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Source of anomalous gold concentrations in termite nests, Moolart Well, Western Australia: implications for exploration

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Abstract

The Moolart Well deposit lies in the Western Australian Goldfields in an area that has seen nearly 150 years of Au exploration with limited success due to the transported cover masking deposits. Here, the site displays no anomaly indicative of underlying mineralization within surface soils. Termites have the ability to burrow to the subsoil and contribute to the development of soil profiles through bioturbation. Consequently, termite nest structures are useful as a geochemical and mineralogical sample medium for the discovery of ore deposits beneath weathered cover and shallow sediments. Termites and their mounds cover vast areas of arid Northern Australia, spanning a variety of soils and landscapes and thus represent a useful exploration sample medium.

This study discusses the use of mounds formed by the termite *Tumulitermes tumuli* from a site where shallow ferruginised palaeochannel sediments with secondary Au enrichment overlays deeper primary mineralization. *Tumulitermes tumuli* is able to bring sub surface mineralized material to the surface from 1 to 4 m depth. Termite mounds over mineralization display an Au anomaly in both <250 and >250 µm fractions. Very high concentrations (>5000 ppb) were found in >2000 µm fractions in nests over mineralization as a result of vertical transport of anomalous pisolitic gravels by termites. This results in termite driven local soil heterogeneity and termite mounds being a consistent sample medium that can be used to explore successfully through transported cover.

Introduction

Transported cover provides significant challenges to geochemical exploration because the dispersion of indicator elements to the surface is restricted (Anand *et al.* 1993; Butt *et al.* 1997; Butt *et al.* 2000; Anand 2005) and geochemical patterns related to any dispersion are masked by chemical and mechanical processes (past or present) unrelated to mineralization (Anand *et al.* 1997). This applies to most regolith settings in Australia. Post-Miocene aridity has substantially modified the geochemistry of both *in situ* and transported cover (Butt & Smith, 1980; Anand & Paine, 2002).

Gold exploration in the northern Yilgarn Craton (including the Moolart Well area) is difficult because lag and soil sampling has had very little or no success in these environments (Anand *et al.*, 2007; Balkau *et al.*, 2007). Despite ore grade Au within a few metres of the surface at Moolart Well, there is no geochemical expression in the surface soil (Anand *et al.*, 2007; Balkau *et al.*, 2007; Radford & Burton 1999).

Although the option of pattern drilling through transported cover is effective, it is expensive over large areas. The most common contemporary approach to orientation surveys has been to use partial extraction geochemistry to target regolith components that are thought to host weak geochemical dispersion haloes. A comparison of studies from a range of regolith terrains indicates that partial extraction techniques have met with less success in deeply weathered and arid terrains than in humid terrains with recent glacial or volcanic cover (Cohen *et al.* 1998; Gray *et al.* 1999; Kelley *et al.* 2003; Cameron *et al.* 2004). Specific mechanisms by which this dispersion occurs is widely discussed. Various mechanisms capable of producing soil anomalies above transported cover, as a result of vertical migration of elements have been reviewed by Cameron *et al.*, (2004) and Aspandiar *et al.* (2004). The mechanisms are classified according to two main processes: phreatic process (below water table) involving groundwater flow, convection, dilatancy, bubbles, diffusion and electro-migration, and vadose processes (above the water table) involving capillary migration, gaseous transport and biological transfer. Most of the mechanisms, especially those associated with vadose processes, are poorly understood and require further investigation (Cameron *et al.*, 2004; Aspandiar *et al.*, 2004). The vadose zone processes are vital in transferring metals from the groundwater to the surface and are especially important to the metal transfer mechanism in semi-arid and arid zones, where vadose zones are thicker and groundwater tables deeper.

