little to no variation. The most notable mineralogic zonation is the abrupt appearance of biotite about halfway up every outcrop. Sanidine and quartz are the most abundant phenocryst phases in the pumices.

In contrast to the San Andres ignimbrite, volcanic rocks from Volcan Copiapo and Volcan Doña Ines are all medium –to high– K andesites and dacites. Plagioclase and hornblende are the most abundant phenocrysts in both andesites and dacites. In comparison to those erupted from Copiapo, lavas and pyroclastics erupted from Doña Ines generally have lower K and Rb concentrations at a given SiO_2 content. The two least-evolved lavas from Doña Ines have anomalously high concentrations of K and Rb. K/Rb ratios are uniform within the two complexes, however, Copiapo characteristically erupts lavas and pyroclastics with lower K/Rb. Major and trace element contents of volcanic rocks from both volcanoes overlap with those of volcanic rocks from selected Quaternary volcanoes in northern Chile (Deruelle, 1982; Gardeweg and others, 1984). Nevertheless, lavas from Tres Cruces volcano, a younger volcano located 40 km northeast of Copiapo, are greatly enriched in K, Rb, Zr and depleted in Sr. Lavas extruded in the valley immediately east of the Volcan Copiapo complex have unusually high Cr, Ni and Mg contents (e.g. Cr 60-100 ppm). At the same time, concentrations of incompatible elements are similar to, or slightly higher than, those in volcanic rocks from Copiapo.

Least squares calculations and trace element modeling indicate that the compositional variation preserved in volcanic rocks at Volcan Copiapo can be accounted for by fractional crystallization, largely of plagioclase and hornblende. The high K and Rb lavas preclude a common heritage for the volcanic rocks of Volcan Doña Ines. Least squares calculations also demonstrate that a mafic basaltic andesite, such as given by Thorpe and others (1984) could represent a parental composition to Copiapo andesites through fractional crystallization of plagioclase, clinopyroxene, olivine and minor amounts of magnetite. Calculated Cr, Ni and Zr concentrations support this lineage, however calculated Rb, Ba and Sr contents are unacceptably low. These trace element misfits may lend credence to Thorpe and others (1984) conclusion that fractional crystallization beneath Central Andean volcanoes is generally accompanied by selective crustal assimilation.

The lavas erupted in the valley east of Volcan Copiapo can be derived by mixing of a Copiapo andesite and a mafic, Cr-rich basaltic andesite. The mixtures were probabley superheated as all of these lavas are aphyric and have trachytic textures (Gerlach and Grove, 1982).

Following Smith (1979) and Hildreth (1979), the compositional gradients displayed through a vertical section of the San Andres ignimbrite can be inverted to characterize compositional zonation in the magma chamber. All of the major and trace element gradients can be explained by crystal-liquid equilibria, particularly sanidine - liquid equilibria. Least squares calculations also suggest that quartz, and to a much lesser extent magnetite, play a supporting role to sanidine during fractionation.

The geochronological results of this study combined with those of Gonzalez - Ferran and others (1985) show that volcanoes at this latitude often have a long eruptive history, possibly persisting even when the main locus of volcanic activity has shifted. Eastward shifting of the volcanic front away from the Doña Ines - Jotabeche line appears to have taken place about 8-9 Ma. Interestingly, this is about the time extensive volcanism ceases

south of 28° S and of the proposed initiation of tectonic segmentation (Maksaev and others, 1984; Jordan and others, 1983a). Quaternary volcanism terminates around 27°-28° S and does not reappear until the latitude of Santiago, some 500 km to the south (Barazangi and Isacks, 1976; Jordan and others, 1983b). This Quaternary volcanic gap coincides with a region of very shallow or flattening subduction. This latitude (27° - 28° S) may also have been the location of an important tectonic discontinuity in the mid-late Miocene volcanic front. As evidence, Volcan Copiapo is a large, complex volcanic center, befitting a volcano on or near a segment boundary (Stoiber and Carr, 1973; Hughes and others, 1980; Kay and others, 1982). In contrast, Doña Ines volcano, away from the boundary, is a morphologically simple composite cone.

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