Tables to Support the Analytical Methods in Use at MURR: NAA, XRF and ICP-MS

by

Michael D. Glascock
Research Reactor Center
University of Missouri
Columbia, MO 65211

PREFACE

Tables to Support the Analytical Methods in Use at MURR: NAA, XRF and ICP-MS became needed after earlier editions of this book were exhausted. This edition of the book provides information useful for all analytical methods employed at MURR such as Neutron Activation Analysis, X-ray Fluorescence (XRF), and various methods of Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The latter includes conventional ICP-MS, laser ablation ICP-MS, and multi-collector ICP-MS. Errors from earlier editions have been corrected. It is hoped that this book will continue to prove useful to students and colleagues using one or more of the analytical methods at MURR.

Michael D. Glascock
Research Reactor Center
University of Missouri
Columbia, MO 65211
USA

Phone number: (573) 882-5270

FAX number: (573-882-6360

Email address: glascockm@missouri.edu

Table of Contents

Table of Contents (continued)

REFERENCES USED FOR TABLES

Anders, E. & N. Grevesse (1989). *Geochimica Cosmochimica Acta*, 53: 197-214.

Baum, E.M., H.D. Knox & T.R. Miller (2002). *Nuclides and Isotopes: Chart of the Nuclides*, 16th edition, Knolls Atomic Power Laboratory, Lockheed Martin.

Blaauw, M. (1996). *The k_0-Consistent IRI Gamma-ray Catalogue for INAA*. Interfacultair Reactor Instituut van de Technische Universiteit Delft.

Brammer standards homepage: http://www.brammerstandard.com/

Calamand, A. (1974). Cross-sections for fission neutron spectrum induced reactions. *Handbook on Nuclear Activation Cross-Sections*, IAEA Technical Reports Serial No. 156 (IAEA, Vienna) pp. 273-309.

Chu, S.Y.F., L.P. Ekstrom and R.B. Firestone (1999).
The Lund/LBNL Nuclear Data Search, version 2.0: *http://nucleardata.nuclear.lu.se/toi/*

Coursey, J. S., D. J. Schwab & R. A. Dragoset (2005). Atomic weights and isotopic compositions with relative atomic masses. National Institutes of Standards and Technology Standard Reference Database 144, http://physics.nist.gov/PhysRefData/Compositions/.

De Bievre, P. and I.L. Barnes (1985). *International Journal of Mass Spectrometry and Ion Processes* **65:** 211.

De Corte, Franz (1987). *The k_0-Standardization Method: A Move to the Optimization of Neutron Activation Analysis.* Rijksuniversiteit, Gent.

Firestone, R.B. (1996). *Table of Isotopes: Volumes I & II (8th edition)*, edited by V.S. Shirley, C.M. Baglin, S.Y. Frank Chu & Jean Zipkin. Wiley-Interscience, New York, NY, 3168 p.

GeoREM website at the University of Mainz, Germany. http://georem.mpch-mainz.gwdg.de/

Gladney, E.S. and C.E. Burns (1983). *Geostandards Newsletter VII*.

Gladney, E.S., B.T. O'Malley, I. Roelandts & T.R. Gills (1987). *NBS Special Publication 260-111*, 531 p.

Glascock, M.D., W.Z. Tian & W.H. Ehmann (1985). *Journal of Radioanalytical and Nuclear Chemistry,* 92: 379-390.

Gromet, L.P., R.F. Dymek, L.A. Haskin & R.L. Korotev (1984). *Geochimica Cosmochimica Acta,* 48: 2469-2482.

Gryntakis, E.M. amd J.I. Kim (1983). *Journal of Radioanalytical Chemistry,* 76(2): 341-496.

Haskin, L.A., M.A. Haskin & F.A. Frey (1968). In *Origin and Distribution of the Elements*, ed. Ahrens, L.H., Oxford: Pergamon, p. 889-912.

Hughes, M. (2007). Neutron activation analysis at the British Museum, London. *Archaeometry* 49(2): 255-270.

Korotev, R.L. (1991). Personnel communication.

Kuleff, I. & R. Djingova (1998). *Journal of Radioanalytical and Nuclear Chemistry*, 237: 3-6.
Kuleff, I & Pernicka, E. (2002). INAA of some geological standard reference materials. *Journal of Radioanalytical and Nuclear Chemistry*, 251(1): 139-143.

Laul, J.C. (1979). *Atomic Energy Review,* 17: 603-695.

Lude, David R. (1996). *Handbook of Chemistry and Physics*, 75th edition, CRC Press.

Masuda, A., N. Nakamura & T. Tanaka (1973). *Geochimica Cosmochimica Acta,* 37: 239-248.

Mughabghab, S.F. (2006). *Atlas of Neutron Resonances: Resonance Parameters and Thermal Cross Sections.* Elsevier Science Ltd.

Mughabghab, S.F., M. Divadeenam & N. E. Holden (1981). *Neutron Cross Sections from Neutron Resonance Parameters and Thermal Cross Sections, Part A, Z=1-60*. Academic Press.

Mughabghab, S.F., M. Divadeenam & N. E. Holden (1983). *Neutron cross sections from Neutron Resonanace Parameters and Thermal Cross Sections, Part B, Z=61-100.* Academic Press.

Nakamura, N. (1974). *Geochimica Cosmochimica Acta,* 38: 757-775.

Perlman, I. & Asaro, F. (1969). Pottery analysis by neutron activation. *Archaeometry* 11: 21-52.

Taylor, S.R. & S.M. McLennan (1985). *The Continental Crust—Its Composition and Evolution*, Blackwell Scientific Publication, Oxford, England, 312 p.

Table 1. Atomic weights, isotope abundances, and densities for the elements.

Atomic Number	Element Name	Isotope	Relative Atomic Mass	Isotope Abundance (%)	Standard Atomic Weight	Density (g/cm^3)
1	Hydrogen	H-1 (p)	1.007 825	99.9885	1.0079	8.9E-05
		H-2 (d)	2.014 102	0.0115		
		H-3 (t)	3.016 049	---		
2	Helium	He-3	3.016 029	0.00013	4.0026	1.78E-04
		He-4 (α)	4.002 603	99.999866		
3	Lithium	Li-6	6.015 123	7.59	6.9410	0.53
		Li-7	7.016 005	92.41		
4	Beryllium	Be-9	9.012 182	100	9.0122	1.85
5	Boron	B-10	10.012 937	19.9	10.8110	2.3
		B-11	11.009 305	80.1		
6	Carbon	C-12	12.000 000	98.93	12.0107	1.6
		C-13	13.003 355	1.07		(graphite)
		C-14	14.003 242	---		
7	Nitrogen	N-14	14.003 074	99.636	14.0067	1.3E-03
		N-15	15.000 109	0.364		
8	Oxygen	O-16	15.994 915	99.757	15.9994	1.4E-03
		O-17	16.999 132	0.038		
		O-18	17.999 161	0.205		
9	Fluorine	F-19	18.998 403	100	18.9984	1.7E-03
10	Neon	Ne-20	19.992 440	90.48	20.1797	9.0E-04
		Ne-21	20.993 847	0.27		
		Ne-22	21.991 385	9.25		
11	Sodium	Na-23	22.989 769	100	22.9898	0.97
12	Magnesium	Mg-24	23.985 042	78.99	24.3050	1.74
		Mg-25	24.985 837	10.00		
		Mg-26	25.982 593	11.01		
13	Aluminum	Al-27	26.981 539	100	26.9815	2.699
14	Silicon	Si-28	27.976 927	92.223	28.0855	2.33
		Si-29	28.976 495	4.685		
		Si-30	29.973 770	3.092		
15	Phosphorus	P-31	30.973 762	100	30.9738	1.82
16	Sulfur	S-32	31.972 071	94.99	32.0650	2.07
		S-33	32.971 459	0.75		
		S-34	33.967 867	4.25		
		S-36	35.967 081	0.01		
17	Chlorine	Cl-35	34.968 853	75.76	35.4530	3.20E-03
		Cl-37	36.965 903	24.24		
18	Argon	Ar-36	35.967 545	0.3365	39.9480	1.80E-03
		Ar-38	37.962 732	0.0632		
		Ar-40	39.962 383	99.6003		

Table 1. Atomic weights, isotope abundances, and densities for the elements.

Atomic Number	Element Name	Isotope	Relative Atomic Mass	Isotope Abundance (%)	Standard Atomic Weight	Density (g/cm^3)
19	Potassium	K-39	38.963 707	93.2581	39.0983	0.86
		K-40	39.963 999	0.0117		
		K-41	40.961 826	6.7302		
20	Calcium	Ca-40	39.962 591	96.941	40.0780	1.55
		Ca-42	41.958 618	0.647		
		Ca-43	42.958 767	0.135		
		Ca-44	43.955 482	2.086		
		Ca-46	45.953 693	0.004		
		Ca-48	47.952 534	0.187		
21	Scandium	Sc-45	44.955 912	100	44.9559	2.5
22	Titanium	Ti-46	45.952 632	8.25	47.8670	4.51
		Ti-47	46.951 763	7.44		
		Ti-48	47.947 946	73.72		
		Ti-49	48.947 870	5.41		
		Ti-50	49.944 791	5.18		
23	Vanadium	V-50	49.947 159	0.25	50.9415	6.1
		V-51	50.943 960	99.75		
24	Chromium	Cr-50	49.946 044	4.345	51.9961	7.19
		Cr-52	51.940 508	83.789		
		Cr-53	52.940 649	9.501		
		Cr-54	53.938 880	2.365		
25	Manganese	Mn-55	54.938 045	100	54.9380	7.43
26	Iron	Fe-54	53.939 611	5.845	55.8450	7.87
		Fe-56	55.934 938	91.754		
		Fe-57	56.935 394	2.119		
		Fe-58	57.933 276	0.282		
27	Cobalt	Co-59	58.933 195	100	58.9332	8.8
28	Nickel	Ni-58	57.935 343	68.0769	58.6934	8.9
		Ni-60	59.930 786	26.2231		
		Ni-61	60.931 056	1.1399		
		Ni-62	61.928 345	3.6345		
		Ni-64	63.927 966	0.9256		
29	Copper	Cu-63	62.929 598	69.15	63.5460	8.96
		Cu-65	64.927 790	30.85		
30	Zinc	Zn-64	63.929 142	48.268	65.3800	7.133
		Zn-66	65.926 033	27.975		
		Zn-67	66.927 127	4.102		
		Zn-68	67.924 844	19.024		
		Zn-70	69.925 319	0.631		
31	Gallium	Ga-69	68.925 574	60.108	69.7230	5.91
		Ga-71	70.924 701	39.892		
32	Germanium	Ge-70	69.924 247	20.38	72.6400	5.36
		Ge-72	71.922 076	27.31		
		Ge-73	72.923 459	7.76		
		Ge-74	73.921 178	36.72		
		Ge-76	75.921 403	7.83		

Table 1. Atomic weights, isotope abundances, and densities for the elements.

Atomic Number	Element Name	Isotope	Relative Atomic Mass	Isotope Abundance (%)	Standard Atomic Weight	Density (g/cm^3)
33	Arsenic	As-75	74.921 597	100	74.9216	5.73
34	Selenium	Se-74	73.922 476	0.89	78.9600	4.81
		Se-76	75.919 214	9.37		
		Se-77	76.919 914	7.63		
		Se-78	77.917 309	23.77		
		Se-80	79.916 521	49.61		
		Se-82	81.916 699	8.73		
35	Bromine	Br-79	78.918 337	50.69	79.9040	7.60E-03
		Br-81	80.916 291	49.31		
36	Krypton	Kr-78	77.920 365	0.355	83.7980	3.70E-03
		Kr-80	79.916 379	2.286		
		Kr-82	81.913 484	11.593		
		Kr-83	82.914 136	11.500		
		Kr-84	83.911 507	56.987		
		Kr-86	85.910 611	17.279		
37	Rubidium	Rb-85	84.911 790	72.17	85.4678	1.53
		Rb-87	86.909 181	27.83		
38	Strontium	Sr-84	83.913 425	0.56	87.6200	2.6
		Sr-86	85.909 260	9.86		
		Sr-87	86.908 877	7.00		
		Sr-88	87.905 612	82.58		
39	Yttrium	Y-89	88.905 848	100	88.9059	5.51
40	Zirconiim	Zr-90	89.904 704	51.45	91.2240	6.5
		Zr-91	90.905 646	11.22		
		Zr-92	91.905 041	17.15		
		Zr-94	93.906 315	17.38		
		Zr-96	95.908 273	2.80		
41	Niobium	Nb-93	92.906 378	100	92.9064	8.57
42	Molybdenum	Mo-92	91.906 811	14.77	95.960	10.2
		Mo-94	93.905 088	9.23		
		Mo-95	94.905 842	15.9		
		Mo-96	95.904 680	16.68		
		Mo-97	96.906 022	9.56		
		Mo-98	97.905 408	24.19		
		Mo-100	99.907 477	9.67		
43	Technetium	Tc-96	96.906 365	---	[98]	11.0
		Tc-97	97.097 216	---		
		Tc-98	98.906 255	---		
44	Ruthenium	Ru-96	95.907 598	5.54	101.070	12.2
		Ru-98	97.905 287	1.87		
		Ru-99	98.905 939	12.76		
		Ru-100	99.904 220	12.60		
		Ru-101	100.905 582	17.06		
		Ru-102	101.904 349	31.55		
		Ru-104	103.905 433	18.62		

Table 1. Atomic weights, isotope abundances, and densities for the elements.

Atomic Number	Element Name	Isotope	Relative Atomic Mass	Isotope Abundance (%)	Standard Atomic Weight	Density (g/cm^3)
45	Rhodium	Rh-103	102.905 504	100	102.910	12.41
46	Palladium	Pd-102	101.905 609	1.02	106.420	12.0
		Pd-104	103.904 036	11.14		
		Pd-105	104.905 085	22.33		
		Pd-106	105.903 486	27.33		
		Pd-108	107.903 892	26.46		
		Pd-110	109.905 153	11.72		
47	Silver	Ag-107	106.905 097	51.839	107.870	10.49
		Ag-109	108.904 752	48.161		
48	Cadmium	Cd-106	105.906 459	1.25	112.410	8.65
		Cd-108	107.904 184	0.89		
		Cd-110	109.903 002	12.49		
		Cd-111	110.904 178	12.80		
		Cd-112	111.902 758	24.13		
		Cd-113	112.904 402	12.22		
		Cd-114	113.903 359	28.73		
		Cd-116	115.904 756	7.49		
49	Indium	In-113	112.904 058	4.29	114.818	7.31
		In-115	114.903 878	95.71		
50	Tin	Sn-112	111.904 818	0.97	118.710	7.298
		Sn-114	113.902 779	0.66		
		Sn-115	114.903 342	0.34		
		Sn-116	115.901 741	14.54		
		Sn-117	116.902 952	7.68		
		Sn-118	117.901 603	24.22		
		Sn-119	118.903 308	8.59		
		Sn-120	119.902 195	32.58		
		Sn-122	121.903 439	4.63		
		Sn-124	123.905 274	5.79		
51	Antimony	Sb-121	120.903 816	57.21	121.76	6.62
		Sb-123	122.904 214	42.79		
52	Tellurium	Te-120	119.904 020	0.09	127.60	6.24
		Te-122	121.903 044	2.55		
		Te-123	122.904 270	0.89		
		Te-124	123.902 818	4.74		
		Te-125	124.904 431	7.07		
		Te-126	125.903 312	18.84		
		Te-128	127.904 463	31.74		
		Te-130	129.906 224	34.08		
53	Iodine	I-127	126.904 473	100	126.90	1.13E-02
54	Xenon	Xe-124	123.905 893	0.0952	131.29	5.90E-03
		Xe-126	125.904 274	0.0890		
		Xe-128	127.903 531	1.9102		
		Xe-129	128.904 779	26.4006		
		Xe-130	129.903 508	4.0710		
		Xe-131	130.905 082	21.2324		
		Xe-132	131.904 154	26.9086		
		Xe-134	133.905 395	10.4357		
		Xe-136	135.907 219	8.8573		

Table 1. Atomic weights, isotope abundances, and densities for the elements.

Atomic Number	Element Name	Isotope	Relative Atomic Mass	Isotope Abundance (%)	Standard Atomic Weight	Density (g/cm^3)
55	Cesium	Cs-133	132.905 452	100	132.91	1.87
56	Barium	Ba-130	129.906 321	0.106	137.33	3.5
		Ba-132	131.905 061	0.101		
		Ba-134	133.904 508	2.417		
		Ba-135	134.905 689	6.592		
		Ba-136	135.904 576	7.854		
		Ba-137	136.905 827	11.232		
		Ba-138	137.905 247	71.698		
57	Lanthanum	La-138	137.907 112	0.09	138.91	6.19
		La-139	138.906 353	99.91		
58	Cerium	Ce-136	135.907 172	0.185	140.12	6.78
		Ce-138	137.905 991	0.251		
		Ce-140	139.905 439	88.450		
		Ce-142	141.909 244	11.114		
59	Praseodymium	Pr-141	140.907 653	100	140.91	6.78
60	Neodymium	Nd-142	141.907 723	27.2	144.24	6.98
		Nd-143	142.909 814	12.2		
		Nd-144	143.910 088	23.8		
		Nd-145	144.912 574	8.3		
		Nd-146	145.913 117	17.2		
		Nd-148	147.916 893	5.7		
		Nd-150	149.920 891	5.6		
61	Promethium	Pm-145	144.912 749	--	[145]	7.26
		Pm-147	146.915 139	--		
62	Samarium	Sm-144	143.911 999	3.07	150.36	6.93
		Sm-147	146.914 898	14.99		
		Sm-148	147.914 823	11.24		
		Sm-149	148.917 185	13.82		
		Sm-150	149.917 276	7.38		
		Sm-152	151.919 732	26.75		
		Sm-154	153.922 209	22.75		
63	Europium	Eu-151	150.919 850	47.81	151.96	5.22
		Eu-153	152.921 230	52.19		
64	Gadolinium	Gd-152	151.919 791	0.20	157.25	7.95
		Gd-154	153.920 866	2.18		
		Gd-155	154.922 622	14.80		
		Gd-156	155.922 123	20.47		
		Gd-157	156.923 960	15.65		
		Gd-158	157.924 104	24.84		
		Gd-160	159.927 054	21.86		
65	Terbium	Tb-159	158.925 347	100	158.93	8.33
66	Dysprosium	Dy-156	155.924 283	0.056	162.50	8.56
		Dy-158	157.924 409	0.095		
		Dy-160	159.925 198	2.329		
		Dy-161	160.926 933	18.889		
		Dy-162	161.926 798	25.475		
		Dy-163	162.928 731	24.896		
		Dy-164	163.929 175	28.260		

Table 1. Atomic weights, isotope abundances, and densities for the elements.

Atomic Number	Element Name	Isotope	Relative Atomic Mass	Isotope Abundance (%)	Standard Atomic Weight	Density (g/cm^3)
67	Holmium	Ho-165	164.930 322	100	164.93	8.76
68	Erbium	Er-162	161.928 778	0.139	167.26	9.16
		Er-164	163.929 200	1.601		
		Er-166	165.930 293	33.503		
		Er-167	166.932 048	22.869		
		Er-168	167.932 370	26.978		
		Er-170	169.935 464	14.910		
69	Thulium	Tm-169	168.934 213	100	168.93	9.35
70	Ytterbium	Yb-168	167.933 897	0.13	173.05	7.01
		Yb-170	169.934 762	3.04		
		Yb-171	170.936 326	14.28		
		Yb-172	171.936 382	21.83		
		Yb-173	172.938 211	16.13		
		Yb-174	173.938 862	31.83		
		Yb-176	175.942 572	12.76		
71	Lutetium	Lu-175	174.940 772	97.41	174.97	9.74
		Lu-176	175.942 686	2.59		
72	Hafnium	Hf-174	173.940 046	0.16	178.49	13.36
		Hf-176	175.941 409	5.26		
		Hf-177	176.943 221	18.60		
		Hf-178	177.943 699	27.28		
		Hf-179	178.945 816	13.62		
		Hf-180	179.946 550	35.08		
73	Tantalum	Ta-180	179.947 465	0.012	180.95	16.6
		Ta-181	180.947 996	99.988		
74	Tungsten	W-180	179.946 704	0.12	183.84	19.2
		W-182	181.948 204	26.50		
		W-183	182.950 223	14.31		
		W-184	183.950 931	30.64		
		W-186	185.954 364	28.43		
75	Rhenium	Re-185	184.952 955	37.40	186.21	20.0
		Re-187	186.955 753	62.60		
76	Osmium	Os-184	183.952 489	0.02	190.23	22.5
		Os-186	185.953 838	1.59		
		Os-187	186.955 751	1.96		
		Os-188	187.955 838	13.24		
		Os-189	188.958 148	16.15		
		Os-190	189.958 447	26.26		
		Os-192	191.961 481	40.78		
77	Iridium	Ir-191	190.960 594	37.30	192.22	22.5
		Ir-193	192.962 926	62.70		
78	Platinum	Pt-190	189.959 932	0.014	195.08	21.45
		Pt-192	191.961 038	0.782		
		Pt-194	193.962 680	32.967		
		Pt-195	194.964 791	33.832		
		Pt-196	195.964 952	25.242		
		Pt-198	197.967 893	7.163		

Table 1. Atomic weights, isotope abundances, and densities for the elements.

Atomic Number	Element Name	Isotope	Relative Atomic Mass	Isotope Abundance (%)	Standard Atomic Weight	Density (g/cm^3)
79	Gold	Au-197	196.966 569	100	196.97	19.32
80	Mercury	Hg-196	195.965 833	0.15	200.59	13.55
		Hg-198	197.966 769	9.97		
		Hg-199	198.968 280	16.87		
		Hg-200	199.968 326	23.10		
		Hg-201	200.970 302	13.18		
		Hg-202	201.970 643	29.86		
		Hg-204	203.973 494	6.87		
81	Thallium	Tl-203	202.972 344	29.52	204.38	11.85
		Tl-205	204.974 428	70.48		
82	Lead	Pb-204	203.973 044	1.4	207.20	11.34
		Pb-206	205.974 465	24.1		
		Pb-207	206.975 897	22.1		
		Pb-208	207.976 652	52.4		
83	Bismuth	Bi-209	208.980 399	100	208.98	9.8
84	Polonium	Po-209	208.982 430	---	[209]	9.2
		Po-210	209.982 874	---		
85	Astatine	At-210	209.987 148	---	[210]	---
		At-211	210.987 496	---		
86	Radon	Rn-222	222.017 578	---	[222]	5.5
87	Francium	Fr-223	223.019 736	---	[223]	1.87
88	Radium	Ra-223	223.018 502	---	[226]	5.5
		Ra-224	224.020 212	---		
		Ra-226	226.025 410	---		
		Ra-228	228.031 070	---		
89	Actinium	Ac-227	227.027 752	---	[227]	10.0
90	Thorium	Th-230	230.033 134	---	232.04	11.71
		Th-232	232.038 055	100		
91	Protactinium	Pa-231	231.035 884	---	231.04	15.37
92	Uranium	U-233	233.039 635	---	238.03	19.1
		U-234	234.040 952	0.0055		
		U-235	235.043 930	0.7200		
		U-236	236.045 568	---		
		U-238	238.050 788	99.2745		
93	Neptunium	Np	---	---	[237]	20.45
94	Plutonium	Pu	---	---	[244]	19.82
95	Americium	Am	---	---	[243]	12.00
96	Curium	Cm	---	---	[247]	13.51
97	Berkelium	Bk	---	---	[247]	14.78
98	Californium	Cf	---	---	[251]	15.1

Table 2. Relative abundances of the naturally-occurring isotopes.

Mass Number	%	%	%	Mass Number	%	%	%	Mass Number	%	%	%	Mass Number	%	%	%
1	H 99.985			**61**			Ni 1.14	**121**			Sb 57.36	**181**	Ta 99.988		
2	H 0.015			**62**			Ni 3.634	**122**	Sn 4.63	Te 2.603		**182**		W 26.3	
3		He 0.00014		**63**	Cu 69.17			**123**		Te 0.908	Sb 42.64	**183**		W 14.3	
4		He 99.9999		**64**		Zn 48.6	Ni 0.926	**124**	Sn 5.79	Te 4.816	Xe 0.10	**184**	Os 0.02	W 30.67	
5				**65**	Cu 30.83			**125**		Te 7.139		**185**			Re 37.4
6			Li 7.5	**66**		Zn 27.9		**126**		Te 18.95	Xe 0.09	**186**	Os 1.58	W 28.6	
7			Li 92.5	**67**		Zn 4.1		**127**	I 100			**187**	Os 1.6		Re 82.6
8				**68**		Zn 18.8		**128**		Te 31.69	Xe 1.91	**188**	Os 13.3		
9	Be 100			**69**			Ga 60.108	**129**			Xe 26.4	**189**	Os 16.1		
10		B 19.9		**70**	Ge 21.23	Zn 0.6		**130**	Ba 0.106	Te 33.6	Xe 4.1	**190**	Os 26.4		Pt 0.01
11		B 80.1		**71**			Ga 39.892	**131**			Xe 21.2	**191**		Ir 37.3	
12			C 98.90	**72**	Ge 27.66			**132**	Ba 0.101		Xe 26.9	**192**	Os 41.0		Pt 0.79
13			C 1.10	**73**	Ge 7.73			**133**		Cs 100		**193**		Ir 62.7	
14	N 99.643			**74**	Ge 35.94	Se 0.69		**134**	Ba 2.417		Xe 10.4	**194**			Pt 32.9
15	N 0.366			**75**			As 100	**135**	Ba 6.592			**195**			Pt 33.8
16		O 99.762		**76**	Ge 7.44	Se 9.36		**136**	Ba 7.854	Ce 0.19	Xe 8.9	**196**	Hg 0.15		Pt 25.3
17		O 0.038		**77**		Se 7.63		**137**	Ba 11.23			**197**		Au 100	
18		O 0.200		**78**	Kr 0.35	Se 23.78		**138**	Ba 71.70	Ce 0.25	La 0.0902	**198**	Hg 9.97		Pt 7.2
19			F 100	**79**			Br 50.69	**139**			La 99.9098	**199**	Hg 16.87		
20	Ne 90.48			**80**	Kr 2.25	Se 49.61		**140**		Ce 88.48		**200**	Hg 23.10		
21	Ne 0.27			**81**			Br 49.31	**141**			Pr 100	**201**	Hg 13.18		
22	Ne 9.25			**82**	Kr 11.6	Se 8.73		**142**	Nd 27.13	Ce 11.08		**202**	Hg 29.86		
23		Na 100		**83**	Kr 11.5			**143**	Nd 12.18			**203**			Tl 29.524
24			Mg 78.99	**84**	Kr 57.0	Sr 0.56		**144**	Nd 23.80	Sm 3.1		**204**	Hg 6.87	Pb 1.4	
25			Mg 10.00	**85**			Rb 72.185	**145**	Nd 8.30			**205**			Tl 70.476
26			Mg 11.01	**86**	Kr 17.3	Sr 9.86		**146**	Nd 17.19			**206**		Pb 24.1	
27	Al 100			**87**		Sr 7.00	Rb 27.835	**147**		Sm 15.0		**207**		Pb 22.1	
28		Si 92.23		**88**		Sr 82.58		**148**	Nd 5.76	Sm 11.3		**208**		Pb 52.4	
29		Sl 4.67		**89**			Y 100	**149**		Sm 13.8		**209**	Bi 100		
30		Si 3.10		**90**	Zr 51.45			**150**	Nd 5.64	Sm 7.4		**210**			
31			P 100	**91**	Zr 11.22			**151**			Eu 47.8	**211**			
32	S 95.02			**92**	Zr 17.15	Mo 14.84		**152**	Gd 0.20	Sm 26.7		**212**			
33	S 0.75			**93**			Nb 100	**153**			Eu 52.2	**213**			
34	S 4.21			**94**	Zr 17.38	Mo 9.25		**154**	Gd 2.18	Sm 22.7		**214**			
35		Cl 75.77		**95**		Mo 15.92		**155**	Gd 14.80			**215**			
38	S 0.02		Ar 0.337	**96**	Zr 2.80	Mo 16.68	Ru 5.52	**156**	Gd 20.47	Dy 0.06		**216**			
37		Cl 24.23		**97**		Mo 9.55		**157**	Gd 15.65			**217**			
38			Ar 0.063	**98**		Mo 24.13	Ru 1.88	**158**	Gd 24.84	Dy 0.10		**218**			
39	K 93.2581			**99**			Ru 12.7	**159**			Tb 100	**219**			
40	K 0.0117	Ca 96.941	Ar 99.600	**100**		Mo 9.63	Ru 12.6	**160**	Gd 21.86	Dy 2.34		**220**			
41	K 6.7302			**101**			Ru 17.0	**161**		Dy 18.9		**221**			
42		Ca 0.647		**102**	Pd 1.02		Ru 31.6	**162**	Er 0.14	Dy 25.5		**222**			
43		Ca 0.135		**103**		Rh 100		**163**		Dy 24.9		**223**			
44		Ca 2.086		**104**	Pd 11.14		Ru 18.7	**164**	Er 1.61	Dy 28.2		**224**			
45			Sc 100	**105**	Pd 22.33			**165**			Ho 100	**225**			
46	Ti 8.0	Ca 0.004		**106**	Pd 27.33	Cd 1.25		**166**	Er 33.6			**226**			
47	Ti 7.3			**107**			Ag 51.839	**167**	Er 22.95			**227**			
48	Ti 73.8	Ca 0.187		**108**	Pd 26.46	Cd 0.89		**168**	Er 26.8	Yb 0.13		**228**			
49	Ti 5.5			**109**			Ag 48.161	**169**			Tm 100	**229**			
50	Ti 5.4	V 0.25	Cr 4.345	**110**	Pd 11.72	Cd 12.49		**170**	Er 14.9	Yb 3.05		**230**			
51		V 99.75		**111**		Cd 12.80		**171**		Yb 14.3		**231**	Pa 100		
52			Cr 83.789	**112**	Sn 0.97	Cd 24.13		**172**		Yb 21.9		**232**	Th 100		
53			Cr 9.501	**113**		Cd 12.22	In 4.3	**173**		Yb 16.12		**233**			
54	Fe 5.80		Cr 2.365	**114**	Sn 0.65	Cd 28.73		**174**		Yb 31.8	Hf 0.162	**234**	U 0.0055		
55		Mn 100		**115**	Sn 0.34		In 95.7	**175**	Lu 97.41			**235**	U 0.7200		
58	Fe 91.72			**116**	Sn 14.53	Cd 7.49		**176**	Lu 2.59	Yb 12.7	Hf 5.206	**236**			
57	Fe 2.20			**117**	Sn 7.68			**177**			Hf 18.606	**237**			
58	Fe 0.28		Ni 68.077	**118**	Sn 24.23			**178**			Hf 27.297	**238**	U 99.2745		
59		Co 100		**119**	Sn 8.59			**179**			Hf 13.629				
80			Ni 26.223	**120**	Sn 32.59	Te 0.096		**180**	Ta 0.012	W 0.13	Hf 35.100				

Table 3. Energies of the principal K-, L-, and M-shell X-rays in keV.

Z		Element Name	$K\alpha_1$	$K\beta_1$	$L\alpha_1$	$L\beta_1$	Z		Element Name	$K\alpha_1$	$K\beta_1$	$L\alpha_1$	$L\beta_1$	$M\alpha_1$	$M\beta_1$
10	Ne	Neon	0.85				53	I	Iodine	28.61	32.29	3.94	4.22		
11	Na	Sodium	1.04				54	Xe	Xenon	29.78	33.62	4.11	4.42		
12	Mg	Magnesium	1.25	1.30			55	Cs	Cesium	30.97	34.98	4.29	4.62		
13	Al	Aluminum	1.49	1.56			56	Ba	Barium	32.19	36.38	4.47	4.83		
14	Si	Silicon	1.74	1.84			57	La	Lanthanum	33.44	37.80	4.65	5.04		
15	P	Phosphorus	2.01	2.14			58	Ce	Cerium	34.72	39.26	4.84	5.26		
16	Si	Sulfur	2.31	2.47			59	Pr	Praseodymium	36.03	40.75	5.04	5.49		
17	Cl	Chlorine	2.62	2.81			60	Nd	Neodymium	37.36	42.27	5.23	5.72		
18	Ar	Argon	2.96	3.19			61	Pm	Promethium	38.73	43.83	5.43	5.96		
19	K	Potassium	3.31	3.59			62	Sm	Samarium	40.12	45.41	5.63	6.20		
20	Ca	Calcium	3.69	4.01	0.34	0.35	63	Eu	Europium	41.54	47.04	5.85	6.46		
21	Sc	Scandium	4.09	4.46	0.40	0.40	64	Gd	Gadolinium	43.00	48.70	6.05	6.71		
22	Ti	Titanium	4.51	4.93	0.45	0.46	65	Tb	Terbium	44.48	50.39	6.27	6.98	1.24	1.27
23	V	Vanadium	4.95	5.43	0.51	0.52	66	Dy	Dysprosium	46.00	52.11	6.50	7.25	1.29	1.33
24	Cr	Chromium	5.42	5.95	0.57	0.58	67	Ho	Holmium	47.55	53.88	6.72	7.53	1.35	1.38
25	Mn	Manganese	5.90	6.49	0.64	0.65	68	Er	Erbium	49.13	55.67	6.95	7.81	1.40	1.45
26	Fe	Iron	6.41	7.06	0.71	0.72	69	Tm	Thulium	50.74	57.51	7.18	8.10	1.46	1.50
27	Co	Cobalt	6.93	7.65	0.78	0.79	70	Yb	Ytterbium	52.39	59.38	7.42	8.40	1.53	1.57
28	Ni	Nickel	7.48	8.27	0.85	0.87	71	Lu	Lutetium	54.07	61.29	7.66	8.71	1.58	1.63
29	Cu	Copper	8.05	8.90	0.93	0.95	72	Hf	Hafnium	55.79	63.24	7.90	9.02	1.65	1.70
30	Zn	Zinc	8.64	9.57	1.01	1.04	73	Ta	Tantalum	57.54	65.22	8.15	9.34	1.71	1.77
31	Ga	Gallium	9.25	10.27	1.10	1.13	74	W	Tungsten	59.32	67.24	8.40	9.67	1.78	1.84
32	Ge	Germanium	9.89	10.98	1.19	1.22	75	Re	Rhenium	61.14	69.31	8.65	10.01	1.84	1.91
33	As	Arsenic	10.54	11.73	1.28	1.32	76	Os	Osmium	63.00	71.41	8.91	10.35	1.91	1.98
34	Se	Selenium	11.22	12.50	1.38	1.42	77	Ir	Iridium	64.90	73.56	9.18	10.71	1.98	2.05
35	Br	Bromine	11.92	13.29	1.48	1.53	78	Pt	Platinum	66.83	75.75	9.44	11.07	2.05	2.13
36	Kr	Krypton	12.65	14.11	1.59	1.64	79	Au	Gold	68.81	77.98	9.71	11.44	2.12	2.20
37	Rb	Rubidium	13.40	14.96	1.69	1.75	80	Hg	Mercury	70.82	80.26	9.99	11.82	2.20	2.28
38	Sr	Strontium	14.17	15.84	1.81	1.87	81	Tl	Thallium	72.87	82.57	10.27	12.21	2.27	2.36
39	Y	Yttrium	14.96	16.74	1.92	2.00	82	Pb	Lead	74.97	84.94	10.55	12.61	2.34	2.44
40	Zr	Zirconium	15.78	17.67	2.04	2.13	83	Bi	Bismuth	77.11	87.35	10.84	13.02	2.42	2.53
41	Nb	Niobium	16.62	18.63	2.17	2.26	84	Po	Polonium	79.29	89.80	11.13	13.45	2.50	2.61
42	Mo	Molybdenum	17.48	19.61	2.29	2.39	85	St	Astatine	81.52	92.30	11.43	13.88	2.58	2.70
43	Tc	Technetium	18.37	20.63	2.42	2.54	86	Rn	Radon	83.79	94.89	11.73	14.32	2.65	2.78
44	Ru	Ruthenium	19.28	21.66	2.56	2.68	87	Fr	Francium	86.11	97.47	12.03	14.77	2.73	2.87
45	Rh	Rhodium	20.22	22.72	2.70	2.83	88	Ra	Radium	88.48	100.13	12.34	15.24	2.81	2.95
46	Pd	Palladium	21.18	23.82	2.84	2.99	89	Ac	Actinium	90.88	102.85	12.65	15.71	2.90	3.05
47	Ag	Sliver	22.16	24.94	2.98	3.15	90	Th	Thorium	93.35	105.61	12.97	16.20	3.00	3.15
48	Cd	Cadmium	23.17	26.09	3.13	3.32	91	Pa	Protactinium	95.87	108.43	13.29	16.70	3.08	3.24
49	In	Indium	24.21	27.28	3.29	3.49	92	U	Uranium	98.44	111.30	13.61	17.22	3.17	3.34
50	Sn	Tin	24.27	28.49	3.44	3.66	93	Np	Neptunium	101.06	114.23	13.95	17.75	3.25	3.44
51	Sb	Antimony	26.36	29.73	3.60	3.84	94	Pu	Plutonium	103.73	117.23	14.28	18.30	3.34	3.53
52	Te	Tellerium	27.47	30.99	3.77	4.03	95	Am	Americium	106.47	120.28	14.62	18.86	3.44	3.65

Table 4. Absorption cross-sections for reactions with thermal and resonance neutrons.

Target Isotope	Product Isotope	Product Half-life		Target Isotope Abundance	Thermal Cross-section (b)	Resonance Integral (b)
H-1	H-2	stable		0.999885	0.3326	---
H-2	H-3	12.3	y	0.000115	0.000508	---
He-3	He-4	stable		0.00000137	0.000055	---
He-3	p + H-3	12.3	y	0.00000137	5333	2400
Li-6	α + H-3	12.3	y	0.0759	940	425
Li-6	Li-7	stable		0.0759	0.0393	0.0177
Li-7	α + α	0.8	s	0.9241	0.0442	0.02
Be-9	Be-10	1.51E+06	y	1.0000	0.00827	0.0037
B-10	α + Li-7*	stable		0.199	3837	1722
B-11	B-12	0.02	s	0.801	0.009	0.0043
C-12	C-13	stable		0.9893	0.00387	0.00183
C-13	C-14	5730	y	0.0107	0.0015	0.0011
N-14	N-15	stable		0.99632	0.0801	0.036
N-14	p + C-14	5730	y	0.99632	1.83	0.85
N-15	N-16	7.13	s	0.00368	0.000024	0.00011
O-16	O-17	stable		0.99757	0.00019	0.00027
O-17	O-18	stable		0.00038	0.000538	0.00041
O-18	O-19	26.91	s	0.00205	0.00016	0.00081
F-19	F-20	11	s	1.0000	0.00951	0.018
Ne-20	Ne-21	stable		0.9048	0.037	0.0165
Ne-21	Ne-22	stable		0.0027	0.666	0.296
Ne-22	Ne-23	37.24	s	0.0925	0.0527	0.0006
Na-23	Na-24	14.96	h	1.0000	0.525	0.312
Mg-24	Mg-25	stable		0.7899	0.0538	0.030
Mg-25	Mg-26	stable		0.1000	0.199	0.104
Mg-26	Mg-27	9.46	m	0.1101	0.0374	0.020
Al-27	Al-28	2.24	m	1.0000	0.231	0.136
Si-28	Si-29	stable		0.922297	0.177	0.080
Si-29	Si-30	stable		0.046832	0.119	0.081
Si-30	Si-31	2.62	h	0.030872	0.107	0.098
P-31	P-32	14.26	d	1.0000	0.166	0.079
S-32	S-33	stable		0.9493	0.518	0.246
S-32	α + Si-29	stable		0.9493	0.007	---
S-33	S-34	stable		0.0076	0.454	0.221
S-33	p + P-33	25.3	d	0.0076	2	---
S-33	α + Si-30	stable		0.0076	0.115	---
S-34	S-35	87.32	d	0.0429	0.256	0.105
S-36	S-37	5.05	m	0.0002	0.236	0.17
Cl-35	Cl-36	3.00E+05	y	0.7578	43.6	17.9
Cl-35	p + S-35	87.32	d	0.7578	0.489	0.554
Cl-35	α + P-32	14.26	d	0.7578	0.00008	---
Cl-37	Cl-38	37.24	m	0.2422	0.433	0.3
Ar-36	Ar-37	35.04	d	0.003365	5.2	---
Ar-38	Ar-39	269	y	0.000632	0.8	---
Ar-40	Ar-41	1.82	h	0.996003	0.66	0.41

Table 4. Absorption cross-sections for reactions with thermal and resonance neutrons.

Target Isotope	Product Isotope	Product Half-life		Target Isotope Abundance	Thermal Cross-section (b)	Resonance Integral (b)
K-39	K-40	stable		0.932581	2.1	1.1
K-40	K-41	stable		0.000117	38	13
K-40	p + Ar-40	stable		0.000117	4.4	2.0
K-40	α + Cl-37	stable		0.000117	0.39	---
K-41	K-42	12.36	h	0.067302	1.46	0.98
Ca-40	Ca-41	1.03E+05	y	0.96941	0.41	0.21
Ca-42	Ca-43	stable		0.00647	0.68	0.39
Ca-43	Ca-44	stable		0.00135	6.2	3.98
Ca-44	Ca-45	162.61	d	0.02086	0.88	0.415
Ca-46	Ca-47	4.54	d	0.00004	0.74	0.96
				100% of Ca-47 decays into Sc-47		
Ca-48	Ca-49	8.72	m	0.00187	1.09	0.89
				100% of Ca-49 decays into Sc-49		
Sc-45	Sc-46	83.79	d	1.0000	17.4	7.0
Sc-45	Sc-46m	18.75	s	1.0000	9.8	5.1
				100% of Sc-46m decays into Sc-46		
Ti-46	Ti-47	stable		0.0825	0.59	0.34
Ti-47	Ti-48	stable		0.0744	1.63	1.5
Ti-48	Ti-49	stable		0.7372	8.32	3.9
Ti-49	Ti-50	stable		0.0541	1.87	1.2
Ti-50	Ti-51	5.76	m	0.0518	0.179	0.09
V-50	V-51	stable		0.0025	40.8	61
V-51	V-52	3.74	m	0.9975	4.94	2.7
Cr-50	Cr-51	27.7	d	0.04345	14.7	7.2
Cr-52	Cr-53	stable		0.83789	0.86	0.66
Cr-53	Cr-54	stable		0.09501	18.6	8.66
Cr-54	Cr-55	3.5	m	0.02365	0.41	0.20
Mn-55	Mn-56	2.58	h	1.0000	13.36	13.3
Fe-54	Fe-55	2.73	y	0.05845	2.30	1.27
Fe-56	Fe-57	stable		0.91754	2.59	1.37
Fe-57	Fe-58	stable		0.02119	2.48	1.51
Fe-58	Fe-59	44.5	d	0.00282	1.32	1.50
Co-59	Co-60	5.27	y	1.0000	17.1	34.8
Co-59	Co-60m	10.47	m	1.0000	20.1	39.7
				99.76% of Co-60m decays into Co-60		
Ni-58	Ni-59	7.60E+04	y	0.680769	4.39	2.1
Ni-60	Ni-61	stable		0.262231	2.45	1.24
Ni-61	Ni-62	stable		0.011399	2.1	1.8
Ni-62	Ni-63	100.1	y	0.036345	14.9	7.38
Ni-64	Ni-65	2.52	h	0.009256	1.63	1.07
Cu-63	Cu-64	12.7	h	0.6917	4.5	4.97
Cu-65	Cu-66	5.12	m	0.3083	2.17	2.19
Zn-64	Zn-65	244.26	d	0.4863	0.731	1.37
Zn-66	Zn-67	stable		0.279	0.62	0.92
Zn-67	Zn-68	stable		0.041	7.5	25.4
Zn-68	Zn-69	56.4	m	0.1875	1.1	3.5
Zn-68	Zn-69m	13.76	h	0.1875	0.072	0.24
				99.97% of Zn-69m decays into Zn-69		
Zn-70	Zn-71	2.45	m	0.0062	0.092	0.96
Zn-70	Zn-71m	3.96	h	0.0062	0.0087	0.04
Zn-71m	Zn-72	46.5	h	---	0.059	0.07
Ga-69	Ga-70	21.14	m	0.60108	1.92	15.9
Ga-71	Ga-72	14.1	h	0.39892	4.62	32.3

Table 4. Absorption cross-sections for reactions with thermal and resonance neutrons.

