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Autor: Afanass'yev, G.D. / Brandt, S.B. / Bagdassaryan, G.P.
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Summarized Analyses of Standards

by G. D. AFANASS'YEV, S. B. BRANDT, G. P. BAGDASSARYAN, I. M. GOROKHOV, V. A. DUNAYEV, S. I. ZYKOV and M. M. RUBINSTEIN

ABSTRACT

1. Standards analysis was carried out in different laboratories of the Soviet Union on following rocks:
   a) Precambrian Karelian pegmatites; methods used: U/Pb, Rb/Sr and K/Ar.
   b) Biotites from the Upper Paleozoic granites, Kazakhstan; methods used: Rb/Sr and K/Ar.
   c) A young muscovite supplied by E. JÄGER; method used: K/Ar.
2. Consistent age values obtained at various times by different methods in different laboratories suggest an age of the Black Salma, Karelia, pegmatites of 1790 ± 10 m.y.
3. Summarized analytical data for the standard muscovite Berne 4M are listed.

As geochronological laboratories in USSR increased in number, systematic work for elaborating geochronometric standards was begun and has been maintained. The first standard for K-Ar method appeared in 1960. Adequately prepared samples of minerals were analyzed in six laboratories active at that time.

The results proved to be in reasonnable agreement. Numerical values obtained on biotite in three separate laboratories (headed by E. K. GERLING, I. E. STARIK and L. V. KOMLEV) were nearly identical (Table 1). At the moment Rb-Sr age values obtained on biotite from the Black Salma (Черная Салма), and Pb-isotopic values determined from syngenetic minerals (monazite, cyrtolite and others) are available.

Numerical values obtained in 26 USSR laboratories by the K-Ar method on the basis of the standard Asia-65 (effusive material) have been thoroughly compared, with a summary published in an article by G. D. AFANASS'YEV and S. I. ZYKOV (1968). In 1969 an analytical check on amazonite and biotite standards has been carried out by Rb-Sr and K-Ar methods.

In addition, the muscovite standard Bern-4M kindly placed at our disposal by Prof. E. JÄGER, has been studied in a number of Soviet laboratories.

In 1958 the National Commission for absolute dating commissioned T. K. KOZHINA to collect the rock-samples for standards. After suitable minerals had been sampled from the Karelian pegmatite veins (Black Salma) and then crushed, split and cleaned, monomineralic standards were prepared.

As early as 1924, K. A. NENADKEVICH first determined the age of uraninites from Karelian pegmatites. Later on, V. G. KHLOPIN and M. V. VLADIMIROVA made 17 determinations on minerals from diverse pegmatite veins.

In the transactions of the 111. Session of the Commission (published in 1955), measurements completed by G. V. AVDEIKO were reported, which are in agreement in

their various isotopic relationships. As I. E. STARIK has noted (1955, p. 9), all these determinations gave practically one and the same numerical value – 1800 m.y. within ± 5%.

Age values obtained separately by six laboratories from the analyzed Black Salma biotite are listed in Table 1.

The data contained in Table 1 have been re-evaluated with due regard to the isotopic abundance of ^{40}K ($= 1.22 \times 10^{-6}$ g/g). Consequently, the mean K-Ar age for a biotite from the Black Salma pegmatite vein, averaged from values obtained by six laboratories, was found to be 1802 m.y.

Table 2 shows the ages of a number of minerals from Black Salma pegmatites, obtained by the Pb-isochron method. The isochron equation gives an age value of 1780 m.y. for these minerals.

The Rb-Sr ages of this same biotite standard from Black Salma pegmatite, given in Table 3, were also determined, at our request, by Prof. E. JÄGER. As may be seen from this table, values obtained in 1969 by different laboratories are in close agreement. The analysis of this biotite carried out by J. V. GOLTSMAN in 1965 showed a somewhat lower age value. The averaged age value derived from different data obtained by three laboratories equals 1764 m.y.

In Table 4 all averaged K-Ar ages derived from muscovite and biotite measurements are summarized, including the Rb-Sr ones on biotite, and those obtained by Pb-isotopic method on cyrtolite, monazite and other minerals. The values of Table 4 unambiguously show that age values obtained for micas by the K-Ar method, with $\lambda_e = 0.557 \times 10^{-10}$ years^{-1} used are in the closest agreement with those obtained by U and Th-Pb methods. The mean Rb-Sr age (1764 m.y.) calculated using $\lambda_{^{87}Rb} = 1.39 \times 10^{-11}$ years^{-1} is also in a better agreement with the U-Pb and K-Ar data, than if the Rb-Sr ages value were calculated by $\lambda_{^{87}Rb} = 1.47 \times 10^{-11}$ years^{-1}.

The K-Ar ages of the Black Salma biotite obtained in three laboratories, which had gained by 1960 considerable experience in determinative studies (Table 5), as well as Rb-Sr values obtained on this same biotite in two laboratories (including that of Prof. E. JÄGER) have proved to be literally identical.

