【Material】

Conversion of K-Ar dates with modern constants: implications for recalculation of dates reported in Kawano and Ueda using constants reported by Steiger and Jäger

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【Material】

Conversion of K-Ar dates with modern constants: implications for recalculation of dates reported in Kawano and Ueda using constants reported by Steiger and Jäger

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Abstract

This report describes details of a procedure used to convert from K-Ar dates with old constants reported in the relevant literature to K-Ar dates with modern decay constants and the isotopic ratio of potassium reported by Steiger and Jäger. Nearly 300 K-Ar dates published by Kawano and Ueda in the 1960s have been recalculated using this procedure. These data are useful for comparing dates reported by Kawano and Ueda to recently obtained K-Ar dates reported by others.

Introduction

In radiometric dating, a date (T) is calculated using a ratio of the radioactive parent isotope (P) and a radiogenic daughter isotope (D), with λ as the decay constant shown in Equation 1, where P is the number or moles of parent atoms in a specimen and D is the number or moles of daughter atoms. The fraction of the parent disintegrating per unit time is λ. The fundamental assumption of radiometric dating is that a single period of a closed system shows no loss or gain of parent or daughter isotopes between the time of formation and time of analysis of the specimen.

$$T = \frac{1}{\lambda}\ln\left(\frac{D}{P}+1\right) \quad \text{Equation 1}$$

For a K-Ar decay system, the relation is more complex. The parent isotope, ^{40}K, undergoes branching decay: ^{40}K decays to ^{40}Ar* (* signifies a radiogenic component) by electron capture and to ^{40}Ca by β^- decay. Moreover, the branches have respective decay constants of λ_e and λ_β. The K-Ar date, T, is calculated using Equation 2.

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$$T = \frac{1}{\lambda} \ln\left(\frac{\lambda}{\lambda_e} \times \frac{^{40}Ar^*}{^{40}K} + 1\right) \qquad \text{Equation 2}$$

Therein, $\lambda = \lambda_e + \lambda_\beta$.

Here, ^{40}K denotes an abundance of ^{40}K at present, as calculated with a constant of $^{40}K_p$ ($=^{40}K/K$), which is multiplied by the total potassium content (K) as shown in Equation 3.

$$T = \frac{1}{\lambda} \ln\left(\frac{\lambda}{\lambda_e} \times \frac{^{40}Ar^*}{^{40}K_p \times K} + 1\right) \qquad \text{Equation 3}$$

Values of λ (λ_e and λ_β) are given as constant, but the value has been improved in the past based on the progress of investigations of radioactive decay phenomena. When the decay constants are changed, conversion of these dates from the original data is strongly recommended.

This manuscript presents a description of a procedure for K-Ar date conversion and its application for data in a series of papers by Kawano and Ueda (Kawano and Ueda, 1964, 1965a,b, 1966a,b, 1967). During the 1960s, Kawano and Ueda provided data for nearly 300 K-Ar age of rocks from throughout Japan. These data have been used widely as fundamental information for establishing the geological history of the Japanese Islands. These classic works used radiometric decay constants that differ from modern values. Therefore, we must perform recalculation when we compare their K-Ar dates to recently obtained K-Ar dates. These data are valuable to people who want to use their results in the field of geology in Japan.

In this manuscript, I use the word "date" in place of "age" based on a definition by Faure and Mensing (2005). The word "date" is used for results of calculation in radiometric dating equation. The word "age" is used for results of K-Ar dating. The word "age" is useful only when the basic assumptions of K-Ar dating are satisfied. These assumptions require careful evaluation in each case and dictate certain restrictions on the geological interpretation of K-Ar dates (Faure and Mensing, 2005).

Date conversion formulae

Generally, conversion of a K-Ar date calculated with old constants (*oldT*) to one calculated with modern constants (*newT*) can be accomplished using Equation 4. In this equation, *oldT* is the K-Ar date calculated using old decay constants, $old\,\lambda_e$, $old\,\lambda_\beta$, and old $^{40}K/K$ ratio of potassium, $old\ ^{40}Kp$. Similarly, *newT* is the calculated K-Ar date obtained using current decay constants, $new\,\lambda_e$, $new\,\lambda_\beta$, and the current $^{40}K/K$ ratio of potassium, $new^{40}Kp$.

$$newT=\frac{1}{new\lambda}\times\ln\left[\frac{new\,\lambda}{new\,\lambda_e}\times\frac{old\lambda_e}{old\lambda}\times\frac{old\ ^{40}K_p}{new^{40}K_p}\times\left\{\exp\left(old\lambda\times oldT\right)-1\right\}+1\right] \quad \text{Equation 4}$$

Therein, $old\,\lambda = old\,\lambda_e + old\,\lambda_\beta$ and $new\,\lambda = new\,\lambda_e + new\,\lambda_\beta$.

