REPORT

OF THE

KEEP RIVER PARTY

1956

I. GEOLOGY OF THE SPIRIT HILL AREA.

II. TYPE SECTIONS OF THE COCKATOO SANDSTONE, BURT RANGE LIMESTONE AND ENGA SANDSTONE.

III. MISCELLANEOUS PROBLEMS.

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SUMMARY

1. The upper Palaeozoic sediments cropping out at Spirit Hill in the Keep River area, Northern Territory, have been mapped and described in detail. A geological map and cross-section at the scale of 880 feet to 1 inch (Sheet 1), three stratigraphical columns (Sheet 2) and three figures (1 to 3) accompany the report.

2. Type-sections of the Cockatoo Sandstone, Burt Range Limestone and Enga Sandstone have been studied in Burt Range Basin (Keep River area), and illustrated as stratigraphical columns (Sheets 3 and 4).

3. (a) Outcrops of trachyte in Weaber sandstone near Sandy Creek have been examined.

(b) Specimens of supposed petroliferous limestone have been collected from Buttons Crossing, for laboratory examination.

(c) Rock specimens have been collected from most of the formations cropping out in the southern portion of Bonaparte Gulf Basin, for determination of their density and porosity, and for petrological examination.

INTRODUCTION

GENERAL :

The Keep River Party, 1956, consisting of R.J. Allen, Geologist, and R.R. Bailey, Field Assistant, spent from 18th May to 13th August, 1956, in the Keep River area, Northern Territory. The following work was completed before ill health forced Allen to return to Brisbane :

Detailed mapping of Spirit Hill	- 6 weeks
Measuring type-sections in the Cockatoo Sandstone, Burt Range Limestone and Enga Sandstone	- 2 weeks
Miscellaneous problems	- 1 week
Photo interpretation and preparation of interim geological map and stratigraphical columns of Spirit Hill for Westralian Oil Ltd.	- 1 week.

FIELD METHODS :

The base map used for the work at Spirit Hill was prepared from aerial photographs and was at a scale of 880 feet to 1 inch. Dips were measured with a Brunton compass. Bearings given in the text are in degrees east of true north, unless otherwise stated. Heights were measured with an aircraft altimeter, the readings being corrected by reference to the diurnal variation curve, obtained from hourly readings of two similar altimeters left at camp. The datum for all heights is the border peg on the Carlton-Legune track, whose height was taken as 130 feet (reduced level is 131.6 feet, according to Seton's survey (Minad, 1955, Sheet 6).) Most boundaries were obtained accurately from the aerial photographs. A few important boundaries and key horizons were traced out on foot, in order to give close control of heights.

The size limits adopted for classifying the sediments were those of Pettijohn (1949, p.13). The grade of roundness of clastic particles was determined in the field by comparison with a copy of the visual chart of Krumbein and Sloss (1953, p.81). This property is expressed in the text as an index, thus "roundness 0.3". For clarity the roundness is expressed in words also, thus "subrounded", the grade terms adopted being those of Pettijohn (1949, p.51).

ACKNOWLEDGMENT :

The party wishes to acknowledge the generous hospitality of Mr. and Mrs. F. Hargreaves of Carlton Hill Station.

PART I. GEOLOGY OF THE SPIRIT HILL AREA.

GEOGRAPHY :

Spirit Hill is the highest of a group of low hills near the western border of the Northern Territory about sixty-four miles east of Wyndham, Western Australia. It lies in the south-eastern portion of the group, is 760 feet high, and rises about 600 feet above the plain. It consists of limestone, capped by sandstone. The hills to the north-west and west consist largely of sandstone, weathering in fantastic beehive patterns. The limestone hills and ridges are steep, but not difficult to climb. The sandstone hills, especially in the southern portion of the mass are almost unscaleable, because of the peculiar weathering forms.

The area is drained by small gullies joining the Keep River, which skirts its western edge (Figure 2.) During most of the dry season, the only surface water available in the Spirit Hill area is found in a few isolated waterholes in the sandy bed of the Keep.

The hills carry a very poor growth of timber, mainly eucalypts; "spinifex" is common on the treeless ridges, specially on sandstone. The low flat ground around and between the hills is covered with cane grass, or less commonly, kangaroo grass, with some eucalypts.

The strata are well exposed over most of the area.

PREVIOUS INVESTIGATIONS :

Traves (1955, p.76) studied the Spirit Hill area briefly in his regional survey of the Ord - Victoria region. Glover (Minad, 1955, p .29 and Sheet 3) in his survey of the Keep River area, mapped Spirit Hill on the scale of 1 inch to 1 mile.

STRATIGRAPHY AND PETROGRAPHY.

The strata cropping out in the Spirit Hill area are divided into the following members ;-

(h) Ferruginous sandstone - 10+ feet

(g) Quartz sandstone ("upper beehive sandstone") - 170 feet

(f) Quartz sandstone conglomerate, siltstone - 80 feet

(e) Quartz sandstone ("lower beehive sandstone") - 80 feet

(d) Undifferentiated quartz sandstone,
siltstone, conglomerate - 600 feet

(d_1) Quartz sandstone - 90 feet

(c) Dark grey dolomitic limestone and calcareous sandstone - 100 feet } Spirit Hill Limestone

(b) Grey to fawn-grey dolomitic limestone and calcareous sandstone - 370 + ft. } Spirit Hill Limestone

(a) Quartz sandstone - 30 feet

Member (a). At the foot of the ridge 3/4 mile south-south-east of Spirit Hill, sandstone dips north-east into the hill at an angle of 10°. It is a friable, fawn-coloured, medium to fine grained quartz sandstone, with a few grains of white clay mineral after felidspar; it is well sorted and the grain roundness is 0.3, ranging up to 0.5 (subrounded to rounded.) This sandstone appears to be overlain conformably by the Spirit Hill Limestone, which crops out higher up in the hill side, but the junction is obscured by rubble and soil and may be a faulted one.

Similar sandstone is overlain conformably by the limestone, 500 yards to the north-west, along the foot of the ridge.

The partly silicified sandstone which crops out 1 mile south of Spirit Hill is correlated with the former sandstone on grounds of structural position and lithology.

As this member (a) appears to be overlain conformably by the Spirit Hill Limestone, it may be correlated with the Nigli Gap Sandstone (Traves 1955, p.72.)

Member (b). This member consists of limestone (with and without quartz sand) and calcareous quartz sandstone. A section 370 feet thick was measured on the south-eastern side of Spirit Hill, and illustrated as Column A in Sheet 2. The base of the member is not exposed here. Much of the limestone appears to be dolomitic, for the weathered surface exhibits rhombs, and fresh surface may be fawn or pink. Selected specimens from various horizons (see Column A Sheet 2) were etched with 2N formic acid. Percentages of calcite were then estimated by eye with the aid of a hand-lens.

The limestone ranges from grey to fawn-grey, or in some cases dark grey, on the weathered surface. On a fresh surface, it is grey to fawn, fawn-grey or pink.

The calcareous quartz sandstone is fawn or fawn-grey on weathered surface, and fawn on fresh surface. The quartz grains are fine to coarse in size.

The limestone beds are generally resistant, and fairly well-bedded; the calcareous sandstone is less resistant, and less well-bedded. The gaps in the column, indicated as "no outcrop", may represent calcareous sandstone rather than limestone.

Much of the limestone contains quartz sand, fine to coarse grained.

There are some fragmentary fossil remains - mostly crinoid columnals, and an occasional coral, similar to Syringopora, which has been recorded from this locality by Traves (1955, p.76). They show that the member is marine.

