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# BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

## RECORDS.

RECORDS 1959/117.



## CAINOZOIC BASALTS OF THE EINASLEIGH 4-MILE SHEET NORTH QUEENSLAND

by

J.G. Best.

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# CAINOZOIC BASALTS ON THE EINASLEIGH 4 MILE SHEET, NORTH QUEENSLAND.

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## SUMMARY

About one third of the area bounded by the Einasleigh Four Mile Sheet is covered by basalt. The McBride Basalt Province is about 2,000 square miles in area and covers the central portion of the sheet. The Wallaroo Basalt Area is a small separate province in the north-east corner of the sheet.

The basalt is mainly effusive and was extruded through many vents,

One hundred and twelve volcanoes have been located on the air photographs, of which one hundred and ten are in the McBride Basalt Province and two are in the Wallaroo Basalt Area, These volcanoes consist of four types; shield volcanoes, pit craters, composite volcanoes and scoria cones; they are present in all stages of preservation.

The location and distribution of many of the vents conforms to two prominent trends in the underlying Precambrian and Palaeozoic rocks, 090° and 010° - 020°.

Twelve vents, representative of the four types were examined on the ground, during the latter part of the 1958 regional geological mapping by the Bureau of Mineral Resources and the Queensland Geological Survey.

In the McBride Province the lava was extruded mainly as "tongues", which coalesced and overlapped and so built a large plateau, which completely buried the pre-basalt topography. Many of the basalt flows were very fluid and lava tunnels were formed. Subsequently the roofs of some of these tunnels collapsed and exposed the lava tunnel. The most prominent of these is Undara Tunnel, the two branches of which can be traced for more than thirty miles, on the air photos. A collapsed portion of this tunnel, about one mile south of Kalkani Cone, was examined during the survey.

The maximum thickness of the basalt is not known, it is at least 375 feet and possibly 2,000 feet.

Most of the drainage in the McBride Basalt Province is subterranean through lava tunnels and other voids.

Around the margin of the basalt, streams have been dammed to form lakes. Diatoms flourished in some of these lakes to form diatomite deposits. Deposits of diatomite have been found in both the McBride Province and the Wallaroo Basalt area. Two ages of diatomite have bee determined; the older, Pliocene, are overlain by younger basalts; the younger, Pleistocene-Recent, was found around the margin of Lake Walters.

The volcanic activity commenced, probably, about upper Miocene and, in the McBride Province continued through till Recent, probably Historical; it probably ceased about Upper Pliocene in the Wallaroo Basalt Area.

The youngest basalt flow is the Kinrara Flow, and both the crater and the flow have all their structures perfectly preserved. This flow has dammed the Burdekin River valley near the "Valley of Lagoons" and "Reedy Brook" and formed countless lagoons and swamps.

Most of the basalt areas, particularly in the McBride Province, is rough and difficult to traverse and its use is limited to cattle.

## INTRODUCTION.

More than 2,000 square miles of the Einasleigh 4-Mile Sheet is covered by basalt.

Twidale (1956) proposed the name McBride Province for the almost continuous basalt mantle covering the central portion and north-east corner of the sheet. Mapping carried out by the Bureau of Mineral Resources and the Geological Survey of Queensland in 1958, showed that the basalt about the Herbert River, in the north-east of the sheet, is separate from the McBride Province. It will be referred to here as the Wallaroo Basalt.

The 1958 mapping of the basalts included a low level (1,000 feet) reconnaissance flight in a Cessna aircraft in July 1958. The area of interest was the Kinrara Basalt Flow.

Towards the end of the field season I spent about eight days on an examination of parts of the McBride Province. Attention was concentrated on the vents, particularly the younger ones, and the Recent, probably Historical, Kinrara Flow, in an endeavour to obtain material for carbon-dating. The search was unsuccessful but added considerably to our knowledge of the history of volcanism in the McBride Basalt Province.

The basalt area is vast, tracks are sparse, and cross-country travel proved difficult and tedious; so that in eight days only a minor portion of the McBride Province was examined in detail.

## PHYSIOGRAPHY

### McBride Province

This province is named from an extinct volcano situated on the north side of the road from "Kinrara" to the Hann Highway (geographic co-ordinates 144°51'E., 18°23'S.).

The basalt mantle is roughly oval in plan with the long axis trending east. The basalt is domed, which appears to be due to an accretion of flow-basalt emitted from the many vents grouped in the central portion of the province. The margin of the province is about 800 feet lower than the central portion.

Around the margin, erosion has exposed thicknesses of basalt, ranging up to 50 feet, in numerous places.

In the centre of the province the thickness is unknown; the deepest bore, a few miles north of Kinrara Crater, was abandoned, still in basalt, at about 375 feet.

The province is an extensive plateau containing many volcanic cones and a very rough surface with numerous "esker-like" stony ridges. Between these ridges are generally black soil flats.

### Wallaroo Basalt

This basalt has been named from Wallaroo Hill, an old extinct volcano about three miles west of "Glen Eagle" Homestead.

Two vents have been recognised in the area, one is Wallaroo Hill, the other is an un-named feature about two miles west of "Glen Ruth" Homestead and they belong to the "Residual Mountain - Skeleton Stage" of erosion (Kear 1957). The Wallaroo Basalt covers about fifty square miles and is a "confined" lava field (Keble 1918). The surface of the Wallaroo Basalt has been considerably modified by erosion and is very much easier to traverse than the McBride Province.

The outliers of basalt on the south side of the Herbert River are, probably, the distal portions of Wallaroo Basalt flows. They are now separated from the parent flow by the Herbert River Gorge, which is about 800 - 1,000 feet deep.

## VEGETATION

The general vegetation in the McBride Province and Wallaroo areas, is open savannah, consisting of eucalypts, generally iron bark, and an extensive area of "spear grass". The spear grass conceals the surface of the ground, and traversing across it is difficult, particularly in a vehicle.

The uniform height of the foliage on the trees provides a very effective screen as viewed from more than several hundred yards. As a result, it is surprisingly difficult to find a topographic feature, particularly in the McBride Province. Features, such as cones, visible above the vegetation from about five or six miles away may be passed without being seen at a distance of a quarter of a mile.

Within this broad expanse of open savannah are isolated "islands" of a different vegetation which show as dark patches on the air photographs.

