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Rb-Sr AGE FOR LOWER CRUST IN THE SOUTHERN RIO GRANDE RIFT, NEW MEXICO

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Lower crustal granulite xenoliths from Kilbourne Hole maar and from Quaternary basalt vents along the western margin of Engle basin record an Rb-Sr isochron age of 1.9 Ga, 500 to 700 Ma older than plutons and related igneous rocks found in uplifts along the southern Rio Grande rift. Thus the country rock intruded during plutonism appears to have been lower Proterozoic. An initial $^{87}Sr/^{86}Sr$ ratio of 0.7070 argues for contamination of this country rock by even older crust (>1.9 Ga) or for a significant period of crustal residence before equilibrating isotopically at 1.9 Ga.

INTRODUCTION

A suite of granulite xenoliths from Kilbourne Hole maar, New Mexico, has been chemically characterized to evaluate the contribution of lower crustal material to Oligocene and Miocene volcanic rocks in the Mogollon-Datil volcanic field (fig. 1). Here we report an isochron based on Rb and Sr isotope-dilution data from five xenoliths. Detailed petrographic descriptions of similar xenoliths are reported by Padovani (1977) and Padovani and Carter (1977a, b). A petrographic summary of the samples is given in table 1.

Singer and others (1985) have reported Rb and Sr isotope dilution data for two granulite xenoliths from Quaternary basalt vents along the western margin of Engle basin, New Mexico (fig. 1). These samples fall on the Kilbourne Hole granulite isochron, suggesting that the bulk chemistry and thermal history of the basement rock under these two Quaternary basalt fields is similar.

ANALYTICAL METHODS

Xenolith samples meeting whole-rock criteria (Brookins and Laughlin, 1983) were broken to gravel size, ultrasonically cleaned in a weak detergent solution and thoroughly rinsed with distilled water. The samples were crushed to −100 mesh utilizing initially a Plattner mortar and pestle and finally a tungsten-carbide capsule and ball in a Spex mixer-mill. Rock powders were tested for caliche contamination by adding a few drops of 6N HCl. If no effervescence occurred, contamination was assumed to be absent and the sample was deemed acceptable. Approximately 0.3 g from each sample was digested in an $HF\text{-}HClO_4$ acid solution, evaporated to dryness, redissolved in 2.25N HCl and filtered. The filtered aliquots were eluted through ion-exchange columns with 2.25N HCl, and the Rb- and Sr-bearing fractions were collected.

Rb fractions were analyzed using a partially automated Nuclide Corporation 90°-sector solid-source mass spectrometer. Sr analyses were obtained with a fully automated VG 354 90°-sector solid-source mass spectrometer. Both instruments are housed in the geochronology laboratory at the University of New Mexico Department of Geology. During the period of analyses, three runs each of Rb Shelf #5 in-house standard and Eimer and Amend $SrCO_3$ standard yielded an average $^{85}Rb/^{87}Rb$ ratio of 2.5945 ± .0046 and $^{87}Sr/^{86}Sr$ ratio of 0.708005 ± .000004 respectively.

Isochrons were calculated using the two-error regression algorithm of York (1969), as implemented by Ward (1986), which additionally accounts for possible correlation of errors between corresponding $^{87}Sr/^{86}Sr$ and $^{87}Rb/^{86}Sr$ values (cf. Brooks and others, 1972). Unless otherwise noted, all precisions in this paper are quoted at the 95% confidence level.

RESULTS

Figure 2 displays three isochrons of slightly different ages. Rb and Sr data for the isochrons are given in table 2. Isochron 1 gives an age of 2.04 ± .19 Ga, with a corresponding initial $^{87}Sr/^{86}Sr$ value of 0.70683 ± .00083. Even with its large error, this age is somewhat older than others reported from southern New Mexico.

A more critical examination of the data reveals an inconsistency in the sample set. Texture and mineralogy (table

TABLE 1. Petrographic descriptions of samples. Modal abundances were estimated visually.

Sample ID	Description
KH 08	Quartzofeldspathic gneiss, fine- to medium-grained, xenomorphic-granular; quartz (60%), microperthite (30%), sillimanite? (8%), opaques (3%), spinel (1%).
KH 09 & 10	Charnockite granulites, medium- to coarse-grained, hypidiomorphic-granular; plagioclase (45%), hypersthene (30%), opaques (15%), perthite (5%), glass? (5%).
KH 11	Quartzofeldspathic gneiss, fine- to medium-grained, xenomorphic-granular; quartz (55%), microperthite (20%), plagioclase (10%), sillimanite? (10%), opaques (4%), spinel (1%).
KH 12	Garnet granulite, medium- to very coarse-grained, hypidiomorphic-granular; orthoclase (50%), orthopyroxene (30% total, 10% as bladed-fan crystals rimming garnet), garnet (15%), opaques (3%), quartz (2%), sphene and clinopyroxene (trace).

