Economic Geology
Vol. 98, 2003, pp. 1311–1328

Fluid Characteristics and Genesis of Early Neoproterozoic Orogenic Gold-Quartz Veins in the Harnäs Area, Southwestern Sweden

Elisabet Alm,† Curt Broman,

Department of Geology and Geochemistry, Stockholm University, SE-106 91 Stockholm, Sweden

Kjell Billström,

Swedish Museum of Natural History, P.O. Box 50 007, SE-104 05 Stockholm, Sweden

Krister Sundblad,

Department of Geology, FIN-20014 University of Turku, Finland

and Peter Torssander

Department of Geology and Geochemistry, Stockholm University, SE-106 91 Stockholm, Sweden

Abstract

Gold-quartz veins occurring in the Mjøsa-Vänern ore district, southeast Norway and southwest Sweden, represent early Neoproterozoic members of the orogenic gold type of deposit. The Harnäs gold-quartz veins, in the central part of the ore district, are steeply dipping veins hosted in a local, west-northwest–east-southeast–trending brittle shear zone, which transects the north-south–trending deformational fabric in the surrounding greenschist grade orthogneisses. This deformation and subsequent vein formation occurred at around 1.0 Ga in a late phase of the Sveconorwegian (Grenvillian) orogeny. Fluid inclusions show that the ore-bearing vein system at Harnäs developed essentially in three successive stages: a quartz stage at a depth of ≈ 4 km, a pyrite-gold stage at a shallower crustal level (≈1.5 km) after rapid exhumation of the area, and finally a galena stage. All stages involved fracturing subparallel to the strike of the host shear zone. During the first two stages, the ore fluid was an aqueous H_2O-CO_2 fluid with a salinity of 4 to 10 wt percent NaCl equiv and a temperature of ≈200°C, whereas in the galena stage it was a purely aqueous fluid with a similar salinity and a temperature of ≈150°C. Oxygen and sulfur isotope results imply a predominantly metamorphic origin for the ore fluid and suggest that important ore constituents, such as lead and sulfur, were derived from the regional orthogneisses.

Other gold-anomalous quartz veins in the Harnäs area, as well as the Brustad gold-quartz vein in the northernmost part of the Mjøsa-Vänern ore district, show some variation in fluid composition. However, aqueous fluid inclusions containing CO_2 and calcite were identified in all veins. This, and other similarities, strongly suggests that the veins throughout the district were formed contemporaneously and were controlled by deformation that, at least in part, affected the entire Mjøsa-Vänern region.

It is inferred from geologic evidence and pressure estimates that veins began to form during the final phase of Sveconorwegian continent-continent collision and were completed during incipient rapid exhumation of the thickened crust.

A set of barren quartz-calcite veinlets, which crosscut the ore-bearing veins at Harnäs, is unrelated to the ore formation. These veinlets were deposited from a surface-derived, low-temperature, saline aqueous fluid during some significantly later, but regionally extensive, hydrothermal event.

†Corresponding author: e-mail, Elisabet.Alm@geo.su.se

0361-0128/01/3382/1311-18 $6.00