1970/20
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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1970 / 20

054841

Rb-Sr Age Determinations of some rocks from the West Kimberley Region,

Western Australia

by

Miss R. Bennett and D.C. Gellatly

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Contents

Introduction

Rb/Sr age determinations were made on samples from the Precambrian terrain of the West Kimberley region in the northern part of Western Australia. The samples were collected in 1966 and 1967 as part of a programme of regional mapping carried out jointly by the Bureau of Mineral Resources and the Geological Survey of Western Australia. The age determination project is an extension of the work carried out in the East Kimberley region by V.M. Bofinger (1967).

Only a comparatively small number of samples (49) was collected, representing sixteen different rock units. Consequently many of the ages obtained are only an approximate guide to the true age of the rocks sampled. A more comprehensive programme of age determination work was originally envisaged but became impractical because of staff movements and as a result only a small number of "contingency samples" collected in the course of routine field work, and a few blasted samples collected mainly from a small area along the Derby - Mount House road during the last two days of field work in 1967, were available for age determination. Because of the small number of samples available, the results obtained have wide error limits, and some problems remain unsolved.

Field work in connection with the Bureau of Mineral Resources - Geological Survey of Western Australia mapping programme is now complete and it is unlikely that any further field work which could provide the opportunity to collect additional samples for age determination will be carried out in the immediate future.

The laboratory work described in this report has been carried out in the Australian National University by Miss R. Bennett. The geological contributions to this report are by D.C. Gellatly.

SUMMARY OF GEOLOGY OF THE KIMBERLEY AREA

The West Kimberley area consists essentially of a complex of metamorphic and igneous rocks ("older Precambrian") overlain by sediments and volcanics ("younger Precambrian"). The older Precambrian forms an elongate northwest-trending belt (the King Leopold Mobile Zone) which is essentially continuous with a similar northeast-trending belt of older Precambrian rocks (the "Halls Creek Mobile Zone") in the East Kimberley. The younger Precambrian comprises unconformably overlying rocks of the Kimberley Basin succession that flank the King Leopold Mobile Zone to the north and west, and a small inlier forming the Oscar Range to the southwest of the mobile zone.

The geology of the areas from which the samples were collected is described in several unpublished reports; Gellatly, Derrick and Plumb (1965); Gellatly, Sofoulis, Derrick, and Morgan (1968); Sofoulis and Gellatly (1968); Derrick and Gellatly (in prep.); and Sofoulis, Gellatly, Derrick, Farbridge, and Morgan (in prep.). A synthesis of the information contained in these reports will be published in Gellatly, Sofoulis, and Derrick (in prep.). The stratigraphy of the West Kimberley area relevant to this age determination study is summarised in Table 1. For the sake of brevity most rock units not mentioned here have been excluded from this table.

Older Precambrian

The oldest rocks in the area belong to the Halls Creek Group, a series of flysch sediments of possible Archaean age that have been strongly folded and metamorphosed in the greenschist and, locally, in the almandine-amphibolite facies. The group contains scattered acid pegmatites, and has been intruded by the Woodward Dolerite which has been metamorphosed together with the Halls Creek Group.

The Whitewater Volcanics - a sequence of quartz and feldsparphyric rhyodacite tuffs and lavas - overlie the Halls Creek Group with inferred unconformity (near-basal conglomerates of the Whitewater Volcanics contain cobbles of Woodward Dolerite), and are intruded by high-level quartz-feldspar-porphyry and granite (<u>Mount Disaster Porphyry</u>, <u>Bickleys Porphyry</u> and

Mondooma Granite) and by later plutonic granites. These later granites include the Lennard, Kongorow, Long Hole, Lerida and Chaneys Granites (mainly porphyritic varieties) and the granites of the Pillara Range Inlier in the Noonkanbah Sheet area (non-porphyritic varieties). With the possible exception of the Kongorow Granite which has probably been derived through anatexis of Halls Creek Group metasediments, all of these later granites are regarded as equivalents of the Bow River Granite of the East Kimberley and are probably closely related magmatically to the Whitewater Volcanics.

The Whitewater Volcanics and all the older Precambrian intrusives comprise the Lamboo Complex. The Halls Creek Group and the Lamboo Complex are referred to collectively as the older Precambrian.

Younger Precambrian

Rocks of the Kimberley Basin succession comprise the Speewah and Kimberley Groups and are intruded extensively by the Hart Dolerite. Intrusions of quartz feldspar porphyry (Wotjulum Porphyry) cut the Kimberley Group in the north-western part of the Yampi Sheet area. The Kimberley Group consists of the following formations:

5. Pentecost Sandstone
4. Elgee Siltstone
3. Warton Sandstone
2. Carson Volcanics
1. King Leopold Sandstone

The Carson Volcanics, the Pentecost Sandstone and the Hart Dolerite have previously been dated by Bofinger (1967). Specimens from the Carson Volcanics, Elgee Siltstone, Pentecost Sandstone and Wotjulum Porphyry are included in the present study.

Rocks of the Oscar Range area form an inlier about 35 miles long overlain on all sides by Devonian strata. The only geological evidence for age of any of the rocks there comes from the Elimberrie Beds near the top of the sequence, where probable glacial rocks have been recognized which are correlated with the late Precambrian glacials of the East Kimberley. (Derrick and Gellatly, in prep). The oldest beds of the Oscar Range succession could possibly be equivalent to parts of the Kimberley Basin succession but correlations are uncertain and unreliable. The topmost beds in the Oscar Range are ashflow tuffs of the Spielers Volcanics. These directly overlie the Elimberrie Beds and are overlain by reef limestone of Frasnian (Upper Devonian) age.

On the basis of lithological correlations and of preliminary ages by Bofinger, the Whitewater Volcanics have previously been assigned to the upper Lower Proterozoic by Dunn, Plumb and Roberts (1966), and the Kimberley Basin succession to the lower Carpentarian. The late Precambrian glacials of the East Kimberley region have been assigned by these writers to the upper Adelaidean.

