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APPLICATION OF THE Rb-Sr DATING TECHNIQUE TO TERTIARY SILICEOUS IGNEOUS ROCKS, NORTHERN SIERRA MADRE OCCIDENTAL, CHIHAUHAU, MEXICO

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In highly evolved cogenetic siliceous calc-alkaline rock suites Rb/Sr ratios increase with degree of differentiation. Two such suites, San Buenaventura and El Divisadero, both located in the northern Sierra Madre Occidental (Chihuahua, Mexico) and named after nearby towns, have been analyzed for Rb and Sr concentration and $^{87}Sr/^{86}Sr$. Whole rock dacitic through rhyolitic samples as well as mineral separates were analyzed by thermal ionization mass spectrometry, and results are plotted on conventional Rb-Sr isochron diagrams. These samples yield an age of 33.2 Ma (±1.5 Ma) for the San Buenaventura suite with initial $^{87}Sr/^{86}Sr$ of 0.70658 ± 43 and 30.0 Ma for the El Divisadero suite with an initial ratio of 0.70532 ± 20 (all statistics are at the 95% confidence level). This study shows that the Rb-Sr dating technique can be successfully applied to Cenozoic rock if Rb/Sr ratios are sufficiently high.

The two locations studied are part of the vast outpouring of Tertiary siliceous rocks in the Sierra Madre Occidental of Mexico. The San Buenaventura suite covers an area of 70 km² and is characterized by dacitic to high-silica rhyolitic ignimbrites and dacitic/rhyolitic lava flows, and is associated with a large caldera complex and a resurgent granite. The El Divisadero suite, covering 40 km², is comprised of 1,400 m of dacitic lava flows and rhyolitic ignimbrites. Field and geochemical data suggest that rocks within each suite are genetically related (Albrecht and Brookins, in press) The sample locations are given in table 1. Most K-Ar age dates of Tertiary igneous rocks from the Sierra Madre are within 27 and 33 Ma (McDowell and others, 1978). Rocks from both suites are characterized as high K calc-alkaline rocks. The northern part of the Sierra Madre Occidental (including San Buenaventura) is more enriched in large ion lithophile elements (Albrecht and others, 1988) and has generally higher Rb/Sr ratios (table 1) relative to the southern part (including El Divisadero). Neither suite has been previously dated, so these Rb/Sr ages are critical, as they indicate that both suites belong to the 27 to 33 Ma time interval of major siliceous volcanism.

TABLE 1. Sample information.

Sample ID	Information	Longitude	Latitude
	San Buenaventura suite		
86/6-1	rhyo-dacitic ignimbrite	W107°20.81′	N29°53.84′
PM3e	rhyo-dacitic ignimbrite	W107°21.00′	N29°55.56′
86/6-4	rhyo-dacitic ignimbrite	W107°21.30′	N29°53.87′
86/6-52	dacitic lava flow	W107°22.29′	N29°56.62′
87/3-1	accumulative diorite	W107°22.67′	N29°56.81′
86/6-31	rhyolitic lava flow	W107°21.52′	N29°53.62′
86/8-5	rhyolitic lava flow	W107°24.37′	N29°55.62′
86/6-53b	high-Si rhyolitic ignimbrite	W107°22.29′	N29°53.00′
86/7-17	high-Si rhyolitic ignimbrite	W107°24.03′	N29°54.16′
	El Divisadero suite		
88/1-2	rhyo-dacitic lava flow	W107°48.15′	N27°28.35′
88/1-3	rhyo-dacitic lava flow	W107°48.17′	N27°28.95′
88/3-6	rhyo-dacitic lava flow	W107°48.17′	N27°28.95′
88/3-5	dacitic lava flow	W107°48.17′	N27°28.95′
88/3-4	rhyo-dacitic lava flow	W107°48.17′	N27°28.95′
88/3-3	rhyo-dacitic lava flow	W107°48.17′	N27°28.95′
88/3-2	rhyo-dacitic lava flow	W107°48.17′	N27°28.95′
88/3-1	rhyo-dacitic lava flow	W107°48.17′	N27°28.95′
88/1-7	dacitic ignimbrite	W107°48.62′	N27°29.73′
88/3-8	rhyo-dacitic ignimbrite	W107°49.61′	N27°30.46′
88/1-17a	rhyo-dacitic ignimbrite	W107°49.67′	N27°30.86′
88/1-17b	rhyo-dacitic ignimbrite	W107°49.67′	N27°30.87′
88/3-9	rhyolitic ignimbrite	W107°49.37′	N27°32.05′
88/3-10	rhyolitic ignimbrite	W107°49.38′	N27°32.06′
87/11-4	rhyolitic ignimbrite	W107°49.39′	N27°32.06′
87/11-8	rhyolitic ignimbrite	W107°47.40′	N27°37.59′
87/11-1	rhyolitic ignimbrite	W107°43.11′	N27°39.57′

