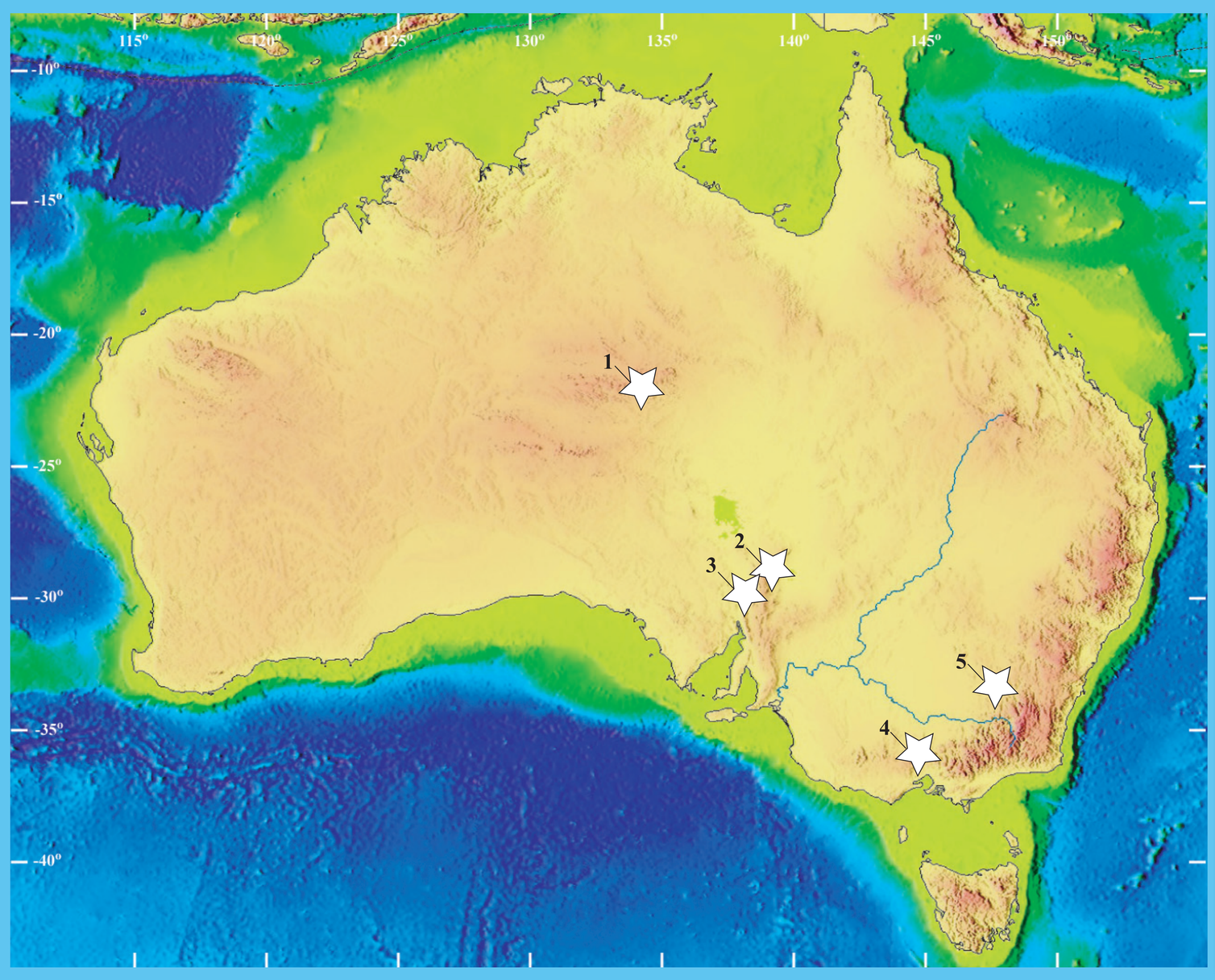
The 440 Ma Event: A Continental-Scale, Mantle-Driven Thermal Phenomenon?

I.M.A. Vos[1], F.P. Bierlein[1], P.S. Heithersay[2] and G.S. Lister[3]

*[1]ACRC/ pmd*CRC, School of Geosciences, Monash University, VIC 3800, Australia*
[2]PIRSA, GPO Box 1671, Adelaide, SA 5001, Australia
[3]RSES, Australian National University, Canberra, ACT 0200, Australia

Introduction

We have compiled available age data that converge around 440 Ma. We note that these ca. 440 Ma ages are not just restricted to gold and related deposits in the Lachlan Fold Belt. An additional set of ~440 Ma ages has been collected from several regions in South and Central Australia. These include the occurrence of a magmatic-hydrothermal event in the Mt. Painter Province (Elburg et al., 2003) and the Arunta Inlier (Möller et al., 1999). Squire and Miller (2003) hypothesised that subduction lock-up outboard of the eastern margin of Australia and associated mantle upwelling could have accounted for ca. 440 Ma mineralisation throughout the Lachlan Fold Belt.
The widespread presence of ca. 440 Ma ages as presented below suggests the occurrence of a large-scale tectono-thermal event that controlled an area greater than the accretion-subduction system of the Lachlan Fold Belt (and genesis of gold deposits within the belt). Therefore, an alternative driving force for the event might be required.



