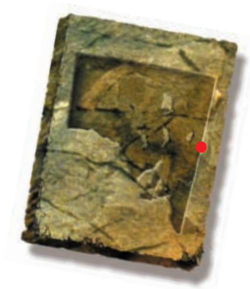

Proterozoic Cu–Au systems of the Curnamona Province
— members of a global family?

Roger G. Skirrow (Minerals Division, AGSO)
Paul M. Ashley (Earth Sciences, University of New England)

Introduction

Copper–gold systems of the Curnamona Province show many of the characteristics of major Cu–Au Fe-oxide systems in other Proterozoic terranes. Large and economic Cu–Au deposits, however, have remained elusive in the province, despite discoveries in recent years of significant gold and copper mineralisation at the Portia, White Dam and Kalkaroo prospects (Fig. 1). A descriptive framework of the mineralising systems across the region is a foundation for developing targeting criteria for major Cu–Au deposits. During this study within the BHEI, a whole-of-system approach has been adopted in an attempt to identify and map the key regional to local-scale 'ingredients' in the Cu–Au systems. Additionally, new geochronological and stable isotope results have placed quite rigorous constraints on the relationships between Cu–Au-mineralising, tectonic and magmatic processes in the Curnamona Province. Full results of BHEI investigations on Cu–Au systems in the Curnamona Province have been reported by Skirrow and Ashley (1998) and Skirrow *et al.* (1999, 2000, in prep.).

Cu–Au mineralisation

Vein, breccia and replacement style Cu–Au mineralisation was investigated at the Kalkaroo, White Dam, Waukaloo, Mundi Mundi, Green & Gold, Walparuta, Wilkins and other prospects in the Olary Domain, and at the Copper Blow deposit in the Broken Hill Domain (Fig. 1). Mineralisation occurs in stratabound and discordant zones, predominantly in albitic and calc-albitic metasedimentary rocks near the top of the lower Willyama Supergroup (including Thackaringa and Curnamona Groups). In places, Cu–Au(–Mo) mineralisation and associated potassic± sodic alteration extends stratigraphically upwards into the aluminous±graphitic metasedimentary base of the upper Willyama Supergroup (including Broken Hill, Sundown, Paragon and Strathearn Groups). A spatial association of sulphide mineralisation with the regional redox interface between the upper and lower Willyama Supergroup in the Olary Domain ('Bimba formation') has long been targeted by explorationists (Ashley, 2000), but structurally controlled Cu–Au zones across and below this interface have yet to be fully evaluated. A spectrum of deposit styles from iron-oxide poor Au(Cu±Mo) to Cu–Au(±Mo) mineralisation associated with Fe-oxides are present in the Curnamona Province (Skirrow and Ashley, 1998).