Termites

Termites are key contributors to movement of regolith particles within the vadose zone. There is greater biomass of termites than mammals on some African savannas and as a result termites remove and digest the majority of plant-originated litter (Wood & Sands 1978; Deshmukh 1989; Bignell & Eggleton 2000). Termites have the ability to burrow to the subsoil and contribute to the development of soil profiles through bioturbation (Watson 1970; Debruyn & Conacher 1995; Sako *et al.* 2009;).

Consequently, termite nest structures have long been used as geochemical and mineralogical sample media for the discovery of ore deposits buried beneath weathered cover and shallow sediments (Watson 1970; d'Orey 1975; Prasad & Saradhi 1984; Gleeson & Poulin, 1989; Prasad *et al*., 1987; Fassil, 2005; Arhin & Nude 2010). Established accumulation patterns within termite nests include biologically-essential macronutrients acquired through food sources, including Mg, Ca, Zn, P and K, are found in termite nests at concentrations above those in adjacent soils (Laker *et al.* 1982; Coventry *et al.* 1988; Debruyn & Conacher,1995; Sileshi *et al.* 2010; Stewart *et al.* 2011). This occurs to the extent that mounds may be used as mineral licks by animals (Ruggiero & Fay 1994). The erosion of termite mounds adds these minerals to nearby soil, creating termite-induced heterogeneity, with the mounds acting as reservoirs (Debruyn & Conacher 1995).

Termites accumulate metals such as Zn and Mn within mandibles as do other insects (Cribb *et al.* 2008). With centralised nest structures termites differ from many insects in that their waste products (including deceased insects with mandibles) are locally concentrated to their nest. These waste products in the form of mineralized concretions harbour high levels of Zn, Ca, P, and K (Stewart *et al.* 2011). This gives rise to the possibility that termite mounds may harbour elevated metal concentrations as a result of excretion that are indicative of source food, groundwater or foraging substrates.

Termite nests studied for mineral prospecting have generally been larger than average. In particular studies have focused on *Macrotermes spp.* from Africa, which reach several metres in height and up to 10 m across (Hesse 1955; Watson 1970; d'Orey 1975). However research to date has not indicated that smaller mounds are any less effective at vertical transport of subsurface material (Debruyn & Conacher 1995, Petts *et al.* 2009). The termite species studied here (*Tumulitermes tumuli*) forms small mounds to 60 cm in height and is locally abundant across the Australian interior (Fig. 1). It feeds principally on surface plant material including grasses and fallen tree leaves, mostly mulga (*Acacia aneura*).

Geology

The Moolart Well Au deposit is located approximately 350 km NNE of Kalgoorlie in Western Australia (Fig. 2). The Moolart Well area has a semi-arid climate, generally with long hot dry summers with a mean average maximum January temperature of 35.8˚C, dropping to an average minimum July temperature of 5.2˚C (Laverton weather station 28.63 °S, 122.41 °E, Alt 461 m). Mean annual rainfall is 225 mm (Australian Bureau of Meteorology, 2011). The region is characterised by a deeply weathered, metamorphosed succession of Archaean mafic, ultramafic and felsic volcanic rocks with associated volcanogenic sedimentary rocks. Thin units of banded chert and banded iron formation also occur (Fig. 2; Balkau *et al.*, 2007). Late stage high level acid to intermediate sills and dykes and associated small plutons intrude the sequence. Exposure of greenstone sequences in the Moolart Well region is generally poor. At Moolart Well, a sequence of high Mg basalts with interbedded chert and sulphidic sediments strike N-S and dip to the E (Balkau *et. al.*, 2007). The basalts are overlain by an ultramafic unit which is 50 to 100 m thick, and forms the hanging-wall of the mine sequence. The footwall contact of the ultramafic unit is thought to represent a regional dextral strike slip fault.