These patches generally consist of a matted tangle of briar bushes with some dark foliaged smooth barked trees, inter-grown with vines. Stag and Elkhorn ferns are generally developed on young bare lava surfaces (Kinrara Flow is completely covered with it) and in depressions such as "pit" craters and collapsed lava tunnels. Two large patches of these "scrubs", as they are known locally, flank the Hann Highway near the northern end of the McBride Province; but there they are not growing on bare lava surfaces.

In the median section of the Kinrara Flow, swamps occupy collapsed lava tunnels; in and near these swamps casuarinas and paper-bark trees thrive.

## ACCESS.

The Almaden-Forsayth railway crosses the north-western section of the McBride Province from north-east to south-west.

The Hann Highway is a formed, unsealed road (usually referred to as "the P.E.I." by the local inhabitants) and crosses the central part of the province from north to south. The

Mt.Garnet - Wairuna road skirts the eastern side of the McBride Province and also provides access to the Wallaroo Basalts. A formed road, completed in 1958, connects Mt.Surprise, on the Almaden - Forsayth railway, to the Hann Highway. Within this framework of main roads, a number of tracks link homesteads to yards, mills and tanks. Elsewhere, access is usually difficult, particularly in the McBride province.

## DRAINAGE MODIFICATION

Drainage is extensively modified in the McBride Province and the following description is confined to that province. However, Pliocene diatomites associated with the Wallaroo basalt may suggest to some drainage modification by earlier lava flows in that area, since diatomite is generally deposited in lakes.

The rocks underlying the McBride Basalt are probably Precambrian metamorphics and later granites and porphyry intervene. The drainage on these rocks was undoubtedly similar to that on similar rocks, around the margin of the basalt.

Volcanism dammed streams and greatly modified the topography of this area. In the centre of the province the old land surface was completely buried, around the margin dammed streams formed lakes and beyond the margin, basalt flowed down old valleys and formed twin lateral streams. This extension of basalt smoothed and straightened the watershed between the westerly and easterly flowing streams and moved the divide, probably, many miles westward. The present course of the upper Burdekin River is of interest in this regard. This stream rises ten to fifteen miles north-west of "Camel Creek" homestead, flows north for about ten miles and then flows north-west and then west for about three miles west of "Wairuna" homestead. From here it flows south-west for about twelve miles; its course then abruptly swings to the north-west for about two miles, and then abruptly changes course again to the south-west and skirts the flank of the McBride Province for about twenty miles.

The upper Burdekin River is a sluggish meandering stream, flowing in a number of anastomosing channels cut in an aggraded valley. This pattern of stream development is probably due to an elevated intermediate base level. Preliminary inspection, suggests that this development is due to the distal portions of the Kinrara Flow, now partly filling the Burdekin valley for about fifteen miles. Undoubtedly, this young basalt has elevated the intermediate base level, but I consider this to be a subsequent and minor elevation.

There is reasonable evidence to assume that the initial elevation of the intermediate base level was by damming of the Burdekin River by flow-basalt several miles below where its course changes abruptly from south-west to north-west. An examination of the air photographs suggests the presence of a large diatomite deposit in this vicinity. This has not yet been confirmed by ground inspection. The lake, in which this diatomite would be deposited, could have been formed by damming of a north-westerly flowing streams by an eastward-bound basalt flow. If the north-west portion of the Burdekin River, between "Wairuna" and the "Valley of Lagoons" homesteads, is projected in this same general direction, it conforms with a pronounced valley, now almost completely filled with basalt, forty miles to the north-west. Further west again, beyond Mt.Surprise, it conforms with the preserved remnant, in basalt, of a former large stream.

It is suggested that in pre-basalt time the present headwaters of the Burdekin River were part of the Einasleigh River catchment, and so flowed into the Gulf of Carpentaria rather than the Pacific Ocean, as they do today. If this is true, parts of the old valley must now be buried beneath about two thousand feet of basalt.

Probably the most drastic and spectacular drainage modifications were made during the Older McBride period of volcanism. The younger basalts, in general, submerged the older flows and so further modified the drainage pattern. The lakes around the margin, formed as a result of the earlier flows were invaded and diatomite deposits buried by basalt; stream channels formed consequent to the first period of volcanism were partly filled with basalt.

The youngest flow, Kinrara, has partly filled channels incised in older basalts. The distal portions of this flow have dammed the Burdekin Valley for about ten miles and formed countless lagoons and swamps, the largest of which is Saltern Lagoon, between "Valley of Lagoons" and Reedy Brook". The size and distribution of some surface streams in the McBride Province suggest that they carry only a small proportion of the water that falls on that area. Most of the water must be drained away beneath the surface through lava tunnels and other voids. For example, more than thirty miles of the Hann Highway, on the McBride Province is free of creeks.

POPULATION

The population of the area is sparse and mainly engaged with the cattle industry.

There are twenty-one cattle stations and two small towns in the area under discussion. One of these towns, Mt.Surprise, and five cattle stations are located entirely within the McBride Province. The rest of the stations are disposed around the margin of the basalt, though their holdings generally include some basalt country.

Einasleigh, the other main centre, originated as a mining town, but it too is now almost exclusively associated with the cattle industry.

PREVIOUS INVESTIGATIONS

Ludwig Leichhardt and party in 1845 were the first Europeans to view the McBride Basalt Province. For a couple of days the party camped on Reedy Brook Creek, probably near the site of the present homestead, while a route across the basalt plateau was reconnoitered. The rough, almost waterless terrain forced them to abandon their attempts to cross the basalt and they were obliged to skirt its eastern edge. This deviation undoubtedly added several hundred miles to their journey to Darwin.

Leichhardt named Mt.Lang, the most prominent volcano in the eastern portion of the McBride Province.

Daintree (1872) recognised two divisions in the Tertiary volcanic rocks. He states (p.313) 'both the "upper" and "lower" volcanic (rocks) are basic in character, and may, with rare exceptions be all grouped under the general term "dolerites".'

Allport's description of a specimen from the Clarke River, which Daintree (1872, p.313) considered was typical of all the basic volcanic rocks from North Queensland, contains the first record of the alteration of the olivine. He states "The olivine has been completely altered to iron oxide, and appears in the sections as bright red grains and crystals".

