PHOSPHATE AND IRON ORE TARGETS IN
HIGHLAND PLAINS AND
BUCHANAN DAM AREAS
NORTHERN TERRITORY

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1 SUMMARY AND CONCLUSIONS

Summary

The marginal marine deposits of the Cambrian Georgina Basin in Queensland and the Northern Territory are prospective for phosphate. In addition, outcropping Proterozoic rocks of the South Nicholson Basin in the tenements are prospective for Clinton-style oolitic iron ore. In this work programme, phosphate and iron ore targets in the tenements EL 25068 (Highlands Plains) and EL 25600 (Buchanan Dam) are examined. The intention is to provide more information on known targets, to recommend further work and to identify new targets. This work programme has been carried out using Landsat imagery in conjunction with the existing 1:250,000 geology maps of the area. Helicopter-supported fieldwork was then completed over the target areas.

Highland Plains

The phosphatic rocks in the Highlands Plain Prospect are part of the Cambrian Border Waterhole Formation. These units are thought to be part of a shallow marine sequence that was deposited in an embayment in the Cambrian sea. The Border Waterhole Formation consists of a basal honey-coloured, mature, medium-grained sandstone. Overlying the sandstone, possibly partly unconformably, is a sequence of grey to cream kaolinitic mudstones. The mudstones are massive to coarsely bedded. Parts of the section are a mudstone breccia in which angular clasts of silicified mudstone of pebble to boulder size are cemented in a fine-grained mudstone matrix. The breccias in the mudstone are interpreted to be the result of syn-sedimentary submarine slumping.

1.1.2 West of Highland Plains

The Cambrian palaeo-coastline extends to the west of Highlands Plain for at least 110km within EL 26650. Embayments or shallow shelf areas along this trend are thought to be prospective for phosphate. A total of 8 ‘zones of exploration interest’ are identified from the Landsat along this palaeo coastline.

1.1.3 Phosphate Prospects in EL 25600

Three phosphate prospects have been discovered by previous explorers near Alexandria Station and at Alroy and Buchanan Dam. The prospects are located within EL 25600 to the southwest of Highlands Plains. The three prospects are located below black soil plains of the Barkly Tableland. The soils reflect the shape and size of the Cambrian sea. The phosphatic units are thought to be contained in the Wonarah Formation which immediately underlies the black soil. It is possible that the phosphorites may be thicker and better developed over shallow shelves or embayments in the Cambrian sea.

Iron Ore Prospects in EL’s 25068 and 26650

Granular iron formations (GIF) are known to occur in the Proterozoic quartzites in EL’s 25068 and 26650. The iron is thought to be of the ‘Clinton-type’ in which the
iron originated as syn-sedimentary iron-rich oolitic sands in the Proterozoic basin. Two main areas of iron ore were examined by the writer. The areas of exploration interest are designated the Central and Western Targets.

1.2 Conclusions

1.2.1 Highland Plains

The Highland Plains prospect represents a considerable resource of phosphate. The phosphatic units are thought to be contained in the mudstone with the highest grades probably occurring in the breccia slump sheets. The rest of the mudstone unit may contain lower grades of phosphate. In the writer’s opinion, the resource could be considerably larger than previously reported (82mt), but much of this will be of lower grade. The writer supports the company’s plans to carry out close spaced drilling.

1.2.2 Palaeo coastline

Eight phosphate targets are identified to the west of Highland Plains in embayments along the Cambrian palaeo coastline in EL 25068. It is thought that the Border Waterhole Formation may be diachronously replaced by the Wonarah Formation in this direction. However, an environment suitable for phosphate precipitation still exists to the west. Units in the Wonarah Formation are also prospective for phosphate.

The potential is good for the discovery of further phosphate deposits in EL 25068. Air photograph mapping followed by drilling is recommended in six of the eight targets.

1.2.3 Iron ore

From field observations, the iron ore targets in EL 25068 together are estimated to contain in the order of 3 million cubic metres of iron-bearing quartzites. This can be considered a conservative figure as the thickness of the units cannot be accurately estimated and the northeastward extension of the western target is under cover. The grades are also not known although the writer estimates that most of the outcropping GIF’s grade about 45% Fe.