PREVIOUS AGE DETERMINATIONS

Apart from one determination in a muscovite from Gussys mica mine (Lennard River 1:250,000 Sheet area) by Wilson et al., (1960) no previous isotopic age determination work has been carried out on rocks of the West Kimberley, but the East Kimberley equivalents of some of the formations have been dated by Bofinger (1967; in press) using the Rb/Sr isochron method. Dates determined by Bofinger which are relevant to rock units of the West Kimberley are as follows:

Late Precambrian glacials - whole-rock determinations on 18 shale specimens give a pooled isochron interpretation: 739±30 m.y.

Hart Dolerite (post-Kimberley Group) - 9 total-rocks: 1800 ± 25 m.y.

Kimberley Group - Carson Volcanics: 2 total-rock determinations suggest an 1800 m.y. age. Pentecost Sandstone: 3 glauconite mineral ages of 1541 m.y., 1541 m.y. and 1696 m.y.

Bow River Granite - 10 total-rocks, 3 minerals: 1854 ± 14 m.y.

Whitewater Volcanics - 9 total-rocks, 1 mineral: 1823 ± 17 m.y.

Halls Creek Group metamorphism - 14 total-rocks: 1961 ± 27 m.y.

Halls Creek Group - muscovite separated from pegmatite intruding Halls Creek Group: 1755 m.y. Duplicate total-rock analyses of the pegmatite containing the muscovite yield an approximate age of 2700 m.y. assuming 0.700 initial Sr^{87}/Sr^{86} ratio (assumptions of higher initial ratios make little difference to the calculated age). However, total-rock pegmatites are difficult to date reliably so little emphasis can be placed on results from a single sample.

Problems arose from the work which it was hoped might be clarified by work in the West Kimberley.

PRINCIPAL PROBLEMS OF WEST KIMBERLEY GEOCHRONOLOGY

The most important problem concerning the older Precambrian was to attempt to establish isotopic age relationships between the Whitewater Volcanics and the West Kimberley equivalents of the Bow River Granite (Lennard, Chaneys, Long Hole, Lerida Granites, and the Pillara Range granites, especially the Lennard Granite) in the hope of clarifying or modifying the results from the East Kimberley, which suggest that the Bow River Granite is slightly older than the Whitewater Volcanics which it intrudes.

It was hoped to establish whether there was an age difference between the Kongorow Granite (anatectic granite probably generated at least in part during the later stages of the Halls Creek Group metamorphism) and the later granites (Lennard Granite, etc) which clearly post-date the Whitewater Volcanics (themselves later than the Halls Creek Group metamorphism).

The age of the Halls Creek Group, interpreted by Bofinger to be 2700 m.y. also required further investigation. To this end, additional specimens of the pegmatites from the Halls Creek Group were included.

The age of the Kimberley Group is known to be about 1800 m.y. from whole-rock determinations on the Carson Volcanics and from the Hart Dolerite which intrudes the Kimberley Group. The ages of deformation and metamorphism however, have not previously been investigated, and could on geological evidence lie anywhere in the range 1800 m.y. to about 350 m.y.

Over most of the Kimberley Basin rocks of the Kimberley Group are only gently folded and are not metamorphosed, but in the western and northwestern parts of the Yampi Peninsula they have been strongly folded and have been metamorphosed to upper greenschist facies (and possibly to low amphibolite facies locally): phyllites from the Elgee Siltstone, Carson Volcanics and Pentecost Sandstone have been included in the present study in order to obtain evidence of the age of this metamorphism.

Similarly phyllites from the Elimberrie Beds and Linesman Beds of the Oscar Range succession have been included to provide evidence of the age of the low-grade metamorphism in that area.

Acid igneous rocks, namely the Wotjulum Porphyry from the Yampi area and the Spielers Volcanics have been dated principally for their own intrinsic value. The age of the Spielers Volcanics however, also has important structural implications. The Spielers Volcanics overlie the probable glacial rocks of the Oscar Range (suggesting a post Upper-Adelaidean age) but closely resemble lithologically the Whitewater Volcanics of Lower Proterozoic age. There are no known acid volcanics in the Kimberley region younger than the Whitewater Volcanics. To have equated the Spielers Volcanics with the Whitewater Volcanics would have implied thrusting of the Spielers Volcanics northward over the Adelaidean rocks. This structural interpretation had much circumstantial geological evidence to support it, especially the strong shearing in the Elimberrie Beds and the Spielers Volcanics, and the presence of strong overfolding and minor thrusting in the Yampi area which is connected structurally with the Oscar Range by a well-defined buried aeromagnetic structure known as the Oscar Ridge.

METHODS

Determinations were made on whole-rocks except for the Halls Creek Group where muscovite from a pegmatite was used. Two methods were used for Rb and Sr determinations. X-ray fluorescence (X.R.F.) determinations of Rb and Sr concentrations were carried out by the method described in Norrish and Chappell (1967). Mass absorption coefficients were not determined on these samples and so accurate quantitative values were not obtained. However, using a dummy mass absorption coefficient, accurate Rb/Sr ratios were given and from this Rb^{87}/Sr^{86} ratios were calculated. An unspiked (U.S.) Sr^{87}/Sr^{86} determination on the sample then allowed isochrons to be drawn. The bias between ages obtained by statistical treatment of standard isotope dilution (I.D.) results and the results obtained by the X.R.F. and U.S. method above is such that

$$\frac{\text{X.R.F. and U.S. age}}{.9376} = \text{I.D. age}$$

To convert Rb^{87}/Sr^{86} values obtained by the X.R.F. method to comparable I.D. values the former should be multifplied by 0.9322.

Isotope dilution (I.D.) determinations of Rb-Sr and strontium isotope ratios were carried out by the method described in Compston, Lovering and Vernon (1965). Data was treated statistically by the method described in McIntyre, Brooks, Compston and Turek, (1966) using a Rb^{87} decay constant of $1.39 \times 10^{-11} y^{-1}$ (Aldrich et al., 1956).

