COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

BULLETIN No. 88

Isotopic Ages of Acid Igneous Rocks in the Cairns Hinterland, North Queensland

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SUMMARY

A REGIONAL K-Ar reconnaissance involving about 80 samples, and supported by Rb-Sr data on six samples, has demonstrated that the Cairns Hinterland region of North Queensland has had a long and complex history, the earliest measured event being the formation of the Croydon Volcanics (1460 m.y.). The granite at Esmeralda homestead, the Forsayth Granite, and the Robin Hood Granite are also Precambrian, probably at least 1200 m.y. old, but have lost argon during later events, the last of which seems to have occurred during the Devonian, 384 ± 11 m.y. ago.

Middle Palaeozoic granites, not previously identified as such, include the Dido Granodiorite (405 ± 21 m.y.), Dumbano Granite (380 ± 8 m.y.), and the granites at Rocky Dam and Perry Creek (350 m.y.) within the Broken River Embayment. The granite near Musgrave, Cape York Peninsula, appears also to be Devonian (360 m.y.). The Newcastle Range Volcanics may also belong to this Period.

Some of the acid igneous rocks which intrude the Dumbano Granite show late Palaeozoic ages in agreement with their field classification, but with a suggestion that they may be older (greater than 300 m.y.) than the more northerly group of Upper Palaeozoic rocks (*average* age 284 ± 5 m.y.). Among these latter no overall age difference is detectable between the possibly simatic Elizabeth Creek Granites and the possibly anatectic Herbert River and Almaden Granites which they intrude. The statistics indicate that these granites may have been intruded at various times in a period whose duration is long compared with the experimental error. The Featherbed Volcanics appear to belong to this period of activity.

Farther to the north and east, two separate groups of possibly anatectic granites have been delineated. The Mareeba Granite (264 ± 2 m.y.) and the granites near Cooktown (Finlayson and Trevethan Granites, 247 ± 6 m.y.) occur within the Hodgkinson Basin, and were formed in two distinct periods of Permian activity which were short compared with the Permo-Carboniferous event and with the expected experimental error (about ± 7 m.y.).

Thus the overall pattern is of an episodic progression in activity from south-west to north-east throughout the whole of the Palaeozoic, originating in an area which had already been subjected to an intrusive period which began about 1000 m.y. earlier. This north-eastward progression is very clear in the possibly anatectic rocks of late Palaeozoic age; the results on the acid igneous rocks of deep-seated origin are inconclusive, but with a suggestion that a similar pattern may eventually be established.

Figure 1. Map of the Cairns Hinterland region, North Queensland, showing location of dated samples. Scale about 1 inch : 50 miles.

ISOTOPIC AGES OF ACID IGNEOUS ROCKS IN THE CAIRNS HINTERLAND, NORTH QUEENSLAND

INTRODUCTION

This study arose out of the regional geological mapping of the Cairns Hinterland* which was begun in 1956 as a joint undertaking by the Bureau of Mineral Resources and the Geological Survey of Queensland. It is another unit in the series of dating surveys stemming from the co-operation between the Australian National University and the Bureau of Mineral Resources. One of us (D.A.W.), assisted by F. de Keyser, was responsible for the supervision of the field operations connected with this study; another (C.D.B.) was concerned with the general investigation of these acid igneous rocks; the others (J.R.R. and A.W.W.) were assisted by J. A. Cooper in the production of the K-Ar results. We are indebted to W. Compston and M. J. Vernon for permission to publish the Rb-Sr results on the Palaeozoic rocks, and for assistance with measurements on the Croydon Volcanics.

Samples were chosen with the aim of defining more closely the time limits of the two periods of activity that were thought to have produced the granites and acid volcanic rocks now covering about half the area. Regional mapping evidence had already suggested that a Precambrian age for the older granites was a reasonable possibility, and that the second event took place in the late Palaeozoic. Fossils collected by the mapping parties suggested that these periods were pre-Upper Ordovician and late Devonian/Carboniferous to Permian/Triassic (White, 1961). The present set of age data offers a most gratifying confirmation of some of these conclusions and provides a basis for the selection of samples for further study.

GENERAL GEOLOGY

Some of the geological background for this study has been published by de Keyser & Wolff (1965), White (1961; 1965), and White, Wyatt, & Bush (1960). For the following summary we have drawn on these accounts, and on accounts by Branch (1966) on the Upper Palaeozoic igneous rocks, and by de Keyser & Lucas (1966, in press) on the Hodgkinson Basin.

The rocks of the Cairns Hinterland have been allocated to three distinct age groups. The oldest are Precambrian, found on a broad shield known as the Georgetown Inlier, 200 miles by 150 miles in extent, and are separated from the main part of the Australian Precambrian Shield to the west by a 200-mile-wide tract of the Mesozoic sediments of the Great Artesian Basin. To the east the Inlier is flanked by about 40,000 feet of Palaeozoic sediments of the Tasman Geosynclinal Zone, which in this part of North Queensland is about 50 to 150 miles wide. Cainozoic basalt provinces cover about 6000 square miles near the fractured boundary between the Precambrian Georgetown Inlier and the Tasman Geosynclinal Zone.

* The extent of the region here called the Cairns Hinterland may be seen from Figure 1. It includes the Croydon, Red River, Georgetown, Gilberton, Cooktown, Mossman, Atherton, Einasleigh, Clarke River, Cairns, Innisfail, and Ingham 1 : 250,000 Sheets; all except the first two are published in the B.M.R. 1 : 250,000 Geological Series.

The geological evolution of the Cairns Hinterland as a unit probably began early in the Precambrian with a period of regional metamorphism to form an area of granulite, amphibolite, and migmatite. This was uplifted later in the Precambrian to form a geanticline or central core, and about 30,000 feet of sediments, mostly fine-grained, were deposited on the western margin in the widespread Etheridge Geosyncline. The final Precambrian events were the intrusion of the Forsayth Batholith into the core of the geanticline, and of ultrabasic rocks along part of its eastern fractured edge.

Marine sedimentation began in the North Queensland section of the Tasman Geosynclinal Zone by the late Ordovician at latest, and was mostly complete by the Middle Carboniferous, but freshwater sedimentation continued into the Upper Permian. White (1961) postulated three periods of deformation in the Broken River Embayment (south-eastern section of Figure 1), in which pre-existing Palaeozoic sediments were uplifted to form land. The first deformation preceded and initiated the main greywacke sedimentation of the late Silurian/early Devonian period, and the other two preceded the Middle Devonian and late Devonian/Middle Carboniferous periods of sedimentation. The only exposed igneous bodies of appreciable size, which were believed to accompany the pre-Middle Devonian deformation, are the basic and ultrabasic intrusions in the Gray Creek and Hall's Reward areas, referred to (White, Wyatt, & Bush, 1960; White, 1965) as the Gray Creek and Boiler Gully Complexes. Other igneous rocks in the Cairns Hinterland which are recognized as belonging in the Middle Palaeozoic are minor basalt and andesite flows associated with possible Upper Ordovician/Lower Silurian sediments in the Gray Creek area; with Upper Silurian limestone reefs in the Gray Creek area; with Upper Silurian limestone reefs in the Gray Creek and Perry Creek areas (White, 1961); and with Upper Silurian/Lower Devonian sediments in the Chillagoe area (de Keyser & Wolff, 1965). It is important to notice that very few Middle Palaeozoic acid igneous rocks have been recognized. Prior to the results we now report, the only clear evidence that such rocks may once have been exposed was the occurrence of acid volcanic pebbles in conglomerates in the Upper Devonian/Lower Carboniferous Hodgkinson Formation, of a thin quartz keratophyre folded with Carboniferous sediments in the Cooktown and Mossman Sheet areas (Morgan, 1965), and the small intrusive mass of the Craigie Granodiorite in the Broken River Embayment.

The final major deformation of the Tasman Geosynclinal Zone is considered to have taken place in the Middle Carboniferous, with a movement probably associated with the beginning of the widespread acid igneous activity referred to in the introduction as 'late Palaeozoic'.

The present investigation began as a study of these Upper Palaeozoic acid igneous rocks, which have been studied in detail by Branch (1966). He has subdivided them on the basis of postulated origin: the volcanics and comagmatic granites derived from fractionated simatic magma, and distinguishable from the contemporaneous granite which was derived from an anatectic magma. Both granites are predominantly adamellite in composition, as also are the volcanics (essentially rhyodacite welded tuff).

The rocks of presumed simatic origin are emplaced in ring complexes, cauldron subsidence areas, rift zones, and high level batholiths, for the most part in the

Precambrian Georgetown Inlier, but to a lesser extent in the Chillagoe/Mount Garnet area of the Tasman Geosynclinal Zone. The volcanics are divided into an earlier minor episode and a slightly younger major episode. Both are intruded by the predominantly pink Elizabeth Creek Granite in the central and eastern parts of the Inlier, although, in the region of the Featherbed Range, the pink granite appears in some places to be cut by the cauldron subsidence faults associated with the younger volcanics. On the western edge of the Inlier, the grey Esmeralda Granite intrudes the Croydon Volcanics in a similar relationship.

The Herbert River and Almaden Granites, apparently contemporaneous and thought to be of anatectic origin, crop out along the north-eastern margin of the Inlier and in the adjacent Tasman Geosynclinal Zone. They intrude the earlier volcanics along the eastern edge of the Inlier, but are invariably unconformably overlain (or cut) by the younger volcanics. Where Elizabeth Creek and Herbert River Granites crop out together, the Herbert River Granite is always the older.

These clear intrusive relationships are only visible in individual structural units. The relationships between similar members in the separate structural units are not indisputable and it is here in particular that dating results were looked to for assistance. Further groups of granite occur well within the Tasman Geosynclinal Zone, in the Hodgkinson Basin. These, the Mareeba, Puckley, Finlayson, and Trevethan Granites, are also classed as anatectic granites.

No age measurements have yet been made upon the Cainozoic basalts. Their only significance for this study, therefore, is in the general possibility that movements associated with their emplacement could have had some effect upon the argon retention of the older acid rocks. Many geologists, including Ball (1923), Richards (1924), and more recently Best (1962), have maintained that major vertical fault movements accompanied the extrusion of these Cainozoic plateau or flood-type basalts in North Queensland. Of these the McBride Basalt occupies the largest area, some 2000 square miles. It is believed to have been extruded through fissures or vents near the junction of the Precambrian Forsayth Batholith with the Upper Palaeozoic (mostly Herbert River) granitic batholith.

EXPERIMENTAL PROCEDURES

Experimental procedures used in this study are similar to those described in a number of recent publications. Mineral separation procedures were largely as outlined by Richards & Pidgeon (1963), with one significant modification, also due to H. Berry (pers. comm.), which produces a greatly improved sample, particularly of biotite. Ultrasonic cleaning of the concentrate in acetone or carbon tetrachloride medium is effective not only in separating the dust, but also in pulverizing, and thus removing much of the edge-chlorite which is otherwise difficult to remove. In this way a reasonably acceptable concentrate may often be achieved from quite unpromising material, although the treatment is not so effective in removing interleaved chlorite.

Potassium was measured with a Perkin-Elmer flame photometer, using techniques described by Cooper (1963). Argon was extracted on a Berkeley-type line (mainly type C of Evernden & Curtis, 1965), and measured by isotopedilution with a Reynolds-type (1956) mass spectrometer, run statically. The physical constants used for the age calculation are $\lambda_\beta = 4.72 \times 10^{-10}y^{-1}$, $\lambda_k = 0.584 \times 10^{-10}y^{-1}$, and ^{40}K abundance $= 1.19 \times 10^{-4}$ gm atoms ^{40}K per gm atom K.

Expected experimental accuracy and precision limits have been discussed by Cooper (1963) and McDougall (1963). In this work all error limits quoted in the text are 95 percent confidence limits ($t\sigma$). For the amounts of air contamination observed in these samples, confidence levels of the *analytical* results should all be within ± 3% — e.g. 250 ± 7 m.y.; 400 ± 12 m.y.; 1200 ± 36 m.y. — for the particular mineral sample analysed. These estimates are comparable to the combined experimental plus geological scatter observed for the best-defined groups in this work.

Thus the two youngest groups of granites which have been recognized as distinct groups in the field are those which occur within the Hodgkinson Basin (A — Upper Permian, and B — Lower Permian). Statistical analysis of the K–Ar results shows (Table 3) that the expected confidence limits of any *one* of the eight Group A results is ± 16 m.y. (± 6.4%); for the seventeen group B results the figure is ± 10 m.y. (± 3.6%). The *average* values for these two groups have confidence limits of 247 ± 6 m.y. for group A; 264 ± 2 m.y. for Group B. These and related statistical facts will be discussed further in a later section.

The relationship of these results to the time of the significant events in the history of the rock is, of course, a matter of geological interpretation.

RESULTS

The location of all analysed samples is shown on the map of North Queensland (Fig. 1). For each site the sample number is followed, in parentheses, by recorded age. The lower case letter indicates the mineral analysed. The acid igneous rock areas are shown in outline. The hatchings indicate the classification into groups, based upon a combination of geology and K–Ar data, which will be examined in the following discussion.

All K–Ar data for possibly Precambrian samples are listed in Table 1; data for the Upper Palaeozoic samples appear in Table 2. Figure 2 represents an attempt to highlight the correlations between the field mapping classifications and the chronological data, and Table 3 presents a summary of the statistical examination of some of the data. The results of a few Rb–Sr measurements are shown in Tables 4 and 5, and in Figure 3. Full sample details, including a petrographic summary, are listed in the Appendix.