Air photograph mapping is recommended over the two target areas with a view to identifying drill targets and planning a drill programme initially in the western area.
2 INTRODUCTION

2.1 Background and Brief

The marginal marine deposits of the Cambrian Georgina Basin in Queensland and the Northern Territory are prospective for phosphate. Phosphate Australia Ltd (PAL) has tenements in the Northern Territory (NT) that cover what is thought to be the Cambrian coastline or shallow marine environment. In addition, outcropping Proterozoic rocks of the South Nicholson Basin in the tenements are prospective for Clinton-style oolitic iron ore.

In August, 2008, Phosphate Australia Ltd commissioned R. Russell to examine the tenements EL 25068 (Highlands Plains), EL 26650 and EL 25600 (Buchanan Dam) with the intention of providing more information on known phosphate and iron ore targets and selecting new targets for drilling. Numerous uranium targets have also been outlined by the company. These targets are beyond the present brief.

2.2 Technique

The work described in this work programme represents first-pass targeting. It has been carried out using Landsat imagery in conjunction with the existing geology maps of the area followed by helicopter-supported fieldwork.

The Landsat is a 1:250,000 scale band 7-4-2 treatment and mapping was done on hard copy imagery rather than on the computer screen. The usual techniques of photogeology are used. Photo linears and faults are mapped from linear elements in the topography. The linears are interpreted either as geomorphological features or deeper fault-related structures according to their surface expression. Relative movements on the faults are interpreted from the geomorphology.

Outcrop geology and soft rock geomorphological units are interpreted from photo tone and texture. While the geomorphological elements are relatively easy to recognise on the imagery, the interpretation of rock types and their relative ages present more of a challenge. The existing geology maps are used to assist in the identification of rock types and the formations to which they belong.

2.3 Report and Maps

The map of EL 25068 and 26650 is presented on Enclosure 1 while the map of EL 25600 is on Enclosure 2. These maps are at the photo-scale of 1:250,000.

This report presents the writers ideas following the field trip from 6th to 12th August 2008.
3 HIGHLAND PLAINS PROSPECT

The writer visited the Highland Plains phosphate prospect and the following are some observations:

3.1 Setting

The phosphatic rocks in the Highlands Plain Prospect are part of the Cambrian Border Waterhole Formation. This formation is thought to be part of a shallow marine sequence which was deposited in an embayment in the Cambrian sea which extended to the south and southeast of the prospect. The Cambrian section rests unconformably on Proterozoic siltstones and shales of the South Nicholson Basin (Plate 1) which represent the old coastline and landmass. The Border Waterhole Formation consists of two main units at Highlands Plain.

3.2 Stratigraphy

3.2.1 Basal sandstone

The basal unit is a honey-coloured, mature, medium-grained sandstone which dips at between 5° and 10° to the southeast. The basal sandstone is interpreted by the writer to have originated as a nearshore sand sheet. The upper part of the sandstone unit is frequently iron and manganese enriched.

3.2.2 Mudstone

Overlying the sandstone, possibly partly unconformably, is a sequence of grey to cream kaolinitic mudstones. The mudstones are massive to coarsely bedded. Parts of the section are a mudstone breccia in which angular clasts of silicified mudstone of pebble to boulder size are cemented in a fine-grained mudstone matrix (Plate 2 and 3). These breccias are generally matrix supported. It is these mudstones which appear to be the most highly phosphatic. In other places, the mudstone forms an iron-stained breccia formed from slabs of mudstone separated by slickensides and numerous minor fractures (Plate 5).

The breccias in the mudstone are interpreted to be slump sheets formed by syn-sedimentary submarine slumping.

3.3 Chert Breccia

Other features in the mudstones are massive chert breccias which appear to form lenses, frequently at the surface of the unit. These breccias may be the same as the mudstone breccias described above but the clasts may have been silicified into chert due to weathering at the top of the sequence. The chert clasts are both angular fragments and nodules which range in size from small chips to boulders of over 20cms diameter.

