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ANALOGUE STUDIES IN THE ALLIGATOR RIVERS REGION — IN-SITU MEASUREMENT OF URANIUM SERIES NUCLIDES WITH SHRIMP —

March 1999

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Analogue Studies in the Alligator Rivers Region
– In-situ Measurement of Uranium Series Nuclides with SHRIMP –

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The SHRIMP analyses have been conducted for rock samples from the Koongarra secondary ore deposit to obtain activity ratios of $^{234}U/^{238}U$ and isotopic ratios of $^{207}Pb/^{206}Pb$ and $^{204}Pb/^{206}Pb$. Target minerals for the analyses were iron minerals and kaolinite, which are the main weathering products in this area. The activity ratios of $^{234}U/^{238}U$ were obtained based on counts at masses of uranium metal. The $^{234}U/^{238}U$ activity ratios based on counts of uranium oxides were not appropriate, because count rates of $^{234}U^{16}O$ were interfered by those of $^{238}U^{12}C$ molecule. The activity ratios of $^{234}U/^{238}U$ were approximately unity for crystalline iron nodules. This fact suggested that the mean residence time of uranium within the iron nodules was at least 1 million years. On the other hand, slightly higher values than unity were obtained for kaolinite. Lead isotopes were investigated and a positive relationship was recognized between $^{207}Pb/^{206}Pb$ and $^{204}Pb/^{206}Pb$ isotope ratios.

Keywords: SHRIMP, Uranium, Lead, Isotope Ratio, Iron Minerals, Kaolinite, Natural Analogue

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アリゲータリバー地域におけるアナログ研究
－ＳＨＲＩＭＰによるウラン系列核種の同位体分析－

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オーストラリア・クンガラウラン鉱床において、ウランは地下水によって流され、風化生成物である鉄鉱物に濃集し二次鉱床を形成している。本研究では、二次鉱床におけるウランの地球化学的挙動のタイムスケールを調べることを目的とし、風化生成物中におけるウラン系列核種の放射能比を高感度・高分解能イオンマイクロプローブ（ＳＨＲＩＭＰ）により測定した。その結果、鉄鉱物からは系が放射平衡に達していることを示唆する１に近い値を得た。この値は、もし鉄鉱物が閉じた系であったとすれば、ウランが保持されてからおよそ百万年程度の年月が経過したことを示すものである。

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1. Introduction

In the vicinity of the Koongarra uranium deposit, uranium dissolved from the primary ore has migrated to down-gradient by groundwater transport. Along the groundwater flow, a tongue-like secondary ore deposit was produced within the weathering zone as a result of uptake of the uranium by weathering products(1). The secondary ore body lies within 25 m from the ground surface, and is referred as a dispersion fan. Among the weathering products of host rocks (quartz chlorite-shcist), iron minerals, especially crystalline iron nodules(2), were found to play a key role in retention of uranium in the secondary ore zone(3, 4). This uranium uptake is not only due to adsorption on surface of iron minerals but also due to precipitation of uranium minerals with iron minerals(2), which produces a high retention capacity in iron minerals.

One of the major objectives of natural analogue study is the validation of migration models associated with assessment of geological disposal of radioactive wastes, by use of natural analogue phenomena(5). The migration-retention process of uranium within the Koongarra secondary deposit is a quite good example of such an analogous phenomenon, because the process is considered to be plausible around the repository(6). In addition, the uranium content of the secondary deposit is well above analytical detection limit(3). For the model validation, information on the detailed chronology related to the redistribution of uranium are definitely required as well as spatial distribution of uranium(7), mobilization or retention mechanisms of uranium associated with geological media, and realistic values for parameters included in the migration models(8, 9).

The Sm-Nd isotopic data and geological observation suggest that the Koongarra primary ore deposit formed about 1550-1600 million years (My) ago(1). On the other hand, though the geomorphological studies suggest that the dispersion fan is between one and six My old(10), interpretation of the whole rock activity ratios of $^{234}U/^{238}U$ as well as the migration equation including the effect of transport by flowing groundwater and equilibrium sorption indicate that the secondary ore deposit began to form about 1-3 My ago(11). The activity ratios of uranium were, however, obtained from bulk rock samples, in which it is impossible to identify the minerals of importance and their mechanistic role in U retention and radioactive disequilibrium.

Selective extraction (SE) procedures are useful for separating and identifying the constituent mineral phases, and have been applied to the study of U series radionuclides(12, 13), which are usually measured by radiochemical techniques such as α-spectrometry. However, the use of SE technique is lacking in information on the textural relationship between the phases because crushing and dissolution of the sample are required.

Isotopic data for small areas, e.g. individual mineral phases within rock samples or different positions within a grain, would be necessary to elucidate isotopic fractionation mechanisms of U series radionuclides. Recently, secondary ion mass spectroscopy (SIMS) has been developed as a micro-analytical techniques for isotopes in solids and applied to geological samples, and is expected to be useful to confirm data obtained with the SE procedure. In this study, a Sensitive High mass-Resolution Ion Micro Probe (SHRIMP), one of the most powerful instruments of SIMS, has been applied to the weathered rock samples from the Koongarra deposit to obtain isotopic composition of uranium series radionuclides. The final goal of this investigation is to estimate the time scales associated with the migration and redistribution of uranium and uranium series nuclides within the iron minerals. This work is crucial in quantifying the roles of iron minerals in the retardation of actinides in sub-surface over geological time. The results will be used to evaluate the migration models against the uranium distributions at Koongarra, and to understand the fate of uranium at Koongarra.

This manuscript introduces the results of collaborative research activities conducted at Australian National University (ANU) between Japan Atomic Energy Research Institute (JAERI), Australian Nuclear Science & Technology Organisation (ANSTO) and the ANU within the framework of ASARR (Analogue Studies in the Alligator Rivers Region) project. Some of the results introduced here were already reported by Sato et al.(14).

2. Experimental

2.1. Sample description

Four Koongarra rock samples from different positions and two uraninite crystals have been analyzed in the present study. The Koongarra rock samples, three weathered rocks and one uraninite, were collected from diamond-drill cores. The three weathered samples were located in the dispersion fan with similar depth and different distances from the primary ore body, and hence could provide information on the spatial distribution of the U-series radionuclides within the dispersion fan. The three samples were therefore investigated in detail and termed DDH58-78, DDH60-65 and DDH87-61, respectively [1] (See Figure 1).

The dispersion fan is composed of primary minerals and weathering products (such as kaolinite and iron minerals). High uranium content was observed within the crystalline iron mineral[3, 4]. This phase had the particular morphological feature of nodule and was then described as "iron nodule"[2]. It is therefore thought that the crystalline iron nodules had played a dominant roll in retention of uranium migration in the dispersion fan more strongly than any other mineral phase. Based on polarized optical transmission micrographs, the iron nodules in DDH58-78 were classified into three phases, namely red nodule (referred to as RN), brown nodule (BN) and yellow nodule (YN), which mineralogically corresponded to amorphous and young, paracrystalline and middle aged, and crystalline and old aged phases, respectively. Samples of DDH60-65 and DDH87-61 contained a primitive iron mineral, which was considered to be a precursor phase of the iron nodules.

Besides the rock samples, standard minerals were required for calibration of peak positions at the beginning of measurements. For this purpose, we obtained two uraninite samples (Tanzanian uraninite and USA uraninite) from Nihon Chikagaku Sha Co. Analyzed phases are listed in Table 1.

2.2. SHRIMP operation

Secondary ion mass spectroscopy (SIMS) is a technique for analyzing the chemical (isotopic) composition of a solid surface by identifying secondary ions, ejected during primary ion bombardment on the solid surface, with mass spectroscopy. The ability of the instrument to focus the primary ion allows micro-isotopic analysis and provides spatial information of the sample [15]. Sensitive High mass-Resolution Ion Micro Probe (SHRIMP) has been developed at the Research School of Earth Sciences of ANU as a powerful tool for the micro-isotopic analysis, and originally used to measure the Pb-U-Th ages of zircon and monazite from a number of locations(16-19). All analyses in this study were made on the SHRIMP II at ANU. Although the SHRIMP is fundamentally similar to SIMS, it is optimized for high sensitivity when operating at high mass resolution, which is achieved by the combination of wide slits and a large secondary mass analyzer. Although some smaller ion microprobes can be operated in such high mass resolution mode, their sensitivity is greatly diminished, and is more than ten times lower than that of the SHRIMP.

In the SHRIMP measurements, a primary beam of O_2^- at 10 kV accelerating voltage and 5-10 nA beam current was focused to a spot of about 30 μm in diameter on the polished thin section, which was coated with an about 30 nm layer of gold to overcome charging. Each analysis comprised sequential ion count-rate measurements at several mass-stations. Target nuclides were ^{204}Pb, ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{230}Th, ^{232}Th, ^{234}U, ^{235}U, ^{246}(ThO), ^{248}(ThO), ^{250}(UO), ^{251}(UO) and ^{252}(UOH). The time required per spot was about 20 minutes, including several minutes to sputter-clean the target area of the polished section prior to analysis.

2.3. Data processing

Isotopic ratios which were measured in the present study were ^{234}U/^{238}U, ^{230}Th/^{234}U, ^{204}Pb/^{206}Pb and ^{207}Pb/^{206}Pb. In estimating activity ratios of ^{234}U/^{238}U, count rates of ^{235}U were used instead of ^{238}U because count rates of ^{238}U are extremely high relative to ^{234}U. In the present study we estimated the activity ratios of ^{234}U/^{238}U and ^{230}Th/^{234}U in the following manner,

$$A_{234U}/A_{238U} = (\lambda_{234U}/\lambda_{238U})\cdot(N_{235U}/N_{238U})\cdot(N_{234U}/N_{235U})$$

$$A_{230Th}/A_{234U} = (\lambda_{230Th}/\lambda_{234U})\cdot(N_{230Th}/N_{234U}) \qquad [1]$$

where A_x, N_x and λ_x are activity, content in a mineral and decay constant of nuclide x, respectively. Decay constants of ^{238}U, ^{234}U and ^{230}Th are 1.551×10^{-10} (y^{-1}), 2.823×10^{-6} (y^{-1}) and 9.195×10^{-6} (y^{-1}), respectively(20), and an atomic ratio of ^{235}U/^{238}U is 1/137.88(20). Consequently the above activity ratios are given as,

$$A_{234U}/A_{238U} = 132.007\cdot(N_{234U}/N_{235U})$$

$$A_{230Th}/A_{234U} = 3.257\cdot(N_{230Th}/N_{234U}). \qquad [2]$$

In estimating an age based on the obtained activity ratios of $^{234}U/^{238}U$ or $^{230}Th/^{234}U$, we made an assumption regarding isotopic setting that an activity of ^{238}U at t=0 would be 1 and those of its daughter nuclides such as ^{234}U or ^{230}Th be 0. Under this assumption and by adding a fact that contribution of ^{234}Th and ^{234}Pa are negligible due to their extremely short half lives, activity of ^{238}U, ^{234}U and ^{230}Th at t are,

$$A_{238U} = e^{-\lambda_{238U} \cdot t}$$

$$A_{234U} = e^{-\lambda_{238U} \cdot t} - e^{-\lambda_{234U} \cdot t}$$

$$A_{230Th} = e^{-\lambda_{238U} \cdot t} + \lambda_{230Th}/(\lambda_{234U}-\lambda_{230Th}) \cdot e^{-\lambda_{234U} \cdot t} + \lambda_{234U}/(\lambda_{230Th}-\lambda_{234U}) \cdot e^{-\lambda_{230Th} \cdot t}. \quad [3]$$

Calculated activity ratios of $^{234}U/^{238}U$ and $^{230}Th/^{234}U$ were plotted as a function of time (y) in Figure 2. The two activity ratios begin to increase at approximately 10^4 years and reach unity around 5×10^6 years, and are hence quite useful in estimating age between 10^4 and 10^6 years. This timescale is considered to be concordant with a period during which uranium migration-fixation have been occurring within the secondary ore deposit, and applicable to the data process.

If the systems are closed, isotope ratios of $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ are formulated in Equation [4] below because contribution of their daughter nuclides are negligibly small due to the extremely short half lives compared to the parent nuclides.

$$N_{206Pb}/N_{238U} = e^{\lambda_{238U} \cdot t} - 1$$

$$N_{207Pb}/N_{235U} = e^{\lambda_{235U} \cdot t} - 1 \quad [4]$$

where N_{206Pb} and N_{207Pb} are content of radiogenic lead from ^{238}U and ^{235}U, respectively. Equation [4] and an atomic ratio of $^{235}U/^{238}U$ (=1/137.88) give isotope ratios of $^{207}Pb/^{206}Pb$ as a function of time (Figure 3). The $^{207}Pb/^{206}Pb$ isotope ratio is subsequently followed by a gradual increase after a plateau region till 10^8 years, and therefore applicable only when an age of event is older than 10^8 years.

3. Results and Discussion

We conducted 6 series of SHRIMP measurements from October of 1996 to November of

1997. Samples and target minerals in the measurements are summarized in Table 1. All data are tabulated and summarized in Appendix 1, 2 and 3.

3.1. Standard uraninites

At the beginning of each series of measurement, we usually analyzed uraninite standards to calibrate peak positions of mass of uranium series radionuclides, and to ascertain whether some isotopic ratios are similar to the previously obtained values. For this purpose, we obtained two different uraninites, i.e. Tanzanian uraninite and USA uraninite, and at first we decided which one is adequate as a standard material in the second measurement.

In the first and the second measurements we omitted ^{234}U count rates, so activity ratios of $^{234}U/^{238}U$ were calculated based on count rates of $^{250}(UO)$ and $^{251}(UO)$: A_{234U}/A_{238U} = $132.007 \cdot (N_{250UO}/N_{251UO})$. We analyzed eight or nine different positions on each surface of the two standards, and results are shown in Figure 4. Activity ratios of $^{234}U/^{238}U$ for the Tanzanian uraninite are close to unity and position-independent, meaning the Tanzanian standard has reached almost secular equilibrium throughout the analyzed surface. On the other hand, the USA standard shows larger uranium activity ratios than unity and larger variation than the Tanzanian uraninite, meaning uranium series disequilibrium in the USA uraninite. Since homogeneous uranium isotopic composition is required for the standard, we concluded that the Tanzanian uraninite is adequate as the standard material for the uranium series radionuclides.

At the third measurement we added three lead isotopes (^{204}Pb, ^{206}Pb and ^{208}Pb) and ^{234}U as analyzed isotopes and the following additional results were obtained from the Tanzanian uraninite,

(1) Isotope ratios of $^{207}Pb/^{206}Pb$ were 0.06, and an age of about 500 My was estimated for the Tanzanian uraninite (Figure 3) if we assume that the system has been closed.

(2) Activity ratios of $^{234}U/^{238}U$ based on $^{234}U/^{235}U$ (1.00 ± 0.03) indicated that this sample had reached secular equilibrium, while those based on $^{250}(UO)/^{251}(UO)$ (1.12 ± 0.05) appeared to be slightly higher. Therefore, we should use count rates of $^{234}U/^{235}U$ when calculating uranium activity ratios. Details on this subject are explained in the next section, where the data of Koongarra samples are presented.

(3) Activity ratios of $^{230}Th/^{234}U$ were around 0.38 ± 0.02 though age of the sample should be enough to reach unity (=1). This discrepancy must be caused from difference in sputtering efficiency between Th and U: the sputtering efficiency of U can be estimated around three times higher than that of Th in the case of the Tanzanian uraninite. Since the other uraninite or mineral phases may be considered to have different sputtering efficiency from the Tanzania uraninite, we cannot correct the $^{230}Th/^{234}U$ activity ratios obtained from the other phases by use of the value of 0.38 obtained here. At this time, we can not quantitatively discuss the $^{230}Th/^{234}U$ activity ratios derived from SHRIMP.

(4) Activity ratios of $^{234}U/^{238}U$ based on $^{234}U/^{235}U$ indicated almost similar values throughout the analyses, while count rates (cps) of ^{235}U had larger dispersion (Figure 5). Therefore, we should not use the count rates of ^{235}U as quantitative values.

3.2. Uranium series disequilibria

Relationship between count rates of ^{235}U and the activity ratios of $^{234}U/^{238}U$: Since activity ratios of $^{234}U/^{238}U$ were estimated from isotope ratios of $^{234}U/^{235}U$ as formulated in Equation [2], we should consider an influence of count rates of ^{235}U on the activity ratios because low count rates could cause large errors of the values. A plausible condition that affects the count rates would be a primary beam current. In order to check this effect, we analyzed adjoining points of kaolinite in DDH60-65 at different beam currents. Beam currents were 6.3 nA (D60-39K), 11.0 nA (D60-39Kb), 7.1 nA (D60-40K) and 11.8 nA (D60-40Kb), where D60-39Kb and D60-40Kb adjoined D60-39K and D60-40K, respectively. Although lower beam currents apparently caused lower count rates of ^{235}U, they did not significantly affect $^{234}U/^{238}U$ activity ratios (See Appendix 3).

All data on activity ratios of $^{234}U/^{238}U$ for the kaolinite and for the iron nodule were plotted as a function of count rates of ^{235}U as shown in Figure 6. Similar to the standard uraninite shown in Figure 5, the count rates of ^{235}U have large dispersion compared to the $^{234}U/^{238}U$ activity ratios and hence are not considered to be quantitative values. In addition, since the activity ratios seem to be irrelevant to the count rates of ^{235}U in Figure 6, we don't need to consider the influence of the count rate of ^{235}U on the $^{234}U/^{238}U$ activity ratios.

Activity ratios based on the metal and on the oxides : Activity ratios of $^{234}U/^{238}U$ can be estimated from isotope ratios of $^{250}(UO)/^{251}(UO)$ (oxide-based ratios) as well as from those of $^{234}U/^{235}U$ (metal-based ratios). In the previous section, the oxide-based ratios of the Tanzanian uraninite were slightly larger than unity, while the metal-based ratios were closer to unity and seemed to be better, though count rates of $^{250}(UO)$ or $^{251}(UO)$ were much larger than those of ^{234}U or ^{235}U (See Appendix). In this section, we examine which procedure is applicable to estimation of the activity ratios in the Koongarra samples.

Metal-based activity ratios of $^{234}U/^{238}U$ obtained from kaolinite and iron nodule were plotted against oxide-based activity ratios (Figure 7). The oxide-based ratios of the kaolinite were quite high compared to the metal-based ratios, and six or seven points had relatively high values of oxide-based ratios for iron nodule. We considered that the higher values of the oxide-based activity ratios of $^{234}U/^{238}U$ might have been resulted from higher values of $^{250}(UO)$ count rates because a peak of $^{234}U^{16}O$ could be superimposed by that of $^{238}U^{12}C$ as follows,

$M_{234U} + M_{16O} = 234.0409 + 15.9949 = 250.0358$ (amu)

$M_{238U} + M_{12C} = 238.0508 + 12.0000 = 250.0504$ (amu).

Since a mass resolution of SIMS is generally given by $M/\Delta M$, at least 17000 (=250.0504 / (250.0504 - 250.0358)) of mass resolution is necessary to discriminate $^{234}U^{16}O$ from $^{238}U^{12}C$. On the other hand, a mass resolution of the present measuring condition was ~6000, and apparently smaller. From the above reasons, $^{234}U^{16}O$ would have been interfered by $^{238}U^{12}C$. Consequently, we should accept the metal-based activity ratios of $^{234}U/^{238}U$ rather than the oxide-based activity ratios.

Uranium series disequilibria in the kaolinite and iron nodules : Line analyses within the iron nodule indicated that a significant difference in $^{234}U/^{238}U$ activity ratio was not found between a center of the grain and its edge. Count ratios of $^{230}Th/^{234}U$ also did not indicate significant difference between DDH58 and DDH60. The values on DDH87 were excluded because the count rates of ^{230}Th were quite low.

Results of metal-based activity ratios of $^{234}U/^{238}U$ obtained with SHRIMP were tabulated in

Table 2, along with previously determined values with SE method for DDH60-65. Most of data on iron nodules seem to be close to unity. On the other hand, slightly higher values of the $^{234}U/^{238}U$ activity ratios were obtained from kaolinites and primitive iron minerals.

If a system has been closed and a sufficient time (at least 1 My according to Figure 2) has passed after an uptake of uranium, the activity ratio must be close to unity. The slightly higher values of $^{234}U/^{238}U$ on the kaolinite and the primitive iron minerals could indicate that these minerals have not been closed and have hence allowed inflow or outflow of groundwaters containing uranium within the grains. If the kaolinite and the iron minerals are opened, it is considered that the groundwaters would be equilibrated with these opened minerals in isotopic composition. However, studies on groundwater geochemistry in the Koongarra uranium deposit revealed that $^{234}U/^{238}U$ activity ratios of groundwater were below unity in the surficial weathered zone (shallower than about 20 m depth), and greater than unity in the deeper unweathered zone (>30 m depth)(21, 22). Although there are no data on the $^{234}U/^{238}U$ activity ratios of the groundwater at the present three positions (DDH58, DDH60 and DDH87), it is possible that the groundwater activity ratios is assumed to be below unity because the sampling positions are located in the weathered zone.

In a sequential extraction (SE) procedure, Morgan solution extracts the uranium fraction in adsorbed or associated with carbonate phases, and subsequent Tamm's Acid Oxalate (TAO) solution extracts the uranium fraction associated with amorphous minerals. As suggested by Lowson et al.(23) and Yanase et al.(12), uranium in the groundwater was equilibrated with adsorbed uranium and uranium associated with amorphous minerals, not with kaolinite, because $^{234}U/^{238}U$ ratios of Morgan's and of TAO's extractable fractions were correspondent with those in the groundwaters. In Table 2, however, the average $^{234}U/^{238}U$ activity ratio of the primitive iron minerals (amorphous iron minerals) with SHRIMP (1.26 ± 0.28) was higher than that of exchangeable phase (0.64) extracted by the Tao reagent. An explanation for the discrepancy may be given by possibility that the TAO preferentially extracts surface coatings whereas the SHRIMP measurement is made on a cut and polished section, which therefore represents the interior of mineral grains.

In Table 2, activity ratios in kaolinite measured with SHRIMP (1.46) are much lower than those for residual mineral phases in the SE study (13.2), which may indicate that phases with low uranium contents such as quartz were contributing to activity ratios of the residue obtained from the SE technique. This would imply that the activity ratio in the quartz must be extremely high. The specific data on the kaolinite would have been impossible without the use of SHRIMP, because the kaolinite is not extracted separately in the SE procedure(12).

The mechanisms leading to lower $^{234}U/^{238}U$ ratios in groundwaters and higher ratios in mineral phases are still under discussion. One of possible explanations of the higher ratios in the mineral phases has been occasionally given by a mechanism considering alpha-recoil(12, 13, 24, 25). If we accept this mechanism, it occurs when ^{238}U existing at an edge of the iron nodule decayed to ^{234}Th, the ^{234}Th moved to the adjoining kaolinite from its previous position as a consequence of alpha-recoil, and ^{234}U, a daughter nuclide of the ^{234}Th, was accumulated in the kaolinite phase. However, a range of a recoiled nucleus was calculated to be approximately 20 nm(26), which was quite small compared to distances of analyzed kaolinite spots from the adjacent iron nodules. This implies that another geochemical processes such as diffusion of daughter nucleus should be considered.

Another possible explanation of the higher $^{234}U/^{238}U$ ratios is that ^{234}Th, daughter nuclide of ^{238}U, is adsorbed on clay and iron minerals produced by weathering of host rock, and the ^{234}Th and its daughter nuclide, ^{234}U, are subsequently fixed in the minerals(27). In this case, the $^{234}U/^{238}U$ ratios in the weathering products are greater than unity and those in the groundwaters are below unity.

Although the primitive iron mineral is considered to be a precursor of the crystalline iron nodule, $^{234}U/^{238}U$ activity ratios in the primitive iron mineral were slightly higher than those in the iron nodule. This implies that transformation of the primitive iron mineral to the nodule could have been accompanied by closing of the system, and inflow and outflow of uranium were prohibited because of change in its structure. In such a closed system, the $^{234}U/^{238}U$ ratios might have decreased with increasing time. This hypothesis is supported by a fact that the activity ratio of more crystallized yellow nodule is lower than that of less crystallized red nodule in DDH57 sample (See Table 2).

On the basis of the above hypothesis, we can estimate a period, during which the primitive iron mineral has crystallized to the iron nodule. When a value of $^{234}U/^{238}U$ activity ratio is 1.26 in a closed system, the ratio (AR) is expressed by the following equation,

$$AR = \frac{e^{-\lambda_{238U} \cdot t} - e^{-\lambda_{234U} \cdot t} + 1.26 \cdot e^{-\lambda_{234U} \cdot t}}{e^{-\lambda_{238U} \cdot t}} \qquad [5]$$

where λ_x is a decay constant of nuclide x. Figure 8 shows a change in the $^{234}U/^{238}U$ activity ratio with increasing time calculated from Equation [5]. It is apparent in this figure that at least 1 My is required for a system with 1.26 of the activity ratio to reach secular equilibrium. This period is considered to be equivalent to a mean residence period of uranium within the iron minerals. As calculated by Airey et al.(11), the secondary ore deposit began to form about 1-3 My ago, and therefore a value obtained in the present study indicates the uranium leached from the primary ore has been fixed at the beginning of the secondary ore formation.

3.3. Lead isotope ratios

Stable lead isotopes existing in the earth are ^{204}Pb, ^{206}Pb, ^{207}Pb and ^{208}Pb. Isotopic abundance of the current terrestrial lead are 1.41% of ^{204}Pb, 24.1% of ^{206}Pb, 22.1% of ^{207}Pb and 52.4% of ^{208}Pb(20). In a system containing significant uranium or thorium, the relative abundance are different from the average terrestrial values. Abundance of ^{206}Pb, ^{207}Pb and ^{208}Pb increase while ^{204}Pb abundance does not increase because the decay of ^{238}U, ^{235}U and ^{232}Th yields stable isotopes of ^{206}Pb, ^{207}Pb and ^{208}Pb, respectively. Thus, the lead isotopic composition in the Koongarra ore deposit could provide information on the period concerned with uranium and also on the migration behavior of lead(28).

Lead produced as a final decay products of uranium and thorium are called the radiogenic lead, while that existed at the formation of the Earth at 4.5 billion years ago is called a primordial or primeval lead. An isotopic composition of the primordial lead is occasionally represented by a value in meteorites, of which uranium and thorium compositions are extremely low compared to lead and hence does not affect the lead isotopic ratio beyond the instrumental measurement error. Values of 9.307 for $^{206}Pb/^{204}Pb$ and 10.294 for $^{207}Pb/^{204}Pb$ were reported as the primordial lead ratios by Tatsumoto et al.(29). The current average terrestrial lead stated above essentially contains the radiogenic lead since the formation of the Earth as well as the primordial lead and called a common lead here.

Lead isotope compositions of different samples are presented on a diagram of $^{207}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$, where data with low count of leads were omitted (Figure 9). Plots on upper-right end of the diagram represent the common lead component of the host rock of the Koongarra deposit. Distribution of the plots to the lower-left direction from the common lead component shows significant influence of the radiogenic lead isotopes from uranium. Figure 9 displays that the secondary ore deposit includes the radiogenic lead, common lead and mixture of both. The interception of the least squares regression line with the $^{207}Pb/^{206}Pb$ axis corresponds to the isotopic ratio of the radiogenic lead component. The interception for the analyses of minerals in DDH60 and DDH87 samples is around 0.1. Since similar values of the $^{207}Pb/^{206}Pb$ ratios were obtained from samples around the primary ore deposit(28), it is considered that the radiogenic lead component in samples of DDH60 and DDH87 is derived from radiogenic lead migrated from the primary ore body before the secondary ore formation.

In the DDH58 sample, the common lead was predominantly detected from kaolinite, while the radiogenic lead was from the iron nodules. The interception of the regression of DDH58 analyses with the vertical axis is lower than that for DDH60 and DDH87 regression line. In the current primary ore body, $^{207}Pb/^{206}Pb$ ratios of uranium minerals are approximately 0.078 and it is lower than that of minerals such as sulfide minerals around the primary ore body(28). Since DDH58 core hole is closer to the primary ore body than DDH60 and DDH87 core holes, radiogenic lead in the primary ore body may affect to lead isotope composition of minerals in DDH58 samples.

The nodules seem to have accumulated not only uranium but also radiogenic lead. In the DDH60 sample, the radiogenic lead tended to be detected mainly from the primitive iron minerals, while the common lead mainly from kaolinite and iron nodule. This suggests that the radiogenic lead has a tendency to be accumulated in the primitive iron mineral, not in the iron nodule nor in the kaolinite, though the radiogenic lead was observed in the iron nodule for the DDH58 sample. A possible explanation of this discrepancy for DDH58 is that the radiogenic lead might have been accumulated in the primitive iron minerals, a precursor of the iron nodule, not in the nodule also for DDH58 sample, and have survived a transformation of the primitive iron minerals to the iron nodule. A fact that the iron nodule in DDH60 does not contain the radiogenic lead indicates that the radiogenic lead migrating from the primary ore deposit did not reach a location of DDH60 when iron nodule was the primitive iron mineral because of a long distance from the primary deposit. In DDH87 sample, however, both kaolinite and nodule seem to contain the radiogenic lead as well as the common lead, that may be influenced by the presence of titanium oxides with high radiogenic lead content.

There seem to be three sources of lead: (1) common lead in the Koongarra host rock, (2) radiogenic lead around the primary ore migrated from the primary ore by the geologic event before the secondary ore formation, (3) radiogenic lead migrated from the primary ore by the secondary ore formation. The lead migrating from the primary ore is dominant in a closer area to the primary ore such as DDH58. In the distant area like DDH87, however, the lead from the primary ore did not reach and the lead originally existing dominates the lead isotope ratios there. In fact, count rates of ^{206}Pb and ^{207}Pb decrease with the distance from the primary ore body (See Appendix).

4. Conclusion

The SHRIMP analyses have been conducted for the samples from the Koongarra secondary ore deposit to obtain activity ratios of $^{234}U/^{238}U$ and isotopic ratios of $^{207}Pb/^{206}Pb$ and $^{204}Pb/^{206}Pb$. We concluded from the analyses the following:

1) Isotopic compositions obtained from the two uraninite standards (Tanzanian uraninite and USA uraninite) indicated that the Tanzanian uraninite was homogeneous in isotopic composition and therefore adequate as a standard material. The USA uraninite was heterogeneous in uranium series equibrium.

2) Activity ratios of $^{234}U/^{238}U$ based on the metal and the oxides were compared and the metal-based ratios were found to be less divergent and acceptable for iron nodules and kaolinite. The anomalous oxide-based count rates of $^{250}(UO)$ were explained by interference from a similar mass due to combination of ^{238}U and ^{12}C. The very small difference between these peaks at 250

amu is insufficient to enable them to be resolved by SHRIMP II.

