TELEGRAPH, LANCEFIELD AND BEASLEY CREEK GOLD DEPOSITS, WESTERN AUSTRALIA

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INTRODUCTION

The Beasley Creek gold deposit lies about 9 km west-northwest of Laverton (Figure 1) at 122°18'E, 28°34'S within the LAVERTON (SH51-02) 1:250 000 map sheet area. The Telegraph and Lancefield deposits lie 7 km from Laverton but to the north-northwest of the town. In both areas Archaean inliers are surrounded by Permian glacial channels, wash plains and modern alluvium. The Archaean and Permian rocks have been deeply weathered. Only saprolite and lateritic duricrust of the Archaean rocks crop out in a few places. The Permian sediments are mainly known from groundwater wells and mineral exploration drilling. This summary has been drawn from several detailed studies covering the geomorphology (Robertson and Churchward, 1989), the lag and soil (Robertson, 1989; 1990), saprolite (Robertson, 1991) and descriptions of the Permian rocks (Robertson *et al.*, 1996).

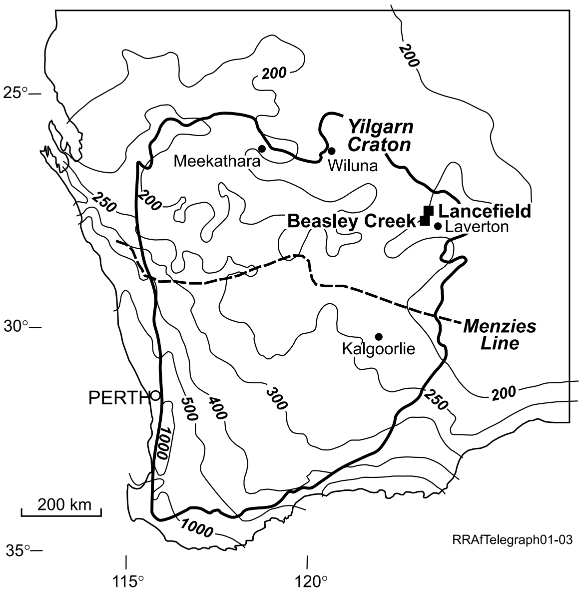

Figure 1. Location of the Beasley Creek gold mine in relation to the Yilgarn Craton and average rainfall.

PHYSICAL SETTING

Geology

The geology at Beasley Creek, as determined from percussion drilling, is illustrated in Figure 2. The gold mineralisation is hosted by a black shale, some 15–40 m thick, which dips at 45° to the east. The shale generally strikes north but swings to the west at its southern end and flattens. This black shale is intensely weathered to >200 m and gold is associated with ferruginous zones within it. The black shale is enclosed by a narrow, north-striking amphibolitic schist which is less intensely weathered, particularly where distant from the black shale. Small porphyry, granitoid and metadolerite lenses intrude the black shale and

