Earth and Planetary Science Letters, 36 (1977) 359–362

SUBCOMMISSION ON GEOCHRONOLOGY: CONVENTION ON THE USE OF DECAY CONSTANTS IN GEO- AND COSMOCHRONOLOGY

compiled by

R.H. STEIGER AND E. JÄGER

Revised version received June 29, 1977

On August 24, 1976 the IUGS Subcommission on Geochronology met in Sydney, Australia, during the 25th International Geological Congress. It was unanimously agreed to recommend the adoption of a standard set of decay constants and isotopic abundances in isotope geology. The values have been selected, based on current information and usage, to provide for uniform international use in published communications. The Subcommission urges that all isotopic data be reported using the recommended values which are listed below:

Uranium

$\lambda(^{238}U) = 1.55125 \times 10^{-10}/yr$	[1]	atomic ratio $^{238}U/^{235}U = 137\,88$	[2]
$\lambda(^{235}U) = 9.8485 \times 10^{-10}/yr$	[1]		

Thorium

$\lambda(^{232}Th) = 4\,9475 \times 10^{-11}/yr$	[3]

Rubidium

$\lambda(^{87}Rb) = 1.42 \times 10^{-11}/yr$	[4–7]	atomic ratio $^{85}Rb/^{87}Rb = 2.59265$	[8]

Strontium

atomic ratios	$^{86}Sr/^{88}Sr = 0.1194$	[9]
	$^{84}Sr/^{86}Sr = 0.056584$	[10]

Potassium

$\lambda(^{40}K_{\beta-}) = 4.962 \times 10^{-10}/yr$	[11,12]	isotopic abundances	$^{39}K = 93\,2581$ atom%	[12]
$\lambda(^{40}K_e) + \lambda'(^{40}K_e) = 0.581 \times 10^{-10}/yr$	[11,12]		$^{40}K = 0\,01167$ atom%	[12]
			$^{41}K = 6\,7302$ atom%	[12]

Argon

atomic ratio $^{40}Ar/^{36}Ar$ atmospheric = 295.5	[13]

The recommendation represents a *convention* for the sole purpose of achieving interlaboratory standardization. The Subcommission does not intend to endorse specific methods of investigation or to specifically select the works of individual authors, institutions, or publications. All selected values are open to and should be the subjects of continuing critical scrutinizing and laboratory investigation. The recommendations will be reviewed by the Subcommission from time to time so as to bring the adopted conventional values in line with significant new research data.

Comment

At the 1972 International Geological Congress in Montreal, Canada, the Subcommission on Geochronology decided to work towards the acceptance of standard decay constants. To achieve this aim the Subcommission organized the following activities.

(A) The Paris 1974 symposium on the status of the decay constants and a concomitant inquiry. The mimeographed report on this meeting [14] was sent to all laboratories together with the 1975 questionnaire.

(B) The 1975 inquiry by questionnaire addressed to all known geochronology laboratories. The results were presented at the 1976 International Geological Congress and summarized as follows:

(1) The 1975 survey reflects the opinion of a large majority of the active geo- and cosmochronologists.

(2) The Subcommission on Geochronology has been entrusted to deal with the decay constants problem.

(3) The Subcommission is urged to adopt and recommend a standard set of decay constants before the close of 1976.

(4) Conditions to assure a wide acceptance of such a recommendation

(a) The U decay constants by Jaffey et al. [1] must be the basis for any standard set of decay constants.

(b) The new value for the ^{87}Rb decay constant should lie within 1.41 and 1.43 $\times 10^{-11}$/yr, but there is some reluctance to change to such a new value before critical experiments now under way are completed.

(c) The decay constants for ^{40}K should be discussed and the values by Beckinsale and Gale [11] taken into consideration.

(C) A session on "The Physical Time Scale and Related Problems" at the Symposium on an International Geochronologic Scale, 25th International Geological Congress. In the course of this session all scientists interested were invited by the Subcommission to attend a working session devoted entirely to the discussion and evaluation of the decay constants. This meeting was held on August 20, 1976, with 23 geochronologists participating [17].

The large majority of the attending scientists supported the idea of proposing a standard set of decay constants It was suggested that such a standard set were to be issued in the form of recommendation and that the numbers should be presented as given in the original publication, not rounded off.

Based on the results of the inquiry it was moved that the U decay constants by Jaffey et al. [1] be the mainstay for a standard set This was accepted together with the ^{238}U/^{235}U ratio of 137.88 [2] used by the majority of workers. Later it was suggested that the Th decay constant be included in a recommendation The value by Le Roux and Glendenin [3], now adopted by most laboratories, was approved without further discussion.

