U-Th-Pb "Dating": An Example of False "Isochrons"

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Abstract

As with other isochron methods, the U-Pb isochron method has been questioned in the open literature, because often an excellent line of best fit between ratios obtained from a set of good cogenetic samples gives a resultant "isochron" and yields a derived "age" that has no distinct geological meaning. At Koongarra, Australia, U-Th-Pb isotopic studies of uranium ore, host rocks, and soils have produced an array of false "isochrons" that yield "ages" that are geologically meaningless. Even a claimed near-concordant U-Pb "age" of 862 Ma on one uraninite grain is identical to a false Pb-Pb isochron "age," but neither can be connected to any geological event. Open system behavior of the U-Th-Pb system is clearly the norm, as is the resultant mixing of radiogenic Pb with common or background Pb, even in soils in the surrounding region. Because no geologically meaningful results can be interpreted from the U-Th-Pb data at Koongarra (three uraninite grains even yield a $^{232}Th/^{208}Pb$ "age" of 0 Ma), serious questions must be asked about the validity of the fundamental/foundational basis of the U-Th-Pb "dating" method. This makes the task of creationists building their model for the geological record much easier, since claims of U-Th-Pb radiometric "dating" having "proven" the claimed great antiquity of the earth, its strata and fossils can be safely side-stepped.

Keywords

Geochronology, U-Th-Pb Isotopes, Isochrons, Uranium Ore, Soils

Introduction

Radiometric dating has now been used for almost 50 years to establish "beyond doubt" the earth's multi-billion year geological column. Although this column and its "age" was firmly settled well before the advent of radiometric dating, the latter has been successfully used to help quantify the "ages" of the strata and the fossils in the column, so that in many people's minds today radiometric dating has "proved" the presumed antiquity of the earth. Of the various methods, uranium-thorium-lead (U-Th-Pb) was the first used and it is still widely employed today, particularly when zircons are present in the rocks to be dated. But the method does not always give the "expected" results, leading to fundamental questions about its validity.

In his conclusion in a recent paper exposing shortcomings and criticizing the validity of the popular rubidium-strontium (Rb-Sr) isochron method, Zheng (1989, p. 14) wrote:

> … some of the basic assumptions of the conventional Rb-Sr isochron method have to be modified and an observed isochron does not certainly define a valid age information for a geological system, even if a goodness of fit of the experimental data points is obtained in plotting $^{87}Sr/^{86}Sr$ vs. $^{87}Rb/^{86}Sr$. This problem cannot be overlooked, especially in evaluating the numerical timescale. Similar questions can also arise in applying Sm-Nd and U-Pb isochron methods.

Amongst the concerns voiced by Zheng were the problems being found with anomalous isochrons, that is, where there is an apparent linear relationship between $^{87}Sr/^{86}Sr$ and $^{87}Rb/^{86}Sr$ ratios, even an excellent line of best fit between ratios obtained from good cogenetic samples, and yet the resultant isochron and derived "age" have no distinct geological meaning. Zheng documented the copious reporting of this problem in the literature where various names had been given to these anomalous isochrons, such as apparent isochron, mantle isochron and pseudoisochron, secondary isochron, source isochron, erupted isochron, mixing line, and mixing isochron.

Similar anomalous or false isochrons are commonly obtained from U-Th-Pb data, which is hardly surprising given the common open system behavior of the U-Th-Pb system. Yet in the literature these problems are commonly glossed over or pushed aside, but their increasing occurrence from a variety of geological settings does seriously raise the question as to whether U-Th-Pb data ever yields any valid

"age" information. One such geological setting that yields these false U-Th-Pb isochrons is the Koongarra uranium deposit and the surrounding area (Northern Territory, Australia).

The Koongarra Area

The Koongarra area is 250km east of Darwin (Northern Territory, Australia) at latitude 12°52'S and longitude 132°50'E. The regional geology has been described in detail by Needham & Stuart-Smith (1980) and by Needham (1984, 1988), while Snelling (1990) describes the Koongarra uranium deposit and the area's local geology.