There is some cross-bedding, on a small scale, in the limestone, indicating that it is of clastic origin. However, no true calcarenites were found, which suggests that there must have been thorough recrystallization.

The thickness of this lower limestone member is estimated to be about 400 feet (measured as 370 + feet in Column (4), where the base is not exposed.)

Member (c). This member, which is about 100 feet thick, crops out well on the north-eastern side of Spirit Hill, where it lies conformably on the lower limestone member (b); together they make up the Spirit Hill Limestone (Traves, 1955, p.76). Member (c) consists of (i) dolomitic limestone, dark grey on weathered surface, grey to fawn or pink on fresh surface, often containing quartz sand, and (ii) calcareous quartz sandstone.

This member has a thin bed of conglomerate, about 2 feet thick, well exposed in the southern side of the outcrop 1/2 mile north-west of Spirit Hill. A similar conglomerate, of about the same thickness, occurs in a similar dark grey dolomitic limestone in the south-eastern corner of the fault-block 1 mile south-west of Spirit Hill; it is correlated with the former conglomerate, on grounds of lithological similarity. This conglomerate is a pebble conglomerate, the average size of phenoclast being 1½ to 2 inches; there are some cobbles ranging up to 5 inches; the index of roundness is 0.5 - 0.7, (rounded to well-rounded) composition of phenoclasts is siliceous quartz sandstone and quartzite; the matrix is calcareous quartz sandstone.

The member contains a few marine fossil shells, crinoid columnals and a coral cf. Syringopora.

Mineralization.

Small subhedra of galena up to 1/2 inch in length were found in this upper "limestone" at two localities, (refer to accompanying geological map Sheet 1): (1) on the eastern side of the fault-block 1 mile south-west of Spirit Hill, (2) 1/2 mile north-north-west of Spirit Hill. In each outcrop the galena occurs within an area about one yard or less in diameter.

Along a fault at the eastern end of the outcrop 1/2 mile north-west of Spirit Hill, there is a ferruginous gossan, with yellow staining.

At mineral locality 3, immediately to the west of 2, is a small outcrop about 30 feet in diameter of rock, purplish-black and shiny on weathered surface, fawn to pink on fresh surface with small patches of dull black, it is of high specific gravity. The material occurs in small blocks of irregular shape, mixed up with which are fragments of crinoidal limestone, partly leached. The material is surrounded by small blocks up to 18 inches long, of siliceous quartz sandstone, lying on, and jumbled up with, blocks of quartz sandstone. The whole lies within a mass of upper "limestone", actually here a grey medium-grained calcareous quartz sandstone, pink on fresh surface, and thus probably dolomitic.

A specimen of the heavy material occurring in the centre of the outcrop was examined in the laboratory (Appendix A) and found to consist of lead carbonate (cerussite) (pink-fawn) with patches of manganese oxide (psilomelane) (dull black), possibly some manganese carbonate (rhodochrosite), together with a silicate (?) and included quartz grains.

The quartz grains indicate that the material was originally a quartz sandy limestone, altered by mineralizing solutions containing (at least) lead and manganese, i.e., there has been metasomatic replacement of calcium carbonate by lead carbonate and manganese carbonate. Probably the solutions were introduced along the inferred fault or strong joint which lies immediately to the east of the outcrop, between it and mineral locality 2.

It is interesting that all these mineral localities, 1 to 4, are adjacent to a fault or strong joint.

Member (d_1). In the section exposed on the south-eastern side of Spirit Hill and illustrated as Column A in Sheet 2, the lower limestone member (b), of the

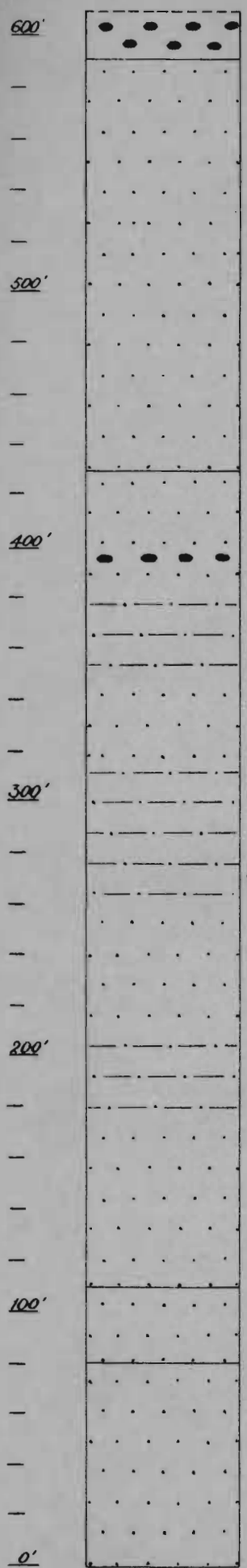
Spirit Hill Limestone, instead of being overlain by the upper limestone member (c), is followed, apparently conformably, by some 90 feet of slightly feldspathic quartz sandstone, (d_1). It is red-brown to fawn in colour, friable to very friable except where silicified locally, medium to coarse grained, fairly well-sorted and well-bedded to poorly bedded. If the base of this sandstone is traced laterally around the eastern side of the hill here, it is found that the arenite gives way abruptly to sandy limestone, and calcareous sandstone of member (c). The point where the "limestone" ceases is readily seen, for this member crops out well. The sandstone (d_1) crops out poorly here, and the relationship of the two is thus difficult to determine. The two members appear, at first glance, to be separated by a fault, but the topmost bed of the underlying "lower limestone" (b), seems to be continuous under both "limestone" (c), and sandstone (d_1). Again, no evidence for faulting was seen in the "limestone." However, the Spirit Hill Limestone rarely shows much effect from even strong faulting.

An alternative explanation is one of lateral gradation from "limestone" to sandstone. This is not likely, as the "limestone" ends abruptly, without interfingering with sandstone.

The sandstone member, (d_1), is distinguished as such only because it lies directly on the lower limestone member (b). Similar sandstone, lying on the upper limestone member (c), is included in member (d) (undifferentiated sandstone, siltstone and conglomerate). There is little or no difference lithologically between these two sandstones.

Member (d). This "member" consists of some 600 feet of sandstone, siltstone and conglomerate, generally poorly outcropping. It appears to follow the upper limestone member, (c), conformably. It is undifferentiated on the accompanying map (Sheet 1) and stratigraphic columns (Sheet 2), except for a bed of conglomerate, occurring at the top of the "member", which was mapped wherever found. The reason for not mapping the various sandstone, siltstone and conglomerate beds separately was because of their paucity of outcrop, and the lack of sufficient time to follow the boundaries (as these, unlike those between the other members, could not be traced on the aerial photographs.)

The general sequence of the member where exposed in the hills about 2000 yards north-west of Spirit Hill is illustrated as a stratigraphic column in Figure 1.



20'+ Pebble and cobble conglomerate, with boulders up to 18" long; phenoclasts mainly of quartzite; rounDness 0·5 – 0·7.

160' Quartz sandstone, medium-grained, slightly felspathic, silicified in part; ripple-marked.

320' Fine-grained quartz sandstone, found in small blocky fragments only; also pebble conglomerate and mustard-coloured siltstone; none of these in situ.

30' Quartz sandstone and quartzite pebble conglomerate; sandstone shows slight beehive weathering.

80' Quartz sandstone, with some grains of white clay mineral after felspar; one bed has red-brown ferruginous matter between grains; sandstone friable, except where silicified in part.

Scale 60' to 1".

Figure 1: Generalised Sequence of Member "d" where exposed in the Hills about 2000 yards North-West of Spirit Hill.

