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Rb-Sr MINERAL AGE DISCORDANCES AND GEOCHRONOLOGY OF PRECAMBRIAN BASIC INTRUSIVES IN THE MOUNT ISA PROVINCE, AUSTRALIA

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Rb-Sr MINERAL AGE DISCORDANCES AND GEOCHRONOLOGY OF PRECAMBRIAN BASIC INTRUSIVES IN THE MOUNT ISA REGION, AUSTRALIA *

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Summary

Rb-Sr geochronology using total-rock and mineral phases from two cross-cutting basic intrusions in the Eastern succession of the Northwest Queensland Province, Australia, gives precise isochron ages of 1498 ± 79 m.y. and 1140 ± 12 m.y. (95-percent confidence level). These results are in agreement with known field relationships, other isotopic ages, and the respective palaeolatitudes of these intrusions on the Australian Precambrian apparent polar wander curve. Nevertheless, isotopic discordance of a type not previously described is evident between total rocks, plagioclases, and some of the clinopyroxenes. As possible causes, consideration is given to primitive interphase discrepancies in initial Sr^{87}/Sr^{86}, and to internal redistribution of rubidium and radiogenic strontium after crystallization.

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1. Introduction

This contribution is part of a more extensive geochronological investigation currently being undertaken in the Mount Isa region of northwest Queensland, Australia, and reports the first isotopic ages determined for Precambrian basic intrusives. Field mapping and recently determined palaeomagnetic pole positions have definitively constrained the relative ages of the intrusions.

The thick sedimentary and volcanic successions of the Mount Isa region were laid down on both sides of an older, north-trending central tectonic welt, whose metamorphic age appears to be a little over 1700 m.y. (Page and Derrick, 1973). The age relations and the isotopic analyses considered in this paper refer only to rocks deposited or intruded east of the tectonic welt, in the eastern geosyncline of Carter et al. (1961), which has a complex history of folding, faulting, metamorphism, and igneous activity.

The many types of basic intrusive rocks in the Mount Isa region have attracted considerable structural and petrological study. On field evidence, Carter et al. (1961) recognized five age groupings of dolerite intrusives for the whole region. Walker (1958) divided the dolerites petrologically and chemically into seven groups, and indicated their importance as a yardstick by which other events in the region could be measured to elucidate the sequence of geological events. The basic intrusives studied in this paper are all from the Marraba area, from which Derrick et al. (1971) described four distinct groups that are largely akin to those of Carter et al. (1961). The various subdivisions of the basic rocks are based mainly on their stratigraphic relations, texteral preservation, and degree of alteration, as well as time relations to the major regional metamorphic episodes. Implicit in these groupings is a definite age sequence, and the four types of basic intrusive in the Marraba area are denoted in younging order as do_2, do_3, do_4, and do_6 (Fig. 1).

The Rb-Sr isotopic dating approach provides a straightforward method of testing and better delineating the proposed sequence of intrusions, provided that the rocks within each group had a constant initial Sr^{87}/Sr^{86} ratio at the time of crystallization, and that the rocks and individual mineral species have since remained closed chemical systems. The most altered (and considered oldest) of the basic intrusive groups (do_2, do_3) are metadolerites, amphibolites, and basic schists, and, as little of their primary igneous mineralogy is preserved, these groups could not be further considered for reliable age determination.

The type examples of the supposedly younger basic intrusive groups, do_4 and do_6, are well exposed in a north-south belt about 9 km east of Mary Kathleen (Fig. 1). In this area the two younger intrusive types are known as the 'Lunch Creek Gabbro' (do_4) and 'Lakeview Dolerite' * (do_6). The latter unequivocally intrudes the 'Lunch Creek Gabbro', and, as seen later, both intrusions have clearly defined field relations with other units. Both the 'Lunch Creek Gabbro' and the 'Lakeview Dolerite' are unweathered and little altered, which, together with their good field control, render them suitable for geochronological study.

The ages of these basic intrusive bodies are of further importance in the light of recent palaeomagnetic results (Duff and Embleton, in prep.), which have yielded distinctly separate pole positions for the 'Lunch Creek Gabbro' and 'Lakeview Dolerite'. Precise isotopic dating of these intrusions

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* The names 'Lunch Creek Gabbro' and 'Lakeview Dolerite' have not yet been formalized, but are reserved at the Central Register of Stratigraphic Nomenclature, Bureau of Mineral Resources, Canberra.

should therefore be useful, not only to substantiate the inferred sequence of intrusion and to learn more of the timing of igneous activity in the Mount Isa region, but also to complement the new palaeomagnetic data and thus better quantify the polar-wander path for the Australian Precambrian.

2. Geological and petrographic descriptions of the basic intrusives

A sequence of acid lavas, tuffs, and metasediments (Argylla Formation) forms part of the basement in the Mount Isa region, and is unconformably overlain in the area east of Mary Kathleen by the Corella Formation, a widespread unit of carbonate-rich, calc-silicate, and quartzitic rocks (Fig. 1). The 'Lunch Creek Gabbro' and 'Lakeview Dolerite' are two of a number of basic and acid igneous bodies that intrude the Corella and older formations. One of the acid bodies, the Burstall Granite, has been dated by the Rb-Sr whole-rock method (Page, unpublished data), and was found to have at least two ages, indicative of its complex intrusive history: the younger isochron age of 1448 ± 46 m.y. is given by unfoliated granite at the northern margin of the mass which clearly intrudes Corella Formation rocks, whereas slightly foliated granite in the centre of the Burstall mass gives an age of 1630 ± 50 m.y.