The chert may be the lagged residue from the Camooweal Dolomite which may have once covered the area. The carbonates have now been dissolved away leaving the chert rubble.
3.4 Superficial Deposits

A large proportion of the Cambrian outcrop area at Highland Plains is covered by a veneer of angular chert fragments. The fragments are weathering out of the chert breccias. About 10% of the surface gravels consist of water worn pebbles and cobbles. This material is thought to be derived from Tertiary alluvial fans shedding from the Proterozoic provenance in the west and north (Plate 3). They are not thought to be related to the Cambrian section.

3.5 Phosphatic Horizons

From earlier drilling (PAL prospectus), it appears that there may be two and possibly three prospective horizons in the Cambrian section.

1. The main phosphatic unit is at the base of the Cambrian section.
2. A horizon higher up the sequence is also phosphatic and
3. Lenses at the top of the Cambrian section are also prospective.

This pattern is difficult to correlate with the observed stratigraphy for the following reasons:

- The basal unit appears to be a sandstone which is unlikely to carry significant grades of phosphate. Perhaps the sandstone outcropping on the edge of the Cambrian section (Plate 1) does not extend very far down-dip.
- The grey-cream mudstones which appear to host the phosphorite outcrops across the whole of the prospect area. This suggests that
  - no cover of the prospective units should be expected and
  - the prospective horizon should comprise the whole of the mudstone unit.
- It is possible that the results of the earlier drilling as presented in the PAL prospectus may present only the ‘best’ P₂O₅ returns. The whole mudstone unit may contain phosphate but at lower grades.

In the extreme east of the prospect, cattle have excavated and enlarged a shallow overhang in the mudstones. The exposed mudstones are clearly being licked for the phosphate content. The ‘lick’ is possibly the best outcrop of phosphatic rocks in the area (Plates 6 and 7). The ‘lick’ is in mudstone breccia, interpreted by the writer to be a syn-sedimentary slump sheet. The siliceous clasts give off a phosphatic smell when struck (the smell of lighted matches). However, the cattle are licking the softer matrix which also must be highly phosphatic (Plate 7). Significantly, this type of mudstone, whether brecciated or bedded, can be seen in outcrop over much of Highland Plains prospect.
4 PROSPECTIVE AREAS TO THE WEST OF HIGHLAND PLAINS

4.1 Setting

The Cambrian palaeo-coastline extends to the west of Highlands Plain for at least 110km within EL 26650. Embayments or shallow shelf areas along this trend are thought to be prospective for phosphate. In general, it is not known how far the prospective Border Waterhole Formation extends to the west. It appears that it may be progressively replaced by carbonates of the Wonarah Formation in this direction and therefore the prospectivity for phosphate may decline. At the Highlands Plains prospect, the prospective section forms low hills. This geomorphology is absent to the west which is further evidence that the Border Waterhole Formation may be absent. However, there are known to be other phosphatic shallow marine units lying below, or interbedded with the carbonates of the Wonarah Formation. These units are also prospective.

A total of 8 ‘zones of exploration interest’ are identified from the Landsat. These were visited in the field. Each is evaluated here in and ranked according to the size, shape and general prospectivity.

4.2 Zone A; Embayment immediately west of Highlands Plains

The Landsat and geological maps suggest that a Cambrian embayment exists about 10km to the west of the Highlands Plains prospect. Outcrop is poor in this area. Much of the area is flooded by Proterozoic quartzite debris shedding from the outcrops to the north. A ferricrete horizon, which is fairly ubiquitous over all rock types in this area, also obscures the bedrock geology.

However, in the northern part of the embayment, manganese-stained mudstones outcrop in a creek bed (Plates 8 and 9). The mudstone overlies honey-coloured medium-grained sandstone, similar to the basal Cambrian unit at Highlands Plains. The section here is thought to be Border Waterhole Formation. Samples S4 and S12 were taken in the sandstone and mudstone respectively. Air photograph mapping followed by drilling is recommended in this embayment.

4.3 Zone B; Open Coastline

A broad area of relatively open Cambrian coastline is interpreted to the west of prospective Zone A. The creek incisions along this trend were all examined for Cambrian outcrop. If the Cambrian section is present, it is generally buried by thick sheets of angular Proterozoic quartzite debris shedding off the provenance to the north (Plate 10). In many places, the transported units are covered by a thick pedogenic ferricrete horizon. The ferricretes may be Tertiary in age (Miocene?) suggesting that the debris sheets are of considerable age. In other places, terraces and other alluvial spreads of water-worn quartzite clasts overlie the older units (Plate 11).