The Koongarra uranium deposit occurs in a metamorphic terrain that has an Archean basement consisting of domes of granitoids and granitic gneisses (the Nanambu Complex), the nearest outcrop being 5km to the north. Some of the lowermost overlying Lower Proterozoic metasediments were accreted to these domes during amphibolite grade regional metamorphism (estimated to represent conditions of 5–8kb and 550–630°C) at 1800–1870Ma. Multiple isoclinal recumbent folding accompanied metamorphism. The Lower Proterozoic Cahill Formation flanking the Nanambu Complex has been divided into two members. The lower member is dominated by a thick basal dolomite and passes transitionally upwards into the psammitic upper member, which is largely feldspathic schist and quartzite. The uranium mineralization at Koongarra is associated with graphitic horizons within chloritized quartz-mica (±feldspar ±garnet) schists overlying the basal dolomite in the lower member. A 150Ma period of weathering and erosion followed metamorphism. A thick sequence of essentially flat-lying sandstones (the Middle Proterozoic Kombolgie Formation) was then deposited unconformably on the Archean-Lower Proterozoic basement and metasediments. At Koongarra subsequent reverse faulting has juxtaposed the lower Cahill Formation schists and Kombolgie Formation sandstone.

Owing to the isoclinal recumbent folding of metasedimentary units of the Cahill Formation, the typical rock sequence encountered at Koongarra is probably a tectono-stratigraphy (from youngest to oldest.)

—muscovite-biotite-quartz-feldspar schist (at least 180m thick)
—garnet-muscovite-biotite-quartz schist (90–100m thick)
—sulphide-rich graphite-mica-quartz schist (±garnet) (about 25m thick)
—distinctive graphite-quartz-chlorite schist marker unit (5–8m thick)
—quartz-chlorite schist (±illite, garnet, sillimanite, muscovite) (50m thick)—the mineralized zone
—reverse fault breccia (5–7m thick)
—sandstone of the Kombolgie Formation

Polyphase deformation accompanied metamorphism of the original sediments, that were probably dolomite, shales and siltstones. Johnston (1984) identified a D_2 event as responsible for the dominant S_2 foliation of the schist sequence, which at Koongarra dips at 55° to the south-east. The dominant structural feature, however, is the reverse fault system that dips at about 60° to the south-east, subparallel to the dominant S_2 foliation and lithological boundaries, just below the mineralized zone.

The Uranium Deposit

There are two discrete uranium orebodies at Koongarra, separated by a 100m wide barren zone. The main (No. 1) orebody has a strike length of 450m and persists to 100m depth. Secondary uranium mineralization is present in the weathered schists, from below the surficial sand cover to the base of weathering at depths varying between 25 and 30m. This secondary mineralization has been derived from decomposition and leaching of the primary mineralized zone, and forms a tongue-like fan of ore-grade material dispersed down-slope for about 80m to the south-east. The primary uranium mineralized zone in cross-section is a series of partially coalescing lenses, which together form an elongated wedge dipping at 55° to the south-east within the host quartz-chlorite schist unit, subparallel to the reverse fault. True widths average 30m at the top of the primary mineralized zone but taper out at about 100m below surface and along strike.

Superimposed on the primary prograde metamorphic mineral assemblages of the host schist units is a distinct and extensive primary alteration halo associated, and cogenetic, with the uranium mineralization. This alteration extends for up to 1.5km from the ore in a direction perpendicular to the host quartz-chlorite schist unit, because the mineralization is essentially stratabound. The outer zone of the alteration halo is most extensively developed in the semi-pelitic schists, and is manifested by the pseudomorphous replacement of biotite by chlorite, rutile and quartz, and feldspar by sericite. Silicification has also occurred in fault planes and within the Kombolgie Formation sandstone beneath the mineralization, particularly adjacent to the reverse fault.