Samples are in stratigraphic order; for further information on petrography and stratigraphy, see Albrecht and Brookins (in press).

ANALYTICAL PROCEDURES

Whole rock samples were crushed to −100 mesh. Mineral separates from 60 to 80 mesh fractions were prepared using heavy liquids. Separations were not strictly quantitative; the biotite fraction may contain traces of amphibole, whereas the feldspar fraction contains substantial quartz (which merely acts as a diluent, however, as quartz contains negligible Rb and Sr). Samples were spiked for Rb and Sr isotope dilution and digested using HT and $HClO_4$. Ion-exchange chromatography was used to separate the Rb and Sr fractions, which were loaded on Ta filaments. Rb and Sr concentrations and $^{87}Sr/^{86}Sr$ were determined on a VG 354 thermal ionization mass spectrometer. For some samples Sr was measured by XRF. Such data are only slightly less precise, and do not adversely affect the precision of the isochron regression. These least-squares regressions were computed using a program written by one of us (DBW) based on the algorithm of York (1967, 1969). Replicate data (13 degrees of freedom) indicate analytical precision of 0.05% (1 standard deviation) for $^{87}Sr/^{86}Sr$ and 0.85% for $^{86}Rb/^{87}Sr$ (1 s.d.).

RESULTS

Table 2 lists Sr and Rb concentrations, 1/Sr, Rb/Sr, ($^{87}Sr/^{86}Sr$) measured and

TABLE 2. Rb and Sr data.

Sample ID	Sr (ppm)	Rb (ppm)	Err (ppm)	1/Sr	Rb/Sr	$Sr^{87/86}$	Err (ppm)	$^{87}Rb/^{86}Sr$
San Buenaventura suite								
86/6-1	75.1	538.6	0.428	0.0133	7.17	0.716715	110.0	20.78
PM3e	85.8	604.1	1.077	0.0117	7.04	0.716422	90.0	20.39
86/6-4	265.5	187.8	0.123	0.0038	0.71	0.707938	40.0	2.05
86/6-52	253.0	207.0	0.460	0.0040	0.82	0.707511	7.0	2.37
87/3-1	689.8	96.7	0.330	0.0014	0.14	0.706243	4.4	0.41
86/6-31	23.4	192.0	XRF	0.0428	8.21	0.715863	4.4	23.78
86/8-5	170.6	126.0	0.140	0.0059	0.74	0.708178	8.2	2.14
86/6-53b	71.7	222.3	0.260	0.0139	3.10	0.710431	80.0	8.97
86/7-17	18.5	335.1	0.160	0.0542	18.16	0.731388	9.2	52.68
El Divisadero suite								
88/1-2	205.3	312.4	0.470	0.0049	1.52	0.706957	5.9	4.40
88/1-3	262.8	176.0	XRF	0.0038	0.67	0.705792	5.6	1.94
88/3-6	316.2	115.0	0.140	0.0032	0.36	0.705528	3.9	1.05
88/3-5	281.5	134.5	0.380	0.0036	0.48	0.705630	3.9	1.38
88/3-4	328.5	73.5	0.010	0.0030	0.22	0.705443	4.4	0.65
88/3-3	281.1	83.6	0.030	0.0036	0.30	0.705540	3.8	0.86
88/3-2	256.9	150.9	0.910	0.0039	0.59	0.705779	7.6	1.70
88/3-1	254.3	155.8	0.030	0.0039	0.61	0.706106	35.4	1.77
88/1-7	457.1	80.6	0.040	0.0022	0.18	0.705354	3.7	0.51
88/3-8	319.4	122.0	XRF	0.0031	0.38	0.705681	4.1	1.11
88/1-17a	337.3	111.0	XRF	0.0030	0.33	0.706071	4.2	0.95
88/1-17b	297.8	113.7	0.100	0.0034	0.38	0.706145	4.6	1.10
88/3-9	326.6	127.0	0.110	0.0031	0.39	0.706197	3.6	1.13
88/3-10	251.4	110.2	0.060	0.0040	0.44	0.706237	3.9	1.27
87/11-4	260.8	93.4	0.090	0.0038	0.36	0.706259	3.7	1.04
87/11-8	145.9	128.0	XRF	0.0069	0.88	0.706295	4.0	2.54
87/11-1	61.9	147.0	XRF	0.0161	2.37	0.708304	4.2	6.87