3) An effect of count rates of ^{235}U on the activity ratios of $^{234}U/^{238}U$ was found to be negligibly small.

4) Activity ratios of $^{234}U/^{238}U$ were closer to unity for the iron nodule and slightly higher values for the primitive iron mineral (precursor of the iron nodule). This suggested that the mean residence time of uranium within the iron mineral was at least 1 My. On the other hand, slightly higher values for kaolinite were obtained.

5) Lead isotopes were investigated and yielded interesting results. There is a positive relationship between $^{207}Pb/^{206}Pb$ and $^{204}Pb/^{206}Pb$ isotope ratios. However, a systematic explanation was extremely difficult probably because there appeared to be three origins of lead.

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References

(1) Snelling, A.A.: Alligator Rivers Analogue Project Final Report, 2; ISBN 0-642-59928-9, Australian Nuclear Science and Technology Organisation, Sydney, 118 (1992).

(2) Sato, T., Murakami, T., Yanase, N., Isobe, H., Payne, T.E. and Airey, P.L.: Environ. Sci. Technol., 31, 2854 (1997).

(3) Edis, R., Cao, L., Cashion, J., Klessa, D., Koppi, A.J., Murakami, T., Nightingale, T., Payne, T., Snelling, A. and Yanase, N.: Alligator Rivers Analogue Project Final Report, 8; ISBN 0-642-59934-3, Australian Nuclear Science and Technology Organisation, Sydney, 255 (1992).

(4) Murakami, T., Isobe, H., Ohnuki, T., Yanase, N., Sato, T., Kimura, H., Sekine, K., Edis, R., Koppi, A.J., Klessa, D.A., Conoley, C., Nagano, T., Nakashima, S. and Ewing, R.C.: Alligator Rivers Analogue Project Final Report, 9; ISBN 0-642-59935-1, Australian Nuclear Science and Technology Organisation, Sydney, 138 (1992).

(5) Miller, W., Alexander, R., Chapman, N., McKinley, I. and Smellie, J.: Natural Analogue Studies in the Geological Disposal of Radioactive Wastes, Elsevier, Amsterdam, 395 (1994).

(6) Skagius, K. and Wingefors, S.: Alligator Rivers Analogue Project Final Report, 16; ISBN 0-642-59942-4, Australian Nuclear Science and Technology Organisation, Sydney, 60 (1992).

(7) Yanase, N., Sato, T., Iida, Y. and Sekine, K.: Radiochim. Acta, 82, 319 (1998).

(8) Airey, P.L.: Chem. Geol., 55, 255 (1986).

(9) Airey, P.L. and Ivanovich, M.: Chem. Geol., 55, 203 (1986).

(10) Wyrwoll, K.-H.: Alligator Rivers Analogue Project Final Report, 3; ISBN 0-642-59929-7, Australian Nuclear Science and Technology Organisation, Sydney, 93 (1992).

(11) Airey, P.L., Golian, C. and Lever, D.A.: Australian Atomic Energy Commission, Topical Report AAEC/C49 (NUREG/CR-5060) (1986).

(12) Yanase, N., Nightingale, T., Payne, T. and Duerden, P.: Radiochim. Acta, 52/53, 387 (1991).

(13) Yanase, N., Sato, T., Isobe, H. and Sekine, K.: Radioactive Waste Research, 2, 121 (1996) (in Japanese with English abstract).

(14) Sato, T., Yanase, N., Williams, I.S., Compston, W., Zaw, M., Payne, T.E. and Airey, P.L.: Radiochim. Acta, 82, 335 (1998).

(15) Hidaka, H. and Sano, Y.: Chikyukagaku (Geochemistry), 31, 1 (1997) (in Japanese with English abstract).

(16) Compston, W., Williams, I.S. and Meyer, C.: J. Geophys. Res., 89, B525 (1984).

(17) Compston, W. and Pidgeon, R.T.: Nature, 321, 766 (1986).

(18) Williams, I.S., Buick, I.S. and Cartwright, I.: J. Metamorphic Geol., 14, 29 (1996).

(19) Meyer, C., Williams, I.S. and Compston, W.: Meteoritics and Planetary Sci., 31, 370 (1996).

(20) Firestone, R.B., Shirley, V.S., Baglin, C.M., Chu, S.Y.F. and Zipkin, J.: Table of Isotopes (Eighth Edition), John Wiley & Sons, Inc., New York, 2877, (1996).

(21) Yanase, N., Payne, T.E. and Sekine, K.: Geochem. J., 29, 31 (1995).

(22) Payne, T.E., Edis, R., Herczeg, A.L., Sekine, K., Seo, T., Waite, T.D. and Yanase, N.: Alligator Rivers Analogue Project Final Report, 7; ISBN 0-642-59933-5, Australian Nuclear Science and Technology Organisation, Sydney, 185 (1992).

(23) Lowson, R.T., Short, S.A., Davey, B.G. and Gray, D.J.: Geochim. Cosmochim. Acta, 50, 1697 (1986).

(24) Sheng, Z.Z. and Kuroda, P.K.: Radiochim. Acta, 39, 131 (1986).

(25) Sheng, Z.Z. and Kuroda, P.K.: Radiochim. Acta, 40, 95 (1986).

(26) Hashimoto, T., Aoyagi, Y., Kudo, H. and Sotobayashi, T.: J. Radioanal. Nucl. Chem., 90/2, 415 (1985).

(27) Ohnuki, T., Watanabe, S. and Murakami, T.: Mat. Res. Soc. Symp. Proc., 212, 733 (1990).

(28) Isobe, H., Hidaka, H. and Ohnuki, T.: Mat. Res. Soc. Symp. Proc., 506, 687 (1998).

(29) Tatsumoto, M., Knight, R.J. and Allegre, C.J.: Science, 180, 1279 (1973).

Table 1 Samples and target minerals of SHRIMP analyses

	Date	Sample ID	Target minerals
1st	Oct/1996	DDH58-129	uraninite
		DDH60-65	nodule, kaolinite, quartz
2nd	Dec/1996	Tanzanian	uraninite
		USA	uraninite
3rd	Mar/1997	DDH60-65	nodule, kaolinite
4th	Jun/1997	Tanzanian	uraninite
		DDH60-65	nodule, kaolinite
		DDH87-61	nodule, kaolinite
5th	Oct/1997	Tanzanian	uraninite
		DDH58-78	nodule, kaolinite
		DDH87-61	nodule, kaolinite
6th	Nov/1997	Tanzanian	uraninite
		DDH60-65	nodule, kaolinite
		DDH87-61	nodule, kaolinite

Table 2 Activity ratios of $^{234}U/^{238}U$ for different minerals obtained with SHRIMP

mineral		SHRIMP			SE
		DDH58-78	DDH60-65	DDH87-61	DDH60-65
iron minerals	primitive	-	1.26 ± 0.28	1.27 ± 0.55	0.64
	fissure	-	-	-	
	red	1.21 ± 0.11	0.93 ± 0.08	0.98 ± 0.09	1.05
	brown	1.13 ± 0.05			
	yellow	1.09 ± 0.10			
kaolinite		1.35 ± 0.21	1.46 ± 0.25	1.28 ± 0.22	13.2
quartz		-	-	-	

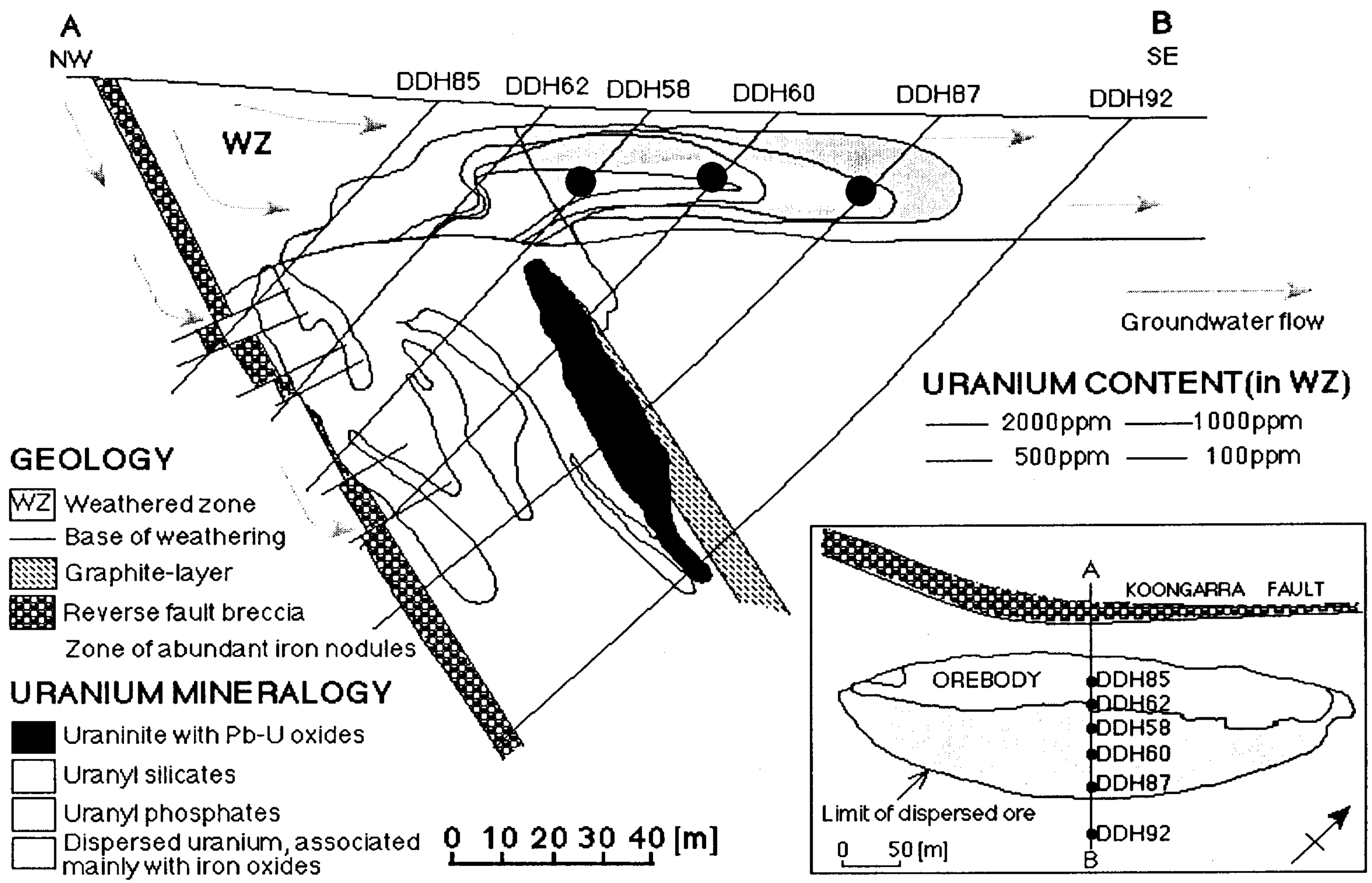


Figure 1 Schematic cross section of the Koongarra ore body modified from Snelling(1). A label of ● stands for sampling positions.

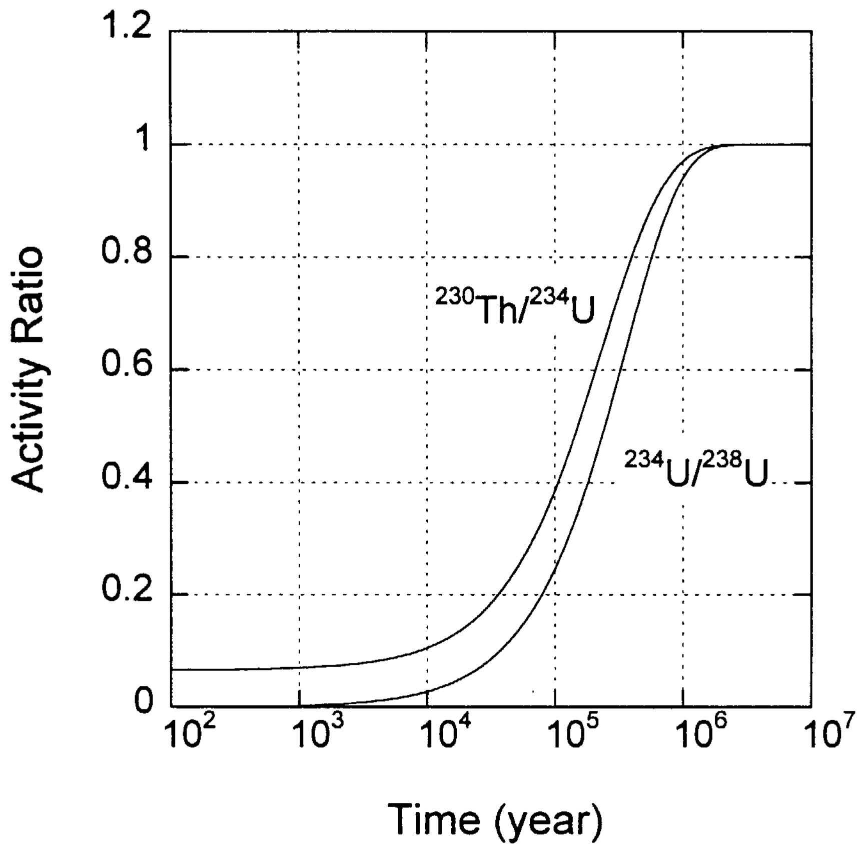


Figure 2 Calculated activity ratios of $^{234}U/^{238}U$ and $^{230}Th/^{234}U$ as a function of time (year).

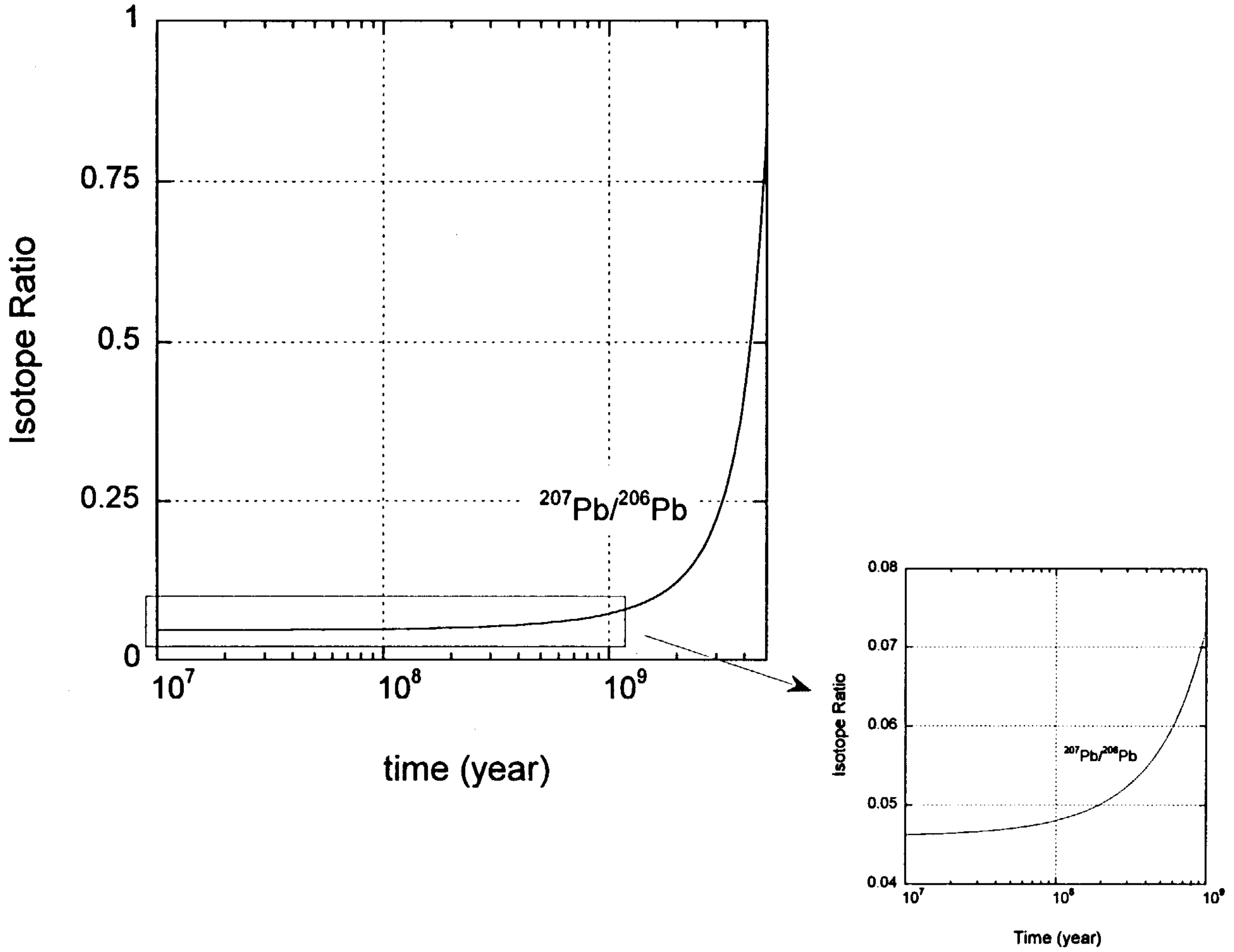


Figure 3 Calculated isotope ratios of $^{207}Pb/^{206}Pb$ as a function of time (year).

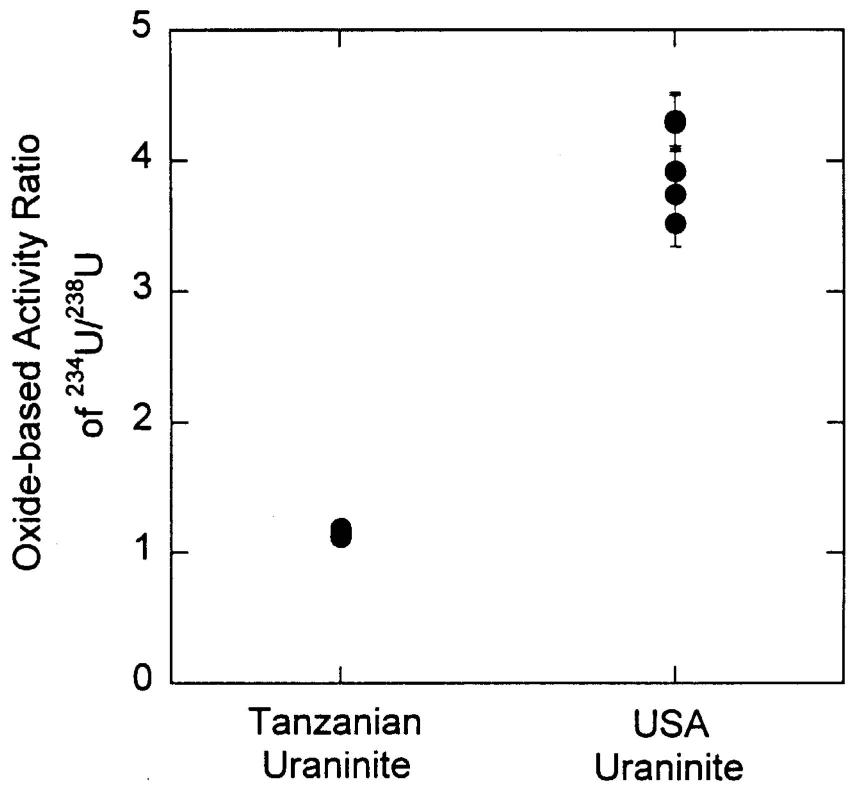


Figure 4 Oxide-based activity ratios of $^{234}U/^{238}U$ obtained with SHRIMP from two standard uraninites.

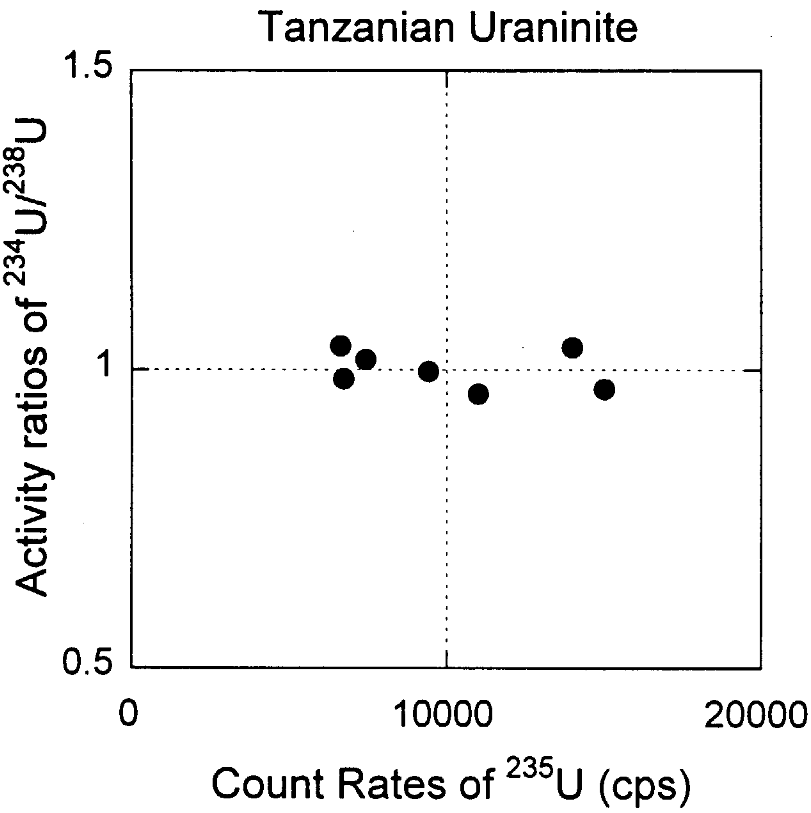
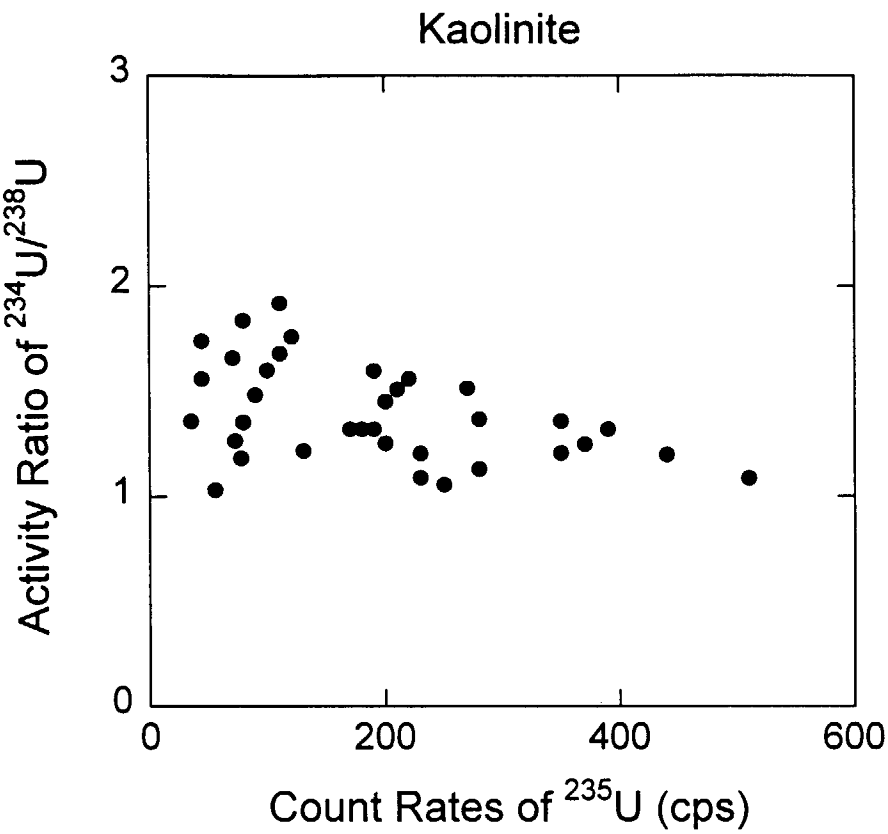


Figure 5 Activity ratios of $^{234}U/^{238}U$ as a function of count rates of ^{235}U obtained with SHRIMP from the Tanzanian uraninite.



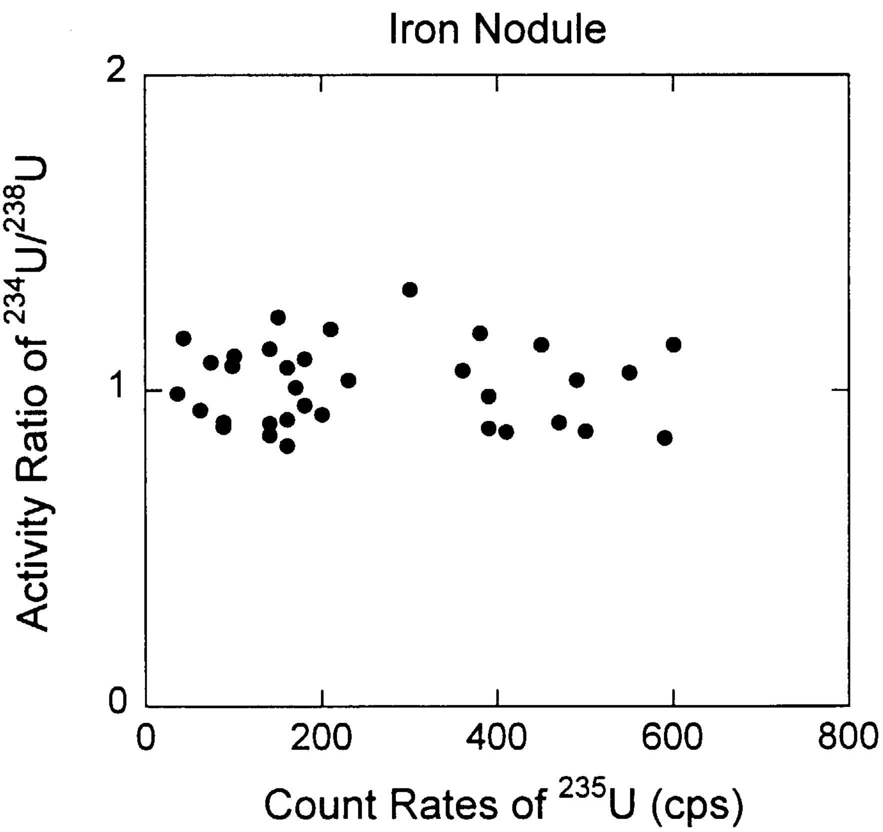
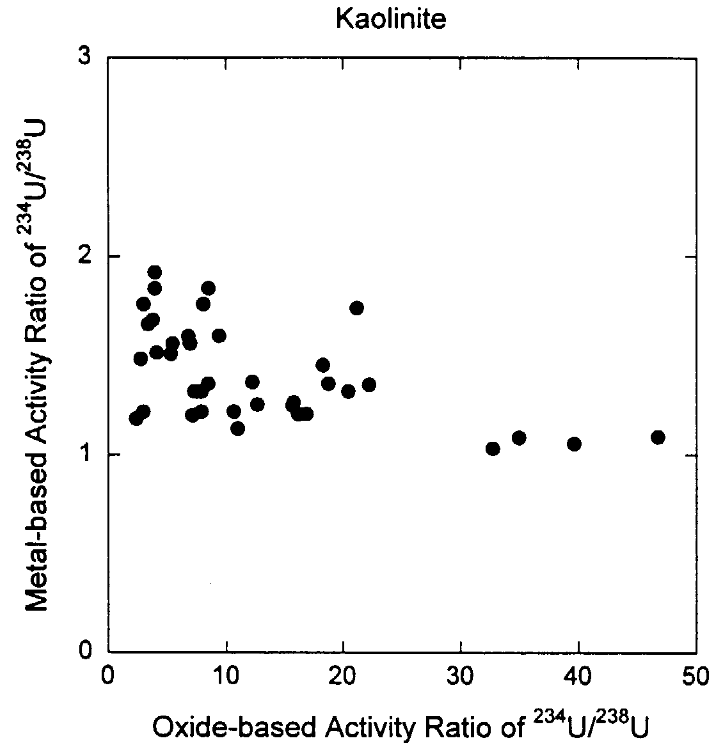


Figure 6 Metal-based activity ratios of $^{234}U/^{238}U$ as a function of count rates of ^{235}U obtained with SHRIMP from kaolinite and iron nodule in the Koongarra secondary ore deposit.



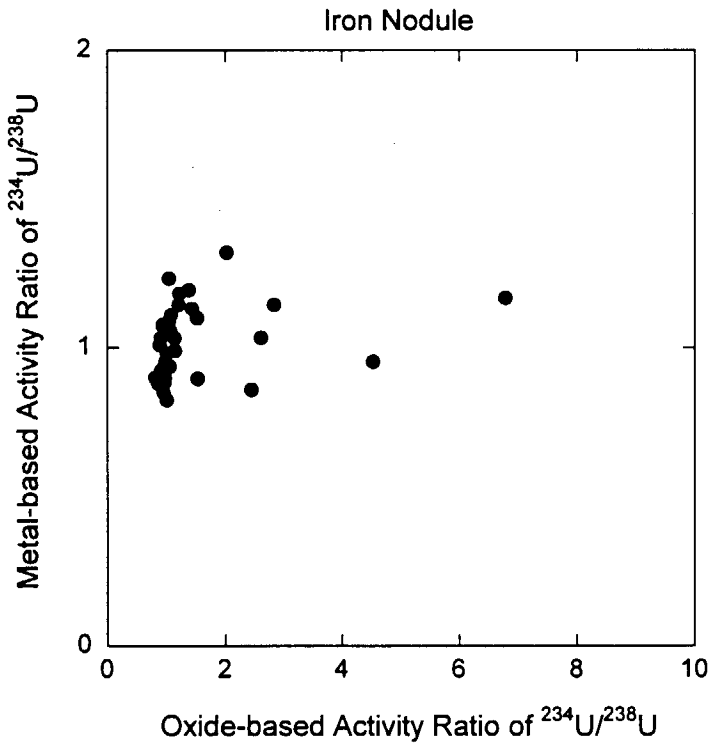


Figure 7 Plots of activity ratios of $^{234}U/^{238}U$ based on metal count rates versus those on oxide count rates obtained with SHRIMP from kaolinite and iron nodule in the Koongarra secondary ore deposit.

