Chapter 3. Field Area Description.

3.1. Introduction.

To find relationships between regolith properties and surface features it is necessary to first understand the regional, local and historical setting of the study area. This chapter describes the bauxitic regolith at Weipa, its regional setting and the local geomorphic and vegetation characteristics. These provide the basis for determining which analyses are appropriate to the dataset, and provide the context for the interpretation and discussion of the results.

The Weipa bauxite deposit has been chosen as the field site to assess the research question of how much the regolith is related to surface measurable features because it has sufficient data available for regolith properties, topography and vegetation. The study area covers part of the mining lease operated by Comalco, who have provided 25 years of exploration drilling data. A DEM of the study area has been generated and a Landsat Thematic Mapper (TM) scene has been obtained. There are few locations with such a supply of good quality data and it is fortunate that this data has been made available.

Two periods of field work were undertaken to gain an understanding of contemporary processes operating in the region and to aid in the interpretation of the datasets. These periods were at the end of one, and the beginning of the next, dry season, and comprised three weeks in August 1995 and ten days in May 1996. The field work was confirmatory in nature, as sample data was provided (see Section 4.2.1), and extensive exposures of the regolith profile were available in mine faces to interpret the system.

3.2. The Weipa Bauxite.

The Weipa bauxite is part of an extensive laterite plateau that covers approximately 11,000 km² of the western side of Cape York Peninsula (Evans, 1975; Figure 1.3).

The field area includes three areas on which bauxite has formed, the Weipa Peninsula, Andoom Peninsula and East Andoom (Figures 3.1 and 3.2).
Weipa Peninsula rises gently from west to east and is bound by the Embley and Mission rivers. The Andoom Peninsula and East Andoom both display a general northwards rise. The Weipa and Andoom Peninsulas exhibit very little local relief while East Andoom has slightly more dissected topography.

The rivers in the study area are estuarine and drain into Albatross Bay. The Mission River flows between Andoom and Weipa, while the Embley River separates Weipa and Pera Head. The Hey River is a wide southern tributary of the Embley, joining approximately between Pera Head and Weipa. The Pine River defines the northern and western boundary of Andoom. Several smaller creeks dissect the bauxite elsewhere. Drainage is centripetal about major river heads, most strongly with the Hey River.

Numerous theories of regolith development at Weipa have been proposed, all of which have been hampered by the difficulty of obtaining a reliable age. Attempts to date the regolith at Weipa have proven, at best, only partially successful. This section describes the general area, its geology, geomorphology, climate, and vegetation, as well as the recent exploitation of the bauxite resource.

3.2.1. Climate and Hydrology.

The climate at Weipa is monsoonal, maximum temperatures are from 30°C to 35°C (Evans, 1975). Most of the annual rainfall is between October and March, causing large seasonal water table fluctuations (Figure 3.3). During the wet season there is near-total saturation of the regolith profile, and the water table can overtop mine sides in lower areas. The water table is generally 10 m below the ground surface at the end of the dry season.
Figure 3.2  Red-Green-Blue false colour composite of Landsat sub-scene, bands 2 (red), 4 (green) & 7 (blue). Location A is a storm surge deposit, B is the Andoom mining area, C is the Weipa mining area, D is a fire scar, and E is a scanner distortion in the data.
Figure 3.3. The water table fluctuations in the study area are extreme. (a) Andoom slot, end of dry season, August 1995. (b) Start of dry season, May 1996. The lineations on the side walls are high water marks.
3.2.2. Geology and Geomorphology.

3.2.2.1. Regional.

The structure of Cape York is controlled by a northerly oriented anticline with a Proterozoic granite core (Coen Inlier). It is flanked on its western margin by Mesozoic and Cretaceous sediments of the Carpentaria basin on which the Weipa bauxite is formed (Grubb, 1971; Bardossy and Aleva, 1990; Evans, 1975).

