



# Tellurides associated with volcanogenic massive sulfide (VMS) mineralization at Yuinmery and Austin, Western Australia



Lee Y. Hassan <sup>a,\*</sup>, Malcolm P. Roberts <sup>b</sup>

<sup>a</sup> Geological Survey of Western Australia, Mineral House, 100 Plain St, EAST PERTH 6004, Australia

<sup>b</sup> Centre for Microscopy Characterisation and Analysis, The University of Western Australia, 35 Stirling Hwy, CRAWLEY, WA 6009, Australia

## ARTICLE INFO

### Article history:

Received 1 April 2016

Received in revised form 6 July 2016

Accepted 11 July 2016

Available online 12 July 2016

### Keywords:

Tellurides

Yuinmery

Austin

Volcanic-hosted massive sulfide deposits

## ABSTRACT

Tellurides have been identified in VMS mineralization at Yuinmery and Austin in the Archean Youanmi Terrane, Yilgarn Craton, Western Australia. Tellurides identified at Yuinmery include: petzite, stützite, hessite, tellurobismuthite, altaite, rucklidgeite, melonite, mattagamite and a nickel-cobalt telluride with chemical composition similar to cobaltian melonite which has previously only been reported once before. Tellurides and related minerals identified at Austin include: stützite, volynskite, tellurobismuthite, tetradymite, tsumoite, rucklidgeite, altaite and a mineral with the formula  $(\text{Bi,Pb})_3(\text{Te,Se,S})_4$  corresponding to the rare mineral poubaite. The tellurides are interpreted to have been deposited with the base metals on and immediately below the sea floor by very hot fluids during a period of quiescence in the volcanism. The mineral assemblage suggests that the fluids in both areas had high  $f_{\text{Te}_2}$  and were oxidising but close to the pyrrhotite-pyrite boundary. The presence of Ni and Co tellurides at Yuinmery but not at Austin is probably due to the derivation of the fluids at Yuinmery from mafic volcanism whereas at Austin the succession is dominantly felsic. The metamorphic grade at Austin is higher than that at Yuinmery and this may have resulted in some re-crystallization of tellurides and tellurosulfides.

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## 1. Introduction

The presence of tellurides in an ore deposit is important as they can provide constraints on the fugacities of  $\text{Te}_2$ ,  $\text{S}_2$ ,  $\text{O}_2$  in the ore-forming fluids and the temperature of formation (Afifi et al., 1988a, 1988b; Cook et al., 2009; Ciobanu et al., 2010).

Tellurides have been identified in association with volcanogenic massive sulfide (VMS) mineralisation at both the Yuinmery and Austin project areas in the northern part of the Archean Youanmi Terrane within the Yilgarn Craton of Western Australia (see Fig. 1 for location). The discovery of tellurides followed examination of multi element trace element data provided by Empire Resources Ltd. that showed that some samples from the Just Desserts VMS deposit at Yuinmery contained over 100 ppm Te with values up to 1010 ppm Te. Tellurides were subsequently also found at Austin. When compared with the average ratios of tellurium to gold found in the Golden Mile lodes at Kalgoorlie in the Eastern Goldfields Superterrane (some 350 km to the southeast of Yuinmery) which ranged from 1.4:1 to 4.0:1 (Golding, 1978) the tellurium to gold ratios in the Just Desserts samples (4.8:1 to 153:1) are far higher (Fig. 2). Kalgoorlie has long been famous for its tellurides and

tellurides have also been recently reported from other gold deposits in the Eastern Goldfields Superterrane of the Yilgarn Craton including Sunrise Dam (Sung et al., 2007) and the Belerophon-Nelson deposit at St Ives (Xue and Campbell, 2015). However, as far as the authors are aware, no tellurides have been reported from VMS deposits in Western Australia and tellurides are relatively uncommon in VMS deposits worldwide.

The samples in which tellurides were found at Yuinmery and Austin were taken from diamond drillcore (YD09-01, YD09-03, YRC10-13D, YRC09-01D) from Yuinmery and diamond drillcore (09ATD-19, 09ATD15) from Austin. The locations of these drillholes are given in Table 1. Detailed petrographic logs and HyLogger data for the Yuinmery drillholes are given as appendices in Hassan (2014) and summary logs for the Austin drillholes are included in DURING et al. (2016).