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This sequence should be regarded as approximate only, and the thicknesses as estimates.

It is interesting to compare the lower part i.e., the first 100 feet, of this sequence with the upper part of Column A illustrating the sequence at the top of Spirit Hill. The two are similar in lithology and thickness of beds, suggesting that the member (d_1), on these grounds, could be equivalent to the basal sandstone of (d).

Another exposure of this "member" (d) was examined in the hillside 1½ miles south-west of Spirit Hill. It is illustrated in Column B on Sheet 2. If the conglomerate at the top is equivalent to the topmost bed in the general sequence (Figure 1), then this exposure is of the upper 400 feet of the "member". The only beds cropping out there are of quartz sandstone, with some white and fawn clay mineral, fine to coarse grained. Fine grained sandstone and siltstone were seen also, but only as blocky fragments on the surface, not in situ. Quartzite pebble and cobble conglomerates are represented by phenoclasts lying loose on the surface; there is no outcrop.

The sequence at this locality corresponds with that of Figure 1, allowing for the lack of outcrops and for a reasonable amount of lateral variation over the distance (1½ miles) between the two.

The best exposure of the siltstone and fine sandstone of this "member" (d), was found at a locality 2½ miles north-north-west of Spirit Hill, a few yards to the east of, and topographically below the point whose height is shown as 455 feet. Here the strata are well exposed for some ten feet or so, in a vertical face overhung by a resistant bed of sandstone.

In the south-western portion of Spirit Hill, where the section illustrated in Column C, Sheet 2, was examined, there crops out at the foot of the ridge, some 20 feet of pebble conglomerate, which the author correlates on structural grounds with the topmost conglomerate of (d), i.e., bed (^{d} cgl). This pebble conglomerate contains cobbles ranging up to 9 inches long; average pebble size is 2 inches; index of roundness 0.5 - 0.7 (rounded to well-rounded); phenoclasts are of quartzite, vein quartz, siliceous quartz sandstone, feldspathic quartz sandstone; the matrix consists of quartz sandstone with a little feldspar. Three lenses of sandstone were seen in this section: the largest 30 feet long and up to 1 foot thick. If this correlation is valid, we have evidence of diminution of size of phenoclasts westward and south-westward, from the

localities discussed above; this is consistent with the reasonable supposition that the provenance of the sediments lay to the east, or possibly north-east, i.e. the area which today is the nearer margin of the basin. Similar diminution of size of phenoclasts was seen in the sediments composing member (f), (q.v.)

This member (d) yielded some fossils (refer Appendix B). A few lamellibranch remains were collected from the basal sandstone at fossil locality 3, 1 mile west-north-west of Spirit Hill, and from a sandstone, believed to be part of (d), at fossil locality 2, 1 mile south-west of Spirit Hill.

Fragments of fossil wood were found in ripple-marked ferruginous sandstone at a point 1¼ miles west of Spirit Hill.

Member (e). This member is well exposed in the south-western portion of Spirit Hill, and was examined in the section illustrated as Column C in Sheet 2. It consists of about 80 feet of quartz sandstone with some clay mineral after feldspar; it is light brown in colour, medium grained, friable, and in part cross-bedded. The sandstone rests conformably on the underlying pebble conglomerate (^{d} cgl). There is a pebble band one layer thick, 10 feet from the base, also a few "floating" pebbles.

The upper part of the member shows beehive weathering structure, less well developed than that in the sandstone member (g). This member (e) was given the field name "lower beehive sandstone".

The top of the member is marked by convolute bands of limonitic sandstone, 1/2 - 2 inches thick, crossing the bedding surfaces of the sandstone.

At a locality 2½ miles north-north-west of Spirit Hill there is a cliff face exposing a pebbly sandstone, with a capping of ferruginous sandstone. If this sandstone can be correlated with the "lower beehive sandstone", which appears likely on structural grounds, then we have evidence of greater carrying power of the medium which transported this sediment. Hence we have further evidence for the belief that the source of these clastic sediments lay to the east or possibly north-east.

The "lower beehive sandstone" (e), is overlain conformably by member (f). Due to differential weathering there is a noticeable "change of slope" from one to the other, readily seen in the aerial photographs under the stereoscope.

Member (f). This member shows considerable lateral variation in lithology, and is best defined as the member lying conformably between the "lower" and "upper beehive sandstones" ((e) and (g) respectively). The type locality is 3 miles west-south-west of Spirit Hill. Here, the member is nearly 80 feet thick, and consists of (Column 3 Sheet 2) :

Medium to coarse grained quartz sandstone with black crystalline ferruginous cement	-	5 feet
Pebble conglomerate, average pebble size 2 inches, index of roundness 0.5 - 0.7 (rounded to well-rounded); pebbles of siliceous quartz sandstone, quartzite, quartz sandstone; matrix of ferruginous quartz sandstone.	-	2 feet
Convolute band of ferruginous sandstone	-	3 inches
Medium grained quartz sandstone with numerous white grains, some of decomposing feldspar, others of indeterminate rock; cement black ferruginous	-	10 feet
No outcrop	-	12 feet
Pebble conglomerate, average pebble size 2 inches, index of roundness 0.5 (rounded) pebbles of brown and white quartz sandstone; matrix of ferruginous medium grained quartz sandstone	-	6 inches
No outcrop	-	3 feet
Medium grained quartz sandstone with a little decomposing feldspar	-	6 inches
White siltstone or very fine sandstone alternating with red-brown ferruginous very fine sandstone	-	3 feet
No outcrop	-	8 feet
Ferruginous fine grained quartz sandstone with oscillation ripple-marks (wave length 5.2 cm., amplitude 0.6 cm., profile symmetrical)	-	6 inches

Friable medium grained quartz sandstone with a little decomposing feldspar and white mica; several thin bands of siltstone.	-	9 feet
Fine grained feldspathic quartz sandstone with red ferruginous cement; 2 inch bands of soft white argillaceous fine grained sandstone or siltstone.	-	3 feet
No outcrop	-	1 foot
Brown fine grained quartz sandstone, with white grains of decomposing feldspar; red and brown ferruginous cement; worm tracks on some bedding surfaces.	-	1 foot
No outcrop	-	18 feet.

A case could be made for including the upper 22 feet of the section in the overlying "upper beehive sandstone", (g), on grounds of similar lithological composition; the main point of difference is that these beds in the upper part of (f) have a black ferruginous cement, thus contrasting strongly with the overlying sandstone, which has very little cement, and that argillaceous. Fossil wood, preserved as limonite, was found in scree from this member, 3½ miles west-south-west of Spirit Hill.

The member may thin northwards for at a point 2½ miles west-north-west of Spirit Hill, it appears to be only 20 feet thick. This thickness, however, is based on an indefinite identification of the top of the "lower beehive sandstone", (e), in that locality.

At a locality 2½ miles west of Spirit Hill, a conglomerate of this member caps a hill of "upper beehive sandstone".

It is a pebble conglomerate some 20 feet thick; near the base it is a fine pebble conglomerate, with a few larger pebbles and cobbles, up to 8 inches in length; average size is 1/2 inch.

The phenoclasts have an index of roundness of 0.3 - 0.5 (subrounded to rounded) and consist mainly of fine siliceous quartz sandstone and quartzite; one pebble of fine grained granite was found. The matrix is of fine grained quartz sandstone; the cement is indeterminate. Towards the top of the hill, the conglomerate becomes coarser: it is still a pebble

conglomerate, of average pebble size 1 - 1½ inches, but contains cobbles up to 12 inches in length. Roundness of phenoclasts is 0.5 (rounded). Composition of phenoclasts remains the same. Matrix is quartz sandstone; cement is ferruginous in part, otherwise indeterminate.