Maitland (1891), spent some time on a study of the Tertiary Basaltic Lavas, and recorded some very interesting observations. His estimate of the extent of the basalt accords well with present-day knowledge from air photographs. He states (p.6) "In addition to this immense plateau there occur other isolated patches in the district shown on the map.....The basalt of which the tableland is made up occurs in a series of superimposed lava flows emanating from numerous volcanic focii, which rise as conspicuous hills all over the plateau". Maitland mentioned "the more recent flows" and recorded changes in texture and colour in other basalts; and he drew attention to the absence of "fragmental deposits (ashes, cinders and the like"). He observed altered olivine in the basalts, and wrote (p.6) "Olivine in crystals and crystalline grains, is altered along its edges into a ferruginous product. Sometimes the whole of the crystals and grains have undergone this alteration, but generally the decomposition is found to extend only a short distance from the periphery".

Jack and Etheridge (1892) considered an Older and Newer volcanic series were represented in Queensland although direct evidence of their age is not forthcoming.....Our Older Volcanic Series forms extensive beds....The New Series occurs as lava-flows or "coulies" which have flowed down the valleys denuded of the Desert Sandstone or out of the lower basalt.

Marks (1911) drew attention to the obvious age differences in the basalts on "Carpentaria Downs" Station. Between the Einasleigh and Copperfield Rivers a basalt capped mesa is exposed about 400 feet above the level of these rivers, which are partly choked with basalt of very much younger age. He suggested Stockman Hill, was an old volcano from which these older lavas were extruded.

Twidale (1956) proposed names for the provinces and suggested three age groups for the basalts.

Much of Twidale's work was obviously done by air photograph interpretation and extrapolation. Some of it was misinterpretation and hence some of his descriptions and conclusions are erroneous.

C.E. Prichard, as a member of the 1954 L.R.R.S. team sampled some of the lavas, both older and younger.

R.D. Stevens (unpublished B.M.R. report) examined thin sections of these basalts and recorded: -

(a) Iddingsitization of the olivine phenocrysts in the older basalts (Older and Newer McBride).

(b) Lack of iddingsitized olivine in the Kinrara (youngest) basalt.

## CENTRES OF ERUPTION

### Number, Distribution and Trend.

One hundred and twelve volcanoes have been recognised on air photographs in all stages of preservation, from "volcano" to "skeleton" stage (Kear, 1957). Twelve of these volcanoes were examined on the ground.

Most of the vents form a broad east-trending belt in the middle of the McBride Province, and a subordinate group is clustered near the south-west margin of the province.

There are a few isolated vents farther beyond the western margin of the McBride Province. All are old vents and were active, probably during the early stages of the volcanism.

Two distinct trends, 090° and 010-020°, in the underlying Precambrian and Palaeozoic rocks may have controlled the distribution of some of the vents:-

(i) In the latitude of most of the vents several plutons have been emplaced in a 090° trending area, and Palaeozoic sediments appear to be absent. The plutons, from west to east, are Elizabeth Creek Granite, Herbert River Granite and Tiger Hill Microgranite.

(ii) In the south-east corner of the sheet, the Precambrian metamorphics, the Precambrian/Palaeozoic boundary, and the lower Palaeozoic sediments trend 010-020°.

From the trends it would appear that a zone of weakness in the Precambrian and Palaeozoic basement has localised most of the vents, and the alignment of some of the young adventive scoria cones, 010-020°, conforms to the regional basement trend. This alignment is best displayed by the adventive scoria cones on Racecourse Knob and the three Tabletops adventive on the flank of Murronga Crater.

### Types, Degree of Preservation and Age.

The vents range considerably in size and degree of preservation, but generally four more or less distinct types, can be recognised. They are described below.

#### Shield Volcano

These are the largest structures and are found only in the McBride Province. They are broad domes with flanks sloping at low angles; generally about five degrees or less. They cover large areas up to one hundred square miles or so, and have been built by numerous very fluid lava flows welling out from a single vent or a number of closely spaced vents. The most prominent shield volcanoes in the McBride Province are: -

(See Figure 1)

(i) Racecourse Knob: (144°18'E. 18°18'S.) is an excellent Shield Volcano. From examination of the air photographs the crest appears to be indented by a "Pit" crater, now somewhat modified by erosion. Four, almost perfectly preserved, scoria cones are located near the crest of this volcano. (Twidale (1956) has incorrectly labelled this vent, Mt.Tabletop).

(ii) Mt.Munana about eight miles south-south-east of Racecourse Knob, is an older vent of the Shield Volcano type, now in the Residual Mountain stage of erosion. These two volcanoes, with altitudes a little over 3,000 feet, are the highest in the province.

Pit Craters

Throughout the McBride Basalt Province there are a number of roughly circular depressions, two to five hundred yards in diameter and ranging from fifty to one hundred feet deep. The more recent have steep to sheer inner walls, usually covered with a litter of rough, vesicular basalt boulders.

In all but the youngest (Kinrara), the crater is partly silted-up, so that they now have a flat, fairly smooth floor, covered in open savannah, which contrasts strongly with the thick, matted vegetation mantling the inner walls. The pit craters are difficult to locate on the ground as they are usually apical in low, tumid mounds, indistinguishable from numerous other mounds and ridges in the area. The dark green vegetation in the younger pit craters distinguishes them on the air photographs. The older pit craters in which the vegetation is all open savannah are not so readily recognised.

The younger craters appear to lead into lava tunnels and this association suggests that these craters were reservoirs for lava, which drained-off down the tunnels. With complete draining of these reservoirs, the walls tended to slump inwards to produce a litter of rough vesicular boulders.

(See Figure 2.)

Hence the Pit Craters are the results of lava drainage and subsequent collapse, and for this reason have been termed "Pit" craters, even though they are not exactly analogous to those described in the literature (Cotton, 1944).

In the older vents the connection with the lava tunnels has been obscured by erosion; but there is little doubt they were also formed in the same way.

Twidale (1956) refers to diatremes in the McBride Province, some of which contain lakes. On the air photographs the pit craters, particularly Undara, resemble diatremes; so it is possible he was referring to them. None of the craters investigated were occupied by lakes.

Kinrara Crater (144°55'E, 18°25'S.) is the youngest in the province and is a pit crater, out different to most, in that explosive activity has aided in building a surmounting cone and reaming out the lower crater. The crater is 300 feet deep and the surmounting cone accounts for 150 feet of this depth.
See -
(Figure 3.)