Regolith

The Moolart Well Au deposit is located in a present-day N-S trending regional drainage corridor. To the E and W of the deposit, the landscape is overlain by thin (0.5 to 1 m) of residual soil. In the vicinity of the deposit, a shallow N-S trending Tertiary palaeochannel overlies residual regolith with variable depths to basement rock. The palaeochannel is approximately 1 to 2 km wide and approximately 20 m deep in the centre and can be clearly identified in aeromagnetic data by the presence of maghemite-rich gravels in the channel sediments. The transported cover is 1 to 3 m thick on the E side of the mineralization to over 10 m at the W side of the mineralization. The palaeochannels, which possibly date to the Eocene (Anand & Paine, 2002), are filled with multigenerational Fe-rich alluvial and colluvial sediments. They have been variously overprinted by pisolith development and mottling. Goethite rich cutans (1 to 2 mm thick) are common on pisoliths. These ferruginised palaeochannel sediments (ferricrete) contain ore-grade supergene Au. Ferricrete is overlain by Quaternary colluvium and alluvium which is silicified to red-brown hardpan (Bettenay & Churchward, 1974). Above the hardpan is a 15 to 30 cm thick sandy soil. The hardpan and mineralized ferricrete may form a physical barrier to tree roots and termites. However, pits dug into the ferricrete reveal that tree roots do penetrate the crust to greater depths (>5 m). The residual profile beneath the sediments consists of lateritic residuum, ferruginous saprolite, saprolite and saprock. Lateritic residuum contains monomictic, coarse, angular nodules that may have goethite-rich cutans and, in some cases, preserved rock fabric. The depth of saprolite exceeds 60 m.

Mineralization

Moolart Well is a mesothermal Au deposit hosted predominantly within intermediate diorite intrusives, but also in dolerite, basalt and, to a lesser degree, ultramafic rocks. Mineralization is structurally controlled in fresh rock and, to a lesser extent, in oxidised rock (Balkau *et al.*, 2007). Pyrite, arsenopyrite and traces of chalcopyrite, sphalerite and galena make up the sulphide assemblage which is generally disseminated (2 to 5% S). Two styles of Au mineralization have been defined in the regolith profile above fresh rock. A ferricrete mineralization style, comprising of nodules and pisolith occurs within the top 20 m in transported regolith (Tertiary palaeochannel; Fig. 3). A second oxide-style lies beneath the ferricrete mineralization in residual regolith (Balkau *et al.*, 2007). The deposit currently comprises a mineralized ferricrete indicated resource of 10.3 Mt at a grade of 1.39 g/t Au for 462 koz Au and an oxide inferred and indicated resource of 15.8 Mt at a grade of 1.20 g/t Au for 611 koz Au (Balkau *et al.*, 2007). The ferricrete mineralization extends over 4 km N-S and up to 1 km E-W, it has an average thickness of 4 m. Although the Ferricrete Zone averages 1.39g/t Au, higher grade zones occur in several locations (up to 11 m @ 6.4 g/t). Gold is depleted in the upper saprolite but increases in grade to the lower parts of the profile with locally high grades below the base of complete oxidation and above the top of fresh rock.

Vegetation

The vegetation is dominated by mulga (*Acacia aneura*) forming irregular stands with sparsely occurring dead finish (*Acacia tetragonophylla*). Also present along water courses are large-fruited mallee (*Eucalyptus youngiana*). The surface is largely free of grasses with only isolated tussocks.

Materials and Methods

Soil and termite sampling

Samples were collected from 22 termite mounds at roughly 50 m intervals along a 1 km E-W line crossing the mineralized area (~ 6945000 N, 436000 E, UTM zone 51J, Datum AGD84). At each site, 3 samples (1 kg) were collected. Nests were dissected using a geological pick, one sample was taken from the upper nest portion, one from the inside of the nest at ground level and one from the soil 1 m away from the nest (10 to 20 cm depth, Fig. 4). In addition to the termite nest samples, a line of 23 soil samples (10 to 20 cm depth) were taken parallel to and 50 m to the N of the termite sample line (Fig. 5).

