Critical tables for conversion of K-Ar ages from old to new constants

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One of the most commonly asked questions in K-Ar dating concerns the conversion of "old" to "new" constants. We reproduce the article below to help answer such questions.
— *Advisory Board*

RESEARCH NOTE

Critical tables for conversion of K-Ar ages from old to new constants

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In 1976, the IUGS Subcommission on Geochronology recommended that a new set of decay and abundance constants be adopted for the calculation of K-Ar ages (table 1; Steiger and Jager, 1977). These new constants are now used by nearly all K-Ar laboratories.

Prior to the 1976 IUGS recommendation, there were primarily two sets of old constants in use. Nearly all laboratories in the Western world used the ^{40}K decay constants recommended by Aldrich and Wetherill (1958) and the ^{40}K abundance of Nier (1950); these values are given in the column headed "Western" in table 1. Most K-Ar ages in the Russian literature were calculated using a different value for $\lambda_\epsilon + \lambda'_\epsilon$, and the Western values for λ_β and $^{40}K/K_{total}$; these values are given in the column headed "Russian." For discussions of the origins of these various constants, see Nier (1950), Aldrich and Wetherill (1958), Wetherill (1957, 1966), Beckinsale and Gale (1969), Garner and others (1975), and Steiger and Jager (1977).

The effect of the new constants is nonlinear, so conversion of ages from one set of constants to another is not straightforward. For example, an age calculated with the new IUGS constants is 2.7% older than one calculated with the old Western constants at 1 m.y., but is 1.7% younger at 4,500 m.y. Thus recomputation is required for each age, a troublesome and time-consuming task for most geologists.

Tables 2 and 3 have been prepared as an aid for the rapid and easy conversion of K-Ar ages calculated with either set of old constants to ages based on the new IUGS constants. An "old" age multiplied by the indicated correction factor will give the "new" age (example 1). The tables are arranged as critical tables, and interpolation is not required. Correction factors are given to the nearest 0.02%. For ages that coincide with a tabulated value, use the correction factor on the line above (example 2). The maximum error resulting from use of these tables is 0.01%, which is better than the precision of K-Ar ages by more than two orders of magnitude.

The tables may also be used to convert "new" ages to "old" ages by using the correction factors as divisors (example 3), a procedure that increases the maximum error by only a few thousandths of a percent.

Example 1: Convert an "old" age of 27.7 m.y. to a "new" age (table 2): 27.7 m.y. × 1.0262 = 28.4 m.y.

Example 2: Convert an "old" age of 108 m.y. to a "new" age (table 2): 108.0 m.y. × 1.0248 = 110.7 m.y.

Example 3: Convert a "new" age of 825 m.y. to an "old" age (table 2): 825 m.y. ÷ 1.0128 = 815 m.y.

Tables 2 and 3 do not cover all the published K-Ar ages. Occasionally, the reader may find K-Ar ages in the literature that have been calculated with a different set of old constants than those given in table 1. These ages may be converted by first calculating a new $^{40}Ar_{rad}/^{40}K$ ratio:

$$\frac{^{40}Ar_{rad}}{^{40}K} = \frac{LK_0(e^{\lambda_0 t} - 1)}{1.167 \times 10^{-4}}, \quad (1)$$

where L = old $(\lambda_\epsilon + \lambda'_\epsilon)/\lambda$, K_0 = old $^{40}K/K_{total}$, λ_0 = old total decay constant $(\lambda_\epsilon + \lambda'_\epsilon + \lambda_\beta)$, and t = old K-Ar age; this new ratio can then by used to calculate the new age T, on the basis of the IUGS constants

$$T = 1.804 \times 10^9 \ln\left(9.541 \frac{^{40}Ar_{rad}}{^{40}K} + 1\right). \quad (2)$$

Old K-Ar ages that are converted by using table 2 or table 3 or equations 1 and 2 will be no more precise than the number of significant digits in the published age. If possible, it is always desirable to recalculate ages using equation 2 and the original analytical data. Users of equation 2 are cautioned that the quantity $^{40}Ar_{rad}/^{40}K$ is an atomic ratio, usually expressed in mole/mole, and that analyses given in weight percent, parts per million, or cubic centimetres STP must be converted to the proper units (table 4).

TABLE 1. Constants used for the calculation of K-Ar ages.