A similar conglomerate caps the mesa 1½ miles west of Spirit Hill (see section line EF on Sheet 1); the small knoll 500 feet to the north-east of this mesa is made up entirely of this conglomerate. At the latter locality, the conglomerate is a fine to coarse pebble conglomerate, with cobbles and small boulders. The phenoclasts, which are of roundness about 0.5 - 0.7 (rounded to well-rounded), include siliceous quartz sandstone, quartzite, and feldspathic quartz sandstone. The matrix consists of argillaceous quartz sandstone. Besides the phenoclasts described above, there are a few large angular blocks, some over 6 feet in length, tending to lie parallel with the bedding. They are composed of purple-grey indurated mudstone, and thus contrast strongly with the other phenoclasts. They are so much larger than the other phenoclasts, and so different in composition and roundness, that it is obvious that they must have experienced an entirely different mode of transportation. They may be glacial erratics, dropped from a melting iceberg.

Member (g). This member, the "upper beehive sandstone", crops out well over the western side of the area mapped. In the type locality, 3 miles west-south-west of Spirit Hill, (Column C, Sheet 2) the lower portion of the member was examined in detail, but it was impossible to obtain a full section due to the peculiar beehive weathering structure, which makes climbing very difficult. Here, the member consists of medium grained friable quartz sandstone, with a little decomposed feldspar; in part the cement is white, argillaceous. There are pebble beds near the base; the phenoclasts range up to 6 inches long, are of average size 2 inches, have an index of roundness of 0.5 - 0.7 (rounded to well-rounded) and consist of quartz sandstone, quartz, and quartz pebble conglomerate.

At the locality 3¾ miles west-north-west of Spirit Hill, the "upper beehive sandstone" is friable quartz sandstone with about 10% of fawn clay mineral after feldspar; it is medium to coarse grained, and the grains are sub-rounded.

The beehive weathering structure, mentioned above, is a strong

characteristic of this member. It is much better developed than in the "lower beehive sandstone". Great blocks of the sandstone, some as much as 100 feet high and 50 feet square at the base have weathered into the general shape of old-fashioned beehives, with a shingled effect visible on the surface.

Another important feature of this upper beehive sandstone is the strong jointing, on a large scale. This probably contributed to the beehive weathering in that it provided large blocks suitable for the process to work on. The joints show up well in the aerial photographs, and were found to be of considerable help in recognising the member. There is a strong system of joints trending about 70 degrees east of north, and a weaker system trending at about right angles or slightly less to this, i.e. about 20 to 10 degrees west of north. The latter joints are less constant in their trend than are the former.

Member (h). This, the topmost member mapped in the Spirit Hill area consists of ferruginous sandstone forming a hard cap to the "upper beehive sandstone" (which it overlies conformably). The thickness is not known, but probably does not excees 10 feet. Possibly this member should be regarded only as the topmost bed of the "upper beehive sandstone", but it was mapped as a separate member because it forms a distinct pattern on the aerial photographs.

Correlation of Members (d) to (h).

Glover (Minad, 1955, p.30), accepting Traves' (1955, p.72) division of the Weaber Group, correlates the beds overlying the Spirit Hill Limestone west of Spirit Hill, i.e. members (d) to (h), with the Point Spring Sandstone. The two formations, though somewhat similar in lithology, differ in their weathering forms; palaeontological evidence is required.

ENVIRONMENT OF DEPOSITION :

The strata exposed in the Spirit Hill area appear to have been deposited in a slowly subsiding marine basin. The lowest beds, of quartz sandstone, with a little white clay mineral, probably after feldspar, suggest a relatively low source area. The grains are well-sorted, and subrounded to rounded (index of roundness 0.3 - 0.5), indicating that they were transported some distance; alternatively, they may be second-cycle, i.e., derived from earlier sediments, such as the sandstones of the Upper

Proterozoic "basement". If the latter holds, then we have to consider where the feldspar came from. The Upper Proterozoic sandstones of the Ord - Victoria region are not strongly feldspathic, no more so than this sandstone; the relatively small amount of feldspar available from them would probably be reduced by mechanical and chemical breakdown during transport. Some igneous or metamorphic rock containing abundant feldspar must, therefore, be invoked.

The "limestone" members (b) and (c), are probably of clastic, rather than chemical or organic origin, for the limestone beds generally contain quartz sand and are interbedded with calcareous sandstone; they are sorted, cross-bedded, and contain only a few fossils, often disarticulated. However, no true calcarenites, that is limestones containing sand-size grains of carbonate detritus cemented by carbonate, were recognised in the hand-specimen.

Many of these limestones of (b) and (c) contain dolomite grains, and most have a granoblastic texture. These facts point to these beds having suffered metasomatism. The magnesium carbonate required for the dolomite may have been present in the carbonate material at or soon after deposition, or may have been introduced later. The first idea is the more probable, though Pettijohn and other writers seem to favour the second. If the clastic material were derived from the dolomitic limestones known to occur in the Upper Proterozoic of the Ord - Victoria region (Traves, 1955; Laing and Allen, 1956), then there must have been an abundant amount of magnesium carbonate available in the sediment.

The change from the "limestone" to the overlying sandstone of member (d) is a significant one, indicating a change in type of clastic material being supplied to the basin, from carbonate plus quartz to quartz (plus a minor amount of feldspar.) In addition, the change indicates that either carbonate was not available in quantity in solution, or chemical conditions did not favour its deposition, for carbonate cement was not found in the sandstone.

There may well be a disconformity here; the time break is unknown. There does not seem to be a structural break, i.e., unconformity.

The lowest bed of (d), a sandstone, reflects relatively quiet conditions in the basin. It is similar in lithology to the sandstone of

member (a), and indeed to nearly all the sandstones in the members (d) to (h); the composition is essentially quartz, with a minor amount of feldspar (up to 15%); in a few there is an appreciable amount of cement, siliceous, ferruginous or rarely, argillaceous. Thus, we may assume that all these sandstones are the product of much the same depositional environment, that discussed for member (a).

The conglomerates of the members (d) to (h) also are similar to each other in lithology, for the main constituents of their phenoclasts are quartzite and quartz sandstone. They range in type from boulder down to pebble conglomerate, the majority falling in the latter class; all show good rounding of phenoclast. The conglomerate of member (f) differs somewhat from the others in having argillaceous material in the matrix; in one outcrop it also carries large blocks of argillite. In general, however, the conglomerates appear to be similar in origin to the sandstones. To account for the deposition of gravel rather than of sand, assuming a similar source area for the sediments, one or more of the following factors must be invoked :-

(1) Uplift of source area, resulting in faster flowing streams, capable of carrying gravel.

(2) Provision (by uplift ?) of a new source area closer at hand, consequently gravel was transported to this part of the basin, where only sand had been carried previously.

(3) Change of climatic conditions, resulting in increased rainfall: faster flowing streams now able to carry gravel. Thin beds of conglomerate may have resulted from increased "run-off" after single storms.

From a study of the conglomerates alone, it is not possible to decide which of the factors is the most likely. However, structural considerations favour (1) or (2), for the Spirit Hill area is bounded on the east by the strong Cockatoo Fault, which is believed to have been active until at least the end of Weaber times.

Whichever factor holds, it is reasonable to expect a progressive decrease in average size of phenoclast away from the source area, i.e. near the source we would expect to find coarse conglomerates, which traced away, basinwards, would become finer, grading eventually into sandstones

or possibly siltstones.

As described above there is this gradual diminution in size of phenoclast from east to west in several beds of conglomerate in the Spirit Hill area.

