MOUNT MORGAN – BILOELA BASIN DISTRICT, QUEENSLAND

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INTRODUCTION

Mount Morgan is one of Queensland's most significant historical gold and copper mines. Landscape evolution played an important role in making the deposit accessible to 1860s explorers. Erosion exposed the Mount Morgan deposit from beneath a cap of siltstone, and also enabled the dispersion of alluvial gold from it and other nearby sources into the upper catchment of the Dee River (Dunstan, 1904; Jones, 2000b; Figure 1). Landscape evolution in the erosional environment at Mount Morgan can be considered in conjunction with the largely depositional environment of the adjacent Biloela Basin to the west.

THE MOUNT MORGAN GOLD DEPOSIT

Mount Morgan produced more than 230 t of gold and 350 000 t of copper during its almost 100 year history, and has been interpreted both as a massive replacement deposit (Cornelius, 1969; Arnold and Sillitoe, 1989) and as a volcanic-hosted massive sulphide deposit (Taube, 1986; Large, 1992). At the time of its discovery, the exposed part of the deposit was located near the top of Ironstone Mountain (later re-named Mount Morgan), which consisted of Devonian volcanic host rocks with a cap of Jurassic sandstone and siltstone (Precipice Sandstone). A gossan was present at the top of the volcanic rocks. Following a visit to Mount Morgan, Jack (1884) described the early mine exposure:

> "The central portion of the upper cutting (exposing the gossan) is a large mass of brown haematite ironstone, generally in great blocks (up to some tons in weight) with a stalactitic structure ... contain(ing) gold of extraordinary fineness ... The ironstone is more or less mixed with fine siliceous granules."

The gossan formed prior to the Jurassic, and was subsequently concealed by deposition of the siltstone. Later erosion re-exposed the gossan as a circular outcrop beneath the crest of Mount Morgan (A. Taube, pers. comm.).

REGIONAL PHYSIOGRAPHY AND GEOLOGY

Mount Morgan lies in the Dee Range, which runs in a SE–NW direction and separates the coastal plains to the east from the interior plains to the west (Figure 1). Along the eastern margin of the Dee Range is a prominent escarpment that overlooks the coastal plains. The range consists of Devonian to Permian volcanic and sedimentary rocks, and intrusions of Permo-Triassic granodiorite, tonalite and gabbro. Along the western edge of the range is a prominent alluvial corridor that extends southeast for 130 km from the Fitzroy River near Gogango to the upper reaches of Callide Creek (Figures 1, 2). This region is the Biloela Basin, which received most of its sediments during the Tertiary. The western margin of the basin is marked by the Gogango