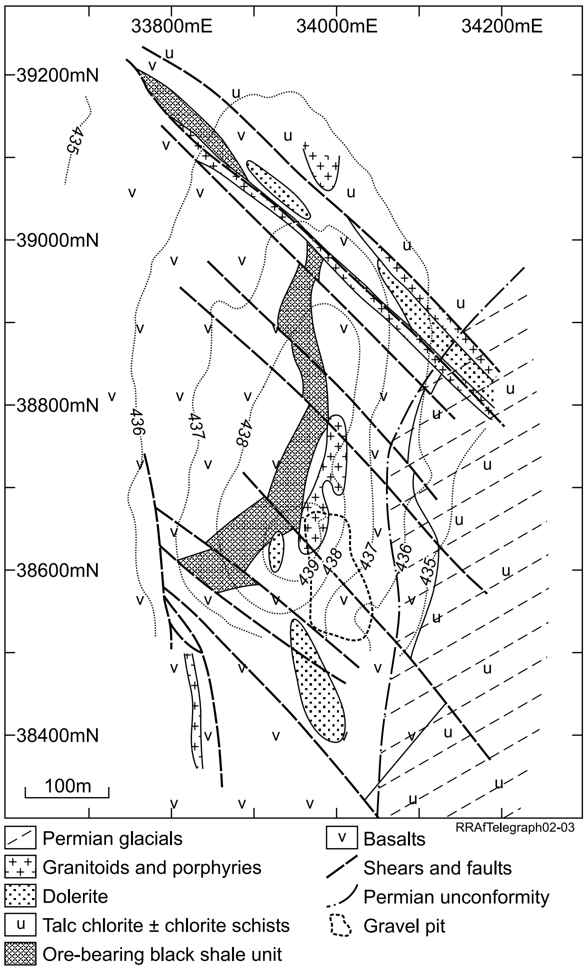

Figure 2. Interpreted solid surface geology of the Beasley Creek Gold Mine. (after WMC Plan BCG/50/1)

schist and are associated with northwest-striking faults and shears. The amphibolite schist is, in turn, enclosed in komatiites of the Mt Margaret Anticline.

At the Lancefield South gold deposit, schistose ultramafics in the west are in contact with tholeiitic basalts (Hronsky *et al.*, 1990). These are overlain in the north by Permian sediments. At Telegraph, the geology is more complex with magnesian basalt and black shale occurring to the west of the tholeiite. Permian rocks occur in the western edge of the pit. A veneer of ferruginous colluvium–alluvium overlies Telegraph and this has formed a wash plain or alluvial plain.

Geomorphology

The Beasley Creek Au deposit is on a low hill, flanked by pediments and alluvial plains. The hill is similar to an undulating tract of low relief, extending northeast to the Lancefield and Telegraph mines. The whole area is underlain by weathered Archaean and Permian rocks. The surrounding pediments comprise a system of low broad rises (Wanderrie banks) with intervening flats. This tract of Wanderrie country forms a low, tabular divide to broad valleys with incised ephemeral stream channels. This pattern is shown in Figure 3.

The detailed physiography at Beasley Creek is shown in Figure 4. The hill has a general north–south orientation and its broad crest is some 3.0–3.5 m above the wash plains. Westwards, this crest merges with a long gentle slope and, eastwards, through a slight convexity, to a shorter, steeper slope. The gradients are generally gentle to moderate (0.3–2.6°). The mineralisation subcrops at the crest of the hill and follows the crest as it swings slightly to the northwest at the northern end (see Figure 2).

In contrast to the high physiographic setting at Beasley Creek, the Telegraph mine straddles a broad valley with incised ephemeral stream channels and an alluvial plain underlain by colluvium–alluvium. Lancefield South occurs on a very slight erosional rise, with extremely thin soil, that has been largely disturbed my mining.

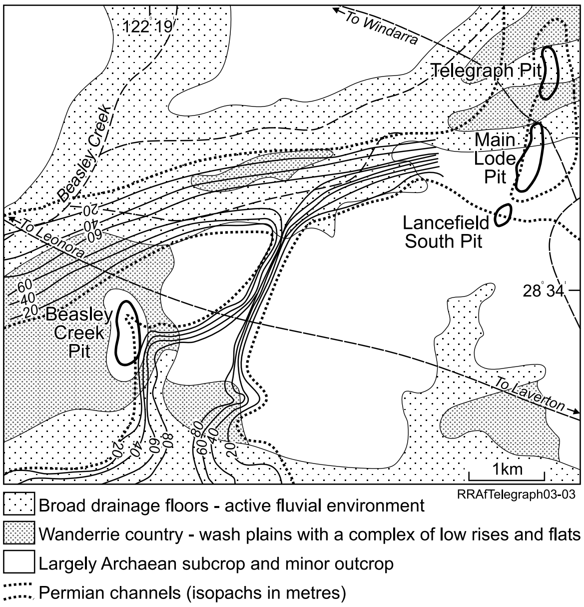

Figure 3 Regional geomorphology of the Beasley Creek and Lancefield Mining Areas, showing the distribution of Permian fluvioglacial channels as determined by WMC (Windarra Nickel Project plan 6/4/89). Isopachs in metres.