When the $^{40}Ar^*/^{40}K$ ratio is provided in the literature with old constants (old ($^{40}Ar^*/^{40}K$)), the new date is calculable using Equation 5.

$$newT=\frac{1}{new\lambda}\times\ln\left[\frac{new\,\lambda}{new\,\lambda_e}\times\frac{old\ ^{40}K_p}{new^{40}K_p}\times old\left(\frac{^{40}Ar^*}{^{40}K}\right)+1\right] \quad \text{Equation 5}$$

Currently, the decay constants of electron capture (λ_e: 0.581×10^{-10}/y) and β^- decay (λ_β: 4.962×10^{-10}/y) of the ^{40}K recommended by Steiger and Jäger (1977) are used. The abundance of ^{40}K is calculated from the isotopic ratio of potassium in nature ($^{40}K_p=1.167\times10^{-4}$; Steiger and Jäger, 1977). These constants were recommended in a meeting of the IUGS Subcommition on Geochronology at the International Geoscience Congress in Sydney, Australia in 1976. They were published in 1977 (Steiger and Jäger, 1977). These constants are based mostly on work by Beckinsale and Gale (1969) and by Garner et al. (1975).

Before that recommendation, decay constants of electron capture (λ_e: 0.585×10^{-10}/y) and β^- decay (λ_β: 4.72×10^{-10}/y) of the ^{40}K suggested by Aldrich and Wetherill (1958) were usually used (Dalrymple and Lanphere, 1969). However, in a series of their papers, Kawano and Ueda used the following constants: $\lambda_\beta=4.72\times10^{-10}$/y, $\lambda_e=0.584\times10^{-10}$/y (Wetherill, 1957) and $^{40}K_p=1.19\times10^{-4}$ (Nier, 1950).

Figure 1 portrays differences between dates calculated using pre-1977 constants and those ascertained with 1977 constants. The K-Ar dates with 1977 constants are less than those calculated with pre-1977 constants in old (> 2000 Ma) specimens. The K-Ar dates calculated with 1977 constants are greater than dates calculated with pre-1977 constants in younger specimen.

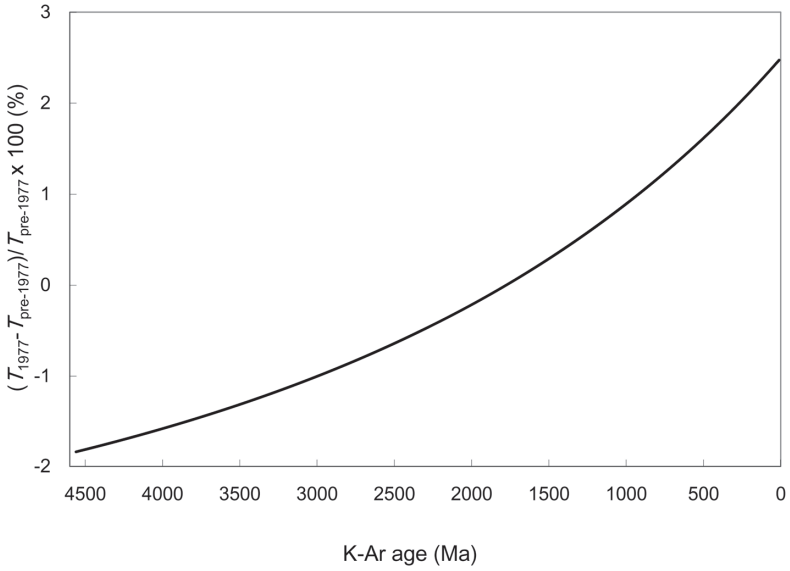

Figure 1 Difference between dates with 1977 constants and pre-1977 constants. K-Ar dates with 1977 constants (T_{1977}) are smaller than dates with pre-1977 constants ($T_{pre\text{-}1977}$) in old (> 2000 Ma) specimens. K-Ar dates with 1977 constants (T_{1977}) are larger than dates with pre-1977 constants ($T_{pre\text{-}1977}$) in younger specimens.