Target Isotope	Product Isotope	Product Half-life		Target Isotope Abundance	Thermal Cross-section (b)	Resonance Integral (b)
Ge-70	Ge-71	11.43	d	0.2084	3.05	2.39
Ge-72	Ge-73	stable		0.2754	0.89	0.86
Ge-73	Ge-74	stable		0.0773	14.7	64
Ge-74	Ge-75	82.78	m	0.3628	0.34	0.43
Ge-74	Ge-75m	47.7	s	0.3628	0.16	0.33
				99.97% of Ge-75m decays into Ge-75		
Ge-76	Ge-77	11.3	h	0.0761	0.06	0.86
				100% of Ge-77 decays into As-77		
Ge-76	Ge-77m	52.9	s	0.0761	0.10	1.00
				19.0% of Ge-77m decays into Ge-77		
				81.0% of Ge-77m decays into As-77		
As-75	As-76	26.32	h	1.0000	4.09	63
As-76	As-77	38.8	h	----	60.8	216.1
Se-74	Se-75	119.78	d	0.0089	52.2	576
Se-76	Se-77	stable		0.0937	62.8	17.4
Se-76	Se-77m	17.36	s	0.0937	22	17
Se-77	Se-78	stable		0.0763	41.5	32.3
Se-78	Se-79	stable		0.2377	0.05	0.8
Se-78	Se-79m	3.92	m	0.2377	0.38	3.7
				99.94% of Se-79m decays into Se-79		
Se-80	Se-81	18.45	m	0.4961	0.53	1.6
Se-80	Se-81m	57.28	m	0.4961	0.08	0.34
				99.95% of Se-81m decays into Se-81		
Se-82	Se-83	22.3	m	0.0873	0.0052	0.09
				100% of Se-83 decays into Br-83		
Se-82	Se-83m	70.1	s	0.0873	0.039	0.039
				100% of Se-83m decays into Br-83		
Br-79	Br-80	17.68	m	0.5069	8.2	95
Br-79	Br-80m	4.42	h	0.5069	2.2	35
				100% of Br-80m decays into Br-80		
Br-81	Br-82	35.3	h	0.4931	0.26	15
Br-81	Br-82m	6.13	m	0.4931	2.10	31
				99.6% of Br-82m decays into Br-82		
Kr-78	Kr-79	35.04	h	0.0035	4.7	26
Kr-80	Kr-81	2.29E+05	y	0.0228	11.5	57.4
Kr-82	Kr-83	stable		0.1158	19	156
Kr-83	Kr-84	stable		0.1149	197	160
Kr-84	Kr-85	10.76	y	0.5700	0.11	2.43
Kr-86	Kr-87	76.3	m	0.1730	0.003	0.18
Rb-85	Rb-86	18.63	d	0.7217	0.427	5.7
Rb-85	Rb-86m	1.02	m	0.7217	0.067	1.1
				100% of Rb-86m decays into Rb-86		
Rb-87	Rb-88	17.78	m	0.2783	0.116	2.38
Sr-84	Sr-85	64.84	d	0.0056	0.35	6.72
Sr-84	Sr-85m	67.63	m	0.0056	0.5	3.20
				86.6% of Sr-85m decays into Sr-85		
Sr-86	Sr-87	stable		0.0986	0.2	---
Sr-86	Sr-87m	2.8	h	0.0986	0.84	4.88
				99.7% of Sr-87m decays into Sr-87		
Sr-87	Sr-88	stable		0.0700	16.7	108
Sr-88	Sr-89	50.53	d	0.8258	0.0055	0.024
Y-89	Y-90	64	h	1.0000	1.28	0.96
Y-89	Y-90m	3.19	h	1.0000	0.001	0.006
				100% of Y-90m decays into Y-90		

Table 4. Absorption cross-sections for reactions with thermal and resonance neutrons.

Target Isotope	Product Isotope	Product Half-life		Target Isotope Abundance	Thermal Cross-section (b)	Resonance Integral (b)
Zr-90	Zr-91	stable		0.5145	0.014	0.13
Zr-91	Zr-92	stable		0.1122	1.30	8.3
Zr-92	Zr-93	1.53E+06	y	0.1715	0.131	0.47
Zr-94	Zr-95	64.02	d	0.1738	0.0511	0.28
				98.9% of Zr-95 decays into Nb-95		
				1.11% of Zr-95 decays into Nb-95m		
Zr-96	Zr-97	16.91	h	0.028	0.0211	5.28
				3.2% of Zr-97 decays into Nb-97		
				96.8% of Zr-97 decays into Nb-97m		
Nb-93	Nb-94	2.03E+04	y	1.0000	0.3	2.00
Nb-93	Nb-94m	6.26	m	1.0000	0.863	6.34
				99.5% of Nb-94m decays into Nb-94		
Nb-94	Nb-95	34.98	d	----	14.9	125
Nb-94	Nb-95m	86.6	h	----	0.6	----
				94.4% of Nb-95m decays into Nb-95		
Mo-92	Mo-93	4.00E+03	y	0.1484	0.08	0.11
Mo-92	Mo-93m	6.85	h	0.1484	0.000002	0.8
				99.88% of Mo-93m decays into Mo-93		
Mo-94	Mo-95	stable		0.0925	0.34	1.28
Mo-95	Mo-96	stable		0.1592	13.4	117
Mo-96	Mo-97	stable		0.1668	0.55	18.2
Mo-97	Mo-98	stable		0.0955	2.2	16.8
Mo-98	Mo-99	65.94	h	0.2413	0.13	6.7
				100% of Mo-99 decays into Tc-99m		
Mo-100	Mo-101	14.61	m	0.0963	0.199	3.76
				100% of Mo-101 decays into Tc-101		
Ru-96	Ru-97	69.12	h	0.0554	0.25	7.34
Ru-98	Ru-99	stable		0.0187	8.0	---
Ru-99	Ru-100	stable		0.1276	7.25	172
Ru-100	Ru-101	stable		0.1260	5.0	11.2
Ru-101	Ru-102	stable		0.1706	5.2	111
Ru-102	Ru-103	39.26	d	0.3155	1.24	4.46
Ru-104	Ru-105	4.44	h	0.1862	0.491	6.3
				100% of Ru-105 decays into Rh-105		
Rh-103	Rh-104	42.3	s	1.0000	143.5	1012
Rh-103	Rh-104m	4.34	m	1.0000	10	75
				99.87% of Rh-104m decays into Rh-104		
Pd-102	Pd-103	16.99	d	0.0102	1.82	23
Pd-104	Pd-105	stable		0.1114	0.65	20.9
Pd-105	Pd-106	stable		0.2233	21	96.4
Pd-106	Pd-107	6.50E+06	y	0.2733	0.305	7.5
Pd-108	Pd-109	13.7	h	0.2646	8.57	244
				100% of Pd-109 decays into Ag-109m		
Pd-108	Pd-109m	4.7	m	0.2646	0.183	2.26
				100% of Pd-109m decays into Pd-109		
Pd-110	Pd-111	23.4	m	0.1172	0.26	2.4
				100% of Pd-111 decays into Ag-111		
Pd-110	Pd-111m	5.5	h	0.1172	0.037	0.7
				73.3% of Pd-111m decays into Pd-111		
				26.7% of Pd-111m decays into Ag-111		
Ag-107	Ag-108	2.37	m	0.51839	34.8	107
Ag-109	Ag-110	24.6	s	0.48161	88.7	1473
Ag-109	Ag-110m	249.79	d	0.48161	4.7	72.3
				98.64% of Ag-110m decays into Cd-110		
				1.36% of Ag-110m decays into Ag-110		

Table 4. Absorption cross-sections for reactions with thermal and resonance neutrons.

Target Isotope	Product Isotope	Product Half-life		Target Isotope Abundance	Thermal Cross-section (b)	Resonance Integral (b)
Cd-106	Cd-107	6.5	h	0.0125	1.0	6.1
Cd-108	Cd-109	462.6	d	0.0089	0.72	12.1
Cd-110	Cd-111	stable		0.1249	11	12.7
Cd-110	Cd-111m	48.54	m	0.1249	0.14	3.0
				100% of Cd-111m decays into Cd-111		
Cd-111	Cd-112	stable		0.128	6.9	45.9
Cd-112	Cd-113	stable		0.2413	2.2	13.1
Cd-112	Cd-113m	14.1	y	0.2413	0.012	---
				99.86% of Cd-113m decays into In-113m		
Cd-113	Cd-114	stable		0.1222	19852	384
Cd-114	Cd-115	53.46	h	0.2873	0.30	9.1
				100% of Cd-115 decays into In-115m		
Cd-114	Cd-115m	44.6	d	0.2873	0.036	3.16
				100% of Cd-115m decays into In-115		
Cd-116	Cd-117	2.49	h	0.0749	0.075	1.65
				100% of Cd-117 decays into In-117m		
				47.0% of In-117m decays into In-117		
Cd-116	Cd-117m	3.36	h	0.0749	0.025	0.422
				100% of Cd-117m decays into In-117m		
				47.0% of In-117m decays into In-117		
In-113	In-114	71.9	s	0.0429	3.9	50
In-113	In-114m	49.51	d	0.0429	8.1	224
				95.75% of In-114m decays into In-114		
In-115	In-116	14.1	s	0.9571	40	662
In-115	In-116m	54.29	m	0.9571	162.3	2638
				100% of In-116m decays into Sn-116		
Sn-112	Sn-113	115.09	d	0.0097	0.71	26.2
				100% of Sn-113 decays into In-113m		
Sn-112	Sn-113m	21.4	m	0.0097	0.3	---
				8.9% of Sn-113m decays into In-113m		
				91.0% of Sn-113m decays into Sn-113		
				100% of Sn-113 decays into In-113m		
Sn-114	Sn-115	stable		0.0066	0.064	3.4
Sn-115	Sn-116	stable		0.0034	43	15.8
Sn-116	Sn-117	stable		0.1454	0.129	11.3
Sn-116	Sn-117m	13.6	d	0.1454	0.006	0.49
				100% of Sn-117m decays into Sn-117		
Sn-117	Sn-118	stable		0.0768	1.07	17.9
Sn-118	Sn-119	stable		0.2422	0.22	1.8
Sn-118	Sn-119m	293.1	d	0.2422	0.01	2
				100% of Sn-119m decays into Sn-119		
Sn-119	Sn-120	stable		0.0859	2.19	4.56
Sn-120	Sn-121	44	y	0.3258	0.14	1.14
Sn-122	Sn-123	129.2	d	0.0463	0.001	0.83
Sn-122	Sn-123m	40.06	m	0.0463	0.18	0.788
				100% of Sn-123m decays into Sb-123		
Sn-124	Sn-125	9.64	d	0.0579	0.004	0.25
				100% of Sn-125 decays into Sb-125		
				100% of Sb-125 decays into Te-125m		
Sn-124	Sn-125m	9.52	m	0.0579	0.13	8
				100% of Sn-125m decays into Sb-125		
				100% of Sb-125 decays into Te-125m		
Sb-121	Sb-122	2.72	d	0.5721	5.77	205
Sb-121	Sb-122m	4.19	m	0.5721	0.06	13
				100% of Sb-122m decays into Sb-122		
Sb-123	Sb-124	60.2	d	0.4279	4.1	129
Sb-123	Sb-124m	93	s	0.4279	0.037	0.93
				74.9% of Sb-124m decays into Sb-124		

Table 4. Absorption cross-sections for reactions with thermal and resonance neutrons.

Target Isotope	Product Isotope	Product Half-life		Target Isotope Abundance	Thermal Cross-section (b)	Resonance Integral (b)
Te-120	Te-121	16.78	d	0.0009	2.0	---
Te-120	Te-121m	154	d	0.0009	0.34	---
				88.9% of Te-121m decays into Te-121		
Te-122	Te-123	stable		0.255	3.4	89
Te-122	Te-123m	119.7	d	0.255	1.1	---
				100% of Te-123m decays into Te-123		
Te-123	Te-124	stable		0.0089	430	5659
Te-124	Te-125	stable		0.0474	6.3	3.1
Te-124	Te-125m	57.4	d	0.0474	0.04	7
				100% of Te-125m decays into Te-125		
Te-125	Te-126	stable		0.0707	1.29	21.9
Te-126	Te-127	9.35	h	0.1884	0.9	8
Te-126	Te-127m	109	d	0.1884	2.9	1.04
				97.6 % of Te-127m decays into Te-127		
Te-128	Te-129	69.6	m	0.3174	0.2	1.58
Te-128	Te-129m	33.6	d	0.3174	0.015	0.077
				64.0% of Te-129m decays into Te-129		
Te-130	Te-131	25.0	m	0.3408	0.27	0.446
				100% of Te-131 decays into I-131		
Te-130	Te-131m	30.0	h	0.3408	0.02	0.0485
				23.1% of Te-131m decays into Te-131		
				76.9% of Te-131m decays into I-131		
				1% of I-131 decays into Xe-131m		
				99% of I-131 decays into Xe-131		
				100% of Xe-131m decays into Xe-131		
I-127	I-128	24.99	m	1.0000	6.15	162
Xe-124	Xe-125	16.9	h	0.0009	150	3600
Xe-126	Xe-127	36.4	d	0.0009	2.47	61
Xe-128	Xe-129	stable		0.0192	3.5	---
Xe-128	Xe-129m	8.88	d	0.0192	0.48	12.5
				100% of Xe-129m decays into Xe-129		
Xe-129	Xe-130	stable		0.2644	21	260
Xe-130	Xe-131	stable		0.0408	26	---
Xe-130	Xe-131m	11.84	d	0.0408	0.45	16
				100% of Xe-131m decays into Xe-131		
Xe-131	Xe-132	stable		0.2118	93	883
Xe-132	Xe-133	5.24	d	0.2689	0.45	4.6
Xe-132	Xe-133m	2.19	d	0.2689	0.05	0.9
				100% of Xe-133m decays into Xe-133		
Xe-134	Xe-135	9.14	h	0.1044	0.265	0.57
Xe-134	Xe-135m	15.29	m	0.1044	0.003	0.101
				100% of Xe-135m decays into Xe-135		
Xe-135	Xe-136	----		----	2650000	7600
Xe-136	Xe-137	3.82	m	0.0887	0.26	0.74
Cs-133	Cs-134	2.06	y	1.0000	27.6	406
Cs-133	Cs-134m	2.9	h	1.0000	2.5	32.3
				100% of Cs-134m decays into Cs-134		
Ba-130	Ba-131	11.5	d	0.00106	8.8	184
				100% of Ba-131 decays into Cs-131		
				100% of Cs-131 decays into Xe-131		
Ba-130	Ba-131m	14.6	m	0.00106	2.5	25
				100% of Ba-131m decays into Ba-131		
				100% of Ba-131 decays into Cs-131		
				100% of Cs-131 decays into Xe-131		
Ba-132	Ba-133	10.51	y	0.00101	7.7	44
Ba-132	Ba-133m	38.9	h	0.00101	0.5	2.8
				100% of Ba-133m decays into Ba-133		
Ba-134	Ba-135	stable		0.02417	1.4	---
Ba-134	Ba-135m	28.7	h	0.02417	0.158	23.9

Table 4. Absorption cross-sections for reactions with thermal and resonance neutrons.

Target Isotope	Product Isotope	Product Half-life	Target Isotope Abundance	Thermal Cross-section (b)	Resonance Integral (b)
			100% of Ba-135m decays into Ba-135		
Ba-135	Ba-136	stable	0.06592	5.8	99
Ba-136	Ba-137	stable	0.07854	0.57	1.0
Ba-136	Ba-137m	2.55 m	0.07854	0.01	0.75
			100% of Ba-137m decays into Ba-137		
Ba-137	Ba-138	stable	0.11232	3.6	4.0
Ba-138	Ba-139	83.06 m	0.7169	0.404	0.32
Ba-139	Ba-140	12.75 d	---	6.2	---
			100% of Ba-140 decays into La-140		
La-138	La-139	stable	0.0009	57.2	409
La-139	La-140	40.27 h	0.9991	9.21	12.1
Ce-136	Ce-137	9.0 h	0.00185	4.2	69
Ce-136	Ce-137m	34.4 h	0.00185	0.95	---
			99.2% of Ce-137m decays into Ce-137		
Ce-138	Ce-139	137.64 h	0.00251	1.03	10.6
Ce-140	Ce-141	32.5 d	0.88450	0.51	0.55
Ce-142	Ce-143	33.04 h	0.11114	0.96	1.15
Pr-141	Pr-142	19.12 h	1.0000	11.3	15.9
Nd-142	Nd-143	stable	0.272	18.7	5.9
Nd-143	Nd-144	stable	0.122	325	131
Nd-144	Nd-145	stable	0.238	3.6	4.3
Nd-145	Nd-146	stable	0.083	42.2	224
Nd-146	Nd-147	10.98 d	0.172	1.49	2.57
			100% of Nd-147 decays into Pm-147		
Nd-148	Nd-149	1.73 h	0.057	2.57	14.3
			100% of Nd-149 decays into Pm-149		
Nd-150	Nd-151	12.44 m	0.056	1.04	15.2
			100% of Nd-151 decays into Pm-151		
Pm-147	Pm-148	5.37 dd	----	96	2064
Pm-147	Pm-148m	41.3 d	----	72.4	790
			5% of Pm-148 decays into Sm-148		
Sm-144	Sm-145	340 d	0.0307	1.64	2.38
Sm-147	Sm-148	stable	0.1499	57	779
Sm-148	Sm-149	stable	0.1124	2.4	27
Sm-149	Sm-150	stable	0.1382	40140	3422
Sm-150	Sm-151	90 y	0.0738	100	333
Sm-152	Sm-153	46.28 h	0.2675	206	2978
Sm-153	Sm-154	----	----	420	---
Sm-154	Sm-155	22.3 m	0.2275	8.5	36
			100 % of Sm-155 decays into Eu-155		
Eu-151	Eu-152	13.54 y	0.4781	5900	1510
Eu-151	Eu-152m	9.31 h	0.4781	3300	1790
			28.4% of Eu-152m decays into Sm-152		
			72.6% of Eu-152m decays into Gd-152		
Eu-152	Eu-153	----	----	12800	2190
Eu-153	Eu-154	8.59 y	0.5219	312	1500
Eu-154	Eu-155	4.76 y	----	1446	1320
Gd-152	Gd-153	240.4 d	0.0020	735	423
Gd-153	Gd-154	stable	----	22460	300
Gd-154	Gd-155	stable	0.0218	85	300
Gd-155	Gd-156	stable	0.1480	60330	1530
Gd-156	Gd-157	stable	0.2047	1.8	103
Gd-157	Gd-158	stable	0.1565	254000	772
Gd-158	Gd-159	18.48 h	0.2484	2.2	73
Gd-160	Gd-161	3.66 m	0.2186	1.4	8.1
Tb-159	Tb-160	72.3 d	1.0000	23.8	430
Tb-160	Tb-161	6.91 d	----	334	3050

Table 4. Absorption cross-sections for reactions with thermal and resonance neutrons.

Target Isotope	Product Isotope	Product Half-life		Target Isotope Abundance	Thermal Cross-section (b)	Resonance Integral (b)
Dy-156	Dy-157	8.14	h	0.0006	33	960
Dy-158	Dy-159	144.4	d	0.0010	43	120
Dy-159	Dy-160	stable		----	8000	---
Dy-160	Dy-161	stable		0.0234	55	1122
Dy-161	Dy-162	stable		0.1891	600	1081
Dy-162	Dy-163	stable		0.2551	194	2350
Dy-163	Dy-164	stable		0.2490	134	1960
Dy-164	Dy-165	2.33	h	0.2818	2650	344
Dy-164	Dy-165m	1.26	m	0.2818	1610	424
				97.7% of Dy-165m decays into Dy-165		
Dy-165	Dy-166	81.6	h	----	2000	22000
				100% of Dy-166 decays into Ho-166		
Ho-165	Ho-166	26.83	h	1.0000	61.2	660
Ho-165	Ho-166m	1200	y	1.0000	3.2	20
Er-162	Er-163	1.25	h	0.0014	19	480
Er-164	Er-165	10.36	h	0.0161	13	105
Er-166	Er-167	stable		0.3361	16.9	110
Er-167	Er-168	stable		0.2293	649	2985
Er-168	Er-169	9.4	d	0.2678	2.74	38.3
Er-170	Er-171	7.52	h	0.1493	8.15	44.5
				100% of Er-171 decays into Tm-171		
Er-171	Er-172	49.3	h	----	280	---
				100% Er-172 decays into Tm-172		
Tm-169	Tm-170	128.6	d	1.0000	107	1629
Tm-170	Tm-171	1.92	y	----	92	491
				100% of Tm-171 decays into Yb-171		
Tm-171	Tm-172	63.6	h	----	190	438
Yb-168	Yb-169	32.03	d	0.0013	3033	19684
Yb-169	Yb-170	stable		----	3600	2080
Yb-170	Yb-171	stable		0.0304	10.2	320
Yb-171	Yb-172	stable		0.1428	58.8	331
Yb-172	Yb-173	stable		0.2138	1.3	26.9
Yb-173	Yb-174	stable		0.1613	15.5	385
Yb-174	Yb-175	4.185	d	0.3183	63.2	27
Yb-176	Yb-177	1.91	h	0.1276	2.85	6.9
				100% of Yb-177 decays into Lu-177		
Lu-175	Lu-176	stable		0.9741	7.1	620
Lu-175	Lu-176m	3.64	h	0.9741	16.2	550
				99.9% of Lu-176m decays into Hf-176		
Lu-176	Lu-177	6.73	d	0.0259	2057	465
Lu-176	Lu-177m	160.4	d	0.0259	2.8	3.8
				22.0% of Lu-177m decays into Lu-177		
				78.0% of Lu-177m decays into Hf-177m		
Lu-177	Lu-178	28.5	m	---	880	---
Lu-177m	Lu-178m	23.1	m	---	3.2	---
Hf-174	Hf-175	70	d	0.0016	549	339
Hf-176	Hf-177	stable		0.0526	23.5	715
Hf-176	Hf-177m2	51.4	m	0.0526	3.0	---
				100% of Hf-177m2 decays into Hf-177		
Hf-177	Hf-178	stable		0.1860	374	7200
Hf-177	Hf-178m1	4.0	s	0.1860	0.96	---
				100% of Hf-178m1 decays into Hf-178		
Hf-178	Hf-179	stable		0.2728	83.3	1886
Hf-178	Hf-179m	18.67	s	0.2728	53	---
				100% of Hf-179m decays into Hf-179		

Table 4. Absorption cross-sections for reactions with thermal and resonance neutrons.

Target Isotope	Product Isotope	Product Half-life		Target Isotope Abundance	Thermal Cross-section (b)	Resonance Integral (b)
Hf-179	Hf-180	stable		0.1362	41	533
Hf-179	Hf-180m	5.5	h	0.1362	0.445	6.9
				99.7% of Hf-180m decays into Hf-180		
				0.3% of Hf-180m decays into Ta-180		
Hf-180	Hf-181	42.39	d	0.3508	13.04	32
Hf-181	Hf-182m	62	m	----	40	---
				58% of Hf-182m decays into Ta-182		
Ta-180	Ta-181	stable		0.00012	563	1457
Ta-181	Ta-182	114.43	d	0.99988	20.4	655
Ta-181	Ta-182m	15.84	m	0.99988	0.011	0.415
				100% of Ta-182m decays into Ta-182		
Ta-182	Ta-183	5.1	d	----	8200	1036
W-180	W-181	121.2	d	0.0012	22.3	226
W-182	W-183	stable		0.2650	19.9	602
W-183	W-184	stable		0.1431	10.4	364
W-184	W-185	75.1	d	0.3064	1.73	14.7
W-184	W-185m	1.67	m	0.3064	0.002	---
				100% of W-185m decays into W-185		
W-185	W-186	stable		---	3.0	183
W-186	W-187	23.72	h	0.2843	38.1	480
W-187	W-188	69.4	d	----	64	2760
Re-185	Re-186	90.64	h	0.374	112	1739
Re-187	Re-188	17.0	h	0.626	74.8	294
Re-187	Re-188m	18.6	m	0.626	2.8	9.4
				100% of Re-188m decays into Re-188		
Os-184	Os-185	93.6	d	0.0002	3000	601
Os-186	Os-187	stable		0.0159	80	247
Os-187	Os-188	stable		0.0196	320	473
Os-188	Os-189	stable		0.1324	5.5	116
Os-189	Os-190	stable		0.1615	25	736
Os-189	Os-190m	9.9	m	0.1615	0.00026	0.013
Os-190	Os-191	15.4	d	0.2626	1.8	7.9
Os-190	Os-191m	13.1	h	0.2626	9.2	22.1
				100% of Os-191m decays into Os-191		
Os-191m	Os-192	stable		----	400	---
Os-192	Os-193	30.11	h	0.4078	3.2	7.45
Os-193	Os-194	6.0	y	----	38	---
Ir-191	Ir-192	73.83	d	0.373	645	3550
Ir-191	Ir-192m	1.45	m	0.373	309	---
				100% of Ir-192m decays into Ir-192		
Ir-192	Ir-193	----		----	1578	3580
Ir-193	Ir-194	19.28	h	0.627	111	1370
Ir-192	Ir-193	----		----	1570	---
Pt-190	Pt-191	2.8	d	0.00014	152	72
Pt-192	Pt-193	50	y	0.00782	8	135
Pt-192	Pt-193m	4.33	d	0.00782	2.2	---
Pt-194	Pt-195	stable		0.32967	1.44	4
Pt-194	Pt-195m	4.02	d	0.32967	0.098	3.1
Pt-195	Pt-196	stable		0.33832	30.6	376
Pt-196	Pt-197	19.89	h	0.25242	0.54	5.2
Pt-196	Pt-197m	95.4	m	0.25242	0.044	0.35
				97.0% of Pt-197m decays into Pt-197		
				3.0% of Pt-197m decays into Au-197m		
Pt-198	Pt-199	30.8	m	0.07163	3.26	55
				100% of Pt-199 decays into Au-199		
Pt-198	Pt-199m	13.6	s	0.07163	0.35	6.0
				100% of Pt-199m decays into Pt-199		
				100% of Pt-199 decays into Au-199		

Table 4. Absorption cross-sections for reactions with thermal and resonance neutrons.

Target Isotope	Product Isotope	Product Half-life		Target Isotope Abundance	Thermal Cross-section (b)	Resonance Integral (b)
Au-197	Au-198	2.7	d	1.000	98.65	1550
Au-198	Au-199	3.14	d	----	25100	---
Hg-196	Hg-197	64.14	h	0.0015	3080	413
Hg-196	Hg-197m	23.8	h	0.0015	109	58.9
				93.2% of Hg-197m decays into Hg-197		
				6.8% of Hg-197m decays into Au-197m		
Hg-198	Hg-199	stable		0.0997	2.0	71
Hg-198	Hg-199m	42.6	m	0.0997	0.018	1.8
				100% of Hg-199m decays into Hg-199		
Hg-199	Hg-200	stable		0.1687	2150	441
Hg-200	Hg-201	stable		0.2310	15	2.1
Hg-201	Hg-202	stable		0.1318	4.9	31
Hg-202	Hg-203	46.61	d	0.2986	4.91	4.2
Hg-204	Hg-205	5.2	m	0.0687	0.43	0.85
Tl-203	Tl-204	3.78	y	0.29524	11.4	39.8
Tl-204	Tl-205	stable		----	21.6	82
Tl-205	Tl-206	4.19	m	0.70476	0.104	0.71
Pb-204	Pb-205	1.40E+07	y	0.014	0.703	2.38
Pb-206	Pb-207	stable		0.241	0.0279	0.11
Pb-207	Pb-208	stable		0.221	0.647	0.35
Pb-208	Pb-209	3.3	h	0.524	0.00023	0.068
Bi-209	Bi-210m	3.00E+06	y	1.000	0.0217	0.05
Bi-209	Bi-210	5.0	d	1.000	0.0179	0.19
				100% of Bi-210m decays into Bi-210		
Th-232	Th-233	22.3	m	1.000	7.35	83.3
				100% of Th-233 decays into Pa-233		
U-234	U-235	7.00E+08	y	0.000055	102.5	659
U-234	fission products			0.000055	< 0.65	6.5
U-235	U-236	2.34E+07	y	0.007200	98.8	146
U-235	fission products			0.007200	582.6	275
U-238	U-239	23.45	m	0.992745	2.68	277
				100% of U-239 decays into Np-239		

Table 5. U-235 fission-neutron averaged cross sections.

Target Isotope	Product Isotope	Product Half-life		Isotope Abundance	Fast neutron averaged Cross-section (mb)
(n,p) reactions:					
Mg-24	Na-24	14.96	h	0.7899	1.53
Al-27	Mg-27	9.46	m	1.0000	4
Si-28	Al-28	2.24	m	0.9223	6.4
Si-29	Al-29	6.56	m	0.0468	3.3
P-31	Si-31	2.52	h	1.0000	36
S-32	P-32	14.26	d	0.9493	69
S-33	P-33	25.34	d	0.0076	76
Cl-35	S-35	87.5	d	0.7578	78
Cl-37	S-37	5.05	m	0.2422	0.218
K-39	Ar-39	269	y	0.9326	20
K-41	Ar-41	1.83	h	0.0673	2.1
Sc-45	Ca-45	163.8	d	1.0000	15
Ti-46	Sc-46	83.79	d	0.0825	12.5
Ti-47	Sc-47	3.35	d	0.0744	20
Ti-48	Sc-48	43.67	h	0.7372	0.315
V-51	Ti-51	5.76	m	0.9975	0.87
Cr-52	V-52	3.74	m	0.8379	1.09
Fe-54	Mn-54	312.3	d	0.0584	82.5
Fe-56	Mn-56	2.58	h	0.9175	1.07
Co-59	Fe-59	44.5	d	1.0000	1.42
Ni-58	Co-58	70.86	d	0.6807	113
Ni-60	Co-60	5.27	y	0.2622	2.3
Cu-65	Ni-65	2.52	h	0.3083	0.48
Zn-64	Cu-64	12.7	h	0.4863	31
Zn-66	Cu-66	5.12	m	0.2790	0.62
Zn-67	Cu-67	2.58	d	0.0410	1.07
(n,α) reactions:					
Al-27	Na-24	14.96	h	1.0000	0.725
Si-30	Mg-27	9.46	m	0.0309	0.155
P-31	Al-28	2.24	m	1.0000	1.9
Cl-35	P-32	14.3	d	0.7578	8.8
V-51	Sc-48	43.67	h	0.9975	0.022
Mn-55	V-52	3.74	m	1.0000	0.11
Fe-54	Cr-51	27.7	d	0.0584	0.6
Co-59	Mn-56	2.58	h	1.0000	0.156
Ni-62	Fe-59	44.5	d	0.0363	0.09
Cu-63	Co-60	5.27	y	0.6917	0.5
(n,2n) reactions:					
F-19	F-18	109.8	m	1.0000	0.0073
Na-23	Na-22	2.6	y	1.0000	0.0022
Ca-48	Ca-47	4.54	d	0.0019	0.36
Ti-46	Ti-45	184.8	m	0.0825	0.0078
Cr-50	Cr-49	42.3	m	0.0435	0.006
Mn-55	Mn-54	312.3	d	1.0000	0.258
Co-59	Co-58	70.86	d	1.0000	0.4
Cu-63	Cu-62	9.74	m	0.6917	0.124
As-75	As-74	17.77	d	1.0000	0.33
Y-89	Y-88	106.65	d	1.0000	0.156
Nb-93	Nb-92m	10.15	d	1.0000	0.48
Au-197	Au-196	6.18	d	1.0000	2.97
(n,n') reactions:					
Se-77	Se-77m	17.45	s	0.0763	733
Sr-87	Sr-87m	2.81	h	0.0700	112
Y-89	Y-89m	16.06	s	1.0000	128
Rh-103	Rh-103m	56.1	m	1.0000	533
Cd-111	Cd-111m	48.6	m	0.1280	228
In-115	In-115m	4.49	h	0.9571	188
Ba-137	Ba-137m	2.55	m	0.1123	225
Au-197	Au-197m	7.73	s	1.0000	380

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
H-3	12.3 y	no γs		-----	H-2(n,γ); He-3(n,p); Li-6(n,α)
Be-7	53.12 d	477.60	*	10.52	accelerator produced
Be-10	1.51E+06 y	no γs		-----	Be-9(n,γ)
C-14	5730 y	no γs		-----	C-13(n,γ); N-14(n,p)
N-16	7.13 s	6128.63	*	67.0	N-15(n,γ); O-16(n,p)
		7115.15		4.9	
O-19	26.91 s	197.14	*	95.9	O-18(n,γ); F-19(n,p)
		1356.84		50.4	
		1444.08		2.6	
F-18	109.77 m	no γs			F-19(n,2n)
		Annhilation abundance = 93.4			
F-20	11 s	1633.60	*	100	F-19(n,γ)
Ne-23	37.24 s	439.99	*	32.9	Ne-22(n,γ)
		1635.96		0.99	
Na-22	2.6 y	1274.53	*	99.9	accelerator produced
		Annhilation abundance = 179.8			
Na-24	14.96 h	1368.63	*	100.0	Na-23(n,γ); Mg-24(n,p); Al-27(n,α)
		2754.03		99.9	
Mg-27	9.46 m	170.68		0.8	Mg-26(n,γ); Al-27(n,p); Si-30(n,α)
		843.76		71.8	
		1014.44	*	28.0	
Al-28	2.24 m	1778.97	*	100	Al-27(n,γ); Si-28(n,p); P-31(n,α)
Al-29	6.56 m	1273.37	*	90.6	Si-29(n,p)
		Annhilation abundance = 200.			
Si-31	2.62 h	1266.12	*	0.07	Si-30(n,γ); P-31(n,p)
P-32	14.26 d	no γs		-----	P-31(n,γ); S-32(n,p)
P-33	25.34 d	no γs		-----	P-31(2n,γ); S-33(n,p)
S-35	87.32 d	no γs		-----	S-34(n,γ); Cl-35(n,p)
S-37	5.05 m	3103.36	*	94	S-36(n,γ); Cl-37(n,p)
Cl-36	3.01E+05 y	no γs		-----	Cl-35(n,γ)
Cl-38	37.24 m	1642.71	*	31.9	Cl-37(n,γ)
		2167.40		42.4	
Ar-37	35.04 d	no γs		-----	Ar-36(n,γ)
Ar-39	269 y	no γs		-----	Ar-38(n,γ)
Ar-41	1.83 h	1293.59	*	99.1	Ar-40(n,γ)
K-40	1.28E+09 y	1460.83	*	10.67	natural product
K-42	12.36 h	312.60		0.34	K-41(n,γ)
		1524.70	*	18	
Ca-41	1.03E+05 y	no γs		-----	Ca-40(n,γ)
Ca-45	163.61 d	no γs		-----	Ca-44(n,γ); Sc-45(n,p)

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Ca-47	4.54 d	489.23		6.2	Ca-46(n,γ)
		807.86		6.2	
		1297.09	*	71	
Ca-49	8.72 m	3084.40	*	92	Ca-48(n,γ)
		4071.90		7	
Sc-46	83.79 d	889.28	*	99.98	Sc-45(n,γ); Ti-46(n,p)
		1120.54		99.99	
Sc-46m	18.8 s	142.53	*	62	Sc-45(n,γ); Ti-46(n,p)
Sc-47	3.35 d	159.38	*	68.3	Ti-47(n,p); parent = Ca-47 [4.54 d]
Sc-48	43.67 h	175.36		7.48	Ti-48(n,p)
		983.52	*	100	
		1037.60		97.6	
		1212.88		2.38	
		1312.10		100	
Sc-49	57.2 m	1622.60		0.01	Ti-49(n,p);
		1761.90	*	0.05	parent = Ca-49 [8.72 m]
Ti-51	5.76 m	320.08	*	93.1	Ti-50(n,γ)
		608.60		1.18	
		928.64		6.9	
V-52	3.74 m	1434.07	*	100	V-51(n,γ)
Cr-51	27.7 d	320.08	*	10.08	Cr-50(n,γ); Fe(n,α)
Cr-55	3.5 m	1528.30	*	0.037	Cr-54(n,γ)
Mn-54	312.3 d	834.85	*	99.98	Fe-54(n,p)
Mn-56	2.58 h	846.77		98.87	Mn-55(n,γ); Fe-56(n,p); Co-59(n,α)
		1810.77	*	27.19	
		2113.12		14.34	
		2522.88		0.99	
		2657.46		0.65	
Fe-55	2.73 y	no γs		-----	Fe-54(n,γ)
Fe-59	44.5 d	142.65		1.02	Fe-58(n,γ); Co-59(n,p)
		192.35		3.08	
		1099.25	*	56.5	
		1291.60		43.2	
Co-56	77.27 d	846.77		100	accelerator produced
		977.37		1.44	
		1037.84		13.99	
		1175.10		2.28	
		1238.28	*	67.60	
		1360.22		4.33	
		1771.35		15.69	
		2015.18		3.08	
		2034.76		7.88	
		2598.46		17.28	
		3009.60		1.05	
		3201.96		3.24	
		3253.42		7.93	
		3272.93		1.89	
Co-57	271.79 d	14.41		9.16	accelerator produced
		122.06	*	85.60	
		136.47		10.68	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Co-58	70.86 d	810.78	*	99.45	Ni-58(n,p)
Co-60	5.27 y	1173.24	*	99.97	Co-59(n,γ); Cu-63(n,α); Ni-60(n,p)
		1332.50		99.98	
Co-60m	10.47 m	58.60	*	2.04	Co-59(n,γ)
		1332.50		0.24	
Ni-59	7.60E+04 y	no γs		-----	Ni-58(n,γ)
Ni-63	100.1 y	no γs		-----	Ni-62(n,γ)
Ni-65	2.52 h	366.27		4.81	Ni-64(n,γ)
		1115.55		15.43	
		1481.84	*	23.50	
Cu-62	9.74 m	875.70		0.15	Cu-63(n,2n)
		1172.90		0.34	
Cu-64	12.7 h	1345.84	*	0.47	Cu-63(n,γ)
		Annhilation abundance =35.8.			
Cu-66	5.12 m	833.54		0.22	Cu-65(n,γ)
		1039.23	*	9.00	
Cu-67	61.83 h	91.27		7.0	Cu-65(2n,γ); Zn-67(n,p)
		93.31		16.1	
		184.58	*	48.7	
		300.22		0.8	
Zn-65	244.26 d	1115.55	*	50.6	Zn-64(n,γ)
Zn-69	56.4 m	weak γs		-----	Zn-68(n,γ)
Zn-69m	13.76 h	438.63	*	94.77	Zn-68(n,γ)
Zn-71	2.45 m	511.56	*	32.0	Zn-70(n,γ)
Zn-71m	3.96 h	386.28	*	93.0	Zn-70(n,γ)
		487.38		62.0	
		511.56		28.4	
		596.14		27.9	
		620.18		57.0	
Zn-72	46.5 h	16.40		8.29	Zn-71(2n,γ)
		145.05	*	82.90	
		191.96		9.37	
Ga-70	21.14 m	1039.20	*	0.65	Ga-69(n,γ)
Ga-72	14.1 h	600.94		5.54	Ga-71(n,γ)
		629.95	*	24.80	
		834.01		95.63	
		894.26		9.88	
		1050.73		6.91	
		1861.09		5.25	
		2201.69		25.90	
		2490.98		7.68	
		2507.82		12.78	
Ge-71	11.43 d	no γs		-----	Ge-70(n,γ)
Ge-75	82.78 m	264.66	*	11.3	Ge-74(n,γ)
Ge-75m	47.7 s	139.68	*	39.0	Ge-74(n,γ)

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Ge-77	11.3 h	211.03		30.8	Ge-76(n,γ)
		215.51		28.6	
		264.44	*	54.0	
		367.40		14.0	
		416.33		21.8	
		558.02		16.1	
		631.82		7.0	
		714.35		7.2	
		1085.19		6.1	
		1368.40		3.3	
Ge-77m	52.9 s	159.70		10.33	Ge-76(n,γ)
		215.51	*	21.40	
As-74	17.77 d	595.85	*	59.4	As-75(n,2n)
		634.78		15.4	
		Annhilation abundance = 59.0			
As-76	26.3 h	559.10	*	44.60	As-75(n,γ)
		563.18		1.20	
		657.04		6.17	
		1212.94		1.44	
		1216.10		3.42	
		1228.60		1.21	
As-77	38.83 h	239.00	*	1.6	As-75(2n,γ); parent = Ge-77 [11.3 h]
Se-75	119.78 d	96.73		3.42	Se-74(n,γ)
		121.12		17.20	
		136.00		58.30	
		198.61		1.48	
		264.66	*	58.90	
		279.54		24.99	
		303.92		1.32	
		400.66		11.47	
Se-77m	17.36 s	161.92	*	52.4	Se-76(n,γ)
Se-79m	3.92 m	95.73	*	9.62	Se-78(n,γ)
Se-81	18.5 m	275.99	*	0.70	Se-80(n,γ)
		290.10		0.55	
Se-81m	57.3 m	103.01	*	13.0	Se-80(n,γ)
Se-83	22.3 m	224.80		32.64	Se-82(n,γ)
		356.70	*	69.90	
		510.17		42.64	
		718.10		14.96	
		799.07		14.82	
		836.52		13.28	
Se-83m	70.1 s	356.69		18.0	Se-82(n,γ)
		673.98	*	15.2	
Br-80	17.68 m	616.60	*	6.7	Br-79(n,γ)
		666.14		1.1	
		Annhilation abundance = 5.0			
Br-80m	4.42 h	37.05	*	39.1	Br-79(n,γ)

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Br-82	35.3 h	221.48		2.26	Br-81(n,γ)
		554.35		70.76	
		606.34		1.20	
		619.11		43.44	
		698.37		28.49	
		776.52	*	83.54	
		827.83		24.03	
		1007.59		1.27	
		1044.08		27.23	
		1317.47		26.48	
		1474.88		16.32	
Br-82m	6.13 m	776.52	*	0.24	Br-81(n,γ)
Kr-85m	4.48 h	151.16	*	75.0	Kr-84(n,γ); fission
		304.87		14.0	
Kr-87	76.3 m	402.59	*	49.60	Kr-86(n,γ); fission
		845.40		7.34	
		2554.80		9.20	
		2558.10		3.92	
Kr-88	2.84 h	196.30	*	25.98	fission
		834.83		12.98	
		1529.77		10.93	
		2195.84		13.18	
		2391.11		34.60	
Rb-86	18.63 d	1076.64	*	8.78	Rb-85(n,γ)
Rb-86m	1.02 m	556.07	*	98.19	Rb-85(n,γ)
Rb-88	17.78 m	898.04	*	14.04	Rb-87(n,γ); fission
		1836.06		21.40	parent = Kr-88 [2.84 h]
Sr-85	64.84 d	514.01	*	99.27	Sr-84(n,γ)
Sr-85m	67.6 m	231.67	*	84.4	Sr-84(n,γ)
Sr-87m	2.8 h	388.53	*	81.9	Sr-86(n,γ)
Sr-89	50.53 d	908.96	*	0.01	Sr-88(n,γ); fission
Y-88	106.65 d	898.04		93.7	accelerator produced
		1836.06	*	99.2	
Y-90m	3.19 h	202.51	*	97.30	Y-89(n,γ)
		479.17		90.74	
Zr-95	64.02 d	724.20		44.15	Zr-94(n,γ); fission
		756.73	*	54.50	
Zr-97	16.91 h	355.40		2.09	Zr-96(n,γ); fission
		507.64		5.03	
		743.36	*	93.00	
		1147.97		2.61	
Nb-92m	10.15 d	934.46	*	99.0	Nb-93(n,2n)
Nb-94m	6.26 m	871.10	*	0.5	Nb-93(n,γ)
Nb-95	34.98 d	765.79	*	99.79	Zr-94(n,γ); fission
					parent = Zr-95 [64.02 d]
Nb-95m	86.6 h	204.12		2.33	Zr-94(n,γ); fission
		235.69	*	24.90	parent = Zr-95 [64.02 d]

