

GOLD DISTRIBUTION THROUGH THE REGOLITH PROFILE: EXAMPLES FROM THE WHITE DAM PROSPECT, OLARY, SOUTH AUSTRALIA

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INTRODUCTION

Soil and more recently calcrete sampling are often utilised for regional scale Au exploration where mineralisation may be located below several metres of regolith. These methods have proven to be equivocal with many false, as well as true, anomalies identified. The reasons how Au is mobilised through a regolith profile and concentrated in certain soil horizons are uncertain. Here we investigate the distribution of Au through two profiles from the White Dam gold prospect in the Curnamona province, South Australia.

GEOLOGY AND PROFILE DESCRIPTION

White Dam lies in the southern margin of the Curnamona Province, approximately 25 km northeast of Olary, South Australia. The geology of the area consists of metasedimentary rocks of the Palaeoproterozoic Willyama Supergroup and Mesoproterozoic granitoids (Flint & Parker, 1993). Au mineralisation at White Dam is associated with a biotite-quartzofeldspathic gneiss unit of the Wiperaminga Subgroup of the Willyama Supergroup. Primary Au mineralisation is located in a stockwork of pyrite and chalcopyrite veins that have been oxidised to 50 m below the surface (Cooke, 2003). Au located within the oxide zone is associated with biotite and exists as small platelets up to 60 µm with occasional larger grains up to 165 µm (Cordon, 1998; Croxford, 1998; Cooke, 2003).

Two profiles exposed in exploration costeans above mineralisation were selected for this research: Profile 1 (Figure 1) is located directly above mineralisation and is approximately 3.5 m deep. It consists of a thin coarse textured A1 horizon, a clay rich B1 horizon and a calcareous B2 horizon that gradually changes to a Bk horizon with carbonate nodules and rhizomorphs. Below this the sequence is repeated with another clay horizon (2B2) and calcareous horizon (2Bk). This has been interpreted as a palaeosol where the A1 horizon has been eroded. Below this is the saprolith (C horizon) consisting of a weathered pegmatite that intrudes a weathered biotite gneiss.

Profile 2 (Figure 2) is located just off the main zone of mineralisation and is approximately 3 m deep. It consists of a thin coarse textured A1 horizon, a sandy clay B1 horizon that becomes calcareous with depth and gradually changes to a Bk horizon with increasing coarse grains and lithic fragments with depth. The Bk horizon gradually changes into the saprolith, which consists of a highly weathered biotite gneiss saprolite that overlies saprock at approximately 1.5 m.

METHODOLOGY

A particle size separation was performed on samples collected from the main horizons of both profiles based on the method described by Gee & Or (2002). Clay (< 2 µm) and silt (2 – 20 µm) fractions were separated through gravity settling and four sand fractions (20 – 53, 53 – 125, 125 – 2,000 and > 2,000 µm) through subsequent sieving. Neutron activation analysis (NAA) was performed on each size fraction and also on a bulk < 2,000 µm sample. The silt fraction, which recorded the highest Au concentrations of all the fractions, was viewed and analysed for Au particles using the University of Adelaide, (Adelaide Microscopy) Philips XL30 field emission gun scanning electron microscope (FEGSEM).

RESULTS

The distribution of the size fractions is shown in Figures 1 and 2. The distribution of the silt and the 20 – 53 µm sand shows little variation (all values are < 10%) throughout the profile with a slight drop at the profile base. The 53 – 125 µm sand fraction is also similar between the two profiles. However, this fraction has a higher content (approximately 10 – 20%) and shows a slightly higher variability than the silt and 20 – 53 µm fractions. The clay fraction shows significant differences between the two profiles. In Profile 1 the clay content steeply rises to approximately 60% in the B1 horizon and gradually decreases to a slight peak at the second clay horizon before dropping off rapidly to < 10% in the saprolith. In Profile 2 the clay content rises to approximately 40% in the B2 horizon before falling to < 1% at the base of the profile. The 125 – 2,000 µm fraction is similar in both profiles with an almost inverse relationship to the clay fraction.