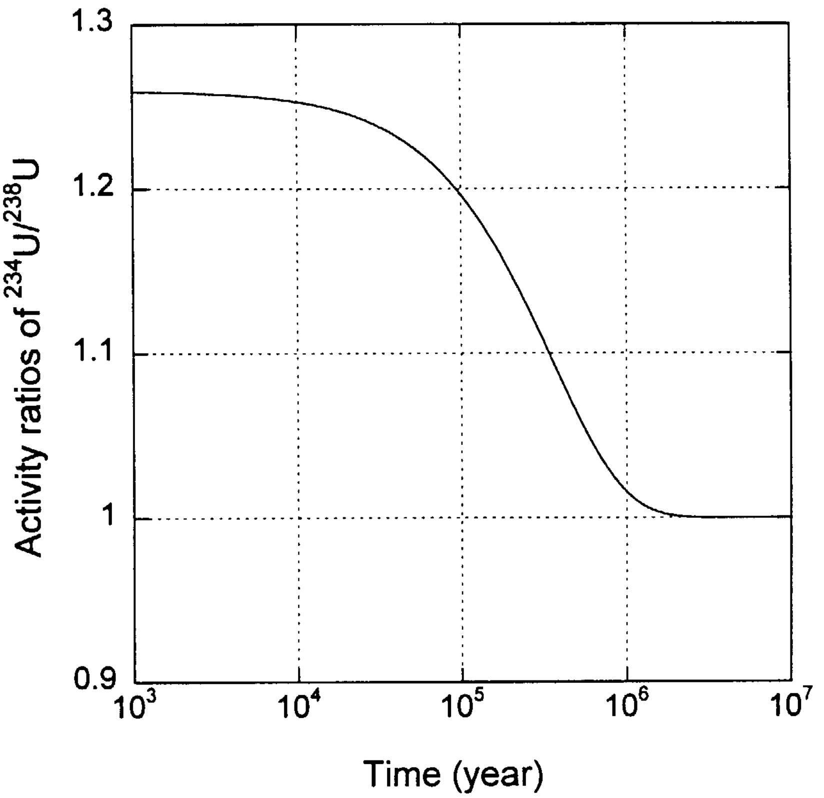


Figure 8 Calculated $^{234}U/^{238}U$ ratios as a function of time (year). An initial value corresponds to an obtained activity ratio with SHRIMP from a primitive iron mineral.

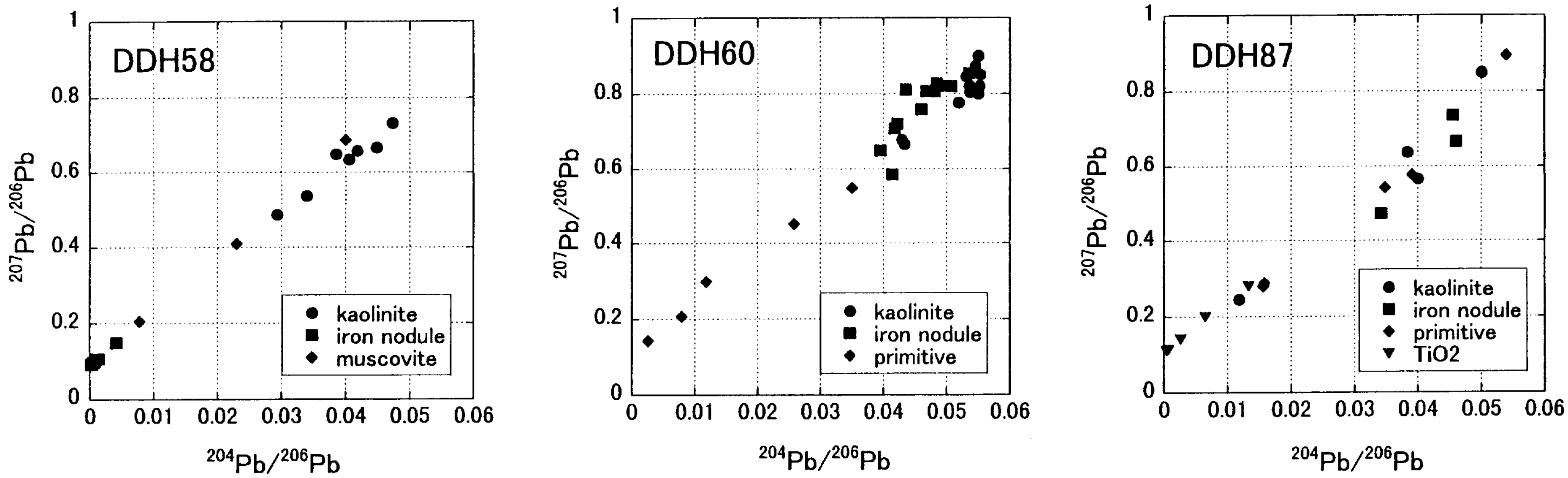


Figure 9 Plots of isotope ratios of $^{207}Pb/^{206}Pb$ versus those of $^{204}Pb/^{206}Pb$ for different minerals of DDH58, DDH60 and DDH87.

Appendix 1 Isotopic data of every SHRIMP measurement

the 1st measurement (count rate)

SAMPLE	Anal.	cps								Oct/1996-(1)
ID	Min.	U-235	RaO-242	ThO-246	PaO-247	Bkg-247	ThO-248	UO-250	UO-251	UO-254
U-1	U	5.9E+3	1.4E+1	9.9E+1	2.4E+0	0.0E+0	1.2E-1	4.9E+2	6.2E+4	
U-1B	U	5.7E+3	1.3E+1	9.7E+1	2.7E+0	7.4E-2	1.2E+0	4.8E+2	6.0E+4	
U-2	U	5.7E+3	1.4E+1	1.0E+2	2.6E+0	1.2E-1	8.0E-1	5.0E+2	6.3E+4	
U-2B	U	5.6E+3	1.3E+1	1.0E+2	3.2E+0	6.9E-2	1.4E+0	4.8E+2	6.3E+4	
U-3	U	4.3E+3	2.2E+1	1.3E+2	4.7E+0	1.2E-1	1.3E+3	6.1E+2	7.8E+4	
U-4	U	4.4E+3	2.7E+1	1.4E+2	5.4E+0	3.7E-2	1.1E+3	6.2E+2	7.9E+4	
U-5	U	7.8E+3	2.3E+1	3.2E+2	1.0E+1	3.2E-1	1.9E+0	1.2E+3	1.6E+5	
U-6	Sk	7.6E+3	2.9E+1	3.5E+2	1.2E+1	3.7E-1	5.0E+0	1.4E+3	1.8E+5	
N-0		3.0E+2	5.7E-1	1.5E+1	6.0E-1	8.7E-2	8.1E+1	6.7E+1	9.3E+3	
N-1	Nod	2.3E+2	5.3E-1	1.7E+1	7.2E-1	4.3E-2	1.2E+1	6.5E+1	1.0E+4	
N-1B	Nod	1.9E+2	5.2E-1	1.4E+1	6.4E-1	3.7E-2	1.0E+1	5.7E+1	8.7E+3	1.2E+6
N-1B	Nod	2.1E+2	8.1E-1	1.4E+1	8.0E-1	0.0E+0	9.1E+0	5.7E+1	8.6E+3	1.1E+6
N-2	Nod	1.9E+2	5.9E-1	1.3E+1	3.2E-1	4.1E-2	1.1E+2	5.3E+1	7.9E+3	1.1E+6
N-3	Nod	2.2E+2	8.5E-1	1.4E+1	8.0E-1	3.9E-2	1.7E+0	5.9E+1	8.2E+3	1.1E+6
N-4	Nod	2.8E+2	6.3E-1	1.4E+1	3.6E-1	4.0E-2	9.5E+1	6.4E+1	8.6E+3	1.2E+6
N-5	Nod	3.4E+2	4.8E-1	1.4E+1	6.0E-1	8.0E-2	1.0E+3	8.3E+1	8.8E+3	1.2E+6
N-6	Nod	3.3E+2	6.3E-1	1.3E+1	5.2E-1	4.1E-2	5.5E+2	6.5E+1	8.9E+3	1.2E+6
N-7	Kao	1.1E+2	1.1E-1	1.1E+0	1.6E-1	0.0E+0	1.0E+1	1.9E+1	3.9E+2	5.3E+4
N-8	Kao	2.0E+2	7.3E-2	1.6E+0	1.1E+0	0.0E+0	7.9E+1	1.4E+2	5.8E+2	7.8E+4
N-9	Kao	1.7E+2	4.6E-2	2.3E+0	6.6E-1	0.0E+0	1.8E+2	1.4E+2	9.9E+2	1.3E+5
N-10	Qz	2.5E+1	9.7E-2	2.7E-1	1.2E-1	4.2E-2	3.0E+1	2.5E+1	1.1E+2	1.5E+4
N-11	Qz	0.0E+0	1.7E-1	7.8E-3	0.0E+0	0.0E+0	4.0E-2	3.0E-2	5.7E-1	5.4E+1
N-12	Qz	0.0E+0	4.7E-2	7.9E-3	0.0E+0	0.0E+0	0.0E+0	1.3E-2	1.4E-1	1.2E+1
N-13	Nod	2.8E+2	4.8E-1	1.3E+1	5.2E-1	1.3E-1	2.3E+2	6.0E+1	8.0E+3	1.1E+6
N-14	Nod	8.1E+1	6.8E-1	7.3E+0	5.2E-1	3.7E-2	2.6E+0	4.0E+1	4.0E+3	5.4E+5
N-15	Nod	6.7E+1	6.4E-1	6.8E+0	2.8E-1	0.0E+0	8.6E-1	2.5E+1	3.5E+3	4.7E+5
N-16	Kao	1.1E+2	1.6E-1	1.4E+0	2.8E-1	3.6E-2	2.1E+2	4.5E+1	4.5E+2	6.0E+4
N-17		2.0E+2	1.0E-1	3.2E+0	8.8E-1	0.0E+0	1.9E+3	5.2E+1	1.1E+3	1.6E+5
N-18		2.4E+2	2.6E-1	1.5E+1	3.2E+0	0.0E+0	4.3E+3	1.9E+2	1.4E+3	1.9E+5
ZR-U	Zr	3.2E+1	0.0E+0	4.4E-1	0.0E+0	1.9E-1	1.8E+4	2.3E+1	1.5E+2	2.0E+4

U: uraninite, Nod: nodule, Kao: kaolinite, Qz: quartz, Zr: zircon the 1st measurement (ratio to ^{251}UO)

SAMPLE ID	Anal. Min.	ratio to UO-251 & error U-235	error	RaO-242	error	ThO-246	error	PaO-247	error	ThO-248	error	UO-250	error	UO-254	Oct/1996-(1) error
U-1	U	0.095512	0.000567	0.000222	0.000013	0.001607	0.000025	0.000039	0.000005	0.000002	0.000002	0.007847	0.000071		
U-1B	U	0.094862	0.000778	0.000222	0.000012	0.001612	0.000019	0.000044	0.000006	0.000019	0.000007	0.007890	0.000053		
U-2	U	0.090339	0.000960	0.000219	0.000012	0.001641	0.000019	0.000040	0.000007	0.000011	0.000007	0.007825	0.000074		
U-2B	U	0.089369	0.000539	0.000210	0.000012	0.001630	0.000019	0.000050	0.000006	0.000020	0.000008	0.007691	0.000050		
U-3	U	0.055186	0.000396	0.000283	0.000014	0.001675	0.000017	0.000059	0.000006	0.016575	0.000154	0.007746	0.000045		
U-4	U	0.055481	0.000378	0.000337	0.000014	0.001767	0.000017	0.000067	0.000007	0.013476	0.000131	0.007808	0.000045		
U-5	U	0.048347	0.000295	0.000139	0.000006	0.001985	0.000014	0.000063	0.000004	0.000010	0.000005	0.007681	0.000040		
U-6	Sk	0.043098	0.000362	0.000160	0.000006	0.001970	0.000017	0.000067	0.000004	0.000026	0.000004	0.007677	0.000056		
N-0		0.032177	0.000595	0.000052	0.000013	0.001595	0.000042	0.000055	0.000020	0.008796	0.000196	0.007249	0.000145		
N-1	Nod	0.023140	0.001135	0.000049	0.000013	0.001694	0.000064	0.000068	0.000018	0.001186	0.000094	0.006496	0.000153		
N-1B	Nod	0.022335	0.000512	0.000055	0.000014	0.001668	0.000044	0.000070	0.000019	0.001172	0.000075	0.006529	0.000101	133.882768	0.293526
N-1B	Nod	0.024447	NaN	0.000094	NaN	0.001599	NaN	0.000093	NaN	0.001052	NaN	0.006627	NaN	128.257435	NaN
N-2	Nod	0.023800	0.000740	0.000070	0.000015	0.001605	0.000052	0.000035	0.000015	0.014066	0.000270	0.006732	0.000155	133.460617	0.588317
N-3	Nod	0.026938	0.000575	0.000099	0.000021	0.001665	0.000045	0.000093	0.000023	0.000202	0.000032	0.007231	0.000114	134.037728	0.571444
N-4	Nod	0.032576	0.000682	0.000069	0.000013	0.001658	0.000055	0.000037	0.000015	0.011090	0.000229	0.007437	0.000109	134.291762	0.296362
N-5	Nod	0.038391	0.000673	0.000046	0.000011	0.001550	0.000043	0.000059	0.000027	0.118059	0.000804	0.009423	0.000313	134.365642	0.378905
N-6	Nod	0.036594	0.000654	0.000066	0.000014	0.001495	0.000041	0.000054	0.000017	0.061289	0.000627	0.007275	0.000126	134.080683	0.417151
N-7	Kao	0.271140	0.009737	0.000272	0.000111	0.002833	0.000272	0.000406	0.000203	0.025315	0.001619	0.049531	0.001363	134.908860	1.654671
N-8	Kao	0.340411	0.009563	0.000127	0.000063	0.002708	0.000218	0.001867	0.000367	0.136137	0.003253	0.248663	0.003216	134.218481	1.149389
N-9	Kao	0.171134	0.004282	0.000047	0.000033	0.002311	0.000220	0.000666	0.000157	0.186443	0.002936	0.142669	0.001829	133.964013	1.016670
N-10	Qz	0.221865	0.016082	0.000500	0.000307	0.002041	0.000411	0.000711	0.000711	0.273316	0.012408	0.224113	0.010048	138.707684	4.019968
N-11	Qz	0.000000	NaN	0.003200	0.001210	0.000144	0.000145	0.000000	NaN	0.000741	0.000744	0.000550	0.000392	0.010496	0.003055
N-12	Qz	0.000000	NaN	0.003911	0.002780	0.000662	0.000664	0.000000	NaN	0.000000	NaN	0.001118	0.001121	0.012028	0.006076
N-13	Nod	0.034663	0.000674	0.000044	0.000011	0.001569	0.000045	0.000049	0.000024	0.029049	0.000402	0.007536	0.000116	134.119372	0.457970
N-14	Nod	0.020305	0.000717	0.000162	0.000028	0.001835	0.000068	0.000122	0.000038	0.000651	0.000106	0.010176	0.000208	135.295522	0.741458
N-15	Nod	0.018854	0.001044	0.000182	0.000032	0.001932	0.000074	0.000079	0.000030	0.000244	0.000055	0.007142	0.000166	133.986221	0.453822
N-16	Kao	0.239709	0.007758	0.000278	0.000119	0.003007	0.000262	0.000542	0.000256	0.473466	0.007828	0.099783	0.002055	135.638111	1.300259
N-17		0.174420	0.005149	0.000089	0.000040	0.002817	0.000152	0.000777	0.000166	1.715095	0.015249	0.046063	0.000837	137.744914	0.942147
N-18		0.168375	0.003726	0.000186	0.000050	0.011043	0.000327	0.002256	0.000265	3.069868	0.026674	0.135107	0.003828	135.616640	1.971003
ZR-U	Zr	0.215658	0.017447	-0.001301	-0.001301	0.001661	0.002877	-0.001301	-0.001301	120.446373	1.979357	0.152407	0.005208	133.013990	2.145615

U: uraninite, Nod: nodule, Kao: kaolinite, Qz: quartz, Zr: zircon the 2nd measurement (count rate)

Sample ID	Anal. Min.	cps														Dec/1996-(2)
		Pb-204	Pb-206	Pb-207	Pb-208	PbH-209	Ra-226	U-235	RaO-242	ThO-246	PaO-247	Bkg-247	ThO-248	UO-250	UO-251	UOH-252
TAN-1	U	2.6E+0	4.4E+5	2.7E+4	5.4E+2			1.3E+4					2.5E+4		7.9E+4	
TAN-2	U	4.0E+0	5.0E+5	3.0E+4	6.4E+2			1.3E+4					2.4E+4		7.9E+4	
TAN-3	U			3.5E+4			1.5E+2	1.7E+4	1.3E+1	1.8E+2	6.0E+0	9.6E-1	6.4E+4	9.3E+2	1.0E+5	1.0E+3
TAN-4	U			3.2E+4			1.1E+2	9.4E+3	1.0E+1	1.2E+2	3.3E+0	9.7E-2	2.2E+4	6.1E+2	7.2E+4	6.2E+2
TAN-5	U			2.6E+4			1.3E+2	1.1E+4	1.0E+1	1.3E+2	3.4E+0	9.0E-2	4.6E+4	7.2E+2	8.0E+4	7.7E+2
TAN-6	U			3.3E+4			1.6E+2	1.5E+4	1.3E+1	1.6E+2	4.6E+0	8.5E-2	5.8E+4	9.1E+2	1.0E+5	7.9E+2
TAN-7	U			3.1E+4			1.3E+2	1.2E+4	1.1E+1	1.4E+2	3.7E+0	1.3E-1	4.8E+4	7.5E+2	8.6E+4	5.9E+2
TAN-8	U			2.9E+4			1.6E+2	1.4E+4	1.2E+1	1.6E+2	4.2E+0	2.0E-1	3.1E+4	8.4E+2	1.0E+5	7.1E+2
TAN-9	U			3.3E+4			1.3E+2	1.2E+4	1.1E+1	1.4E+2	4.1E+0	1.1E-1	2.7E+4	7.4E+2	8.7E+4	6.3E+2
USA-1	U			1.6E+3			6.2E+1	1.2E+4	2.4E+0	1.0E+2	4.0E+0	3.0E-1	7.0E+5	1.6E+3	5.8E+4	1.9E+2
USA-2	U			3.0E+3			5.9E+1	1.1E+4	2.3E+0	9.6E+1	3.5E+0	1.9E-1	6.0E+5	1.4E+3	5.4E+4	2.2E+2
USA-3	U			2.0E+3			6.2E+1	1.1E+4	2.7E+0	1.0E+2	4.1E+0	3.0E-1	8.5E+5	1.9E+3	5.7E+4	2.5E+2
USA-4	U			1.7E+3			6.5E+1	1.1E+4	2.4E+0	9.5E+1	2.8E+0	4.0E-1	7.3E+5	1.6E+3	5.5E+4	2.0E+2
USA-5	U			1.9E+3			6.3E+1	1.2E+4	2.6E+0	1.0E+2	4.0E+0	2.7E-1	7.1E+5	1.7E+3	5.8E+4	2.2E+2
USA-6	U			1.5E+3			5.4E+1	1.1E+4	2.0E+0	9.8E+1	4.3E+0	3.9E-1	7.2E+5	1.7E+3	5.4E+4	1.9E+2
USA-7	U	7.7E-1	2.9E+4	1.5E+3	8.7E+2	9.8E+0		1.1E+4					5.2E+5		5.3E+4	
USA-8	U	3.1E-1	2.7E+4	1.4E+3	9.2E+2	1.1E+1		1.0E+4					5.5E+5		5.0E+4	

U: uraninite

the 2nd measurement (ratio to ^{251}UO-1)

Sample ID	Anal. Min.	ratio to UO-251 & error-1										Dec/1996-(2)	
		Pb-204	error	Pb-206	error	Pb-207	error	Pb-208	error	PbH-209	error	Ra-226	error
TAN-1	U	0.000033	0.000002	5.576885	0.024707	0.341409	0.000520	0.006930	0.000036				
TAN-2	U	0.000051	0.000004	6.285507	0.014091	0.384851	0.000687	0.008054	0.000050				
TAN-3	U					0.333763	0.000955					0.001447	0.000015
TAN-4	U					0.445770	0.001070					0.001509	0.000017
TAN-5	U					0.327449	0.003143					0.001588	0.000018
TAN-6	U					0.317696	0.000909					0.001530	0.000015
TAN-7	U					0.368345	0.000929					0.001555	0.000017
TAN-8	U					0.286467	0.000721					0.001647	0.000017
TAN-9	U					0.379727	0.001172					0.001544	0.000017
USA-1	U					0.027528	0.000263					0.001077	0.000017
USA-2	U					0.056436	0.000489					0.001095	0.000017
USA-3	U					0.035239	0.000386					0.001073	0.000016
USA-4	U					0.030859	0.000288					0.001170	0.000023
USA-5	U					0.031923	0.000381					0.001069	0.000016
USA-6	U					0.027268	0.000274					0.001002	0.000017
USA-7	U	0.000015	0.000002	0.557120	0.001264	0.029219	0.000120	0.016429	0.000098	0.000185	0.000014		
USA-8	U	0.000006	0.000001	0.545962	0.001129	0.028615	0.000097	0.018583	0.000106	0.000214	0.000011		

U: uraninite

the 2nd measurement (ratio to ^{251}UO-2)

Sample ID	Anal. Min.	ratio to UO-251 & error-2													Dec/1996-(2)
		U-235	error	RaO-242	error	ThO-246	error	PaO-247	error	ThO-248	error	UO-250	error	UOH-252	error
TAN-1	U	0.166378	0.000356							0.315348	0.000560				
TAN-2	U	0.165136	0.000330							0.308415	0.000611				
TAN-3	U	0.167761	0.000340	0.000111	0.000004	0.001693	0.000017	0.000049	0.000004	0.610468	0.000774	0.008922	0.000046	0.009748	0.000053
TAN-4	U	0.130568	0.000297	0.000142	0.000005	0.001621	0.000018	0.000044	0.000003	0.312440	0.000656	0.008534	0.000042	0.008628	0.000060
TAN-5	U	0.142073	0.000593	0.000127	0.000005	0.001608	0.000022	0.000041	0.000003	0.571201	0.002317	0.008965	0.000053	0.009663	0.000070
TAN-6	U	0.145512	0.000308	0.000123	0.000006	0.001578	0.000015	0.000043	0.000003	0.565309	0.002554	0.008843	0.000040	0.007654	0.000051
TAN-7	U	0.142175	0.000288	0.000131	0.000005	0.001605	0.000019	0.000041	0.000003	0.561933	0.001029	0.008783	0.000040	0.006924	0.000055
TAN-8	U	0.140233	0.000281	0.000116	0.000006	0.001594	0.000019	0.000040	0.000003	0.309045	0.000588	0.008448	0.000036	0.007105	0.000046
TAN-9	U	0.137696	0.000265	0.000129	0.000006	0.001619	0.000023	0.000046	0.000003	0.312396	0.000740	0.008443	0.000038	0.007237	0.000050
USA-1	U	0.203933	0.000449	0.000037	0.000004	0.001804	0.000021	0.000064	0.000004	12.089036	0.014172	0.028262	0.000094	0.003273	0.000043
USA-2	U	0.202760	0.000455	0.000040	0.000005	0.001774	0.000022	0.000062	0.000005	11.126562	0.013411	0.026588	0.000110	0.004174	0.000048
USA-3	U	0.190962	0.000375	0.000043	0.000004	0.001794	0.000029	0.000066	0.000004	14.749907	0.032210	0.032527	0.000118	0.004298	0.000047
USA-4	U	0.195021	0.000409	0.000037	0.000004	0.001719	0.000021	0.000043	0.000004	13.202454	0.036858	0.029598	0.000096	0.003661	0.000044
USA-5	U	0.200780	0.000432	0.000039	0.000004	0.001773	0.000021	0.000063	0.000004	12.102948	0.027394	0.029586	0.000112	0.003759	0.000050
USA-6	U	0.203860	0.000480	0.000030	0.000004	0.001817	0.000022	0.000072	0.000005	13.421824	0.038168	0.032380	0.000131	0.003530	0.000049
USA-7	U	0.209810	0.000559							9.888188	0.023079				
USA-8	U	0.204151	0.000488							10.961190	0.014651				

U: uraninite

the 3rd measurement (count rate)

Sample ID	Anal. Min.	cps													Mar/97-(3)
		Pb-207	Ra-226	Th-230	Th-232	U-234	U-235	RaO-242	ThO-246	PaO-247	Bkg-247	ThO-248	UO-250	UO-251	UOH-252
TAN10	U	8.9E+4	1.0E+2	5.7E+0	1.1E+3	5.2E+1	6.6E+3	2.1E+1	1.4E+2	2.2E+0	4.3E-2	2.4E+4	6.5E+2	8.1E+4	6.2E+2
TAN11	U	1.0E+5	1.3E+2	6.7E+0	1.3E+3	5.7E+1	7.4E+3	2.3E+1	1.6E+2	2.7E+0	6.8E-2	2.8E+4	7.3E+2	9.1E+4	5.7E+2
TAN11	U	7.9E+4	1.1E+2	6.1E+0	1.2E+3	5.0E+1	6.7E+3	1.7E+1	1.3E+2	2.9E+0	9.6E-2	2.5E+4	6.4E+2	8.0E+4	6.3E+2
NODULE-20	Nod	1.2E+2	1.0E+0	1.2E-1	2.0E-2	6.0E-1	8.8E+1	3.8E-1	7.9E+0	2.3E-1	3.5E-2	2.5E-1	2.5E+1	4.1E+3	5.4E+1
NODULE-21	Nod	8.7E+1	1.5E+0	2.2E-1	0.0E+0	5.9E-1	8.8E+1	4.6E-1	7.3E+0	2.3E-1	4.8E-2	6.3E-1	3.0E+1	4.1E+3	5.1E+1
NODULE-22	Nod	1.6E+2	8.8E-1	2.4E-1	2.4E-2	8.0E-1	9.8E+1	3.7E-1	9.2E+0	3.4E-1	1.3E-1	1.0E-1	3.2E+1	4.5E+3	5.4E+1
NODULE-23K	Kao	7.0E+2	1.1E-1	5.4E-1	1.8E+1	1.4E+0	1.1E+2	3.9E-2	2.0E+0	1.8E-1	2.0E-2	9.6E+1	1.1E+1	3.9E+2	2.0E+1
NODULE-24K	Kao	6.1E+2	1.0E-1	2.9E-1	3.4E+0	1.6E+0	1.1E+2	4.0E-2	1.6E+0	1.5E-1	2.3E-2	1.2E+1	1.0E+1	3.4E+2	1.6E+1
NODULE-25K	Kao	8.1E+2	2.3E-1	5.4E-1	2.0E+1	1.9E+0	2.0E+2	2.1E-2	2.6E+0	8.4E-1	4.0E-2	1.3E+2	8.9E+1	9.3E+2	2.2E+2
NODULE-26K	Kao	3.0E+2	6.5E-2	2.5E-1	1.6E+1	1.2E+0	9.9E+1	2.1E-2	1.1E+0	1.4E-1	1.5E-2	6.7E+1	2.2E+1	3.1E+2	4.4E+1
NODULE-27K	Kao	3.5E+2	7.6E-2	4.9E-1	3.1E+1	2.2E+0	2.0E+2	6.0E-2	1.5E+0	7.0E-1	2.0E-2	1.3E+2	8.7E+1	6.3E+2	1.4E+2
NODULE-28K	Kao	6.7E+2	1.1E-1	3.8E-1	3.5E+1	1.9E+0	1.9E+2	5.9E-2	2.0E+0	3.4E-1	5.7E-2	1.8E+2	3.4E+1	5.7E+2	5.8E+1
NODULE-29K	Kao	9.0E+2	2.6E-1	6.1E-1	8.7E+1	1.8E+0	1.8E+2	7.8E-2	2.5E+0	5.0E-1	0.0E+0	5.4E+2	3.9E+1	6.9E+2	7.4E+1
NODULE-30	Nod	5.5E+1	1.3E+0	2.9E-1	0.0E+0	1.3E+0	1.6E+2	4.8E-1	8.6E+0	3.0E-1	9.4E-2	1.4E-1	3.8E+1	5.4E+3	8.3E+1
NODULE-31K	Kao	4.2E+2	7.3E-2	4.1E-1	5.0E+1	2.0E+0	2.5E+2	1.6E-1	1.5E+0	2.1E+0	4.3E-2	1.0E+2	1.5E+2	5.0E+2	2.5E+2
NODULE-32K	Kao	1.0E+3	3.8E-1	4.3E-1	6.1E+1	3.5E+0	3.7E+2	6.2E-2	2.1E+0	2.4E+0	1.5E-2	2.4E+2	1.1E+2	9.3E+2	3.2E+2
NODULE-33F	Fis	1.3E+2	1.2E+0	6.1E-1	1.7E+2	2.0E+0	2.7E+2	3.0E-1	6.7E+0	2.7E+0	4.6E-2	1.5E+3	1.1E+2	1.7E+3	4.6E+2
NODULE-34K	Kao	1.1E+3	2.6E-1	5.8E-1	2.4E+2	3.2E+0	3.5E+2	1.8E-1	5.3E+0	2.8E+0	0.0E+0	1.1E+3	1.4E+2	1.1E+3	4.1E+2
NODULE-35F	Fis	2.5E+3	2.0E-1	9.2E-2	4.9E+0	5.2E-1	5.9E+1	1.4E-1	1.6E+0	4.6E-1	0.0E+0	5.6E+1	2.0E+1	7.2E+2	4.7E+1
NODULE-36K	Kao	4.0E+2	2.2E-1	3.1E-1	3.6E+1	1.6E+0	1.2E+2	2.1E-2	1.6E+0	8.2E-2	1.7E-2	1.9E+2	9.1E+0	4.1E+2	2.2E+1
NODULE-37K	Kao	7.2E+2	2.1E-1	2.8E-1	4.0E+1	1.6E+0	1.2E+2	5.9E-2	2.0E+0	3.1E-1	0.0E+0	2.2E+2	2.8E+1	4.6E+2	6.2E+1

U: uraninite, Nod: nodule, Kao: kaolinite, Fis: fischer

the 3rd measurement (ratio to ^{251}UO-1)

