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THE KOMATIITE-HOSTED PAHTAVAARA GOLD MINE NEAR SODANKYLÄ, NORTHERN FINLAND

by
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GEOLOGY AND HYDROTHERMAL ALTERATION

The Paleoproterozoic Pahtavaara gold mine is situated in the eastern part of the Central Lapland Greenstone Belt, within the extensive, predominantly pyroclastic Sattasvaara komatiite complex (Fig. 8). The present mineral composition of the weakly altered komatiites consists of an amphibole-chlorite assemblage resulting from regional greenschist facies metamorphism. The intensively altered rocks form a subvertically dipping alteration zone about 100 m x 500 m in extent, represented by two heterogeneous and intercalated lithological types: (1) biotite schists with talc-carbonate ± pyrite ± magnetite veins and (2) coarse-grained and non-schistose amphibole rocks with associated quartz±barite veins and pods (Korkiakoski 1992).

The least altered amphibole-chlorite schists correspond compositionally to Geluk-type basaltic komatiites. The original komatiitic nature of the altered rock types is indicated by (1) the similarity in homogeneous immobile element ratios (Al/Ti) compared to those of less altered type, (2) mineralogical and geochemical gradations between rock types, and (3) similar REE patterns to those of the Sattasvaara komatiites.

Mass balance calculations have shown that biotite schists have been enriched in CO_2, K, Fe, Au, Ba, S, W, Te, Sr, and Mn, and depleted in Mg, Ca, Co, Si, and Zn, accompanied by a general 10–30% decrease in volume. Amphibole rocks record a marked increase in volume, with gains in Ca, Si, Au, Na, Ba, Te, S, W, Sr and P, and conversely losses of CO_2, Co, Mg, Fe and Zn.

The two major altered rock types reflect two stages of hydrothermal alteration (Fig. 9),

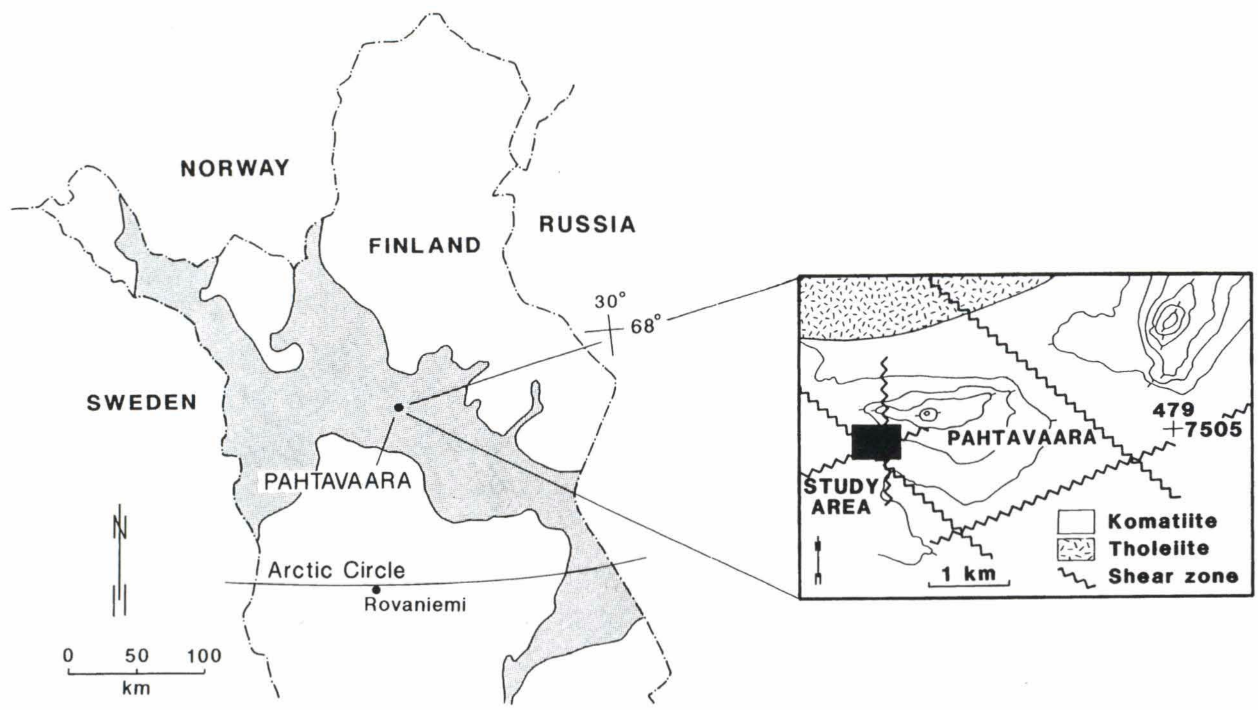

Fig. 8. Location of the Pahtavaara gold mine within the NW–SW trending Lapland Greenstone Belt (shadowed), also showing the more detailed study area (after Korkiakoski et al. 1989).

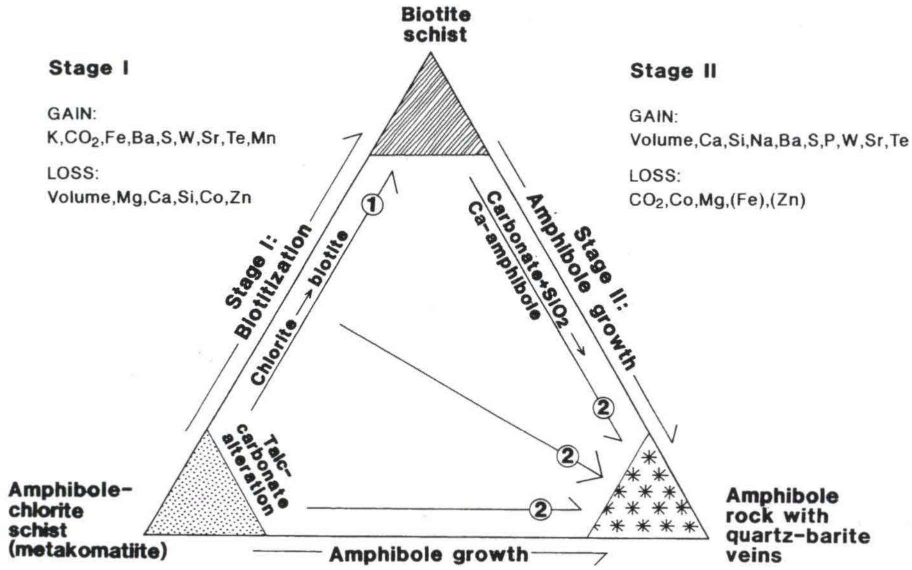

Fig. 9. Schematic diagram of the major chemical and mineralogical changes associated with the different stages of hydrothermal alteration in the komatiite-hosted Pahtavaara gold deposit (after Korkiakoski 1992).

which, on the basis of textural and geochemical evidence, include: (1) biotitization (K-alteration) and (2) later amphibole overgrowth (Ca-Si-alteration). The former has been interpreted to have taken place during or immediately after the peak of regional metamorphism, and during ductile deformation. Its distribution was controlled by a combination of high permeability in the originally pyroclastic komatiites, and NE-SW trending deformation zones. Later amphibole growth was related to the NNE-trending shearing resulting in the formation of zones of dilation into which hydrothermal fluids were focused under conditions straddling the brittle-ductile transition (Korkeakoski et al. 1988).

Despite its Proterozoic age, the Lapland Greenstone Belt is comparable to mineralized late Archaean greenstone belts in many respects. The ore forming processes at Pahtavaara were related to wider cratonization processes associated with the Svecofennian orogeny, and the widespread emplacement of granitoids (Korkiakoski et al. 1989, Ward et al. 1989).

MINING

The rights to the Pahtavaara gold deposit were purchased in 1991 by Terra Mining Oy (the then Finnish subsidiary of the Swedish company Terra Mining, which as of late 1996 has been controlled by the Canadian William Resources Inc) after a round of bidding was invited by the Finnish Ministry of Trade and Industry. At the time of purchase, reserves at Pahtavaara were estimated at around 350 000 tonnes of gold ore, with a mean grade of 5.7g/t. Subsequent investigations and a more detailed evaluation were carried out between 1991–1994, based principally on a drilling program involving nearly 25 km of RC drilling and 2 km of diamond drilling. The decision to commence mining was announced on February 9, 1995, by which time a estimates of reserves had been revised to around 1.3 Mt of ore with an average grade of 3.4 g/t Au. A total investment of 70 million Finnish marks was required and construction at the site commenced in early 1995, with the mine coming into production in July 1996. At present the mine employs around sixty persons.

The gold ore at Pahtavaara typically forms narrow lodes generally 5-10 m wide, trending almost E-W and dipping northwards at about 70–80 degrees. For practical quarrying purposes, the ore has been designated into the A+, A- and E-zones. A- zone ores are characterized by biotite-talc breccias that are typically surrounded by a more massive tremolitic amphibole rock characterized by irregular dilatational arrays of barite-carbonate-quartz veins. The A+ zone contains abundant barite and the A- zone veins also typically contain barite, in addition to quartz and carbonate. The E- zone comprises smaller lodes associated with quartz-carbonate-barite veins trending predominantly E-W and NNW-SSE. The only economically recoverable metal is gold, sulfides being relatively rare, with pyrite being the most abundant, comprising about 1% of the ore. Magnetite can constitute up to 5–10% of ore grade material, particularly in the biotite schists. Gold occurs as discrete grains, highly variable in size, between silicate grains and along fracture surfaces; some 50–60% of gold grains are less than 50 µmin diameter.

Currently planned production from the A zone is about 450 000 tonnes annually, requiring the additional removal of nearly 2 Mt of waste rock. So far mining has been from an open pit, but underground mining is scheduled to commence at the beginning of 1998, together with open cut operations. In order to optimize production , a selective approach to separating ore from waste prior to crushing was adopted in April 1997, as an alternative to selective quarrying. Presently proven and probable reserves amount to about 1.6 Mt, of which some 700 000 t can be obtained by open cut mining. The deposit is still open at depth and towards the west.

The ore is concentrated at the Pahtavaara plant using gravimetric processes. Authogenic grinding, where amphibole-rich gangue rock is used as the grinding agent, precedes hydrocyclonic separation, followed by a gravimetric circuit including Reichert cones and spirals, with two shaking tables being used to enhance recovery at the final stages. Investigations are under way to establish the feasibility of enhancing recovery of the finer-grained ore by flotation.

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