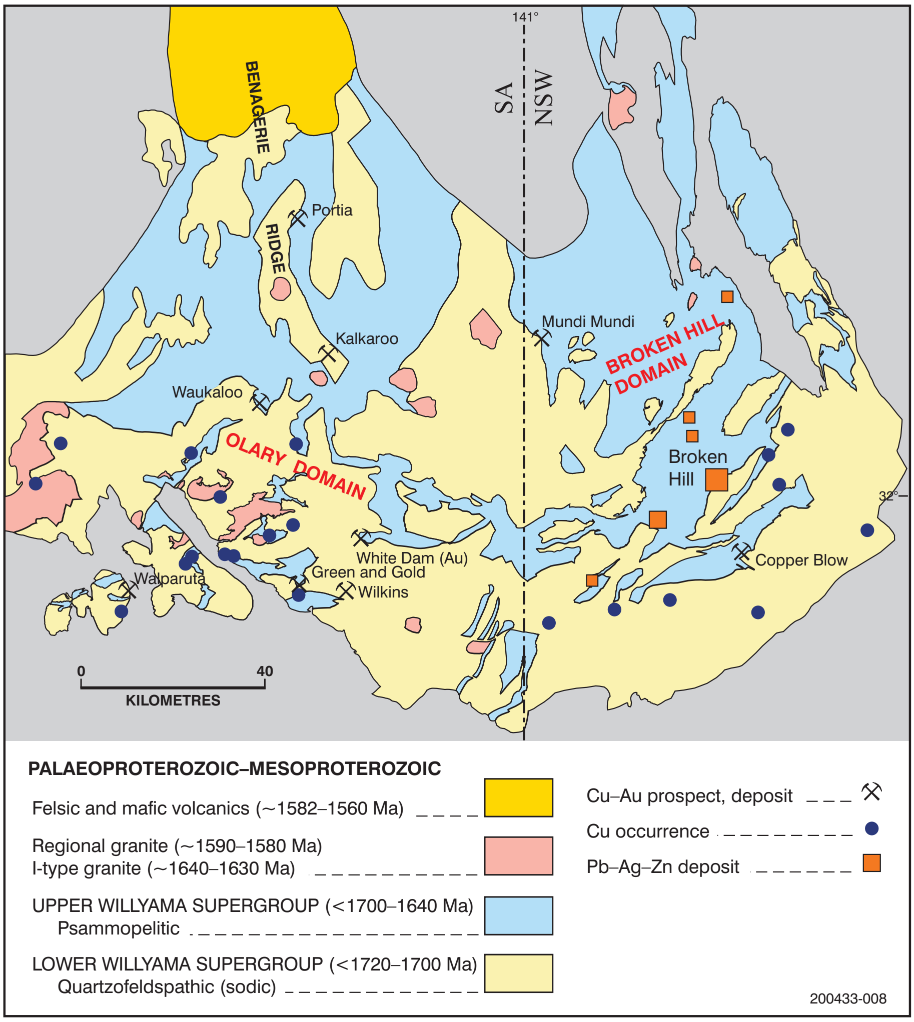

***Fig. 1** Location of Cu–Au mineralisation in the southern Curnamona Province.*

Comparison with Cu–Au Fe-oxide systems elsewhere

Several of the shared characteristics of Cu–Au systems in the Curnamona Province, and of Fe-oxide associated Cu–Au systems globally (Hitzman *et al.*, 1992; Williams, 1998; Davidson and Large, 1998), are summarised below.

Fe-oxide association — Most of the principal Curnamona Cu–Au deposits are closely associated with disseminated, vein or massive magnetite (±haematite in Benagerie Ridge systems), although in several cases it is only the footwall rocks that are magnetic. Some gold-rich members of the spectrum of deposit styles are poor in Fe-oxides (e.g. White

Dam). Identification of larger ironstone 'traps' for mineralisation than have been found to date would be a positive indicator for a major Cu–Au system.

Age — Direct dating of mineralisation (molybdenite, Re–Os) in four prospects in the Olary Domain indicates molybdenum and Cu–Au introduction at ~1630 to ~1612 Ma (Fig. 2; Skirrow *et al.*, 2000; Suzuki *et al.*, in prep.). This metallogenic phase in the Curnamona Province is broadly associated with tectonothermal events of the Olarian Orogeny, which peaked within ~10–20 million years of the formation at ~1590 Ma of the Olympic Dam deposit in the Gawler Craton (Johnson and Cross, 1995). The late Palaeoproterozoic (from ~1900 Ma) and early Mesoproterozoic (to ~1450 Ma) appear to have been particularly favourable for large and/or high-grade Cu–Au Fe-oxide systems in Australia (e.g. Tennant Creek, Cloncurry, Olympic Dam; Davidson and Large, 1998).

Local and regional alteration — Cu–Au mineralisation in the Curnamona systems is closely associated with potassic – Fe-oxide alteration (biotite, K-feldspar, magnetite ± haematite) and calcic-iron alteration (amphibole, Fe-oxides, carbonate; Skirrow and Ashley, 1998; Skirrow *et al.*, 2000). These hydrothermal assemblages are commonly zoned within the deposits and match those observed in Cu–Au Fe-oxide systems globally (Hitzman *et al.*, 1992; Williams, 1998; Davidson and Large, 1998). Regional sodic–calcic alteration is characteristic of many Cu–Au Fe-oxide districts. In the Olary Domain, two dominant regional alteration styles are recognised: early (pre- to early tectonic), stratabound, sodic metasomatism, and syntectonic Na–Ca–Fe metasomatism. SHRIMP U–Pb (titanite) dating of the latter has yielded ages of ~1588–1583 Ma, which places this alteration during the waning phases (D_3?) of the Olarian Orogeny (Fig. 2; Skirrow *et al.*, 2000).

Structural control and syntectonic timing — The strong structural control commonly present in major Cu–Au Fe-oxide mineralised systems is also evident in the Curnamona Cu–Au deposits, although regional-scale structures controlling mineralisation may be a prerequisite for large systems to develop. Observed variations range from brittle–ductile shear-hosted magnetite–biotite ironstone(s) with chalcopyrite–pyrrhotite–pyrite (e.g. Copper Blow), to dominantly brittle deformation style vein-network and disseminated replacement mineralisation at Kalkaroo and Waukaloo. Sulphide–oxide formation temperatures reached ~450ºC (Skirrow *et al.*, 2000). Stratigraphic controls also were important in most Cu–Au and Pb–Zn systems of the Curnamona Province (Ashley, 2000; Leyh and Conor, 2000).