The fine sandstones and siltstones of member (d), and of member (f), probably were deposited under quiet, shallow water conditions; the streams which brought down the clastic material must have had little carrying power, possibly as a result of the source area having low elevation.

PALAEONTOLOGY :

The strata in the Spirit Hill area were found to be rather poorly fossiliferous, and as a result, it was possible to make only a meagre collection (Appendix A). All the specimens came from the Spirit Hill Limestone and overlying sandstone. The collection was forwarded to Mr. G. Thomas, of the Bureau of Mineral Resources, for palaeontological examination; the results of this are not yet available.

Opik (Traves, 1955) on field determination of fossils, considered that the Spirit Hill Limestone was of Permian age. Thomas (1956) examined fossils collected from a limestone very similar to the Spirit Hill Limestone, cropping out 3½ miles north-north-east of Spirit Hill. He suggested that the formation was Moscovian in age.

STRUCTURE :

The main structural features of the Spirit Hill area are :-

(i) the faulted anticline 1 mile west of Spirit Hill.

(ii) the anticline 500 feet east of Spirit Hill.

(iii) the syncline between (i) and (ii).

(iv) the regional dip of about 2° or 3° to the west-north-west, of the beds west of (i).

(i) About 1 mile west of Spirit Hill is a strong fault, with meridional trend, which cuts off Spirit Hill Limestone on the east against beds of member (d), on the west. West-south-west of Spirit Hill, the fault forks; in the vee so formed lies a fault block of limestone and sandstone cut by minor faults. The limestone lies in the middle of the vee; on the eastern side it is overlain by sandstone, which is correlated with member (d). On the western side, it appears to overlie another sandstone, whose position in the stratigraphic succession is doubtful.

At a point 1 mile south-west of Spirit Hill, the dip of the fault surface was deduced from that of a set of strong fractures in the limestone adjacent to the fault, to be westward at 65°. The dip elsewhere is not known, but is expected to be similar. The fault is thus a normal one, for the arenites of member (d), though younger than the limestones of members (b) and (c), now lie against them. The throw of the fault, from the evidence, must be between 150 feet and 450 feet.

West and south-west of Spirit Hill, the structure is actually a faulted anticline, for the beds on each side of the fault dip away from it, at an angle of up to 10° (See Section on Sheet 1). This feature could not be due to faulting alone, on the evidence available. On the eastern side there appears to be closure to the north, for the beds strike north-west into the fault and dip north-east.

(ii) Spirit Hill lies on the western flank of an anticline. This plunges in the direction 35 degrees east of north at an angle of between 8 and 10 degrees. It is slightly asymmetrical, the eastern limb (average dip 10 degrees) being a little steeper than the western (average dip 8 degrees). It is open to the south-west. This anticline is developed mainly in beds of the "lower limestone member", (b). Beds of member (a) are exposed in the "open" portion of the anticline, i.e., to the south-west, and beds of members (c), (d_1) and (d) overlie those of (b).

(iii) Between the two anticlines (i) and (ii) lies a small complementary syncline. It plunges in the direction 20 degrees west of north, at an angle of about 7 degrees. It, too, appears to be slightly asymmetrical, for dips in the eastern limb average 8 degrees while those in the western limb average only 7 degrees.

(iv) The uniform, gentle dip of 2-3 degrees west- north-west is a striking feature of the beds exposed in the western half of the area mapped. This is gentle enough to be an initial dip. However, it is probable that the beds when formed were flat-lying or very nearly so, and gradually assumed their present attitude as a result of gentle downwarp of the middle part of the basin.

Numerous small faults have been mapped; the existence of most is inferred, the only evidence being faint lineations on the aerial photographs.

OTHER LOCALITIES :

A number of isolated outcrops to the south-west of Spirit Hill (Figure 2) were examined to determine the relationship of the strata there to those in the area mapped.

Four miles west-south-west of Spirit Hill lies a knoll, 215 feet high. The beds exposed consist of (1) fine grained feldspathic quartz sandstone, cross-bedded, and containing fossil plant stems, overlain by (2) friable medium grained quartz sandstone with hard bands forming platforms. The total thickness is about 15 feet. The beds dip in direction 335 degrees at an angle of 5 degrees. They are correlated, on lithology, with the sandstone beds towards the top of member (d).

Three-quarters of a mile south-west of this knoll lies another, an inlier in black soil of the Southern Keep Plain. Its height is 200 fee, and the top is 40 feet above the level of the plain. The rock at the foot of the knoll is well-bedded medium grained quartz sandstone, with white clay mineral; its colour is a faintly purplish shade of fawn. Near the top it becomes more resistant, and the bedding is less clearly defined. At the top of the knoll is a less resistant sandstone, and a thin grit. The sandstone contains fragments of tree trunks ranging up to 3 feet long and 1 foot thick. There are also thin beds of fine sandstone containing small pellets of fine sandstone, roughly ellipsoidal in section, up to 1/2 inch long, and lying parallel to the bedding. From an examination under the hand-lens, it appears that there is no lithological difference between the sandstone of the pellets, and that of the matrix. The pellets show only on weathered surfaces, not on fresh.

These beds dip in the direction 335 degrees at an angle of 7 degrees. They too are correlated with the sandstones in the upper part of member (d).

One and one-quarter miles north of this knoll is a low rise, 210 feet high. The strata exposed here are :-

Pebble conglomerate, with cobbles up to 7 inches long; average size of phenoclasts lies within range 1 - 2 inches; index of roundness is about 0.5 (rounded); phenoclasts are of quartzite, quartz sandstone and feldspathic quartz sandstone; the matrix is of ferruginous quartz sandstone - 25 + feet;

