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CHIME AGES FOR GRANULITES FROM THE NAPIER COMPLEX, EAST ANTARCTICA

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Abstract: Th-U-bearing minerals (monazite, zircon, xenotime and polycrase) in five granulite samples from Mt Riiser-Larsen (MA88022102), Beaver Island (2023B), Reference Peak (2306E and 2306J) and Mt Cronus (2275) in the western Napier Complex of East Antarctica were dated by CHIME on the basis of electron microprobe ThO_2, UO_2 and PbO analyses Rocks from these localities, including some of the studied samples, are characterized by sapphirine-quartz-, orthopyroxene-sillimanite- and osumilite-bearing mineral assemblages, indicating ultra-high-temperature granulite-facies metamorphism A few grains of monazite in Sample MA88022102 and of zircon in Sample 2275 are chronologically heterogeneous, but other analyzed grains of monazite and zircon in these samples and all analyzed grains in the other samples, including xenotime, are almost homogeneous The core of a Mt Cronus zircon grain gives the oldest CHIME age, 3646±136 Ma, which could be a minimum age for protolith formation The homogeneous minerals, together with the older domains of Mt Riiser-Larsen zoned monazite and some grains of Mt Cronus zircon, give well-defined isochrons yielding consistent ages of 2404 Ma to 2441 Ma (within ±54Ma) on the ThO_2*-PbO or UO_2*-PbO plots Data points from zircon in Sample 2306J and from polycrase in Sample 2275 yield no isochron Given the petrographic characteristics of the samples and the high Pb-retentivity of the Th-U-bearing minerals, we interpret the 2404-2441 Ma CHIME ages to date the ultra-high-temperature granulite-facies metamorphism The 2404-2441 Ma ages lie in the 2400-2500 Ma range of ages reported from numerous localities in the Napier Complex In the absence of decisive evidence for inherited older grains and of significant retrograde features in the analyzed samples, we consider that the Napier ultra-high-temperature metamorphism occurred not ~2800 Ma ago as interpreted by most investigators, but 2400-2500 Ma ago

key words: CHIME dating, 2500 Ma event, ultra-high-temperature metamorphism, Napier Complex, Antarctica

1. Introduction

The Napier Complex in East Antarctica is characterized by the widespread occurrence of granulite-facies mineral assemblages such as sapphirine-quartz, orthopyroxene-sillimanite-quartz and osumilite (SHERATON *et al.*, 1987), which have been considered to

be products of ultra-high-temperature metamorphism (1000°C and 11 kb, HARLEY and HENSEN, 1990). Ion microprobe (SHRIMP) zircon dating for tonalitic to granitic orthogneisses, a charnockite and paragneisses from this complex gave *ca.* 3800, 2980, 2840 and 2480 Ma, and suggests the formation of protolith around 3800 and 2980 Ma (HARLEY and BLACK, 1997). However, there are two different views on the timing of the ultra-high-temperature metamorphism: about 2800 Ma (BLACK *et al.*, 1983a, 1986; SHERATON and BLACK, 1983; MCCULLOCH and BLACK, 1984; SHERATON *et al.*, 1987, HARLEY and BLACK, 1997) and about 2500 Ma (GREW and MANTON, 1979; DEPAOLO *et al.*, 1982; GREW *et al.*, 1982; OSANAI *et al.*, 1995; OWADA *et al.*, 1996; SHIRAISHI *et al.*, 1997; GREW, 1998).

Dating of highly Pb-retaining metamorphic minerals provide reliable geochronologic information about high-grade metamorphic events (*e.g.* PARRISH, 1990; SUZUKI *et al.*, 1994). The chemical Th-U-total Pb isochron method (CHIME) is an excellent way for such dating (*e.g.* SUZUKI and ADACHI, 1991a). Recently CHIME applied to Antarctic rocks gave a new perspective of the timing of their granulite-facies metamorphism and protolith formation (ASAMI *et al.*, 1996, 1997). In order to date the ultra-high-temperature metamorphism of the Napier Complex, we measured the CHIME ages of monazite, zircon and xenotime. This paper presents a brief description of these results, a listing of the analytical data, and preliminary interpretation.

2. Locality and Description of Analyzed Samples

Five granulite samples from four localities in the Napier Complex were selected for analysis: one from Mt. Riiser-Larsen, one from Beaver Island, two from Reference Peak and one from Mt. Cronus (Fig. 1, Tables 1, 2).

2.1. Sample MA88022102, Mt. Riiser-Larsen

Basement rocks at Mt. Riiser-Larsen are made up mainly of felsic gneiss with subordinate pyroxene granulite, pelitic gneiss, quartzite, magnetite-rich rock and pyroxenite, among which the pelitic gneiss contains characteristic mineral assemblages such as sapphirine-sillimanite-orthopyroxene-quartz-mesoperthite, sapphirine-sillimanite-garnet-quartz-mesoperthite, osumilite-sillimanite-orthopyroxene-quartz and osumilite-sapphirine-garnet-quartz (MOTOYOSHI and MATSUEDA, 1984; MAKIMOTO *et al.*, 1989). Sample MA88022102 was collected from a pyroxene granulite layer several meters thick interlayered with felsic gneiss. This layer consists of a dark-gray, medium-grained, quartzofeldspathic granulite.

This sample is a orthopyroxene quartzofeldspathic granulite with granoblastic texture. Mesoperthite is abundant and quartz is subordinate in amount. Orthopyroxene is the only essential mafic constituent and shows marked pleochroism Monazite occurs as anhedral discrete grains, 0.1–0.5 mm in size, which are in contact with quartz, mesoperthite, orthopyroxene and ore (Fig. 2A, B). Zircon forms subhedral rounded grains or rounded stubby prisms up to 0.4 mm long, and occurs in mesoperthite and quartz and at their grain boundaries (Fig 2B).

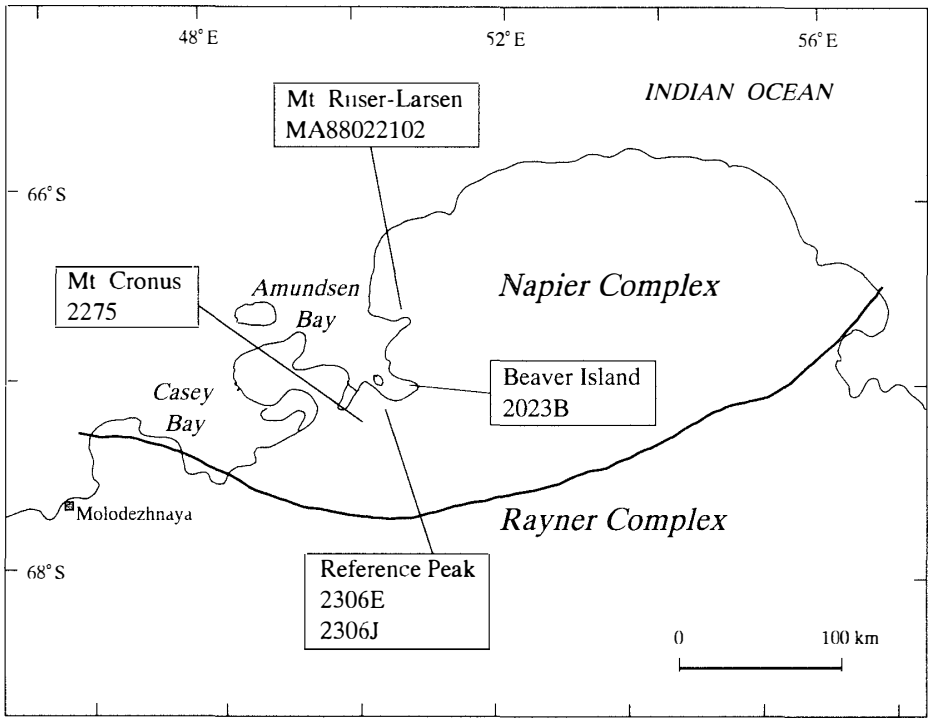

Fig 1 Map of sample localities The boudary between the Napier and the Rayner Complexes is taken from SHERATON et al (1987)

Table 1 Sample numbers, rock types and localities of the analyzed samples

Sample No	Rock type	Locality
(1) MA88022102	Opx quartzofeldspathic granulite	Mt Riiser-Larsen
(2) 2023B	Spr-Grt-Opx reaction skarn	Beaver Island
(3) 2306E	Spr-Sil-Opx-Bt quartzofeldspathic granulite	Reference Peak
(4) 2306J	Osm-Spr-Sil-Opx-Bt quartzofeldspathic gneiss	Reference Peak
(5) 2275	Opx-Grt-Bt quartzofeldspathic gneiss	Mt Cronus

Mineral abbreviations Bt-biotite, Grt-garnet, Sil-sillimanite, Spr-sapphirine, Opx-orthopyroxene, Osm-osumilite (1) collected by M ASAMI (2)-(5) collected by E S GREW

2 2. *Sample 2023B, Beaver Island*

The Beaver Island sample was collected from a sapphirine-bearing orthopyroxene-rich zone in a reaction skarn roughly 20 cm thick developed between an ultramafic lens and enclosing garnetiferous quartzofeldspathic gneiss. Most of the skarn is dark pyroxenite Sapphirine is found only in a zone a few cm thick closest to the gneiss Sapphirine occurs with garnet in the outermost zone next to the gneiss, then sapphirine ±biotite, and, finally, pyroxene appears further in towards the ultramafic. The ultramafic lens consists of metapyroxenite, in part well layered, and contains bright-green clinopyroxene and pale brown orthopyroxene, which is dominant and varies in intensity of the brown color The lens is cut by veins of coarse (>1 cm) orthopyroxene This lens appears to be one of several in a string of lenses (boudins) along strike

Table 2 Mineral assemblages of the analyzed samples

Sample	Osm	Spr	Sil	Opx	Grt	Crd	Bt	Kfs	Pl	Qtz	Rt	Mnz	Zrn	Xnt	Plc	Prr	Ore
Mt Riiser-Larsen																	
(1) MA88022102				+				+		+		−	−				−
Beaver Island																	
(2) 2023B		+		+	−		−	−	−		−	−	−				−
Reference Peak																	
(3) 2306E		+	+	+		(+)	+		+	+	−	−	−				−
(4) 2306J	+	−	+	+		(+)	+		+	+	−	−	−	−			−
Mt Cronus																	
(5) 2275				+	+		+		+	+	−		−		−	−	−

Mineral abbreviations Bt-biotite, Crd-cordierite, Grt-garnet, Kfs-K-feldspar (perthite), Mnz-monazite, Opx-orthopyroxene, Ore-ore mineral, Osm-osumilite, Pl-plagioclase, Plc-polycrase, Prr-perrierite, Qtz-quartz, Rt-rutile, Sil-sillimanite, Spr-sapphirine, Xnt-xenotime, Zrn-zircon +, − major consitituent and minor constituent, respectively (+) probably secondary

In Sample 2023B, orthopyroxene is predominant (*ca.* 78% modal), whereas sapphirine (*ca.* 15%) forms discrete grains and selvages between orthopyroxene grains, and appears to be interstitial to it. Sapphirine has inclusions of garnet. Sapphirine and orthopyroxene are conspicuously pleochroic. Biotite is brownish. Garnet tends to be interstitial to orthopyroxene; some includes vermicular sapphirine and orthopyroxene. Monazite is found as rounded grains, less than 0.05 mm in size, in orthopyroxene and also at orthopyroxene and sapphirine-orthopyroxene grain boundaries. Zircon is present in trace amount as minute rounded grains in orthopyroxene and sapphirine.

2.3. Samples 2306E and 2306J, Reference Peak

Rocks exposed at Reference Peak include sapphirine-sillimanite-orthopyroxene quartzite (GREW, 1980) and osumilite-sillimanite-orthopyroxene gneiss (GREW, 1982). Both Samples 2306E and 2306J were collected in a fold-hinge area. Sample 2306E is a light-gray, medium-grained, sapphirine-sillimanite-orthopyroxene-biotite granulite collected from a biotitic lens some 10 cm thick in a light-gray quartzofeldspathic gneiss Sample 2306J is a light-gray, medium-grained, osumilite-sapphirine-sillimanite-orthopyroxene-biotite quartzofeldspathic gneiss which is similar to that from which the osumilite-bearing sample (2306B: GREW, 1982) was collected.

In both samples, quartz and plagioclase are of brown tint. Sapphirine is colorless and orthopyroxene is nearly so Biotite is light brownish yellow. Sillimanite grains are prismatic in Sample 2306E and aggregated or prismatic in Sample 2306J. Osumilite in Sample 2306J is partially replaced by a symplectite. Cordierite in Sample 2306J appears around sapphirine. Monazite in Sample 2306E occurs as subhedral rounded grains about 0.1 mm across in orthopyroxene and also as discrete anhedral grains 0.1–0.2 mm across which are in contact with sapphirine, sillimanite, quartz, plagioclase and biotite. Monazite and xenotime in Sample 2306J form subhedral rounded to anhedral irregular grains 0.05–0.1 mm across; monazite is found in quartz, orthopyroxene and osumilite, and xenotime at quartz grain boundaries as well as in quartz Zircon appears

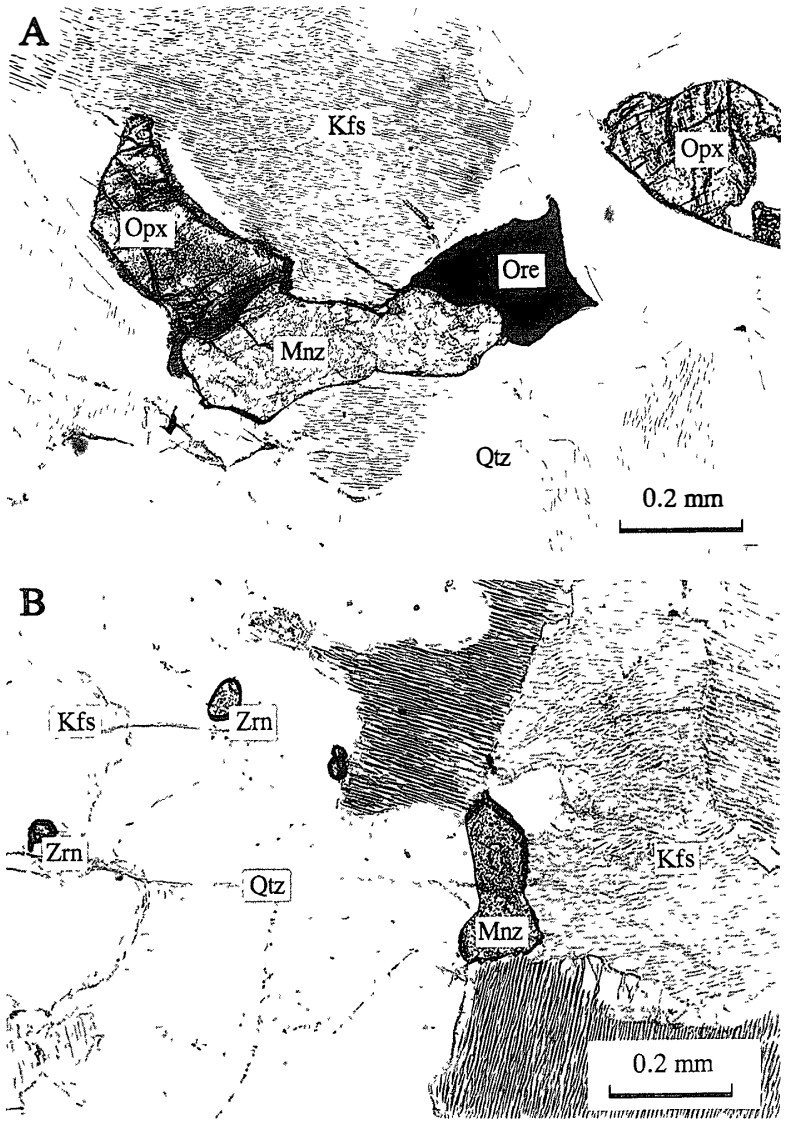

Fig 2 Photomicrographs showing modes of occurrence of monazite and zircon in Sample MA 88022102 from Mt. Riiser-Larsen A a monazite grain (Mnz) associated with orthopyroxene (Opx), quartz (Qtz), mesoperthite (Kfs) and ore (Ore) (plane-polarized light) B. a monazite grain present at the grain boudary of quartz and mesoperthite, and zircon grains (Zrn) in quartz and mesoperthite (plane-polarized light)

as minute rounded to ellipsoidal grains in quartz, plagioclase, sapphirine, orthopyroxene and biotite in both samples, and also in osumilite in Sample 2306J.