Regolith Characterization

The composition of termite nests and surface soil was compared to the regolith profile from a pit dug over the shallow occurrence of mineralized ferricrete. Profile samples were taken at 20 cm intervals to 50 cm then 50 cm intervals to 6 m depth.

Analytical methods

All samples were crushed and then dry sieved into 2 fractions (<250 µm and >250 µm). After initial analysis the remaining portion of samples of mound core from 5 nests which recorded the highest Au concentrations were further sieved. Fractions of <2 µm, 2 to 53 µm, 53 to 2000 µm and >2000 µm were separated and analysed. Pit profile samples were also separated and analysed for the above fractions. The mound core samples had insufficient >2000 µm fraction for analysis in 2 of the 5 nests.

Both bulk and separated fractions were analysed for Cu, Zn, Ni, Cr, Mn, P, Sc, V, Fe, Al, Ca, Mg, Ti, Na, K, S, Co, As, Ag, Ba, Bi, Cd, Ga, Li, Mo, Pb, Sb, Sn, Sr, W, Y, Zr, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Ho, Er, Tm, Yb, Lu, Th, U, Se, Rb, In, Te, Cs, Tl and Dy by ICP-MS/OES following a mixed acids digest method (AR 200) employed by Ultratrace Pty. Ltd, Perth, Australia. (nitric, perchloric, hydrochloric and hydrofluoric). Gold, Pt, Pd, Hg, Ir, Rh and Ru were analysed by ICP after an aqua regia (nitric and hydrochloric) digest.

SEM characterisation

Termite mound sample fractions (<2 µm, 2 to 53 µm, 53 to 2000 µm and >2000 µm) were cut, mounted on carbon stubs and carbon coated for examination in a Zeiss Ultra-Plus Field Emission Scanning Electron Microscope (FESEM) fitted with a Bruker Energy Dispersive X-ray Spectrometer (EDX). The SEM was operated in high vacuum mode and images were collected with a Robinson backscattered electron detector (BSE). For EDX assessment of individual particles the SEM was set to 8 mm working distance with a 30 kV beam recording 30 seconds live time. Standardless quantification was used with ZAF matrix correction.

RESULTS

Regolith Characterization

SEM imaging and EDX analysis revealed and abundance of goethite cutan covered gravel >2000 µm (Fig. 6D). Finer fractions contain aluminium phyllosilicates, quartz and hematite. There were also inclusions of organically bound conglomerates particularly within the termite mound samples. These also occurred to a lesser extent within the soil samples where they are attributed as old graveyards and tunnel workings by the termites. The upper nest portion contains spherical pre-masticated cellulotic material derived from surface plant material which serves as food store for the termites. This stored food material was tapped free of the sample at the time of collection.

The upper profile consists of four units:
Gravelly soil (0 to 50 cm): Consists of clayey sand with loose nodules, pisoliths and quartz. Soil have <25% coarse (>2000 µm) ferruginous material, which is much less than the underlying regolith units. Here, 53 to 2000 µm fraction forms the major component of the soils.

Silicified colluvium and alluvium (50 cm to 2 m): Consists of reddish brown laminated cemented matrix and very poorly sorted, subangular to rounded polymictic clasts of various composition. The clasts include saprolite fragments, quartz, pisoliths and nodules to 25 mm. Coarse fraction (>2000 µm) of ferruginous nodules and pisoliths dominates followed by the 53 to 2000 µm fraction.

Partially silicified, hematite coated pisoliths and nodules (2.5 to 4.5 m): Consists of cemented, poorly sorted, angular to sub-rounded red and black nodules and pisoliths in a red, sandy clay matrix. The matrix of this unit resembles to that of the overlying unit. The main difference between this and the underlying unit is in the abundance of red pisoliths which dominate the >2000 µm fraction of this unit. The upper part of this unit is affected by the silicification and may give laminated appearance.

