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Advances in the Geochronology of the Rice Lake – Beresford Lake Area, Southeastern Manitoba

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NOTES

Advances in the Geochronology of the Rice Lake – Beresford Lake Area, Southeastern Manitoba[1,2]

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The Rice Lake – Beresford Lake area consists of an easterly trending Precambrian greenstone belt which is flanked on the north by granitic rocks and on the south by granitic and metamorphic rocks. Analyses of an intrusive, late tectonic quartz monzonite at Black Lake, yield an isochron age of 2735 ± 55 m.y. with an initial $^{87}Sr/^{86}Sr$ composition 0.7019 ± 0.0008. This age is a minimum for the granitic rocks to the south of the greenstone belt and is the oldest age obtained in this area. On the other hand, analyses of a quartz diorite pluton intrusive into the greenstones give a metamorphic age of 2555 ± 70 m.y. with an initial $^{87}Sr/^{86}Sr$ of 0.7016 ± 0.0012. Mylonite zones are developed along the northern and southern boundaries of the greenstone belt. Analyses of whole-rock samples from these zones yield an age of 2345 ± 100 m.y. with initial $^{87}Sr/^{86}Sr$ 0.7044 ± 0.0024, and is the youngest age obtained in the area.

These new data, combined with our previous work, indicate three major events. The first and oldest event is 2730 ± 50 m.y. and is interpreted as a period of regional metamorphism, granite emplacement, and the emplacement of gold–quartz veins which postdate the greenstones. A second period of metamorphism and granite emplacement occurred at 2530 ± 40 m.y. and it affected the area as a whole, as evidenced by updated mineral ages. The third and youngest event, 2345 ± 100 m.y., is recorded by the mylonites and may represent epeirogenic movement in the area.

Introduction

The Rice Lake – Beresford Lake area (Fig. 1) is approximately 100 miles (161 km) northeast of Winnipeg. Definitive geological work in this area is that by Stockwell (1938, 1942*a*, *b*, *c*) Stockwell and Lord (1939), Davies (1953), and Russell (1948, 1952). This study is a contribution to a more comprehensive investigation of the area in progress (Project Pioneer, Davies 1966) by the Manitoba Department of Mines and Natural Resources and the Department of Earth Sciences at the University of Manitoba. The oldest rocks here, the Rice Lake Group, constitute a typical Precambrian greenstone belt trending easterly to southeasterly. The basic to acid lavas and associated sediments of the Rice Lake Group are intruded by basic sills and these in turn are intruded by quartz diorite plutons. Unconformably overlying these rocks is the San Antonio Formation, an arkosic quartzite. Extensive mylonite zones are noted along the north and south boundaries of the greenstone belt. To the north of the belt is a potassic granite and to the south are high-grade gneisses. Informally we refer to these rocks as the northern granite and the southern gneissic belt respectively. The youngest rocks, postfolding in age, are an ultramafic intrusive plug at Garner Lake and ultramafic dikes northwest of Beresford Lake.

In our previous publication (Tureck and Peterman 1968) we showed that the gold–quartz veins were emplaced at 2720 ± 185 m.y.