$^{87}Rb/^{86}Sr$ for all samples from the San Buenaventura and the El Divisadero localities. In addition some information for each rock sample is given. In table 3 data are given for mineral separates from different samples from the El Divisadero suite. Figures 1 and 2 show conventional Rb-Sr isochron plots for both suites. The spread of the data above the regression line is below the analytical error. This indicates that the regression lines represent true isochrons.

DISCUSSION

Petrological and geochemical information from both suites establish the cosanguinity of each suite and that all samples could be derived from a homogeneous magma by fractional crystallization (Albrecht and Brookins, in press). If the magmatic system was closed with respect to Rb and Sr during fractionation, the variously fractionated samples will form an isochron provided that they also have been closed to Rb and Sr subsequent to emplacement. The measured results are consistent with this hypothesis. To test the possibility that the isochrons reflect two component mixing, measured $^{87}Sr/^{86}Sr$ are plotted against 1/Sr for both suites (fig. 3). As the samples do not indicate a linear trend, two component mixing can be excluded. The 33.2 Ma age of the Buenaventura suite and the 30.0 Ma age of the El Divisadero suite fall within the interval of ages for siliceous rocks in the northern Sierra (McDowell and others, 1978).

We attribute the difference in initial $^{87}Sr/^{86}Sr$ between these rocks of otherwise similar petrology, age and tectonic setting, to be due to differences in age and composition of the basement beneath each locality. San Buenaventura is located above Precambrian cratonic basement, whereas El Divisadero lies above a younger poorly known accreted terrane (Albrecht and Brookins, in press).

CONCLUSIONS

This work shows that Rb-Sr isotope work on Tertiary igneous rocks can yield meaningful age data and initial $^{87}Sr/^{86}Sr$ as well as additional information regarding the cosanguinity of samples. A large spread in Rb/Sr ratios is necessary to overcome errors inherent in the analytical procedures. In high-silica Rb-rich suites this can be achieved solely by measuring whole rock samples. If the $^{87}Rb/^{86}Sr$ spread does not exceed 5 it is necessary to measure mineral separates with higher Rb/Sr ratios.

TABLE 3. Rb and Sr data for mineral separates from El Divisadero.

Sample ID	Information	Sr (ppm)	Rb (ppm)	Err (ppm)	1/Sr	Rb/Sr	$Sr^{87/86}$	Err (ppm)	$^{87}Rb/^{86}Sr$
88/1-5	feldspar plus quartz	293.3	107.0	0.040	0.0034	0.36	0.705731	88.6	1.06
88/1-7	feldspar plus quartz	385.4	112.3	0.040	0.0026	0.29	0.705454	4.4	0.84
88/3-10	feldspar plus quartz	306.0	49.8	0.040	0.0033	0.16	0.705716	4.4	0.47
88/3-10	biotite plus minor amphibole	47.2	303.0	0.020	0.0212	6.41	0.713287	4.4	18.57