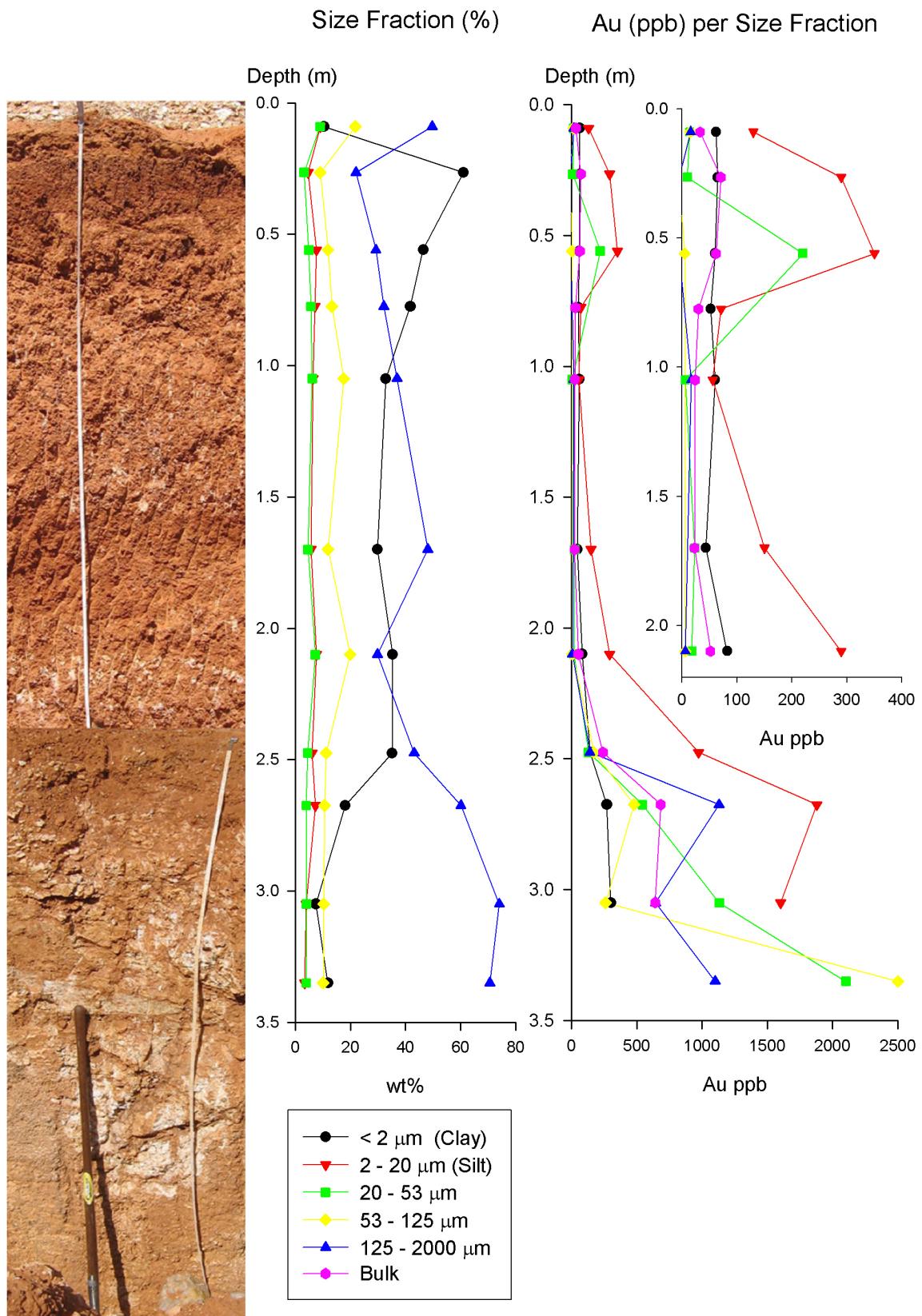