This vent is almost perfectly preserved and is obviously very young. It is roughly circular in plan and about 400 yards in diameter at the crest. Two lava tunnels lead away from it, one to the north-east, the other to the south-west. Near the crater both these tunnels have collapsed.

Within the crater there are two well defined "terraces". The highest terrace is confined to the south-east side and consists of a narrow ledge of basalt, ten to fifteen feet below the rim. This ledge probably indicates the highest level of the magma in the crater. (Figure 3.)

The lower terrace lies about 150 feet below the crest and although not as clearly defined as the higher one, extends right around the crater. Below this terrace the walls of the crater are sheer for three quarters of the way around, but in the south-west sector there is a steep slope, which affords access to the lower part of the crater.

The lower crater is very much narrower than the upper section and is elongated roughly north. It is floored with a jumble of large angular boulders of basalt and was obviously formed by explosive activity.

There are many interesting features associated with the Kinrara Crater:-

(a) Pancake-like "flaps" of basalt are draped over the south-eastern portion of the crater rim. These "flaps" must have been deposited during a "fountaining" stage, probably when the magma stood at the level of the high terrace. Their restricted distribution, close to the high terrace, suggests this origin for them.

(b) On the sheer north wall of the lower crater, a solitary narrow tongue of solidified basalt reaches to within about six feet of the crater floor. This is interpreted as confirmatory evidence of the explosive origin of the lower crater. It is probable that the basalt, which formed this tongue drained back into the newly "blasted-out" crater, from the north-east lava tunnel.

(c) Beneath a projecting ledge on the north-east wall of the lower crater, remnants of siliceous sinter adhere to the crater walls. How long it is since the solfataric activity ceased, cannot be determined, but it is possibly not more than a few hundred years. The crater now contains a fairly dense stand of tall trees.

To date I have seen little of volcanic craters in Australia, and so cannot draw comparisons; but the Kinrara Crater which is beautifully preserved must compare well with other Recent Volcanoes in Australia.

Scoria Cones

This type of structure is built by "fire-fountaining" and mildly explosive activity in the declining stages of a cycle of volcanic activity. Many of these vents, are almost perfectly preserved in the McBride Province.

The younger members of this type, are symmetrical cones, 300-400 feet high and 300-400 yards wide at the rim. All have shallow apical craters and the rim is usually highest on the south-west side, probably owing to the influence of the prevailing wind. The cones are built of basalt scoria with subordinate flows and pyroclasts.

The porosity and permeability of the scoria cones leaves them particularly unaffected by "channelling". In consequence they retain their pristine form far longer than cones built of more impervious forms of lava, such as flows and fine grained pyroclasts.

The scoria cones are commonly adventive on the shield volcanoes and in a number of places are aligned 020°. Racecourse Knob is the best example of this association, containing four adventive scoria cones.

The Tabletops, about ten miles south-south-east of Racecourse Knob are three very symmetrical scoria cones aligned 020°. They are adventive on Murronga Crater, but the relationship is not obvious, as the parasitic vents are more prominent than the host shield volcano.

(See Figures 4 and 5).

Composite Cones.

True composite or strato cones, that is those made up of alternating layers of effusive and pyroclastic lava, appear to be absent in both the McBride and Wallaroo areas. However, there are some cones with too much effusive lava to be classified as scoria cones, so they have been classified as Composite Cones.

Mt.Lang, the most prominent volcano on the eastern side of the McBride Province is the best example of a composite cone. It is now deeply dissected, particularly on the northern, western and southern sides, and part of the inner structure is revealed. Near the crest, a thick deposit of ash and lapilli, containing a few volcanic bombs, is exposed. About 100 feet below the crest, on the western side, a lava tunnel about eight feet wide, four feet high and twenty feet long is exposed. The flow basalt surrounding itis now deeply weathered.

Chubber's Hill two miles north-east of "Meadowbank" is a smaller, more recent composite cone. The cone itself appears to be built essentially of scoria, but the late activity from this vent was almost purely effusive. The lava welled up through the central vent, filled the apical crater and then overflowed on the low, north-east, side of the cone.

THE BASALT FLOWS

Age

Twidale (1956) proposed three ages for the McBride Basalt: -

1. Kinrara - late Pleistocene to early Recent.
2. Newer McBride - early to mid Pleistocene.
3. Older McBride - late Pliocene to early Pleistocene.

The 1958 mapping was not sufficiently detailed to outline separate time-rock units within the basalt; but observations suggest there may have been four main periods of volcanism; or there may be three, consisting of a prolonged middle period, the latter part of which was confined to the McBride Province.

As a result of the 1958 mapping, Twidale's (1956) proposed ages have been modified and the following four ages proposed.

1. Kinrara - late Pleistocene to Recent (Historical?)
2. Undara - early to mid Pleistocene
3. Newer McBride - mid Pliocene to late Pliocene
4. Older McBride - late Miocene to early Pliocene.

In the Wallaroo Basalt, only the equivalents of the lower two "stages" appear to be present.

The "stages" are dealt with below and evidence for their ages discussed.

(a) Older McBride Basalt.

Diatomite deposits closely associated with the basalts provide a means of roughly dating some of them. Two ages of diatomite have been determined (White and Crespin, 1959), the older are Pliocene and the younger Pleistocene to Recent. The diatomite was deposited in lakes which were undoubtedly formed by basalt dams. Pliocene diatomites, would require an early Pliocene or older basalt to impound the lakes. These basalts have been named Older McBride.

Pliocene diatomites have been described from both the McBride Province and the Wallaroo Basalt area, so it is assumed that the oldest basalt in both areas is the same age.

(b) Newer McBride Basalt.

The Pliocene diatomites in both the McBride Province and the Wallaroo Basalt area are overlain by basalt. This basalt is the Newer McBride Basalt.

(c) Undara Basalt.

(i) The surface of the Wallaroo Basalt is more subdued than the surface of the McBride Province.

(ii) In the McBride Province there are many vents older than Kinrara Crater, (the youngest in the whole area) and obviously younger than the two vents in the Wallaroo Basalt area.

(iii) Around the McBride Province are a number of lakes and swamps formed by basalt impounding the drainage.

