REGOLITH-LANDFORM EVOLUTION ON CAPE YORK PENINSULA: IMPLICATIONS FOR MINERAL EXPLORATION

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A number of landform features on Cape York Peninsula (CYP) contain important clues for the development of landforms and regolith in the area The Great Escarpment, up to 200 m high, separates old landforms and regolith on the western side from younger landforms and regolith on the eastern side West of the Great Escarpment there are smaller less continuous scarps which also form important boundaries between different regolith types There is clear evidence for superimposed drainage, river capture and reversal, and inversion of relief on CYP

Formation of the Carpentaria and Laura Basins during Middle to Late Jurassic and Early Cretaceous time covered the Palaeozoic and Proterozoic rocks of the Coen Inlier with coarse terrestrial to fine marine sediment The uplift and emergence of these basin sediments in the Late Cretaceous marks the beginning of the latest stage of landform and regolith evolution on CYP The sediments probably covered most, if not all, of the Coen Inlier, and post-Mesozoic erosion subsequently uncovered the basement to form the Inlier

Substantial erosion and surface lowering in the area followed emergence at the end of the Cretaceous, leaving the basement rocks high in the landscape The breakup of the north eastern part of the Australian continent and the opening of the Coral Sea had a profound effect on landforms on CYP Down warping to the east formed the Great Divide and resulted in drainage modifications and the formation of the Great Escarpment Subsequent retreat of the Great Escarpment formed the lowlands to the east

West of the Coen Inlier, on plains formed on Mesozoic sediments, there was post-Mesozoic erosion of several tens of metres of material, and inversion of relief Further north, plateaus with a deep bauxitic weathering profile are formed on Rolling Downs Group sediments

A considerable amount of sedimentation took place in the Karumba Basin on the western side of CYP at the same time as the erosion mentioned above

The importance of this evolutionary sequence for mineral exploration is discussed The main finding is that different parts of the landscape have very different histories, and therefore different regolith This in turn means that exploration strategies must be tailored to specific landscape types and positions

Key words: Cape York Peninsula, regolith, landforms, landform evolution, mineral exploration

INTRODUCTION

During regolith landform mapping on Cape York Peninsula (CYP) in the early 1990s it was noted that there was a close correlation between landforms and regolith distribution (Pain *et al* 1995). This relationship was used to map the regolith of the area in the way described by Pain *et al* (1991)

Earlier, Galloway *et al* (1970) reported on the landsystems of the Mitchell river area, and reconnaissance soil maps and reports were produced by Isbell *et al* (1968) and Isbell (1983) Whitehouse (1941) Twidale (1956a, b, c) and Watkins (1967) wrote on the geomorphology of the southern part of CYP, while Nash (1991) considered landform evolution in the Cooktown region Grimes (e g 1979, 1980) discusses land surfaces and regolith in the area, and Grimes & Doutch (1978), Jones *et al* (1988) and Nanson *et al* (1991) consider aspects of the Late Cainozoic evolution of the Carpentaria Plains

The study area is divided into regolith-landform units which were mapped using a combination of 1:80 000 panchromatic aerial photography (1970), 1:50 000 colour aerial photography (1990), Landsat TM image data, airborne magnetic and gamma-ray spectrometric image data, and field work carried out over the period 1990-1994 by the Australian Geological Survey Organisation (AGSO) New data were collected mainly north of 16°S, and this discussion is limited to the area north of this line (Figure 1)

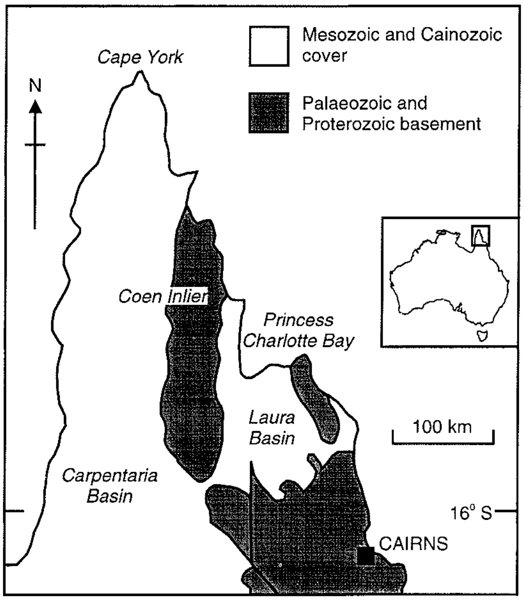

Figure 1: *Location of the study area*

This paper first presents information about the regolith and landforms in the area It then presents a discussion about the evolution of the landscape before commenting briefly on the significance of the results

