U-PB SYSTEMATICS OF THE ULTRAMAFIC ACHONDRITE NORTHWEST AFRICA 5400.

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Introduction: Northwest Africa 5400 is a metal-bearing ultramafic achondrite petrologically similar to brachinites, but with oxygen isotopic composition indistinguishable from that of the Earth [1]. A previous attempt to determine the formation age of this meteorite using the ^{53}Mn-^{53}Cr system [2] yielded an internal isochron with zero slope and elevated ε(^{53}Cr) of 0.44, corresponding to the age younger than 4541 Ma. Here we report U-Pb data for NWA 5400.

Techniques: A portion of coarsely crushed meteorite was leached in warm 7M HCl to remove weathering products (mostly iron hydroxides). Three fractions of clinopyroxene with variable abundance of inclusions and turbidity, one fraction of olivine and one fraction of orthopyroxene were hand-picked from this acid-washed material. These fractions, and three whole rock fractions and their leachates were analyzed using the procedures of [3].

Results: Acid-washed minerals and rocks contain between 0.13-0.72 ppb U and between 1.2-7.7 ppb Pb. Their Pb isotopic compositions, with ^{206}Pb/^{204}Pb between 9.35 and 13.69, plot along the mixing line between primordial Pb [4] and modern terrestrial crustal Pb. The least radiogenic Pb isotopic compositions are indistinguishable, within error, from primordial Pb. The ^{206}Pb/^{204}Pb ratios are correlated with ^{238}U/^{204}Pb. If interpreted as an isochron, this correlation corresponds to the date of 1570 Ma.

The whole rock contains 13-32 ppb of acid leachable U, and 49-173 ppb of acid leachable Pb. The most easily soluble Pb in whole rocks is similar to modern terrestrial crustal Pb; the Pb extracted with hot concentrated acids is slightly less radiogenic. No correlation between ^{206}Pb/^{204}Pb and ^{238}U/^{204}Pb ratios is observed for the leachates.

On a Pb-Pb isochron diagram~~,~~ all residue and leachate data points plot along a single line that yields a date of 4478±55 Ma if interpreted as a single-stage isochron.

Discussion: The U-Pb isotopic systematics of NWA 5400 are explained by mixing between initial primordial Pb and modern crustal Pb introduced by terrestrial weathering. Acid-soluble uranium was also accumulated during weathering. The linear arrays in U-Pb and Pb-Pb isotopic space are mixing lines with no chronological significance. This meteorite contains chlorapatite, a potentially suitable mineral for U-Pb dating, but it would be necessary to completely remove weathering products by a non-acidic treatment before dating of apatite can be attempted.

Although the U-Pb data reported here do not constrain the crystallization age of NWA 5400, they rule out a terrestrial origin: the initial Pb isotopic composition is far more primitive than the least radiogenic terrestrial Pb [5]. Instead, these data are consistent with origin from a body that either differentiated very early, or escaped an extensive loss of volatile elements. We suggest that the evolution of the NWA 5400 parent body differed from that of the Earth, Moon and parent bodies of angrites and eucrites, but was possibly akin to evolution of some of the parent bodies of iron meteorites, where the most primitive Pb is found.

References: [1] Irving A.J. et al. (2009) 40th Lunar & Planetary Science Conference, Abstract #2332. [2] Shukolyukov A. et al. (2010). 41st Lunar & Planetary Science Conference, Abstract #1492. [3] Amelin Y. et al. (2010) Earth Planet. Sci. Lett. 300, 343-350. [4] Tatsumoto M. (1973) Science 180, 1279-1283. [5] Frei R. and Rosing M.T. (2001) Chem. Geol. 181, 47–66.