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Nb-97	72.1 m	658.08	*	98.39	Zr-96(n,γ); fission parent = Zr-97 [16.91 h]
Nb-97m	52.7 s	743.36	*	100	Zr-96(n,γ); fission parent = Zr-97 [16.91 h]
Mo-93m	6.85 h	263.06		56.7	Mo-93(n,γ)
		684.67	*	99.7	
		1477.13		99.1	
Mo-99	65.9 h	140.51		89.43	Mo-98(n,γ); fission
		181.06		5.99	
		366.42		1.19	
		739.58	*	12.13	
		777.92		4.26	
Mo-101	14.61 m	191.92		18.00	Mo-100(n,γ); fission
		505.92		11.62	
		590.10	*	20.30	
		695.56		6.66	
		934.21		4.12	
		1012.47		13.00	
		1160.98		4.02	
		1532.49		6.14	
		2032.10		6.59	
Tc-99m	6.01 h	140.51	*	89.0	Mo-98(n,γ); fission parent = Mo-99 [65.9 h]
Tc-101	14.22 m	306.86	*	89.00	Mo-100(n,γ); fission
		545.12		5.96	parent = Mo-101 [14.61 m]
Ru-97	69.1 h	215.72	*	86.00	Ru-96(n,γ)
		324.48		10.79	
Ru-103	39.26 d	443.80		3.27	Ru-102(n,γ); fission
		497.08	*	90.90	
		610.33		5.75	
Ru-105	4.44 h	262.83		6.57	Ru-104(n,γ); fission
		316.44		11.12	
		469.37		17.55	
		676.36		15.66	
		724.30	*	47.30	
Rh-102	207 d	468.58		2.42	Rh-103(n,2n)
		475.10	*	38.40	
		555.60		96.00	
		628.05		3.80	
		1103.16		2.42	
Rh-104	42.3 s	555.80	*	2.00	Rh-103(n,γ)
Rh-104m	4.34 m	51.42	*	48.20	Rh-103(n,γ)
		77.55		2.08	
		97.10		2.99	
		555.80		0.13	
Rh-105	35.4 h	306.25		5.10	Rh-104(n,γ); fission
		319.14	*	19.00	parent = Ru-105 [4.44 h]
Pd-103	16.99 d	39.76		0.07	Pd-102(n,γ)
		357.47	*	0.02	
Pd-107m	21.3 s	214.90	*	69.0	Pd-106(n,γ)
Pd-109	13.7 h	88.04	*	3.61	Pd-108(n,γ)

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Pd-109m	4.7 m	188.99	*	55.9	Pd-108(n,γ)
Pd-111	23.4 m	59.78		0.55	Pd-110(n,γ)
		70.44		0.78	
		376.71		0.46	
		580.02	*	0.90	
		650.40		0.57	
		1388.36		0.56	
		1458.90		0.58	
Pd-111m	5.5 h	70.44		2.14	Pd-110(n,γ)
		172.18	*	34.00	
		391.28		1.53	
Ag-108	2.37 m	433.94		0.50	Ag-107(n,γ)
		618.86		0.26	
		632.98	*	1.76	
Ag-110	24.6 s	657.76	*	4.50	Ag-109(n,γ)
Ag-110m	249.79 d	446.81		3.72	Ag-109(n,γ)
		620.36		2.79	
		657.76	*	94.00	
		677.62		10.28	
		687.02		6.39	
		706.68		16.33	
		744.28		4.70	
		763.94		22.14	
		818.03		7.29	
		884.68		72.20	
		937.49		34.13	
		1384.30		24.12	
		1475.79		3.97	
		1505.04		12.95	
		1562.30		1.02	
Cd-107	6.5 h	93.12	*	4.80	Cd-106(n,γ)
Cd-109	462.6 d	88.04	*	3.61	Cd-108(n,γ)
Cd-111m	48.54 m	150.82	*	29.1	Cd-110(n,γ)
		245.40		94.0	
Cd-113m	14.1 y	263.70	*	0.023	Cd-112(n,γ)
Cd-115	53.5 h	260.89		1.94	Cd-114(n,γ)
		336.24		45.90	
		492.30		8.03	
		527.90	*	27.45	
Cd-115m	44.6 d	484.47		0.29	Cd-114(n,γ)
		933.80	*	2.00	
		1290.58		0.89	
Cd-117	2.49 h	273.35	*	28.00	Cd-116(n,γ)
		344.46		17.90	
		434.19		9.80	
		1303.27		18.40	
		1576.62		11.19	
Cd-117m	3.36 h	564.40		14.70	Cd-116(n,γ)
		860.41		7.90	
		1029.06		11.70	
		1065.98	*	23.10	
		1234.59		11.00	
		1432.91		13.40	
		1997.33		26.00	
		2096.40		7.44	
		2322.75		7.86	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
In-113m	1.66 h	391.69		64.20	Cd-112(n,γ); parent = Cd-113m [14y]
In-114m	49.5 d	190.29	*	15.56	In-113(n,γ)
		558.46		3.24	
		725.30		3.24	
In-115m	4.49 h	336.26	*	45.83	In-115(n,n'); Cd-114(n,γ) parent = Cd-115 [53.5 h]
In-116m	54.29 m	138.33		3.29	In-115(n,γ)
		416.86		27.70	
		818.72		11.50	
		1097.33	*	56.20	
		1293.55		84.40	
		1507.67		10.00	
		1752.72		2.46	
		2112.31		15.50	
In-117	43.2 m	158.56		87.0	Cd-116(n,γ)
		553.00	*	100.0	parents = Cd-117 [2.47 h] & Cd-117m [3.36 h]
In-117m	116.2 m	158.56		16.0	Cd-116(n,γ)
		315.30	*	19.0	parents = Cd-117 [2.47 h] & Cd-117m [3.36 h]
Sn-113	115.09 d	255.05		1.82	Sn-112(n,γ)
		391.69	*	64.00	
Sn-113m	21.4 m	77.38	*	0.50	Sn-112(n,γ)
Sn-117m	13.6 d	156.02		2.11	Sn-116(n,γ)
		158.56	*	86.40	
Sn-119m	293.1 d	23.87	*	16.1	Sn-118(n,γ)
		25.27		14.3	
Sn-123	129.2 d	1088.64	*	0.6	Sn-122(n,γ); fission
Sn-123m	40.08 m	160.33	*	86.0	Sn-122(n,γ); fission
Sn-125	9.64 d	332.10		1.41	Sn-124(n,γ); fission
		469.85		1.48	
		822.48		4.28	
		915.55		4.13	
		1067.10	*	10.00	
		1089.19		4.59	
		2002.15		1.92	
Sn-125m	9.52 m	332.10	*	97.2	Sn-124(n,γ); fission
Sb-122	2.72 d	564.12	*	71.0	Sb-121(n,γ)
		692.79		3.85	
Sb-122m	4.19 m	61.41	*	55	Sb-121(n,γ)
		76.06		18.5	
Sb-124	60.2 d	602.73		98.26	Sb-123(n,γ)
		645.85		7.46	
		713.78		2.29	
		722.79		10.81	
		968.26		1.89	
		1045.13		1.84	
		1325.51		1.59	
		1368.17		2.62	
		1690.98	*	47.79	
		2090.94		5.51	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Sb-124m	93 s	498.40		24.50	Sb-123(n,γ)
		602.73		25.00	
		645.86	*	25.00	
Sb-125	2.76 y	176.31		6.82	Sb-123(2n,γ); Sn-124(n,γ); fission
		380.45		1.52	parent = Sn-125 [9.64 d]
		427.88	*	30.00	
		463.36		10.49	
		600.60		17.86	
		606.72		5.03	
		635.95		11.31	
		671.44		1.80	
Te-121	16.78 d	507.59		17.7	Te-120(n,γ)
		573.14	*	80.3	
Te-121m	154 d	212.19	*	81.0	Te-120(n,γ)
		1102.15		2.54	
Te-123m	119.7 d	158.97	*	84.0	Te-122(n,γ)
Te-125m	57.4 d	35.49	*	6.67	Te-124(n,γ)
		109.28		0.27	
Te-127	9.35 h	417.95	*	1.0	Te-126(n,γ)
Te-127m	109 d	57.61	*	0.5	Te-126(n,γ)
Te-129	69.6 m	27.81		16.30	Te-128(n,γ); fission
		459.60	*	7.70	
		487.39		1.42	
Te-129m	33.6 d	105.50		0.15	Te-128(n,γ); fission
		695.88	*	3.07	
Te-131	25 m	149.72	*	68.90	Te-130(n,γ); fission
		452.33		18.18	parent = Te-131m [30.0 h]
Te-131m	30 h	102.06		10.37	Te-130(n,γ); fission
		200.63		9.86	
		240.93		9.91	
		334.27		12.49	
		773.67	*	49.90	
		782.49		10.16	
		793.75		18.10	
		822.78		7.99	
		852.21		27.00	
		1125.46		14.90	
		1206.60		12.74	
Te-132	3.2 d	49.72		15	fission
		228.16	*	88	
I-125	59.4 d	35.49	*	6.68	Xe-124(n,γ)
					parent = Xe-125 [16.9 h]
I-128	24.99 m	442.90	*	17	I-127(n,γ)
		526.56		1.58	
I-131	8.02 d	80.18		2.62	Xe-130(n,γ); fission
		284.30		6.14	parents = Te-131 [25.0 m]
		364.49	*	81.70	& Te-131m [30.0 h]
		636.99		7.17	
		722.91		1.77	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
I-132	2.3 h	505.79		4.94	fission parent = Te-132 [3.2 d]
		522.65		16.00	
		630.19		13.30	
		667.72	*	99.00	
		669.80		4.60	
		671.40		3.50	
		772.60		75.60	
		812.00		5.50	
		954.66		17.60	
		1136.00		3.01	
I-132m	83.2 m	98.00		3.72	fission parent = Te-132 [3.2 d]
		173.70	*	8.80	
I-133	20.8 h	529.87	*	87.00	fission
		875.33		4.51	
I-134	52.5 m	595.36		11.1	fission
		621.70		10.6	
		847.02	*	95.4	
		884.09		64.9	
		1072.55		14.9	
I-135	6.57 h	526.56		13.3	fission
		546.56		7.2	
		836.80		6.7	
		1038.76		8.0	
		1131.51		22.7	
		1260.41	*	28.9	
		1457.56		8.7	
Xe-125	16.9 h	58.97		6.8	Xe-124(n,γ)
		188.40	*	54.0	
		243.38		30.1	
		453.80		4.7	
Xe-127	36.4 d	172.13		25.5	Xe-126(n,γ)
		202.86	*	68.0	
Xe-129m	8.88 d	39.58	*	7.5	Xe-128(n,γ)
		196.56		4.6	
Xe-131m	11.84 d	163.93	*	1.9	Xe-130(n,γ); Te-130(n,γ); fission parents = Te-131m [30.0 h] & Te-131 [25.0 m] parent = I-131 [8.02 d]
Xe-133	5.24 d	81.00	*	38.0	Xe-132(n,γ); fission
Xe-133m	2.19 d	233.22	*	10.0	Xe-132(n,γ); fission
Xe-135	9.14 h	249.77	*	90.2	Xe-134(n,γ); fission
Xe-135m	15.29 m	526.56	*	80.5	Xe-134(n,γ); fission parent = I-135 [6.57 h]
Xe-137	3.82 m	455.49	*	31.0	Xe-136(n,γ); fission
Xe-138	14.1 m	258.41	*	31.50	fission
		434.56		20.32	
		1768.26		16.73	
		2015.82		12.25	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Cs-134	2.06 y	475.36		1.49	Cs-133(n,γ)
		563.25		8.35	
		569.33		15.38	
		604.72		97.62	
		795.86	*	85.53	
		801.95		8.69	
		1167.97		1.79	
		1365.18		3.01	
Cs-134m	2.9 h	127.50	*	13.0	Cs-133(n,γ)
Cs-135m	53 m	786.84	*	100.0	
		846.10		95.9	
Cs-137	30.07 y	661.66	*	85.1	Xe-136(n,γ); fission
Cs-138	33.4 m	462.80		30.7	fission
		547.00		10.8	parent = Xe-138 [14.1 m]
		1009.78		29.8	
		1435.80	*	76.3	
		2218.00		15.2	
Ba-131	11.5 d	123.80		28.97	Ba-130(n,γ)
		133.61		2.12	
		216.08		19.66	
		239.63		2.41	
		249.43		2.81	
		373.25		14.04	
		404.05		1.31	
		486.52		2.09	
		496.33	*	47.00	
Ba-131m	14.6 m	108.08	*	55.00	Ba-130(n,γ)
Ba-133	10.51 y	53.16		2.20	Ba-132(n,γ)
		79.61		2.62	
		81.00		34.06	
		276.40		7.16	
		302.85		18.33	
		356.02	*	62.05	
		383.85		8.94	
Ba-133m	38.9 h	275.92	*	17.50	Ba-132(n,γ)
Ba-135m	28.7 h	268.22	*	15.60	Ba-134(n,γ)
Ba-137m	2.55 m	661.66	*	90.11	Ba-136(n,γ); fission
Ba-139	83.06 m	165.85	*	23.70	Ba-138(n,γ); fission
Ba-140	12.75 d	162.66		6.22	fission
		304.85		4.29	
		423.72		3.15	
		437.58		1.93	
		537.31	*	24.39	
La-140	40.27 h	328.76		20.30	La-139(n,γ); fission
		432.49		2.90	parent = Ba-140 [12.75 d]
		487.02		45.50	
		751.64		4.33	
		815.77		23.28	
		867.85		5.50	
		919.55		2.66	
		925.19		6.90	
		1596.21	*	95.40	
		2521.40		3.46	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Ce-137	9 h	436.59		0.27	Ce-136(n,γ)
		447.15	*	1.80	
Ce-137m	34.4 h	254.29	*	11.00	Ce-136(n,γ)
Ce-139	137.64 d	165.86	*	80.00	Ce-138(n,γ)
Ce-139m	54.8 s	754.24	*	92.45	Ce-138(n,γ)
Ce-141	32.5 d	145.44	*	48.20	Ce-140(n,γ); fission
Ce-143	33.0 h	57.36		11.70	Ce-142(n,γ); fission
		231.55		2.05	
		293.27	*	42.80	
		350.62		3.23	
		490.37		2.16	
		664.57		5.69	
		721.93		5.39	
		880.46		1.03	
Ce-144	284.9 d	133.52	*	11.09	fission
Pr-142	19.12 h	1575.85	*	3.70	Pr-141(n,γ); fission
Nd-147	10.98 d	91.10		28.00	Nd-146(n,γ); fission
		319.41		1.95	
		398.16		0.87	
		439.90		1.20	
		531.01	*	13.10	
		685.90		0.81	
Nd-149	1.73 h	114.31		19.20	Nd-148(n,γ); fission
		155.87		5.93	
		211.31	*	25.90	
		240.22		3.94	
		267.69		6.03	
		270.17		10.72	
		326.55		4.56	
		423.55		7.40	
		540.51		6.58	
		654.83		8.00	
Nd-151	12.4 m	116.80		39.00	Nd-151(n,γ); fission
		138.89		7.05	
		175.07		6.33	
		255.68		14.80	
		423.56		5.92	
		736.23		5.92	
		797.53		4.72	
		1122.63		4.08	
		1180.89	*	13.30	
Pm-148	5.37 d	550.28		22.00	fission
		914.85		11.46	
		1465.12	*	22.00	
Pm-148m	41.29 d	288.51		12.51	fission
		311.57		3.90	
		414.03		18.59	
		432.74		5.33	
		501.31		6.72	
		550.28	*	94.50	
		599.81		12.49	
		611.29		5.46	
		629.99		89.00	
		725.67		32.70	
		915.33		17.10	
		1013.81		20.20	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Pm-149	53.1 h	285.95	*	3.1	Nd-148(n,γ); fission parent = Nd-149 [1.73 h]
Pm-151	28.4 h	100.02		2.54	Nd-150(n,γ); fission parent = Nd-151 [12.4 m]
		104.84		3.51	
		167.75		8.30	
		177.16		3.82	
		240.09		3.82	
		275.21		6.80	
		340.08	*	23.00	
		344.90		2.11	
		445.68		4.00	
		717.72		4.05	
Sm-145	340 d	61.25	*	12.0	Sm-144(n,γ)
Sm-153	46.28 h	69.67	*	4.85	Sm-152(n,γ); fission
		103.18		30.00	
Sm-155	22.3 m	104.33	*	74.60	Sm-154(n,γ); fission
		141.44		1.98	
		245.77		3.70	
Eu-152	13.54 y	121.78		28.58	Eu-151(n,γ)
		244.70		7.58	
		344.28		26.50	
		411.12		2.23	
		443.89		3.14	
		778.90		12.94	
		867.38		4.24	
		964.08		14.61	
		1085.87		10.21	
		1112.07		13.64	
		1212.95		1.42	
		1299.14		1.62	
		1408.00	*	21.00	
Eu-152m	9.31 h	121.78		7.00	Eu-151(n,γ)
		344.28		2.38	
		841.57	*	14.20	
		963.39		11.67	
Eu-154	8.59 y	123.07		40.79	Eu-153(n,γ)
		247.92		6.95	
		591.76		4.99	
		692.42		1.80	
		723.30		20.22	
		756.76		4.57	
		873.19		12.27	
		996.26		10.60	
		1004.72		18.01	
		1274.44	*	35.19	
Eu-155	4.76 y	45.30		1.33	Eu-153(2n,γ)
		60.01		1.13	
		86.54		30.80	
		105.30	*	21.20	
Gd-153	240.4 d	69.67		2.42	Gd-152(n,γ)
		97.43	*	29.00	
		103.18		21.11	
Gd-159	18.48 h	58.00		2.15	Gd-158(n,γ)
		363.55	*	11.40	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Gd-161	3.66 m	102.32		13.87	Gd-160(n,γ)
		283.55		5.95	
		314.92		22.70	
		360.94	*	60.05	
Tb-160	72.3 d	86.79		13.15	Tb-159(n,γ)
		197.04		5.18	
		215.65		4.02	
		298.58		26.13	
		392.51		2.34	
		765.28		2.14	
		879.38	*	30.10	
		962.32		9.81	
		966.17		25.10	
		1002.88		1.04	
		1115.12		1.56	
		1177.96		14.87	
		1199.89		2.38	
		1271.88		7.44	
		1312.14		2.86	
Tb-161	6.9 d	25.65		23.20	Tb-159(2n,γ); Gd-160(n,γ)
		48.92		17.00	parent = Gd-161 [3.66 m]
		74.57	*	10.20	
Dy-157	8.14 h	326.16	*	92.0	Dy-156(n,γ)
Dy-159	144.4 d	58.00	*	2.22	Dy-158(n,γ)
Dy-165	2.33 h	94.70	*	3.58	Dy-164(n,γ)
		279.76		0.50	
		361.67		0.84	
		633.43		0.57	
Dy-165m	1.26 m	108.16	*	3.01	Dy-164(n,γ)
		515.47		1.53	
Dy-166	81.6 h	82.47	*	14.00	Dy-164(2n,γ)
		371.76		0.52	
		426.00		0.58	
Ho-166	26.83 h	80.57	*	6.71	Ho-165(n,γ);
		1379.40		0.93	parent = Dy-166 [81.6 h]
Ho-166m	1200 y	80.57		12.33	Ho-165(n,γ)
		184.41	*	72.60	
		280.46		29.77	
		300.76		3.73	
		410.94		11.41	
		451.52		2.98	
		529.80		9.69	
		570.99		5.55	
		670.50		5.48	
		711.68		55.32	
		752.28		12.29	
		778.82		3.08	
		810.28		58.08	
		830.58		9.82	
Er-163	75 m	297.88		0.01	Er-162(n,γ)
		436.10	*	0.29	
		439.94		0.03	
		1113.50		0.05	
Er-165	10.36 h	no (s		-----	Er-164(n,γ)

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Er-167m	2.27 s	207.81	*	41.7	Er-166(n,γ)
Er-169	9.4 d	weak γs		-----	Er-168(n,γ)
Er-171	7.52 h	111.62		20.5	Er-170(n,γ)
		124.02		9.1	
		295.90		28.9	
		308.29	*	64.4	
Er-172	49.3 h	59.69		2.69	Er-170(2n,γ)
		68.11		3.29	
		127.80		2.13	
		202.72		1.03	
		383.50		2.35	
		407.34	*	42.1	
		446.02		2.96	
		475.44		1.04	
		610.06		44.2	
Tm-170	128.6 d	84.25	*	2.50	Tm-169(n,γ)
Tm-171	1.92 y	66.72	*	0.14	Tm-169(2n,γ); Er-170(n,γ) parent = Er-171 [7.52 h]
Tm-172	63.6 h	78.74		6.50	Er-170(2n,γ)
		181.53		2.75	parent = Er-172 [49.3 h]
		1093.66	*	6.00	
		1387.09		5.60	
		1465.93		4.50	
		1529.72		5.10	
		1608.56		4.14	
Yb-169	32.03 d	63.12		44.20	Yb-168(n,γ)
		109.78		17.47	
		130.52		11.31	
		177.21	*	22.16	
		197.96		35.80	
		307.74		10.05	
Yb-175	4.19 d	113.80		1.88	Yb-174(n,γ)
		282.52		3.01	
		396.33	*	6.40	
Yb-177	1.91 h	121.62		3.42	Yb-176(n,γ)
		138.61		1.34	
		150.39	*	20.30	
		1080.21		5.60	
		1241.20		3.47	
Lu-176m	3.64 h	88.34	*	8.9	Lu-175(n,γ)
Lu-177	6.73 d	112.95		6.40	Lu-176(n,γ); parent = Yb-177 [1.91 h]
		208.37	*	11.00	
		249.67		0.21	
		321.32		0.22	
Lu-177m	160.4 d	105.36		12.3	Lu-176(n,γ)
		112.95		20.4	most gamma rays are from
		128.50		15.5	decay of Hf-177m [1.0 s]
		153.28		16.9	
		174.40		12.6	
		204.10		13.8	
		208.37	*	57.7	
		228.48		37.0	
		281.79		14.1	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
		319.02		10.5	
		327.68		18.1	
		378.50		29.7	
		413.66		17.4	
		418.54		21.3	
Hf-175	70 d	343.40	*	84.00	Hf-174(n,γ)
		433.00		1.44	
Hf-177m2	51.4 m	214.00		42.0	Hf-176(n,γ)
		277.30		78.0	
		295.10		72.0	
		311.50		61.0	
		326.70	*	68.0	
Hf-180m	5.5 h	57.55		48.0	Hf-179(n,γ)
		215.26		81.3	
		332.28	*	94.1	
		443.09		81.9	
Hf-181	42.39 d	133.02		43.30	Hf-180(n,γ)
		136.27		5.85	
		345.92		15.12	
		482.18	*	80.50	
Hf-182m	61.5 m	50.80		12.22	Hf-181(2n,γ)
		97.80		8.52	
		224.40		34.90	
		344.10	*	42.23	
		455.80		18.50	
		506.60		21.64	
		799.60		9.42	
		942.80		18.85	
Ta-182	114.43 d	65.71		2.92	Ta-181(n,γ)
		67.75		41.20	
		84.68		2.65	
		100.11		14.10	
		113.67		1.88	
		152.43		6.93	
		156.39		2.64	
		179.39		3.08	
		222.11		7.49	
		229.32		3.63	
		264.07		3.61	
		1001.70		2.07	
		1121.30		34.90	
		1189.05		16.23	
		1221.41	*	26.98	
		1231.02		11.44	
		1257.42		1.49	
		1289.16		1.35	
Ta-182m	15.84 m	146.78		37.2	Ta-181(n,γ)
		171.58	*	49.0	
		184.95		24.5	
		318.36		6.9	
Ta-183	5.1 d	99.08		6.70	Ta-181(2n,γ)
		107.93		11.00	
		144.12		2.49	
		160.53		2.92	
		161.53		8.90	
		162.32		4.88	
		209.87		4.48	
		244.26		8.50	
		246.06	*	27.00	
		291.72		3.73	
		313.27		4.20	
		353.99		11.20	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
W-181	121.2 d	136.27	*	0.031	W-180(n,γ)
		152.32		0.008	
W-185	75.1 d	125.36	*	0.019	W-184(n,γ)
W-185m	1.67 m	65.86	*	5.80	W-184(n,γ)
		131.55		4.33	
		173.68		3.26	
W-187	23.72 h	72.00		11.14	W-186(n,γ)
		134.24		8.85	
		479.53	*	21.80	
		551.53		5.08	
		618.36		6.28	
		685.77		27.30	
		772.89		4.12	
		864.64		0.34	
W-188	69.4 d	227.08		0.22	W-186(n,γ)
		290.67	*	0.40	
Re-186	90.64 h	122.30		0.60	Re-185(n,γ)
		137.16	*	9.42	
Re-188	17 h	155.03	*	15.10	Re-187(n,γ); W-186(2n,γ)
		477.99		1.02	parent = W-188 [69.4 d]
		632.99		1.27	
Re-188m	18.6 m	63.58		21.6	Re-187(n,γ); W-186(2n,γ)
		92.46		5.2	parent = W-188 [69.4 d]
		105.87	*	10.8	
Os-185	93.6 d	646.12	*	78.00	Os-184(n,γ)
		717.42		3.94	
		874.81		6.29	
		880.52		5.17	
Os-190m	9.9 m	186.72		70.20	Os-189(n,γ)
		361.14	*	94.88	
		502.53		97.79	
		616.08		98.62	
Os-191	15.4 d	129.42	*	29.00	Os-190(n,γ)
Os-191m	13.1 h	74.38	*	0.07	Os-190(n,γ)
Os-193	30.1 h	73.04		3.20	Os-192(n,γ)
		138.94		4.27	
		280.46		1.24	
		321.60		1.28	
		387.52		1.26	
		460.55	*	3.95	
		557.43		1.30	
Os-194	6 y	43.12	*	5.00	Os-192(2n,γ)
Ir-192	73.8 d	205.80		3.30	Ir-191(n,γ)
		295.96		28.67	
		308.46		30.00	
		316.51	*	82.81	
		468.07		47.83	
		484.58		3.18	
		588.59		4.52	
		604.41		8.23	
		612.46		5.31	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Ir-192m	1.45 m	58.00	*	0.04	Ir-191(n,γ)
Ir-194	19.28 h	293.54		2.52	Ir-193(n,γ)
		328.46	*	13.10	
Ir-194m2	171 d	328.46		92.8	Ir-193(n,γ)
		338.80	*	55.1	
		390.80		35.1	
		482.83		96.9	
		562.64		69.9	
		600.50		62.3	
		687.70		59.1	
		1011.80		3.6	
Pt-191	2.8 d	82.41		4.90	Pt-190(n,γ)
		96.52		3.28	
		129.42		3.20	
		172.18		3.52	
		268.73		1.65	
		351.21		3.36	
		359.90		6.00	
		409.44		8.10	
		456.50		3.36	
		538.91	*	13.70	
		624.08		1.41	
Pt-193	50 y	no γs		-----	Pt-192(n,γ)
Pt-193m	4.33 d	weak γs		-----	Pt-192(n,γ)
Pt-195m	4.02 d	30.90		2.28	Pt-194(n,γ)
		98.85	*	11.40	
		129.70		2.83	
Pt-197	19.89 h	77.34	*	17.0	Pt-196(n,γ)
		191.44		3.7	
Pt-197m	95.41 m	279.01		2.4	Pt-196(n,γ)
		346.50	*	11.1	
Pt-199	30.8 m	185.77		3.32	Pt-198(n,γ)
		191.71		2.34	
		246.46		2.23	
		317.06		4.95	
		493.77		5.59	
		542.99	*	15.00	
Pt-199m	13.6 s	391.93	*	85.0	Pt-198(n,γ)
Au-196	6.18 d	332.98		22.9	Au-197(n,2n)
		355.68	*	87.0	
		426.00		7.0	
Au-198	2.70 d	411.80	*	96.0	Au-197(n,γ)
		675.88		0.80	
		1087.68		0.16	
Au-199	3.14 d	158.38	*	40.00	Au-197(2n,γ); Pt-198(n,γ)
		208.20		8.73	parent = Pt-199 [30.8 m]
Hg-197	64.14 h	77.35	*	18.7	Hg-196(n,γ)
Hg-197m	23.8 h	133.99	*	33.0	Hg-197(n,γ)
		279.01		6.0	
Hg-199m	42.6 m	158.38	*	52.0	Hg-198(n,γ)
		374.10		13.8	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Hg-203	46.6 d	279.20	*	81.0	Hg-202(n,γ)
Hg-205	5.2 m	203.75	*	2.2	Hg-204(n,γ)
Tl-208	3.05 m	277.35		6.31	parent = Th-232 [1.40E10 y]
		510.77		22.60	
		583.19		84.50	
		860.56		12.42	
		2614.53	*	99.00	
Pb-212	10.64 h	238.63	*	43.30	parent = Th-232 [1.40E10 y]
		300.09		3.28	
Pb-214	26.8 m	242.00		7.43	parent = U-238 [4.5E09 y]
		295.22		19.30	
		351.93	*	37.60	
Bi-212	60.6 m	727.33	*	6.58	parent = Th-232 [1.40E10 y]
		785.37		1.10	
		1620.50		1.49	
Bi-214	19.9 m	609.31	*	46.10	parent = U-238 [4.5E09 y]
		768.35		4.94	
		934.04		3.03	
		1120.27		15.10	
		1238.11		5.79	
		1377.66		4.00	
		1407.98		2.15	
		1509.23		2.11	
		1729.58		2.92	
		1764.49		15.40	
		1847.42		2.11	
		2204.21		5.08	
Ra-226	1600 y	186.21	*	3.59	parent= U-238 [4.5E09 y]
Ac-228	6.15 h	99.51		1.26	parent= Th-232 [1.40E10 y]
		129.06		2.42	
		209.25		3.89	
		270.24		3.46	
		328.00		2.95	
		338.32		11.27	
		409.46		1.92	
		463.00		4.44	
		772.29		1.49	
		794.95		4.25	
		835.71		1.61	
		911.20	*	25.80	
		964.77		4.99	
		968.97		15.80	
		1588.21		3.22	
		1630.63		1.51	
Th-233	22.3 m	29.37		2.50	Th-232(n,γ)
		86.47		2.70	
		94.66		0.80	
		459.22	*	1.40	
		669.90		0.68	
Pa-233	27 d	75.35		1.39	Th-232(n,γ)
		86.81		1.97	parent = Th-233 [22.3 m]
		103.97		0.87	
		300.34		6.62	
		312.17	*	38.60	
		340.81		4.47	
		398.62		1.39	
		415.76		1.74	

Table 6. Properties of the radioactive isotopes arranged by atomic number.

Isotope	Half-life	Energy (keV)		Abundance (%)	Production Mode(s)
Th-234	24.1 d	63.29	*	4.80	parent= U-238 [4.5E09 y]
		92.38		2.81	
		92.80		2.77	
Pm-234m	1.17 m	766.38		0.29	parent= U-238 [4.5E09 y]
		1001.03	*	0.84	
U-235	7.10E+08 y	109.16		1.54	natural product
		143.76		10.96	
		163.36		5.08	
		185.71	*	57.00	
		205.31		5.01	
U-239	23.47 m	43.53		4.14	U-238(n,γ)
		74.66	*	48.00	
Np-239	2.36 d	106.12		27.20	U-238(n,γ)
		209.75		3.42	parent = U-239 [23.47 m]
		228.18		10.76	
		277.60	*	14.38	
		315.88		1.60	
		334.31		2.07	
Am-241	432.2 y	59.54	*	35.9	multiple neutron captures

Table 7. Background peaks commonly observed in gamma-ray spectra.

Energy (keV)	Radionuclide	Source
63.2	Th-234	U-238 (half-life = 4.5E+09 y)
75.0	Kα X-ray from Pb	induced X-ray fluorescence on lead
84.9	Kβ X-ray from Pb	induced X-ray fluorescence on lead
92.4	Th-234	U-238 (half-life = 4.5E+09 y)
92.8	Th-234	U-238 (half-life = 4.5E+09 y)
99.5	Ac-228	Th-232 (half-life = 1.405E+10 y)
109.2	U-235	U-235 (half-life = 7.0E+08 y)
129.1	Ac-228	Th-232 (half-life = 1.405E+10 y)
143.8	U-235	U-235 (half-life = 7.0E+08 y)
154.0	Ac-228	Th-232 (half-life = 1.405E+10 y)
163.4	U-235	U-235 (half-life = 7.0E+08 y)
185.7	U-235	U-235 (half-life = 7.0E+08 y)
186.2	Ra-226	U-238 (half-life = 4.5E+09 y)
209.2	Ac-228	Th-232 (half-life = 1.405E+10 y)
238.6	Pb-212	Th-232 (half-life = 1.405E+10 y)
242.0	Pb-214	U-238 (half-life = 4.5E+09 y)
270.2	Ac-228	Th-232 (half-life = 1.405E+10 y)
277.4	Tl-208	Th-232 (half-life = 1.405E+10 y)
300.1	Pb-212	Th-232 (half-life = 1.405E+10 y)
295.2	Pb-214	U-238 (half-life = 4.5E+09 y)
328.0	Ac-228	Th-232 (half-life = 1.405E+10 y)
338.3	Ac-228	Th-232 (half-life = 1.405E+10 y)
351.9	Pb-214	U-238 (half-life = 4.5E+09 y)
356.0	Bi-214 & Tl-210	U-238 (half-life = 4.5E+09 y)
409.5	Ac-228	Th-232 (half-life = 1.405E+10 y)
463.0	Ac-228	Th-232 (half-life = 1.405E+10 y)
510.7	Tl-208	Th-232 (half-life = 1.405E+10 y)
511.0	Annihilation peak	Cosmic rays & pair production
562.5	Ac-228	Th-232 (half-life = 1.405E+10 y)
583.2	Tl-208	Th-232 (half-life = 1.405E+10 y)
609.3	Bi-214	U-238 (half-life = 4.5E+09 y)
661.6	Cs-137	Fission product
665.4	Bi-214	U-238 (half-life = 4.5E+09 y)
703.1	Bi-214	U-238 (half-life = 4.5E+09 y)
719.9	Bi-214	U-238 (half-life = 4.5E+09 y)
726.9	Ac-228	Th-232 (half-life = 1.405E+10 y)
727.3	Bi-212	Th-232 (half-life = 1.405E+10 y)
755.3	Ac-228	Th-232 (half-life = 1.405E+10 y)
766.4	Pa-234	U-238 (half-life = 4.5E+09 y)
768.4	Bi-214	U-238 (half-life = 4.5E+09 y)

Table 7. Background peaks commonly observed in gamma-ray spectra.

Energy (keV)	Radionuclide	Source
772.3	Ac-228	Th-232 (half-life = 1.405E+10 y)
785.4	Bi-212	Th-232 (half-life = 1.405E+10 y)
786.3	Pa-234m	U-238 (half-life = 4.5E+09 y)
794.9	Ac-228	Th-232 (half-life = 1.405E+10 y)
806.2	Bi-214	U-238 (half-life = 4.5E+09 y)
835.7	Ac-228	Th-232 (half-life = 1.405E+10 y)
840.4	Ac-228	Th-232 (half-life = 1.405E+10 y)
860.6	Tl-208	Th-232 (half-life = 1.405E+10 y)
911.2	Ac-228	Th-232 (half-life = 1.405E+10 y)
934.0	Bi-214	U-238 (half-life = 4.5E+09 y)
964.8	Ac-228	Th-232 (half-life = 1.405E+10 y)
969.0	Ac-228	Th-232 (half-life = 1.405E+10 y)
1001.0	Pm-234m	U-238 (half-life = 4.5E+09 y)
1120.3	Bi-214	U-238 (half-life = 4.5E+09 y)
1155.2	Bi-214	U-238 (half-life = 4.5E+09 y)
1173.2	Co-60	Co-60 (half-life = 5.27 y)
1238.1	Bi-214	U-238 (half-life = 4.5E+09 y)
1281.0	Bi-214	U-238 (half-life = 4.5E+09 y)
1332.5	Co-60	Co-60 (half-life = 5.27 y)
1377.7	Bi-214	U-238 (half-life = 4.5E+09 y)
1401.5	Bi-214	U-238 (half-life = 4.5E+09 y)
1408.0	Bi-214	U-238 (half-life = 4.5E+09 y)
1460.8	K-40	K-40 (half-kife = 1.251e+09 y)
1509.2	Bi-214	U-238 (half-life = 4.5E+09 y)
1588.2	Ac-228	Th-232 (half-life = 1.405E+10 y)
1592.5	Tl-208 [DE from 2614]	Th-232 (half-life = 1.405E+10 y)
1620.5	Bi-212	Th-232 (half-life = 1.405E+10 y)
1630.6	Ac-228	Th-232 (half-life = 1.405E+10 y)
1661.3	Bi-214	U-238 (half-life = 4.5E+09 y)
1729.6	Bi-214	U-238 (half-life = 4.5E+09 y)
1764.5	Bi-214	U-238 (half-life = 4.5E+09 y)
1847.4	Bi-214	U-238 (half-life = 4.5E+09 y)
2103.5	Tl-208 [SE from 2614]	Th-232 (half-life = 1.405E+10 y)
2204.2	Bi-214	U-238 (half-life = 4.5E+09 y)
2614.5	Tl-208	Th-232 (half-life = 1.405E+10 y)

Table 8. Gamma rays arranged by energy (half-lives < 1 day).

Energy 1 (keV)	Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
27.8	Te-129	69.6	m	459.6	487.4	-----
29.4	Th-233	22.3	m	459.2	86.5	94.7
37.1	Br-80m	4.42	h	-----	-----	-----
43.5	U-239	23.47	m	74.7	-----	-----
50.8	Hf-182m	61.5	m	344.1	244.4	506.6
51.4	Rh-104m	4.34	m	97.1	77.6	555.8
57.6	Hf-180m	5.5	h	332.3	443.1	215.3
58.0	Ir-192m	1.45	m	-----	-----	-----
58.0	Gd-159	18.48	h	363.6	-----	-----
58.6	Co-60m	10.47	m	1332.5	-----	-----
59.0	Xe-125	16.9	h	188.4	243.4	453.8
59.8	Pd-111	23.4	m	580.0	650.4	376.7
61.4	Sb-122m	4.19	m	76.1	-----	-----
63.6	Re-188m	18.6	m	105.9	92.5	-----
70.4	Pd-111m	5.5	h	172.2	391.3	-----
70.4	Pd-111	23.4	m	580.0	650.4	376.7
72.0	W-187	23.72	h	479.5	685.8	618.4
74.7	U-239	23.47	m	43.5	-----	-----
76.1	Sb-122m	4.19	m	61.4	-----	-----
77.3	Pt-197	19.89	h	191.4	-----	-----
77.4	Sn-113m	21.4	m	-----	-----	-----
77.6	Rh-104m	4.34	m	51.4	97.1	555.8
86.5	Th-233	22.3	m	459.2	94.7	669.9
88.0	Pd-109	13.7	h	-----	-----	-----
88.3	Lu-176m	3.64	h	-----	-----	-----
92.5	Re-188m	18.6	m	105.9	63.6	-----
93.1	Cd-107	6.5	h	-----	-----	-----
94.7	Th-233	22.3	m	459.2	86.5	669.9
95.7	Se-79m	3.92	m	-----	-----	-----
97.1	Rh-104m	4.34	m	51.4	77.6	555.8
97.8	Hf-182m	61.5	m	344.1	224.4	506.6
98.0	I-132m	83.2	m	173.7	-----	-----
102.3	Gd-161	3.66	m	360.9	314.9	283.6
103.0	Se-81m	57.3	m	-----	-----	-----
104.3	Sm-155	22.3	m	245.8	141.4	-----
105.9	Re-188m	18.6	m	63.6	92.5	-----
108.1	Ba-131m	14.6	m	-----	-----	-----
108.2	Dy-165m	1.26	m	515.5	-----	-----
111.6	Er-171	7.52	h	308.3	295.9	124.0
114.3	Nd-149	1.73	h	211.3	270.2	423.6
116.8	Nd-151	12.4	m	1180.9	255.7	-----
121.6	Yb-177	1.91	h	150.4	1080.2	1241.2
121.8	Eu-152m	9.31	h	841.6	963.4	344.3
124.0	Er-171	7.52	h	308.3	295.9	111.6
127.5	Cs-134m	2.9	h	-----	-----	-----
129.1	Ac-228	6.15	h	911.2	969.0	338.3
131.6	W-185m	1.67	m	173.7	-----	-----
134.0	Hg-197m	23.8	h	279.0	-----	-----
134.2	W-187	23.72	h	479.5	685.8	618.4
138.3	In-116m	54.15	m	1097.3	1293.6	416.9
138.6	Yb-177	1.91	h	150.4	1080.2	1241.2
139.7	Ge-75m	47.7	s	-----	-----	-----
140.5	Tc-99m	6.01	h	-----	-----	-----
141.4	Sm-155	22.3	m	104.3	245.8	-----
142.5	Sc-46m	18.8	s	-----	-----	-----
146.8	Ta-182m2	15.84	m	171.6	185.0	-----
149.7	Te-131	25	m	452.3	-----	-----
150.4	Yb-177	1.91	h	1080.2	1241.2	121.6

Table 8. Gamma rays arranged by energy (half-lives < 1 day).

Energy 1 (keV)	Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
150.8	Cd-111m	48.5	m	245.4	-----	-----
151.2	Kr-85m	4.48	h	304.9	-----	-----
155.0	Re-188	17	h	-----	-----	-----
155.9	Nd-149	1.73	h	211.3	270.2	114.3
158.4	Hg-199m	42.6	m	374.1	-----	-----
158.6	In-117	43.2	m	553.0	-----	-----
158.6	In-117m	116.2	m	315.3	-----	-----
159.7	Ge-77m	52.9	s	215.5	-----	-----
160.3	Sn-123m	40.08	m	-----	-----	-----
161.9	Se-77m	17.36	s	-----	-----	-----
165.9	Ba-139	83.06	m	-----	-----	-----
171.6	Ta-182m2	15.84	m	146.8	185.0	-----
172.2	Pd-111m	5.5	h	391.3	70.4	-----
173.7	W-185m	1.67	m	131.6	-----	-----
173.7	I-132m	83.2	m	98.0	-----	-----
185.0	Ta-182m2	15.84	m	171.6	146.8	-----
185.8	Pt-199	30.8	m	543.0	493.8	317.1
186.7	Os-190m	9.9	m	361.1	616.1	502.5
188.4	Xe-125	16.9	h	243.4	453.8	59.0
189.0	Pd-109m	4.7	m	-----	-----	-----
191.4	Pt-197	19.89	h	77.3	-----	-----
191.7	Pt-199	30.8	m	543.0	493.8	317.1
191.9	Mo-101	14.6	m	590.1	505.9	1012.5
196.3	Kr-88	2.84	h	834.8	1529.8	2391.1
197.1	O-19	26.91	s	1356.8	1444.2	-----
202.5	Y-90m	3.19	h	479.2	-----	-----
203.8	Hg-205	5.2	m	-----	-----	-----
207.8	Er-167m	2.27	s	-----	-----	-----
209.3	Ac-228	6.15	h	911.2	969.0	338.3
211.0	Ge-77	11.3	h	264.4	215.5	367.4
211.3	Nd-149	1.73	h	270.2	114.3	423.6
214.0	Hf-177m2	51.4	m	295.1	277.3	326.7
214.9	Pd-107m	21.3	s	-----	-----	-----
215.3	Hf-180m	5.5	h	332.3	443.1	57.6
215.5	Ge-77	11.3	h	264.4	211.0	367.4
215.5	Ge-77m	52.9	s	159.7	-----	-----
224.4	Hf-182m	61.5	m	344.1	506.6	455.8
224.8	Se-83	22.3	m	356.7	718.1	799.1
231.7	Sr-85m	67.6	m	-----	-----	-----
238.6	Pb-212	10.64	h	300.1	-----	-----
240.2	Nd-149	1.73	h	211.3	270.2	114.3
243.4	Xe-125	16.9	h	188.4	453.8	59.0
245.4	Cd-111m	48.6	m	150.8	-----	-----
245.8	Sm-155	22.3	m	104.3	141.4	-----
246.5	Pt-199	30.8	m	543.0	493.8	317.1
249.0	Pb-214	26.8	m	351.9	295.2	-----
249.8	Xe-135	9.14	h	-----	-----	-----
255.7	Nd-151	12.4	m	1180.9	116.8	-----
258.4	Xe-138	14.1	m	434.6	1768.3	2015.8
262.8	Ru-105	4.44	h	724.3	469.4	676.4
263.1	Mo-93m	6.85	h	684.7	1477.1	-----
264.4	Ge-77	11.3	h	211.0	215.5	367.4
264.7	Ge-75	82.8	m	-----	-----	-----
267.7	Nd-149	1.73	h	211.3	270.2	114.3
270.2	Nd-149	1.73	h	211.3	114.3	423.6
270.2	Ac-228	6.15	h	911.2	969.0	338.3
273.4	Cd-117	2.49	h	344.5	434.2	1303.3
276.0	Se-81	18.5	m	290.1	-----	-----

Table 8. Gamma rays arranged by energy (half-lives < 1 day).