Association of this outer halo alteration with the mineralization is demonstrated by the apparent symmetrical distribution of this alteration about the orebody. In the inner alteration zone, less than 50m from ore, the metamorphic rock fabric is disrupted, and quartz is replaced by pervasive chlorite and phengitic mica, and garnet by chlorite. Uranium

mineralization is only present where this alteration has taken place.

The primary ore consists of uraninite veins and veinlets (1–10 mm thick) that cross-cut the S_2 foliation of the brecciated and hydrothermally altered quartz-chlorite schist host. Groups of uraninite veinlets are intimately intergrown with chlorite, which forms the matrix to the host breccias. Small (10–100 μm) euhedral and subhedral uraninite grains are finely disseminated in the chloritic alteration adjacent to veins, but these grains may coalesce to form clusters, strings, and massive uraninite. Coarse colloform and botryoidal uraninite masses and uraninite spherules with internal lacework textures have also been noted, but the bulk of the ore appears to be of the disseminated type, with thin (<0.5 mm) discontinuous wisps and streaks of uraninite, and continuous strings both parallel and discordant to the foliation (S_2), and parallel to phyllosilicate (001) cleavage planes.

Associated with the ore are minor volumes (up to 5%) of sulphides, which include galena and lesser chalcopyrite, bornite, and pyrite, with rare grains of native gold, clausthalite (PbSe), gersdorffite-cobaltite (NiAsS-CoAsS) and mackinawite (Fe, Ni), S. Galena is the most abundant, commonly occurring as cubes (5–10 μm wide) disseminated in uraninite or gangue, and as stringers and veinlets particularly filling thin fractures within uraninite. Galena may also overgrow clausthalite, and replace pyrite and chalcopyrite. Chlorite, predominantly magnesium chlorite, is the principal gangue, and its intimate association with the uraninite indicates that the two minerals formed together.

Oxidation and alteration of uraninite within the primary ore zone has produced a variety of secondary uranium minerals, principally uranyl silicates (Snelling, 1980b). Uraninite veins, even veins over 1 cm wide, have been completely altered in situ. Within the primary ore zone this in situ replacement of uraninite is most pronounced immediately above the reverse fault breccia, and this alteration and oxidation diminish upwards stratigraphically. It is accompanied by hematite staining of the schists, the more intense hematite alteration in and near the reverse fault breccia being due to hematite replacement of chlorite. The secondary mineralization of the dispersion fan in the weathered schist above the No. 1 orebody is characterized by uranyl phosphates found exclusively in the "tail" of the fan. Away from the tail uranium is dispersed in the weathered schists and adsorbed onto clays and iron oxides.

The age of the uranium mineralization is problematical. The mineralization, however, must post-date both the Kombolgie Formation sandstone and the Koongarra reverse fault, since it occupies the breccia zones generated by the post-Kombolgie reverse faulting. The pattern of alteration which is intimately associated with the ore also crosses the reverse fault into the Kombolgie sandstone beneath the ore zone, so this again implies that the ore was formed after the reverse fault and therefore is younger than both the Kombolgie sandstone and the reverse fault. Because of these geological constraints, Page, Compston, & Needham (1980) suggested the mineralization was younger than 1600–1688 Ma because of their determination of the timing of the Kombolgie Formation deposition to that period. Sm-Nd isotopic data obtained on Koongarra uraninites (Maas, 1987, 1989) appears to narrow down the timing of mineralization to 1550–1650 Ma. It is unclear as to when deep ground-water circulation began to cause oxidation and alteration of the primary uraninite ore at depth, but Airey, Golian, & Lever (1986) suggest that the weathering of the primary ore to produce the secondary dispersion fan in the weathered schists above the No. 1 orebody seems to have begun only in the last 1–3 Ma.

U-Th-Pb Data

"Dating" of the Primary Ore

Hills & Richards (1976) isotopically analyzed individual grains of uraninite and galena that had been hand-picked from drill core. Only one of the five uraninite samples gave a near-concordant "age" of 862 Ma, that is, the sample plotted almost on the standard concordia curve, and Hills & Richards (1972) interpreted this as recording fresh formation of Pb-free uraninite at 870 Ma. The other four uraninite samples all lie well below concordia and do not conform to any regular linear array. Hills & Richards were left with two possible interpretations. On the one hand, preferential loss of the intermediate daughter products of ^{238}U (that is, escape of radon, a gas) would cause vertical displacement of points below an episodic-loss line, but this would only produce a significant Pb isotopic effect if the loss had persisted for a very long proportion of the life of the uraninite (which is incidentally not only feasible but likely). Alternatively, they suggested that contamination by small amounts of an older (pre-900 Ma) Pb could cause such a pattern as on their concordia plot, to which they added mixing lines that they postulated arose from the restoration to each uraninite sample of the galena which separated from it.

This of course assumes that the Pb in the galenas was also derived predominantly from uranium decay. They plotted their Pb ratios in all their uraninite samples on a standard $^{207}Pb/^{206}Pb$ diagram, and contended that the pattern of data points did not conform to a simple age interpretation. Instead, they contended that the scatter of points could be contained between two lines radiating from the diagram's

origin, lines that essentially represented isochrons for uraninites and galenas from the Ranger and Nabarlek uranium deposits in the same geological region. From the positions of the Koongarra uraninites and galenas on these diagrams they claimed that the galenas contained left-over radiogenic Pb from earlier uraninites as old as 1700–1800Ma (the "age" of the Ranger uranium mineralization), these earlier uraninites being obliterated by the uranium having remobilized at 870Ma, the "age" of the lone Pb-free uraninite sample.

In a separate study Carr & Dean (1986) isotopically analyzed whole-rock samples from the Koongarra primary ore zone. These were samples of drill core that had been crushed. Their isotopic data on four samples were plotted on a U-Pb isochron diagram and indicated a non-systematic relationship between the ^{238}U parent and the ^{206}Pb daughter. In other words, the quantities of ^{206}Pb could not simply be accounted for by radioactive decay of ^{238}U, implying open system behavior. They also plotted their four results on a standard ^{207}Pb/^{206}Pb isochron diagram and found that these samples fell on a very poorly defined linear array whose apparent age they did not quantify.

"Dating" of Weathered Rocks and Soils

Carr & Dean (1986) also isotopically analyzed a further nine whole-rock samples from the weathered schist zone at Koongarra. Some of these samples were again crushed drill core, but the majority were crushed percussion drill chips. When their isotopic data were plotted on a U-Pb isochron diagram six of the nine samples plotted close to the reference 1000Ma isochron, while the other three were widely scattered. However, on the ^{207}Pb/^{206}Pb diagram all nine weathered rock samples plotted on a linear array which gave an apparent isochron "age" of 1270±50Ma.

In an unrelated investigation, Dickson, Gulson, & Snelling (1985, 1987b) collected soil samples from above the mineralization at Koongarra and from surrounding areas, and these were analyzed for Pb isotopes to see if there was any Pb-isotopic dispersion halo around the mineralization sufficiently large enough to warrant the use of Pb-isotopic analyses of soils as an exploration technique to find new uranium orebodies. The technique did in fact work, Pb-isotopic traces of the deeply buried No. 2 orebody mineralization being found in the soils above. This mineralization, 40m below the surface, is blind to other detection techniques.

Dickson, Gulson, & Snelling (1987b) found that all 113 soil samples from their two studies were highly correlated (r=0.99986) on a standard ^{207}Pb/^{206}Pb diagram, yielding an apparent (false) isochron representing an "age" of 1445±20Ma for the samples. However, most of the soil samples consisted of detritus eroded from the Middle Proterozoic Kombolgie sandstone, so because the samples from near the mineralization gave a radiogenic Pb signature Dickson et al. interpreted the false "isochron" as being due to mixing of radiogenic Pb from the uranium mineralization with the common Pb from the sandstone.