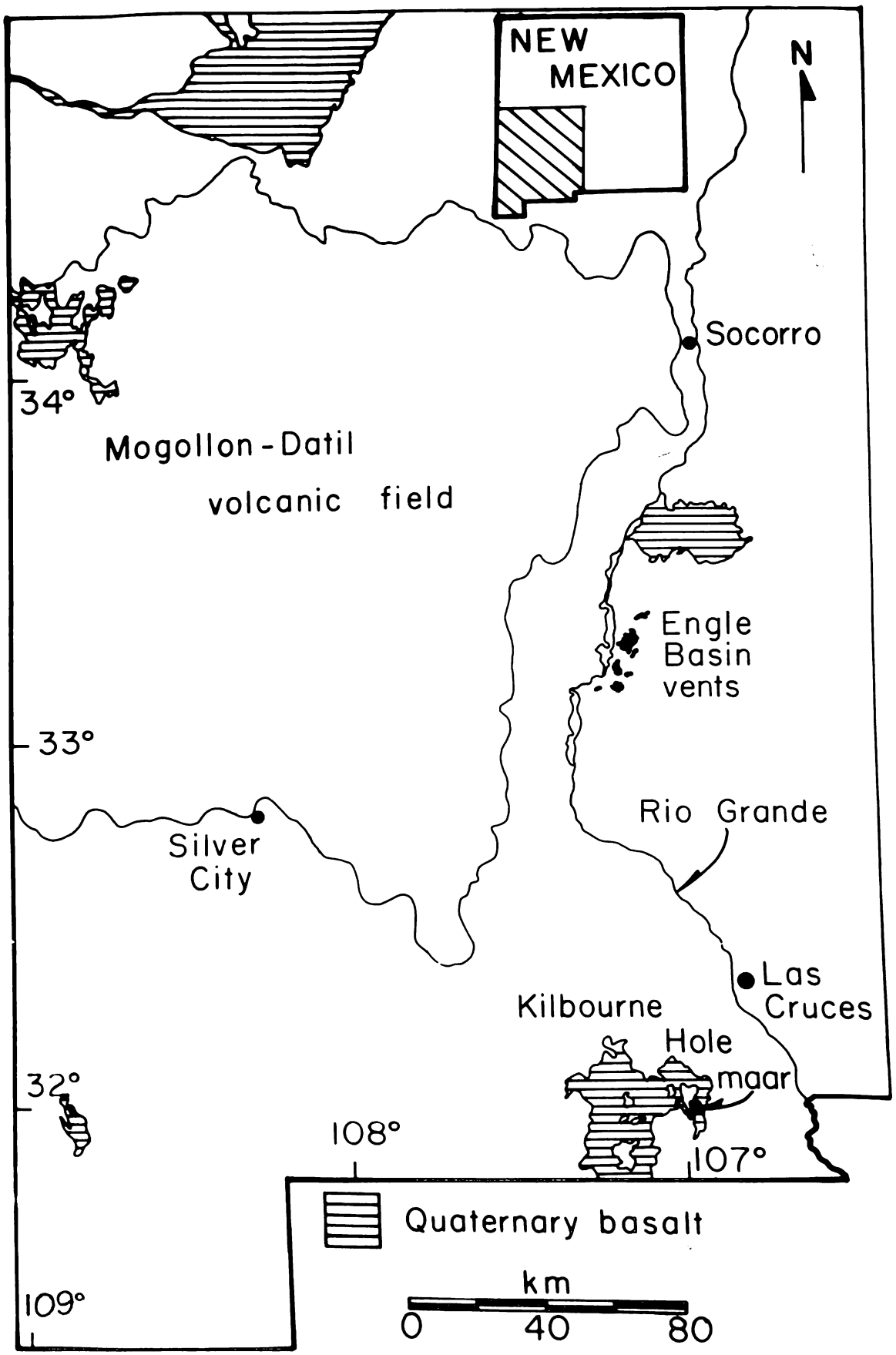

FIGURE 1. Index map showing the Tertiary Mogollon-Datil volcanic field and Quaternary basalt flows in southwestern New Mexico. Xenoliths discussed in this paper are from Kilbourne Hole maar and Engle basin vents.