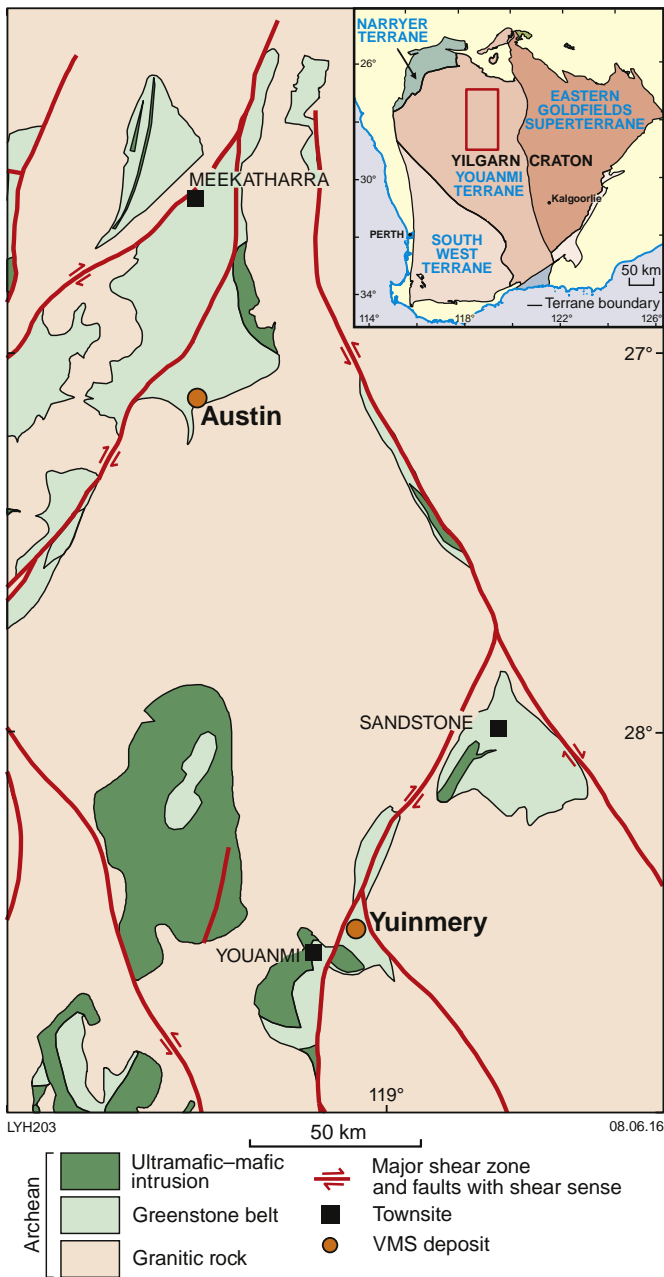
## 2. Geological setting

### 2.1. Yuinmery

The Yuinmery project area is situated in a triangular-shaped segment of Archean greenstones bounded by major shear zones to the east and west and granites to the south (Fig. 1). Metamorphic grade is low (lower greenschist). The greenstones have been intruded by gabbro, pyroxenite, granophyre and tonalite. The age of the greenstones is

\* Corresponding author.

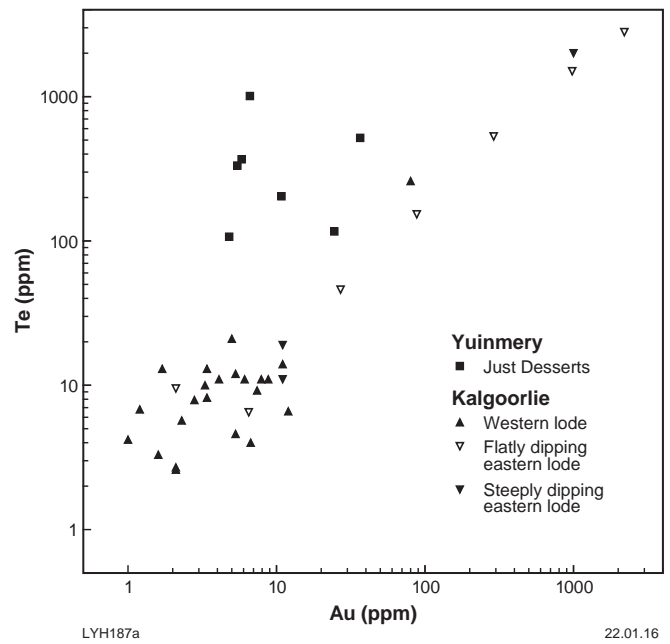
E-mail addresses: [lee.hassan@dmp.wa.gov.au](mailto:lee.hassan@dmp.wa.gov.au) (L.Y. Hassan), [malc.roberts@uwa.edu.au](mailto:malc.roberts@uwa.edu.au) (M.P. Roberts).