DISCUSSION

Upon examination of Figure 1, there is immediately apparent a regional grouping of ages which suggests that the granites to the north and east are progressively younger. A similar pattern was observed by Evernden & Richards (1962) in the southern section of the Tasman Geosynclinal Zone in New South Wales, although statistical tests were not applied to this earlier work. This eastward progression

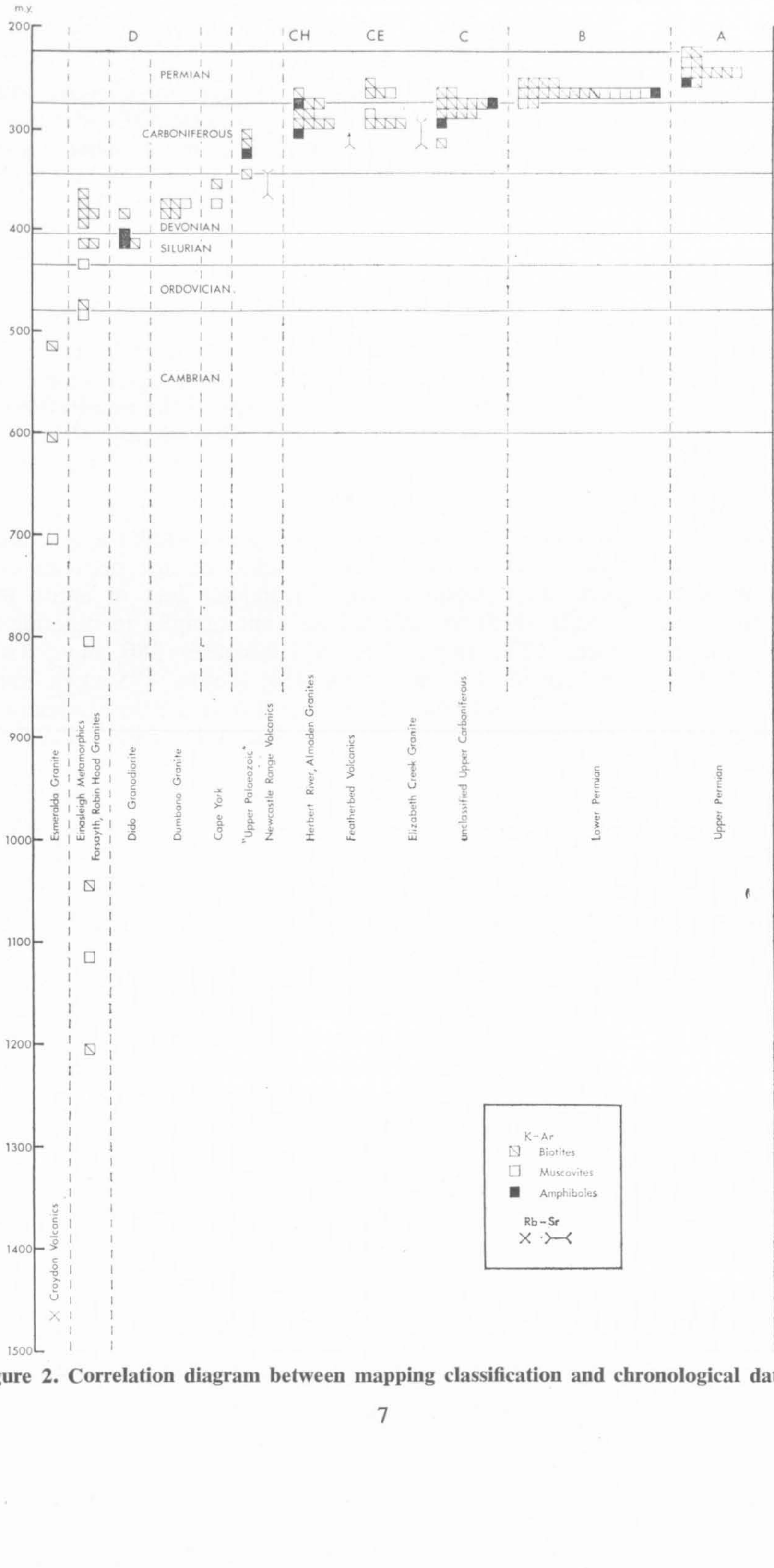

Figure 2. Correlation diagram between mapping classification and chronological data.

of ages appears, therefore, to be a general phenomenon associated with the Palaeozoic granites along the full extent of the eastern Australian coastal region.

Because of the large mass of data (analyses on over 100 minerals from more than 80 samples), detailed discussion of the results is presented under two general headings: (*a*) The rocks of the Georgetown Inlier, provisionally classified as Precambrian, and (*b*) the Upper Palaeozoic acid igneous rocks which occur both in the Georgetown Inlier and in the Tasman Geosynclinal Zone.

PRECAMBRIAN

The age range for the older rocks is wide, from 370 m.y. to 1200 m.y.; but two facts emerge which appear to be of some significance: the close grouping of a number of results in the Middle and Lower Devonian region of the currently accepted time-scale (*cf.* Evernden & Richards, 1962), and the clearly Precambrian values for at least some of the granites of the Forsayth Batholith which had been assigned to the Precambrian (GA 441, 1200 m.y.; GA 410, 1120 m.y.).

Field evidence gives good reason to suppose that the Forsayth Granite samples (GA 412-416, GA 429) are related, and are of similar age to the Robin Hood Granite samples (GA 410,411). Discordance in age between cogenetic biotite-muscovite pairs are compatible with incomplete loss of argon during a post-crystallization event, which has affected different samples to differing degrees (GA 410, muscovite, 1120 m.y., G.A. 411, biotite, 380 m.y., GA 412, biotite, 370 m.y., muscovite, 480 m.y.; GA 414, biotite, 475 m.y., muscovite, 800 m.y.). We do not feel constrained to invoke 'external argon pressure' effects (*cf.* Richards & Pidgeon, 1963; Lovering & Richards, 1964) because clear samples are encountered only rarely and the conditions here do not seem appropriate. We admit to insufficient evidence upon which to base this judgement, but conclude that the Forsayth and Robin Hood Granites are indeed Precambrian, and are at least 1120 m.y. old. This limit becomes 1200 m.y. if we include GA 441, from the mass near Forest Home Station (see next section).

We wish to emphasize that, although the evidence shows clearly that all the rocks listed above must have been emplaced in the Precambrian, the strong evidence for at least one later event implies that not even the 1200 m.y. of GA 441 biotite can safely be interpreted as anything other than a *minimum* value for their age. Individual differences in recorded K-Ar ages need not bear significant relationship to any postulated succession of intrusion events. An apparently favourable petrographic report (see Appendix) for GA 441 is no criterion for assuming that 1200 m.y. is near to the true age, for GA 412 also appears relatively undisturbed in thin section, whereas the muscovite-biotite discordance for it clearly points to a loss of argon which may have been considerable. Tilton & Hart (1963) have also reported cases of argon loss with little apparent petrographic indication.

We come now to examine the 'younger' age limit suggested by the results on these 'Precambrian' granites. Twelve biotites group around 384 m.y. with 95 percent confidence limits upon each result of 2.9% (± 11 m.y.). This is open to two possible interpretations. Either there was an event at this time of sufficient intensity to cause complete loss of argon from older biotites, but not necessarily other minerals, or alternatively at least some of these masses are the Middle Palaeozoic acid rocks whose non-discovery was alluded to in the geological summary.

We have referred to the fact that some mineral-pair discordances are clear evidence for the loss of argon from a Precambrian rock. Figure 1 shows further that Forsayth samples GA 412, 413, 415 are from sites within two miles of the edge of the Newcastle Range Volcanics (probable Rb-Sr age 360 m.y.), which White (1961) and Branch (1966) consider to occupy a major cauldron subsidence area. Thus the emplacement of the Palaeozoic volcanics may have been associated with the heating required for the argon loss in the granites. Samples GA414, 429 are from slightly farther away, and the apparent ages are consistent with this pattern, in being somewhat greater, and with the muscovite 'age' greater than the biotite 'age'. Robin Hood samples GA 410, 411, also fit into this pattern. Sample GA 416 (370 m.y.) is farther away from known Palaeozoic intrusions and the result is not therefore so easily explained in this way. Further study may show that the nearby Cainozoic basalt either provided some heat, or covered evidence for some manifestation of the greater spread of the Devonian event.

A different interpretation is offered for the Dido and Dumbano samples. For each Dido Granodiorite sample (GA 430, 431) we have essentially concordant biotite-hornblende pairs, with the possibility, consistent with the state of the sample, that the slight discordance on GA 431, and its slightly lower age compared to GA 430, represent a partial response to the apparent deformation. In one of the four Dumbano Granite samples there is a concordant biotite-muscovite pair (GA 418). These concordances constitute strong evidence for a claim that the two masses are part of the hitherto undetected Middle Palaeozoic acid intrusions.

Further, a statistical significance test (t-test, Table 3) on even this small amount of information suggests that the apparent age difference between the average for the Dido samples (405 ± 21 m.y., preferred age about 410 m.y.) and that for the Dumbano (380 ± 8 m.y.) is real at the 99 percent level—i.e., this statement has only a one percent chance of being wrong. Thus we are free to say that the Dido Granodiorite and the Dumbano Granite almost certainly represent two separate intrusions during the Middle Palaeozoic, and that the event which caused argon to be lost from the much older Forsayth and Robin Hood Granites seems to have been related in time to the intrusion of the younger Dumbano Granite.

The Esmeralda Granite—Croydon Volcanics Problem

The Croydon Volcanics (Branch, 1966), formerly known as the Croydon Felsite, are flanked on their eastern and western margins by a number of granite bodies which have been grouped together as Esmeralda Granite (Branch, White, & Wyatt, 1960, White, 1962a). The literature contains widely differing opinions about the age of the rocks in this most westerly portion of the Georgetown Inlier. As these rely very largely upon the grounds of lithology and relief, they are naturally none too secure. Jensen (1923) thought the granites in the Croydon region as old as the 'Etheridge granites' which intrude the metamorphic gneisses of the Etheridge Geosyncline. These he equated with the 'Cloncurry Series'. He claimed only 'pre-Silurian' for the volcanic rocks (Croydon Felsite), but thought some at least could be older than the granites. Jones (1947) expressed similar opinions. If we extrapolate from present knowledge about the Cloncurry region, this would imply a Precambrian age for the Esmeralda Granite, and for at least some of the volcanics. On the other hand Branch, White, & Wyatt (1960) and White (1962a) were led by their extensive field observations to postulate a late Palaeozoic age for these rocks by comparison with the volcanics of this undoubted age farther to the east.

Branch (1966) now defines the Esmeralda Granite more closely as the granitic rock that intrudes the Croydon Volcanics in the Croydon cauldron subsidence area. Granitic rock of this definition, which he observed to intrude the Volcanics near Croydon Township, has not been dated because the collected samples proved unsuitable. Samples GA 411 (biotite, 1200 m.y.), GA 658 (biotite, 515 m.y.; muscovite, 700 m.y.) and GA 659 (biotite, 600 m.y.) were classified upon collection as Esmeralda Granite. However, there is room for doubt, on lithological grounds, about the correlation of GA 658 and GA659, from near Esmeralda homestead, with the intrusive Esmeralda Granite near Croydon. The granite near Forest Home Station is a separate mass, not clearly related lithologically or geographically either to the Forsayth Granite or to the Esmeralda Granite. But since it does not lie within the Croydon cauldron subsidence area, and is only 5 miles from the main western edge of the Forsayth batholith, it seems more reasonable to classify it provisionally with the Forsayth rather than with the Esmeralda Granite.

Thus, although all three granite samples, from either side of the Volcanics, are Precambrian—the lack of concordance shows that GA 658 and GA 659 are older than 700 m.y., and have lost argon during a later event—we have no unequivocal K-Ar age for the intrusive Esmeralda Granite near Croydon. For this reason total-rock Rb-Sr measurements were made upon the only two available samples of the Croydon Volcanics. Samples GA 1379 and GA 1380, individually and together (Tables 4 and 5), date the Volcanics at 1460 m.y. or 1380 m.y. according to the preferred value for Rb half-life. This result, which is not very different from the K-Ar biotite ages reported for the metamorphic region east of the Kalkadoon Granite near Mount Isa (Richards, Cooper, & Webb, 1963), appears to justify the conclusions of the earlier workers. It also points to the conclusion that all the Precambrian granites in this area, including the Forsayth and Robin Hood Granites, may turn out to be younger than the Croydon Volcanics. Further study is clearly required.

Metamorphic rocks

The K-Ar results upon a pegmatite in the Einasleigh Metamorphics (GA 442: biotite, 414 m.y.; muscovite, 432 m.y.) suggest either that the rock was sufficiently affected by a Palaeozoic event (possibly earlier than the major 380 m.y. event) for even the muscovite to lose almost all its argon; or that the Archaear age assigned to this pegmatite is in error, and the true age lies somewhere withir the Ordovician-Silurian period. Further study is required.

The Barnard Metamorphics have previously been considered to be Precambrian (Jones & Jones, 1960), because of their high metamorphic grade. Alternatively, de Keyser (1965a) suggests that they are sediments of the Middle Palaeozoic (Silurian—early Carboniferous) Hodgkinson Basin which have been metamorphosed and folded during the Carboniferous orogeny. The results on GA 5180 muscovites (coarse-grained pegmatite, 355 m.y.; fine-grained rock, 305 m.y.) suggest, but do not prove conclusively, that the last significant event—possibly the metamorphism—occurred within the late Devonian, according to the currently accepted time-scales (Evernden & Richards, 1962). We must assume that the recorded age difference between the two mineral concentrates represents some size-dependent response, either to slow cooling after the metamorphism or to some later event. Until further evidence is obtained, the older result is to be preferred as a minimum age for the metamorphism.

The Cape York sample

Although it comes from an area completely separate from the Georgetown Inlier, granite sample GA 529 is included in this section because it comes from the Cape York Peninsula, where the granites have been classified by Jensen (1964) as 'Older granites—Precambrian', admittedly (Jensen, 1960) upon inadequate grounds. On the other hand de Keyser (pers. comm.) has observed that the granites in the vicinity of Iron Range (about lat. 12½° S.) bear a strong lithological resemblance in the field to those of the Atherton region, rather than to the Precambrian granites. The Cape York granites have been classified as belonging to the Palaeozoic on the Tectonic Map of Australia (1960).

This sample was collected by K. G. Lucas, Bureau of Mineral Resources, during a reconnaissance trip; hence exact details of its geological setting are not known. The concordant biotite-muscovite ages (average 360 m.y.) suggest a close correlation of the Cape York granite with the Devonian events of the central Georgetown Inlier, with a presumption that the intrusive age is indicated. This conclusion cannot, however, be regarded as completely valid until more measurements and mapping have been completed.