Sample ID	Anal. Min.	ratio to UO-251 & error-1											Mar/1997-(3)
		Pb-207	error	Ra-226	error	Th-230	error	Th-232	error	U-234	error	U-235	error
TAN10	U	1.106519	0.002313	0.001288	0.000026	0.000069	0.000004	0.013631	0.000063	0.000644	0.000013	0.081524	0.000224
TAN11	U	1.122732	0.001962	0.001396	0.000018	0.000073	0.000004	0.013842	0.000085	0.000628	0.000007	0.081719	0.000208
TAN11	U	0.985025	0.002505	0.001387	0.000019	0.000076	0.000004	0.014510	0.000086	0.000623	0.000016	0.084255	0.000342
NODULE-20	Nod	0.029055	0.003403	0.000245	0.000035	0.000021	0.000015	-0.000004	-0.000006	0.000137	0.000028	0.021296	0.000526
NODULE-21	Nod	0.021286	0.003816	0.000366	0.000045	0.000043	0.000018	-0.000012	-0.000008	0.000133	0.000033	0.021563	0.000564
NODULE-22	Nod	0.035004	0.001648	0.000165	0.000041	0.000023	0.000016	-0.000024	-0.000013	0.000147	0.000017	0.021599	0.000453
NODULE-23K	Kao	1.787815	0.046815	0.000227	0.000120	0.001332	0.000297	0.046266	0.001833	0.003391	0.000247	0.277185	0.007591
NODULE-24K	Kao	1.768833	0.046901	0.000236	0.000145	0.000782	0.000279	0.009731	0.000816	0.004558	0.000327	0.317711	0.008694
NODULE-25K	Kao	0.870814	0.016177	0.000199	0.000094	0.000533	0.000316	0.021434	0.000727	0.002032	0.000123	0.212776	0.003717
NODULE-26K	Kao	0.974443	0.055870	0.000162	0.000121	0.000746	0.000247	0.052607	0.003617	0.003677	0.000358	0.319763	0.017826
NODULE-27K	Kao	0.553594	0.017292	0.000089	0.000066	0.000747	0.000183	0.049657	0.001464	0.003483	0.000209	0.313098	0.006765
NODULE-28K	Kao	1.184180	0.035842	0.000089	0.000125	0.000578	0.000163	0.060979	0.005418	0.003251	0.000203	0.334910	0.007438
NODULE-29K	Kao	1.308182	0.031651	0.000373	0.000131	0.000894	0.000161	0.127257	0.007596	0.002581	0.000161	0.265619	0.006172
NODULE-30	Nod	0.010295	0.000892	0.000232	0.000036	0.000036	0.000018	-0.000018	-0.000009	0.000232	0.000025	0.029815	0.000503
NODULE-31K	Kao	0.848935	0.070672	0.000060	0.000073	0.000739	0.000272	0.099685	0.016279	0.003985	0.000235	0.508918	0.010202
NODULE-32K	Kao	1.089297	0.036787	0.000394	0.000126	0.000447	0.000137	0.065286	0.009347	0.003709	0.000169	0.394542	0.005766
NODULE-33F	Fis	0.073962	0.002834	0.000639	0.000088	0.000325	0.000086	0.099795	0.001420	0.001132	0.000085	0.153014	0.002572
NODULE-34K	Kao	0.979398	0.019129	0.000244	0.000065	0.000539	0.000100	0.225176	0.040482	0.002910	0.000141	0.327719	0.005734
NODULE-35F	Fis	3.438554	0.050569	0.000281	0.000070	0.000127	0.000064	0.006781	0.000441	0.000714	0.000081	0.082015	0.002335
NODULE-36K	Kao	0.969209	0.026257	0.000500	0.000191	0.000700	0.000234	0.087556	0.002504	0.003761	0.000254	0.292461	0.009253
NODULE-37K	Kao	1.588866	0.038659	0.000458	0.000138	0.000611	0.000170	0.088687	0.002387	0.003532	0.000249	0.273156	0.008288

U: uraninite, Nod: nodule, Kao: kaolinite, Fis: fischer

the 3rd measurement (ratio to ^{251}UO-2)

Sample	Anal.	ratio to UO-251 & error -2											Mar/1997-(3)
ID	Min.	RaO-242	error	ThO-246	error	PaO-247	error	ThO-248	error	UO-250	error	UOH-252	error
TAN10	U	0.000257	0.000008	0.001677	0.000024	0.000027	0.000003	0.299768	0.000710	0.007992	0.000060	0.007634	0.000062
TAN11	U	0.000249	0.000010	0.001710	0.000024	0.000028	0.000003	0.309346	0.000618	0.008020	0.000043	0.006244	0.000056
TAN11	U	0.000216	0.000007	0.001644	0.000023	0.000035	0.000003	0.314421	0.000831	0.007950	0.000047	0.007820	0.000064
NODULE-20	Nod	0.000083	0.000026	0.001910	0.000100	0.000048	0.000018	0.000053	Inf	0.006064	0.000295	0.012988	0.000529
NODULE-21	Nod	0.000101	0.000024	0.001778	0.000094	0.000045	0.000016	0.000142	0.000075	0.007369	0.000194	0.012452	0.000375
NODULE-22	Nod	0.000052	0.000021	0.001991	0.000096	0.000046	0.000020	-0.000007	-0.000005	0.006948	0.000179	0.011927	0.000329
NODULE-23K	Kao	0.000049	0.000085	0.004979	0.000569	0.000413	0.000163	0.245078	0.027473	0.029077	0.005031	0.051708	0.002368
NODULE-24K	Kao	0.000051	0.000088	0.004543	0.000787	0.000378	0.000162	0.035365	0.002146	0.029794	0.001557	0.047824	0.002491
NODULE-25K	Kao	-0.000020	-0.000035	0.002748	0.000245	0.000861	0.000177	0.138246	0.002878	0.094884	0.002424	0.230423	0.005160
NODULE-26K	Kao	0.000022	Inf	0.003607	0.000548	0.000417	0.000198	0.215694	0.017312	0.069430	0.004247	0.140583	0.008485
NODULE-27K	Kao	0.000063	0.000063	0.002411	0.000285	0.001079	0.000191	0.211027	0.008055	0.137234	0.011546	0.214762	0.010638
NODULE-28K	Kao	0.000004	Inf	0.003493	0.000438	0.000492	0.000182	0.314620	0.023614	0.059697	0.001713	0.101828	0.003064
NODULE-29K	Kao	0.000114	0.000057	0.003698	0.000332	0.000723	0.000180	0.785272	0.011815	0.056876	0.010637	0.107907	0.002803
NODULE-30	Nod	0.000072	0.000026	0.001578	0.000078	0.000037	0.000020	0.000009	0.000023	0.007121	0.000168	0.015423	0.000351
NODULE-31K	Kao	0.000238	0.000126	0.002865	0.000360	0.004074	0.000429	0.206024	0.075732	0.307015	0.081594	0.494543	0.010147
NODULE-32K	Kao	0.000051	0.000051	0.002256	0.000301	0.002529	0.000237	0.262386	0.025194	0.120311	0.050259	0.342681	0.005137
NODULE-33F	Fis	0.000148	0.000052	0.003815	0.000213	0.001553	0.000144	0.837723	0.008879	0.064393	0.005378	0.265764	0.003450
NODULE-34K	Kao	0.000163	0.000054	0.004892	0.000307	0.002548	0.000249	1.019994	0.103107	0.130281	0.042624	0.375286	0.006919
NODULE-35F	Fis	0.000194	0.000073	0.002151	0.000264	0.000639	0.000147	0.077516	0.002255	0.027100	0.004002	0.064842	0.002709
NODULE-36K	Kao	0.000008	Inf	0.003833	0.000441	0.000156	0.000116	0.465193	0.017307	0.021993	0.001282	0.052420	0.003096
NODULE-37K	Kao	0.000129	0.000074	0.004309	0.000435	0.000686	0.000177	0.489662	0.009616	0.060524	0.013434	0.135924	0.003936

U: uraninite, Nod: nodule, Kao: kaolinite, Fis: fischer

the 4th measurement (count rate)

Sample	Anal.	cps																Jun/1997-(4)
ID	Min.	Pb-204	Pb-206	Pb-207	Pb-208	Th-230	Th-232	U-234	Bkg-234	U-235	ThO-246	Bkg-247	ThO-248	UO-250	UO-251	UOH-252	UO2-266	UO2-267
NODULE-39K	Kao	6.9E+1	1.3E+3	1.1E+3	2.6E+3	3.2E-1	3.9E+1	1.1E+0	6.2E-2	7.9E+1	1.5E+0		2.5E+2	2.5E+1	3.9E+2	3.4E+1	7.9E+0	2.2E+2
NODULE-39Kb	Kao	1.1E+2	2.0E+3	1.8E+3	4.0E+3	9.5E-1	9.5E+1	2.3E+0	0.0E+0	1.9E+2	3.0E+0		5.7E+2	4.6E+1	9.0E+2	7.1E+1	1.5E+1	4.5E+2
NODULE-40K	Kao	1.1E+2	2.0E+3	1.6E+3	3.9E+3	3.8E-1	4.4E+1	1.1E+0	1.9E-2	7.9E+1	1.3E+0		3.5E+2	1.3E+1	4.4E+2	2.1E+1	6.7E+0	3.3E+2
NODULE-40Kb	Kao	1.5E+2	2.8E+3	2.3E+3	5.4E+3	4.3E-1	1.2E+2	2.4E+0	2.1E-2	2.1E+2	3.5E+0		8.4E+2	4.4E+1	1.1E+3	7.1E+1	1.5E+1	7.3E+2
NODULE-41K	Kao	9.1E+1	2.1E+3	1.4E+3	3.4E+3	7.1E-1	1.3E+2	2.9E+0	4.1E-2	2.8E+2	4.2E+0		1.0E+3	1.2E+2	1.3E+3	2.4E+2	3.1E+1	8.3E+2
NODULE-43K	Kao	3.7E+1	6.7E+2	5.5E+2	1.3E+3	3.9E-1	6.2E+0	1.7E+0	3.8E-2	1.7E+2	1.5E+0		2.3E+1	2.7E+1	4.9E+2	4.5E+1		
NODULE-44K	Kao	6.0E+1	1.1E+3	9.6E+2	2.3E+3	8.8E-1	1.0E+2	4.2E+0	2.1E-2	5.1E+2	3.9E+0		3.8E+2	3.7E+2	1.4E+3	6.3E+2		
NODULE-45K	Kao	3.9E+1	7.1E+2	5.7E+2	1.4E+3	8.6E-1	6.2E+1	3.6E+0	1.7E-2	3.5E+2	3.3E+0		3.3E+2	8.3E+1	1.3E+3	3.6E+2		
NODULE-46K	Kao	1.4E+2	2.7E+3	2.1E+3	5.1E+3	8.0E-1	1.9E+2	3.1E+0	5.9E-2	2.7E+2	5.3E+0		1.3E+3	4.0E+1	1.3E+3	8.6E+1		
NODULE-47K	Kao	1.2E+2	2.8E+3	1.9E+3	4.3E+3	8.9E-1	4.1E+2	4.0E+0	6.0E-2	4.4E+2	9.1E+0		2.8E+3	1.4E+2	2.6E+3	5.1E+2		
D87-K5	Kao	6.5E-1	2.5E+1	5.4E+0	2.3E+1	3.0E-1	4.5E+2	1.2E+0	0.0E+0	1.3E+2	3.6E+0		2.8E+3	4.1E+1	5.1E+2	4.0E+1		
D87-K6	Kao	2.0E-1	5.7E+0	1.9E+0	4.0E+0	1.1E-1	1.6E+1	8.1E-1	1.9E-2	7.9E+1	8.2E-1		8.5E+1	4.2E+1	2.5E+2	4.4E+1		
D87-K13	Kao	7.0E-1	3.0E+1	1.3E+1	3.3E+1	1.8E-1	9.3E+1	6.9E-1	1.7E-2	7.2E+1	1.5E+0		4.9E+2	3.1E+1	2.6E+2	2.8E+1		
NODULE-38N	Nod	1.4E+1	2.8E+2	2.3E+2	4.6E+2	3.4E-1	1.8E-1	1.1E+0	6.1E-2	1.6E+2	1.4E+1		4.0E+0	4.9E+1	6.8E+3	8.7E+1	2.0E+2	2.6E+4
NODULE-42N	Nod	1.2E+1	2.9E+2	1.7E+2	4.1E+2	3.1E-1	3.7E-2	1.3E+0	2.1E-2	1.7E+2	1.4E+1		2.4E-1	5.0E+1	7.5E+3	9.1E+1	2.1E+2	2.9E+4
D87-N1	Nod	4.8E-1	2.2E+1	1.3E+1	2.4E+1	2.4E-1	1.1E+1	9.2E-1	0.0E+0	1.1E+1	6.6E+0		5.8E+2	2.9E+1	3.6E+3	7.7E+1		
D87-N2	Nod	5.0E+0	1.1E+2	8.1E+1	1.9E+2	1.7E-1	1.7E+1	9.1E-1	8.2E-2	1.4E+2	5.6E+0		5.0E+2	6.1E+1	3.3E+3	1.9E+2		
D87-N3	Nod	4.1E-1	2.2E+1	5.8E+0	1.4E+1	1.7E-1	1.3E+1	9.5E-1	4.1E-2	1.4E+2	6.6E+0		4.1E+2	4.4E+1	3.8E+3	9.0E+1		
D87-N4	Nod	8.5E-1	2.6E+1	9.1E+0	2.4E+1	3.4E-1	1.3E+1	8.4E-1	1.9E-2	1.0E+2	6.7E+0		5.4E+2	3.0E+1	3.7E+3	7.7E+1		
D87-N7	Nod	6.3E-1	7.5E+1	1.3E+1	2.9E+1	4.9E-1	7.5E+1	1.3E+0	3.7E-2	1.8E+2	6.0E+0		8.6E+2	1.2E+2	3.5E+3	2.2E+2		
D87-N9	Nod	1.3E+0	3.8E+1	1.8E+1	4.2E+1	2.3E-1	3.3E+0	6.1E-1	6.1E-2	7.4E+1	4.7E+0		1.3E+2	2.2E+1	2.8E+3	5.8E+1		
D87-U8	TiO2	3.6E+1	2.7E+3	7.6E+2	2.6E+3	1.8E-1	4.2E-1	5.8E-2	5.0E-2	2.5E+0	1.2E+0		1.6E+1	6.8E-1	4.8E+1	9.3E-1		
D87-T10	TiO2	6.2E+0	2.4E+3	3.4E+2	4.6E+2	1.2E-1	5.3E+1	5.9E-2	5.6E-2	1.1E+0	1.0E-1		9.7E+2	3.2E+0	1.9E+1	9.0E-2		
D87-T11	TiO2	8.7E-1	3.6E+2	5.2E+1	5.3E+1	3.6E-2	6.2E+0	6.0E-2	2.1E-2	4.0E-1	1.5E-2		6.3E+1	1.6E-1	3.3E+0	0.0E+0		
D87-U12	TiO2	3.5E+0	9.9E+3	1.1E+3	2.7E+3	4.7E-2	8.1E+1	5.0E-2	4.1E-2	2.8E+0	1.9E-1		6.3E+3	1.2E+1	6.3E+1	2.6E-1		
TAN16	U	1.1E+1	1.1E+6	6.4E+4	2.3E+3	1.4E+1	4.6E+3	1.1E+2		1.4E+4	1.8E+2	1.3E+0	6.1E+4	9.1E+2	1.1E+5	1.2E+3	1.2E+3	1.4E+5
TAN17	U	6.0E+0	1.2E+6	7.3E+4	1.5E+3	1.3E+1	2.7E+3	1.1E+2	1.6E-1	1.5E+4	2.0E+2		3.7E+4	9.3E+2	1.1E+5	1.3E+3	1.2E+3	1.4E+5
TAN18	U	2.8E+0	1.7E+6	1.0E+5	1.8E+3	6.8E+0	1.3E+3	5.7E+1	1.3E-1	7.4E+3	1.5E+2		2.9E+4	7.5E+2	9.1E+4	1.0E+3	1.0E+3	1.3E+5

U: uraninite, Nod: nodule, Kao: kaolinite

the 4th measurement (ratio to ^{251}UO-1)

Sample	Anal.	ratio to UO-251 & error-1											Jun/1997-(4)
ID	Min.	Pb-204	error	Pb-206	error	Pb-207	error	Pb-208	error	Th-230	error	Th-232	error
NODULE-39K	Kao	0.176141	0.004732	3.356968	0.073313	2.895679	0.048247	6.663952	0.131063	0.000660	0.000231	0.098395	0.002901
NODULE-39Kb	Kao	0.119031	0.002942	2.236627	0.046012	1.948791	0.049829	4.454817	0.071061	0.001060	0.000154	0.105222	0.002153
NODULE-40K	Kao	0.241365	0.004907	4.429247	0.079475	3.667601	0.056140	8.722289	0.143977	0.000817	0.000398	0.098517	0.003055
NODULE-40Kb	Kao	0.138237	0.002090	2.634395	0.037508	2.144961	0.021714	5.048537	0.057666	0.000388	0.000064	0.111804	0.001809
NODULE-41K	Kao	0.067169	0.001163	1.529669	0.015253	1.051904	0.011109	2.512401	0.023185	0.000499	0.000094	0.097501	0.001483
NODULE-43K	Kao	0.074787	0.002338	1.364495	0.026223	1.113089	0.023380	2.664026	0.049135	0.000717	0.000244	0.012440	0.000749
NODULE-44K	Kao	0.042861	0.000888	0.812560	0.010904	0.680889	0.008482	1.606824	0.040339	0.000607	0.000095	0.073350	0.001302
NODULE-45K	Kao	0.029303	0.000741	0.533474	0.008295	0.429048	0.006171	1.032182	0.013226	0.000631	0.000099	0.046823	0.001050
NODULE-46K	Kao	0.108692	0.002102	2.084288	0.036959	1.626732	0.047164	3.857792	0.101011	0.000564	0.000109	0.142649	0.002032
NODULE-47K	Kao	0.046267	0.000653	1.050368	0.008752	0.718841	0.019194	1.641811	0.085640	0.000315	0.000053	0.157411	0.001458
D87-K5	Kao	0.001273	0.000246	0.049962	0.004607	0.010517	0.001119	0.044970	0.013359	0.000585	0.000179	0.880292	0.316696
D87-K6	Kao	0.000707	0.000245	0.022333	0.002008	0.007283	0.001238	0.015762	0.001584	0.000373	0.000198	0.060893	0.002834
D87-K13	Kao	0.002588	0.000586	0.116082	0.004836	0.050822	0.002973	0.125199	0.012453	0.000613	0.000242	0.353029	0.009497
NODULE-38N	Nod	0.002106	0.000077	0.041440	0.001103	0.033244	0.001408	0.068016	0.001760	0.000040	0.000013	0.000017	0.000010
NODULE-42N	Nod	0.001596	0.000064	0.038774	0.001808	0.022572	0.000501	0.054925	0.003013	0.000038	0.000011	0.000002	0.000004
D87-N1	Nod	0.000133	0.000030	0.006021	0.001043	0.003611	0.000231	0.006666	0.001923	0.000066	0.000021	0.003177	0.002704
D87-N2	Nod	0.001496	0.000130	0.032390	0.000716	0.024604	0.000675	0.056289	0.001143	0.000026	0.000022	0.005093	0.000179
D87-N3	Nod	0.000096	0.000027	0.005794	0.000255	0.001518	0.000127	0.003659	0.000197	0.000033	0.000017	0.003358	0.000180
D87-N4	Nod	0.000226	0.000050	0.007172	0.000283	0.002488	0.000163	0.006534	0.000331	0.000087	0.000025	0.003671	0.000170
D87-N7	Nod	0.000168	0.000033	0.021349	0.004869	0.003673	0.000256	0.008120	0.000371	0.000130	0.000029	0.021328	0.010810
D87-N9	Nod	0.000444	0.000068	0.013523	0.000434	0.006403	0.000432	0.014939	0.000531	0.000062	0.000027	0.001169	0.000094
D87-U8	TiO2	0.739988	0.040608	56.769310	2.803310	15.803360	0.785120	53.471728	2.635903	0.002765	0.001125	0.007741	0.008951
D87-T10	TiO2	0.316371	0.032007	122.327193	10.294590	17.745613	1.515231	23.546564	1.999032	0.003221	0.003232	2.724018	0.240486
D87-T11	TiO2	0.256835	0.063965	108.346964	21.226322	15.652646	3.092518	15.976137	3.155960	0.004502	0.007847	1.875082	0.382335
D87-U12	TiO2	0.054979	0.004834	157.447830	6.171640	17.271840	0.693497	42.667558	1.731570	0.000094	Inf	1.275489	0.053822
TAN16	U	0.000090	0.000004	10.187117	0.048783	0.606804	0.006313	0.021511	0.000239	0.000119	0.000005	0.043754	0.000134
TAN17	U	0.000052	0.000003	10.675034	0.028697	0.648814	0.001734	0.012935	0.000172	0.000116	0.000005	0.023567	0.000089
TAN18	U	0.000029	0.000003	18.742476	0.202715	1.122448	0.012621	0.019995	0.000208	0.000073	0.000006	0.013995	0.000057

U: uraninite, Nod: nodule, Kao: kaolinite

the 4th measurement (ratio to ^{251}UO-2)

Sample ID	Anal. Min.	ratio to UO-251 & error -2									Jun/1997-(4)
		U-234	error	U-235	error	ThO-246	error	ThO-248	error	UO-250	error
NODULE-39K	Kao	0.002544	0.000247	0.201571	0.005694	0.003668	0.000485	0.646189	0.013523	0.063949	0.002752
NODULE-39Kb	Kao	0.002525	0.000142	0.213565	0.004348	0.003388	0.000279	0.631398	0.010497	0.051711	0.002768
NODULE-40K	Kao	0.002433	0.000195	0.176800	0.004769	0.002907	0.000375	0.777610	0.014265	0.028796	0.001505
NODULE-40Kb	Kao	0.002210	0.000180	0.194411	0.003282	0.003298	0.000263	0.789435	0.010251	0.040812	0.001051
NODULE-41K	Kao	0.002143	0.000104	0.203907	0.003013	0.003049	0.000311	0.750378	0.009102	0.086298	0.013369
NODULE-43K	Kao	0.003297	0.000232	0.343682	0.008032	0.002981	0.000367	0.047063	0.002155	0.055613	0.004971
NODULE-44K	Kao	0.002950	0.000122	0.362196	0.005054	0.002765	0.000200	0.271444	0.006478	0.264927	0.017179
NODULE-45K	Kao	0.002710	0.000171	0.262495	0.004162	0.002445	0.000288	0.249757	0.005053	0.061869	0.001173
NODULE-46K	Kao	0.002284	0.000110	0.208109	0.003319	0.003976	0.000249	0.972522	0.011932	0.030280	0.000898
NODULE-47K	Kao	0.001501	0.000076	0.166639	0.001984	0.003424	0.000164	1.078107	0.008035	0.054140	0.005071
D87-K5	Kao	0.002363	0.000208	0.252900	0.005972	0.007038	0.002486	5.425760	2.198515	0.080357	0.013316
D87-K6	Kao	0.003108	0.000293	0.310302	0.016482	0.003136	0.000519	0.334772	0.009952	0.163937	0.006230
D87-K13	Kao	0.002582	0.000262	0.275681	0.008514	0.005706	0.000849	1.873464	0.120327	0.118765	0.019921
NODULE-38N	Nod	0.000157	0.000014	0.023212	0.000432	0.002055	0.000081	0.000585	0.000060	0.007144	0.000161
NODULE-42N	Nod	0.000165	0.000012	0.022889	0.000363	0.001883	0.000072	0.000029	0.000018	0.006643	0.000138
D87-N1	Nod	0.000257	0.000024	0.029372	0.000603	0.001848	0.000103	0.160459	0.005444	0.008129	0.000220
D87-N2	Nod	0.000252	0.000033	0.043500	0.000814	0.001681	0.000103	0.151612	0.001913	0.018467	0.002551
D87-N3	Nod	0.000239	0.000021	0.036415	0.000641	0.001715	0.000097	0.108511	0.001197	0.011461	0.000254
D87-N4	Nod	0.000224	0.000020	0.028601	0.000577	0.001836	0.000105	0.147822	0.001506	0.008133	0.000299
D87-N7	Nod	0.000365	0.000032	0.051551	0.000829	0.001710	0.000146	0.245067	0.002384	0.033350	0.002412
D87-N9	Nod	0.000196	0.000022	0.026562	0.000942	0.001662	0.000111	0.048427	0.001153	0.008085	0.000247
D87-U8	TiO2	0.000156	0.000008	0.051200	0.013504	0.024114	0.064516	0.339375	0.024837	0.013146	0.023891
D87-T10	TiO2	0.000146	0.000056	0.053242	0.013244	0.002286	0.003239	50.023060	4.222235	0.163821	0.019059
D87-T11	TiO2	0.011768	0.005190	0.115866	0.048341	-0.002079	Inf	18.958895	3.735547	0.043041	0.022591
D87-U12	TiO2	0.000131	0.000022	0.043893	0.005661	0.002319	0.001103	99.272839	3.960103	0.195053	0.011982
TAN16	U	0.001002	0.000008	0.133434	0.000288	0.001697	0.000018	0.572691	0.000726	0.008589	0.000042
TAN17	U	0.000996	0.000008	0.128839	0.000456	0.001747	0.000027	0.325533	0.000918	0.008255	0.000051
TAN18	U	0.000621	0.000007	0.081056	0.000269	0.001633	0.000019	0.318719	0.000601	0.008219	0.000043

U: uraninite, Nod: nodule, Kao: kaolinite

the 4th measurement (ratio to ^{251}UO-3)

Sample ID	Anal. Min.	ratio to UO-251 & error -3				Jun/1997-(4)	
		UOH-252	error	UO2-266	error	UO2-267	error
NODULE-39K	Kao	0.085812	0.003566	0.019960	0.001836	0.565387	0.014993
NODULE-39Kb	Kao	0.079176	0.002182	0.016929	0.000901	0.498278	0.010345
NODULE-40K	Kao	0.048274	0.002172	0.014934	0.001205	0.731700	0.020730
NODULE-40Kb	Kao	0.066929	0.002278	0.014188	0.001026	0.685782	0.011371
NODULE-41K	Kao	0.177282	0.003156	0.023037	0.000988	0.616416	0.008536
NODULE-43K	Kao	0.092444	0.003172				
NODULE-44K	Kao	0.450435	0.006337				
NODULE-45K	Kao	0.267694	0.004954				
NODULE-46K	Kao	0.065884	0.001551				
NODULE-47K	Kao	0.193809	0.009785				
D87-K5	Kao	0.077575	0.002714				
D87-K6	Kao	0.173415	0.008209				
D87-K13	Kao	0.107463	0.004651				
NODULE-38N	Nod	0.012746	0.000379	0.028612	0.000495	3.880029	0.038428
NODULE-42N	Nod	0.012104	0.000258	0.027802	0.000405	3.911191	0.018763
D87-N1	Nod	0.021554	0.000624				
D87-N2	Nod	0.056193	0.001122				
D87-N3	Nod	0.023773	0.000509				
D87-N4	Nod	0.020982	0.000485				
D87-N7	Nod	0.061412	0.001978				
D87-N9	Nod	0.020955	0.000577				
D87-U8	TiO2	0.018191	0.063022				
D87-T10	TiO2	0.001768	0.003957				
D87-T11	TiO2	-0.006483	-0.006606				
D87-U12	TiO2	0.003455	0.001826				
TAN16	U	0.011091	0.000066	0.011043	0.000081	1.291267	0.001436
TAN17	U	0.011405	0.000102	0.010316	0.000066	1.265981	0.003483
TAN18	U	0.011272	0.000071	0.011510	0.000091	1.396198	0.002234

U: uraninite, Nod: nodule, Kao: kaolinite

the 5th measurement (count rate)