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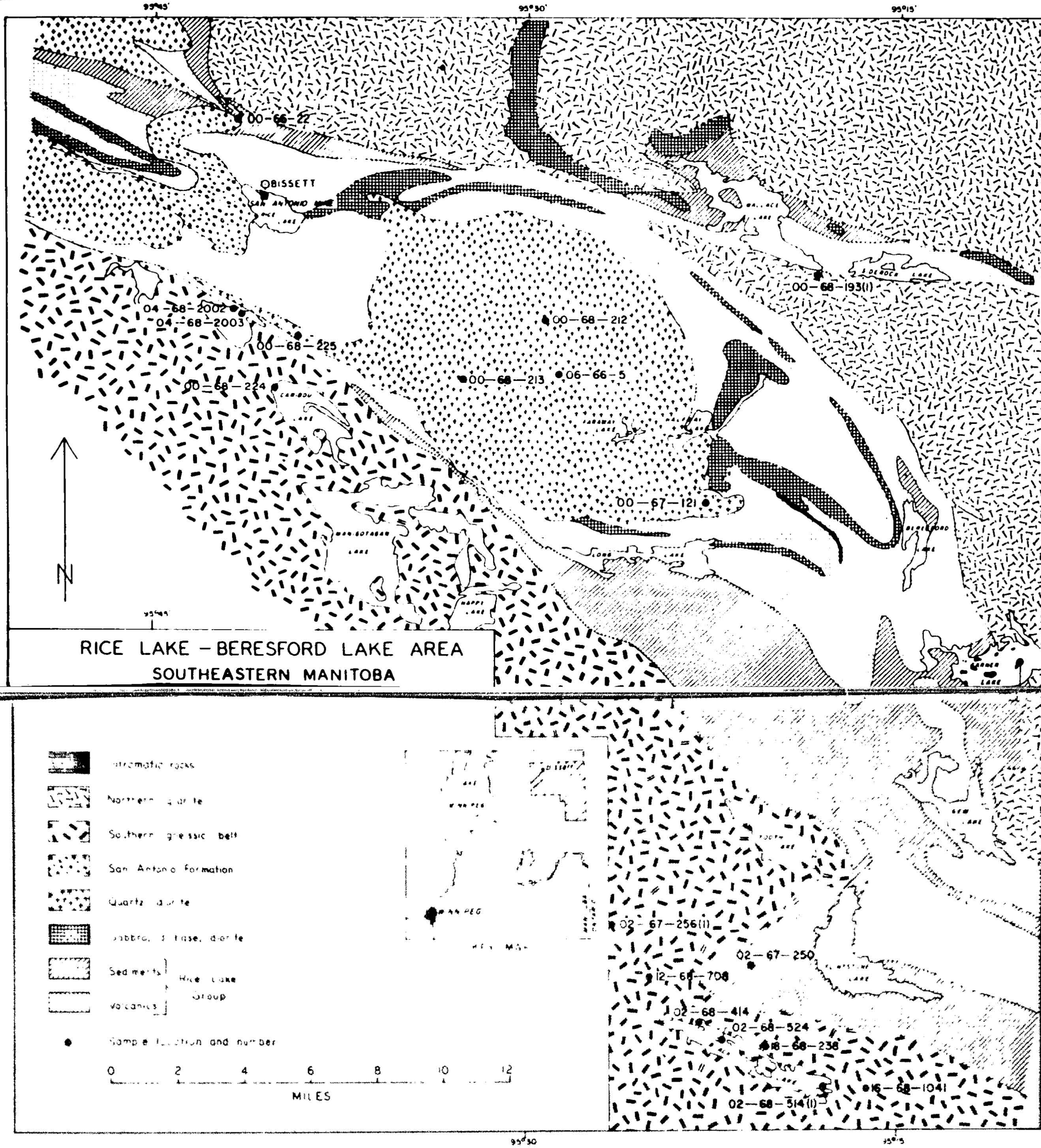

FIG. 1. Geological map of the Precambrian rocks in the Rice Lake – Beresford Lake area, southeastern Manitoba (Based on Stockwell 1942*a*, *b*, *c*).

