Hiekkapohja ore showings in Paleoproterozoic Central Finland Granitoid Complex - a Hydrothermal System?

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Abstract

Porphyritic Cu-Mo mineralizations can be found in modern and old convergent plate-tectonic settings. They are more abundant in younger successions than in older, oldest know economical deposits of this type are Paleozoic. In the Fennoscandian shield, the largest deposits proposed to be porphyritic origin is Aitik in Northern Sweden located in volcanic succession and related to quartz monzonite intrusions (Wanhanainen 2005). Paleoproterozoic Central Finland Granitoid complex (CFGC, Fig.1) can be considered as a potential host for porphyry type deposits, as it formed in convergent setting and is volumetrically dominated by granitoids (Nurmi 1984). One being the Hiekkapohja area, where small high grade mineralizations (Zn, Pb, Cu, Ag, Au; Ikävalko 1981) and mineralized boulders with unknown sources are known from a geographically constrained area.

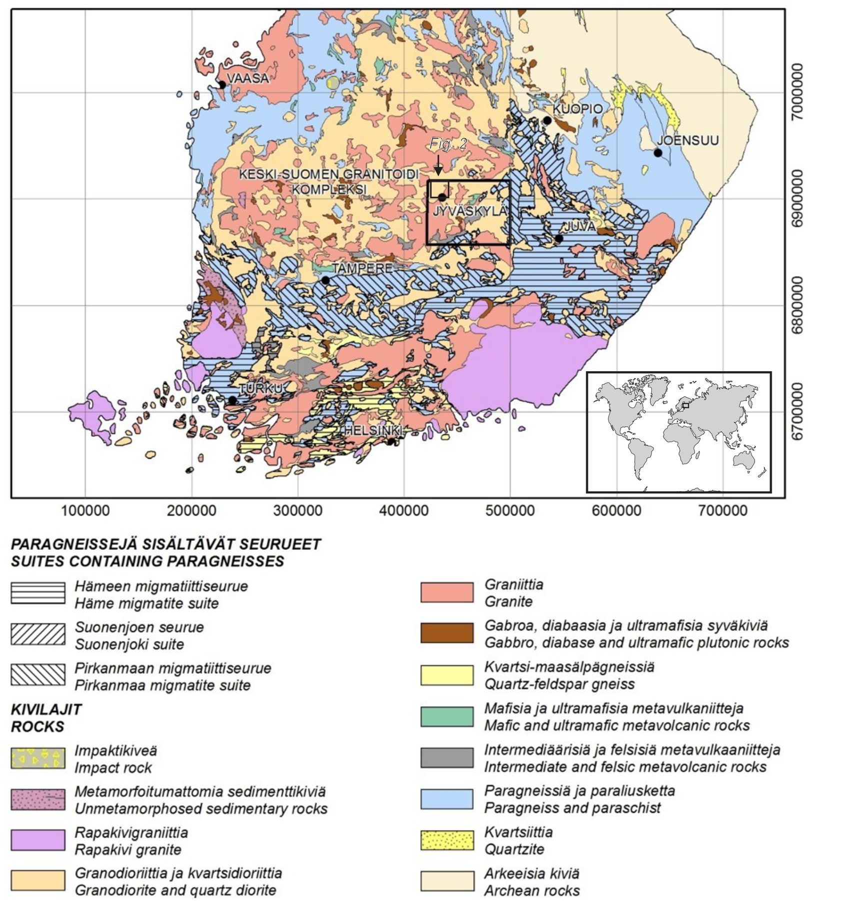

Figure 1. The study area of project shown on a general geological map of southern Finland. Hiekkopohja locates north from city of Jyväskylä. Base map modified from Bedrock of Finland – DigiKP.