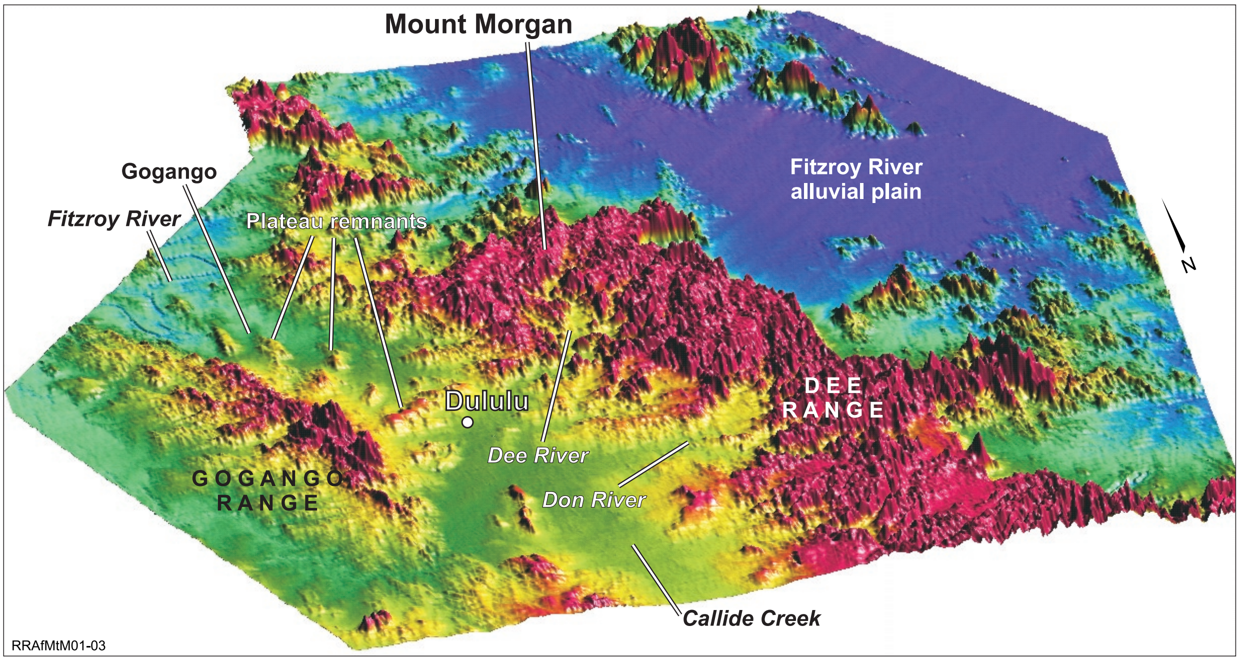

Figure 1. 3D view to the north-northeast of the Dululu district covering the area from 23° 15' - 24°15' S and 149° 45' - 151° 00' E. The central mountainous area (Dee Range) contains the Mount Morgan gold and copper deposit. The Dee River flows southwest from Mount Morgan through a narrow valley and enters a flat-lying alluvial plain at the surface of the Biloela Basin near Dululu. The plain receives sediments from the Dee and Don rivers in the north and east, and Callide Creek in the south. Tertiary sandstone and mudstone are present as plateau remnants (mesas) across the surface of the Biloela Basin. Fine iron-stained regolith is present on these landforms. The southern edge of the image is approximately 125 km across.

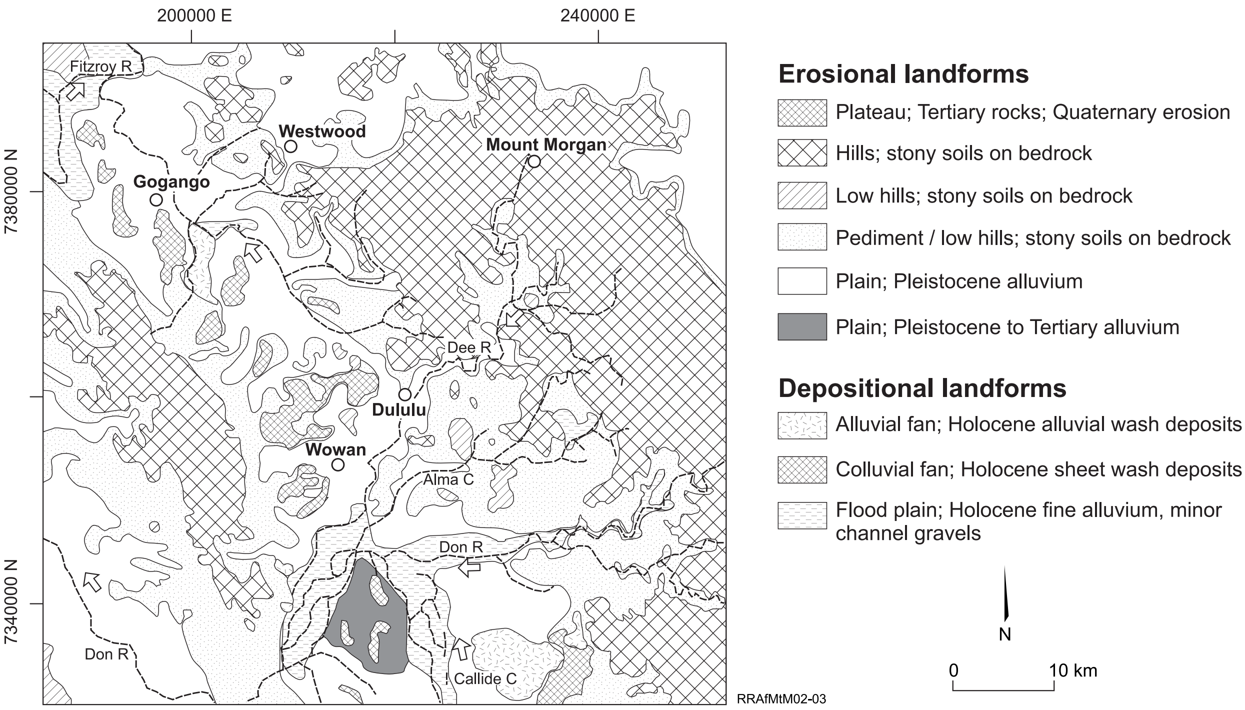

Figure 2. Landforms and regolith in the Biloela Basin region. Arrows show drainage directions.