Felsic and mafic magmatism — Although felsic to intermediate or mafic magmatism may be coeval with Proterozoic Fe-oxide Cu–Au in some districts globally (e.g. Hitzman *et al.*, 1992; Davidson and Large, 1998), there are few cases where a direct genetic association between magmatism and Cu–Au has been demonstrated unequivocally. This also applies in the Curnamona Province. New oxygen and hydrogen isotope results point to magmatic as well as metamorphic contributions to the ore fluids (Skirrow *et al.*, 2000, in prep.). However, additional age dating and geochemical and isotopic fingerprinting of intrusive rocks are required to establish whether ~1640–1630 or ~1616–1580 Ma granitoids, or other intrusions, were directly involved in the Cu–Au mineralising systems.

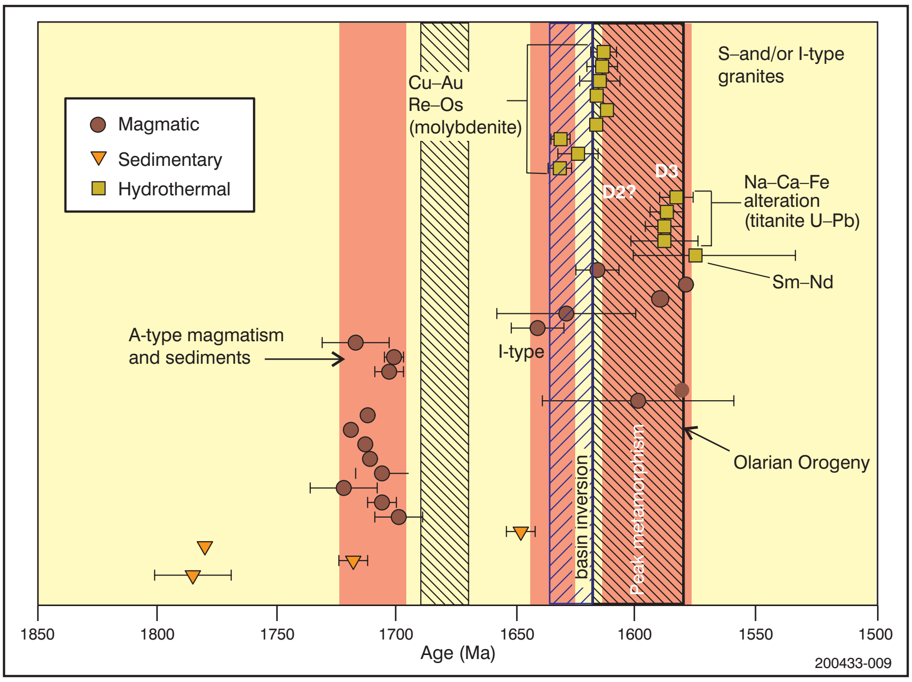

Fig. 2 *Summary of U–Pb and Re–Os geochronological data for the Olary Domain. Magmatic zircon and sedimentary (i.e. maximum depositional ages from detrital zircons) SHRIMP age data are from Fanning et al. (1998), Ashley et al. (1996) and Page et al. (1998, 2000). Re–Os (molybdenite) ages are from Skirrow et al. (2000) and Suzuki et al. (in prep.). Titanite U–Pb (SHRIMP) ages are from Skirrow et al. (2000), and a Sm–Nd age of 1574±26 Ma is from Kent et al. (in press).*

Acknowledgements

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For further information contact Dr Roger Skirrow (ph. 02 6249 9442, email roger.skirrow@agso.gov.au).

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New products from the BHEI

AGSO, PIRSA and NSWDMR have recently released two new products from the BHEI: a geoscientific GIS data set of the Curnamona Province (on CD), and a Geophysical Atlas of the Curnamona Province (hardcopy, A3 format). The GIS is an integrated package of geological, structural, metallogenic, geochronological, geophysical, geochemical and petrophysical information. Core elements of the GIS include structural information for the Broken Hill Domain, and metallogenic and alteration data sets for the Olary Domain. For further information or purchase of these products contact the AGSO Sales Centre (ph. 02 6249 9333, email sales@agso.gov.au).