Table 1 *Landforms and associated regolith types on Cape York Peninsula north of 16°S Colour refers to Figure 2*

LANDFORMS	REGOLITH TYPE	COLOUR
Alluvial plain, flood plain, meander plain, alluvial terraces, stagnant alluvial plain	Alluvial sediments, channel deposits, overbank deposits	Yellow
Beach ridge, chenier plain, coral reef, tidal flat, coastal plain	Coastal sediments, beach sediments, estuarine sediments, coral	Blue
Coastal dunes, dunefield alluvial fans, colluvial fans	Aeolian sediments, aeolian sand Fanglomerate, scree deposits, sheet flow deposits, colluvial sediments	YellowFans, Yellow
Volcanic cones and plains	Saprolite, volcanic ash	Red
Erosional plain, pediment, plateaus, rises, low hills	Residual clay, residual sand, moderately to completely weathered saprolite	Red
Erosional plains	moderately weathered saprolite on marine sediments	Light green
Erosional plains, plateaus	bauxite	Light brown
Hills, escarpments	Soil on bedrock, slightly to moderately weathered saprolite, colluvial sediments, scree deposits	Red

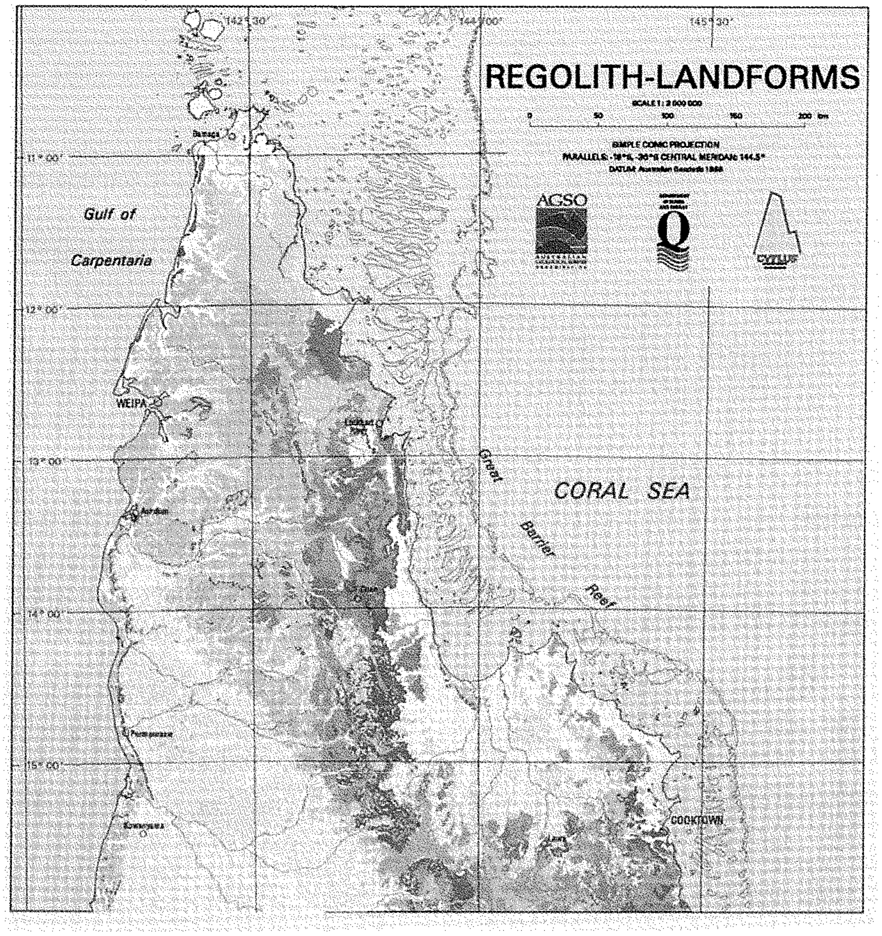

Figure 2: *Regolith map of the study area, reproduced from Bain & Draper (1997), Plate 27 Regolith types are shown according to the colours listed in Table 1*

MAIN LANDFORM AND REGOLITH TYPES

This section briefly presents information about the main regolith types that occur in the area The regolith types are described, and their relationship to landforms and landscape position is noted Some aspects of geomorphic processes are also considered For more information see Pain *et al* (1997)

LANDFORMS AND ASSOCIATED REGOLITH TYPES

Table 1 lists the main landforms and associated regolith types in the study area, while Figure 2 is a simplified regolith map of the area For more details see the 1:1m regolith-landform map of Pain *et al* 1995, and Plate 27 in Bain & Draper (1997) McConachie *et al* (1997) and Blewett *et al* (1997) also discuss regolith and landforms of various parts of the study area

