BOTTLE CREEK AREA, WESTERN AUSTRALIA

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INTRDUCTION

Multi-element geochemistry of lateritic pisoliths/nodules was used in the discovery of the Bottle Creek gold deposit (Legge *et al*., 1990). It was thus opportune to use the Bottle Creek gold deposit as one of several sites to investigate regolith as a sampling medium for gold exploration in weathered terrains (Churchward *et al*., 1998). This study seeks to establish a regolith–landform framework for subsequent, more specific geochemical studies.

PHYSICAL SETTING

Bottle Creek, at 120° 27´E, 29° 10´ S, is located some 200 km northwest of Kalgoorlie, in the MENZIES (SH 51-30) 1:250,000 map sheet area (Figure 1).

Geology

The gold deposits occur at the northwestern tip of the Mt Ida Greenstone Belt in the Archaean Yilgarn Craton. This belt comprises a north–northwesterly-striking, eastward dipping greenstone succession, surrounded by adamellitic rocks (Kriewaldt, 1970). The mineralization is hosted by sulphidic black shales in biotite-altered mafic metavolcanics, which are elements of a high-magnesian metabasalt sequence.

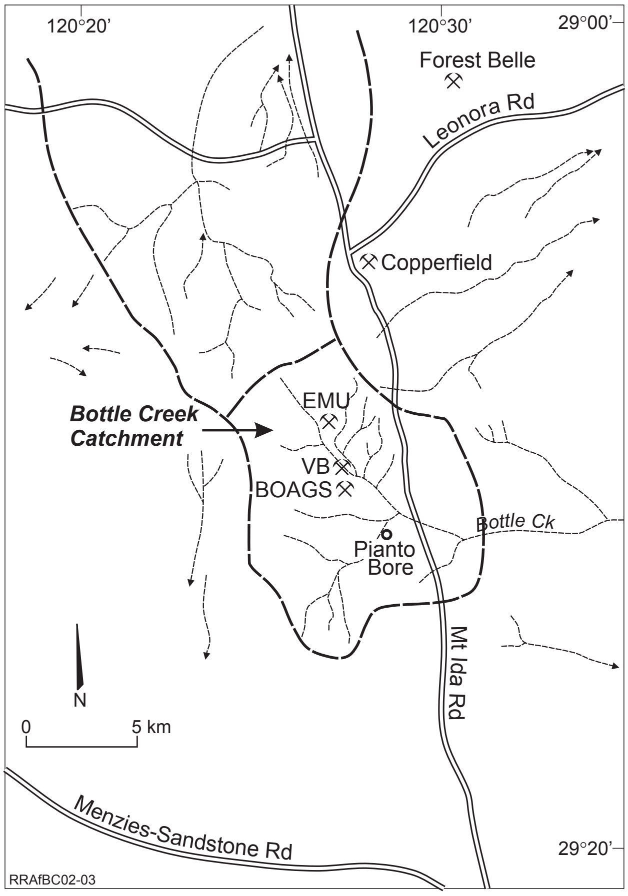

Figure 1. Location of the Bottle Creek mining area.

Physiography

The area forms part of the extensive Great Plateau of southwest Australia. Here the gently undulating terrain is interspersed with sheet flood plains, tributary to the major valleys that are in part occupied by playa lakes. The overall low relief of the plateau is broken sporadically by strike ridges, usually associated with elements of greenstone belts and having a general northerly trend. Other significant relief complexities are discontinuous erosional scarps, locally known as breakaways.

The gold deposit lies in a narrow northwesterly-trending valley plain occupied by colluvial/alluvial tracts, which rise to a slightly undulating tract marking the divide between the Lake Raeside drainage basin to the north, and the Lake Ballard drainage basin to the south (Figure 1). The crests of this undulating tract rise eastwards, and to the west, merging with low hill tracts, comprising a complex of steep slopes and associated breakaways.

