

Argon 40 in Potassium Minerals

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An investigation has been made of the isotopic composition of the argon from four potassium minerals. In each case a high A^{40}/A^{36} ratio compared to that of atmospheric argon is observed showing directly that K^{40} decays to both Ca^{40} and A^{40} . From the absolute amounts of radiogenic A^{40} and K^{40} in the minerals a lower limit on the branching ratio λ_K/λ_β can be made. If the half-life, 7×10^8 yrs., is assumed for $K^{40} \rightarrow Ca^{40}$, λ_K/λ_β must be at least 0.02. The possibility of using this method for measuring geological age is suggested.

IT was suggested by von Weizsäcker¹ in 1937 that the abnormally high abundance of A^{40} in argon might be explained by assuming that K^{40} not only decays to Ca^{40} through β -emission but also to A^{40} through K -capture. Indirect evidence to support this view has been obtained by a number of investigators.²⁻⁶ Bleuler and Gabriel⁷ studied the X -radiation emitted during the decay process of potassium and concluded that there are 1.9 times as many K -captures occurring as there are β -rays emitted. Suess⁸ was unsuccessful in his search for argon in sylvine and carnallite

minerals and concluded from this investigation together with general geological considerations that the branching ratio, λ_K/λ_β , was 0.05 ± 0.02 .

An investigation of the gas evolved from four potassium minerals has been made with a high sensitivity mass spectrometer. In all cases small amounts of argon were discovered and in each case the A^{40}/A^{36} ratio was appreciably greater than that observed for atmospheric argon. Figure 1 shows a comparison between the spectra observed for atmospheric argon and for the argon found in one of the minerals.

The procedure employed in extracting the argon from the minerals was as follows: A weighed amount of the mineral was introduced into a high temperature vacuum furnace which was heated to a temperature above $1000^\circ C$. The condensable vapors were removed by a liquid oxygen trap. If the amount of gas remaining after this treatment was less than 20 std. cc, an investigation of the A^{40}/A^{36} ratio was made directly without further purification. The extremely high sensitivity of the spectrometer permitted one to do this. For samples larger than 20 std. cc the argon concentration was too low to permit accurate isotope analysis and the gas was further purified with hot lithium metal. The principal impurity which diluted the argon was nitrogen. That the lithium treatment had no effect on the A^{40}/A^{36} ratio was shown in a test in which this ratio was determined in a sample of air before and after purification.

Table I contains pertinent data for the minerals investigated. From the data in column 6 together with the ages of the minerals and the decay constant for $K^{40} \rightarrow Ca^{40}$ one may compute the branching ratio. The results of such calcula-

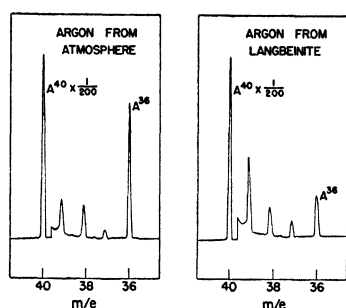


FIG. 1. Mass spectra for atmospheric argon and for argon from mineral Langbeinite. Note that this mineral has an A^{40}/A^{36} ratio greater than three times that for atmospheric argon. Peaks at 37 and 39 and part of 38 are due to residual impurities in spectrometer. There were no detectable residual impurity peaks at either mass 36 or 40.

¹ C. v. Weizsäcker, *Physik. Zeits.* **38**, 623 (1937).

² F. C. Thompson and S. Rowlands, *Nature* **152**, 103 (1943).

³ L. H. Gray and G. T. P. Tarrant, *Proc. Roy. Soc.* **A143**, 681 (1934).

⁴ O. Hirzel and H. Wäffler, *Helv. Phys. Acta* **19**, 216 (1946).

⁵ E. Gleditsch and T. Graf, *Phys. Rev.* **72**, 640 (1947).

⁶ H. A. Meyer, G. Schwachheim, and M. D. deSousa Santos, *Phys. Rev.* **71**, 908 (1947).

⁷ E. Bleuler and M. Gabriel, *Helv. Phys. Acta* **20**, 67 (1947).

⁸ H. E. Suess, *Phys. Rev.* **73**, 1209 (1948).

TABLE I. Data for several potassium minerals.

Mineral	Total wt. grams	Potassium* grams	Argon std. cc	Radiogenic A ⁴⁰ std. cc†	g radio. A ⁴⁰ ‡ g K-40	Age of mineral ×10 ⁻³ yr.	Branching ratios for three half-lives		
							4 ×10 ⁸ yr.	7 ×10 ⁸	14 ×10 ⁸
Orthoclase	450	62	0.31	0.25	7.0 ×10 ⁻²	14	0.007	0.02	0.07
Microcline	450	72	0.10	0.035	0.8 ×10 ⁻²	3.5	0.010	0.02	0.04
Sylvite	250	135	0.08	0.011	0.13 ×10 ⁻²	2.0	0.003	0.006	0.013
Langbeinite	400	80	0.065	0.045	0.9 ×10 ⁻²	2.0	0.02	0.04	0.09

* This column was estimated from the accepted composition of the mineral. Slight impurities would lower this number.

† This column computed from the measured A⁴⁰/A³⁶ ratio for the mineral and that for air. It was assumed that the non-radiogenic argon had the composition of present-day atmospheric argon.

‡ There is good reason to feel that the errors in analysis together with the assumptions made in computation should not affect this ratio by more than 25 percent.

tions are shown for three different assumed decay constants.

Since an exact determination of the potassium content of the mineral was not made, the amount of potassium present is at most that given. Moreover, since it is assumed that the non-radiogenic argon had the composition of present-day atmospheric argon and that no leakage of radiogenic argon occurred during the life of the mineral, the ratio given in column 6, if in error, is too small and would therefore give a minimum value for the branching ratio. Since the branching ratio computed here depends upon the assumed value for the half-life of K⁴⁰→Ca⁴⁰, no definite value can be decided upon until this constant is better established. All three values used here have appeared in the literature.

It is seen from columns 8-10 of the table that there is reasonable agreement among the values of the branching ratio obtained except in the case of sylvite. The low value for the branching ratio for sylvite could be attributed to the leakage of argon from the mineral. The fair agreement obtained for the branching ratio from the other three minerals indicates that with improved

techniques in carrying out experimental work of this type, together with a careful redetermination of the half-life of K⁴⁰, the K⁴⁰→A⁴⁰ decay might become extremely useful in the measurement of geological time.

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