After the recommendation by Steiger and Jäger (1977), Audi et al. (1997) and Audi et al. (2003) reported total decay constants of 5.428×10^{-10}/y and 5.540×10^{-10}/y, as cited in the nuclear physics literature, with a branching ratio of 89.28% and ${}^{40}K_p = 1.17 \times 10^{-4}$. However, to maintain the consistency of dating results among dating laboratories, these values have not been used yet for K-Ar dating work.

Application for K-Ar dates by Kawano and Ueda

A series of papers by Kawano and Ueda used the constants of $\lambda_\beta = 4.72 \times 10^{-10}$/y and $\lambda_e = 0.584 \times 10^{-10}$/y (Wetherill, 1957) with one exception: Kawano and Ueda (1965b) used $\lambda_e = 0.585 \times 10^{-10}$/y. The $^{40}K/K$ ratio was not shown in their paper, but a value of 0.00119% (Nier, 1950) might be used because this value was used widely during 1950－1960s. The appropriate $^{40}Ar^*/^{40}K$ ratios are indicated in the series of papers by Kawano and Ueda. Therefore, Equation 5 was used for this study.

Tables 1－6 present results of K-Ar date conversion. The leftmost two columns show $^{40}Ar^*/^{40}K$ ratio and the calculated K-Ar date in papers by Kawano and Ueda. The rightmost two columns show recalculated dates. Values in "pre-1977 const." are K-Ar dates calculated using $^{40}Ar^*/^{40}K$ ratio and constants used in the Kawano and Ueda papers. Values in "1977 const." are K-Ar dates recalculated using the $^{40}Ar^*/^{40}K$ ratio from Kawano and Ueda papers and modern constants from Steiger and Jäger (1977). Most of the recalculated K-Ar dates are about 2% greater than the original ones.

Because uncertainty values of K-Ar dates in papers by Kawano and Ueda are not indicated, it is difficult to estimate the precision of their dates. Moreover, Kawano and Ueda (1964) confirmed that the reproducibility of their K-Ar dates were obtainable within maximum errors of +/- 5% based on repeated measurements of the same specimen. I recommend that the recalculated K-Ar date must be used with the same precision (= same digit number) of the date in original Kawano and Ueda papers.

For samples of G-258 (Kitagishima, Okayama Pref.) and G-275 (Kosyosan, Fukuoka Pref.) in Table 5, K-Ar dates written in Kawano and Ueda (1966b) differ from those calculated using their $^{40}Ar^*/^{40}K$ ratio and constants written in Kawano and Ueda (1966b). It remains unclear whether the K-Ar dates of G-258 and G-275 are real or not. These dates cannot be used in detailed geochronological studies.

The converted K-Ar dates must be used for compilation of geological history in the studied area using both K-Ar ages in the modern (post-1977) literature and those in a series of papers by Kawano and Ueda (Kawano and Ueda, 1964, 1965a,b, 1966a,b, 1967).

Table 1. List of recalculated K-Ar dates published in Tables 4 and 5 of Kawano and Ueda, 1964

Sample No.	Kawano and Ueda, 1964		Recalculated K-Ar date (Ma)		Remarks
	$^{40}Ar^{*}/^{40}K$	K-Ar age (Ma)	-1977 constants	1977 constants	
Sy-93-Mi	0.00644	107	107.2	109.6	
Gb-91-B	0.00668	111	111.0	113.6	
Gb-91-Mi	0.00599	100	99.9	102.2	
Gb-95-B	0.00639	106	106.4	108.8	
U-94-B	0.00696	116	115.6	118.2	
G-5-Or	0.01374	222	221.7	226.3	
G-90-B	0.00530	89	88.6	90.7	
G-21-B	0.00503	84	84.2	86.2	
G-22-B	0.00724	120	120.1	122.8	
G-24-B	0.00606	101	101.0	103.3	
G-25-B	0.00616	103	102.6	105.0	
G-46-B	0.00715	119	118.6	121.3	
D-28-Hr	0.00583	97	97.3	99.5	
G-51-B	0.00371	63	62.5	64.0	
G-52-B	0.00382	64	64.3	65.8	
G-58-B	0.00460	77	77.2	79.0	
G-53-B	0.00544	91	90.9	93.0	
G-82-B	0.00068	12	11.6	11.9	
G-85-B	0.00055	9	9.4	9.6	
G-83-B	0.00046	8	7.9	8.1	
G-49-B	0.00132	22	22.5	23.0	
WDcT-54-B	0.00145	25	24.7	25.3	
WDcT-57-B	0.00060	10	10.2	11.5	
Dc-92-B	0.00094	16	16.0	16.4	
R-87-whole	0.00077	13	13.1	13.5	
R-59-whole	0.00023	4	3.9	4.0	
P-67-Sd	0.00097	17	16.5	16.9	

N.B.