From these three facts it is deduced that there was a later stage of volcanism in the McBride Province. For this stage the name Undara is proposed. It is named from the well defined pit crater in about the centre of the McBride Province.

(d) Kinrara Basalt.

This has been named after the vent from which it was emitted. It is obviously the youngest basalt in the McBride Province. No definite evidence of its age has been obtained, but it is probably historical since siliceous sublimation products still adhere to the walls of the crater, and the crater and lava flow are well preserved.

## Distribution

1. Older McBride Basalt.

Undoubtedly the Older McBride Basalt underlies most, if not all the McBride Province, but it has only been recognised beyond the margin of the province. It commonly occurs as a capping on mesas and may be underlain by "billy" (silicified quartz sand and gravel). Ridges of "billy" have been mapped in the "Greenvale - Camel Creek" area.

The distribution of the outliers of the Older McBride basalt suggest that the McBride Province was formerly more extensive.

2. Newer McBride Basalt.

This member is also difficult to delineate. In places it has transgressed the Older McBride Basalt and buried diatomites deposited in lakes marginal to the older basalt. East of the Burdekin River and about eight - ten miles north of the "Valley of Lagoons" Homestead, an outlier of basalt filling a former channel of the Burdekin River is probably of Newer McBride age.

3. Undara Basalt

There appear to have been four main active centres during extrusion of the Undara Basalt. They do not appear to be strictly contemporaneous; undoubtedly the activity migrated from centre to centre during the period. The centres are dealt with briefly in order of assumed ascending age:-

(i) Racecourse Knob poured out vast quantities of basalt which flowed radially out from this centre, and built a large shield volcano. This vent may be late Newer McBride or early Undara age.

(ii) Chubber's Hill, Razorback and Round Hill, located two-three miles north-east of "Meadowbank" Homestead, emitted considerable quantities of basalt, which appears to have flowed mainly to the north-east and the west.

(iii) Undara Crater, located in about the middle of the McBride Province, extruded vast quantities of basalt which flowed mainly to the north and north-west, around the base of Racecourse Knob, and extended beyond Mt. Surprise.

(iv) Murronga Crater about twelve miles south-south-west Racecourse Knob, emitted a large quantity of basalt which flowed mainly to the south, into the Einasleigh River.

4. Kinrara Basalt

This basalt shows up very clearly on the air photographs, consequently it is easy to map. The Kinrara Basalt was extruded through two vents, one major and one minor, situated close together near the north-west margin of the flow. The basalt flowed south-east into two stream channels incised in the older basalt. Near the vents the stream channels were completely buried beneath a sheet of lava. About six miles from the vents the stream channels confined the lava flows and beyond this rigidly controlled the course of the flows. The Kinrara Basalt Flow is about thirty miles long and covers an area of about one hundred square miles. It is undoubtedly the youngest, possibly the smallest, and definitely the most spectacular basalt in the entire area.

## Features

Throughout the history of both the McBride and Wallaroo basalts it is evident that they generally have been extruded in a very fluid state. On the older basalts, most of the obvious flow structures have been erased by weathering. In marked contrast to this is the Kinrara Flow, with all structures perfectly preserved. A close examination was made of parts of this flow and the knowledge gained was of considerable assistance in evaluating the more weathered structures in the older basalts.

(i) Kinrara Basalt

The direction of flow of the basalt, extruded from Kinrara Crater, has been controlled by a pre-existing drainage pattern. The proximal portion of the flows buried the shallow headwater channels and formed an "extensive" lava field (Keble, 1918).

About six miles south-south-east of Kinrara Crater the stream channels were sufficiently incised to confine the lava and so the "extensive" lava field split into three "confined" lava fields. Two of these subsequently re-united in the Burdekin valley near the "Valley of Lagoons".

The gradient of the channels, down which the Kinrara basalt flowed, was sufficient to ensure rapid draining of the fluid basalt from beneath the chilled lava surface, commonly only a foot or so thick. Subsequent collapse of much of this surface has led to the formation of a chaotic assemblage of sinks, depressions and open fissures.

Below Saltern Lagoon, in the Burdekin Valley, the distal portions of the Kinrara Flow, contain very few collapse structures. Their absence indicates that the basalt was becoming "sluggish" in its movement and was not drained from beneath the chilled crust.

Some of the distinctive features of the Kinrara Flow are described below.

The Edge of the Flow.

In both the "extensive" and "confined" lava-field tracts, the Kinrara Flow stands above the immediate surrounding country. The difference in elevation is usually about four-six feet. In the "extensive" lava field, the edge of the flow is usually marked by a jumble of boulders of pahoehoe basalt, obviously broken from the chilled margin of a slowly advancing flow. (See Figure 6). In the "confined" areas, this litter of boulders is generally more pronounced and is reminiscent of a lateral moraine. (Figure 6.) In some sections of the "confined" field, the litter of lateral boulders is buried beneath the edge of the flow which has "slabbed-off". This "slabbing" is evidently caused by fracturing of the solidified crust, a few feet in from the edge and parallel to it. The edge of the flow then collapses outwards, under its own weight; much in the manner of soil turned by a single furrow mouldboard plow.

(See Figure 7.)

Sinks.

The sinks range from small circular holes, a few feet in diameter to large irregular holes hundreds of square yards in area; the smaller sinks are the most common. Those investigated ranged in depth, from a few feet to about twenty feet; the depth is obviously a function of the thickness of the flow. The floor of the sinks usually contain a litter of pahoehoe boulders and many contain water. These holes normally progressively increase in diameter below the surface of the flow.

(See Figure 8)

Depressions

These are similar to the sinks, but in these the roof has only sagged, rather than completely collapsed. The "sinks" are the more common form.

Rectangular Pavements and Pressure Ridges.

Regular fracturing of sections of the basalt crust has produced rectangles of pahoehoe lava, 80 - 100 square feet in area, bounded by ridges, six to eight inches wide and two to three inches high, of broken lava. These rectangles usually have their long axis parallel to the direction of flow of the lava.

They are formed as a result of the drag of the fluid lava on the thin solidified crust.

(ii) The Older Basalts.

Basalt Boulder Barriers (Lava Tongues).

The McBride Province is littered with countless barriers of basalt boulders which ramify across the surface, and form numerous impediments to access across the area.