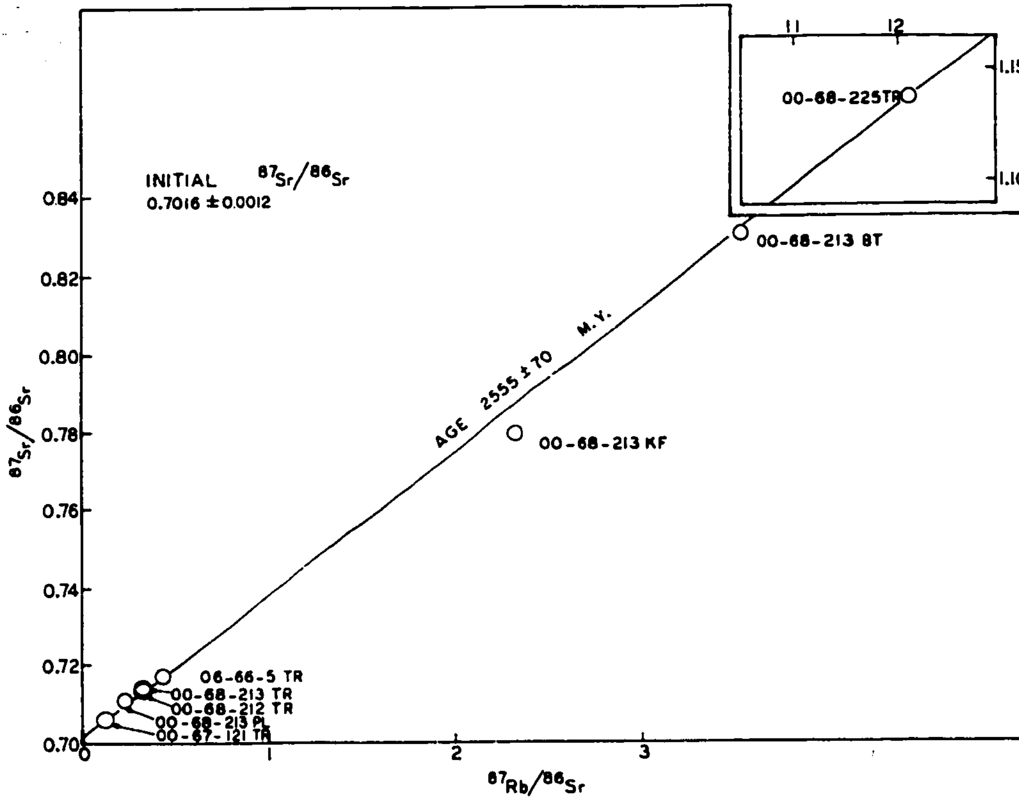

FIG. 2. Total rock and mineral Rb–Sr isochron for quartz diorite (TR, total rock; BT, biotite; Pl, plagioclase; K.T., potash feldspar).

This dating placed a minimum on the Rice Lake Group, the basic intrusive dikes and sills, the quartz diorite, and the San Antonio Formation. The northern granite was emplaced at 2550 ± 80 m.y. and phyllites of the Rice Lake Group register this event, as a metamorphism, with an isochron age of 2490 ± 90 m.y. The southern gneissic belt was shown to be older than 2630 m.y., a whole-rock age obtained on a transgressive pegmatite.

Our present paper reports additional age determinations made on a quartz monzonite in the southern gneissic belt, on a quartz diorite pluton (Fig. 1) within the greenstone belt, and on the mylonites from the north and south boundaries of the greenstone belt.

The Rb–Sr analyses were made at the U.S. Geological Survey's Denver laboratory using a 6 in. (15 cm) solid source mass spectrometer. Concentrations were measured by isotope dilution and the $^{87}Sr/^{86}Sr$ ratios by separate unspiked runs. The isotopic constants used in the calculations are:

$$\lambda^{87}Rb = 1.39 \times 10^{-11}\ y^{-1},$$
$$^{85}Rb/^{87}Rb = 2.591,\ ^{86}Sr/^{88}Sr = 0.1194$$

The double error regression of McIntyre *et al.* (1966) was used in the statistical evaluation of isochrons with estimates of the analytical errors as reported by us previously. The analytical results are listed in Table 1 and shown as isochrons in Figs. 2, 3, and 4. All uncertainties quoted are the 95% confidence limits.