2.4. Sample 2275, Mt. Cronus

Sillimanite-orthopyroxene and sapphirine are found at Mt. Cronus (GREW, 1984) Sample 2275 is a light-gray, fine-grained, orthopyroxene-garnet-biotite quartzofeldspathic gneiss from a well-layered quartzofeldspathic gneiss unit. This sample contains a flattened mass of an yttrium titanoniobate, possibly polycrase. These masses reach 5 cm across but do not exceed 1 cm in thickness; they are flattened parallel to compositional layering.

Orthopyroxene is pale in color, but distinctly pleochroic. Garnet is embayed, anhedral porphyroblasts and includes biotite and quartz. Biotite is of pale color and shows preferred orientation. Plagioclase is the dominant mineral; it contains abundant antiperthite lamellae. Rutile is locally dichroic in green and brown. Perrierite is isotropic (metamict) and light-brown. Polycrase is isotropic (metamict) with red-brown to olive patchy color, and occurs as rounded to ellipsoidal aggregates 0.2–0 7 mm across enclosed in garnet. Zircon forms subhedral rounded grains less than 0.2 mm across found in quartz and plagioclase and also at their grain boundaries.

3. Analytical Method

Monazite, zircon, xenotime and polycrase were analyzed in polished thin sections prepared for conventional electron microprobe analyses. All analyses were carried out on a JEOL JXA-733 microprobe analyzer equipped with three wavelength-dispersive type spectrometers. Instrument operating conditions were 15 kV accelerating voltage, 0.3 μA beam current and 5 μm beam diameter.

The ThM_α, UM_β, PbM_α and YL_γ lines were simultaneously measured with the PET crystal for the monazite and zircon analysis, and the superimposition of YL_γ upon PbM_α was corrected through the procedure described by ÅMLI and GRIFFIN (1975). The YL_γ interference on PbM_α becomes severe for the analysis of Y-rich xenotime and polycrase. The PbM_β line, therefore, was used for the Pb determination of these minerals. The NbL_β interference upon PbM_β encountered at the polycrase analysis was carefully corrected. No other elements were analyzed. X-ray intensity was integrated over a 200-s period for the line-peak position and a 100-s period for two optimum positions on both side of each line-peak. The measurement was repeated twice, and the arithmetic average was taken as the true intensity. Standards are euxenite provided by SMELLIE *et al.* (1978) for Th and U and a synthesized glass (10.18% PbO, 47.15% SiO_2, 14.21% Al_2O_3, 8.99% MgO and 19.58% CaO, analyst: K. SUZUKI) for Pb. The Y and Nb standards, used for determination of YL_γ at PbM_α position /YL_α and NbL_β at PbM_β position /NbL_β intensity ratios, are synthesized YPO_4 and Nb-bearing silicate glass (Nb_2O_5=*ca.* 15%). The detection limit of PbO at the 2σ confidence level is 0.01 wt%, and the relative error in the PbO determination is 5–10% at the 0.1 wt% concentration level and is much better for the higher concentrations.

The X-ray intensity data were converted into concentrations by the BENCE and ALBEE (1968) method using the compositions of a natural monazite (10.29% ThO_2, 0.08 % UO_2 and 0.523% PbO, 0.90% SiO_2, 0.95% Y_2O_3, 11.18% La_2O_3, 27.42% Ce_2O_3, 2.68 % Pr_2O_3, 12.02 % Nd_2O_3, 2.12% Sm_2O_3, 0.70% Gd_2O_3, 0.16% Tb_2O_3, 0.21% Dy_2O_3, 1.29% CaO, and 28.64% P_2O_5), zircon (31.1% SiO_2, 60.4% ZrO_2, 3.73% HfO_2, 1.57% Y_2O_3, and 0.767% P_2O_5), xenotime (41.3% Y_2O_3, 0.59% Sm_2O_3, 3.26% Gd_2O_3, 5.02% Dy_2O_3, 1.58% Ho_2O_3, 4.87% Er_2O_3, 4.75% Yb_2O_3, and 34.5% P_2O_5) and polycrase (25.3% TiO_2, 11.4% Y_2O_3, 1.31% Sm_2O_3, 2.16% Gd_2O_3, 3.53% Dy_2O_3, 0.49% Ho_2O_3, 1.44% Er_2O_3, 0.28% Tm_2O_3, 0.78% Yb_2O_3, 1.16% CaO, 24.7% Nb_2O_3, and 2.545% Ta_2O_3) as references. The small difference in the matrix between the reference and analyzed mineral barely affects the ThO_2, UO_2 and PbO determinations; the maximum error in this calculation, about 0.5% of the concentration, is less than the uncertainty in

the X-ray counting.

4. Results

Analyses were made for monazite and zircon in Sample MA88022102 (Mt. Riiser-Larsen), monazite in 2023 (Beaver Island), monazite in 2306E and monazite, zircon and xenotime in 2306J (Reference Peak), and zircon and polycrase in 2275 (Mt. Cronus) The CHIME ages were calculated through the method described by SUZUKI and ADACHI (1991a, b, 1994), SUZUKI *et al* (1991, 1992, 1994), and ADACHI and SUZUKI (1992). The ThO_2, UO_2 and PbO contents together with the apparent age, ThO_2* value (sum of the measured ThO_2 and ThO_2 equivalent of the measured UO_2 for monazite) and UO_2* value (sum of the measured UO_2 and UO_2 equivalent of the measured ThO_2 for zircon, xenotime and polycrase) are listed in the Appendix, and CHIME age data are summarized in Table 3

Monazite grains from Sample MA88022102 are chronologically heterogeneous; the apparent ages range from 3858 to 1430 Ma with conspicuous concentrations at *ca.* 2400, 2200 and 2000 Ma (Fig. 3A) Figure 4 illustrates the intra-grain variation of apparent ages within M17, M18 and M19 grains from Sample MA88022102. Three spots in the left of M17 grains (enclosed with bold lines) give exceptionally older ages (3858, 3472 and 2797 Ma). These spots locate within the chronologically homogeneous domain (dotted area) with older ($>$2360 Ma) apparent ages, and possibly represent inherited Archaean monazite. The homogeneous older ($>$2360 Ma) domain is surrounded, at least towards the right, by domains as young as *ca.* 2000 Ma. The age variations within M18 and M19 grains are essentially the same to that in M17 grain, but one spot in M18 grain (shown with mesh) gives a distinctly young age of 1529 Ma. This spot locates close to a fracture extending from left to right. The exceptionally young age presumably resulted from Pb-loss along the fracture, and has no geological meaning. A total of 59 analyses within the homogeneous older domains in M17, M18 and M19 grains gives a CHIME age of 2404$\pm$54 Ma (Fig 5). Data points with apparent ages of 2200–2300 and 2000–2100 Ma in M01 to M19 grains give CHIME ages of 2232$\pm$18 Ma (68 spots) and 2026$\pm$25 Ma (65 spots), respectively.

Zircon grains from Sample MA88022102 give apparent ages from 3078 to 1574 Ma with a conspicuous concentration at *ca.* 2400 Ma (Fig. 3B) Apparent ages younger than 2000 Ma are for spots in metamict portions and seems to have no geological meaning, and those between 1800–2200 Ma are for spots in the margin of individual grains. Of 18 analyzed grains, Z12 grain gives uniform *ca.* 2400 Ma apparent ages with two younger ones (Z12-13: 2187 Ma, Z12-14: 2292 Ma, Appendix). Thirteen data points in Z12 zircon grain yield a 2445$\pm$82 Ma CHIME age. Z17 grain shows older ages (3078 and 2749 Ma) in the center and younger ages (2261 and 2049 Ma) in the margin. The remaining data points (11 spots) are regressed with an isochron of 2402 $\pm$32 Ma. Fourteen data points in the center of Z18 grain yield a 2428$\pm$105 Ma isochron. Regression of data points with 2360–2500 Ma in whole analyzed grains yields a 2441$\pm$15 Ma CHIME age (Fig. 6).

Monazite grains from Samples 2023B, 2306E and 2306J, unlike those from Sample MA88022102, are chronologically homogeneous, and give CHIME ages of 2412$\pm$42,

Table 3 CHIME ages of monazite, zircon and xenotime from the granulite samples

Sample	Mineral	Number of analyses	Age (Ma)	Number of analyses used for age calculation
Mt Ruser-Larsen				
(1) MA88022102	Monazite	329 spots on 19 grains		
		M17, M18 and M19	2404±54	59 spots on older (>2360 Ma) domains except 3858, 3472 and 2797 Ma spots
		Whole-grains	2232±18	68 spots on intermediate (2200–2300 Ma) domains
		Whole-grains	2026±25	65 spots on younger (2000–2100 Ma) domains
	Zircon	140 spots on 18 grains		
		Z08	2445±82	13 of 15 spots
		Z17	2402±32	11 of 15 spots
		Z18	2428±105	14 of 20 spots
		Whole-grains	2441±15	82 spots showing 2360–2500 Ma apparent ages
Beaver Island				
(2) 2023B	Monazite	84 spots on 7 grains	2412±42	71 spots
Reference Peak				
(3) 2306E	Monazite	194 spots on 3 grains	2429±36	151 spots
(4) 2306J	Monazite	58 spots on 6 grains	2421±18	58 spots
	Zircon	77 spots on 14 grains	n d	(no meaningful isochron)
	Xenotime	68 spots on 4 grains	2431±22	66 spots
Mt Cronus				
(5) 2275	Zircon	254 spots on 30 grains		
		Z01 core	3646±136	4 of 4 spots
		mantle	3042±51	4 of 4 spots
		Z05 mantle	3004±29	5 of 7 spots, except 3560 and 3628 Ma sopts
		Z08	2469±18	7 of 7 spots
		Z16	3050±39	10 of 12 spots, except 2428 and 2676 Ma sopts
		Z28	2428±85	9 of 15 spots
		Whole-grains	3056±14	47 spots showing 3000–3100 Ma apparent ages
		Whole-grains	2720±44	33 spots showing 2640–2760 Ma apparent ages
		Whole-grains	2437±24	42 spots showing 2360–2500 Ma apparent ages
	Polycrase	170 spots on 17 grains	n d	(no meaningful isochron)

Grain numbers, such as M17 and Z08, correspond to those in the Appendix. n d not determined

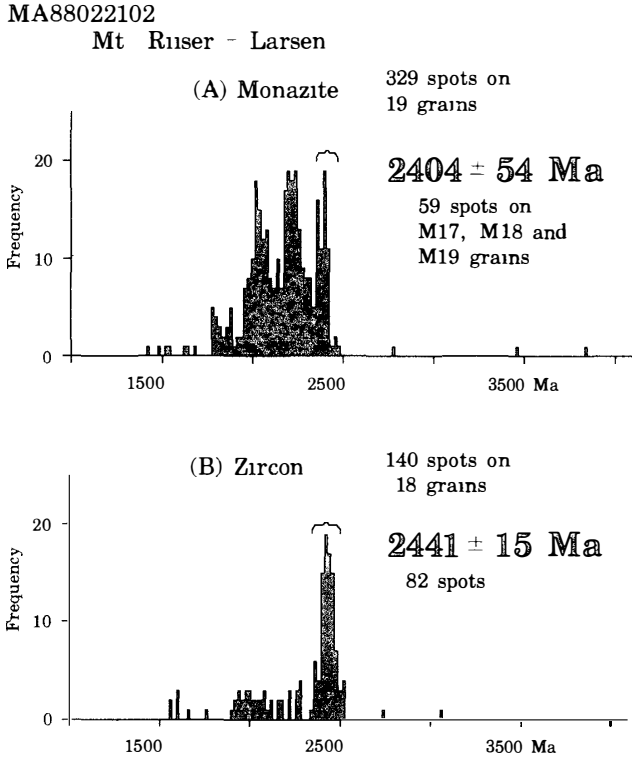

Fig 3 Histograms of apparent ages for all analyzed spots on monazite and zircon from Sample MA88022102 (Mt Riiser-Larsen) A monazite, B zircon

2429±36 and 2421±18 Ma, respectively Data points on xenotime grains in Sample 2306J, except two young ones (2168 and 2059 Ma) in small X04 grain, yield an age of 2431±22 Ma Zircon grains from Sample 2306J show variable apparent ages from 3780 Ma (Z07-03) to 1167 Ma (Z12-04) with no marked age concentration, and so define no meaningful isochron.

Zircon grains in Sample 2275 are also chronologically heterogeneous, but show marked concentration of apparent ages at *ca.* 3000, 2700 and 2400 Ma Some zircon grains in this sample show distinct core-mantle relation under the microscope Small rounded Z01 grain contains a rounded core; 4 data points in the core yield a 3646±136 Ma isochron, and 4 data points in the mantle yield a 3042±51 Ma isochron Z05 grain also has a small rounded core with 3628 Ma and 3560 Ma apparent ages, and a mantle of 3004±29 Ma (5 spots). Z28 grain is uniform under the microscope, but contains older (2728-3117 Ma) material in the center of 2428±85 Ma domain (9 spots). Z08 and Z16 grains are chronologically uniform except for their marginal portion, and give ages of 2468±18 Ma (7 spots) and 3050±39 Ma (10 spots), respectively Regression of 47 data points with 3000-3100 Ma apparent ages, 33 data points with 2640-2760 Ma apparent ages and 42 data points with 2360-2500 Ma apparent ages yield isochrons of 3056±14, 2720±44 and 2437±24 Ma, respectively

Polycrase grains from Sample 2275 give variable apparent ages from 3093 Ma (P 16/130187) to 1667 Ma (P16/016224) with no distinct age concentration. Thus their UO_2* and PbO data define no meaningful isochron

The CHIME ages of 2404 Ma to 2441 Ma (within ±54 Ma) obtained on monazite,

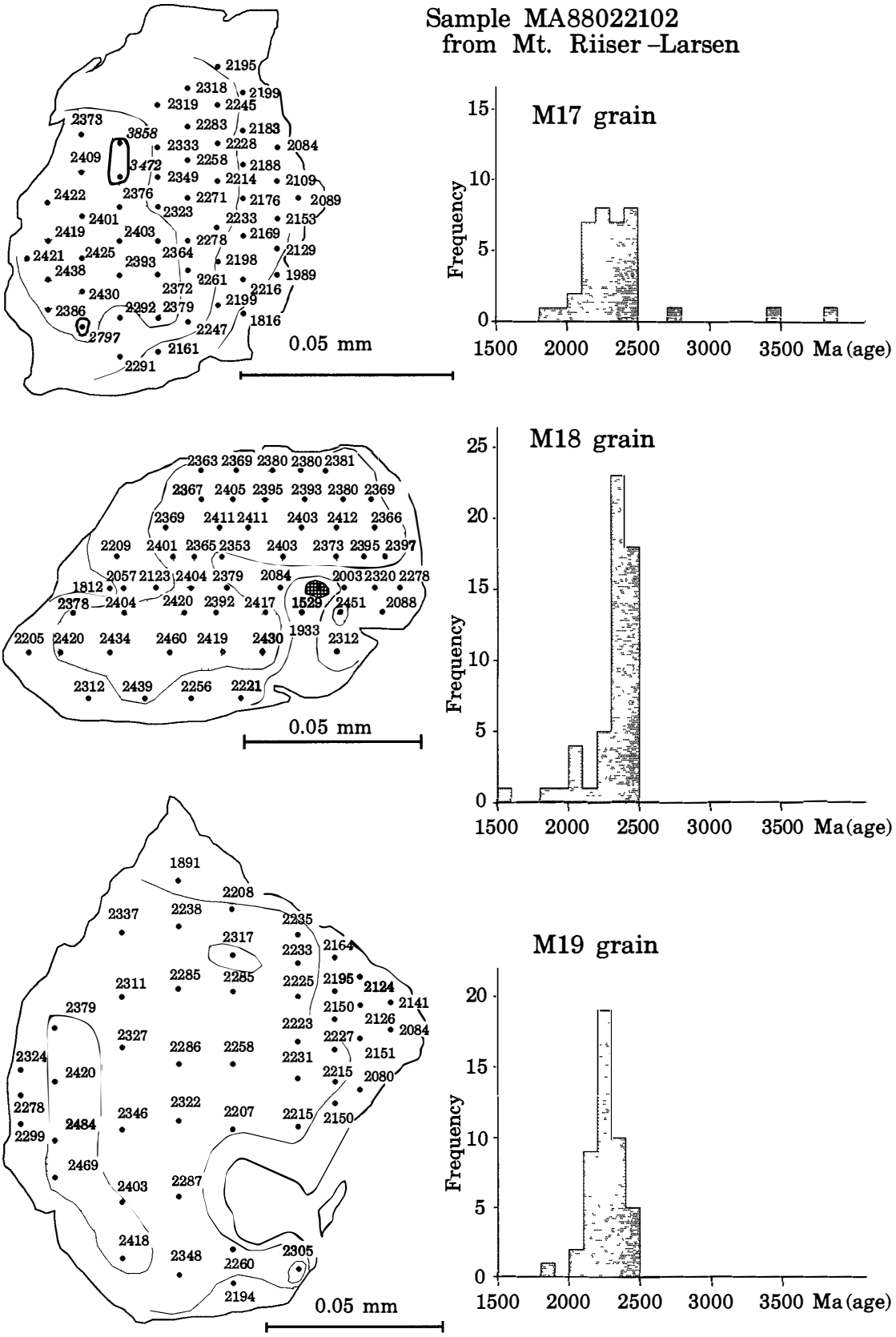

Fig 4 Sketch of three monazite grains from Sample MA88022102 (Mt Riiser-Larsen) showing zoning in apparent age, with histograms of apparent ages