DISCUSSION OF RESULTS

Halls Creek Group

Determinations on muscovite from Gussys Mica Mine - Lennard River Sheet area - a pegmatite in the Halls Creek Group - gave ages of 1465 m.y. Geological evidence indicates that these ages are much too young but are of the same order as that determined on muscovite from a Halls Creek Group pegmatite in the East Kimberley by Bofinger (1755 m.y.). Also, a determination reported by Wilson et al., (1960) indicated an age of 1700 m.y. for muscovite from Gussys Mica Mine. Apparently all have been updated by later metamorphic processes. The results neither substantiate nor invalidate the earlier suggestion of a 2,700 m.y. (?Archaean) age for the Halls Creek Group (Bofinger, in press). Since geological evidence suggests only a slight unconformity between the Halls Creek Group and the Whitewater

Volcanics, the ?Archaean age of the Halls Creek Group remains doubtful on geological grounds.

Whitewater volcanics and associated intrusives (Bickleys and Mount Disaster Porphyries)

The Whitewater Volcanics and the associated porphyry intrusives are closely related spatially and in time of intrusion. The age obtained from the West Kimberley samples of 1940 ± 110 m.y. (Fig. 1) is older than that measured on the East Kimberley samples (Bofinger, 1967) at 1823 ± 17 m.y. All results from the Whitewater Volcanics from both the East and West Kimberley show complications due to variation in initial ratios between samples, and a further complication arises when comparative enrichment in Sr^{87} is considered. All West Kimberley samples have Rb^{87}/Sr^{86} 10 and yield an age of 1940 ± 110 m.y. East Kimberley samples with $Rb^{87}/Sr^{86} < 10$ when regressed give an age of 1940 ± 200 m.y. The enriched samples (those with $Rb^{87}/Sr^{86} > 10$) dominate Bofinger's Whitewater Volcanics isochron and depress the age to 1823 ± 17 m.y.

From these data alone it is impossible to interpret which age determination to accept. However, the Bow River Granite in the East Kimberley and their equivalents in the West Kimberley intrude the Whitewater Volcanics. All these granite have now been dated older than 1823 ± 17 m.y. as will be seen in the following section and this evidence favours accepting the older 1940 m.y. age for the Whitewater Volcanics.

This older result from the unenriched group of samples places the Whitewater Volcanics closer in the geologic time scale to the date of metamorphism of the Halls Creek Group. This supports the circumstantial geological evidence of the slight unconformity suggesting only a small time break between folding and metamorphism of the Halls Creek Group and extrusion of the Whitewater Volcanics.

Later Plutonic Granites

The later granites all intrude the Whitewater Volcanics with the possible exception of Lerida Granite (which may be associated with the Mount Disaster Porphyry) and the Kongorow Granite (probably derived by anatexis of the Halls Creek Group).

All granites (14 samples) fit within experimental error on two parallel isochrons with discrete initial ratios. Kongorow, Lerida and Lennard Granite samples fit the upper isochron of age 1880 ± 160 m.y. with an initial ratio of 0.703 ± .004. (Fig. 2). These isochrons give identical ages and have been pooled to yield a weighted mean of 1880 ± 50 m.y. for the 14 specimens. The higher initial ratio for Kongorow Granite fits with the field evidence suggesting an anatectic origin. Lerida and Lennard Granites are isotopically similar to the Kongorow Granite. A slightly younger age is suggested for the Kongorow Granite and the Pillara Range granite than for the other granites but this difference may not be significant.

Elgee Siltstone and Carson Volcanics

Three specimens of phyllite from the Yampi Peninsula, two from the Elgee Siltstone, and one from the Carson Volcanics, were measured. Only the two Elgee Siltstone samples can be definitely related to each other isotopically, although the Carson Volcanics sample falls on the join of these two points. The suggested age is 630 m.y. (Fig. 3). Strong shearing of trend and style similar to that in the Yampi Peninsula has occurred in the Oscar Range which is connected to the southern part of the Yampi Peninsula by a continuous aeromagnetic anomaly and the results from these specimens have been regressed with those of phyllites from the Oscar Range (see below).

Pentecost Sandstone

Three total-rock determinations on samples of phyllite from the Pentecost Sandstone when regressed indicate an age of 1550 ± 100 m.y. (Fig. 3).

Two of Bofinger's three glauconite mineral ages give a similar age (1540 m.y.). However, this age appears to be too young to be the date of sedimentation which is controlled by the intrusion of the Hart Dolerite at greater than 1800 m.y. Thus, despite the linearity of the three data points this age does not seem to be an age of deposition and could possibly represent the age of the first post-Kimberley Group metamorphism. This metamorphism, which has affected the north-western part of the Yampi 1:250,000 Sheet area, appears to be largely a thermal event (e.g. andalusite developed locally in undeformed siltstone and silty sandstone) distinct from the dynamic metamorphism reflected by the phyllites of the Elgee Siltstone and Carson Volcanics. Although this suggestion of an early post-Kimberley Group metamorphic episode could explain the 1550 m.y. age from the Yampi area it is unlikely to be the explanation for the glauconite ages of around this value, since the specimens measured by Bofinger come from localities remote from metamorphosed or strongly deformed areas.

Wotjulum Porphyry

Only two samples of the Wotjulum Porphyry were available for measurement. Both of these were relatively enriched in radiogenic Sr. If regressed together they indicate an absurdly low initial ratio. The simplest interpretation is that they are both about 1750 m.y. old, and have initial ratios of approximately 0.70, and 0.72 respectively. It is possible that the porphyry is penecontemporaneous with the Hart Dolerite (1800 ± 25 m.y.). The Wotjulum Porphyry is definitely distinct in age from the other acid intrusives of the area in that it post-dates the Kimberley Group sedimentation whereas the others pre-date it.