Quartz Diorite

The central quartz diorite pluton (Fig. 1) has high Sr and low Rb content as well as a remarkably consistent Rb/Sr ratio, and it has therefore not been possible to obtain a total-rock isochron age. A total-rock and mineral

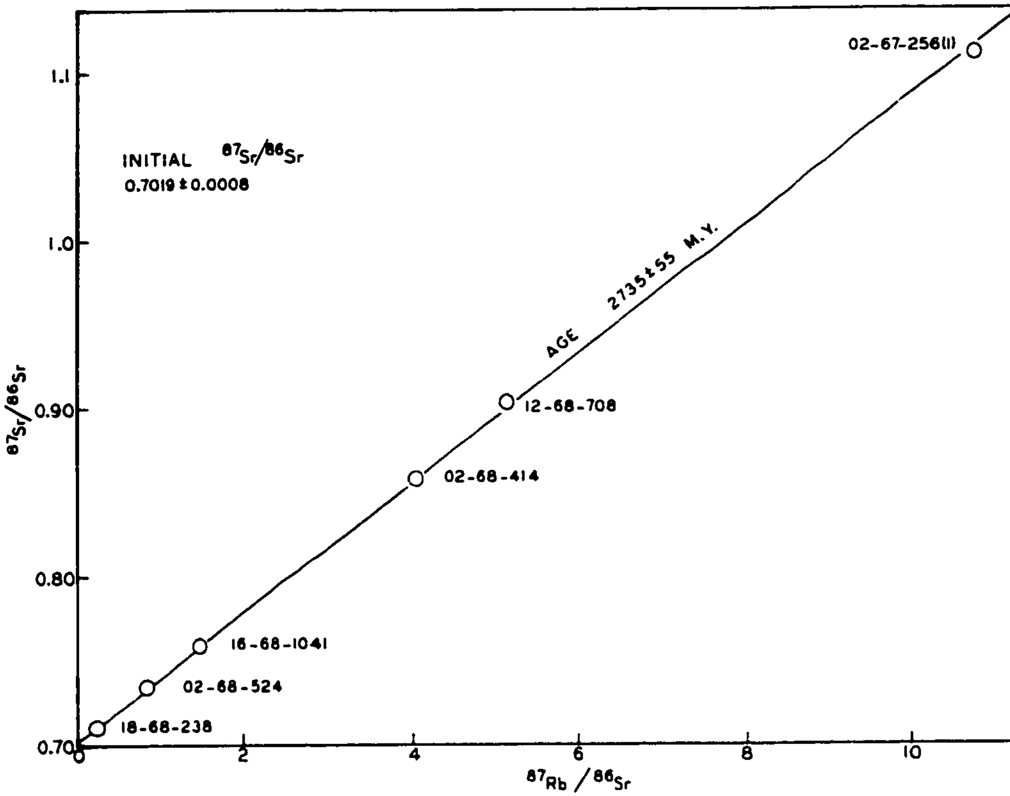

FIG. 3. Total rock Rb–Sr isochron for quartz monzonite at Black Lake.

isochron, Fig. 2, indicates an age of 2555 ± 70 m.y. with an initial ratio of 0.7016 ± 0.0012. Excluded from the regression is a potash feldspar which lies outside the limits of the regression and indicates an age of 2340 m.y. An isochron incorporating this point would have an intercept less than 0.70. As the plagioclase, biotite, and total rock are collinear, the radiogenic Sr lost from the potash feldspar must have been incorporated in other mineral phases. One sample (00-68-225) is an aplite cutting the quartz diorite; exclusion of this sample from the regression would give an isochron age of 2665 ± 120 with an initial ratio 0.7016 ± 0.0016, a change not statistically significant at the 5% level of confidence. Though the aplite on field evidence is younger than the quartz diorite geochronologically this is not discernible, it may of course be younger only in the crystallization sequence of the pluton. The above isochron is interpreted as registering a metamorphic event. The quartz diorite shows retrograde metamorphism, and is cut by gold–quartz veins. The latter was dated by us (op. cit.) at 2720 ± 185 m.y. Statistically the 2555 ± 70 and 2720 ± 185 ages are distinct at the 5% level of confidence.

A K–Ar age on a biotite from the same pluton is 2670 m.y. (Lowdon 1961). This is in reasonable agreement with our result, when uncertainties in the decay constant and analytical errors are taken into consideration.