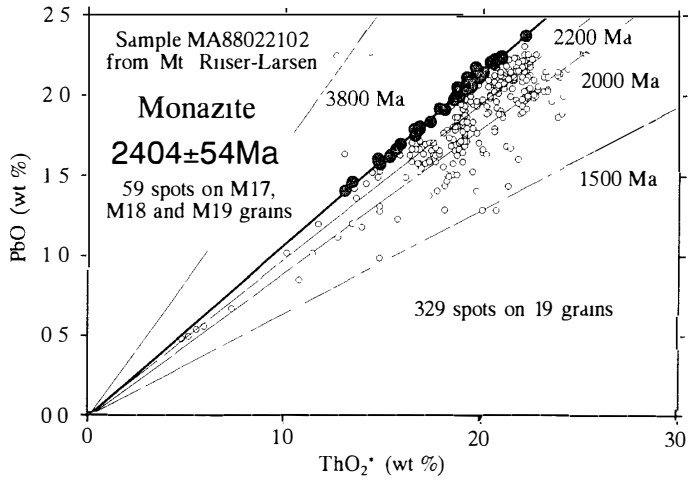

Fig 5 ThO_2-PbO plot for monazites in Sample MA88022102 (Mt Riiser-Larsen) Filled circles indicate data points from the chronologically homogeneous older domains in M17, M18 and M19 grains, open circles indicate data points from the other domains in the three grains and from the other analyzed grains (see Fig 4)*

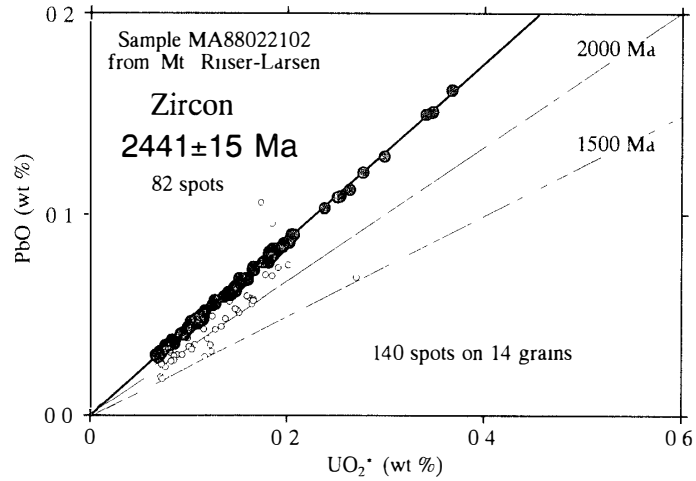

Fig 6 UO_2-PbO plot for zircons in Sample MA88022102 (Mt Riiser-Larsen) Filled circles indicate data points with 2360–2500 Ma apparent ages in whole analyzed grains, open circles indicate data points with the other apparent ages*

zircon and xenotime from Mt. Riiser-Larsen, Beaver Island and Reference Peak are in good agreement. Comparable ages ranging from 2429 + 17/ − 16 Ma to 2496 + 16/ − 13 Ma have been reported on monazite from a felsic paragneiss and on zircon from a granitic orthogneiss, pegmatite and leuconorite (*e.g.* BLACK *et al.*, 1984, SHERATON *et al.*, 1987, HARLEY and BLACK, 1997; GREW, 1998)

5. Discussion

The analyzed samples gave consistent CHIME monazite, xenotime and zircon ages of 2404–2441 Ma (Table 3) As noted above, metamorphic rocks at the four localities

are characterized by sapphirine-quartz-, sillimanite-orthopyroxene- and osumilite-bearing associations, and thus must have undergone ultra-high-temperature, granulite-facies metamorphism. In addition, petrographic observation indicates that monazite, zircon and xenotime are in textural equilibrium with the other constituent minerals, such as orthopyroxene, sapphirine and osumilite, in each sample. Thus monazite, zircon and xenotime from Mt. Riiser-Larsen, Beaver Island and Reference Peak and some grains of zircon from Mt. Cronus are considered to have either crystallized with the other constituents or totally lost Pb during the ultra-high-temperature metamorphism. Moreover, significant retention of Pb in the U-Th-bearing minerals after their crystallization has been demonstrated in upper amphibolite- to lower granulite-facies metamorphic rocks elsewhere (PARRISH, 1990; SMITH and BARREIRO, 1990; SUZUKI and ADACHI, 1991a, 1994; SUZUKI *et al.*, 1994). The closure temperature for Pb of monazite is as high as 725°C (PARRISH, 1990). Consequently, the U-Th-Pb system in these minerals could have remained closed even if the rocks were subjected to metamorphism in the upper amphibolite-facies subsequent to the ultra-high-temperature granulite-facies metamorphism. A reasonable interpretation is that the 2404–2441 Ma ages date the ultra-high-temperature, granulite-facies metamorphic event in the Napier Complex.

Later thermal effects suggested from *ca.* 2200 and 2000 Ma ages obtained on the Mt. Riiser-Larsen monazite probably result from relatively high temperature activity. The oldest core age of 3646 Ma for Mt. Cronus zircon could be a minimum age for protolith formation. The *ca.* 2700 Ma age observed on some Mt. Cronus zircons presumably represents a thermal event in the provenance.

To date, many isotopic ages between 2400 and 2500 Ma determined with different methods have been reported from the Napier Complex (GREW and MANTON, 1979; DEPAOLO *et al.*, 1982; GREW *et al.*, 1982; SHERATON *et al.*, 1987; OSANAI *et al.*, 1995; OWADA *et al.*, 1995; SHIRAISHI *et al.*, 1997; TAINOSHO *et al.*, 1997; HARLEY and BLACK, 1997, GREW, 1998). The CHIME ages of 2404–2441 Ma lie in this range. The ubiquitous occurrence of the 2400–2500 Ma ages in the western Napier Complex implies that pervasive isotopic equilibration took place during a major thermal event in the complex. Some researchers have correlated this age with the time of upper amphibolite- to lower granulite-facies metamorphism subsequent to the ultra-high-temperature granulite-facies metamorphism 2820–2840 Ma ago (BLACK *et al.*, 1983a, b, 1986, SHERATON and BLACK, 1983; MCCULLOCH and BLACK, 1984; SHERATON *et al.*, 1987; HARLEY and BLACK, 1997). If this were the case, some 2820–2840 Ma grains should have been inherited in the monazite, zircon and xenotime, especially in M17 monazite grain from Mt. Riiser-Larsen sample, because of their high Pb retentivity as mentioned previously. In addition, retrogression of the ultra-high-temperature assemblages should be evident. However, no decisive inheritance or significant retrograde change is observed in the studied samples, with the exception of the Mt. Cronus zircon. Accordingly, it is our present opinion that 2404–2441 Ma CHIME ages date the Napier ultra-high-temperature metamorphism.

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References

ADACHI, M and SUZUKI, K (1992) A preliminary note on the age of detrital monazites and zircons from sandstones in the Upper Triassic Nabae Group, Maizuru terrane Mem Geol Soc Jpn, **38**, 111–120 (in Japanese with English abstract)

ÅMLI, R and GRIFFIN, W L (1975) Microprobe analyses of REE minerals using empirical correction factors Am Mineral, **60**, 599–606

ASAMI, M, SUZUKI, K and ADACHI, M (1996) Monazite ages by the chemical Th-U-total Pb isochron method for pelitic gneisses from the eastern Sør Rondane Mountains, East Antarctica Proc NIPR Symp Antarct Geosci, **9**, 49–64

ASAMI, M, SUZUKI, K and ADACHI, M (1997) Th, U and Pb data and CHIME dating of monazites from metamorphic rocks of the Rayner, Lutzow-Holm, Yamato-Belgica and Sør Rondane Complexes, East Antarctica Proc NIPR Symp Antarct Geosci, **10**, 130–152

BENCE, A E and ALBEE, A L (1968) Empirical correction factors for the electron microanalysis of silicates and oxides J Geol, **76**, 382–403

BLACK, L P, JAMES, P R and HARLEY, S L (1983a) The geochronology, structure and metamorphism of early Archaean rocks at Fyfe Hills, Enderby Land, Antarctica Precambrian Res, **21**, 197–222

BLACK, L P, JAMES, P R and HARLEY, S L (1983b) Geochronology and geological evolution of metamorphic rocks in the Field Island area, East Antarctica J Metamorph Geol, **1**, 277–303

BLACK, L P, FITZGERALD, D and HARLEY, S L (1984) Pb isotopic composition, colour, and microstructure of monazites from a polymetamorphic rock in Antarctica Contrib Mineral Petrol, **85**, 141–148

BLACK, L P, WILLIAMS, I S and COMPSTON, W (1986) Four zircon ages from one rock the history of a 3930 Ma-old granulite from Mount Sones, Enderby Land, Antarctica Contrib Mineral Petrol, **94**, 427–437

DEPAOLO, D J, MANTON, W I, GREW, E S and HALPERN, M (1982) Sm-Nd, Rb-Sr, and U-Th-Pb systematics of granulite-facies rocks from Fyfe Hills, Enderby Land, Antarctica Nature, **298**, 614–618

GREW, E S (1980) Sapphirine+quartz association from Archean rocks in Enderby Land, Antarctica Am Mineral, **65**, 821–836

GREW, E S (1982) Osumilite in the sapphirine-quartz terrane of Enderby Land, Antarctica implications for osumilite petrogenesis in the granulite facies Am Mineral, **67**, 762–787

GREW, E S (1984) A review of Antarctic granulite-facies rocks Tectonophysics, **105**, 177–191

GREW, E S (1998) Boron and beryllium minerals in granulite-facies pegmatites and implications of beryllium pegmatites for the origin and evolution of the Archean Napier Complex of East Antarctica Mem Natl Inst Polar Res, Spec Issue, **53** (in press)

GREW, E S and MANTON, W I (1979) Archean rocks in Antarctica 2 5-billion-year uranium-lead ages of pegmatites in Enderby Land Science, **206**, 443–445

GREW, E S, MANTON, W I and SANDIFORD, M (1982) Geochronologic studies in East Antarctica Age of pegmatites in Casey Bay, Enderby Land Antarct J U S, **17** (5), 1–2

HARLEY, S L and BLACK, L P (1997) A revised Archaean chronology for the Napier Complex, Enderby Land, from SHRIMP ion-microprobe studies Antarct Sci, **9**, 74–91

HARLEY, S L and HENSEN, B J (1990) Archean and Proterozoic high-grade terrains of East Antarctica (40-80°E) A case study of diversity in granulite facies metamorphism High Temperature Metamorphism and Crustal Anatexis, ed by J R ASHWORTH and M BROWN London, Unwin Hyman, 320–370

MAKIMOTO, H, ASAMI, M and GREW, E S (1989) Some geological observations on the Archean Napier Complex at Mt Riiser-Larsen, Amundsen Bay Proc NIPR Symp Antarct Geosci, **3**, 128–141

MCCULLOCH, M T and BLACK, L P (1984) Sm-Nd isotopic systematics of Enderby Land granulites and

evidence for the redistribution of Sm and Nd during metamorphism Earth Planet Sci Lett , **71**, 46–58

MOTOYOSHI, Y and MATSUEDA, H (1984) Archean granulites from Mt Riiser-Larsen in Enderby Land, East Antarctica Mem Natl Inst Polar Res , Spec Issue, **33**, 103–125

OSANAI, Y , OWADA, M , SHIRAISHI, K , HENSEN, B J and TSUCHIYA, N (1995) Metamorphic evolution of deep crustal high temperature granulites from Tonagh Island in the Archaean Napier Complex, East Antarctica Abstracts VII International Symposium on Antarctic Earth Sciences, 10–15 Sep 1995, Siena (Italy) Siena, Univ Studi Siena, 289

OWADA, M , OSANAI, Y , KAGAMI, H and SHIRAISHI, K (1995) Isotopic re-equilibration of early to middle Archaean crust by late Archaean tectonothermal event in the Napier Complex, East Antarctica Abstracts VII International Symposium on Antarctic Earth Sciences, 10–15 Sep 1995, Siena (Italy) Siena, Univ Studi Siena, 292

OWADA, M , OSANAI, Y , HAMAMOTO, T and KAGAMI, H (1996) Sm-Nd garnet-whole rock isochron age from Tonagh Island, Napier Complex The 16th Symposium on Antarctic Geosciences, Program and Abstracts, 15–16 October 1996 Tokyo, Natl Inst Polar Res , 42–43 (in Japanese)

PARRISH, R R (1990) U-Pb dating of monazite and its application to geological problems Can J Earth Sci , **270**, 1431–1450

SHERATON, J W and BLACK, L P (1983) Geochemistry of Precambrian gneiss Relevance for the evolution of the East Antarctic Shield Lithos, **16**, 273–296

SHERATON, J W , TINGEY, R J , BLACK, L P , OFFE, L A and ELLIS, D J (1987) Geology of Enderby Land and western Kemp Land BMR Bull , **223**, 51 p

SHIRAISHI, K , ELLIS, D J , FANNING, C M , HIROI, Y , KAGAMI, H and MOTOYOSHI, Y (1997) Re-examination of the metamorphic and protolith ages of the Rayner Complex, Antarctica Evidence for the Cambrian (Pan-African) regional metamorphic event Antarctic Regions Geological Evolution and Processes, ed by C A RICCI Siena, Terra Antartica Publication, 79–88

SMELLIE, J A T , COGGER, N and HERRINGTON, J (1978) Standards for quantitative microprobe determination of uranium and thorium with additional information on the chemical formulae of davidite and euxenite-polycrase Chem Geol , **22**, 1–10

SMITH, H A and BARREIRO, B (1990) Monazite U-Pb dating of staurolite grade metamorphism in pelitic schist Contrib Mineral Petrol , **105**, 602–615

SUZUKI, K and ADACHI, M (1991a) Precambrian provenance and Silurian metamorphism of the Tsubonosawa paragneiss in the South Kitakami terrane, revealed by the chemical Th-U-total Pb isochron ages of monazite, zircon and xenotime Geochem J , **25**, 357–376

SUZUKI, K and ADACHI, M (1991b) The chemical Th-U-total Pb isochron ages of zircon and monazite from the Gray Granite of the Hida terrane, Japan J Earth Sci , Nagoya Univ., **38**, 11–37

SUZUKI, K and ADACHI, M (1994) Middle Precambrian detrital monazite and zircon from the Hida gneiss on Oki-Dogo Island, Japan Their origin and implications for the correlation of basement gneiss of Southwest Japan and Korea Tectonophysics, **235**, 277–292

SUZUKI, K , ADACHI, M and TANAKA, T (1991) Middle Precambrian provenance of Jurassic sandstone in the Mino terrane, central Japan Th-U-total Pb evidence from an electron microprobe monazite study Sediment Geol., **75**, 141–147

SUZUKI, K , ADACHI, M and KAJIZUKA, I (1994) Electron microprobe observations of Pb diffusion in metamorphosed detrital monazites Earth Planet. Sci. Lett , **128**, 391–405.

