New data on the geological evolution and gold mineralization of the Southern Cross greenstone belt

by

MP Doublier, N Thébaud[1], D Mole[1], MTD Wingate, CL Kirkland, SS Romano, S Wyche, and G Duclaux[2]

Introduction

Understanding the kinematic interaction between Archean greenstone belts and adjacent granites is crucial to constraining the formation and localization of major lode gold deposits. GSWA has performed detailed structural mapping in the central part of the Southern Cross Domain of the Youanmi Terrane, with a particular focus on the SOUTHERN CROSS 1:100 000 map sheet. Southern Cross is a key area that contains well-preserved granite–gneiss domes separated by greenstone successions (Fig. 1), both of which have been affected by a complex geological history.

Stratigraphy

A detailed stratigraphy of the Southern Cross greenstone belt is difficult to establish due to its complex structure. However, the sequence broadly consists of a lower volcanic succession up to 5 km thick, overlain by a package of clastic sedimentary rocks at least 2 km thick. The lower part of the volcanic succession consists of tholeiitic and komatiitic basalt, whereas the upper part is dominated by komatiite. Several thin units of banded iron-formation are interbedded with the volcanic rocks, and minor amounts of gabbro have intruded this sequence. In the sedimentary package, the basal part is represented by black metamudstone (‘black shale’), which is overlain by a mixed succession of psammitic and pelitic units, and minor quartzite and metaconglomerate.

Until recently, it was thought that the Southern Cross greenstones formed prior to 2.9 Ga, based on SHRIMP U–Pb ages of zircons from ‘altered quartz porphyry sills’ (Mueller and McNaughton, 2000) at the Southern Star (2934 ± 7 Ma; interpreted as a magmatic age) and Copperhead gold deposits (2912 ± 5 Ma; interpreted as a minimum age). However, a new SHRIMP U–Pb zircon age obtained from the lower part of the sedimentary succession, southeast of the Transvaal mine, indicates a maximum depositional age of 2702 ± 17 Ma for these rocks (Thébaud and Miller, 2009). This date suggests that at least the upper part of the stratigraphy is considerably younger than 2.9 Ga. Metasedimentary rocks from the Spotted Quoll mine in the Forrestania greenstone belt yield a maximum depositional age of 2832 ± 13 Ma, which again indicates sedimentary deposition younger than 2.9 Ga.

Structure and gold mineralization

The Southern Cross greenstone sequence is steeply dipping, and has been affected at various stages of the structural evolution by intense, commonly layer-parallel, shearing. This caused the formation of discrete shear zones traceable for tens of kilometres, and high-strain corridors up to several hundred metres wide. Furthermore, several generations of tight to isoclinal folds are developed in the area, some of which might represent sheath folds (Gee, 1995). These structures have complicated the internal structure of the Southern Cross greenstone belt. Although most gold deposits in the Southern Cross greenstone belt are located at contacts between different rock types, or between interflow and chemical sedimentary rocks, in proximity to the high magnesian and ultramafic part of the volcanic succession, gold mineralization is essentially controlled by shear zone networks (Gee, 1995).

Several studies have aimed to constrain the timing of gold mineralization in the Southern Cross greenstone belt. Figure 2 shows new data from Marvel Loch, which constrains the age of terminal shearing along the Marvel Loch shear zone, and therefore the gold mineralization, to between c. 2635 and 2630 Ma (GSWA 199043, Mueller et al., 2004). A younger date obtained from the Corinthia deposit possibly represents a minimum age for mineralization, or else indicates a separate, younger, mineralization event.

Magmatism

The Southern Cross area has a long-lasting history of felsic magmatism (Qiu et al., 1999). Our new geochronology data, together with previously published data, indicate a composite character for the Ghooli Dome, recording about 150 m.y. of granite magmatism between c. 2780 and 2630 Ma.