Southern Gneissic Belt

The gneissic terrain to the south of the greenstone belt consists essentially of paragneiss, granitic rocks, and pegmatites. It has been studied in detail by McRitchie and Weber (1970). One of their units, a biotite-bearing leucocratic quartz monzonite at Black Lake, is considered to be a late tectonic intrusive. We analyzed six total-rock samples of this unit;

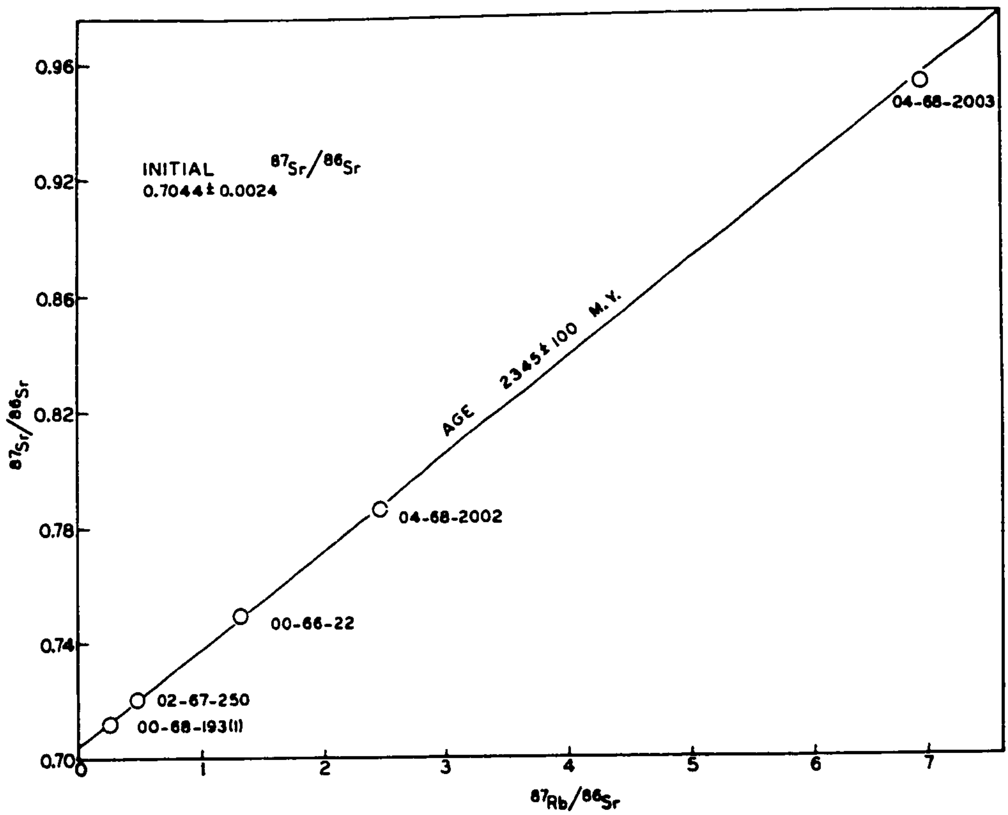

FIG. 4. Total rock Rb–Sr isochron for mylonites.

the isochron, Fig. 3, is well within experimental error; the age is 2735 ± 55 m.y. with an initial $^{87}Sr/^{86}Sr$ of 0.7019 ± 0.0008. We interpret this as the age of emplacement of this body; and it is also a realistic estimate for the age of the regional metamorphism.

Previously we reported an age of 2630 m.y. on a crosscutting pegmatite from Tooth Lake as a minimum age for the gneissic belt. The analyses of the quartz monzonite at Black Lake therefore warrant an increase of this minimum age estimate to 2735 m.y.