UPPER PALAEOZOIC

General Conditions

The Upper Palaeozoic rocks are subdivided into three age groups (Figs 1 and 2). Those which have been used in the following statistical analysis are distinguished by the letters A, B, C, in Tables 1 and 2. The samples not so used have been excluded principally because of the uncertainty of their classification. In Group A are those granites, of late Permian age, which intrude the Hodgkinson Basin, and occur along the coast from Cooktown south to Mossman. Stratigraphic names are Finlayson and Trevethan Granites (Lucas, 1965). Group B, of early Permian age, is mapped for the most part as Mareeba Granite, and also intrudes the Hodgkinson Basin (de Keyser, 1965). The Puckley Granite (Lucas, 1965), west of Cooktown, has been included because its age and position relative to the other contemporaneous granites makes this seem reasonable. The granite on Hinchinbrook Island appears to belong to this group also, but has not been included because of its isolated position. Group C includes the granites of Permo-Carboniferous age, south and west of the first two groups. They intrude both the northerly regions of the Georgetown Inlier and the neighbouring parts of the Tasman Geosynclinal Zone. For closer examination, we have grouped the Herbert River and Almaden Granites as subgroup CH, and the Elizabeth Creek Granite as subgroup CE. Finally, in a fourth group D, we have collected all the Middle Palaeozoic results, on biotites only, from the 'Precambrian' section, as representing a reasonable estimate of the time of this event, whether by fresh formation, or by complete resetting of an older Precambrian biotite. To respective pairs of these groups we have applied the Student's *t* test (Moroney, 1956) to determine whether their average ages are statistically distinguishable. The relevant statistical data for for these tests are listed in Table 3, along with those for the Dido-Dumbano Granite samples reported in the previous section. From these results we may confirm impressions derived from the display in Figure 2.

(*a*) There is no doubt whatsoever that the granites of Group C (Herbert River, Elizabeth Creek, and others of Permo-Carboniferous age) were later, by an average of 100 m.y., than the Dumbano Granite and the event that caused loss of argon from Forsayth and Robin Hood Granites (Group D biotites).

(*b*) The three Upper Palaeozoic groupings A, B, C, are also clearly distinct (there is considerably less than one chance in one thousand that they are the same age). A and B each form homogeneous groups with 95 percent confidence limits (approximately twice the standard deviation) so close to the experimental accuracy estimate of McDougall (1963) that the possibility of geological scatter is quite small. We conclude then that the Mareeba Granite was formed during one distinct period of upheaval in the Hodgkinson Basin, and that the Finlayson and Trevethan Granites were formed during a later, and separate, movement.

(*c*) Confidence limits for Group C are wider. This suggests a significant geological scatter: that there was not just one single pulse of granite formation in this Permo-Carboniferous period of activity. This is well illustrated in Figure 2. The statistics show that, whatever its cause, the scatter is not related to the two granite types distinguished by Branch (1966). The average age for the Herbert River and Almaden Granites (CH), grey biotite-hornblende rocks associated with copper and lead mineralization, is less than 4 million years greater than that of the pink, tin-bearing, Elizabeth Creek Granite (CE); the oldest Elizabeth Creek Granites are no younger than the oldest Herbert River Granites. The two subgroups are statistically indistinguishable. (There is more than one chance in four that this age difference could occur in two contemporaneous groups of rocks.) Therefore we must conclude that in this fairly broad region it was not just a simple matter of an early igneous activity everywhere producing grey granite, and then, some time later, further activity producing a pink granite and volcanics. If two separate granite-forming mechanisms were indeed involved, then the evidence suggests that for much of this period of activity they were operating simultaneously, although not necessarily in the same locality at the same time. A postulate of argon loss by all Herbert River samples does not appear to be tenable. No simple geographical pattern has been detected on the information presently available, but the field evidence is clear : where contacts may be observed, a pink granite is always seen to intrude a grey one. Unfortunately, samples from only one such intrusive pair survived the preliminary tests of suitability for K-Ar dating. In the Dimbulah/Wolfram Camp area, the Herbert River Granite, represented by Sample GA 506

(290 m.y.) is intruded to the north-west by Elizabeth Creek Granite. Within the latter, muscovite from a wolframite-molybdenite-bearing greisen vein (GA 1354) yielded an age of 280 m.y. It is probably fair to argue that the age difference may be significant; that in another area (GA 541, 542, 543) a greisen muscovite gave the same age as the rock it intruded; and hence that the 10 m.y. difference at Dimbulah could conceivably represent a real difference in age between the two granite phases. More measurements on such pairs are desirable.

Rb-Sr data

Measurements reported by permission of W. Compston (pers. comm.) are on one total-rock sample from the Featherbed Volcanics (GA 301); total-rock, microcline, and biotite from an Elizabeth Creek Granite (GA 302); and two total-rocks, with K-feldspar from one, from the Newcastle Range Volcanics (GA 652, 653). Two measurements are reported also for total-rocks from the Croydon Volcanics

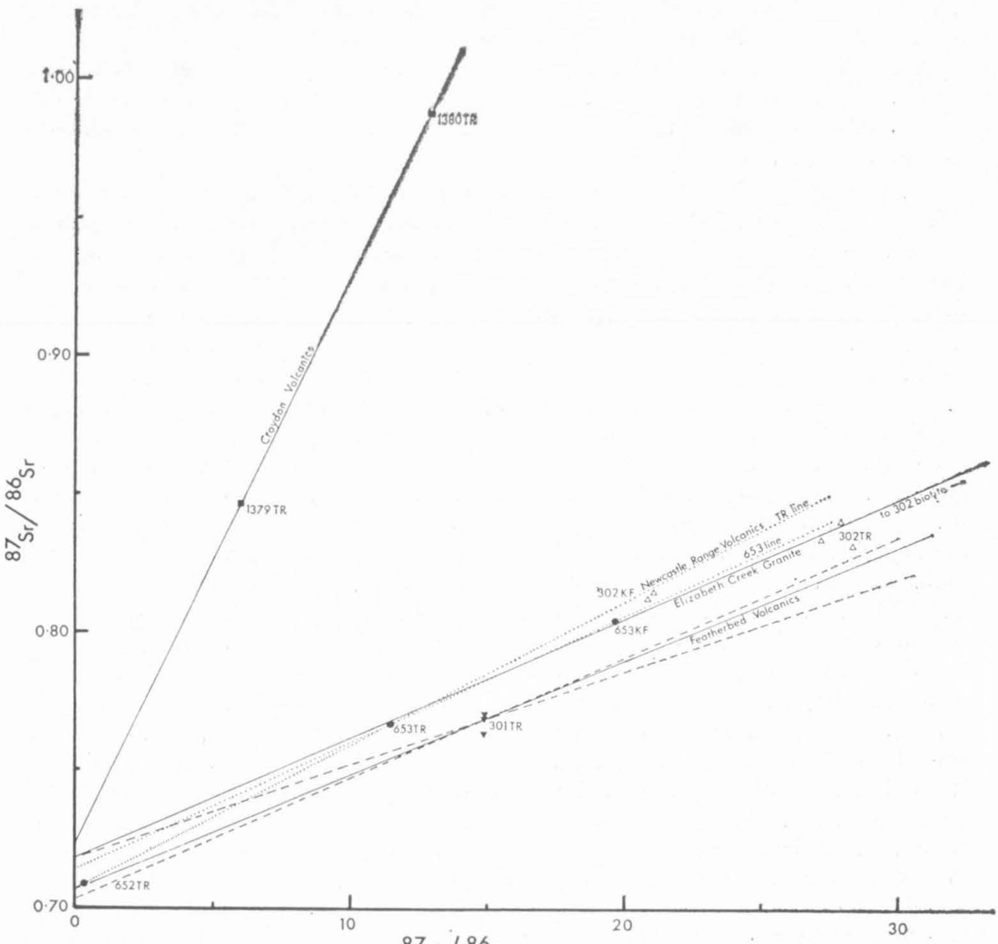

Figure 3. Rb-Sr isochron plot.

(GA 1379, 1380). All available experimental results are shown in Table 4 and Figure 3, and the deduced age limits are listed in Table 5. All calculations are based upon the value 8.34 for $^{88}Sr/^{86}Sr$ (inverse value 0.1199).

The amount of information provided by these measurements is altogether too small for reasonably confident interpretation by contemporary standards, but cannot be augmented until another sampling expedition has been undertaken. In the meantime, however, the following conclusions may fairly be drawn.

(1) The slope of the biotite total-rock line in Figure 3 for the Elizabeth Creek Granite (GA 302) yields an age between 315 and 297 m.y., depending on which of the two alternative ^{87}Rb decay constants is favoured. Another uncertainty is that the biotite may have lost ^{87}Sr after it was formed, but that this effect, if present, could be small is evidenced by the closeness of the microcline point to the line. The result compares quite well with the K–Ar data, where the maximum Elizabeth Creek age is 300 m.y., the average 280 m.y. The nearest K–Ar dated samples are the Ixe Micromonzonite (GA 540, 298 m.y.) and a hybrid sample of Herbert River and Elizabeth Creek Granites (GA 537, 300 m.y.). Thus the correlations between the two methods appear to be within the usual limits. Unfortunately, Sample GA 302 did not contain enough material to date the biotite by K–Ar also.

(2) The intercept of the GA 302 line on the ordinate yields an initial $^{87}Sr/^{86}Sr$ ratio of 0.718. This is higher than the 'mantle' value, and is similar to values reported for anatectic rocks in other areas (*cf.* Pidgeon & Compston, 1965). Thus it may be deduced that this sample of Elizabeth Creek Granite was derived at least in part from regenerated (or digested) crustal material.

(3) Next in order of certainty are the results on the Newcastle Range Volcanics, GA 652 and 653. GA 652 comes from the base of the sequence in the northern part of the Main Range, and GA 653 from the base of the upper member of the sequence in the eastern Newcastle Range area (see Appendix). They may be treated as belonging to a single system in Figure 3 if the time interval is thought to be small, and if the correlation between the two masses is truly justifiable. The absence of replicate analyses throws some uncertainty on the significance of the deviation of the three points from linear behaviour, but limits may be set by drawing two lines, (*a*) through the two total-rock points, and (*b*) through the two GA 653 points. The range of results is shown in Table 5, where it can be seen that these rocks must be older than the Elizabeth Creek Granite (GA 302) on any reasonable interpretation of the admittedly inadequate data. The implication of these two lines, taken literally, is that either GA 653 was more contaminated by crustal material before final emplacement than was GA 652, or that the K–feldspar has lost ^{87}Sr to another constituent mineral. If the first alternative were correct, we should choose the line between the GA 653 points as giving the age of the upper member of the sequence. The second alternative, which is also quite possible, would lead us to prefer the line through the two total-rock points. In view of the experimental scatter shown for the other samples where replicates are available, perhaps the most reasonable construction is a 'line of best fit' to all three points. Since this line, ruled in by eye, will be strongly influenced by the GA 652 point, the result will be similar to the 'total-rock' line. From this we deduce that the Newcastle Range Volcanics were

probably formed some time in the period 360-380 m.y.; and that the initial $^{87}Sr/^{86}Sr$ ratio was of the order of 0.707, which suggests that this material contains only minor amounts of contamination from the Precambrian country rock. On this basis the age of these volcanics would seem to conform reasonably well either to the Devonian event deduced from the K–Ar measurements, or to another event not very long afterwards, but probably preceding the Mount Rous Ring Dyke intrusion (GA 660, 325 m.y.). However, the evidence is not at all clear. Detailed geological conclusions on these points must be delayed until more evidence has been obtained.

(4) Turning to the single Featherbed Volcanics (GA 301) result, we have depicted in Table 5 the range in possible ages for three conceivable values of the initial strontium ratio. Elizabeth Creek sample site GA 302 lies some distance south of the Range, and is not directly related to it. However, the generally accepted closeness in age of this type of granite to the Volcanics enables us to suggest that the best value for the initial ratio may be somewhere in the range 0.703 (minimum 'mantle' value) to 0.707 (Newcastle Range Volcanics). It appears to be the case, on any construction, that the maximum possible age of this Featherbed Range sample is less than the age of the Newcastle Range Volcanics. If, by analogy with the Croydon and Eastern Newcastle Range implications, one chooses a higher value for initial ratio, then the Featherbed sample is even younger. Thus both K–Ar and Rb–Sr methods agree in suggesting that the locus of activity may have progressed to the north-east as time passed by, for the acid rocks of 'simatic' as well as of 'anatectic' origin.

(5) Samples GA 1379 and GA 1380 represent the only two samples of Croydon Volcanics collected. They were not suitable for separation of any mineral. Only a single total-rock measurement was made on each. Thus the isochron line through the two analytical points is subject to some error. Nevertheless, a Precambrian age (1380-1460 m.y.) for this mass is inescapable. The results also imply a high value for the initial $^{87}Sr/^{86}Sr$ ratio (about 0.72), which, if confirmed by later measurements, would suggest some contamination with crustal material. All the Croydon Volcanics contain graphite pellets, which also suggest contamination (Branch, 1966).

The implications of this result have been discussed in a previous section.

Further Comment

Despite the known variations in composition and in associated mineralization (W. R. Morgan, pers. comm., and K. G. Lucas, 1965), the K–Ar data suggest that the granite at Cooktown, the unmineralized Trevethan Granite, and the significantly mineralized Finlayson Granite belong to the same well-defined late Permian period of intrusion. Further, we must conclude that the granite mass associated with Mount Peter Botte, sampled at China Camp (GA 504), must belong to this younger group, even although it was tentatively mapped as the older Mareeba Granite on the Mossman 1 : 250,000 Sheet. This suggested reclassification seems not unreasonable when general trends of granite masses are considered, and is acceptable (de Keyser, pers. comm.) on lithological grounds. Sample GA 5172, north of Cairns, and the mass south of Cairns (GA 5175, 5187, 5189) may also prove to belong to this group, although the close proximity to the last three of strong shearing (see Appendix) makes their ages quite unreliable, and their position (see Fig. 1) makes regional classification somewhat uncertain.

Similarly, the present data appear to demand that the Puckley Granite (GA 534), despite compositional difference, should be correlated in time with the Mareeba Granite. The regional trends suggest that this grouping also is reasonable.

The two masses from the Broken River Embayment (GA 449 and 450) have been classed (White, 1961, 1962) as part of the Upper Palaeozoic Herbert River Batholith. Even GA 450, which has evidently been somewhat sheared (see Appendix), yields an age which seems significantly older than ages of Group C. Thus we must conclude that these small masses, seen clearly to intrude the Silurian sediments of the Embayment, are further isolated representatives of the hitherto unrecognized Middle Palaeozoic acid igneous rocks referred to in the section on General Geology. There is not yet sufficient evidence for an unequivocal association of this granite with any one specific deformation event.