SUZUKI, K , ADACHI, M , SANGO, K and CHIBA, H (1992) Chemical Th-U-total Pb isochron ages of monazites and zircons from the Hikami Granite and "Siluro-Devonian" clastic rocks in the South Kitakami terrane J Mineral Petrol. Econ Geol , **87**, 330–349 (in Japanese with English abstract)

TAINOSHO, Y , KAGAMI, H , HAMAMOTO, T and TAKAHASHI, Y (1997) Preliminary result for the Nd and Sr isotope characteristics of the Archean gneisses from Mount Pardoe Proc NIPR Symp Antarct Geosci , **10**, 92–101

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Appendix Microprobe ThO_2, UO_2 and PbO analyses, apparent ages and ThO_2* or UO_2* values of monazite, zircon, xenotime and polycrase in granulites from the Napier Complex

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*	Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
Sample MA88022102 from Mt Riiser-Larsen						M05-09	20 4	0 357	1 98	2057	21 7
M01-01	20 9	0 371	2 24	2258	22 3	M05-10	18 6	0 475	2 00	2205	20 4
M01-02	21 3	0 343	2 26	2246	22 7	M06-01	15 8	0 270	1 58	2124	16 8
M01-03	19 7	0 296	2 05	2217	20 8	M06-02	15 8	0 263	1 53	2057	16 8
M01-04	19 1	0 493	2 13	2279	21 1	M06-03	15 8	0 274	1 57	2110	16 8
M01-05	18 9	0 525	2 06	2217	21 0	M06-04	18 7	0 484	2 13	2328	20 6
M01-06	18 5	0 495	2 01	2219	20 4	M06-05	19 3	0 409	2 09	2252	20 9
M01-07	20 1	0 417	2 16	2238	21 8	M06-06	17 1	0 448	1 87	2232	18 8
M01-08	22 1	0 284	2 27	2208	23 2	M06-07	17 9	0 468	1 97	2255	19 7
M01-09	18 7	0 495	2 06	2242	20 7	M06-08	18 8	0 483	2 06	2244	20 7
M02-01	19 2	0 477	2 12	2264	21 0	M06-09	19 0	0 453	2 02	2197	20 8
M02-02	18 6	0 493	2 07	2269	20 6	M06-10	15 8	0 269	1 53	2057	16 8
M02-03	16 8	0 438	1 81	2201	18 5	M07-01	18 7	0 510	1 93	2115	20 7
M02-04	20 3	0 464	1 99	2040	22 1	M07-02	18 7	0 509	1 80	1984	20 6
M02-05	20 7	0 402	1 98	2020	22 2	M07-03	16 0	0 391	1 63	2112	17 5
M02-06	17 6	0 394	1 74	2066	19 1	M07-04	19 5	0 475	2 15	2260	21 4
M02-07	15 9	0 400	1 66	2151	17 4	M07-05	18 9	0 476	2 02	2192	20 8
M02-08	17 7	0 450	1 95	2258	19 5	M08-01	17 0	0 410	1 87	2259	18 6
M02-09	17 4	0 393	1 81	2150	19 0	M08-02	17 6	0 383	1 91	2246	19 1
M02-10	19 3	0 496	2 17	2289	21 3	M08-03	20 9	0 296	2 31	2349	22 1
M03-01	19 4	0 477	2 11	2237	21 3	M08-04	20 7	0 375	2 37	2402	22 2
M03-02	19 9	0 465	2 19	2264	21 8	M08-05	20 9	0 289	2 26	2304	22 1
M03-03	19 6	0 446	2 13	2248	21 4	M08-06	17 5	0 379	1 92	2271	19 0
M03-04	19 3	0 448	2 11	2258	21 1	M08-07	17 2	0 382	1 84	2219	18 7
M03-05	19 2	0 488	2 11	2257	21 1	M08-08	14 8	0 389	1 63	2250	16 3
M04-01	19 9	0 425	2 10	2197	21 5	M08-09	15 5	0 398	1 70	2242	17 1
M04-02	21 1	0 289	2 15	2186	22 2	M08-10	15 8	0 394	1 71	2216	17 3
M04-03	21 0	0 279	2 09	2145	22 0	M09-01	18 8	0 437	2 21	2406	20 6
M04-04	17 4	0 364	1 71	2056	18 8	M09-02	17 5	0 239	1 69	2080	18 4
M04-05	21 0	0 288	2 13	2169	22 2	M09-03	17 6	0 212	1 73	2124	18 5
M04-06	18 0	0 304	1 87	2200	19 2	M09-04	17 1	0 259	1 44	1814	18 1
M04-07	21 2	0 238	2 15	2195	22 1	M09-05	17 3	0 222	1 47	1845	18 2
M04-08	19 4	0 443	2 09	2233	21 1	M09-06	16 9	0 352	1 47	1831	18 2
M04-09	17 4	0 459	1 76	2079	19 1	M09-07	17 7	0 491	1 53	1787	19 5
M05-01	18 2	0 455	1 97	2220	20 0	M09-08	17 0	0 428	1 66	2013	18 6
M05-02	19 4	0 424	2 05	2196	21 1	M09-09	17 5	0 252	1 51	1865	18 5
M05-03	18 5	0 323	1 94	2215	19 7	M09-10	16 4	0 463	1 29	1625	18 1
M05-04	15 7	0 308	1 70	2266	16 9	M10-01	19 7	0 456	1 44	1550	21 3
M05-05	15 7	0 314	1 68	2239	16 9	M10-02	19 4	0 482	1 69	1813	21 2
M05-06	15 7	0 328	1 64	2184	17 0	M10-03	13 0	0 103	1 20	2038	13 4
M05-07	15 6	0 303	1 67	2231	16 8	M10-04	13 5	0 355	1 28	1964	14 8
M05-08	20 8	0 339	1 97	2021	22 1	M10-05	18 5	0 395	1 65	1880	20 0

ThO_2* is for monazite (M) and UO_2* for zircon (Z), xenotime (X) and polycrase (P), refer to the text for definition
Apparent ages were calculated through equation 1 in SUZUKI's papers cited (*e g* SUZUKI and ADACHI, 1991a)
Analyzed position is shown for some grains *e g* M17 037103 means 37μm from right and 103μm from top

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2^* UO_2^*	Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2^* UO_2^*
M10-06	19 1	0 453	1 29	1430	20 7	M13-12	21 5	0 421	2 03	1991	23 1
M10-07	14 6	0 308	1 23	1781	15 7	M13-13	21 1	0 448	2 04	2021	22 8
M10-08	16 6	0 253	1 59	2041	17 6	M13-14	20 8	0 484	2 00	1999	22 7
M10-09	17 2	0 268	1 51	1883	18 2	M13-15	23 1	0 336	2 17	2017	24 3
M11-01	19 8	0 513	1 96	2037	21 8	M14-01	22 1	0 458	2 14	2027	23 9
M11-02	20 5	0 462	2 04	2070	22 3	M14-02	21 5	0 483	2 04	1981	23 3
M11-03	16 2	0 340	1 61	2080	17 5	M14-03	22 4	0 431	1 89	1793	24 0
M11-04	16 6	0 264	1 63	2087	17 6	M14-04	22 1	0 448	1 87	1791	23 8
M11-05	16 2	0 238	1 58	2084	17 1	M14-05	17 1	0 443	1 63	1969	18 7
M11-06	19 0	0 481	1 91	2075	20 9	M14-06	17 6	0 407	1 72	2028	19 2
M11-07	18 4	0 484	1 90	2108	20 3	M14-07	16 7	0 413	1 50	1872	18 3
M11-08	20 1	0 476	2 12	2179	22 0	M14-08	22 7	0 370	2 00	1885	24 1
M11-09	19 6	0 499	2 10	2202	21 5	M14-09	21 4	0 499	2 03	1981	23 3
M11-10	18 3	0 490	1 94	2167	20 2	M14-10	16 9	0 425	1 58	1938	18 5
M11-11	16 4	0 416	1 56	1966	18 0	M14-11	17 3	0 440	1 65	1977	19 0
M11-12	20 4	0 516	2 13	2143	22 4	M14-12	20 8	0 518	2 06	2044	22 8
M11-13	20 3	0 511	2 12	2153	22 3	M14-13	17 5	0 428	1 69	2006	19 1
M11-14	18 3	0 496	1 89	2113	20 2	M14-14	17 4	0 442	1 72	2037	19 1
M11-15	18 2	0 412	1 71	1962	19 8	M14-15	21 8	0 437	1 97	1908	23 5
M11-16	15 8	0 387	1 60	2086	17 3	M15-01	17 9	0 460	1 77	2041	19 7
M11-17	17 4	0 354	1 51	1839	18 7	M15-02	19 1	0 481	1 87	2020	21 0
M11-18	19 5	0 504	2 00	2108	21 4	M15-03	20 5	0 400	1 94	2000	22 0
M11-19	19 1	0 487	1 88	2032	21 0	M15-04	21 2	0 366	2 01	2015	22 6
M11-20	17 1	0 467	1 65	1985	18 8	M15-05	20 8	0 354	1 92	1968	22 2
M12-01	17 4	0 367	1 66	2006	18 8	M15-06	19 1	0 402	1 78	1959	20 6
M12-02	16 5	0 308	1 41	1820	17 7	M15-07	21 8	0 534	2 13	2025	23 8
M12-03	20 2	0 439	1 89	1962	21 9	M15-08	24 2	0 353	2 31	2042	25 6
M12-04	20 2	0 505	2 10	2138	22 2	M15-09	24 0	0 311	2 27	2037	25 2
M12-05	19 5	0 514	1 68	1790	21 4	M15-10	24 1	0 320	2 29	2043	25 3
M12-06	19 6	0 506	2 10	2197	21 6	M15-11	21 9	0 503	2 15	2044	23 8
M12-07	17 1	0 458	1 86	2220	18 9	M15-12	23 6	0 392	2 29	2064	25 1
M12-08	17 3	0 464	1 77	2098	19 1	M15-13	23 5	0 491	2 29	2041	25 4
M12-09	10 2	0 323	1 02	2020	11 4	M15-14	22 9	0 488	2 27	2069	24 8
M12-10	20 9	0 446	2 10	2102	22 6	M16-01	19 9	0 533	1 90	1958	22 0
M12-11	17 1	0 421	1 82	2182	18 8	M16-02	19 9	0 559	1 98	2033	22 0
M12-12	21 5	0 450	2 15	2089	23 2	M16-03	21 5	0 465	2 12	2063	23 3
M12-13	20 4	0 514	2 05	2069	22 4	M16-04	18 8	0 533	1 89	2051	20 9
M12-14	20 3	0 491	2 02	2064	22 2	M16-05	19 4	0 222	1 64	1845	20 2
M12-15	21 4	0 441	2 12	2079	23 1	M16-06	18 6	0 569	1 89	2061	20 8
M13-01	20 3	0 535	2 00	2025	22 4	M16-07	20 3	0 483	2 03	2079	22 1
M13-02	20 3	0 521	1 99	2023	22 3	M16-08	20 0	0 497	1 61	1688	21 8
M13-03	23 8	0 585	2 13	1861	26 0	M16-09	18 8	0 240	1 41	1640	19 7
M13-04	22 6	0 349	2 12	2012	23 9	M16-10	19 1	0 245	1 29	1481	20 0
M13-05	20 9	0 456	1 99	1991	22 6	M17 032098	14 3	0 462	1 49	2089	16 1
M13-06	24 0	0 308	2 24	2017	25 2	M17 037086	15 9	0 495	1 64	2084	17 8
M13-07	18 0	0 266	1 59	1899	19 0	M17 037094	15 8	0 499	1 66	2109	17 8
M13-08	20 3	0 516	2 00	2030	22 3	M17 037103	15 7	0 487	1 68	2153	17 6
M13-09	21 0	0 466	2 06	2042	22 8	M17 037110	14 9	0 476	1 58	2129	16 7
M13-10	20 9	0 461	2 02	2022	22 7	M17 037116	11 1	0 412	1 12	1989	12 7
M13-11	17 8	0 274	1 67	2009	18 8	M17 045073	16 6	0 533	1 82	2199	18 7

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*	Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
M17 045082	16 7	0 526	1 81	2183	18 7	M18 117095	11 7	0 451	1 42	2363	13 5
M17 045090	16 9	0 530	1 84	2188	19 0	M18 069103	16 3	0 624	1 98	2369	18 8
M17 045098	16 9	0 544	1 84	2176	19 0	M18 077103	16 9	0 629	2 06	2380	19 5
M17 045107	16 6	0 517	1 79	2169	18 6	M18 088103	16 7	0 620	2 05	2393	19 2
M17 045117	16 2	0 523	1 79	2216	18 2	M18 099103	17 6	0 559	2 12	2395	19 8
M17 045125	9 39	0 347	0 853	1816	10 7	M18 108103	17 8	0 561	2 15	2405	20 0
M17 051067	16 4	0 546	1 81	2195	18 6	M18 117103	16 1	0 577	1 94	2367	18 4
M17 051076	18 4	0 608	2 07	2245	20 8	M18 068111	18 0	0 400	2 06	2366	19 6
M17 051085	20 1	0 499	2 18	2228	22 0	M18 079111	14 3	0 385	1 70	2412	15 8
M17 051094	20 7	0 432	2 20	2214	22 4	M18 089111	16 7	0 601	2 04	2403	19 1
M17 051105	20 8	0 436	2 23	2233	22 5	M18 104111	16 5	0 567	2 02	2411	18 8
M17 051113	20 7	0 416	2 18	2198	22 4	M18 112111	17 6	0 571	2 14	2411	19 9
M17 051123	18 6	0 473	1 99	2199	20 4	M18 127111	17 0	0 621	2 06	2369	19 5
M17 058072	19 3	0 597	2 24	2318	21 7	M18 065119	13 5	0 521	1 67	2397	15 6
M17 058081	20 6	0 430	2 26	2283	22 3	M18 071119	15 2	0 404	1 79	2395	16 8
M17 058089	20 4	0 436	2 22	2258	22 1	M18 079119	13 2	0 384	1 56	2373	14 8
M17 058098	20 3	0 422	2 22	2271	22 0	M18 094119	17 0	0 573	2 07	2403	19 3
M17 058108	20 1	0 431	2 21	2278	21 8	M18 111119	17 5	0 570	2 07	2353	19 8
M17 058115	20 1	0 414	2 18	2261	21 7	M18 119119	17 2	0 600	2 07	2365	19 6
M17 058127	19 9	0 448	2 16	2247	21 7	M18 125119	16 8	0 612	2 07	2401	19 3
M17 065076	18 2	0 541	2 10	2319	20 3	M18 141119	15 2	0 585	1 71	2209	17 5
M17 065086	19 9	0 435	2 24	2333	21 6	M18 061128	8 69	0 346	1 02	2278	10 1
M17 065093	19 6	0 433	2 23	2349	21 3	M18 068128	12 8	0 510	1 53	2320	14 8
M17 065100	19 5	0 432	2 19	2323	21 2	M18 077128	13 3	0 407	1 31	2003	14 8
M17 065108	19 4	0 442	2 23	2364	21 1	M18 084128	13 3	0 418	0 988	1529	14 8
M17 065116	19 3	0 443	2 22	2372	21 0	M18 095128	15 2	0 546	1 59	2084	17 3
M17 065126	18 9	0 438	2 18	2379	20 6	M18 110128	15 6	0 616	1 92	2379	18 1
M17 065134	4 87	0 246	0 558	2161	5 83	M18 120128	16 5	0 607	2 03	2404	18 9
M17 074085	10 2	0 464	2 25	3858	12 6	M18 130128	16 5	0 646	1 78	2123	19 0
M17 074093	12 2	0 437	2 27	3472	14 3	M18 139128	16 4	0 639	1 72	2057	18 9
M17 074100	19 1	0 479	2 23	2376	21 0	M18 143128	15 1	0 604	1 38	1812	17 3
M17 074108	19 2	0 429	2 24	2403	20 9	M18 066135	6 18	0 279	0 670	2088	7 25
M17 074116	19 2	0 447	2 24	2393	21 0	M18 078135	12 9	0 443	1 61	2451	14 7
M17 074126	19 1	0 462	2 13	2292	20 9	M18 089135	12 5	0 382	1 18	1933	13 9
M17 074135	3 92	0 199	0 480	2291	4 71	M18 099135	16 6	0 546	2 03	2417	18 8
M17 083083	18 5	0 529	2 18	2373	20 7	M18 113135	16 1	0 606	1 98	2392	18 6
M17 083092	18 8	0 527	2 25	2409	20 9	M18 122135	16 4	0 647	2 06	2420	19 0
M17 083102	18 9	0 518	2 24	2401	20 9	M18 139135	16 1	0 634	2 00	2404	18 6
M17 083112	18 5	0 530	2 23	2425	20 6	M18 153135	13 2	0 522	1 62	2378	15 3
M17 083120	18 3	0 512	2 21	2430	20 4	M18 079146	12 4	0 429	1 45	2312	14 1
M17 083128	11 1	0 459	1 64	2797	13 0	M18 100146	13 2	0 380	1 59	2430	14 7
M17 091099	18 4	0 567	2 23	2422	20 7	M18 111146	16 9	0 558	2 06	2419	19 1
M17 091108	18 4	0 556	2 23	2419	20 7	M18 126146	16 2	0 626	2 06	2460	18 7
M17 091117	17 5	0 563	2 15	2438	19 7	M18 143146	14 2	0 567	1 79	2434	16 5
M17 091124	13 3	0 505	1 63	2386	15 3	M18 157146	11 2	0 463	1 41	2420	13 1
M17 096112	15 5	0 563	1 92	2421	17 8	M18 166146	4 01	0 265	0 494	2205	5 05
M18 082095	12 9	0 492	1 57	2381	14 8	M18 106159	4 54	0 233	0 538	2221	5 45
M18 089095	15 2	0 548	1 84	2380	17 4	M18 120159	11 9	0 439	1 36	2256	13 6
M18 097085	16 5	0 580	2 00	2380	18 8	M18 133159	11 8	0 413	1 46	2439	13 4
M18 107095	12 6	0 470	1 52	2369	14 4	M18 149159	9 93	0 439	1 20	2312	11 7