A sample of biotite from a paragneiss at Black Lake, which is intruded by the quartz monzonite, gives a Rb–Sr age of 2530 m.y. The sample locality for this biotite is exactly the same as for a sample analyzed by the Geological Survey of Canada (Lowdon 1961), for which a biotite K–Ar age of 1700 m.y. was reported. Dr. R. K. Wanless of the Geological Survey of Canada has rerun the original sample (No. GSC 60-90) and the new determination is 2470 m.y. Analysis of our sample (02-68-514(1)) also by Dr. Wanless gives a K–Ar age of 2415 m.y., which is considered to be in agreement with the Rb–Sr 2530 m.y. age.

Another biotite sample (00-68-224, Table 1) from the paragneiss at Caribou Lake gives an Rb–Sr age of 2630 m.y.; we regard this as a partially updated age in response to the younger, 2530-m.y., metamorphism.

Mylonites

Extensive mylonite zones are developed along the north and south boundaries of the greenstone belt. On field evidence the parent material of these mylonites is inferred to have been sediments, granite, and quartz diorite. Five samples of what is now mylonite were analyzed. The results are plotted in Fig. 4 and the line fitting the five points has a slope cor-

TABLE 1. Analytical results. (Samples are whole rocks except where labelled: BT, biotite; KF, potash feldspar; PL, plagioclase)

Sample No.	Latitude north	Longitude west	^{87}Rb micromols/g	^{86}Sr micromols/g	^{87}Rb/^{86}Sr	^{87}Sr/^{86}Sr
		Quartz monzonite at Black Lake				
18-68-238	50° 39′ 55″	95° 19′ 2″	0.1327	0.5723	0.232	0.7107
02-68-524	50° 39′ 57″	95° 21′ 58″	0.4323	0.5354	0.808	0.7336
16-68-1041	50° 38′ 34″	95° 16′ 47″	0.3690	0.2507	1.472	0.7586
02-68-414	50° 40′ 25″	95° 22′ 56″	0.5214	0.1292	4.035	0.8576
12-68-708	50° 41′ 27″	95° 24′ 55″	0.6192	0.1205	5.139	0.9036
02-67-256(1)	50° 42′ 44″	95° 26′ 47″	0.6321	0.5894	10.72	1.1111
		Paragneiss (southern gneissic belt)				
00-68-224 BT	50° 56′ 19″	95° 40′ 20″	1.704	0.00957	178.1	7.3372
02-68-514(1) BT	50° 38′ 45″	95° 18′ 00″	1.748	0.0191	91.64	3.9832
		Quartz diorite				
00-67-121	50° 53′ 20″	95° 22′ 50″	0.0786	0.4914	0.160	0.7056
00-68-212	50° 58′ 03″	95° 29′ 18″	0.1355	0.4139	0.327	0.7140
06-66-5	50° 56′ 40″	95° 28′ 41″	0.1585	0.3704	0.428	0.7169
00-68-213	50° 56′ 31″	95° 32′ 33″	0.1240	0.3754	0.330	0.7140
00-68-213 PL	50° 56′ 31″	95° 32′ 33″	0.0727	0.3186	0.228	0.7109
00-68-213 KF	50° 56′ 31″	95° 32′ 33″	0.3633	0.1544	2.352	0.7793
00-68-213 BT	50° 56′ 31″	95° 32′ 33″	0.4590	0.1289	3.561	0.8307
00-68-225	50° 57′ 50″	95° 39′ 15″	0.3469	0.0287	12.01	1.1375
		Mylonites				
00-68-193(1)	50° 59′ 22″	95° 18′ 15″	0.1396	0.5467	0.225	0.7116
02-67-250	50° 41′ 48″	95° 20′ 56″	0.2226	0.4793	0.464	0.7209
00-66-22	50° 03′ 20″	95° 41′ 45″	0.1760	0.1331	1.322	0.7489
04-68-2002	50° 58′ 16″	95° 41′ 31″	0.2751	0.1122	2.452	0.7849
04-68-2003	50° 58′ 12″	95° 41′ 25″	0.1646	0.2390	6.887	0.9324

responding to an age of 2345 ± 100 m.y. and an intercept of 0.7044 ± 0.0024. We regard this result as a minimum age for the development of these mylonite zones and the shearing, as any subsequent movement along the shears would tend to reset the Rb–Sr clock. The error of the regression is slightly greater than the experimental error, most likely owing to partially open system behavior and to possible differences in the isotopic composition of the parent materials. The process of homogenization of mylonites is not clearly understood. Redistribution of Rb and Sr was reported in mylonites by Watanabe (1965). Field observation in this area using a portable gamma-ray spectrometer indicated a marked increase over the regional background of potassium in shear zones. It is likely that mylonitization was accompanied by potash metasomatism and the latter is effectively being dated here.