Climate and vegetation

The climate is arid with a very variable rainfall of about 190 mm/yr, much of which is received between January and April. Spring (Sept.–Nov.) is the driest season; summer is hot to very hot; winter is cool and frosts are common. The vegetation is dominated by mulga (*Acacia aneura*) scrub communities with a shrub understory of various species, such as *Cassia* spp and *Eremophyla* spp. Small patches of low eucalypt trees (commonly *E. kingsmillii*) occur.

REGOLITH–LANDFORM RELATIONSHIPS

The rocks of the Yilgarn Craton have been deeply weathered resulting in an extensive, often thick mantle of kaolinized rock, commonly having its upper parts variably ferruginized so the term lateritic is often applied to it. This lateritic mantle and other products of secondary weathering, are major contributors to the array of regolith types at Bottle Creek.

Variation in the regolith can to a large degree be explained in terms of erosional and depositional modification of the deeply weathered landsurface. The recognition of physiographic regimes (Figures 2 and 3) has provided a useful framework for considering the pattern of regolith types. In this framework, those areas occupying regimes referred to as relict have thick mantles of weathered materials. Erosional regimes are to a large degree dominated by kaolinized and/or fresh rock outcrop and subcrop and it seems likely that areas of this regime are the result of stripping of part or all of the weathered mantle. Depositional regimes are dominated by thick fluvial sediments.

Exposures in three mining pits in the north-trending valley plain

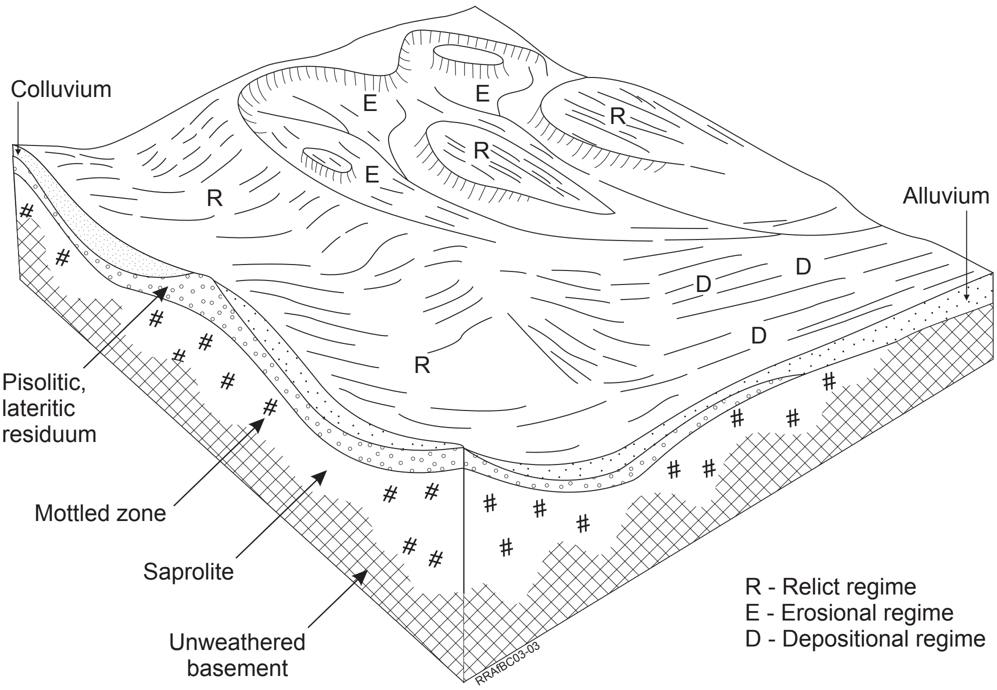

Figure 2. General relationship of the relict, erosional and depositional regimes at Bottle Creek.

provided an opportunity to examine the regolith in detail, along with drill spoil observed while traversing the lease. Salient features of the regolith are as follows.