There are only two K-Ar results on 'Upper Palaeozoic' rocks from the southern part of the Georgetown Inlier (GA 544, GA 660); too few to offer any clear guidance on the age-pattern of this area. Their young age, compared with the Dumbano Granite which they intrude, lends general confirmation to Branch's (1966) classification. There is no apparent reason for suspecting the result on GA 544, for the rock is comparatively unweathered and unstressed, and the K-content of the biotite is sufficiently high to suggest that it is not significantly altered. The age results hint, however, that these two rocks are older than the corresponding Elizabeth Creek Granite farther to the north, and that a more detailed isotopic study may emphasize that rocks of similar petrology and field relationship may have been emplaced in different areas over quite a range of geological time.

The results on the mass north-west from Tully, west of Innisfail, suggest a complex history. GA 5184 biotite, and the hornblende of GA 5181, both yield ages which suggest correlation with the Herbert River Batholith. Other results, including GA 5181 biotite, which does not agree with the hornblende in the same sample, and the northerly GA 5186 biotite-hornblende pair, suggest either that some components of this probably Herbert River mass were formed later during the Mareeba event, or that the later event caused argon loss from rocks of Herbert River age. The regional position of this mass (Fig. 1) suggests that such interpretations may not be unreasonable.

The large mass west and north-west of Ingham has been allotted to Group C, in line with the classification by White (1961). These six results were not, however, included in the detailed Herbert River/Elizabeth Creek statistical comparison since they have never been subdivided. Their inclusion would not have affected the general result. The range in ages, although within the general Permo-Carboniferous span for Group C, suggests that this mass also has had a relatively complex history .

We report two 'ages' upon very-low-potash minerals which provide yet further evidence for the occasional presence of argon, derived from some source other than in situ decay of potassium, but which cannot be accounted for by air contamination. Previous examples have been reported by Damon & Kulp (1958), Hart & Dodd (1962), McDougall & Green (1964), Lovering & Richards (1964), Damon (1965), and York (Canadian Association of Physicists meeting, Vancouver, 1965). For GA 5171 tourmaline, an approximation to the K-content was made by X-ray fluorimetry (by A. J. R. White), since this mineral is not very easy to dissolve. The content of excess non-air ^{40}Ar (0.1 to 0.3 x 10^{-6} std cc/gm) may be significant, but at best only one-hundredth of the values for tourmalines reported by Damon & Kulp (1958), This could indicate that comparatively little radiogenic argon had been available in the parent material which was subsequently melted to form the granite, in accord with the postulated derivation of this granite from the sediments of the Hodgkinson Basin.

GA 5190 hornblende comes from a metamorphosed basic rock within the Barron River Metamorphics. The apparent age is again at least twice the expected value (by comparison with GA 1580, the 'excess' ^{40}Ar is 0.3 x 10^{-6} std cc/gm), in line with Damon's suggestion that low-potash hornblende may also contain 'excess argon' (Damon & Kulp, 1958).

GA 494 actinolite, however, gives a satisfactory age. Even if the difference from the biotite age were attributable to this effect, the amount involved comes to less than 0.1 x 10^{-6} std cc/gm. The difference, however, is within experimental error, and therefore we have an example of at least one actinolite where excess ^{40}Ar can be said to be negligible.

There is need for a detailed isotopic study of the acid volcanic rocks, to determine the true nature of the age distribution. For example, there are three principal masses of rock grouped as Nychum Volcanics (Fig. 1). The most easterly, near Nychum homestead, is clearly cut by faults associated with the Featherbed cauldron subsidence, and must therefore be older. F. de Keyser (pers. comm.) reports that the Elizabeth Creek Granite near Wolfram Camp (GA 1354 greisen, 280 m.y.) is cut by Featherbed Volcanics; on the other hand these same volcanics are intruded by some undated Elizabeth Creek masses (Best, 1962). The deduction from this that the Featherbed Volcanics must be around 280 m.y. old is not in serious disagreement with a reasonable interpretation of the single Rb-Sr measurement on GA 301. The volcanics at Nychum homestead must, then, be older than this—i.e. not younger than late Carboniferous on current time-scales.

The other two masses of Nychum Volcanics are west of the Palmerville Fault. Available evidence on the southern mass is again that it should be older than 300 m.y., in that rhyolite inclusions, similar to these Volcanics, are found in an isolated mass, near Beaverbrook, classified as Almaden Granite. Dates on the main mass of the Almaden Granite are GA443 (biotite, 290 m.y.; hornblende, 300 m.y.) GA 444 (biotite, 280 m.y.). Again there is an element of uncertainty because of the isolation of this small granite mass, and because its contact with this southerly part of the Nychum Volcanics may be obscured by the Palmerville Fault; but the implication is that both southern and eastern masses of Nychum Volcanics are older than the granites, and therefore earlier than late Carboniferous.

The north-western mass of Nychum Volanics, on the banks of the Mitchell River, on the other hand, appears to be much younger than late Carboniferous. These volcanics are interbedded with shales containing plant and microfossils ascribed to the late Permian (M. E. White, B. E. Balme), perhaps even early Triassic (M. E. White) (quoted White, 1965, and de Keyser & Wolff, 1965). It seems, therefore, that the volcanics on Mitchell River are younger than the Nychum Volcanics, and should not be classed with them (see Branch, 1966). This reconstruction should be tested by further isotopic measurements.

CONCLUSIONS

(1) Precambrian igneous rocks of the Georgetown Inlier in the Cairns Hinterland include the Croydon Volcanics (1460 m.y.), the granite at Esmeralda homestead, the Forsayth Granite, and the Robin Hood Granite (not less than 1200 m.y.).

(2) Middle Palaeozoic event(s) caused argon loss in many of the Precambrian granites, and were associated with the formation of the Dido Granodiorite, the Dumbano Granite, and the granites within the Broken River Embayment. The Newcastle Range Volcanics and the granites of Cape York Peninsula are probably also of this age.

(3) Upper Palaeozoic (Permo-Carbiniferous) 'granites' are those classified as Herbert River Granite, Almaden Granite, and Elizabeth Creek Granite. There is no detectable overall age difference btween the Herbert River/Almaden and Elizabeth Creek Granites, but the results indicate that representatives of each group were being intruded at different times over a significantly long time-period.

(4) Within the Hodgkinson Basin the Lower Permian (Mareeba) granites and the Upper Permian granites (near Cooktown) were each formed in a distinct pulse of activity.

(5) The overall pattern in the Palaeozoic granite rocks is of a progression of activity from south-west to north-east, which is distinctly visible in the anatectic granites, but may also turn out to be a property of the acid igneous rocks of more deep-seated origin.

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TABLE 1: K-Ar RESULTS ON POSSIBLY PRECAMBRIAN ACID IGNEOUS ROCKS

Sample No. GA–	Rock Type	'Age group'	Mineral	K (%)	^{40}Ar(atm) (%)	^{40}Ar*/^{40}K	Age (m.y.)
410	Robin Hood	—	muscovite ..	9.04	1.4	0.08891	1116
411	Robin Hood	D	biotite ..	7.53	3.6	0.02464	381
412	Forsayth	D	biotite ..	7.84	5.4	0.02374	368
		—	muscovite ..	7.34	1.8	0.03217	482
413	Forsayth	D	biotite ..	7.93	4.5	0.02510	387
414	Forsayth	—	biotite ..	7.24	2.5	0.03159	475
			muscovite ..	9.11	1.8	0.05853	804
415	Forsayth	D	biotite ..	7.50	3.4	0.02578	397
416	Forsayth	D	biotite ..	7.53	4.4	0.02407	373
428	(?)Forsayth (Dargalong)	—	biotite ..	5.98	4.3	0.08143	1044
429	Forsayth	D	biotite ..	7.16	2.1	0.02699	413
441	(?)Forsayth (Forest Home)	—	biotite ..	6.83	2.4	0.09798	1200
658	(?)Esmeralda	—	biotite ..	6.69	1.9	0.03459	515
		—	muscovite ..	8.46	1.0	0.04964	701
659	(?)Esmeralda	—	biotite ..	7.33	1.2	0.04143	602
442	Pegmatite	—	biotite ..	6.88	9.6	0.02704	414
	Einasleigh Metamorphics	—	muscovite ..	8.91	6.3	0.02834	432
430	Dido	D	biotite ..	7.56	3.1	0.02684	411
		—	hornblende ..	0.511	7.8	0.02722	416
431	Dido	D	biotite ..	7.52	1.2	0.02502	386
		—	hornblende ..	0.487	5.7	0.02673	408
417	Dumbano	D	biotite ..	7.43	3.6	0.02450	379
418	Dumbano	D	biotite ..	7.49	{ 1.2	0.02435	377
					4.8	0.02535	391
		—	muscovite ..	8.84	{ 1.7	0.02458	380
					2.8	0.02393	371
419	Dumbano	D	biotite ..	6.63	5.7	0.02516	388
427	Dumbano	D	biotite ..	6.05	3.8	0.02393	371
529	Cape York	—	biotite ..	6.65	{ 2.1	0.02256	351
					1.4	0.02317	360
		—	muscovite ..	8.84	6.3	0.02401	372

$\lambda_\beta = 4.72 \times 10^{-10} y^{-1}$ $\lambda_K = 0.584 \times 10^{-10} y^{-1}$ $^{40}K = 1.19 \times 10^{-4}$ gm atom ^{40}K/gm atom K

TABLE 2: K–Ar RESULTS ON UPPER PALAEOZOIC ACID IGNEOUS ROCKS

Sample No. GA–	Rock Type	'Age group'	Mineral	K (%)	^{40}Ar(atm) (%)	^{40}Ar*/^{40}K	Age (m.y.)
449	Granite at Rocky Dam . .	D	biotite . .	6.91	4.0	0.02248	350
450	Granite at Perry Creek . .	—	biotite . .	7.37	4.2	0.02005	315
544	Black Braes	—	biotite . .	7.20	3.7	0.01931	305
660	Mt Rous	—	hornblende . .	0.627	14.8	0.02072	325
443	Almaden (HR ?) (*a*) . .	CH	biotite . .	6.81	10.7	0.01843	292
		CH	hornblende . .	0.579	7.1	0.01913	302
444	Almaden (HR ?) . .	CH	biotite . .	6.33	7.9	0.01788	284
445	Herbert River . .	CH	biotite . .	5.15	11.8	0.01799	285
		CH	hornblende . .	0.560	8.6	0.01703	271
446	Herbert River . .	CH	biotite . .	5.88	16.3	0.01678	267
447	Herbert River . .	CH	biotite . .	7.03	2.8	0.01751	278
505	Herbert River . .	CH	biotite . .	6.25	10.4	0.01749	278
506	Herbert River . .	CH	biotite . .	6.22	7.6	0.01838	291
539	Herbert River . .	CH	biotite . .	6.04	2.5	0.01869	296
540	Ixe (HR ?)	CH	biotite . .	5.81	4.5	0.01883	298
448	Elizabeth Ck	CE	biotite . .	7.51	3.1	0.01902	300
536	Elizabeth Ck	CE	biotite . .	6.96	7.5	0.01620	259
537	Hybrid (HR–EC) (*b*) . .	CE	biotite . .	6.62	4.1	0.01901	300
538	Elizabeth Ck	CE	biotite . .	7.05	8.2	0.01878	297
541	Elizabeth Ck	CE	biotite . .	4.96	4.4	0.01682	268
542	Elizabeth Ck greisen . .	CE	muscovite . .	8.97	2.4	0.01691	269
543	Elizabeth Ck	CE	biotite . .	7.63	2.8	0.01696	270
666	Elizabeth Ck	CE	biotite . .	5.45	4.4	0.01851	293
1354	Elizabeth Ck greisen . .	CE	muscovite . .	8.69	3.2	0.01761	280
5159	North-west from Ingham	C	biotite . .	7.47	2.4	0.01708	272
5160	North-west from Ingham	C	biotite . .	7.22	3.3	0.01746	277
5161	North-west from Ingham	C	biotite . .	5.35	2.7	0.01974	311
5164	North-west from Ingham	C	biotite . .	7.36	1.2	0.01804	286
5165	North-west from Ingham	C	biotite . .	7.37	2.2	0.01791	284
5166	North-west from Ingham	C	biotite . .	7.19	1.5	0.01810	287
5176	North-west from Ingham	C	biotite . .	5.52	1.4	0.01724	274
5181	(?)Herbert River . .	—	biotite . .	6.91	2.5	0.01739	276
		—	hornblende . .	1.064	6.8	0.01832	290
5182	(?)Herbert River . .	—	biotite . .	6.94	4.7	0.01697	270
5183	(?)Herbert River . .	—	biotite . .	7.51	2.5	0.01644	262
5184	(?)Herbert River . .	—	biotite . .	7.44	1.3	0.01822	289
5186	(?)Herbert River . .	—	biotite . .	7.58	1.9	0.01684	268
		—	hornblende . .	0.365	8.8	0.01737	276
498	Mareeba	B	biotite . .	6.96	12.0	0.01640	262
		B	muscovite . .	8.56	2.2	0.01665	265
499	Mareeba	B	biotite . .	7.48	8.2	0.01661	265
500	Mareeba	B	biotite . .	6.48	5.2	0.01671	266
501	Mareeba	B	biotite . .	6.85	36.0	0.01611	257
502	Mareeba	B	biotite . .	7.26	8.2	0.01687	269
503	Mareeba	B	biotite . .	5.84	7.0	0.01599	256
		B	muscovite . .	8.59	7.1	0.01702	271
507	Mareeba	B	biotite . .	6.93	12.8	0.01644	262
		B	muscovite . .	8.31	18.3	0.01684	268
534	Puckley	B	biotite . .	7.31	2.0	0.01657	264
535	Mareeba	B	biotite . .	7.47	4.0	0.01646	263
		B	muscovite . .	7.94	2.6	0.01660	265