Oscar Range Succession

Isotope ratios of two specimens of phyllite, one from the Elimberrie Beds and one from the unconformably underlying Linesman Beds have been measured. These specimens suggest an age of 580 m.y. (Fig. 3) for the metamorphism responsible for the phyllitic cleavage.

Taken together with results from phyllites of the Elgee Siltstone and Carson Volcanics from the Yampi Peninsula they suggest an age of 600 m.y. for this metamorphic episode although no reliable isochron can be drawn and thus no limits can be specified.

Spielers Volcanics

The Spielers Volcanics overlie the Elimberrie Beds which contain probable galcial rocks correlated with the proven glacial rocks of the East Kimberley region, dated by Bofinger (1967) at 740 ± 30 m.y. They are overlain by reef limestones of Frasnian age (360 m.y.).

One rhyolite sample with a Rb^{87}/Sr^{86} ratio of approximately 200 yields an age of 365 m.y. assuming an initial ratio of 0.705. This age estimate falls only slightly, to 357 m.y., for an assumed initial ratio of 0.73. This suggests that the Spielers Volcanics could be close to Devonian in age. However, the volcanics are highly sheared as are almost all the Precambrian rocks of the Oscar Range whereas the Devonian rocks are completely undeformed. This feature, together with the tentative date of 600 m.y. for the dynamic metamorphism of the region (see previous section) suggests that the Spielers Volcanics could possibly be as old as late Precambrian.

Further sampling is required to obtain an isochron supporting the Rb/Sr evidence of the single, enriched rhyolite.

SUGGESTIONS FOR FURTHER WORK

No problems have been solved completely by the present study and fresh ones have been raised. Many more specimens would be required before reliable age estimates could be obtained. The two new events which have emerged, namely possible periods of metamorphism at around 1550 m.y. and around 600 m.y., could be tested, but additional material would be required, and satisfactory material could be collected only from remote localities. Rocks suitable for dating the thermal post-Kimberley metamorphic episode (andalusite granofelses) are best developed in the northwestern part of Gibbings Island, on Dunvert Island, and nearby parts of the mainland e.g. the ridge of Warton Sandstone between the Graveyard and Wotjulum Mission. Phyllite suitable for dating the dynamic phase of metamorphism is present in many parts of the Yampi Peninsula, but especially in the Elgee Siltstone between the Graveyard and the southern tip of Dugong Bay and in the Halls Creek Group in a zone of strong post-Kimberley Group shearing and low-grade metamorphism immediately southwest of Mount Nellie. Suitable phyllite is present also in several places in the Oscar Range but fresh material is scarce. m In both of the first two areas mentioned, rocks affected by this period of tectonism are readily recognisable by the presence of well developed kink-folds.

The principal igneous rock suites that warrant further dating, are the Spielers Volcanics, (are they Precambrian or mid-Devonian, or somewhere in between?); the Kongorow Granite (is it really younger than the Lennard Granite and is there a significant age difference between it and the Whitewater Volcanics?); the Pillara Range granites (are they really younger than the other plutonic granites of the area?) the Wotjulum Porphyry (is it closely related in its time of intrusion to the Hart Dolerite?); the Whitewater Volcanics (probably the most important time-rock reference unit in the older Precambrian); the Halls Creek Group metamorphics (is the metamorphism of the Halls Creek Group closely associated with the eruption of the Whitewater Volcanics); and of course the Halls Creek Group pegmatites (are they really Archaean?).

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TABLE 1

PRECAMBRIAN STRATIGRAPHY OF THE WEST KIMBERLEY REGION

(RELEVANT TO AGE DETERMINATION PROGRAMME)

PROTEROZOIC	PALAEOZOIC OR ADELAIDEAN		Spielers Volcanics*	Grey and grey green quartz and feldsparphyric ashflow tuff
	ADELAIDEAN OR CARPENTARIAN	OSCAR RANGE SUCCESSION	Ninety Seven Mile Beds	White to grey quartzite, cobble and boulder conglomerate, phyllite and phyllitic sandstone, amyadaloidal epidotised tholeiitic basalt, chlorite schist, epidotised quartzite.
			Elimberrie Beds*	Quartz and feldspathic sandstone, cobble and boulder conglomerate, grey phyllitic, sandstone grey-brown limestone, ironstone lenses.
			Linesman Beds*	Grey-green and purple-grey siltstone and shale, buff feldspathic sandstone, minor boulder-beds
			Ellendale Beds	Grey-green to brown phyllitic sandstone and shale, cobble and boulder conglomerate, sheared feldspathic sandstone and minor siltstone, hematite lenses.
			Le Lievre Beds	Pale grey quartz, grey-green and brown phyllite dark grey-green phyllite
			Christopher Beds	White to purple-grey quartz sandstone, feldspathic sandstone grey and red-brown shale and siltstone, pebble conglomerate, altered basic igneous rocks.
			Mount Wilson Beds	Grey to white granule sandstone, gritty feldspathic sandstone and arkose; buff, green and white quartz sandstone.

PROTEROZOIC	CARPENTARIAN	KIMBERLEY GROUP	Wotjulum Porphyry*	Quartz feldspar porphyry
			Hart Dolerite	Dark grey and grey-green tholeiitic dolerite; pink-grey granophyre
			Pentecost Sandstone*	White quartz sandstone, buff feldspathic sandstone; grey siltstone.
			Yampi Member	Hematite sandstone and hematite rock, feldspathic sandstone arkose, siltstone.
			Elgee Sandstone*	Interbedded red-brown siltstone and grey-green to red brown fine-grained felspathic sandstone, Minor arkose, feldspathic and quartz sandstone
			Warton Sandstone	White and buff quartz sandstone and feldspathic sandstone. Minor hematitic siltstone
			Carson Volcanics*	Tholeiitic basalt, spilite, amygdaloidal basalt; feldspathic sandstone, arkose, micaceous siltstone and subgreywacke; minor tuffaceous agglomerate
			King Leopold Sandstone	White, buff and pale purple-brown medium-grained quartz sandstone; minor coarse-grained sand-stone and granule sandstone
		SPEEWAH GROUP		Quartz sandstone, feldspathic sandstone and arkose; siltstone, minor conglomerate
	LOWER PROTEROZOIC	LAMBOO COMPLEX	Granites of the Phillara Range Inlier*1	Grey coarse to medium-grained biotite granite, granodiorite and tonalite.
			Lennard Granite*	Leucocratic coarse porphyritic biotite granite; muscovite granite
			Chaneys Granite*	Leucocratic coarse porphyritic and even-grained biotite granite