Skeats and James (1932) described basalt boulder barriers from the Newer Basalt areas of western Victoria to be predominantly ring-shaped and to extend outward and down to form a central vent, in a series of concentric steps.

This structure is not obvious in the McBride Province, but detailed mapping would probably reveal it.

Most of the basalt boulder barriers in the McBride Province appear to radiate out from the vents, rather than form concentric rings around them, and many of the barriers can be traced for miles. Undoubtedly these boulder barriers are the crustal portions of lava tongues. They are usually flanked by depressions partly filled with black soil.

In the younger flow-basalt areas the depressions between lava tongues are rough and virtually free of soil. In the older areas, meandering lines of rounded basalt boulders, completely surrounded and almost covered with soil, indicate earlier lava tongues. It is quite easy to visualise how this mode of distribution of the lava, extruded from numerous vents, over a long period of time, has built up a vast lava plain such as the McBride Basalt Province.

Growth of the Lava Tongues and Formation of Lava Tunnels.

On extrusion, the lava was usually very fluid and tended to follow the topographic "lows". The surface of the flows cooled and solidified to form a tube, through which, further accessions of lava were ducted. The snout of the tube was repeatedly breached by the weight of contained fluid, which broke through and was quickly chilled and solidified around its margin. In this manner the tubes grew by accretion at the snout and their flanks became littered with fragments of basalt.

Where the gradient of the slope was low, the advance of the lava flow was slow and the tubes were always filled with molten lava. The flows ceased to advance owing to a decrease of supply of lava and gradually cooled and solidified.

Where the gradient was steeper, the basalt flowed through the tubes more rapidly and often only partly filled them. When the supply of lava ceased, the tubes drained and empty lava tunnels were left. Subsequently, portions of the roofs of some of the tunnels collapsed and so revealed the tunnels.

Undara Lava Tunnel is the most prominent in the McBride Province. The collapsed portions of this tunnel contain a tangled mass of dark green vegetation, which is in marked contrast to the surrounding open savannah. As a result, the collapsed portions of the Undara Tunnel can be traced, on the photographs for more than thirty miles. The tunnel trends north-north-west from Undara Crater for about three miles and bifurcates. The northern branch can be traced, in the same general direction, for about another nine miles. The main branch, the western one, can be traced for more than twenty miles towards Mt.Surprise.

An enormous volume of lava must have flowed through these tunnels, and the vent from which it was extruded seems incongruously small and inconspicuous, particularly when viewed from the ground.

Undoubtedly there are numerous lava tunnels with no surface expression. A hole drilled for water, several miles north of Kinrara Crater passed through a number of "large holes" and was finally abandoned at a depth of about 375 feet after the drill bit had "dropped about twenty feet" (Mr.J. Champney, Kinrara Station, personal communication). It seems safe to assume that these "holes" are lava tunnels and it is interesting to note that the drill hole passed through a number of them in so short a distance as 375 feet.

## ECONOMIC GEOLOGY

(i) Diatomite deposits (White and Crespin, 1959) have been discovered in both the McBride and Wallaroo areas and no doubt detailed mapping would reveal more. At present, the distance from potential markets precludes the exploitation of these deposits.

(ii) Underground Water. A shortage of water prevents the stocking of much of the McBride Province. If water could be recovered from buried pre-basalt channels, perched aquifers or lava tunnels, many more cattle could be run in this area.

(iii) Minerals. Copper, lead, tin, wolfram and gold have been mined from areas around the margin of the basalt. It is probable that beneath the McBride Basalt there are other minerals, but it is unlikely these will be recovered. But there is a possibility that careful prospecting may locate some stanniferous deep leads, particularly in the Elizabeth Creek and "Greenvale - Camel Creek" areas.

Alluvial tin has been mined from two areas on Elizabeth Creek, one about twenty miles east of Mt.Surprise, the other about the same distance west-north-west of Mt.Surprise. The eastern deposits were in the vicinity of Durban's, Messmate, and Whitewater Creeks. C.C. Morton (1942) investigated these deposits and concluded "I am not convinced that, even if an old lead exists, its catchment area was sufficiently large or stanniferous to render it potentially important".

Morton appears to have discounted the fact that pre-basalt the area of granite exposed and thus shedding tin was considerably greater than it is now. Consequently it is possible that both the provenance and the derived alluvial tin are buried by Tertiary Basalt. Prospecting for such deposits would undoubtedly require some geophysical aid, such as gravity surveys.

Little is known of the Angor Tinfield, west of Mt. Surprise, other than, that alluvial tin has been mined (Morton, 1944b).

Granite crops out near the head of Perry Creek between "Camel Creek" and the "Valley of Lagoons". Alluvial tin is mined from around the margin of the outcrop. Older basalt flows formerly covered much of this area and obviously considerably modified the drainage. Denmead (1947), examined a deposit of alluvial tin about five miles west of "Camel Creek" and reported 'The source of the tin appears to be a series of horizontally disposed soft sandstones, grits, and clays overlaying deeply weathered slates of the Kangaroo Hills Series. This deposit is reported by Mr.J.R.Atkinson, of Camel Creek Station, to be traceable for several miles along a roughly east-west line. It is seldom more than a quarter of a mile wide, however, which suggests that it represents an ancient watercourse now silted up. "Billy, or silicified sandstone, occurs here and there as a capping at intervals along its course'.

To the north of the Perry Creek granite outcrop, an ancient drainage pattern, now preserved in basalt, is clearly visible on the air photographs. Time did not permit its examination on the ground but it possibly would be worth prospecting for alluvial tin deposits.

One of the major problems in mining tin in the area between the "Valley of Lagoons" and "Camel Creek" is the shortage of water. Mining would have to be carried out in the wet seasons. Even during the wet season, it is unlikely that sufficient head of water could be obtained for hydraulic sluicing, and so ground sluicing would have to be employed.

<u>Factors affecting the formation of the Diatomite Deposits.</u>

Two ages of diatomite have been recognised (White and Crespin, 1959). The older (Pliocene) deposits are overlain by basalt and the younger (Pleistocene-Recent) is deposited along the margin of Lake Walters.