TABLE 2: K–Ar RESULTS ON UPPER PALAEOZOIC ACID IGNEOUS ROCKS—*continued*

Sample No. GA-	Rock Type	'Age group'	Mineral	K (%)	^{40}Ar(atm) (%)	^{40}Ar*/^{40}K	Age (m.y.)
5169	Mareeba	B	biotite ..	6.72	3.0	0.01706	271
		B	muscovite ..	8.88	2.2	0.01677	267
5170	Mareeba	B	biotite ..	7.20	1.6	0.01644	262
		B	muscovite ..	8.42	2.7	0.01691	269
5171	Mareeba	B	muscovite ..	8.69	2.1	0.01609	257
		—	tourmaline ..	0.02–0.04	25.0	(0.0414–0.0207)	(600–320)
5177	Hinchinbrook Island ..	—	biotite ..	6.31	7.4	0.01566	251
					5.3	0.01604	256
		—	riebeckite ..	0.897	5.5	0.01666	266
494	Trevethan	A	biotite ..	7.62	7.6	0.01580	253
		A	actinolite ..	0.449	7.7	0.01607	257
495	Trevethan	A	biotite ..	7.56	7.6	0.01536	246
496	Finlayson	A	biotite ..	7.02	12.0	0.01533	246
497	Finlayson	A	biotite ..	6.43	16.9	0.01534	246
504	(?)Mareeba	A	biotite ..	7.31	3.8	0.01542	251
					9.5	0.01528	249
		A	muscovite ..	8.33	2.4	0.01453	234
					4.9	0.01502	241
533	Trevethan dyke ..	A	biotite ..	5.02	2.8	0.01482	238
5172	North of Cairns ..	—	muscovite ..	8.67	2.1	0.01551	248
5175	South of Cairns ..	—	biotite ..	7.03	3.7	0.01419	228
5187	South of Cairns ..	—	biotite ..	7.34	2.1	0.01419	228
5189	South of Cairns ..	—	biotite ..	7.60	2.5	0.01502	241
5180A	Barnard metamorphics..	—	muscovite ..	8.12	2.5	0.01894	299
					2.1	0.01966	310
5180B	Associated pegmatite ..	—	muscovite ..	8.36	3.5	0.02258	352
					2.8	0.02318	360
5190	Basic rock in Barron River metamorphics	—	hornblende ..	0.023	45.0	0.04290	620

(*a*) HR—Herbert River. (*b*) EC—Elizabeth Creek

TABLE 3: STATISTICAL EXAMINATION OF THE 'AGE GROUPS'

(a) Statistical parameters

Group (*see* Tables 1 and 2)	Mean age (m.y.)	Number of samples (n)	Standard Deviations	
			(i) of single age $\sigma = \left(\frac{\Sigma \Delta^2_1}{n-1}\right)^{\frac{1}{2}}$	(ii) of mean $\sigma_m = \left(\frac{\Sigma \Delta^2_1}{n(n-1)}\right)^{\frac{1}{2}}$
Late Permian (A)	247	8	6.7	2.4
Early Permian (B)	264	18	4.5	1.1
Permo-Carboniferous (C) ..	284	27	13.0	2.5
Herbert River (CH)	286	11	11.2	3.4
Elizabeth Creek (CE)	282	9	15.9	5.3
Siluro-Devonian (D) (biotites only)	384	12	17.8	5.1
Dido	405	4	13.3	6.6
Dumbano	380	5	6.7	3.0

(b) Significance of differences between mean values

Groups	Difference (δ) (m.y.)	Standard deviation of differencd $\sigma_d \left(\sigma^2_{m_1} + \sigma^2_{m_2}\right)^{\frac{1}{2}}$ (m.y.)	Degrees of freedom	$t = \frac{\delta}{\sigma_d}$	Level of significance
B–A ..	17.6	2.58	24	6.82	>>99.9%
C–B ..	19.6	2.71	43	7.23	>>99.9%
D–C ..	99.9	5.70	37	17.52	>>99.9%
CH–CE ..	3.8	6.29	18	<1	<<75%
Dido–Dumbano	25.7	7.26	7	3.54	>99%

TABLE 4: Rb-Sr DATA ON ACID IGNEOUS ROCKS (SEE FIG. 3)

Sample No. GA–	Name	Mineral	Rb (μg/g)	Common Sr (μg/g)	Estimated total Sr (μg/g)	$^{87}Rb/^{86}Sr$	$(^{87}Sr/^{86}Sr)$ now
301	Featherbed Volcanics	Total Rock A(*a*)	266	51.3	51.6	14.93	0.770(*b*)
		B	268	51.7	52.0	14.90	0.763(*b*)
		C	—	—	—	(average 14.91)	0.769
302	Elizabeth Creek Granite	Total Rock A(*a*)	299	30.8	31.2	27.91	0.841(*b*)
		B	300	30.5	30.8	28.35	0.832(*b*)
		C	294	31.2	31.6	27.14	0.835
		Microcline A(*a*)	358	48.8	49.3	21.10	0.815(*b*)
		B	358	49.4	49.9	20.89	0.812(*b*)
		C	—	—	—	(average 20.99)	0.813
		Biotite A(*a*)	1664	9.43	11.50	507.7	2.95(*b*)
		B	1672	9.26	11.31	519.5	2.98(*b*)
652	Augite Andesite (Newcastle Ra.)	Total Rock ..	39.7	320	320	0.3569	0.709
653	Rhyodacite (Newcastle Ra.)	Total Rock ..	156	39.2	39.4	11.47	0.767
		K-feldspar ..	338	49.5	50.0	19.67	0.805
1379	Croydon Volcanics	Total Rock ..	204	98.1	99.3	6.003	0.847
1380	Croydon Volcanics	Total Rock ..	301	67.3	69.0	12.88	0.988

(*a*) Separate dissolutions of sample. Sr runs normalized to $^{88}Sr/^{86}Sr = 8.340$.
(*b*) Values calculated from a mixture of sample and tracer Sr.

TABLE 5: RANGE OF POSSIBLE AGE INFORMATION DEDUCIBLE FROM THE Rb/Sr DATA OF TABLE 4 AND FIGURE 3

Sample No. GA–	Name	Choice of line	Slope (from Fig. 3)	Calculated age	
				$\lambda = 1.47 \times 10^{-11}y^{-1}$	$\lambda = 1.39 \times 10^{-11}y^{-1}$
302	Elizabeth Creek Granite	Through biotite and TR points, on small-scale plot. *deduced* $R_i = 0.718$	0.00437	297	315
652–653	Newcastle Ranges Volcanics	(a) Through two TR points *deduced* $R_i = 0.707$	0.00524	357	377
		(b) Through two GA653 points *deduced* $R_i = 0.714$	0.00462	314	333
301	Featherbed Range Volcanics	Using line C in table 4 assume various 'possible' values for R_i			
		(a) mantle $R_i = 0.703$	0.00445	303	320
		(b) (652–653) TR $R_i = 0.707$	0.00420	286	302
		(c) GA302 $R_i = 0.718$	0.00344	234	248
1379–1380	Croydon Volcanics	Through two TR points *deduced* $R_i = 0.724$	0.0205	1380	1460

APPENDIX

SAMPLE DETAILS

The GA serial number refers to the geochronology collection in the Department of Geophysics, ANU; the other is the registered number for the sample in the Geological Branch BMR—e.g. E54/12/9 refers to the ninth sample collected for age purposes in the E54/12 map area (1 : 250,000 series).

Most of the notes on petrography have been condensed from preseparation reports by W. R. Morgan and C. D. Branch, who were each involved in the collection of many of the samples, and by J. M. Rhodes. All dates recorded in this appendix are by the K-Ar method, and have been rounded to the nearest 10 m.y. for the older rocks, and 5 m.y. for the younger. Latitudes and longitudes have been read from the appropriate 1 : 250,000 map.

NOTE: Although, in the petrographic descriptions, biotite is described as fresh to chloritized, in most cases the biotite concentrate contained less than 2 percent chlorite.

GA 301: *Ignimbrite, Featherbed Volcanics* — Total-rock, Rb-Sr. (See Fig. 3, Tables 4 & 5)

Locality: 17° 02′ S, 144° 37′ E. (on E55/5 map) 10 miles east-north-east of Chillagoe, across the Walsh River.

Geology: Top of section, in the main part of the Featherbed Range, which is a group of acid volcanics of Upper Palaeozoic age, occupying a large cauldron subsidence area. Collector C.D.B., field reference C.74 (Branch, 1966).

GA 302: *Elizabeth Creek Granite* — Biotite, K-feldspar, total rock Rb-Sr. (See Figure 3, Tables 4 & 5).

Locality: 17° 51′ S, 144° 35′ E. (on E55/5 map) 10 miles south-south-east of Barwidgi homestead.

Geology: Correlatable on the map with the granite intruding the Ixe Monzonite GA540. Collected by C.D.B., field reference A305 (Branch 1966).

GA 410: *Robin Hood Granite, E54/12/8* — Muscovite, 1120 m.y.

Locality: 18° 49′ S, 143° 39′ E. 3 miles north-west of Robin Hood homestead, on track to Forsayth.

Geology: A granitic mass which intrudes metamorphic rocks of the Precambrian Georgetown Inlier, and is considered part of the Forsayth Batholith (White & Wyatt, 1960).

Petrography: A grey-white biotite-muscovite adamellite (pegmatitic), noticeable iron-staining in hand-specimen. Quartz is strongly distorted and granulated with, in places, a xenoblastic texture; feldspars show some alteration and signs of strain; muscovite is moderately to strongly strained; biotite is partly bleached, and altered to leucoxene. The recorded age is almost certainly less than the time since formation.

GA 411: *Robin Hood Granite, E54/12/9* — Biotite, 380 m.y.

Locality: 18° 50′ S, 143° 42′ E. 1 mile north-west of Robin Hood homestead, on track to Forsayth.

Geology: As for GA 410.

Petrography: A grey-blue biotite granodiorite, with tabular phenocrysts of white potash feldspar. All minerals show distortion and recrystallization. Biotite is moderately distorted, but fresh. Thus argon loss subsequent to crystallization is to be expected.

GA 412: *Forsayth Granite, E54/12/10* — Biotite, 370 m.y. Muscovite, 480 m.y.

Locality: 18° 13′ S, 143° 51′ E. 10 miles west of Eveleigh homestead.

Geology: This mass is considered part of the Forsayth Batholith (See GA 413) but is separated from the main part of the batholith by the Upper Palaeozoic Newcastle Range Volcanics. It intrudes (?)Archaean Einasleigh Metamorphics (White & Wyatt, 1960).

Petrography: A grey-pink biotite adamellite, massive and fresh. Most minerals show little alteration, or strain. Biotite is slightly strained and somewhat chloritized. The age discordance suggests however that argon loss has occurred.

GA 413: *Forsayth Granite, E54/12/13* Biotite, 390 m.y.

Locality: 18° 35′ S, 143° 39′ E. 5 miles east of Forsayth on road to Einasleigh.

Geology: Part of the main mass of the Forsayth Batholith, which trends north-west in the central 10,000 square miles of the Georgetown Inlier. It intrudes the (?)Lower Proterozoic sediments of the Etheridge Geosyncline and the (?)Archaean Einasleigh Metamorphics, and is regarded as the youngest Precambrian member of the Inlier (White & Wyatt 1960, White 1965).

Petrography: A dark grey biotite adamellite, with white tabular phenocrysts of K-feldspar, somewhat foliated, and fresh. Minerals show little strain, but distinct signs of recrystallization. Biotite appears fresh, is moderately strained. Loss of argon is expected.

GA 414: *Forsayth Granite, E54/12/14* Biotite, 480 m.y.
Muscovite, 800 m.y.

Locality: 18° 13′ S, 143° 20′ E. Turn-off from Georgetown-Croydon Road, 6.5 miles along road to Mt Turner homestead.

Geology: See GA 413. This sample was from a large boulder outcrop, in which could also be seen very broad bands of a more finely crystalline granite containing xenoliths of quartzite and banded 'metasediment'.

Petrography: A grey biotite-muscovite adamellite, with large phenocrysts of white K-feldspar; appears fresh. The minerals show clear evidence of distortion and recrystallization. Biotite shows slight to moderate distortion, is slightly chloritized; muscovite is moderately to strongly distorted. Loss of argon is confirmed by the age discordancy.

GA 415: *Forsayth Granite, E54/12/15* Biotite, 400 m.y.

Locality: 18° 17′ S, 143° 37′ E. 5 miles east of Georgetown, on the old coach road to Eveleigh.

Geology: See GA 413.

Petrography: A grey-pink biotite granodiorite, appears fresh. Major minerals show some distortion, possibility of complete recrystallization of the quartz. Biotite is slightly strained, moderately chloritized, with some alteration to prehnite.

GA 416: *Forsayth Granite, E55/9/4* Biotite, 370 m.y.

Locality: 18° 35′ S, 144° 22′ E. 10 miles north-east of Carpentaria Downs homestead on road to Rosella Plains homestead.

Geology: See GA 413. This sample is from the most easterly part of the central section of the Forsayth Batholith.

Petrography: A grey-pink biotite granodiorite; some signs of iron stain. The major minerals show strong signs of distortion, recrystallization; some alteration. Biotite is moderately distorted, slightly chloritized, and associated with prehnite.

GA 417: *Dumbano Granite, E55/13/2* Biotite, 380 m.y.

Locality: 19° 13′ S, 144° 17′ E. 5 miles west of Lyndhurst homestead on road to Oak Park homestead.

Geology: This unit occupies 1700 square miles in the southern extent of the Forsayth Batholith, both north and south of the Palaeozoic sediments of the Broken River Embayment. It has been considered part of the Batholith. although the most westerly part of it intrudes the Forsayth Granite, the most extensive granite in the Forsayth Batholith. It is generally tectonically foliated (White & Wyatt, 1960; White, 1965).

Petrography: A grey-pink medium-grained biotite adamellite. Quartz shows moderate to strong strain effects, but in places forms a mosaic of roughly equant strain-free grains, suggestive of recrystallization; feldspars do not appear to be strained, nor particularly altered; biotite is slightly strained, moderately chloritized, associated with epidote.

GA 418: *Dumbano Granite, E55/13/5* Biotite 385 m.y.
Muscovite, 375 m.y.

Locality: 19° 57′ S, 144° 44′ E. 3 miles east of Reedy Springs homestead on road to Cargoon homestead.

Geology: See GA417. This sample is from the most southerly part of the Dumbano Granite mass.