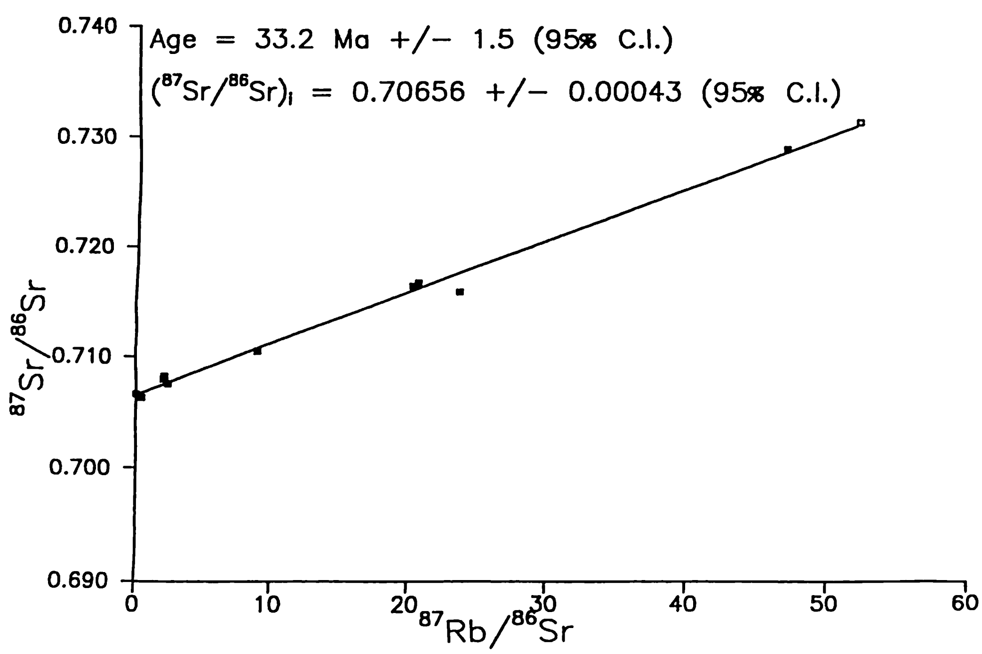

FIGURE 1. Conventional Rb-Sr isochron plot for different rock samples from the San Buenaventura area.

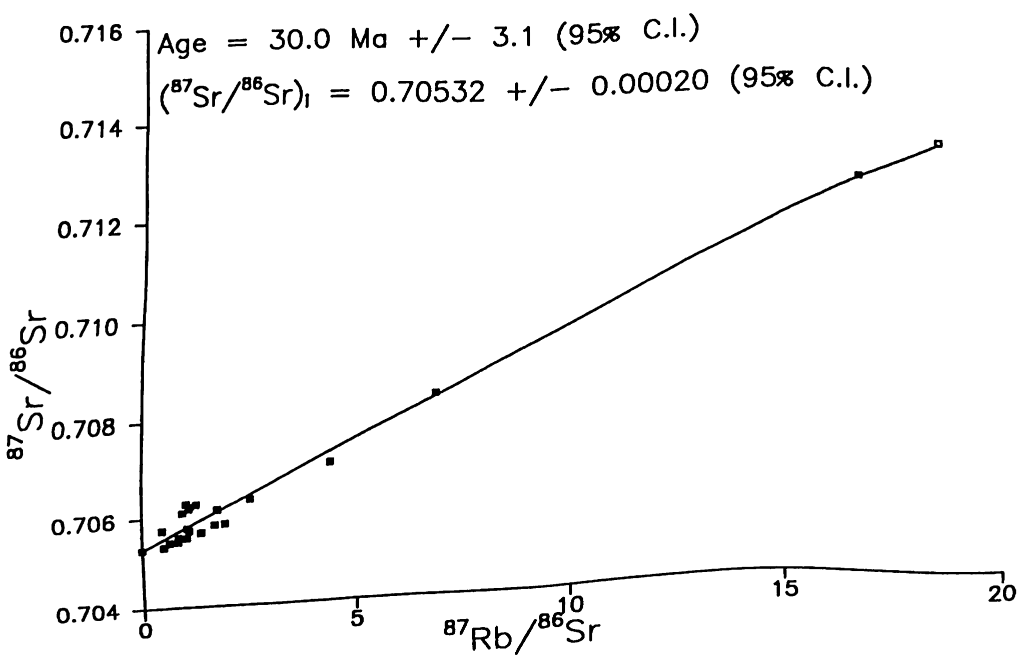

FIGURE 2. Conventional Rb-Sr isochron plot for different rock samples and mineral separates from the El Divisadero area.