Sample ID	Anal. Min.	cps													Nov/1997-(5)
		Pb-204	Pb-206	Pb-207	Pb-208	Th-230	Th-232	U-234	Bkg-234	U-235	ThO-246	ThO-248	UO-250	UO-251	UOH-252
TAN19	U	8.7E+0	4.3E+5	2.6E+4	1.2E+3	8.3E+0	2.9E+3	7.1E+1	1.0E-1	9.4E+3	1.1E+2	4.2E+4	5.8E+2	6.8E+4	1.4E+3
NOD58-1	YN	7.9E+0	1.9E+4	1.8E+3	3.6E+2	7.2E-1	2.9E-1	2.9E+0	0.0E+0	3.6E+2	1.7E+1	1.0E+1	7.0E+1	8.9E+3	2.1E+2
NOD58-2	BN	2.8E+1	6.6E+3	9.9E+2	1.1E+3	5.2E-1	7.2E+0	3.9E+0	1.6E-1	4.5E+2	5.5E+0	5.5E+1	6.0E+1	2.8E+3	7.2E+1
NOD58-3	RN	1.9E+1	1.4E+4	1.5E+3	7.3E+2	4.6E-1	5.4E+0	1.5E+0	0.0E+0	1.8E+2	3.9E+0	7.5E+1	2.3E+1	2.0E+3	4.2E+1
NOD58-4	Kao	9.4E+1	2.1E+3	1.4E+3	3.3E+3	3.3E-1	1.3E+0	1.2E+0	2.0E-2	1.3E+2	7.0E-1	4.4E+0	2.2E+1	3.7E+2	1.1E+1
NOD58-5	YN	5.2E+0	2.6E+4	2.4E+3	2.7E+2	7.5E-1	1.1E+0	2.9E+0	9.6E-2	3.9E+2	2.0E+1	3.2E+1	7.6E+1	1.0E+4	2.4E+2
NOD58-6	Kao	6.1E+1	1.8E+3	9.7E+2	2.2E+3	1.9E-1	5.2E+0	1.2E+0	6.0E-2	1.3E+2	7.7E-1	1.8E+1	7.7E+0	3.5E+2	6.6E+0
NOD58-7	Kao	7.7E+1	2.0E+3	1.3E+3	3.0E+3	3.4E-1	3.7E+0	8.8E-1	6.0E-2	7.0E+1	4.7E-1	1.2E+1	5.8E+0	2.3E+2	5.0E+0
NOD58-8	Mus	6.4E+1	1.6E+3	1.1E+3	2.5E+3	2.2E-1	1.3E+1	1.1E+0	1.2E-1	8.8E+1	5.7E-1	4.1E+1	5.3E+0	2.5E+2	3.0E+0
NOD58-9	BN	3.5E+1	4.3E+4	4.3E+3	1.4E+3	9.3E-1	3.3E+1	4.4E+0	4.3E-2	5.5E+2	2.2E+1	6.2E+2	9.7E+1	1.2E+4	2.6E+2
NOD58-10	RN	3.6E+1	1.0E+5	9.6E+3	1.7E+3	6.9E-1	3.4E+1	3.0E+0	8.0E-2	3.0E+2	7.4E+0	3.2E+2	4.9E+1	3.2E+3	6.1E+1
NOD58-11	RN	2.8E+1	8.5E+4	7.9E+3	1.2E+3	5.3E-1	2.1E+1	1.9E+0	1.1E-1	2.1E+2	9.3E+0	5.2E+2	4.8E+1	4.6E+3	8.5E+1
NOD58-12	Qz	9.3E-1	1.5E+1	1.1E+1	3.2E+1	5.9E-2	8.0E-2	6.6E-2	1.6E-1	2.9E-1	5.7E-2	2.4E-1	1.3E-1	9.2E-1	1.6E-1
NOD58-13	BN	2.1E+1	3.7E+4	3.6E+3	8.6E+2	1.5E+0	1.8E+1	5.2E+0	7.9E-2	6.0E+2	2.1E+1	3.0E+2	1.0E+2	1.1E+4	2.4E+2
NOD58-14	BN	3.7E+1	3.3E+4	3.5E+3	1.5E+3	8.7E-1	1.2E+1	3.4E+0	1.2E-1	3.8E+2	1.8E+1	1.7E+2	8.0E+1	8.7E+3	1.9E+2
NOD58-15	YN	1.9E+1	2.9E+4	3.0E+3	8.2E+2	6.7E-1	5.3E+0	2.3E+1	6.1E-2	3.5E+2	1.8E+1	9.2E+1	7.5E+1	9.2E+3	2.1E+2
NOD58-16	Mus	1.4E+2	1.8E+4	3.7E+3	5.6E+3	6.2E-1	1.0E+2	1.6E+0	1.4E-1	1.6E+2	2.4E+0	8.1E+2	1.1E+1	9.0E+2	1.4E+1
NOD58-17	Kao	3.3E+1	7.9E+2	5.2E+2	1.2E+3	2.1E-1	2.1E+1	1.0E+0	1.6E-1	8.9E+1	7.0E-1	7.1E+1	5.3E+0	2.6E+2	2.5E+0
58-18	YN	6.0E+1	4.8E+4	5.1E+3	2.5E+3	3.3E-1	3.0E+0	1.2E+0	3.8E-2	1.4E+2	1.0E+1	9.5E+1	5.2E+1	4.8E+3	8.4E+1
58-19	Qz	5.8E-1	6.4E+0	5.5E+0	1.3E+1	1.5E-1	2.2E-1	5.2E-2	0.0E+0	5.9E-1	2.2E-2	0.0E+0	8.8E-1	2.7E-1	2.2E-1
58-20	YN	1.8E+1	4.6E+4	4.3E+3	8.1E+2	3.2E-1	2.6E-1	1.4E+0	1.4E-1	1.5E+2	1.3E+1	6.3E+0	5.2E+1	6.6E+3	8.8E+1
58-21	Fis	8.8E+1	1.1E+4	2.2E+3	3.3E+3	2.9E-1	5.0E+1	1.5E+0	6.2E-2	1.3E+2	1.4E+0	3.1E+2	4.2E+1	6.9E+2	1.2E+1
58-22	Mus	2.3E+2	1.0E+4	4.1E+3	8.6E+3	1.9E-1	1.6E+1	7.7E-1	8.0E-2	7.2E+1	1.1E+0	1.3E+2	1.3E+1	3.8E+2	5.1E+0
58-23	Kao	7.1E+1	1.5E+3	1.1E+3	2.6E+3	1.8E-1	3.9E+1	5.2E-1	2.1E-2	4.4E+1	2.9E-1	1.9E+2	6.3E+0	1.2E+2	2.0E+0
58-24	Kao	3.0E+2	7.4E+3	4.7E+3	1.1E+4	3.7E-1	2.7E+1	2.1E+0	1.4E-1	2.3E+2	1.6E+0	1.4E+2	1.0E+2	8.2E+2	2.8E+1
58-25	Kao	1.2E+2	4.1E+3	2.0E+3	4.4E+3	4.9E-1	1.5E+1	2.4E+0	2.2E-2	2.8E+2	2.0E+0	7.7E+1	8.2E+1	9.9E+2	2.1E+1
87-14	TiO2	1.5E+0	2.1E+3	2.4E+2	5.9E+1	5.5E-2	3.8E-1	6.0E-2	1.1E-1	6.0E-1	1.4E-1	2.3E+1	1.3E-1	1.7E+1	2.8E-1
87-15	TiO2	2.4E+0	3.7E+2	7.4E+1	2.0E+2	7.1E-2	6.0E+0	5.3E-2	1.1E-1	9.4E-2	0.0E+0	2.7E+2	5.2E-1	2.8E+0	6.0E-2
87-16	Kao	1.0E+1	2.0E+2	1.7E+2	4.1E+2	1.1E+0	2.4E+1	4.3E-1	1.0E-1	5.5E+1	6.2E-1	1.1E+2	5.2E+1	2.1E+2	5.1E+1
87-17	YN	4.4E-1	1.9E+1	6.9E+0	1.9E+1	2.7E-1	4.1E+0	2.7E-1	6.1E-2	3.6E+1	2.6E+0	2.0E+2	1.3E+1	1.5E+3	3.3E+1
87-18	Kao	5.7E-1	8.3E+0	3.9E+0	1.2E+1	1.6E-1	1.5E+1	3.6E-1	6.1E-2	3.5E+1	4.9E-1	6.0E+1	1.7E+1	1.2E+2	1.3E+1
87-19	YN	4.4E-1	2.0E+1	9.8E+0	2.3E+1	1.2E-1	2.2E+1	4.4E-1	1.7E-1	6.2E+1	2.6E+0	8.4E+2	1.6E+1	2.0E+3	4.9E+1
87-20	CPb	6.8E+1	1.1E+3	1.1E+3	2.4E+3	1.9E-1	2.2E+0	6.0E-2	1.2E-1	1.4E-1	1.3E-1	1.2E+0	4.0E-2	5.5E-1	1.4E-1
87-21	Fis	4.1E+0	2.4E+2	7.1E+1	2.4E+2	1.3E-1	2.0E+1	1.1E-1	2.3E-2	7.9E+0	4.7E-1	3.5E+2	1.6E+0	1.3E+2	2.3E+0
87-22	Kao	1.8E+1	4.7E+2	3.0E+2	6.9E+2	5.0E-1	6.2E+1	1.9E+0	1.4E-1	2.3E+2	2.7E+0	3.1E+2	3.5E+2	9.9E+2	3.8E+2
87-23	BN	6.9E+0	1.5E+2	1.0E+2	2.7E+2	1.4E-1	6.8E+0	3.8E-1	8.1E-2	4.3E+1	8.5E-1	5.0E+1	2.0E+1	3.9E+2	3.9E+1
87-24	Kao	3.3E+0	2.8E+2	6.9E+1	1.6E+2	1.4E-1	8.6E+1	5.8E-1	4.0E-2	4.4E+1	8.2E-1	5.3E+2	4.0E+1	2.5E+2	3.5E+1

U: uraninite, YN: yellow nodule, BN: brown nodule, RN: red nodule, Kao: kaolinite
Mus: muscovite, Qz: quartz, Fis: fischer, CPb: common Pb rich mineral

the 5th measurement (ratio to ^{251}UO-1)

Sample	Anal.	ratio to UO-251 & error-1									Nov/1997-(5)
ID	Min.	Pb-204	error	Pb-206	error	Pb-207	error	Pb-208	error	Th-230	error	Th-232	error
TAN19	U	0.000126	0.000006	6.241442	0.034055	0.378475	0.002429	0.017559	0.000151	0.000120	0.000006	0.042525	0.000165
NOD58-1	YN	0.000893	0.000040	2.196903	0.011603	0.207972	0.003020	0.041102	0.003034	0.000081	0.000018	0.000033	0.000007
NOD58-2	BN	0.009864	0.000339	2.369321	0.042432	0.354411	0.014407	0.387506	0.034675	0.000166	0.000031	0.002556	0.000132
NOD58-3	RN	0.009580	0.000301	7.008424	0.120800	0.760207	0.015510	0.374825	0.004058	0.000236	0.000049	0.002771	0.000175
NOD58-4	Kao	0.250634	0.006637	5.667576	0.096183	3.793693	0.064791	8.847038	0.146880	0.000817	0.000302	0.003339	0.000616
NOD58-5	YN	0.000496	0.000031	2.557734	0.010913	0.234880	0.001357	0.026684	0.000360	0.000064	0.000013	0.000100	0.000018
NOD58-6	Kao	0.174190	0.004574	5.221541	0.103178	2.790407	0.056564	6.450293	0.124011	0.000361	0.000186	0.014725	0.000969
NOD58-7	Kao	0.343404	0.013593	9.062831	0.293712	5.655661	0.187769	13.191750	0.427511	0.001226	0.000394	0.016135	0.001624
NOD58-8	Mus	0.254783	0.006809	6.397436	0.132297	4.213164	0.089935	9.859723	0.201901	0.000386	0.000318	0.051268	0.002285
NOD58-9	BN	0.002951	0.000303	3.666073	0.032122	0.366695	0.006704	0.119298	0.009536	0.000075	0.000012	0.002830	0.000071
NOD58-10	RN	0.011138	0.000272	31.531058	0.219662	2.966349	0.018724	0.527815	0.021170	0.000188	0.000038	0.010296	0.000258
NOD58-11	RN	0.005981	0.000164	18.581531	0.283133	1.717728	0.028412	0.260065	0.002157	0.000093	0.000023	0.004583	0.000145
NOD58-12	Qz	1.009015	Inf	19.243782	Inf	13.768568	Inf	40.812938	Inf	-0.125584	Inf	-0.098585	Inf
NOD58-13	BN	0.001958	0.000057	3.479994	0.011726	0.338515	0.001641	0.080791	0.000581	0.000129	0.000017	0.001705	0.000059
NOD58-14	BN	0.004284	0.000500	3.788907	0.052857	0.397647	0.009598	0.169381	0.015103	0.000087	0.000016	0.001416	0.000174
NOD58-15	YN	0.002061	0.000334	3.195328	0.630927	0.320333	0.061483	0.088525	0.014397	0.000066	0.000016	0.000567	0.000098
NOD58-16	Mus	0.160882	0.002527	20.505598	0.495874	4.123351	0.045622	6.210567	0.068695	0.000655	0.000176	0.116536	0.002295
NOD58-17	Kao	0.127338	0.005437	3.008550	0.069414	1.973695	0.049427	4.517674	0.138831	0.000568	0.000293	0.080006	0.003094
58-18	YN	0.012326	0.000237	9.864420	0.083558	1.053151	0.010857	0.509200	0.012474	0.000061	0.000023	0.000615	0.000051
58-19	Qz	2.166047	1.577356	23.822513	16.899138	20.726182	14.713897	47.732420	33.826240	0.180099	0.180099	0.830945	0.634645
58-20	YN	0.002674	0.000129	6.965165	0.028587	0.661316	0.006318	0.123137	0.003876	0.000043	0.000011	0.000033	0.000012
58-21	Fis	0.127512	0.011863	16.615198	0.697642	3.236270	0.122722	4.832098	0.301983	0.000328	0.000133	0.072248	0.003148
58-22	Mus	0.610841	0.011357	26.560293	0.937347	10.787717	0.268115	22.506455	0.521737	0.000291	0.000181	0.040612	0.001597
58-23	Kao	0.592075	0.019985	12.363226	0.373915	9.288301	0.276052	22.056902	0.638252	0.001344	0.000533	0.322181	0.011975
58-24	Kao	0.362082	0.029672	8.999493	0.679940	5.762125	0.449480	13.274805	1.065848	0.000401	0.000127	0.032800	0.002120
58-25	Kao	0.116122	0.002146	4.109123	0.196450	2.000848	0.082401	4.438274	0.189830	0.000472	0.000105	0.015113	0.000593
87-14	TiO2	0.078635	0.013098	121.007879	10.076612	14.217495	1.196220	3.443169	0.299933	-0.003122	-0.004423	0.015682	0.005640
87-15	TiO2	0.846693	0.224758	139.495816	34.869290	27.799759	6.972969	73.515715	18.407481	-0.013065	-0.039330	2.221332	0.572274
87-16	Kao	0.046652	0.002626	0.963068	0.095303	0.822339	0.090305	1.948799	0.211436	0.000039	Inf	0.114895	0.004793
87-17	YN	0.000250	0.000062	0.012486	0.000587	0.004493	0.000347	0.012184	0.000578	0.000002	Inf	0.002655	0.000189
87-18	Kao	0.004386	0.000885	0.071353	0.005366	0.032725	0.003056	0.099003	0.005889	0.000809	0.000537	0.132379	0.006875
87-19	YN	0.000133	0.000049	0.009477	0.000663	0.004688	0.000380	0.011339	0.000642	-0.000024	-0.000080	0.010574	0.000450
87-20	CPb	160.416	532.045	2537.303	8415.296	2509.553	8323.263	5739.265	19035.003	-0.080849	-0.297059	0.058474	0.286465
87-21	Fis	0.032209	0.002327	1.929161	0.060264	0.567071	0.021146	1.937828	0.060627	0.000821	0.000435	0.161294	0.006867
87-22	Kao	0.017895	0.001448	0.473715	0.030499	0.305745	0.025405	0.691153	0.045320	0.000462	0.000107	0.062729	0.001813
87-23	BN	0.017619	0.000941	0.390624	0.036515	0.269760	0.009618	0.704523	0.053297	0.000156	0.000172	0.017424	0.001374
87-24	Kao	0.012799	0.000878	1.086162	0.081534	0.269980	0.009533	0.641341	0.066399	0.000407	0.000245	0.337301	0.023582

U: uraninite, YN: yellow nodule, BN: brown nodule, RN: red nodule, Kao: kaolinite
Mus: muscovite, Qz: quartz, Fis: fischer, CPb: common Pb rich mineral

the 5th measurement (ratio to ^{251}UO-2)

Sample ID	Anal. Min.	ratio to UO-251 & error -2 U-234	error	U-235	error	ThO-246	error	ThO-248	error	UO-250	error	UOH-252 (Nov/1997-(5))	error
TAN19	U	0.001042	0.000010	0.137863	0.000346	0.001615	0.000027	0.611250	0.001108	0.008538	0.000051	0.020447	0.000114
NOD58-1	YN	0.000329	0.000016	0.040970	0.000666	0.001966	0.000075	0.001122	0.000078	0.007890	0.000140	0.023656	0.000421
NOD58-2	BN	0.001360	0.000058	0.162262	0.002658	0.001952	0.000173	0.019671	0.000554	0.021551	0.006769	0.025637	0.000708
NOD58-3	RN	0.000755	0.000051	0.093367	0.001544	0.002020	0.000198	0.038380	0.000924	0.011539	0.001743	0.021426	0.000968
NOD58-4	Kao	0.003134	0.000242	0.358391	0.008490	0.001816	0.000327	0.011758	0.001142	0.057497	0.055314	0.029566	0.002056
NOD58-5	YN	0.000273	0.000013	0.038222	0.000420	0.001931	0.000062	0.003134	0.000153	0.007439	0.000125	0.023104	0.000450
NOD58-6	Kao	0.003314	0.000259	0.369491	0.009491	0.002036	0.000363	0.051658	0.003397	0.021839	0.008291	0.018858	0.001536
NOD58-7	Kao	0.003633	0.000364	0.312767	0.018396	0.001842	0.000479	0.051918	0.015398	0.025591	0.025727	0.021804	0.002272
NOD58-8	Mus	0.003916	0.000393	0.350156	0.012436	0.001785	0.000490	0.164604	0.006129	0.020595	0.004675	0.011548	0.001414
NOD58-9	BN	0.000371	0.000015	0.046852	0.000422	0.001834	0.000056	0.052390	0.000452	0.008218	0.000977	0.021761	0.000364
NOD58-10	RN	0.000885	0.000058	0.092852	0.001381	0.002258	0.000120	0.098961	0.001247	0.015060	0.003704	0.018734	0.000564
NOD58-11	RN	0.000397	0.000024	0.046222	0.000683	0.001995	0.000095	0.112966	0.001221	0.010479	0.000837	0.018389	0.000513
NOD58-12	Qz	-0.117029	Inf	0.172782	Inf	-0.128816	Inf	-0.147629	Inf	-0.029903	Inf	-0.125918	Inf
NOD58-13	BN	0.000486	0.000018	0.056446	0.000541	0.001964	0.000094	0.027991	0.000354	0.009468	0.000620	0.022401	0.000302
NOD58-14	BN	0.000375	0.000020	0.043844	0.000465	0.002094	0.000095	0.019936	0.000295	0.009211	0.000860	0.021317	0.000372
NOD58-15	YN	0.002438	0.001591	0.038238	0.008625	0.001921	0.000390	0.009962	0.002018	0.008185	0.001951	0.023144	0.005211
NOD58-16	Mus	0.001720	0.000237	0.178903	0.003605	0.002683	0.000251	0.901604	0.012779	0.012570	0.002441	0.015694	0.000968
NOD58-17	Kao	0.003584	0.000312	0.339707	0.010112	0.002451	0.000670	0.269055	0.008546	0.019896	0.006348	0.009401	0.001235
58-18	YN	0.000240	0.000018	0.027969	0.000513	0.002077	0.000094	0.019611	0.000528	0.010811	0.000270	0.017239	0.000424
58-19	Qz	0.194274	0.153587	2.187550	1.661564	0.082507	0.101050	0.000000	NaN	3.271117	2.391459	0.820036	0.686092
58-20	YN	0.000201	0.000018	0.022850	0.000382	0.001992	0.000078	0.000948	0.000110	0.007864	0.000159	0.013421	0.000307
58-21	Fis	0.002089	0.000211	0.191891	0.004371	0.001963	0.000228	0.458327	0.008136	0.060494	0.014603	0.017390	0.000977
58-22	Mus	0.001796	0.000179	0.186658	0.005339	0.002663	0.000438	0.334818	0.008483	0.032409	0.013230	0.013031	0.001241
58-23	Kao	0.004139	0.000495	0.362774	0.015110	0.002268	0.000651	1.583095	0.050858	0.052112	0.003789	0.016175	0.002427
58-24	Kao	0.002548	0.000204	0.283528	0.016937	0.001936	0.000250	0.174211	0.015635	0.122189	0.014955	0.034402	0.002335
58-25	Kao	0.002394	0.000176	0.282602	0.004980	0.001972	0.000203	0.077323	0.005974	0.083009	0.016927	0.021367	0.000940
87-14	TiO2	-0.002801	-0.002630	0.028694	0.015235	0.001997	0.003462	1.358431	0.127139	0.001159	0.002009	0.010019	0.033239
87-15	TiO2	-0.019809	-0.024316	-0.004677	-0.004287	-0.039770	-0.020371	102.350655	30.581215	0.154876	0.057405	-0.017194	-0.011371
87-16	Kao	0.001543	0.000222	0.258231	0.010573	0.002456	0.000573	0.512727	0.018568	0.243474	0.016792	0.241203	0.023132
87-17	YN	0.000136	0.000024	0.023445	0.000800	0.001674	0.000153	0.131307	0.002629	0.008257	0.000483	0.021402	0.000857
87-18	Kao	0.002574	0.000388	0.299702	0.016200	0.003681	0.000917	0.515396	0.085494	0.148668	0.008515	0.114048	0.009263
87-19	YN	0.000136	0.000042	0.030425	0.001544	0.001189	0.000146	0.410035	0.025780	0.007852	0.000380	0.023707	0.000958
87-20	CPb	-0.143959	-0.512353	0.035176	0.121855	-0.209671	-0.711030	2.623861	8.724570	-0.191377	-0.648992	0.042429	0.146980
87-21	Fis	0.000699	0.000228	0.062771	0.004839	0.003525	0.000940	2.769749	0.086969	0.012265	0.001477	0.017886	0.002402
87-22	Kao	0.001888	0.000115	0.228881	0.009610	0.002688	0.000239	0.311421	0.005075	0.348494	0.011527	0.387135	0.021735
87-23	BN	0.000775	0.000153	0.110651	0.005060	0.001989	0.000364	0.129752	0.004753	0.052562	0.002074	0.099743	0.004741
87-24	Kao	0.002127	0.000243	0.173670	0.025263	0.003057	0.000528	2.088343	0.379095	0.158896	0.005635	0.137608	0.006070

U: uraninite, YN: yellow nodule, BN: brown nodule, RN: red nodule, Kao: kaolinite
Mus: muscovite, Qz: quartz, Fis: fischer, CPb: common Pb rich mineral

the 6th measurement (count rate)

Sample ID	Anal. Min.	cps													Nov/1997-(6)
		Pb-204	Pb-206	Pb-207	Pb-208	Th-230	Th-232	U-234	Bkg-234	U-235	ThO-246	ThO-248	UO-250	UO-251	UOH-252
TANB-1	U	6.6E+0	9.2E+5	5.6E+4	1.2E+3	8.6E+0	1.7E+3	8.0E+1	1.2E-1	1.1E+4	1.5E+2	2.8E+4	7.8E+2	9.3E+4	1.2E+3
60-N-48	YN	4.5E+1	9.3E+2	7.7E+2	1.8E+3	8.7E-1	3.2E+1	3.3E+0	1.4E-1	5.0E+2	2.0E+1	1.0E+3	9.0E+1	1.3E+4	4.0E+2
60-N-49	YN	2.5E+1	5.2E+2	4.2E+2	1.0E+3	7.2E-1	8.2E+0	3.2E+0	2.0E-1	4.7E+2	2.2E+1	2.9E+2	9.6E+1	1.3E+4	4.3E+2
60-N-50	BN	2.2E+1	4.7E+2	3.8E+2	9.1E+2	5.9E-1	1.3E+0	1.8E+0	1.0E-1	2.3E+2	1.8E+1	1.3E+1	6.4E+1	9.4E+3	1.4E+2
60-K-51	Kao	5.2E+1	9.4E+2	8.0E+2	1.9E+3	7.4E-1	2.4E+1	3.9E+0	4.4E-2	3.9E+2	3.3E+0	8.2E+1	1.7E+2	1.1E+3	3.9E+2
60-N-52	YN	7.6E+0	1.8E+2	1.3E+2	3.1E+2	5.2E-1	1.1E+0	1.4E+0	1.8E-1	2.0E+2	1.2E+1	4.0E+1	4.3E+1	6.3E+3	1.3E+2
60-N-53	YN	5.9E+0	1.1E+2	9.4E+1	2.2E+2	1.7E-1	3.1E-1	1.0E+0	9.9E-2	1.6E+2	4.3E+0	5.6E+0	1.9E+1	2.5E+3	5.8E+1
60-N-54	YN	3.4E+1	6.7E+2	5.5E+2	1.4E+3	7.5E-1	9.9E+0	3.8E+0	1.0E-1	5.9E+2	1.9E+1	2.6E+2	8.6E+1	1.2E+4	3.3E+2
60-N-55A	YN	1.0E+1	2.4E+2	1.7E+2	4.0E+2	3.9E-1	3.6E-1	1.4E+0	6.3E-2	2.0E+2	1.3E+1	1.5E+1	4.8E+1	6.6E+3	1.4E+2
60-N-55B	YN	1.9E+0	7.0E+1	2.9E+1	5.9E+1	3.6E-1	4.8E-1	1.6E+0	0.0E+0	2.3E+2	1.3E+1	1.3E+1	4.6E+1	6.8E+3	1.5E+2
60-N-55C	YN	1.5E+0	6.6E+1	2.9E+1	5.6E+1	3.8E-1	4.7E-1	1.7E+0	1.9E-1	2.4E+2	1.3E+1	1.1E+1	4.9E+1	7.0E+3	1.5E+2
60-N-55D	YN	2.7E+0	7.5E+1	4.2E+1	8.8E+1	4.6E-1	5.0E-1	2.0E+0	6.5E-2	3.0E+2	1.3E+1	1.1E+1	5.5E+1	7.7E+3	1.7E+2
60-N-56	YN	7.9E+0	2.0E+2	1.3E+2	3.1E+2	4.1E-1	4.1E-1	1.3E+0	7.9E-2	1.8E+2	1.2E+1	1.4E+1	4.8E+1	6.5E+3	1.3E+2
60-N-56	YN	3.8E+0	1.1E+2	5.5E+1	1.2E+2	5.4E-1	0.0E+0	3.1E-1	1.3E-1	1.7E+2	1.4E+1	6.3E+0	5.5E+1	5.9E+3	1.2E+2
60-N-56	YN	1.5E+0	7.9E+1	8.3E+1	5.7E+1	4.4E-1	9.1E-1	6.7E-1	1.0E+0	1.7E+2	1.0E+0	2.1E+1	3.9E+1	5.6E+3	1.2E+2
60-N-56	YN	1.2E+0	1.1E+2	3.2E+1	3.4E+1	1.2E-1	7.2E-1	1.2E+0	8.1E-2	2.1E+2	1.4E+1	7.8E+0	4.5E+1	7.6E+3	2.0E+2
60-N-56	YN	1.0E+0	1.6E+2	7.1E+0	6.8E+0	2.2E+0	1.7E-1	1.2E+0	4.9E-1	2.2E+2	1.7E+1	2.8E+1	6.3E+1	8.3E+3	1.5E+2
60-N-56	YN	1.0E+0	3.0E+0	3.0E+0	3.0E+0	8.8E-1	0.0E+0	2.8E+0	0.0E+0	2.3E+2	1.8E+1	1.0E+0	8.7E+0	7.3E+3	2.1E+2
60-N-56	YN	1.5E+1	3.0E+2	2.4E+2	5.8E+2	2.6E+0	1.6E+1	1.2E+1	6.0E-2	1.7E+3	9.4E+0	6.5E+1	3.2E+3	6.1E+3	3.0E+3
60-K-57	Kao	2.2E+1	4.1E+2	3.3E+2	7.7E+2	6.3E-1	7.9E+0	2.6E+0	6.0E-2	2.2E+2	2.2E+0	3.9E+1	3.0E+1	7.3E+2	1.1E+2
60-FE-58	Prm	2.8E+1	8.0E+2	4.4E+2	1.0E+3	7.5E-1	2.0E+2	3.3E+0	2.1E-2	4.4E+2	9.4E+0	1.5E+3	3.0E+2	2.5E+3	9.3E+2
60-FE-59	Prm	8.0E+0	3.1E+2	1.4E+2	2.9E+2	8.2E-1	1.5E+2	3.3E+0	8.1E-2	4.0E+2	7.9E+0	1.2E+3	3.1E+2	2.2E+3	8.3E+2
60-FE-60	Prm	1.1E+2	1.4E+4	2.9E+3	4.6E+3	3.4E-1	1.8E+1	8.9E-1	2.0E-2	7.7E+1	2.2E+0	2.1E+2	1.6E+1	8.1E+2	4.1E+1
60-FE-61	Prm	1.0E+2	3.9E+4	5.6E+3	6.3E+3	2.1E-1	8.3E+0	1.0E+0	5.9E-2	8.3E+1	1.8E+0	6.2E+1	4.0E+1	1.0E+3	2.6E+1
60-FE-62	Prm	1.3E+1	1.1E+3	3.3E+2	7.2E+2	7.1E-1	1.3E+2	3.3E+0	1.4E-1	3.9E+2	7.3E+0	1.6E+3	1.2E+2	2.7E+3	8.6E+2
60-N-63	YN	2.3E+1	5.0E+2	3.8E+2	9.3E+2	8.1E-1	3.3E+1	2.6E+0	2.0E-1	3.9E+2	2.0E+1	1.2E+3	7.8E+1	1.2E+4	3.9E+2
60-N-63	YN	6.8E+0	2.2E+2	1.2E+2	2.9E+2	6.1E-1	2.9E+1	2.4E+0	1.0E+0	4.7E+2	2.2E+1	1.3E+3	7.8E+1	1.2E+4	4.1E+2
60-N-63	YN	4.8E+0	1.3E+2	6.3E+1	1.3E+2	1.1E+0	3.3E+1	3.6E+0	6.4E-1	6.0E+2	1.9E+1	1.4E+3	9.7E+1	1.5E+4	4.9E+2
60-N-64	YN	3.0E+1	6.9E+2	5.6E+2	1.3E+3	8.3E-1	2.5E+1	2.7E+0	1.1E-1	4.1E+2	2.1E+1	1.0E+3	8.4E+1	1.2E+4	4.0E+2
60-N-64	YN	1.7E+1	2.8E+2	2.2E+2	4.1E+2	1.3E+0	3.1E+1	3.1E+0	0.0E+0	4.0E+2	2.5E+1	1.0E+3	8.2E+1	1.2E+4	4.2E+2
87-FE-25	Prm	1.0E+1	6.4E+2	1.8E+2	6.1E+2	1.3E-1	2.1E+0	8.0E-2	1.4E-1	4.7E+0	1.8E-1	3.1E+1	7.7E-1	5.7E+1	3.6E+0
87-N-26	YN	4.9E-1	4.1E+1	1.5E+1	3.2E+1	4.3E-1	1.5E+1	1.8E+0	9.8E-2	2.3E+2	6.5E+0	3.0E+2	7.5E+1	3.8E+3	2.1E+2
87-FE-27	Prm	1.6E+0	4.6E+1	2.5E+1	7.0E+1	1.9E-1	1.7E+2	9.4E-1	8.2E-2	1.1E+2	2.2E+0	1.3E+3	2.2E+1	6.1E+2	1.0E+2
87-FE-28	Prm	1.2E+0	7.6E+1	2.2E+1	7.2E+1	2.9E-1	1.4E+2	8.1E-1	7.8E-2	1.0E+2	2.7E+0	1.0E+3	1.7E+1	5.9E+2	1.1E+2
87-FE-29	Prm	2.5E+0	6.4E+1	3.7E+1	8.8E+1	2.2E-1	1.0E+2	5.1E-1	1.3E-1	6.7E+1	1.8E+0	7.8E+2	1.1E+1	3.8E+2	3.8E+1
87-FE-30	Prm	4.1E+1	7.6E+2	6.8E+2	1.7E+3	2.8E-1	3.9E+2	7.7E-1	1.2E-1	1.1E+2	6.9E+0	1.7E+3	1.9E+1	3.1E+2	2.3E+2
87-K-31	Kao	1.2E+0	3.0E+1	1.7E+1	5.8E+1	2.2E-1	4.6E+1	6.9E-1	1.2E-1	7.7E+1	6.3E-1	1.9E+2	4.2E+0	2.4E+2	1.4E+1

U: uraninite, YN: yellow nodule, BN: brown nodule, Kao: kaolinite, Prm: primitive iron mineral

the 6th measurement (ratio to ^{251}UO-1)