Climate and vegetation

The climate is semi-arid (Figure 1), with hot dry summers and cool to mild winters. The rainfall is erratic (average 225 mm/yr; range 65–453 mm/yr) which is greatly exceeded by evaporation (2700–2900 mm/yr). The vegetation consists of *Acacia* (mulga), *Cassia, Brachychiton* (kurrajong), *Casuarina* (she-oak) and some *Kochia* (sagobush) and *Eremophila* in erosional areas of outcrop and subcrop. *Acacia* and *Eremophila* mark the wash plains. There is additional *Eucalyptus, Santalum* (sandalwood) and *Cassia* in defined creeks (Burbridge, 1942; Gower, 1976).

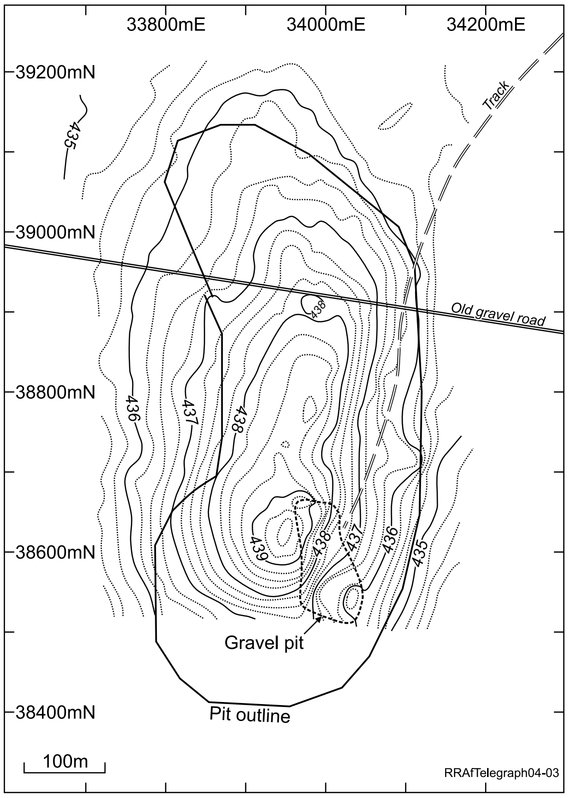

Figure 4. Physiography of the Beasley Creek hill. Contours in metres.

REGOLITH–LANDFORM RELATIONSHIPS

The mines at Beasley Creek and Lancefield South were situated on slight erosional rises; that at Telegraph is beneath a depositional plain of colluvium and alluvium. All three pits intersect weathered Permian sediments that fill channels eroded into the mottled zone and saprolite of the basement.

At the Beasley Creek deposit, mafic saprolites subcrop on the western side of a low hill beneath a thin lithosol and a patchily developed calcrete. The crest of the hill is marked by ironstone lag beneath which the weathered mineralised black shale subcrops. The eastern flank of the low hill is duricrust. Pisoliths from the duricrust are incorporated into the shallow soil. Mafic rocks at the Telegraph Pit subcrop beneath a veneer (0.5–1.0 m) of ferruginous colluvium–alluvium, overlain by wash plains.

The Permian rocks do not outcrop but are overlain largely by wash plains and modern alluvium. Drilling by Western Mining Corporation and pit exposures west of Laverton have outlined extensive channels, over 80 m deep, of Lower Permian Paterson Formation sediments, comprising conglomerates, gritty sandstones, sandstones and claystones. There were two major channels, one that is now followed by the course of the Beasley Creek (Figure 3) and another that has been followed by the modern Skull Creek drainage to the south.

The wash plains surrounding the basement outcrops comprise a system of low, broad rises, or Wanderrie banks and intervening flats. The banks are oriented to the contours. Below these are low drainage floors of alluvium into which ephemeral stream channels are incised.