Using regional magnetic, gravity and Landsat data, Bourke et al (1988) have inferred that the Carpentaria basin sits astride an early Proterozoic rift complex. This can be traced along the west coast of Cape York Peninsula and south into the Eromanga Basin. The extent of riftning is postulated as small, not exceeding that of modern rift systems in East Africa. A period of north-south wrench faulting after 1,450 Ma BP further broke up the basement rocks with some extensional basins forming adjacent to the faults. These wrench faults control the structure of the western coast of Cape York, evident as a series of offset, arcuate features. These structures appear to control some of the drainage patterns seen in the field area.

The Gulf of Carpentaria is shallow (<70 m) and between 35,000 and 12,000 years BP, during the low sea levels of the most recent glacial period, became a shallow lake with brackish to fresh waters (Torgersen et al, 1988). The Torres Strait (~12 m depth) also dried out and northern Australia was joined with New Guinea by a land bridge (see Voris, 2000). The implication of this is that the Weipa bauxite has occupied vastly different positions relative to the coast during the Pleistocene.

3.2.2.2. Parent Material.

The parent material for the Weipa peninsula appears to be the Bulimba Formation while the Andoom and East Andoom areas have formed on the Rolling Downs Group (Schaap, 1990).

The Rolling Downs Group consists of labile glauconitic sandstone and siltstone with shale and siltstone that is calcareous in part (Smart, 1977). The Bulimba Formation overlies the Rolling Downs Group and consists of poorly sorted clayey
quartzose sand and granular conglomerate, pebbly in places and interbedded with sandy claystone (Smart, 1977).

More recent geological mapping, seismic surveys and satellite mapping indicate that the Bulimba formation represents a marine transgression of the Rolling Downs group (Bardossy and Aleva, 1990). Evidence for a buried palaeosol directly above the Rolling Downs Formation has been interpreted by Le Glauder et al. (1994) to imply that the Rolling Downs sediments were exposed for some time before high energy Bulimba sediments were deposited.

### 3.2.2.3. Local Geomorphic Units.

The Weipa Peninsula area has been divided into three geomorphic units by Smart (1977), the coastal lowlands, the breakaway country and the bauxite plateau (Figure 3.2). These may also be applied to Andoom and East Andoom.

1. The coastal lowland, or Mapoon Plain, is an irregular, narrow coastal plain along the north western margin of the Weipa region. It consists of a series of cheniers, mudflats, salt pans, black soil plains and swamps (Smart, 1977, Morgan, no date, Zambelli, 1988; Bardossy and Aleva, 1990).

2. The bauxite plateau includes all bauxitic areas. It is covered by open woodland and runs parallel to the coast extending up to 60 km inland. Elevation ranges from 5-50 m above sea level. It is characterised by low angle dendritic drainage and gentle undulation (Smart, 1977; Morgan, no date; Zambelli, 1988; Bardossy and Aleva, 1990). The Andoom and East Andoom areas are part of the bauxite plateau, but are not part of the Weipa plateau.

3. The breakaway country, also known as the Merluna Plain, is an eroded inland plain which lies to the east of the Weipa plateau approximately 40 km inland. The plain is undulating and developed on the Rolling Downs group. It is dominated by heavy clay soils and much of it appears to have developed from fluvial dissection of the bauxite plateau. The laterites on the breakaway country appear to have formed on the lower members of the Rolling Downs group and are much younger than those on the Weipa plateau (Smart, 1977; Morgan, no date; Zambelli, 1988; Bardossy and
Aleva, 1990). The eroded plain coincides with the heads of the Mission and Embley rivers.

3.2.2.4. The Bauxite.

The bauxite is thought to have formed by de-silicification of clay rich parent material (Tilley, 1998). However, this is only a broad description, and there are a number of aspects of the bauxite at Weipa that require consideration in this study. These are the spatial variation, physical reworking, seasonal swamps and waterbodies known locally as melon holes, and the age of the regolith.