Energy 1 (keV)	Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
277.3	Hf-177m2	51.4	m	295.1	326.7	311.5
277.4	Tl-208	3.05	m	2614.5	583.2	860.6
279.0	Hg-197m	23.8	h	134.0	-----	-----
279.0	Pt-197m	95.41	m	346.5	-----	-----
279.8	Dy-165	2.33	h	94.7	361.7	633.4
283.6	Gd-161	3.66	m	360.9	314.9	102.3
290.1	Se-81	18.5	m	276.0	-----	-----
293.5	Ir-194	19.28	h	328.5	-----	-----
295.1	Hf-177m2	51.4	m	277.3	326.7	311.5
295.2	Pb-214	26.8	m	351.9	249.0	-----
295.9	Er-171	7.52	h	308.3	111.6	124.0
297.9	Er-163	75	m	436.1	439.9	1113.5
300.1	Pb-212	10.64	h	238.6	-----	-----
304.9	Kr-85m	4.48	h	151.2	-----	-----
306.9	Tc-101	14.2	m	545.1	-----	-----
308.3	Er-171	7.52	h	295.9	111.6	124.0
311.4	Pd-109	13.7	h	88.0	647.3	-----
311.5	Hf-177m2	51.4	m	295.1	277.3	326.7
312.6	K-42	12.36	h	1524.7	-----	-----
314.9	Gd-161	3.66	m	360.9	102.3	283.6
315.3	In-117m	116.2	m	158.6	-----	-----
316.4	Ru-105	4.44	h	724.3	469.4	676.4
317.1	Pt-199	30.8	m	543.0	493.8	191.7
320.1	Ti-51	5.76	m	928.6	608.6	-----
326.2	Dy-157	8.14	h	-----	-----	-----
326.6	Nd-149	1.73	h	211.3	270.2	114.3
326.7	Hf-177m2	51.4	m	295.1	277.3	311.5
328.0	Ac-228	6.15	h	911.2	969.0	338.3
328.5	Ir-194	19.28	h	293.5	-----	-----
332.1	Sn-125m	9.52	m	-----	-----	-----
332.3	Hf-180m	5.5	h	443.1	215.3	57.6
336.3	In-115m	4.49	h	-----	-----	-----
338.3	Ac-228	6.15	h	911.2	969.0	964.8
344.1	Hf-182m	61.5	m	224.4	506.6	455.8
344.3	Eu-152m	9.31	h	841.6	963.4	121.8
344.5	Cd-117	2.49	h	273.4	434.2	1303.3
346.5	Pt-197m	95.41	m	279.0	-----	-----
351.9	Pb-214	26.8	m	295.2	249.0	-----
355.4	Zr-97	16.91	h	743.4	507.6	1148.0
356.7	Se-83m	70.1	s	674.0	-----	-----
356.7	Se-83	22.3	m	224.8	718.1	799.1
360.9	Gd-161	3.66	m	314.9	102.3	283.6
361.1	Os-190m	9.9	m	616.1	502.5	186.7
361.7	Dy-165	2.33	h	94.7	279.8	633.4
363.6	Gd-159	18.48	h	58.0	-----	-----
366.3	Ni-65	2.52	h	1481.8	1115.6	-----
367.4	Ge-77	11.3	h	264.4	211.0	215.5
374.1	Hg-199m	42.6	m	158.4	-----	-----
376.7	Pd-111	23.4	m	580.0	650.4	1388.4
386.3	Zn-71m	3.96	h	487.4	620.2	596.1
388.5	Sr-87m	2.8	h	-----	-----	-----
391.3	Pd-111m	5.5	h	172.2	70.4	-----
391.7	In-113m	1.66	h	-----	-----	-----
391.9	Pt-199m	13.6	s	-----	-----	-----
402.6	Kr-87	76.3	m	845.4	2554.8	2558.1
409.5	Ac-228	6.15	h	911.2	969.0	338.3
416.3	Ge-77	11.3	h	264.4	211.0	215.5
416.9	In-116m	54.15	m	1097.3	1293.6	2112.3

Table 8. Gamma rays arranged by energy (half-lives < 1 day).

Energy 1 (keV)	Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
418.0	Te-127	9.35	h	-----	-----	-----
423.6	Nd-149	1.73	h	211.3	270.2	114.3
433.9	Ag-108	2.37	m	633.0	618.9	-----
434.2	Cd-117	2.49	h	273.4	344.5	1303.3
434.6	Xe-138	14.1	m	258.4	1768.3	2015.8
436.1	Er-163	75	m	439.9	1113.5	297.9
436.6	Ce-137	9	h	447.2	-----	-----
438.6	Zn-69m	13.76	h	-----	-----	-----
439.9	Er-163	75	m	436.1	1113.5	297.9
440.0	Ne-23	37.2	s	1636.0	-----	-----
442.9	I-128	24.99	m	526.6	-----	-----
443.1	Hf-180m	5.5	h	332.3	215.3	57.6
447.2	Ce-137	9	h	436.6	-----	-----
452.3	Te-131	25	m	149.7	-----	-----
453.8	Xe-125	16.9	h	188.4	243.4	59.0
455.5	Xe-137	3.82	m	-----	-----	-----
455.8	Hf-182m	61.5	m	344.1	224.4	506.6
459.2	Th-233	22.3	m	86.5	94.7	669.9
459.6	Te-129	69.6	m	27.8	487.4	-----
462.8	Cs-138	33.4	m	1435.8	1009.8	547.0
463.0	Ac-228	6.15	h	911.2	969.0	338.3
469.4	Ru-105	4.44	h	724.3	676.4	316.4
479.2	Y-90m	3.19	h	202.5	-----	-----
479.5	W-187	23.72	h	685.8	618.4	551.5
487.4	Zn-71m	3.96	h	386.3	620.2	596.1
487.4	Te-129	69.6	m	459.6	27.8	-----
493.8	Pt-199	30.8	m	543.0	317.1	191.7
498.4	Sb-124m	93	s	645.9	602.7	-----
502.5	Os-190m	9.9	m	361.1	616.1	186.7
505.8	I-132	2.3	h	667.7	772.6	522.7
505.9	Mo-101	14.6	m	590.1	191.9	1012.5
506.6	Hf-182m	61.5	m	344.1	224.4	455.8
507.6	Zr-97	16.91	h	743.4	355.4	1148.0
510.2	Se-83	22.3	m	356.7	224.8	718.1
510.8	Tl-208	3.05	m	2614.5	583.2	860.6
511.0 (Ann)	F-18	109.77	m	-----	-----	-----
511.0 (Ann)	Al-29	6.56	m	1273.4	-----	-----
511.0 (Ann)	Cu-64	12.7	h	1345.8	-----	-----
511.0 (Ann)	Br-80	17.68	m	616.6	-----	-----
511.6	Zn-71	2.45	m	-----	-----	-----
511.6	Zn-71m	3.96	h	386.3	487.4	620.2
515.5	Dy-165m	1.26	m	108.2	-----	-----
522.7	I-132	2.3	h	667.7	772.6	630.2
526.6	I-135	6.57	h	1260.4	1131.5	1678.0
526.6	Xe-135m	15.29	m	-----	-----	-----
526.6	I-128	24.99	m	442.9	-----	-----
529.9	I-133	20.8	h	875.3	-----	-----
540.5	Nd-149	1.73	h	211.3	270.2	114.3
543.0	Pt-199	30.8	m	493.8	317.1	191.7
545.1	Tc-101	14.2	m	306.9	-----	-----
546.6	I-135	6.57	h	1260.4	1131.5	1678.0
547.0	Cs-138	33.4	m	1435.8	462.8	1009.8
551.5	W-187	23.72	h	479.5	685.8	618.4
553.0	In-117	43.2	m	158.6	-----	-----
555.8	Rh-104m	4.34	m	51.4	97.1	77.6
555.8	Rh-104	42.3	s	-----	-----	-----
556.1	Rb-86m	1.02	m	-----	-----	-----
558.0	Ge-77	11.3	h	264.4	211.0	215.5

Table 8. Gamma rays arranged by energy (half-lives < 1 day).

Energy 1 (keV)	Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
564.4	Cd-117m	3.36	h	1066.0	1997.3	1029.1
580.0	Pd-111	23.4	m	650.4	376.7	1388.4
583.2	Tl-208	3.05	m	2614.5	860.6	510.8
590.1	Mo-101	14.6	m	191.9	505.9	1012.5
595.4	I-134	52.5	m	847.0	884.1	1072.6
596.1	Zn-71m	3.96	h	386.3	487.4	620.2
600.9	Ga-72	14.1	h	630.0	834.0	2201.7
602.7	Sb-124m	93	s	645.9	498.4	-----
608.6	Ti-51	5.76	m	320.1	928.6	-----
609.3	Bi-214	19.9	m	1120.3	1764.5	1238.1
616.1	Os-190m	9.9	m	361.1	502.5	186.7
616.6	Br-80	17.68	m	511.0	-----	-----
618.4	W-187	23.72	h	479.5	685.8	551.5
618.9	Ag-108	2.37	m	633.0	433.9	-----
620.2	Zn-71m	3.96	h	386.3	487.4	596.1
621.7	I-134	52.5	m	847.0	884.1	595.4
630.0	Ga-72	14.1	h	834.0	2201.7	2507.8
630.2	I-132	2.3	h	667.7	772.6	522.7
631.8	Ge-77	11.3	h	264.4	211.0	215.5
633.0	Ag-108	2.37	m	433.9	618.9	-----
633.4	Dy-165	2.33	h	94.7	361.7	279.8
645.9	Sb-124m	93	s	498.4	602.7	-----
647.3	Pd-109	13.7	h	88.0	311.4	-----
650.4	Pd-111	23.4	m	580.0	376.7	1388.4
654.8	Nd-149	1.73	h	211.3	270.2	114.3
657.8	Ag-110	24.6	s	-----	-----	-----
658.1	Nb-97	72.1	m	-----	-----	-----
661.7	Ba-137m	2.55	m	-----	-----	-----
667.7	I-132	2.3	h	772.6	522.7	630.2
669.9	Th-233	22.3	m	459.2	86.5	94.7
671.4	I-132	2.3	h	772.6	522.7	630.2
674.0	Se-83m	70.1	s	356.7	-----	-----
676.4	Ru-105	4.44	h	724.3	469.4	316.4
684.7	Mo-93m	6.85	h	1477.1	263.1	-----
685.8	W-187	23.72	h	479.5	618.4	551.5
695.6	Mo-101	14.6	m	590.1	191.9	505.9
714.4	Ge-77	11.3	h	264.4	211.0	215.5
715.3	Dy-165	2.33	h	94.7	361.7	633.4
718.1	Se-83	22.3	m	356.7	224.8	799.1
724.3	Ru-105	4.44	h	469.4	676.4	316.4
727.3	Bi-212	60.6	m	1620.5	785.4	-----
743.4	Zr-97	16.91	h	507.6	355.4	1148.0
743.4	Nb-97m	52.7	s	-----	-----	-----
754.2	Ce-139m	54.8	s	-----	-----	-----
768.4	Bi-214	19.9	m	609.3	1120.3	1764.5
772.6	I-132	2.3	h	667.7	522.7	630.2
772.9	W-187	23.72	h	479.5	685.8	618.4
776.5	Br-82m	6.13	m	-----	-----	-----
785.4	Bi-212	60.6	m	727.3	1620.5	-----
786.8	Cs-135m	53	m	846.1	-----	-----
795.0	Ac-228	6.15	h	911.2	969.0	338.3
799.1	Se-83	22.3	m	356.7	224.8	718.1
799.6	Hf-182m	61.5	m	344.1	224.4	506.6
812.0	I-132	2.3	h	667.7	772.6	522.7
818.7	In-116m	54.15	m	1097.3	1293.6	416.9
833.5	Cu-66	5.12	m	1039.2	-----	-----
834.0	Ga-72	14.1	h	630.0	2201.7	2507.8
834.8	Kr-88	2.84	h	196.3	1529.8	2391.1

Table 8. Gamma rays arranged by energy (half-lives < 1 day).

Energy 1 (keV)	Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
836.5	Se-83	22.3	m	356.7	224.8	718.1
836.8	I-135	6.57	h	1260.4	1131.5	1678.0
841.6	Eu-152m	9.31	h	963.4	121.8	344.3
843.7	Mg-27	9.46	m	1014.4	-----	-----
845.4	Kr-87	76.3	m	402.6	2554.8	2558.1
846.1	Cs-135m	53	m	786.8	-----	-----
846.8	Mn-56	2.58	h	1810.8	2113.1	-----
847.0	I-134	52.5	m	884.1	595.4	1072.6
860.4	Cd-117m	3.36	h	1066.0	1997.3	1029.1
860.6	Tl-208	3.05	m	2614.5	583.2	510.8
871.1	Nb-94m	6.26	m	-----	-----	-----
875.3	I-133	20.8	h	529.9	-----	-----
884.1	I-134	52.5	m	847.0	595.4	1072.6
894.3	Ga-72	14.1	h	630.0	834.0	2201.7
898.0	Rb-88	17.78	m	1836.1	-----	-----
911.2	Ac-228	6.15	h	969.0	338.3	964.8
928.6	Ti-51	5.76	m	320.1	608.6	-----
934.0	Bi-214	19.9	m	609.3	1120.3	1764.5
934.2	Mo-101	14.6	m	590.1	191.9	1012.5
942.8	Hf-182m	61.5	m	344.1	224.4	506.6
954.7	I-132	2.3	h	667.7	772.6	522.7
963.4	Eu-152m	9.31	h	841.6	121.8	344.3
964.8	Ac-228	6.15	h	911.2	969.0	338.3
969.0	Ac-228	6.15	h	911.2	338.3	964.8
1009.8	Cs-138	33.4	m	1435.8	462.8	547.0
1012.5	Mo-101	14.6	m	590.1	191.9	505.9
1014.4	Mg-27	9.46	m	843.8	-----	-----
1029.1	Cd-117m	3.36	h	1066.0	1997.3	1234.6
1038.8	I-135	6.57	h	1260.4	1131.5	1678.0
1039.2	Cu-66	5.12	m	833.5	-----	-----
1039.2	Ga-70	21.14	m	-----	-----	-----
1050.7	Ga-72	14.1	h	630.0	834.0	2201.7
1066.0	Cd-117m	3.36	h	1997.3	1029.1	1234.6
1072.6	I-134	52.5	m	847.0	884.1	595.4
1080.2	Yb-177	1.91	h	150.4	1241.2	121.6
1085.2	Ge-77	11.3	h	264.4	211.0	215.5
1097.3	In-116m	54.15	m	1293.6	416.9	2112.3
1113.5	Er-163	75	m	436.1	439.9	297.9
1115.6	Ni-65	2.52	h	1481.8	366.3	-----
1120.3	Bi-214	19.9	m	609.3	1764.5	1238.1
1131.5	I-135	6.57	h	1260.4	1678.0	526.6
1136.0	I-132	2.3	H	772.6	522.7	630.2
1148.0	Zr-97	16.91	h	743.4	507.6	355.4
1161.0	Mo-101	14.6	m	590.1	191.9	1012.5
1180.9	Nd-151	12.4	m	116.8	255.7	-----
1234.6	Cd-117m	3.36	h	1066.0	1997.3	1029.1
1238.1	Bi-214	19.9	m	609.3	1120.3	1764.5
1241.2	Yb-177	1.91	h	150.4	1080.2	121.6
1260.4	I-135	6.57	h	1131.5	1678.0	526.6
1266.1	Si-31	2.62	h	-----	-----	-----
1273.4	Al-29	6.56	m	511.0	-----	-----
1293.6	In-116m	54.15	m	1097.3	416.9	2112.3
1293.6	Ar-41	1.83	h	-----	-----	-----
1303.3	Cd-117	2.49	h	273.4	344.5	434.2
1332.5	Co-60m	10.47	m	58.6	-----	-----
1345.8	Cu-64	12.7	h	511.0	-----	-----
1356.8	O-19	26.91	s	197.1	1444.2	-----
1368.4	Ge-77	11.3	h	264.4	211.0	215.5

Table 8. Gamma rays arranged by energy (half-lives < 1 day).

Energy 1 (keV)	Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
1368.6	Na-24	14.96	h	2754.0	-----	-----
1377.7	Bi-214	19.9	m	609.3	1120.3	1764.5
1388.4	Pd-111	23.4	m	580.0	650.4	376.7
1432.9	Cd-117m	3.36	h	1066.0	1997.3	1029.1
1434.1	V-52	3.74	m	-----	-----	-----
1435.8	Cs-138	33.4	m	462.8	1009.8	547.0
1444.1	O-19	26.91	s	197.1	1356.8	-----
1457.6	I-135	6.57	h	1260.4	1131.5	1678.0
1458.9	Pd-111	23.4	m	580.0	650.4	376.7
1477.1	Mo-93m	6.85	h	684.7	263.1	-----
1481.8	Ni-65	2.52	h	1115.6	366.3	-----
1507.7	In-116m	54.15	m	1097.3	1293.6	416.9
1524.7	K-42	12.36	h	312.6	-----	-----
1528.3	Cr-55	3.5	m	-----	-----	-----
1529.8	Kr-88	2.84	h	196.3	834.8	2391.1
1532.5	Mo-101	14.6	m	590.1	191.9	505.9
1575.9	Pr-142	19.12	h	-----	-----	-----
1576.6	Cd-117	2.49	h	273.4	344.5	434.2
1588.2	Ac-228	6.15	h	911.2	969.0	338.3
1620.5	Bi-212	60.6	m	727.3	785.4	-----
1622.6	Sc-49	57.2	m	1761.9	-----	-----
1633.6	F-20	11	s	-----	-----	-----
1636.0	Ne-23	37.24	s	440.0	-----	-----
1642.7	Cl-38	37.24	m	2167.4	-----	-----
1729.6	Bi-214	19.9	m	609.3	1120.3	1764.5
1752.7	In-116m	54.29	m	416.9	1097.3	1293.6
1761.9	Sc-49	57.2	m	1622.6	-----	-----
1764.5	Bi-214	19.9	m	609.3	1120.3	1238.1
1768.3	Xe-138	14.1	m	258.4	434.6	2015.8
1779.0	Al-28	2.24	m	-----	-----	-----
1810.8	Mn-56	2.58	h	846.8	2113.1	-----
1836.1	Rb-88	17.78	m	898.0	-----	-----
1861.1	Ga-72	14.1	h	630.0	834.0	2201.7
1997.3	Cd-117m	3.36	h	1066.0	1029.1	1234.6
2015.8	Xe-138	14.1	m	258.4	434.6	1768.3
2032.1	Mo-101	14.6	m	590.1	191.9	1012.5
2096.4	Cd-117m	3.36	h	1066.0	1029.1	1234.6
2112.3	In-116m	54.15	m	1097.3	1293.6	416.9
2113.1	Mn-56	2.58	h	846.8	1810.8	-----
2167.4	Cl-38	37.24	m	1642.7	-----	-----
2195.8	Kr-88	2.84	h	196.3	834.8	1529.8
2201.7	Ga-72	14.1	h	630.0	834.0	2507.8
2204.1	Bi-214	19.9	m	609.3	1120.3	1764.5
2218.0	Cs-138	33.4	m	1435.8	462.9	1009.8
2322.8	Cd-117m	3.36	h	1066.0	1029.1	1234.6
2391.1	Kr-88	2.84	h	196.3	834.8	1529.8
2491.0	Ga-72	14.1	h	630.0	834.0	2201.7
2507.8	Ga-72	14.1	h	630.0	834.0	2201.7
2522.9	Mn-56	2.58	h	846.8	1810.8	2113.1
2554.8	Kr-87	76.3	m	402.6	845.4	2558.1
2558.1	Kr-87	76.3	m	402.6	845.4	2554.8
2614.5	Tl-208	3.05	m	583.2	860.6	510.8
2657.5	Mn-56	2.58	h	846.8	1810.8	2113.1
2754.0	Na-24	14.96	h	1368.6	-----	-----
3084.4	Ca-49	8.72	m	4071.9	-----	-----
3103.4	S-37	5.05	m	-----	-----	-----
4071.9	Ca-49	8.72	m	3084.4	-----	-----

Table 9. Gamma rays arranged by energy (half-lives > 1 day).

Energy 1 (keV)		Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
14.4		Co-57	271.8	d	122.1	136.5	-----
16.4		Zn-72	46.5	h	145.0	192.0	-----
23.9	*	Sn-119m	293.1	d	25.3	-----	-----
25.3		Sn-119m	293.1	d	23.9	-----	-----
25.6		Tb-161	6.9	d	74.6	48.9	-----
30.9		Pt-195m	4.02	d	98.9	129.7	-----
35.5	*	I-125	59.4	d	-----	-----	-----
35.5	*	Te-125m	57.4	d	109.3	-----	-----
39.6	*	Xe-129m	8.88	d	196.6	-----	-----
39.8		Pd-103	16.99	d	357.5	-----	-----
43.1		Os-194	6	y	-----	-----	-----
45.3		Eu-155	4.76	y	86.5	105.3	60.0
48.9		Tb-161	6.9	d	74.6	25.7	-----
49.7		Te-132	3.2	d	228.2	-----	-----
53.2		Ba-133	10.51	y	356.0	81.0	302.9
57.4		Ce-143	33.0	h	293.3	664.6	721.9
57.6	*	Te-127m	109	d	-----	-----	-----
58.0	*	Dy-159	144.4	d	-----	-----	-----
59.5	*	Am-241	432.2	y	-----	-----	-----
59.7		Er-172	49.3	h	407.3	610.1	446.0
60.0		Eu-155	4.76	y	86.5	105.3	45.3
61.3	*	Sm-145	340	d	-----	-----	-----
63.1		Yb-169	32.03	d	177.2	198.0	109.8
65.7		Ta-182	114.43	d	1221.4	1189.1	67.8
66.7	*	Tm-171	1.92	y	-----	-----	-----
67.8		Ta-182	114.43	d	1221.4	1189.1	1121.3
68.1		Er-172	49.3	h	407.3	610.1	446.0
69.7		Gd-153	240.4	d	97.4	103.2	-----
69.7		Sm-153	46.28	h	103.2	-----	-----
73.0		Os-193	30.1	h	460.6	138.9	-----
74.6	*	Tb-161	6.9	d	25.7	48.9	-----
75.4		Pa-233	27.0	d	312.2	300.3	340.8
77.4	*	Hg-197	64.14	h	-----	-----	-----
78.7		Tm-172	128.6	d	181.5	1093.7	1387.1
79.6		Ba-133	10.51	y	356.0	81.0	302.9
80.2		I-131	8.02	d	364.5	637.0	284.3
80.6	*	Ho-166	26.83	h	1379.4	-----	-----
80.6		Ho-166m	1200	y	184.4	184.4	711.7
81.0		Ba-133	10.51	y	356.0	302.9	276.4
81.0	*	Xe-133	5.24	d	-----	-----	-----
82.4		Pt-191	2.8	d	538.9	409.4	359.9
82.5	*	Dy-166	81.6	h	-----	-----	-----
84.3	*	Tm-170	128.6	d	-----	-----	-----
84.7		Ta-182	114.43	d	1221.4	1189.1	67.8
86.5	*	Eu-155	4.76	y	105.3	60.0	45.3
86.8		Pa-233	27.0	d	312.2	300.3	340.8
86.8		Tb-160	72.3	d	879.4	966.2	298.6
88.0	*	Cd-109	462.6	d	-----	-----	-----
91.1		Nd-147	10.98	d	531.0	319.4	439.9
91.3		Cu-67	61.8	h	184.6	93.3	300.2
93.3		Cu-67	61.8	h	184.6	91.3	300.2
96.5		Pt-191	2.8	d	538.9	409.4	359.9
96.7		Se-75	119.78	d	264.7	136.0	279.5
97.4	*	Gd-153	240.4	d	103.2	69.7	-----
98.9	*	Pt-195m	4.02	d	129.7	30.9	-----
100.0		Pm-151	28.4	h	340.1	167.8	275.2
100.1		Ta-182	114.43	d	1221.4	1189.1	67.8
102.1		Te-131m	30	h	773.7	852.2	793.8

Table 9. Gamma rays arranged by energy (half-lives > 1 day).

Energy 1 (keV)	Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
103.2	Gd-153	240.4	d	97.4	69.7	-----
103.2 *	Sm-153	46.28	h	69.7	-----	-----
104.0	Pa-233	27.0	d	312.2	300.3	340.8
104.8	Pm-151	28.4	h	340.1	167.8	275.2
105.3	Eu-155	4.76	y	86.5	60.0	45.3
105.4	Lu-177m	160.4	d	208.4	228.5	378.5
105.5	Te-129m	33.6	d	695.9	-----	-----
106.1	Np-239	2.36	d	277.6	228.2	209.8
107.9	Ta-183	5.1	d	246.1	354.0	161.5
109.2	U-235	7.10E+08	y	185.7	143.8	163.4
109.3	Te-125m	57.4	d	35.5	-----	-----
109.8	Yb-169	32.03	d	177.2	198.0	307.7
113.0	Lu-177	6.73	d	208.4	249.7	321.3
113.0	Lu-177m	160.4	d	208.4	228.5	378.5
113.7	Ta-182	114.43	d	1221.4	1189.1	67.8
113.8	Yb-175	4.19	d	396.3	282.5	-----
116.4	Ta-182	114.43	d	1221.4	1189.1	67.8
121.1	Se-75	119.78	d	264.7	136.0	279.5
121.8	Eu-152	13.54	y	1408.0	344.3	778.9
122.1 *	Co-57	271.8	d	136.5	14.4	-----
122.3	Re-186	90.64	h	137.2	-----	-----
123.1	Eu-154	8.59	y	1274.4	723.3	1004.7
123.8	Ba-131	11.50	d	496.3	216.1	373.3
125.4 *	W-185	75.1	d	-----	-----	-----
127.8	Er-172	49.3	h	407.3	610.1	446.0
128.5	Lu-177m	160.4	d	208.4	228.5	378.5
129.1	Th-232(Ac-228)	1.40E+10	y	911.2	338.3	969.0
129.4 *	Os-191	15.4	d	-----	-----	-----
129.4	Pt-191	2.8	d	538.9	409.4	359.9
129.7	Pt-195m	4.02	d	98.9	30.9	-----
130.5	Yb-169	32.03	d	177.2	198.0	109.8
133.0	Hf-181	42.39	d	482.2	345.9	136.3
133.5 *	Ce-144	284.9	d	-----	-----	-----
133.6	Ba-131	11.50	d	496.3	123.8	216.1
136.0	Se-75	119.78	d	264.7	279.5	400.7
136.3	Hf-181	42.39	d	482.2	133.0	345.9
136.3 *	W-181	121.2	d	152.3	-----	-----
136.5	Co-57	271.8	d	122.1	14.4	-----
137.2	Re-186	90.64	h	122.3	-----	-----
138.9	Os-193	30.1	h	460.6	73.0	280.5
140.5	Mo-99	65.9	h	739.6	181.1	777.9
142.6	Fe-59	44.5	d	1099.3	1291.6	192.4
143.8	U-235	7.10E+08	y	185.7	163.4	205.3
144.1	Ta-183	5.1	d	246.1	354.0	107.9
145.0 *	Zn-72	46.5	h	192.0	16.4	-----
145.4 *	Ce-141	32.5	d	-----	-----	-----
152.3	W-181	121.2	d	136.3	-----	-----
152.4	Ta-182	114.43	d	1221.4	1189.1	67.8
153.3	Lu-177m	160.4	d	208.4	228.5	378.5
156.0	Sn-117m	13.6	d	158.6	-----	-----
156.4	Ta-182	114.43	d	1221.4	1189.1	67.8
158.4 *	Au-199	3.14	d	208.2	-----	-----
158.6 *	Sn-117m	13.6	d	156.0	-----	-----
159.0 *	Te-123m	119.7	d	-----	-----	-----
159.4 *	Sc-47	3.35	d	-----	-----	-----
160.5	Ta-183	5.1	d	246.1	354.0	107.9
161.5	Ta-183	5.1	d	246.1	354.0	107.9
162.3	Ta-183	5.1	d	246.1	354.0	107.9

Table 9. Gamma rays arranged by energy (half-lives > 1 day).

Energy 1 (keV)		Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
162.7		Ba-140	12.75	d	537.3	304.9	423.7
163.4		U-235	7.10E+08	y	185.7	143.8	205.3
163.9	*	Xe-131m	11.84	d	-----	-----	-----
165.9	*	Ce-139	137.64	d	-----	-----	-----
167.8		Pm-151	28.4	h	340.1	275.2	445.7
172.1		Xe-127	36.4	d	202.9	-----	-----
172.2		Pt-191	2.8	d	538.9	409.4	359.9
174.4		Lu-177m	160.4	d	208.4	228.5	378.5
175.4		Sc-48	43.67	h	983.5	1037.6	1312.1
176.3		Sb-125	2.76	y	427.9	600.6	463.4
177.2		Pm-151	28.4	h	340.1	167.8	275.2
177.2	*	Yb-169	32.03	d	198.0	307.7	109.8
179.4		Ta-182	114.43	d	1221.4	1189.1	67.8
181.1		Mo-99	65.9	h	739.6	140.5	777.9
181.5		Tm-172	63.6	h	1093.7	1387.1	1465.9
184.4	*	Ho-166m	1200	y	711.7	810.3	280.5
184.6	*	Cu-67	61.8	h	93.3	91.3	300.2
185.7	*	U-235	7.10E+08	y	143.8	163.4	205.3
186.2	*	Ra-226	1600	y	-----	-----	-----
190.3	*	In-114m	49.5	d	558.5	725.3	-----
192.0		Zn-72	46.5	h	145.0	16.4	-----
192.4		Fe-59	44.5	d	1099.3	1291.6	142.7
196.6		Xe-129m	8.88	d	39.6	-----	-----
197.0		Tb-160	72.3	d	879.4	966.2	298.6
198.0		Yb-169	32.03	d	177.2	307.7	109.8
198.4		Ta-182	114.43	d	1221.4	1189.1	67.8
198.6		Se-75	119.78	d	264.7	136.0	279.5
200.6		Te-131m	30	h	773.7	852.2	793.8
202.7		Er-172	49.3	h	407.3	610.1	446.0
202.9	*	Xe-127	36.4	d	172.1	-----	-----
204.1		Lu-177m	160.4	d	208.4	228.5	378.5
204.1		Nb-95m	86.6	h	235.7	-----	-----
205.3		U-235	7.10E+08	y	185.7	143.8	163.4
205.8		Ir-192	73.8	d	316.5	468.1	308.5
208.2		Au-199	3.14	d	158.4	-----	-----
208.4	*	Lu-177	6.73	d	113.0	249.7	321.3
208.4	*	Lu-177m	160.4	d	228.5	378.5	418.5
209.2		Th-232(Ac-228)	1.40E+10	y	911.2	338.3	969.0
209.8		Np-239	2.36	d	277.6	228.2	106.1
209.9		Ta-183	5.1	d	246.1	354.0	107.9
212.2	*	Te-121m	154	d	1102.2	-----	-----
215.7	*	Ru-97	69.1	h	324.5	-----	-----
215.7		Tb-160	72.3	d	879.4	966.2	298.6
215.9		Ho-166m	1200	y	184.4	810.3	711.7
216.1		Ba-131	11.50	d	496.3	123.8	373.3
221.5		Br-82	35.3	h	776.5	554.4	619.1
222.1		Ta-182	114.43	d	1221.4	1189.1	67.8
227.1		W-188	69.4	d	290.7	-----	-----
228.2		Np-239	2.36	d	277.6	106.1	106.1
228.2	*	Te-132	3.2	d	49.7	-----	-----
228.5		Lu-177m	160.4	d	208.4	378.5	418.5
229.3		Ta-182	114.43	d	1221.4	1189.1	67.8
231.6		Ce-143	33.0	h	293.3	57.4	664.6
233.2	*	Xe-133m	2.19	d	-----	-----	-----
235.7	*	Nb-95m	86.6	h	204.1	-----	-----
238.6	*	Th-232(Pb-212)	1.40E+10	y	300.1	-----	-----
239.0	*	As-77	38.9	h	-----	-----	-----
239.6		Ba-131	11.50	d	496.3	123.8	216.1

Table 9. Gamma rays arranged by energy (half-lives > 1 day).

Energy 1 (keV)		Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
240.1		Pm-151	28.4	h	340.1	167.8	275.2
240.9		Te-131m	30	h	773.7	852.2	793.8
242.0		U-238(Pb-214)	4.50E+09	y	351.9	295.1	-----
242.3		Ta-183	5.1	d	246.1	107.9	354.0
244.7		Eu-152	13.54	y	1408.0	344.3	778.9
246.1	*	Ta-183	5.1	d	354.0	107.9	161.5
247.9		Eu-154	8.59	y	1274.4	123.1	723.3
249.4		Ba-131	11.50	d	496.3	123.8	216.1
249.7		Lu-177	6.73	d	208.4	113.0	321.3
254.3	*	Ce-137m	34.4	h	-----	-----	-----
255.1		Sn-113	115.09	d	391.7	-----	-----
259.8		Ho-166m	1200	y	184.4	810.3	711.7
260.9		Cd-115	53.5	h	527.9	336.2	492.3
263.7	*	Cd-113m	14.1	y	-----	-----	-----
264.1		Ta-182	114.43	d	1221.4	1189.1	67.8
264.7	*	Se-75	119.78	d	136.0	279.5	400.7
268.2	*	Ba-135m	28.7	h	-----	-----	-----
268.7		Pt-191	2.8	d	538.9	409.4	359.9
270.2		Th-232(Ac-228)	1.40E+10	y	911.2	338.3	969.0
275.2		Pm-151	28.4	h	340.1	167.8	445.7
275.9	*	Ba-133m	38.9	h	-----	-----	-----
276.4		Ba-133	10.51	y	356.0	81.0	302.9
277.4		Th-232(Tl-208)	1.40E+10	y	583.2	2614.5	510.8
277.6	*	Np-239	2.36	d	228.2	106.1	209.8
279.2	*	Hg-203	46.6	d	-----	-----	-----
279.5		Se-75	119.78	d	264.7	136.0	400.7
280.5		Os-193	30.1	h	460.6	138.9	73.0
280.5		Ho-166m	1200	y	184.4	810.3	711.7
281.8		Lu-177m	160.4	d	208.4	228.5	378.5
282.5		Yb-175	4.19	d	396.3	113.8	-----
284.3		I-131	8.02	d	364.5	637.0	80.2
286.0	*	Pm-149	53.1	h	-----	-----	-----
288.5		Pm-148m	41.3	d	550.3	630.0	725.7
290.7	*	W-188	69.4	d	227.1	-----	-----
291.7		Ta-183	5.1	d	246.1	354.0	107.9
293.3	*	Ce-143	33.0	h	57.4	664.6	721.9
295.2		U-238(Pb-214)	4.50E+09	y	351.9	241.9	-----
296.0		Ir-192	73.8	d	316.5	468.1	308.5
298.6		Tb-160	72.3	d	879.4	966.2	1178.0
300.1		Th-232(Pb-212)	1.40E+10	y	238.6	-----	-----
300.2		Cu-67	61.8	h	184.6	93.3	91.3
300.3		Pa-233	27.0	d	312.2	340.8	415.8
300.8		Ho-166m	1200	y	184.4	810.3	711.7
302.9		Ba-133	10.51	y	356.0	81.0	276.4
303.9		Se-75	119.78	d	264.7	136.0	279.5
304.9		Ba-140	12.75	d	537.3	162.7	423.7
306.3		Rh-105	35.4	h	319.1	-----	-----
307.7		Yb-169	32.03	d	177.2	198.0	109.8
308.5		Ir-192	73.8	d	316.5	468.1	296.0
311.6		Pm-148m	41.3	d	550.3	630.0	725.7
312.2	*	Pa-233	27.0	d	300.3	340.8	415.8
313.3		Ta-183	5.1	d	246.1	354.0	107.9
315.9		Np-239	2.36	d	228.2	106.1	209.8
316.5	*	Ir-192	73.8	d	468.1	308.5	296.0
319.0		Lu-177m	160.4	d	208.4	228.5	378.5
319.1	*	Rh-105	35.4	h	306.3	-----	-----
319.4		Nd-147	10.98	d	531.0	91.1	439.9
320.1	*	Cr-51	27.7	d	-----	-----	-----

Table 9. Gamma rays arranged by energy (half-lives > 1 day).

Energy 1 (keV)		Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
321.3		Lu-177	6.73	d	208.4	113.0	249.7
321.6		Os-193	30.1	h	460.6	138.9	73.0
324.5		Ru-97	69.1	h	215.7	-----	-----
327.7		Lu-177m	160.4	d	208.4	228.5	378.5
328.0		Th-232(Ac-228)	1.40E+10	y	911.2	338.3	969.0
328.5		Ir-194m2	171	d	338.8	482.8	562.6
328.8		La-140	40.27	h	1596.2	487.0	867.9
332.1		Sn-125	9.64	d	1067.1	1089.2	822.5
333.0		Au-196	6.18	d	355.7	426.0	-----
334.3		Np-239	2.36	d	277.6	228.2	209.8
334.3		Te-131m	30	h	773.7	852.2	793.8
336.2		Cd-115	53.5	h	527.9	492.3	260.9
338.3		Th-232(Ac-228)	1.40E+10	y	911.2	338.3	969.0
338.8	*	Ir-194m2	171	d	328.5	482.8	562.6
340.1	*	Pm-151	28.4	h	167.8	275.2	445.7
340.8		Pa-233	27.0	d	312.2	300.3	415.8
343.4	*	Hf-175	70	d	433.0	-----	-----
344.3		Eu-152	13.54	y	1408.0	778.9	121.8
344.9		Pm-151	28.4	h	340.1	167.8	275.2
345.9		Hf-181	42.39	d	482.2	133.0	136.3
350.6		Ce-143	33.0	h	293.3	57.4	664.6
351.2		Pt-191	2.8	d	538.9	409.4	359.9
351.9	*	U-238(Pb-214)	4.50E+09	y	295.1	241.9	-----
354.0		Ta-183	5.1	d	246.1	107.9	161.5
355.7	*	Au-196	6.18	d	333.0	426.0	-----
356.0	*	Ba-133	10.51	y	81.0	302.9	276.4
357.5		Pd-103	16.99	d	39.8	-----	-----
359.9		Pt-191	2.8	d	538.9	409.4	82.4
364.5	*	I-131	8.02	d	637.0	284.3	80.2
365.8		Ho-166m	1200	y	184.4	810.3	711.7
366.4		Mo-99	65.9	h	739.6	140.5	181.1
371.8		Dy-166	81.6	h	82.5	426.0	-----
373.3		Ba-131	11.50	d	496.3	123.8	216.1
378.5		Lu-177m	160.4	d	208.4	228.5	418.5
380.5		Sb-125	2.76	y	427.9	600.6	636.0
383.5		Er-172	49.3	h	407.3	610.1	446.0
383.9		Ba-133	10.51	y	356.0	81.0	302.9
387.5		Os-193	30.1	h	460.6	138.9	73.0
390.8		Ir-194m2	171	d	338.8	328.5	482.8
391.7	*	Sn-113	115.09	d	255.1	-----	-----
392.5		Tb-160	72.3	d	879.4	966.2	298.6
396.3	*	Yb-175	4.19	d	282.5	113.8	-----
398.2		Nd-147	10.98	d	91.1	531.0	319.4
398.6		Pa-233	27.0	d	312.2	300.3	340.8
400.7		Se-75	119.78	d	264.7	136.0	279.5
404.1		Ba-131	11.50	d	496.3	123.8	216.1
407.3	*	Er-172	49.3	h	610.1	446.0	68.1
409.4		Pt-191	2.8	d	538.9	359.9	82.4
409.5		Th-232(Ac-228)	1.40E+10	y	911.2	338.3	969.0
410.9		Ho-166m	1200	y	184.4	810.3	711.7
411.1		Eu-152	13.54	y	1408.0	344.3	778.9
411.8	*	Au-198	2.70	d	675.9	1087.7	-----
413.7		Lu-177m	160.4	d	208.4	228.5	378.5
414.0		Pm-148m	41.3	d	550.3	630.0	725.7
415.8		Pa-233	27.0	d	312.2	300.3	340.8
418.5		Lu-177m	160.4	d	208.4	228.5	378.5
423.7		Ba-140	12.75	d	537.3	162.7	304.9
426.0		Au-196	6.18	d	355.7	333.0	-----

Table 9. Gamma rays arranged by energy (half-lives > 1 day).

Energy 1 (keV)		Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
426.0		Dy-166	81.6	h	82.5	371.8	-----
427.9	*	Sb-125	2.76	y	600.6	463.4	636.0
432.5		La-140	40.27	h	1596.2	487.0	328.8
432.7		Pm-148m	41.3	d	550.3	630.0	725.7
433.0		Hf-175	70	d	343.4	-----	-----
437.6		Ba-140	12.75	d	537.3	162.7	304.9
439.9		Nd-147	10.98	d	531.0	91.1	319.4
443.8		Ru-103	39.3	d	497.1	610.3	-----
443.9		Eu-152	13.54	y	1408.0	344.3	778.9
445.7		Pm-151	28.4	h	340.1	167.8	275.2
446.0		Er-172	49.3	h	407.3	610.1	446.0
446.8		Ag-110m	249.79	d	657.8	884.7	937.5
451.5		Ho-166m	1200	y	184.4	810.3	711.7
456.5		Pt-191	2.8	d	538.9	409.4	359.9
460.6	*	Os-193	30.1	h	138.9	73.0	280.5
463.0		Th-232(Ac-228)	1.40E+10	y	911.2	338.3	969.0
463.4		Sb-125	2.76	y	427.9	600.6	636.0
464.8		Ho-166m	1200	y	184.4	810.3	711.7
468.1		Ir-192	73.8	d	316.5	308.5	296.0
468.6		Rh-102	207	d	475.1	555.6	628.1
469.9		Sn-125	9.64	d	1067.1	1089.2	822.5
475.1	*	Rh-102	207	d	555.6	628.1	468.6
475.4		Cs-134	2.06	y	795.9	604.7	569.3
477.6	*	Be-7	53.12	d	-----	-----	-----
482.2	*	Hf-181	42.39	d	133.0	345.9	136.3
482.8		Ir-194m2	171	d	338.8	328.5	562.6
484.5		Cd-115m	44.6	d	933.8	1290.6	-----
484.6		Ir-192	73.8	d	316.5	468.1	308.5
487.0		La-140	40.27	h	1596.2	328.8	867.9
489.2		Ca-47	4.54	d	1297.1	489.2	-----
490.4		Ce-143	33.0	h	293.3	57.4	664.6
492.3		Cd-115	53.5	h	527.9	336.2	260.9
496.3	*	Ba-131	11.50	d	123.8	216.1	373.3
497.1	*	Ru-103	39.3	d	443.8	610.3	-----
501.3		Pm-148m	41.3	d	550.3	630.0	725.7
507.6		Te-121	16.78	d	573.1	-----	-----
510.8		Th-232(Tl-208)	1.40E+10	y	583.2	2614.5	860.6
511.0		Na-22	2.6	y	1274.5	-----	-----
514.0	*	Sr-85	64.84	d	-----	-----	-----
527.9	*	Cd-115	53.5	h	336.2	492.3	-----
529.8		Ho-166m	1200	y	184.4	810.3	711.7
531.0	*	Nd-147	10.98	d	91.1	319.4	439.9
537.3	*	Ba-140	12.75	d	162.7	304.9	423.7
538.9	*	Pt-191	2.8	d	409.4	359.9	82.4
550.3		Pm-148	5.37	d	1465.1	914.8	-----
550.4	*	Pm-148m	41.3	d	630.0	725.7	1013.8
554.4		Br-82	35.3	h	776.5	619.1	698.4
555.6		Rh-102	207	d	475.1	628.1	468.6
557.4		Os-193	30.1	h	460.6	138.9	73.0
558.5		In-114m	49.5	d	190.3	725.3	-----
559.1	*	As-76	26.3	h	657.0	1216.1	1212.9
562.6		Ir-194m2	171	d	338.8	328.5	482.8
563.2		As-76	26.3	h	559.1	657.0	1216.1
563.3		Cs-134	2.06	y	795.9	604.7	569.3
564.1	*	Sb-122	2.72	d	692.8	-----	-----
569.3		Cs-134	2.06	y	795.9	604.7	563.3
571.0		Ho-166m	1200	y	184.4	810.3	711.7
573.1	*	Te-121	16.78	d	507.6	-----	-----

Table 9. Gamma rays arranged by energy (half-lives > 1 day).