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
M19 061093	17 3	0 520	1 83	2141	19 3
M19 061103	17 5	0 530	1 80	2084	19 5
M19 072084	17 2	0 519	1 80	2124	19 2
M19 072094	17 4	0 530	1 84	2126	19 5
M19 072106	18 3	0 608	1 97	2151	20 7
M19 072124	15 0	0 487	1 55	2080	16 9
M19 081077	17 1	0 543	1 84	2164	19 2
M19 081089	19 1	0 652	2 11	2195	21 6
M19 081099	19 1	0 632	2 05	2150	21 5
M19 081110	18 3	0 608	2 04	2227	20 7
M19 081121	16 8	0 585	1 88	2215	19 1
M19 081129	16 2	0 543	1 74	2150	18 3
M19 094069	19 2	0 647	2 16	2235	21 8
M19 094079	18 9	0 631	2 11	2233	21 3
M19 094091	18 6	0 644	2 08	2225	21 1
M19 094107	18 1	0 631	2 03	2223	20 6
M19 094120	17 5	0 629	1 98	2231	20 0
M19 094137	15 8	0 556	1 77	2215	18 0
M19 094188	14 7	0 522	1 72	2305	16 8
M19 117060	19 3	0 581	2 12	2208	21 6
M19 117076	18 3	0 643	2 15	2317	20 9
M19 117089	18 0	0 639	2 09	2285	20 6
M19 117115	16 6	0 531	1 87	2258	18 7
M19 117138	18 1	0 590	2 00	2207	20 4
M19 117181	14 6	0 509	1 67	2260	16 6
M19 117193	14 4	0 504	1 59	2194	16 4
M19 136050	17 6	0 631	1 67	1891	20 0
M19 136066	18 6	0 571	2 07	2238	20 8
M19 136088	17 6	0 667	2 06	2285	20 3
M19 136115	16 6	0 623	1 94	2286	19 1
M19 136135	16 6	0 651	1 98	2322	19 2
M19 136162	16 9	0 621	1 97	2287	19 4
M19 136190	17 1	0 618	2 04	2348	19 5
M19 156068	14 8	0 400	1 71	2337	16 4
M19 156091	17 1	0 604	2 00	2311	19 4
M19 156109	16 4	0 617	1 95	2327	18 9
M19 156138	16 9	0 629	2 03	2346	19 4
M19 156164	17 1	0 598	2 09	2403	19 5
M19 156184	17 7	0 548	2 14	2418	19 9
M19 180102	14 5	0 527	1 76	2379	16 6
M19 180121	14 6	0 537	1 81	2420	16 8
M19 180142	17 3	0 590	2 18	2484	19 7
M19 180155	16 7	0 628	2 12	2469	19 2
M19 192117	13 7	0 536	1 63	2324	15 8
M19 192126	12 7	0 498	1 49	2278	14 7
M19 192136	14 2	0 548	1 67	2299	16 4
Z01-01	0 034	0 060	0 024	2081	0 068
Z01-02	0 026	0 159	0 072	2441	0 166
Z01-03	0 025	0 159	0 074	2488	0 165
Z01-04	0 055	0 096	0 048	2453	0 110
Z01-05	0 021	0 136	0 060	2404	0 141
Z02-01	0 053	0 135	0 062	2368	0 148
Z02-02	0 057	0 176	0 083	2444	0 190
Z02-03	0 035	0 118	0 056	2449	0 127
Z02-04	0 052	0 168	0 076	2375	0 181
Z02-05	0 035	0 105	0 052	2532	0 114
Z03-01	0 010	0 157	0 068	2389	0 160
Z03-02	0 011	0 182	0 079	2410	0 185
Z03-03	0 019	0 172	0 078	2472	0 177
Z03-04	0 006	0 268	0 068	1611	0 270
Z03-05	0 014	0 178	0 081	2488	0 182
Z04-01	0 021	0 192	0 086	2440	0 197
Z04-02	0 042	0 193	0 088	2431	0 203
Z04-03	0 040	0 195	0 090	2460	0 204
Z04-04	0 027	0 174	0 076	2389	0 181
Z04-05	0 027	0 189	0 084	2415	0 195
Z04-06	0 029	0 178	0 083	2488	0 185
Z05-01	0 030	0 340	0 151	2440	0 347
Z05-02	0 033	0 269	0 121	2446	0 277
Z05-03	0 031	0 117	0 049	2278	0 124
Z05-04	0 023	0 130	0 059	2438	0 136
Z05-05	0 022	0 121	0 043	2008	0 127
Z05-06	0 022	0 146	0 065	2423	0 151
Z05-07	0 027	0 360	0 162	2468	0 367
Z05-08	0 045	0 529	0 236	2445	0 540
Z05-09	0 010	0 339	0 150	2454	0 341
Z05-10	0 009	0 079	0 031	2230	0 081
Z06-01	0 052	0 169	0 080	2444	0 182
Z06-02	0 050	0 163	0 076	2440	0 175
Z06-03	0 045	0 130	0 057	2296	0 141
Z06-04	0 041	0 141	0 051	2020	0 151
Z06-05	0 038	0 139	0 053	2087	0 149
Z07-01	0 042	0 078	0 030	2020	0 088
Z07-02	0 025	0 127	0 044	1990	0 133
Z07-03	0 029	0 154	0 058	2125	0 162
Z07-04	0 043	0 112	0 032	1618	0 123
Z07-05	0 042	0 072	0 027	1967	0 083
Z08-01	0 037	0 075	0 029	2048	0 085
Z08-02	0 018	0 197	0 075	2172	0 201
Z08-03	0 022	0 200	0 089	2441	0 205
Z08-04	0 037	0 077	0 037	2434	0 086
Z08-05	0 025	0 145	0 068	2504	0 151
Z09-01	0 044	0 073	0 027	1945	0 085
Z09-02	0 030	0 068	0 024	1911	0 076
Z09-03	0 030	0 108	0 029	1579	0 116
Z09-04	0 021	0 121	0 057	2514	0 126
Z09-05	0 041	0 069	0 035	2466	0 079
Z10-01	0 016	0 109	0 045	2289	0 113
Z10-02	0 021	0 096	0 044	2426	0 101
Z10-03	0 020	0 101	0 035	1985	0 106

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*	Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
Z11-01	0 049	0 112	0 055	2466	0 124	Z16-09	0 041	0 058	0 029	2380	0 068
Z11-02	0 068	0 089	0 047	2476	0 105	Z17-01	0 031	0 084	0 040	2463	0 092
Z11-03	0 051	0 134	0 053	2125	0 147	Z17-02	0 011	0 162	0 073	2465	0 164
Z11-04	0 051	0 152	0 058	2082	0 165	Z17-03	0 007	0 183	0 095	2749	0 185
Z11-05	0 048	0 135	0 063	2423	0 146	Z17-04	0 005	0 172	0 106	3078	0 173
Z11-06	0 047	0 134	0 062	2403	0 145	Z17-05	0 009	0 195	0 085	2427	0 197
Z11-07	0 059	0 132	0 064	2443	0 147	Z17-06	0 013	0 175	0 070	2261	0 178
Z12-01	0 044	0 102	0 050	2472	0 112	Z17-07	0 010	0 261	0 112	2404	0 263
Z12-02	0 044	0 073	0 036	2432	0 083	Z17-08	0 013	0 203	0 090	2438	0 207
Z12-03	0 033	0 101	0 047	2412	0 109	Z17-09	0 009	0 182	0 081	2456	0 184
Z12-04	0 015	0 098	0 044	2439	0 101	Z17-10	0 010	0 200	0 086	2400	0 202
Z12-05	0 014	0 096	0 043	2429	0 100	Z17-11	0 010	0 163	0 057	2049	0 165
Z12-06	0 022	0 109	0 048	2359	0 114	Z17-12	0 022	0 293	0 129	2427	0 299
Z12-07	0 008	0 152	0 066	2426	0 154	Z17-13	0 011	0 248	0 109	2429	0 251
Z12-08	0 013	0 153	0 067	2416	0 157	Z17-14	0 014	0 234	0 103	2433	0 238
Z12-09	0 027	0 136	0 060	2379	0 143	Z17-15	0 012	0 154	0 067	2416	0 157
Z12-10	0 006	0 094	0 040	2368	0 096	Z18-01	0 014	0 154	0 068	2431	0 157
Z12-11	0 006	0 189	0 082	2418	0 190	Z18-02	0 034	0 108	0 052	2488	0 116
Z12-12	0 011	0 179	0 080	2472	0 181	Z18-03	0 037	0 093	0 047	2532	0 102
Z12-13	0 019	0 180	0 069	2187	0 185	Z18-04	0 031	0 101	0 045	2367	0 109
Z12-14	0 008	0 110	0 045	2292	0 112	Z18-05	0 019	0 186	0 073	2226	0 191
Z12-15	0 026	0 139	0 063	2429	0 145	Z18-06	0 042	0 061	0 025	2069	0 072
Z13-01	0 046	0 147	0 060	2187	0 159	Z18-07	0 036	0 084	0 030	1943	0 093
Z13-02	0 047	0 152	0 055	2015	0 164	Z18-08	0 026	0 065	0 031	2408	0 072
Z13-03	0 047	0 103	0 043	2175	0 115	Z18-09	0 032	0 075	0 037	2515	0 082
Z13-04	0 032	0 091	0 038	2237	0 099	Z18-10	0 032	0 075	0 036	2439	0 083
Z13-05	0 054	0 099	0 050	2461	0 113	Z18-11	0 030	0 093	0 034	2018	0 100
Z14-01	0 037	0 065	0 033	2456	0 074	Z18-12	0 035	0 074	0 036	2465	0 082
Z14-02	0 041	0 072	0 027	1965	0 082	Z18-13	0 038	0 067	0 034	2477	0 076
Z14-03	0 027	0 075	0 027	1958	0 082	Z18-14	0 027	0 096	0 033	1925	0 103
Z14-04	0 048	0 058	0 019	1675	0 071	Z18-15	0 047	0 109	0 035	1770	0 122
Z14-05	0 010	0 251	0 109	2417	0 254	Z18-16	0 022	0 181	0 080	2412	0 187
Z14-06	0 006	0 176	0 077	2428	0 177	Z18-17	0 028	0 133	0 061	2444	0 140
Z14-07	0 050	0 064	0 035	2524	0 076	Z18-18	0 032	0 100	0 048	2485	0 107
Z14-08	0 043	0 060	0 032	2498	0 070	Z18-19	0 026	0 094	0 045	2465	0 101
Z14-09	0 049	0 059	0 030	2401	0 071	Z18-20	0 034	0 088	0 041	2399	0 096
Z14-10	0 046	0 070	0 035	2417	0 081						
Z15-01	0 058	0 104	0 038	1936	0 119	Sample 2023B from Beaver Island					
Z15-02	0 057	0 071	0 034	2271	0 086	M01-01	8 72	0 125	0 991	2410	9 22
Z15-03	0 055	0 080	0 041	2443	0 094	M01-02	8 00	0 240	0 960	2404	8 96
Z15-04	0 050	0 086	0 044	2469	0 099	M01-03	8 04	0 242	0 975	2425	9 01
Z15-05	0 060	0 122	0 048	2077	0 137	M01-04	8 09	0 220	0 968	2418	8 98
Z16-01	0 045	0 057	0 030	2490	0 068	M01-05	8 28	0 135	0 952	2418	8 82
Z16-02	0 073	0 056	0 019	1619	0 076	M01-06	8 70	0 141	0 992	2400	9 27
Z16-03	0 049	0 060	0 018	1574	0 073	M01-07	8 51	0 142	0 951	2353	9 08
Z16-04	0 044	0 074	0 036	2361	0 085	M01-08	8 23	0 264	0 981	2371	9 29
Z16-05	0 049	0 089	0 034	1997	0 102	M01-09	8 08	0 247	0 967	2391	9 07
Z16-06	0 046	0 069	0 032	2287	0 081	M01-10	8 30	0 154	0 955	2402	8 92
Z16-07	0 039	0 062	0 026	2114	0 072	M01-11	8 03	0 146	0 928	2415	8 62
Z16-08	0 044	0 055	0 030	2520	0 066	M01-12	7 52	0 197	0 830	2252	8 30

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
M01-13	8 19	0 253	0 972	2371	9 20
M01-14	8 09	0 205	0 941	2372	8 91
M01-15	7 58	0 179	0 819	2229	8 28
M01-16	8 43	0 136	0 958	2394	8 98
M01-17	8 03	0 138	0 851	2238	8 57
M02-01	7 14	0 155	0 830	2397	7 76
M02-02	7 51	0 139	0 858	2386	8 07
M02-03	8 78	0 148	0 985	2361	9 37
M02-04	9 11	0 157	0 965	2234	9 73
M02-05	8 31	0 139	0 941	2383	8 86
M02-06	7 21	0 152	0 841	2413	7 82
M02-07	10 4	0 147	1 19	2423	11 0
M02-08	10 3	0 154	1 17	2399	11 0
M02-09	10 5	0 136	1 18	2397	11 0
M02-10	7 14	0 154	0 825	2384	7 76
M02-11	8 92	0 149	1 01	2374	9 51
M02-12	10 2	0 136	1 14	2391	10 7
M02-13	8 77	0 171	1 01	2402	9 45
M02-14	10 5	0 143	1 18	2390	11 0
M02-15	8 74	0 133	1 00	2423	9 27
M02-16	10 0	0 148	0 998	2127	10 6
M02-17	10 7	0 131	1 20	2404	11 2
M02-18	8 10	0 147	0 927	2392	8 69
M02-19	7 73	0 153	0 876	2361	8 33
M02-20	7 58	0 166	0 879	2391	8 24
M02-21	8 26	0 147	0 886	2257	8 84
M02-22	7 19	0 156	0 839	2408	7 82
M03-01	10 3	0 141	1 15	2382	10 8
M03-02	9 40	0 202	1 07	2364	10 2
M03-03	9 95	0 155	1 12	2387	10 6
M03-04	9 96	0 160	1 14	2407	10 6
M04-01	8 73	0 165	1 00	2393	9 39
M04-02	8 31	0 184	0 918	2286	9 04
M04-03	8 61	0 175	0 984	2374	9 30
M04-04	7 89	0 207	0 849	2199	8 70
M04-05	7 38	0 204	0 870	2383	8 20
M04-06	9 46	0 175	1 08	2390	10 2
M04-07	8 70	0 170	0 926	2228	9 36
M04-08	8 63	0 176	0 996	2393	9 34
M05-01	8 21	0 149	0 936	2386	8 81
M05-02	9 08	0 129	1 02	2379	9 59
M05-03	8 60	0 138	0 990	2423	9 16
M05-04	8 50	0 142	0 954	2362	9 07
M05-05	8 52	0 142	0 968	2389	9 09
M05-06	8 49	0 124	0 963	2402	8 99
M05-07	8 77	0 142	0 987	2373	9 34
M05-08	8 79	0 149	0 994	2377	9 39
M05-09	8 21	0 135	0 929	2383	8 75
M06-01	8 60	0 252	1 02	2388	9 61
M06-02	8 77	0 258	0 984	2262	9 79
M06-03	8 30	0 248	0 900	2189	9 27
M06-04	8 71	0 297	0 988	2252	9 88
M06-05	7 05	0 137	0 786	2324	7 60
M06-06	7 33	0 151	0 845	2389	7 94
M06-07	7 20	0 129	0 826	2401	7 72
M06-08	6 44	0 145	0 746	2386	7 01
M06-09	7 26	0 144	0 845	2417	7 84
M07-01	8 91	0 301	1 08	2400	10 1
M07-02	9 02	0 286	1 09	2403	10 2
M07-03	8 21	0 204	0 961	2386	9 03
M07-04	8 79	0 301	1 06	2387	10 00
M07-05	8 88	0 270	1 07	2416	9 97
M07-06	8 10	0 285	0 985	2392	9 24
M07-07	8 23	0 198	0 963	2396	9 02
M07-08	8 89	0 300	1 10	2431	10 1
M07-09	8 89	0 289	1 07	2394	10 1
M07-10	8 84	0 296	1 08	2417	10 0
M07-11	8 85	0 308	1 09	2419	10 1
M07-12	8 71	0 288	1 05	2394	9 86
M07-13	8 77	0 298	1 06	2395	9 96
M07-14	8 79	0 286	1 07	2420	9 94
M07-15	8 68	0 310	1 06	2400	9 92
Sample 2306E from Reference Peak					
M01 035050	9 84	0 198	1 14	2407	10 6
M01 022068	9 83	0 218	1 13	2370	10 7
M01 022093	9 63	0 223	1 13	2414	10 5
M01 022109	9 70	0 206	1 14	2418	10 5
M01 015125	9 60	0 215	1 12	2410	10 5
M01 019139	9 78	0 215	1 14	2400	10 6
M01 019155	9 76	0 223	1 14	2402	10 7
M01 019165	9 82	0 215	1 16	2433	10 7
M01 035071	9 58	0 211	1 10	2367	10 4
M01 035091	9 72	0 212	1 14	2417	10 6
M01 035112	9 76	0 194	1 14	2424	10 5
M01 035136	9 74	0 198	1 13	2412	10 5
M01 035166	10 7	0 202	1 24	2405	11 6
M01 035193	9 96	0 217	1 16	2408	10 8
M01 059024	9 79	0 203	1 16	2441	10 6
M01 059035	9 61	0 212	1 13	2416	10 5
M01 059050	9 74	0 222	1 14	2399	10 6
M01 059077	9 80	0 201	1 13	2398	10 6
M01 059097	9 65	0 218	1 13	2410	10 5
M01 059127	9 97	0 200	1 17	2438	10 8
M01 059147	10 9	0 193	1 26	2423	11 7
M01 059178	9 75	0 219	1 15	2425	10 6
M01 059211	10 0	0 212	1 17	2412	10 9
M01 059224	9 91	0 220	1 16	2401	10 8
M01 084007	9 77	0 221	1 14	2398	10 7
M01 084021	9 77	0 219	1 15	2419	10 6