Table 1 (p.2)

Table 1 (p.3)

Era	Sub-era	Group	Rock unit	Description
PROTEROZOIC	LOWER PROTEROZOIC	LAMBOO COMPLEX	McSherrys Granodiorite	Mesocratic coarse even-grained and porphyritic hornblende granodiorite and tonalite; minor adamellite and quartz gabbro
			Lerida Granite*	Grey coarse to medium-grained porphyritic granodiorite and minor tonalite
			Mondooma Granite	Grey porphyritic microgranite and coarse to medium-grained, even-grained granite
			Mount Disaster Porphyry*	Coarsely porphyritic pink to grey biotite microgranite and microgranodiorite
			Bickleys Porphyry*	Grey porphyritic microgranite
			Whitewater Volcanics*	Massive crystal-rich rhyodacite ash flow tuff, minor agglomerate. Massive crystal-poor rhyodacite ash flow tuff, minor crystal-rich tuff Dacite and minor rhyodacite biotite-rich ash flow tuff Bedded rhyodacite tuff; minor tuffaceous siltstone and sandstone; conglomerate
			Kongorow Granite*	Coarsely porphyritic grey biotite granite; remnant gneissic bands locally
			Woodward Dolerite	Dark grey-green uralitised dolerite, commonly coarsely porphyritic; minor ultramafic patches
?ARCHAEAN		HALLS CREEK GROUP	Undifferentiated	Grey phyllitic siltstone and greywacke; chloritoid, andalusite, staurolite, kyanite and garnet-mica achist; quartz-feldspar-biotite-gneiss and migmatite

1 Not formally named
* Specimens from these rock units have been included in this age determination study

TABLE 2. SUMMARY OF EXPERIMENTAL RESULTS

Rock Unit	GA Number	B.M.R. Number	GRID	CO-ORDINATES	*X.R.F. Rb (ppm)	X.R.F. Sr (ppm)	+ I.D. Rb (ppm)	I.D. Sr (ppm)	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86} (calc)	Sr^{87}/Sr^{86} (U.S.)
Halls Creek	5903	67160289	2591E;	28392N	1781.4	10.6	1727.4	13.0	1450.84	29.08617	
Pegmatite	muscovite	66160262	2589E;	28390N	1388.9	18.3	1266.9	10.2	1295.79	27.36110	
	5905										
	muscovite										
Whitewater	5621	67160296	2883E;	28465N	182.3	152.9	224.1	205.5	3.1760	0.79440	
Volcanics	5622	66160269	2966E;	28467N	203.4	140.7	209.8	162.6	3.7650	0.81440	
	5623	66160147	2924E;	28433N	290.8	77.8	295.2	86.6	10.1130	0.98620	
	5624	66160254	2739E;	28375N	140.9	167.6	150.0	184.2	2.3640	0.77080	
	5922	67165001	3753E;	26871N	178.0	86.5	147.0	77.5	5.5560	0.85440	
Mt Disaster Porphyry	5605	66160270	3008E;	28458N	181.8	172.3	191.0	202.2	2.7470	0.78326	
Bickleys	5612	67160224	3773E;	27907N	142.2	212.2	158.4	250.6	1.8340	0.75710	
Porphyry	5613	67160283	3844E;	27592N	207.3	141.0	217.1	154.7	4.09434	0.81564	
Wotjulum	5907	66162040	1147E;	29455N	387.3	44.8			(calculated)		
Porphyry									26.42078		1.30792
	5908	66162041	1259E;	29493N	370.5	48.4			23.27871		1.25845

TABLE 2 (page 2)

Rock Unit	G.A. Number	B.M.R. Number	GRID CO-ORDINATES	X.R.F. Rb (ppm)	X.R.F. Sr (ppm)	I.D. Rb (ppm)	I.D. Sr (ppm)	Rb^{87}/Sr^{86} (Calculated)	Sr^{87}/Sr^{86} (calc.)	Sr^{87}/Sr^{86} (U.S.)
Kongorow	5606	67160286	2584E; 28408N	89.5	206.3			1.2567		0.74000
Granite	5607	67160285	2697E; 28309N	233.7	115.8			5.9110		0.85238
	5608	67160284	2697E; 28309N	168.9	188.9			2.5979		0.77287
	5609	67160292	2705E; 28385N	175.3	134.6					
	5610	67160294	2753E; 28384N	177.6	137.1			3.7977		0.80551
	5611	66160255	2789E; 28401N	104.2	293.0			1.0294		0.73363
				120.9	266.3			1.3151		0.74000
Lennard	5616	67160291	2710E; 28236N	135.0	186.0	146.0	218.5	1.9399	0.76024	
Granite	5617	67160293	2743E; 28399N	106.8	281.4	125.4	355.9	1.0200	0.73533	
Lerida Granite	5918	67163010	4289E; 27503N	196	211	169.7	212.7	2.3188	0.77058	
Long Hole Granite	5919	67163011	4180E; 27389N	263	209	235.4	208.4	3.2879	0.79152	
Chaneys Granite	5920	67164000	4251E; 27326N	172	295	171.3	296.0	1.6774	0.74668	
								(Calculated)		
Pillara	5923	67165003	3778E; 26902N	105.8	383.5			0.7981		0.72326
Range	5924	67165004	3798E; 26866N	152.2	193.2			2.2861		0.75795
granites	5925	67165005	3751E; 26892N	100.4				1.0226		0.72919