Energy 1 (keV)		Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
583.2		Th-232(Tl-208)	1.40E+10	y	2614.5	510.8	860.6
588.6		Ir-192	73.8	d	316.5	468.1	308.5
591.8		Eu-154	8.59	y	1274.4	123.1	723.3
595.9	*	As-74	17.77	d	634.8	Ann.	-----
599.8		Pm-148m	41.3	d	550.3	630.0	725.7
600.5		Ir-194m2	171	d	338.8	328.5	482.8
600.6		Sb-125	2.76	y	427.9	463.4	636.0
602.7		Sb-124	60.2	d	1691.0	722.8	645.9
604.4		Ir-192	73.8	d	316.5	468.1	308.5
604.7		Cs-134	2.06	y	795.9	569.3	563.3
606.3		Br-82	35.3	h	776.5	554.4	619.1
606.7		Sb-125	2.76	y	427.9	600.6	463.4
609.3	*	U-238(Bi-214)	4.50E+09	y	1120.3	1764.5	2204.1
610.1		Er-172	49.3	h	407.3	-----	-----
610.3		Ru-103	39.3	d	497.1	443.8	-----
611.3		Pm-148m	41.3	d	550.3	630.0	725.7
611.6		Ho-166m	1200	y	184.4	810.3	711.7
612.5		Ir-192	73.8	d	316.5	468.1	308.5
619.1		Br-82	35.3	h	776.5	554.4	698.4
620.4		Ag-110m	249.79	d	657.8	884.7	937.5
624.1		Pt-191	2.8	d	538.9	409.4	359.9
628.1		Rh-102	207	d	475.1	555.6	468.6
630.0		Pm-148m	41.3	d	550.3	725.7	1013.8
634.8		As-74	17.77	d	595.9	Ann.	-----
636.0		Sb-125	2.76	y	427.9	600.6	463.4
637.0		I-131	8.02	d	364.5	284.3	80.2
645.9		Sb-124	60.2	d	1691.0	602.7	722.8
646.1	*	Os-185	93.6	d	-----	-----	-----
657.0		As-76	26.3	h	559.1	1216.1	1212.9
657.8	*	Ag-110m	249.79	d	884.7	937.5	1384.3
661.7	*	Cs-137	30.07	y	-----	-----	-----
664.6		Ce-143	33.0	h	293.3	57.4	721.9
670.5		Ho-166m	1200	y	184.4	810.3	711.7
671.4		Sb-125	2.76	y	427.9	600.6	636.0
675.9		Au-198	2.70	d	411.8	1087.7	-----
677.6		Ag-110m	249.79	d	657.8	884.7	937.5
685.9		Nd-147	10.98	d	91.1	531.0	319.4
687.0		Ag-110m	249.79	d	657.8	884.7	937.5
687.7		Ir-194m2	171	d	338.8	328.5	482.8
691.3		Ho-166m	1200	y	184.4	810.3	711.7
692.4		Eu-154	8.59	y	1274.4	123.1	723.3
692.8		Sb-122	2.72	d	564.1	-----	-----
695.9	*	Te-129m	33.6	d	105.5	-----	-----
698.4		Br-82	35.3	h	776.5	554.4	619.1
706.7		Ag-110m	249.79	d	657.8	884.7	937.5
709.3		Sb-124	60.2	d	1691.0	602.7	722.8
711.7		Ho-166m	1200	y	184.4	810.3	280.5
713.8		Sb-124	60.2	d	1691.0	602.7	722.8
717.7		Pm-151	28.4	h	340.1	167.8	275.2
721.9		Ce-143	33.0	h	293.3	57.4	664.6
722.8		Sb-124	60.2	d	1691.0	602.7	645.9
722.9		I-131	8.02	d	364.5	637.0	284.3
723.3		Eu-154	8.59	y	1274.4	123.1	1004.7
724.2		Zr-95	64.02	d	756.7	-----	-----
725.3		In-114m	49.5	d	190.3	558.5	-----
725.7		Pm-148m	41.3	d	550.3	630.0	1013.8
727.3	*	Th-232(Bi-212)	1.40E+10	y	785.4	1620.7	-----
739.6	*	Mo-99	65.9	h	140.5	181.1	777.9

Table 9. Gamma rays arranged by energy (half-lives > 1 day).

Energy 1 (keV)		Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
744.3		Ag-110m	249.79	d	657.8	884.7	937.5
751.6		La-140	40.27	h	1596.2	487.0	328.8
752.3		Ho-166m	1200	y	184.4	810.3	711.7
756.7	*	Zr-95	64.02	d	724.2	-----	-----
756.8		Eu-154	8.59	y	1274.4	123.1	723.3
763.9		Ag-110m	249.79	d	657.8	884.7	937.5
765.3		Tb-160	72.3	d	879.4	966.2	298.6
765.8	*	Nb-95	34.98	d	-----	-----	-----
768.4		U-238(Bi-214)	4.50E+09	y	609.3	1120.3	1764.5
772.3		Th-232(Ac-228)	1.40E+10	y	911.2	338.3	969.0
773.7	*	Te-131m	30	h	852.2	793.8	1125.5
776.5	*	Br-82	35.3	h	554.4	619.1	698.4
777.9		Mo-99	65.9	h	739.6	140.5	181.1
778.8		Ho-166m	1200	y	184.4	810.3	711.7
778.9		Eu-152	13.54	y	1408.0	344.3	121.8
782.5		Te-131m	30	h	773.7	852.2	793.8
785.4		Th-232(Bi-212)	1.40E+10	y	727.3	1620.7	-----
793.8		Te-131m	30	h	773.7	852.2	1125.5
795.0		Th-232(Ac-228)	1.40E+10	y	911.2	338.3	969.0
795.9	*	Cs-134	2.06	y	604.7	569.3	563.3
802.0		Cs-134	2.06	y	795.9	604.7	569.3
807.9		Ca-47	4.54	d	1297.1	489.2	-----
810.3		Ho-166m	1200	y	184.4	184.4	711.7
810.8	*	Co-58	70.9	d	-----	-----	-----
815.8		La-140	40.27	h	1596.2	487.0	328.8
818.0		Ag-110m	249.79	d	657.8	884.7	937.5
822.5		Sn-125	9.64	d	1067.1	1089.2	915.6
822.8		Te-131m	30	h	773.7	852.2	793.8
827.8		Br-82	35.3	h	776.5	554.4	619.1
830.6		Ho-166m	1200	y	184.4	810.3	711.7
834.8	*	Mn-54	312.3	d	-----	-----	-----
835.7		Th-232(Ac-228)	1.40E+10	y	911.2	338.3	969.0
846.8		Co-56	77.3	d	1238.3	1771.4	1037.8
852.2		Te-131m	30	h	773.7	793.8	1125.5
860.6		Th-232(Tl-208)	1.40E+10	y	583.2	2614.5	510.8
867.4		Eu-152	13.54	y	1408.0	344.3	778.9
867.9		La-140	40.27	h	1596.2	487.0	328.8
873.2		Eu-154	8.59	y	1274.4	123.1	723.3
879.4	*	Tb-160	72.3	d	966.2	298.6	1178.0
880.5		Ce-143	33.0	h	293.3	57.4	664.6
884.7		Ag-110m	249.79	d	657.8	937.5	1384.3
889.3	*	Sc-46	83.79	d	1120.5	-----	-----
898.0		Y-88	106.65	d	1836.1	-----	-----
909.0	*	Sr-89	50.53	d	-----	-----	-----
911.2	*	Th-232(Ac-228)	1.40E+10	y	338.3	969.0	964.8
914.8		Pm-148	5.37	d	550.3	1465.1	-----
915.3		Pm-148m	41.3	d	550.3	630.0	725.7
915.6		Sn-125	9.64	d	1067.1	1089.2	822.5
919.6		La-140	40.27	h	1596.2	487.0	328.8
925.2		La-140	40.27	h	1596.2	487.0	328.8
933.8	*	Cd-115m	44.6	d	1290.6	484.5	-----
934.0		U-238(Bi-214)	4.50E+09	y	609.3	1120.3	1764.5
934.5	*	Nb-92m	10.15	d	-----	-----	-----
937.5		Ag-110m	249.79	d	657.8	884.7	1384.3
951.0		Ho-166m	1200	y	184.4	810.3	711.7
962.3		Tb-160	72.3	d	879.4	966.2	298.6
964.1		Eu-152	13.54	y	1408.0	344.3	778.9
964.8		Th-232(Ac-228)	1.40E+10	y	338.3	911.2	969.0

Table 9. Gamma rays arranged by energy (half-lives > 1 day).

Energy 1 (keV)		Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
966.2		Tb-160	72.3	d	879.4	298.6	1178.0
968.2		Sb-124	60.2	d	1691.0	602.7	722.8
969.0		Th-232(Ac-228)	1.40E+10	y	338.3	911.2	964.8
977.4		Co-56	77.3	d	1238.3	846.8	1037.8
983.5	*	Sc-48	43.67	h	1037.6	1312.1	-----
996.3		Eu-154	8.59	y	1274.4	123.1	723.3
1001.7		Ta-182	114.43	d	1221.4	1189.1	67.8
1002.9		Tb-160	72.3	d	879.4	966.2	298.6
1004.7		Eu-154	8.59	y	1274.4	123.1	723.3
1007.6		Br-82	35.3	h	776.5	554.4	619.1
1011.8		Ir-194m2	171	d	338.8	328.5	482.8
1013.8		Pm-148m	41.3	d	550.3	630.0	725.7
1037.6		Sc-48	43.67	h	983.5	1312.1	-----
1037.8		Co-56	77.3	d	1238.3	846.8	1771.4
1044.1		Br-82	35.3	h	776.5	554.4	619.1
1045.1		Sb-124	60.2	d	1691.0	602.7	722.8
1067.1	*	Sn-125	9.64	d	1089.2	822.5	915.6
1076.6	*	Rb-86	18.63	d	-----	-----	-----
1085.9		Eu-152	13.54	y	1408.0	344.3	778.9
1087.7		Au-198	2.70	d	411.8	675.9	-----
1088.6	*	Sn-123	129.2	d	-----	-----	-----
1089.2		Sn-125	9.64	d	1067.1	822.5	915.6
1093.7	*	Tm-172	63.6	h	1387.1	1465.9	1608.6
1099.3	*	Fe-59	44.5	d	1291.6	192.4	142.7
1102.2		Te-121m	154	d	212.2	-----	-----
1103.2		Rh-102	207	d	475.1	555.6	628.1
1112.1		Eu-152	13.54	y	1408.0	344.3	778.9
1115.1		Tb-160	72.3	d	879.4	966.2	298.6
1115.6	*	Zn-65	244.3	d	-----	-----	-----
1120.3		U-238(Bi-214)	4.50E+09	y	609.3	1120.3	1764.5
1120.5		Sc-46	83.79	d	889.3	-----	-----
1121.3		Ta-182	114.43	d	1221.4	1189.1	67.8
1125.5		Te-131m	30	h	773.7	852.2	793.8
1168.0		Cs-134	2.06	y	795.9	604.7	569.3
1173.2	*	Co-60	5.27	y	1332.5	-----	-----
1175.1		Co-56	77.3	d	1238.3	846.8	1771.4
1178.0		Tb-160	72.3	d	879.4	966.2	298.6
1189.1		Ta-182	114.43	d	1221.4	67.8	1121.3
1199.9		Tb-160	72.3	d	879.4	966.2	298.6
1206.6		Te-131m	30	h	773.7	852.2	793.8
1212.9		As-76	26.3	h	559.1	657.0	1216.1
1213.0		Eu-152	13.54	y	1408.0	344.3	778.9
1216.1		As-76	26.3	h	559.1	657.0	1212.9
1218.9		Sc-48	43.67	h	983.5	1037.6	1312.0
1221.4	*	Ta-182	114.43	d	1189.1	67.8	1121.3
1228.6		As-76	26.3	h	559.1	657.0	1216.1
1231.0		Ta-182	114.43	d	1221.4	1189.1	67.8
1238.1		U-238(Bi-214)	4.50E+09	y	609.3	1120.3	1764.5
1238.3	*	Co-56	77.3	d	846.8	1771.4	1037.8
1257.4		Ta-182	114.43	d	1221.4	1189.1	67.8
1271.9		Tb-160	72.3	d	879.4	966.2	298.6
1274.4	*	Eu-154	8.59	y	123.1	723.3	1004.7
1274.5	*	Na-22	2.6	y	511.0	-----	-----
1289.2		Ta-182	114.43	d	1221.4	1189.1	67.8
1290.6		Cd-115m	44.6	d	933.8	484.5	-----
1291.6		Fe-59	44.5	d	1099.3	192.4	142.7
1297.1	*	Ca-47	4.54	d	489.2	807.4	-----
1299.1		Eu-152	13.54	y	1408.0	344.3	778.9

Table 9. Gamma rays arranged by energy (half-lives > 1 day).

Energy 1 (keV)		Isotope	Half-life		Energy2 (keV)	Energy3 (keV)	Energy4 (keV)
1312.1		Sc-48	43.67	h	983.5	1037.6	-----
1312.1		Tb-160	72.3	d	879.4	966.2	298.6
1317.5		Br-82	35.3	h	776.5	554.4	619.1
1325.5		Sb-124	60.2	d	1691.0	602.7	722.8
1332.5		Co-60	5.27	y	1173.2	-----	-----
1355.2		Sb-124	60.2	d	1691.0	602.7	722.8
1360.2		Co-56	77.3	d	1238.3	846.8	1771.4
1365.2		Cs-134	2.06	y	795.9	604.7	569.3
1368.2		Sb-124	60.2	d	1691.0	602.7	722.8
1377.7		U-238(Bi-214)	4.50E+09	y	609.3	1120.3	1764.5
1379.4		Ho-166	26.83	h	80.6	-----	-----
1384.3		Ag-110m	249.79	d	657.8	884.7	937.5
1387.1		Tm-172	63.6	h	1093.7	1465.9	1608.6
1408.0	*	Eu-152	13.54	y	344.3	778.9	121.8
1436.6		Sb-124	60.2	d	1691.0	602.7	722.8
1460.8	*	K-40	1.28E+09	y	-----	-----	-----
1465.1	*	Pm-148	5.37	d	550.3	914.8	-----
1465.9		Tm-172	63.6	h	1093.7	1387.1	1608.6
1474.9		Br-82	35.3	h	776.5	554.4	619.1
1475.8		Ag-110m	249.79	d	657.8	884.7	937.5
1505.0		Ag-110m	249.79	d	657.8	884.7	937.5
1509.2		U-238(Bi-214)	4.50E+09	y	609.3	1120.3	1764.5
1529.7		Tm-172	63.6	h	1903.7	1387.1	1465.9
1562.3		Ag-110m	249.79	d	657.8	884.7	937.5
1588.2		Th-232(Ac-228)	1.40E+10	y	338.3	911.2	969.0
1596.2	*	La-140	40.27	h	487.0	328.8	867.9
1608.6		Tm-172	63.6	h	1093.7	1387.1	1465.9
1620.5		Th-232(Bi-212)	1.40E+10	y	727.3	785.4	-----
1630.6		Th-232(Ac-228)	1.40E+10	y	338.3	911.2	969.0
1691.0	*	Sb-124	60.2	d	602.7	722.8	645.9
1729.6		U-238(Bi-214)	4.50E+09	y	609.3	1120.3	1764.5
1764.5		U-238(Bi-214)	4.50E+09	y	609.3	1120.3	1729.6
1771.4		Co-56	77.3	d	1238.3	846.8	1037.8
1836.1	*	Y-88	106.65	d	898.0	-----	-----
1847.4		U-238(Bi-214)	4.50E+09	y	609.3	1120.3	1764.5
2002.2		Sn-125	9.64	d	1067.1	1089.2	822.5
2015.2		Co-56	77.3	d	1238.3	846.8	1771.4
2034.8		Co-56	77.3	d	1238.3	846.8	1771.4
2090.9		Sb-124	60.2	d	1691.0	602.7	722.8
2204.1		U-238(Bi-214)	4.50E+09	y	609.3	1120.3	1764.5
2521.4		La-140	40.27	h	1596.2	487.0	328.8
2598.5		Co-56	77.3	d	1238.3	846.8	1771.4
2614.5	*	Th-232(Tl-208)	1.40E+10	y	583.2	510.8	860.6
3009.6		Co-56	77.3	d	1238.3	846.8	2598.5
3202.0		Co-56	77.3	d	1238.3	846.8	2598.5
3253.4		Co-56	77.3	d	1238.3	846.8	2598.5
3272.9		Co-56	77.3	d	1238.3	846.8	2598.5

Table 10. Concentrations of elements in SRM-1515, SRM-1547 and SRM-1566.

Element/Units		SRM-1515 Apple Leaves Certificate values (mean & std. dev.)	SRM-1547 Peach Leaves Certificate values (mean & std. dev.)	SRM-1566 Oyster Tissue Certificate values (mean & std. dev.)	SRM-1566 Oyster Tissue Literature values (mean & std. dev.)
Ag	(ppm)	---	---	0.89 ± 0.09	0.94 ± 0.11
Al	(ppm)	286 ± 9	249 ± 8	---	263 ± 8
As	(ppm)	0.038 ± 0.007	0.060 ± 0.018	13.4 ± 1.9	13.0 ± 1.2
Au	(ppm)	(0.001)	---	---	---
B	(ppm)	27 ± 2	29 ± 2	---	7 ± 1
Ba	(ppm)	49 ± 2	124 ± 4	---	---
Br	(ppm)	(1.8)	(11)	(55)	53 ± 6
Ca	(%)	1.53 ± 0.02	1.56 ± 0.02	0.15 ± 0.02	0.140 ± 0.012
Cd	(ppm)	(0.013)	(0.026)	3.5 ± 0.4	3.43 ± 0.16
Ce	(ppm)	(3)	(10)	---	(0.42)
Cl	(%)	0.579 ± 0.0023	0.036 ± 0.018	(1.0)	0.99 ± 0.02
Co	(ppm)	(0.09)	(0.07)	(0.4)	0.37 ± 0.04
Cr	(ppm)	(0.3)	(1)	0.69 ± 0.27	0.65 ± 0.08
Cs	(ppm)	---	---	---	(0.04)
Cu	(ppm)	5.64 ± 0.22	3.7 ± 0.4	63.0 ± 3.5	63 ± 2
Dy	(ppm)	---	---	---	---
Er	(ppm)	---	---	---	---
Eu	(ppm)	(0.2)	(0.17)	---	0.016 ± 0.003
F	(ppm)	---	---	(5.2)	(5.15)
Fe	(ppm)	83 ± 5	218 ± 14	195 ± 34	195 ± 11
Gd	(ppm)	(3)	(1)	---	---
Hf	(ppm)	---	---	---	---
Hg	(ppm)	0.044 ± 0.004	0.031 ± 0.007	0.057 ± 0.015	0.056 ± 0.004
I	(ppm)	(0.3)	(0.3)	(2.8)	2.8 ± 0.3
K	(%)	1.61 ± 0.02	2.43 ± 0.02	0.969 ± 0.005	0.93 ± 0.07
La	(ppm)	(20)	(9)	---	(0.37)
Li	(ppm)	---	---	---	---
Lu	(ppm)	---	---	---	---
Mg	(ppm)	2710 ± 80	4320 ± 86	1280 ± 90	1330 ± 100
Mn	(ppm)	54 ± 3	98 ± 3	17.5 ± 1.2	17.0 ± 1.2
Mo	(ppm)	0.094 ± 0.013	0.060 ± 0.008	< 0.2	0.14 ± 0.04
Na	(ppm)	24.4 ± 1.2	24 ± 2	0.51 ± 300	0.495 ± 0.022
Nd	(ppm)	(17)	(7)	---	---
Ni	(ppm)	0.91 ± 0.12	0.69 ± 0.09	1.03 ± 0.19	1.01 ± 0.09
P	(%)	0.159 ± 0.011	0.137 ± 0.010	(0.81)	0.76 ± 0.05
Pb	(ppm)	0.470 ± 0.024	0.87 ± 0.03	0.48 ± 0.04	0.48 ± 0.03
Rb	(ppm)	10.2 ± 1.5	19.7 ± 1.2	4.45 ± 0.09	4.5 ± 0.5
S	(%)	(0.18)	(0.2)	(0.76)	0.87 ± 0.07
Sb	(ppm)	---	(0.02)	---	0.19 ± 0.20
Sc	(ppm)	(0.013)	(0.04)	---	0.076 ± 0.008
Se	(ppm)	0.050 ± 0.009	0.120 ± 0.009	2.1 ± 0.5	2.08 ± 0.20
Si	(ppm)	---	---	---	(1100)
Sm	(ppm)	(3)	(1)	---	(0.7)
Sn	(ppm)	(< 0.2)	(< 0.2)	---	---
Sr	(ppm)	25 ± 2	53 ± 4	10.36 ± 0.56	10.1 ± 0.7
Ta	(ppm)	---	---	---	---
Tb	(ppm)	(0.4)	(0.1)	---	---
Te	(ppm)	---	---	---	---
Th	(ppm)	(0.03)	(0.05)	(0.1)	(0.052)
Ti	(ppm)	---	---	---	(7.32)
Tl	(ppm)	---	---	(< 0.005)	---
Tm	(ppm)	---	---	---	---
U	(ppm)	(0.006)	(0.015)	0.116 ± 0.006	0.121 ± 0.008
V	(ppm)	0.26 ± 0.03	0.37 ± 0.03	2.3 ± 0.1	2.7 ± 0.2
W	(ppm)	(0.007)	---	---	---
Y	(ppm)	---	---	---	---
Yb	(ppm)	(0.3)	(0.02)	---	---
Zn	(ppm)	12.5 ± 0.2	17.9 ± 0.4	852 ± 14	854 ± 24

Table 11. Concentrations of elements in SRM-1566a, SRM-1566b, SRM-1567 and SRM-1568.

Element/Units		SRM-1566a Oyster Tissue Certificate values (mean & std. dev.)	SRM-1566b Oyster Tissue Certificate values (mean & std. dev.)	SRM-1567 Wheat Flour Certificate values (mean & std. dev.)	SRM-1568 Rice Flour Certificate values (mean & std. dev.)
Ag	(ppm)	1.68 ± 0.15	0.666 ± 0.009	---	---
Al	(ppm)	202.5 ± 12.5	197.2 ± 6.0	---	---
As	(ppm)	14.0 ± 1.2	7.65 ± 0.65	(0.006)	0.41 ± 0.05
Au	(ppm)	(0.01)	---	---	---
B	(ppm)	---	4.5 ± 1.9	---	---
Ba	(ppm)	---	8.6 ± 0.3	---	---
Br	(ppm)	---	---	(9)	(1)
Ca	(ppm)	1960 ± 190	838 ± 20	190 ± 10	140 ± 20
Cd	(ppm)	4.15 ± 0.38	2.48 ± 0.08	0.032 ± 0.007	0.029 ± 0.004
Ce	(ppm)	(0.4)	---	---	---
Cl	(ppm)	8290 ± 140	5140 ± 100	---	---
Co	(ppm)	0.57 ± 0.11	0.371 ± 0.009	---	0.02 ± 0.01
Cr	(ppm)	1.43 ± 0.46	---	---	---
Cs	(ppm)	(0.02)	---	---	---
Cu	(ppm)	66.3 ± 4.3	71.6 ± 1.6	2.0 ± 0.3	2.2 ± 0.3
Dy	(ppm)	---	---	---	---
Er	(ppm)	(0.01)	---	---	---
Eu	(ppm)	---	---	---	---
F	(ppm)	(240)	---	---	---
Fe	(ppm)	539 ± 15	205.8 ± 6.8	18.3 ± 1.0	8.7 ± 0.6
Gd	(ppm)	---	---	---	---
Hf	(ppm)	(0.04)	---	---	---
Hg	(ppm)	0.0642 ± 0.0067	0.371 ± 0.0013	0.0010 ± 0.0008	0.0060 ± 0.0007
I	(ppm)	4.46 ± 0.42	---	---	---
K	(ppm)	7900 ± 470	6520 ± 90	1360 ± 40	1120 ± 20
La	(ppm)	(0.3)	---	---	---
Li	(ppm)	---	---	---	---
Lu	(ppm)	---	---	---	---
Mg	(ppm)	1180 ± 170	1085 ± 23	---	---
Mn	(ppm)	12.3 ± 1.5	18.5 ± 0.2	8.5 ± 0.5	20.1 ± 0.4
Mo	(ppm)	---	---	(0.4)	(1.6)
Na	(ppm)	4170 ± 130	3297 ± 53	8.0 ± 1.5	6.0 ± 1.5
Nd	(ppm)	---	---	---	---
Ni	(ppm)	2.25 ± 0.44	1.04 ± 0.09	(0.18)	(0.16)
P	(ppm)	6230 ± 180	---	---	---
Pb	(ppm)	0.371 ± 0.014	0.308 ± 0.009	0.02 ± 0.01	0.045 ± 0.010
Rb	(ppm)	(3)	3.26 ± 0.14	(1)	(7)
S	(ppm)	8620 ± 190	6890 ± 140	---	---
Sb	(ppm)	(0.01)	0.011 ± 0.002	---	---
Sc	(ppm)	(0.06)	---	---	---
Se	(ppm)	2.21 ± 0.25	2.06 ± 0.15	1.1 ± 0.2	0.4 ± 0.1
Si	(ppm)	---	---	---	---
Sm	(ppm)	(0.06)	---	---	---
Sn	(ppm)	(3)	0.31 ± 0.008	---	---
Sr	(ppm)	11.1 ± 1.0	6.8 ± 0.2	---	---
Ta	(ppm)	(0.003)	---	---	---
Tb	(ppm)	(0.007)	---	---	---
Te	(ppm)	---	---	(< 0.002)	(< 0.002)
Th	(ppm)	(0.04)	0.0367 ± 0.0043	---	---
Ti	(ppm)	---	---	---	---
Tl	(ppm)	---	---	---	---
Tm	(ppm)	---	---	---	---
U	(ppm)	0.132 ± 0.012	0.2550 ± 0.0014	---	---
V	(ppm)	4.68 ± 0.15	0.577 ± 0.023	---	---
W	(ppm)	---	---	---	---
Y	(ppm)	---	---	---	---
Yb	(ppm)	---	---	---	---
Zn	(ppm)	830 ± 57	1424 ± 46	10.6 ± 1.0	19.4 ± 1.0

Table 12. Concentrations of elements in SRM-1570, SRM-1570a and SRM-1571.

Element/Units		SRM-1570 Spinach Leaves Certificate values (mean & std. dev.)	SRM-1570a Spinach Leaves Certificate values (mean & std. dev.)	SRM-1571 Orchard Leaves Certificate values (mean & std. dev.)	SRM-1571 Orchard Leaves Literature values (mean & std. dev.)
Ag	(ppm)	---	---	---	(0.32)
Al	(ppm)	870 ± 50	310 ± 11	---	323 ± 112
As	(ppm)	0.15 ± 0.05	0.068 ± 0.012	10 ± 2	10.7 ± 1.3
Au	(ppm)	---	---	---	0.0014 ± 0.0004
B	(ppm)	(30)	37.6 ± 1.0	33 ± 3	33 ± 3
Ba	(ppm)	---	---	(44)	43 ± 4
Br	(ppm)	(54)	---	(10)	9.5 ± 1.1
Ca	(%)	1.35 ± 0.03	1.527 ± 0.041	2.09 ± 0.03	2.04 ± 0.12
Cd	(ppm)	(1.5)	2.89 ± 0.07	0.11 ± 0.01	0.119 ± 0.022
Ce	(ppm)	---	---	---	0.99 ± 0.12
Cl	(ppm)	---	---	(690)	730 ± 40
Co	(ppm)	(1.5)	0.39 ± 0.05	(0.2)	0.160 ± 0.037
Cr	(ppm)	4.6 ± 0.3	---	2.6 ± 0.3	2.6 ± 0.3
Cs	(ppm)	---	---	(0.04)	0.038 ± 0.009
Cu	(ppm)	12 ± 2	12.2 ± 0.6	12 ± 1	12.0 ± 1.4
Dy	(ppm)	---	---	---	0.082 ± 0.023
Er	(ppm)	---	---	---	0.0297 ± 0.0015
Eu	(ppm)	(0.02)	(0.0054)	---	0.024 ± 0.003
F	(ppm)	---	---	(4)	3.9 ± 0.5
Fe	(ppm)	550 ± 20	---	300 ± 20	286 ± 28
Gd	(ppm)	---	---	---	0.068 ± 0.048
Hf	(ppm)	---	---	---	0.030 ± 0.005
Hg	(ppm)	0.030 ± 0.005	0.030 ± 0.003	0.155 ± 0.015	0.155 ± 0.014
I	(ppm)	---	---	(0.17)	0.186 ± 0.018
K	(%)	3.56 ± 0.03	2.903 ± 0.052	1.47 ± 0.03	1.44 ± 0.07
La	(ppm)	(0.37)	---	---	1.17 ± 0.11
Li	(ppm)	---	---	(0.6)	0.70 ± 0.15
Lu	(ppm)	---	---	---	0.0051 ± 0.0025
Mg	(%)	---	(0.89)	0.62 ± 0.02	0.605 ± 0.038
Mn	(ppm)	165 ± 6	75.9 ± 1.9	91 ± 4	89 ± 5
Mo	(ppm)	---	---	0.3 ± 0.1	0.29 ± 0.07
Na	(ppm)	---	18180 ± 430	82 ± 6	89 ± 15
Nd	(ppm)	---	---	---	0.51 ± 0.13
Ni	(ppm)	(6)	2.14 ± 0.10	1.3 ± 0.2	1.3 ± 0.2
P	(%)	0.55 ± 0.02	0.518 ± 0.011	0.21 ± 0.01	0.200 ± 0.018
Pb	(ppm)	1.2 ± 0.2	(0.20)	45 ± 3	44 ± 3
Rb	(ppm)	12.1 ± 0.2	(13)	12 ± 1	11.4 ± 1.2
S	(%)	---	(0.46)	(0.19)	0.204 ± 0.024
Sb	(ppm)	(0.04)	---	2.9 ± 0.3	2.9 ± 0.3
Sc	(ppm)	(0.16)	(0.055)	---	0.063 ± 0.014
Se	(ppm)	---	0.117 ± 0.009	0.08 ± 0.01	0.081 ± 0.010
Si	(ppm)	---	---	---	550 ± 110
Sm	(ppm)	---	---	---	0.114 ± 0.020
Sn	(ppm)	---	---	---	0.29 ± 0.06
Sr	(ppm)	87 ± 2	55.6 ± 0.8	37 ± 1	36 ± 3
Ta	(ppm)	---	---	---	0.008 ± 0.002
Tb	(ppm)	---	---	---	0.013 ± 0.003
Te	(ppm)	---	---	(0.01)	(0.011)
Th	(ppm)	0.12 ± 0.03	0.048 ± 0.003	0.064 ± 0.006	0.058 ± 0.012
Ti	(ppm)	---	---	---	20 ± 7
Tl	(ppm)	(0.03)	---	---	0.036 ± 0.003
Tm	(ppm)	---	---	---	0.007 ± 0.003
U	(ppm)	0.046 ± 0.009	(0.15)	0.029 ± 0.005	0.029 ± 0.003
V	(ppm)	---	0.57 ± 0.03	---	0.50 ± 0.11
W	(ppm)	---	---	---	0.03 ± 0.02
Y	(ppm)	---	---	---	(0.48)
Yb	(ppm)	---	---	---	0.025 ± 0.005
Zn	(ppm)	50 ± 2	82 ± 3	25 ± 3	25 ± 2

Table 13. Concentrations of elements in SRM-1572 and SRM-1573.

Element/Units		SRM-1572 Citrus Leaves		SRM-1573 Tomato Leaves	
		Certificate values (mean & std. dev.)	Literature values (mean & std. dev.)	Certificate values (mean & std. dev.)	Literature values (mean & std. dev.)
Ag	(ppm)	---	---	---	(0.18)
Al	(ppm)	92 ± 15	75 ± 2	(0.12)	0.1146 ± 0.0036
As	(ppm)	3.1 ± 0.3	3.0 ± 0.3	0.27 ± 0.05	0.253 ± 0.036
Au	(ppm)	---	---	---	(0.0008)
B	(ppm)	---	(66.6)	(30)	33 ± 4
Ba	(ppm)	21 ± 3	(23.5)	---	57 ± 9
Br	(ppm)	(8.2)	(8.36)	(26)	21 ± 2
Ca	(%)	3.15 ± 0.10	3.13 ± 0.04	3.00 ± 0.03	2.83 ± 0.23
Cd	(ppm)	0.03 ± 0.01	(0.046)	(3)	2.5 ± 0.2
Ce	(ppm)	(0.28)	(0.45)	(1.6)	1.3 ± 0.2
Cl	(ppm)	(414)	(404)	---	10700 ± 300
Co	(ppm)	(0.02)	(0.016)	(0.6)	0.525 ± 0.046
Cr	(ppm)	0.8 ± 0.2	(1)	4.5 ± 0.5	4.0 ± 0.5
Cs	(ppm)	(0.098)	0.093 ± 0.016	---	0.057 ± 0.008
Cu	(ppm)	16.5 ± 1.0	16 ± 1	11 ± 1	11 ± 2
Dy	(ppm)	---	---	---	(0.068)
Er	(ppm)	---	(0.022)	---	(0.051)
Eu	(ppm)	(0.01)	(0.0135)	(0.04)	0.022 ± 0.006
F	(ppm)	---	(40)	---	5.5 ± 0.4
Fe	(ppm)	90 ± 10	101 ± 6	690 ± 25	580 ± 110
Gd	(ppm)	---	---	---	(0.075)
Hf	(ppm)	---	---	---	(0.25)
Hg	(ppm)	0.08 ± 0.02	0.081 ± 0.003	(0.1)	0.103 ± 0.022
I	(ppm)	1.84 ± 0.03	(1.46)	---	0.323 ± 0.058
K	(%)	1.82 ± 0.06	1.83 ± 0.04	4.46 ± 0.03	4.44 ± 0.24
La	(ppm)	(0.19)	(0.198)	(0.9)	0.71 ± 0.07
Li	(ppm)	---	---	---	0.0093 ± 0.0025
Lu	(ppm)	---	---	---	---
Mg	(%)	0.58 ± 0.03	0.560 ± 0.007	(0.70)	0.685 ± 0.033
Mn	(ppm)	23 ± 2	22.9 ± 1.4	238 ± 7	224 ± 13
Mo	(ppm)	0.17 ± 0.09	(0.152)	---	0.53 ± 0.09
Na	(ppm)	160 ± 20	163 ± 1	---	470 ± 110
Nd	(ppm)	---	---	---	0.62 ± 0.07
Ni	(ppm)	0.6 ± 0.3	(0.715)	---	1.3 ± 0.2
P	(%)	0.13 ± 0.02	0.131 ± 0.002	0.34 ± 0.02	0.337 ± 0.022
Pb	(ppm)	13.3 ± 2.4	(13.4)	6.3 ± 0.3	5.9 ± 0.8
Rb	(ppm)	4.84 ± 0.06	---	16.5 ± 0.1	17.3 ± 2.5
S	(%)	0.407 ± 0.009	0.408 ± 0.018	---	0.62 ± 0.04
Sb	(ppm)	(0.04)	(0.034)	---	0.036 ± 0.007
Sc	(ppm)	(0.01)	0.0104 ± 0.0005	(0.13)	0.173 ± 0.026
Se	(ppm)	(0.025)	---	---	0.054 ± 0.006
Si	(%)	---	(0.19)	---	(0.30)
Sm	(ppm)	(0.052)	(0.05)	---	0.092 ± 0.016
Sn	(ppm)	(0.24)	---	---	---
Sr	(ppm)	100 ± 2	98 ± 3	44.9 ± 0.3	42 ± 5
Ta	(ppm)	---	---	---	(0.43)
Tb	(ppm)	---	---	---	0.009 ± 0.005
Te	(ppm)	(0.02)	---	---	---
Th	(ppm)	---	---	0.17 ± 0.03	(0.205)
Ti	(ppm)	---	(22)	---	56 ± 39
Tl	(ppm)	(< 0.01)	---	(0.05)	---
Tm	(ppm)	---	---	---	---
U	(ppm)	< 0.15	0.040 ± 0.002	0.061 ± 0.003	0.059 ± 0.006
V	(ppm)	---	(0.24)	---	1.2 ± 0.2
W	(ppm)	---	---	---	< 0.04
Y	(ppm)	---	---	---	---
Yb	(ppm)	---	---	---	0.063 ± 0.016
Zn	(ppm)	29 ± 2	29.9 ± 1.4	62 ± 6	61 ± 4

Table 14. Concentrations of elements in SRM-1577, SRM-1577a and SRM-1577b.

Element/Units		SRM-1577 Bovine Liver Certificate values (mean & std. dev.)	SRM-1577 Bovine Liver Literature values (mean & std. dev.)	SRM-1577a Bovine Liver Certificate values (mean & std. dev.)	SRM-1577b Bovine Liver Certificate values (mean & std. dev.)
Ag	(ppm)	(0.06)	0.062 ± 0.013	0.04 ± 0.01	0.039 ± 0.007
Al	(ppm)	---	0.7 ± 0.2	(2)	(3)
As	(ppm)	0.055 ± 0.005	0.055 ± 0.006	0.047 ± 0.006	(0.05)
Au	(ppm)	---	0.0028 ± 0.0030	---	---
B	(ppm)	---	2.9 ± 0.8	---	---
Ba	(ppm)	---	0.94 ± 1.1	---	---
Br	(ppm)	---	9.1 ± 0.9	(9)	(9.7)
Ca	(ppm)	124 ± 6	122 ± 14	120 ± 7	116 ± 4
Cd	(ppm)	0.27 ± 0.04	0.281 ± 0.021	0.44 ± 0.06	0.50 ± 0.03
Ce	(ppm)	---	0.020 ± 0.004	---	---
Cl	(%)	(0.27)	0.268 ± 0.014	0.28 ± 0.01	0.278 ± 0.010
Co	(ppm)	(0.18)	0.23 ± 0.04	0.21 ± 0.05	(0.25)
Cr	(ppm)	0.088 ± 0.012	0.116 ± 0.052	---	---
Cs	(ppm)	---	0.017 ± 0.007	---	---
Cu	(ppm)	193 ± 10	190 ± 9	158 ± 7	160 ± 8
Dy	(ppm)	---	(0.0029)	---	---
Er	(ppm)	---	---	---	---
Eu	(ppm)	---	0.0003 ± 6E-05	---	---
F	(ppm)	---	(0.08)	---	---
Fe	(ppm)	268 ± 8	265 ± 18	194 ± 20	184 ± 15
Ga	(ppm)	---	---	---	---
Hf	(ppm)	---	(0.00415)	---	---
Hg	(ppm)	0.016 ± 0.002	0.0164 ± 0.0016	0.004 ± 0.002	(0.003)
I	(ppm)	(0.18)	0.234 ± 0.031	---	---
K	(%)	0.97 ± 0.06	0.98 ± 0.06	0.996 ± 0.007	0.994 ± 0.002
La	(ppm)	---	0.016 ± 0.004	---	---
Li	(ppm)	---	---	---	---
Lu	(ppm)	---	---	---	---
Mg	(ppm)	604 ± 9	---	600 ± 15	601 ± 28
Mn	(ppm)	10.3 ± 1.0	---	9.9 ± 0.8	10.5 ± 1.7
Mo	(ppm)	(3.4)	3.2 ± 0.4	3.5 ± 0.5	3.5 ± 0.3
Na	(%)	0.243 ± 0.013	0.2395 ± 0.0200	0.243 ± 0.013	0.242 ± 0.006
Nd	(ppm)	---	0.014 ± 0.004	---	---
Ni	(ppm)	---	---	---	---
P	(%)	(1.1)	---	1.11 ± 0.04	1.10 ± 0.03
Pb	(ppm)	0.34 ± 0.08	---	0.135 ± 0.015	0.129 ± 0.004
Rb	(ppm)	18.3 ± 1.0	---	12.5 ± 0.1	13.7 ± 1.1
S	(ppm)	---	7900 ± 1000	7800 ± 100	7850 ± 60
Sb	(ppm)	(0.005)	0.0096 ± 0.0047	(0.003)	(0.003)
Sc	(ppm)	---	0.0009 ± 0.0003	---	---
Se	(ppm)	1.1 ± 0.1	1.09 ± 0.08	0.71 ± 0.07	0.73 ± 0.06
Si	(ppm)	(17)	17.5 ± 1.3	---	---
Sm	(ppm)	---	0.0016 ± 0.0003	---	---
Sn	(ppm)	---	0.018 ± 0.005	---	---
Sr	(ppm)	(0.14)	0.17 ± 0.07	0.138 ± 0.003	0.136 ± 0.001
Ta	(ppm)	---	(0.003)	---	---
Tb	(ppm)	---	0.0008 ± 0.001	---	---
Te	(ppm)	---	(0.09)	---	---
Th	(ppm)	---	---	---	---
Ti	(ppm)	0.05)	---	---	---
Tl	(ppm)	---	---	(0.003)	---
Tm	(ppm)	---	---	---	---
U	(ppm)	(0.0008)	(0.001)	0.0007 ± 3E-05	---
V	(ppm)	---	0.058 ± 0.008	0.099 ± 0.008	(0.123)
W	(ppm)	---	0.008 ± 0.005	---	---
Y	(ppm)	---	< 1	---	---
Yb	(ppm)	---	0.0004 ± 0.0001	---	---
Zn	(ppm)	130 ± 13	130 ± 7	123 ± 8	127 ± 16

Table 15. Concentrations of elements in SRM-1d, SRM-97b and SRM98b.