The 'Lunch Creek Gabbro' is a rhythmically and cryptically layered sill-like mass about 9 km long and 1.5 km across. It flanks the eastern margin of, and is intruded by, unfoliated phases of the Burstall Granite considered to be coeval with the same 1448 m.y. phase dated in the main Burstall mass.

The 'Lakeview Dolerite' is a northeast-trending dyke at least 30 km in length and up to 30 m wide. It has a well chilled margin in places, and cuts greenschist to amphibolite-grade rocks of the Corella Formation, all phases of the Burstall Granite, and the 'Lunch Creek Gabbro'.

The age constraints applicable to the two basic intrusions considered here can therefore be summarized as follows: (i) the 'Lunch Creek Gabbro' antedates the younger granite phase, and is therefore probably older than 1448 m.y.; its relation to the 1630 m.y. granite phase is not known; and (ii) the 'Lakeview Dolerite' is younger than all the other igneous rocks and metamorphic episodes, and thus has no younger age constraints.

The single sampling locality, QD-5, in the 'Lunch Creek Gabbro' (Fig. 1) is in the type section in Lunch Creek 3.3 km west-northwest of Timberoo homestead. This is part of the same palaeomagnetic section studied by Duff and Embleton (1975). The sample was blasted from an outcrop of massive microgabbro, as far away as possible (350 m) from any of the later granitic intrusions. This rock, QD-5, has a subophitic texture, and contains the following primary minerals: zoned plagioclase (An_{50-60}), clinopyroxene, hypersthene, red-brown biotite, opaque iron mineral, apatite, and a mesostasis of quartz-potash feldspar intergrowths. Small amounts of secondary amphibole rimming some clinopyroxene grains, and sericite and epidote alteration of some plagioclase grains, are the only evidence of alteration. Thus, the excellent preservation of primary igneous texture and mineralogy in QD-5 appears to indicate that the 'Lunch Creek Gabbro' was emplaced after the main regional metamorphism. However, other samples of the gabbro that were examined were not nearly as fresh as QD-5, and exhibited moderate to strong chloritization and saussuritization; as this alteration or metamorphic imprint of some of the rocks is localized, it is difficult to assess petrographically whether the 'Lunch Creek Grabbro' is older or younger than the regional metamorphism. Derrick (pers. comm., 1975) suggests, however, that the 'Lunch Creek Gabbro' was intruded in the waning stages of regional metamorphism.

Two 'Lakeview Dolerite' localities (QD-1, QD-7; Fig. 1) sampled in Duff and Embleton's (1975) palaeomagnetic study were also sampled for isotopic study. At site QD-1 (500 m south of the Mount Isa/Cloncurry road) the central part of the dyke (QD-1B), and a finer rock (QD-1A) 5 metres away, nearer the margin, were collected. Site QD-7 is 2 km south of QD-1, near Lake Corella. Except for minor deuteric alteration, the dolerites are moderately fresh, and the primary igneous texture and mineralogy are also well preserved. Both clinopyroxene and orthopyroxene are present, but in QD-1 the latter is almost wholly pseudomorphed by serpentine minerals. Slight sericite and carbonate alteration of plagioclase are further evidence of deuteric alteration. Interstitial biotite, amphibole, opaque iron mineral, and chlorite, and micrographic intergrowths of quartz and potash feldspar, are late-stage crystallization products, and indicate that the 'Lakeview Dolerite' is alkali-rich, similar in some respects to the 'Lunch Creek Gabbro', which it cuts.

3. Analytical methods

Total-rock powders and mineral separates from the dolerites and gabbros were prepared (Table 2) so that internal mineral /total-rock Rb-Sr isochrons for each sampling site could be established. Chemical dissolutions of the samples were performed in teflon-ware along the lines reported by Compston et al. (1965), except that much smaller samples were processed and smaller quantities of reagents were used. About 100 mg of total rock was used, and the amount of mineral concentrate per analysis ranged from 10 to 100 mg, depending on the quantity available. The isotope dilution procedure employed the one-mixed-spike solution enriched in Rb^{85} and Sr^{84}; this was added to and homogenized with the whole sample before the rubidium and strontium were isolated by cation exchange. Total processing blanks per analysis were 8×10^{-9} g for Rb and 7×10^{-9} g for Sr. These blanks were significant for only the smallest samples, and appropriate corrections are incorporated in the data reported in Table 2.