Recalculated K-Ar dates with -1977 constants are calculated from the $^{40}Ar^{*}/^{40}K$ value and constants used in Kawano and Ueda, 1964.

Table 2. List of recalculated K-Ar dates published in Table 1 of Kawano and Ueda, 1965a

Sample No.	Kawano and Ueda, 1965a		Recalculated K-Ar date (Ma)		Remarks
	$^{40}Ar^{*}/^{40}K$	K-Ar age (Ma)	-1977 constants	1977 constants	
Sy-93	0.006439	107	107.2	109.6	
Gb-91	0.006683	111	111.1	113.6	
Gb-95	0.005999	100	100.0	102.3	
U-94	0.006391	106	106.4	108.8	Bi-1
U-94	0.006960	116	115.6	118.2	Bi-2
G-30	0.007244	120	120.1	122.9	
G-32	0.007236	120	120.0	122.7	
G-29	0.007022	117	116.6	119.2	
G-33	0.007332	122	121.5	124.3	
G-34	0.007021	117	116.5	119.2	
G-35	0.006708	112	111.5	114.0	
G-36	0.007122	118	118.2	120.9	
G-37	0.007286	121	120.8	123.5	
G-38	0.007128	118	118.3	121.0	
G-39	0.006824	113	113.4	116.0	
G-8	0.007362	122	122.0	124.8	
G-7	0.006607	110	109.9	112.4	
Gb-105	0.006916	115	114.9	117.5	
G-106	0.007222	120	119.8	122.5	
G-9	0.007258	120	120.4	123.1	
G-149	0.006834	114	113.5	116.1	
G-11	0.007286	121	120.8	123.5	
G-12	0.006727	112	111.8	114.4	
G-102	0.006549	109	108.9	111.4	

Table 2. (Continued)

Sample No.	Kawano and Ueda, 1965a		Recalculated K-Ar date (Ma)		Remarks
	$^{40}Ar^{*}/^{40}K$	K-Ar age (Ma)	-1977 constants	1977 constants	
G-119	0.006829	114	113.5	116.0	
G-40	0.006855	114	113.9	116.5	
G-41	0.007171	119	119.0	121.7	
G-1	0.007220	120	119.7	122.5	
G-2	0.007339	122	121.7	124.4	
G-118	0.007336	122	121.6	124.4	
G-113	0.006583	110	109.5	112.0	
G-111	0.007363	122	122.0	124.8	
G-112	0.007181	119	119.1	121.8	
G-107	0.007228	120	119.9	122.6	
G-42	0.007186	119	119.2	121.9	
G-115	0.007792	129	128.9	131.8	
G-15	0.007073	117	117.4	120.1	
G-16	0.007271	121	120.6	123.3	
G-17	0.007404	123	122.7	125.5	
G-18	0.007213	120	119.6	122.4	
G-108	0.007058	117	117.1	119.8	
G-109	0.006874	114	114.2	116.8	
G-43	0.006711	112	111.5	114.1	
G-116	0.007599	126	125.8	128.7	
G-117	0.007786	128	128.8	131.7	
G-44	0.007008	116	116.3	119.0	
G-45	0.006078	107	101.3	103.6	
G-5	0.009980	164	163.6	167.2	Bi
G-5	0.013738	222	221.7	226.3	Or
G-3	0.006838	114	113.6	116.2	
G-90	0.005301	89	88.7	90.7	
G-120	0.007241	120	120.1	122.8	
G-21	0.006521	109	108.5	111.0	
G-22	0.007173	119	119.0	121.7	

N.B.

Bi and Or in remarks respectively denote mineral type biotite and orthoclase.