Element/Units		SRM-1d Limestone Certificate values (mean & std. dev.)			SRM-97b Flint Clay Certificate values (mean & std. dev.)			SRM-98b Plastic Clay Certificate values (mean & std. dev.)		
Al	(%)	0.278	±	0.007	20.76	±	0.15	14.3	±	0.2
As	(ppm)		---			---			---	
Ba	(ppm)	30	±	10		(180)			(700)	
Ca	(%)	37.8	±	0.1	0.0249	±	0.0026	0.0759	±	0.0035
Cd	(ppm)		(0.3)			---			---	
Ce	(ppm)		(4)			---			---	
Cl	(ppm)		(130)			---			---	
Co	(ppm)		---			(3.8)			(16.3)	
Cr	(ppm)	8	±	2	227	±	12	119	±	5
Cs	(ppm)		(0.4)			(3.4)			(16.5)	
Dy	(ppm)		(0.6)			---			---	
Er	(ppm)		(0.4)			---			---	
Eu	(ppm)		(0.1)			(.84)			(1.3)	
F	(ppm)		(160)			---			---	
Fe	(%)	0.223	±	0.005	0.831	±	0.008	1.18	±	0.01
Ga	(ppm)		(1)			---			---	
Gd	(ppm)		(0.5)			---			---	
Hf	(ppm)		---			(13)			(7.2)	
Ho	(ppm)		(0.1)			---			---	
K	(%)	0.113	±	0.004	0.513	±	0.023	2.81	±	0.07
La	(ppm)		(4)			---			---	
Li	(ppm)				550	±	10	215	±	3
Lu	(ppm)		---			---			---	
Mg	(%)	0.182	±	0.006	0.113	±	0.002	0.358	±	0.012
Mn	(ppm)	209	±	5	47	±	5	116	±	5
Na	(%)	0.0081	±	0.0012	0.0492	±	0.0023	0.1496	±	0.0066
Nb	(ppm)		(0.7)			---			---	
Nd	(ppm)		(3)			---			---	
Ni	(ppm)		(4)			---			---	
P	(ppm)	180	±	11		(200)			(300)	
Pr	(ppm)		(0.6)			---			---	
Rb	(ppm)		(6)			(33)			(180)	
S	(ppm)	1030	±	60		---			---	
Sb	(ppm)					(2.2)			(1.6)	
Sc	(ppm)					(22)			(22)	
Si	(%)	1.91	±	0.03	19.81	±	0.04	26.65	±	0.16
Sm	(ppm)		(0.5)			---			---	
Sn	(ppm)		(1)			---			---	
Sr	(ppm)	256	±	8	84	±	2	189	±	8
Tb	(ppm)		(0.09)			---			---	
Th	(ppm)		(0.5)			(36)			(21)	
Ti	(%)	0.0183	±	0.0039	1.43	±	0.04	0.809	±	0.012
U	(ppm)		(1)			---			---	
V	(ppm)		(10)			---			---	
Y	(ppm)		(5)			---			---	
Yb	(ppm)		(0.3)			---			---	
Zn	(ppm)	18	±	2		(87)			(110)	
Zr	(ppm)		---			(500)			(220)	

Table 16. Concentrations of elements in SRM-278, SRM-679 and SRM-688.

Element/Units		SRM-278 Obsidian Rock Certificate values (mean & std. dev.)	SRM-679 Brick Clay Certificate values (mean & std. dev.)	SRM-688 Basalt Rock Certificate values (mean & std. dev.)
Al	(%)	7.49 ± 0.08	11.01 ± 0.34	9.19 ± 0.05
B	(ppm)	(25)	---	---
Ba	(ppm)	(1140)	432.2 ± 9.8	(200)
Br	(ppm)	---	---	---
Ca	(%)	0.702 ± 0.001	0.1628 ± 0.0013	(8.7)
Ce	(ppm)	(62.2)	(105)	(13.3)
Cl	(ppm)	---		---
Co	(ppm)	(1.5)	(26)	(49.7)
Cr	(ppm)	(6.1)	109.7 ± 4.9	332 ± 9
Cs	(ppm)	(5.5)	(9.6)	---
Cu	(ppm)	5.9 ± 0.2	---	(96)
Dy	(ppm)	---	---	---
Er	(ppm)	---	---	(1.07)
Eu	(ppm)	(0.84)	(1.9)	(200)
Fe	(%)	1.43 ± 0.01	9.05 ± 0.21	7.23 ± 0.03
Ga	(ppm)	---	---	---
Gd	(ppm)	(5.3)	---	---
Hf	(ppm)	(8.4)	(4.6)	(1.6)
Ho	(ppm)	---	---	---
K	(%)	3.45 ± 0.02	2.433 ± 0.047	0.155 ± 0.007
La	(ppm)	---	---	---
Li	(ppm)	---	71.7 ± 6.2	---
Lu	(ppm)	(0.73)	---	(0.34)
Mg	(%)	(0.14)	0.7552 ± 0.0088	(5.1)
Mn	(ppm)	400 ± 15	(1730)	1290 ± 20
Na	(%)	0.359 ± 0.04	0.1304 ± 0.0038	2.00 ± 0.02
Nd	(ppm)	---	---	---
Ni	(ppm)	3.6 ± 0.3	---	(150)
P	(ppm)	160 ± 13	(750)	580 ± 10
Pb	(ppm)	16.4 ± 0.2	---	3.3 ± 0.2
Rb	(ppm)	127.5 ± 0.3	(190)	1.91 ± 0.01
Sb	(ppm)	(1.5)	---	---
Sc	(ppm)	(5.1)	(22.5)	(38.1)
Si	(%)	34.11 ± 0.06	24.34 ± 0.30	22.6 ± 0.05
Sm	(ppm)	(5.7)	---	(2.79)
Sr	(ppm)	63.5 ± 0.1	73.4 ± 2.6	169.2 ± 0.7
Ta	(ppm)	(1.2)	---	---
Tb	(ppm)	(1)	---	(0.448)
Th	(ppm)	12.4 ± 0.3	(14)	3300 ± 200
Ti	(%)	0.147 ± 0.004	0.577 ± 0.033	0.700 ± 0.006
Tm	(ppm)	---	---	---
U	(ppm)	4.58 ± 0.04	---	(0.37)
V	(ppm)	---	(162)	(250)
Y	(ppm)	---	---	---
Yb	(ppm)	(4.5)	---	(2.09)
Zn	(ppm)	(55)	(150)	(58)
Zr	(ppm)	---	---	---

Table 17. Concentrations of elements in SRM-1632, SRM-1632a and SRM-1633.

Element/Units		SRM-1632 Coal Certificate values (mean & std. dev.)	SRM-1632a Bituminous Coal Certificate values (mean & std. dev.)	SRM-1633 Coal Fly Ash Certificate values (mean & std. dev.)
Al	(%)	---	(3.1)	---
As	(ppm)	5.9 ± 0.6	9.3 --- 1.0	61 ± 6
B	(ppm)	---	---	---
Ba	(ppm)	---	---	---
Ca	(%)	---	---	---
Cd	(ppm)	0.19 ± 0.03	0.17 ± 0.02	1.45 ± 0.06
Ce	(ppm)	---	(30)	---
Co	(ppm)	(6)	(6.8)	(38)
Cr	(ppm)	20.2 ± 0.5	34.3 ± 1.5	131 ± 2
Cs	(ppm)	---	(2.4)	---
Cu	(ppm)	18 ± 2	16.5 ± 1	128 ± 5
Dy	(ppm)	---	---	---
Eu	(ppm)	---	(0.54)	---
F	(ppm)	---	---	
Fe	(%)	0.87 ± 0.03	1.11 ± 0.02	---
Ga	(ppm)	---	(8.49)	---
Gd	(ppm)	---	---	---
Hf	(ppm)	---	(1.6)	---
Hg	(ppm)	0.12 ± 0.02	0.13 ± 0.03	0.14 ± 0.01
Ho	(ppm)	---	---	
K	(%)	---	---	(1.72)
La	(ppm)	---	---	---
Li	(ppm)	---	---	
Lu	(ppm)	---	---	---
Mg	(%)	---	---	---
Mn	(ppm)	40 ± 3	28 ± 2	493 ± 7
Na	(%)	---	---	---
Nd	(ppm)	---	---	---
Ni	(ppm)	15 ± 1	19.4 ± 1.0	98 ± 3
P	(ppm)	---	---	---
Pb	(ppm)	30 ± 9	12.4 ± 0.6	70 ± 4
Rb	(ppm)	---	(31)	(112)
S	(ppm)	---	(1.64)	---
Sb	(ppm)	---	(0.58)	---
Sc	(ppm)	---	(6.3)	---
Se	(ppm)	2.9 ± 0.3	2.6 ± 0.7	9.4 ± 0.5
Si	(%)	(3.2)	---	---
Sm	(ppm)	---	---	---
Sr	(ppm)	---	---	(1380)
Ta	(ppm)	---	---	---
Tb	(ppm)	---	---	---
Th	(ppm)	(3.0)	4.5 ± 0.1	(24)
Ti	(%)	(0.08)	(0.175)	---
U	(ppm)	1.4 ± 0.1	1.28 ± 0.02	11.6 ± 0.2
V	(ppm)	35 ± 3	44 ± 3	214 ± 8
Y	(ppm)	---	---	
Yb	(ppm)	---	---	---
Zn	(ppm)	37 ± 4	28 ± 2	210 ± 20
Zr	(ppm)	---	---	---

Table 18. Concentrations of elements in SRM-1633a Coal Fly Ash.

Element/Units		SRM-1633a Coal Fly Ash Certificate values (mean & std. dev.)			SRM-1633a Coal Fly Ash MURR values (mean & std. dev.)		
Al	(%)	14.3	±	1.0	14.08	±	0.02
As	(ppm)	145	±	15	145	±	3
B	(ppm)		---		39.2	±	1.0
Ba	(ppm)		(1500)		1320	±	40
Br	(ppm)		---		2.31	±	0.16
Ca	(%)	1.11	±	0.01	1.11	±	0.01
Cd	(ppm)	1.00	±	0.15	1.0	±	0.2
Ce	(ppm)		(180)		168.3	±	1.6
Cl	(ppm)		---			< 69	
Co	(ppm)		(46)		44.1	±	1.0
Cr	(ppm)	196	±	6	193	±	5
Cs	(ppm)		(11)		10.42	±	0.23
Cu	(ppm)	118	±	3		(120)	
Dy	(ppm)		---		14.6	±	0.3
Eu	(ppm)		(4)		3.58	±	0.07
Fe	(%)	9.40	±	0.01	9.38	±	0.19
Ga	(ppm)		(58)		58	±	5
Gd	(ppm)		---		16.0	±	0.2
Hf	(ppm)		(8)		7.29	±	0.22
Hg	(ppm)	0.16	±	0.01		(0.15)	
K	(%)	1.88	±	0.06	1.89	±	0.08
La	(ppm)		---		79.1	±	0.8
Lu	(ppm)		---		1.075	±	0.013
Mg	(%)	0.455	±	0.001	0.455	±	0.001
Mn	(ppm)	179	±	8	190	±	10
Mo	(ppm)		(29)		31.3	±	3.6
Na	(%)	0.17	±	0.01	0.165	±	0.004
Nd	(ppm)		---		75.7	±	2.0
Ni	(ppm)	127	±	4	130	±	27
P	(%)		---		0.183	±	0.015
Pb	(ppm)	72.4	±	0.4		(65)	
Rb	(ppm)	131	±	2	134	±	3
S	(%)		(0.18)		0.27	±	0.01
Sb	(ppm)	6.8	±	0.4	6.15	±	0.15
Sc	(ppm)		(40)		38.6	±	1.1
Se	(ppm)	10.3	±	0.6	10.3	±	0.6
Si	(%)	22.8	±	0.8	22.8	±	0.8
Sm	(ppm)		---		16.83	±	0.20
Sr	(ppm)	830	±	30	835	±	40
Ta	(ppm)		---		1.93	±	0.07
Tb	(ppm)		---		2.53	±	0.04
Th	(ppm)	24.7	±	0.3	24.0	±	0.3
Ti	(%)		(0.8)		0.823	±	0.039
U	(ppm)	10.2	±	0.1	10.3	±	0.3
V	(ppm)	297	±	6	300	±	50
W	(ppm)		---		4.6	±	0.5
Yb	(ppm)		---		7.50	±	0.13
Zn	(ppm)	220	±	10	220	±	10
Zr	(ppm)		---		340	±	30

Table 19. Concentrations of elements in SRM-1633b Coal Fly Ash.

Element/Units		SRM-1633b Coal Fly Ash Certificate values (mean & std. dev.)			SRM-1633b Coal Fly Ash MURR values (mean & std. dev.)		
Al	(%)	15.05	±	0.27	14.8	±	0.2
As	(ppm)	136.2	±	2.6	132	±	5
B	(ppm)		---			---	
Ba	(ppm)	709	±	27	683	±	47
Br	(ppm)		(2.9)			(3)	
Ca	(%)	1.51	±	0.06	1.61	±	0.06
Cd	(ppm)	0.784	±	0.006		---	
Ce	(ppm)		(190)		184	±	2.4
Cl	(ppm)		---			---	
Co	(ppm)		(50)		48.6	±	0.7
Cr	(ppm)	198.2	±	4.7	197	±	4
Cs	(ppm)		(11)		10.53	±	0.23
Cu	(ppm)	112.8	±	2.6		---	
Dy	(ppm)		(17)		15.5	±	0.3
Eu	(ppm)		(4.1)		3.93	±	0.09
Fe	(%)	7.78	±	0.23	7.71	±	0.12
Ga	(ppm)		---			---	
Gd	(ppm)		(13)			(17)	
Hf	(ppm)		(6.8)		6.76	±	0.20
Hg	(ppm)	0.141	±	0.019		---	
K	(%)	1.95	±	0.03	2.00	±	0.11
La	(ppm)		(94)		85.5	±	1.3
Lu	(ppm)		(1.2)		1.05	±	0.04
Mg	(%)	0.482	±	0.008		---	
Mn	(ppm)	131.8	±	1.7	143	±	4
Mo	(ppm)		---			---	
Na	(%)	0.201	±	0.003	0.194	±	0.036
Nd	(ppm)		(85)		82	±	7
Ni	(ppm)	120.6	±	1.8	116	±	35
P	(%)		(0.23)			---	
Pb	(ppm)	68.2	±	1.1		---	
Rb	(ppm)		(140)		138.5	±	5.9
S	(%)	0.2075	±	0.0011		---	
Sb	(ppm)		(6)		4.85	±	0.16
Sc	(ppm)		(41)		40.2	±	0.6
Se	(ppm)	10.26	±	0.17	10.2	±	0.2
Si	(%)	23.02	±	0.08		---	
Sm	(ppm)		(20)		18.6	±	0.7
Sr	(ppm)	1041	±	14	1036	±	97
Ta	(ppm)		(1.8)		1.84	±	0.09
Tb	(ppm)		(2.6)		2.73	±	0.24
Th	(ppm)	25.7	±	1.3	24.4	±	0.4
Ti	(%)	0.791	±	0.014	0.73	±	0.05
U	(ppm)	8.79	±	0.36	8.8	±	0.8
V	(ppm)	295.7	±	3.6	300	±	5
W	(ppm)		(5.6)			(4.6)	
Yb	(ppm)		(7.6)		7.43	±	0.34
Zn	(ppm)		(210)		206	±	18
Zr	(ppm)		---		270	±	37

Table 20. Concentrations of elements in SRM-1633c Coal Fly Ash.

Element/Units		SRM-1633c Coal Fly Ash Certificate values (mean & std. dev.)			SRM-1633c Coal Fly Ash MURR values (mean & std. dev.)		
Al	(%)	13.28	±	0.61	12.88	±	0.25
As	(ppm)	186.2	±	3	186.3	±	2.1
B	(ppm)		---			---	
Ba	(ppm)	1126	±	33	1077	±	34
Br	(ppm)		---			---	
Ca	(%)	1.365	±	0.040	1.358	±	0.050
Cd	(ppm)	0.758	±	0.005		---	
Ce	(ppm)		(180)		185	±	2
Cl	(ppm)		---			---	
Co	(ppm)	42.9	±	3.5	40.1	±	0.4
Cr	(ppm)	258	±	6	247	±	2.9
Cs	(ppm)	9.39	±	0.22	9.3	±	0.2
Cu	(ppm)	173.7	±	6.4		---	
Dy	(ppm)	18.70	±	0.30	19.0	±	0.3
Eu	(ppm)	4.67	±	0.07	4.6	±	0.1
Fe	(%)	10.49	±	0.39	10.44	±	0.14
Ga	(ppm)		---			---	
Gd	(ppm)		---			---	
Hf	(ppm)		(6.0)		6.16	±	0.16
Hg	(ppm)	1.005	±	0.022		---	
K	(%)	1.773	±	0.066	1.834	±	0.056
La	(ppm)	87.0	±	2.6	83.8	±	1.0
Lu	(ppm)	1.32	±	0.03	1.24	±	0.06
Mg	(%)	0.498	±	0.052		---	
Mn	(ppm)	240.2	±	3.4	259	±	5
Mo	(ppm)		---			---	
Na	(%)	0.1707	±	0.0059	0.175	±	0.006
Nd	(ppm)		(87)		90.6	±	4.6
Ni	(ppm)	132	±	10	146	±	21
P	(%)	0.192	±	0.010		---	
Pb	(ppm)	95.2	±	2.5		---	
Rb	(ppm)	117.4	±	0.5	117	±	2.8
S	(%)	0.110	±	0.019		---	
Sb	(ppm)	8.56	±	0.29	8.3	±	0.1
Sc	(ppm)	37.6	±	0.6	36.9	±	0.4
Se	(ppm)	13.9	±	0.5		---	
Si	(%)	21.30	±	0.57		---	
Sm	(ppm)		(19)		20.8	±	0.2
Sr	(ppm)	901	±	56	966	±	79
Ta	(ppm)	1.58	±	0.03	1.7	±	0.1
Tb	(ppm)	3.12	±	0.06	3.4	±	0.1
Th	(ppm)	23.0	±	0.4	21.6	±	0.3
Ti	(%)	0.724	±	0.030	0.665	±	0.029
U	(ppm)		---		9.1	±	0.6
V	(ppm)	286.2	±	7.9	279	±	9
W	(ppm)		---			---	
Yb	(ppm)		(7.7)		8.8	±	0.1
Zn	(ppm)		---		242	±	27
Zr	(ppm)		---		220	±	22

Table 21. Concentrations of elements in SRM-1635, SRM-1645 and SRM-1646.

Element/Units		SRM-1635 Subbituminous Coal Certificate values (mean & std. dev.)	SRM-1645 River Sediment Certificate values (mean & std. dev.)	SRM-1646 Estuarine Sediment Certificate values (mean & std. dev.)
Al	(%)	(0.32)	2.26 ± 0.04	6.25 ± 0.2
As	(ppm)	0.42 ± 0.15	(66)	11.6 ± 1.3
B	(ppm)	---	---	---
Ba	(ppm)	---	---	---
Ca	(%)	---	(2.9)	0.83 ± 0.03
Cd	(ppm)	0.03 ± 0.01	10.2 ± 1.5	0.36 ± 0.07
Ce	(ppm)	(3.6)	---	(80)
Co	(ppm)	(0.65)	10.1 ± 0.6	10.5 ± 1.3
Cr	(ppm)	2.5 ± 0.3	29600 ± 2800	76 ± 3
Cs	(ppm)	---	---	(3.7)
Cu	(ppm)	3.6 ± 0.3	109 ± 19	18 ± 3
Dy	(ppm)	---	---	---
Eu	(ppm)	(0.064)	---	(1.5)
Fe	(%)	0.239 ± 0.005	11.3 ± 1.2	3.35 ± 0.10
Ga	(ppm)	(1.05)	---	---
Gd	(ppm)	---	---	---
Hf	(ppm)	(0.29)	---	---
Hg	(ppm)	---	1.1 ± 0.5	0.063 ± 0.012
K	(%)	---	1.26 ± 0.05	(1.4)
La	(ppm)	---	(9)	---
Lu	(ppm)	---		---
Mg	(%)	---	0.74 ± 0.02	1.09 ± 0.08
Mn	(ppm)	21.4 ± 1.5	785 ± 97	375 ± 20
Na	(%)	(0.24)	0.54 ± 0.01	(2.0)
Nd	(ppm)	---	---	---
Ni	(ppm)	1.74 ± 0.1	45.8 ± 2.9	32 ± 3
P	(ppm)	---	510 ± 10	540 ± 50
Pb	(ppm)	1.9 ± 0.2	714 ± 28	28.2 ± 1.8
Rb	(ppm)	---	---	(87)
S	(%)	0.33 ± 0.03	(1.1)	(0.96)
Sb	(ppm)	(0.14)	(51)	(0.4)
Sc	(ppm)	(0.63)	(2)	(10.8)
Se	(ppm)	0.9 ± 0.3	(1.5)	(0.6)
Si	(%)	---	(24)	(31)
Sm	(ppm)	---	---	---
Sr	(ppm)	---	---	---
Ta	(ppm)	---	---	---
Tb	(ppm)	---	---	---
Th	(ppm)	0.62 ± 0.04	1.62 ± 0.22	(10)
Ti	(%)	(0.02)	---	(0.51)
Tl	(ppm)	---	1.44 ± 0.07	
U	(ppm)	0.024 ± 0.02	1.11 ± 0.05	---
V	(ppm)	5.2 ± 0.5	23.5 ± 6.9	94 ± 1
Y	(ppm)	---	---	---
Yb	(ppm)	---	---	---
Zn	(ppm)	4.7 ± 0.5	1720 ± 169	138 ± 6
Zr	(ppm)	---	---	---

Table 22. Concentrations of elements in SRM-2704 and SRM-2709.

Element/Units		SRM-2704 Buffalo River Sed. Certificate values (mean & std. dev.)			SRM-2709 San Joaquin Soil Certificate values (mean & std. dev.)		
Ag	(ppm)		---		0.41	±	0.03
Al	(%)	6.11	±	0.16	7.50	±	0.06
As	(ppm)	23.4	±	0.8	17.7	±	0.8
Au	(ppm)		---			(0.3)	
Ba	(ppm)	414	±	12	968	±	40
Ca	(%)	2.60	±	0.03	1.89	±	0.05
Cd	(ppm)	3.45	±	0.22	0.38	±	0.01
Ce	(ppm)		(72)			(42)	
Co	(ppm)	14.0	±	0.6	13.4	±	0.7
Cr	(ppm)	135	±	5	130	±	4
Cs	(ppm)		(6.0)			(5.3)	
Cu	(ppm)	98.6	±	5.0	34.6	±	0.7
Dy	(ppm)		(6.0)			(3.5)	
Eu	(ppm)		(1.3)			(0.9)	
Fe	(%)	4.11	±	0.10	3.50	±	0.11
Hf	(ppm)		(8.0)			(3.7)	
Hg	(ppm)	1.44	±	0.07	1.40	±	0.08
K	(%)	2.00	±	0.04	2.03	±	0.06
La	(ppm)		(29)			(23)	
Mg	(%)	1.20	±	0.02	1.51	±	0.05
Mn	(ppm)	555	±	19	538	±	17
Mo	(ppm)		---			(2)	
Na	(%)	0.547	±	0.014	1.16	±	0.03
Nd	(ppm)		---			(19)	
Ni	(ppm)	44.1	±	3.0	88	±	5
P	(%)	0.0998	±	0.0028	0.062	±	0.005
Pb	(ppm)	161	±	17	18.9	±	0.5
Rb	(ppm)		(100)			(96)	
S	(%)	0.397	±	0.004	0.890	±	0.002
Sb	(ppm)	3.79	±	0.15	7.9	±	0.6
Sc	(ppm)		(12)			(12)	
Se	(ppm)	1.12	±	0.05	1.57	±	0.08
Si	(%)	29.08	±	0.13	29.66	±	0.23
Sm	(ppm)		(6.7)			(3.8)	
Sr	(ppm)		(130)		231	±	2
Th	(ppm)		(9.2)			(11)	
Ti	(%)	0.457	±	0.018	0.342	±	0.024
U	(ppm)	3.13	±	0.13		(3)	
V	(ppm)	95	±	4	112	±	5
W	(ppm)		---			(2)	
Y	(ppm)		---			(18)	
Yb	(ppm)		(2.8)			(1.6)	
Zn	(ppm)	438	±	12	106	±	3
Zr	(ppm)		(300)			(160)	

Table 23. Concentrations of elements in SRM-2710 and SRM-2711.

Element/Units		SRM-2710 Montana Soil Highly Elevated Trace Elements Certificate values (mean & std. dev.)			SRM-2711 Montana Soil Moderately Elevated Trace Elements Certificate values (mean & std. dev.)		
Ag	(ppm)	35.3	±	1.5	4.63	±	0.39
Al	(%)	6.44	±	0.08	6.53	±	0.09
As	(ppm)	626	±	38	105	±	8
Au	(ppm)		(0.6)			(0.03)	
Ba	(ppm)	707	±	51	726	±	38
Ca	(%)	1.25	±	0.03	2.88	±	0.08
Cd	(ppm)	21.80	±	0.2	41.70	±	0.25
Ce	(ppm)		(57)			(69)	
Co	(ppm)		(10)			(10)	
Cr	(ppm)		(39)			(47)	
Cs	(ppm)		(107)			(6.1)	
Cu	(ppm)	2950	±	130	114	±	2
Dy	(ppm)		(5.4)			(5.6)	
Eu	(ppm)		(1)			(1.1)	
Fe	(%)	3.38	±	0.10	2.89	±	0.06
Ga	(ppm)		(34)			(15)	
Hf	(ppm)		(3.2)			(7.3)	
Hg	(ppm)	32.6	±	1.8	6.25	±	0.19
In	(ppm)		(5.1)			(1.1)	
K	(%)	2.11	±	0.11	2.45	±	0.08
La	(ppm)		(34)			(40)	
Mg	(%)	0.853	±	0.042	1.05	±	0.03
Mn	(ppm)	1.01	±	0.04	0.0638	±	0.0028
Mo	(ppm)		(19)			(1.6)	
Na	(%)	1.14	±	0.06	1.14	±	0.03
Nd	(ppm)		(23)			(31)	
Ni	(ppm)	14.3	±	1	20.6	±	1.1
P	(%)	0.106	±	0.015	0.086	±	0.007
Pb	(ppm)	5532	±	80	1162	±	31
Rb	(ppm)		(120)			(110)	
S	(%)	0.240	±	0.006	0.042	±	0.001
Sb	(ppm)	38	±	3	19.4	±	1.8
Sc	(ppm)		(8.7)			(9)	
Se	(ppm)		---		1.52	±	0.14
Si	(%)	28.97	±	0.18	30.44	±	0.19
Sm	(ppm)		(7.8)			(5.9)	
Sr	(ppm)		(330)		245	±	1
Th	(ppm)		(13)			(14)	
Ti	(%)	0.283	±	0.101	0.306	±	0.023
U	(ppm)		(25)			(2.6)	
V	(ppm)	76.6	±	2.3	82	±	3
W	(ppm)		(93)			(3)	
Y	(ppm)		(23)			(25)	
Yb	(ppm)		(1.3)			(2.7)	
Zn	(ppm)	6952	±	91	350	±	5
Zr	(ppm)		---			(230)	

Table 24. Concentrations of elements in USGS Rocks - AGV-1, AGV-2, BCR-1 and BCR-2.

Element/Units		AGV-1 Andesite Guano Valley (mean & std. dev.)	AGV-2 Andesite Guano Valley (mean & std. dev.)	BCR-1 Basalt Columbia River (mean & std. dev.)	BCR-2 Basalt Columbia River (mean & std. dev.)
Ag	(ppm)	0.08	---	0.027 ± 0.004	---
Al	(%)	9.08 ± 0.18	8.95 ± 0.11	7.21 ± 0.13	7.14 ± 0.10
As	(ppm)	0.88	---	0.64 ± 0.14	---
Au	(ppb)	0.62 ± 0.11	---	0.66 ± 0.18	---
B	(ppm)	7.8	---	3.1 ± 0.3	---
Ba	(ppm)	1230 ± 16	1140 ± 32	678 ± 16	683 ± 28
Ca	(%)	3.53 ± 0.10	3.72 ± 0.09	4.97 ± 0.11	5.09 ± 0.08
Cd	(ppm)	0.07	---	0.127 ± 0.008	---
Ce	(ppm)	67 ± 6	68 ± 3	53.7 ± 0.8	53 ± 2
Co	(ppm)	15 ± 1.2	16 ± 1	36.3 ± 1.6	37 ± 3
Cr	(ppm)	10 ± 3	17 ± 2	16 ± 4	18 ± 2
Cs	(ppm)	1.3 ± 0.1	1.16 ± 0.08	0.97 ± 0.13	1.1 ± 0.1
Cu	(ppm)	60 ± 6	53 ± 4	19 ± 4	19 ± 2
Dy	(ppm)	3.6 ± 0.4	3.6 ± 0.2	6.35 ± 0.12	---
Er	(ppm)	1.7	1.79 ± 0.11	3.61 ± 0.09	---
Eu	(ppm)	1.6 ± 0.1	1.54 ± 0.1	1.96 ± 0.05	2.0 ± 0.1
F	(ppm)	425 ± 50	(440)	480 ± 40	(440)
Fe	(%)	4.73 ± 0.13	4.68 ± 0.09	9.38 ± 0.22	9.65 ± 0.15
Ga	(ppm)	20 ± 3	20 ± 1	22 ± 2	23 ± 2
Gd	(ppm)	5.0 ± 0.6	4.69 ± 0.26	6.68 ± 0.13	6.8 ± 0.3
Hf	(ppm)	5.1 ± 0.4	5.08 ± 0.20	4.9 ± 0.3	4.8 ± 0.2
Hg	(ppm)	0.02	---	0.012 ± 0.007	---
Ho	(ppm)	0.73 ± 0.08	---	1.25 ± 0.14	1.33 ± 0.06
In	(ppm)	0.04	---	0.092 ± 0.005	---
K	(%)	2.42 ± 0.31	2.39 ± 0.09	1.40 ± 0.07	1.49 ± 0.04
La	(ppm)	38 ± 2	38 ± 1	25.0 ± 0.8	25 ± 1
Li	(ppm)	12 ± 2	(11)	12.9 ± 0.4	9 ± 2
Lu	(ppm)	0.27 ± 0.03	0.25 ± 0.01	0.512 ± 0.025	0.51 ± 0.02
Mg	(%)	0.92 ± 0.06	1.08 ± 0.02	2.08 ± 0.10	2.16 ± 0.03
Mn	(ppm)	710 ± 50	770 ± 20	1410 ± 90	1520 ± 60
Mo	(ppm)	2.7 ± 0.9	---	1.2 ± 0.2	248 ± 17
Na	(%)	3.16 ± 0.09	3.11 ± 0.09	2.43 ± 0.08	2.34 ± 0.08
Nb	(ppm)	15	15 ± 1	14 ± 3	---
Nd	(ppm)	33 ± 3	30 ± 2	28.7 ± 0.6	28 ± 2
Ni	(ppm)	16	19 ± 3	13 ± 4	---
P	(ppm)	2200 ± 100	2100 ± 100	1900 ± 90	1500 ± 100
Pb	(ppm)	36 ± 5	13 ± 1	13.56 ± 0.03	11 ± 2
Pr	(ppm)	7.6	8.3 ± 0.6	6.9 ± 0.6	6.8 ± 0.3
Rb	(ppm)	67 ± 1	68.6 ± 2.3	47.1 ± 0.6	48 ± 2
S	(ppm)	---	---	412 ± 13	---
Sb	(ppm)	4.3 ± 0.4	(0.6)	0.62 ± 0.10	---
Sc	(ppm)	12 ± 1	13 ± 1	32.8 ± 1.7	33 ± 2
Si	(%)	27.5 ± 0.3	27.7 ± 0.35	25.38 ± 0.24	25.3 ± 0.4
Sm	(ppm)	5.9 ± 0.4	5.7 ± 0.3	6.58 ± 0.17	6.7 ± 0.3
Sn	(ppm)	4.2	2.3 ± 0.4	2.1 ± 0.6	---
Sr	(ppm)	660 ± 9	658 ± 17	330 ± 5	346 ± 14
Ta	(ppm)	0.90 ± 0.09	0.89 ± 0.08	0.79 ± 0.09	---
Tb	(ppm)	0.70 ± 0.1	0.64 ± 0.04	1.05 ± 0.09	1.07 ± 0.04
Th	(ppm)	6.5 ± 0.5	6.1 ± 0.6	6.04 ± 0.60	6.2 ± 0.7
Ti	(%)	0.63 ± 0.03	0.63 ± 0.13	1.33 ± 0.06	1.35 ± 0.03
Tm	(ppm)	0.34	0.26 ± 0.02	0.59 ± 0.035	(0.54)
U	(ppm)	1.92 ± 0.15	1.88 ± 0.16	1.71 ± 0.16	1.69 ± 0.19
V	(ppm)	120 ± 11	120 ± 5	404 ± 40	416 ± 14
W	(ppm)	0.55	---	0.40 ± 0.09	---
Y	(ppm)	20 ± 3	20 ± 1	39 ± 7	37 ± 2
Yb	(ppm)	1.72 ± 0.2	1.6 ± 0.2	3.39 ± 0.08	3.5 ± 0.2
Zn	(ppm)	88 ± 9	86 ± 8	129 ± 1	127 ± 9
Zr	(ppm)	227 ± 18	230 ± 4	191 ± 5	188 ± 16

Table 25. Concentrations of elements in USGS Rocks - BHVO-1, BHVO-2, BIR-1 and DNC-1.

Element/Units		BHVO-1 Basalt Hawaiian (mean & std. dev.)	BHVO-2 Basalt Hawaiian (mean & std. dev.)	BIR-1 Basalt Icelandic (mean & std. dev.)	DNC-1 Dolerite (mean & std. dev.)
Ag	(ppm)	(0.057)	---	---	---
Al	(%)	7.35 ± 0.18	7.16 ± 0.08	8.21 ± 0.08	9.71 ± 0.09
As	(ppm)	(0.4)	---	(0.44)	(0.12)
Au	(ppb)	1.53 ± 0.31	---	---	---
B	(ppm)	2.5 ± 0.6	---	(0.33)	(0.9)
Ba	(ppm)	139 ± 14	130 ± 13	(7)	118 ± 11
Ca	(%)	8.18 ± 0.13	8.17 ± 0.12	9.51 ± 0.09	8.21 ± 0.05
Cd	(ppm)	(0.12)	---	---	---
Ce	(ppm)	39 ± 4	38 ± 2	1.9 ± 0.4	---
Co	(ppm)	45 ± 2	45 ± 3	52 ± 2	57 ± 2.2
Cr	(ppm)	290 ± 30	280 ± 19	370 ± 8	270 ± 8.5
Cs	(ppm)	0.13 ± 0.06	---	---	---
Cu	(ppm)	130 ± 13	127 ± 7	125 ± 4	100 ± 2.6
Dy	(ppm)	5.2 ± 0.3	5.22 ± 0.21	4 ± 1	(3)
Er	(ppm)	(2.1)	2.53 ± 0.17	---	0.59 ± 0.03
Eu	(ppm)	2.06 ± 0.08	2.07 ± 0.07	0.55 ± 0.05	---
F	(ppm)	385 ± 31	(370)	(44)	(66)
Fe	(%)	8.51 ± 0.19	8.63 ± 0.14	7.90 ± 0.08	6.97 ± 0.10
Ga	(ppm)	21 ± 2	21.7 ± 0.9	(16)	(15)
Gd	(ppm)	5.35 ± 0.46	6.3 ± 0.2	1.8 ± 0.4	(2)
Hf	(ppm)	4.1 ± 0.3	4.1 ± 0.3	0.6 ± 0.08	---
Hg	(ppm)	4.4 ± 0.2	---	---	---
Ho	(ppm)	(0.93)	1.04 ± 0.04	---	(0.62)
In	(ppm)	---	---	---	---
K	(%)	0.46 ± 0.07	0.43 ± 0.01	0.025 ± 0.002	0.194 ± 0.007
La	(ppm)	16 ± 1	15 ± 1	0.63 ± 0.07	3.6 ± 0.3
Li	(ppm)	4.6 ± 1.5	(5)	3.6 ± 0.2	5.2 ± 0.29
Lu	(ppm)	(0.32)	0.28 ± 0.01	(0.26)	---
Mg	(%)	4.28 ± 0.12	4.36 ± 0.07	5.85 ± 0.05	6.11 ± 0.07
Mn	(ppm)	1280 ± 30	1290 ± 40	1350 ± 0.002	1160 ± 23
Mo	(ppm)	0.96 ± 0.04	(2.9)	---	---
Na	(%)	1.64 ± 0.06	1.64 ± 0.06	1.35 ± 0.03	1.40 ± 0.04
Nb	(ppm)	19 ± 2	18 ± 2	(0.6)	(3)
Nd	(ppm)	25 ± 2	25.0 ± 1.8	2.5 ± 0.7	5.2 ± 0.56
Ni	(ppm)	120 ± 16	119 ± 7	170 ± 6	247 ± 12
P	(ppm)	1200 ± 100	1200 ± 100	92 ± 40	305 ± 22
Pb	(ppm)	2.6 ± 0.2	(1.5)	(3)	(6.3)
Pr	(ppm)	(5.6)	---	---	---
Rb	(ppm)	11 ± 2	9.8 ± 1.0	---	(4.5)
S	(ppm)	(100)	---	---	---
Sb	(ppm)	0.17 ± 0.01	(0.3)	(0.58)	0.96 ± 0.03
Sc	(ppm)	31.8 ± 1.3	32 ± 1	44 ± 1	31 ± 1
Si	(%)	23.2 ± 0.5	23.3 ± 0.3	22.42 ± 0.09	22.03 ± 0.1
Sm	(ppm)	6.2 ± 0.3	6.2 ± 0.4	(1.1)	---
Sn	(ppm)	(2.2)	(1.9)	---	---
Sr	(ppm)	403 ± 25	389 ± 23	110 ± 2	144 ± 1.8
Ta	(ppm)	1.08 ± 0.18	(1.4)	---	---
Tb	(ppm)	1.0 ± 0.3	(0.9)	---	---
Th	(ppm)	(1.1)	1.2 ± 0.3	---	---
Ti	(%)	1.63 ± 0.10	1.63 ± 0.02	0.575 ± 0.006	0.288 ± 0.004
Tm	(ppm)	0.30 ± 0.04	0.33 ± 0.02	---	---
U	(ppm)	0.40 ± 0.06	0.42 ± 0.06	---	---
V	(ppm)	317 ± 12	317 ± 11	310 ± 11	148 ± 8.3
W	(ppm)	(0.27)	---	---	---
Y	(ppm)	28 ± 2	26 ± 2	16 ± 1	18 ± 0.8
Yb	(ppm)	2.0 ± 0.2	2.0 ± 0.2	1.7 ± 0.1	2.0 ± 0.1
Zn	(ppm)	105 ± 5	103 ± 6	70 ± 9	70 ± 2.4
Zr	(ppm)	179 ± 21	172 ± 11	18 ± 1	38 ± 1

Table 26. Concentrations of elements in USGS Rocks - DTS-1, DTS-2B, G-1 and G-2.

Element/Units		DTS-1 Dunite Twin Sisters (mean & std. dev.)	DTS-2B Dunite Twin Sisters (mean & std. dev.)	G-1 Granite Rhode Island (mean & std. dev.)	G-2 Granite Rhode Island (mean & std. dev.)
Ag	(ppm)	0.014 ± 0.007	---	0.046 ± 0.003	0.045 ± 0.006
Al	(%)	0.17 ± 0.09	0.24 ± 0.03	7.53 ± 0.11	8.15 ± 0.12
As	(ppm)	0.034 ± 0.006	---	0.67 ± 0.13	0.27 ± 0.12
Au	(ppb)	0.88 ± 0.27	---	3.2 ± 1.0	1.0 ± 0.2
B	(ppm)	0.5 ± 0.1	---	1.7 ± 0.5	1.3 ± 0.2
Ba	(ppm)	(2.35)	(16)	1080 ± 60	1880 ± 20
Ca	(%)	0.10 ± 0.03	0.09 ± 0.01	0.986 ± 0.049	1.41 ± 0.07
Cd	(ppm)	(0.009)	---	0.061 ± 0.012	0.025 ± 0.011
Ce	(ppm)	0.067 ± 0.016	---	171 ± 23	159 ± 11
Co	(ppm)	139 ± 10	120 ± 10	2.3 ± 0.2	4.6 ± 0.4
Cr	(ppm)	3920 ± 170	15500 ± 1100	20 ± 6	9 ± 2
Cs	(ppm)	---	---	1.48 ± 0.21	1.33 ± 0.14
Cu	(ppm)	7.5 ± 2.4	(3)	12 ± 3	11 ± 3
Dy	(ppm)	(0.0034)	---	2.48 ± 0.31	2.5 ± 0.5
Er	(ppm)	(0.0039)	---	1.30 ± 0.09	1.2 ± 0.3
Eu	(ppm)	0.0011 ± 0.0003	---	1.21 ± 0.20	1.41 ± 0.12
F	(ppm)	12 ± 6	---	720 ± 30	1260 ± 90
Fe	(%)	6.08 ± 0.15	5.43 ± 0.15	1.36 ± 0.10	1.87 ± 0.07
Ga	(ppm)	(0.15)	---	19.5 ± 1.5	22 ± 2
Gd	(ppm)	---	---	4.7 ± 0.7	4.1 ± 0.8
Hf	(ppm)	---	---	5.7 ± 1.2	7.9 ± 0.7
Hg	(ppm)	0.010 ± 0.005	---	0.09 ± 0.03	0.049 ± 0.013
Ho	(ppm)	0.0013 ± 0.0010	---	0.40 ± 0.13	0.37 ± 0.02
In	(ppm)	0.0024 ± 0.0003	---	0.025 ± 0.001	0.030 ± 0.002
K	(%)	0.0008 ± 0.0001	---	4.55 ± 0.12	3.73 ± 0.12
La	(ppm)	0.029 ± 0.009	---	104 ± 15	86 ± 5
Li	(ppm)	2.1 ± 0.5	---	21.3 ± 0.6	36 ± 5
Lu	(ppm)	0.0026 ± 0.0005	---	0.143 ± 0.017	0.113 ± 0.024
Mg	(%)	29.94 ± 0.29	29.8 ± 1.1	0.235 ± 0.031	0.46 ± 0.04
Mn	(ppm)	940 ± 80	830 ± 40	215 ± 42	260 ± 40
Mo	(ppm)	0.14 ± 0.09	---	6.5 ± 0.8	1.0 ± 0.6
Na	(%)	0.013 ± 0.008	(0.02)	2.47 ± 0.08	3.02 ± 0.09
Nb	(ppm)	(0.032)	---	20.4 ± 2.0	13 ± 4
Nd	(ppm)	0.030 ± 0.004	---	57 ± 2	53 ± 8
Ni	(ppm)	2350 ± 180	3780 ± 220	---	4.9 ± 2.3
P	(ppm)	9 ± 7	---	380 ± 90	600 ± 40
Pb	(ppm)	12 ± 3	(4)	46 ± 8	31 ± 4
Pr	(ppm)	0.0063 ± 0.0004	---	17 ± 3	19 ± 2
Rb	(ppm)	0.058 ± 0.01	(2)	215 ± 2	170 ± 3
S	(ppm)	13 ± 4	---	140 ± 55	---
Sb	(ppm)	0.47 ± 0.04	(0.6)	0.32 ± 0.06	0.078 ± 0.032
Sc	(ppm)	3.5 ± 0.3	(3)	2.8 ± 0.2	3.5 ± 0.4
Si	(%)	18.90 ± 0.25	18.4 ± 0.4	33.84 ± 0.14	32.24 ± 0.28
Sm	(ppm)	0.0048 ± 0.0012	---	7.9 ± 0.7	7.2 ± 0.6
Sn	(ppm)	(0.36)	---	3.3 ± 0.6	1.6 ± 0.5
Sr	(ppm)	0.33 ± 0.06	---	249 ± 10	478 ± 3
Ta	(ppm)	---	---	1.4 ± 0.4	0.88 ± 0.12
Tb	(ppm)	0.0006 ± 0.0002	---	0.59 ± 0.16	0.48 ± 0.07
Th	(ppm)	0.010 ± 0.002	---	50 ± 6	24.6 ± 1.5
Ti	(%)	---	---	0.150 ± 0.017	0.295 ± 0.022
Tm	(ppm)	0.00140 ± 0.0004	---	0.165 ± 0.02	0.17 ± 0.07
U	(ppm)	0.0036 ± 0.0005	---	3.5 ± 0.5	2.04 ± 0.17
V	(ppm)	12 ± 6	22 ± 8	18 ± 4	36 ± 5
W	(ppm)	0.021 ± 0.007	---	0.43 ± 0.05	0.15 ± 0.06
Y	(ppm)	---	---	14 ± 4	11.4 ± 2.3
Yb	(ppm)	0.015 ± 0.011	---	0.86 ± 0.15	0.78 ± 0.14
Zn	(ppm)	48 ± 11	45 ± 5	45 ± 6	85 ± 7
Zr	(ppm)	---	---	201 ± 24	300 ± 30

Table 27. Concentrations of elements in USGS Rocks - GSP-1, GSP-2, MAG-1 and PCC-1.