Relict regimes

Excavation of Emu Pit, situated in the undulating part of the valley plain close to the drainage divide, has exposed 5 m of pisolitic lateritic residuum. This merges at depth with a slightly or strongly mottled mass and then to pale, sometimes diffusely mottled, clay thence to pale brown saprolite or saprock (Figure 3). Much of the lateritic residuum is infused by silica with consequent development of a red–brown hardpan (Teakle, 1936) with its characteristic porous, earthy appearance, its platy structure and brittle consistency. The surface soil on this is less than 1 m thick and is a brown, very friable, acid, sandy loam with large amounts of black to yellow–brown pisoliths. The yellow–brown pisoliths commonly have prominent yellow–brown cutans and some of the black pisoliths are magnetic. The relict regime commonly includes large lensoid to irregularly shaped ferruginous bodies that are commonly non-magnetic, have a fragmentary fabric, and can have very few localized gossanous pockets (Figure 3). These bodies are referred to as Fe-segregations (Anand *et al.,* 2002) although the broader term Fe-rich duricrust has also been used.

In relict regimes the crests of this generally gently undulating terrain commonly represent loci of mild bevelling with consequent exposure of a wide array of weathered ferruginized materials including ferruginous saprolite, ferruginous duricrust, Fe–segregations and ferruginized lithic fragments (Figure 3). These materials are the prime contributors to the colluvium that mantles the flanking slopes. Here acid gravelly red sandy loams occur with a lag of fine gravel and granules which reflect the clastic fraction of the colluvium. Pisolitic residuum is a common substrate to the colluvium, and hardpan, generally several metres thick, appears at about 35 cm depth.

Depositional regimes

Sections in VB and Boags pits show regolith stratigraphy of depositional regimes. Here the lag is dominated by ferruginised lithic granules with which is associated a coarse fraction of medium sized lithic gravel including a significant amount of vein quartz. This rests on a red earth soil developed in a colluvium/ alluvium comprising a friable clay loam to light clay containing the same array of clasts as in the lag. At a depth of between 1 and 1.5 m a stone line makes a sharp stratigraphic break between the upper, more clayey materials, emplaced by unconfined sheet flow, and coarse palaeochannel deposits. The palaeochannel forms a clearly defined trench some 12 m deep and 400 m wide is occupied by crudely stratified alluvium of rounded ferruginous and lithic cobbles and gravels (Figure 3). Some pisoliths /nodules are present. These materials contrast with that which are commonly referred to as palaeochannel deposits in regolith in the eastern Yilgarn Craton. The latter largely comprise pale kaolinitic clays, commonly coarsely mottled, with which are associated a wide scatter of quartzose gravels and coarse granules as pockets and lenses. Some of the pit sections show the upper colluvial/alluvial deposits resting on other substrates such as lateritic residuum or saprock. Hardpan has developed at a depth of about 40 cm towards the base of the colluvium, and continues at depth into any of the substrates, for several metres.

Erosional regimes

These dominate the low hill belts flanking the central plain. The upper elements of the topographic sections of this regime comprise the breakaway scarps in which ferruginous saprolite is generally