Goethite coated pisoliths and nodules (4.5 to 6.5 m): Consists of low to moderately indurated, poorly to moderately sorted packed pisolitic and nodular sediments, within a goethite matrix. It has well developed goethite yellow cutans on all nodules and pisoliths. Pisoliths and nodules (>2000 µm) vary from 55 to 75% in this unit.

Line samples

Gold occurs in higher concentrations in mound cores (mean 1.9 ppb, standard error (SE) 0.2 ppb), mound cap (mean 2.4 ppb, SE 0.24 ppb) and soil <1 m from the nest (mean 2.0 ppb, SE 0.2 ppb) than soil >5 m from the nest (mean 0.4 ppb, SE 0.1 ppb). Potassium concentration in both nest samples and adjacent soil is greater than samples taken >5 m away. This trend is not found with Mg, Cu or As which all have similar concentrations in all sample media.

Biologically important elements Ca and Na are shown to have significantly greater concentrations in mound core and mound cap than in the adjacent soil or soil >5 m from the nests. A summary of analytical results for elements of interest from termite mounds, adjacent soil and soil away from nests is given in Fig. 7.

When mound core Au concentration is plotted W to E, elevated concentrations can be seen expressed over the mineralization. This anomaly is not expressed over the W portion of the mineralization where depth of the mineralized ferricrete (>1 ppm) drops significantly from 1 to 2 m in the E to >10 m (Fig.8). Nor is it evident in soil samples collected away from termite mounds. Arsenic and Cu are patchily associated with the mineralization at depth, do not show notable variation in concentration across the sample line. This trend occurs for both <250 µm and >250 µm fractions (Fig. 8).

Termite mounds have only a small percentage fraction >2000 µm. Of samples from the 5 nests over the mineralization containing >2 ppb Au in the <250 µm fraction, only 3 contained sufficient volume for analysis. The relative concentration of Au in <2 µm, 2 to 53 µm, 53 to 2000 µm and >2000 µm is given in Fig. 9.

Profile samples >2000 µm

The source of gravels within the termite mound can be determined by comparing Au concentrations taken from various depths from the pit (Fig. 10). The >2000 µm fraction surface soils (0 to 10 cm) have low concentrations (1.8ppb) of Au. Samples from less than 1m depth are relatively low in Au concentration (1.8 to 3.2ppb). At 1 m Au is an order of magnitude more abundant (75 ppb). Concentrations increase to greater than 1000 ppb at >4 m depth (Fig. 10). The larger >2000 µm fraction which host high concentrations was demonstrated to host Au particles on its interior by SEM examination. Silver is not found in association with Au in these pisoliths or within the elevated <250 µm fraction of the termites mounds. This is consistent with precipitated secondary Au in the ferricrete. These gravels are large in comparison to the termites and this is likely the reason that this fraction is not represented as a large portion of the nest material. It is possible that specific targeting of particle sizes that termites can more easily transport e.g. 1000 µm to >1500 µm, may represent deeper gravels better.

Termite mound cores over the mineralization contain very high Au concentrations in the >2000 µm fraction (84 to 5960 ppb). Concentrations are comparable to that found between 1 and 4m depth in the analysed pit (Fig. 11). Key elements that show a general correlation with Au are Cu and As. The concentration of As is low to the depth of 2m but is higher (325 ppm) in nodules and pisoliths at 4 to 5m where Au is accumulated. Copper concentrations are low from 2 to 4m depth but are elevated form 2m towards the surface and at 4 to 6 m depth (Fig. 10). Goethite covered pisolithic gravels within termite mounds also contain high levels of As (20 to 260 ppm) and Cu (145 to 2440 ppm). Arsenic is associated with the Fe within pisolithic gravels, consequently concentrations within the fine fraction of termite mound core across all nests in the >250 µm fraction (median 19 ppm) is much higher than in <250 µm fraction (median 5 ppm).

The exact location of Au within gravel was found using SEM backscatter imaging (Fig. 12, 13). Particles of Au are located within the inner body of the pisoliths. These particles have largely occur within cracks, and range in size from <1 µm to >5 µm.

Discussion and conclusions

Tumulitermes tumuli are capable of tunnelling down and incorporating subsoil into nest structures resulting in expression of underlying Au mineralization. Because the depth of ferricrete enrichment varies across the deposit, it is possible to draw conclusions as to the effective depth that termites can provide this function. Fig. 5 shows that 5 nests occurring over mineralization containing >1 ppm at 1 to 4 m depth. All of these nest show elevated Au concentrations compared to the background area in <250 µm fraction for nest core, nest cap and soil immediately adjacent to the nest. However, where the depth of the mineralization is greater than 4 m there is no expression within the nests. This provides strong evidence that *T. tumuli* nests have an effective bioturbation profile of 4m. Even if the termites are tunnelling much deeper to the water table, insignificant amount of material is moved vertically during the process. Any material from these greater depths is overwhelmingly diluted by material derived from shallower horizons.

The finding here that termites nests contain Na, Mg, P, Ca and Zn at concentrations higher than surrounding soil is in general agreement with other studies (Coventry *et al.* 1988, Debruyn & Conacher 1995, Mahaney *et al.* 1999, Miranda & D'Cruz 2007, Watson 1976). Accumulation in mounds and adjacent soil is due in part to selective use of soil particle fractions. For example, constructed foraging structures (galleries) have more fine fraction clay, Mg, Ca and much more organic carbon (Jouquet *et al.* 2002, Samra *et al.* 1979) than soil. Another significant input comes from food sources as has been demonstrated for *Macrotermes spp* induced carbonates with Ca sourced largely from plant matter (Mujinya *et al.* 2011).

It is clear that termite activities have an influence on relative elemental abundances in soils immediately adjacent to mounds. This effect may be different in extent for different elements. This halo extends at least 1 m for Au. Future work should address the nature of termite induced heterogeneity in soils. This is important specifically in relation to exploration sampling protocols which may otherwise ignore these processes resulting in unnecessary sampling noise. We propose that the ecosystem conditions which allow successful use of termite nests as exploration sample media compared to soils require that the rate of erosion/leaching of soils is greater than the recharge rate from the termite mounds. The Moolart Well site sits on a contemporary flood plain where surface erosion due to sheet wash and flooding contribute to these conditions (Anand *et al*. 2007).

The species of termite studied here is widespread across Australia and represents a potential sampling medium where shallow bioturbation processes could provide useful information. However, targeting *T. tumuli* specifically may not be necessary, as other termite species may have very simular effects on vertical movement of soil materials.

Previous understanding on termites ability to vertically move subsoils advantageously for mineral prospecting is predominantly based on large nests from the genus Macrotermes in Africa. This group of termites creates massive nest structures up to several metres in height and 10 m across making them obvious targets for the geologist engaging in orientation surveys. It is not clear that these large nesting species confer any advantage over other species in their ability to vertically move subsoils (such as *T. tumuli* studied here). Termites may dig down large distances to source water, and observations of termites at depth foraging for water is often used in evidence of their ability to vertically transport subsoils. However, the depth to which termites can forage for water is a fundamentally a different question to; “from what depth do termites vertically move subsoil”. For example Awadh (2010) provided evidence of termites (species and nest size unknown) digging to a depth of 25 m in the western Iraq desert. However specific evidence of transported materials was from only beneath 2 to 4 m of overburden as demonstrated from inclusions in mounds of distinctive sands. The much referenced paper by d'Orey (1975) was significant in the description of 7 nests (*Macrotermes* sp) in central Mozambique containing anomalous levels of Cu and Ni, where local colluvial cover was 15 m thick. It is not clear if the source found in the termite mounds was actually from the ore body rather than from much shallower overburden. d'Orey (1975) does not make claim of the actual source. Likewise, in a Zimbabwean Kalahari desert investigation of 4 termite species (*Macrotermes bellicosus*, *Macrotermes natalensis*, *Odontotermes latericius* and *Rhadinotermes coarctatus*), Zn was found in mounds over a 10 m deep mica schist, but the immediate source of Zn incorporated in termite nests was demonstrated to be sourced from subsoils 60 to 274 cm deep (Watson, 1970).