Range, composed of deformed Permian rocks of the Back Creek Group (previously known as the Rannes beds) and the Camboon Volcanics.

Meteorological records for Biloela, situated 65 km south of Dululu show that the climate is subtropical, with an annual rainfall of approximately 680 mm. The rain falls throughout the year, although highest falls are typically recorded in summer (Bureau of Meteorology).

The Biloela Basin sediments were supplied chiefly by streams which drained the western side of the Dee Range. Stratigraphic drilling on Callide Creek (Figure 1) identified 335 m of Tertiary continental sediments below 27 m of Quaternary cover (Noon, 1982). The Tertiary rocks include mudstone, siltstone, minor sand and gravel, and some oil shale and lignite. Basalt was intersected at the base of the hole at 374 m. Previous drilling for groundwater in the central and southern part of the Biloela Basin (Pearce, 1971) intersected mostly clays, mudstones, and organic-rich deposits over basement at depths up to 250 m. A similar sequence occurs in the neighbouring Duaringa Basin situated to the west of the Gogango Range (Malone *et al*., 1969). An alluvial to lacustrine environment of deposition is inferred for both basins.

The general lack of sand and gravel sequences in the Biloela Basin is notable. This may be related to the source areas providing only fine-grained deposits. However, a more likely scenario is that the streams entering the basin deposited most of their coarse sediment load at the change of slope at the basin edge. Hence, there may be a time-transgressive alluvial sequence of coarse sand and gravel concealed in buried valleys around the margin of the basin. The fine deposits observed in the drill-holes are typical of the central basin and result from mainly suspended sediment transport across a flat landscape. Coarse sand and gravel supplied from the east may not have been transported beyond the Biloela Basin.

Other Tertiary rocks in the region give an indication of the maximum elevation of the accretionary surface at the top of the Biloela Basin. Plateau remnants (mesas) of Tertiary mudstone and sandstone are scattered along the basin (Figure 1, 2). The elevation of the tops of the mesas declines from about 260–240 m AHD in the south, to about 140 m AHD in the north near Gogango. The Dee Range is free of Tertiary deposits, except for a small area 10 km southeast of Mount Morgan (not shown on Figure 2).

HOLOCENE DRAINAGE

Dee River

The Dee River has eroded a V-shaped valley along its course to the southwest of Mount Morgan (Figure 1). For 30 km downstream from Mount Morgan, the confined valley has little potential for retaining alluvial deposits. Those that are present are likely to be young deposits, in transit to depositional areas further downstream.

The Dee River emerges from the hills of the Dee Range about 12 km upstream from Dululu, and enters an extensive flat-lying alluvial plain at the margin of the Biloela Basin (Figures 1, 2). At present, the Dee River occupies a narrow channel extending to the southwest, part way across a flat alluvial plain. Further across the plain, the stream becomes less distinct as it forms a series of divergent shallow channels and waterholes. The Don River from the east and Callide Creek from the south also cross the plain within the confines of a Holocene flood corridor. The channels of all three streams merge to form the Don River as they pass through the low saddle at the southern end of the Gogango Range (Figures 1, 2).

Don River

The Don River also has a bedrock-confined catchment in the ranges to the east of the Biloela Basin. In upstream areas, the history of the Don River has been dominated by downcutting to form narrow V-shaped valleys. Flat-topped ridges between some valleys are remnants of a palaeo-surface. Downcutting has proceeded further in other valleys where neighbouring catchments are separated by sharp crested ridges below the level of the palaeo-surface.

Callide Creek

Callide Creek has developed a drainage network of shallow channels and billabongs across the flat-lying surface of the alluvial plain. Deposition during the Holocene has been confined to a broad flood plain along the centre of the Biloela Basin.

Fitzroy River

The Fitzroy River crosses the northwestern corner of the study area (Figure 1), where a number of palaeochannels are present. These channels formed during Holocene episodes of progressive meander development, interspersed with interludes of comparatively rapid channel realignment. The palaeochannels are closely associated with the modern Fitzroy River channel and record a detailed sequence of progressive channel movement and re-alignment.