There are a variety of alluvial land forms in the study area Alluvial deposition is responsible for the large fans in the south western part of the area, the somewhat smaller alluvial fans around Princess Charlotte Bay, and the alluvial plains of the Lockhart and Nesbit Rivers Elsewhere, alluvial deposition is not very important, and rivers such as the Archer and the Wenlock are mainly transportational channels, with very little alluvium

Coastal landforms are associated with some important areas of coastal regolith materials in the area Wave-built forms and associated tidal flats and estuaries are important on both sides of the Peninsula, including chenier plains and beach ridges indicating old shore lines Wind blown sand forms important areas of dunes mainly on the east coast

There are a variety of colluvial sediments, including fanglomerate, scree deposits, and sheet flow deposits These deposits are associated with small colluvial fans, and areas of steeper slopes in erosional areas

Areas with low relief such as erosional plains, pediments, plateaus, rises, and low hills, have a variety of regolith covers ranging from residual clay and sand to moderately to completely weathered saprolite and bauxite Shrinking and swelling of soil clays has produced gilgai forms in some places. The residual materials form part of the mobile zone mentioned below

Hills and escarpments, with higher relief and steeper slopes, have slightly to moderately weathered saprolite. This saprolite is usually covered with a mobile zone made up of soil on bedrock, colluvial sediments, and scree deposits.

GEOMORPHIC PROCESSES

The geomorphic processes responsible for sedimentary materials and associated landforms are usually clear However, for in situ regolith materials on erosional landscapes, the responsible geomorphic processes may not be so obvious Never-the-less, we can make some generalisations

Apart from a few areas of steep slopes, rapid mass movement is virtually nonexistent in the study area Most surface movement of regolith material takes place by surface wash, creep, and bioturbation These processes together produce the ubiquitous mobile zone in CYP (For a more detailed discussion of the mobile zone in regolith, see Pain 1998)

Sub-surface solution and removal of material by water movement is important in all landscapes, but evidence for such processes is hard to find. The melon holes (shallow depressions often less than 1 m deep but up to several 100 m wide) that are so abundant in parts of the landscape in the study area are probably a result of sub-surface solution and removal of materials In addition, the various hard pans and duricrusts that are found through the area are clear evidence that at least iron and silica have moved, and probably continue to move, in solution from one part of the landscape to another In this regard, both ferricrete and silcrete are locally very important parts of the regolith (see Pain & Ollier 1992) Another obvious regolith material is the siliceous hardpan, or "creek rock", that is found in many valley floors both in and outside the study area. This hardpan is a result of partial cementing of material by silica It occurs in valley floors beneath and adjacent to channels The cemented material is mainly alluvium, but in smaller channels weathered bedrock adjacent to the channel alluvium is also cemented (Figure 3) It can be quite young; we have a radiocarbon age of 1320 ± 80 years BP (ANU-8129) for charcoal from within hardpan material. The origin of the hardpan seems to lie in the movement of silica in solution to the lowest parts of the landscape during wet seasons, and precipitation of the silica as the valley floors dry up during dry seasons

There is a tendency to assume that silicification, and by implication ferruginisation, is confined in some way to alluvium However, the association between alluvium and siliceous induration is because both are formed by processes that occur in valley floors This is shown by the fact that siliceous and ferruginous induration affect not only alluvium, but any materials, including saprolite, that are found on valley floors Pain & Ollier (1992) give several examples

Colluvial processes occur on most slopes, and are dominated by surface wash. Surface wash is most effective where ground cover is low, and is probably most active in recently burnt areas during the first few rain storms of each wet season Colluvial deposition from surface wash is responsible for a few small areas of colluvial fans and footslopes. Soil creep almost certainly is active on many of the steeper slopes in the area, but evidence for such processes is difficult to observe However, lag deposits on hill slopes south of Coen, for example, are probably derived by creep Evidence for soil flows or land sliding is present on the slopes of the Embley range, where slabs of sandstone have been tilted back against the slope, and low ridges indicate the movement of the upper metre or so of the regolith These colluvial processes, together with bioturbation in the form of tree fall and termite activity, lead to the formation of a disturbed layer, or mobile zone, at the surface of much of the study area.