Rubidium isotopic ratios were measured on a 15.25-cm, 90°-sector mass spectrometer (MS-X), and strontium analyses were performed using a Nuclide Analysis Associates (NAA) machine (30.5 cm, 60° sector). Both mass spectrometers employed 6 kV accelerating voltage, and were operated on-line to a HP-2116B computer which also controlled the magnetic-field switching. The Sr^{87}/Sr^{86} ratio for E and A standard on the NAA machine is 0.70813 $\pm$ 0.00004 (Page and Johnson, 1974) normalized to 8.3752 for the Sr^{88}/Sr^{86} ratio; for NBS 987, the mean Sr^{87}/Sr^{86} for the BMR/ANU laboratory is 0.71035 $\pm$ 0.00006 (1 limits). Throughout the calculations, the Rb^{85}/Rb^{87} in natural Rb is taken as 2.600, and the 1.39×10^{-11} yr^{-1} decay constant of Rb^{87} is used. In the McIntyre et al. (1966) isochron regressions applied to the Rb-Sr data, coefficients of variation of 0.8 percent for Rb^{87}/Sr^{86} and 0.015 percent for Sr^{87}/Sr^{86} were used. All errors are quoted hereafter at the 95 percent confidence level.

The duplicate K-Ar analysis reported in this paper was performed by Dr A.W. Webb (AMDL report AN 1770/75); the following constants were used in the age calculations: K^{40} = 0.0119 atom percent; $\beta = 4.72 \times 10^{-10}$ yr^{-1}; $\varepsilon = 0.584 \times 10^{-10}$ yr^{-1}.

4. Age of the 'Lunch Creek Gabbro'

A minimum age estimate for the 'Lunch Creek Gabbro' is given by the duplicate K-Ar analysis on sample QD-5 biotite (Table 1). The K-Ar age of 1431 $\pm$ 10 m.y. is not statistically different from the figure of 1448 $\pm$ 46 m.y. for part of the intrusive Burstall Granite, and is similar to the many K-Ar mica ages of granites from the Mount Isa area (Richards et al., 1963). As these ages almost certainly reflect the 1400-1450 m.y. regional metamorphic imprint, the 1431 m.y. result for the 'Lunch Creek Gabbro' biotite is best regarded as a minimum age of emplacement.

Figure 2 is an Rb-Sr isochron diagram plotting the 'Lunch Creek Gabbro' sample QD-5 total-rock and mineral data given in Table 2; biotite is too enriched in rubidium to plot on the diagram. Although only the cleanest hand-picked plagioclase was analysed, it has a high rubidium content, evidently due to partial sericitization of some grains. The biotite, the potash feldspar-rich mesostasis, and the clinopyroxene and orthopyroxene do, however, provide a reasonable dispersion in Rb/Sr. To balance the high-rubidium components analysed, a high-strontium, low rubidium phase, such as fine unaltered plagioclase, must also be present in the rock, but it could not be isolated for analysis.

Statistical regression of the five mineral points and one total-rock point by the method of McIntyre et al. (1966) demonstrates significant departure from straight-line relationships (mean square of weighted deviates, MSWD = 74.1), and a model 2 isochron of slope equivalent to 1532 $\pm$ 160 m.y. fits the data. The duplicate plagioclase analyses lie well above the fitted isochron, and the plagioclase/total-rock tie-line would have an unrealistically old age of 1804 m.y. Deletion of plagioclase from the isochron is thus justified, and this gives another model 2 solution, but with a much lower MSWD of 8.0. This isochron (Fig. 2) has a shallower gradient corresponding to an age of 1498 $\pm$ 79 m.y. and an ititial Sr^{87}/Sr^{86} of 0.7088 $\pm$ 0.0016. This result is quite consistent with the other known ages and field relations, but it remains a <u>minimum</u> estimate as the slope of the line is dominated by the biotite data. The duplicate biotite analyses give model ages which closely agree at 1470 and 1476 m.y. The minimum age proviso is especially pertinent because the same biotite has a K-Ar age of 1431 m.y., and has thus lost radiogenic argon either during later heating associated with the intrusion of the Burstall Granite, or during the regional metamorphism at about this time. If, at the time of metamorphism, the biotite also lost some of its radiogenic strontium, this may have been incorporated in a strontium-rich mineral such as plagioclase, thus providing a possible explanation for the anomalous position of plagioclase relative to the 1498 m.y. isochron (Fig. 2). A similar pattern of mineral age discordance has been well documented in some granitic rocks in which radiogenic strontium has apparently been expelled from potash feldspar and taken up by plagioclase (Arriens et al., 1966; Brooks, 1966).

As the biotite may have acted partly as an open isotopic system, a further data regression, including QD-5 total rock, potash feldspar, orthopyroxene, and clinopyroxene, was made. This procedure again gives a model 2 isochron (MSWD = 4.8), but the age (1531 ± 130 m.y.) and initial ratio (0.7083 ± 0.0023) are not defined precisely enough to serve as an adequate check of the 1498 ± 79 m.y. isochron. It is thus concluded that the biotite has probably not lost significant radiogenic strontium, and the pooled total-rock/mineral age of 1498 ± 79 m.y. is a reliable minimum estimate for the time of emplacement of the 'lunch Creek Gabbro'.