A similar close agreement was revealed between the K-Ar and Rb-Sr ages of a Paleozoic biotite from Central Kazakhstan (Table 6) using $\lambda_e = 0.557 \times 10^{-10}$ years^{-1}.

And, finally, Table 7 shows the results obtained in four Soviet laboratories on K-Ar age measurements on the muscovite standard Bern-4M. The numerical values (which are slightly discrepant) are calculated with $\lambda_e = 0.557 \times 10^{-10}$ years^{-1}.

Conclusion

The analytical evidence reported above which was obtained in different Soviet laboratories, by K-Ar, Rb-Sr and U-Th-Pb methods on Soviet standards, is consistent; and furthermore in agreement with the results obtained in one of the best laboratories in the world, headed by Prof. E. JÄGER.

However, geologists and geochronologists face a new problem – that of differing age values obtained by different methods. The problem lies either in the methodological approach, or in the inconsistency with the geological position of the rock unit studied

by these methods. Yet this new problem may be resolved on the basis of a thorough diverse geological-mineralogical-petrographical and geochronological study of key rock units.

In conclusion it may be said that the above results of standard investigations by different methods encourage us to recommend the practical use of constants approved by the III. Session of National Commission as long as reliable λ_e and $\lambda_{^{87}Rb}$ values are not obtained by computing methods. Still, we believe it necessary for the Commission on Geochronology of the IUGS to adopt a recommendation for every laboratory concerned to publish the original analytical data on parent and daughter isotopic content. Undoubtedly, in every publication, values of constants used should be listed.

Table 1. Age values for a standard biotite sample from Karelia (AFANASS'YEV et al., 1960) ($\lambda_e = 0{,}557 \times 10^{-10}$)

Laboratory and author	K, %	Ar, STP mm³/g	Age values (m.y.) calculated using $^{40}K/K_{com} = 0{,}0122\%$
RIAN (Starik)	7.84	0.893	1795
RIAN (Komlev)	7.81	0.872	1774
LAGED	7.83	0.885	1785
UFAN	7.97	0.940	1838
VSEGEI	7.78	0.899	1816
GIN AN USSR	7.47	0.855	1801
		Averaged value	1802

Table 2. Black Salma

Mineral	Age, m.y. 207/206	206/238	207/235	208/232
Cyrtolite 1	1860	1750	1780	1770
Cyrtolite 11	1820	1830	1800	1840
Cyrtolite (altered)	850	605	650	435
Monazite	1750	1230	1420	1120
Uraninite	1820	1670	1660	5200
Uraninite	1800	1730	1750	

Notes: 1) Isochron gives the value of T = 1780 m.y.

2) Common lead correction: 204: 1.00; 206: 14.58; 207: 14.80; 208: 35.40.

3) Conventions: 207/206 = Pb^{207}/Pb^{206}; 206/238 = Pb^{206}/U^{238}; 207/235 = Pb^{207}/U^{235} 208/232 = Pb^{208}/Th^{232}.

4) The following values for the decay constants were used for calculations: $\lambda_{235} = 0.9722 \times 10^{-9}$ years^{-1}; $\lambda_{238} = 0.1535 \times 10^{-9}$ years^{-1}; $\lambda_{232} = 0.4987 \times 10^{-10}$ years^{-1}; $U^{238}/U^{235} = 137.7$.

Table 3. Age values obtained by the Rb-Sr method from the Black Salma, N. Karelia, pegmatite vein using $^{87}Sr/^{87}Rb = (e^{\lambda t} - 1)$

Author and date of analysis	^{87}Rb, ppm	$^{87}Sr_{rad.}$, ppm	Age values, m.y. with $\lambda_\beta = 1.39 \times 10^{-11}$ years^{-1}	Age values, m.y. with $\lambda_\beta = 1.47 \times 10^{-11}$ years^{-1}
GUKASSYAN, 1969	242.0	6.110	1793	1695
GOLTSMAN, 1965	258.0	6.220	1713	1620
E. JÄGER, 1969	245.0	6.156	1785	1690
Averaged values	248.3	6.162	1764	1668
Age values calculated from averaged amounts of ^{87}Rb and $^{87}Sr_{rad.}$				
Mean value			1764	1668

Table 4. Age values in m.y. for various minerals from the Black Salma, N. Karelia, pegmatite vein obtained by potassium/argon, rubidium/strontium and common lead methods in different laboratories