Sample ID	Anal. Min.	ratio to UO-251 & error-1											Nov/1997-(6)
		Pb-204	error	Pb-206	error	Pb-207	error	Pb-208	error	Th-230	error	Th-232	error
TANB-1	U	0.000069	0.000004	9.838454	0.055296	0.600025	0.003347	0.012337	0.000079	0.000091	0.000003	0.018531	0.000072
60-N-48	YN	0.003546	0.000332	0.074400	0.005827	0.061031	0.005405	0.147059	0.011968	0.000059	0.000007	0.002519	0.000079
60-N-49	YN	0.001844	0.000047	0.038946	0.002609	0.031804	0.002294	0.077089	0.005888	0.000039	0.000006	0.000604	0.000032
60-N-50	BN	0.002358	0.000318	0.050118	0.006199	0.040894	0.005712	0.096939	0.013986	0.000053	0.000011	0.000020	0.000010
60-K-51	Kao	0.045041	0.001150	0.826707	0.011270	0.700481	0.009053	1.688252	0.031527	0.000611	0.000074	0.021269	0.000836
60-N-52	YN	0.001176	0.000070	0.028369	0.002577	0.020619	0.001527	0.048228	0.003820	0.000052	0.000010	0.000145	0.000026
60-N-53	YN	0.002313	0.000126	0.045445	0.002841	0.037295	0.002279	0.086666	0.001598	0.000030	0.000010	0.000083	0.000046
60-N-54	YN	0.002715	0.000274	0.053906	0.003995	0.044150	0.003218	0.108656	0.008045	0.000052	0.000007	0.000785	0.000036
60-N-55A	YN	0.001570	0.000197	0.035376	0.003685	0.025448	0.003502	0.059854	0.008692	0.000049	0.000009	0.000044	0.000014
60-N-55B	YN	0.000280	0.000028	0.010305	0.000288	0.004252	0.000220	0.008699	0.000243	0.000054	0.000009	0.000070	0.000022
60-N-55C	YN	0.000201	0.000033	0.009451	0.000357	0.004118	0.000161	0.008068	0.000229	0.000041	0.000008	0.000054	0.000019
60-N-55D	YN	0.000347	0.000035	0.009731	0.000277	0.005486	0.000254	0.011420	0.000304	0.000051	0.000008	0.000057	0.000014
60-N-56	YN	0.001188	0.000220	0.030217	0.003462	0.019711	0.003007	0.047124	0.007242	0.000050	0.000009	0.000050	0.000015
60-N-56	YN	0.000634	0.000056	0.018348	0.000388	0.009321	0.000302	0.019647	0.000628	0.000069	0.000015	-0.000109	-0.000040
60-N-56	YN	0.000273	0.000052	0.013948	0.000317	0.014737	0.000549	0.010208	0.000307	0.000083	0.000016	0.000165	0.000037
60-N-56	YN	0.000141	0.000028	0.014604	0.000426	0.004200	0.000186	0.004378	0.000134	0.000004	0.000001	0.000083	0.000013
60-N-56	YN	-0.001080	-0.000146	0.018854	0.000616	0.000789	0.000052	0.000754	0.000025	0.000206	0.000045	-0.000050	-0.000008
60-N-56	YN	-0.000322	-0.000044	-0.059861	-0.007398	-0.064462	-0.016875	-0.146520	-0.042995	0.000218	0.000039	0.000027	0.000004
60-N-56	YN	0.002479	0.000113	0.048398	0.000674	0.038735	0.000679	0.094132	0.001254	0.000421	0.000027	0.002556	0.000093
60-K-57	Kao	0.030546	0.001644	0.560293	0.020666	0.447089	0.016900	1.047904	0.044693	0.000770	0.000108	0.010715	0.000694
60-FE-58	Prm	0.011446	0.001338	0.324845	0.035894	0.180583	0.020972	0.418208	0.048486	0.000298	0.000048	0.080696	0.008927
60-FE-59	Prm	0.003562	0.000188	0.141490	0.006712	0.061531	0.002193	0.130527	0.002095	0.000331	0.000040	0.068214	0.000907
60-FE-60	Prm	0.129815	0.003022	17.050764	0.207037	3.536420	0.044489	5.697893	0.082206	0.000398	0.000086	0.022033	0.000783
60-FE-61	Prm	0.101066	0.001694	38.172510	0.376854	5.503173	0.056336	6.117874	0.061689	0.000143	0.000038	0.008092	0.000410
60-FE-62	Prm	0.004843	0.000230	0.416416	0.006498	0.120186	0.002271	0.260710	0.003079	0.000246	0.000030	0.049150	0.000748
60-N-63	YN	0.001983	0.000289	0.042850	0.004982	0.033052	0.004751	0.079634	0.011365	0.000052	0.000009	0.002813	0.000071
60-N-63	YN	0.000582	0.000041	0.018785	0.000325	0.009938	0.000237	0.024446	0.000417	0.000053	0.000007	0.002468	0.000056
60-N-63	YN	0.000272	0.000027	0.008460	0.000163	0.004125	0.000170	0.008513	0.000177	0.000032	0.000004	0.002128	0.000054
60-N-64	YN	0.002450	0.000055	0.056372	0.005518	0.046001	0.004580	0.108841	0.011336	0.000059	0.000007	0.002035	0.000058
60-N-64	YN	0.001421	0.000119	0.022366	0.000430	0.017496	0.001098	0.033326	0.000459	0.000117	0.000017	0.002524	0.000064
87-FE-25	Prm	0.183269	0.012379	11.309561	0.577085	3.173108	0.144257	10.791900	0.535906	-0.000137	-0.000116	0.033943	0.005401
87-N-26	YN	0.000101	0.000020	0.010637	0.000445	0.003920	0.000254	0.008274	0.000305	0.000087	0.000016	0.003887	0.000194
87-FE-27	Prm	0.002505	0.000300	0.075610	0.002697	0.040379	0.001772	0.115228	0.004467	0.000181	0.000070	0.283808	0.006929
87-FE-28	Prm	0.001884	0.000270	0.128468	0.010726	0.036694	0.003398	0.121717	0.004204	0.000352	0.000081	0.238088	0.005306
87-FE-29	Prm	0.006279	0.000858	0.166790	0.005049	0.096731	0.005173	0.228420	0.006758	0.000231	0.000080	0.261031	0.005549
87-FE-30	Prm	0.132759	0.004252	2.458911	0.144645	2.198782	0.150026	5.620724	0.549015	0.000533	0.000391	1.268012	0.104548
87-K-31	Kao	0.004520	0.000686	0.123294	0.005785	0.069455	0.011209	0.238524	0.034846	0.000442	0.000141	0.186670	0.009657

U: uraninite, YN: yellow nodule, BN: brown nodule, Kao: kaolinite, Prm: primitive iron mineral

the 6th measurement (ratio to ^{251}UO-2)

Sample ID	Anal. Min.	ratio to UO-251 & error -2									Nov/1997-(6)	
		U-234	error	U-235	error	ThO-246	error	ThO-248	error	UO-250	error	UOH-252	error
TANB-1	U	0.000859	0.000008	0.112720	0.001248	0.001610	0.000019	0.305268	0.001597	0.008392	0.000044	0.012679	0.000112
60-N-48	YN	0.000250	0.000012	0.039528	0.000371	0.001621	0.000125	0.082055	0.000561	0.007172	0.000123	0.032106	0.000330
60-N-49	YN	0.000224	0.000011	0.035552	0.000391	0.001608	0.000094	0.021595	0.000259	0.007188	0.000138	0.032760	0.000363
60-N-50	BN	0.000183	0.000017	0.024606	0.000434	0.001879	0.000064	0.001370	0.000080	0.006876	0.000155	0.015482	0.000334
60-K-51	Kao	0.003395	0.000145	0.338611	0.006112	0.002820	0.000225	0.071942	0.002233	0.152454	0.009040	0.338352	0.004820
60-N-52	YN	0.000187	0.000020	0.031289	0.000533	0.001940	0.000082	0.006327	0.000299	0.006763	0.000159	0.020538	0.000486
60-N-53	YN	0.000373	0.000032	0.065298	0.001103	0.001661	0.000149	0.002190	0.000244	0.007436	0.000251	0.023147	0.000629
60-N-54	YN	0.000297	0.000015	0.047356	0.000413	0.001525	0.000050	0.020490	0.000283	0.006843	0.000133	0.026790	0.000298
60-N-55A	YN	0.000198	0.000018	0.029699	0.000456	0.002011	0.000089	0.002236	0.000117	0.007158	0.000179	0.020686	0.000373
60-N-55B	YN	0.000242	0.000019	0.033660	0.000539	0.001974	0.000077	0.001847	0.000104	0.006768	0.000149	0.021459	0.000385
60-N-55C	YN	0.000233	0.000015	0.034542	0.000688	0.001808	0.000076	0.001561	0.000128	0.006960	0.000167	0.021842	0.000502
60-N-55D	YN	0.000246	0.000015	0.039291	0.000584	0.001658	0.000067	0.001433	0.000095	0.007151	0.000144	0.022499	0.000357
60-N-56	YN	0.000186	0.000015	0.027687	0.000647	0.001795	0.000093	0.002142	0.000117	0.007300	0.000212	0.019928	0.000522
60-N-56	YN	0.000031	0.000002	0.029507	0.000443	0.002374	0.000091	0.001046	0.000117	0.009347	0.000202	0.020051	0.000360
60-N-56	YN	0.000123	0.000009	0.030502	0.000437	-0.000658	-0.000033	0.003786	0.000220	0.006896	0.000147	0.021629	0.000546
60-N-56	YN	0.000145	0.000010	0.027003	0.000387	0.001834	0.000077	0.001014	0.000036	0.005929	0.000322	0.026784	0.000474
60-N-56	YN	0.000082	0.000006	0.026793	0.000405	0.001927	0.000087	0.003271	0.000104	0.007457	0.000214	0.017901	0.000375
60-N-56	YN	0.000479	0.000033	0.031224	0.000540	0.002562	0.000124	0.000030	0.000001	0.001280	0.000031	0.028827	0.000600
60-N-56	YN	0.001900	0.000063	0.273211	0.013524	0.001521	0.000072	0.010564	0.000270	0.516807	0.020436	0.485329	0.011833
60-K-57	Kao	0.003525	0.000211	0.298852	0.011826	0.002971	0.000364	0.052416	0.002550	0.040530	0.002119	0.149116	0.008545
60-FE-58	Prm	0.001320	0.000166	0.178252	0.023203	0.003811	0.000460	0.602106	0.102327	0.123821	0.021705	0.380485	0.053050
60-FE-59	Prm	0.001458	0.000073	0.178627	0.002151	0.003510	0.000217	0.519616	0.005203	0.139769	0.004254	0.371669	0.008180
60-FE-60	Prm	0.001075	0.000095	0.094719	0.002478	0.002716	0.000378	0.262385	0.005222	0.020086	0.000773	0.050422	0.001685
60-FE-61	Prm	0.000931	0.000083	0.081506	0.001937	0.001725	0.000233	0.060491	0.002101	0.039510	0.000905	0.025548	0.001011
60-FE-62	Prm	0.001192	0.000065	0.142316	0.001945	0.002659	0.000196	0.577969	0.006141	0.044698	0.002682	0.314193	0.003701
60-N-63	YN	0.000204	0.000011	0.033904	0.000353	0.001682	0.000056	0.105363	0.000956	0.006648	0.000118	0.033650	0.000477
60-N-63	YN	0.000201	0.000011	0.039738	0.000525	0.001834	0.000069	0.106518	0.000720	0.006579	0.000102	0.034758	0.000344
60-N-63	YN	0.000194	0.000009	0.039453	0.000478	0.001199	0.000040	0.090877	0.000553	0.006393	0.000099	0.032096	0.000324
60-N-64	YN	0.000213	0.000013	0.033149	0.000347	0.001666	0.000074	0.083547	0.000648	0.006810	0.000120	0.032665	0.000343
60-N-64	YN	0.000260	0.000014	0.032737	0.000325	0.002038	0.000062	0.080964	0.000537	0.006702	0.000101	0.034319	0.000332
87-FE-25	Prm	-0.001004	-0.000877	0.080875	0.008783	0.000814	0.001628	0.551211	0.038553	0.011166	0.003308	0.061457	0.007664
87-N-26	YN	0.000455	0.000029	0.059618	0.000836	0.001680	0.000126	0.077699	0.001391	0.019559	0.002720	0.053577	0.000926
87-FE-27	Prm	0.001416	0.000127	0.176631	0.004806	0.003470	0.000359	2.116190	0.043239	0.036926	0.001453	0.170885	0.004712
87-FE-28	Prm	0.001244	0.000119	0.171570	0.005071	0.004356	0.000404	1.734994	0.032513	0.028844	0.003588	0.192823	0.004444
87-FE-29	Prm	0.000988	0.000129	0.174361	0.005066	0.004281	0.000553	2.035458	0.039171	0.029141	0.005874	0.100069	0.004064
87-FE-30	Prm	0.002121	0.000339	0.365128	0.010015	0.021833	0.001835	5.662386	0.388739	0.061626	0.002554	0.752842	0.017145
87-K-31	Kao	0.002343	0.000384	0.316649	0.011941	0.002094	0.000500	0.793941	0.026315	0.016681	0.001715	0.055214	0.003822

U: uraninite, YN: yellow nodule, BN: brown nodule, Kao: kaolinite, Prm: primitive iron mineral

Appendix 2 Isotopic data of every mineral and sample with SHRIMP

Sample ID	Anal. Min.	cps																				
		Pb-204	Pb-206	Pb-207	Pb-208	Ra-226	Th-230	Th-232	U-234	Bkg-234	U-235	RaO-242	ThO-246	PaO-247	Bkg-247	ThO-248	UO-250	UO-251	UOH-252	UO-254	UO2-266	UO2-267
D58-21	Fis	8.8E+1	1.1E+4	2.2E+3	3.3E+3		2.9E-1	5.0E+1	1.5E+0	6.2E-2	1.3E+2		1.4E+0			3.1E+2	4.2E+1	6.9E+2	1.2E+1			
D60-33F	Fis			1.3E+2		1.2E+0	6.1E-1	1.7E+2	2.0E+0		2.7E+2	3.0E-1	6.7E+0	2.7E+0	4.6E-2	1.5E+3	1.1E+2	1.7E+3	4.6E+2			
D60-35F	Fis			2.5E+3		2.0E-1	9.2E-2	4.9E+0	5.2E-1		5.9E+1	1.4E-1	1.6E+0	4.6E-1	0.0E+0	5.6E+1	2.0E+1	7.2E+2	4.7E+1			
D87-21	Fis	4.1E+0	2.4E+2	7.1E+1	2.4E+2		1.3E-1	2.0E+1	1.1E-1	2.3E-2	7.9E+0		4.7E-1			3.5E+2	1.6E+0	1.3E+2	2.3E+0			
D58-4	Kao	9.4E+1	2.1E+3	1.4E+3	3.3E+3		3.3E-1	1.3E+0	1.2E+0	2.0E-2	1.3E+2		7.0E-1			4.4E+0	2.2E+1	3.7E+2	1.1E+1			
D58-6	Kao	6.1E+1	1.8E+3	9.7E+2	2.2E+3		1.9E-1	5.2E+0	1.2E+0	6.0E-2	1.3E+2		7.7E-1			1.8E+1	7.7E+0	3.5E+2	6.6E+0			
D58-7	Kao	7.7E+1	2.0E+3	1.3E+3	3.0E+3		3.4E-1	3.7E+0	8.8E-1	6.0E-2	7.0E+1		4.7E-1			1.2E+1	5.8E+0	2.3E+2	5.0E+0			
D58-17	Kao	3.3E+1	7.9E+2	5.2E+2	1.2E+3		2.1E-1	2.1E+1	1.0E+0	1.6E-1	8.9E+1		7.0E-1			7.1E+1	5.3E+0	2.6E+2	2.5E+0			
D58-23	Kao	7.1E+1	1.5E+3	1.1E+3	2.6E+3		1.8E-1	3.9E+1	5.2E-1	2.1E-2	4.4E+1		2.9E-1			1.9E+2	6.3E+0	1.2E+2	2.0E+0			
D58-24	Kao	3.0E+2	7.4E+3	4.7E+3	1.1E+4		3.7E-1	2.7E+1	2.1E+0	1.4E-1	2.3E+2		1.6E+0			1.4E+2	1.0E+2	8.2E+2	2.8E+1			
D58-25	Kao	1.2E+2	4.1E+3	2.0E+3	4.4E+3		4.9E-1	1.5E+1	2.4E+0	2.2E-2	2.8E+2		2.0E+0			7.7E+1	8.2E+1	9.9E+2	2.1E+1			
D60-7	Kao										1.1E+2	1.1E-1	1.1E+0	1.6E-1	0.0E+0	1.0E+1	1.9E+1	3.9E+2		5.3E+4		
D60-8	Kao										2.0E+2	7.3E-2	1.6E+0	1.1E+0	0.0E+0	7.9E+1	1.4E+2	5.8E+2		7.8E+4		
D60-9	Kao										1.7E+2	4.6E-2	2.3E+0	6.6E-1	0.0E+0	1.8E+2	1.4E+2	9.9E+2		1.3E+5		
D60-16	Kao										1.1E+2	1.6E-1	1.4E+0	2.8E-1	3.6E-2	2.1E+2	4.5E+1	4.5E+2		6.0E+4		
D60-23K	Kao			7.0E+2		1.1E-1	5.4E-1	1.8E+1	1.4E+0		1.1E+2	3.9E-2	2.0E+0	1.8E-1	2.0E-2	9.6E+1	1.1E+1	3.9E+2	2.0E+1			
D60-24K	Kao			6.1E+2		1.0E-1	2.9E-1	3.4E+0	1.6E+0		1.1E+2	4.0E-2	1.6E+0	1.5E-1	2.3E-2	1.2E+1	1.0E+1	3.4E+2	1.6E+1			
D60-25K	Kao			8.1E+2		2.3E-1	5.4E-1	2.0E+1	1.9E+0		2.0E+2	2.1E-2	2.6E+0	8.4E-1	4.0E-2	1.3E+2	8.9E+1	9.3E+2	2.2E+2			
D60-26K	Kao			3.0E+2		6.5E-2	2.5E-1	1.6E+1	1.2E+0		9.9E+1	2.1E-2	1.1E+0	1.4E-1	1.5E-2	6.7E+1	2.2E+1	3.1E+2	4.4E+1			
D60-27K	Kao			3.5E+2		7.6E-2	4.9E-1	3.1E+1	2.2E+0		2.0E+2	6.0E-2	1.5E+0	7.0E-1	2.0E-2	1.3E+2	8.7E+1	6.3E+2	1.4E+2			
D60-28K	Kao			6.7E+2		1.1E-1	3.8E-1	3.5E+1	1.9E+0		1.9E+2	5.9E-2	2.0E+0	3.4E-1	5.7E-2	1.8E+2	3.4E+1	5.7E+2	5.8E+1			
D60-29K	Kao			9.0E+2		2.6E-1	6.1E-1	8.7E+1	1.8E+0		1.8E+2	7.8E-2	2.5E+0	5.0E-1	0.0E+0	5.4E+2	3.9E+1	6.9E+2	7.4E+1			
D60-31K	Kao			4.2E+2		7.3E-2	4.1E-1	5.0E+1	2.0E+0		2.5E+2	1.6E-1	1.5E+0	2.1E+0	4.3E-2	1.0E+2	1.5E+2	5.0E+2	2.5E+2			
D60-32K	Kao			1.0E+3		3.8E-1	4.3E-1	6.1E+1	3.5E+0		3.7E+2	6.2E-2	2.1E+0	2.4E+0	1.5E-2	2.4E+2	1.1E+2	9.3E+2	3.2E+2			
D60-34K	Kao			1.1E+3		2.6E-1	5.8E-1	2.4E+2	3.2E+0		3.5E+2	1.8E-1	5.3E+0	2.8E+0	0.0E+0	1.1E+3	1.4E+2	1.1E+3	4.1E+2			
D60-36K	Kao			4.0E+2		2.2E-1	3.1E-1	3.6E+1	1.6E+0		1.2E+2	2.1E-2	1.6E+0	8.2E-2	1.7E-2	1.9E+2	9.1E+0	4.1E+2	2.2E+1			
D60-37K	Kao			7.2E+2		2.1E-1	2.8E-1	4.0E+1	1.6E+0		1.2E+2	5.9E-2	2.0E+0	3.1E-1	0.0E+0	2.2E+2	2.8E+1	4.6E+2	6.2E+1			
D60-39K	Kao	6.9E+1	1.3E+3	1.1E+3	2.6E+3		3.2E-1	3.9E+1	1.1E+0	6.2E-2	7.9E+1		1.5E+0			2.5E+2	2.5E+1	3.9E+2	3.4E+1		7.9E+0	2.2E+2
D60-39Kb	Kao	1.1E+2	2.0E+3	1.8E+3	4.0E+3		9.5E-1	9.5E+1	2.3E+0	0.0E+0	1.9E+2		3.0E+0			5.7E+2	4.6E+1	9.0E+2	7.1E+1		1.5E+1	4.5E+2
D60-40K	Kao	1.1E+2	2.0E+3	1.6E+3	3.9E+3		3.8E-1	4.4E+1	1.1E+0	1.9E-2	7.9E+1		1.3E+0			3.5E+2	1.3E+1	4.4E+2	2.1E+1		6.7E+0	3.3E+2
D60-40Kb	Kao	1.5E+2	2.8E+3	2.3E+3	5.4E+3		4.3E-1	1.2E+2	2.4E+0	2.1E-2	2.1E+2		3.5E+0			8.4E+2	4.4E+1	1.1E+3	7.1E+1		1.5E+1	7.3E+2
D60-41K	Kao	9.1E+1	2.1E+3	1.4E+3	3.4E+3		7.1E-1	1.3E+2	2.9E+0	4.1E-2	2.8E+2		4.2E+0			1.0E+3	1.2E+2	1.3E+3	2.4E+2		3.1E+1	8.3E+2
D60-43K	Kao	3.7E+1	6.7E+2	5.5E+2	1.3E+3		3.9E-1	6.2E+0	1.7E+0	3.8E-2	1.7E+2		1.5E+0			2.3E+1	2.7E+1	4.9E+2	4.5E+1			
D60-44K	Kao	6.0E+1	1.1E+3	9.6E+2	2.3E+3		8.8E-1	1.0E+2	4.2E+0	2.1E-2	5.1E+2		3.9E+0			3.8E+2	3.7E+2	1.4E+3	6.3E+2			
D60-45K	Kao	3.9E+1	7.1E+2	5.7E+2	1.4E+3		8.6E-1	6.2E+1	3.6E+0	1.7E-2	3.5E+2		3.3E+0			3.3E+2	8.3E+1	1.3E+3	3.6E+2			
D60-46K	Kao	1.4E+2	2.7E+3	2.1E+3	5.1E+3		8.0E-1	1.9E+2	3.1E+0	5.9E-2	2.7E+2		5.3E+0			1.3E+3	4.0E+1	1.3E+3	8.6E+1			
D60-47K	Kao	1.2E+2	2.8E+3	1.9E+3	4.3E+3		8.9E-1	4.1E+2	4.0E+0	6.0E-2	4.4E+2		9.1E+0			2.8E+3	1.4E+2	2.6E+3	5.1E+2			
D60-51	Kao	5.2E+1	9.4E+2	8.0E+2	1.9E+3		7.4E-1	2.4E+1	3.9E+0	4.4E-2	3.9E+2		3.3E+0			8.2E+1	1.7E+2	1.1E+3	3.9E+2			
D60-57	Kao	2.2E+1	4.1E+2	3.3E+2	7.7E+2		6.3E-1	7.9E+0	2.6E+0	6.0E-2	2.2E+2		2.2E+0			3.9E+1	3.0E+1	7.3E+2	1.1E+2			
D87-5	Kao	6.5E-1	2.5E+1	5.4E+0	2.3E+1		3.0E-1	4.5E+2	1.2E+0	0.0E+0	1.3E+2		3.6E+0			2.8E+3	4.1E+1	5.1E+2	4.0E+1			
D87-6	Kao	2.0E-1	5.7E+0	1.9E+0	4.0E+0		1.1E-1	1.6E+1	8.1E-1	1.9E-2	7.9E+1		8.2E-1			8.5E+1	4.2E+1	2.5E+2	4.4E+1			
D87-13	Kao	7.0E-1	3.0E+1	1.3E+1	3.3E+1		1.8E-1	9.3E+1	6.9E-1	1.7E-2	7.2E+1		1.5E+0			4.9E+2	3.1E+1	2.6E+2	2.8E+1			
D87-16	Kao	1.0E+1	2.0E+2	1.7E+2	4.1E+2		1.1E+0	2.4E+1	4.3E-1	1.0E-1	5.5E+1		6.2E-1			1.1E+2	5.2E+1	2.1E+2	5.1E+1			

Sample ID	Anal. Min.	cps																				
		Pb-204	Pb-206	Pb-207	Pb-208	Ra-226	Th-230	Th-232	U-234	Bkg-234	U-235	RaO-242	ThO-246	PaO-247	Bkg-247	ThO-248	UO-250	UO-251	UOH-252	UO-254	UO2-266	UO2-267
D87-18	Kao	5.7E-1	8.3E+0	3.9E+0	1.2E+1		1.6E-1	1.5E+1	3.6E-1	6.1E-2	3.5E+1		4.9E-1			6.0E+1	1.7E+1	1.2E+2	1.3E+1			
D87-22	Kao	1.8E+1	4.7E+2	3.0E+2	6.9E+2		5.0E-1	6.2E+1	1.9E+0	1.4E-1	2.3E+2		2.7E+0			3.1E+2	3.5E+2	9.9E+2	3.8E+2			
D87-24	Kao	3.3E+0	2.8E+2	6.9E+1	1.6E+2		1.4E-1	8.6E+1	5.8E-1	4.0E-2	4.4E+1		8.2E-1			5.3E+2	4.0E+1	2.5E+2	3.5E+1			
D87-31	Kao	1.2E+0	3.0E+1	1.7E+1	5.8E+1		2.2E-1	4.6E+1	6.9E-1	1.2E-1	7.7E+1		6.3E-1			1.9E+2	4.2E+0	2.4E+2	1.4E+1			
D58-8	Mus	6.4E+1	1.6E+3	1.1E+3	2.5E+3		2.2E-1	1.3E+1	1.1E+0	1.2E-1	8.8E+1		5.7E-1			4.1E+1	5.3E+0	2.5E+2	3.0E+0			
D58-16	Mus	1.4E+2	1.8E+4	3.7E+3	5.6E+3		6.2E-1	1.0E+2	1.6E+0	1.4E-1	1.6E+2		2.4E+0			8.1E+2	1.1E+1	9.0E+2	1.4E+1			
D58-22	Mus	2.3E+2	1.0E+4	4.1E+3	8.6E+3		1.9E-1	1.6E+1	7.7E-1	8.0E-2	7.2E+1		1.1E+0			1.3E+2	1.3E+1	3.8E+2	5.1E+0			
D60-1	Nod										2.3E+2	5.3E-1	1.7E+1	7.2E-1	4.3E-2	1.2E+1	6.5E+1	1.0E+4				
D60-1B	Nod										1.9E+2	5.2E-1	1.4E+1	6.4E-1	3.7E-2	1.0E+1	5.7E+1	8.7E+3		1.2E+6		
D60-2	Nod										1.9E+2	5.9E-1	1.3E+1	3.2E-1	4.1E-2	1.1E+2	5.3E+1	7.9E+3		1.1E+6		
D60-3	Nod										2.2E+2	8.5E-1	1.4E+1	8.0E-1	3.9E-2	1.7E+0	5.9E+1	8.2E+3		1.1E+6		
D60-4	Nod										2.8E+2	6.3E-1	1.4E+1	3.6E-1	4.0E-2	9.5E+1	6.4E+1	8.6E+3		1.2E+6		
D60-5	Nod										3.4E+2	4.8E-1	1.4E+1	6.0E-1	8.0E-2	1.0E+3	8.3E+1	8.8E+3		1.2E+6		
D60-6	Nod										3.3E+2	6.3E-1	1.3E+1	5.2E-1	4.1E-2	5.5E+2	6.5E+1	8.9E+3		1.2E+6		
D60-13	Nod										2.8E+2	4.8E-1	1.3E+1	5.2E-1	1.3E-1	2.3E+2	6.0E+1	8.0E+3		1.1E+6		
D60-14	Nod										8.1E+1	6.8E-1	7.3E+0	5.2E-1	3.7E-2	2.6E+0	4.0E+1	4.0E+3		5.4E+5		
D60-15	Nod										6.7E+1	6.4E-1	6.8E+0	2.8E-1	0.0E+0	8.6E-1	2.5E+1	3.5E+3		4.7E+5		
D60-20	Nod			1.2E+2		1.0E+0	1.2E-1	2.0E-2	6.0E-1		8.8E+1	3.8E-1	7.9E+0	2.3E-1	3.5E-2	2.5E-1	2.5E+1	4.1E+3	5.4E+1			
D60-21	Nod			8.7E+1		1.5E+0	2.2E-1	0.0E+0	5.9E-1		8.8E+1	4.6E-1	7.3E+0	2.3E-1	4.8E-2	6.3E-1	3.0E+1	4.1E+3	5.1E+1			
D60-22	Nod			1.6E+2		8.8E-1	2.4E-1	2.4E-2	8.0E-1		9.8E+1	3.7E-1	9.2E+0	3.4E-1	1.3E-1	1.0E-1	3.2E+1	4.5E+3	5.4E+1			
D60-30	Nod			5.5E+1		1.3E+0	2.9E-1	0.0E+0	1.3E+0		1.6E+2	4.8E-1	8.6E+0	3.0E-1	9.4E-2	1.4E-1	3.8E+1	5.4E+3	8.3E+1			
D60-38	Nod	1.4E+1	2.8E+2	2.3E+2	4.6E+2		3.4E-1	1.8E-1	1.1E+0	6.1E-2	1.6E+2		1.4E+1			4.0E+0	4.9E+1	6.8E+3	8.7E+1		2.0E+2	2.6E+4
D60-42	Nod	1.2E+1	2.9E+2	1.7E+2	4.1E+2		3.1E-1	3.7E-2	1.3E+0	2.1E-2	1.7E+2		1.4E+1			2.4E-1	5.0E+1	7.5E+3	9.1E+1		2.1E+2	2.9E+4
D87-1	Nod	4.8E-1	2.2E+1	1.3E+1	2.4E+1		2.4E-1	1.1E+1	9.2E-1	0.0E+0	1.1E+1		6.6E+0			5.8E+2	2.9E+1	3.6E+3	7.7E+1			
D87-2	Nod	5.0E+0	1.1E+2	8.1E+1	1.9E+2		1.7E-1	1.7E+1	9.1E-1	8.2E-2	1.4E+2		5.6E+0			5.0E+2	6.1E+1	3.3E+3	1.9E+2			
D87-3	Nod	4.1E-1	2.2E+1	5.8E+0	1.4E+1		1.7E-1	1.3E+1	9.5E-1	4.1E-2	1.4E+2		6.6E+0			4.1E+2	4.4E+1	3.8E+3	9.0E+1			
D87-4	Nod	8.5E-1	2.6E+1	9.1E+0	2.4E+1		3.4E-1	1.3E+1	8.4E-1	1.9E-2	1.0E+2		6.7E+0			5.4E+2	3.0E+1	3.7E+3	7.7E+1			
D87-7	Nod	6.3E-1	7.5E+1	1.3E+1	2.9E+1		4.9E-1	7.5E+1	1.3E+0	3.7E-2	1.8E+2		6.0E+0			8.6E+2	1.2E+2	3.5E+3	2.2E+2			
D87-9	Nod	1.3E+0	3.8E+1	1.8E+1	4.2E+1		2.3E-1	3.3E+0	6.1E-1	6.1E-2	7.4E+1		4.7E+0			1.3E+2	2.2E+1	2.8E+3	5.8E+1			
D58-2	BN	2.8E+1	6.6E+3	9.9E+2	1.1E+3		5.2E-1	7.2E+0	3.9E+0	1.6E-1	4.5E+2		5.5E+0			5.5E+1	6.0E+1	2.8E+3	7.2E+1			
D58-9	BN	3.5E+1	4.3E+4	4.3E+3	1.4E+3		9.3E-1	3.3E+1	4.4E+0	4.3E-2	5.5E+2		2.2E+1			6.2E+2	9.7E+1	1.2E+4	2.6E+2			
D58-13	BN	2.1E+1	3.7E+4	3.6E+3	8.6E+2		1.5E+0	1.8E+1	5.2E+0	7.9E-2	6.0E+2		2.1E+1			3.0E+2	1.0E+2	1.1E+4	2.4E+2			
D58-14	BN	3.7E+1	3.3E+4	3.5E+3	1.5E+3		8.7E-1	1.2E+1	3.4E+0	1.2E-1	3.8E+2		1.8E+1			1.7E+2	8.0E+1	8.7E+3	1.9E+2			
D60-50	BN	2.2E+1	4.7E+2	3.8E+2	9.1E+2		5.9E-1	1.3E+0	1.8E+0	1.0E-1	2.3E+2		1.8E+1			1.3E+1	6.4E+1	9.4E+3	1.4E+2			
D87-23	BN	6.9E+0	1.5E+2	1.0E+2	2.7E+2		1.4E-1	6.8E+0	3.8E-1	8.1E-2	4.3E+1		8.5E-1			5.0E+1	2.0E+1	3.9E+2	3.9E+1			
D58-3	RN	1.9E+1	1.4E+4	1.5E+3	7.3E+2		4.6E-1	5.4E+0	1.5E+0	0.0E+0	1.8E+2		3.9E+0			7.5E+1	2.3E+1	2.0E+3	4.2E+1			
D58-10	RN	3.6E+1	1.0E+5	9.6E+3	1.7E+3		6.9E-1	3.4E+1	3.0E+0	8.0E-2	3.0E+2		7.4E+0			3.2E+2	4.9E+1	3.2E+3	6.1E+1			
D58-11	RN	2.8E+1	8.5E+4	7.9E+3	1.2E+3		5.3E-1	2.1E+1	1.9E+0	1.1E-1	2.1E+2		9.3E+0			5.2E+2	4.8E+1	4.6E+3	8.5E+1			
D58-1	YN	7.9E+0	1.9E+4	1.8E+3	3.6E+2		7.2E-1	2.9E-1	2.9E+0	0.0E+0	3.6E+2		1.7E+1			1.0E+1	7.0E+1	8.9E+3	2.1E+2			
D58-5	YN	5.2E+0	2.6E+4	2.4E+3	2.7E+2		7.5E-1	1.1E+0	2.9E+0	9.6E-2	3.9E+2		2.0E+1			3.2E+1	7.6E+1	1.0E+4	2.4E+2			
D58-15	YN	2.8E+1	3.7E+4	3.7E+3	1.1E+3		8.3E-1	4.5E+0	3.8E+0	6.1E-2	4.9E+2		2.4E+1			1.2E+2	9.7E+1	1.1E+4	2.6E+2			
D58-18	YN	6.0E+1	4.8E+4	5.1E+3	2.5E+3		3.3E-1	3.0E+0	1.2E+0	3.8E-2	1.4E+2		1.0E+1			9.5E+1	5.2E+1	4.8E+3	8.4E+1			
D58-20	YN	1.8E+1	4.6E+4	4.3E+3	8.1E+2		3.2E-1	2.6E-1	1.4E+0	1.4E-1	1.5E+2		1.3E+1			6.3E+0	5.2E+1	6.6E+3	8.8E+1			
D60-48	YN	4.5E+1	9.3E+2	7.7E+2	1.8E+3		8.7E-1	3.2E+1	3.3E+0	1.4E-1	5.0E+2		2.0E+1			1.0E+3	9.0E+1	1.3E+4	4.0E+2			
D60-49	YN	2.5E+1	5.2E+2	4.2E+2	1.0E+3		7.2E-1	8.2E+0	3.2E+0	2.0E-1	4.7E+2		2.2E+1			2.9E+2	9.6E+1	1.3E+4	4.3E+2			
D60-52	YN	7.6E+0	1.8E+2	1.3E+2	3.1E+2		5.2E-1	1.1E+0	1.4E+0	1.8E-1	2.0E+2		1.2E+1			4.0E+1	4.3E+1	6.3E+3	1.3E+2			