Discussion

Snelling (1981) has already highlighted a telling omission by Hills & Richards (1976). Having included all the Pb isotopic ratios they had obtained on their five uraninite samples, they tabulated also the derived "ages," except for those obtainable from ^{208}Pb. These Th-derived "dates" should normally be regarded as the most reliable, since Th is less mobile in geochemical environments and therefore open system behavior is less likely than for U. Significantly, three of the five uraninite samples therefore give, within their experimental error, a 0Ma "age" (Snelling, 1981). In any case, their "age" of 1700–1800Ma for the first generation of uranium mineralization at Koongarra neither fits the geological criteria for an expected 1550–1600Ma "age," nor does their 870Ma "date" correlate with any geological event capable of remobilizing U and Pb to produce the presumed second generation of uranium mineralization.

Using Ludwig (1993), standard ^{207}Pb/^{206}Pb diagrams were prepared for the uraninite, galena, and whole-rock data sets, and combinations thereof, to check the regression statistics and possible derived "isochrons" using the standard York (1969) method. In each case the mean square of weighted deviates (MSWD), which tests the "goodness of fit" of data to a line, is large to extremely large, which reflects in the derived isochron "ages" of 841±140Ma (uraninites), 1008±420Ma (galenas), 668±330Ma (whole-rocks), 818±150Ma (uraninites plus galenas) and 863±130Ma (all three data sets combined), all "ages" being within the 95% confidence limits. It is perhaps fortuitously significant that the combination of all three data sets yields an isochron "age" of 863±130Ma, almost identical to Hills' & Richards' near-concordant "age" of 862Ma, although this was using a line-fitting routine of Ludwig that assigns equal weights and zero error-correlations to each data point to avoid the mistake of weighting the points according to analytical errors when it is clear that some other cause of scatter is involved, which is clearly the case here. The normal York algorithm assumes that the only cause for scatter from a straight line are the assigned errors, and for the combined data set here the amount of scatter calculated thereby yields an astronomical MSWD of 669000 and a bad line of fit that yields an isochron "age" of 1632±410Ma.

This "result" may make more geological sense, but the regression statistics are such that derivation of any "age" information from these data is totally unjustified, even though it can be rightfully argued that these samples form a cogenetic set (they are all samples of uranium ore or its components from the same primary ore zone at Koongarra).

It is not uncommon to find that "ages" derived from standard $^{207}Pb/^{206}Pb$ plots are erroneous, even though the data fit well-defined linear arrays ("isochrons"). Ludwig, Nash, & Naeser (1981) found that this was due to migration of both Pb and radioactive daughters of ^{238}U yielding a $^{207}Pb/^{206}Pb$ "isochron" giving "superficially attractive results which would nonetheless be seriously misleading" because the derived "age" (in their example) was more than six times higher than the U-Pb isochron "age." Similarly, Cunningham et al. (1982) obtained $^{207}Pb/^{206}Pb$ isochron "ages" up to 50 times higher than those derived from "more reliable" U-Pb isochrons for whole-rock uranium ore samples, even though "the apparent slight degree of scatter is almost entirely a misleading artifact." Ironically, at Koongarra the U-Pb isochron using Ludwig (1993) yields an "age" of 857±149Ma (with an MSWD of 13400, tolerably large compared to that obtained with the Pb-Pb isochron), almost identical to the "fortuitous" Pb-Pb isochron "age" obtained using Ludwig's modified algorithm on the combined three data sets (863±130Ma), as well as Hills' & Richards' single near-concordant 862Ma "age."