LANDFORM FEATURES

A number of landform features in the area contain important clues for the development of landforms and regolith in the area These are discussed briefly before a general outline of regolith-landform evolution in the area is presented

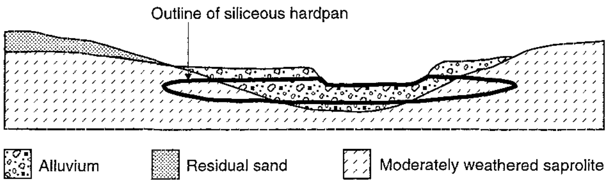

Figure 3: *Diagrammatic section through a valley floor on a tributary of the Holroyd River. Note that the siliceous hardpan occurs in both the alluvium and the adjacent saprolite.*

Scarps

The most important geomorphic boundary in the area is the Great Escarpment (Figures 2, 4 and 5), a feature which, with a few gaps, runs from just south of Cape York all the way to Victoria (Ollier 1982; Ollier & Stevens 1989). As elsewhere, in the study area it separates old landforms and regolith on the western side from younger landforms and regolith on the eastern side. On CYP the Great Escarpment is up to 200 m high. For much of its length it coincides with the Great Divide. Places where the Great Divide is west of the Great Escarpment are often associated with evidence for drainage diversion, for example the Stewart River west of Coen (Figure 6). Elsewhere small streams have been captured. A particularly good example occurs east of the former mining settlement of Ebagoola, where a stream flows for about 5 km north before abruptly turning and plunging over the scarp. The former course is clearly marked by a dry valley. This particular capture must have occurred fairly recently because the stream has not yet eroded a bedrock channel, flowing instead across joint planes in the granite.

West of the Great Escarpment there are smaller less continuous scarps. These erosion breaks occur around the headwaters of some drainage basins, around low cuestas and mesas, and parallel to some streams (Figure 5). Examples are the scarp around the Embley Range, the "jump-up" that marks the eastern boundary of the bauxite area east of Weipa, and the scarp south of Merapah. These erosion breaks separate more active from less active drainage basins. In many cases these scarps also form important boundaries between different regolith types, with generally older regolith materials above and younger materials below.

Drainage

Figure 5 shows drainage patterns on CYP north of the major fans. There are remnants of an original SE-NW drainage pattern still preserved in some places. Post-breakup drainage into the Coral Sea tends to be irregular, while modern drainage into the Gulf of Carpentaria is dendritic in plan. Minor scarps and erosion breaks occur around drainage basins which are currently most active. A number of west-flowing streams, including the Archer, Holroyd and Coleman Rivers, rise within the Coen Inlier near the Great Escarpment at elevations of about 200-250 m and flow in gorges cut through the higher metamorphic ridges (up to 400 m elevation) on the western side of the uplands (Figure 4). The Pascoe and Wenlock Rivers, at the northern end of the Coen Inlier, also rise close to the Great Escarpment on a low relief surface, and then flow through much higher hills (Figure 7). This superimposed drainage indicates inheritance from a higher surface.

The Archer and Wenlock Rivers, together with smaller streams to the north, appear to be antecedent to a slight uplift along the north western side of CYP (Figure 4). The headwater tributaries of these drainage networks all come together before the trunk streams cut through trenches a few tens of metres deep to the Gulf of Carpentaria. The trenches are cut in the so-called Weipa Plateau, which coincides in large part with the area of bauxite (Figure 2). This configuration suggests that the Weipa Plateau was uplifted after the main drainage lines had been established.

The Pascoe River is a good example of a river that has been disrupted either by capture or, more likely, reversal. After flowing north west for some distance, it turns first to the north and then to the east, to flow into the sea north of Portland Roads. There is a very clear former river coarse, now dry, above the Pascoe River where it turns north (Figure 5). It seems clear that the northwesterly-flowing headwaters of the Pascoe River once flowed into the Wenlock River, and that a southwesterly tributary was reversed, to lead the whole drainage system into the Coral Sea. Another obvious disruption of drainage is the Stewart River. The headwaters of the Stewart were once part of the westerly flowing Holroyd drainage system. Their diversion into the Stewart is indicated by an abrupt change of channel direction near where the Stewart flows in rapids over the Great Escarpment (Figure 6). This diversion is also indicated by the presence of high level gravels at this bend and by low, poorly drained areas on and west of the Great Divide at the present headwaters of the Holroyd River.

Clear evidence for inversion of relief can be found in a number of places in the area. At one extreme, this evidence consists of narrow sinuous ridges with a capping of silcreted quartz alluvial gravels. On one of these ridges, between Strathburn and Strathhaven, the central depression of the palaeo-valley floor is still preserved. At the other extreme, active stream channels occupy narrow linear mesas surrounded by erosion breaks. A good example is found west of the Strathburn fault scarp, and north of the Coleman River. Another is east of Merapah, where an active channel tributary to the Archer River becomes separated from the surrounding streams by low scarps in its upstream reaches. Further upstream it becomes a series of ponds on a narrow mesa (Figure 8). Thus one channel moves from normal to inverted (Pain & Ollier 1995).