Geological setting

Precambrian basement of Central Finland was formed during the Paleoproterozoic Svecofennian orogeny, during which volcanic arcs amalgamated with the Archean Karelia craton (eg. Nironen 1997; Lahtinen et al. 2005; Fig. 1). Oldest Svecofennian rocks are found north of the CFGC and they are 1.93–1.91 Ga in age. The main phase of the orogeny occurred at 1.89–1.87 Ga, rocks of this age include arc volcanic rocks and granitoids, which of two most voluminous groups are synkinematic and younger postkinematic groups (Nironen 2005). Based on the age determinations the two types overlap in age as available age determinations cluster at 1.88 Ga. Third, less voluminous granitoid group is formed by leucogranitoids interpreted as small degree partial melts of pre-existing crust. Rocks belonging to this group typically yield ages close to 1.875 Ga (Mikkola et al. 2016). The sedimentary-volcanic sequences in the area show geochemically arc type characteristics A significant feature of CFGC are crustal scale shear zones, which can be divided to three age groups, which are from oldest to youngest; 1) 20°-40° trending , 2) 120°-135° trending, and 3) 0° trending (Mikkola et al. 2016).

Results

Hiekkapohja area observations

In the Hiekkapohja area a ca 9 x 4.5 km local aeromagnetic low (Fig. 2) is observable in an area dominated by typical variably deformed K-feldspar porphyritic granites of CFGC (Fig. 3), age of which is 1882 ± 4 Ma (Mikkola et al. 2016). On the west side of the aeromagnetic low is a porphyritic granite variant with two cross-cutting unfoliated granitic hypabyssal dykes (max. width 130 m). In the northern part of the aeromagnetic low two round intrusions, less than 1.3 km across are known. Age of these unfoliated, evengrained pale grey granite intrusions, referred to as Soimavuori type, is 1879 ± 4 Ma. Based on field observations Soimavuori type intrusions cross-cut the surrounding porphyritic granite could be the youngest intrusions in the area (Fig. 3). It is readily observable on the geophysical map that the magnetic low is transected by a large scale dextral fault belonging to the 120°-135° trending group.

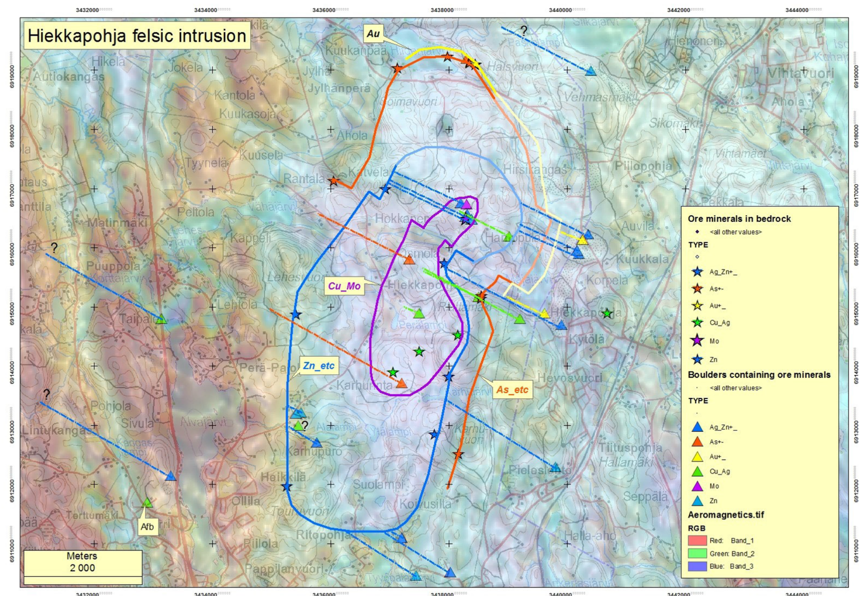

Figure 2. Low altitude aeromagnetic map of Hiekkapohja area in the Central Finland granitoid complex with ore showings. Direction of glacier transport shown as a line.

Figure 3 C) Grey 1879 ± 4 Ma old Soimavuori granite at outcrop with a xenolith of 1879 ± 4 Ma old K-feldspar porphyritic Hiekkopohja granite crosscut by a leucogranite vein as an enclave. Scale bar with cm scale. Photo: Marjaana Ahven, GTK.