TABLE 2 (page 3)

Rock Unit	G.A. Number	B.M.R. Number	GRID CO-ORDINATES	X.R.F. Rb (ppm)	X.R.F. Sr (ppm)	I.D. Rb (ppm)	I.D. Sr (ppm)	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86} (calc)	Sr^{87}/Sr^{86} (U.S.)
Carson Volcanics	5914	66162036	1525E: 29249N	55.5	27.9			(Calculated) 5.8193		0.86649
Elgee Siltstone	5915	67162125	1226E: 29298N	28.2	10.3			(Calculated) 8.0209		0.88789
	5916	66162038	1551E: 29377N	156.3	12.2			36.6068		1.13896
Pentecost Sandstone	5909	67162126	1354E: 29595N	98.1	11.7			(Calculated) 25.4843		1.22658
	5912	67162128	1332E: 29414N	127.7	12.6			31.1412		1.34309
	5913	66162039	1377E: 29356N	114.6	41.0			8.1980		0.87392
Linesman Beds	5628	67150301	3163E: 27534N	183.8	15.9			(Calculated) 34.2927		1.00961
Elimberrie Beds	5625	67160300	3134E: 27537N	111.9	22.0			(Calculated) 14.9357		0.86265
Spielers Volcanics	5626	67160302	2139E: 27517N	148.9	2.4			(Calculated) 199.5352		1.71804
	5627	66160251	3132E: 27491N	132.1	27.1	133.9	30.6	(measured) 12.8578	0.88569	

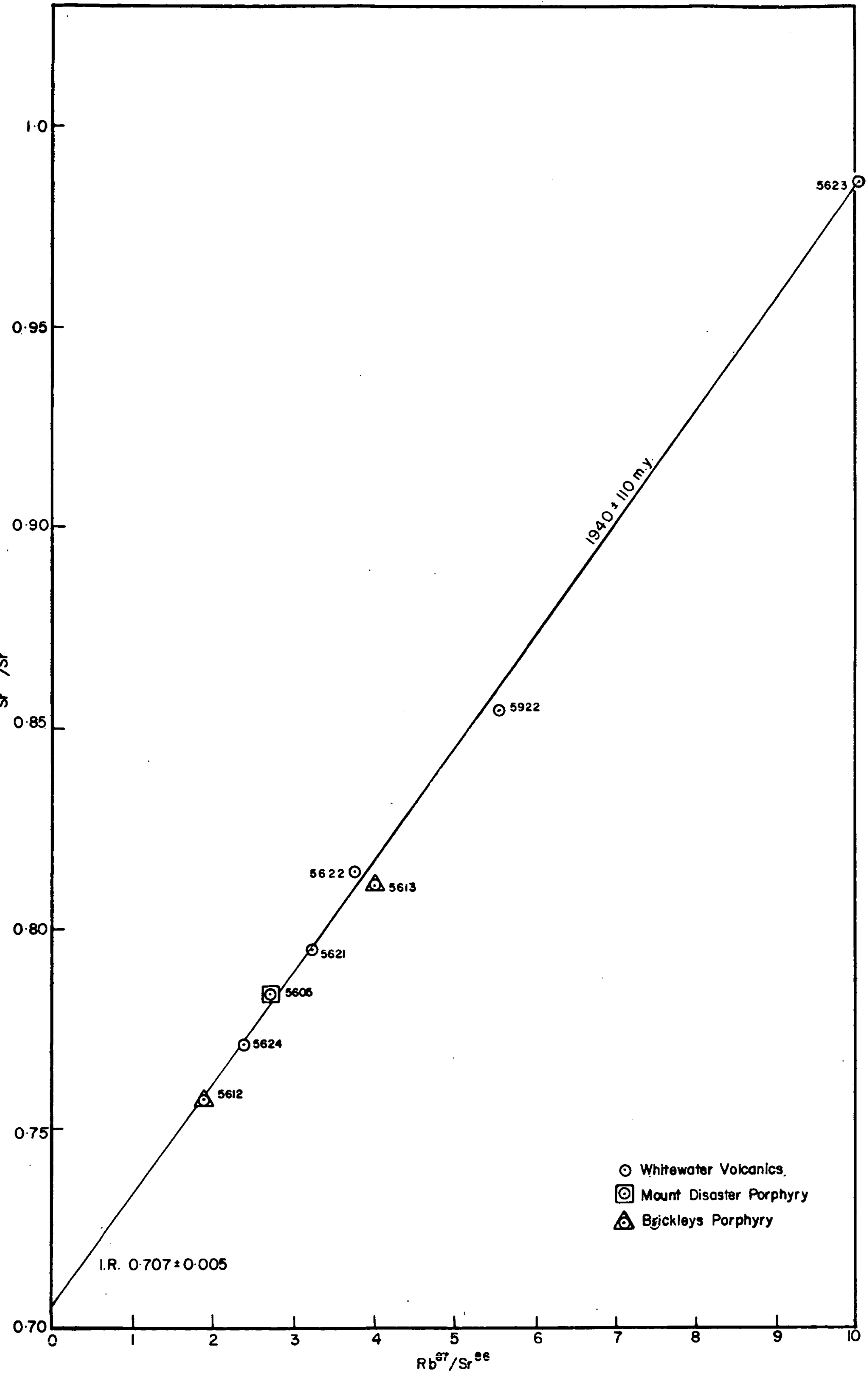
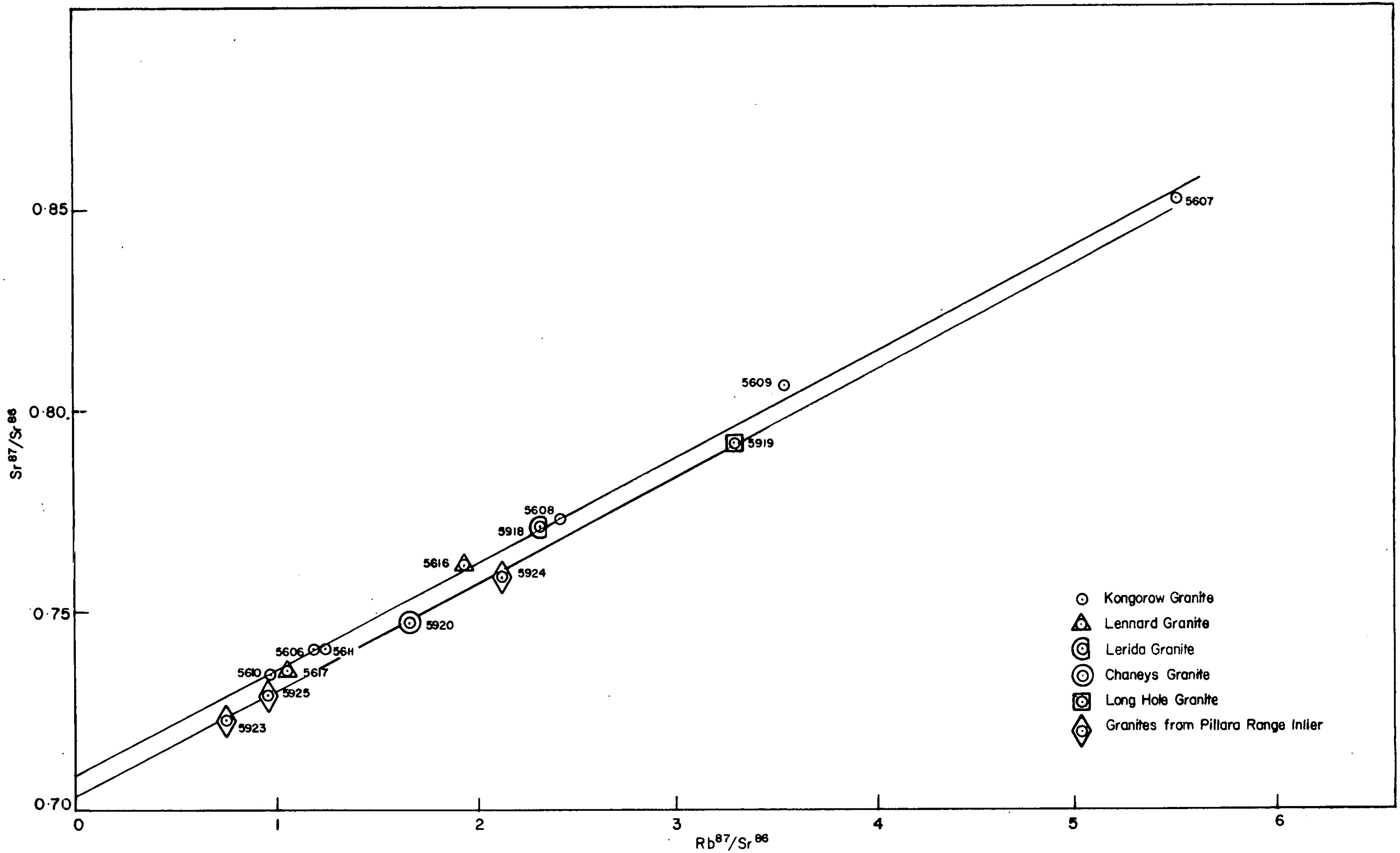