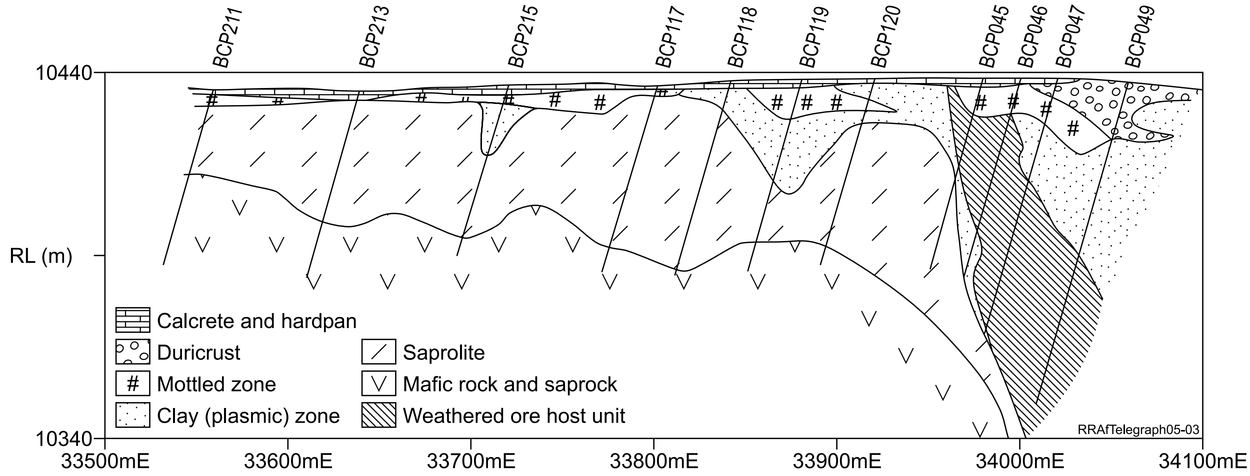

Figure 5. Section through the regolith at the Beasley Creek gold mine.

REGOLITH CHARACTERISTICS

Saprolite

On the surface at Beasley Creek, exposures of saprolite are very small, relatively uncommon and are found along the axis of the hill and along its western flank. The saprolite is brown to cream coloured, soft and has little recognisable fabric. Some calcretes contain numerous saprolite fragments. Saprolite fragments make a significant contribution to the fine fraction of the lag in places. Preservation of small outcrops of saprolite on the surface is probably due to slight silicification or calcification. Weathering of the saprolite, distant from the sulphide-rich mineralisation, reaches 30–50 m (Figure 5) but, close to mineralisation, the depth of weathering exceeds 230 m. The depth of weathering seems to be, at least in part, related to the sulphide content (Robertson, 1991).

Lateritic Duricrust

Lateritic duricrust is exposed on or underlies the eastern flank of the hill at Beasley Creek, indicated by khaki lag. The lateritic duricrust has a reddish yellow, vermiform lower part. Voids are so abundant in the upper part of the duricrust that it passes into nodular fragments that form the lag. The duricrust consists kaolinite, goethite, hematite and minor gibbsite.

Permian Sediments

Outcropping glacial and fluvioglacial deposits at Laverton, consisting of boulder beds of rounded, smooth boulders up to 3 m diameter and pebbles in a fine-grained bluish clay, have been described by Clarke (1919-20), Hobson and Miles (1950) and Gower (1976). Boulder fields indicate subcrop. Good sectional exposures occur in the eastern face of the Beasley Creek pit, the northern part of the Lancefield pit and western part of the Telegraph pit.

At Lancefield, poorly sorted matrix-supported conglomerates, with some gritty sandstones and sandstones, form the base of the Permian. Clasts include metavolcanics, chert, quartzite, granite, quartz, gneiss and banded iron-formation. All clasts have been deeply weathered since deposition to clay-rich saprolites in which fabrics are clearly preserved. Higher in the profile they pass into megamottled horizons and into a mottled duricrust.