Both target scale ore prospecting and more general mineral potential mapping has been carried out in the Hiekkapohja area, the first in 1980s and latter in the recent years. Mineralizations and ore showings contain variable combinations of the following elements: Cu, Mo, Zn, W, Ag, As, and Au. The highest concentrations reported for 1 meter drill core sample are: Cu 0.7 %, Zn 230 ppm and Ag 17 ppm (Ikävalko et al. 1986). This sample is from the Riuttamäki mineralization located in conjugant shears of the major 120°-135° trending shear system. Highest concentrations from boulder/outcrop samples are: Cu ≤ 7.7%, Zn ≤ 6.7%, Pb ≤ 8%, Ag ≤ 500 ppm, Au ≤1 ppm (Figure 4).

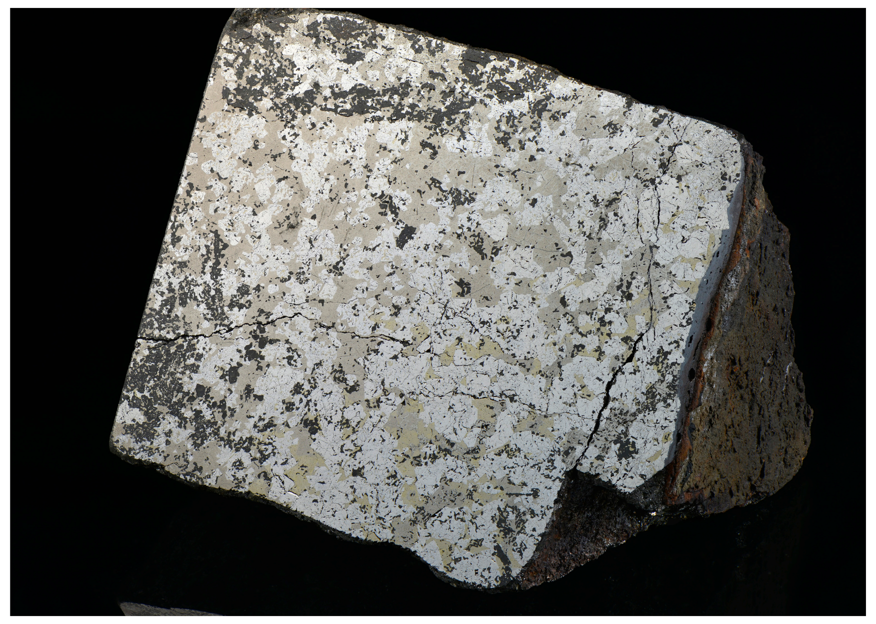

Figure 4. Polished sample from the Riuttamäki mineralization containing arsenopyrite, pyrrhotite and chalcopyrite. Width of the sample 8.5 cm. Photo: Jouko Ranua

Samples enriched in Au and As most often coincide with the outermost parts of the aeromagnetic low, forming a ring structure. Ag-Zn-Pb showing concentrate closer to the centre of the aeromagnetic low, whereas Cu and the few known Mo showings occur in the middle of the aeromagnetic low. The boulder samples support the observations made from outcrop showings, albeit it is based on average glacial transport in the area (Fig. 2).

Geochemistry of granitoids

All of the granitoids are calc-alkalic to alkali-calcic and ferroan showing I-type composition. The dominant porphyritic granite in the area is compositionally similar to other parts of CFGC, having arc type signature. The younger Soimavuori type is enriched in from K_2O (~5 wt.%) and SiO_2 (~75 wt.%). In respect to main elements the hypabyssal dykes do not differ significantly from the other granitoids, despite the fact that its REE pattern is almost flat [$(La)_n$ =17.4 and $(La/Lu)_n$ = 1.7] . At this stage it is unclear if this peculiarity is due to later alteration or if it represents original composition.