Constant*	Old		New
	Western	Russian	IUGS
$^{40}K/K$	1.19×10^{-4} mol/mol†	1.19×10^{-4} mol/mol†	1.167×10^{-4} mol/mol
λ_β	4.72×10^{-10} yr^{-1}	4.72×10^{-10} yr^{-1}	4.962×10^{-10} yr^{-1}
$\lambda_\epsilon + \lambda'_\epsilon$	0.585×10^{-10} yr^{-1}	0.557×10^{-10}	0.581×10^{-10} yr^{-1}

*The old constants did not take into account λ'_ϵ; that is, it was assumed to be zero or negligible.
†Sometimes given as 1.22×10^{-4} weight percent, which is equivalent.

TABLE 2. Critical table for conversion of K-Ar ages from old Western constants to new IUGS constants.

Age	F	Age	F	Age	F	Age	F	Age	F	Age	F	Age	F	Age	F	Age	F	Age	F
0		259		555		889		1270		1712		2233		2865		3656		4693	
	1.0268		1.0218		1.0168		1.0118		1.0068		1.0018		0.9968		0.9918		0.9868		0.9818
5		271		568		903		1287		1731		2256		2893		3692		4741	
	66		16		66		16		66		16		66		16		66		16
15		282		580		918		1303		1750		2279		2922		3728		4790	
	64		14		64		14		64		14		64		14		64		14
25		293		593		932		1320		1770		2302		2950		3765		4840	
	62		12		62		12		62		12		62		12		62		12
35		305		606		947		1336		1789		2326		2979		3802		4891	
	1.0260		1.0210		1.0160		1.0110		1.0060		1.0010		0.9960		0.9910		0.9860		0.9810
45		316		619		961		1353		1809		2350		3008		3840		4942	
	58		08		58		08		58		08		58		08		58		08
56		327		632		976		1370		1829		2373		3038		3878		4994	
	56		06		56		06		56		06		56		06		56		06
66		339		645		990		1387		1849		2397		3068		3916		5049	
	54		04		54		04		54		04		54		04		54		04
76		350		658		1005		1404		1869		2422		3098		3955			
	52		02		52		02		52		02		52		02		52		
87		362		671		1020		1421		1889		2446		3128		3994			
	1.0250		1.0200		1.0150		1.0100		1.0050		1.0000		0.9950		0.9900		0.9850		
97		374		684		1035		1439		1909		2471		3159		4034			
	48		1.0198		48		1.0098		48		0.9998		48		0.9898		48		
108		385		697		1050		1456		1930		2495		3189		4074			
	46		96		46		96		46		96		46		96		46		
118		397		710		1065		1474		1950		2520		3221		4115			
	44		94		44		94		44		94		44		94		44		
129		409		724		1081		1491		1971		2546		3252		4156			
	42		92		42		92		42		92		42		92		42		
139		421		737		1096		1509		1992		2571		3284		4198			
	1.0240		1.0190		1.0140		1.0090		1.0040		0.9990		0.9940		0.9890		0.9840		
150		433		750		1111		1527		2013		2597		3316		4240			
	38		88		38		88		38		88		38		88		38		
161		445		764		1127		1545		2035		2622		3348		4283			
	36		86		36		86		36		86		36		86		36		
172		457		778		1142		1563		2056		2648		3381		4326			
	34		84		34		84		34		84		34		84		34		
182		469		791		1158		1581		2078		2675		3414		4370			
	32		82		32		82		32		82		32		82		32		
193		481		805		1174		1599		2099		2701		3448		4414			
	1.0230		1.0180		1.0130		1.0080		1.0030		0.9980		0.9930		0.9880		0.9830		
204		493		819		1190		1618		2121		2728		3482		4459			
	28		78		28		78		28		78		28		78		28		
215		506		833		1206		1636		2143		2755		3516		4505			
	26		76		26		76		26		76		26		76		26		
226		518		847		1222		1655		2165		2782		3550		4551			
	24		74		24		74		24		74		24		74		24		
237		530		861		1238		1674		2188		2809		3585		4597			
	22		72		22		72		22		72		22		72		22		
248		543		875		1254		1693		2210		2837		3620		4645			
	1.0220		1.0170		1.0120		1.0070		1.0020		0.9970		0.9920		0.9870		0.9820		
259		555		889		1270		1712		2233		2865		3656		4693			

Note: To convert an age based on the old Western constants to one based on the new IUGS constants, multiply by the indicated correction factor (F). Ages are in 10^6 yr.
Old Western constants: $\lambda_\epsilon + \lambda'_\epsilon = 0.585 \times 10^{-10}$ yr^{-1}, $\lambda_\beta = 4.72 \times 10^{-10}$ yr^{-1}, $^{40}K/K_{total} = 1.19 \times 10^{-4}$ mol/mol.
New IUGS constants: $\lambda_\epsilon + \lambda'_\epsilon = 0.581 \times 10^{-10}$ yr^{-1}, $\lambda_\beta = 4.962 \times 10^{-10}$ yr^{-1}, $^{40}K/K_{total} = 1.167 \times 10^{-4}$ mol/mol.