Snelling & Dickson (1979) demonstrated that there is significant radiometric disequilibrium in the primary ore and surrounding host rocks at Koongarra due to the redistribution of both U and its Ra decay product. That Ra mobility at depth in the primary ore zone is currently more significant than U migration was confirmed by Dickson & Snelling (1980), which of course results ultimately in the redistribution of ^{206}Pb, the end-member of the whole ^{238}U decay chain. Dickson, Giblin, & Snelling (1987) Dickson, Gulson, & Snelling (1987) demonstrated that Ra is transported through the unweathered rocks in this area in the ground waters, while Davey, Dudaitis, & O'Brien (1978) determined the emanation rate of radon gas from the Koongarra No. 1 orebody, an ever present hazard in uranium ore mining operations. The radon gas is known to migrate along fractures and rise through the ground over considerable distances to form a halo in the air above, while radon is also transported in ground waters.

These observations alone demonstrate the open system behavior of the U-Th-Pb system that renders meaningless any "age" information derived. However, both Hills (1973) and Snelling (1980a, b) have recognized that U also has migrated on a considerable scale in the primary ore zone, since supergene uraninites, often with colloform banding, are found as fracture and cavity infillings, and between quartz and gangue grain boundaries. The unit cell dimensions of these uraninites, plus this textural evidence, supports the conclusion that these uraninites have precipitated after dissolution of earlier formed uraninite and transportation in low-temperature ground waters. With such wholesale migration of U also, all attempts at "dating" must be rendered useless, especially when whole-rock samples, in which different generations of uraninites are lumped together, are used.

In contrast to the poor-fitting linear arrays produced from the Pb-Pb data of minerals and whole-rocks from the primary ore zone, that all appear to give an apparent (false) isochron "age" grouped around 857–863Ma, both Carr & Dean (1986) and Dickson, Gulson, & Snelling (1987) found that weathered whole-rock and soil samples produced good fitting linear arrays that would normally represent "isochrons" that yield "ages" of 1270Ma and 1445Ma respectively. The weathered whole-rock samples all of course come from Koongarra itself, and consist of secondary ore samples from the weathered schist zone, plus weathered schist samples that contain uranium dispersed down-slope by ground waters moving through the weathered rock. Because these whole-rock samples come from a volume of rock through which U is known to be migrating, leading to redistribution not only of U but of its decay products, it is therefore very surprising to find that these whole-rock samples define a good enough linear array to yield an "isochron." Even the observed scatter calculated using Ludwig (1993) is much less than that associated with fitting an "isochron" to the ^{207}Pb-^{206}Pb data from the primary ore zone samples, which is again surprising given U migration in the weathered zone, the data from which one would expect to show considerable scatter and thus no "age" consensus. Furthermore, it is baffling as to why the "isochron"-derived "age" should be so much "older" than the "age" of the primary ore, which of course is ultimately the source through weathering and ground-water transport of the U, decay products and the stable Pb isotopes. Perhaps the only explanation is that the "isochron" represents the mixing of radiogenic Pb from the mineralization with the common or background Pb in the surrounding schists.

The idea of such an "isochron" being a mixing line was suggested by Dickson, Gulson, & Snelling (1987). They were however, dealing with the Pb isotopic data obtained from soil samples collected from depths of only about 30–40cm, the majority of which represented sandy soils consisting of detritus eroded from the Kombolgie sandstone. For this mixing explanation to be feasible there should be