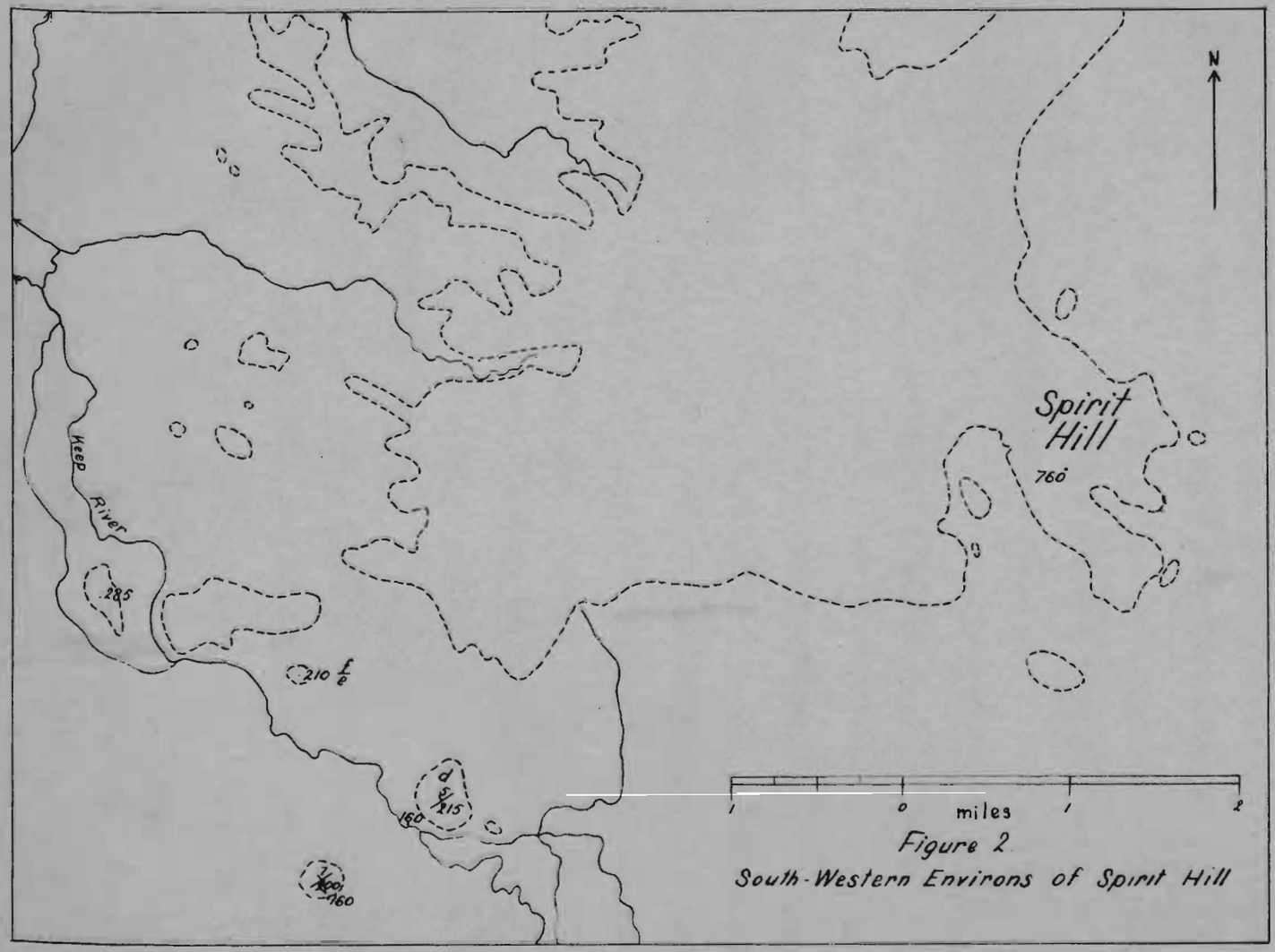

Figure 2.
South-Western Environs of Spirit Hill

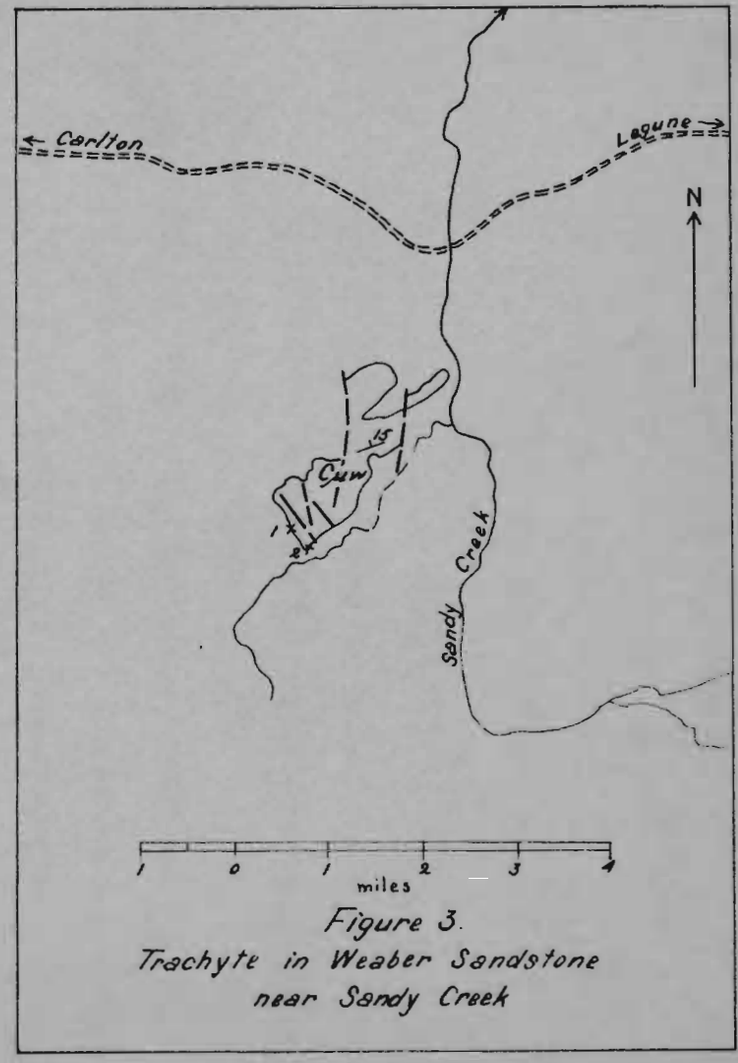

Figure 3.
Trachyte in Weaber Sandstone
near Sandy Creek

Ferruginous quartz sandstone	- 3 inches.
Quartz sandstone, with white to fawn clay mineral; friable; medium grained; poorly developed beehive sandstone	- 10 + feet.

These beds dip in direction 290 degrees at an angle of 2 degrees. They appear to be equivalent to members (e) and (f), i.e., the "lower beehive sandstone" and overlying conglomerate.

One half mile to the north-west of this rise, is a group of low rises covered with loose pebbles and cobbles, with a few boulders up to 20 inches long. There are also large blocks of medium to coarse grained ferruginous quartz sandstone, not in situ.

West of the Keep River, 5¾ miles west of Spirit Hill is an isolated hill 285 feet high. Eighty-five feet below the top of the hill, the strata consist of :-

Friable quartz sandstone, showing poorly developed beehive weathering.

Convolute band of ferruginous quartz sandstone.

Pebble conglomerate, with cobbles.

At the top of the hill is some 15 feet of medium to coarse grained quartz sandstone, with white clay mineral grains, and mustard coloured ferruginous cement; the rock has a hard surface, but is slightly friable within. The beds near the foot of the hill dip in the direction 20 degrees at an angle of 10 degrees. The attitude of the higher beds is uncertain, as they are somewhat disturbed. The correlation of the beds at this locality is doubtful: they may be equivalent to the lower part of the "upper beehive sandstone", and the beds underlying it, or possibly they may be stratigraphically higher.

At Milligans Yard Hills, 7½ miles south-west of Spirit Hill are "steep residual mounds of Keaber sandstone and conglomerate." (Minad, 1955, p.28). The members cropping out here closely resemble, in their weathering forms, lithology, and stratigraphic sequence, the members (e), (f) and (g) at Spirit Hill, and it is reasonable, on these grounds, to correlate the two exposures (compare Sheet 5, Column 6 of Minad, 1955, with Sheet 2, Column 3 of this report.)

PART II. STRATIGRAPHIC COLUMNS.

I. COCKATOO SANDSTONE :

A section of the Cockatoo Sandstone was examined in the Cockatoo Sands area, about 75 miles south-east of Wyndham, on the road to Newry. The section is illustrated as a stratigraphic column on Sheet 3. Dips were measured with a Brunton level, and heights with an aircraft altimeter.

The lower part (2,000 feet) of the formation is resistant to weathering and crops out in high strike ridges to the south of the road. The sandstone lies on fine grained basic volcanic rock of the Antrim Plateau Volcanics; scree and soil hide the contact.

In this lower part, the formation consists in general of feldspathic quartz sandstone, more or less friable, but silicified in parts. The grain size ranges from fine to coarse, but mostly is medium grained. It contains a few pebbles, and bands of pebble conglomerate with cobbles and a few small boulders. Most of the phenoclasts are composed of quartzite or quartz sandstone, much of which is thin bedded; they tend to be discoidal, with an index of roundness of 0.3 - 0.5 (subrounded to rounded). Some of the sandstones are cross-bedded; the bands of conglomerate and pebbly sandstones tend to be lenticular. Ripple marking is uncommon. No fossils were found.

