Variations in Isotopic Abundances of Strontium

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Isotopic abundances of mineral sources of Sr have been measured. Variations in the ratio Sr^{86}/Sr^{88} of unknown origin have been found from 0.1160 to 0.1220. In Rb free minerals, the variation of the ratio Sr^{87}/Sr^{88} (0.0832 to 0.0868) is small enough to be completely attributable to the decay of Rb^{87} in geologic time. The large Sr^{87}/Sr^{88} variation in Rb minerals (biotite) from 0.0840 to 0.2629 indicates their suitability for use in the determination of mineral age.

SR isotope abundances have been determined in the minerals biotite and feldspar extracted from crystalline rocks of varying age and from celestites of sedimentary origin. The determination of the relative Rb-Sr content of biotite[1] showed the possibility of using this mineral in age determination work. The feldspar and celestite analyses were made to determine variations in Sr^{87} content of Sr in Rb-free minerals. The mineral fractions were separated and treated chemically at the Massachusetts Institute of Technology; Sr separation from Ca-Sr concentrates and mass spectrometric analysis were done at the Department of Terrestrial Magnetism.

The mass spectrometer used was adapted from that described by Nier.[2] Ion current ratios were measured by the null method from which the ratios 87/88, 86/88, and 88/(87+86+84) could be determined. From these the atom-percent of each isotope could be calculated. The ions were formed by thermal evaporation of 20–100 μg of $SrCl_2$ or $SrSO_4$ from a nickel-plated tungsten filament. The only residual peaks present during runs were those due to Rb. The Rb^{85} peak height for the work reported here was always less than 0.05 that due to Sr^{86}, so that the small correction to the mass 87 ion current owing to Rb^{87} could be made. For example, the error in the ratio, Sr^{87}/Sr^{86} attributable to Rb could be made less than 0.5 percent under these conditions if the ratio Rb^{85}/Sr^{86} is known within 15 percent. The smaller the latter ratio, the less accurately it need be measured to correct the Sr isotope ratios.

Peaks were also found on occasion at masses 83, 87, and 89 at temperatures below which Sr^+ ions were emitted. These were not present during runs on Sr from which these data are taken.

TABLE I. Relative abundance of isotopes of commercial strontium.

	88	87	86	84
Abundance this work	100	8.50±0.04	11.95±0.03	0.67±0.05
Nier	100	8.50	11.94	0.68

Table I shows the results of 6 separate analyses of Sr obtained as $SrCO_3$ from Eimer and Amend. They are compared with the results of Nier[3] obtained by electron bombardment of Sr metal. The agreement is remarkable. The error shown is the mean deviation of 6 determinations and is less than the error of each determination, which is of the order of 0.5 percent. Repeat measurements on minerals where sufficient material was available were consistent to the same precision as shown for commercial Sr.

Figure 1 is a histogram showing the variation in the ratio Sr^{87}/Sr^{88} in the minerals celestite and feldspar which, in general, have large ratios of Sr to Rb. The two lowest values for the ratio Sr^{87}/Sr^{88} are for feldspars whose ages are thought to be greater than 1.5×10^9 years and, therefore, should be representative of the change in this ratio for these rocks in over half the earth's history. Figure 2 is a histogram showing the variation in the ratio Sr^{86}/Sr^{88} for all the minerals tested. The variation in this ratio cannot at present be correlated with the age of the mineral or with any other known parameter. In both figures the interval chosen is the error in isotope determination.

Figure 3 is a histogram showing the number of

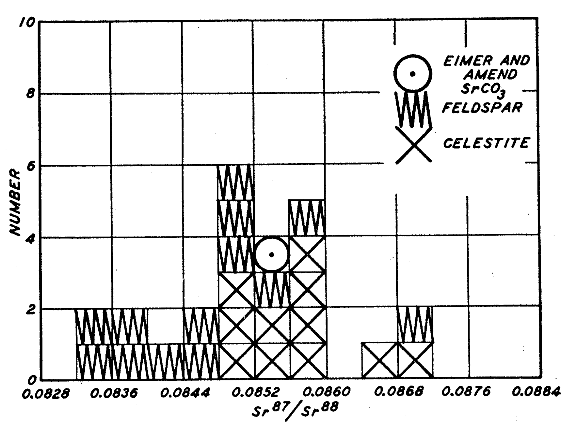

FIG. 1. The ratio Sr^{87}/Sr^{88} in celestite and feldspar mineral samples.

[1] L. H. Ahrens and F. B. Whiting, Bull. Geol. Soc. Am. 61, 1439 (1950).
[2] A. O. Nier, Rev. Sci. Instr. 18, 398 (1947).
[3] A. O. Nier, Phys. Rev. 54, 275 (1938).

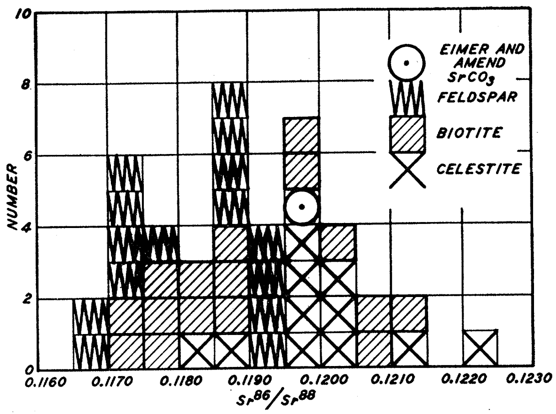

FIG. 2. The ratio Sr^{86}/Sr^{88} in celestite, feldspar, and biotite mineral samples.

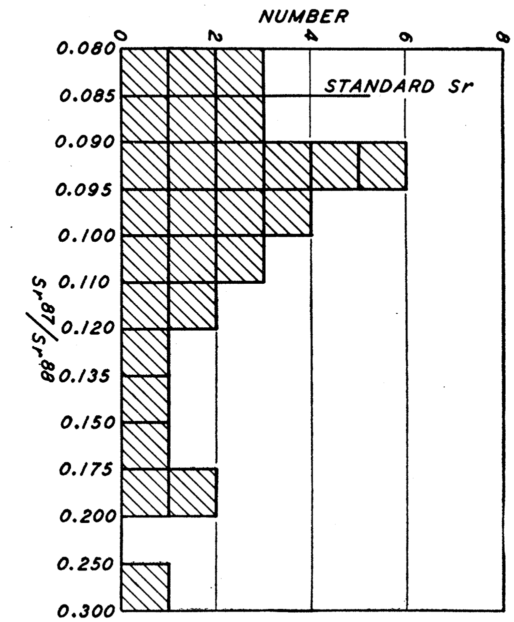

FIG. 3. The ratio Sr^{87}/Sr^{88} in biotite, a Rb-rich mineral. Note nonlinear scale.

biotites with a given Sr^{87}/Sr^{88} ratio. The scale of the abscissa is compressed. The variation in this ratio for biotites is seen to be many times that found in Rb-low minerals. Biotites appear to fulfill the promise predicted for them as suitable for use in the measurement of mineral age.

Two obvious conclusions may be made from these results. First, any age method requiring a measurement of small amounts of radiogenic Sr^{87} in the presence of preponderant amounts of common Sr will be subject to considerable error because of variations of undetermined origin in the relative abundances of the Sr isotopes. Secondly, for Rb rich minerals such as biotites, the Sr^{87} of radiogenic origin is sufficient to make these uncertainties unimportant for age determinations.