Element/Units		GSP-1 Granodiorite Silver Plume (mean & std. dev.)	GSP-2 Granodiorite Silver Plume (mean & std. dev.)	MAG-1 Marine Mud (mean & std. dev.)	PCC-1 Peridotite E. Austin Creek (mean & std. dev.)
Ag	(ppm)	0.086 ± 0.014	---	(0.08)	0.008 ± 0.004
Al	(%)	8.02 ± 0.15	7.88 ± 0.11	8.68 ± 0.16	0.39 ± 0.10
As	(ppm)	---	---	(9.2)	0.057 ± 0.009
Au	(ppb)	1.3 ± 0.2	---	(2.4)	0.9 ± 0.4
B	(ppm)	0.9 ± 0.1	---	140 ± 6	1.4 ± 0.2
Ba	(ppm)	1310 ± 10	1340 ± 44	480 ± 41	(1.2)
Ca	(%)	1.46 ± 0.07	1.50 ± 0.04	0.98 ± 0.07	0.373 ± 0.044
Cd	(ppm)	0.056 ± 0.007	---	0.20 ± 0.03	0.019 ± 0.003
Ce	(ppm)	406 ± 20	410 ± 30	88 ± 9	0.10 ± 0.02
Co	(ppm)	6.5 ± 0.8	7.3 ± 0.8	20 ± 1.6	110 ± 7
Cr	(ppm)	13.0 ± 2.6	20 ± 8	97 ± 8	2730 ± 240
Cs	(ppm)	0.95 ± 0.16	1.2 ± 0.1	8.6 ± 0.7	0.0055 ± 0.0004
Cu	(ppm)	34 ± 5	43 ± 4	30 ± 3	10 ± 2
Dy	(ppm)	5.4 ± 0.4	(6.1)	5.2 ± 0.3	0.009 ± 0.002
Er	(ppm)	2.5 ± 0.4	(2.2)	(3)	(0.008)
Eu	(ppm)	2.36 ± 0.22	2.3 --- 0.1	1.6 ± 0.14	0.0018 ± 0.0008
F	(ppm)	3600 ± 300	(3000)	770 ± 80	12 ± 7
Fe	(%)	3.01 ± 0.09	3.43 ± 0.11	4.76 ± 0.42	5.78 ± 0.17
Ga	(ppm)	22 ± 3	22 ± 2	20.0 ± 1.5	0.7 ± 0.4
Gd	(ppm)	13 ± 2	12 ± 2	5.8 ± 0.7	---
Hf	(ppm)	15.0 ± 1.3	14 ± 1	3.7 ± 0.5	0.052 ± 0.035
Hg	(ppm)	0.019 ± 0.006	---	(0.02)	0.010 ± 0.005
Ho	(ppm)	1.2 ± 0.5	1.0 ± 0.1	1.0 ± 0.1	0.0023 ± 0.0013
In	(ppm)	0.051 ± 0.003	---	---	0.0037 ± 0.0004
K	(%)	4.57 ± 0.12	4.48 ± 0.12	2.95 ± 0.14	0.004 ± 0.002
La	(ppm)	183 ± 13	180 ± 12	43 ± 4	0.09 ± 0.06
Li	(ppm)	31 ± 4	36 ± 1	79 ± 4	1.6 ± 0.7
Lu	(ppm)	0.22 ± 0.05	0.23 ± 0.03	0.40 ± 0.04	0.0062 ± 0.0014
Mg	(%)	0.596 ± 0.047	0.58 ± 0.02	1.81 ± 0.06	26.07 ± 0.29
Mn	(ppm)	310 ± 40	320 ± 20	760 ± 70	920 ± 75
Mo	(ppm)	---	2.1 ± 0.6	(1.6)	---
Na	(%)	2.08 ± 0.07	2.06 ± 0.07	2.84 ± 0.08	0.020 ± 0.014
Nb	(ppm)	26 ± 4	27 ± 2	(12)	1.2 ± 0.4
Nd	(ppm)	190 ± 17	200 ± 12	38 ± 5	0.044 ± 0.01
Ni	(ppm)	9.8 ± 3.2	17 ± 2	53 ± 8	2400 ± 160
P	(ppm)	1230 ± 80	1300 ± 100	700 ± 90	8 ± 7
Pb	(ppm)	54 ± 7	42 ± 3	24 ± 3	11.5 ± 4
Pr	(ppm)	51 ± 8	51 ± 5	(7.7)	0.015 ± 0.005
Rb	(ppm)	254 ± 2	245 ± 7.0	150 ± 6	0.066 ± 0.006
S	(ppm)	350 ± 120	---	0.39 ± 0.06	20 ± 1
Sb	(ppm)	3.2 ± 0.4	---	0.96 ± 0.10	1.3 ± 0.3
Sc	(ppm)	6.1 ± 0.5	6.3 ± 0.7	17 ± 1	8.5 ± 0.8
Si	(%)	31.46 ± 0.23	31.1 ± 0.4	23.6 ± 0.4	19.56 ± 0.28
Sm	(ppm)	26.8 ± 2.5	27 ± 1	7.5 ± 0.6	0.0074 ± 0.0015
Sn	(ppm)	6.6 ± 1.4	---	(3.6)	1.3 ± 0.8
Sr	(ppm)	234 ± 3	240 ± 10	150 ± 15	0.40 ± 0.03
Ta	(ppm)	0.91 ± 0.14	---	(1.1)	---
Tb	(ppm)	1.36 ± 0.14	---	0.96 ± 0.09	0.0015 ± 0.0003
Th	(ppm)	105 ± 5	105 ± 8	12 ± 1	0.013 ± 0.004
Ti	(%)	0.393 ± 0.024	0.40 ± 0.01	0.45 ± 0.04	0.0085 ± 0.0058
Tm	(ppm)	---	(0.29)	(0.43)	0.0027 ± 0.0004
U	(ppm)	2.2 ± 0.3	2.40 ± 0.19	2.7 ± 0.3	0.0045 ± 0.0007
V	(ppm)	53 ± 7	52 ± 4	140 ± 6	30 ± 5
W	(ppm)	0.31 ± 0.13	---	(1.4)	---
Y	(ppm)	29 ± 6	28 ± 2	28 ± 3	---
Yb	(ppm)	1.7 ± 0.4	1.6 ± 0.2	2.6 ± 0.3	0.026 ± 0.005
Zn	(ppm)	103 ± 9	120 ± 10	130 ± 6	42 ± 9
Zr	(ppm)	530 ± 70	550 ± 30	130 ± 13	8 ± 4

Table 28. Concentrations of elements in USGS Rocks - QLO-1, RGM-1, RGM-2 and SCo-1.

Element/Units		QLO-1 Quartz Latite (mean & std. dev.)	RGM-1 Rhyolite Glass Mountain (mean & std. dev.)	RGM-2 Rhyolite Glass Mountain (mean & std. dev.)	SCo-1 Cody Shale (mean & std. dev.)
Ag	(ppm)	(0.0045)	(0.103)	---	(0.019)
Al	(%)	8.60 ± 0.08	7.24 ± 0.16	7.29	7.21 ± 0.20
As	(ppm)	< 5	< 5	---	< 54
Au	(ppb)	(1.3)	(0.33)	---	(2.4)
B	(ppm)	35 ± 3	28 ± 2	---	76 ± 6
Ba	(ppm)	1380 ± 40	800 ± 60	810 ± 20	530 ± 130
Ca	(%)	2.27 ± 0.06	0.81 ± 0.07	0.89	1.87 ± 0.14
Cd	(ppm)	---	(0.06)	0.28 ± 0.02	(0.15)
Ce	(ppm)	61 ± 10	53 ± 7	44 ± 2	62 ± 7
Co	(ppm)	7.1 ± 0.4	2.0 ± 0.2	1.8 ± 0.1	10 ± 1
Cr	(ppm)	(1.5)	2.6 ± 0.4	4 ± 1	67 ± 6
Cs	(ppm)	1.8 ± 0.2	10.0 ± 0.4	10.3 ± 0.2	7.5 ± 0.6
Cu	(ppm)	29 ± 3	12 ± 2	10 ± 0.8	30 ± 2
Dy	(ppm)	< 3.2	(4.3)	3.55 ± 0.06	(3.8)
Er	(ppm)	< 2.2	< 2.2	2.24 ± 0.08	(2.5)
Eu	(ppm)	1.4 ± 0.2	0.75 ± 0.14	0.60 ± 0.01	1.2 ± 0.2
F	(ppm)	(280)	(370)	325	< 1500
Fe	(%)	3.04 ± 0.07	1.32 ± 0.05	1.27	3.54 ± 0.12
Ga	(ppm)	18 ± 1	14 ± 2	15.1 ± 0.2	13 ± 3
Gd	(ppm)	< 6.0	(3.1)	3.55 ± 0.06	4.0 ± 0.2
Hf	(ppm)	4.4 ± 0.2	6.0 ± 0.5	5.7 ± 0.2	4.4 ± 0.2
Hg	(ppm)	---	---	---	---
Ho	(ppm)	< 1.0	< 1.0	0.74 ± 0.04	(0.93)
In	(ppm)	---	---	---	---
K	(%)	3.03 ± 0.16	3.64 ± 0.18	3.61	2.28 ± 0.08
La	(ppm)	(31)	(25)	22.4 ± 0.6	31 ± 3
Li	(ppm)	(24)	51 ± 9	(58)	(42)
Lu	(ppm)	(0.42)	(0.42)	0.38 ± 0.01	(0.37)
Mg	(%)	0.61 ± 0.04	0.168 ± 0.012	0.18	1.61 ± 0.14
Mn	(ppm)	720 ± 70	280 ± 20	300	420 ± 50
Mo	(ppm)	2.9 ± 0.7	2.4 ± 0.7	2.1 ± 0.4	< 2.8
Na	(%)	3.09 ± 0.10	3.00 ± 0.10	3.06	0.67 ± 0.09
Nb	(ppm)	11 ± 4	10 ± 4	8.8 ± 0.2	10 ± 3
Nd	(ppm)	31 ± 5	17 ± 2	18.8 ± 0.4	26 ± 2
Ni	(ppm)	< 9.2	< 14	2.6 ± 0.6	28 ± 4
P	(ppm)	1200 ± 200	200 ± 10	---	1000 ± 200
Pb	(ppm)	20.0 ± 0.8	(21)	20	< 30
Pr	(ppm)	(6.1)	(4.1)	---	(5.4)
Rb	(ppm)	78 ± 10	157 ± 4	140	120 ± 10
S	(ppm)	(13)	(10)	---	(0.06)
Sb	(ppm)	2.1 ± 0.4	1.3 ± 0.2	0.50 ± 0.02	2.50 ± 0.07
Sc	(ppm)	9.7 ± 1.4	5.0 ± 0.9	4.6 ± 0.4	10 ± 1
Si	(%)	30.5 ± 0.5	34.0 ± 0.6	34.3 ± 0.2	29.2 ± 0.4
Sm	(ppm)	4.8 ± 0.6	4.3 ± 0.5	3.8 ± 0.1	5.2 ± 0.4
Sn	(ppm)	(2.4)	(3.9)	---	(4.1)
Sr	(ppm)	360 ± 40	110 ± 10	105 ± 3	180 ± 20
Ta	(ppm)	0.76 ± 0.12	0.95 ± 0.10	0.90 ± 0.02	0.89 ± 0.08
Tb	(ppm)	0.84 ± 0.09	(0.74)	0.60 ± 0.01	0.75 ± 0.04
Th	(ppm)	4.1 ± 0.9	16 ± 2	14 ± 1	10.2 ± 0.8
Ti	(%)	0.37 ± 0.02	0.16 ± 0.02	0.15	0.37 ± 0.05
Tm	(ppm)	(0.39)	(0.37)	(0.36)	(0.35)
U	(ppm)	1.9 ± 0.2	(5.84)	(5.5)	(3)
V	(ppm)	60 ± 5	13 ± 2	11 ± 1	118 ± 13
W	(ppm)	(0.58)	(1.5)	---	---
Y	(ppm)	(28)	(27)	21.5 ± 0.4	(26)
Yb	(ppm)	2.8 ± 0.8	2.6 ± 0.4	2.5 ± 0.1	2.5 ± 0.4
Zn	(ppm)	59 ± 7	32 ± 7	32 ± 6	106 ± 9
Zr	(ppm)	175 ± 15	214 ± 14	220 ± 10	165 ± 23

Table 29. Concentrations of elements in USGS Rocks - SDC-1, SDO-1, SGR-1 and STM-1

Elemen	Units	SDC-1 Mica Schist Schist (mean & std. dev.)	SDO-1 Shale Devonian Ohio (mean & std. dev.)	SGR-1 Shale Green River (mean & std. dev.)	STM-1 Nepheline Syenite (mean & std. dev.)
Ag	(ppm)	(0.009)	---	< 0.1	(0.079)
Al	(%)	8.51 ± 0.20	6.49 ± 0.12	3.53 ± 0.23	9.79 ± 0.12
As	(ppm)	< 5	68.5 ± 8.6	66 ± 6	< 5
Au	(ppb)	(1.5)	---	(9.8)	(0.4)
B	(ppm)	12.2 ± 1.1	128 ± 11	55 ± 4	6.1 ± 0.8
Ba	(ppm)	620 ± 70	397 ± 38	270 ± 25	600 ± 90
Ca	(%)	1.02 ± 0.03	0.75 ± 0.03	5.82 ± 0.23	0.79 ± 0.06
Cd	(ppm)	(0.11)	---	(1.03)	(0.27)
Ce	(ppm)	104 ± 14	79.3 ± 7.8	34.4 ± 4	290 ± 50
Co	(ppm)	18 ± 2	46.8 ± 6.3	11.7 ± 2.0	< 7.5
Cr	(ppm)	69 ± 7	66.4 ± 7.6	31.2 ± 2.0	2.3 ± 0.8
Cs	(ppm)	3.84 ± 0.02	6.9 ± 1.2	5.19 ± 0.4	1.53 ± 0.10
Cu	(ppm)	30 ± 2	60.2 ± 9.6	66 ± 4	3.7 ± 1.9
Dy	(ppm)	< 3.2	6 ± 0.7	(1.8)	(7.8)
Er	(ppm)	< 2.2	3.6 ± 0.6	(1.0)	(4.4)
Eu	(ppm)	1.8 ± 0.2	1.60 ± 0.22	0.466 ± 0.110	3.6 ± 0.4
F	(ppm)	(620)	697 ± 88	---	(950)
Fe	(%)	4.91 ± 0.13	6.53 ± 0.15	2.03 ± 0.14	3.64 ± 0.14
Ga	(ppm)	25 ± 5	16.8 ± 1.8	8.8 ± 3.4	37 ± 1
Gd	(ppm)	< 9.8	---	(1.9)	(11)
Hf	(ppm)	7.9 ± 0.5	4.7 ± 0.8	1.37 ± 0.04	26.8 ± 1.7
Hg	(ppm)	---	---	---	---
Ho	(ppm)	< 1.0	1.2 ± 0.1	(0.38)	(1.7)
In	(ppm)	---	< 0.0002	---	(0.12)
K	(%)	2.72 ± 0.08	4.04 ± 0.05	1.24 ± 0.13	3.57 ± 0.06
La	(ppm)	48 ± 9	38.5 ± 4.4	18.4 ± 2.0	170 ± 30
Li	(ppm)	(34)	28.6 ± 5.5	(130)	29 ± 7
Lu	(ppm)	(0.49)	540 ± 140	(146)	(0.66)
Mg	(%)	1.00 ± 0.04	0.93 ± 0.02	2.69 ± 0.08	0.055 ± 0.010
Mn	(ppm)	890 ± 70	325 ± 38	280 ± 40	1720 ± 140
Mo	(ppm)	(1.9)	134 ± 21	(36)	5.7 ± 1.4
Na	(%)	1.52 ± 0.09	0.274 ± 0.019	2.25 ± 0.24	6.61 ± 0.14
Nb	(ppm)	18 ± 3	11.4 ± 1.2	4.5 ± 1.3	250 ± 50
Nd	(ppm)	39 ± 6	36.6 ± 3.3	13.8 ± 3.0	74 ± 13
Ni	(ppm)	42 ± 11	99.5 ± 9.9	32 ± 6	< 8
P	(ppp)	770 ± 180	480 ± 30	1400 ± 200	710 ± 20
Pb	(ppm)	(24)	27.9 ± 5.2	(37)	(17)
Pr	(ppm)	(8.7)	---	(3.7)	(19.4)
Rb	(ppm)	129 ± 8	126 ± 3.9	79 ± 7	123 ± 8
S	(ppm)	(580)	---	(17500)	(43)
Sb	(ppm)	0.49 ± 0.09	(4.5)	3.29 ± 0.40	1.69 ± 0.11
Sc	(ppm)	17 ± 2	12.9 ± 1.5	4.94 ± 0.80	0.68 ± 0.01
Si	(%)	30.5 ± 0.6	23.0 ± 0.3	13.4 ± 0.6	27.8 ± 0.4
Sm	(ppm)	8.5 ± 1.0	7.7 ± 0.8	2.6 ± 0.3	15 ± 3
Sn	(ppm)	(3)	3.7 ± 1.2	(1.6)	10 ± 3
Sr	(ppm)	200 ± 20	75 ± 11	393 ± 70	730 ± 70
Ta	(ppm)	1.1 ± 0.2	1.1 ± 0.1	(0.402)	18 ± 2
Tb	(ppm)	(1.3)	1.2 ± 0.2	0.297 ± 0.050	1.7 ± 0.4
Th	(ppm)	12 ± 1	10.5 ± 0.6	4.48 ± 0.03	33 ± 5
Ti	(%)	0.06 ± 0.03	0.425 ± 0.019	0.17 ± 0.03	0.091 ± 0.005
Tm	(ppm)	(0.72)	0.45 ± 0.08	(0.15)	(0.69)
U	(ppm)	(3)	48.8 ± 6.5	(5.31)	(9.12)
V	(ppm)	110 ± 30	160 ± 21	128 ± 9	(2)
W	(ppm)	(0.8)	---	(23)	(3.6)
Y	(ppm)	< 70	(3.3)	(10.3)	(52)
Yb	(ppm)	5.2 ± 1.6	3.4 ± 0.5	(0.966)	4.3 ± 0.3
Zn	(ppm)	102 ± 8	64 ± 7	80 ± 9	241 ± 20
Zr	(ppm)	270 ± 30	165 ± 24	45 ± 6	1260 ± 80

Table 30. Concentrations of elements in USGS Rocks - W-1, W-2, NKT-1 and TLM-1.

Element/Units		W-1 Diabase Centreville (mean & std. dev.)	W-2 Diabase Centreville (mean & std. dev.)	NKT-1 Nephelinite Knippa, TX (mean & std. dev.)	TLM-1 Tonalite Lake View Mtn (mean & std. dev.)
Ag	(ppm)	0.069 ± 0.010	(0.043)	---	< 2
Al	(%)	7.93 ± 0.14	8.18 ± 0.08	5.39 ± 0.02	2.73
As	(ppm)	2.2 ± 0.3	(1.2)	---	2.73
Au	(ppb)	4.3 ± 1.2	(1.2)	---	< 4
B	(ppm)	13 ± 4	(12)	---	---
Ba	(ppm)	162 ± 5	163 ± 11	724 ± 31	729
Ca	(%)	7.82 ± 0.12	7.76 ± 0.06	9.44 ± 0.03	4.82
Cd	(ppm)	0.17 ± 0.06	(0.104)	---	---
Ce	(ppm)	23 ± 2	22.8 ± 1.5	127 ± 4	28.2
Co	(ppm)	46 ± 4	44.7 ± 2.1	---	19.4
Cr	(ppm)	120 ± 14	92.5 ± 4.4	443 ± 9	14.3
Cs	(ppm)	0.95 ± 0.20	(0.99)	0.50 ± 0.02	2.88
Cu	(ppm)	114 ± 10	110 ± 4.9	49.2 ± 2.8	---
Dy	(ppm)	3.9 ± 0.5	3.8 ± 0.8	6.74 ± 0.24	(4.4)
Er	(ppm)	2.3 ± 0.3	(2.5)	2.64 ± 0.09	(2.6)
Eu	(ppm)	1.11 ± 0.09	1.09 ± 0.06	3.85 ± 0.16	0.992
F	(ppm)	230 ± 40	(205)	---	---
Fe	(%)	7.79 ± 0.16	7.57 ± 0.15	9.32 ± 0.035	5.22
Ga	(ppm)	17.4 ± 1.3	17 ± 1	---	---
Gd	(ppm)	3.9 ± 0.4	(3.5)	10.9 ± 0.4	(4.3)
Hf	(ppm)	2.6 ± 0.3	2.59 ± 0.18	6.52 ± 0.26	3.87
Hg	(ppm)	0.21 ± 0.07	---	---	---
Ho	(ppm)	0.81 ± 0.20	(0.76)	1.13 ± 0.05	(0.95)
In	(ppm)	0.064 ± 0.002	---	---	---
K	(%)	0.530 ± 0.034	0.52 ± 0.01	1.06 ± 0.006	1.31
La	(ppm)	10.9 ± 1.3	10.6 ± 0.6	64.2 ± 2.7	12.3
Li	(ppm)	12 ± 2	9.6 ± 0.5	17.8 ± 0.6	---
Lu	(ppb)	0.34 ± 0.04	(0.33)	0.23 ± 0.01	0.355
Mg	(%)	3.99 ± 0.08	3.84 ± 0.03	8.64 ± 0.03	---
Mn	(ppm)	1300 ± 125	1290 ± 31	---	---
Mo	(ppm)	0.75 ± 0.28	(0.6)	0.80 ± 0.04	---
Na	(%)	1.58 ± 0.08	1.33 ± 0.03	2.58 ± 0.015	2.21
Nb	(ppm)	8 ± 2	(7.9)	87.5 ± 2.5	---
Nd	(ppm)	15 ± 3	12.2 ± 1.0	61.7 ± 2.4	16.4
Ni	(ppm)	75 ± 9	70 ± 3	---	< 50
P	(ppm)	600 ± 60	610 ± 520	4220 ± 40	---
Pb	(ppm)	7.5 ± 1.5	(9.3)	3.01 ± 0.20	---
Pr	(ppm)	3.2 ± 0.4	(2.8)	15.0 ± 0.6	(3.7)
Rb	(ppm)	21.4 ± 0.3	21.2 ± 1.1	31.2 ± 0.8	62.1
S	(ppm)	160 ± 70	(79)	---	---
Sb	(ppm)	1.05 ± 0.12	(0.75)	---	(1.43)
Sc	(ppm)	35 ± 2	35.6 ± 1.1	22.4 ± 0.9	21.8
Si	(%)	24.54 ± 0.14	24.62 ± 0.14	18.08 ± 0.03	---
Sm	(ppm)	3.5 ± 0.3	3.33 ± 0.13	---	4.18
Sn	(ppm)	2.6 ± 0.5	---	---	---
Sr	(ppm)	187 ± 7	206 ± 2	1203 ± 27	307
Ta	(ppm)	0.50 ± 0.07	(0.45)	4.85 ± 0.18	0.39
Tb	(ppm)	0.65 ± 0.07	(0.605)	1.31 ± 0.05	0.711
Th	(ppm)	2.4 ± 0.4	2.12 ± 0.10	7.18 ± 0.16	3.5
Ti	(%)	0.641 ± 0.038	0.635 ± 0.06	2.37 ± 0.01	---
Tm	(ppm)	0.34 ± 0.07	(0.32)	0.31 ± 0.01	(0.37)
U	(ppm)	0.57 ± 0.07	(0.47)	2.18 ± 0.07	(1.22)
V	(ppm)	260 ± 25	260 ± 12	293 ± 8	---
W	(ppm)	0.48 ± 0.07	---	---	< 3
Y	(ppm)	26 ± 4	(22)	29.7 ± 0.7	(26)
Yb	(ppm)	2.12 ± 0.18	2.05 ± 0.20	1.78 ± 0.05	2.41
Zn	(ppm)	84 ± 6	80 ± 2	132 ± 8	---
Zr	(ppm)	100 ± 9	93 ± 2	286 ± 7	131

Table 31. Concentrations of elements in GSJ Rocks - JA-1, JA-2, JA-3, JB-2, JG-2, and JG-3.

Element	Units	JA-1 Andesite (mean)	JA-2 Andesite (mean)	JA-3 Andesite (mean)	JB-2 Basalt (mean)	JG-2 Granite (mean)	JG-3 Granodiorite (mean)
Al	(%)	8.04	8.16	8.23	7.74	6.60	8.19
As	(ppm)	2.78	0.71	---	2.87	0.68	0.37
B	(ppm)	21.0	21.1	24.8	30	1.78	2.15
Ba	(ppm)	304	308	323	218	75.0	466
Ca	(%)	4.09	4.50	4.46	7.04	0.50	2.64
Ce	(ppm)	13.15	32.86	22.8	6.55	48.3	40.3
Co	(ppm)	11.5	28.3	21.1	37.6	3.62	11.7
Cr	(ppm)	7.5	424.8	66.2	26.6	6.37	22.4
Cs	(ppm)	0.627	4.78	2.08	0.80	6.79	1.78
Cu	(ppm)	42.5	29.0	43.4	222	0.49	6.81
Dy	(ppm)	4.75	2.85	3.01	3.87	10.5	2.59
Er	(ppm)	2.959	1.676	1.57	2.54	6.04	1.52
Eu	(ppm)	1.110	0.893	0.82	0.836	0.10	0.90
F	(ppm)	161	230	---	90	972	317
Fe	(%)	4.93	4.34	4.62	9.99	0.68	2.58
Ga	(ppm)	16.7	16.8	16.3	16.6	18.6	17.1
Gd	(ppm)	4.15	3.01	2.96	3.12	8.01	2.92
Hf	(ppm)	2.51	2.84	3.42	1.49	4.73	4.29
Ho	(ppm)	1.032	0.591	0.51	0.863	1.67	0.38
K	(%)	0.66	1.50	1.17	0.35	3.91	2.19
La	(ppm)	4.88	15.4	9.33	2.28	19.9	20.6
Li	(ppm)	10.4	29.2	14.5	8.08	42.2	20.9
Lu	(ppm)	0.454	0.255	0.32	0.389	1.22	0.26
Mg	(%)	0.93	4.58	2.24	2.67	0.02	1.08
Mn	(ppm)	1195	840	8100	1650	120	550
Mo	(ppm)	1.43	0.581	1.89	1.01	0.37	0.45
Na	(%)	2.90	2.31	2.37	1.52	2.63	2.94
Nb	(ppm)	12	9.3	3.41	15	14.7	5.88
Nd	(ppm)	10.7	14.0	12.3	6.39	26.4	17.2
Ni	(ppm)	2.2	136	32.2	14.8	4.35	14.3
P	(ppm)	696	640	510	423	10	530
Pb	(ppm)	5.86	18.9	7.7	5.25	31.5	11.7
Pr	(ppm)	2.08	3.69	2.4	1.13	6.20	4.7
Rb	(ppm)	11.2	69.8	36.7	6.4	301	67.3
Sb	(ppm)	0.23	0.15	---	2.61	0.057	0.08
Sc	(ppm)	27.9	18.93	22.0	54.1	2.42	8.76
Si	(%)	30.11	26.37	29.11	24.84	35.91	31.45
Sm	(ppm)	3.40	3.03	3.05	2.27	7.78	3.39
Sn	(ppm)	0.88	1.69	---	0.635	3.00	1.4
Sr	(ppm)	259	246	287	178	17.9	379
Ta	(ppm)	0.098	0.652	0.27	0.039	2.76	0.70
Tb	(ppm)	0.727	0.478	0.52	0.586	1.62	0.46
Th	(ppm)	0.761	4.80	3.25	0.258	31.6	8.28
Ti	(ppm)	5094	4000	4200	6990	260	2900
Tm	(ppm)	0.445	0.255	---	0.393	1.16	0.24
U	(ppm)	0.34	2.18	1.18	0.15	11.3	2.21
V	(ppm)	106	120	169	572	3.78	70.1
W	(ppm)	0.49	1.15	---	0.31	23.0	14.1
Y	(ppm)	28.0	16.9	21.2	23.6	86.5	17.3
Yb	(ppm)	2.95	1.64	2.16	2.53	6.85	1.77
Zn	(ppm)	88.3	64.5	67.7	108	13.6	46.5
Zr	(ppm)	83.7	108.3	118	51.2	97.6	144

Table 32. Concentrations of elements in GSJ Rocks - JCh-1, JDo-1, JLs-1, JF-1, JGb-1, and JSy-1.

Element	Units	JCh-1 Chert (mean)	JDo-1 Dolomite (mean)	JLs-1 Limestone (mean)	JF-1 Feldspar (mean)	JGb-2 Gabbro (mean)	JSy-1 Syenite (mean)
Al	(%)	0.3884	0.0092	0.011	9.57	12.43	12.26
As	(ppm)	0.567	0.114	0.145	0.92	0.96	0.9
B	(ppm)	---	---	---	1.8	4.9	14.5
Ba	(ppm)	302	6.14	476	1750	36.5	15.7
Ca	(%)	0.0321	24.27	39.37	0.66	10.08	0.179
Cd	(ppm)	0.006	0.644	0.159	0.003	0.087	---
Ce	(ppm)	5.21	2.49	0.521	4.19	3.0	2.6
Co	(ppm)	15.5	0.168	0.0825	0.12	25.8	0.16
Cr	(ppm)	7.04	7.93	3.37	5.48	125	2.0
Cs	(ppm)	0.243	0.070	0.020	2.09	0.51	0.69
Cu	(ppm)	15.3	1.41	0.268	0.82	11.4	1.3
Dy	(ppm)	0.378	0.814	0.0283	0.39	0.6	0.37
Er	(ppm)	0.233	---	---	0.31	0.36	0.30
Eu	(ppm)	0.059	0.176	0.0072	0.87	0.59	0.16
F	(ppm)	134	246	57.5	78	na	---
Fe	(%)	0.0238	0.0145	0.0117	0.06	4.68	0.059
Ga	(ppm)	---	---	---	17.4	15.9	23.5
Gd	(ppm)	1.7	(1.3)	(0.03)	0.93	0.48	0.27
Hf	(ppm)	0.195	0.0897	0.126	1.18	0.25	1.2
Ho	(ppm)	0.112	(0.42)	---	0.11	0.15	0.094
K	(%)	0.18	0.0019	0.0025	8.29	0.05	4.00
La	(ppm)	1.52	7.93	0.153	2.80	1.5	1.2
Li	(ppm)	6.48	(0.4)	(0.2)	9.81	15.7	15.3
Lu	(ppm)	0.0344	0.0494	0.022	---	0.062	0.076
Mg	(%)	0.0455	11.14	0.365	40	3.73	0.01
Mn	(ppm)	134	51	16	10	1000	18.6
Mo	(ppm)	---	(0.78)	---	0.3	0.42	0.048
Na	(%)	0.0226	0.0096	0.0014	2.50	0.68	8.97
Nb	(ppm)	1.7	(0.4)	(1)	0.74	1.9	0.51
Nd	(ppm)	2.05	5.25	(0.136)	1.46	1.8	1.2
Ni	(ppm)	8.76	2.9	0.362	1.36	13.6	1.1
P	(ppm)	73	206	129	40	74	61
Pb	(ppm)	2.0	(0.95)	(0.7)	33.4	1.5	4.9
Pr	(ppm)	4.25	0.956	(0.032)	0.48	0.39	0.32
Rb	(ppm)	8.61	(1.75)	(0.18)	266	2.9	66.3
Sb	(ppm)	---	(0.036)	(0.0166)	0.55	0.12	0.15
Sc	(ppm)	0.979	0.136	0.0307	0.23	27	---
Si	(%)	45.71	0.06	0.10	31.17	21.72	28.05
Sm	(ppm)	0.359	(0.788)	0.135	0.41	0.51	0.27
Sn	(ppm)	---	---	---	0.3	0.48	0.17
Sr	(ppm)	4.2	116	295	172	438	19.3
Ta	(ppm)	0.182	(0.009)	(0.014)	0.079	0.29	0.013
Tb	(ppm)	0.0385	0.116	(0.0041)	0.076	0.15	0.057
Th	(ppm)	0.735	0.0429	0.0287	1.17	0.19	0.23
Ti	(ppm)	189	8.0	12.0	30	3480	9
Tm	(ppm)	---	(0.059)	---	0.04	0.059	0.053
U	(ppm)	0.736	0.858	1.75	0.33	0.041	0.20
V	(ppm)	10.4	3.14	3.59	5.43	174	2.1
W	(ppm)	92.3	---	---	0.8	1.6	0.06
Y	(ppm)	1.81	10.3	0.223	2.84	4.5	2.6
Yb	(ppm)	0.182	0.323	0.0164	0.35	0.39	0.41
Zn	(ppm)	7.93	35.4	3.19	4.41	48.5	3.2
Zr	(ppm)	11.5	6.21	(4.19)	38.6	11.6	70.2

Table 33. Concentrations of elements in GSJ, Chinese Rocks, and Mediterranean obsidian sources including - JR-1, JR-2, JR-3, GBW7113, Mt. Arci, and Pantelleria.

Element	Units	JR-1 Rhyolite (mean)	JR-2 Rhyolite (mean)	JR-3 Rhyolite (mean)	GBW7113 Rhyolite (mean)	ARC Obsidian (mean)	PAN Obsidian (mean)
Al	(%)	6.79	6.73	6.29	6.86	6.90	4.04
As	(ppm)	16.3	19.2	0.6	0.66	10.3	7.19
B	(ppm)	117	145	---	3.5	---	---
Ba	(ppm)	50.3	39.5	65.8	506	174	29
Ca	(%)	0.48	0.357	0.066	0.42	0.499	0.205
Ce	(ppm)	47.2	38.8	327	163	49.9	440
Co	(ppm)	0.83	0.46	0.98	2.4	3.89	0.17
Cr	(ppm)	2.83	3.1	3.5	7.3	---	---
Cs	(ppm)	20.8	25.0	1.0	3.34	4.15	2.51
Cu	(ppm)	2.68	1.36	2.9	10.9	21.7	9.6
Dy	(ppm)	5.69	6.63	---	8.19	6.4	33.6
Er	(ppm)	3.61	4.36	---	4.31	---	---
Eu	(ppm)	0.30	0.14	0.53	1.18	0.39	4.1
F	(ppm)	991	1109	---	1300	---	---
Fe	(%)	0.62	0.54	3.16	2.14	1.41	6.09
Ga	(ppm)	16.1	17.9	36.6	20.5	23.5	35.4
Gd	(ppm)	5.06	5.83	---	9.47	6.18	31.2
Hf	(ppm)	4.51	5.14	40.3	10.8	3.97	46.2
Ho	(ppm)	1.11	1.39	---	1.64	---	---
K	(%)	3.66	3.69	3.56	4.51	4.30	3.46
La	(ppm)	19.7	16.3	179	82.7	21.3	230
Li	(ppm)	61.4	79.2	---	12.8	---	---
Lu	(ppm)	0.71	0.88	2.8	0.67	0.38	2.4
Mg	(%)	0.07	0.02	0.03	0.096	0.07	0.02
Mn	(ppm)	770	870	640	1084	487	2300
Mo	(ppm)	3.25	3.35	0.49	2.46	30.4	13.6
Na	(%)	2.98	2.96	3.48	1.91	2.6	5.05
Nb	(ppm)	15.2	18.7	510	34.3	47.4	367
Nd	(ppm)	23.3	20.4	107	64.5	23.5	181.8
Ni	(ppm)	1.67	1.2	---	64.5	---	---
P	(ppm)	90	50	---	---	---	---
Pb	(ppm)	19.3	21.5	32.8	33.3	---	---
Pr	(ppm)	5.58	4.75	33.1	18.4	---	---
Rb	(ppm)	257	303	453	213	248	196
Sb	(ppm)	1.19	1.51	---	0.38	1.7	0.8
Sc	(ppm)	5.07	5.59	0.5	5.15	4.05	0.66
Si	(%)	35.27	36.73	34.01	34.02	34.2	32.3
Sm	(ppm)	6.03	5.63	21.3	11.7	5.9	33.0
Sn	(ppm)	2.86	3.51	17.4	3.35	3.8	13.5
Sr	(ppm)	29.1	8.11	10.4	43	43	5
Ta	(ppm)	1.86	2.29	36.8	2.41	4.8	23.6
Tb	(ppm)	1.01	1.10	4.29	1.51	1.09	5.46
Th	(ppm)	26.7	31.4	112	27.1	16.6	35
Ti	(ppm)	660	400	1260	1800	620	1440
Tm	(ppm)	0.67	0.74	---	0.73	---	---
U	(ppm)	8.88	10.9	21.1	4.83	5.6	10.6
V	(ppm)	7.0	3.0	4.2	3.8	---	---
W	(ppm)	1.59	---	---	1.1	---	---
Y	(ppm)	45.1	51.1	166	42.5	32.9	170
Yb	(ppm)	4.55	5.33	20.3	4.51	2.8	16.8
Zn	(ppm)	30.6	27.8	209	86.3	521	453
Zr	(ppm)	99.9	96.3	1494	403	103	2010

Table 34. Element-to-oxide and oxide-to-element conversion factors.

Element-to-oxide			Multiplier	Oxide-to-element			Multiplier
Ag	→	Ag_2O	1.0742	Ag_2O	→	Ag	0.9309
Al	→	Al_2O_3	1.8895	Al_2O_3	→	Al	0.5292
As	→	As_2O_3	1.3203	As_2O_3	→	As	0.7574
Au	→	Au_2O_3	1.1218	Au_2O_3	→	Au	0.8914
B	→	B_2O_3	3.2120	B_2O_3	→	B	0.3113
Ba	→	BaO	1.1165	BaO	→	Ba	0.8957
Be	→	BeO	2.7754	BeO	→	Be	0.3603
Bi	→	Bi_2O_3	1.1148	Bi_2O_3	→	Bi	0.8970
C	→	CO_2	3.6642	CO_2	→	C	0.2729
Ca	→	CaO	1.3992	CaO	→	Ca	0.7147
Ca	→	$CaCO_3$	2.4972	$CaCO_3$	→	Ca	0.4004
Cd	→	CdO	1.1423	CdO	→	Cd	0.8754
Ce	→	CeO_2	1.2284	CeO_2	→	Ce	0.8141
Co	→	CoO	1.2715	CoO	→	Co	0.7865
Cr	→	Cr_2O_3	1.4616	Cr_2O_3	→	Cr	0.6842
Cs	→	Cs_2O	1.0602	Cs_2O	→	Cs	0.9432
Cu	→	CuO	1.2518	CuO	→	Cu	0.7988
Dy	→	Dy_2O_3	1.1477	Dy_2O_3	→	Dy	0.8713
Er	→	Er_2O_3	1.1435	Er_2O_3	→	Er	0.8745
Eu	→	Eu_2O_3	1.1579	Eu_2O_3	→	Eu	0.8636
Fe	→	FeO	1.2865	FeO	→	Fe	0.7773
Fe	→	Fe_2O_3	1.4298	Fe_2O_3	→	Fe	0.6994
FeO	→	Fe_2O_3	1.1114	Fe_2O_3	→	FeO	0.8998
Ga	→	Ga_2O_3	1.3442	Ga_2O_3	→	Ga	0.7439
Gd	→	Gd_2O_3	1.1526	Gd_2O_3	→	Gd	0.8676
Ge	→	GeO_2	1.4398	GeO_2	→	Ge	0.6945
H	→	H_2O	8.9373	H_2O	→	H	0.1119
Hf	→	HfO_2	1.1793	HfO_2	→	Hf	0.8480
Ho	→	Ho_2O_3	1.1455	Ho_2O_3	→	Ho	0.8730
In	→	In_2O	1.0697	In_2O	→	In	0.9348
Ir	→	IrO_2	1.1665	IrO_2	→	Ir	0.8573
K	→	K_2O	1.2046	K_2O	→	K	0.8302
La	→	La_2O_3	1.1728	La_2O_3	→	La	0.8527
Li	→	Li_2O	2.1526	Li_2O	→	Li	0.4646
Lu	→	Lu_2O_3	1.1372	Lu_2O_3	→	Lu	0.8794
Mg	→	MgO	1.6583	MgO	→	Mg	0.6030
Mn	→	MnO	1.2912	MnO	→	Mn	0.7745
Mo	→	MoO_3	1.5003	MoO_3	→	Mo	0.6665
Na	→	Na_2O	1.3480	Na_2O	→	Na	0.7418
Nb	→	NbO_2	1.3444	NbO_2	→	Nb	0.7438

Table 34. Element-to-oxide and oxide-to-element conversion factors.

Element-to-oxide			Multiplier	Oxide-to-element			Multiplier
Nd	→	Nd_2O_3	1.1664	Nd_2O_3	→	Nd	0.8573
Ni	→	NiO	1.2726	NiO	→	Ni	0.7858
P	→	P_2O_5	2.2914	P_2O_5	→	P	0.4364
Pb	→	PbO	1.0772	PbO	→	Pb	0.9283
Pd	→	PdO	1.1504	PdO	→	Pd	0.8693
Pr	→	Pr_2O_3	1.1703	Pr_2O_3	→	Pr	0.8545
Pt	→	PtO_2	1.1640	PtO_2	→	Pt	0.8591
Rb	→	Rb_2O	1.0936	Rb_2O	→	Rb	0.9144
Re	→	ReO_2	1.1747	ReO_2	→	Re	0.8513
Rh	→	Rh_2O_3	1.2332	Rh_2O_3	→	Rh	0.8109
Ru	→	Ru_2O_3	1.2375	Ru_2O_3	→	Ru	0.8181
S	→	SO_3	2.4970	SO_3	→	S	0.4005
Si	→	SiO_2	2.1394	SiO_2	→	Si	0.4674
Sb	→	Sb_2O_3	1.1971	Sb_2O_3	→	Sb	0.8354
Sc	→	Sc_2O_3	1.5339	Sc_2O_3	→	Sc	0.6519
Se	→	SeO_2	1.4053	SeO_2	→	Se	0.7116
Sm	→	Sm_2O_3	1.1596	Sm_2O_3	→	Sm	0.8624
Sn	→	SnO_2	1.2696	SnO_2	→	Sn	0.7876
Sr	→	SrO	1.1826	SrO	→	Sr	0.8456
Ta	→	Ta_2O_5	1.2211	Ta_2O_5	→	Ta	0.8189
Tb	→	Tb_2O_3	1.1510	Tb_2O_3	→	Tb	0.8688
Th	→	ThO_2	1.1379	ThO_2	→	Th	0.8788
Ti	→	TiO_2	1.6685	TiO_2	→	Ti	0.5993
Tm	→	Tm_2O_3	1.1421	Tm_2O_3	→	Tm	0.8756
U	→	UO_2	1.1344	UO_2	→	U	0.8815
V	→	V_2O_5	1.7852	V_2O_5	→	V	0.5602
W	→	WO_2	1.1741	WO_2	→	W	0.8517
Y	→	Y_2O_3	1.2700	Y_2O_3	→	Y	0.7874
Yb	→	Yb_2O_3	1.1387	Yb_2O_3	→	Yb	0.8782
Zn	→	ZnO	1.2446	ZnO	→	Zn	0.8085
Zr	→	ZrO_2	1.3508	ZrO_2	→	Zr	0.7403

Table 35. Concentrations of major oxides in USGS and NIST rocks in weight (%).