Discussion of Results

A synthesis of the radiometric ages determined here and previously (Turek and Peterman 1968) clearly allows definition of three major geologic events (Fig. 5). Observed geologic relations can be placed within this framework. In the following discussion, isochron ages that are thought to reflect the same events are pooled according to the method of Bofinger and Compston (1967) in order to permit estimating the mean ages of these plutonic, metamorphic, and structural episodes.

The oldest event recognized occurred at 2730 ± 50 m.y. as indicated by late tectonic quartz monzonite at Black Lake (2735 ± 55 m.y.) in the southern gneissic belt and gold quartz veins (2720 ± 185 m.y.) in the greenstone belt. The 2730-m.y. age is a minimum for the San Antonio Formation, the Rice Lake Group, and plutonic rocks, mafic sills and quartz diorite, in the greenstone belt. Similarly, the precursors of the paragneiss in the southern gneissic belt must have been deposited prior to 2730 m.y. ago. Geologic relations indicate that metamorphism of the paragneiss to the present grade essentially occurred at the same time as the emplacement of the quartz monzonite at Black Lake. W. D. McRitchie (personal communication 1969) has observed that pink pegmatite veins in the southern gneissic belt become progressively more silicic and almost

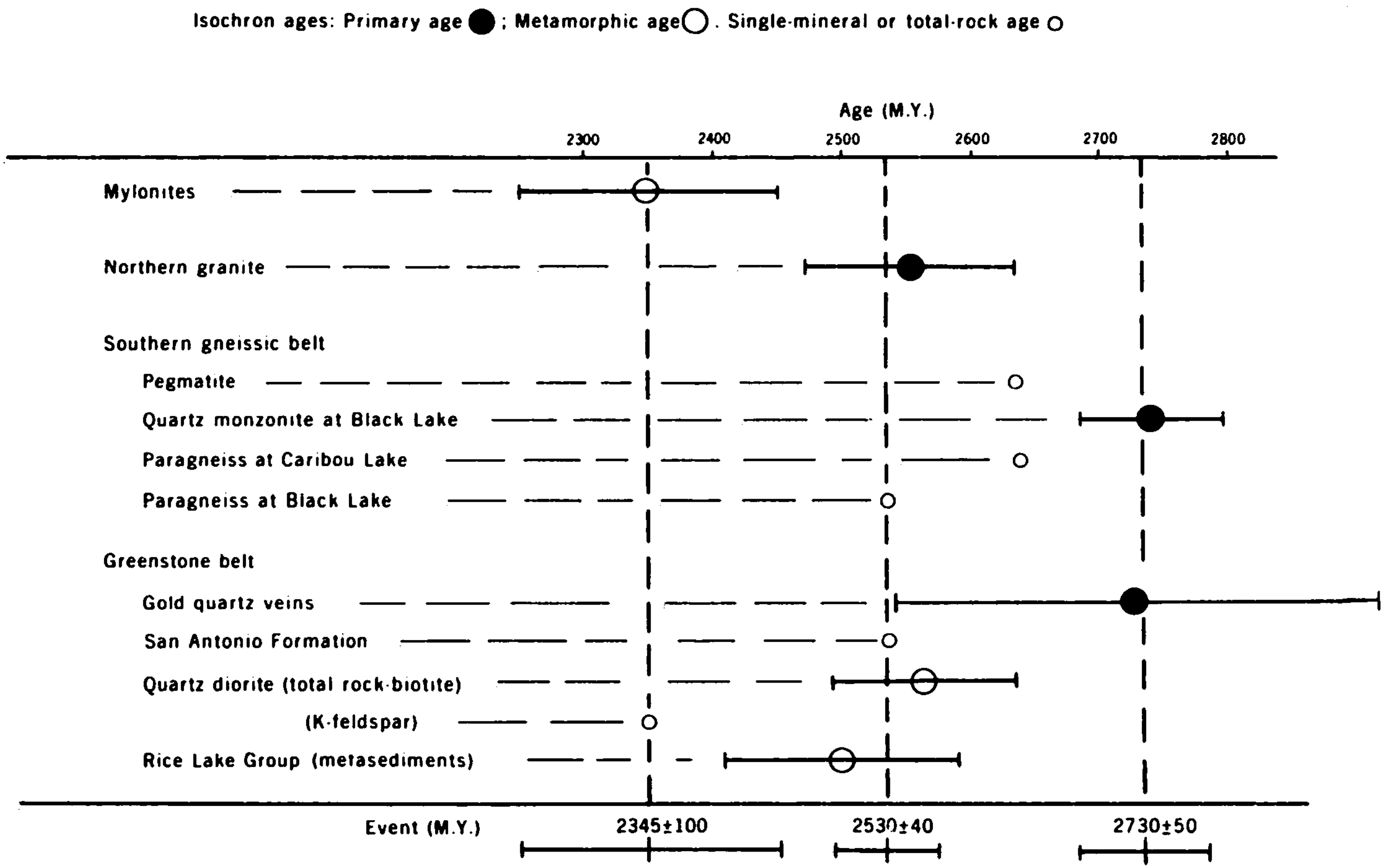

FIG. 5. Summary of isotopic age determinations. The indicated uncertainties of isochron ages and of the pooled events are the 95% confidence limits.

pure quartz towards the greenstone belt, which suggests that the gold quartz veins are genetically related to these. This is a further evidence that granitic plutonism, metamorphism, and gold mineralization were essentially coeval.

