Introduction: Northwest Africa (NWA) 7397 is an incompatible trace element enriched poikilitic (previously known as ‘herzolitic’) shergottite. This 2.12 kg stone was discovered in the hot desert of Smara, Morocco in 2012 [1]. The meteorite has two textural lithologies. One is poikilitic lithology consists of large anhedral pyroxene (up to 6 mm) enclosing subhedral olivine (~100-700 µm) and fine-grained euhedral chromite (<100 µm). The other is non-poikilitic lithology, consists mainly of euhedral olivine (up to 1200 µm), that often contain melt inclusions [2]. The other dominant phase present in non-poikilitic lithology are pyroxene (~600 µm), maskelynite (shocked plagioclase) with minor fine-grained phosphate (<400 µm), sulfide, and Fe-oxide (<100 µm) phases. The modal mineral abundances of NWA 7397 for olivine, pyroxene, maskelynite and minor phases are 50:40:8:2 vol%. A detailed petrographic study of NWA 7397 has been done by [3, 4].

The average cosmic ray exposure (CRE) age of NWA 7397, obtained from noble gases, is ~4.3 Ma [5]. The crystallization age of this meteorite is yet to be measured. Therefore, the objective of this study is to determine the long-lived $^{147}$Sm-$^{143}$Nd crystallization age and Nd isotopic compositions of NWA 7397, and draw comparisons with those of other martian meteorites to define a petrogenetic relationship among the shergottite source regions.

Analytical Techniques: A ~1.18 g aliquot of NWA 7397 was used for Sm-Nd isotopic study at the University of Houston. The sample was crushed and sieved at >325 mesh, 200-325 mesh and 100-200 mesh size fractions. The fraction of >325 mesh was used as bulk-rock fraction. The 200-325 mesh size fraction was put through density separation, while the 100-200 mesh size fraction was underwent magnetic separation, to obtain plagioclase- and pyroxene-rich mineral fractions. All the fractions were leached with acetic acid to remove terrestrial alteration, and with 2N HCl to remove phosphates. The residues and leachates were then dissolved with acids in multiple steps, prior to performing column chemistry for Sm and Nd isolation. Samarium and Nd isotopic compositions were then measured using a ThermoFinnigan Triton Plus TIMS at the University of Houston.

Sm-Nd Results: An age is defined by five sample fractions, including two pyroxene residue fractions (H-PX-R, HL-PX-R), one bulk-rock residue fraction (Bulk1-R), one pyroxene leachate fraction (HL-PX-L) and one bulk-rock leachate fraction (Bulk1-L). The calculated $^{147}$Sm-$^{143}$Nd isochron age for NWA 7397 is 182±28 Ma with an initial εNd = -7.0±0.3 relative to CHUR (Fig. 1). The leachate samples lying on the isochron are most likely controlled by the sample phosphate which is dissolved in the dilute HCl used for leaching [6]. The bulk-rock fraction plots midway between the pyroxene residue and leachates. The negative initial εNd value of -7.0±0.3 is within the range of values for other enriched shergottites (εNd = -6.3 to -7.23) and indicates NWA 7397 is derived from a long-term LREE-enriched source regions.

![Figure 1. Internal Sm-Nd isochron for NWA 7397. The dotted lines are 95% confidence envelope.](image-url)
Interestingly, in terms of the Sm/Nd ratios, both of the leachate ratios from TIMS (pyroxene= 0.368, bulk-rock= 0.369) match well with the in-situ phosphate ratio from ICPMS (0.361) consistent with the Sm/Nd ratios of leachates being dominated by phosphates from the sample. This observation is consistent with the previous findings [6, 8, 9].

![Figure 2](image)

Figure 2. CI-chondrite normalized Sm- and Nd-concentrations of minerals (i.e. pyroxene, phosphate) and bulk-rock samples measured by TIMS compared with minerals measured by LA-ICPMS and bulk-rock [3, 4, 7]. LCP-P= low-Ca pyroxene in poikilitic lithology, LCP-Np= low-Ca pyroxene in non-poikilitic lithology, HCP-P= high-Ca pyroxene in poikilitic lithology, HCP-Np= high-Ca pyroxene in non-poikilitic lithology. Phos= phosphate.

The Sm-Nd crystallization age of NWA 7397 is 182±28 Ma is within the enriched shergottite age range (150-230 Ma). The overall shergottite age range is ~150-587 Ma with the exceptions of NWA 7635 (2403±140 Ma) and NWA 8159 (2370±250 Ma) (Fig. 3) [10, 11]. There is a correlation between the crystallization ages and ejection ages of shergottites [5, 12]. The ejection age of enriched poikilitic shergottite, NWA 7397, is ~4.3 Ma [5] and is loosely clustered with the ejection ages for intermediate poikilitic shergottites such as LEW 88516, Yamato 793605 and Yamato 000097 (Fig. 3) and have similar respective crystallization ages of 152-183 Ma.

![Figure 3](image)

Figure 3. Sm–Nd crystallization ages vs. Mars ejection ages of the shergottites. The light blue shaded area is the age range of enriched shergottites. Yellow, green and purple symbols are depleted, intermediate and enriched shergottites, respectively. All the errors are in ±2σ.

Conclusions: The initial $^{147}\text{Sm-}^{143}\text{Nd}$ isotope data obtained here for the enriched poikilitic shergottite NWA 7397 yields a crystallization age of 182±28 Ma. Bulk mineral fraction Sm and Nd concentrations obtained via isotope dilution and measured on the TIMS are in good agreement with those obtained in-situ for single spots on the same minerals using LA-ICPMS. The Sm/Nd ratios of the leachates via TIMS overlap those obtained from in-situ analysis of phosphate using LA-ICPMS. The Sm-Nd crystallization age as well as initial Nd isotopic composition of NWA 7397 are within the range of other enriched shergottites and closely resembles to that of LAR 06319 [8], and are consistent with these samples being from the same source, i.e. LREE-enriched, oxidized, and highly evolved. However, the ejection ages of these two shergottites are ~1 Ma apart such that they could be from different ejection events at different locations. The ejection age of NWA 7397 of 4.3 Ma is similar to the other intermediate poikilitic shergottites.

References: