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Pre-mineralization thermal evolution of the Palaeoproterozoic gold-rich Ashanti belt, Ghana

V. HARCOUËT[1,2], L. GUILLOU-FROTTIER[1], A. BONNEVILLE[2] & J. L. FEYBESSE[1]

[1]*Bureau de Recherches Géologiques et Minières, Orléans, France*
(e-mail: v.harcouet@brgm.fr)
[2]*Institut de Physique du Globe, Paris, France*

Abstract: The region of the gold-rich Ashanti belt in southern Ghana was chosen as the subject for a detailed regional thermal modelling study. Geological studies, in addition to laboratory measurements of thermal properties and heat-production rates, allow us to constrain a finite-element thermal modelling. Scenarios integrating variations of the structure of the crust and various chronological settings were examined. We calculated the thermal regime before and after the thrust tectonism that affected the region during the Eburnean orogeny (2130–2095 Ma), just before ore deposit formation. This gives a new insight into the regional thermal state of the crust before the mineralizing events. To satisfy the thermobarometric observations, the most probable mantle heat flow must be 60 mW m^{-2}, which is at least three times greater than the present-day value. At shallow depths, our results also indicate anomalies of lateral heat flow reaching 25 mW m^{-2}, focused on the margins of each lithological unit, including the Ashanti belt. These anomalies are related to the distortion of the isotherms in the first few kilometres that can be explained mostly by lateral contrasts in thermal conductivity. Such anomalies could be of importance for the mineralizing events, as they would favour fluid circulation locally.

Over the past decade, the increasing volume of high-precision geochronological data has demonstrated that gold deposition was not a continuous process through geological time. The pattern for orogenic gold deposits in the Precambrian shows distinct peaks separated by several hundreds of millions of years (Goldfarb *et al.* 2001). Two main periods (at 2800–2500 and 2100–1800 Ma) correlate well with episodes of increased continental growth. Geochronological data on juvenile continental crust have been compiled and revised by Condie (2000), who suggested that the three major crustal formation episodes (estimated at 2700, 1900 and 1200 Ma) were related to '*superevents*' in the mantle. For the Palaeoproterozoic peak (1900 Ma), a superplume event has been proposed (e.g. Condie *et al.* 2000). Similarly, the associated periods of orogenic gold formation are 'most commonly explained by major mantle overturning in the hotter early Earth, with associated plumes causing extreme heating at the base of the crust' (Goldfarb *et al.* 2001). Indeed, it is now generally agreed that global geodynamics played a key role in the formation of several classes of ore deposits (e.g. Barley *et al.* 1998; de Boorder *et al.* 1998; Isley & Abbott 1999; Pirajno 2001). If the occurrence of superevents in the mantle, the formation of supercontinents, and the genesis of world-class orogenic gold deposits (or 'superdeposits') are all related, then studies on the possible thermal conditions prevailing at the time of ore deposit formation could provide useful results.

Deep thermal processes beneath continents are well constrained below thermally stable areas for present times (e.g. Jaupart & Mareschal 1999; Lenardic *et al.* 2000). Heat flow studies in the Canadian and Fennoscandian shields (e.g. Kukkonen 1998; Rolandone *et al.* 2002) as well as petrological studies on mantle xenoliths (Kukkonen & Peltonen 1999; Russell & Kopylova 1999) have shown that mantle heat flow values at the base of the Precambrian crust range from 10 mW m^{-2} to 16 mW m^{-2}. However, these present estimates cannot be applied to Precambrian times, and the possibility of studying thermal regimes billions of years ago thus becomes a real challenge. A number of distinct arguments suggest that the thermal regime of the Archaean continental crust was not very different from that of the present-day crust (e.g. Richter 1985). If this were indeed the case, one would expect similar, low mantle heat flow values at the base of continents, unless some large-scale thermal perturbation, such as a superplume event, affected the base of the crust. The formation of world class deposits

From: McDONALD, I., BOYCE, A. J., BUTLER, I. B., HERRINGTON, R. J. & POLYA, D. A. (eds) 2005. *Mineral Deposits and Earth Evolution.* Geological Society, London, Special Publications, **248**, 103–118. 0305-8719/$15.00