A Nuclear Production Ratio Th/U ≈ 0.96 from Lunar and Terrestrial Rocks: Implications for Future Lunar Sample Return Missions

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1$^{186}$Re - 1$^{187}$Os nuclear geochronometry

Nuclear geochronometry is a new research field, developed to bridge the gap between geochronology and nuclear astrophysics. It is based upon the discovery of terrestrial signatures from at least two rapid (r-) neutron-capture processes, which plot on the astrophysical model line of sudden nucleosynthesis (see 2): Burbidge et al. (1957). It aims at dating rocks by means of radioactivity, which makes it a subfield of nuclear chemistry. The dating method is embedded in other scientific fields like cosmology, cosmochemistry and nuclear technology, which impose tight constraints on nuclear geochronometry. Or, in other words: in nuclear geochronometry we start with Becquerel and Curie, move on to Rutherford and Soddy, pass Chadwick and Fermi, and finally end up with Fowler, Mather and Smood...

The most powerful nuclear chronometer currently used is $^{186}$Re. Five nuclear $^{187}$Os chronometers (Re/Os ≈ 1) have been identified so far. There are two age clusters: At $^{186}$Os/Re 1 = 13.78 Ga and at $^{187}$Os/Re 3 Ga.

Some constraints from meteoritics / astronomy


1$^{187}$Re/1$^{187}$Os (Nuclear Production)

Nuclear astrophysics: $^{187}$Re/1$^{187}$Os nuclear production ratio (PR) from IDMS

The two data points are the BARBERTON $^{187}$Re chronometer and the Thiel Mountains Pb/Lu. The model age is constrained by this $^{187}$Re age, which is also a lower bound for the age of the Universe.

Conclusions

1. Planets may be regarded as one possible site of the astrophysical rapid (Burbidge et al. 1957, Rev. Mod. Phys. 29, 547) or fast (Cameron 1957, CrL-41) chlorite, Ontario) neutron-capture process (n-process).

2. Element and isotopic data reported here suggest a robust r-process at least in some meteorites (Morgan et al. 1979, 2004, 1999, 2004).

3. These findings encourage the combined use of isotopic signatures from lunar and terrestrial rocks to constrain models of r-process nucleosynthesis.

4. The Moon could become an astrophysical reference as to pristine r-process isotopic signatures at Earth-like core collapse or multiple r-process events.

5. It is recommended to consider these results in any strategy which aims at sampling the Moon in the course of future lunar sample return missions.