A second event at 2530 ± 40 m.y. (Fig. 5) is represented by emplacement of the northern granite (2550 ± 80 m.y.) and by metamorphic ages obtained on metasedimentary rocks of the Rice Lake Group (2490 ± 90 m.y.) and on the quartz diorite (2555 ± 70 m.y.). Single-mineral ages that apparently are related to this event are the 2530-m.y. biotite age from paragneiss at Black Lake and a 2530-m.y. age obtained on sericitic material in a shear zone within the San Antonio Formation. The ages of 2630 m.y. on biotite from a paragneiss at Caribou Lake and 2630 m.y. on pegmatite (whole rock) may represent partial resetting at 2530 m.y.; the possibility that these are real ages cannot, however, be discounted. As discussed earlier (Turek and Peterman 1968), the synchroneity of the emplacement of the northern granite with low-grade metamorphism and tectonism in the greenstone belt is compatible with inferred geologic relations between the northern granite and the San Antonio Formation.

The third and youngest event in the area (Fig. 5) is registered by mylonites (2345 ± 100 m.y.) which occur along zones of faulting at the northern and southern limits of the greenstone belt. A microcline from the quartz diorite gives an age of 2340 m.y., which may indicate that this structural event affected rocks within the major fault blocks.

This faulting juxtaposed terrains of different metamorphic grade. The greenstone belt is greenschist facies, and the southern gneissic belt is amphibolite facies, whereas the northern granite shows only mild retrogression. The 2730-m.y. event which is registered in the greenstone belt and the southern gneissic belt transgresses metamorphic boundaries. In all probability we are looking at belts that were metamorphosed at different levels in the crust. One would suspect that the greenstones were at one time more extensive in area and have since been removed by uplift and erosion. The quartz veins in the greenstone belt would represent epi-mezozonal effect while the granite emplacement and metamorphism of the southern gneissic belt would reflect the catazonal effect of the 2730-m.y. event.

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