New U-Th-Pb Data On SNC Meteorite ALHA 84001. E. Jagoutz,[1] S. Bowring [2] R. Jotter[3] and G. Dreibus[3]
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Abstract: We report **n**ew Th-U-Pb data on ALHA 84001. A ^{206}Pb-^{207}Pb age of 4135±12 Ga and U – Pb of 41173±2,3 are found. However**, ^{208}Pb** systematic is not consistent with U –Pb evolution. The new high precision data demonstrate that the U-Pb system indicates an undisturbed evolution since 4135±12Ma but the Th-Pb system shows a much younger age of 2926±410 Ma. To change the Th-Pb systematic but not to disturb the U-Pb systematic requires an addition of an essentially Pb and U free Thorogenic mineral; possibly a phosphate. We suggest that our new data demonstrate that minor changes in the phosphate chemistry dominate the chronology of SNC meteorites.

Introduction: We reported previously (Jagoutz et al. 1994) [1] a Sm-Nd crystallization age for ALH84001 of 4.56 Ga, which was later confirmed by Nyquist et al. (1995) [2]. Nd isotopes ages agree within in error, while the initial ^{143}Nd/^{144}Nd ratio of 0.50669±0.00018 is within error identical to the chondritic initial indicating that ALHA 84001 was derived from a chondritic reservoir.

We also reported the Pb–Pb data of ALHA 84001[1]. Pb isotopes measured in ALHA 84001 are the most radiogenic of all SNC meteorites. Borg et al. [3] published ^{206}Pb/^{204}Pb–^{207}Pb/^{204}Pb isotopes of ALHA 84001 but 208Pb data were not published in this study. All these data plot close to a 4,1 isochrone,. On the same isochron plot the Pb whole Rock data reported by Bouvier[4]. With the exception of the Nakhlites[5] and olivine Shergotittes[6,7] all Shergotittes are plotting close to a 4.1 Ga isochron. Terrestrial common Pb is also close to this isochron, which causes many isotope geologists to be worried about the nature of this isochron. However, we observed a considerable scatter in the ^{208}Pb/^{204}Pb ratio in ALHA 84001 which was not consistent with a 4,1 Ga age. In order to solve this inconsistency we analyzed two samples of ALHA 84001 for Th-U and Pb.

Experimental and Results: Two samples (each about 50 mg) consisting of several interior fragments of ALHA 84001 are processed for this study. These samples were leached in 2N HCl over 48 hours and ultrasonicated several times. The residue were washed 3 times in H_2O then centrifugated and then added to the leaches. Leaches and residue were spiked using a mixed U-Th-Pb isotopic tracer. U, Th and Pb isotopes were analyzed using the VG Sector 54 masspec at MIT. U-Pb results are shown in Figure 1a,b and Th-Pb results are shown in Figure 2a,b

Discussion: SNC meteorites are poly-metamorphic rocks and they are rich in volatile elements. This is a combination which makes it very difficult for radiometric dating. It is common to get different ages with different isotopic systems for some SNC meteorites (Shergotittes). This is especially sad, since the "young crystallization ages" are often used as an important argument for a Martian origin."

U-Pb systematic: Our new data on Pb isotopes in ALHA 84001 combined with the Pb isotopic initials of Shergotty, Zagami and Los Angeles and DAG (Jagoutz in prep.) are forming a 4135±12 Ma isochron (Fig. 1a). However, since common Pb plots also close to this isochron, a mixing line towards terrestrial Pb could produce a similar isotopic arrangement. Nevertheless, there are good arguments against such a mixing scenario. First, Pb isotopic initials for Shergotittes calculated using U Pb internal isochrones are independent of the influence of terrestrial U-Pb. These initials are plotting onto the isochron. Second, the U-Pb systematic of ALHA 84001 as shown in Fig. 1b also argues for a 4.117 Ga U-Pb age. The whole rock samples (WR1 and WR2) plot very close to the Concordia at 4.1 Ga, whereas leachates and residues are disturbed by the leaching process. The calculated intercept gives an age of 4117.3±2.3, Ma which is nearly identical to the combined Pb-Pb age of 4135±12 Ma in Fig. 1a. This fact demonstrates impressively that the U/Pb ratio in ALHA 84001 was established at 4.12 Ga and has remained unchanged since then.

Th-Pb systematic: In1994 we were astonished by the scatter in the ^{208}Pb/^{204}Pb - 206Pb/^{204}Pb plot for ALHA 84001. It was a clear sign that the Th was disturbed. To solve this question we had to dissolve these two samples and measure Pb isotopic compositions as well as Pb, U, and Th concentration data. The data are shown in Fig2. We were very successful in dissolving the Th-rich mineral selectively and hypothesized it might be a phosphate. The high Th/Pb ratio explains the radiogenic ^{208}Pb. The Th-Pb isochron suggests an age of 2926±410 Ma which is much younger than the U-Pb. Actually at 2926 Ma U-Pb system was not noticeable disturbed. The only explanation remains that at 2926 Ma essentially Pb and U free Th mineral was added to ALHA 84001, very likely a hydrothermally precipitated phosphate.