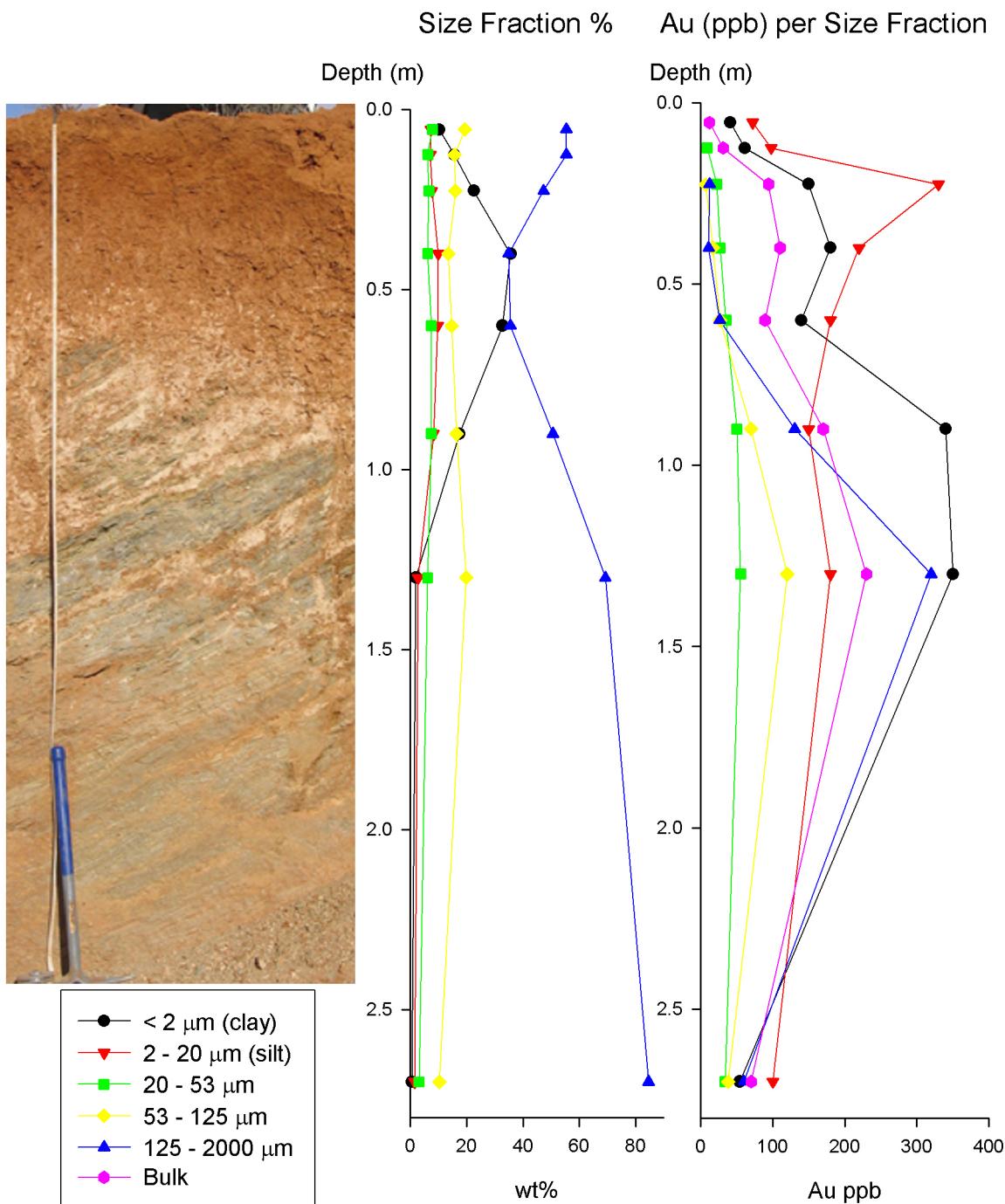