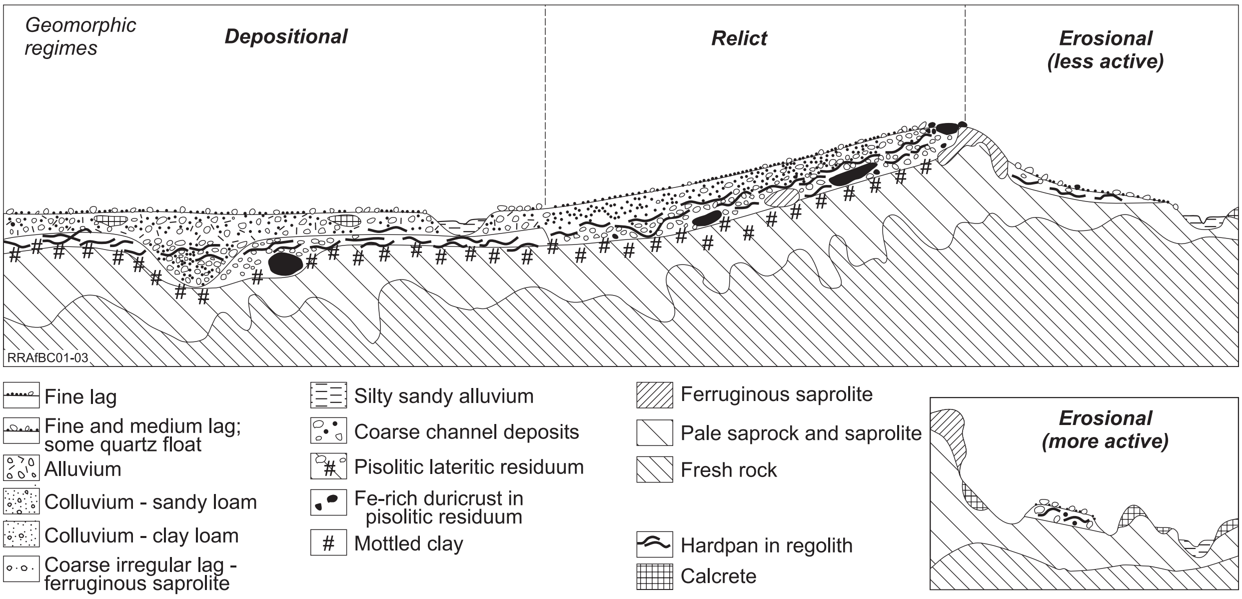

Figure 3. Idealised cross-section illustrating the relationship between landforms and regolith types at Bottle Creek.

exposed. Black, pisolitic lateritic residuum, a phenomenon of scattered occurrence on greeenstones of the eastern Yilgarn Craton, is rare for the breakaway scarps at Bottle Creek.

Two breakaway/pediment combinations have been identified. One type features low, broadly concavo–convex breakaways leading down to a smooth, gently graded pediment, capped by a thin mantle of hardpanized sediment, on a saprock substrate (Figure 3). The other type features steep, commonly cliff-like breakaways that lead down to steeply graded pediments with a more complex array of regolith materials. Hardpan is absent. There is widespread outcrop/subcrop of weathered and fresh rock and the lag is predominantly lithic and can include much coarse vien quartz as well as large patches of Fe-segregations. Shallow calcareous earths are common.

Areas of erosional terrain commonly comprise a complex of both types. The former type is commonly flanked by active erosional scarps capped by hardpanized sediment, so that the latter type is expanding at its expense.

GENERAL CONCLUSIONS ON REGOLITH AND LAND-FORM DEVELOPMENT

The relief at Bottle Creek reflects a deeply weathered landsurface variably modified by geomorphic processes. The lateritic residuum extends from upper to lower parts of the landscape (Figure 3) suggesting its development on an undulating landsurface that was then sufficiently stable to ensure retention of many by-products of weathering, yet was not much different from the present scene. Major landscape changes in valley pattern are not evident. Landscape inversion is not supported by the observations made at Bottle Creek.

Drainage incision, reflected by the deep palaeochannel, in the VB and Boags pits, would have resulted in some fragmentation of the lateritic mantle at least along portions of the valley floors. The lateritic mantle has been retained extensively on the adjacent slopes. Subsequent to this early phase of drainage incision there has been significant fluvial deposition first as coarse bedload material filling the palaeachannels. This coarse material, containing ferruginous clasts, derived from lateritic residuum, indicates that both of these phases of incision and deposition look place after development of the lateritic mantle. The appearance of finer, unconfined colluvial/ alluvial materials, above these, suggests a further change in the erosional/depositional environment. Furthermore, the apparent increase in lithic fragments in the upper sediment indicates that erosion has accessed less weathered parts as the lateritic mantle.

It would seem that in the process of landscape modification the more recent focus of erosion has significantly shifted from the valley floors to the slopes particularly in the mid and upper parts of the topographic profile as is here well expressed by the complex of breakaways and pediments. The less active form was, perhaps, once the earlier and more extensive state of erosional terrains and is now being destroyed by an increasingly active erosional environment. These trends suggest significant changes in the nature of the landscape proceses, a subject that was not developed further in this study. Of present relevance at Bottle Creek, however, is that, although there has been widespread redisrtibution of major parts of the regolith, this process has commonly had only a local effect so that many regolith types can now be found relatively close to sites of genesis, commonly as outcrop or subcrop, or as elements of local deposits.

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