440 Ma ages throughout Australia:

1) An overall change from extensional to compressional tectonics associated with hydrothermal activity in the Arunta Inlier (Mawby et al., 1999; Möller et al., 1999; Scrimgeour and Raith, 1999).

2) The occurrence of a magmatic-hydrothermal event associated with mantle signatures as shown by Nd isotopic data in the Mt. Painter Inlier (Elburg et al., 2003).

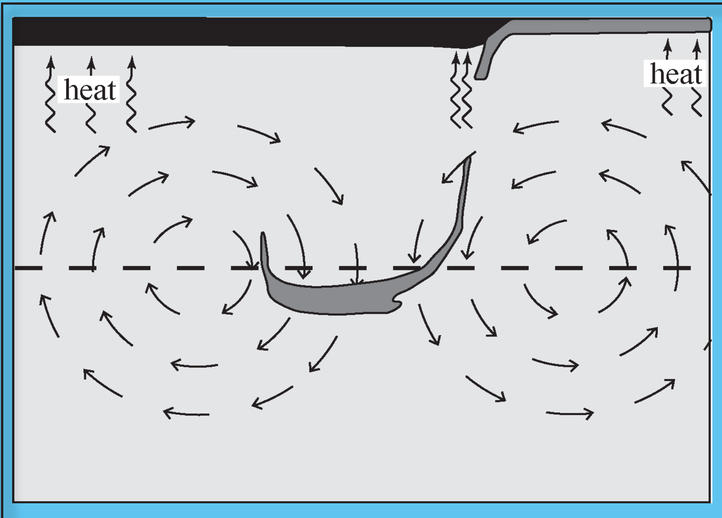
3) The genesis of the Beltana willemite deposits in the northern Flinders Ranges (Groves et al., 2003).

4) Genesis of the principal Victorian orogenic gold deposits, together with a significant change in tectonic regime elsewhere in the Lachlan Fold Belt as evident from magmatism and sedimentation records, which suggest a tectonic mode switch from an overall compressional to extensional regime (Vos et al., 2003; see adjacent poster).

5) Genesis of the principal porphyry copper-gold deposits in the Macquarie Volcanic Arc in NSW simultaneously with a sudden end to arc magmatism and the emission of shoshonites with a distinct mantle-source character (Heithersay and Walshe, 1990; Carr et al., 1995).

An alternative driving force ?

Taking into account the widespread occurrence of ~440 Ma ages throughout eastern and central Australia, we propose a possible crustal-scale driving mechanism for this event. We base our model on the presence of mantle signatures associated with the majority of the ~440 Ma occurrences in Australia. Although in the western Lachlan Fold Belt no such signatures have been recorded, a first-order driving force is required to generate the large quantity of gold and quartz in this region.
We consider the driving force for the ~440 Ma continental-scale event to be a large-scale mantle-driven tectono-thermal phenomenon. The sudden tectonic mode switches that occur at ca. 440 Ma at least in the Lachlan Fold Belt and the Arunta Inlier are testament to tectonic reorganisations as a result of such an event. A possible scenario to explain these features would be a 'mantle avalanche'. Other mechanisms could also account for the occurrence of a continental-scale event as illustrated by deformation as a result of subduction more than 3000 km inboard of the East Asian Kuril Trench (Schellart and Lister, in prep). The applicability of the mechanism proposed herein and other processes that can be a driving force for this large-scale event are currently under consideration.



Mantle avalanche

A mantle avalanche is the event where cold, dense, subducted slab material would penetrate the upper-lower mantle boundary. The occurrence of a slab avalanche could potentially be associated with slab detachment and would cause upwelling of mantle asthenosphere and associated heating of a large portion of the crust (see adjacent figure).

Mantle avalanches have been modelled previously and are considered responsible for punctuated events associated with large-scale tectonic reorganisation, including rapid arc migration and subduction polarity reversals (e.g. Pysklywec et al., 2003). This model could also explain the occurrence of rapid tectonic switching, a sudden influx of enriched mantle melts that could evolve into high-K to shoshonitic volcanics, the occurrence of unusual PGE-bearing Alaskan ultramafic intrusions near Fifield, and continental-scale heating as supported by evidence for metamorphism and heating in central Australia (e.g. Mawby et al., 1999). Furthermore, destabilisation of the overall thermal regime on a crustal- and mantle-scale potentially could have triggered the enormous crustal-scale fluid movement required for the formation of giant gold deposits.

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