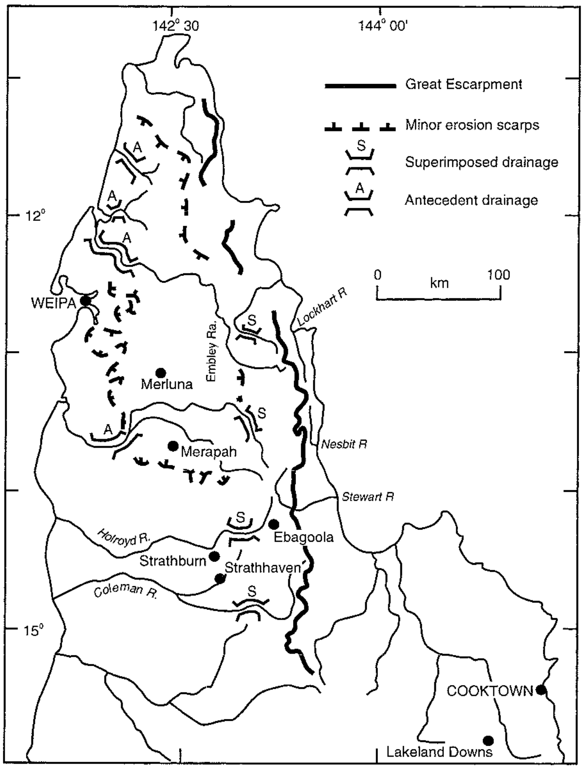

Figure 4: *Main rivers, scarps, antecedent and superimposed drainage on CYP.*

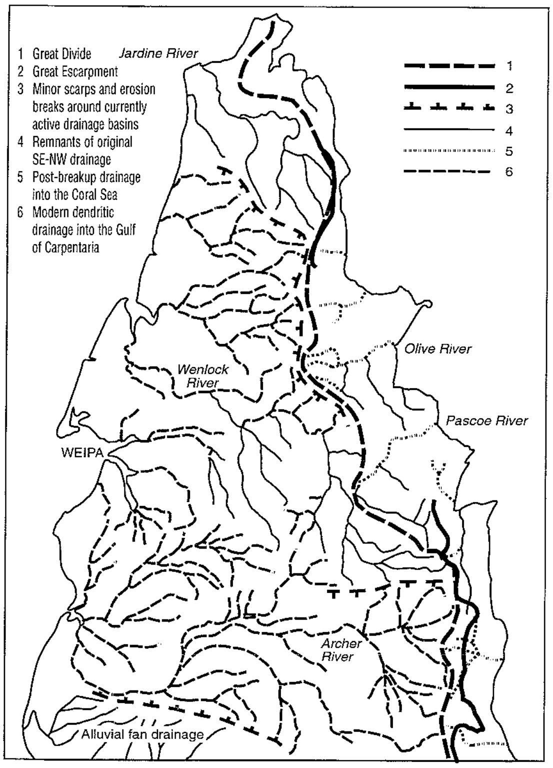

Figure 5: *Drainage patterns on CYP north of the major fans.*

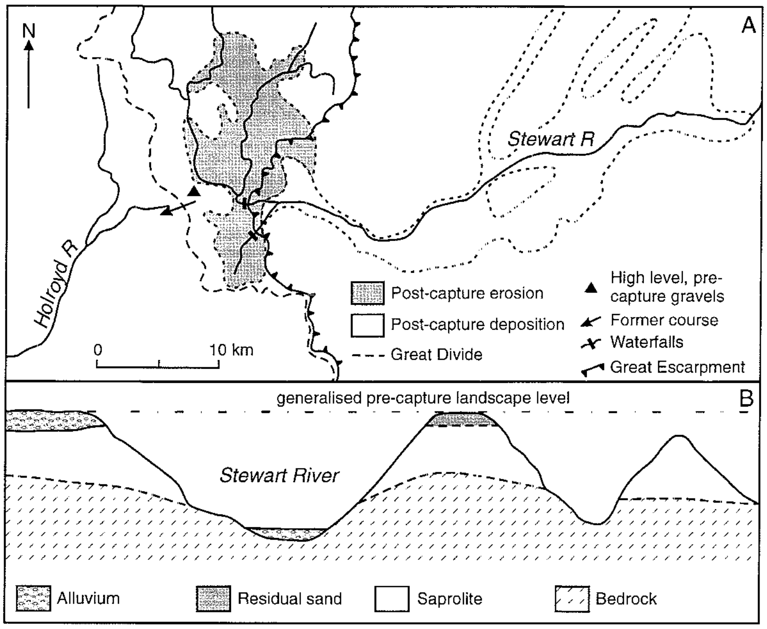

Figure 6: *The Stewart River drainage diversion.*

A - Simplified extract from the EBAGOOLA 1 250 000 regolith landform maps (Pain et al. 1994) showing the Stewart and Holroyd Rivers, the location of river diversion, and the areas affected by the capture, both upstream and downstream.