The lakes in which the diatoms grew, were undoubtedly formed by basalt dams and it is interesting to speculate on the growth of the diatoms within these lakes. Cleveland (1958) states that "Diatoms require well-lighted water containing dissolved nitrogen, phosphorous, potassium, sodium, magnesium, oxygen, hydrogen, carbon, sulphur, iron and silica. The concentration of dissolved nitrogen (as $NH_3$ and $NO_3$) and phosphorous (as $PO_4$) is generally considered a limiting factor in diatom growth because of the relative paucity of these compounds in lake and ocean waters. Silica is more abundant than either nitrogen or phosphorous in such waters and the size of the diatom population is ordinarily directly proportional to the concentration of dissolved or finely divided silica".

Cleveland (1958), describes fresh water diatomites from Inyo County, California and makes the interesting observation that, though basalt flows dammed the stream and formed a lake, deposition of the diatomite did not commence for a long time. He states (p.13), "At least 260 feet of coarse clastic sediments were deposited before the fine grained volcanic sediments entered the lake. Only after the ash was introduced did suitable conditions develop for the growth of large numbers of diatoms". By "suitable conditions" he means a supply of silica, and this is presumed to have been supplied by the volcanic ash.

This is of particular interest in the McBride and Wallaroo areas, because there, there do not appear to be any pyroclastics associated with the diatomite. I have not examined any exposures in which a complete section through a diatomite deposit is revealed, and so cannot be certain of their complete absence: but the "Glen Eagle" and "Cashmere" deposits appear to directly overlie the granite basement and are directly overlain by flow-basalt. These diatomites are very pure. The younger diatomite, Lake Walters, is impure (Konecki in White and Crespin, 1959), and this diatomite is interbedded with quartz sand and silt.

If then, there was no volcanic ash to provide the silica, we must look elsewhere for the source. As the diatomites are very often in close proximity to basalt flows, it is natural to assume that the basalt is the source of the silica: but this assumption appears to be a fallacy. Firstly, basalts are inherently low in silica and it is unlikely that fresh, unweathered basalt could contribute the quantity of dissolved silica necessary to encourage the growth of the diatoms. Secondly, the lakes form on the upstream side of the basalt so that any solutions draining out of the basalt would tend to flow away from, rather than in to, the lake.

The hinterland for each of the known diatomite deposits is composed, mainly of acid igneous rocks, now deeply weathered. Water draining from this provenance would contain, in solution, many ions including silica from the decomposing rock minerals. Here then, is the source of the necessary nutrients for vigorous diatom growth.

It is suggested, in the case of these diatomites, the association diatomite-basalt is purely fortuitous, and had the lakes been formed by some other means, the diatomite would still have been deposited.

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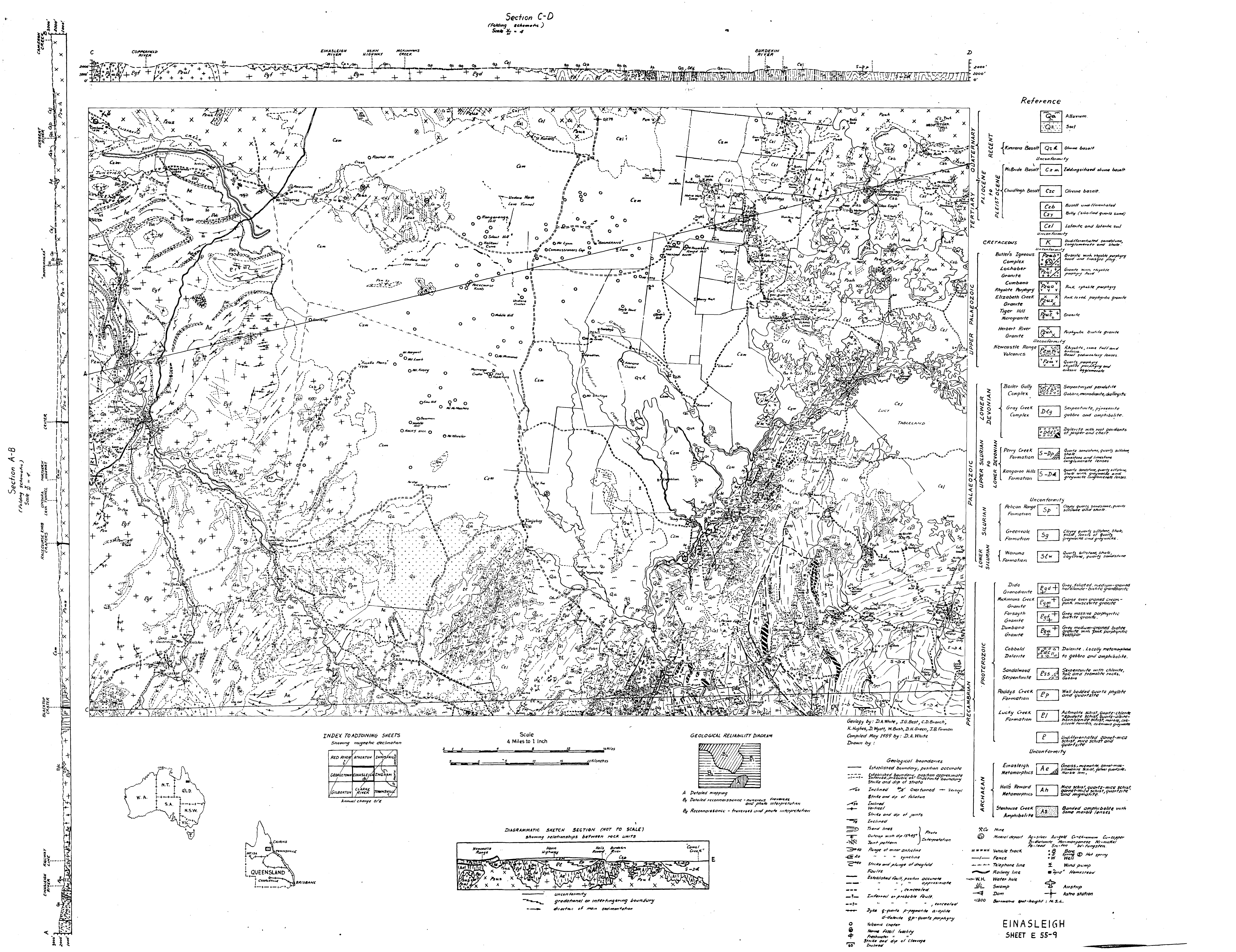
FIGURE 1. Racecourse Knob, a shield volcano, viewed from the north-west. Note the adventive scoria cones on the northern flank. The Mt.Surprise - Mann Highway is visible in the right foreground.

