Redox paths of granitic magma in Chiquicamata, northern Chile.

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The western cordillera of South America is one of the largest-scale magnetite-series granitic terranes in the world. The granitoids consist mainly of granodiorite to quartz diorite in Cretaceous, and often contain copper porphyries that were mineralized under highly oxidized magmatic conditions. To investigate the redox paths of granitic magma of this terrane, petrography of granitic rocks in the Chiquicamata area of northern Chile has been conducted using the rock collection by Dr. Shunso Ishihara. The rock specimens 79CHU7 and 79CHU3 (Ishihara et al., 1984 Bull GSJ, 35, 503-536) were selected from the collection because they are the least hydrothermally altered. 79CHU7 is a bt-cpx-opx quartz monzodiorite with a magnetic susceptibility of 14.5 x 10^{-3} SI units. In the rock, maghemite occurs as subhedral grains without ilmenite lamellae, whereas magnetite or martite could not be found. Ilmenite occurs as composite grains with maghemite and discrete grains. The Fe-Ti oxides occur with/within pyroxenes, biotite, and as fine-grained inclusions in calcic plagioclase. The compositions of cpx-opx pairs yield 910 to 862 ˚C by two-px geothermometer (Putirka, 2008 RiMG, 69, 61-120). 79CHU3 is a bt-hbl granodiorite with a magnetic susceptibility of 13.5 x 10^{-3} SI units. Maghemite occurs as subhedral grains without ilmenite lamellae similarly to 79CHU7, whereas magnetite could not be found. Mn-rich ilmenite is found with maghemite, but is mostly replaced by rutile/hematite aggregates or titanite. The Fe-Ti oxides and titanite occur mostly with hornblende and biotite. Hornblende occurs as subhedral to euhedral and homogeneous grains, and shows the compositions of magnesiohornblende (Si= 7.2-7.4 apfu, O=23). The compositions of hbl-pl pairs yield 689 to 588 ˚C by hbl-pl geothermometer (Holland and Blundy, 1994 CMP, 116. 433-447). The petrography above mentioned indicates the following crystallization sequence: 1) magnetite crystallization began in the early magmatic stage, and continued to the late magmatic stage. 2) magnetite was oxidized to maghemite in the late magmatic to subsolidus stages under relatively dry conditions. In 79CHU3, ilmenite was decomposed by further oxidation. These phenomena are attributable to the Chiquicamata magma containing enough sulfuric gas to maintain fO_2 along the H_2S-SO_2 gas buffer (Takagi and Tsukimura, 1997 Econ Geol, 92, 81-86). Throughout the magmatic to subsolidus stages, the magma/rock were continuously oxidized by SO_2 during cooling.

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