At Telegraph, schistose mafic basement rocks are unconformably overlain by a conglomerate of metavolcanic rocks, granite and gneiss in a gritty matrix, of similar composition, now deeply weathered to saprolite. The section becomes progressively more mottled towards the surface and the lithology becomes obscured.

In the eastern pit face at Beasley Creek, a channel is exposed. At the base, the channel fill consists of weathered clays, sands and boulders that pass upward into a megamottled zone. Robertson (1995) described ferruginised fluvioglacial materials from the lag overlying the Beasley Creek deposit.

Calcrete

Parts of the crest of the hill at Beasley Creek are permeated with calcrete. The calcrete consists of relatively pure carbonate, carbonate indurated saprolite (saprolite veined with calcrete or saprolitic fragments in a calcrete matrix) and calcrete cemented pisoliths (particularly prevalent in calcretes to the south and southeast of the hill). The pisoliths have yellow to khaki cutans and are commonly fractured and veined by the carbonate cement. Where calcrete is strongly developed, excavation by goannas and rabbits has left patches of pale, calcareous soils, slightly raised above the surrounding ground. These show as pale bluish-white patches on colour air photographs. Gypsum veins brecciate the saprolite in the footwall of the mineralisation.

Ironstone

The ironstones at Beasley Creek are very variable but most are hard, dark and dense. They vary from black to red, yellow-brown and dull brown and have vitreous, cavernous, botryoidal or vesicular surfaces. Their fabrics vary from very fine, even-grained to cellular and they are thought to be of saprolitic origin. Veins of dark, metallic goethite with colloform structures cut the fabric.

Outcrops of the ironstones are generally restricted to the crest of the hill, where they form discontinuous pods, lenses and dark brown irregular boulders with a hackly surface. They are

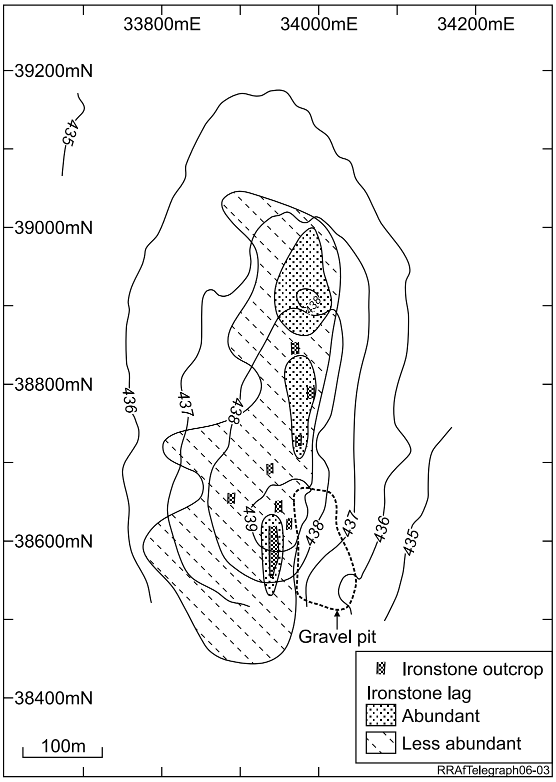

Figure 6. Distribution of ironstone outcrop and related lag over the Beasley Creek gold deposit.

surrounded by a coarse lag, derived from them (Figure 6). This ironstone lag is most strongly developed along the axis of the hill and, to a lesser extent, on the upper southwest flank. The distribution of some represents the subcrop of the mineralisation. Some ironstones show sulphide pseudomorph micro-textures and are rich in pathfinder elements (As, W, Cu), indicating that they are gossans (Robertson, 1999).