3.2.2.4.1 Spatial Variation.

As with all regolith, the bauxite at Weipa varies both laterally and vertically. An understanding of this is of particular importance to this study. Determining the degree of relationship between these variations and surface measurable features is the aim of this research.

3.2.2.4.1.1 Vertical Variation.

The regolith profile comprises less than one metre of, sometimes bauxitic, surface soil mixed with bauxite pisoliths overlying 1.2 to 10 m of nodular bauxite (Evans, 1965; see Figure 3.4). The bauxite is underlain by ironstone up to 1.5 m thick and containing bauxite pisoliths. Laterally the contact between bauxite and ironstone is irregular to undulating, vertically it is abrupt to gradational. Beneath the ironstone layer is either a mottled zone (in Andoom) and kaolinite (in the Weipa Peninsula) that can be up to 16 m thick (see Figure 3.4a). Some vertical variation in the bauxite profile is related to mineral mobilisation (Morgan, no date).

The undulating surface of the ironstone layer (Figure 3.4b) was interpreted by Evans (1975) as being the result of gentle folding and the subsequent erosion of the crests. However, it is more likely a result of water table fluctuations, and the ironstone layer is interpreted to be the redox front where iron mobilised from the bauxite profile precipitates. Abrupt vertical variations within the undulations may be caused by tree roots or past erosional features.
Figure 3.4. Layers within the bauxite. (a) Bauxite above a thin ironstone layer, with mottled kaolin clays below. (b) The mine floor shows the lateral variation of the depth to the ironstone layer.
Figure 3.5. Generalised mineral profile in the Andoom Peninsula (courtesy L. Foster). PDM (Poorly Diffracting Material) contains silicates and hydroxides of Al and Fe that are difficult to separate using X-ray diffraction.
The dominant minerals in the bauxite profile are silica, kaolin, haematite, goethite, gibbsite and boehmite (Figure 3.5). Part of this mineral content is in the form of Poorly Diffracting Material (PDM), which contains Aluminium and Iron hydroxydes and silicates that are difficult to separate using X-ray diffraction techniques (Tilley, 1994). There are smaller amounts of anatase, zircon, rutile and other trace minerals (Schaap, 1990). There is very little free quartz within the bauxite, and also little evidence of amorphous silica (Le Gleuher, pers. comm., 2001). Much of the silica in the profile is therefore contained within the clays. The pattern of change in mineralogy with depth appears consistent across the bauxite, although there is sometimes a higher proportion of quartz in the upper part of the profile.

3.2.2.4.1.2 Lateral Variation.

Lateral variation in the bauxite is fundamental to the research question. Empirical work by Morgan (no date) has shown the bauxite chemistry and mineralogy vary laterally at four scales of distance.

1. A one metre scale variation. Tree roots disturb the profile (Figure 3.6) and pisoliths fall down the profile as a result. There is also some shallow disturbance from lateral roots due to trees falling over in high winds.

2. Elongated domains with mappable trends related to lenses of enhanced void filling within the bauxite, and other effects, occur at a 10 m to 100 m scale. This is possibly caused by changes in groundwater access due to variations in the porosity of the bauxite.

3. Minor creeks cause variation at the 1000 m scale. This affects the degree of bauxitisation, the cementation (which appears to be related to slope), iron mobility, the thickness of the bauxite, the porosity of the underlying rocks, and the degree of reworking of the regolith at Weipa (see Section 3.2.2.4.2).

4. The parent sediment types (Rolling Downs Group and Bulimba Formation) affect the amount of silica and the degree of bauxitisation at the regional scale.
Figure 3.6. Vegetation effects on the bauxite.  (a) Columns in an eroded profile caused by mineral precipitation around tree roots. There is some chemical effect on the matrix material but the effect on pisoliths should be limited.  (b) Disturbance of regolith by tree throw. Much of the disturbance is in the soil layer and not the bauxite.