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NEVADOS DE CHILLÁN VOLCANIC COMPLEX (SOUTHERN ANDES, 36°55'S): GEOLOGY, MINERALOGY, GEOCHEMISTRY AND MAGMA EVOLUTION

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INTRODUCTION

Nevados de Chillán is the southernmost volcanic complex (36°55'S) of the TSVZ of the Andes and is separated by about 60 km from Antuco volcano (37°25'S), which is the northernmost stratovolcano of the CSVZ. Within the TSVZ, there are marked changes in tectonism along strike that controlled the relative role of petrogenetic processes. In this presentation we discuss the geological setting, mineralogy, and chemical and isotopic composition of Upper Pleistocene-Holocene lavas from Nevados de Chillán in order to better understand the evolution of these magmas.

GEOLOGICAL SETTING

Nevados de Chillán, an elongated volcanic chain striking N140° for ~10 km, is constructed on a basement of granitic intrusive rocks and Cenozoic lavas. Block-type lava flows (20 to 50 m thick) predominate over aa-type lavas (~ 5 to 10 m thick)(Naranjo et al. 1994). Dixon et al. (1999) divided the complex into the NW Cerro Blanco subcomplex (predominantly andesitic) and the SE Las Termas subcomplex (predominantly dacitic and rhyolitic). This chain is located inside the remnants of a caldera which was probably related to Upper Pleistocene ignimbrite eruptions. The youngest of these deposits has been dated at 37,500±500 BP (Dixon et al., 1999). On this basis, the Nevados de Chillán post-caldera stratovolcanoes and cones are Upper Pleistocene to Holocene in age.

PETROGRAPHY AND MINERALOGY

Post-caldera andesites, dacites and rhyolites contain phenocrysts of plagioclase (An_{71-46} in andesites to An_{59-30} in dacites), orthopyroxene (En_{78} in andesites to En_{48} in dacites), clinopyroxene ($En_{40}Fs_{20}Wo_{40}$), magnetite, and rare olivine, apatite and ilmenite. Hornblende and biotite are absent in these lavas. Olivine ($Fo_{70.4-72.4}$) is observed in one basaltic andesite which also contain just clinopyroxene phenocrysts. Olivine xenocrysts occur in some lavas and typically have a pyroxene reaction rim.

GEOCHEMISTRY

The post-caldera products of Nevados de Chillán range in composition from basaltic andesite (55.5 wt% SiO_2) to low silica rhyolite (69.5 wt% SiO_2). Lavas are calc-alkaline, medium-K_2O, with high Al_2O_3 contents and no iron enrichment. SiO_2 shows negative correlations with Al_2O_3, Fe_2O_3*, CaO, Sr, Sc, V, Cr, Co and Ni, and positive correlations with K_2O, Rb, Ba, Y, Zr, Hf, Nb, Th and REE. Primitive mantle normalized trace element diagrams are characterized by a Ta and Nb trough and relative LREE enrichment, typical of arc-type lavas. Eu negative anomaly are presented just by the most evolved lavas. The Sr- and Nd-isotope ratios are 0.70386 and 0.512872 respectively in one basaltic andesite and 0.70388 and 0.512877 in one rhyolite. These isotopic values are amonst the lowest of the SVZ Quaternary lavas.

DISCUSSION

Our results for Nevados de Chillán combined with published literature data show that from 35° to 37° S there are major changes in magma evolution, that probably are controlled by tectonism. From 35° to 36° S, major volcanic centers are characterized by open system processes during the evolution of basaltic to silicic magmas. At 36°12' S, the Nevado de Longaví complex is dominated by andesite and two nearly CSFC sequences, including an older series of lavas created by fractionation of anhydrous phases and a younger system where amphibole was a dominant fractionating phase (Sellés et al. 2004; Rodríguez et al., 2005). At Nevados de Chillán (36°55'S) basalt is absent and although the lava sequence from basaltic andesite to rhyolite can be explained by CSFC of just anhydrous phases, other factors, such as the linear trends in element – element plots, the continuity of lava compositions in the range of 55.5-69.5% SiO_2, and the Rb and Th enrichments in Nevados de Chillán rhyolites compared to Puyehue rhyolites, which are generated by CSFC (Gerlach et al., 1988), also favor mixing as a major process. The high Rb-Th endmember could be (based on similar Sr and Nd isotopes in mafic and silicic endmembers) due to: 1) super-differentiated liquid trapped in cumulus minerals, 2) partial melt of young volcanic pile related to earlier eruptive episodes, 3) bulk contamination by underlying relatively young granitic intrusives and 4) contamination by partial melts of underlying young granitic intrusives.

CONCLUSIONS

Post-caldera lavas from the Nevados de Chillán volcanic complex in the Southern Volcanic Zone of the Andes are calc-alkaline andesite, dacite and rhyolite. Basaltic andesite is rare and basalt is absent. The phenocrysts of the most silicic phases are dominantly plagioclase with lesser amounts of olivine, clinopyroxene, orthopyroxene and magnetite; hornblende and biotite are absent. Sr and Nd isotopic ratios in a basaltic andesite and rhyolite samples are similar. CSCF of the anhydrous phenocryst phases present and magma mixing are major processes controlling the evolution of this complex from basaltic andesite to rhyolite.

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REFERENCES

Dixon. H.; Murphy, M.; Sparks, S.; Chávez, R.; Naranjo, J.; Dunkley, P.; Young, S.; Gilbert, J.; Pringle, M. 1999. The geology of Nevados de Chillán volcano. *Revista Geológica de Chile*, Vol. 26, No.2, p. 227-253.

Gerlach, D.C.; Frey, F.A.; Moreno, H.; López-Escobar, L. 1988. Recent volcanism in the Puyehue—Cordón Caulle región, Southern Andes, Chile (40.5^{o}S): Petrogenesis of evolved lavas. *Journal Petrology*, Vol. 29, p. 333-382.

Naranjo, J.A.; Chávez, R.; Sparks, S.J.; Gilbert, J.; Dunkley, P. 1994. Nuevos antecedentes sobre la evolución cuaternaria del complejo volcánico Nevados de Chillán. *In Congreso Geológico Chileno, No. 7*, Actas, Vol. 1, 342-345. Concepción.

Rodríguez, A.C.; Sellés, D.; Dungan, M.; Leeman, W.; Langmuir, C. 2005. Nevado de Longaví volcano (Chilean Andes, 36.2°S): The origin of adakitic magmas by fractional crystallization of amphibole-rich assemblages from water-rich parent magmas. *In Symposium on Andean Geodynamics (ISAG)*, No. 6, p. 608-611. Barcelona.

Sellés, D.; Rodríguez, A.C.; Dungan, M.A.; Naranjo, J.A.; Gardeweg, M. 2004. Geochemistry of Nevado de Longaví Volcano (36.2^{o}S): a compositionally atypical arc volcano in the Southern Volcanic Zone of the Andes. *Revista Geológica de Chile*, Vol. 31, No.2, p. 293-315.