Table 3. List of recalculated K-Ar dates published in Table 3 of Kawano and Ueda, 1965b

Sample No.	Kawano and Ueda, 1965b		Recalculated K-Ar date (Ma)		Remarks
	$^{40}Ar^{*}/^{40}K$	K-Ar age (Ma)	-1977 constants	1977 constants	
G-153	0.005413	91	90.3	92.6	
G-154	0.005313	89	88.7	90.9	
G-145	0.005367	90	89.6	91.8	
G-143	0.005701	95	95.0	97.4	
G-142	0.006023	100	100.2	102.7	
G-158	0.005426	91	90.5	92.8	
G-141	0.005490	92	91.6	93.9	
Gb-134	0.005167	87	86.3	88.5	
G-132	0.005355	90	89.4	91.6	
G-135	0.005383	90	89.8	92.1	
G-125	0.006442	107	107.0	109.7	
G-130	0.005885	98	98.0	100.4	
G-129	0.005523	93	92.1	94.4	
G-24	0.00606	101	100.8	103.3	
G-25	0.00616	103	102.5	105.0	
G-122	0.006258	104	104.0	106.6	
G-124	0.005307	89	88.6	90.8	
G-46	0.005434	90	90.7	92.9	
G-159	0.018957	300	299.0	305.4	

Table 4. List of recalculated K-Ar dates published in Table 1 of Kawano and Ueda, 1966a

Sample No.	Kawano and Ueda, 1966a		Recalculated K-Ar date (Ma)		Remarks
	$^{40}Ar^{*}/^{40}K$	K-Ar age (Ma)	-1977 constants	1977 constants	
G-246	0.007506	124	124.3	127.1	
G-245	0.006652	111	110.6	113.1	
H-171	0.006479	108	107.8	110.3	
G-193	0.005681	95	94.9	97.0	
G-263	0.005541	93	92.6	94.7	
G-20	0.003765	63	63.4	64.9	
G-170	0.001082	18	18.4	18.9	
G-250	0.000680	12	11.6	11.9	
G-250	0.000874	15	14.9	15.3	
G-161	0.006123	102	102.0	104.4	
G-272	0.005305	89	88.7	90.8	
G-98	0.005250	88	87.8	89.9	
G-273	0.004698	79	78.8	80.6	
G-160	0.006171	103	102.8	105.2	
G-55	0.005933	99	98.9	101.2	
D-28	0.005828	97	97.2	99.5	
G-188	0.003642	61	61.4	62.8	
G-181	0.003492	59	58.9	60.3	
G-183	0.003228	55	54.5	55.8	
G-187	0.004215	71	70.8	72.5	
G-184	0.003727	63	62.8	64.3	
G-186	0.005173	87	86.6	88.6	
G-185	0.005305	89	88.7	90.8	
G-182	0.005096	85	85.3	87.3	
G-228	0.005030	84	84.2	86.2	
G-230	0.005881	98	98.1	100.4	
G-231	0.003204	54	54.1	55.4	
G-232	0.003748	63	63.1	64.6	
G-260	0.005516	92	92.2	94.3	

Table 4. (Continued)

Sample No.	Kawano and Ueda, 1966a		Recalculated K-Ar date (Ma)		Remarks
	$^{40}Ar^{*}/^{40}K$	K-Ar age (Ma)	-1977 constants	1977 constants	
G-254	0.005251	88	87.8	89.9	
G-274	0.005379	90	89.9	92.0	
G-271	0.003911	66	65.8	67.4	
G-261	0.003988	67	67.1	68.7	
G-223	0.003379	57	57.0	58.4	
Gp-268	0.001189	20	20.3	20.7	
G-270	0.000347	5.9	5.9	6.1	
G-269	0.001425	24	24.2	24.8	
G-52	0.003934	66	66.2	67.8	
G-266	0.003472	59	58.5	59.9	
G-265	0.004990	84	83.6	85.5	
G-58	0.007041	116	116.9	119.5	
G-51	0.003166	53	53.4	54.7	
G-264	0.003764	63	63.4	64.9	
G-53	0.005218	87	87.3	89.3	
G-277	0.003705	62	62.4	63.9	
G-278	0.003740	63	63.0	64.5	
G-279	0.003515	59	59.2	60.7	
G-280	0.003506	59	59.1	60.5	
G-281	0.003506	59	59.1	60.5	
G-189	0.000302	5.2	5.2	5.3	
G-191	0.000249	4.3	4.3	4.4	
G-74	0.000442	7.6	7.6	7.7	
G-82	0.000470	8	8.0	8.2	
G-85	0.000429	7.3	7.3	7.5	
G-262	0.000710	12	12.1	12.4	
G-282	0.000812	14	13.9	14.2	
G-194	0.000661	11	11.3	11.6	
G-66	0.000499	8.5	8.5	8.7	
G-60	0.000501	8.6	8.6	8.8	
G-283	0.001210	21	20.6	21.1	

