

Fluid Evolution in a Subvolcanic Granodiorite Pluton Related to Fe and Pb-Zn Mineralization, Banská Štiavnica Ore District, Slovakia

PETER KODĚRA,[†] JAROSLAV LEXA,

Geological Survey of the Slovak Republic, Mlynská dolina 1, 817 04 Bratislava, Slovakia

ANDREW H. RANKIN,

Centre for Earth and Environmental Science Research, Kingston University, Kingston-upon-Thames, Surrey KT12EE, United Kingdom

AND ANTHONY E. FALICK

Scottish Universities Environmental Research Centre, East Kilbride, Glasgow G75 0QF, Scotland, United Kingdom

Abstract

The central zone of the Miocene Štiavnica stratovolcano (Western Carpathians) hosts an extensive subvolcanic intrusive complex dominated by a granodiorite pluton (14.5–15.5 Ma). The granodiorite intrusion has a bell-jar form and was emplaced mainly into basement rocks, although its central part extends to the base of a subvolcanic and volcanic andesitic complex, 1.5 to 3 km below the paleosurface. In the more uplifted western part of the complex, the margin of the granodiorite includes numerous apophyses with associated magnetite skarns, whereas in the central, apical part it contains an irregular network of fractures hosting base metal stockwork mineralization that extends to a depth of 250 m. The granodiorite intrusion, especially in the marginal facies, is altered. High-temperature subsolidus deuteritic (K-feldspar, secondary biotite, and amphibole) and endoskarn (pyroxene) alteration, intimately related to magnetite skarns, resulted in depletion in Fe_{total} and increase in CaO and MgO in the intrusion. Low-temperature, hydrothermal alteration (epidote, chlorite, K-feldspar, sericite), closely related to the stockwork mineralization, is characterized by enrichment in K₂O, Pb, Zn, Cu, and MnO, and depletion in Na₂O. The overlying andesites are affected by acid leaching.

Fluid inclusions and stable isotopes (O,H) were studied in samples of granodiorite related to the skarn and to the stockwork, from the top of the pluton down to 1,230 m in depth. Magmatic quartz contains hypersaline fluid inclusions (up to 71 wt % NaCl equiv), vapor-rich saline and low-salinity inclusions, as well as moderate- to low-salinity liquid-rich aqueous inclusions with homogenization temperatures (T_h) ranging from 161° to >600°C. Brine inclusions from magmatic quartz in marginal phases of the granodiorite show signs of NaCl saturation during entrapment, with the majority probably having been captured under vapor unsaturated conditions. Most vapor-rich inclusions represent early stages of fluid immiscibility, whereas the low-salinity liquids are products of dilution by meteoric fluid and/or late-stage portions of magmatic fluids. Inclusion-bearing minerals in the skarn assemblage contain moderate- to low-salinity fluid inclusions (T_h = 215°–371°C) with evidence of late-stage boiling at low hydrostatic pressure. Hydrothermal minerals from base metal stockwork and massive silica-rich rock contains only low-salinity inclusions (up to 5 wt % NaCl equiv, T_h = 191°–367°C).

The isotopic composition of magmatic biotite and hornblende from granodiorite indicates open magmatic degassing (deuterium depletion) during granodiorite crystallization, influenced by reequilibration to variable degrees. Fluids in equilibrium with skarn and stockwork-related minerals show a clear progressive mixing trend with isotopically relatively heavy, possibly δ¹⁸O-shifted, meteoric water.

Magnetite skarns and zones of high-temperature subsolidus deuteritic alteration are related to ponding of magmatic brines in the roof of the intrusion, resulting from fluid immiscibility at relatively low pressures. The associated escaping vapor was responsible for acid leaching in andesites above the apical part of the pluton. Stockwork mineralization and associated low-temperature potassic alteration are probably related to the large convective hydrothermal system and upflow of late-stage, deep, exsolved supercritical fluids, using the increased permeability (fracturing) of the central apical part of the intrusion.

[†] Corresponding author: email, kodera@gssr.sk