In one creek incision about 2km west-southwest of Prospective Zone A, medium/fine grained kaolinitic sandstone is exposed dipping about 10° to the south (Plate 12). The sandstone is heavily iron-stained and carries an ironstone cap. The Proterozoic units outcropping to the north dip in a northerly direction. The indications are that the
sandstone is part of the Cambrian section and may represent the basal unit of the Border Waterhole Formation.

A sample of the sandstone was collected for analysis. Photo mapping is recommended here and two reconnaissance drill traverses extending southward from the Proterozoic outcrop should be planned.

4.4 Zone C; Embayments to the west of the main promontory

Three minor embayments on the Cambrian coastline are mapped from the Landsat to the west of the main Proterozoic/Cambrian promontory. These are designated C1 to C3. It is thought likely that the Border Waterhole Formation does not extend this far west. The Cambrian units probably consist of carbonates and clastic units of the Wonarah Formation.

The embayment C1 is a shallow indentation which is located to the north, that is, on the landward side, of a major fault. The fault may have controlled the actual coastline in the Cambrian. C1 may therefore be a later erosional feature.

A similar geomorphological setting exists at C2 at Wild Cow Creek. The fault crosses the mouth of the embayment which may, or may not, be a positive feature for phosphate. If the Cambrian sea had actually entered the embayment, it could be an ideal environment for phosphate deposition. No outcrop was found in the embayment and an extensive ferricrete sheet covers the bedrock.

C3 is potentially the largest of the three embayments in this group. It extends eastward from a structurally-controlled Proterozoic peninsula which extends south-southwest along strike. No Cambrian outcrops could be found in the embayment. If there is Cambrian section, it subcrops below a thick superficial cover of colluvial and alluvial sand and gravel.

Drilling is not recommended at C3 at present. If positive results are obtained in the drilling further west, then the C1 to C3 targets can be considered for drilling.

4.5 Zone D; Double embayment on palaeo-valley

A deep double embayment is mapped at D. The embayment is possibly part of a Cambrian-age valley which extended up a strike valley to the east-northeast. Traces of bedding can be seen on the Landsat imagery which run parallel to the edges of the embayment. The area was examined in the field and no Cambrian outcrop could be found. It is thought that the bedding traces may be ferricrete layers which developed in the basin in the Tertiary. The Proterozoic edge of the embayment is easily recognised but extensive Recent superficial cover obscures any possible Cambrian section. The Proterozoic quartzite units dip at 30° to the northwest at 330°.

An exploration drill traverse is recommended to locate the Cambrian section. The traverse should extend for about 2km southeastward (155°) from approximately the point 730°E 7937°N. Hole spacing of 100m and depth of up to 50m is recommended.
4.6 Zone E

A further embayment is identified at E. The Proterozoic margin of the embayment is quite distinct (Plate 13). Bedding traces can be seen running parallel to the margins of the embayment. However, no Cambrian outcrop can be seen on the ground.

An exploration drill traverse is recommended to locate the Cambrian section. The traverse should extend for about 2km southeastward (140°) from approximately the point 718°15′E 793°35′N. Hole spacing of 200m and depths of up to 50m, or as required to test the Cambrian section, is recommended.

4.7 Zone F; Carbonate embayments in the west

A series of large Cambrian embayments are mapped in the extreme west of EL 25068. The outcropping Cambrian units are Wonarah Formation overlying Helen Springs volcanics. The Wonarah Formation appears to consist mainly of carbonates. However, minor phosphatic clastic units are known in the sequence which suggests that the Cambrian environment was at least partly shallow marine. In outcrop, the Wonarah Formation is dominantly silicified chert breccia (Plates 14 and 15). The more easily eroded units probably subcrop under superficial cover.

An exploration drill traverse about 7km long is recommended along the axis of the main embayment. The traverse should extend southwestward (200°) from a point about 715°50′E 7941°50′N. Hole spacing should be about 500m and depth as required to test the Wonarah Formation.
5 EL 25600, PHOSPHATE PROSPECTS

Three phosphate prospects have been discovered by previous explorers near Alexandria Station and to the southwest at Alroy and Buchanan Dam. The prospects are located within PAL’s EL 25600 to the southwest of Highlands Plains.