Table 5. List of recalculated K-Ar dates published in Table 1 of Kawano and Ueda, 1966b

Sample No.	Kawano and Ueda, 1966b		Recalculated K-Ar date (Ma)		Remarks
	$^{40}Ar^{*}/^{40}K$	K-Ar age (Ma)	-1977 constants	1977 constants	
G-295	0.000168	3	2.9	2.9	
G-294	0.010656	174	174.2	178.0	
G-374	0.008682	143	143.1	146.3	
G-376	0.005982	100	99.7	102.0	
G-297	0.002403	41	40.7	41.7	
G-298	0.002997	51	50.6	51.8	
G-299	0.003184	54	53.7	55.0	
G-307	0.010999	180	179.5	183.4	
G-308	0.009928	163	162.8	166.3	
G-309	0.009476	156	155.7	159.1	
G-99	0.003560	60	60.0	61.4	
G-225	0.003609	61	60.8	62.3	
G-226	0.003787	64	63.8	65.3	
G-227	0.003847	65	64.7	66.3	
G-179	0.003958	67	66.6	68.2	
G-174	0.003928	66	66.1	67.7	
G-177	0.004257	72	71.5	73.2	
G-285	0.003860	65	65.0	66.5	
G-286	0.003980	67	66.9	68.5	
G-310	0.003818	64	64.3	65.8	
G-314	0.003914	67	65.9	67.4	
G-311	0.003665	62	61.7	63.2	
G-312	0.003735	63	62.9	64.4	
G-313	0.004352	73	73.1	74.8	

N.B.

#: Doubtful K-Ar date in the original literature

Table 5. (Continued)

Sample No.	Kawano and Ueda, 1966b		Recalculated K-Ar date (Ma)		Remarks
	$^{40}Ar^{*}/^{40}K$	K-Ar age (Ma)	-1977 constants	1977 constants	
G-301	0.004350	73	73.1	74.8	
G-306	0.003849	65	64.8	66.3	
G-304	0.003435	58	57.9	59.3	
G-303	0.004630	78	77.7	79.5	
G-257	0.004775	80	80.0	81.9	
G-251	0.004335	73	72.8	74.5	
G-252	0.004547	76	76.3	78.1	
G-253	0.004565	77	76.6	78.4	
G-247	0.004607	77	77.3	79.1	
G-241	0.004488	75	75.3	77.1	
G-242	0.004270	72	71.7	73.4	
G-243	0.004124	69	69.3	71.0	
G-300	0.003491	59	58.8	60.3	
G-302	0.003789	64	63.8	65.3	
G-238	0.004057	68	68.2	69.8	
G-240	0.003253	55	54.9	56.2	
G-199	0.003560	60	60.0	61.4	
G-196	0.003699	62	62.3	63.8	
G-198	0.002217	38	37.6	38.5	
G-197	0.002170	38	36.8	37.7	
G-220	0.003725	63	62.7	64.2	
G-195	0.003540	60	59.7	61.1	
G-221	0.003720	63	62.6	64.1	
G-222	0.003001	51	50.7	51.9	
G-315	0.001474	25	25.1	25.7	
G-316	0.001983	34	33.7	34.5	
G-168	0.002095	36	35.5	36.4	

Table 5. (Continued)