5. Age of the 'Lakeview Dolerite'

Eleven mineral separates and three total rocks were prepared from material collected at sites QD-1 and QD-7, and, from these, twenty Rb-Sr analyses (Table 2) have been made, six being duplicate determinations on the plagioclases, clinopyroxenes, and total rocks. The isochron plot of these data (Fig. 3) shows that the three total-rock points conform to the general alignment, but they would not define a useful isochron by themselves. Plagioclase and clinopyroxene data points are respectively well above and below the fitted regression line. The somewhat high rubidium content in the plagioclase analysis is due to incomplete removal of some partly sericitized and saussuritized grains, but the duplicate values agree well, considering the sampling problems met with in taking small (10 mg) aliquots for each plagioclase dissolution. A more serious sampling problem, due to contamination with a few biotite flakes, is encountered in QD-7 clinopyroxene, in which there is a 14 percent measured difference between the two Rb^{87}/Sr^{87} values. These differences do, however, correlate with differences in calculated Sr^{87}/Sr^{86}, the resultant tie-line representing a mix of the respective minerals. In the ensuing regression analyses of the isotopic data, only a mean value of the duplicate results is used.

The less abundant and more alkali-rich components (biotite, amphibole, potash feldspar) in the 'Lakeview Dolerite' samples provide an excellent spread in Rb/Sr, and, except for QD-1 potash feldspar, are well aligned on the isochron diagram (Fig. 3). The McIntyre et al. (1966) regression treatment of all three total-rock and eleven mineral analyses in Table 2 and Figure 3 gives a model 3 solution with a high MSWD of 433.0, indicative of the observed poor fit of the plagioclase and clinopyroxene data points; the resultant isochron age is 1143 ± 14 m.y. for an initial ratio of 0.699 ± 0.006. Deletion of the obviously aberrant plagioclase and clinopyroxene data, as well as QD-1 potash feldspar, significantly reduces the MSWD to 62.8, but barely alters the model 3 fit, which gives an age of 1140 ± 12 m.y. and initial Sr^{87}/Sr^{86} of 0.704 ± 0.002. The individual biotite ages for QD-1 and QD-7 are essentially independent of the choice of initial Sr^{87}/Sr^{86}, and the calculated model ages are in excellent agreement at 1146 m.y. and 1145 m.y. respectively. It could be argued that these two analyses of highly enriched biotite are unduly weighting the 1140 ± 12 m.y. isochron slope given by the combined mineral/total-rock data. However, this is not so, as the two biotites are enriched to quite different degrees and yet give the same age.

Furthermore, even if the biotites are deleted from the pooled mineral/total-rock data, the resultant model 4 isochron (MSWD = 87.5) still has a similar age (1137 ± 29 m.y.) and initial Sr^{87}/Sr^{86} ratio (0.7046 ± 0.0019). It is therefore appropriate that the biotite data, which improve the precision of the isochron, be retained.

Separate assessment of the Rb-Sr isotopic analyses at each of the QD-1 and QD-7 sampling sites does not alter the above age estimates given by the data pooled from both sites. For example (given that the extraneous plagioclase and clinopyroxene data as well as QD-1 potash feldspar warrant exclusion) the internal mineral/total-rock isochron at site QD-1 gives an age of 1144 ± 33 m.y., and at site QD-7 the corresponding result is 1137 ± 27 m.y. It is noteworthy that, unlike the clinopyroxenes, the orthopyroxene analysis is quite concordant with this isochron. Another treatment of the data from QD-7 is suggested by the approximate alignment of its total-rock, plagioclase, potash feldspar, and amphibole points; such an isochron has a higher indicated initial Sr^{87}/Sr^{86} ratio (0.708) and a younger apparent age of 1118 m.y., but, as the consistent biotite ages of 1145 m.y. are minimum values, they discount such an interpretation.

In summary, the best age determined for the 'Lakeview Dolerite' is the combined result of 1140 ± 12 m.y., the indicated initial ratio being 0.704 ± 0.002. The good age agreement between different sites, and between biotite model ages and the remaining mineral/total-rock isochron ages, strongly suggests that this age is the time of emplacement and crystallization, and that there has been no significant postemplacement alteration or metamorphism. The result is entirely consistent with the field relations, and with isotopic data on nearby rock units which are cut by the 'Lakeview Dolerite'.

6. Isotopic discordance of plagioclase and clinopyroxene

Although the age of crystallization of the 'Lakeview Dolerite' is adequately determined at 1140 ± 12 m.y., some of the data, in particular for the plagioclases and clinopyroxenes, do not fit this isochron to within the predicted experimental uncertainties, and geological effects must be invoked to explain the scatter. Neglecting for the moment the gross discordance of the plagioclases and clinopyroxenes, the model 3 solution of the 1140 m.y. isochron suggests that the observed scatter of the other mineral and the total-rock data is most likely due to small primary differences in their initial strontium composition at the time of crystallization. The non-linearity of the three total-rock points also serves as a further demonstration of the limitations of the total-rock isochron approach in basaltic rocks (cf. Compston, 1974), in which small perturbations in initial Sr^{87}/Sr^{86}, even in a single dyke, can so readily affect isochron alignment.

Clinopyroxene and plagioclase, the ubiquitous and major mineral phases of doleritic intrusions, are the usual constituents sought to provide (with the total-rock analysis) internal Rb-Sr mineral isochrons for such rocks. Unequivocal age determinations obtained from this approach alone are, however, relatively rare, and the 'Lakeview Dolerite', in which there is clear isotopic disequilibrium between primary clinopyroxene, plagioclase, and total rocks, is no exception. Were it not for the other independent mineral data, an age could not have been interpreted for the 'Lakeview Dolerite'.

