NORTHWEST AFRICA 13188: A METEORITE FROM THE EARTH?

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Meteorites are usually first identified visually by their fusion crust before more detailed analyses (mineralogical observations, elemental concentrations, isotope compositions, …) enable to propely assign them to a specific meteorite group. Based on the observation of a fusion crust, texture and mineralogy, NWA 13188 was classified as an ungrouped achondrite [1]. This single stone was purchased by AJ from a Moroccan meteorite dealer at Ste Marie aux Mines Mineral Show in June 2018. It is an igneous rock with overall subophitic texture and typical silicate grain size of 350 µm. The mineralogy is dominated by plagioclase (49 vol%) and pyroxene (26 vol%), as well as fine-grained mesosta-sis of plagioclase, pyroxene (18 vol% of the mesostasis), accessory FeTi oxides and glass. Vesicles with typical size 250 µm represent 8 vol% of the rock. No metal is observed.

The oxygen isotopic composition of NWA 13188 is very close to the terrestrial fractionation line: $\delta^{18}O$=8.03‰, $\delta^{17}O$=4.16‰ and $\Delta^{17}O$=-0.02‰ (n=2; analytical uncertainties typically of ±0.08‰, ±0.12‰, ±0.03‰ respectively). With a SiO_2 content of 52.3 wt% and Total Alkali content of 2.1 wt%, it is classified as a basaltic andesite (Mg# of 58.5). NWA 13188 has a CI-normalized REE pattern displaying an enrichment in more incompatible trace elements, with $(La/Sm)_N$= 2 and $(La/Lu)_N$= 3.5, and the trace element pattern shows a clear depletion in Nb-Ta as observed in typical terrestrial arc volcanism. Such patterns in trace elements are unusual for an achondrite. We measured $\mu^{142}Nd$, $\varepsilon^{143}Nd$ and $\varepsilon^{176}Hf$. The $\mu^{142}Nd$ of NWA 13188 is -0.59 ± 3.3, i.e. within the terrestrial range. Taken together, these observations cast doubt on the extraterrestrial origin of NWA 13188, at odd with its fusion crust.

Measurement of the concentration of cosmogenic nuclide ^{10}Be does not resolve this ambiguity. The ^{10}Be concentration of 31.7 x 10^6 atoms/g (or 0.028 dpm/kg) cannot be accounted for by any reasonable exposure age at an altitude similar to where the stone was recovered (~1500 m above sea level). But at the same time, this concentration is very low for a meteorite (usually in the range of 10-20 dpm/kg for a chondrite) which would imply an extremely short transfer time to the Earth, on the order of a few kyr, or important shielding. Noble gases will be measured to provide additional constraints on the cosmic ray exposure history of this rock sample.

A possible way to reconcile a sample displaying a typical terrestrial composition with a fusion crust and a moderate enrichment in ^{10}Be is to invoke a terrestrial origin for this meteorite. In this scenario, a rock that was ejected from the Earth's surface, spent some time in orbit (to build up ^{10}Be) and then fell back to Earth (generating a fusion crust). Such a process would require a recent large impact event or direct ejection during a large volcanic eruption. Those two scenarios will be discussed.

References:

[1] Gattacceca J., McCubbin F., Grossman J., Bouvier A., Bullock E., Chennaoui Aoudjehane H., Debaille V., D'orazio M., Komatsu M., Miao B., Schrader D., Jull A.J.T., (2021), The Meteoritical Bulletin, No. 109. *Meteoritics and Planetary Science*, Wiley, ⟨10.1111/maps.13714⟩.