5.1 Setting

The three prospects are located in black soil plains of the Barkly Tableland (Plate 16). The soils have developed over the flat-lying units of the Cambrian Georgina Basin and reflect, to a large extent, the shape and size of the Cambrian sea. Proterozoic inliers in the black soil plains, for the most part, represent Cambrian islands. The phosphatic units are thought to be contained in the Wonarah Formation which immediately underlies the black soil. This formation is described as limestone, shale and siltstone with minor phosphorites and a basal quartz sandstone. It is possible that the phosphorites may be thicker and better developed over shallow shelves or embayments in the Cambrian sea.

The Alroy and Buchanan Dam prospects appear to be located on a buried Cambrian ridge. The ridge is the southwestern extension of the Mittiebah Ranges and is named the ‘Buchanan/Alroy Ridge’ here. Lineaments in the black soil may represent the boundary faults of the buried Proterozoic block.

The phosphorites in the Alexandria prospect may have been deposited on a shallow shelf extending north-northwest from the Proterozoic ridge to the south near Shady Camp Waterhole (‘Shady Camp Ridge’).

5.2 Field and Landsat Observations

Little can be seen of the bedrock geology in the field in EL 25600. The phosphatic units intersected in the earlier drilling were over 10m below the surface. The geomorphology and vegetation patterns of the black soil probably do not reflect the bedrock geology (Plate 17) but relate rather to local soil drainage. The black soil is at least 2m thick (Plate 18) and forms a complete blanket over the Wonarah Formation.

The Landsat interpretation suggests that phosphatic sediments may also occur to the southwest of the Buchanan Dam prospect at location ‘A’. This area should be checked by drilling.

The mapping also identifies two possible shallow shelf areas on the northwestern flank of the Shady Camp Ridge. The first area of exploration interest is a fault controlled bench near the western end of the ridge (B). The second is between the Alexandria prospect and Shady Camp Ridge. Here, a narrowing of the shelf is interpreted between the ridge and faults to the north along the Playford River (C).

5.3 Recommendations

A pattern of broadly-spaced drill holes is recommended over the Buchanan Dam and Alroy prospects. A grid of 400m by 400m extending over an area of about 5km by 5km is recommended for each area. For each prospect, the total number of drill holes
would therefore be 144. With a drill depth averaging 25m, total metres drilled will therefore be 3,600m for each prospect. Infill drilling can be carried out later as required.

At Alexandria, the phosphatic unit may be part of a shelf deposit extending northward from Shady Camp Ridge. A drill traverse extending 10km northward from the point 695°E 7887°N to the Playford River is recommended. Hole spacing should be about 500m with a drill depth up to 30m. If average hole depth is 20m, then the total metres drilled will be about 450m.
6 IRON ORE, EL 25068 AND EL 26650

6.1 Setting

Granular iron formations (GIF’s) are known to occur in the Proterozoic quartzites in EL’s 25068 and 26650. The iron is thought to be of the ‘Clinton-type’. This type of deposit originated as syn-sedimentary iron-rich delta sands in the Proterozoic basin. Oolitic iron-rich fragments were eroded from a provenance containing ferruginous soils and reworked into shallow deltas in the sedimentary sequence. The GIF’s are therefore lens-shaped but recur along strike in specific horizons in the South Nicholson Basin.

Two main areas of iron ore outcrop were examined by the writer in EL 25068. The iron occurrences in EL 26650 to the north were examined only from the air as the tenement has not yet been granted. The areas of exploration interest in EL 25068 are designated the ‘Central’ and ‘Western Targets’.