The divergent positions of the plagioclase and clinopyroxene data points with respect to the 1140 m.y. isochron are consistent for both samples QD-1 and QD-7. Apparent excess radiogenic strontium in the plagioclases is accompanied by apparent depletion of radiogenic strontium in the clinopyroxenes. Because high Rb/Sr, interstitial, late-stage minerals are generally well aligned with the 1140 m.y. isochron (which is the same as the biotite ages), later faulting or other tectonic disturbance cannot be invoked as possible causes of the plagioclase-clinopyroxene discordance. Because only these two - the earliest-crystallized - minerals are not in isotopic equilibrium, the relevant process or processes causing the discordance must be more subtle and selective. A number of propositions between the two extremes of (i) primary differences in Sr^{87}/Sr^{86}, and (ii) secondary, postcrystallization isotopic redistribution, can now be assessed.

For primary differences in Sr^{87}/Sr^{86} between plagioclase and clinopyroxene, the igneous melt must have been contaminated by strontium from the enclosing crustal rocks before the dyke solidified. This model, similar in many respects to that of Compston and McElhinny (1975), assumes that the alkali-rich fraction of the melt equilibrated with the external strontium whereas the clinopyroxene did not; the strontium-receptive plagioclase lattice absorbed the excessive radiogenic strontium (hence the aberrant plagioclase data), but the clinopyroxene retained its initial Sr^{87}/Sr^{86} - about 0.702 for QD-1. This chemical transfer through wall-rock contamination certainly seems realistic for a long thin slab of dolerite magma, such as the 'Lakeview Dolerite', en route through tens of kilometres of more radiogenically enriched crustal rocks. The degree of contamination may be mild, but is probably quite variable along the length and downward extent of the dyke, leading to the observed non-uniform initial ratios in total rocks. A possible objection to the above model for the 'Lakeview Dolerite' data is that the orthopyroxene apparently equilibrated with the external strontium, whereas the clinopyroxene did not. Further, the excess contamination required for plagioclase with respect to the total rocks is a somewhat <u>ad hoc</u> corollary to the model that clearly requires far more data for clarification.

Postcrystallization isotopic redistribution of rubidium or strontium, or both, may have been a contributing or overriding factor which led to the anomalous plagioclase and clinopyroxene data. The only time-constraint on such intermineral migration is that it took place less than 1140 m.y. ago, and could even have taken place in recent time, say, as a result of weathering. Given the well documented precedent in granitic rocks (Arriens et al., 1966), and a similar suggestion in the Great Dyke gabbroic intrusives (Allsopp, 1965), the phenomenom of radiogenic strontium transfer from rebidium-rich minerals to plagioclase would seem a plausible mechanism for explaining the observed results in this study. Whether the conditions for such isotopic exchange be due to weathering or the sericitization of plagioclase, or some other process, cannot be determined. The model would also involve transfer of rubidium to clinopyroxene to account for the consistent offset of this mineral below the isochron. The total rock may well have behaved as a closed system in spite of the internal redistribution among constituent minerals.

7. Conclusions

Despite large isotopic discordance reflected in some minerals, a successful attempt has been made, using Rb-Sr internal mineral/total-rock isochrons, to date two basic intrusive rock bodies in the Mount Isa region. The mineral age discordances, especially indicated by clinopyroxene and plagioclase data in the 'Lakeview Dolerite', are attributed to isotopic disequilibrium of these phases with each other and with the rocks. This disequilibrium may be due to insufficient mixing of the components of the partly crystalline magma with external strontium during emplacement, which caused the intial enrichment in radiogenic strontium of plagioclase, in particular, relative to clinopyroxene and the rock. This discordance is considered to have been enhanced by some postcrystallization internal isotopic migration of rubidium and radiogenic strontium. Although the two basic intrusions are mineralogically similar, a slightly higher indicated initial Sr^{87}/Sr^{86} ratio for the 'Lunch Creek Gabbro' (0.7088 ± 0.0016) than that of the 'Lakeview Dolerite' (0.7044 ± 0.0020) suggests different petrogenetic histories - the former being more influenced by crustal processes.

The Rb-Sr isochron ages substantiate the sequence of intrusion indicated by field and petrographic evidence, namely that the 'Lunch Creek Gabbro' (1498 ± 79 m.y.) is cut by non-foliated phases of Burstall Granite considered to be 1448 m.y. old, and both of these bodies are intruded by the 'Lakeview Dolerite' (1140 ± 12 m.y.). Intrusion of the 'Lakeview Dolerite' (part of the youngest dolerite group, do_6, of Derrick et al., 1971) at 1140 m.y. (Adelaidean) is consistent with its postmetamorphic (1400-1450 m.y.) age, and makes it the youngest documented igneous event in the Mount Isa region. The 'Lunch Creek Gabbro' result is important in that it provides a minimum age (1498 ± 79 m.y.) for the deposition of the Corella Formation, which is correlated with the Mount Isa Group in the Western succession (Plumb and Derrick, 1975); this has important regional implications which will be discussed in a subsequent paper.

The relative ages of the 'Lunch Creek Gabbro' and 'Lakeview Dolerite', as given by the palaeomagnetic pole positions on the Precambrian polar-wander curve (Duff and Embleton, 1975), are in accord with the 1498 m.y. and 1140 m.y. ages given by the Rb-Sr work. However, these authors' tentative correlation, based on palaeomagnetism, between the 'Lakeview Dolerite' (do_6) and a dolerite body (do_4 group) in the Western succession (near the Mount Isa microwave station) is contrary to field and petrographic considerations. Because of its greenschist metamorphic imprint, the latter (Microwave dolerite) could not be dated in this study, and is unlikely to equate with the relatively unaltered 1140 m.y. 'Lakeview Dolerite', whose emplacement postdated any known metamorphism by at least 250 million years. This anomaly may be rationalized in view of the recognized non-uniqueness of such palaeomagnetic correlations (e.g., Giddings, 1975): if for example, as suggested by field relations and petrography, the Microwave dolerite intrusion is older than the regional metamorphism, the geomagnetic field may have attained a similar direction at 1140 m.y. to that which it had when the Microwave dolerite intruded, at least 250 m.y. ago (Embleton, pers. comm. 1975; Giddings, 1975).

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TABLE 1 K-Ar analysis of biotite from 'Lunch Creek Gabbro'

Sample	BMR No.	K%	Radiogenic Ar^{40}/K^{40}	% Radiogenic Ar^{40}	Age (m.y.)
QD-5	7320.0257	7.85	0.12468	99.9	1427
		7.86	0.12570	99.9	1435

TABLE 2 Rb-Sr analytical data for samples of the Mount Isa area dolerites and separated minerals. The BMR registered number for sample QD-1 is 7320.0251; for QD-7, 7320.0260; and for QD-5, 7320.0257.

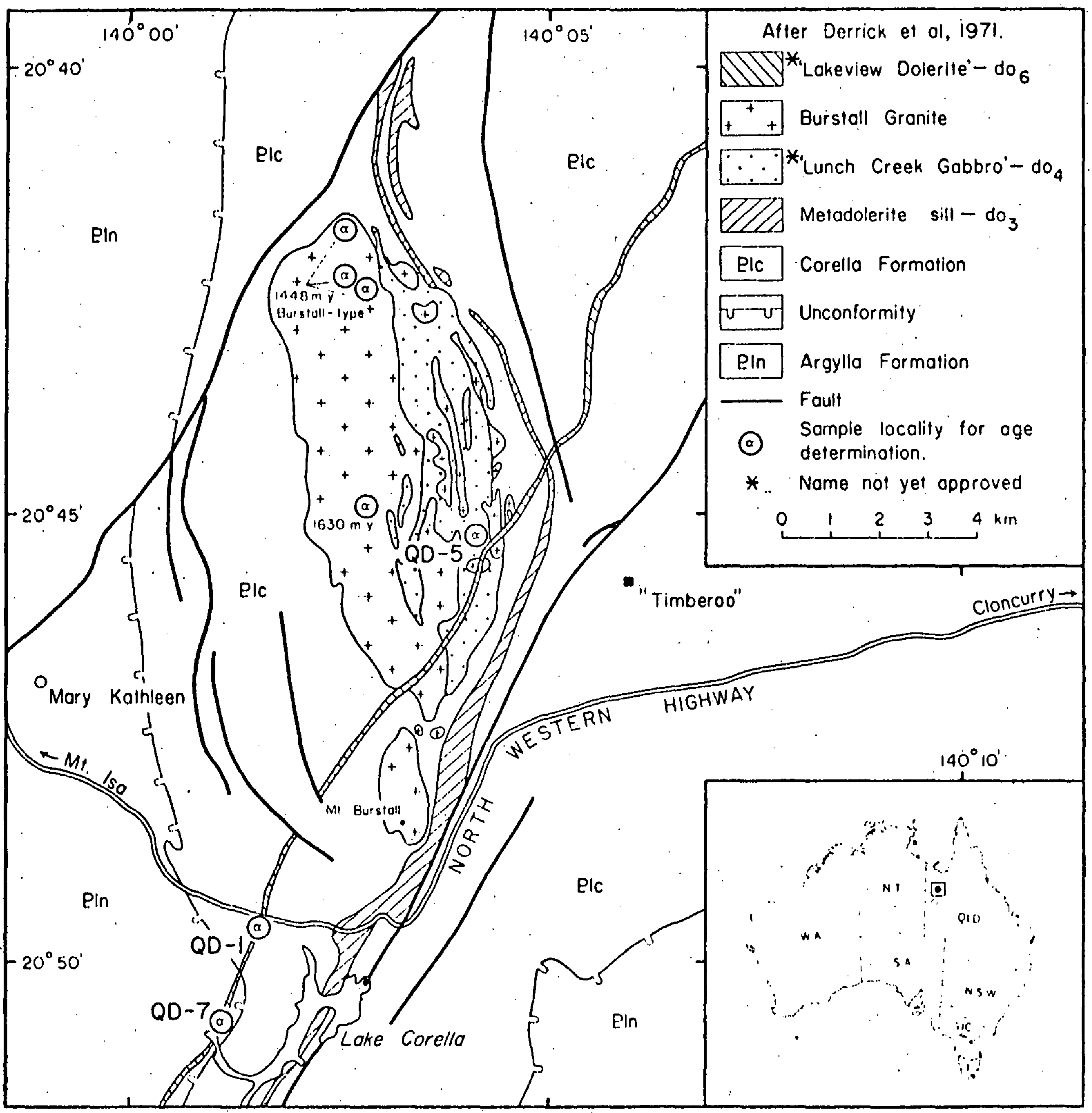
Site No.	Sample	Rb (ppm)	Sr (ppm)	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86}
LAKEVIEW DOLERITE					
QD-1A	Total rock	90.0	140.3	1.857	0.73446
QD-1A	Total rock	49.2 47.6	121.1 120.0	1.175 1.147	0.72141 0.72164
	Biotite	969.8	6.1	1645.04	27.1177
	K feldspar	282.5	44.3	18.915	0.98119
	Amphibole	26.5	6.7	11.623	0.88918
	Clinopyroxene	6.2 6.2	22.1 21.5	0.810 0.833	0.71208 0.71202
	Plagioclase	63.5 61.5	192.5 194.9	0.955 0.913	0.72181 0.72169
QD-7	Total rock	29.2 28.9	134.8 132.7	0.626 0.629	0.71588 0.71606
	Biotite	903.3	9.5	486.49	8.50400
	K feldspar	195.5	64.2	8.924	0.84974
	Amphibole	131.4	10.6	37.868	1.30087
	Clinopyroxene	52.3 41.7	19.3 17.6	7.910 6.878	0.80483 0.78900
	Orthopyroxene	1.76	13.0	0.391	0.70983
	Plagioclase	96.4 102.1	110.4 109.3	2.530 2.708	0.74873 0.75104
LUNCH CREEK GABBRO					
QD-5	Total rock	47.2	179.2	0.762	0.72456
	Biotite	606.5 605.6	8.3 8.1	364.27 383.58	8.21968 8.64909
	K feldspar	301.4	300.6	2.913	0.77134
	Clinopyroxene	8.2	9.7	2.453	0.76011
	Orthopyroxene	5.1	11.0	1.343	0.73767
	Plagioclase	193.4 185.7	278.7 277.8	2.013 1.939	0.75532 0.75503