Sample ID	Anal. Min.	cps																				
		Pb-204	Pb-206	Pb-207	Pb-208	Ra-226	Th-230	Th-232	U-234	Bkg-234	U-235	RaO-242	ThO-246	PaO-247	Bkg-247	ThO-248	UO-250	UO-251	UOH-252	UO-254	UO2-266	UO2-267
D60-53	YN	5.9E+0	1.1E+2	9.4E+1	2.2E+2		1.7E-1	3.1E-1	1.0E+0	9.9E-2	1.6E+2		4.3E+0			5.6E+0	1.9E+1	2.5E+3	5.8E+1			
D60-54	YN	3.4E+1	6.7E+2	5.5E+2	1.4E+3		7.5E-1	9.9E+0	3.8E+0	1.0E-1	5.9E+2		1.9E+1			2.6E+2	8.6E+1	1.2E+4	3.3E+2			
D60-55A	YN	1.0E+1	2.4E+2	1.7E+2	4.0E+2		3.9E-1	3.6E-1	1.4E+0	6.3E-2	2.0E+2		1.3E+1			1.5E+1	4.8E+1	6.6E+3	1.4E+2			
D60-55B	YN	1.9E+0	7.0E+1	2.9E+1	5.9E+1		3.6E-1	4.8E-1	1.6E+0	0.0E+0	2.3E+2		1.3E+1			1.3E+1	4.6E+1	6.8E+3	1.5E+2			
D60-55C	YN	1.5E+0	6.6E+1	2.9E+1	5.6E+1		3.8E-1	4.7E-1	1.7E+0	1.9E-1	2.4E+2		1.3E+1			1.1E+1	4.9E+1	7.0E+3	1.5E+2			
D60-55D	YN	2.7E+0	7.5E+1	4.2E+1	8.8E+1		4.6E-1	5.0E-1	2.0E+0	6.5E-2	3.0E+2		1.3E+1			1.1E+1	5.5E+1	7.7E+3	1.7E+2			
D60-56	YN	7.9E+0	2.0E+2	1.3E+2	3.1E+2		4.1E-1	4.1E-1	1.3E+0	7.9E-2	1.8E+2		1.2E+1			1.4E+1	4.8E+1	6.5E+3	1.3E+2			
D60-56	YN	3.8E+0	1.1E+2	5.5E+1	1.2E+2		5.4E-1	0.0E+0	3.1E-1	1.3E-1	1.7E+2		1.4E+1			6.3E+0	5.5E+1	5.9E+3	1.2E+2			
D60-56	YN	1.5E+0	7.9E+1	8.3E+1	5.7E+1		4.4E-1	9.1E-1	6.7E-1	1.0E+0	1.7E+2		1.0E+0			2.1E+1	3.9E+1	5.6E+3	1.2E+2			
D60-56	YN	1.2E+0	1.1E+2	3.2E+1	3.4E+1		1.2E-1	7.2E-1	1.2E+0	8.1E-2	2.1E+2		1.4E+1			7.8E+0	4.5E+1	7.6E+3	2.0E+2			
D60-56	YN	1.0E+0	1.6E+2	7.1E+0	6.8E+0		2.2E+0	1.7E-1	1.2E+0	4.9E-1	2.2E+2		1.7E+1			2.8E+1	6.3E+1	8.3E+3	1.5E+2			
D60-56	YN	1.0E+0	3.0E+0	3.0E+0	3.0E+0		8.8E-1	0.0E+0	2.8E+0	0.0E+0	2.3E+2		1.8E+1			1.0E+0	8.7E+0	7.3E+3	2.1E+2			
D60-56	YN	1.5E+1	3.0E+2	2.4E+2	5.8E+2		2.6E+0	1.6E+1	1.2E+1	6.0E-2	1.7E+3		9.4E+0			6.5E+1	3.2E+3	6.1E+3	3.0E+3			
D60-63	YN	2.3E+1	5.0E+2	3.8E+2	9.3E+2		8.1E-1	3.3E+1	2.6E+0	2.0E-1	3.9E+2		2.0E+1			1.2E+3	7.8E+1	1.2E+4	3.9E+2			
D60-63	YN	6.8E+0	2.2E+2	1.2E+2	2.9E+2		6.1E-1	2.9E+1	2.4E+0	1.0E+0	4.7E+2		2.2E+1			1.3E+3	7.8E+1	1.2E+4	4.1E+2			
D60-63	YN	4.8E+0	1.3E+2	6.3E+1	1.3E+2		1.1E+0	3.3E+1	3.6E+0	6.4E-1	6.0E+2		1.9E+1			1.4E+3	9.7E+1	1.5E+4	4.9E+2			
D60-64	YN	3.0E+1	6.9E+2	5.6E+2	1.3E+3		8.3E-1	2.5E+1	2.7E+0	1.1E-1	4.1E+2		2.1E+1			1.0E+3	8.4E+1	1.2E+4	4.0E+2			
D60-64	YN	1.7E+1	2.8E+2	2.2E+2	4.1E+2		1.3E+0	3.1E+1	3.1E+0	0.0E+0	4.0E+2		2.5E+1			1.0E+3	8.2E+1	1.2E+4	4.2E+2			
D87-17	YN	4.4E-1	1.9E+1	6.9E+0	1.9E+1		2.7E-1	4.1E+0	2.7E-1	6.1E-2	3.6E+1		2.6E+0			2.0E+2	1.3E+1	1.5E+3	3.3E+1			
D87-19	YN	4.4E-1	2.0E+1	9.8E+0	2.3E+1		1.2E-1	2.2E+1	4.4E-1	1.7E-1	6.2E+1		2.6E+0			8.4E+2	1.6E+1	2.0E+3	4.9E+1			
D87-26	YN	4.9E-1	4.1E+1	1.5E+1	3.2E+1		4.3E-1	1.5E+1	1.8E+0	9.8E-2	2.3E+2		6.5E+0			3.0E+2	7.5E+1	3.8E+3	2.1E+2			
D60-58	Prm	2.8E+1	8.0E+2	4.4E+2	1.0E+3		7.5E-1	2.0E+2	3.3E+0	2.1E-2	4.4E+2		9.4E+0			1.5E+3	3.0E+2	2.5E+3	9.3E+2			
D60-59	Prm	8.0E+0	3.1E+2	1.4E+2	2.9E+2		8.2E-1	1.5E+2	3.3E+0	8.1E-2	4.0E+2		7.9E+0			1.2E+3	3.1E+2	2.2E+3	8.3E+2			
D60-60	Prm	1.1E+2	1.4E+4	2.9E+3	4.6E+3		3.4E-1	1.8E+1	8.9E-1	2.0E-2	7.7E+1		2.2E+0			2.1E+2	1.6E+1	8.1E+2	4.1E+1			
D60-61	Prm	1.0E+2	3.9E+4	5.6E+3	6.3E+3		2.1E-1	8.3E+0	1.0E+0	5.9E-2	8.3E+1		1.8E+0			6.2E+1	4.0E+1	1.0E+3	2.6E+1			
D60-62	Prm	1.3E+1	1.1E+3	3.3E+2	7.2E+2		7.1E-1	1.3E+2	3.3E+0	1.4E-1	3.9E+2		7.3E+0			1.6E+3	1.2E+2	2.7E+3	8.6E+2			
D87-25	Prm	1.0E+1	6.4E+2	1.8E+2	6.1E+2		1.3E-1	2.1E+0	8.0E-2	1.4E-1	4.7E+0		1.8E-1			3.1E+1	7.7E-1	5.7E+1	3.6E+0			
D87-27	Prm	1.6E+0	4.6E+1	2.5E+1	7.0E+1		1.9E-1	1.7E+2	9.4E-1	8.2E-2	1.1E+2		2.2E+0			1.3E+3	2.2E+1	6.1E+2	1.0E+2			
D87-28	Prm	1.2E+0	7.6E+1	2.2E+1	7.2E+1		2.9E-1	1.4E+2	8.1E-1	7.8E-2	1.0E+2		2.7E+0			1.0E+3	1.7E+1	5.9E+2	1.1E+2			
D87-29	Prm	2.5E+0	6.4E+1	3.7E+1	8.8E+1		2.2E-1	1.0E+2	5.1E-1	1.3E-1	6.7E+1		1.8E+0			7.8E+2	1.1E+1	3.8E+2	3.8E+1			
D87-30	Prm	4.1E+1	7.6E+2	6.8E+2	1.7E+3		2.8E-1	3.9E+2	7.7E-1	1.2E-1	1.1E+2		6.9E+0			1.7E+3	1.9E+1	3.1E+2	2.3E+2			
D58-12	Qz	9.3E-1	1.5E+1	1.1E+1	3.2E+1		5.9E-2	8.0E-2	6.6E-2	1.6E-1	2.9E-1		5.7E-2			2.4E-1	1.3E-1	9.2E-1	1.6E-1			
D58-19	Qz	5.8E-1	6.4E+0	5.5E+0	1.3E+1		1.5E-1	2.2E-1	5.2E-2	0.0E+0	5.9E-1		2.2E-2			0.0E+0	8.8E-1	2.7E-1	2.2E-1			
D60-10	Qz										2.5E+1	9.7E-2	2.7E-1	1.2E-1	4.2E-2	3.0E+1	2.5E+1	1.1E+2		1.5E+4		
D87-8	TiO2	3.6E+1	2.7E+3	7.6E+2	2.6E+3		1.8E-1	4.2E-1	5.8E-2	5.0E-2	2.5E+0		1.2E+0			1.6E+1	6.8E-1	4.8E+1	9.3E-1			
D87-10	TiO2	6.2E+0	2.4E+3	3.4E+2	4.6E+2		1.2E-1	5.3E+1	5.9E-2	5.6E-2	1.1E+0		1.0E-1			9.7E+2	3.2E+0	1.9E+1	9.0E-2			
D87-11	TiO2	8.7E-1	3.6E+2	5.2E+1	5.3E+1		3.6E-2	6.2E+0	6.0E-2	2.1E-2	4.0E-1		1.5E-2			6.3E+1	1.6E-1	3.3E+0	0.0E+0			
D87-12	TiO2	3.5E+0	9.9E+3	1.1E+3	2.7E+3		4.7E-2	8.1E+1	5.0E-2	4.1E-2	2.8E+0		1.9E-1			6.3E+3	1.2E+1	6.3E+1	2.6E-1			
D87-14	TiO2	1.5E+0	2.1E+3	2.4E+2	5.9E+1		5.5E-2	3.8E-1	6.0E-2	1.1E-1	6.0E-1		1.4E-1			2.3E+1	1.3E-1	1.7E+1	2.8E-1			
D87-15	TiO2	2.4E+0	3.7E+2	7.4E+1	2.0E+2		7.1E-2	6.0E+0	5.3E-2	1.1E-1	9.4E-2		0.0E+0			2.7E+2	5.2E-1	2.8E+0	6.0E-2			
D58b-1	U										5.9E+3	1.4E+1	9.9E+1	2.4E+0	0.0E+0	1.2E-1	4.9E+2	6.2E+4				
D58b-1B	U										5.7E+3	1.3E+1	9.7E+1	2.7E+0	7.4E-2	1.2E+0	4.8E+2	6.0E+4				
D58b-2	U										5.7E+3	1.4E+1	1.0E+2	2.6E+0	1.2E-1	8.0E-1	5.0E+2	6.3E+4				
D58b-2B	U										5.6E+3	1.3E+1	1.0E+2	3.2E+0	6.9E-2	1.4E+0	4.8E+2	6.3E+4				
D58b-3	U										4.3E+3	2.2E+1	1.3E+2	4.7E+0	1.2E-1	1.3E+3	6.1E+2	7.8E+4				
D58b-4	U										4.4E+3	2.7E+1	1.4E+2	5.4E+0	3.7E-2	1.1E+3	6.2E+2	7.9E+4				

Sample ID	Anal. Min.	cps																				
		Pb-204	Pb-206	Pb-207	Pb-208	Ra-226	Th-230	Th-232	U-234	Bkg-234	U-235	RaO-242	ThO-246	PaO-247	Bkg-247	ThO-248	UO-250	UO-251	UOH-252	UO-254	UO2-266	UO2-267
D58b-5	U										7.8E+3	2.3E+1	3.2E+2	1.0E+1	3.2E-1	1.9E+0	1.2E+3	1.6E+5				
TAN-1	U	2.6E+0	4.4E+5	2.7E+4	5.4E+2						1.3E+4					2.5E+4		7.9E+4				
TAN-2	U	4.0E+0	5.0E+5	3.0E+4	6.4E+2						1.3E+4					2.4E+4		7.9E+4				
TAN-3	U			3.5E+4		1.5E+2					1.7E+4	1.3E+1	1.8E+2	6.0E+0	9.6E-1	6.4E+4	9.3E+2	1.0E+5	1.0E+3			
TAN-4	U			3.2E+4		1.1E+2					9.4E+3	1.0E+1	1.2E+2	3.3E+0	9.7E-2	2.2E+4	6.1E+2	7.2E+4	6.2E+2			
TAN-5	U			2.6E+4		1.3E+2					1.1E+4	1.0E+1	1.3E+2	3.4E+0	9.0E-2	4.6E+4	7.2E+2	8.0E+4	7.7E+2			
TAN-6	U			3.3E+4		1.6E+2					1.5E+4	1.3E+1	1.6E+2	4.6E+0	8.5E-2	5.8E+4	9.1E+2	1.0E+5	7.9E+2			
TAN-7	U			3.1E+4		1.3E+2					1.2E+4	1.1E+1	1.4E+2	3.7E+0	1.3E-1	4.8E+4	7.5E+2	8.6E+4	5.9E+2			
TAN-8	U			2.9E+4		1.6E+2					1.4E+4	1.2E+1	1.6E+2	4.2E+0	2.0E-1	3.1E+4	8.4E+2	1.0E+5	7.1E+2			
TAN-9	U			3.3E+4		1.3E+2					1.2E+4	1.1E+1	1.4E+2	4.1E+0	1.1E-1	2.7E+4	7.4E+2	8.7E+4	6.3E+2			
TAN-10	U			8.9E+4		1.0E+2	5.7E+0	1.1E+3	5.2E+1		6.6E+3	2.1E+1	1.4E+2	2.2E+0	4.3E-2	2.4E+4	6.5E+2	8.1E+4	6.2E+2			
TAN-11	U			1.0E+5		1.3E+2	6.7E+0	1.3E+3	5.7E+1		7.4E+3	2.3E+1	1.6E+2	2.7E+0	6.8E-2	2.8E+4	7.3E+2	9.1E+4	5.7E+2			
TAN-11	U			7.9E+4		1.1E+2	6.1E+0	1.2E+3	5.0E+1		6.7E+3	1.7E+1	1.3E+2	2.9E+0	9.6E-2	2.5E+4	6.4E+2	8.0E+4	6.3E+2			
TAN-16	U	1.1E+1	1.1E+6	6.4E+4	2.3E+3		1.4E+1	4.6E+3	1.1E+2		1.4E+4		1.8E+2		1.3E+0	6.1E+4	9.1E+2	1.1E+5	1.2E+3		1.2E+3	1.4E+5
TAN-17	U	6.0E+0	1.2E+6	7.3E+4	1.5E+3		1.3E+1	2.7E+3	1.1E+2	1.6E-1	1.5E+4		2.0E+2			3.7E+4	9.3E+2	1.1E+5	1.3E+3		1.2E+3	1.4E+5
TAN-18	U	2.8E+0	1.7E+6	1.0E+5	1.8E+3		6.8E+0	1.3E+3	5.7E+1	1.3E-1	7.4E+3		1.5E+2			2.9E+4	7.5E+2	9.1E+4	1.0E+3		1.0E+3	1.3E+5
TAN-19	U	8.7E+0	4.3E+5	2.6E+4	1.2E+3		8.3E+0	2.9E+3	7.1E+1	1.0E-1	9.4E+3		1.1E+2			4.2E+4	5.8E+2	6.8E+4	1.4E+3			
TANB-1	U	6.6E+0	9.2E+5	5.6E+4	1.2E+3		8.6E+0	1.7E+3	8.0E+1	1.2E-1	1.1E+4		1.5E+2			2.8E+4	7.8E+2	9.3E+4	1.2E+3			
USA-1	U			1.6E+3		6.2E+1					1.2E+4	2.4E+0	1.0E+2	4.0E+0	3.0E-1	7.0E+5	1.6E+3	5.8E+4	1.9E+2			
USA-2	U			3.0E+3		5.9E+1					1.1E+4	2.3E+0	9.6E+1	3.5E+0	1.9E-1	6.0E+5	1.4E+3	5.4E+4	2.2E+2			
USA-3	U			2.0E+3		6.2E+1					1.1E+4	2.7E+0	1.0E+2	4.1E+0	3.0E-1	8.5E+5	1.9E+3	5.7E+4	2.5E+2			
USA-4	U			1.7E+3		6.5E+1					1.1E+4	2.4E+0	9.5E+1	2.8E+0	4.0E-1	7.3E+5	1.6E+3	5.5E+4	2.0E+2			
USA-5	U			1.9E+3		6.3E+1					1.2E+4	2.6E+0	1.0E+2	4.0E+0	2.7E-1	7.1E+5	1.7E+3	5.8E+4	2.2E+2			
USA-6	U			1.5E+3		5.4E+1					1.1E+4	2.0E+0	9.8E+1	4.3E+0	3.9E-1	7.2E+5	1.7E+3	5.4E+4	1.9E+2			
USA-7	U	7.7E-1	2.9E+4	1.5E+3	8.7E+2						1.1E+4					5.2E+5		5.3E+4				
USA-8	U	3.1E-1	2.7E+4	1.4E+3	9.2E+2						1.0E+4					5.5E+5		5.0E+4				

Fis: fischer, Kao: kaolinite, Mus: muscovite
Nod: nodule, BN: brown nodule, RN: red nodule, YN: yellow nodule
Prm: primitive iron mineral, Qz: quartz, U: uraninite

Appendix 3 Lead and uranium isotopic data of every mineral and sample with SHRIMP

Sample	Anal.	cps								Pb	U	isotope ratio (/Pb-206)		activity ratio (U-234/U-238)		Th-230/U-234
ID	Min.	Pb-204	Pb-206	Pb-207	Th-230	U-234	U-235	UO-250	UO-251	206+207	234+235	Pb-204	Pb-207	metal	oxide	metal
D58-21	Fis	8.8E+1	1.1E+4	2.2E+3	2.9E-1	1.5E+0	1.3E+2	4.2E+1	6.9E+2	1.3E+4	1.3E+2	0.0080	0.2000	1.5232	8.0352	0.6297
D60-33	Fis			1.3E+2	6.1E-1	2.0E+0	2.7E+2	1.1E+2	1.7E+3	1.3E+2	2.7E+2			0.9778	8.5416	0.9934
D60-35	Fis			2.5E+3	9.2E-2	5.2E-1	5.9E+1	2.0E+1	7.2E+2	2.5E+3	6.0E+1			1.1635	3.6669	0.5762
D87-21	Fis	4.1E+0	2.4E+2	7.1E+1	1.3E-1	1.1E-1	7.9E+0	1.6E+0	1.3E+2	3.1E+2	8.0E+0	0.0171	0.2958	1.8381	1.6247	3.8492
D58-4	Kao	9.4E+1	2.1E+3	1.4E+3	3.3E-1	1.2E+0	1.3E+2	2.2E+1	3.7E+2	3.5E+3	1.3E+2	0.0448	0.6667	1.2185	7.8491	0.8957
D58-6	Kao	6.1E+1	1.8E+3	9.7E+2	1.9E-1	1.2E+0	1.3E+2	7.7E+0	3.5E+2	2.8E+3	1.3E+2	0.0339	0.5389	1.2185	2.9042	0.5157
D58-7	Kao	7.7E+1	2.0E+3	1.3E+3	3.4E-1	8.8E-1	7.0E+1	5.8E+0	2.3E+2	3.3E+3	7.1E+1	0.0385	0.6500	1.6595	3.3289	1.2584
D58-17	Kao	3.3E+1	7.9E+2	5.2E+2	2.1E-1	1.0E+0	8.9E+1	5.3E+0	2.6E+2	1.3E+3	9.0E+1	0.0418	0.6582	1.4832	2.6909	0.6840
D58-23	Kao	7.1E+1	1.5E+3	1.1E+3	1.8E-1	5.2E-1	4.4E+1	6.3E+0	1.2E+2	2.6E+3	4.5E+1	0.0473	0.7333	1.5601	6.9304	1.1274
D58-24	Kao	3.0E+2	7.4E+3	4.7E+3	3.7E-1	2.1E+0	2.3E+2	1.0E+2	8.2E+2	1.2E+4	2.3E+2	0.0405	0.6351	1.2053	16.0984	0.5739
D58-25	Kao	1.2E+2	4.1E+3	2.0E+3	4.9E-1	2.4E+0	2.8E+2	8.2E+1	9.9E+2	6.1E+3	2.8E+2	0.0293	0.4878	1.1315	10.9339	0.6650
D60-7	Kao						1.1E+2	1.9E+1	3.9E+2	0.0E+0	1.1E+2				6.4311	
D60-8	Kao						2.0E+2	1.4E+2	5.8E+2	0.0E+0	2.0E+2				31.8638	
D60-9	Kao						1.7E+2	1.4E+2	9.9E+2	0.0E+0	1.7E+2				18.6677	
D60-16	Kao						1.1E+2	4.5E+1	4.5E+2	0.0E+0	1.1E+2				13.2007	
D60-23	Kao			7.0E+2	5.4E-1	1.4E+0	1.1E+2	1.1E+1	3.9E+2	7.0E+2	1.1E+2			1.6801	3.7233	1.2563
D60-24	Kao			6.1E+2	2.9E-1	1.6E+0	1.1E+2	1.0E+1	3.4E+2	6.1E+2	1.1E+2			1.9201	3.8826	0.5903
D60-25	Kao			8.1E+2	5.4E-1	1.9E+0	2.0E+2	8.9E+1	9.3E+2	8.1E+2	2.0E+2			1.2541	12.6329	0.9257
D60-26	Kao			3.0E+2	2.5E-1	1.2E+0	9.9E+1	2.2E+1	3.1E+2	3.0E+2	1.0E+2			1.6001	9.3682	0.6785
D60-27	Kao			3.5E+2	4.9E-1	2.2E+0	2.0E+2	8.7E+1	6.3E+2	3.5E+2	2.0E+2			1.4521	18.2295	0.7254
D60-28	Kao			6.7E+2	3.8E-1	1.9E+0	1.9E+2	3.4E+1	5.7E+2	6.7E+2	1.9E+2			1.3201	7.8741	0.6514
D60-29	Kao			9.0E+2	6.1E-1	1.8E+0	1.8E+2	3.9E+1	6.9E+2	9.0E+2	1.8E+2			1.3201	7.4613	1.1038
D60-31	Kao			4.2E+2	4.1E-1	2.0E+0	2.5E+2	1.5E+2	5.0E+2	4.2E+2	2.5E+2			1.0561	39.6021	0.6677
D60-32	Kao			1.0E+3	4.3E-1	3.5E+0	3.7E+2	1.1E+2	9.3E+2	1.0E+3	3.7E+2			1.2487	15.6137	0.4001
D60-34	Kao			1.1E+3	5.8E-1	3.2E+0	3.5E+2	1.4E+2	1.1E+3	1.1E+3	3.5E+2			1.2069	16.8009	0.5903
D60-36	Kao			4.0E+2	3.1E-1	1.6E+0	1.2E+2	9.1E+0	4.1E+2	4.0E+2	1.2E+2			1.7601	2.9299	0.6310
D60-37	Kao			7.2E+2	2.8E-1	1.6E+0	1.2E+2	2.8E+1	4.6E+2	7.2E+2	1.2E+2			1.7601	8.0352	0.5700
D60-39	Kao	6.9E+1	1.3E+3	1.1E+3	3.2E-1	1.1E+0	7.9E+1	2.5E+1	3.9E+2	2.4E+3	8.0E+1	0.0531	0.8462	1.8381	8.4620	0.9475
D60-39b	Kao	1.1E+2	2.0E+3	1.8E+3	9.5E-1	2.3E+0	1.9E+2	4.6E+1	9.0E+2	3.8E+3	1.9E+2	0.0550	0.9000	1.5980	6.7470	1.3453
D60-40	Kao	1.1E+2	2.0E+3	1.6E+3	3.8E-1	1.1E+0	7.9E+1	1.3E+1	4.4E+2	3.6E+3	8.0E+1	0.0550	0.8000	1.8381	3.9002	1.1251
D60-40b	Kao	1.5E+2	2.8E+3	2.3E+3	4.3E-1	2.4E+0	2.1E+2	4.4E+1	1.1E+3	5.1E+3	2.1E+2	0.0536	0.8214	1.5087	5.2803	0.5835
D60-41	Kao	9.1E+1	2.1E+3	1.4E+3	7.1E-1	2.9E+0	2.8E+2	1.2E+2	1.3E+3	3.5E+3	2.8E+2	0.0433	0.6667	1.3672	12.1853	0.7974
D60-43	Kao	3.7E+1	6.7E+2	5.5E+2	3.9E-1	1.7E+0	1.7E+2	2.7E+1	4.9E+2	1.2E+3	1.7E+2	0.0552	0.8209	1.3201	7.2739	0.7472
D60-44	Kao	6.0E+1	1.1E+3	9.6E+2	8.8E-1	4.2E+0	5.1E+2	3.7E+2	1.4E+3	2.1E+3	5.1E+2	0.0545	0.8727	1.0871	34.8876	0.6824
D60-45	Kao	3.9E+1	7.1E+2	5.7E+2	8.6E-1	3.6E+0	3.5E+2	8.3E+1	1.3E+3	1.3E+3	3.5E+2	0.0549	0.8028	1.3578	8.4281	0.7781
D60-46	Kao	1.4E+2	2.7E+3	2.1E+3	8.0E-1	3.1E+0	2.7E+2	4.0E+1	1.3E+3	4.8E+3	2.7E+2	0.0519	0.7778	1.5156	4.0618	0.8405
D60-47	Kao	1.2E+2	2.8E+3	1.9E+3	8.9E-1	4.0E+0	4.4E+2	1.4E+2	2.6E+3	4.7E+3	4.4E+2	0.0429	0.6786	1.2001	7.1081	0.7247
D60-51	Kao	5.2E+1	9.4E+2	8.0E+2	7.4E-1	3.9E+0	3.9E+2	1.7E+2	1.1E+3	1.7E+3	3.9E+2	0.0553	0.8511	1.3201	20.4011	0.6180