TABLE 3. Critical table for conversion of K-Ar ages from old Russian constants to new IUGS constants.

Age	F	Age	F	Age	F	Age	F	Age	F
		588		1410		2551		4338	
			0.9738		0.9698		0.9658		0.9618
0		624		1458		2620		4457	
	0.9776		36		96		56		16
10		660		1506		2692		4581	
	74		34		94		54		14
39		697		1556		2765		4708	
	72		32		92		52		12
68		734		1606		2839		4841	
	0.9770		0.9730		0.9690		0.9650		0.9610
98		772		1657		2916		4978	
	68		28		88		48		08
128		811		1710		2994		5120	
	66		26		86		46		
158		849		1763		3074			
	64		24		84		44		
189		889		1817		3156			
	62		22		82		42		
220		929		1871		3240			
	0.9760		0.9720		0.9680		0.9640		
252		969		1927		3327			
	58		18		78		38		
284		1011		1984		3415			
	56		16		76		36		
316		1052		2042		3506			
	54		14		74		34		
348		1095		2102		3600			
	52		12		72		32		
381		1138		2162		3696			
	0.9750		0.9710		0.9670		0.9630		
415		1181		2223		3795			
	48		08		68		28		
448		1226		2286		3897			
	46		06		66		26		
483		1271		2350		4003			
	44		04		64		24		
517		1316		2416		4111			
	42		02		62		22		
552		1363		2483		4223			
	0.9740		0.9700		0.9660		0.9620		
558		1410		2551		4338			

Note: To convert an age based on the old Russian constants to one based on the new IUGS constants, multiply by the indicated correction factor (F). Ages are in 10^6 yr.

Old Russian constants: $\lambda_\epsilon + \lambda'_\epsilon = 0.557 \times 10^{-10}$ yr^{-1}, $\lambda_\beta = 4.72 \times 10^{-10}$ yr^{-1}, $^{40}K/K_{total} = 1.19 \times 10^{-4}$ mol/mol.
New IUGS constants: $\lambda_\epsilon + \lambda'_\epsilon = 0.581 \times 10^{-10}$ yr^{-1}, $\lambda_\beta = 4.962 \times 10^{-10}$ yr^{-1}, $^{40}K/K_{total} = 1.167 \times 10^{-4}$ mol/mol.

TABLE 4. Conversion factors.

To convert	To	Multiply by
Weight percent	ppm	10^4
ppm	weight percent	10^{-4}
percent K	percent K_2O	1.205 K_2O/K
percent K_2O	percent K	0.8301 K/K_2O
moles ^{40}Ar/gram	ppm ^{40}Ar	4.000×10^7 gram ppm/mole
moles Ar	cc STP Ar	2.241×10^4 cc STP/mole
cc STP Ar	moles Ar	4.462×10^{-5} mole/cc STP
cc STP ^{40}Ar/gram	ppm ^{40}Ar	1.785×10^3 gram ppm/cc STP
ppm ^{40}Ar	moles ^{40}Ar/gram	2.500×10^{-8} mole/gram ppm
ppm ^{40}Ar	cc STP ^{40}Ar/gram	5.602×10^{-4} cc STP/gram ppm

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Geologic time chart references

The 1983 revision of this geologic time chart was prepared by the Geologic Names Committee for U.S. Geological Survey use. It supersedes the 1980 chart. Numerical ages of chronostratigraphic boundaries are subject to many uncertainties besides the analytical precision of the dating. The placement of boundary stratotypes and the achievement of international agreements on these ages is a slow process subject to much revision and review. Recent studies and revisions of the geologic time scale of especial interest are reported in *A geologic time scale,* by W. B. Harland, A. V. Cox, P. G. Llewellyn, C. A. G. Pickton, A. G. Smith, and R. Walters, 1982: Cambridge University Press, 132 p.; *The decade of North American geology 1983 geologic time scale,* by A. R. Palmer, 1983: Geology, v. 11, p. 503–504; and *The chronology of the geological record,* N. J. Snelling (ed.), 1985: Blackwell Scientific Publishers, The Geological Society, Memoir No. 10, 343 p.

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