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
M01 084041	9 99	0 214	1 16	2398	10 8
M01 084071	9 54	0 210	1 13	2445	10 4
M01 084097	9 57	0 213	1 10	2371	10 4
M01 084136	9 70	0 217	1 12	2381	10 6
M01 084170	9 81	0 196	1 14	2412	10 6
M01 084208	9 10	0 228	1 07	2406	10 0
M01 084234	9 58	0 218	1 13	2412	10 5
M01 118012	9 97	0 213	1 14	2375	10 8
M01 118035	9 57	0 238	1 12	2391	10 5
M01 118059	10 3	0 220	1 19	2397	11 2
M01 118098	10 4	0 209	1 21	2412	11 3
M01 118132	10 4	0 205	1 20	2405	11 2
M01 118178	10 1	0 218	1 18	2399	11 0
M01 118203	9 95	0 216	1 15	2381	10 8
M01 118231	9 51	0 238	1 13	2411	10 5
M01 139035	9 57	0 206	1 07	2320	10 4
M01 139060	10 4	0 205	1 21	2411	11 2
M01 139103	10 2	0 211	1 19	2401	11 1
M01 139150	10 4	0 200	1 20	2407	11 2
M01 139169	10 1	0 229	1 19	2420	11 1
M01 139201	9 65	0 227	1 13	2395	10 6
M01 158068	9 41	0 226	1 10	2390	10 3
M01 158087	9 44	0 210	1 12	2446	10 3
M01 158112	9 44	0 227	1 11	2404	10 4
M01 158138	10 4	0 210	1 22	2437	11 3
M01 158162	9 99	0 211	1 17	2414	10 8
M01 158179	9 79	0 226	1 15	2417	10 7
M01 181089	9 40	0 225	1 12	2433	10 3
M01 181106	9 27	0 225	1 10	2429	10 2
M01 181118	9 52	0 223	1 12	2406	10 4
M01 181130	9 71	0 225	1 14	2402	10 6
M01 181141	9 71	0 211	1 13	2404	10 6
M02 051038	9 15	0 235	1 06	2367	10 1
M02 051060	9 23	0 178	1 07	2417	9 95
M02 051080	9 37	0 289	1 13	2406	10 5
M02 051099	8 89	0 234	1 02	2333	9 82
M02 051117	9 26	0 201	1 08	2399	10 1
M02 051144	9 18	0 222	1 08	2404	10 1
M02 051168	9 16	0 236	1 10	2430	10 1
M02 033162	9 21	0 241	1 09	2400	10 2
M02 033141	9 36	0 212	1 10	2415	10 2
M02 033118	9 27	0 221	1 08	2396	10 2
M02 033100	9 11	0 239	1 09	2428	10 1
M02 033077	9 33	0 228	1 10	2411	10 3
M02 021060	9 18	0 237	1 07	2373	10 1
M02 013085	8 93	0 244	1 04	2360	9 90
M02 074122	8 96	0 241	1 07	2411	9 93
M02 074148	9 12	0 250	1 09	2404	10 1
M02 074162	9 16	0 241	1 09	2406	10 1
M02 080162	9 12	0 235	1 03	2298	10 1
M02 108162	9 16	0 249	1 01	2240	10 1
M02 127162	8 79	0 240	0 664	1573	9 66
M02 145162	9 15	0 240	0 972	2175	10 1
M02 168162	9 14	0 224	1 09	2431	10 0
M02 146176	8 49	0 271	0 564	1374	9 45
M02 116176	8 74	0 239	1 00	2326	9 69
M02 099176	9 28	0 237	1 03	2271	10 2
M02 146037	9 47	0 231	1 12	2416	10 4
M02 146057	9 40	0 219	1 11	2426	10 3
M02 146076	9 33	0 223	1 10	2418	10 2
M02 146097	9 47	0 215	1 11	2409	10 3
M02 146119	9 39	0 235	1 09	2372	10 3
M02 146141	9 20	0 240	1 09	2406	10 2
M02 130119	9 61	0 218	1 05	2258	10 5
M02 130112	9 32	0 227	1 11	2426	10 2
M02 130018	9 44	0 221	1 11	2401	10 3
M02 090018	9 34	0 238	1 06	2313	10 3
M02 130037	9 33	0 229	1 10	2409	10 2
M02 160050	4 83	0 130	0 572	2399	5 35
M02 021078	9 40	0 237	1 10	2385	10 4
M02 021097	9 36	0 249	1 06	2307	10 3
M02 021111	9 31	0 236	1 06	2325	10 2
M02 021125	9 26	0 234	1 07	2348	10 2
M02 043162	9 33	0 244	1 10	2399	10 3
M02 043178	9 32	0 250	1 11	2410	10 3
M02 043156	9 49	0 242	1 13	2414	10 5
M02 043131	9 45	0 247	1 12	2401	10 4
M02 043112	9 27	0 266	1 10	2382	10 3
M02 043094	9 36	0 302	1 10	2338	10 6
M02 043050	9 34	0 249	1 11	2404	10 3
M02 064034	9 25	0 252	1 07	2338	10 3
M02 064066	9 38	0 223	1 07	2339	10 3
M02 064094	9 94	0 230	1 13	2344	10 9
M02 064133	8 99	0 250	1 07	2396	9 99
M02 064154	9 24	0 242	1 10	2424	10 2
M02 064172	9 35	0 245	1 10	2395	10 3
M02 064190	5 79	0 176	0 648	2249	6 48
M02 084170	9 28	0 246	1 08	2369	10 3
M02 084162	9 26	0 242	1 05	2318	10 2
M02 084039	9 39	0 241	1 09	2357	10 4
M02 112016	9 49	0 236	1 11	2379	10 4
M02 112028	9 40	0 239	1 09	2354	10 4
M02 112167	9 31	0 246	0 929	2051	10 2
M02 112185	9 02	0 256	1 05	2352	10 0
M02 138180	8 95	0 244	0 676	1574	9 84
M02 138138	9 70	0 243	1 13	2384	10 7
M02 138121	9 63	0 234	1 09	2325	10 6
M02 138043	9 05	0 219	1 06	2390	9 93
M02 138030	9 43	0 228	1 12	2427	10 3
M02 160069	9 63	0 227	1 14	2427	10 5

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*	Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
M02 160089	9 56	0 231	1 12	2403	10 5	M03 103156	9 28	0 238	1 08	2371	10 2
M02 160109	9 59	0 230	1 14	2426	10 5	M03 103169	10 2	0 222	1 01	2068	11 0
M02 160122	9 48	0 235	1 11	2390	10 4	M03 103193	10 2	0 217	1 00	2051	11 0
M02 160161	9 66	0 225	1 14	2417	10 6	M03 121049	9 16	0 277	1 07	2344	10 3
M02 160172	9 37	0 231	1 09	2373	10 3	M03 121067	9 22	0 275	1 11	2406	10 3
M02 173127	9 31	0 231	1 07	2359	10 2	M03 121084	9 26	0 240	1 09	2394	10 2
M03 029050	9 14	0 235	1 08	2401	10 1	M03 121105	8 92	0 240	1 05	2389	9 89
M03 031069	9 14	0 236	1 08	2405	10 1	M03 121126	9 15	0 255	1 08	2385	10 2
M03 031081	8 82	0 253	1 06	2406	9 84	M03 121143	9 20	0 243	1 09	2396	10 2
M03 043041	9 15	0 249	1 09	2399	10 2	M03 121160	9 34	0 251	1 12	2417	10 3
M03 043052	8 78	0 269	1 05	2394	9 86	M03 137074	9 34	0 257	1 10	2379	10 4
M03 043073	9 00	0 247	1 06	2382	9 99	M03 137103	9 14	0 216	1 07	2397	10 0
M03 043086	8 88	0 277	1 06	2383	9 99	M03 137122	8 93	0 243	1 04	2363	9 90
M03 043103	9 13	0 234	1 07	2376	10 1	M03 137150	9 36	0 252	1 06	2305	10 4
M03 043118	4 31	0 112	0 486	2298	4 75	M03 145115	9 48	0 229	1 09	2357	10 4
M03 043133	9 52	0 276	1 15	2432	10 6	M03 115115	9 18	0 237	1 09	2411	10 1
M03 043158	9 32	0 233	1 10	2412	10 3	M03 090115	8 84	0 265	1 07	2414	9 90
M03 043167	10 6	0 214	1 16	2269	11 5	M03 073115	8 80	0 252	1 06	2415	9 81
M03 064022	9 35	0 252	1 11	2394	10 4						
M03 064034	9 04	0 239	1 08	2430	10 0	Sample 2306J from Reference Peak					
M03 064045	8 89	0 255	1 07	2408	9 92	M01-01	5 80	0 221	0 708	2379	6 68
M03 064058	9 16	0 215	1 07	2395	10 0	M01-02	5 59	0 221	0 696	2408	6 48
M03 064071	9 12	0 217	1 07	2400	9 99	M01-03	6 16	0 309	0 786	2385	7 40
M03 064086	9 35	0 246	1 11	2406	10 3	M01-04	5 13	0 358	0 705	2409	6 56
M03 064101	9 06	0 255	1 07	2391	10 1	M01-05	6 09	0 324	0 787	2391	7 38
M03 064114	9 16	0 252	1 08	2376	10 2	M01-06	6 38	0 236	0 780	2390	7 32
M03 064129	9 19	0 233	1 06	2352	10 1	M01-07	5 71	0 331	0 753	2399	7 04
M03 064145	9 76	0 295	1 13	2315	10 9	M01-08	6 30	0 222	0 759	2371	7 19
M03 064164	10 4	0 220	1 05	2106	11 3	M01-09	6 30	0 264	0 795	2423	7 36
M03 064177	11 0	0 213	1 10	2105	11 8	M01-10	6 01	0 366	0 798	2394	7 47
M03 082016	9 37	0 255	1 08	2337	10 4	M02-01	4 00	0 109	0 473	2390	4 44
M03 082026	9 16	0 245	1 09	2401	10 1	M02-02	4 01	0 125	0 486	2414	4 51
M03 082044	9 08	0 254	1 08	2404	10 1	M02-03	3 97	0 119	0 474	2394	4 45
M03 082056	9 14	0 229	1 07	2392	10 1	M02-04	4 04	0 131	0 484	2383	4 56
M03 082069	9 29	0 229	1 08	2385	10 2	M02-05	4 03	0 107	0 476	2394	4 46
M03 082084	9 05	0 255	1 07	2382	10 1	M02-06	3 98	0 133	0 482	2396	4 52
M03 082102	8 80	0 233	1 04	2398	9 74	M02-07	3 86	0 130	0 467	2390	4 38
M03 082123	8 60	0 248	1 03	2407	9 60	M02-08	4 04	0 114	0 479	2387	4 50
M03 082142	9 86	0 247	1 11	2302	10 8	M02-09	3 99	0 115	0 480	2413	4 46
M03 082159	10 7	0 222	1 13	2188	11 6	M02-10	4 16	0 118	0 499	2412	4 64
M03 082175	10 7	0 228	1 12	2184	11 6	M02-11	3 80	0 123	0 455	2377	4 29
M03 082191	10 1	0 228	1 04	2131	11 0	M02-12	3 76	0 129	0 454	2386	4 27
M03 103026	9 22	0 255	1 09	2387	10 2	M03-01	2 39	0 181	0 338	2430	3 12
M03 103038	9 15	0 256	1 09	2393	10 2	M03-02	3 50	0 257	0 480	2379	4 53
M03 103050	9 37	0 234	1 10	2401	10 3	M03-03	7 57	0 215	0 898	2390	8 43
M03 103065	9 13	0 265	1 08	2379	10 2	M03-04	3 17	0 143	0 398	2386	3 74
M03 103084	9 04	0 233	1 06	2385	9 97	M03-05	3 97	0 162	0 498	2416	4 62
M03 103097	8 98	0 256	1 07	2397	10 0	M03-06	2 31	0 189	0 333	2429	3 07
M03 103128	8 83	0 248	1 05	2392	9 82	M03-07	6 06	0 277	0 765	2395	7 17
M03 103138	8 97	0 241	1 06	2394	9 94	M03-08	4 66	0 134	0 564	2428	5 21