1 Centre for Exploration Targeting, The University of Western Australia, 35 Stirling Highway, M006, Crawley WA 6009

2 CSIRO Earth Science and Resource Engineering, Australian Resources Research Centre, 26 Dick Perry Avenue, Kensington WA 6151

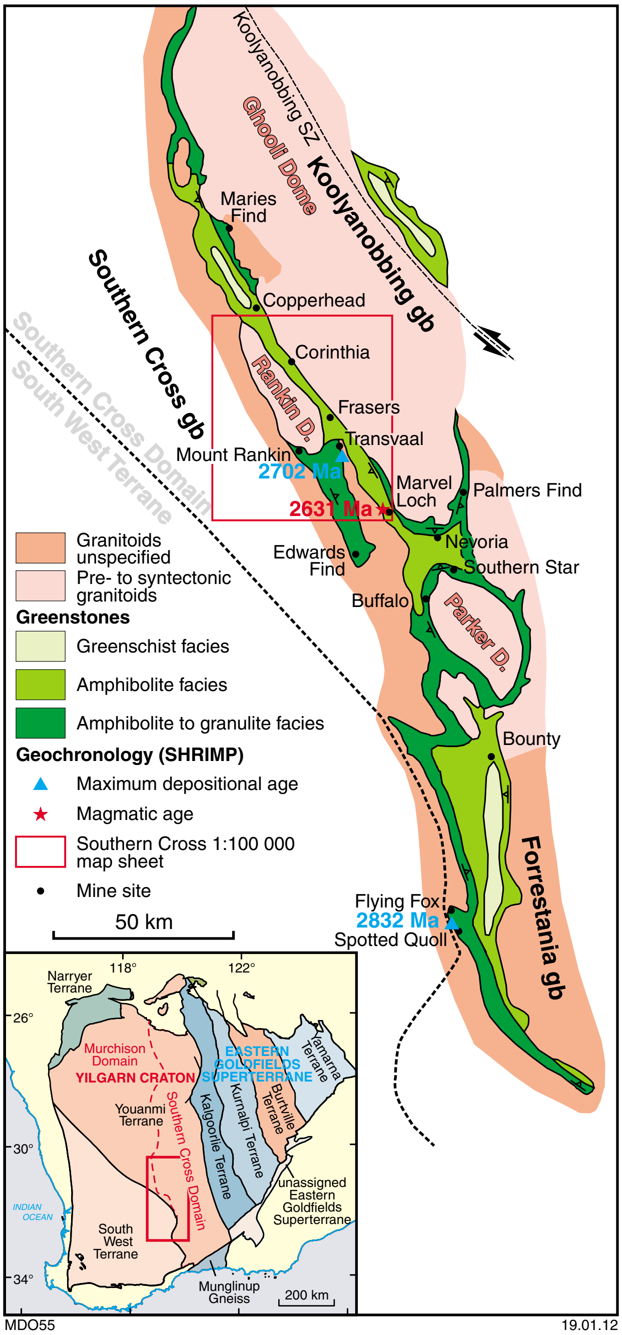

Figure 1. ***Geological overview of the Southern Cross region (after Ahmat, 1986; Mueller and McNaughton, 2000), showing important mines and selected geochronology sample sites. Abbreviations used in figure: SZ —shear zone; gb — greenstone belt; D. — dome.***

Future work

The structural framework, metamorphic history, and the relative timing of granite emplacement and mineralization relative to orogenic events, are critical parameters for distinguishing between different processes associated with the formation of granite–greenstones and mineralized gold systems. The results of this field-based study are now being inputed into a set of 3D thermal–mechanical numerical simulations as part of an ARC Linkage project. Results of this work are expected to be published in the near future.

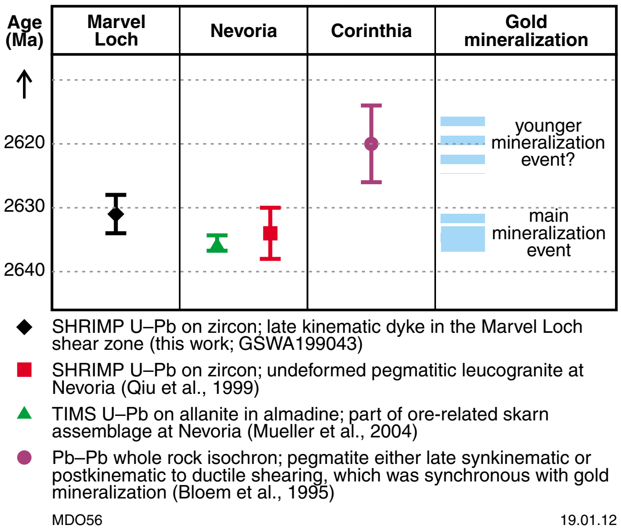

Figure 2. Timing constraints on gold mineralization

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