REGOLITH–LANDSCAPE EVOLUTION

During the Tertiary and Pleistocene, the general drainage patterns were probably similar to those during the Holocene. Although the streams may have been less incised in their upper catchments, their locations were probably very similar to that those present. The depositional/erosional environment of the Biloela Basin was dependent on the relationship between incoming sediments from the east and south, and outgoing sediments to the west and north. When sediment input dominated, the basin accreted; when sediment output dominated, the basin eroded. Recent erosion has lowered the surface by over 120 m, indicated by the preservation of mesas of Tertiary rocks in the Basin. Evidence of other erosional interludes is provided by mottled and multi-coloured clay layers recorded in groundwater drilling (Pearce, 1971). The mottling is interpreted as relating to near-surface weathering during erosional episodes.

During accretionary episodes, the boundary between net erosion and deposition migrated back up the valleys into the hills. During erosional episodes, the store of sediment around the fringes of the basin was re-mobilised as the lower parts of the valleys along the base of the ranges were exhumed. The erosion probably commenced downstream and migrated back up the valleys as re-invigorated streams incised alluvial deposits.

The regional landforms and regolith map (Figure 2) is based on interpretations of TM imagery, digital elevation data, aerial photography, 1:100 000 topographic maps and field exposures. The interpretations are made within a conceptual framework of landscape evolution that envisages a long-term progression from an elevated landform to one at low levels on the landscape, beginning with mountains (elevation >300 m), evolving to hills, then pediments, and eventually to a valley floor or plain (mountains →hills → pediments → plains (erosional) → plains (depositional)).

Based on field visits and the study of landforms, the main process driving landscape evolution appears to have been scarp retreat initiated by stream incision. Accordingly, mountains are surrounded by hills, which in turn are surrounded by pediments, which border the plains. This evolutionary sequence of landforms can be seen across the Dee Range and into the Biloela Basin (Figure 3).

A variation of this regional style of landscape evolution is mountains → hills → plateaux → low hills and pediments → plains (erosional) → plains (depositional). In this case, differential erosion may produce both low hills and pediments bordering the plains. In general, all the landforms are erosional except for the plains, where deposition may dominate. Even here, erosional episodes occur from time to time, and large areas of erosional plains are present in the Biloela Basin (Figure 2).

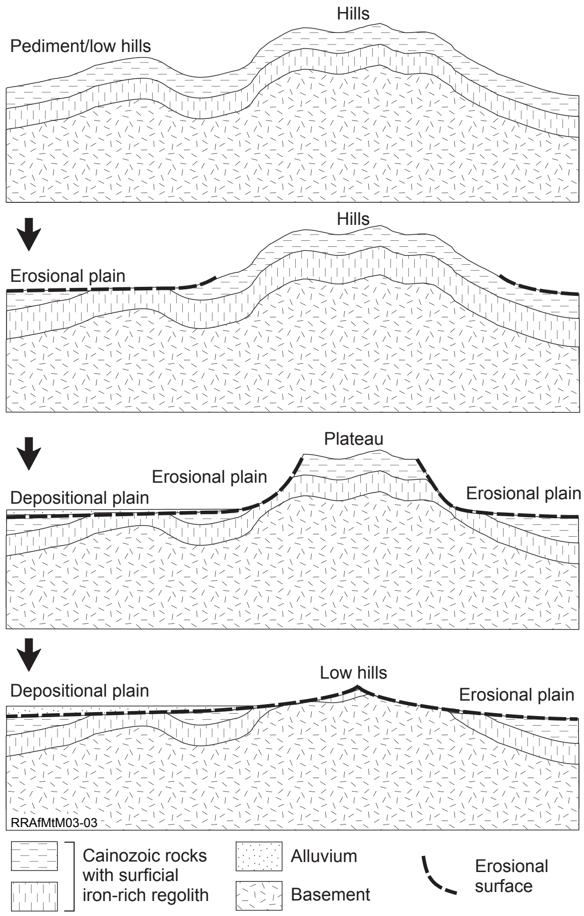

Figure 3. Scarp retreat model of landscape evolution in the Biloela Basin.