CAPTIONS FOR FIGURES

Figure 1 Geological map of part of the Eastern succession of the Northwest Queensland Province, Australia.

Figure 2 Rb-Sr isochron relations for the 'Lunch Creek Gabbro' total rocks and minerals.

Figure 3 Rb-Sr isochron relations for the 'Lakeview Dolerite' total rocks and minerals.



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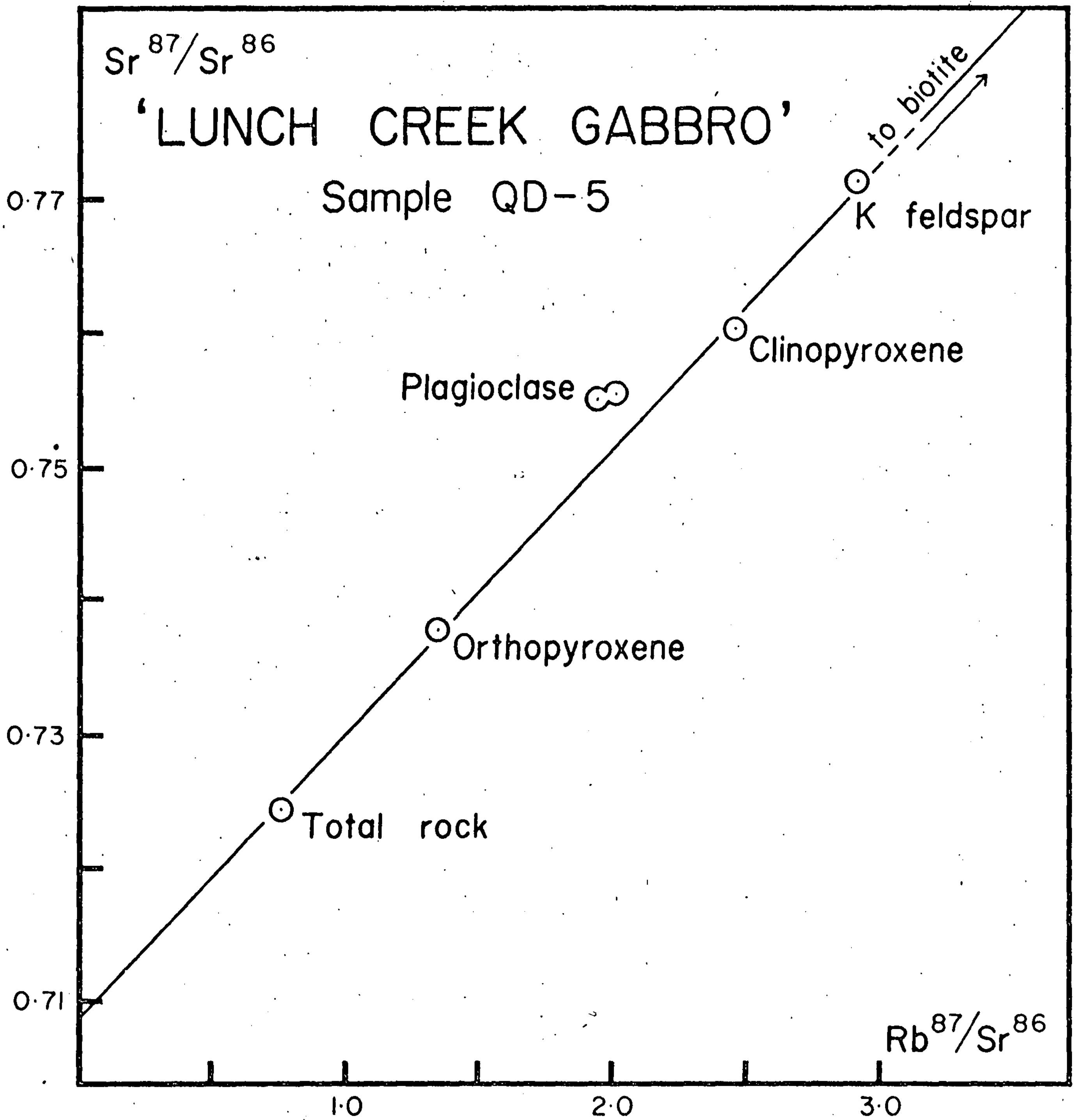

