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Editorial: Orogenic gold deposits

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Editorial on the Research Topic
Orogenic gold deposits

This Research Topic comprises papers submitted on the geology, geochemistry, and mineralogy-petrography of orogenic gold deposits. The accepted papers include detailed mineralogical analysis and regional-scale contributions from different geological terranes, which aim to bridge the gap between laboratory studies and fieldwork of different scales (e.g., He; Zhen et al.; Li et al.; Yan et al.).

Orogenic gold deposits are found in metamorphic terranes spanning from the Paleoarchean to the Tertiary. These deposits contribute approximately one-third of the world's total gold production (Goldfarb and Groves, 2015; Groves et al., 2020; Nassif et al., 2022). Orogenic gold deposits occur in different tectonic settings in subduction-related accretionary to collisional terranes. Worldwide exploration of gold deposits has focused on the orogenic belts of different ages, geological backgrounds, tectonic settings, and formation processes (e.g., Hronsky et al., 2012). Since the 1980s, studies from different parts of orogenic terranes focused mainly on the controls on ore formation, the source of metals, the ore-forming fluids, and the mineralizing processes. Several studies have presented evidence for and against certain models of orogenic gold ore genesis in recent years. This Research Topic focuses on the source of ore-bearing fluids and discusses the main controls and genesis of orogenic systems and associated ore deposits. The area of research covers a broad range of geographical locations.

The goal of this Research Topic is to better understand the geological processes triggering the transport and deposition of metals (Au, Ag, Sb, As, Hg, etc.) over space and time, main controls on ore, and alteration of mineral assemblages. The topics related to SI are summarized below:

- Detailed alteration mineralogy-petrography studies critical to understanding many of the studied deposits, which were complicated by the following tectonic and metamorphic overprint.
- The geochemistry, and origin of granitoids, which act either as a source for ore-bearing magmatic-hydrothermal fluids or as a heat source for remobilization of the earlier mineralization.
- Isotope geochemistry and integrated fluid inclusion studies focus on mixing fluids from different sources or later overprints to test the convenience of metamorphic models.

The papers describe the mode of occurrence, ore petrography, structural geology, metamorphic petrology, and geochemistry. The contributions to this Research Topic range from detailed mineralogical analysis (e.g., the correlation between fluid inclusion composition and Au mineralization in three dimensions or the relationship between gold and mineral paragenesis, which represents reducing and oxidizing conditions) to a regional scale synthesis (e.g., mineralization and structural controls both in brittle and ductile deformation).

Despite the increasing economic interest in orogenic gold deposits, the models explaining the sources of the metals and fluids and ore-forming processes are still under debate. The presence of CO_2-CH_4±H_2S-NaCl-bearing fluids in the orogenic gold system is unequivocally accepted and the source of volatiles, especially CO_2 is variously interpreted from lower crustal to mantle origin. However, the relationship of CO_2 with gold for mineral exploration is questionable to use as an exploration guide due to the presence of CO_2 in both mineralized and barren quartz of the orogenic gold deposits. Limited but significant studies on gas composition by laser Raman at the Sigma Mine (Val-d'Or, Quebec) recorded enrichment of only CH_4 as well as H_2S in the gold-rich veins, although CO_2 is abundant in both mineralized and barren veins (Sherlock et al., 1993). Zaw et al. (1994) also noted that high-grade mineralized ironstones contain CH_4 and N_2-rich ore fluids compared to barren ironstones at Tennant Creek (Northern Territory, Australia). In an earlier study, Bottrell et al. (1988) recorded that the auriferous zone (>6.7 Au ppm) showed higher CH_4 values and low CO_2/CH_4 ratios than those of the barren veins by bulk inclusion analyses at Dolgellau Gold Belt, North Wales. The enrichment of reduced carbon and sulfur is also consistent with the precipitation of $Au\,(HS)_2^- + 0.5\ H_2 + H^+ = Au\Downarrow + 2H_2S \Uparrow$ and hydrocarbon-rich fluids and organic matters in the orogenic gold system (e.g., Gaboury, 2019; Gaboury, 2021; Gaboury et al., 2021; Makoundi et al., 2021). The studies and implementation of the analysis of volatile compounds in the context of orogenic gold deposits can prove highly valuable in the initial stages of exploration targeting.

The source of gold in the orogenic gold deposits is widely debated from magmatic rocks, such as basalts, lamprophyre, and felsic rocks, to sedimentary rocks rich in carbonaceous matters and iron-rich sediments as reviewed by Tomkins (2013) and Gaboury (2019), although sedimentary source model is becoming popular (e.g., Large et al., 2012; Tomkins, 2013; Gaboury et al., 2021). For exploration targeting, a well-defined "gold source" will be required for the development of the practical exploration model, especially for emerging prospective terrane, such as Phanerozoic SE Asia (e.g., Zaw et al., 2014a; Zaw et al., 2014b; Goldfarb et al., 2014; Zaw, 2019; Khaing et al., 2020; Bounliyong et al., 2021; Hlaing et al., 2021; Myint et al., 2022; Makoundi et al., 2023). Although orogenic gold (low-salinity, gas-rich fluid) and porphyry copper-gold deposits (high-salinity fluid) possess differing ore fluid characteristics, these two types are found in the same orogenic/tectonic settings and sometimes occur spatially in close proximity. Recent advances in a range of precise U-Pb-Hf zircon geochronological methods and their trace elements should be harnessed to pinpoint the timing and characteristics of these ore types in connection with the evolving orogenic belts in both time and space, which would provide guides and valuable insights for the appropriate area selection. The special edition is unable to cover all the advancements in tectonic/geodynamic evolution and metallogeny of orogenic gold deposits. However, forthcoming research promises to yield valuable insights.

Author contributions

TO: Conceptualization, Methodology, Writing–original draft, Writing–review and editing. KZ: Conceptualization, Supervision, Validation, Visualization, Writing–review and editing. MG: Conceptualization, Validation, Writing–review and editing. C-KL: Supervision, Validation, Writing–review and editing.

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Conflict of interest

Author C-KL was employed by Fortescue Metals Group Ltd.

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