Hills are not the only primary elevated landform, as stream incision and differential erosion on a regional scale has produced elevated parts of the landscape by lowering intervening areas. Rather than being hills, these elevated residual areas are plateaux or mesas, and commonly have flat or gently undulating upper surfaces representing ancient land surfaces. Plateaux typically evolve through scarp retreat, which continues until the scarps from opposite sides meet at a boundary ridge. With further erosion, the boundary ridge is gradually lowered to the level of the surrounding landscape. Hence, a plateau can evolve through a series of landforms (basinal plain → plateaux → mesas → boundary ridges (or hills) along catchment divides → low hills → pediments → erosional plains).

Digital elevation data can be used to model the effect of the former high level of accumulation in the Biloela Basin (Figure 4). When the upper surface of the Biloela Basin was approximately 120 m above its present elevation, it merged with adjacent basins to form an extended regional plain across the interior of central Queensland. At this time (Tertiary), the central parts of the Dee and Gogango Ranges were still present as hills overlooking extensive plains. The valleys of the Dee River and other streams draining westwards from the Dee Range were back-filled with alluvium (Figure 4A). However, most of the areas of mineralisation known today would have been at or near outcrop in the ranges, or perhaps partially covered by sediments of the Surat Basin.

On the western side of the Gogango Range, the Dawson River and its tributary the Don River flowed northwards to join the Mackenzie and Fitzroy rivers northeast of Duaringa. In the vicinity of Duaringa and to the south along the western side of the Dawson River are extensive plateaux similar to the iron-stained remnants in the Biloela Basin. These "tablelands" are typically between 60 and 120 m high and are "lateritised" at the surface (Malone *et al*., 1969). Small thicknesses of oil shales have been identified in the sequence (Swarbrick, 1974), similar to the Biloela Basin (Noon, 1982). Hence filling of the Biloela Basin was part of a regional aggradation episode and was not solely restricted to sedimentation along the Callide-Dululu-Gogango corridor. The iron-staining of the rocks forming the mesas presumably occurred during the late Cenozoic.

From the regional distribution of landforms, it is inferred that there was a widespread change from accretion to erosion during the Tertiary and Quaternary. Landscape evolution then proceeded by stream incision, which provided the catalyst for lateral erosion by scarp retreat, a process that commenced downstream and migrated back up the valleys. The upper catchments in the ranges contained large volumes of sediments when the erosional episode commenced. These areas probably only began to empty of sediments when the new phase of stream incision and erosion extended back across the plains and up into the hills. During this erosional phase, large areas of the bedrock substructure of the Dee Range were re-exposed (Figure 4B).

The change from accretion to erosion in the Tertiary probably commenced when:

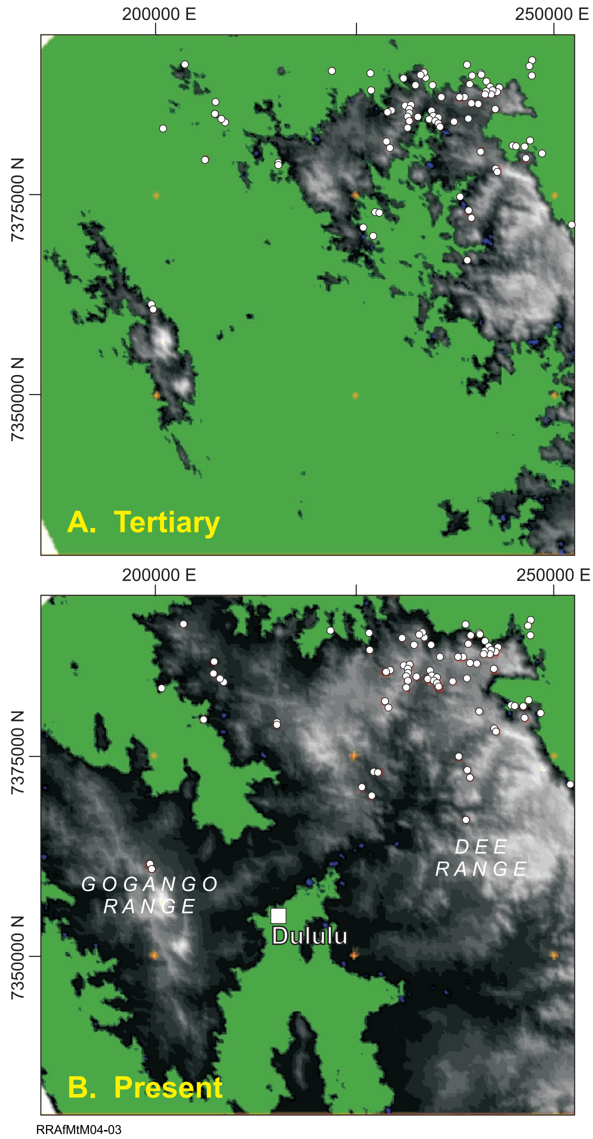

Figure 4. Model of the extent of the Biloela and surrounding basins during the Tertiary and present based on digital elevation data (Department of Mines & Energy). The green (light grey) area represents the extent of alluvial deposition during (A) the Tertiary, based the elevation of the tops of mesas of Tertiary rocks in the Biloela Basin (270 m); and (B) the present based on the current valley floor (150 m). The area of highlands (grey to black) is based on present day landforms, and understates their extent in the Tertiary, as no account is taken of erosion that has occurred during the time period depicted. Note that mineral prospects, shown as white dots, are mostly located in elevated areas beyond the extent of Cenozoic deposits.

1. The upper catchment supply rate diminished. This would have occurred gradually as the expanding basins encroached upon the supply areas in the ranges. Supply from the highlands may also have been exhausted as erosion stripped the readily removable regolith.
2. The capacity for sediment removal increased downstream. This was probably connected with activity of the Fitzroy River. It is proposed that the coastal Fitzroy River expanded its catchment into the interior through stream capture. The river provided an efficient means to erode the sediments stored on the western plains, and transport them to the

coast. An erosional phase such as this would have expanded westwards through the newly captured catchments, and eventually swept across the Biloela Basin. The erosional episode continued through the Quaternary, removing large quantities of Tertiary alluvial sediments and causing a regional lowering of the interior landscape. Based on the elevations of the mesas, more than 120 m of mainly Tertiary deposits were eroded from the Fitzroy catchment west of the coastal ranges.

Stream downcutting and scarp retreat produced extensive areas of tablelands, plateaux and mesas. Erosion in these areas continues around the perimeter scarps, but large areas on the tops of the tablelands have not been severely affected. These remnants of the former landscape are seen today in the Biloela Basin. Sediments eroded from the Duaringa and Biloela Basins in the Fitzroy River catchment contributed to filling the Casuarina Basin in the lower reaches of the Fitzroy River, and the Capricorn Basin situated offshore (Day *et al*., 1983).

The zone of coarse fraction deposition at stream entry points along the western side of the Dee Range would have prograded and retreated in concert with erosional and depositional episodes affecting the Biloela Basin as a whole. There may not have been much mixing of the coarse alluvial sediments from the main contributing streams. Therefore, it would be expected that the most prospective areas for alluvial gold are to be found within or immediately in front of the lower part of the Dee Valley where the bedrock confining walls were no longer effective in restricting sediment accumulation (Jones, 2000a, b). The timing of gold-rich alluvial deposition from the Mount Morgan area is important in terms of the depositional/erosional history of the Biloela Basin, and the likelihood that any such deposits may be preserved.

CONCLUSIONS

The Biloela Basin received mainly fine-grained sediments from the Dee Range in the Tertiary. The depositional environment consisted of swamps, lagoons, and low-lying alluvial plains. Most of the coarse-grained deposits are likely to underlie the eastern edge of the basin where streams emerge from the ranges. These deposits are likely to occur as fans and channel bed sequences.

In the Dee Range at Mount Morgan, erosion of the Precipice Sandstone during the Tertiary exposed the gossan of the Mount Morgan gold and copper deposit. Most of the ore body was preserved due to the cap of Jurassic siltstone. However, some gold was probably released from Mount Morgan and other sources in the upper catchment, and transported along the Dee River. Some of the alluvial gold may have been deposited in the Biloela Basin in the late Tertiary to Quaternary.

Subsequent erosion of the uppermost 150–200 m in the Biloela Basin may have been instigated by the expansion of the catchment of the Fitzroy River through stream capture. This episode may not have removed all alluvial gold deposits derived from the upper catchment of the Dee River.

Erosion of the upper catchments in the Dee Ranges has been continuous since at least the Tertiary. Stream incision and scarp retreat have been the main erosional mechanisms.

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