6.2 Western Iron Target

6.2.1 Setting

The GIF’s in the western part of EL 25068 are located on the dip slope of a cuesta formed by the Burangoo Sandstone member of the Constance Sandstone (Plate 21). The units dip north-northwest at about 10°. The writer did not observe many oolites in the iron. Rather, iron enrichment of the matrix of the sandstone appears to predominate. Grade is estimated by the writer to be in the order of 40% to 50% Fe. Four samples were collected along the strike of the iron-bearing unit in this target area. At the time of writing, assay results are not yet available. While the host quartzite unit (Burangoo Sandstone) is consistent along strike, the iron enrichment is lensoid. In the southwest of the target area, the GIF lenses appear to be between 1 and 3m thick and to extend for about 100m to 200m along strike. The width is controlled by the length of the dip slope of the cuesta which is about 200m. However, the iron-enrichment probably extends down-dip to the northwest below the present land surface.

6.2.2 Iron

Within the iron deposits, the iron is bedded with individual beds containing more or less silica. The individual beds are commonly 0.5cm to 5cm in width. In places, enrichment has occurred in discrete layers and the iron has the appearance of high grade ‘blue dust’ hematite. Enrichment also produces more massive goethitic lenses in the GIF section but these are relatively rare (Plate 22).

6.2.3 Size of deposit

The writer has the impression that the GIF’s become thicker and more consistent in a northeasterly direction. In this direction, the unit runs into a Tertiary land surface. Extensive areas of iron-rich canga from the Tertiary weathering profile characterise the strike extension in this area.
The total strike length of the GIF’s appears to be about 12km. Probably less than half this strike length is iron-bearing (say, 4.5 kilometres). If the average width is 200m and the thickness is 2m, then the total volume of iron-bearing quartzites is about 1.8 million cubic metres. While this can be considered a very rough estimate, it does indicate that the west iron target is a relatively small iron prospect.

However, this is a cursory estimate from a brief field visit. The prospect is very much under-explored and it could be larger. Iron grade may also be higher than estimated although the silica content is always likely to be high.

6.2.4 Recommendations

Detailed work has not been possible due to the constraints of the present brief. The mineralisation could extend along strike, particularly to the northeast into EL 26650, and down-dip into the strike vale to the northwest. Further extensions are also possible along strike to the southwest.

Air photo mapping should be carried out over the prospective area to delineate the likely configuration and extent of mineralisation. Based on the air photo map, individual targets can be outlined within the prospective zone and drill programmes planned.

6.3 Central Iron Target

6.3.1 Setting

The iron ore target in the central part of EL 25068 is also a granular iron formation (GIF), possibly of the Clinton-type. Enrichment occurs along a northwest trending fault zone. The northwest trending fault is a relay fault lying between the Wild Cow Fault to the northwest and the Rocky Creek Fault to the southeast. The iron is hosted in the Brumby Formation sandstones in the Palaeoproterozoic Lawn Hill Platform sequence.

The GIF’s outcrop in the sandstones on the southwest side of the fault zone (Plate 21). Dip is about 50° to the northeast. The iron enrichment is lensoid in shape with individual lenses extending for about 30m along strike and 50m down-dip. The GIF extends along strike for an estimated 2.5km. However, this mineralisation is not continuous.

The mineralised sandstone unit is terminated to the northeast by the main northwest trending relay fault. Where the fault intersects with the iron-rich lenses in the Brumby Formation sandstones, enrichment into vitreous goethite has occurred (Plate 22). Enrichment is only partial and the pods of goethite are about 30m in diameter.

6.3.2 Iron and Size of the Deposit

The GIF’s to the southwest of the fault are grading an estimated 45% Fe. Parts of the goethite pods on the fault appear to be much richer, probably reaching 60% Fe. However, the volumes of this material are small. The writer estimates that the
volumes of goethite probably do not exceed 1 million cubic metres along the entire fault trend. The volumes of GIF are likely to be less than this.

6.3.3 Recommendations

Air photograph mapping is recommended along this trend. A better idea should then be obtained of the configuration and extent of the mineralisation. Further work can be planned on the basis of the photo map.
Plate 1 The western margin of the Highlands Plains Phosphate prospect. The Cambrian Border Waterhole Formation forms the low brown hills in the middle distance. The Cambrian section rests on purple Proterozoic shales and siltstone units of the South Nicholson Basin.