B - Diagrammatic cross section showing the pre-capture level of the landscape and the former Holroyd River, and the present regolith distribution in the vicinity of the capture.

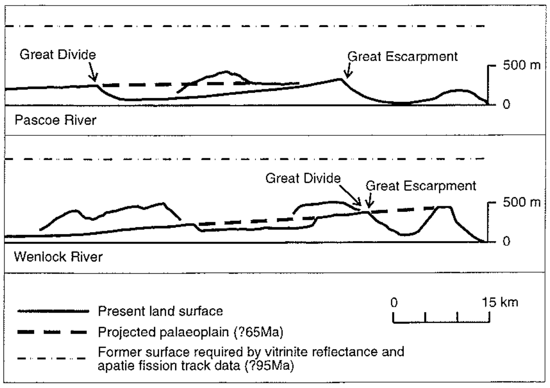

Figure 7: *Sections near the Pascoe and Wenlock Rivers. The former (?95Ma) surface is derived from data in Webb et al (1996). Both the Pascoe and Wenlock Rivers flow through high ground downstream from their headwaters.*

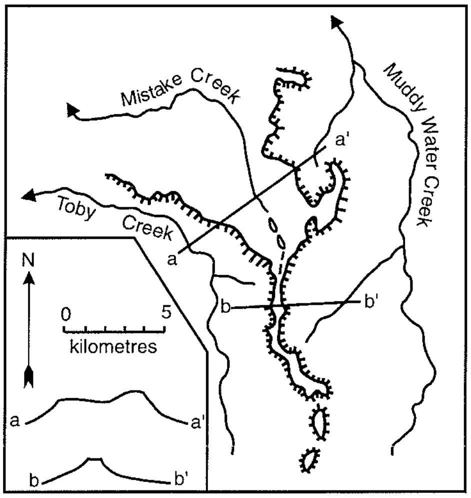

Figure 8: *An example of inversion of relief south of the Archer River (from Pain and Ollier 1995). Moving upstream, the active channel of Mistake Creek first becomes inactive, and then passes into a chain of depressions. This in turn passes to a narrow plateau, and then a series of small mesas. In their lower reaches, Muddy Water, Mistake and Toby Creeks are all active, and part of the same "land surface". However, Mistake Creek becomes separated by a scarp from the other two in its upper reaches, and if only this part of its catchment were studied, it would appear to be on an older land surface than the other two streams. In reality, this anomalous situation is a result of inversion of relief.*

REGOLITH-LANDFORM EVOLUTION

PRE-MESOZOIC AND EARLY MESOZOIC LANDFORMS

Prior to inundation of the area in the Middle to Late Jurassic and Early Cretaceous, at least part of the area would have been land. Surfaces formed during this time may still be present in the landscape as exhumed surfaces, although they have certainly undergone considerable modification during the late Cretaceous and Cainozoic.

MESOZOIC SEDIMENTATION AND UPLIFT

Formation of the Carpentaria and Laura Basins during Middle to Late Jurassic and Early Cretaceous time (Smart *et al.* 1980; McConachie *et al.* 1997), covered the Palaeozoic and Proterozoic rocks of the Coen Inlier with a veneer of coarse terrestrial to fine marine sediment (Blewett *et al.* 1992: McConachie *et al.* 1997). When deposition stopped about 95 Ma, the two basins probably covered a much larger area than they do today, and the sediments may have covered most, if not all, of the Coen Inlier. There are 3 lines of evidence consistent with this interpretation. First, the marine basin sediments adjacent to the basement inliers are all deep-water in origin, and there is no indication of shallow marine or near shore sediments that would be expected if the Coen Inlier was a basement island in the Cretaceous sea (McConachie *et al.* 1997). Second the superimposed drainage already described for the area indicates a former higher surface over the area. Third, vitrinite reflectance and apatite fission track data reported by Webb *et al.* (1997) are consistent with at least 1.5 km of denudation over the Laura Basin in the late Cretaceous, up to about 80Ma.

Deposition probably ceased as a result of uplift of the area. This uplift may have been greater in the east than in the west, as evidenced by the fact that the highest parts of the area are found on the eastern margin of CYP.