Soil and hardpan

The hill at Beasley Creek is mantled by red, very friable, clay soils (red earths of Stace *et al*, 1968) and hardpan is generally encountered at a depth of <0.5 m. On the alluvial plain to the west, the soils are very friable, acidic, sandy loams to fine sandy clay loams, underlain by hardpan at 0.3–0.4 m. On the long, gentle, western slope to the broad crest, the soil distribution is complex. Patches of very friable, light brown, alkaline, calcareous clays (calcareous earths of Stace *et al.*, 1968) are associated with goanna mounds. More extensive red, very friable, fine sandy clay loams surround these. Hardpan or, in places saprolite, occurs at 0.15–0.2 m. On the mid to lower eastern slopes, pisolitic gravel occurs in the red, acidic, sandy, clay loams. The soils on the eastern wash-plain are similar to those to the west but small amounts of khaki pisolitic gravel occur and the soils are slightly more clayey.

Lag

Near Laverton an uncemented desert armour of semi-residual stony lag commonly overlies mafic rocks. It consists of a variety of rock fragments including ferruginous nodules, less abundant pieces of ferruginous saprolite, pisoliths of lateritic duricrust and

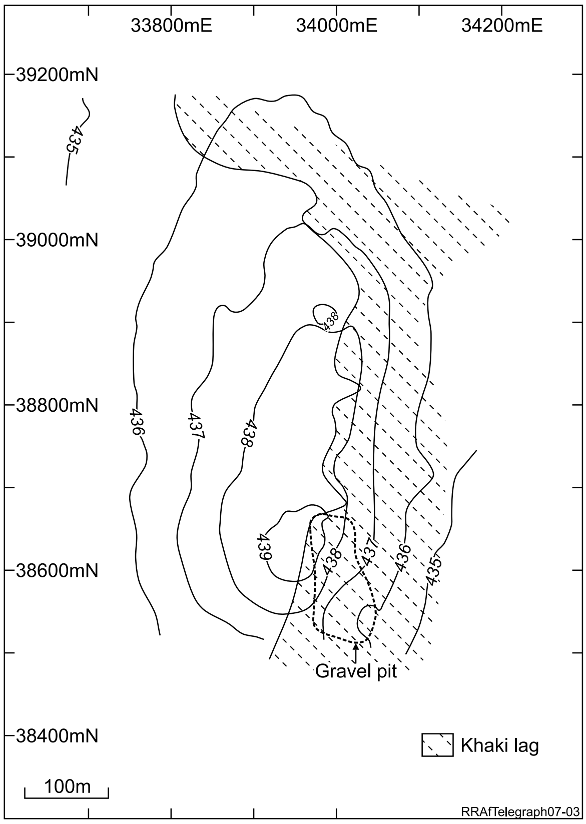

Figure 7. Distribution of khaki lag over the Beasley Creek gold mine.

varying proportions of white vein quartz. The black, ferruginous nodules are dominant and are mostly sub-round, although some are angular. Surface textures vary from glazed by desert varnish to mat or desert polished and some show dreikanter form.

On the hill, the size distribution of the lag is variable, consisting of varying proportions of fine (<10 mm) and coarse (10–50 mm) lag. In places, the distribution is strongly bimodal, with one size fraction dominating, due to concentration or removal by sheetwash. In other places, the lag has a more continuous size distribution where there has been less sorting by sheetwash. The fine lag tends to be granular and subround and the coarse lag subround to subangular and lithic. The coarse, pebbly fraction is best developed near the crest of the hill where the lag is generally black to blue-black. Fragments exceeding 50 mm (cobbles) are common and fragments of ironstone abound.

Fine lag dominates the lower slopes of the northwest and west of the Beasley Creek hill. On the slope to the east of the mineralisation, which is underlain by lateritic duricrust, ubiquitous black to dark brown nodular material is generally dominant but is accompanied by a lesser amount of khaki lag and red–brown lag that appears to be derived from the underlying lateritic duricrust (Figure 7). Both the coarse and the fine lag fractions here show these varieties. Fine polymictic lag dominates the wash plains.

