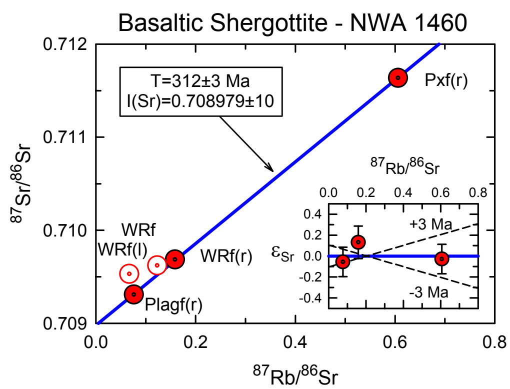
CRYSTALLIZATION AGE OF NWA 1460 SHERGOTTITE: PARADOX REVISITED. L. E. Nyquist[1], C-Y. Shih[2], Y. D. Reese[3], and A. J. Irving[4], [1]Mail Code SR, NASA Johnson Space Center, Houston, TX 77058, l.nyquist@nasa.gov , [2]Mail Code C23, Lockheed-Martin Space Mission Systems and Service Co., Houston, TX 77058, [3]Mail Code C23, Hernandez Engineering Co., Houston, TX 77062, [4]Dept. of Earth and Space Sciences, University of Washington, Seattle, WA 98195.

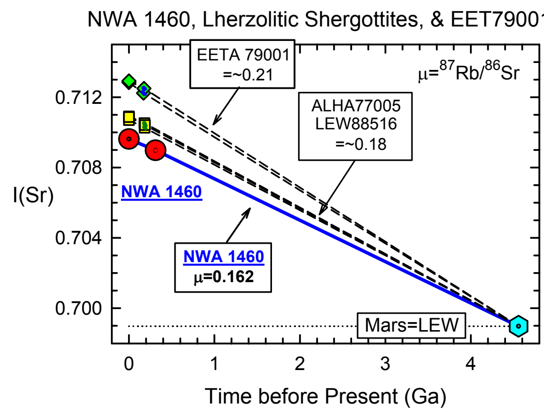
Introduction: We have determined the Rb-Sr age of basaltic shergottite NWA 1460 to be 312±3 Ma, and the Sm-Nd age to be 352±30 Ma. The initial Sr and Nd isotopic compositions of NWA 1460 suggest it is an earlier melting product of a Martian mantle source region similar to those of the lherzolitic shergottites and basaltic shergottite EETA79001, lithology B. The new ages of NWA 1460 and other recently analyzed Martian meteorites leads us to reexamine the paradox that most of the Martian meteorites appear to be younger from the majority of the Martian surface [1]. This paradox continues to pose a challenge to determining a reliable Martian chronology.



Rb-Sr Mineral Isochron: Petrologic studies [2] indicate that NWA 1460 is a fresh, unweathered rock, lacking mineralogical evidence for terrestrial alteration seen in many Northwest Africa meteorites. Thus, it was possible to prepare plagioclase, pyroxene, and whole rock samples essentially free of terrestrial contamination to determine its age. The Rb-Sr data are shown in Fig. 1.

The sample used for these first analyses was obtained from fragments (f) of the interior portion of the rock. A whole rock sample was leached (l) to remove surface contamination. The linear array formed by the Rb-Sr data for unleached whole rock (WRf), leachate (WRf(l)), and residue (WRf(r)) is interpreted to be an unmixing line. The plagioclase and pyroxene mineral separates were treated similarly. The data for the cleaned residue samples determine an isochron for an age of 312±3 Ma, and initial $^{87}Sr/^{86}Sr$, I(Sr) = 0.708979±10 (uncertainties refer to last digits). As shown by the alignment of the WRf(l), WRf, and WRf(r) data, the effect of terrestrial contamination would be to decrease the slope of the isochron, thus lowering the age. Such an effect is unlikely because of the precise alignment of the residue data determining the isochron.

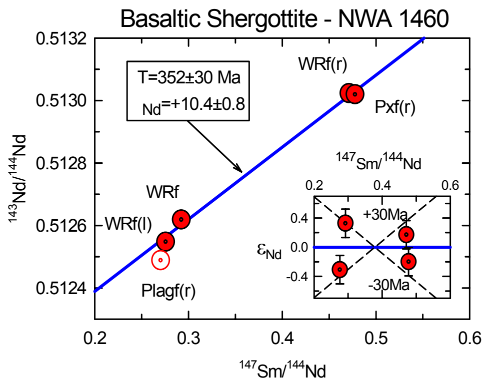
Initial $^{87}Sr/^{86}Sr$. Figure 2 compares the initial $^{87}Sr/^{86}Sr$ ratio of NWA 1460 to that of the lherzolitic shergottites ALHA77005 and LEW88516 [3], and basaltic shergottite EETA79001(B) [4]. All of these rocks appear to have derived from source regions of