The inquiry had revealed that a two-third majority of the laboratories were using the 1.39 $\times 10^{-11}$/yr ^{87}Rb decay constant [16], which is founded on the U decay constants by Fleming et al. [15] While most participants of the working session agreed that a change in the ^{87}Rb decay constant was mandatory because of the new U values, there was disagreement as to how far the adjustment should go. Mere adaption to the new U constants requiring a change to about 1.41 $\times 10^{-11}$/yr was supported by some. Others argued that a value obtained by independent physical measurement such as the counting experiment by Neumann and Huster [4] and the new value by the University of Alberta group, Edmonton [6], should be preferred The Edmonton result of 1.417 $\pm$ 0 011 (95% C L.) $\times 10^{-11}$/yr obtained by measurement of ^{87}Sr accumulated in Sr-free Rubidium salt had been timely announced at the symposium, just two days earlier. Further arguments for a ^{87}Rb decay constant of 1.42 $\times 10^{-11}$/yr included the results of intercomparison of coexisting minerals in terrestrial rocks (Afanass'yev et al [5]), and the comparison of Rb-Sr and U-Pb ages in meteorites (Wetherill [18]). An interesting new comparison of K-Ar and Rb-Sr ages in rapidly cooled igneous rocks was presented at the meeting by Tetley et al. [7]. Their ^{87}Rb constant estimated on the basis of the Beckinsale and Gale [11] decay constants for ^{40}K gave 1 42 $\pm$ 0.01 $\times 10^{-11}$/yr.

It was then moved that in view of the uncertainties still involved a value for the ^{87}Rb decay constant be accepted by convention and recommended for pro-

visional use. Although the need for more good experiments was recognized some participants were concerned as to whether a provisional recommendation would have much impact. While the participants subsequently acceded to the idea of a convention recommending a value of 1.42×10^{-11}/yr, it was agreed that the problem of the ^{87}Rb decay constant was not definitely solved Further efforts to obtain high-quality determinations were generally advocated

A proposal recommending the use of the ^{87}Rb isotopic abundance ($^{85}Rb/^{87}Rb = 2\ 59265$) [8] and the Sr isotopic abundance ($^{84}Sr/^{86}Sr = 0.05655$ or an updated value) [10] as measured at the U S. National Bureau of Standards was accepted. On the other hand it was agreed that the $^{86}Sr/^{88}Sr$ ratio of 0.1194 [9], universally applied for the normalization of Sr isotopic data, should be further used by convention, regardless of a possible minor change suggested by measurements currently under way at the National Bureau of Standards.

The paper read by Tetley et al [7] had quite an impact on the discussion regarding the ^{40}K constant It was argued that the Beckinsale and Gale [11] values for the ^{40}K decay were based on a number of newer and independent counting experiments, which yielded fairly consistent results. The audience was informed about some criticism of the Beckinsale and Gale [11] paper, which had been raised in response to the questionnaire. The objections were directed at the methods used to derive the new ^{40}K decay constants not at the values themselves. A convention combining the Beckinsale and Gale [11] values with the new K abundances ($^{40}K = 0\ 01167$ atom%) determined by Garner et al. [12] was proposed and agreed on.

The Subcommission on Geochronology is a body of the Commission on Stratigraphy of the International Union of Geological Sciences (IUGS). The officers of the Subcommission for the 1972–1976 term responsible for the convention on the decay constants are·

Chair * E. Jager, Switzerland.
Secretary * R.H. Steiger, Switzerland.
Members G.D Afanass'yev †/* A I. Tugarinov, U.S.S.R., * U.G. Cordani, Brazil, * R.E. Folinsbee, Canada, J.R. Lancelot, France, * I McDougall, Australia; L.O. Nicolaysen, South Africa, * K. Shibata, Japan, * L.T. Silver, U.S.A., N.J. Snelling, U K.

* Officers present at the August 24, 1976 meeting in Sydney, Australia

References

1 A H Jaffey, K F Flynn, L F Glendenin, W C Bentley and A M Essling, Precision measurements of half-lives and specific activities of ^{235}U and ^{238}U, Phys Rev. C. 4 (1971) 1889–1906

2 W R Shields, Comparison of Belgian Congo and Synthetic "Normal" Samples Table 6 in Appendix A, Report No. 8, U S National Bureau of Standards Meeting of the Advisory Committee for Standard Materials and Methods of Measurement, May 17 and 18 (1960) 37 pp (unpublished)
G A Cowan and H H Adler, The variability of the natural abundance of ^{235}U, Geochim. Cosmochim. Acta 40 (1976) 1487–1490.