Most of the upper part (1500 feet) of the formation has weathered to a loose sandy soil. The only outcrops occur in a few isolated low knolls.

In this upper part, the formation consists of feldspathic quartz sandstone, fine to medium grained; the roundness index is 0.5 - 0.7 (rounded to well-rounded) and sorting is fair; the rock is very friable and cross-bedded. In the main, it is free from phenoclasts, though the highest beds contain a few pebbles. Near the top is a bed of sandstone containing a few black mineral grains, some of which are lath-like (tourmaline ?), and a few grains of red garnet.

The Cockatoo Sandstone is overlain conformably by the Burt Range Limestone (Traves, 1955, p.61). The boundary was not found. It has been drawn along Eight Mile Creek by Traves (1955, Plate 1) and Minad (1955, Sheet 3), but only sandy alluvium was seen there; the nearest outcrop of sandstone lies about 1/2 mile south of the creek, and that of limestone between 1/2 and 1 mile to the north.

The measured thickness of the formation is 3,500 feet, from the base to the highest bed exposed. If the boundary is assumed to be along Eight Mile Creek, then the estimated thickness is 3,800 feet.

The age of the Cockatoo Sandstone is probably Upper Devonian (Traves, 1955, p.61).

BURT RANGE LIMESTONE :

Two sections of Burt Range Limestone were examined (Sheet 4), one in the southern slope of the eastern part of Enga Ridge (Column A) and the other between Eight Mile Creek and Mount Septimus (Column B).

Column A shows the upper part (600 feet) of the formation, and the lower part of the Enga Sandstone, which follows it conformably. This upper part of the Burt Range Limestone consists of calcareous quartz sandstone, and limestone containing quartz sand, together with non-calcareous quartz sandstone, containing a little feldspar; this sandstone is fawn or brown in colour and fine to medium grained. It is very similar lithologically to the overlying Enga Sandstone. For convenience a division is made between the two formations, at the horizon selected by Traves (1955, p.62) (the topmost bed of calcareous rock), but actually the column indicates that below this horizon there is an alternation of calcareous and non-calcareous beds. Thus between 230 feet and 320 feet, the beds exposed are mainly of non-calcareous sandstone, similar to the Enga Sandstone. The beds from 320 feet to 480 feet are of calcareous sandstone and limestone. At 480 feet is a bed of sandstone very similar to the Enga Sandstone. Between this horizon and the top of the formation at 620 feet the beds are nearly all of sandstone like the Enga, except for a few of calcareous sandstone the topmost bed of which marks the top of the formation.

The section examined between Eight Mile Creek and Mount Septimus (Column B) is almost complete, except that the bottom and top of the unit, i.e., the boundaries with the Cockatoo Sandstone and Enga Sandstone, respectively, are obscured by soil. The lowest bed exposed is a limestone, cropping out one mile east of Sandy Creek. Further east, there are other outcrops, some with secondary limestone associated, and many others consisting only of secondary limestone.

The beds cropping out consist of calcarenite, calcareous quartz sandstones and coquinite. The calcarenites and calcareous quartz sandstones range in grain size from fine to coarse, and many are fossiliferous, containing shell and crinoid fragments, and some well-preserved rhynchonellids. Some of the calcarenites contain quartz grains. Both shell and crinoid coquinites were found.

No correlation could be made between the two columns A and B. It appears that the top of the unit, represented in A, does not outcrop in the

section represented by B, or if it does, is lithologically dissimilar.

The thickness of that part of the formation exposed was calculated, from the width of its exposure, and the average dip, to be 3000 feet. The average dip was taken as 10 degrees, but it may be less: Traves (1955, p.62) considers it to be 5 to 10 degrees.

Allowing for non-exposure at the base and top of the unit, the estimated maximum thickness is 4000 feet, assuming the 10 degree dip.

The Burt Range Limestone is overlain conformably by the Enga Sandstone, and is of Upper Devonian age (Traves, 1955, p.65).

3. ENGA SANDSTONE :

This formation was examined in the section at the eastern end of Enga Ridge (Sheet 3, Column A). Only the lower 340 feet of it are exposed here, between the top of the Burt Range Limestone (which it overlies conformably) and the highest point of Enga Ridge at this locality. The full thickness of the unit is not known, but probably would not exceed 500 feet. This figure includes the 120 feet of transitional beds underlying the Septimus Limestone, six miles south of Mount Septimus (Minad 1955, p.21).

In the lower part, exposed on Enga Ridge, the Enga Sandstone consists of quartz sandstone, with a small amount of feldspar; it is white to fawn, and less commonly reddish in colour, well jointed, well bedded, friable to silicified, except for some beds which have an argillaceous cement; sand pellets, worm tracks and a few poorly preserved lamellibranchs were found.

The Enga Sandstone probably represents the earliest sedimentation in Lower Carboniferous times, in Bonaparte Gulf Basin. It is overlain conformably by the Septimus Limestone (Lower Carboniferous) (Traves, 1955, p.66).

PART III : MISCELLANEOUS PROBLEMS.

1. TRACHYTE AT SANDY CREEK.

Traves (1955, p.74) found trachyte near the base of the Migli Gap Sandstone at several localities adjacent to the eastern margin of the Burt Range Basin. There has been some controversy about the relationship of the trachyte to the sandstone: Traves believes that the volcanic materia was extruded at the same time as the sediment was being laid down. Rade (1955, p.2) holds that the trachyte is younger than the sediment.

At a locality 3½ miles south-south-west of the Sandy Creek crossing, trachyte crops out in the south-western and south-eastern slo

of a hill of Weaber sandstone (refer Figure 3.) (This is the locality referred to by Traves, 1955, p.74 as "the hills to the east and north-east of fossil locality 18.")

In the south-western slope of the hill, (locality 1, in Figure 3), large blocks of trachyte were found, though none was seen in situ. The rock is a fine to medium grained dark purplish-grey volcanic, weathering red-brown, with pin-head inclusions of soft brown material (weathered zeolite ?). In the hand specimen, it could be mistaken for basalt, especially as it is vesicular in part. One of the blocks showed irregular shaped fragments of vesicular trachyte, ranging up to about 6 inches by 3 inches in size, surrounded by fine grained non-vesicular trachyte. There were numerous fine irregular veins of a white mineral, with radiating habit and harder than steel. There were also several small blocks showing fragments of vesicular trachyte included in sandstone. The latter appears unaltered; it is a fine to medium grained quartz sandstone, with light grey argillaceous (?) cement. The fragments range from about 1/2 inch to 12 inches in size, and most are sub-angular.

On the south-eastern slope of the hill (locality 2 in Figure 3), the trachyte is better exposed, though not definitely in situ. It may be as much as 15 feet thick here, and probably at least 10 feet. It consists of vesicular trachyte, some of which contains small included fragments of quartz sandstone, similar to that which contained inclusions of vesicular trachyte, on the south-western slope of the hill.

The base of the trachyte was not found. At the foot of the slope is a small exposure of plicated, thin bedded quartzite and siliceous siltstone, striking in the direction 30 degrees east of north, and dipping north-west at about 60 degrees.

The trachyte is overlain here by medium grained quartz sandstone, with a few grains of white clay mineral; it is slightly ferruginous, resistant, and "blocky" in appearance. About 20 feet above its base is a pebble conglomerate containing a few cobbles; the phenoclasts are mostly of quartzite.

