CHARNOCKITIZATION OF GRANITOID ROCKS IN THE FOOTWALL OF THE DULUTH COMPLEX (MINNESOTA, USA)

BENKÓ, Zs.[1]*, MOLNÁR, F.[2], MOGESSIE, A.[1], SEVERSON, M.[3], HAUCK, S.[3] & AREHART, G.[4]
[1] Institute of Earth Sciences, Mineralogy and Petrology, Karl-Franzens-University of Graz, A-8010 Graz, Austria
[2] Geological Survey of Finland, PO. Box 96, FI-02151 Espoo, Finland
[3] Natural Resources Research Centre, Duluth, 55811 Minnesota, USA
[4] University of Nevada, Reno, 89557 Nevada, USA
* Email: zsolt.benko@uni-graz.at

The South Kawishiwi Intrusion (SKI) is a part of the Mesoproterozoic (1.1 Ga) Duluth Complex. The footwall of the SKI consists of Archaean granite-gneiss, diorite, granodiorite (Giant Range Batholith), thin condensed sequences of Paleoproterozoic shale (Virginia Fm.), as well as banded iron formation (Biwabik Iron Fm.).

The footwall granite in some zones contains Cu and PGE mineralization, whereas fluids and melts emerging from the contact-metamorphosed footwall probably played an important role in the distribution of PGE and base metals in the SKI. The aim of our study was to understand the metamorphic history in the partially melted (charnockitised) footwall rocks and to show that this process released fluids from the footwall. Detailed drill core logging, petrographic analysis, mineral chemistry and whole rock geochemical analysis have been carried out on the granitic footwall rocks in the NM-57 drill hole.

In the studied drill hole, the footwall consists of foliated metagranite that is intersected by mafic (dioritic) dykes of older age than the SKI. In the proximal contact zones the orthopyroxene + clinopyroxene + plagioclase + quartz + Fe-Ti-oxide porphyroblasts embedded in a plagioclase + K-feldspar + orthopyroxene + apatite matrix, indicating pyroxene-hornfels facies conditions in the mafic dykes. Non-equilibrium metamorphic mineral is assemblage characterized by abundant relict mineral phases as well as quartz grains showing dynamic recrystallisation that can be related to the rapid upheating and retrograde metamorphism. Partial melting in the vicinity of the magmatic complex is revealed by the euhedral crystal faces of plagioclase and pyroxene against anhedral quartz crystals, quartz-K-feldspar symplectites (granophyres) and occurrence of plagioclase ± biotite leucosome segregations. Sulphide mineralization is localized on the diorite dykes in form of disseminated chalcopyrite ± millerite ± sphalerite.

Two generations of biotite have been distinguished on the basis of their petrographic positions and fluorine contents. High modal proportion of F-rich biotite suggests to a fluid rich environment during retrograde metamorphism after the de-volatilization of peak metamorphism.

Syntectonic fluid flow was restricted on some mylonitic shear zones defined by extremely high modal proportion of F-poor biotite with lepidoblastic texture.

Apatite is an omnipresent accessory mineral in all rock types, with up to 1–3% modal proportion. Crystal habit is columnar or rarely needle-like. X_{Cl}/X_F and X_{OH}/X_F ratios of apatite were compared with depth in the drill hole and in relation to the host rock type. Apatite in the metagranite and in the dioritic dykes is fluorine-rich ($X_{F\,granite} \approx 1.27–1.63$; $X_{F\,mafic\ dyke} \approx 1.51–1.83$) and their $X_{Cl}/X_{F\,granite} \approx 0.083$ to 0.051 and $X_{Cl}/X_{F\,mafic\ dyke} \approx 0.051$ to 0.044 ratios decrease towards the distal parts of the contact. Apatite in biotite-rich mylonite, as well as in the porphyroblasts of mafic dykes, is extremely depleted in chlorine- and hydroxyl-anions ($X_{Cl}/X_{F\,mylonite} \approx 0.02$ and $X_{OH}/X_{F\,mylonite} \approx 0.14$), whereas apatite in felsic dykes and in the in-source leucosome are enriched in hydroxyl and chlorine relative to fluorine ($X_{Cl}/X_{F\,felsic\ vein} \approx 0.21$ and $X_{OH}/X_{F\,felsic\ vein} \approx 0.37$). These variations suggest release of chlorine enriched fluids from the partially melted contact zones and movement and enrichments of these fluids in migration channels of partial melts.

It has been for a long time accepted that sulphur originated from the metamorphosed Virginia Formation played an essential role in the sulphur saturation and sulphide segregation at the bottom of the gabbroic intrusions in the northwestern marginal zones of the Duluth Complex. Our study proves that the granitic footwall was also an important source of aqueous fluids and melts.