Petrography: A dark-grey muscovite-biotite granodiorite with pink phenocrysts of K-feldspar, appears fresh. All minerals show distortion, with granulation in the quartz. Biotite is moderately distorted, slightly chloritized and associated with epidote; muscovite is significantly distorted. This is suggestive of possible argon loss, but the age concordance suggests either that the distortion occurred very soon after crystallization, or that a subsequent event was sufficiently severe to cause complete loss of argon from muscovite. The low grade of regional metamorphism in the surrounding rocks leads us to prefer the first alternative.

GA 419: *Dumbano Granite, E55/13/6* Biotite, 390 m.y.

Locality: 19° 37′ S, 144° 52′ E. Creek crossing 4 miles north of Wando Vale homestead on road to Pandanus Creek homestead.

Geology: See GA 417. From 5 miles south of the Broken River Embayment.

Petrography: A fairly fresh grey-pink biotite granodiorite. Quartz is somewhat distorted and granulated; feldspars are unstrained and relatively unaltered; biotite shows slight to moderate distortion, is slightly chloritized, and associated with epidote.

GA 427: *Dumbano Granite, E54/16/8* Biotite, 390 m.y.

Locality: 19° 18′ S, 143° 54′ E. 7 miles south-west of Glenmore (Ten-mile) homestead, on track to Gorge Creek homestead.

Geology: See GA 417. This sample is 2 miles from, and within, the Upper Palaeozoic Mount Rous Ring Dyke, (Branch, White, & Wyatt, 1960).

Petrography: A fresh pale-grey biotite adamellite, with pale pink K-feldspar phenocrysts. Quartz is moderately to strongly strained, with considerable granulation; the feldspars show little strain and only slight alteration; biotite shows slight to moderate distortion, is moderately chloritized, and is associated with epidote.

GA 428: *Forsayth Granite (Dargalong), E55/5/9* Biotite, 1040 m.y.

Locality: 17° 13′ S, 144° 27′ E. Bed of Muldiva Creek, 7 miles south-west of Chillagoe, on track to Bolwarra homestead.

Geology: Small mass of Forsayth-type granite surrounded by Dargalong Metamorphics, which are regarded as equivalent to the possibly Archaean Einasleigh Metamorphics. (White & Wyatt, 1960; White, 1965).

Petrography: A dark-grey biotite granodiorite, with white K-feldspar phenocrysts. Strong distortion and granulation in the quartz; other minerals show distortion, and some alteration. Biotite is distorted, slightly seriticized, and associated with epidote and possibly ilmenite. The rock is cut by veins containing possible zeolite (2V. very small), carbonate, and chlorite, which are thin and occupy possible shears. Also present are veins containing epidote, with intense sericitization of plagioclase in their immediate neighbourhood. Loss of argon is expected.

G9 429: *Forsayth Granite, E55/9/1* Biotite, 410 m.y.

Locality: 18° 50′ S, 144° 10′ E. Copperfield River Crossing, 3 miles north of Kidston on road to Einasleigh.

Geology: See GA 413.

Petrography: A fresh dark grey hornblende-biotite granodiorite. All minerals show strong distortion, granulation in the quartz; biotite is slightly to moderately strained.

GA 430: *Dido Granodiorite, E55/9/6* Biotite, 410 m.y.
Hornblende, 415 m.y.

Locality: 18° 59′ S, 144° 35′ E. 7 miles east-south-east of Lynd homestead on old road to Ninety Mile copper mine.

Geology: This mass covering about 210 square miles has been considered to be part of the Forsayth Batholith. It intrudes (?)Lower Proterozoic sediments and the (?)Archaean Hall's Reward Metamorphics (equivalent to Einasleigh Metamorphics). (White & Wyatt, 1960; White, 1965).

Petrography: A grey hornblende-biotite granodiorite (almost tonalite). Plagioclase and quartz show distortion, some granulation. Biotite is slightly chloritized, and shows varying amounts of distortion, some of which may be caused by the growing against each other of two crystals; hornblende is slightly distorted, and somewhat altered.

GA 431: *Dido Granodiorite, E55/9/8* Biotite, 385 m.y.
Hornblende, 410 m.y.

Locality: 18° 50′ S, 144° 50′ E. 5 miles south of Wyandotte homestead on old road to Ninety Mile copper mine.

Geology: See GA 430. Distinct evidence for shearing in vicinity.

Petrography: A fresh, strongly foliated grey biotite-hornblende granodiorite. Zoned andesine is slightly distorted, with slight alteration; quartz is severely granulated and distorted, and altered to biotite, epidote, chlorite, and prehnite; biotite is moderately distorted and slightly chloritized.

GA 441: (*Forsayth ?*) *Granite at Forest Home, E54/12/3* Biotite, 1200 m.y.

Locality: 18° 16′ S, 143° 6′ E. Near Forest Home Station, 30 miles west of Georgetown on south bank of Gilbert River.

Geology: Correlated (White, 1962c) with the main mass of granite which crops out along the eastern and western edges of the Croydon Volcanics, and which was believed to belong to the late Palaeozoic period of igneous activity. However, it does not intrude into the cauldron subsidence area of the Croydon Volcanics, and cannot therefore be regarded, *sensu stricto,* as Esmeralda Granite. Thus its classification with the Forsayth Granite seems preferable, despite lithological differences (White, 1956).

Petrography: A grey biotite granodiorite. Quartz shows slight distortion, only marginal granulation; feldspars appear unstrained, only slight alteration. Some rare flakes of biotite show either small crenulations or recrystallization growth on the end of cleavage feathers, but most is unstrained. The overall impression is of an unstrained rock.

GA 442: *Pegmatite in Einasleigh Metamorphics, E54/12/12* Biotite, 415 m.y.
Muscovite, 430 m.y.

Locality: 18° 33′ S, 143° 58′ E. Stockman's Creek Crossing, 8 miles west-south-west of Einasleigh on road to Forsayth.

Geology: The Einasleigh Metamorphics are regarded as the oldest unit in the Georgetown Inlier. This pegmatite 'intrudes' the banded granulite and paragneiss of the Metamorphics, which are presumably intruded by the Forsayth Batholith about 5 miles to the east of this locality (White, 1965).

Petrography: Coarse-grained pegmatite, slightly weathered, with a little iron staining between grains and around biotites. Major minerals appear unstrained, with some kaolinization of plagioclase. Biotite is slightly distorted, interleaved with chlorite, and associated with epidote; muscovite is present, also iron oxide and leucoxene: the state of the sample is consistent with its situation in a creek-bed. The exact influence of this upon the apparent age is not certain.

GA 443: *Almaden Granite, E55/5/6* — Biotite, 290 m.y.; Hornblende, 300 m.y.

Locality: 17° 21′ S, 144° 40′ E. 1 mile west of Almaden on road to Chillagoe.

Geology: This is in the northern part of the Herbert River Batholith, an early phase of the Upper Palaeozoic igneous activity (White, 1961; Best, 1962; de Keyser & Wolff, 1965).

Petrography: A grey biotite-hornblende adamellite (almost granodiorite) very slightly weathered. An almost completely unstrained rock, with some alteration of feldspars. Biotite is interleaved with chlorite and associated with iron oxide; hornblende is fresh, with some patches of iron oxide.

GA 444: *Hybrid Granite at Almaden, E55/5/7* — Biotite, 285 m.y.

Locality: 17° 22′ S, 144° 42′ E. 4 miles south-east of Almaden, on road to Koorboora.

Geology: Classed as part of the Herbert River Batholith. See GA 443.

Petrography: A pale-pink-grey porphyritic biotite-hornblende adamellite, comparatively unweathered, and apparently unstrained. Biotite is slightly chloritized; hornblende is associated with a little iron oxide and chlorite. Any alteration is in patches, affecting all minerals, and appears to be the localized effect of hydrothermal alteration.

GA 445: *Herbert River Granite, E55/5/8* — Biotite, 285 m.y.; Hornblende, 270 m.y.

Locality: 17° 16′ S, 144° 22′ E. 12 miles south-west of Chillagoe on track to Bolwarra Station.

Geology: North-western part of the Herbert River Batholith, which intrudes the (?) Archaean Dargalong Metamorphics. See GA 443.

Petrography: A pink porphyritic biotite-hornblende adamellite, slightly iron-stained. There is little strain or alteration. Biotite is somewhat chloritized; chlorite and iron oxide are present as alteration products of green hornblende.

GA 446: *Herbert River Granite (Watsonville), E55/5/12* — Biotite, 265 m.y.

Locality: 17° 23′ S, 145° 17′ E. 1 mile west of Watsonville on track to Stannary Hills.

Geology: See GA 443.

Petrography: A slightly weathered grey biotite adamellite. Quartz shows slight strain, other minerals are essentially strain-free; there is some alteration of feldspars. Biotite appears fresh.

GA 447: *Herbert River Granite (Herberton), E55/5/13* — Biotite, 280 m.y.

Locality: 17° 25′ S, 145° 23′ E. 2 miles south of Herberton on road to Ravenshoe.

Geology: See GA 443.

Petrography: An essentially fresh, unstrained, grey biotite granite (almost adamellite).

GA 448: *Elizabeth Creek Granite (Cumbana), E55/9/3* — Biotite, 300 m.y.

Locality: 180° 02′ S, 144° 02′ E. ½ mile east of Cumbana homestead.

Geology: Upper Palaeozoic granites of the pink Elizabeth Creek type are observed to be intrusive into the grey Herbert River type. The mass represented by this sample also intrudes the Newcastle Range Volcanics (White, 1962b).

Petrography: A deep pink biotite granite, iron-stained in patches and along cracks. In thin section, the rock shows little sign of strain, but the feldspars are considerably altered. Biotite is slightly chloritized and associated with iron oxide; undistorted apart from a little strong distortion due to hydration on weathering. Despite the unpromising report, a biotite concentrate of 95% grain purity was prepared and analysed.

GA 449: *Granite at Rocky Dam, E55/9/9* Biotite, 350 m.y.

Locality: 18° 50′ S, 145° 17′ E. 12 miles west of Camel Creek Station.

Geology: One of a number of small granite masses which have been classed as Herbert River Granite, but which occur somewhat to the west of the main Herbert River Batholith, within the Broken River Embayment. It intrudes Silurian sediments of the Greenvale Formation (White, 1965).

Petrography: A grey biotite granodiorite (almost adamellite), a little iron-stained. The rock appears to be comparatively unstrained and unaltered. Strain-free biotite is moderately chloritized, with some marginal iron oxide.

GA 450: *Granite at Perry Creek, E55/9/10* Biotite, 315 m.y.

Locality: 18° 44′ S, 145° 20′ E. At the Perry Creek tinfield, 12 miles north-west of Camel Creek homestead on track to Valley of Lagoons homestead.

Geology: See GA 449.

Petrography: A grey foliated biotite granodiorite, somewhat weathered. All minerals appear strongly distorted in thin section, but seem comparatively unaltered. Biotite flakes are bent, marginally recrystallized, and slightly chloritized. All the evidence leads to the expectation of argon loss.

GA 494: *Trevethan Granite, D55/13/1* Biotite, 255 m.y.
Actinolite, 255 m.y.

Locality: 15° 40′ S, 145° 13′ E. Mulligan Highway, ¼ mile north of Helenvale Junction.

Geology: A small mass, 10 to 12 miles south of Cooktown, which intrudes tightly folded Upper Devonian/Lower Carboniferous sediments of the Hodgkinson Formation, and is overlain by Tertiary and Recent stream gravels. Metamorphism of the sediments is observable at the contact, which is somewhat irregular (Lucas, 1965).

Petrography: A fresh grey actinolite-biotite granodiorite. The thin section show some strain effects, some alteration. Biotite, slightly strained, occurs in clusters which replace and pseudomorph the amphibole, and is associated with sphene; actinolite is moderately altered to biotite and prehnite, and contains some remnants of clinopyroxene.

GA 495: *Trevethan Granite, D55/13/3* Biotite, 245 m.y.

Locality: 15° 38′ S, 145° 14′ E. On Mulligan Highway, 1 mile north of Black Gap.

Geology: As for GA 494.

Petrography: A fresh grey actinolite-biotite tonalite (almost granodiorite). Biotite shows little distortion, and is slightly chloritized; actinolite is replaced by biotite in places. Other minerals show some strain; some alteration products in the plagioclase.

GA 496: *Finlayson Granite (Cooktown), D55/13/4* Biotite, 245 m.y.

Locality: 15° 29′ S, 145° 15′ E. On southern outskirts of Cooktown township.

Geology: A small mass equated to the Finlayson Granite. See GA 497. This mass has sharp contacts with the Hodgkinson Formation.

Petrography: A very slightly iron-stained grey porphyritic biotite adamellite. The rock shows little signs of strain, apart from strain-shadow effects in the quartz. There is some alteration of the feldspars. Some grains of biotite are chloritized.

GA 497: *Finlayson Granite, D55/13/5* Biotite, 245 m.y.

Locality: 15° 44′ S, 145° 15′ E. 3 miles west of Rossville in Wallaby Creek.

Geology: Intrudes the Hodgkinson Formation (cf. Trevethan Granite, GA 494).

Petrography: A grey biotite adamellite, with coarse phenocrysts of K-feldspar, very slight iron-staining. Some distortion effects are visible in the major minerals, but no granulation in the quartz; little alteration, apart from patchy kaolinization in the microcline. Biotite is slightly strained, slightly chloritized, and contains some muscovite intergrowths.

GA 498: *Mareeba Granite, E55/1/5* Biotite, 260 m.y.
Muscovite, 265 m.y.

Locality: 16° 50′ S, 145° 13′ E. ½ mile south of Southedge homestead.

Geology: Intrudes sediments of the Upper Devonian/Lower Carboniferous Hodgkinson Formation, and is overlain unconformably by Tertiary and Recent gravels (Amos & de Keyser, 1964).

Petrography: A grey muscovite-biotite granite with coarse phenocrysts of K-feldspar; has sparse but noticeable patches of iron stain. Slight strain effects visible, with some possible deuteric alteration of the feldspars. Biotite and muscovite are slightly distorted, the biotite is slightly chloritized, the muscovite is commonly rimmed by fine muscovite flakes.

GA 499: *Mareeba Granite, E55/1/6* Biotite, 265 m.y.