Oxide	AGV-1	AGV-2	BCR-1	BCR-2	BIR-1
Al_2O_3	17.11	17.03	13.56	13.48	15.51
CaO	4.89	5.15	6.98	7.11	13.29
Fe_2O_3 total	6.76	6.78	13.43	13.77	11.40
K_2O	2.94	2.90	1.73	1.77	0.03
MgO	1.51	1.80	3.47	3.60	9.69
MnO	0.097	0.100	0.184	0.197	0.173
Na_2O	4.25	4.20	3.33	3.12	1.83
P_2O_5	0.493	0.483	0.365	0.359	0.030
SiO_2	59.38	59.14	54.53	54.00	47.79
TiO_2	1.05	1.05	2.24	2.27	0.96
Trace element sum	0.34	---	0.32	---	0.14
L.O.I. (calc)	1.59	---	1.67	---	0.74
Total	100.35	100.00	101.34	100.00	101.06

Oxide	BHVO-1	BHVO-2	DTS-1	DTS-2b	DNC-1
Al_2O_3	13.69	13.44	0.20	0.45	18.30
CaO	11.40	11.40	0.17	0.12	11.27
Fe_2O_3 total	12.32	12.39	8.68	7.76	9.93
K_2O	0.53	0.51	0.00	---	0.23
MgO	7.21	7.26	49.50	49.40	10.05
MnO	0.169	0.169	0.116	---	0.149
Na_2O	2.31	2.22	0.01	---	1.87
P_2O_5	0.277	0.269	0.001	---	0.085
SiO_2	49.79	49.60	40.40	39.40	47.04
TiO_2	2.74	2.73	---	---	0.48
Trace element sum	0.26	---	0.66	---	0.18
L.O.I. (calc)	-0.71	---	-0.28	---	0.60
Total	100.08	100.00	99.77	100.00	100.18

Oxide	G-1	G-2	GSP-1	GSP-2	MAG-1
Al_2O_3	14.23	15.31	15.16	14.90	16.37
CaO	1.38	1.91	2.04	2.10	1.37
Fe_2O_3 total	1.94	2.64	4.30	4.90	6.80
K_2O	5.48	4.50	5.51	5.38	3.55
MgO	0.39	0.75	0.99	0.96	3.00
MnO	0.028	0.031	0.040	---	0.098
Na_2O	3.33	4.05	2.80	2.78	3.83
P_2O_5	0.087	0.129	0.280	0.290	0.163
SiO_2	72.46	68.74	67.37	66.60	50.36
TiO_2	0.25	0.48	0.66	0.66	0.75
Trace element sum	0.34	0.48	0.81	0.93	3.90
L.O.I. (calc)	0.35	0.53	0.46	0.50	10.14
Total	100.27	99.82	100.41	100.00	100.33

Table 35. Concentrations of major oxides in USGS and NIST rocks in weight (%) [continued].

Oxide	PCC-1	QLO-1	RGM-1	RGM-2	SCo-1
Al_2O_3	0.74	16.18	13.83	13.96	13.67
CaO	0.52	3.17	1.18	1.21	2.62
Fe_2O_3 total	8.26	4.35	1.87	1.89	5.14
K_2O	0.01	3.60	4.29	4.20	2.77
MgO	43.23	1.00	0.28	0.29	2.72
MnO	0.119	0.093	0.039	0.039	0.053
Na_2O	0.03	4.20	4.09	3.89	0.90
P_2O_5	0.002	0.254	0.049	0.04	0.206
SiO_2	41.88	65.55	73.12	73.38	62.78
TiO_2	0.01	0.62	0.27	0.26	0.63
Trace element sum	0.55	0.30	0.26	0.30	0.32
L.O.I. (calc)	4.72	0.23	0.57	0.60	8.34
Total	100.02	99.55	100.01	99.85	100.15

Oxide	SDC-1	SDO-1	SGR-1	STM-1	W-1
Al_2O_3	15.75	12.27	6.52	18.39	14.99
CaO	1.40	1.05	8.38	1.09	10.94
Fe_2O_3 total	6.90	9.34	3.03	5.22	11.14
K_2O	3.28	3.35	1.66	4.28	0.64
MgO	1.69	1.54	4.44	0.10	6.62
MnO	0.114	0.042	0.034	0.220	0.168
Na_2O	2.05	0.38	2.99	8.94	2.13
P_2O_5	0.158	0.110	0.328	0.158	0.140
SiO_2	65.85	49.28	28.24	59.64	52.55
TiO_2	1.01	0.71	0.26	0.14	1.07
Trace element sum	0.33	5.55	1.90	0.53	0.20
L.O.I. (calc)	1.57	21.70	31.04	1.48	-0.23
Total	100.10	105.32	88.82	100.18	100.36

Oxide	W-2	SRM-278	SRM-679	SRM-688	SRM-2704
Al_2O_3	15.38	14.15	20.80	17.36	11.54
CaO	10.91	0.98	0.23	12.17	3.64
Fe_2O_3 total	10.80	2.04	12.94	10.35	5.88
K_2O	0.62	4.16	2.93	0.19	2.41
MgO	6.43	0.23	1.25	8.40	1.99
MnO	0.166	0.052	0.223	0.167	0.072
Na_2O	2.20	4.84	0.17	2.15	0.74
P_2O_5	0.136	0.036	0.170	0.134	0.229
SiO_2	52.57	73.05	52.07	48.40	62.21
TiO_2	1.06	0.25	0.96	1.17	0.76
Trace element sum	0.18	0.32	0.12	0.19	0.62
L.O.I. (calc)	0.59	0.33	8.00	---	12.28
Total	100.66	100.44	99.70	100.02	102.37

Table 36. Concentrations of major oxides in GSJ and Chinese rocks in weight (%).

Oxide	JA-1	JA-2	JB-2	JG-2	JG-3
Al_2O_3	15.19	15.41	14.62	12.47	15.48
CaO	5.72	6.29	9.85	0.70	3.69
Fe_2O_3 total	7.05	6.21	14.28	0.97	3.69
K_2O	0.78	1.81	0.42	4.71	2.64
MgO	1.54	7.60	4.43	0.04	1.79
MnO	0.154	0.108	0.213	0.016	0.071
Na_2O	3.91	3.11	2.05	3.54	3.96
P_2O_5	0.159	0.146	0.097	0.002	0.122
SiO_2	64.43	56.42	53.14	76.83	67.29
TiO_2	0.85	0.66	1.17	0.04	0.48
Trace element sum	---	---	---	---	---
L.O.I. (calc)	---	2.37	---	---	---
Total	99.31	100.13	100.55	99.32	99.21

Oxide	JGb-2	JDo-1	JLs-1	JCh-1	JF-1
Al_2O_3	23.48	0.02	0.02	0.73	18.08
CaO	14.10	33.96	55.09	0.04	0.93
Fe_2O_3 total	6.69	0.02	0.02	0.36	0.08
K_2O	0.06	---	---	0.22	9.99
MgO	6.18	18.470	0.606	0.075	0.006
MnO	0.130	0.007	0.002	0.017	0.001
Na_2O	0.92	0.01	---	0.03	3.37
P_2O_5	0.017	0.034	0.030	0.017	0.010
SiO_2	46.47	0.22	0.12	97.81	66.69
TiO_2	0.56	---	---	0.03	0.01
CO_2	---	46.50	43.58	0.03	---
Trace element sum	---	---	---	---	---
L.O.I. (calc)	---	---	---	---	---
Total	98.61	99.24	99.47	99.39	99.16

Oxide	JR-1	JR-2	JR-3	JSy-1	GBW07113
Al_2O_3	12.83	12.82	12.10	23.17	12.96
CaO	0.67	0.45	0.09	0.25	0.59
Fe_2O_3 total	0.89	0.86	4.75	0.08	3.24
K_2O	4.41	4.45	4.33	4.82	5.43
MgO	0.12	0.05	0.05	0.016	0.16
MnO	0.099	0.110	0.085	0.002	0.14
Na_2O	4.02	4.03	4.68	10.74	2.57
P_2O_5	0.021	0.010	0.009	0.014	0.045
SiO_2	75.45	75.65	72.76	60.02	72.78
TiO_2	0.11	0.090	0.210	0.00	0.30
Trace element sum	---	---	---	---	---
L.O.I. (calc)	---	---	---	---	---
Total	98.62	98.52	99.06	99.12	98.22

Table 37. Concentrations of elements in well-known shale and granite composites.

Element	Units	North American Shale Composite (NASC)	Post-Archaen Australian Shale (PAAS)	Marine Shale Group: Black Shale (MSG:BSC)	Upper Crust (UC)	Average Singo Granite (SINGO)
Al	(%)	8.94	10.0	8.21	8.04	7.05
As	(ppm)	28.4	---	29	1.50	---
Au	(ppm)	---	---	0.02	---	---
Ba	(ppm)	636	650	1120	550	552
Br	(ppm)	0.69	---	4.0	---	---
Ca	(%)	2.59	0.93	1.71	3.00	0.78
Ce	(ppm)	66.7	80	80	64	101
Co	(ppm)	25.7	23	17.0	10.0	5.81
Cr	(ppm)	125	110	111	35.0	27.7
Cs	(ppm)	5.16	15	9.0	3.7	7.09
Cu	(ppm)	---	50	---	25	---
Dy	(ppm)	---	4.40	4.85	---	---
Eu	(ppm)	1.18	1.10	1.27	0.88	1.30
Fe	(%)	3.94	5.05	3.68	3.50	1.82
Ga	(ppm)	---	20	22	---	---
Gd	(ppm)	---	4.70	---	3.80	8.56
Hf	(ppm)	6.30	5.00	4.30	5.80	5.45
In	(ppm)	---	---	0.21	---	---
K	(%)	3.30	3.07	2.99	2.82	4.04
La	(ppm)	31.1	38.0	44.0	30.0	56.5
Lu	(ppm)	0.46	0.43	0.47	0.32	0.90
Mg	(%)	1.72	1.33	1.04	1.33	0.36
Mn	(ppm)	465	850	383	620	620
Na	(%)	0.85	0.89	0.53	2.89	2.63
Nb	(ppm)	13	19	---	25	20
Nd	(ppm)	27.4	32.0	55.0	26.0	39.6
Ni	(ppm)	58	55	---	20	11
P	(ppm)	570	700	---	---	570
Rb	(ppm)	125	160	131	112	348
Sb	(ppm)	2.09	---	5.7	0.20	0.30
Sc	(ppm)	14.9	16.0	15.6	11.0	8.37
Si	(%)	30.29	29.4	---	30.9	33.96
Sm	(ppm)	5.59	5.60	6.20	4.50	7.43
Sr	(ppm)	142	200	310	350	103
Ta	(ppm)	1.12	---	0.90	2.2	1.87
Tb	(ppm)	0.85	0.77	0.95	0.64	1.44
Th	(ppm)	12.3	14.6	11.6	10.7	28.8
Ti	(%)	0.42	0.60	0.43	0.30	0.25
Tm	(ppm)	---	0.40	---	0.33	0.56
U	(ppm)	2.66	3.10	15.2	2.80	11.8
V	(ppm)	130	150	500	60	28
W	(ppm)	2.1	2.7	3.3	---	---
Yb	(ppm)	35	27	---	22	57
Yb	(ppm)	3.06	2.80	3.10	2.20	5.70
Zn	(ppm)	---	85.0	310	71.0	40.2
Zr	(ppm)	200	210	230	190	159

Table 38. Chondritic (primordial) abundances used for normalizing REE concentrations.

Atomic Number		Element	Chondrite Normalizing Values in ppm (a)	(b)	(c)	(d)	(e)
39	Y	Yttrium	--	1.96 ± .09	--	--	2.12
57	La	Lanthanum	0.315	0.330 ± .013	0.34	0.329	0.319
58	Ce	Cerium	0.813	0.880 ± .010	0.87	0.865	0.82
59	Pr	Prasedymium	--	0.112 ± .003	0.12	--	0.121
60	Nd	Neodymium	0.597	0.600 ± .010	0.64	0.63	0.015
61	Pm	Promethium	--	--	--	--	--
62	Sm	Samarium	0.192	0.181 ± .006	0.195	0.203	0.2
63	Eu	Europium	0.072	0.069 ± .001	0.073	0.077	0.076
64	Gd	Gadolinium	0.259	0.249 ± .011	0.26	0.276	0.267
65	Tb	Terbium	--	0.047 ± .001	0.047	--	0.049
66	Dy	Dypsrosium	0.325	--	0.3	0.343	0.33
67	Ho	Holium	--	0.070 ± .001	0.078	--	0.076
68	Er	Erbium	0.213	0.200 ± .005	0.2	0.225	0.216
69	Tm	Thulium	--	0.030 ± .002	0.032	--	0.033
70	Yb	Ytterbium	0.208	0.200 ± .007	0.22	0.22	0.221
71	Lu	Lutetium	0.032	0.034 ± .002	0.034	0.034	0.033

Column:
(a) Values for Leedy Chondrites by Masuda et al. (1973) divided by 1.20
(b) Values for a composite of nine chondrites from Haskin et al. (1968)
(c) Values from J.C. Laul (1979)
(d) Values from Nakamura (1974)
(e) Values from Anders & Grevesse (1989) multiplied by 1.3596

Table 39. Concentrations of elements in Old Ohio Red, New Ohio Red, and Ohio Gold clays.

Element	Units	Old Ohio Red Clay MURR values (n = 9)	New Ohio Red Clay MURR values (n = 275)	Ohio Gold Clay MURR values (n = 5)
Al	(%)	8.89 ± 0.15	9.49 ± 0.28	16.30 ± 0.11
As	(ppm)	13 ± 0.4	14.8 ± 1.1	12.4 ± 1.3
Ba	(ppm)	614 ± 26	611 ± 34	367 ± 17
Ca	(%)	0.38 ± 0.04	0.14 ± 0.02	0.08 ± 0.03
Ce	(ppm)	106.1 ± 1.9	112.3 ± 2.9	109.0 ± 3.0
Co	(ppm)	20.2 ± 0.3	22.6 ± 0.7	4.8 ± 0.1
Cr	(ppm)	89 ± 2	90 ± 2	177 ± 4
Cs	(ppm)	10.3 ± 0.2	10.1 ± 0.2	9.9 ± 0.1
Dy	(ppm)	6.03 ± 0.12	7.02 ± 0.25	6.71 ± 0.12
Eu	(ppm)	1.54 ± 0.03	1.72 ± 0.05	1.13 ± 0.03
Fe	(%)	5.19 ± 0.08	5.05 ± 0.18	0.99 ± 0.02
Hf	(ppm)	7.11 ± 0.40	7.34 ± 0.23	11.9 ± 0.2
K	(%)	3.31 ± 0.03	3.45 ± 0.12	1.29 ± 0.05
La	(ppm)	48.0 ± 0.5	50.1 ± 1.1	61.6 ± 0.8
Lu	(ppm)	0.55 ± 0.03	0.59 ± 0.02	0.80 ± 0.03
Mn	(ppm)	252 ± 8	263 ± 11	30 ± 1
Na	(ppm)	1290 ± 20	1380 ± 40	881 ± 9
Nd	(ppm)	40 ± 2	47 ± 8	39 ± 2
Ni	(ppm)	78 ± 21	75 ± 19	18 ± 24
Rb	(ppm)	176 ± 3	181 ± 6	100 ± 3
Sb	(ppm)	1.34 ± 0.08	1.11 ± 0.06	1.47 ± 0.04
Sc	(ppm)	17.8 ± 0.3	18.3 ± 0.6	25.3 ± 0.5
Sm	(ppm)	7.99 ± 0.30	9.25 ± 0.47	6.90 ± 0.10
Sr	(ppm)	50 ± 14	60 ± 23	586 ± 29
Ta	(ppm)	1.48 ± 0.06	1.48 ± 0.05	3.56 ± 0.07
Tb	(ppm)	1.02 ± 0.06	1.24 ± 0.31	1.00 ± 0.03
Th	(ppm)	14.4 ± 0.3	14.9 ± 0.4	32.5 ± 0.7
Ti	(%)	0.57 ± 0.02	0.62 ± 0.03	1.36 ± 0.06
U	(ppm)	2.98 ± 0.24	3.30 ± 0.40	8.20 ± 0.40
V	(ppm)	198 ± 3	203 ± 6	192 ± 6
Yb	(ppm)	3.94 ± 0.12	4.31 ± 0.21	5.10 ± 0.14
Zn	(ppm)	97 ± 16	94 ± 13	56 ± 3
Zr	(ppm)	166 ± 10	181 ± 22	300 ± 14

Table 40. Concentrations of elements in Talc Free, Terracotta, and Pikermi clays.

Element	Units	Talc Free Clay MURR values (n = 5)	Terracotta Clay MURR values (n = 5)	Pikermi Clay MURR values (n = 14)
Al	(%)	11.9 ± 0.2	9.9 ± 0.2	7.7 ± 0.1
As	(ppm)	2.8 ± 0.5	9.9 ± 0.7	31.7 ± 1.4
Ba	(ppm)	375 ± 11	577 ± 11	199 ± 52
Ca	(%)	0.23 ± 0.05	0.24 ± 0.02	10.85 ± 0.22
Ce	(ppm)	84.5 ± 1.1	109.9 ± 3.4	68.3 ± 1.6
Co	(ppm)	4.1 ± 0.1	17.7 ± 0.5	23.9 ± 0.7
Cr	(ppm)	103 ± 2	90 ± 2	156 ± 3
Cs	(ppm)	8.03 ± 0.05	8.81 ± 0.17	6.18 ± 0.09
Dy	(ppm)	4.95 ± 0.22	6.47 ± 0.28	5.41 ± 0.36
Eu	(ppm)	1.10 ± 0.02	1.55 ± 0.04	1.50 ± 0.04
Fe	(%)	1.04 ± 0.02	4.46 ± 0.12	4.83 ± 0.08
Hf	(ppm)	9.46 ± 0.10	7.78 ± 0.21	4.67 ± 0.12
K	(%)	1.27 ± 0.10	3.09 ± 0.04	1.59 ± 0.11
La	(ppm)	47.4 ± 0.8	51.7 ± 0.9	38.9 ± 0.9
Lu	(ppm)	0.50 ± 0.02	0.58 ± 0.01	0.45 ± 0.03
Mn	(ppm)	57 ± 2	225 ± 3	869 ± 65
Na	(%)	0.57 ± 0.01	0.13 ± 0.01	0.55 ± 0.12
Nd	(ppm)	33.6 ± 2.5	44.1 ± 2.1	34.6 ± 3.4
Ni	(ppm)	7 ± 16	65 ± 16	121 ± 29
Rb	(ppm)	69 ± 1	152 ± 4	96 ± 4
Sb	(ppm)	0.90 ± 0.02	1.24 ± 0.04	1.68 ± 0.06
Sc	(ppm)	14.9 ± 0.2	17.7 ± 0.4	17.9 ± 0.4
Sm	(ppm)	6.05 ± 0.10	8.58 ± 0.12	7.04 ± 0.17
Sr	(ppm)	141 ± 8	71 ± 17	77 ± 40
Ta	(ppm)	2.10 ± 0.02	1.82 ± 0.04	1.11 ± 0.03
Tb	(ppm)	0.80 ± 0.03	1.09 ± 0.06	0.96 ± 0.07
Th	(ppm)	14.4 ± 0.2	15.5 ± 0.3	10.3 ± 0.2
Ti	(%)	0.85 ± 0.04	0.81 ± 0.04	0.47 ± 0.09
U	(ppm)	4.78 ± 0.17	3.32 ± 0.25	2.63 ± 0.29
V	(ppm)	132 ± 4	196 ± 4	126 ± 7
Yb	(ppm)	3.81 ± 0.26	4.48 ± 0.33	3.19 ± 0.17
Zn	(ppm)	47 ± 6	87 ± 6	112 ± 10
Zr	(ppm)	241 ± 8	195 ± 14	131 ± 21

Table 41. Concentrations of elements in Lefkandi Brick Clay.

Element	Units	R.E. Jones (private comm.)	MURR values (n = 10)	Kuleff & Pernicka (2002) (n = 3)
Al	(%)	---	9.21 ± 0.21	---
As	(ppm)	---	26.3 ± 8.8	26.6 ± 1.2
Ba	(ppm)	546 ± 33	557 ± 45	509 ± 34
Ca	(%)	---	3.53 ± 0.17	---
Ce	(ppm)	71 ± 2	76.5 ± 2.9	75.2 ± 2.2
Co	(ppm)	22.8 ± 0.2	19.8 ± 0.4	18.5 ± 0.5
Cr	(ppm)	160 ± 30	150 ± 6	149 ± 3
Cs	(ppm)	---	7.50 ± 0.22	8.0 ± 0.2
Dy	(ppm)	---	5.28 ± 0.22	---
Eu	(ppm)	1.24 ± 0.24	1.40 ± 0.02	1.40 ± 0.03
Fe	(%)	4.34 ± 0.28	4.43 ± 0.09	4.37 ± 0.09
Hf	(ppm)	4.8 ± 0.7	5.54 ± 0.23	5.1 ± 0.1
K	(%)	2.44 ± 0.23	2.73 ± 0.17	2.68 ± 0.17
La	(ppm)	38.7 ± 5.1	37.4 ± 0.8	37.2 ± 1.2
Lu	(ppm)	---	0.43 ± 0.02	0.40 ± 0.02
Mn	(ppm)	---	954 ± 25	---
Na	(%)	1.06 ± 0.11	1.09 ± 0.02	1.16 ± 0.06
Nd	(ppm)	43 ± 6	34 ± 3	40 ± 8
Ni	(ppm)	---	91 ± 12	---
Rb	(ppm)	120 ± 18	132 ± 4	116 ± 3
Sb	(ppm)	---	2.17 ± 0.07	2.42 ± 0.23
Sc	(ppm)	16.1 ± 1.1	17.7 ± 0.4	19.2 ± 0.4
Sm	(ppm)	6.6 ± 0.4	6.82 ± 0.21	6.9 ± 0.2
Sr	(ppm)	---	72 ± 34	---
Ta	(ppm)	---	1.07 ± 0.04	1.18 ± 0.03
Tb	(ppm)	---	0.93 ± 0.11	0.87 ± 0.06
Th	(ppm)	13.8 ± 1.1	12.2 ± 0.4	12.3 ± 0.4
Ti	(%)	---	0.50 ± 0.08	---
U	(ppm)	---	2.31 ± 0.31	2.4 ± 0.2
V	(ppm)	---	116 ± 9	---
Yb	(ppm)	2.4 ± 0.8	3.11 ± 0.12	3.1 ± 0.10
Zn	(ppm)	99 ± 11	109 ± 6	---
Zr	(ppm)	182 ± 5	143 ± 17	223 ± 31

Table 42. Concentrations of elements in SARM-69 Ceramic standard.

Element	Units	SARM-69 Certificate	MURR values (n = 10)
Al	(%)	7.62 ± 0.105	7.45 ± 0.18
As	(ppm)	---	4.10 ± 0.71
Ba	(ppm)	518 ± 19	507 ± 31
Ca	(%)	1.69 ± 0.03	1.70 ± 0.11
Ce	(ppm)	67 ± 3	66.9 ± 1.9
Co	(ppm)	28.0 ± 1.0	26.5 ± 0.4
Cr	(ppm)	223 ± 8	216 ± 5
Cs	(ppm)	---	2.86 ± 0.11
Dy	(ppm)	---	4.90 ± 0.30
Eu	(ppm)	---	1.30 ± 0.03
Fe	(%)	5.02 ± 0.06	4.94 ± 0.53
Hf	(ppm)	---	8.39 ± 0.31
K	(%)	1.63 ± 0.03	1.54 ± 0.17
La	(ppm)	---	29.5 ± 0.4
Lu	(ppm)	---	0.41 ± 0.01
Mn	(ppm)	999 ± 15	1061 ± 37
Na	(%)	0.59 ± 0.02	0.56 ± 0.02
Nb	(ppm)	(9)	---
Nd	(ppm)	30 ± 3	28 ± 1
Ni	(ppm)	53 ± 2	41 ± 31
Pb	(ppm)	(14)	---
Rb	(ppm)	66 ± 4	68 ± 2
Sb	(ppm)	---	0.44 ± 0.06
Sc	(ppm)	20 ± 19	19.5 ± 0.5
Sm	(ppm)	±	6.07 ± 0.14
Sr	(ppm)	109 ± 30	67 ± 48
Ta	(ppm)	---	0.64 ± 0.03
Tb	(ppm)	---	1.02 ± 0.30
Th	(ppm)	9 ± 1	8.76 ± 0.29
Ti	(%)	0.47 ± 0.05	0.52 ± 0.75
U	(ppm)	---	2.14 ± 0.23
V	(ppm)	157 ± 10	160 ± 6
Y	(ppm)	(29)	---
Yb	(ppm)	---	2.88 ± 0.10
Zn	(ppm)	68 ± 3	74 ± 5
Zr	(ppm)	271 ± 50	195 ± 60

Table 43. Concentrations of elements in the British Museum's Standard pottery with conversion factors to MURR.

Element	Units	Hughes (2007) publication	MURR values (n = 17)	Conversion Factors BM-to-MURR
Al	(%)	---	9.94 ± 0.18	**1.000**
As	(ppm)	12.0 ± 0.5	10.1 ± 1.8	**0.834**
Ba	(ppm)	580 ± 18	598 ± 22	**1.031**
Ca	(%)	---	0.201 ± 0.037	**1.000**
Ce	(ppm)	106.2 ± 3.7	107.3 ± 3.9	**1.011**
Co	(ppm)	9.37 ± 0.21	9.24 ± 0.17	**0.986**
Cr	(ppm)	145 ± 3	130 ± 3	**0.900**
Cs	(ppm)	35.4 ± 0.9	33.8 ± 0.7	**0.955**
Dy	(ppm)	---	8.35 ± 0.23	**1.000**
Eu	(ppm)	1.92 ± 0.04	1.73 ± 0.04	**0.900**
Fe	(%)	4.34 ± 0.10	4.29 ± 0.08	**0.986**
Hf	(ppm)	9.54 ± 0.22	9.23 ± 0.23	**0.967**
K	(%)	2.17 ± 0.08	2.12 ± 0.10	**1.000**
La	(ppm)	50.5 ± 0.9	52.2 ± 1.0	**0.979**
Lu	(ppm)	0.729 ± 0.021	0.666 ± 0.023	**0.914**
Mn	(ppm)	---	152 ± 3	**1.000**
Na	(%)	0.101 ± 0.003	0.091 ± 0.002	**0.898**
Nd	(ppm)	---	45.9 ± 4.2	**1.000**
Ni	(ppm)	---	47 ± 27	**1.000**
Rb	(ppm)	161 ± 6	143 ± 4	**0.880**
Sb	(ppm)	1.65 ± 0.10	1.35 ± 0.06	**0.820**
Sc	(ppm)	18.7 ± 0.4	18.5 ± 0.3	**0.988**
Sm	(ppm)	8.92 ± 0.36	8.47 ± 0.24	**0.950**
Sr	(ppm)	---	101 ± 20	**1.000**
Ta	(ppm)	1.71 ± 0.09	1.76 ± 0.07	**1.032**
Tb	(ppm)	1.40 ± 0.04	1.40 ± 0.30	**1.000**
Th	(ppm)	17.7 ± 0.4	15.7 ± 0.3	**0.889**
Ti	(%)	---	0.74 ± 0.03	**1.000**
U	(ppm)	3.78 ± 0.25	4.69 ± 0.40	**1.240**
V	(ppm)	---	152 ± 2	**1.000**
Yb	(ppm)	4.52 ± 0.10	4.72 ± 0.23	**1.045**
Zn	(ppm)	---	76 ± 4	**1.000**
Zr	(ppm)	---	241 ± 30	**1.000**

Table 44. Concentrations of elements in the Perlman-Asaro Standard pottery used at the Lawrence Berkeley National Laboratory (LBNL) with conversion factors to MURR

Element	Units	Perlman & Asaro (1969) publication	MURR values (n = 37)	Conversion Factors PA Std-to-MURR
Al	(%)	15.9 ± 0.2	15.7 ± 0.2	**0.987**
As	(ppm)	30.8 ± 2.2	30.0 ± 0.6	**0.974**
Ba	(ppm)	712 ± 32	711 ± 6	**0.999**
Ca	(%)	0.28 ± 0.05	0.30 ± 0.03	**1.071**
Ce	(ppm)	80.3 ± 3.9	79.3 ± 1.7	**0.988**
Co	(ppm)	14.1 ± 0.2	13.9 ± 0.2	**0.989**
Cr*	(ppm)	115 ± 4	111 ± 3	**0.963**
Cs	(ppm)	8.31 ± 0.55	8.27 ± 0.21	**0.995**
Dy	(ppm)	4.79 ± 0.19	4.56 ± 0.14	**0.952**
Eu*	(ppm)	1.29 ± 0.03	1.28 ± 0.01	**0.992**
Fe	(%)	1.02 ± 0.01	1.01 ± 0.02	**0.990**
Hf	(ppm)	6.23 ± 0.44	6.12 ± 0.18	**0.982**
K	(%)	1.45 ± 0.04	1.39 ± 0.07	**0.959**
La	(ppm)	44.9 ± 0.5	45.1 ± 0.8	**1.004**
Lu*	(ppm)	0.43 ± 0.04	0.46 ± 0.04	**1.069**
Mn	(ppm)	40.9 ± 0.5	43 ± 2	**1.050**
Na	(%)	0.258 ± 0.004	0.25 ± 0.01	**0.969**
Nd	(ppm)	---	34.9 ± 1.3	**1.000**
Ni	(ppm)	279 ± 20	229 ± 33	**0.821**
Rb	(ppm)	70 ± 6	65 ± 3	**0.929**
Sb	(ppm)	1.71 ± 0.05	1.63 ± 0.07	**0.953**
Sc	(ppm)	20.6 ± 0.3	19.5 ± 0.5	**0.949**
Sm	(ppm)	5.78 ± 0.12	6.46 ± 0.13	**1.118**
Sr	(ppm)	145 ± 22	123 ± 22	**0.848**
Ta	(ppm)	1.55 ± 0.04	1.67 ± 0.05	**1.077**
Tb	(ppm)	---	0.72 ± 0.07	**1.000**
Th	(ppm)	14.0 ± 0.4	13.4 ± 0.3	**0.960**
Ti	(%)	0.78 ± 0.03	0.91 ± 0.08	**1.164**
U	(ppm)	4.82 ± 0.14	5.18 ± 0.15	**1.075**
V	(ppm)	---	152 ± 5	**1.000**
Yb	(ppm)	2.80 ± 0.38	2.81 ± 0.15	**1.004**
Zn	(ppm)	59 ± 8	64 ± 44	**1.080**
Zr	(ppm)	---	175 ± 16	**1.000**

* Other Perlman-Asaro data

Table 45. Concentrations of elements in the old Ohio Red Clay used at the Brookhaven National Laboratory (BNL) with conversion factors to MURR.

Element	Units	Harbottle (1987) private communication	MURR values (n = 240)	Conversion Factors Ohio Red-to-MURR
Al	(%)	---	9.19 ± 0.18	**1.000**
As	(ppm)	---	13.3 ± 1.1	**1.000**
Ba	(ppm)	703	617 ± 30	**0.878**
Ca	(%)	---	0.41 ± 0.04	**1.000**
Ce	(ppm)	110.7	106.4 ± 3.4	**0.961**
Co	(ppm)	19.9	20.1 ± 0.5	**1.010**
Cr	(ppm)	91.0	90.8 ± 2.3	**0.998**
Cs	(ppm)	10.2	10.3 ± 0.2	**1.010**
Dy	(ppm)	---	6.33 ± 0.21	**1.000**
Eu	(ppm)	1.76	1.54 ± 0.05	**0.875**
Fe	(%)	5.31	5.15 ± 0.13	**0.970**
Hf	(ppm)	6.3	7.41 ± 0.24	**1.176**
K	(%)	3.41	3.47 ± 0.11	**1.018**
La	(ppm)	---	48.2 ± 1.3	**1.000**
Lu	(ppm)	0.77	0.56 ± 0.22	**0.721**
Mn	(ppm)	248	258 ± 11	**1.040**
Na	(%)	0.137	0.129 ± 0.003	**0.942**
Nd	(ppm)	---	41.7 ± 3.6	**1.000**
Ni	(ppm)	---	66 ± 15	**1.000**
Rb	(ppm)	175	177 ± 5	**1.011**
Sb	(ppm)	1.24	1.20 ± 0.06	**0.968**
Sc	(ppm)	20.0	17.8 ± 0.4	**0.890**
Sm	(ppm)	8.30	8.28 ± 0.37	**0.998**
Sr	(ppm)	---	56 ± 16	**1.000**
Ta	(ppm)	1.79	1.45 ± 0.05	**0.810**
Tb	(ppm)	---	1.07 ± 0.24	**1.000**
Th	(ppm)	15.5	14.5 ± 0.3	**0.935**
Ti	(%)	---	0.60 ± 0.03	**1.000**
U	(ppm)	2.98	3.08 ± 0.34	**1.034**
V	(ppm)	---	201 ± 5	**1.000**
Yb	(ppm)	4.31	4.08 ± 0.21	**0.947**
Zn	(ppm)	96.4	98 ± 10	**1.017**
Zr	(ppm)	---	179 ± 22	**1.000**

Table 46. Concentrations of elements in copper-based SRMs from NIST

Element	Units	SRM-37e Sheet Brass	SRM-124c Ounce Metal	SRM-158a Silicon Bronze	SRM-400 Unalloyed Copper	SRM-1252c Phosphorized Copper IX
Ag	(ppm)	---	---	22	181 ± 4	167 ± 10
Al	(ppm)	---	---	4600	---	---
As	(ppm)	---	---	---	140 ± 13	115 ± 2
Au	(ppm)	---	---	---	(10)	34.9 ± 1.4
Bi	(ppm)	---	---	---	24.5	21 ± 2
Co	(ppm)	---	---	2.8	0.6	90 ± 4
Cr	(ppm)	---	---	---	---	7.4 ± 2.0
Cu	(%)	69.61	84.22	90.93	99.7	99.89 ± 0.13
Fe	(ppm)	40	1070	12300	41 ± 2	(35)
Mn	(ppm)	---	---	11100	---	---
Ni	(ppm)	5300	6000	10	603 ± 3	128 ± 1
P	(ppm)	---	240	260	---	---
Pb	(%)	1.0	4.74	970 ppm	128 ppm	60 ppm
S	(ppm)	---	480	---	---	---
Sb	(ppm)	---	2000	8	102 ± 4	42 ± 1
Se	(ppm)	---	---	---	201 ± 10	53.6 ± 8
Si	(ppm)	---	20	30300	---	---
Sn	(%)	1.0	5.13	0.96	160 ppm	110 ppm
Te	(ppm)	---	---	---	153 ± 2	51 ± 3
Zn	(%)	27.85	4.93	2.08	114 ppm	60 ppm

Table 47. Concentrations of elements in copper standards for XRF calibration: BCR-691 series

Element	Units	BCR-691A Quaternary Bronze	BCR-691B Modern Brass	BCR-691C Arsenic-Copper	BCR-691D Lead-Bronze Copper	BCR-691E Tin-Bronze Copper IX
Cu	%	78.726	82.651	94.968	80.267	92.445
Zn	%	6.020	14.800	0.055	0.148	1.157
As	%	0.194	0.099	4.600	0.285	0.194
Sn	%	7.160	2.060	0.202	10.100	7.000
Pb	%	7.900	0.390	0.175	9.200	0.204

Table 48. Concentrations of elements in copper standards for XRF: Brammer Standards

Element	Units	BS-314A Copper Alloy	BS-360A Copper Alloy	BS-510A Copper Alloy	BS-544A Copper Alloy	BS-674A Copper Alloy
Cu	%	89.75	61.42	95.1	88.4	58.5
Zn	%	8.7	35.63	0.21	3.42	39.1
As	%	< 0.003	0.002	0.0008	0.011	0.003
Sn	%	0.0019	0.13	4.6	4.42	0.8
Pb	%	1.47	2.51	0.016	4.16	0.074
Fe	%	0.019	0.151	0.005	0.092	1.12
Ni	%	0.009	0.058	0.02	0.16	0.019

Table 49. Concentrations of elements in copper standards for XRF: Metal Standards Company

Element	Units	BS-932A Copper Alloy	CD 706 Hussey Copper Ltd	M 400 Thyssen Krupp
Cu	%	82.9	87.89	32.08
Zn	%	3.35	0.03	< 0.01
As	%	0.014	---	---
Sn	%	6.26	---	---
Pb	%	7.09	0.013	0.001
Fe	%	0.068	1.44	1.6
Ni	%	0.12	10	64.7

Table 50. Concentrations of elements in precious metals for XRF calibration:

European Reference Materials, Canadian Gold Bullion & Fluxana

Element	Units	EB-506 Rose Gold	EB-507 Yellow Gold	EB-508 White Gold	8079 BRM4 Foil	Fluxana 0738-16 16 mm
Au	%	58.56 ± 0.06	75.10 ± 0.11	75.12 ± 0.11	79.96	58.58
Ag	%	3.90 ± 0.05	3.02 ± 0.05	24.9 ± 0.05	15.09	19.8
Cu	%	35.65 ± 0.06	14.69 ± 0.05	---	5.00	21.1
Ni	%	---	4.99 ± 0.04	---	---	---
Zn	%	1.891 ± 0.018	2.107 ± 0.016	---	---	5.2

Table 51. Concentrations of elements in glass reference materials: Brill Glass.

Element	Units	Glass A	Glass B	Glass C	Glass D
Al	(%)	0.529	2.307	0.460	2.805
Ba	(%)	0.502	0.107	10.211	0.457
Ca	(%)	3.595	6.118	3.624	10.578
Co	(%)	0.134	0.036	0.142	0.018
Cu	(%)	0.935	2.125	0.903	0.304
Fe	(%)	0.981	0.306	0.306	0.468
K	(%)	2.383	0.830	2.358	9.381
Mg	(%)	1.604	0.621	1.664	2.376
Mn	(%)	0.775	0.194	---	0.426
Na	(%)	10.608	12.611	0.794	0.890
Ni	(%)	---	0.078	---	---
P	(%)	0.057	0.358	0.061	1.715
Pb	(%)	0.111	0.566	34.069	0.446
Sb	(%)	1.317	0.346	0.023	0.730
Sn	(%)	0.150	0.032	0.150	0.079
Sr	(%)	0.085	0.016	0.245	0.048
Ti	(%)	0.473	0.053	0.473	0.228
V	(%)	---	0.020	---	---
Zn	(%)	0.036	0.154	0.042	0.081

These data are from:
Brill (1999). Chemical Analyses of Early Glass, Volume 1: Catalogue of Samples.

Table 52. Concentrations of elements in glass reference materials: NIST and MURR.

Element	Units	SRM-612	SRM-610	Glass Buttes Obsidian	Pachuca Obsidian
Al	(%)	1.12	1.08	7.09	6.51
As	(ppm)	37.3	317	0.9	3.1
B	(ppm)	(32)	350	---	---
Ba	(ppm)	37.7	424	1270	16.6
Be	(ppm)	39.8	421	---	---
Ca	(%)	8.53	8.18	0.68	0.12
Ce	(ppm)	38.4	448	48.4	92.0
Co	(ppm)	35.3	405	---	---
Cr	(ppm)	39.9	405	---	---
Cs	(ppm)	41.6	361	3.4	3.9
Cu	(ppm)	36.7	430	---	---
Dy	(ppm)	36.0	427	3.6	15.8
Er	(ppm)	37.4	426	2.0	12.0
Eu	(ppm)	34.4	461	0.6	1.6
Fe	(ppm)	56.3	457	6840	15800
Gd	(ppm)	37.0	420	3.5	11.6
Hf	(ppm)	34.8	418	3.7	27.0
Ho	(ppm)	37.9	449	0.6	3.7
In	(ppm)	42.9	441	---	---
K	(ppm)	66.3	486	34300	34600
La	(ppm)	35.8	457	25.8	38.6
Li	(ppm)	41.5	457	33.1	63.0
Lu	(ppm)	37.7	435	---	1.9
Mg	(ppm)	77.4	465	501	286
Mn	(ppm)	38.4	433	327	1149
Mo	(ppm)	38.3	377	---	---
Na	(%)	10.37	9.91	2.84	3.80
Nb	(ppm)	38.1	419	9.1	116.0
Nd	(ppm)	35.2	431	18.7	33.0
Ni	(ppm)	38.4	444	---	---
P	(ppm)	55.2	343	244	196
Pb	(ppm)	39.0	413	17.0	35.0
Pr	(ppm)	37.2	430	4.5	10.5
Rb	(ppm)	31.6	431	95.0	192.0
Sb	(ppm)	38.4	369	---	---
Si	(%)	33.58	32.68	35.60	35.20
Sm	(ppm)	36.7	451	3.7	9.9
Sn	(ppm)	38.0	396	---	---
Sr	(ppm)	76.2	497	52.0	1.9
Tb	(ppm)	35.9	443	0.6	2.3
Th	(ppm)	37.2	451	8.5	17.9
Ti	(ppm)	48.1	434	595	1050
Tm	(ppm)	37.6	420	0.3	1.8
U	(ppm)	37.2	457	4.1	6.9
V	(ppm)	39.2	442	1.4	4.4
Y	(ppm)	38.3	450	18.0	111.0
Yb	(ppm)	40.0	462	2.8	12.3
Zn	(ppm)	37.9	440	26.5	191.0
Zr	(ppm)	36.0	440	83	1058

Table 53. Reference materials for lead isotope studies.

Standard	Pb 206/204	Pb 207/204	Pb 208/204
	National Institute of Standards and Technology		
SRM-981	16.9416 ± 0.0011	15.4999 ± 0.0011	36.7258 ± 0.0160
SRM-982	36.7384 ± 0.0072	17.1590 ± 0.0030	36.7443 ± 0.0077
	US Geological Survey		
AGV-2	18.8640 ± 0.0070	15.6090 ± 0.0060	38.5110 ± 0.0200
BCR-2	18.7500 ± 0.0110	15.6150 ± 0.0030	38.6910 ± 0.0210
BHVO-2	18.6490 ± 0.0190	15.5400 ± 0.0150	38.2490 ± 0.0220
G-2	18.4019 ± 0.0209	15.6353 ± 0.0025	38.9001 ± 0.0190
RGM-2	18.9550 ± 0.0170	15.6180 ± 0.0020	38.6600 ± 0.0080
W-2	18.7497 ± 0.0045	15.6623 ± 0.0030	38.6321 ± 0.0089
	Geological Society of Japan		
JA-1	18.3020 ± 0.0009	15.5340 ± 0.0010	38.2374 ± 0.0034
JA-2	18.3898 ± 0.0009	15.5927 ± 0.0009	38.6202 ± 0.0030
JA-3	18.3171 ± 0.0008	15.5539 ± 0.0009	38.3736 ± 0.0028
JB-1a	18.3713 ± 0.0009	15.5504 ± 0.0009	38.6601 ± 0.0030
JB-2	18.3315 ± 0.0025	15.5460 ± 0.0021	38.2240 ± 0.0055
JB-3	18.2839 ± 0.0011	15.2280 ± 0.0011	38.1996 ± 0.0034
JR-1	18.3493 ± 0.0009	15.5490 ± 0.0009	38.3662 ± 0.0028
JR-2	18.3454 ± 0.0008	15.5482 ± 0.0009	38.3605 ± 0.0028
JG-1a	18.6057 ± 0.0008	15.6102 ± 0.0008	38.6874 ± 0.0028
JG-2	18.6050 ± 0.0007	15.6345 ± 0.0008	38.9829 ± 0.0024
JG-3	18.3530 ± 0.0009	15.5640 ± 0.0010	38.4469 ± 0.0030

Table 54. Reference materials for strontium isotope studies.

Standard	Sr 87/86
BCR-2	0.704997 ± 0.000042
BHVO-2	0.703468 ± 0.000012
G-2	0.709775 ± 0.000008
RGM-2	0.704230 ± 0.000020
W-2	0.706977 ± 0.000017

NOTES