Evolution of granitic magma chamber in the Donner Pass region granodiorite, Sierra Nevada

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Considering the origin of the Mesozoic batholiths in the circum Pacific region, it is important to reveal the mechanism of producing various chemical compositions observed in the rocks that compose the batholiths. The main aim of this study is to understand the processes responsible for producing these chemical variations in the granitic magma chamber during the emplacements.

The studied area is located in the northern Sierra Nevada batholith, California, and composed of three petrologically distinct bodies: the granodiorite of Donner Pass (Dgd), the granodiorite of Summit Lake (Sgd) and the granodiorite of Frog Lake (Fgd). The intrusive relationship indicates that the intrusion of plutonic bodies in the studied area proceeded from the south to the north. The southernmost Dgd is the oldest lithodemes. The northern Sgd intrudes this lithodeme. Sgd has marginal chilled zones against Dgd. Then the Sgd is intruded by the northernmost Fgd.

Mafic dikes and enclaves composed of hornblende diorite and aplite veins are commonly enclosed in the granitoids of the studied area. Two zones of accumulated enclaves are observed in the Dgd. One zone of accumulated enclaves, thickness of 2 to 6 m, is interbedded with dioritic sheets. Another zone is cylinder-shaped with horizontal outcrop of over 5000 m2 and thickness of 30 to 40 m. These mafic rocks are composed of the same minerals as the enclosing granitoid but different in modal propositions.

The bulk rock composition of the Dgd has SiO2 content from 58.8 to 67.0 wt.%. The Sgd has SiO2 content from 67.1 to 73.9 wt. The Fgd has SiO2 contents of 65.7-74.5 wt.%. The marginal zone of Sgd has a constant SiO2 content of 67 wt.%. Harker diagrams of the granitoids show continuous smooth trends for each lithodemes. The hornblende diorites have SiO2 values of 51.8–59.0 wt.%, and the enclaves in Dgd, Sgd, and Fgd have SiO2 variations roughly the same as the hornblende diorites.

Various crystallization models were tested using MELTS (Ghiroso and Sack, 1995) to examine the origin of chemical variations observed in the granodiorites of the studied area. The results show that as for the Dgd, calculated chemical variations and the mineral compositions are inconsistent with the observed data. The batch crystallization model applied to the Sgd and Fgd showed similar mineral compositions compared to the observed results, under the water content of 2 wt.%, the temperatures were varied from 1200C to 750C with 10C step, with a constant pressure of 1 kbar, and fO2 set to QFM buffer. In addition, the linear trends of Sgd and Fgd in the Harker diagrams can be obtained from removing approximately 30 wt.% total of hornblende, plagioclase, and biotite crystals from the initial liquid. These results indicate that the crystal differentiation process is probably responsible for the chemical variations observed in Sgd and Fgd. In contrast, the continuous linear trend of the hornblende diorite and Dgd in the Harker diagrams and hybridized textures observed in the field indicates that the linear chemical variations of Dgd may be produced from magma mixing.