Mineral	Potassium/argon method[a])	$^{40}K = 1.22 \times 10^{-4}$ g/g^{-}K	Rubidium/strontium method[b])		Common lead method[c])
	$\lambda_e = 0.557 \times 10^{-10}$ y^{-1} $\lambda_\beta = 0.472 \times 10^{-9}$ y^{-1}	$\lambda_e = 0.585 \times 10^{-10}$ y^{-1} $\lambda_\beta = 0.472 \times 10^{-9}$ y^{-1}	$\lambda_\beta = 1.39 \times 10^{-11}$ y^{-1}	$\lambda_\beta = 1.47 \times 10^{-11}$ y^{-1}	$\lambda_{238} = 1.535 \times 10^{-10}$ y^{-1} $\lambda_{235} = 9.72 \times 10^{-10}$ y^{-1} $\lambda_{232} = 4.99 \times 10^{-11}$ y^{-1}
Muscovite	1800	(1740)	–	–	–
Biotite	1800	(1740)	1764	(1668)	–
Three cyrtolites, one monazite, three uraninites (pitchblendes)	–	–	–	–	1786

[a]) Averaged values from 6 determinations in different laboratories.
[b]) Averaged values from determinations carried out in three laboratories.
[c]) Averaged values from data obtained in two laboratories.
Mean date for the Black Salma (Черная Салма), Karelia, determined from 4 age values $t = \frac{(1800 + 1800 + 1780 + 1764}{4} = 1786$

Table 5. Comparison of K/Ar and Rb/Sr ages

Laboratory, date of determination	K/Ar; $\lambda_e = 0.557 \times 10^{-10}$ y^{-1}			Rb/Sr; $\lambda_{^{87}Rb} = 1.39 \times 10^{-11}$ y^{-1}		
	K %	$^{40}Ar_{rad.}$, STP mm^3/g	T m.y.	^{87}Rb ppm	^{87}Sr ppm	T m.y.
Biotites from Karelia						
I. S. STARIK, 1960	7.84	0.893	1795			
L. V. KOMLEV, 1960	7.81	0.872	1774			
E. K. GERLING, 1960	7.83	0.885	1785			
E. JÄGER, 1969	–	–	–	245.0	6.156	1785
R. GUKASSYAN, 1969	–	–	–	242.0	6.11	1793
Mean value			1785			1789

Table 6. Age values obtained by K/Ar and Rb/Sr methods on a standard biotite sample (c-4-d) from granites C_2–C_3

Laboratory, author, date of determination	K/Ar: $\lambda_e = 0.557 \times 10^{-10}$ y^{-1}, $\lambda_\beta = 4.720 \times 10^{-10}$ y^{-1}			Rb/Sr: $\lambda_{^{87}Rb} = 1.39 \times 10^{-11}$ y^{-1}		
	K %	$^{40}Ar_{rad.}$, STP mm^3/g	T m.y.	^{87}Rb ppm	^{87}Sr ppm	T m.y.
IGEM, L. L. SHANIN, 1964	7.27	0.091	304	910	3.58	289 ± 8
Bashkir. branch Ac. Sci. USSR, M. A. HARRIS, 1964	6.92	0.083	292	–	–	–
Kazakhskaya Ac. Sci., A. I. IVANOV	7.46	0.091	295	–	–	–
Armenian Ac. Sci., G. P. BAGDASARYAN, 1964	7.28	0.096	320	1035	4.16	290 ± 15
Bern, E. JÄGER, 1969	–	–	–	923	3.81	296 ± 11
Geochem. Inst. Sib. Dep. Ac. Sci. USSR, S. B. BRANDT, 1969	7.47	0.089	292	–	–	–
Geol. Inst. Sib. Dep. Ac. Sci. USSR, L. V. FIRSOV, 1969	7.42	0.089	295	–	–	–
Mean value			299			292

Table 7. Results of Muscovite Bern-4M analysis by the K-Ar method

Laboratory	K (%)	$^{40}Ar_{rad.}$ (μg/g)	Ages in 10^6 years $\lambda_e = 0.557 \times 10^{-10}\ y^{-1}$ $\lambda_\beta = 0.472 \times 10^{-9}\ y^{-1}$	$\lambda_e = 0.585 \times 10^{-10}\ y^{-1}$ $\lambda_\beta = 0.472 \times 10^{-9}\ y^{-1}$
Inst. Geol. Sci. Ac. Sci. Armen. Soc. Rep., Erevan	8.55	11.80	20.3	19.3
Geol. Inst. Ac. Sci. Georg. S. Rep., Tbilisi	8.66	11.15	18.8	18.0
Inst. Ore-geol., Petr. Min. & Geochem., Ac. Sci. USSR, Moscow	8.56	11.70	20.0	19.1
Geochem. Inst. Sib. Div. Ac. Sci. USSR, Irkutsk	8.60	11.42	19.5	18.5
Mean values	8.59_2	11.51_8	19.6	18.7

Remarks: 1. The concentration in argon was determined by isotope dilution method using ^{38}Ar.

2. The concentration in potassium was determined by flamephotometry and perchlorate techniques.

3. $^{40}K = 1.22 \times 10^{-4}$ g/g K.

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