There is no evidence that termites forming larger mounds bring material from deeper horizons than termites forming relatively smaller mounds. In a Western Australian study of nest structures of several termite species (*Drepanotermes tamminensis, Amitermes obeuntis*) of comparable size to the species studied here, 33% of termite mound material came from 30 to 45 cm (Debruyn & Conacher 1995). Petts *et al.* (2009) compared the large (>2 m) nests of the Australian termite *Nasutitermes triodiae* and found it to be equally efficient at vertically moving from 2 m depth to smaller mound forming species *Drepanotermes rubriceps* and *Amitermes vitiosus*. *Trinervitermes trinervoides* forms mounds 45 cm high in the Democratic Republic of Congo and uses subsoil from 20 to 40 cm as a substantial component of the mound (Laker *et al.* 1982). Five to 10m high nests of *Macrotermes goliath*, *Macrotermes bellicosus* and *Macrotermes natalensis* construct nests using subsoil from 60 to 150 cm deep (Hesse 1955). In Niger, where soil cover is thin (<2 m) Au is found in large mounds (*Macrotermes spp*; Gleeson & Poulin 1989). All of these studies demonstrate the vertical movement of soil from relatively shallow horizons of up to a couple of metres depth. This is consistent with our findings of material from 1 to 4 m depth.

By studying the termites at Moolart Well we demonstrate the use of Au content in all particle fractions from termite mounds to be more effective than use of soil located at distance from nests. The literature and this study support that the use of termites mound sampling regardless of termite mound size. Occurrence within nests of a signature through a few metres of transported cover can be expected but significant vertical movement from more than 3 to 4 m is unlikely. Exploration success will be improved by applying this in similar regolith settings.

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Figure captions:

Fig. 1. Distribution of *T. tumuli* in Australia, covering much of the arid interior (after Watson & Abbey (1993)).

Fig. 2. Geological setting of the Moolart Well Au prospect (GSWA, 2011).

Fig. 3. Generalised profile of the Moolart well site depicting a termite mound driving local bioturbation processes, not drawn to scale. Adapted from Regis Resources (2012).

Fig. 4. Areas of termite nest and adjacent soil sampled for analysis.

Fig. 5. Location of individual soil and termite mounds sampled. Shading indicates depth of mineralized ferricrete occurrence (UTM zone 51J, Datum AGD84).

Fig. 6. SEM images of different fractions; A <2 µm, B: 2 µm to 53 µm, C: 53 µm to 2000 µm, D: >2000 µm.

Fig. 7. Box plots showing concentrations of various elements in <250 µm fractions from termite mounds, adjacent soil and soil away (>5 m) from the termite nest (box plot line is the median; box represents standard error; 95 percentile the whiskers. Outliers represented by circles).

Fig. 8. Plot of termite mound core and soil samples taken along lines spaning background and mineralized area (<250 µm and >250 µm fractions). Bar indicates mineralized area.

Fig. 9. Box plots of Au concentration from various fractions of mound core taken from nests expressing a Au anomaly directly over the mineralization (N=5, except >2000 µm, N=3).

Fig. 10. Concentration of Au, As and Cu to 6 m depth taken from over the mineralized ferricrete body (particle size fraction is >2000 µm).

Fig. 11. Plot of mean Au sample concentrations shown in comparison to that measured in termite mounds. Concentration in mound corresponds to expected concentration at ~ 3 m depth.

Fig. 12. Location of Au found within gravel from termite nest in gravel goethite cross section of grave showing cutan and cracks which host Au (Arrow).

Fig. 13. SEM backscatter image of Au particle within a pisolith.