Lag fabrics have been used to identify the underlying rocks (Robertson, 1989; 1995) identifying mafic-ultramafic rocks, shale and tillite. Using lag as a geochemical sampling medium in the residual-erosional areas gave clear indications of the

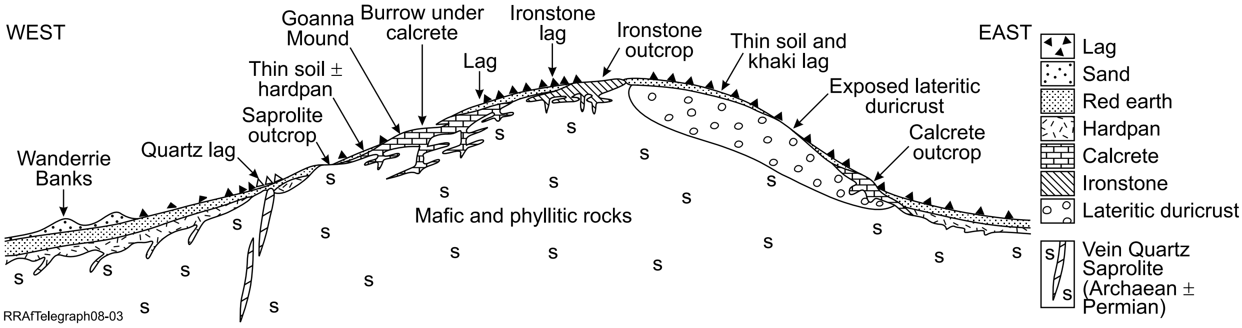

Figure 8. Sketch cross section showing regolith relationships at Beasley Creek.

mineralisation beneath.

Opaque, white, vein quartz lag is dispersed around small outcropping quartz veins on the northwest of the hill. It is a significant component of the lag on the wash plains but it makes little contribution to the lag overlying lateritic duricrust on the eastern hill flank.

DATING

Carbonaceous material from a deep channel of fluvioglacial sediments underlying Skull Creek has been dated as Permian by palynology (J. Hronsky, WMC, verbal communication, April 1996).

REGOLITH EVOLUTION

During the Permian, or before, channels were eroded into fresh basement rocks and fluvioglacial sediments were deposited, some attaining thicknesses of 80 m. Much of the detritus was unweathered. Later, the upper 40 m of the basement and the Permian sediments were deeply weathered during a humid phase to saprolites, a mottled zone and duricrust. Although weathering penetrated particularly deeply in sulphide-rich lithologies, some of the sediments in the deeper parts of the Permian channels remain sufficiently unweathered to allow pollen dating.

During a subsequent arid phase, erosion and regolith stripping occurred accompanied by sedimentation on the wash plains. The hill at Beasley Creek is asymmetric, being steeper on the eastern flank. The steeper slope is preserved by hard lateritic duricrust and appears to be maintained by more active erosion at the foot of the hill, by run-off from the gently undulating terrain to the east. Lateritic duricrust, calcrete and surficial ironstone protected the crest of the hill. The western part has been stripped more deeply. Products of this erosion were deposited on the alluvial plains surrounding the hill.

The occurrence of calcrete seems related to the shallow depth to saprolite at the top of the hill and to a mafic lithology. The Beasley Creek site is in keeping with regoliths elsewhere in the northeastern Goldfields in which hardpan is abundant. Both the hardpan (silicification) and the calcrete (calcification) developed during arid conditions.

The regolith at Beasley Creek has been partly stripped (Figure 8). This is indicated by the absence of a lateritic duricrust over all but the eastern flank of the hill. The extent of stripping is probably more severe at Telegraph, where there is no lateritic duricrust and only a mottled zone is preserved. Much of the saprolite at Telegraph is overlain by several metres of recent colluvial-alluvial sediments (and in places by patches of Permian glacial tills, now saprolite). This contrasts with Beasley Creek, which is overlain by only a few tens of millimetres of colluvial material. Saprolitic Permian sediments only overlap the eastern margin of the orebody.

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