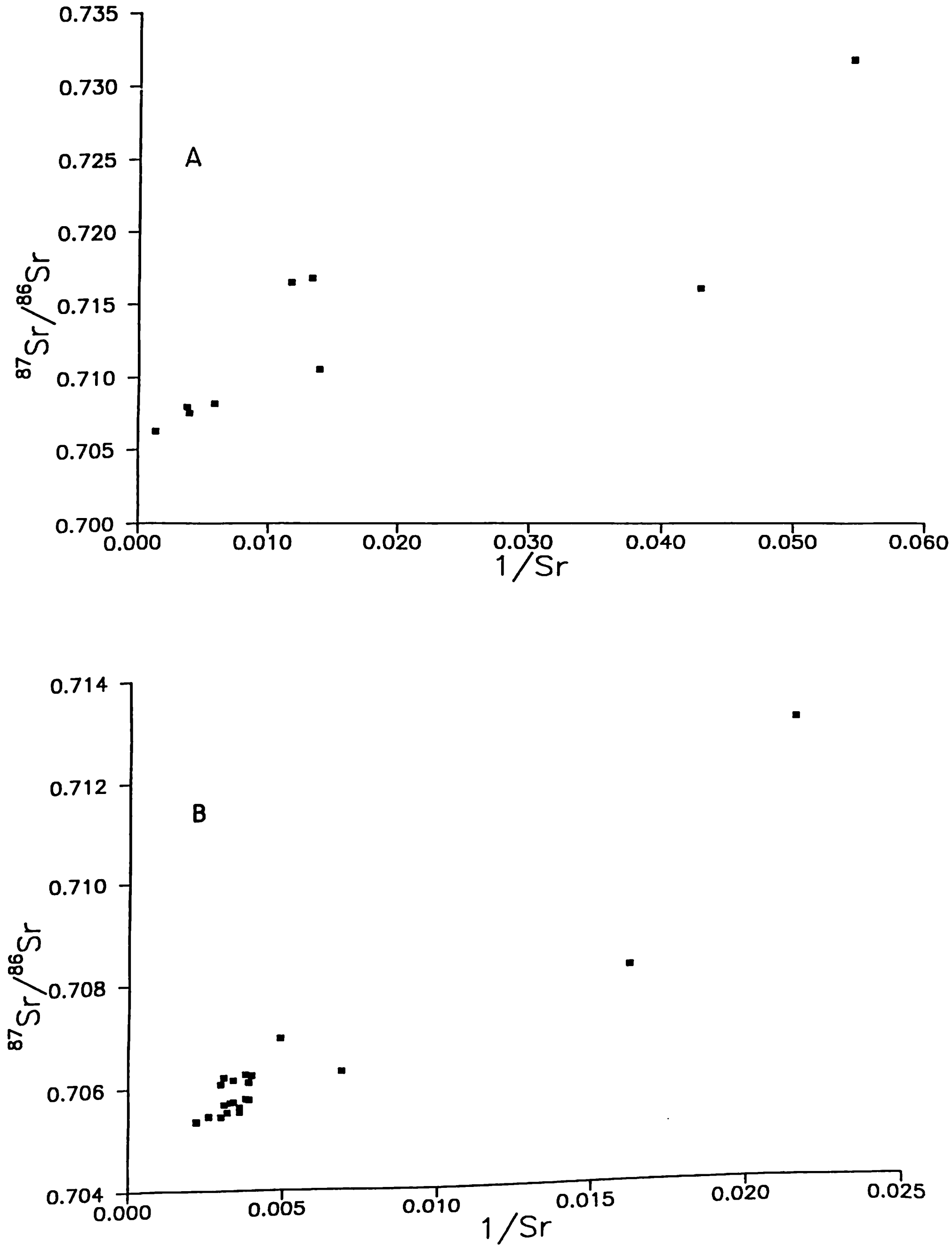

FIGURE 3. Two component mixing test for the San Buenaventura (A) and the El Divisadero suite (B).

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