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*	Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
M03-09	3 89	0 211	0 506	2397	4 73	X01-23	1 91	0 189	0 286	2426	0 663
M03-10	7 88	0 182	0 923	2404	8 61	X01-24	1 97	0 173	0 288	2436	0 662
M04-01	1 94	0 341	0 356	2413	3 31	X01-25	2 51	0 144	0 328	2405	0 769
M04-02	2 10	0 324	0 364	2400	3 40	X01-26	2 27	0 193	0 325	2417	0 756
M05-01	7 80	0 112	0 894	2428	8 25	X01-27	1 82	0 176	0 274	2455	0 625
M05-02	9 64	0 109	1 08	2402	10 1	X01-28	2 78	0 226	0 397	2436	0 914
M05-03	10 7	0 098	1 20	2422	11 1	X02-01	1 99	0 222	0 306	2405	0 718
M05-04	8 50	0 128	0 949	2366	9 01	X02-02	2 00	0 247	0 321	2424	0 745
M05-05	7 46	0 115	0 865	2447	7 92	X02-03	1 91	0 215	0 302	2456	0 688
M05-06	7 48	0 112	0 839	2376	7 92	X02-04	1 93	0 223	0 302	2421	0 701
M05-07	7 51	0 116	0 860	2418	7 97	X02-05	1 58	0 196	0 256	2438	0 589
M05-08	9 69	0 148	1 11	2414	10 3	X02-06	1 98	0 177	0 289	2429	0 668
M05-09	8 55	0 144	0 985	2419	9 13	X02-07	1 66	0 189	0 259	2421	0 601
M05-10	9 19	0 140	1 05	2422	9 75	X02-08	1 52	0 172	0 239	2439	0 550
M05-11	7 33	0 130	0 843	2407	7 85	X02-09	1 56	0 177	0 240	2388	0 568
M05-12	7 34	0 127	0 854	2438	7 85	X02-10	1 67	0 176	0 255	2423	0 591
M05-13	7 43	0 120	0 854	2419	7 91	X02-11	1 93	0 227	0 308	2447	0 706
M05-14	7 60	0 114	0 881	2447	8 06	X02-12	1 92	0 223	0 297	2387	0 704
M05-15	7 94	0 137	0 926	2442	8 50	X02-13	1 99	0 225	0 311	2435	0 718
M06-01	14 7	0 151	1 64	2406	15 3	X02-14	1 93	0 221	0 305	2445	0 699
M06-02	6 43	0 132	0 767	2467	6 96	X02-15	1 94	0 218	0 299	2409	0 700
M06-03	7 57	0 149	0 883	2422	8 17	X02-16	2 00	0 226	0 314	2439	0 721
M06-04	6 98	0 163	0 815	2396	7 63	X03-01	2 90	0 236	0 413	2429	0 955
M06-05	6 54	0 138	0 754	2386	7 09	X03-02	2 36	0 220	0 341	2384	0 809
M06-06	6 31	0 138	0 740	2417	6 87	X03-03	1 86	0 219	0 290	2392	0 685
M06-07	7 05	0 096	0 798	2405	7 44	X03-04	1 89	0 176	0 279	2430	0 644
M06-08	6 11	0 132	0 715	2416	6 64	X03-05	2 30	0 194	0 324	2388	0 768
M06-09	7 93	0 140	0 920	2428	8 49	X03-06	2 42	0 217	0 355	2434	0 819
X01-01	3 26	0 227	0 444	2407	1 04	X03-07	2 75	0 222	0 388	2415	0 905
X01-02	2 32	0 164	0 319	2421	0 741	X03-08	2 56	0 214	0 369	2433	0 851
X01-03	2 79	0 201	0 386	2424	0 894	X03-09	2 19	0 212	0 325	2416	0 756
X01-04	2 26	0 204	0 334	2449	0 763	X03-10	1 92	0 188	0 289	2439	0 664
X01-05	1 58	0 203	0 261	2455	0 594	X03-11	2 01	0 182	0 295	2427	0 682
X01-06	1 30	0 225	0 236	2422	0 548	X03-12	2 53	0 221	0 367	2430	0 849
X01-07	1 16	0 209	0 211	2392	0 498	X03-13	3 02	0 240	0 429	2435	0 989
X01-08	1 65	0 194	0 257	2399	0 605	X03-14	2 61	0 229	0 383	2448	0 875
X01-09	2 50	0 183	0 351	2451	0 802	X03-15	2 51	0 211	0 355	2393	0 838
X01-10	2 54	0 176	0 352	2450	0 804	X03-16	3 11	0 240	0 438	2429	1 01
X01-11	2 30	0 159	0 316	2430	0 730	X03-17	2 37	0 215	0 353	2458	0 802
X01-12	2 09	0 165	0 298	2447	0 683	X03-18	2 29	0 210	0 332	2397	0 781
X01-13	1 40	0 216	0 243	2423	0 565	X03-19	2 46	0 205	0 350	2412	0 818
X01-14	1 19	0 221	0 222	2420	0 515	X03-20	2 51	0 222	0 359	2391	0 850
X01-15	1 53	0 215	0 252	2393	0 595	X03-21	2 42	0 219	0 356	2440	0 819
X01-16	2 18	0 223	0 330	2427	0 764	X04-01	1 39	0 120	0 200	2410	0 467
X01-17	2 09	0 181	0 304	2437	0 700	X04-02	2 43	0 260	0 328	2168	0 885
X01-18	2 00	0 174	0 293	2455	0 668	X04-03	1 11	0 144	0 150	2059	0 433
X01-19	2 04	0 181	0 301	2448	0 688	Z01-01	0 006	0 040	0 025	3065	0 041
X01-20	2 39	0 200	0 344	2432	0 794	Z01-02	0 006	0 027	0 016	2905	0 028
X01-21	1 67	0 205	0 267	2422	0 620	Z01-03	0 185	0 073	0 051	2422	0 119
X01-22	2 24	0 186	0 313	2376	0 745	Z01-04	0 007	0 040	0 027	3167	0 041

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*	Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
Z01-05	0 008	0 034	0 024	3198	0 036	Z10-04	0 012	0 028	0 026	3713	0 030
Z02-01	0 010	0 026	0 012	2434	0 028	Z10-05	0 017	0 040	0 023	2752	0 044
Z02-02	0 006	0 025	0 018	3247	0 027	Z10-06	0 008	0 024	0 011	2375	0 026
Z02-03	0 010	0 040	0 014	1952	0 042	Z11-01	0 004	0 018	0 004	1242	0 019
Z02-04	0 012	0 034	0 014	2132	0 037	Z11-02	0 006	0 019	0 014	3313	0 020
Z02-05	0 007	0 028	0 011	2179	0 029	Z11-03	0 011	0 019	0 015	3329	0 021
Z03-01	0 079	0 097	0 060	2768	0 115	Z11-04	0 011	0 023	0 017	3224	0 025
Z03-02	0 008	0 093	0 047	2683	0 095	Z11-05	0 008	0 027	0 014	2619	0 029
Z03-03	0 011	0 039	0 034	3642	0 041	Z12-01	0 023	0 136	0 065	2518	0 142
Z03-04	0 015	0 040	0 024	2859	0 044	Z12-02	0 011	0 032	0 025	3388	0 034
Z03-05	0 015	0 049	0 022	2381	0 053	Z12-03	0 007	0 059	0 032	2823	0 060
Z04-01	0 016	0 056	0 034	2943	0 060	Z12-04	0 056	0 040	0 010	1167	0 056
Z04-02	0 208	0 097	0 042	1723	0 153	Z12-05	0 029	0 124	0 048	2147	0 131
Z04-03	0 005	0 035	0 012	1901	0 037	Z13-01	0 009	0 037	0 018	2574	0 039
Z04-04	0 004	0 033	0 014	2415	0 034	Z13-02	0 020	0 031	0 022	3065	0 035
Z04-05	0 005	0 030	0 019	3102	0 031	Z13-03	0 018	0 044	0 027	2863	0 048
Z04-06	0 064	0 129	0 074	2732	0 144	Z13-04	0 030	0 033	0 025	3110	0 040
Z04-07	0 041	0 042	0 032	3088	0 051	Z13-05	0 009	0 030	0 016	2689	0 032
Z04-08	0 089	0 048	0 039	2950	0 068	Z14-01	0 033	0 084	0 039	2371	0 093
Z05-01	0 059	0 157	0 076	2483	0 171	Z14-02	0 238	0 134	0 085	2468	0 193
Z05-02	0 006	0 039	0 020	2668	0 041	Z14-03	0 137	0 095	0 055	2384	0 129
Z05-03	0 018	0 040	0 022	2706	0 044	Z14-04	0 011	0 079	0 034	2361	0 082
Z05-04	0 041	0 148	0 070	2483	0 158	Z14-05	0 007	0 017	0 014	3379	0 019
Z05-05	0 037	0 052	0 034	2907	0 060						
Z06-01	0 044	0 139	0 063	2372	0 150	Sample 2275 from Mt Cromus					
Z06-02	0 021	0 069	0 032	2398	0 074	P01-01	8 24	9 90	5 58	2555	11 9
Z06-03	0 023	0 055	0 039	3162	0 060	P01-02	8 75	9 88	4 66	2216	12 1
Z06-04	0 054	0 155	0 072	2398	0 169	P01-03	8 25	9 80	4 52	2190	11 9
Z06-05	0 021	0 078	0 039	2558	0 083	P01-04	8 47	9 73	4 27	2097	11 9
Z07-01	0 029	0 254	0 147	2916	0 260	P01-05	8 35	9 96	4 82	2276	12 1
Z07-02	0 014	0 014	0 014	3705	0 017	P02-01	8 24	9 58	4 76	2316	11 7
Z07-03	0 007	0 019	0 018	3780	0 021	P02-02	8 32	9 73	4 09	2033	11 9
Z07-04	0 008	0 097	0 048	2643	0 099	P02-03	8 39	9 68	5 21	2456	11 8
Z07-05	0 006	0 039	0 026	3170	0 040	P02-04	8 45	9 85	5 01	2358	12 0
Z07-06	0 063	0 119	0 058	2421	0 135	P02-05	8 24	9 96	4 83	2285	12 0
Z07-07	0 006	0 069	0 035	2656	0 071	P03-01	8 66	9 20	4 08	2092	11 4
Z08-01	0 017	0 069	0 044	3025	0 073	P03-02	8 45	8 89	4 18	2185	11 1
Z08-02	0 016	0 061	0 037	2948	0 064	P03-03	8 73	8 99	4 32	2215	11 2
Z08-03	0 012	0 065	0 040	2997	0 068	P03-04	8 69	9 26	4 19	2124	11 5
Z08-04	0 013	0 067	0 039	2899	0 070	P03-05	8 56	9 21	4 47	2250	11 4
Z08-05	0 010	0 070	0 042	2959	0 072	P04-01	8 38	8 81	4 89	2483	10 9
Z09-01	0 213	0 143	0 083	2384	0 196	P04-02	8 32	8 69	4 27	2258	10 8
Z09-02	0 159	0 059	0 043	2425	0 099	P04-03	8 19	8 80	3 92	2100	10 9
Z09-03	0 084	0 046	0 034	2742	0 066	P04-04	8 43	8 67	4 14	2204	10 8
Z09-04	0 130	0 065	0 052	2860	0 095	P04-05	8 28	8 41	4 24	2294	10 5
Z09-05	0 091	0 078	0 053	2814	0 099	P05-01	8 00	9 12	4 17	2163	11 2
Z09-06	0 301	0 071	0 074	2745	0 142	P05-02	8 29	9 99	4 10	2002	12 2
Z10-01	0 004	0 022	0 012	2770	0 023	P05-03	8 07	9 66	4 30	2135	11 7
Z10-02	0 005	0 026	0 013	2626	0 027	P05-04	8 19	9 51	4 97	2405	11 5
Z10-03	0 088	0 231	0 121	2614	0 252	P05-05	8 28	9 77	4 88	2329	11 9

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*	Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
P06-01	7 26	7 65	4 37	2533	9 43	P14-01	7 78	9 55	5 33	2543	11 4
P06-02	8 09	7 95	4 75	2594	9 91	P14-02	7 94	9 89	4 71	2262	11 9
P06-03	8 21	8 38	4 50	2409	10 4	P14-03	7 96	9 85	4 03	2004	11 9
P06-04	8 39	8 97	5 13	2542	11 0	P14-04	8 07	9 87	4 90	2330	11 9
P06-05	7 67	9 28	4 89	2433	11 2	P14-05	7 96	9 62	4 14	2080	11 7
P07-01	8 15	9 75	4 96	2366	11 8	P15-01	7 64	9 11	4 36	2257	11 1
P07-02	7 70	9 03	3 72	2000	11 1	P15-02	7 89	9 58	4 06	2055	11 6
P07-03	8 11	9 78	4 54	2209	11 9	P15-03	7 86	9 00	3 33	1824	11 1
P07-04	7 94	9 82	4 64	2244	11 8	P15-04	7 73	8 81	3 81	2071	10 8
P07-05	8 00	9 73	5 31	2499	11 7	P15-05	7 64	9 19	4 33	2233	11 1
P08-01	7 86	8 47	3 66	2051	10 5	P16 275030	8 79	8 73	4 21	2225	11 0
P08-02	7 82	8 54	3 57	2004	10 6	P16 390048	8 96	8 51	4 94	2543	10 7
P08-03	7 83	8 72	3 77	2063	10 8	P16 352048	8 94	8 46	4 57	2409	10 7
P08-04	7 89	8 81	3 73	2028	10 9	P16 321048	8 91	8 73	4 50	2339	11 0
P08-05	7 74	8 35	3 45	1979	10 4	P16 270048	8 49	8 02	5 05	2696	10 1
P09-01	8 93	8 52	4 20	2236	10 8	P16 220048	8 44	8 06	3 85	2197	10 2
P09-02	8 76	8 33	4 27	2302	10 5	P16 428070	9 16	8 65	3 86	2075	11 0
P09-03	8 92	9 00	4 04	2093	11 3	P16 410085	8 97	8 50	4 61	2419	10 7
P09-04	8 83	8 51	4 52	2371	10 7	P16 370085	8 90	8 36	4 77	2507	10 5
P09-05	8 85	8 86	4 18	2176	11 1	P16 331085	8 66	7 88	4 76	2603	9 98
P09-06	8 67	8 53	4 32	2292	10 7	P16 285085	8 39	7 33	4 11	2449	9 41
P09-07	9 00	8 88	4 23	2184	11 2	P16 236085	8 43	7 31	4 57	2647	9 34
P09-08	9 15	10 2	4 84	2218	12 6	P16 180085	8 04	7 00	4 12	2534	8 97
P09-09	9 06	9 71	4 55	2189	12 0	P16 140085	8 75	7 28	4 26	2507	9 43
P09-10	8 85	9 09	3 96	2051	11 4	P16 366108	9 16	8 15	4 76	2531	10 4
P10-01	8 92	9 00	4 03	2091	11 3	P16 340103	8 63	8 24	4 83	2564	10 3
P10-02	8 66	8 64	4 09	2182	10 9	P16 300115	8 59	7 55	4 47	2550	9 65
P10-03	8 78	8 66	3 86	2074	10 9	P16 233100	8 96	7 74	5 25	2806	9 85
P10-04	8 67	8 83	4 09	2151	11 1	P16 218123	8 20	6 79	4 70	2828	8 71
P10-05	8 72	8 79	3 88	2066	11 1	P16 157123	8 49	7 01	4 15	2526	9 09
P11-01	8 03	6 51	4 40	2756	8 41	P16 114123	8 10	6 94	4 20	2582	8 91
P11-02	8 10	6 61	3 79	2442	8 62	P16 058123	8 20	7 39	4 35	2548	9 40
P11-03	7 66	6 96	4 20	2582	8 82	P16 036123	7 17	8 20	5 15	2763	9 89
P11-04	7 61	7 09	4 07	2501	8 96	P16 425130	9 10	8 29	4 47	2390	10 6
P11-05	8 17	7 71	4 53	2548	9 70	P16 352151	9 01	7 61	5 20	2813	9 73
P11-06	8 22	6 55	3 64	2373	8 61	P16 290140	8 51	6 69	3 84	2448	8 79
P11-07	7 94	6 88	4 18	2577	8 81	P16 250135	8 48	6 63	4 14	2602	8 68
P11-08	8 80	8 17	4 41	2386	10 4	P16 100155	7 96	6 92	4 29	2635	8 84
P11-09	8 78	8 20	4 34	2352	10 4	P16 060146	7 97	7 36	4 11	2462	9 33
P11-10	8 47	7 80	4 47	2490	9 89	P16 398166	9 14	7 92	4 98	2657	10 1
P12-01	8 18	9 78	5 00	2373	11 8	P16 312161	8 60	7 01	4 40	2631	9 08
P12-02	8 02	9 73	5 01	2393	11 7	P16 288172	8 66	7 04	4 28	2568	9 15
P12-03	7 96	9 58	4 23	2123	11 6	P16 226162	8 44	6 79	5 36	3082	8 68
P12-04	8 07	9 94	4 49	2167	12 0	P16 164165	8 31	6 79	4 56	2763	8 75
P12-05	7 96	9 79	3 54	1810	11 9	P16 494175	8 14	8 71	3 51	1952	10 9
P13-01	8 17	9 52	4 83	2351	11 6	P16 374186	9 15	7 92	5 49	2849	10 1
P13-02	7 22	8 76	3 35	1894	10 7	P16 343186	9 02	7 83	5 29	2800	9 95
P13-03	8 03	9 46	4 60	2282	11 5	P16 257186	8 79	7 12	4 20	2510	9 28
P13-04	7 59	8 93	4 35	2284	10 9	P16 226186	8 56	6 58	4 76	2880	8 57
P13-05	7 43	8 76	5 07	2599	10 6	P16 193173	8 58	6 75	5 16	3006	8 70