Sample ID	Anal. Min.	cps Pb-204	Pb-206	Pb-207	Th-230	U-234	U-235	UO-250	UO-251	Pb 206+207	U 234+235	isotope ratio (/Pb-206) Pb-204	Pb-207	activity ratio (U-234/U-238) metal	oxide	Th-230/U-234 metal
D60-57	Kao	2.2E+1	4.1E+2	3.3E+2	6.3E-1	2.6E+0	2.2E+2	3.0E+1	7.3E+2	7.4E+2	2.2E+2	0.0537	0.8049	1.5601	5.4249	0.7892
D87-5	Kao	6.5E-1	2.5E+1	5.4E+0	3.0E-1	1.2E+0	1.3E+2	4.1E+1	5.1E+2	3.0E+1	1.3E+2	0.0260	0.2160	1.2185	10.6123	0.8143
D87-6	Kao	2.0E-1	5.7E+0	1.9E+0	1.1E-1	8.1E-1	7.9E+1	4.2E+1	2.5E+2	7.6E+0	8.0E+1	0.0351	0.3333	1.3535	22.1772	0.4423
D87-13	Kao	7.0E-1	3.0E+1	1.3E+1	1.8E-1	6.9E-1	7.2E+1	3.1E+1	2.6E+2	4.3E+1	7.3E+1	0.0233	0.4333	1.2651	15.7393	0.8497
D87-16	Kao	1.0E+1	2.0E+2	1.7E+2	1.1E+0	4.3E-1	5.5E+1	5.2E+1	2.1E+2	3.7E+2	5.5E+1	0.0500	0.8500	1.0321	32.6874	8.4076
D87-18	Kao	5.7E-1	8.3E+0	3.9E+0	1.6E-1	3.6E-1	3.5E+1	1.7E+1	1.2E+2	1.2E+1	3.5E+1	0.0687	0.4699	1.3578	18.7010	1.4476
D87-22	Kao	1.8E+1	4.7E+2	3.0E+2	5.0E-1	1.9E+0	2.3E+2	3.5E+2	9.9E+2	7.7E+2	2.3E+2	0.0383	0.6383	1.0905	46.6691	0.8571
D87-24	Kao	3.3E+0	2.8E+2	6.9E+1	1.4E-1	5.8E-1	4.4E+1	4.0E+1	2.5E+2	3.5E+2	4.5E+1	0.0118	0.2464	1.7401	21.1211	0.7862
D87-31	Kao	1.2E+0	3.0E+1	1.7E+1	2.2E-1	6.9E-1	7.7E+1	4.2E+0	2.4E+2	4.7E+1	7.8E+1	0.0400	0.5667	1.1829	2.3101	1.0385
D58-8	Mus	6.4E+1	1.6E+3	1.1E+3	2.2E-1	1.1E+0	8.8E+1	5.3E+0	2.5E+2	2.7E+3	8.9E+1	0.0400	0.6875	1.6501	2.7985	0.6514
D58-16	Mus	1.4E+2	1.8E+4	3.7E+3	6.2E-1	1.6E+0	1.6E+2	1.1E+1	9.0E+2	2.2E+4	1.6E+2	0.0078	0.2056	1.3201	1.6134	1.2621
D58-22	Mus	2.3E+2	1.0E+4	4.1E+3	1.9E-1	7.7E-1	7.2E+1	1.3E+1	3.8E+2	1.4E+4	7.3E+1	0.0230	0.4100	1.4117	4.5160	0.8037
D60-1	Nod						2.3E+2	6.5E+1	1.0E+4	0.0E+0	2.3E+2				0.8580	
D60-1B	Nod						1.9E+2	5.7E+1	8.7E+3	0.0E+0	1.9E+2				0.8649	
D60-2	Nod						1.9E+2	5.3E+1	7.9E+3	0.0E+0	1.9E+2				0.8856	
D60-3	Nod						2.2E+2	5.9E+1	8.2E+3	0.0E+0	2.2E+2				0.9498	
D60-4	Nod						2.8E+2	6.4E+1	8.6E+3	0.0E+0	2.8E+2				0.9824	
D60-5	Nod						3.4E+2	8.3E+1	8.8E+3	0.0E+0	3.4E+2				1.2451	
D60-6	Nod						3.3E+2	6.5E+1	8.9E+3	0.0E+0	3.3E+2				0.9641	
D60-13	Nod						2.8E+2	6.0E+1	8.0E+3	0.0E+0	2.8E+2				0.9901	
D60-14	Nod						8.1E+1	4.0E+1	4.0E+3	0.0E+0	8.1E+1				1.3201	
D60-15	Nod						6.7E+1	2.5E+1	3.5E+3	0.0E+0	6.7E+1				0.9429	
D60-20	Nod			1.2E+2	1.2E-1	6.0E-1	8.8E+1	2.5E+1	4.1E+3	1.2E+2	8.9E+1			0.9000	0.8049	0.6514
D60-21	Nod			8.7E+1	2.2E-1	5.9E-1	8.8E+1	3.0E+1	4.1E+3	8.7E+1	8.9E+1			0.8850	0.9659	1.2145
D60-22	Nod			1.6E+2	2.4E-1	8.0E-1	9.8E+1	3.2E+1	4.5E+3	1.6E+2	9.9E+1			1.0776	0.9387	0.9771
D60-30	Nod			5.5E+1	2.9E-1	1.3E+0	1.6E+2	3.8E+1	5.4E+3	5.5E+1	1.6E+2			1.0726	0.9289	0.7266
D60-38	Nod	1.4E+1	2.8E+2	2.3E+2	3.4E-1	1.1E+0	1.6E+2	4.9E+1	6.8E+3	5.1E+2	1.6E+2	0.0500	0.8214	0.9075	0.9512	1.0067
D60-42	Nod	1.2E+1	2.9E+2	1.7E+2	3.1E-1	1.3E+0	1.7E+2	5.0E+1	7.5E+3	4.6E+2	1.7E+2	0.0414	0.5862	1.0095	0.8800	0.7767
D87-1	Nod	4.8E-1	2.2E+1	1.3E+1	2.4E-1	9.2E-1	1.1E+1	2.9E+1	3.6E+3	3.5E+1	1.2E+1	0.0218	0.5909	11.0406	1.0634	0.8497
D87-2	Nod	5.0E+0	1.1E+2	8.1E+1	1.7E-1	9.1E-1	1.4E+2	6.1E+1	3.3E+3	1.9E+2	1.4E+2	0.0455	0.7364	0.8580	2.4401	0.6085
D87-3	Nod	4.1E-1	2.2E+1	5.8E+0	1.7E-1	9.5E-1	1.4E+2	4.4E+1	3.8E+3	2.8E+1	1.4E+2	0.0186	0.2636	0.8958	1.5285	0.5828
D87-4	Nod	8.5E-1	2.6E+1	9.1E+0	3.4E-1	8.4E-1	1.0E+2	3.0E+1	3.7E+3	3.5E+1	1.0E+2	0.0327	0.3500	1.1089	1.0703	1.3183
D87-7	Nod	6.3E-1	7.5E+1	1.3E+1	4.9E-1	1.3E+0	1.8E+2	1.2E+2	3.5E+3	8.8E+1	1.8E+2	0.0084	0.1733	0.9534	4.5260	1.2276
D87-9	Nod	1.3E+0	3.8E+1	1.8E+1	2.3E-1	6.1E-1	7.4E+1	2.2E+1	2.8E+3	5.6E+1	7.5E+1	0.0342	0.4737	1.0882	1.0372	1.2280
D58-2	BN	2.8E+1	6.6E+3	9.9E+2	5.2E-1	3.9E+0	4.5E+2	6.0E+1	2.8E+3	7.6E+3	4.5E+2	0.0042	0.1500	1.1441	2.8287	0.4343
D58-9	BN	3.5E+1	4.3E+4	4.3E+3	9.3E-1	4.4E+0	5.5E+2	9.7E+1	1.2E+4	4.7E+4	5.5E+2	0.0008	0.1000	1.0561	1.0671	0.6884
D58-13	BN	2.1E+1	3.7E+4	3.6E+3	1.5E+0	5.2E+0	6.0E+2	1.0E+2	1.1E+4	4.1E+4	6.1E+2	0.0006	0.0973	1.1441	1.2001	0.9395
D58-14	BN	3.7E+1	3.3E+4	3.5E+3	8.7E-1	3.4E+0	3.8E+2	8.0E+1	8.7E+3	3.7E+4	3.8E+2	0.0011	0.1061	1.1811	1.2139	0.8334
D60-50	BN	2.2E+1	4.7E+2	3.8E+2	5.9E-1	1.8E+0	2.3E+2	6.4E+1	9.4E+3	8.5E+2	2.3E+2	0.0468	0.8085	1.0331	0.8988	1.0676
D87-23	BN	6.9E+0	1.5E+2	1.0E+2	1.4E-1	3.8E-1	4.3E+1	2.0E+1	3.9E+2	2.5E+2	4.3E+1	0.0460	0.6667	1.1666	6.7696	1.1999

Sample ID	Anal. Min.	cps Pb-204	cps Pb-206	cps Pb-207	cps Th-230	cps U-234	cps U-235	cps UO-250	cps UO-251	Pb 206+207	U 234+235	isotope ratio (/Pb-206) Pb-204	isotope ratio (/Pb-206) Pb-207	activity ratio (U-234/U-238) metal	activity ratio (U-234/U-238) oxide	Th-230/U-234 metal
D58-3	RN	1.9E+1	1.4E+4	1.5E+3	4.6E-1	1.5E+0	1.8E+2	2.3E+1	2.0E+3	1.6E+4	1.8E+2	0.0014	0.1071	1.1001	1.5181	0.9988
D58-10	RN	3.6E+1	1.0E+5	9.6E+3	6.9E-1	3.0E+0	3.0E+2	4.9E+1	3.2E+3	1.1E+5	3.0E+2	0.0004	0.0960	1.3201	2.0214	0.7491
D58-11	RN	2.8E+1	8.5E+4	7.9E+3	5.3E-1	1.9E+0	2.1E+2	4.8E+1	4.6E+3	9.3E+4	2.1E+2	0.0003	0.0929	1.1943	1.3775	0.9085
D58-1	YN	7.9E+0	1.9E+4	1.8E+3	7.2E-1	2.9E+0	3.6E+2	7.0E+1	8.9E+3	2.1E+4	3.6E+2	0.0004	0.0947	1.0634	1.0383	0.8086
D58-5	YN	5.2E+0	2.6E+4	2.4E+3	7.5E-1	2.9E+0	3.9E+2	7.6E+1	1.0E+4	2.8E+4	3.9E+2	0.0002	0.0923	0.9816	1.0033	0.8423
D58-15	YN	2.8E+1	3.7E+4	3.7E+3	8.3E-1	3.8E+0	4.9E+2	9.7E+1	1.1E+4	4.1E+4	4.9E+2	0.0007	0.0995	1.0327	1.1397	0.7053
D58-18	YN	6.0E+1	4.8E+4	5.1E+3	3.3E-1	1.2E+0	1.4E+2	5.2E+1	4.8E+3	5.3E+4	1.4E+2	0.0013	0.1063	1.1315	1.4301	0.8957
D58-20	YN	1.8E+1	4.6E+4	4.3E+3	3.2E-1	1.4E+0	1.5E+2	5.2E+1	6.6E+3	5.0E+4	1.5E+2	0.0004	0.0935	1.2321	1.0401	0.7445
D60-48	YN	4.5E+1	9.3E+2	7.7E+2	8.7E-1	3.3E+0	5.0E+2	9.0E+1	1.3E+4	1.7E+3	5.0E+2	0.0484	0.8280	0.8712	0.9139	0.8587
D60-49	YN	2.5E+1	5.2E+2	4.2E+2	7.2E-1	3.2E+0	4.7E+2	9.6E+1	1.3E+4	9.4E+2	4.7E+2	0.0481	0.8077	0.8988	0.9748	0.7328
D60-52	YN	7.6E+0	1.8E+2	1.3E+2	5.2E-1	1.4E+0	2.0E+2	4.3E+1	6.3E+3	3.1E+2	2.0E+2	0.0422	0.7222	0.9240	0.9010	1.2097
D60-53	YN	5.9E+0	1.1E+2	9.4E+1	1.7E-1	1.0E+0	1.6E+2	1.9E+1	2.5E+3	2.0E+2	1.6E+2	0.0536	0.8545	0.8250	1.0033	0.5537
D60-54	YN	3.4E+1	6.7E+2	5.5E+2	7.5E-1	3.8E+0	5.9E+2	8.6E+1	1.2E+4	1.2E+3	5.9E+2	0.0507	0.8209	0.8502	0.9461	0.6428
D60-55A	YN	1.0E+1	2.4E+2	1.7E+2	3.9E-1	1.4E+0	2.0E+2	4.8E+1	6.6E+3	4.1E+2	2.0E+2	0.0417	0.7083	0.9240	0.9601	0.9073
D60-56	YN	7.9E+0	2.0E+2	1.3E+2	4.1E-1	1.3E+0	1.8E+2	4.8E+1	6.5E+3	3.3E+2	1.8E+2	0.0395	0.6500	0.9534	0.9748	1.0272
D60-63	YN	2.3E+1	5.0E+2	3.8E+2	8.1E-1	2.6E+0	3.9E+2	7.8E+1	1.2E+4	8.8E+2	3.9E+2	0.0460	0.7600	0.8800	0.8580	1.0147
D60-64	YN	3.0E+1	6.9E+2	5.6E+2	8.3E-1	2.7E+0	4.1E+2	8.4E+1	1.2E+4	1.3E+3	4.1E+2	0.0435	0.8116	0.8693	0.9240	1.0012
D87-17	YN	4.4E-1	1.9E+1	6.9E+0	2.7E-1	2.7E-1	3.6E+1	1.3E+1	1.5E+3	2.6E+1	3.6E+1	0.0232	0.3632	0.9901	1.1441	3.1967
D87-19	YN	4.4E-1	2.0E+1	9.8E+0	1.2E-1	4.4E-1	6.2E+1	1.6E+1	2.0E+3	3.0E+1	6.2E+1	0.0220	0.4900	0.9368	1.0561	0.8883
D87-26	YN	4.9E-1	4.1E+1	1.5E+1	4.3E-1	1.8E+0	2.3E+2	7.5E+1	3.8E+3	5.6E+1	2.3E+2	0.0120	0.3659	1.0331	2.6054	0.7781
D60-58	Prm	2.8E+1	8.0E+2	4.4E+2	7.5E-1	3.3E+0	4.4E+2	3.0E+2	2.5E+3	1.2E+3	4.4E+2	0.0350	0.5500	0.9901	15.8408	0.7402
D60-59	Prm	8.0E+0	3.1E+2	1.4E+2	8.2E-1	3.3E+0	4.0E+2	3.1E+2	2.2E+3	4.5E+2	4.0E+2	0.0258	0.4516	1.0891	18.6010	0.8093
D60-60	Prm	1.1E+2	1.4E+4	2.9E+3	3.4E-1	8.9E-1	7.7E+1	1.6E+1	8.1E+2	1.7E+4	7.8E+1	0.0079	0.2071	1.5258	2.6075	1.2442
D60-61	Prm	1.0E+2	3.9E+4	5.6E+3	2.1E-1	1.0E+0	8.3E+1	4.0E+1	1.0E+3	4.5E+4	8.4E+1	0.0026	0.1436	1.5904	5.2803	0.6840
D60-62	Prm	1.3E+1	1.1E+3	3.3E+2	7.1E-1	3.3E+0	3.9E+2	1.2E+2	2.7E+3	1.4E+3	3.9E+2	0.0118	0.3000	1.1170	5.8670	0.7007
D87-25	Prm	1.0E+1	6.4E+2	1.8E+2	1.3E-1	8.0E-2	4.7E+0	7.7E-1	5.7E+1	8.2E+2	4.8E+0	0.0156	0.2813	2.2469	1.7833	5.2926
D87-27	Prm	1.6E+0	4.6E+1	2.5E+1	1.9E-1	9.4E-1	1.1E+2	2.2E+1	6.1E+2	7.1E+1	1.1E+2	0.0348	0.5435	1.1281	4.7609	0.6583
D87-28	Prm	1.2E+0	7.6E+1	2.2E+1	2.9E-1	8.1E-1	1.0E+2	1.7E+1	5.9E+2	9.8E+1	1.0E+2	0.0158	0.2895	1.0693	3.8036	1.1661
D87-29	Prm	2.5E+0	6.4E+1	3.7E+1	2.2E-1	5.1E-1	6.7E+1	1.1E+1	3.8E+2	1.0E+2	6.8E+1	0.0391	0.5781	1.0048	3.8213	1.4050
D87-30	Prm	4.1E+1	7.6E+2	6.8E+2	2.8E-1	7.7E-1	1.1E+2	1.9E+1	3.1E+2	1.4E+3	1.1E+2	0.0539	0.8947	0.9240	8.0908	1.1844
D58-12	Qz	9.3E-1	1.5E+1	1.1E+1	5.9E-2	6.6E-2	2.9E-1	1.3E-1	9.2E-1	2.6E+1	3.6E-1	0.0620	0.7333	30.0430	18.6532	2.9116
D58-19	Qz	5.8E-1	6.4E+0	5.5E+0	1.5E-1	5.2E-2	5.9E-1	8.8E-1	2.7E-1	1.2E+1	6.4E-1	0.0906	0.8594	11.6345	430.2450	9.2699
D60-10	Qz						2.5E+1	2.5E+1	1.1E+2	0.0E+0	2.5E+1				30.0016	
D87-8	TiO2	3.6E+1	2.7E+3	7.6E+2	1.8E-1	5.8E-2	2.5E+0	6.8E-1	4.8E+1	3.5E+3	2.6E+0	0.0133	0.2815	3.0626	1.8701	10.1079
D87-10	TiO2	6.2E+0	2.4E+3	3.4E+2	1.2E-1	5.9E-2	1.1E+0	3.2E+0	1.9E+1	2.7E+3	1.2E+0	0.0026	0.1417	7.0804	22.2328	6.6244
D87-11	TiO2	8.7E-1	3.6E+2	5.2E+1	3.6E-2	6.0E-2	4.0E-1	1.6E-1	3.3E+0	4.1E+2	4.6E-1	0.0024	0.1444	19.8011	6.4003	1.9542
D87-12	TiO2	3.5E+0	9.9E+3	1.1E+3	4.7E-2	5.0E-2	2.8E+0	1.2E+1	6.3E+1	1.1E+4	2.9E+0	0.0004	0.1111	2.3573	25.1442	3.0616
D87-14	TiO2	1.5E+0	2.1E+3	2.4E+2	5.5E-2	6.0E-2	6.0E-1	1.3E-1	1.7E+1	2.3E+3	6.6E-1	0.0007	0.1143	13.2007	1.0095	2.9856
D87-15	TiO2	2.4E+0	3.7E+2	7.4E+1	7.1E-2	5.3E-2	9.4E-2	5.2E-1	2.8E+0	4.4E+2	1.5E-1	0.0065	0.2000	74.4295	24.5156	4.3632
D58b-1	U						5.9E+3	4.9E+2	6.2E+4	0.0E+0	5.9E+3				1.0433	

Sample	Anal.	cps								Pb	U	isotope ratio (/Pb-206)		activity ratio (U-234/U-238)		Th-230/U-234
ID	Min.	Pb-204	Pb-206	Pb-207	Th-230	U-234	U-235	UO-250	UO-251	206+207	234+235	Pb-204	Pb-207	metal	oxide	metal
D58b-1B	U						5.7E+3	4.8E+2	6.0E+4	0.0E+0	5.7E+3				1.0561	
D58b-2	U						5.7E+3	5.0E+2	6.3E+4	0.0E+0	5.7E+3				1.0477	
D58b-2B	U						5.6E+3	4.8E+2	6.3E+4	0.0E+0	5.6E+3				1.0058	
D58b-3	U						4.3E+3	6.1E+2	7.8E+4	0.0E+0	4.3E+3				1.0324	
D58b-4	U						4.4E+3	6.2E+2	7.9E+4	0.0E+0	4.4E+3				1.0360	
D58b-5	U						7.8E+3	1.2E+3	1.6E+5	0.0E+0	7.8E+3				0.9901	
TAN-1	U	2.6E+0	4.4E+5	2.7E+4			1.3E+4		7.9E+4	4.7E+5	1.3E+4	0.0000	0.0614			
TAN-2	U	4.0E+0	5.0E+5	3.0E+4			1.3E+4		7.9E+4	5.3E+5	1.3E+4	0.0000	0.0600			
TAN-3	U			3.5E+4			1.7E+4	9.3E+2	1.0E+5	3.5E+4	1.7E+4				1.2277	
TAN-4	U			3.2E+4			9.4E+3	6.1E+2	7.2E+4	3.2E+4	9.4E+3				1.1184	
TAN-5	U			2.6E+4			1.1E+4	7.2E+2	8.0E+4	2.6E+4	1.1E+4				1.1881	
TAN-6	U			3.3E+4			1.5E+4	9.1E+2	1.0E+5	3.3E+4	1.5E+4				1.2013	
TAN-7	U			3.1E+4			1.2E+4	7.5E+2	8.6E+4	3.1E+4	1.2E+4				1.1512	
TAN-8	U			2.9E+4			1.4E+4	8.4E+2	1.0E+5	2.9E+4	1.4E+4				1.1089	
TAN-9	U			3.3E+4			1.2E+4	7.4E+2	8.7E+4	3.3E+4	1.2E+4				1.1228	
TAN-10	U			8.9E+4	5.7E+0	5.2E+1	6.6E+3	6.5E+2	8.1E+4	8.9E+4	6.7E+3			1.0401	1.0593	0.3570
TAN-11	U			1.0E+5	6.7E+0	5.7E+1	7.4E+3	7.3E+2	9.1E+4	1.0E+5	7.5E+3			1.0168	1.0590	0.3828
TAN-11	U			7.9E+4	6.1E+0	5.0E+1	6.7E+3	6.4E+2	8.0E+4	7.9E+4	6.8E+3			0.9851	1.0561	0.3974
TAN-16	U	1.1E+1	1.1E+6	6.4E+4	1.4E+1	1.1E+2	1.4E+4	9.1E+2	1.1E+5	1.2E+6	1.4E+4	0.0000	0.0582	1.0372	1.0921	0.4145
TAN-17	U	6.0E+0	1.2E+6	7.3E+4	1.3E+1	1.1E+2	1.5E+4	9.3E+2	1.1E+5	1.3E+6	1.5E+4	0.0000	0.0608	0.9681	1.1161	0.3849
TAN-18	U	2.8E+0	1.7E+6	1.0E+5	6.8E+0	5.7E+1	7.4E+3	7.5E+2	9.1E+4	1.8E+6	7.5E+3	0.0000	0.0588	1.0168	1.0880	0.3886
TAN-19	U	8.7E+0	4.3E+5	2.6E+4	8.3E+0	7.1E+1	9.4E+3	5.8E+2	6.8E+4	4.6E+5	9.5E+3	0.0000	0.0605	0.9971	1.1259	0.3807
TANB-1	U	6.6E+0	9.2E+5	5.6E+4	8.6E+0	8.0E+1	1.1E+4	7.8E+2	9.3E+4	9.8E+5	1.1E+4	0.0000	0.0609	0.9601	1.1072	0.3501
USA-1	U			1.6E+3			1.2E+4	1.6E+3	5.8E+4	1.6E+3	1.2E+4				3.6416	
USA-2	U			3.0E+3			1.1E+4	1.4E+3	5.4E+4	3.0E+3	1.1E+4				3.4224	
USA-3	U			2.0E+3			1.1E+4	1.9E+3	5.7E+4	2.0E+3	1.1E+4				4.4002	
USA-4	U			1.7E+3			1.1E+4	1.6E+3	5.5E+4	1.7E+3	1.1E+4				3.8402	
USA-5	U			1.9E+3			1.2E+4	1.7E+3	5.8E+4	1.9E+3	1.2E+4				3.8692	
USA-6	U			1.5E+3			1.1E+4	1.7E+3	5.4E+4	1.5E+3	1.1E+4				4.1558	
USA-7	U	7.7E-1	2.9E+4	1.5E+3			1.1E+4		5.3E+4	3.1E+4	1.1E+4	0.0000	0.0517			
USA-8	U	3.1E-1	2.7E+4	1.4E+3			1.0E+4		5.0E+4	2.8E+4	1.0E+4	0.0000	0.0519			

Fis: fischer, Kao: kaolinite, Mus: muscovite
Nod: nodule, BN: brown nodule, RN: red nodule, YN: yellow nodule
Prm: primitive iron mineral, Qz: quartz, U: uraninite

国際単位系（SI）と換算表

表1　SI基本単位および補助単位

量	名　称	記　号
長　　さ	メートル	m
質　　量	キログラム	kg
時　　間	秒	s
電　　流	アンペア	A
熱力学温度	ケルビン	K
物　質　量	モル	mol
光　　度	カンデラ	cd
平　面　角	ラジアン	rad
立　体　角	ステラジアン	sr

表3　固有の名称をもつSI組立単位

量	名　称	記号	他のSI単位による表現
周　波　数	ヘルツ	Hz	s^{-1}
力	ニュートン	N	$m \cdot kg/s^2$
圧力，応力	パスカル	Pa	N/m^2
エネルギー,仕事,熱量	ジュール	J	$N \cdot m$
工率，放射束	ワット	W	J/s
電気量，電荷	クーロン	C	$A \cdot s$
電位，電圧，起電力	ボルト	V	W/A
静　電　容　量	ファラド	F	C/V
電　気　抵　抗	オーム	Ω	V/A
コンダクタンス	ジーメンス	S	A/V
磁　　束	ウェーバ	Wb	$V \cdot s$
磁　束　密　度	テスラ	T	Wb/m^2
インダクタンス	ヘンリー	H	Wb/A
セルシウス温度	セルシウス度	℃	
光　　束	ルーメン	lm	$cd \cdot sr$
照　　度	ルクス	lx	lm/m^2
放　射　能	ベクレル	Bq	s^{-1}
吸　収　線　量	グレイ	Gy	J/kg
線　量　等　量	シーベルト	Sv	J/kg

表2　SIと併用される単位

名　称	記　号
分，時，日	min，h，d
度，分，秒	°，′，″
リットル	l，L
トン	t
電子ボルト	eV
原子質量単位	u

$1\ eV = 1.60218 \times 10^{-19} J$

$1\ u = 1.66054 \times 10^{-27} kg$

表4　SIと共に暫定的に維持される単位

名　称	記　号
オングストローム	Å
バーン	b
バール	bar
ガル	Gal
キュリー	Ci
レントゲン	R
ラド	rad
レム	rem

$1\ Å = 0.1 nm = 10^{-10} m$

$1\ b = 100 fm^2 = 10^{-28} m^2$

$1\ bar = 0.1 MPa = 10^5 Pa$

$1\ Gal = 1 cm/s^2 = 10^{-2} m/s^2$

$1\ Ci = 3.7 \times 10^{10} Bq$

$1\ R = 2.58 \times 10^{-4} C/kg$

$1\ rad = 1 cGy = 10^{-2} Gy$

$1\ rem = 1 cSv = 10^{-2} Sv$

表5　SI接頭語

倍数	接頭語	記　号
10^{18}	エクサ	E
10^{15}	ペタ	P
10^{12}	テラ	T
10^{9}	ギガ	G
10^{6}	メガ	M
10^{3}	キロ	k
10^{2}	ヘクト	h
10^{1}	デカ	da
10^{-1}	デシ	d
10^{-2}	センチ	c
10^{-3}	ミリ	m
10^{-6}	マイクロ	μ
10^{-9}	ナノ	n
10^{-12}	ピコ	p
10^{-15}	フェムト	f
10^{-18}	アト	a

（注）

1．表1－5は「国際単位系」第5版，国際度量衡局1985年刊行による。ただし，1 eVおよび1 uの値はCODATAの1986年推奨値によった。
2．表4には海里，ノット，アール，ヘクタールも含まれているが日常の単位なのでここでは省略した。
3．barは，JISでは流体の圧力を表わす場合に限り表2のカテゴリーに分類されている。
4．EC閣僚理事会指令ではbar，barnおよび「血圧の単位」mmHgを表2のカテゴリーに入れている。

換　　算　　表

力	$N(=10^5 dyn)$	kgf	lbf
	1	0.101972	0.224809
	9.80665	1	2.20462
	4.44822	0.453592	1

粘　度　$1 Pa \cdot s(N \cdot s/m^2) = 10 P$（ポアズ）$(g/(cm \cdot s))$

動粘度　$1 m^2/s = 10^4 St$（ストークス）(cm^2/s)

圧力	MPa(=10bar)	kgf/cm^2	atm	mmHg(Torr)	lbf/in^2(psi)
	1	10.1972	9.86923	7.50062×10^3	145.038
	0.0980665	1	0.967841	735.559	14.2233
	0.101325	1.03323	1	760	14.6959
	1.33322×10^{-4}	1.35951×10^{-3}	1.31579×10^{-3}	1	1.93368×10^{-2}
	6.89476×10^{-3}	7.03070×10^{-2}	6.80460×10^{-2}	51.7149	1

エネルギー・仕事・熱量	$J(=10^7 erg)$	$kgf \cdot m$	$kW \cdot h$	cal(計量法)	Btu	$ft \cdot lbf$	eV
	1	0.101972	2.77778×10^{-7}	0.238889	9.47813×10^{-4}	0.737562	6.24150×10^{18}
	9.80665	1	2.72407×10^{-6}	2.34270	9.29487×10^{-3}	7.23301	6.12082×10^{19}
	3.6×10^6	3.67098×10^5	1	8.59999×10^5	3412.13	2.65522×10^6	2.24694×10^{25}
	4.18605	0.426858	1.16279×10^{-6}	1	3.96759×10^{-3}	3.08747	2.61272×10^{19}
	1055.06	107.586	2.93072×10^{-4}	252.042	1	778.172	6.58515×10^{21}
	1.35582	0.138255	3.76616×10^{-7}	0.323890	1.28506×10^{-3}	1	8.46233×10^{18}
	1.60218×10^{-19}	1.63377×10^{-20}	4.45050×10^{-26}	3.82743×10^{-20}	1.51857×10^{-22}	1.18171×10^{-19}	1

1 cal＝4.18605J（計量法）

＝4.184J（熱化学）

＝4.1855J（15℃）

＝4.1868J（国際蒸気表）

仕事率　1 PS（仏馬力）

＝75 $kgf \cdot m/s$

＝735.499W

放射能	Bq	Ci
	1	2.70270×10^{-11}
	3.7×10^{10}	1

吸収線量	Gy	rad
	1	100
	0.01	1

照射線量	C/kg	R
	1	3876
	2.58×10^{-4}	1

線量当量	Sv	rem
	1	100
	0.01	1

（86年12月26日現在）

ANALOGUE STUDIES IN THE ALLIGATOR RIVERS REGION — IN-SITU MEASUREMENT OF URANIUM SERIES NUCLIDES WITH SHRIMP —