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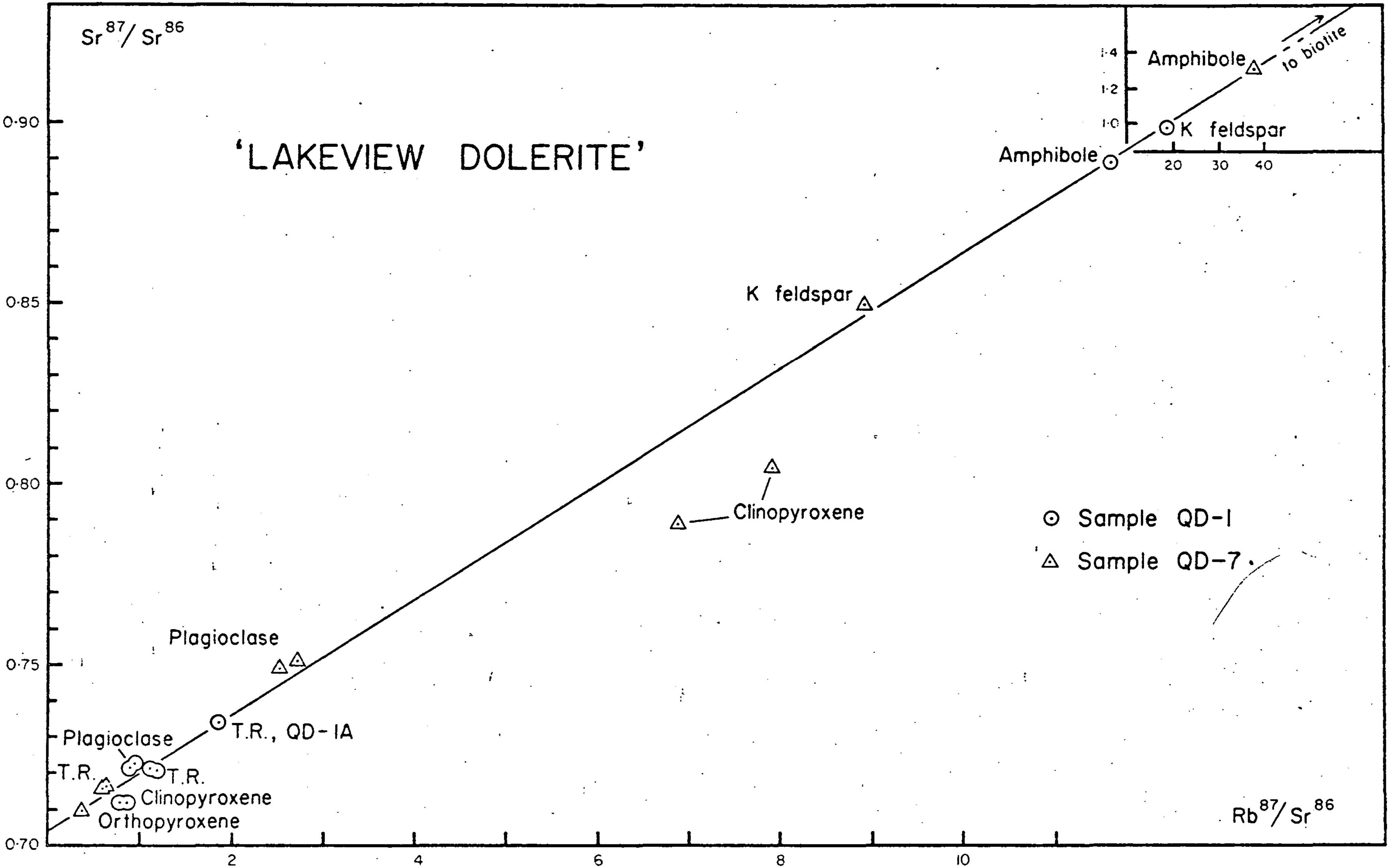

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