Locality: 16° 35′ S, 145° 18′ E. About 3 miles west of Rumula, on the Mount Lewis forestry road, 1.8 miles from junction.

Geology: See GA 498.

Petrography: A grey biotite granite (almost adamellite) with large K-feldspar phenocrysts, essentially fresh, but with a few spots of iron stain. Quartz is moderately strained, with some recrystallization. Feldspars appear unstrained, relatively unaltered. Biotite is slightly chloritized, with very slight distortion.

GA 500: *Mareeba Granite, E55/1/7* Biotite, 265 m.y.

Locality: 16° 40′ S, 145° 14′ E. At Lighthouse Mountain, 7 miles west of Molloy.

Geology: See GA 498.

Petrography: A grey slightly porphyritic biotite-muscovite adamellite, slightly iron-stained, somewhat weathered appearance in hand-specimen. Some strain shows in the quartz, the feldspars are somewhat altered. Biotite is also very slightly distorted, slightly chloritized, and associated with some tourmaline, but was beneficiated to better than 98% grain purity, with some chloritized material persisting in the final concentrate.

GA 501: *Mareeba Granite, E55/1/9* Biotite, 255 m.y.

Locality: 16° 26′ S, 145° 08′ E. From Mulligan Highway, 16.1 miles along track to Mount Spurgeon.

Geology: See GA 498.

Petrography: A grey biotite adamellite with K-feldspar phenocrysts, and some isolated specks of iron stain. The minerals show slight distortion with some granulation in the quartz, but only slight alteration. Biotite shows slightly distorted flakes with a little chlorite.

GA 502: *Granodiorite near Curraghmore, E55/1/11* Biotite, 270 m.y.

Locality: 16° 32′ S, 144° 51′ E. From Curraghmore homestead, 9 miles west-south-west, on old Cooktown road.

Geology: Probably related to the Mareeba Granite, see GA 498.

Petrography: A grey slightly porphyritic medium-grained biotite granodiorite, with slight iron-staining. The major minerals show a little distortion and slight amounts of alteration. Biotite is slightly distorted, with slight chloritization.

GA 503: *Mareeba Granite, E55/1/12* Biotite, 255 m.y.
Muscovite, 270 m.y.

Locality: 16° 24′ S, 144° 47′ E. 1 mile east of Spring Hill homestead.

Geology: See GA 498.

Petrography: A grey biotite-muscovite adamellite. The feldspars show slight alteration, but there is little apparent strain, apart from the quartz, which also shows marginal granulation. Muscovite is slightly distorted, biotite is slightly distorted, slightly chloritized.

GA 504: (?)*Mareeba Granite (China Camp), E55/1/15* Biotite, 250 m.y.
Muscovite, 240 m.y.

Locality: 16° 02′ S, 145° 18′ E. 1 mile north-east of China Camp, near Roaring Meg Falls.

Geology: Classed as part of the Mareeba Granite by de Keyser (1964) (*cf.* GA 498), but may prove to be part of the period of activity in which the Finlayson and Trevethan Granites were intruded (see p. 15).

Petrography: A grey porphyritic biotite adamellite, with a very few patches of iron-stain. It appears relatively unstrained, with patchy alteration in the plagioclase. Biotite is slightly strained, slightly sericitized, in places intergrown with muscovite.

GA 505: *Herbert River Granite (Mount Cardwell), E55/5/22* Biotite, 280 m.y.

Locality: 17° 37′ S, 144° 57′ E. North of Mount Cardwell homestead, 1½ miles along track to Ord railway siding.

Geology: From a central plug in the Claret Creek (Gilmore) Ring Complex, it is classed from its appearance as Herbert River Granite, part of the Upper Palaeozoic period of igneous activity. It intrudes rocks of the Upper Silurian/Lower Devonian Mount Garnet Formation (Best, 1962).

Petrography: A grey biotite-hornblende granodiorite, essentially fresh, although with minor specks of iron stain. It is unstressed, and comparatively unaltered. Biotite is slightly chloritized and associated with some iron ore.

GA 506: *Herbert River Granite (Dimbulah), E55/5/39* Biotite, 290 m.y.

Locality: 17° 09′ S, 145° 02′ E. West of Dimbulah, 5 miles along track to Wolfram Camp.

Geology: From the north-eastern edge of the Herbert River Batholith. It intrudes the Hodgkinson Formation, and is intruded by the Featherbed Volcanics (Best, 1962; de Keyser & Wolff, 1965).

Petrography: A pale-pink biotite adamellite (almost granite) with large K-feldspar phenocrysts, fresh and unstressed. Biotite is slightly chloritized and associated with iron ore.

GA 507: *Mareeba Granite (Gillies Highway), E55/6/2* Biotite, 260 m.y.
Muscovite, 270 m.y.

Locality: 17° 13′ S, 145° 42′ E. On Gillies Highway 7.1 miles west of bridge over Little Mulgrave River.

Geology: At the southern end of mass referred to as the Mareeba Granite (see GA 498). It intrudes the Barron River Metamorphics, the metamorphosed equivalent of the Hodgkinson Formation (de Keyser, 1965).

Petrography: A grey muscovite-biotite adamellite with large K-feldspar phenocrysts, slight iron-staining. Quartz shows strong strain shadow effects; the feldspars are comparatively unstrained, only slightly altered. Some biotite shows distortion, grains vary from moderately chloritized to fresh; muscovite, possibly secondary, is associated with both biotite and feldspar.

GA 529: *Granite near Musgrave, Cape York, D54/12/1* Biotite, 355 m.y.
Muscovite, 370 m.y.

Locality: Approximately 14° 40′ S, 143° 25′ E. On Coen road about 10 to 15 miles north-west of Violet Vale homestead.

Geology: Probably part of the Cape York mass, described as Precambrian by Jensen (1964); as Palaeozoic on the Tectonic Map of Australia (1960).

Petrography: A grey biotite-muscovite granodiorite, generally fresh, with a trace of iron stain. Some distortion visible, with granulation of the quartz in places; some alteration of the feldspars. Muscovite is slightly distorted, as is the slightly chloritized biotite.

GA 533: *Acid Dyke (in Trevethan Granite)*, D55/13/2 Biotite, 240 m.y.

Locality: 15° 39′ S, 145° 13′ E. At the Black Gap, Mulligan Highway, 3 miles north of the Annan River Gorge crossing.

Geology: An acid dyke intruding the Trevethan Granite. See GA 494.

Petrography: A grey biotite granophyre porphyry, with comparatively little iron-staining. The distinguishable minerals show some alteration, with moderate strain in the quartz; biotite is strongly chloritized, associated with epidote, and with prehnite in cleavages, but a final concentration of 98% grain purity was obtained. A residual rim of chlorite which persisted after dechloritization may partly explain the low K-content (5.02%) of this sample.

GA 534: *Puckley Granite, D55/13/7* Biotite, 265 m.y.

Locality: 15° 24′ S, 144° 51′ E. 1 mile south-east of Battle Camp Siding, between Cooktown and Laura.

Geology: This mass intrudes the Hodgkinson Formation, and is overlain unconformably by Jurassic and Cretaceous sediments in the Battle Camp area (Lucas, 1965).

Petrography: A grey biotite adamellite, appears fresh. In thin section some alteration and distortion are visible, with some granulation in the quartz. Biotite is slightly strained, slightly chloritized, and associated with prehnite.

GA 535: *Mareeba Granite (Mt Elephant), E55/1/10* Biotite, 265 m.y.
Muscovite, 265 m.y.

Locality: 16° 29′ S, 144° 55′ E. ½ mile north of Mulligan Highway, 6 miles west of the McLeod River crossing.

Geology: See GA 498.

Petrography: A pale-grey biotite adamellite, with dark 'xenolith' of fine-grained biotite, many small spots of iron-stain. Some strain and alteration is visible. Biotite is slightly distorted and moderately chloritized; muscovite is a little distorted.

GA 536: *Elizabeth Creek Granite (Hann Highway), E55/5/24* Biotite, 260 m.y.

Locality: 17° 58′ S, 144° 52′ E. Group of tors at west side of Hann Highway, 15 miles south of turn-off to Sundown homestead.

Geology: Colour of rock classes it as Elizabeth Creek Granite. In this area its intrusive relationships are masked by younger rocks (Best, 1962).

Petrography: A red biotite adamellite, with some apparent iron-staining. It is virtually unstrained, with moderate kaolinization of the feldspars. Biotite is unstrained, with very little apparent chlorite, some iron-staining.

GA 537: *'Hybrid Granite' (Sundown), E55/5/25* Biotite, 300 m.y.

Locality: 17° 47′ S, 144° 56′ E. North side of track, 12 miles east of Sundown homestead.

Geology: From appearance and composition this was classed as a hybrid of Herbert River and Elizabeth Creek types. Apart from intrusion by Elizabeth Creek Granite in its northern quarter, contacts of this small area, mapped as Herbert River Granite, are obscured by Quaternary soil cover (Best, 1962).

Petrography: A porphyritic biotite adamellite, with large pink phenocrysts of K-feldspar, and pale green plagioclase, minor amounts of iron stain. It appears to be unstrained, some kaolinization of feldspars. Biotite is fresh and unstressed.

GA 538: *Elizabeth Creek Granite (Tate River), E55/5/28* Biotite, 295 m.y.

Locality: 17° 25′ S, 144° 25′ E. About 3 miles south-west of Crystal Brook homestead on the Almaden-Tate River road.

Geology: Intrudes Precambrian metamorphic rocks at the north-eastern sector of the Georgetown Inlier (Best, 1962).

Petrography: A pink biotite adamellite, with fluorite, and noticeable distribution of iron-stain. It is unstrained, with moderate alteration of feldspars. Biotite is unstrained, with minor chlorite and anatase. The presence of fluorite implies that much of the alteration and iron oxide could arise from hydrothermal effects.

GA 539: *Herbert River Granite (True Blue mine), E55/5/31* Biotite, 295 m.y.

Locality: 17° 36′ S, 144° 18′ E. 20 miles north-west of Bullock Creek Siding on track to the True Blue fluorite mine.

Geology: A small exposure, thought to be part of the north-western edge of the Herbert River Batholith. It lies within the limits of the Georgetown Inlier, and is largely surrounded by exposures of Upper Palaeozoic volcanics, and of Elizabeth Creek Granite, both of which are thought to belong to the Upper Palaeozoic igneous activity. (See GA 443) (Best, 1962.)

Petrography: A grey biotite granite (almost adamellite), some iron-staining. In thin section it is unstrained, but the feldspars are strongly altered, in accord with their cloudy appearance in hand specimen. Biotite is strongly chloritized, and associated with iron oxide. The final concentrate, after dechloritization, had a grain of purity of 98%, although appreciable chlorite still remained in individual grains.

GA 540: *Ixe Monzonite, E55/5/34* Biotite, 300 m.y.

Locality: 17° 46′ S, 144° 27′ E. 5 miles south-west of Bullock Creek Siding, near railway.

Geology: A small micromonzonite stock intruding Precambrian rocks of the Georgetown Inlier. It is correlated with the Herbert River Granite, and is intruded by Elizabeth Creek Granite (Best, 1962).

Petrography: A fresh fine-grained grey hornblende-biotite adamellite, with prominent feldspar phenocrysts, some pink, but mostly white. It is unstrained, with some alteration of feldspars. Biotite is slightly chloritized; amphibole was possibly hornblende, but has been strongly altered to chlorite and epidote.

GA 541: *Elizabeth Creek Granite, E55/9/17* Biotite, 270 m.y.

Locality: 18° 00′ S, 144° 32′ E. 5 miles north-east of Whitechalk (Mt Surprise) homestead.

Geology: Normal type of Elizabeth Creek granite, surrounded by the Cainozoic McBride Basalt. To the north it is very close to the granite which intrudes GA 540. See GA 448 (White, 1962b).

Petrography: A pink biotite adamellite with fluorite, appears to be reasonably fresh and unstrained with a little iron-staining. Biotite is chloritized and associated with iron ore, but a clean separation was achieved.

GA 542: *Greisen lode in Elizabeth Creek Granite, E55/9/18* Muscovite, 270 m.y.

Locality: 18° 00′ S, 144° 32′ E. Near GA 541.

Geology: This is from a greisen lode intrusive into GA 541.

Petrography: Hand specimen is heavily iron-stained and friable—a sericite greisen with a trace of fluorite. Quartz and muscovite are unstrained. The final muscovite concentrate was of 99% grain purity, and only slightly iron-stained.

GA 543: (?)*Elizabeth Creek Granite (grey variety), E/55/9/19* Biotite, 270 m.y.

Locality: Near GA 541.

Geology: This grey granite appears to be associated with the pink normal-type sample GA 541.

Petrography: A grey biotite micro-adamellite, some small spots of iron stain, but otherwise appears fresh and unstrained. Biotite appears fresh.

GA 544: *Granite (near Black Braes), E55/13/13* Biotite, 305 m.y.

Locality: 19° 32′ S, 144° 03′ E. 10 miles west of Black Braes homestead.

Geology: Isolated granite mass which intrudes the Dumbano Granite in the southern part of the Georgetown Inlier. It is thought to belong to the general Upper Palaeozoic igneous activity, and may be related to the Bagstowe Ring Dyke Complex, which crops out 10 miles to the north (White, 1965).

Petrography: A pink porphyritic fine biotite ademellite, carrying cassiterite and fluorite, somewhat iron-stained; is relatively unstrained; feldspars somewhat kaolinized. Biotite is unaltered except in the vicinity of cassiterite and fluorite grains, where it is extensively chloritized.

GA 652: *Augite andesite (Newcastle Ranges), E54/8/1* Total-rock Rb/Sr (See Fig. 3, Tables 4 & 5).

Locality: 17° 55′ S, 143° 46′ E. 20 miles north-west of Talaroo homestead on track to Dagworth Station.

Geology: A lower member of the Newcastle Range Volcanics, attributed to the Upper Palaeozoic period of igneous activity (White, 1965).

Petrography: A dark grey porphyritic pyroxene andesite, with large phenocrysts of green andesine (An_{34}), which is slightly kaolinized. Also recognizable in the fine groundmass are pyroxene, too fine for separation, quartz, strongly bleached biotite, and small amygdules containing chlorite, rimmed by carbonate.

GA 653: *Rhyodacite (Newcastle Ranges), E55/9/16* Total-rock, K-feldspar, Rb/Sr. (See Fig. 3, Tables 4 & 5).