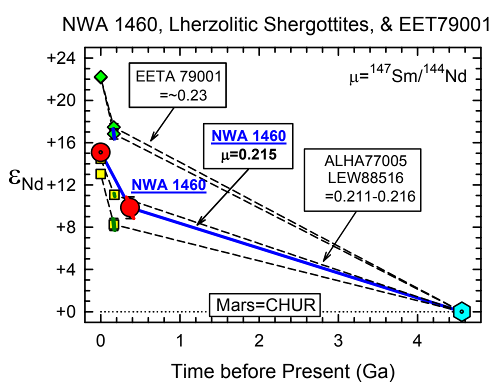
similar time-averaged $^{87}Rb/^{86}Sr$ in the range 0.16-0.21. These initial $^{87}Sr/^{86}Sr$ ratios are intermediate to those of the "depleted" and "enriched" shergottites, and it is tempting to view them as characteristic of "typical" Martian mantle. The time-averaged $^{87}Rb/^{86}Sr$ ~0.16 for NWA 1460 is identical to that estimated for bulk Mars by [5] and only slightly greater than $^{87}Rb/^{86}Sr$ ~0.13 estimated by [6].

Sm-Nd Mineral Isochron: The Sm-Nd isotopic data are shown in Figure 3. The data for Plagf(r) appear to be displaced from the linear alignment of the other data. Since plagioclase has a low rare earth element (REE) content, this analysis of a small mineral separate might have been affected by terrestrial contamination. Regression of the other data alone gives an age of 352±30 Ma. We plan additional analyses to improve the plagioclase data and resolve the discrepancy between the Rb-Sr and Sm-Nd ages.

Initial ^{143}Nd/^{144}Nd. Figure 4 compares the initial ^{143}Nd/^{144}Nd ratio of NWA 1460, expressed as ε_{Nd}, to that of the lherzolitic shergottites ALHA77005 and LEW88516 [3], and basaltic shergottite EETA 79001(B) [4]. These rocks appear to have derived from source regions of similar time-averaged ^{147}Sm/^{144}Nd in the range 0.21-0.23. From REE patterns, Barrat et al. [7] suggested that the paired meteorite NWA 480 shared a similar mantle source to lherzolitic shergottites. Moreover, time-averaged ^{147}Sm/^{144}Nd in the

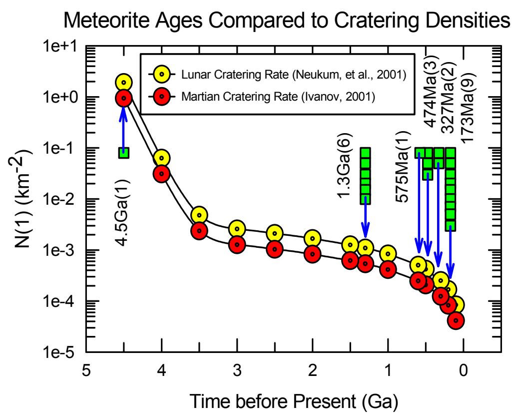


source(s) was similar to that in the nakhlite source (*cf.* [6]). This group of shergottites probably derived from Martian mantle "typical" in its Rb-Sr and Sm-Nd systematics. The change in evolution of ε_{Nd} at magma genesis suggests prior "depletion" events during which Sm/Nd in the source(s) was increased while Rb/Sr remained nearly constant.



The Age Paradox: The average Rb-Sr and Sm-Nd ages of NWA 1460, ~330 Ma, is the same as the age of basaltic shergottite QUE94201 [5]. Marty et al. [8] concluded that NWA 480 was ejected from Mars in the same event as "depleted" QUE94201 and "enriched" Shergotty and Zagami. The latter have crystallization ages of ~173 Ma [9]. The ejection age of lherzolite ALHA77005 is within uncertainty of those of Shergotty and Zagami, although ejection ages of lherzolites LEW88516 and Y793605 appear older [9].

The paradox of too many ~170-330 Ma old shergottites from too little Martian surface area is relieved if all of them are associated with a single ejection event, and/or the Martian cratering rate was higher than customarily assumed [1]. Identification of young volcanics covering older surfaces [10], and older ages of ~474 Ma and ~575 Ma for recently recovered shergottites [11,12, JSC, unpub.] further relieves the para-



dox. Nevertheless, Fig. 5 comparing resolvably different radiometric ages for Martian meteorites to surface crater densities on the Moon and Mars as a function of surface age [13,14], shows that the paradox remains even for conservative assumptions of the number of ejection events. All of the basaltic Martian meteorites correspond to Martian surface ages belonging only to the mid- and late-Amazonian; i.e., to ~25% of the Martian surface volcanics [1,10].

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