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*	Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
P16 130187	8 21	6 79	5 36	3093	8 63	Z01-06 rim	0 026	0 060	0 041	3101	0 066
P16 091182	8 39	6 88	4 37	2656	8 90	Z01-07 rim	0 045	0 250	0 158	3056	0 260
P16 026184	8 66	7 86	4 85	2642	9 95	Z01-08 rim	0 029	0 113	0 074	3077	0 120
P16 434205	9 34	8 23	4 76	2508	10 5	Z02-01	0 020	0 069	0 026	2091	0 074
P16 186202	8 35	6 80	4 46	2715	8 79	Z02-02	0 036	0 058	0 035	2767	0 067
P16 157196	7 93	6 96	5 01	2932	8 79	Z02-03	0 073	0 165	0 104	2943	0 182
P16 390237	9 21	8 10	5 35	2761	10 3	Z02-04	0 028	0 040	0 028	3032	0 046
P16 364226	9 00	7 83	5 35	2824	9 94	Z03-01	0 188	0 562	0 375	3090	0 604
P16 330228	8 50	7 75	5 11	2773	9 76	Z03-02	0 058	0 120	0 082	3067	0 133
P16 300215	8 60	6 89	4 58	2735	8 93	Z03-03	0 086	0 335	0 214	3039	0 355
P16 270215	8 47	6 90	4 48	2693	8 93	Z04-01	0 030	0 153	0 093	2958	0 160
P16 215220	8 34	7 41	4 52	2614	9 43	Z04-02	0 173	0 577	0 360	2974	0 617
P16 147215	8 07	7 20	5 05	2886	9 07	Z04-03	0 016	0 094	0 059	3030	0 098
P16 126220	8 11	6 91	5 07	2955	8 77	Z04-04	0 020	0 177	0 094	2760	0 181
P16 085208	8 45	7 70	4 95	2721	9 72	Z05-01	0 020	0 154	0 098	3086	0 158
P16 439247	9 05	8 49	5 17	2630	10 7	Z05-02	0 017	0 194	0 121	3062	0 198
P16 340245	8 66	8 09	5 41	2810	10 1	Z05-03	0 009	0 080	0 065	3560	0 081
P16 252229	8 70	7 06	4 71	2747	9 12	Z05-04	0 031	0 091	0 080	3628	0 097
P16 188240	8 35	7 38	4 06	2417	9 46	Z05-05	0 024	0 138	0 088	3068	0 144
P16 145241	8 65	7 57	3 46	2085	9 82	Z05-06	0 087	0 191	0 130	3080	0 210
P16 115241	8 58	7 84	3 64	2130	10 1	Z05-07	0 190	0 347	0 235	3033	0 390
P16 093241	8 71	8 09	3 28	1916	10 4	Z06-01	0 041	0 161	0 088	2730	0 171
P16 078224	8 38	7 82	4 20	2393	9 91	Z06-02	0 012	0 089	0 047	2720	0 092
P16 069241	8 75	8 50	3 69	2038	10 8	Z06-03	0 110	0 252	0 169	3052	0 277
P16 047224	8 56	8 42	3 96	2177	10 6	Z06-04	0 090	0 296	0 185	2973	0 317
P16 016224	8 50	9 26	3 08	1667	11 6	Z07-01	0 010	0 104	0 065	3061	0 107
P16 410264	8 79	8 45	5 16	2643	10 6	Z07-02	0 018	0 131	0 070	2764	0 135
P16 358264	8 68	8 55	5 33	2693	10 6	Z07-03	0 043	0 353	0 194	2808	0 363
P16 319262	8 70	8 06	4 69	2540	10 2	Z07-04	0 021	0 260	0 131	2674	0 265
P16 242262	8 44	7 81	4 60	2561	9 87	Z08-01	0 036	0 157	0 071	2408	0 166
P16 187262	8 58	7 84	3 84	2224	10 0	Z08-02	0 029	0 158	0 069	2376	0 165
P16 148270	8 11	8 46	3 26	1873	10 6	Z08-03	0 040	0 387	0 171	2429	0 396
P16 130260	8 05	7 90	3 30	1982	10 0	Z08-04	0 034	0 318	0 142	2435	0 327
P16 114270	7 55	8 42	3 52	2024	10 4	Z08-05	0 081	0 678	0 230	1979	0 699
P16 090260	6 01	7 07	2 48	1765	8 69	Z08-06	0 093	0 435	0 199	2433	0 458
P16 342290	8 86	8 56	4 93	2535	10 7	Z08-07	0 020	0 100	0 037	2073	0 105
P16 291285	9 11	8 07	4 45	2423	10 3	Z08-08	0 097	0 095	0 041	2033	0 120
P16 240285	8 12	8 91	4 43	2311	11 0	Z08-09	0 036	0 289	0 129	2431	0 298
P16 187280	8 56	8 29	3 67	2072	10 5	Z08-10	0 108	0 516	0 238	2452	0 542
P16 180302	8 26	9 23	4 54	2300	11 3	Z09-01	0 060	0 118	0 071	2813	0 132
P16 157284	8 02	9 18	3 99	2096	11 3	Z09-02	0 067	0 112	0 067	2787	0 128
P16 131323	8 94	8 26	3 97	2195	10 5	Z09-03	0 063	0 124	0 077	2889	0 139
P16 090302	8 53	9 38	4 05	2073	11 6	Z09-04	0 060	0 103	0 064	2858	0 117
P17-01	9 06	8 07	4 67	2512	10 3	Z09-05	0 070	0 110	0 075	3008	0 126
P17-02	8 55	7 30	4 78	2732	9 33	Z09-06	0 062	0 135	0 080	2817	0 150
Z01-01 core	0 018	0 045	0 039	3554	0 049	Z09-07	0 075	0 099	0 070	3042	0 116
Z01-02 core	0 031	0 033	0 032	3588	0 039	Z09-08	0 071	0 148	0 092	2890	0 165
Z01-03 core	0 027	0 043	0 039	3612	0 048	Z09-09	0 054	0 133	0 081	2885	0 146
Z01-04 core	0 011	0 027	0 023	3543	0 029	Z09-10	0 047	0 126	0 080	2969	0 137
Z01-05 rim	0 034	0 086	0 057	3044	0 093	Z10-01	0 048	0 124	0 072	2806	0 135

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*	Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
Z10-02	0 076	0 195	0 117	2867	0 213	Z15-04	0 044	0 237	0 127	2746	0 247
Z10-03	0 035	0 081	0 064	3399	0 088	Z15-05	0 185	0 375	0 237	2923	0 418
Z10-04	0 046	0 094	0 073	3317	0 104	Z15-06	0 176	0 375	0 232	2891	0 416
Z10-05	0 048	0 078	0 063	3358	0 088	Z15-07	0 104	0 256	0 154	2869	0 280
Z10-06	0 080	0 199	0 136	3106	0 217	Z15-08	0 039	0 123	0 065	2644	0 133
Z10-07	0 052	0 146	0 097	3078	0 158	Z15-09	0 100	0 219	0 143	3002	0 242
Z10-08	0 038	0 116	0 087	3331	0 124	Z15-10	0 046	0 214	0 124	2864	0 225
Z10-09	0 050	0 099	0 075	3285	0 109	Z16-01	0 034	0 072	0 047	3005	0 080
Z10-10	0 046	0 061	0 052	3417	0 071	Z16-02	0 037	0 110	0 070	2984	0 119
Z11-01	0 019	0 041	0 028	3073	0 046	Z16-03	0 030	0 146	0 092	3034	0 153
Z11-02	0 022	0 076	0 030	2148	0 082	Z16-04	0 068	0 140	0 095	3060	0 155
Z11-03	0 031	0 076	0 050	3024	0 083	Z16-05	0 051	0 124	0 082	3038	0 135
Z11-04	0 032	0 042	0 036	3455	0 048	Z16-06	0 152	0 272	0 181	2997	0 306
Z11-05	0 026	0 033	0 023	2970	0 039	Z16-07	0 016	0 077	0 049	3076	0 080
Z11-06	0 015	0 036	0 024	3026	0 040	Z16-08	0 026	0 050	0 033	2982	0 056
Z11-07	0 032	0 063	0 043	3059	0 070	Z16-09	0 079	0 128	0 090	3081	0 146
Z11-08	0 045	0 358	0 159	2420	0 369	Z16-10	0 052	0 105	0 051	2428	0 118
Z11-09	0 053	0 082	0 040	2365	0 095	Z16-11	0 145	0 335	0 225	3065	0 368
Z11-10	0 021	0 047	0 030	2961	0 052	Z16-12	0 064	0 200	0 107	2676	0 215
Z11-11	0 025	0 055	0 030	2682	0 061	Z17-01	0 020	0 185	0 096	2713	0 190
Z12-01	0 030	0 069	0 051	3248	0 076	Z17-02	0 023	0 410	0 138	1995	0 416
Z12-02	0 010	0 056	0 039	3245	0 058	Z17-03	0 019	0 223	0 117	2746	0 227
Z12-03	0 009	0 062	0 028	2462	0 064	Z17-04	0 029	0 165	0 097	2913	0 171
Z12-04	0 074	0 133	0 103	3291	0 149	Z17-05	0 019	0 203	0 092	2460	0 208
Z12-05	0 036	0 075	0 057	3278	0 083	Z17-06	0 054	0 404	0 212	2717	0 417
Z12-06	0 220	0 320	0 191	2735	0 373	Z17-07	0 011	0 286	0 124	2418	0 289
Z12-07	0 040	0 096	0 053	2707	0 105	Z17-08	0 020	0 203	0 089	2419	0 208
Z12-08	0 032	0 092	0 066	3233	0 099	Z17-09	0 020	0 258	0 128	2645	0 263
Z12-09	0 122	0 203	0 157	3277	0 229	Z17-10	0 018	0 185	0 083	2444	0 190
Z12-10	0 084	0 151	0 089	2761	0 171	Z17-11	0 059	0 610	0 312	2684	0 624
Z12-11	0 038	0 062	0 049	3320	0 070	Z17-12	0 030	0 316	0 165	2732	0 323
Z13-01	0 108	0 144	0 095	2910	0 169	Z17-13	0 030	0 373	0 194	2728	0 380
Z13-02	0 117	0 224	0 131	2763	0 251	Z17-14	0 031	0 250	0 150	2967	0 257
Z13-03	0 139	0 214	0 142	2953	0 246	Z17-15	0 075	0 202	0 107	2632	0 220
Z13-04	0 169	0 297	0 192	2938	0 336	Z18-01	0 077	0 191	0 099	2583	0 210
Z13-05	0 056	0 140	0 089	2969	0 153	Z18-02	0 025	0 119	0 055	2459	0 125
Z13-06	0 072	0 168	0 104	2904	0 185	Z18-03	0 098	0 148	0 085	2663	0 171
Z13-07	0 118	0 240	0 149	2890	0 267	Z18-04	0 072	0 137	0 078	2721	0 154
Z13-08	0 070	0 142	0 093	2996	0 158	Z18-05	0 064	0 355	0 180	2634	0 370
Z14-01	0 031	0 054	0 037	3026	0 061	Z18-06	0 038	0 229	0 103	2423	0 239
Z14-02	0 028	0 064	0 038	2848	0 070	Z18-07	0 108	0 151	0 094	2804	0 176
Z14-03	0 032	0 112	0 061	2729	0 120	Z19-01	0 079	0 127	0 070	2628	0 146
Z14-04	0 021	0 040	0 031	3295	0 044	Z19-02	0 094	0 157	0 078	2415	0 181
Z14-05	0 023	0 066	0 042	2964	0 072	Z19-03	0 075	0 127	0 079	2854	0 145
Z14-06	0 031	0 065	0 027	2182	0 073	Z19-04	0 041	0 092	0 044	2410	0 102
Z14-07	0 036	0 062	0 043	3078	0 070	Z19-05	0 082	0 152	0 087	2715	0 172
Z14-08	0 033	0 120	0 063	2651	0 128	Z19-06	0 074	0 145	0 081	2679	0 163
Z15-01	0 117	0 256	0 160	2910	0 283	Z19-07	0 043	0 094	0 050	2605	0 105
Z15-02	0 054	0 209	0 136	3077	0 221	Z19-08	0 083	0 131	0 085	2921	0 150
Z15-03	0 260	0 237	0 165	2880	0 297	Z20-01	0 014	0 136	0 068	2636	0 139

Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*	Spot No	ThO_2 (wt%)	UO_2 (wt%)	PbO (wt%)	Age (Ma)	ThO_2* UO_2*
Z20-02	0 021	0 062	0 033	2663	0 067	Z26-04	0 023	0 031	0 018	2723	0 036
Z20-03	0 020	0 164	0 087	2734	0 169	Z26-05	0 027	0 036	0 028	3247	0 041
Z20-04	0 017	0 108	0 056	2683	0 112	Z26-06	0 022	0 046	0 036	3365	0 050
Z20-05	0 010	0 155	0 079	2702	0 157	Z27-01	0 044	0 279	0 126	2443	0 290
Z20-06	0 065	0 558	0 275	2611	0 574	Z27-02	0 029	0 232	0 103	2423	0 239
Z20-07	0 042	0 440	0 192	2405	0 451	Z27-03	0 078	0 168	0 094	2702	0 187
Z20-08	0 067	0 637	0 324	2673	0 653	Z27-04	0 010	0 092	0 048	2701	0 094
Z20-09	0 032	0 133	0 070	2682	0 140	Z27-05	0 054	0 202	0 093	2419	0 215
Z21-01	0 032	0 050	0 043	3468	0 056	Z28-01	0 039	0 157	0 073	2459	0 166
Z21-02	0 020	0 070	0 045	3036	0 074	Z28-02	0 058	0 122	0 070	2728	0 136
Z21-03	0 033	0 069	0 046	3049	0 076	Z28-03	0 098	0 172	0 087	2470	0 196
Z21-04	0 025	0 081	0 049	2938	0 086	Z28-04	0 019	0 147	0 081	2826	0 151
Z21-05	0 039	0 092	0 055	2822	0 101	Z28-05	0 050	0 086	0 059	3042	0 097
Z21-06	0 017	0 029	0 026	3577	0 033	Z28-06	0 016	0 089	0 041	2439	0 093
Z21-07	0 021	0 037	0 027	3228	0 041	Z28-07	0 016	0 128	0 059	2482	0 132
Z21-08	0 026	0 063	0 038	2882	0 069	Z28-08	0 020	0 186	0 081	2397	0 191
Z21-09	0 024	0 061	0 035	2771	0 067	Z28-09	0 033	0 069	0 033	2386	0 077
Z22-01	0 032	0 066	0 025	1985	0 074	Z28-10	0 051	0 082	0 057	3057	0 093
Z22-02	0 008	0 074	0 031	2342	0 076	Z28-11	0 052	0 097	0 053	2613	0 110
Z22-03	0 011	0 054	0 025	2431	0 057	Z28-12	0 031	0 071	0 034	2395	0 079
Z22-04	0 006	0 104	0 055	2779	0 105	Z28-13	0 117	0 227	0 107	2362	0 257
Z22-05	0 088	0 146	0 102	3071	0 166	Z28-14	0 024	0 043	0 031	3117	0 049
Z22-06	0 079	0 140	0 092	2982	0 158	Z28-15	0 030	0 103	0 049	2477	0 110
Z22-07	0 047	0 157	0 082	2647	0 168	Z29-01	0 005	0 047	0 033	3278	0 048
Z23-01	0 034	0 092	0 054	2808	0 100	Z29-02	0 004	0 036	0 023	3129	0 036
Z23-02	0 045	0 092	0 056	2861	0 103	Z29-03	0 011	0 046	0 020	2349	0 048
Z23-03	0 054	0 109	0 052	2388	0 122	Z29-04	0 029	0 050	0 032	2888	0 057
Z23-04	0 046	0 104	0 058	2716	0 115	Z29-05	0 007	0 026	0 020	3355	0 028
Z23-05	0 018	0 045	0 017	2036	0 050	Z29-06	0 011	0 100	0 044	2416	0 102
Z23-06	0 031	0 068	0 036	2597	0 075	Z29-07	0 011	0 104	0 048	2488	0 107
Z23-07	0 018	0 052	0 032	2912	0 056	Z30-01	0 018	0 066	0 033	2574	0 070
Z23-08	0 054	0 126	0 060	2417	0 139	Z30-02	0 036	0 166	0 072	2352	0 175
Z23-09	0 022	0 056	0 034	2891	0 061	Z30-03	0 048	0 165	0 073	2339	0 177
Z23-10	0 033	0 062	0 044	3106	0 070	Z30-04	0 058	0 092	0 055	2746	0 106
Z24-01	0 016	0 141	0 087	3032	0 145	Z30-05	0 058	0 102	0 059	2736	0 115
Z24-02	0 019	0 198	0 088	2443	0 203	Z30-06	0 022	0 058	0 027	2364	0 064
Z24-03	0 244	0 504	0 281	2686	0 562	Z30-07	0 021	0 050	0 026	2606	0 055
Z24-04	0 051	0 089	0 052	2764	0 101	Z30-08	0 017	0 053	0 034	3047	0 057
Z24-05	0 034	0 116	0 065	2770	0 124	Z30-09	0 136	0 326	0 180	2701	0 358
Z24-06	0 032	0 061	0 037	2812	0 068	Z30-10	0 065	0 113	0 063	2663	0 128
Z25-01	0 033	0 049	0 021	2183	0 057	Z30-11	0 139	0 324	0 182	2728	0 357
Z25-02	0 039	0 050	0 032	2852	0 059	Z30-12	0 052	0 203	0 093	2416	0 215
Z25-03	0 044	0 038	0 022	2488	0 049	Z30-13	0 081	0 202	0 115	2749	0 222
Z25-04	0 039	0 137	0 064	2456	0 146	Z30-14	0 031	0 066	0 037	2703	0 073
Z25-05	0 035	0 048	0 032	2978	0 055	Z30-15	0 023	0 040	0 027	3008	0 045
Z25-06	0 040	0 052	0 026	2371	0 062	Z30-16	0 026	0 114	0 068	2912	0 120
Z25-07	0 036	0 048	0 030	2755	0 057	Z30-17	0 044	0 093	0 052	2659	0 103
Z26-01	0 020	0 029	0 026	3592	0 033	Z30-18	0 019	0 101	0 045	2413	0 106
Z26-02	0 022	0 046	0 036	3365	0 050	Z30-19	0 014	0 133	0 071	2747	0 137
Z26-03	0 025	0 031	0 021	2933	0 037						