Ore mineralogy observations

The mineralized boulder samples include granitoids, volcanic rocks and altered samples whose protholith(s) cannot be recognised.The ore mineralogy doesn't correlate with the host rock. Almost all outcrop and boulder samples contain arsenopyrite, sphalerite, chalcopyrite, and pyrrhotite as well as galena, magnetite and pyrite as minor amounts. In microscope studies ore minerals display evidence for multiple events that are not in line with textbook evolution of epithermal porphyritic deposits, but more likely represent several events of hydrothermal activity. Ore mineral assemblages, grain size and mineral textures vary between samples. Minerals appear massive (Fig. 5), disseminated and as veins (Fig. 6). Intergranular texture is the primary feature and the secondary features are bird eye-texture and chalcopyrite disease. Common feature of samples is that almost all the samples have colloform alteration of pyrrhotite and pyrite and ore mineralogy, although the quantity of each mineral varies between samples. Most typical is alternation of pyrrhotite and pyrite to marcasite during cooling (Fig. 7; Halonen 2015).

Prospecting

Geochemical study of basal till was executed in central part of the aeromagnetic low. Based on this sampling significant mineralizations are unprobable in Hiekkapohja area (Heilimo and Niemi 2015).

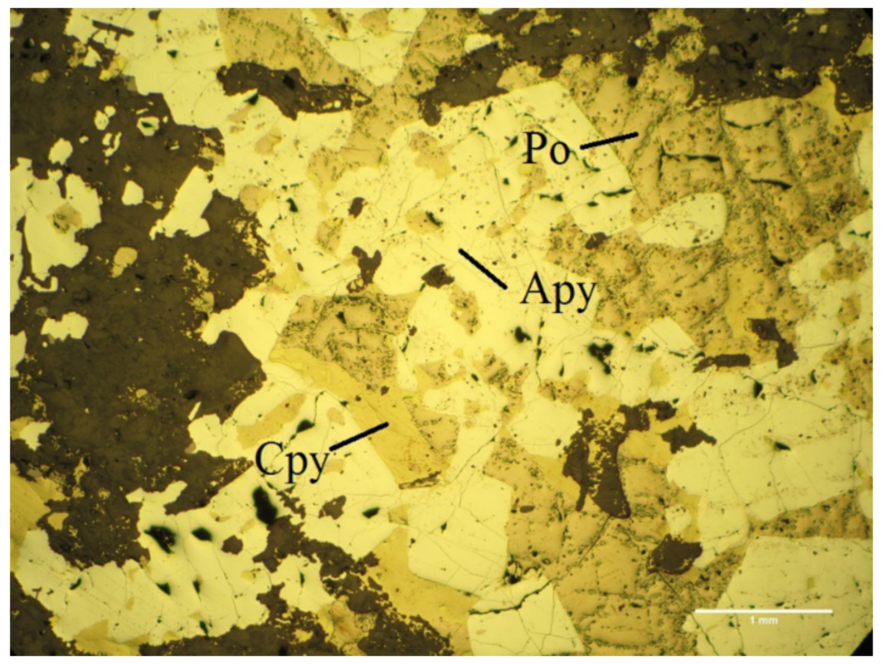

Figure 5. Ore microscopic photo of Massive texture of pyrrhotite (=Po), chalcopyrite (=Cpy) and arsenopyrite (=Apy). High concentration of silver, 96 ppm, . Reflective light, parallel nicols. Photo: Sini Halonen