3 L J Le Roux and L E Glendenin, Half-life of ^{232}Th, Proc Natl Meet. on Nuclear Energy, Pretoria, South Africa, April (1963) 83–94

4 W Neumann and E Huster, The half-life of ^{87}Rb measured as difference between the isotopes ^{87}Rb and ^{85}Rb, Z Physik 270 (1974) 121–127
W Neumann and E Huster, Discussion of the ^{87}Rb half-live determined by absolute counting, Earth Planet Sci. Lett. 33 (1976) 277–288

5 G D Afanass'yev, S I Zykov and I M Gorokhov, Correlativity of geochronometric ages yielded by coexisting (cogenetic) minerals with diffferent ^{40}K, ^{87}Rb and some other radioactive elements decay constants, Manuscript (1974) 19 pp (unpublished)

6 D W Davis, J Gray, G L Cumming and H Baadsgaard, Determination of the ^{87}Rb decay constant, Geochim Cosmochim Acta (in press).

7 N W Tetley, I S Williams, I McDougall and W Compston, A comparison of K-Ar and Rb-Sr Ages in rapidly cooled igneous rocks, Preprint (1976) 3 pp

8 E J Catanzaro, T J Murphy, E L Garner and W R Shields, Absolute isotopic abundance ratio and atomic weight of terrestrial rubidium, J Res U S Natl Bur. Stand , Sect. A, 73A (1969) 511–516.

9 A O. Nier, Isotopic constitution of Sr, Ba, Bi, Tl, and Hg, Phys Rev 54 (1938) 275–278

10 L J Moore, I L Barnes and T J Murphy, The absolute abundance ratios and the atomic weight of a reference sample of strontium J. Res U.S Natl. Bur Stand , Sect A (1977) in press.

Note

The new values measured at the U S. National Bureau of Standards are 0.119353 ± 3 for $^{86}Sr/^{88}Sr$ and 0 056562 for $^{84}Sr/^{86}Sr$ (personal communication by I L Barnes,

1977) To obtain a $^{84}Sr/^{86}Sr$ ratio compatible with the conventionally used $^{86}Sr/^{88}Sr$ ratio of 0.1194, the absolute $^{84}Sr/^{86}Sr$ ratio of 0 056562 was normalized to a value of 0 056584 using a factor of 0 1194/0 119353

11 R D Beckinsale and N H Gale, A reappraisal of the decay constants and branching ratio of ^{40}K, Earth Planet Sci Lett 6 (1969) 289–294.

12 E L Garner, T J Murphy, J W Gramlich, P J Paulsen and I L Barnes, Absolute isotopic abundance ratios and the atomic weight of a reference sample of potassium. J Res. U.S Natl. Bur. Stand., Sect. A, 79A (1976) 713–725.

13 A O. Nier, A redetermination of the relative abundances of carbon, nitrogen, oxygen, argon, and potassium, Phys. Rev 77 (1950) 789–793.

14 I McDougall, R H Steiger, and E. Jager, Report on the Activities of the IUGS Subcommission on Geochronology at the "International Meeting for Geochronology, Cosmochronology and Isotope Geology", organized by Prof C J Allègre, Paris, August 26–31 (1974) 5 pp (unpublished)

15 E H Fleming, Jr., A Ghiorso and B B Cunningham, The specific alpha-activities and half-lives of ^{234}U, ^{235}U, and ^{238}U, Phys Rev 88 (1952) 642–652.

16 G W Wetherill, Radioactive decay constants and energies, in Handbook of Physical Constants, S Clark, ed , Geol Soc. Am. Mem. 97 (1966) 513–519.

17 Participants at working session of August 20, 1976, 25th International Geological Congress, Sydney, Australia *Australia* W. Compston, J A Cooper, C.M Gray, I McDougall, D A Nieuwland, R Pidgeon, J. Richards, G Riley, N Tetley, J S Williams, *Brazil* U Cordani, *Canada* R L Armstrong, R E. Folinsbee, *France* G S. Odin, M Roques, M Vachette, *Japan* K Shibata, *Switzerland* E Jager, R.H Steiger, *USA* P Damon, M Lanphere, M Shafiqullah, L.T. Silver.

18 G W Wetherill, Radiometric chronology of the early solar system, Annu Rev Nucl Sci 25 (1975) 283–328

Note added in proof

The value of 295 5 for atmospheric $^{40}Ar/^{36}Ar$ adopted in this convention is derived from Nier's widely used but rounded percentage abundances given on p. 792 [13] ^{40}Ar = 99 600, ^{38}Ar = 0 063, ^{36}Ar = 0.337 atom% However, in Table III of the same paper a measured value of 0.003378 ± 0.000006 is listed for the $^{36}Ar/^{40}Ar$ ratio of atmospheric argon which actually corresponds to a value of 296 $0^{+0\,6}_{-0\,5}$ for the $^{40}Ar/^{36}Ar$ ratio