Sample No.	Kawano and Ueda, 1966b		Recalculated K-Ar date (Ma)		Remarks
	$^{40}Ar^{*}/^{40}K$	K-Ar age (Ma)	-1977 constants	1977 constants	
G-239	0.005104	85	85.4	87.4	
G-334	0.004703	79	78.9	80.7	
G-256	0.005064	85	84.8	86.8	
G-166	0.004816	81	80.7	82.6	
G-259	0.004257	72	71.5	73.2	
G-27	0.004628	78	77.6	79.5	
G-110	0.005021	84	84.1	86.0	
G-258	0.004730	96	79.3	81.2	#
G-172	0.005197	87	87.0	89.0	
G-26	0.004439	75	74.5	76.3	
G-326	0.004265	72	71.7	73.3	
G-337	0.005288	88	88.4	90.5	
G-336	0.004167	70	70.0	71.7	
G-335	0.004770	80	80.0	81.8	
G-328	0.004556	76	76.4	78.2	
G-287	0.005177	87	86.6	88.6	
G-233	0.005440	91	90.9	93.0	
G-235	0.004930	83	82.6	84.5	
G-164	0.005087	85	85.2	87.1	
G-332	0.005035	84	84.3	86.3	
G-163	0.005025	84	84.1	86.1	
G-320	0.005125	86	85.8	87.8	
G-165	0.004991	84	83.6	85.5	
G-321	0.006717	112	111.6	114.2	
G-325	0.005686	95	94.9	97.1	
G-167	0.004925	83	82.5	84.4	
G-317	0.005494	92	91.8	93.9	
G-318	0.010500	172	171.7	175.5	
G-323	0.005461	91	91.3	93.4	
G-319	0.004682	79	78.5	80.4	
G-324	0.027749	424	423.8	431.1	
G-322	0.005501	92	91.9	94.1	

Table 5. (Continued)

Sample No.	Kawano and Ueda, 1966b		Recalculated K-Ar date (Ma)		Remarks
	$^{40}Ar^{*}/^{40}K$	K-Ar age (Ma)	-1977 constants	1977 constants	
G-347	0.005319	89	88.9	91.0	
G-348	0.005503	92	92.0	94.1	
G-345	0.005666	93	94.6	96.8	
G-346	0.005605	94	93.6	95.8	
G-349	0.005452	91	91.1	93.2	
G-352	0.005650	94	94.3	96.5	
G-351	0.005423	91	90.6	92.8	
G-350	0.005522	92	92.3	94.4	
G-275	0.005653	86	94.4	96.6	#
G-353	0.005375	89	89.9	92.0	
G-255	0.005650	94	94.3	96.5	
G-344	0.005461	91	91.3	93.4	
G-343	0.004770	80	80.0	81.8	
G-338	0.005380	90	89.9	92.0	
G-341	0.005339	89	89.3	91.4	
G-340	0.004528	76	76.0	77.8	
G-339	0.005116	86	85.6	87.6	
G-354	0.004953	83	83.0	84.9	
G-355	0.004897	82	82.0	84.0	
G-290	0.005238	88	87.6	89.7	
G-357	0.005213	87	87.2	89.2	
G-356	0.004123	69	69.3	70.9	
G-363	0.005780	97	96.5	98.7	
G-358	0.004771	80	80.0	81.9	
G-362	0.024020	372	372.1	378.9	
G-361	0.012925	209	209.3	213.7	
Gp-67	0.000972	17	16.6	17.0	
G-364	0.000738	13	12.6	12.9	
G-259	0.000628	11	10.7	11.0	
G-48	0.000785	13	13.4	13.7	
G-49	0.001324	22	22.5	23.1	
G-366	0.000689	12	11.8	12.1	
G-100	0.003630	61	61.2	62.6	
G-365	0.001255	21	21.4	21.9	

Table 6. List of recalculated K-Ar dates published in Table 1 of Kawano and Ueda, 1967

Sample No.	Kawano and Ueda, 1967		Recalculated K-Ar date (Ma)		Remarks
	$^{40}Ar^{*}/^{40}K$	K-Ar age (Ma)	-1977 constants	1977 constants	
G-395	0.001766	30	30.0	30.7	
G-396	0.001347	23	22.9	23.5	
G-397	0.001832	31	31.1	31.9	
G-398	0.001881	32	31.9	32.7	
G-399	0.002116	36	35.9	36.8	
G-378	0.001009	17	17.2	17.6	
G-379	0.000495	8	8.5	8.7	
G-291	0.006625	110	110.2	112.7	
G-292	0.005253	88	87.9	89.9	
G-293	0.006078	101	101.3	103.6	
G-383	0.002524	43	42.7	43.8	
G-384	0.002365	40	40.1	41.0	
G-385	0.002858	48	48.3	49.5	
G-386	0.002989	51	50.5	51.7	
G-387	0.002122	36	36.0	36.9	
G-388	0.002820	48	47.7	48.8	
G-389	0.003453	58	58.2	59.6	
G-390	0.002595	44	43.9	45.0	
G-391	0.002694	46	45.6	46.7	
G-392	0.002903	49	49.1	50.2	
G-393	0.002550	43	43.2	44.2	
G-394	0.003082	52	52.0	53.3	

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