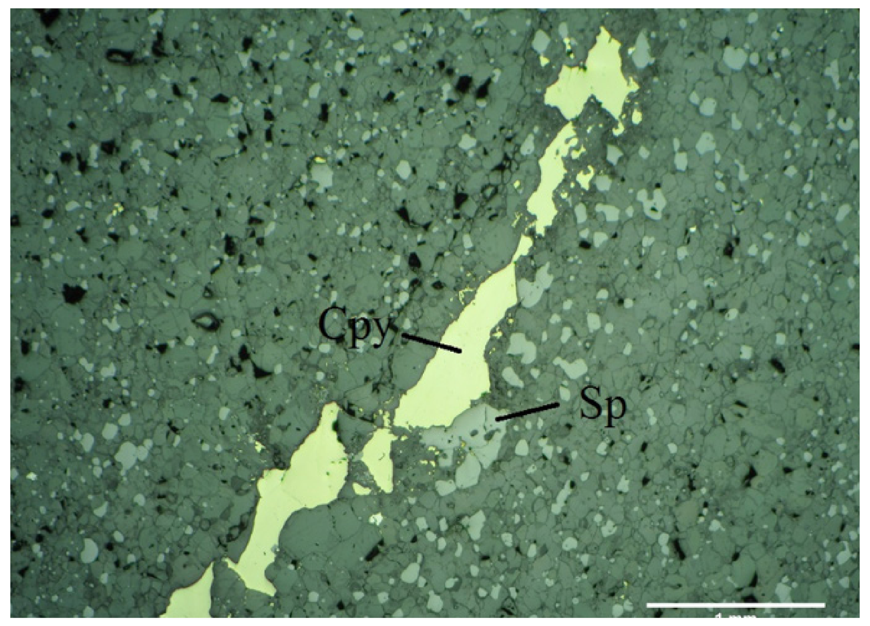

Figure 6. Ore microscopic photo of Sphalerite(=Sp) as disseminated form and chalcopyrite vein . Reflective light, parallel nicols.Photo: Sini Halonen

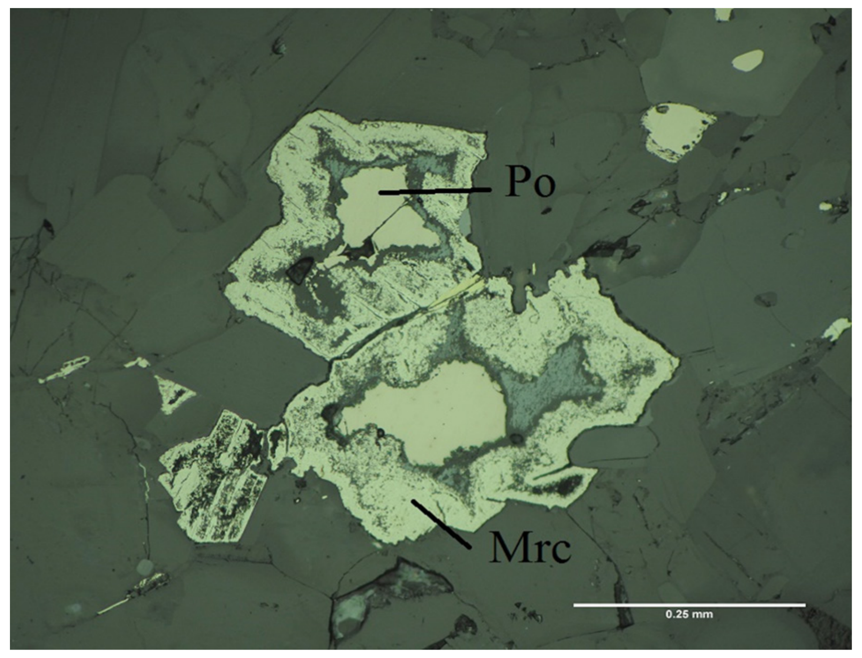

Figure 7. Ore microscopic photo of Pyrrhotite (Po) altering to marcasite (Mrc). Reflective light, parallel nicols. Photo: Sini Halonen

Summary

As based on bedrock mapping the aeromagnetic low in the Hiekkapohja area does not correlate with lithological boundaries it must be a younger feature unrelated to the original rock forming events. We propose that fluids released from Soimavuori type intrusions during their crystallization could have hydrated the overlying granitoids, and altered the magnetite to hematite. The same fluids could have caused the small scattered mineralizations. The mineralization processes concentrated in existing fractures, possibly due to limited fluid flux. The observed ring structure of the mineralizations is typical for porphyrite systems. Alternatively the mineralizations could be linked only to the fault system in the area, but as similar faulting and host rocks occur over the whole CFGC this does not explain the concentration of the mineralizations in Hiekkapohja area. Based on till geochemical studies it is relatively certain that Hiekkapohja area does not host significant porphyry type deposits, at least in current erosion level. However it demonstrates the potential for such deposits within the CFGC.

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