Conclusion: Previously different ages for Shergottites meteorites were found by comparing vastly different isotopic systems. In the present case of ALH84001, however, we find different ages in the closely related Th-U-Pb system. The isotopic effects are so pronounced that all possible minor influences are not relevant. It is a rare case in isotope geology: we can infer that the U/Pb ratio was constant for 4.1 Ga, while about 3 Ga a Th-rich mineral was added to ALHA 84001, very likely a phosphate. Considering that for the most part Sm and Nd also reside in phosphates, we are forced to acknowledge that all we are dating in SNC meteorites may be minor changes in phosphate chemistry. The only exception may be the Rb-Sr system, where Jagoutz (1991) showed that SNC whole rocks are plotting as close to the 4.5 Ga reference line as can be reasonably expected for polymetamorphic rocks.

Fig 1

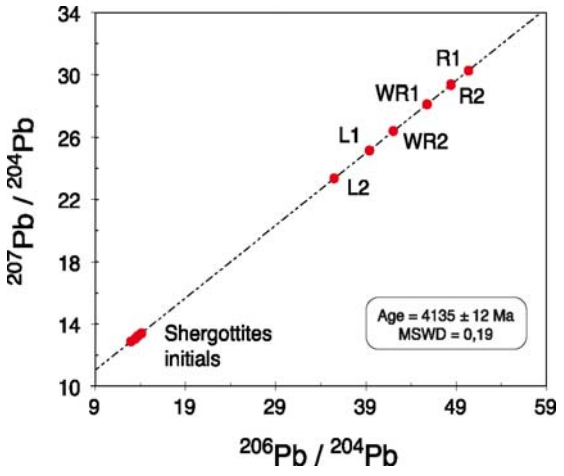


Fig 1 b

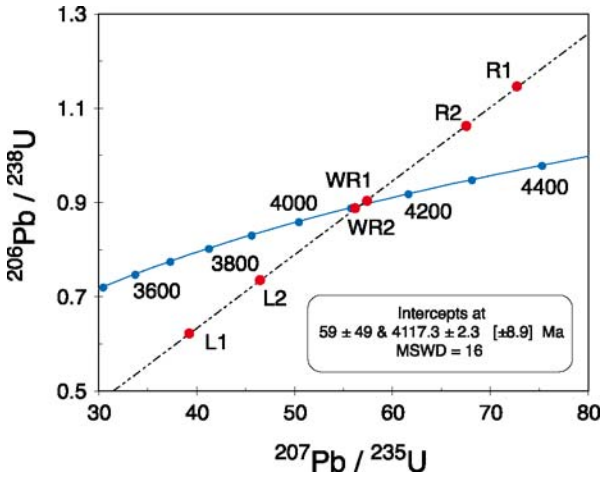


Fig2a

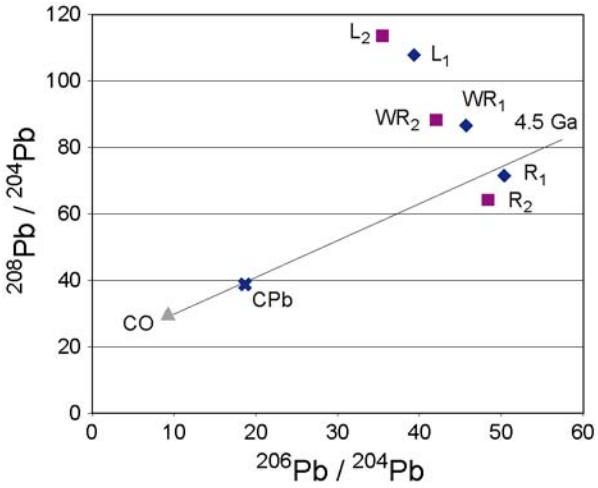
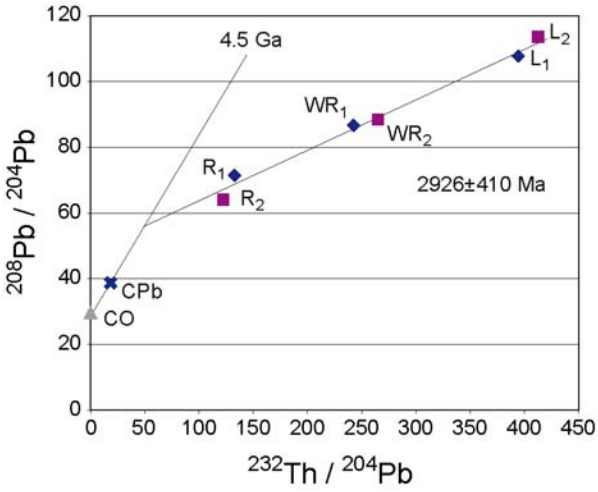


Fig2b



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