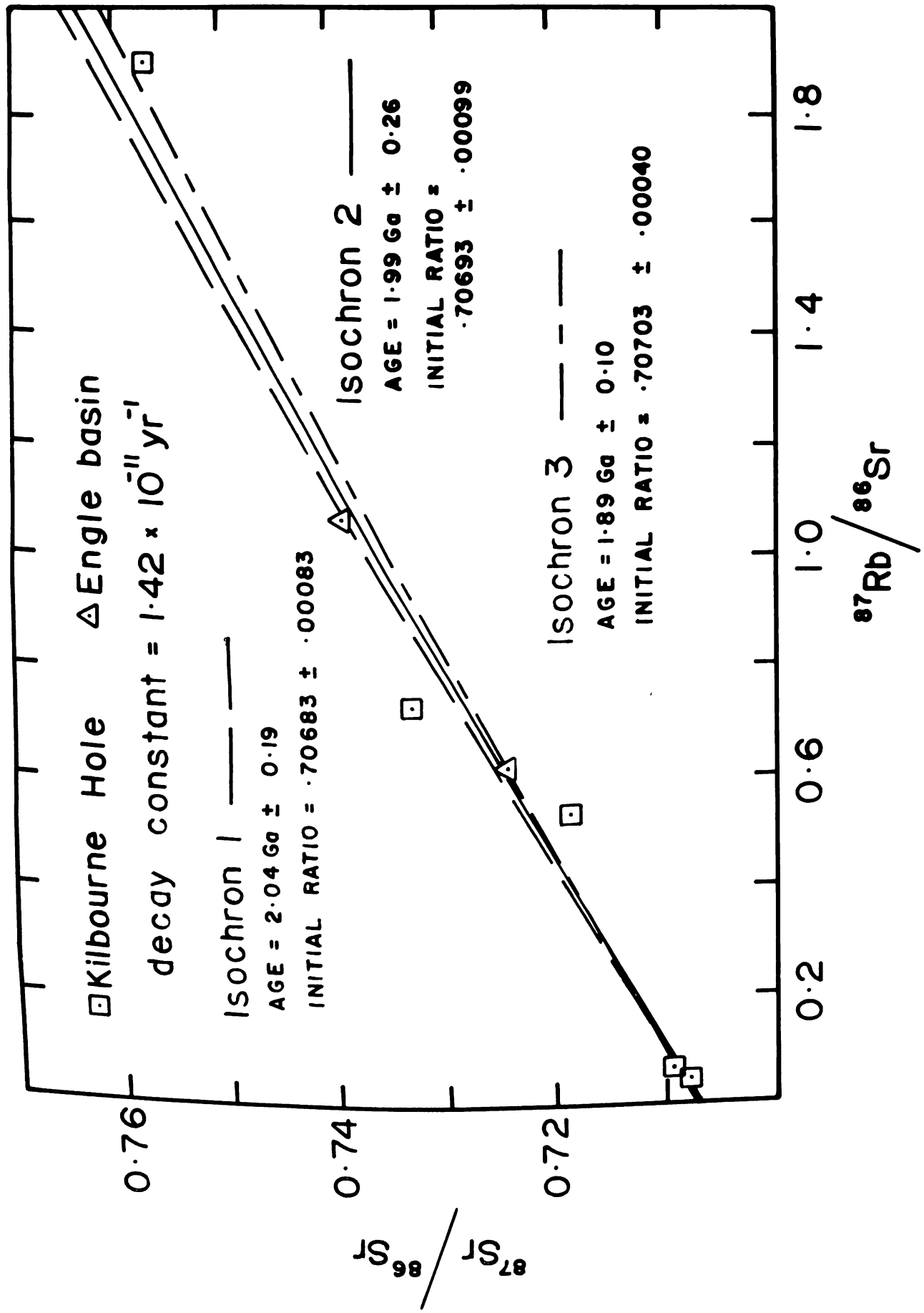

FIGURE 2. Isochrons on xenoliths from Kilbourne Hole and Engle basin. See text for discussion.

TABLE 2. Rb and Sr isotope-dilution data.