**Fig. 1.** Simplified geological map showing location of the Yuiumery and Austin VMS projects.

uncertain but they are at least 2813 Ma (age of intruding tonalite) and are possibly part of the  $\geq 2820$  to 2805 Norie Group (Hassan, 2014).

Within the Yuiumery project area, VMS prospects are associated with banded iron-formation (BIF) at or close to the contact between calc-alkaline basalt and andesite. The BIF can be traced intermittently for about 2 km around the western limb and closure of a broad syncline (Hassan, 2014). The main deposit is Just Desserts with a resource of 1.07 Mt at 1.82% copper and 0.78 g/t gold (Empire Resources Ltd, 2009). Mineralization at Just Desserts is situated on the southwest trending limb of the syncline within three closely spaced banded iron-formation (BIF) and chert horizons and the intervening highly altered basaltic hyaloclastite and underlying basalt. The uppermost BIF horizon is overlain by andesite. The Trajan prospect is the southern extension of the Just Desserts deposit and C Zone is associated with a single east-west trending BIF and sulfide



**Fig. 2.** Plot of Te vs Au for mineralization from Yuiumery compared with that from Kalgoorlie (Yuiumery data courtesy of Empire Resources Ltd.; Kalgoorlie data from Golding, 1978).

breccias on the fold closure 1.3 km southwest of Just Desserts (Hassan, 2014). Trace element geochemistry of the calc-alkaline basalt underlying mineralization and the andesite overlying mineralization is consistent with extrusion of the volcanics in an oceanic arc-rift setting (Hassan, 2014).

HyLogger data on diamond drill core and petrographic examination shows that talc is the main alteration mineral associated with mineralization and that chlorite is dominant distal to mineralization. However there are localized zones containing anthophyllite, cordierite, and in places cummingtonite and hypersthene within or adjacent to fluid pathways. Hassan (2014) concluded that deposition of mineralization at Yuiumery took place around hydrothermal vents on the sea-floor and in fractures and voids in the rocks of the subsea floor accompanied by widespread precipitation of BIF during periods of relative volcanic quiescence.

## 2.2. Austin

The Austin deposit is located 14 km southwest of the old Quinns gold mining centre within a greenstone belt 165 km north-northwest of the Yuiumery project area (Fig. 1). In the Quinns district, metamorphosed rhyolite, basalt and clastic sedimentary rocks of the 2814 to 2806 Ma Yaloginda Formation of the Norie Group are overlain by meta BIF and basalt of the 2800 to 2733 Ma Polelle Group. The rocks have been tightly folded, sheared, intruded by dolerite and granite and metamorphosed to at least upper greenschist facies and possibly amphibolite facies. There are several VMS prospects in the Quinns area that are associated with BIF at the base of the Polelle Group but Austin (the only deposit with a defined resource) is associated with sheared and folded BIF and minor mafic schist after basalt within rhyolite of the Yaloginda Formation. Two mineralized zones 40–50 m apart were intersected in the diamond drillcore. The lower horizon is zinc-rich but has an upper copper-rich horizon and the upper horizon is mostly copper-rich but has some zinc-rich intervals. Facing directions are uncertain and it is not known if these are two separate horizons or the same horizon repeated by faulting or folding (Duuring et al., 2016). The Austin deposit has a resource of 1.48 Mt at 1.02% copper, 1.39% zinc, 3.51 g/t silver and 0.24 g/t gold (Silver Swan Group Limited, 2010). HyLogger data

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