Plate 2 Iron-staining in the basal sandstone unit of the Cambrian Border Waterhole Formation can be seen on the hillside in the middle distance. The Cambrian section dips at a shallow angle to the southeast away from the observer. Proterozoic shales and siltstones form the outcrops in the foreground which dip steeply to the north.
Plate 3  Mesoproterozoic Constance Sandstone forms the cliff line at the Border Waterhole (foreground). The phosphatic Cambrian units outcrop about 400m to the south of the waterhole behind the observer. This quartzitic unit probably formed the coastline in the Cambrian.

Plate 4  Heavy manganese and iron staining characterises the upper part of the basal sandstone in the Border Waterhole Formation. To the right are outcropping Proterozoic shales and siltstones while in the background are fault-emplaced sandstones and siltstones of the Lawn Hill Formation and the Widdallion Member.
Plate 5  The outcrop of the Cambrian phosphatic mudstone is complex. The mudstones are kaolinised and form a light-coloured fine-grained residue. The low hills are capped by chert fragments and water worn clasts. In the centre of the view, a dark, iron-stained block of mudstone is thought to represent the remnants of a syn-sedimentary submarine slump block.

Plate 6  Phosphatic mudstone breccia exposed in an overhang in the eastern part of the Highlands Plains prospect. The cave has been enlarged by stock which use the outcrop as a lick.
Plate 7 A licking place. The stock are particularly attracted to the finer matrix of the breccia but this may be because it is easier on the tongue. The siliceous clasts are also thought to be phosphatic.

Plate 8 Mudstone outcropping in a creek cutting in the Zone ‘A’ embayment about 10km west of Highlands Plain. The unit has been invaded and partly replaced by iron. It is thought to be part of the Border Waterhole Formation.
Plate 9  Mudstone almost entirely replaced by iron in a creek bed in the Zone ‘A’ embayment. The mudstone may be phosphatic.

Plate 10  Coarse angular debris shedding southward from the Proterozoic provenance forms a conglomerate which buries the Cambrian section on the ‘Open Coastline’ to the west of Highland Plains. The conglomerate is capped by a ferricrete horizon.
Plate 11  Major terrace gravels flank a creek bed close to the ‘Open Coastline’. Superficial deposits such as these bury any potential Cambrian units.

Plate 12  Medium, mature, iron-stained sandstone outcropping in a creek bed about 2km west of the ‘Zone A area of exploration interest’. 2 metres of cemented alluvial gravels overlie the unit. This sandstone may be the basal unit of the Cambrian section.
Plate 13  Proterozoic quartzite units forming the Cambrian coastline on the western side of the embayment at Zone D. Cambrian section is possibly buried below superficial cover in the middle distance and drilling is recommended here.

Plate 14  The outcrop of the Wonarah Formation generally consists of these silicified chert breccias. However, this is probably a weathering product and the section below is thought to comprise carbonates, siltstone and minor phosphatic units.
Plate 15  Wonarah chert breccias form the bed of a waterhole on McNicol Creek near the head of the Cambrian embayment

Plate 16  The black soil plains of the Barkley Tableland near Alexandria Station. Here, the plains are underlain by the Wonarah Formation which contains phosphatic units probably on shelves where the sea was shallower and warmer than elsewhere.
Plate 17  The pattern of the grass reflects subtle changes in drainage. Better drained ‘islands’ in the black soil plains carry much better-developed grass communities. A large flock of white Corella cockatoo’s in the foreground has been disturbed by the helicopter.

Plate 18  18 Mile Waterhole on Alroy Station in the black soil plain. The phosphatic unit in the proximity of the dam is 12m to 20m below the surface.
Plate 19  Granular Iron Formation (GIF) in the west of EL 25068. The iron-rich sandstones are part of the Burangoo Sandstone member of the Constance Sandstone. The Gif here is lensoid and follows the gentle dip slope of the unit in the background.

Plate 20  Parts of the GIF unit are enriched. Here, the GIF is enriched into goethite that forms the dark lens in the middle distance. The goethite rests on sandstone which outcrops in the foreground.
Plate 21  GIF in the central part of EL 25068. The dark hills in the distance are also capped by iron-rich sandstones.

Plate 22  The GIF’s in the central EL 25068 are enriched into goethites along a major northwest trending fault. The view is looking directly along the trend of the fault which dips to the northeast (right). The sharp angle on the hill on the skyline is the fault scarp. The goethites are lensoid and are not continuous along the fault trend.