FIG. 1 ISOCHRON OF WHITEWATER VOLCANICS AND ASSOCIATED HIGH LEVEL ACID INTRUSIVES FROM WEST KIMBERLEY

W/A211

To accompany Record 1970/20



To accompany Record 1970/20 FIG. 2 ISOCHRONS OF WEST KIMBERLEY PLUTONIC GRANITES W/A212

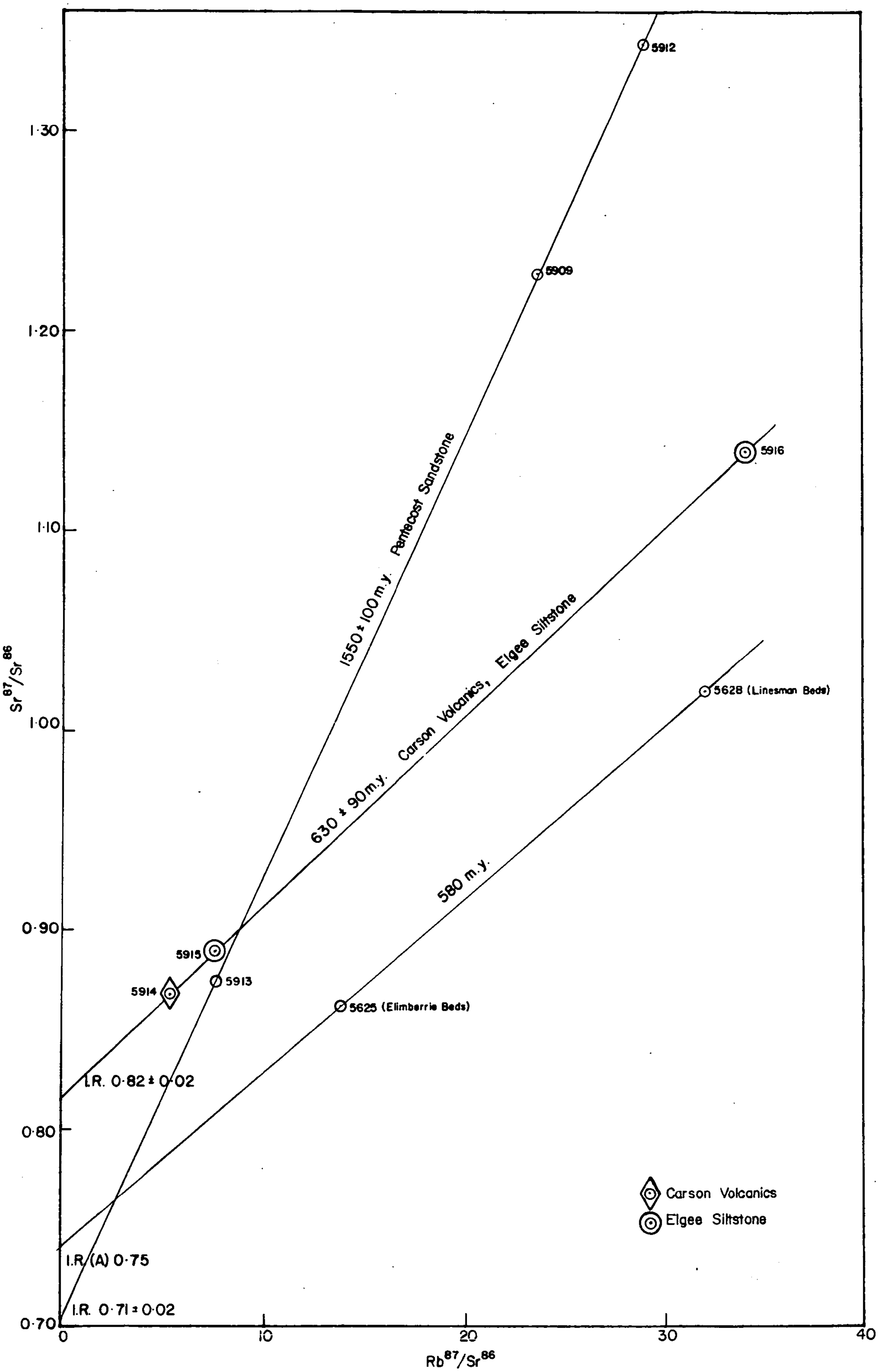
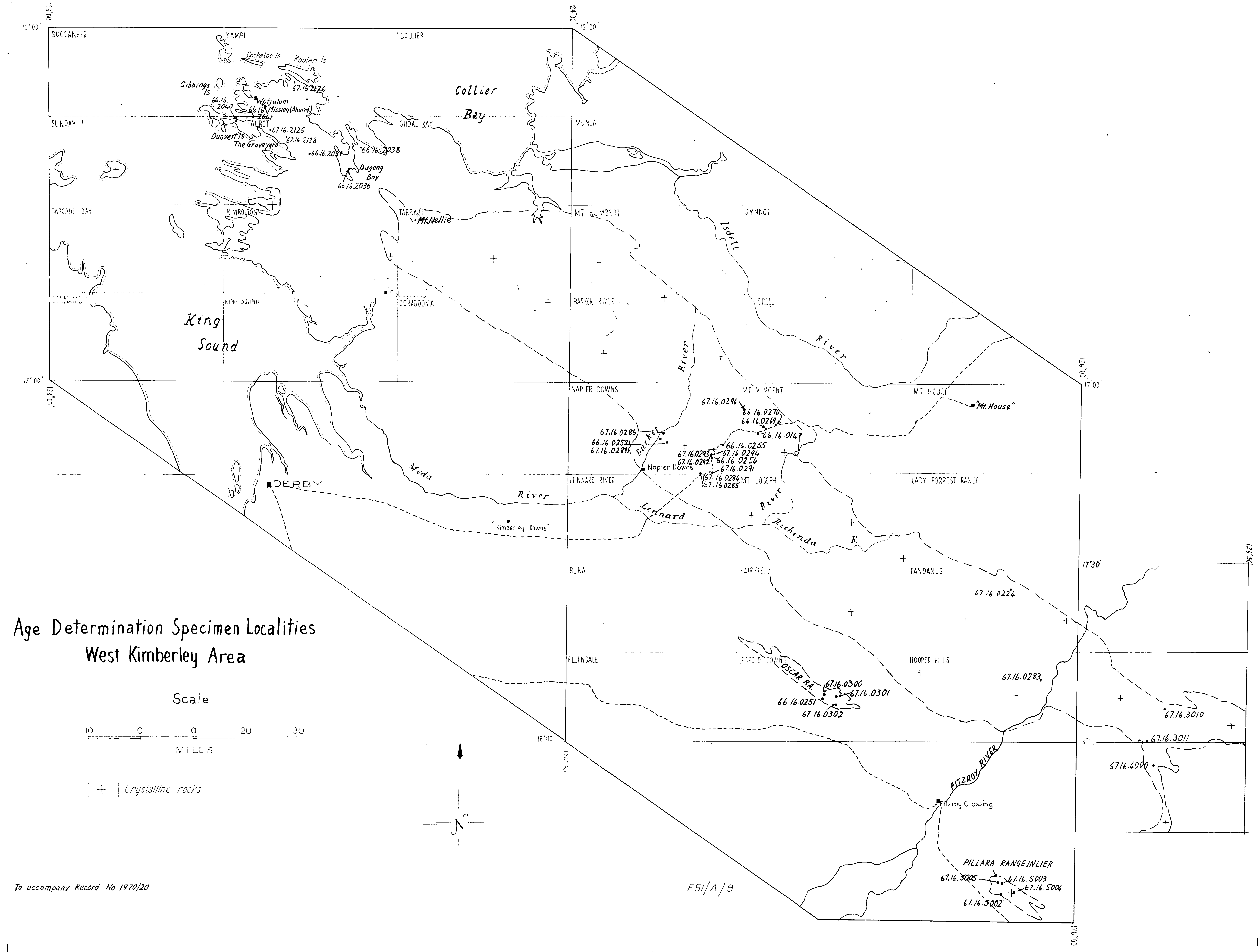


FIG. 3 ISOCHRONS OF PROBABLE METAMORPHIC EPISODES

AFFECTING YOUNGER PRECAMBRIAN ROCKS OF WEST KIMBERLEY REGION

To accompany Record 1970 / 20 W/A213



Age Determination Specimen Localities
West Kimberley Area

Scale

10 0 10 20 30
MILES

+ Crystalline rocks

To accompany Record No 1970/20

E51/A/9