FIGURE 2. Internal southern wall of Undara Crater. Note litter of rough vesicular boulders, and thick vegetation.



Section C-D
(Folding schematic)
Section A-B
(Folding schematic)
Reference
Qa Alluvium.
Qs Soil
QUATERNARY
RECENT
Kinrara Basalt Qzk Olivine basalt
Unconformity
TERTIARY
PLIOCENE to PLEISTOCENE
McBride Basalt Czm Iddingsitized olivine basalt
Chudleigh Basalt Czc Olivine basalt.
Czb Basalt undifferentiated
Czy Billy (silicified quartz sand)
Czl Laterite and lateritic soil
Unconformity
CRETACEOUS
K Undifferentiated sandstone, conglomerate and shale.
Unconformity
UPPER PALAEOZOIC
Butler's Igneous Complex Pzub Granite with rhyolite porphyry hood and trachyte plug.
Lochaber Granite Pzul Granite with rhyolite porphyry hood
Cumbana Rhyolite Porphyry Pzua Pink rhyolite porphyry
Elizabeth Creek Granite Pzuz Pink to red porphyritic granite
Tiger Hill Microgranite Pzut Granite
Herbert River Granite Pzuh Porphyritic biotite granite
Unconformity
Newcastle Range Volcanics Pzun Rhyolite, some tuff and breccia. Basal sedimentary lenses.
Pzu Quartz porphyry rhyolite porphyry and arkosic agglomerate
PALAEOZOIC
LOWER DEVONIAN
Boiler Gully Complex Dlb Serpentinized peridotite Gabbro, microdiorite, diallagite
Gray Creek Complex Dlg Serpentinite, pyroxenite gabbro and amphibolite.
Dld Dolerite with roof pendants of jasper and chert.
UPPER SILURIAN to LOWER DEVONIAN
Perry Creek Formation S-Dp Quartz sandstone, quartz siltstone, shale. Limestone and limestone conglomerate lenses.
Kangaroo Hills Formation S-Dk Quartz sandstone, quartz siltstone, shale with greywacke and greywacke conglomerate lenses.
Unconformity
SILURIAN
Pelican Range Formation Sp Clayey quartz sandstone, quartz siltstone and shale.
Greenvale Formation Sg Clayey quartz siltstone, shale, shale, lenses of quartz greywacke and greywacke.
LOWER SILURIAN
Wairuna Formation Slw Quartz siltstone, shale, claystone, quartz sandstone
PRECAMBRIAN
PROTEROZOIC
Dido Granodiorite Pgd Grey, foliated, medium-grained hornblende-biotite granodiorite
McKinnons Creek Granite Pgm Coarse even grained cream-pink muscovite granite
Forsayth Granite Pgf Grey massive porphyritic biotite granite.
Dumbano Granite Pgu Grey medium-grained biotite granite with pink porphyritic feldspar
Cobbold Dolerite Pdc Dolerite. Locally metamorphosed to gabbro and amphibolite.
Sandalwood Serpentinite Pss Serpentinite with chlorite, talc and tremolite rocks. Gabbro
Paddys Creek Formation Pp Well bedded quartz phyllite and quartzite
Lucky Creek Formation Pl Actinolite schist, quartz-chlorite-epidote schist, quartz-albite-hornblende schist, marble, calc-silicate hornfels, calcareous greywacke
P Undifferentiated garnet-mica schist, mica schist and quartzite
Unconformity
ARCHAEAN
Einasleigh Metamorphics Ae Gneiss, migmatite, garnet-mica-sillimanite schist, garnet quartzite. Marble lens.
Hall's Reward Metamorphics Ah Mica schist, quartz-mica schist, garnet-mica schist, quartzite and migmatite.
Stenhouse Creek Amphibolite As Banded amphibolite with some marble lenses
Geology by: D.A. White, J.G. Best, C.D. Branch, K. Hughes, D. Wyatt, W. Bush, D.H. Green, J.B. Firman
Compiled May 1959 by: D.A. White
Drawn by:
Geological boundaries
Established boundary, position accurate
Established boundary, position approximate
Inferred, probable or indefinite boundary
Strike and dip of strata
Inclined Overturned Vertical
Strike and dip of foliation
Inclined
Vertical
Strike and dip of joints
Inclined
Trend lines
Outcrop with dip 15°-45°
Joint pattern
Photo Interpretation
Plunge of minor anticline
" " " syncline
Strike and plunge of dragfold
Faults
Established fault, position accurate
" " , " approximate
" " , concealed
Inferred or probable fault.
" " " " , concealed
Dyke q-quartz p-pegmatite a-aplite d-dolerite qp-quartz porphyry
Volcanic crater
Marine fossil locality
Freshwater " "
Strike and dip of Cleavage
Inclined
Mine
Mineral deposit Ag-silver Au-gold Cr-chromium Cu-copper D-diatomite Mn-manganese Ni-nickel Pb-lead Sn-tin W-tungsten.
Vehicle track
Fence
Telephone line
Railway line
W.H. Water hole
Swamp
Dam
1300 Barometric spot-height : M.S.L.
Bore
Spring
Well
Hot spring
Wind pump
"Lynd" Homestead
Airstrip
Astro station
INDEX TO ADJOINING SHEETS
Showing magnetic declination
RED RIVER
ATHERTON
INNISFAIL
GEORGETOWN
EINASLEIGH
INGHAM
GILBERTON
CLARKE RIVER
TOWNSVILLE
Scale
4 Miles to 1 Inch
GEOLOGICAL RELIABILITY DIAGRAM
A Detailed mapping
B1 Detailed reconnaissance - numerous traverses and photo interpretation
B2 Reconnaissance - traverses and photo interpretation
DIAGRAMMATIC SKETCH SECTION (NOT TO SCALE)
showing relationships between rock units
unconformity
gradational or interfingering boundary
direction of main sedimentation
N.T.
QLD.
W.A.
S.A.
N.S.W.
VIC.
QUEENSLAND
CAIRNS
TOWNSVILLE
BRISBANE
LUCY TABLELAND
EINASLEIGH
SHEET E 55-9