POST MESOZOIC REGIONAL TECTONICS AND EROSION.

The Mesozoic Carpentaria Basin was subsequently cut by Tertiary or younger N- to NNW-trending faults. Regional uplift of the inlier and modest down-warping of the Carpentaria Basin would appear to be the primary driving forces behind regional erosion and aggradation.

The emergence of the Mesozoic basin sediments in the Late Cretaceous marks the beginning of the latest stage of landform and regolith evolution in the study area. Substantial erosion and surface lowering in the area following emergence at the end of the Cretaceous is evidenced by the landform features described above. Superimposition of drainage reflects an early drainage pattern inherited from the post-Palaeozoic cover.

Erosion following emergence left the basement rocks high in the landscape, forming the uplands of the Coen Inlier Initial drainage directions were to the west and north west from a divide east of the present Great Divide Indeed, it is likely that rivers at that time, before continental breakup, had their headwaters east of the present coastline, because the continental edge was then much further to the east

The breakup of the north eastern part of the Australian continent and the opening of the Coral Sea had a profound effect on landforms on CYP. Such effects are well known from studies of a number of passive continental margins (e g. Ollier 1985; Ollier & Pain 1997), and many have their origins in pre-separation rifting In the study area, separation began with tectonism which created rift grabens in the troughs east of the present land area (Mutter & Karner 1980, see also Ollier & Stevens 1989) Sea floor spreading occurred from about 65Ma (Wellman *et al*, 1997). Major geomorphic affects probably began at this time Down warping to the east of the peninsula formed the present Great Divide, which runs from north to south along the eastern edge of the Coen inlier, as well as to the north and south.

This down warping had two major results

First, the head-water streams of the formerly west flowing rivers were reversed, to flow towards the newly formed depression and then ocean to the east The Stewart and Pascoe Rivers are good examples of this Some of the sediment supply to the lower reaches of major rivers such as the Holroyd was cut off, and this may have resulted in some down cutting along their valleys This down-cutting appears to have initiated small scarps along some rivers within the Coen Inlier These scarps have subsequently retreated up to 10 km from their place of initiation. The low scarp between Ebagoola and the Holroyd River is a good example.

Second, the new easterly flowing steams were steeper than those flowing to the west, and increased energy and resulting erosion in both the river channels and on adjacent hill slopes led to the formation of the Great Escarpment. Subsequent retreat of the Great Escarpment formed the lowlands to the east, some of which are now covered with a thin (10 m) layer of alluvium Scarp retreat has also caused river capture in a few places

West of the Coen Inlier, on erosional plains formed on Mesozoic sediments, there is clear evidence for erosion of at least several tens of metres of material, and inversion of relief Valley floor materials, both alluvium and adjacent weathered bedrock, were cemented by silica to form silcrete Subsequent erosion has left this very resistant silcrete as a cap on the higher parts of the landscape The best examples are between Strathburn and Strathhaven homesteads, where long narrow sinuous ridges with a central depression mark former stream courses These remnants have resulted from scarp retreat initiated along rivers such as the Coleman and the Holroyd. Further north, both west and east of Pretender Creek, plateaus with a deep bauxitic weathering profile on Rolling Downs Group sediments provide further evidence of the retreat of low scarps across the landscape. This picture is continued on both sides of the Archer River, near Merapah and Merluna

CAINOZOIC SEDIMENTATION AND VOLCANIC ACTIVITY

Although Mesozoic deposition in the Carpentaria and Laura Basins stopped about 95 Ma, and there has been land exposed in the study area since that time, the oldest sediments in the overlying Karumba and Kalpowar Basins are probably Late Oligocene to Early Miocene in age (McConachie *et al* 1997)

The sediments of the Karumba Basin, west of the Coen inlier, contains three fluvial sequences (the Bulimba Formation, Wyaaba Beds and Claraville Beds) and a number of coastal units consisting of beach, lagoon and beach ridge materials Details are provided by McConachie *et al* (1997) The three fluvial sequences have distinctive surface patterns that show up clearly on Landsat TM imagery. They have been described in some detail by Grimes (1979) and Grimes & Doutch (1978), who attribute their evolution to three cycles of stability followed by instability. However, it is likely that the action of internal thresholds of fan development have also been important in their development.

There are Cainozoic volcanic cones and lava flows in the Cooktown and Lakeland Downs areas The youngest igneous event recorded in the area was extrusion of the Silver Plains Nephelinite (3 72 ± 0 06 Ma - Sutherland 1991) This small lava mound had very little effect except for local drainage diversion.