some other evidence of mobilization of Pb in the area. *Dickson et al.* found that not only were there high $^{206}Pb/^{204}Pb$ ratios in three of their soil samples from the near-surface (0–1 m) zone south of the No. 1 orebody, but there was a lack of any other U-series daughter products in the same samples. This near-surface zone is inundated for approximately six months of the year as a result of the high monsoonal rainfall in this tropical area. Towards the end of the ensuing six-month dry season the water table has been known to drop in some cases more than ten meters from its wet season "high." This means that the top of the weathered schist zone is regularly fluctuating between wet and dry conditions, so that any trace elements such as Pb leached from the weathered ore and transported by ground water in the weathered schist zone would also be dispersed vertically up into the thin surficial sand cover on top of the weathered schist—the sandy soils that were sampled by Dickson, Gulson, & Snelling (1985, 1987). Snelling (1984) found that Pb was a significant pathfinder element for uranium ore in the Koongarra environment, anomalous Pb being present in the surficial sand cover above the zone of weathered primary ore, and that there was even hydrodynamic dispersal of Pb at a depth of 0.5–1.5 m. Dickson, Gulson, & Snelling (1985) found a similarity between the isotopic ratios for Pb extracted from their soil samples by either a mild HCI-hydroxylamine (pH 1) or a strong 7*M* HCI-7*M* HNO_3 leach, which indicates that Pb is loosely attached to sand grain surfaces in the samples rather than tightly bound in silicate or resistate mineral lattices. This in turn suggests Pb is adsorbed from ground waters, meaning that radiogenic Pb is being added to the common or background Pb in the sand by both vertical and lateral ground-water dispersion.

However, not all of Dickson et al.'s soil samples came from the immediate area to the Koongarra orebodies, nor were they all the samples of Kombolgie sandstone detritus. That this mixing line explanation for the apparent "isochron" is clearly demonstrated for these samples from the immediate Koongarra area is not in question, although it is somewhat surprising that these soil samples should give an apparent isochron "age" somewhat higher than that obtained from the weathered schist samples beneath. Indeed, the common or background Pb in the respective samples should reflect an "older" apparent age in the schists compared to the sandstone, due to their relative ages based on geological relationships between them. However, the apparent ages are the other way around, the sandy soils yielding an "older" apparent age compared to that yielded by the weathered schists. Perhaps this difference is a reflection of the extent of mixing in each type of sample at their respective levels in the weathering profile. Nevertheless, what is astounding is that Dickson, Gulson, & Snelling (1987) found that even though several of their soil samples consisted of weathered schist or basement granite (containing accessory zircon) up to 17 km from the known uranium mineralization, they still plotted on the same apparent "isochron." Indeed, the "fit" is comparatively good, as indicated by the MSWD of only 964 using Ludwig (1993), yet much of this observed scattered can be attributed to two samples out of the 113, one of which was subsequently known to be probably contaminated by cuttings from an adjacent drill hole (Dickson, Gulson, & Snelling, 1985). If that sample is removed from the regression analysis the MSWD drops to 505, indicating that almost half of the observed scatter is due to that one data point alone. If the data point that is the next worst for fitting to the apparent "isochron" is removed, then the MSWD drops by a further 315 to a mere 190. Yet in both cases the apparent "isochron" or "mixing line" still has lying on or close to it the samples from up to 17 km away from the known uranium mineralization **and** the samples that are not Kombolgie sandstone detritus. The final "isochron" fitted to the remaining 111 samples still yields an "age" of 1420±18 Ma.

While Carr & Dean's nine weathered whole-rock samples are not strictly cogenetic with Dickson et al.'s 113 soil samples, the two sample sets are obviously related because the source of the radiogenic Pb in the majority of the soil samples from the immediate Koongarra area is the same as that in the weathered rocks. Not surprisingly, when the regression analysis was performed on Carr & Dean's nine weathered whole-rock samples using Ludwig (1993), the MSWD for the observed scatter was 24100, indicating a poor fit to an "isochron" which yielded an "age" of 1287±120 Ma. Yet when these nine samples were added to the 113 soil samples the MSWD dropped substantially to 1210, and not surprisingly the fitted "isochron" yielded an "age" of 1346±27 Ma, an "isochron age" intermediate between those of the two data sets being combined. However, when the two soil samples responsible for the majority of the scatter in that data set were removed the MSWD dropped to 430 and yielded an "isochron age" of 1336±17 Ma.