Locality: 18° 26′ S, 144° 02′ E. 8 miles north of Einasleigh on road to Eveleigh homestead.

Geology: A densely welded tuff from the base of the upper member in the Newcastle Range Volcanics. Five miles to the north-west, these rocks are intruded by granite of the Elizabeth Creek type (White, 1962b).

Petrography: A pink weathered kaolinized fine-grained quartz-feldspar porphyry, containing small phenocrysts of K-feldspar, plagioclase, and quartz in a fine groundmass of quartz, K-feldspar, plagioclase, and chlorite with small amounts of carbonate. Both feldspars are strongly kaolinized.

GA 658: (?)*Esmeralda Granite, E54/12/1* Biotite, 515 m.y. Muscovite, 700 m.y.

Locality: 18° 48′ S, 142° 35′ E. 4 miles north of Esmeralda homestead.

Geology: Rocks attributed to the Esmeralda Granite occur on both western and eastern flanks of the Croydon Volcanics, which have been classed as the most westerly of the Palaeozoic acid volcanics of the Cairns Hinterland (see GA 1379). Near Croydon, rocks of this type are observed to intrude the Volcanics but their relationship to the two present samples is obscure. This sample is of the fine-grained variety near Esmeralda homestead. (White, 1965; Branch, 1966).

Petrography: A grey comparatively leucocratic muscovite-biotite microadamellite, reasonably fresh and unstrained. Biotite is slightly chloritized, fine-grained and rather ragged; muscovite may be secondary after plagioclase.

GA 659: (?)*Esmeralda Granite, E54/12/2* Biotite, 600 m.y.

Locality: See GA 658.

Geology: A coarse-grained variety which occurs in patches and veins within the finer-grained mass represented by GA 658.

Petrography: A coarse biotite adamellite. Appears somewhat strained in thin section, with slight alteration. Biotite is slightly chloritized and the cleavage flakes are slightly bent. The rock has a vague foliation.

GA 660: *Mount Rous Ring Dyke, E54/16/7* Hornblende, 325 m.y.

Locality: 19° 19′ S, 143° 53′ E. About 10 miles south-west of Glenmore (Ten-mile) homestead.

Geology: This ring dyke is part of a major igneous complex—the Bagstowe Complex—which intrudes the Dumbano Granite in the central-southern part of the Georgetown Inlier. Sample GA 427 came from the country-rock within this ring (Branch, White, & Wyatt, 1960; Branch, 1966).

Petrography: A grey (with a touch of pink) porphyritic granophyric hornblende micro-adamellite. Some signs of strain, and of alteration, are apparent in thin section. Hornblende is slightly altered to chlorite and biotite.

GA 666: *Elizabeth Creek Granite, E55/5/37* Biotite, 295 m.y.

Locality: 17° 56′ S, 144° 24′ E. 8 miles south of Burlington homestead.

Geology: Possibly related to GA 448, some 24 miles to the west-south-west (Best, 1962).

Petrography: A pink coarse-grained biotite adamellite, with some evident iron-staining, comparatively slight strain effects. Biotite is unstrained, with a little chlorite; alteration effects are visible in other minerals. The quartz included in the K-feldspar is generally hexagonal, suggesting a high-temperature variety.

GA 1354: *Ore vein in Elizabeth Creek Granite* Muscovite, 280 m.y.

Locality: 17° 05′ S, 144° 57′ E. At Wolfram Camp, 12 miles north-west of Dimbulah, J. F. Lovering (A.N.U.) reference R441A.

Geology: Vein in Elizabeth Creek Granite mass on northern flank of the Featherbed Range (de Keyser & Wolff, 1965).

Petrography: Hand specimen of molybdenite ore containing easily detachable flakes of muscovite.

GA 1379: *Croydon Volcanics, E54/11/2* Total-rock Rb-Sr (See Fig. 3 and Tables 4 & 5).

Locality: 18° 12′ S, 142° 15′ E. About 2 miles north of Croydon, on road to Tabletop homestead.

Geology: The most westerly group of volcanic rocks in the Cairns Hinterland, which crop out on the western flank of the Georgetown Inlier. In previous publications these rocks have been referred to as Croydon Felsite (Branch, White, & Wyatt, 1960; White, 1961). The present name has been proposed by Branch (1966).

Petrography: A massive fine-grained acid volcanic rock containing a few scattered quartz phenocrysts in a felsic groundmass, which appears to have been recrystallized.

GA 1380: *Croydon Volcanics, E54/12/17* Total-rock, Rb-Sr (See Fig. 3 and Tables 4 & 5).

Locality: 18° 28′ S, 142° 30′ E. Stanhills area, 20 miles south-east of Croydon on track to Esmeralda homestead.

Geology: As for GA 1379.

Petrography: A massive fine-grained porphyritic acid volcanic rock. The felsic groundmass appears to have been recrystallized.

GA 5159: *Biotite adamellite, E55/10/1* Biotite, 270 m.y.

Locality: 18° 49½′ S, 145° 54′ E. 1½ miles south of Mount Fox sawmill on track from Ingham to Mount Fox.

Geology: GA 5159, 5160, 5161, 5164, 5165, 5166, 5176 are varieties of granite composing the large batholith which occupies most of the Ingham 1 : 250,000 Sheet area. The grey hornblende granodiorites are thought to be older than the pink leucocratic granites. This is not completely borne out by the ages obtained, and is similar to the overlap in ages of the Herbert River and Elizabeth Creek Granites farther to the north-west. The whole batholith intrudes Upper Palaeozoic volcanic formations (de Keyser et al., 1966).

Petrography: Massive, medium grained. Plagioclase and K-feldspar fresh, biotite fresh and undeformed.

GA 5160: *Biotite adamellite, E55/10/3* Biotite, 275 m.y.

Locality: 18° 50′ S, 145° 46′ E. Ingham-Kangaroo Hills road about 3 miles due west from Mount Fox.
Geology: See GA 5159.
Petrography: Massive, medium to coarse grained. Few indications of deformation. Biotite varies from fresh to moderately chloritized.

GA 5161: *Pink biotite granite, E55/10/4* Biotite, 310 m.y.

Locality: 18° 40½′ S, 145° 45′ E. On Ingham-Oak Hills road, 5.7 miles past Wallaman Falls road junction.
Geology: See GA 5159.
Petrography: Massive, fine to medium grained, undeformed. Biotite is greenish brown, moderately chloritized. Also present, garnet and primary albite.

GA 5164: *Granodiorite,* E55/10/7 Biotite, 285 m.y.

Locality: 18° 12′ S, 145° 51′ E. On road from Kennedy to Kirrama, 3.3 miles in from the foot of the range.
Geology: See GA 5159.
Petrography: Massive, medium grained. Some signs of strain in quartz and biotite. Biotite varies from fresh to strongly chloritized.

GA 5165: *Adamellite, E55/10/8* Biotite, 285 m.y.

Locality: 18° 10′ S, 145° 41′ E, on Kennedy-Kirrama road, about 10 miles east of Kirrama homestead.
Geology: See GA 5159.
Petrography: Massive, medium grained, undeformed. Biotite varies from fresh to moderately chloritized.

GA 5166: *Granodiorite, E55/10/9* Biotite, 285 m.y.

Locality: 18° 06′ S, 145° 35′ E. On track from Kirrama homestead to Koombooloomba.
Geology: See GA 5159.
Petrography: Massive, medium grained, undeformed. Biotite is fresh.

GA 5169: *Adamellite, E55/6/4* Biotite, 270 m.y.
Muscovite, 265 m.y.

Locality: 17° 09′ S, 145° 33½′ E. North shore road, Tinaroo Falls Reservoir, 1.4 miles from Dam.
Geology: Mareeba Granite. Intrudes the Barron River Metamorphics.
Petrography: Massive, medium to coarse grained, indications of slight deformation of biotite. Muscovite is primary. Biotite varies from fresh to chloritized.

GA 5170: *Mareeba Granite, E55/6/5* Biotite, 260 m.y.
Muscovite, 270 m.y.

Locality: 17° 11′ S, 145° 32′ E. Quarry at Tinaroo Falls Dam.
Geology: See GA 5169.
Petrography: Fine grained, foliated appearance in hand specimen. Biotite fresh to moderately chloritized. Muscovite fresh.

GA 5171: *Pegmatite in Mareeba Granite, E55/6/6* Muscovite, 255 m.y.
Tourmaline, excess argon?

Locality: 17° 11′ S, 145° 32′ E. Quarry at Tinaroo Falls Dam.
Geology: See GA 5169.
Petrography: A white leucocratic inequigranular pegmatite containing abundant fresh muscovite. Tourmaline occurs as acicular crystals along joint planes.

GA 5172: *Adamellite, E55/2/1* Muscovite, 250 m.y.

Locality: 16° 38½′ S, 145° 33′ E. Rex Lookout, White Cliffs, on Cook Highway, north of Cairns.
Geology: Intrudes the Barron River Metamorphics.
Petrography: Massive, medium-grained. Biotite and muscovite, both fresh.

GA 5175: *Biotite granite, E55/2/4* Biotite, 230 m.y.

Locality: 16° 57′ S, 145° 48½′ E. On track from Gordonvale to Murray Prior Range, 13 miles from Gordonvale.
Geology: Intrudes the Barron River Metamorphics and the Babalangee Amphibolite. It borders a wide belt of shearing.
Petrography: Medium-grained, slightly foliated in hand specimen. Quartz appears recrystallized. Biotite slightly distorted and varies from fresh to chloritized.

GA 5176: *Granodiorite, E55/10/11* Biotite, 275 m.y.

Locality: 18° 51½′ S, 146° 05½′ E. Flagstone Creek, 14 miles from Bruce Highway on track from Ingham to Hidden Valley.
Geology: See GA 5159
Petrography: Massive, medium-grained, unstrained. Biotite varies from fresh to chloritized.

GA 5177: *Riebeckite granite, E55/10/12* Biotite, 255 m.y.
Riebeckite, 265 m.y.

Locality: 18° 24′ S, 146° 14½′ E. Hinchinbrook Island, southernmost inlet on west coast, at tidal limit of left branch of creek.
Geology: Probably intrudes late Palaeozoic volcanics.
Petrography: Massive, medium-grained, unstrained. A one-feldspar granite (K-feldspar with irregular albite rims). Biotite and riebeckite both fresh.

GA 5180A: *Barnard Metamorphics, E55/6/9* Muscovite, 310 m.y.

Locality: 17° 57½′ S, 146° 05′ E. South Mission Beach, about 16 miles east of Tully.
Geology: A fine-grained banded gneiss intruded by later quartz-muscovite veins. The Barnard Metamorphics are thought to be a higher metamorphic facies of the Barron River Metamorphics, and hence of middle Palaeozoic age (de Keyser, 1965).
Petrography: Biotite-muscovite schist. Well banded, medium-grained. Muscovite is fresh. Biotite not sufficiently abundant to separate.

GA 5180B: *Coarse quartz-muscovite vein in* GA 5180A Muscovite, 360 m.y.

GA 5181: *Granodiorite, E55/6/10* Biotite, 275 m.y.
Hornblende, 290 m.y.

Locality: 17° 45′ S, 145° 39′ E. On private (Cairns Regional Electricity Board) track from Cardstone to the Atherton Tableland, 4.5 miles from Tully River Bridge.
Geology: Tully Granite Complex, intrusive into the Barron River Metamorphics.
Petrography: Massive, coarse-grained. The quartz appears to be recrystallized. Biotite is fresh to slightly chloritized, and does not appear strained.

GA 5182: *Foliated porphyritic biotite granite, E55/6/11* Biotite, 270 m.y.

Locality: 17° 44′ S, 145° 39′ E. C.R.E.B. road, 6.3 miles from Tully River Bridge.
Geology: See GA 5181.
Petrography: Medium to coarse-grained, foliated in hand specimen. Quartz shows strain effects and indications of recrystallization. Biotite is slightly bleached and chloritized.

GA 5183: *Foliated biotite granite, E55/6/12* Biotite, 260 m.y.

Locality: 17° 43′ S, 145° 38½′ E. C.R.E.B. road 8.5 miles from Tully River Bridge.
Geology: See GA 5181.
Petrography: Fine to medium-grained, foliated with a recrystallized texture. Biotite is fairly fresh with a preferred orientation.

GA 5184: *Granodiorite, E55/6/13* Biotite, 290 m.y.

Locality: 17° 40½′ S, 145° 39′ E. Road cutting on C.R.E.B. road, 13.3 miles from Tully River Bridge.

Geology: See GA 5181.

Petrography: Massive, medium-grained. Quartz strained and recrystallized. Biotite fresh but slightly deformed.

GA 5186: *Diorite, E55/6/15* Biotite, 270 m.y.
Hornblende, 275 m.y.

Locality: 17° 25′ S, 145° 36′ E. About 2 miles north of Tarzali on Millaa Millaa-Malandra road.

Geology: See GA 5181.

Petrography: Massive, medium-grained, undeformed. Biotite and hornblende both fresh.

GA 5187: *Foliated biotite granite, E55/6/16* Biotite, 230 m.y.

Locality: 17° 11′ S, 145° 49′ E. On track to Clamshill Falls, west of Gordonvale.

Geology: Mapped as Mareeba Granite. This sample and GA 5189 border a wide belt of shearing (see also GA 5175) and their 'ages' may have been influenced by this disturbance.

Petrography: Medium-grained, with foliated appearance on hand specimen. Quartz deformed and recrystallized. Plagioclase twin lamellae bent. Biotite chloritized and deformed.

GA 5189: *Biotite granite, E55/6/18* Biotite, 240 m.y.

Locality: 17° 20½′ S, 145° 52′ E. The Boulders; about 4 miles west of Babinda.

Geology: See GA 5187.

Petrography: Massive, coarse-grained. Biotite is fresh to slightly chloritized, and slightly deformed.

GA 5190: *Amphibolite, E55/6/19* Hornblende, excess argon?

Locality: 17° 19′ S, 145° 57′ E. 5 miles north-east of Babinda.

Geology: The Babalangee Amphibolite is probably a metamorphosed basic igneous rock intruding the Barron River Metamorphics and intruded by the Mareeba granite.

Petrography: Composed essentially of plagioclase and fresh amphibole.

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