Sample ID	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
KH 08	46.85	183.64	0.740±.007	0.73270±.00002
KH 09	7.84	420.35	0.050±.001	0.70791±.00001
KH 10	8.10	336.35	0.070±.001	0.70940±.00001
KH 11	89.33	480.17	0.540±.005	0.71387±.00002
KH 12	113.86	174.15	1.900±.019	0.75710±.00001

1) show that samples KH 08 and 11 may be metasediments, unlike metaigneous xenoliths KH 09, 10 and 12. Normalized Ce/Yb ratios further support two subsets for the data. KH 08 and 11 have Ce/Yb values of 7.65 and >10.35, respectively, which compare favorably with average North America shale (cf. Haskin and others, 1966). Metaigneous samples KH 09, 10 and 12 have Ce/Yb values of 1.78, 3.16 and 2.74, respectively. Thus these subsets apparently represent different levels of the crust which may have experienced dissimilar thermal histories. The isochron obtained without the metasedimentary samples gives an age of 1.99 ± .26 Ga (isochron 2 in fig. 2), not significantly different than isochron 1, but with a larger error. This decrease in precision is attributable to the presence of KH 09 and 10 at the low end of the isochron. Although KH 09 and 10 are separate xenoliths, their similar Rb and Sr contents, textures and mineralogies (table 1) imply that they may be samples of the same lower crustal material. To eliminate bias due to proximal samples, data for KH 09 and 10 were averaged and the isochron was recalculated, producing an isochron of 1.89 ± .10 Ga (isochron 3 in fig. 2). Acknowledging the limitations of a 4-point isochron, we suggest that isochron 3 gives the most realistic age and error for the granulite xenoliths.

DISCUSSION

Early geochronologic work in southern New Mexico and neighboring parts of Arizona is summarized by Condie and Budding (1979). Most of this work concentrated on establishing ages for the many Proterozoic plutons in this region, and indicated that the earliest igneous events were intrusions of hypabyssal siliceous rocks in the Los Pinos and Manzano Mountains at 1.65 to 1.7 Ga. Thus the intruded country rock is probably older than 1.7 Ga.

Outcrops of Precambrian country rock are scarce in southern New Mexico and have not previously been the subject of Rb-Sr geochronologic studies. Two $^{207}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ studies have been done using an approach similar to the one presented here. Davis and Grew (1978) report an age of 1.38 Ga on zircons from a garnet granulite xenolith from Kilbourne Hole maar. U-Pb ages are extremely discordant, suggesting lead loss, and so the ^{207}Pb-^{206}Pb age of 1.38 Ga is a minimum value. In the second study, Kempton and others (1986) report an age of 1.57 Ga from the Geronimo Volcanic Field in southeast Arizona on xenoliths which may have been derived from metamorphosed quartz monzodiorite plutons.

Ages obtained in this study are conspicuously older than previously reported ages, suggesting that these samples may represent Proterozoic country rock rather than 1.4 to 1.6 Ga plutons or related igneous rocks. Our most selective isochron, which excluded two probable metasedimentary xenoliths and averaged two others, gave the youngest age at 1.89 Ga, whereas the isochron which included all samples gave the oldest age at 2.04 Ga. Thus it appears that at least some parts of the crust in southern New Mexico are older than 1.8 Ga and may be as old as 2.0 Ga.

Isochrons in this study indicate an initial $^{87}Sr/^{86}Sr$ ratio of 0.7070, which is somewhat higher than the value of 0.7048 observed in primary mantle differentiates of this age in northern New Mexico (cf. amphibolite isochrons in Ward, 1986). This relatively high initial ratio suggests that these xenoliths were either slightly contaminated with older crustal material or experienced a significant period of residence in the crust before equilibrating isotopically 1.9 Ga ago. The metasediment samples straddle the 1.9 Ga isochron, lending support to the contamination hypothesis and indicating that these samples must also have had an initial $^{87}Sr/^{86}Sr$ ratio near 0.7070. The metasediments probably inherited a higher initial ratio from their source terrane, but the combination of igneous activity and granulite-facies metamorphism may have isotopically equilibrated the entire package of country rocks. Alternatively, the metasediments may have been derived from a source terrane that itself had only recently differentiated from the mantle and thus were bequeathed a low initial ratio. This in turn would require an extended crustal residence period for the metaigneous and metasedimentary samples to acquire a high initial $^{87}Sr/^{86}Sr$ ratio.

CONCLUSIONS

Whole-rock isochrons for granulite xenoliths from Kilbourne Hole maar and basalt vents along the western margin of Engle basin suggest that the lower crust in south-central New Mexico may be as old as 1.9 Ga. Further analyses of the xenolith population is needed to substantiate our results. Additional granulite xenolith sites (e.g. Puerco necks in Mt. Taylor volcanic field) should be investigated to establish their relationship to the 1.9 Ga isochron, and outcrops of Proterozoic country rock suitable for geochronologic studies should also be sought. Such studies can enhance our understanding of basement compositions and tectonic and thermal histories.

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