As with all the other apparent isochron "ages" this result has no apparent geological meaning, because there is no geological event to which these "ages" might correlate. Indeed, even in the evolutionary time frame the weathering of the Koongarra uranium mineralization is extremely recent, and in any case these "ages" derived from Pb-Pb "isochrons" from the weathered rock and soil samples are much "older" than the supposedly more reliable U-Pb "isochron age" of the Koongarra primary ore. But since that latter result has no apparent geological meaning,

because it also cannot be correlated with any known geological event, nothing then is certain at all from any of these U-Th-Pb isotopic studies of the Koongarra ores, rocks, and surrounding soils. Indeed, it is just as certain that the primary ore is 0 years old, based on three $^{232}Th/^{208}Pb$ single sample ages, as is the claim that one near-concordant result means that there was formation of Pb-free uraninite at 870 Ma. After all, this postulated formation of Pb-free uraninite is supposed to have occurred in an environment where there was Pb left over from an earlier 1700–1800 Ma original uranium mineralization for which we no longer have any evidence, textural or otherwise, apart from a rather tenuous interpretation of Pb isotopic evidence that has otherwise shown itself to be devoid of any capability of providing any "age" information.

All these results raise serious fundamental questions about the claimed validity of the U-Th-Pb "dating" method. It may seem reasonable to regard an apparent "isochron" as a "mixing line" within the restricted area close to the known source of radiogenic Pb, which can be shown by independent evidence to be migrating into rocks and soils that contain common or background Pb in the immediate environs. However, it strains all credulity to suggest that a false "isochron" through a data set derived from samples representing a variety of rock types, of significantly different evolutionary "ages," over an area of up to 17 km lateral extent from the known radiogenic Pb source, can still represent mixing! One can only conclude that all assumptions used to derive the estimates of common or background Pb, including models for the supposed evolution of the stable Pb isotopes through earth history, from their presumed commencement on the protoearth with its claimed original Pb isotope content some 4.6 billion or so years ago, cannot be valid. Equally, we cannot be sure what the U-Th-Pb system's isotopic ratios really mean, because the basic assumptions that are foundational to the interpretation of these isotopic ratios are fatally flawed. Not only has open system behavior of these isotopes been demonstrated as the norm, but even where there is an apparent "isochron" with an excellent "goodness of fit" the derived "age" is invariably geologically meaningless. Thus creationists need not be hindered in their building of the creation-Flood young-earth model for the geological record by the many claims in the open geological literature that U-Th-Pb radiometric "dating" has "proved" the presumed great antiquity of the earth, and the strata and fossils of the so-called geological column.

Conclusion

The concerns raised by Zheng (1989) regarding U-Pb isochrons are warranted. At Koongarra a $^{207}Pb/^{206}Pb$ "isochron" produced from 11 hand-picked uraninite and galena grains, plus four whole-rock samples, yields an "age" of 863 Ma, the same as a near-concordant "age" from one of the uraninite grains. Nine weathered whole-rock samples yield an "isochron age" of 1270 Ma, while 113 soil samples produce an excellent "isochron" with an "age" of 1445 Ma. All of these "ages" are geologically meaningless. While the apparent isochron produced by the soil samples may be identified as a mixing line, produced by the mixing of radiogenic Pb with common or background Pb in the surrounding rocks and soils, even this explanation strains credulity because the samples come from up to 17 km away from known uranium mineralization, and a few of the soil samples represent different rock types. Not only then has open system behavior of these isotopes been demonstrated, but apparent "isochrons" and their derived "ages" are invariably geologically meaningless. Thus none of the assumptions used to interpret the U-Th-Pb isotopic system to yield "ages" can be valid. If these assumptions were valid, then the $^{232}Th/^{208}Pb$ "age" of 0 Ma for three of the five uraninite samples should be taken seriously. Creationists should therefore not be intimidated by claims that U-Th-Pb radiometric "dating" has "proved" the presumed great antiquity of the earth, and the strata and fossils of the so-called geological column.

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