The evidence suggests that the deposition of sandstone and extrusion of trachyte were contemporaneous events. The phenoclasts of trachyte within sandstone may have been scoriae from an adjacent explosive vent, falling into a sand in process of deposition. Alternatively, they may have resulted from

flow of trachyte into water, the sudden cooling causing shrinkage and breakage into small blocks and fragments. The former theory is favoured for two reasons :-

(a) Traves (ibid) has noted a volcanic vent of this type, at the eastern end of Nigli Gap.

(b) The trachyte phenoclasts examined do not have the characteristics of spilites or pillow lavas, which might be expected had the lava flowed into water.

The slight rounding of the phenoclasts may be explained, under the first theory, as being due to slight flow of the still-molten scoriaceous material during its flight; under the second theory, it may be attributed to abrasion by quartz sand during possible transport by water.

The fragments of sandstone found in the trachyte at the second locality were probably picked up by the parent lava forcing its way up through a sandstone member, possibly at or near the base of this Nigli Gap Sandstone, with which the trachyte is believed to be contemporaneous.

It is interesting to note that the known outcrops of the trachyte occur adjacent to the great Cockatoo Fault, or lesser faults associated with it. The fault zone evidently provided a line of weakness up which the magma rose.

2. PETROLIFEROUS (?) LIMESTONE FROM BUTTONS CROSSING :

Specimens of brown petroliferous (?) limestone were collected from the outcrop of Burt Range Limestone at Buttons Crossing of the Ord River, near Kimberley Research Station. The specimens came from several bands in the lower middle horizons of the outcrop.

When broken open, the rock smells slightly of petroleum. Some of the material was crushed, and extract attempted with acetone and carbon tetrachloride. A small amount of water was added to a portion of each of the solutions, which then turned slightly cloudy. The original solutions were examined under ultra-violet light; they fluoresced only very slightly, if at all.

As results of these tests were inconclusive, a sample of the rock was sent to the Chief Petroleum Technologist, Bureau of Mineral Resources for examination.

3. STRATA SAMPLES AND ROCK SPECIMENS:

Representative specimens were collected from all the formations cropping out in the southern part of Bonaparte Gulf Basin, except the Pander Greensand and Keep Inlet Beds. A set of these (Appendix C) typical of the strata from which they came, were forwarded to the Chief Petroleum Technologist, Bureau of Mineral Resources, for porosity and density determinations.

A second set of specimens (Appendix D) including, for completeness, some collected by the Keep River Party in 1955, was forwarded to Dr. J. Glover, University of Western Australia, for petrological examination. Not all of these specimens were typical of the rocks of the units from which they came, as consolidated representatives, suitable for sectioning, were selected.

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APPENDIX A.

Laboratory Examination of a Mineral Specimen from Mineral Locality 3, Spirit Hill.

Colour : pink-fawn on weathered surface; pink-fawn with small dull black patches on fresh surface.

Streak : pink-fawn, (lighter than colour).

Hardness : 4 (harder than calcite, but scratched fairly readily if pressure applied.)

Specific gravity : 4.2

Acid reaction : Reacted with cold concentrated hydrochloric acid; dull black patches gave yellowish-green tinge to whole solution. Medium sized grains of quartz appeared on weathered surface.

Heating resulted in a further (vigorous) reaction, and formation of a white skin, up to 1 mm. thick of siliceous (?) material on surface of sample.

On cooling, solution gave precipitate of fine white crystals, which re-dissolved on heating. This precipitate on treatment with excess ammonia, did not dissolve, nor change colour, thus indicating lead carbonate.

Concluded that the specimen consisted of cerussite (pink-fawn) with patches of psilomelane (dull black), possibly some rhodochrosite, together with a silicate (?) (white insoluble coat on acid reaction) and included quartz grains. The purplish-black, shiny surface is probably due to manganese, possibly together with iron.

APPENDIX B.

List of Fossils collected from Spirit Hill (forwarded to Mr. G. Thomas, Bureau of Mineral Resources).

Number	Unit or Member	Locality
F.1	Spirit Hill Limestone	Fossil Locality 1, Spirit Hill.
F.2 - F.3	Spirit Hill Limestone	Spirit Hill.
F.4	Sandstone overlying Spirit Hill Limestone.	Spirit Hill.
F.5	Sandstone in small fault-block, probably overlying Spirit Hill Limestone.	Fossil Locality 2, Spirit Hill
F.6 - F.9	Sandstone overlying Spirit Hill Limestone.	Fossil Locality 3, Spirit Hill
F.10 - F.12	Spirit Hill Limestone	Spirit Hill
F.13	Spirit Hill Limestone	Fossil Locality 4, Spirit Hill.

APPENDIX C.

List of Strata Samples from Bonaparte Gulf Basin, forwarded to Chief Petroleum Technologist, Bureau of Mineral Resources.

Number	Formation	Locality
AAO/KR/1	Upper Proterozoic Sandstone	Pincombe Range
AAO/KR/2	Antrim Plateau Volcanics	Ord River Crossing
AAO/KR/3	Skewthorpe Formation	Skewthorpe Ridge.
AAO/KR/4	Hart Spring Sandstone	Skewthorpe Ridge.
AAO/KR/5	Clark Sandstone	Clark Jump-up.
AAO/KR/6	Cockatoo Sandstone	Cockatoo Sands.
AAO/KR/7	Burt Range Limestone	Burt Range
AAO/KR/8	Enga Sandstone	Enga Ridge
AAO/KR/9	Septimus Limestone	Mt.Septimus
AAO/KR/10) 10A)	Spirit Hill Limestone	Spirit Hill
AAO/KR/11	Sandstone overlying Spirit Hill Limestone	Spirit Hill
AAO/KR/12	Sandy Creek Limestone	Sandy Creek
AAO/KR/13	Point Spring Sandstone	Point Spring.

APPENDIX D.

List of Rock Specimens from Bonaparte Gulf, forwarded to Mr. J. Glover, University of Western Australia.

Number	Formation	Locality
1.	Upper Proterozoic Sandstone	-
2.	Antrim Plateau Volcanics	Ord River Crossing.
3.	Skewthorpe Formation	Skewthorpe Ridge
4.	Hart Spring Sandstone	Near Skewthorpe Ridge.
5.	Clark Sandstone	Clark Jump-up.
5A	Pretlove Sandstone	Pretlove Hills.
6A, 6B, 6C	Cockatoo Sandstone (indurated varieties.)	Cockatoo Sands.
7A	Burt Range Limestone	Enga Ridge
7B	Burt Range Limestone	Enga Ridge
7C	Burt Range Limestone	Central Burt Range
7D	Burt Range Limestone	About 5 miles W. of Mt. Septimus.
7E	Burt Range Limestone	Locality W.A.R.3 of 1955.
8A, 8B	Enga Sandstone	Enga Ridge
9	Septimus Limestone	Mt. Septimus
9A	Nigli Gap Sandstone	?
10A, 11B, 11A, 11B	Spirit Hill Limestone	Spirit Hill
12A, 12B, 12C	Sandstone overlying Spirit Hill Limestone	Spirit Hill
13	Sandy Creek Limestone	Sandy Creek
14	Point Spring Sandstone	Point Spring
14A	Weaber Sandstone (Keep Inlet Beds?)	Tidal flats N.E. of Cleanskin Bore.
14B	Weaber Sandstone (Keep Inlet Beds?)	Tidal flats near Cleanskin Bore.
15	Trachyte (?)	3 miles SSW. of Sandy Ck. crossing on Legune track.

APPENDIX D (Cont.)

Number	Formation	Locality
16A) 16B)	Trachyte (?)	3 miles SSW. of Sandy Creek crossing on Legune Track.
16C)		