There are thus a wide variety of different kinds of surfaces, with different ages and stability

GAMMA-RAY SPECTROMETRIC IMAGERY

Gamma-ray imagery over the Ebagoola, Hann River, Walsh and Red River 1: 250 000 map sheets area was useful in mapping regolith materials and understanding geomorphic processes. A gamma-ray image is a geochemical map showing the distribution of radio-elements K, Th and U in rocks and regolith. Gamma-rays emanating from the surface can be separated into primary and secondary sources. Primary sources relate to the geochemistry and mineralogy of bedrock. Secondary sources relate to changes or modification of radio-element distribution due to weathering and pedogenesis. The modification of radionuclides by weathering and geomorphic processes are complex (Wilford *et al* 1997). In general Th and U are associated with silt/clay fraction and sesquioxides in soils and tend to concentrate in highly weathered profiles relative to K. Th and U are typically associated with residual clays, oxides and accessory minerals. K is typically high in slightly weathered regolith (depending on bedrock composition) and low in highly weathered regolith due to leaching.

In areas of bedrock terrain, gamma-ray responses show a broad correlation with major geological units. Variations within these units can correspond to lithological variation and different styles of weathering, which reflect underlying lithology, time and geomorphic processes. In bedrock terrains gamma-ray relationships and responses are often specific to major lithological types and therefore interpretation is best made within these major groups. Once the gamma-ray responses and relationships between bedrock and regolith materials are understood gamma-ray data can provide information on regolith properties including mineralogy and chemistry. From this inferences can be made about the style of weathering, degree of leaching, pH, texture, nutrient status, and thickness of regolith material, and relative geomorphic process rates (Wilford 1995).

Radio-element responses over actively eroding landforms are likely to be closely correlated to bedrock geochemistry and mineralogy. However, in more stable landforms where regolith materials are accumulating, radio-element responses relate to weathered materials and processes. These relationships can then be used to assess the denudation balance in the landscapes or the relative rates of regolith formation and removal (erosion) (Figure 9). The lack of radio-elements in quartz can be used in places to indirectly map highly siliceous, leached and poorly fertile soils.

Gamma-ray responses from transported sediments will reflect the bedrock source, texture and style of weathering which is in part controlled by the rates of erosion, transport and deposition in the catchment. Interpretation of gamma-ray imagery in depositional landforms are best made within major river catchments since relationships between gamma-ray responses and regolith materials are likely to change depending on the lithologies being eroded and the rates of erosion within catchments.

REGOLITH-LANDFORM MAPS IN MINERAL EXPLORATION

There are now enough regolith maps available for various parts of Australia to show the very clear relationship between the distribution of landforms and their associated regolith types. This ranges from the detailed work carried out by CSIRO Division of Mining and Exploration (e.g. Anand & Smith 1993) to the regional mapping of AGSO (e.g. Chan 1995) and the CRC for Landscape Evolution and Mineral Exploration (e.g. Gibson & Wilford 1995). These maps all illustrate the landform/regolith inter-relationship. Equally, however, a study of these maps also shows that particular relationships that apply in one place do not necessarily apply elsewhere. This paper, and the regolith-landform maps of CYP referenced herein, underlines the importance of carrying out regolith and landform studies in all new areas, before sampling or shallow drilling programs are put in place.

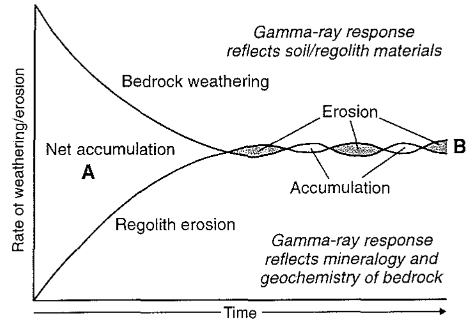

Figure 9: *Relationships between denudation balance and gamma-ray response. A - weathering rates higher than erosional rates, resulting in deeper soil/regolith development, B - weathering and erosional rates similar, resulting in thin, and less mature, soil/regolith materials.*

A related factor is the importance for mineral exploration of recognising the different regolith materials found in the area A very good example is the mobile zone found over much of the study area Its presence indicates that the upper part of the regolith has been disturbed, and that only a careful study of the regolith and its landscape position will allow explorers to assess whether its geochemistry will reflect underlying bedrock or not Another example is the presence of siliceous and ferruginous induration that seems to be associated with the lower parts of either the present or a past landscape This shows that materials are moving in solution laterally around the landscape Both these examples stress the importance for mineral exploration of understanding the nature of the regolith, its distribution in the landscape, and its origin and evolution, which may be related to past rather than present landscapes

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