Figure 1. Profile 1

**Figure 2.** Profile 2.

In Profile 1, the pedolith has Au values from below detection limit (5 ppb) to approximately 350 ppb for the various size fractions (Figure 1). Within the saprolith there is a significant elevation in Au content with many samples $> 1,000$ ppb. The highest concentration of Au in Profile 1 is within the silt size fraction, which has a peak of approximately 350 ppb in the B2 horizon. The Au concentration in this fraction then falls back to between 50 and 100 ppb before rising again to approximately 300 ppb at the second carbonate layer. The Au concentration in the 20 – 53 μm fraction is the only other fraction to show any significant variation through the pedolith, which like the silt fraction, is within the B2 horizon. Of the remaining size fractions, clay has a consistent Au concentration of between 50 and 100 ppb and the 53 – 125 μm and 125 – 2,000 μm size fractions have Au concentrations < 50 ppb (with some even below detection limits). The Au values of the bulk samples are consistently lower than the clay and silt fractions through the pedolith with values around 50 ppb.

The Au concentration through Profile 2 (Figure 2) peaks at approximately 350 ppb in the pedolith and drops to < 100 ppb within the saprolith. The silt fraction has a peak within the B1 horizon, at the top of the highest carbonate content region. The Au concentration in the clay fractions has considerable variability with a small peak (~ 150 ppb) at the base of the B1 horizon and another larger peak (~ 350 ppb) in the saprolite. The Au concentrations of the remaining size fractions are all < 50 ppb through the pedolith. Within the saprolite, all size fractions apart from the 20 – 53 µm fraction have a peak in concentration. The bulk samples follow a similar pattern to the clay fraction with a lower overall Au content.

Observations made using the FEGSEM on the silt fraction revealed several Au particles within the saprolith samples and a single particle within the B2 sample of profile 1. Considerable difference in morphology between the saprolith and the pedolith sample was observed. The Au particles within the saprolith had a smooth, rounded and almost crystalline morphology. The grain sizes were approximately 1 µm in diameter. The single Au particle located within the pedolith was larger (~ 3 µm) and had a nodule-like surface texture. No Au particles could be located within profile 2.

DISCUSSION

The major difference between the two profiles is the Au content at the base of the profiles. The values highlight that Profile 1 is directly above mineralisation whereas Profile 2 is not. However, similar Au values were recorded for both profiles within the pedolith. The silt fraction had the highest Au concentration of the various size fractions, throughout the pedolith of both profiles with a similar peak near the boundary of the clay rich and more calcareous horizons. Because of the method of separation (gravity settling) and the high density of Au (19.3 g.cm⁻³) compared with most silicate minerals (~ 2.7 g.cm⁻³), the size of the Au particles within the silt fraction was actually from 0.6 – 6 µm. The observed Au particles were well within this range at approximately 1 µm. The size of the Au particles is considerably smaller than the Au platelets described for the oxide zone by Cordon (1998), Croxford (1998) and Cooke (2003). This suggests that the Au has either been altered through weathering processes during the formation of the profile or that the Au has been mobilised in solution and reprecipitated. The Au particles observed within the saprolith could be described as small platelets that may reflect weathering processes. However the texture and shape of the Au particle in the pedolith is significantly different. This suggests that the Au was precipitated from solution. The texture of this particle is similar in appearance to SEM micrographs of microbiota growing on a Au pellet by Reith & McPhail (2006). It is therefore possible that the Au within the pedolith was concentrated and precipitated through microbial activity. More Au particles need to be studied to make a firm conclusion.

The fact that both profiles had similar Au values in the pedolith shows that Au is very mobile within the regolith and that it will travel beyond the extent of mineralisation. There seems to be a preference for Au to be accumulated within the top of the calcareous horizon. The Au content of the bulk samples lie within the ranges of the size fractions and there is no obvious evidence for any nugget effect. Therefore the Au must be very finely disseminated throughout the samples. To be able to observe any Au particles the samples must have a Au content of at least 350 ppb, otherwise the ratio of Au to other materials is too low to be able to detect the presence of any Au particles by electron microscopy.

There are several factors affecting Au distribution within the two profiles, especially Profile 2, that require further investigation. One is the high Au values observed in the saprolite. Both profiles show the same trend, however, Profile 1 is showing an increase because of underlying mineralisation yet Profile 2 is not. The other point that should be noted is the variability of Au concentration in the clay fraction in Profile 2. It is possible that these differences are linked and possibly due to the smaller profile depth. If there has been a loss in material from this profile through erosion, it is possible that the concentration of Au has increased because of this loss, rather than an actual increase in Au content.

No Au particles could be located in the silt fraction samples of Profile 2 despite having a similar Au content to the pedolith in Profile 1. This may simply be a reflection of the luck involved in finding the single Au particle within Profile 1.

CONCLUSION

The two profiles described here show that Au is highly mobile in the regolith and that particular horizons seem to favour Au accumulation. In this case study, Au shows a preference for accumulation near the top of the calcareous horizon. Bulk samples had anomalous Au values, however, higher Au values can be expected if analyses are performed on the finer fractions. The lateral migration of the Au will make target areas larger and hence, easier to locate. However, consideration of possible transport pathways, such as alluvial channels must be well thought out to narrow the final target area.

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