THE PETROGENESIS AND CHRONOLOGY OF LUNAR METEORITE NORTHEAST AFRICA 003-A: Sm-Nd AND Rb-Sr ISOTOPIC STUDIES. Jakub Haloda[1,2], Patricie Tycova[1,2], Martin Thöni[3] and Monika Jelenc[3], [1]Institute of Geochemistry, Charles University, 128 43 Prague 2, Czech Republic, [2]Czech Geological Survey, Barrandov, 150 00 Prague 5, Czech Republic (jakub.haloda@geology.cz; patricie.tycova@geology.cz), [3]Department of Litosphere Research, University of Vienna, Vienna, A-1090, Austria (martin.thoeni@univie.ac.at; monika.jelenc@univie.ac.at).

Introduction: NEA 003-A is a lunar mare basalt, previously described by [1,2]. The younger ages 2.315 ± 0.04 Ga and 1.762 ± 0.054 Ga, which were obtained by Ar-Ar dating [3], are discordant to our Sm-Nd age, suggesting the resetting of K-Ar system during single or multiple impact event(s). Here we present the Sm-Nd and Rb-Sr data in order to address the problem of meteorite origin and age of crystallization.

Sample preparation: Five mineral separates were prepared for Sm-Nd isotopic measurements - the pure plagioclase (Pl) fraction, clinopyroxene fraction (Cpx), impure fractions of plagioclase (Pl-impure), pyroxene (Cpx-impure), containing olivine and some maskelynite intergrowths, and Fe-rich clinopyroxene (Cpx-Fe-rich). The duplicate mineral separates for Rb-Sr inculed fractions Pl, Pl impure, Cpx, and Cpx impure. Before dissolution the handpicked mineral fractions were rinsed repeatedly in acetone and deionised water in an ultrasonic bath. Sample splits for Sm-Nd analysis were washed for 30 minutes in warm (~70 °C) 0.8 N HCl to eliminate dust and surface contamination (terrestrial weathering and fluid infiltration, e.g. calcite). Splits for Rb-Sr analysis were washed for 20 min at room temperature, using 0.24 N HCl.

Neodymium and Sm were separated from the REE fraction in a Teflon-coated HdEHP column, and 0.18 N and 0.4 N HCl, respectively, as elution media. Maximum total procedural blanks were < 50 pg for Sm and Nd, and thus taken as negligible. Samples for Rb-Sr analysis were spiked directly and subsequently dissolved in ultrapure HF-HNO_3 (4:1 v/v). Elemental separation followed conventional techniques, using Bio-Rad AG® 50W-X8 (200-400 mesh) resin and 2.5 N and 1.0 N HCl as eluants.

Measurements of Nd and Sr isotope compositions and ID fractions were run in static mode on a ThermoFinnigan® Triton TIMS instrument at the University of Vienna, Austria.

Sm-Nd results: The Sm-Nd analytical data are plotted in an isochron diagrams in Figure 1, which shows that four out of five data points (Cpx, Cpx impure, Pl impure, Pl) plot on a linear array (solid line). If pooled together in one single regression calculation the age obtained is t = 3.089±0.064 Ga, with $(^{143}Nd/^{144}Nd)_i$ = 0.508610±0.000095 and $\varepsilon_{Nd3.089}$ = -0.4±0.3 (MSWD = 1.01). Interestingly, Cpx Fe-rich plots clearly off the 3.1 Ga "mean" trend line. If Cpx Fe-rich fraction is regressed with the Cpx and Cpx impure fractions (dashed line), it defines an age of 3.31±0.14 Ga and an initial $^{143}Nd/^{144}Nd$ of 0.50817±0.00025, corresponding to a significantly more negative $\varepsilon_{Nd3.31}$ of -3.3±0.7; MSWD = 1.6.

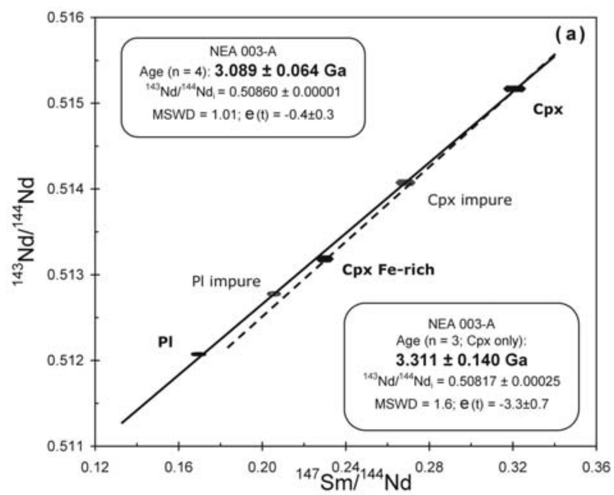

Fig. 1.: Sm-Nd isotopic data for mineral fractions of NEA 003-A shown as an isochron diagram.

Rb-Sr results: The Rb-Sr analytical data are plotted as an isochron diagram, Fig. 2. The measured $^{87}Sr/^{86}Sr$ ratios for Pl fractions are very low, ranging from 0.6999 (for Pl) to 0.7007 (for Pl impure 2). In the isochron plot, however, the data points show extreme scatter, and no obvious correlation between Sr isotope composition and Rb/Sr is observed. This prevents any reliable age information to be drawn from this data set. It is evident that high $^{87}Sr/^{86}Sr$ ratios and low $^{87}Rb/^{86}Sr$ ratios, mainly for clinopyroxene fractions, are tending towards the present seawater value of $^{87}Sr/^{86}Sr$~0.7090, strongly suggesting that the hot-desert environment alteration processes has affected the Rb-Sr isochron system of the meteorite. If we construct the reference isochron for the least altered mineral fraction Pl impure2 (Fig. 2) and for Sm-Nd age 3.089±0.064, we can estimate an initial $^{87}Sr/^{86}Sr_i$ of ~ 0.69949.

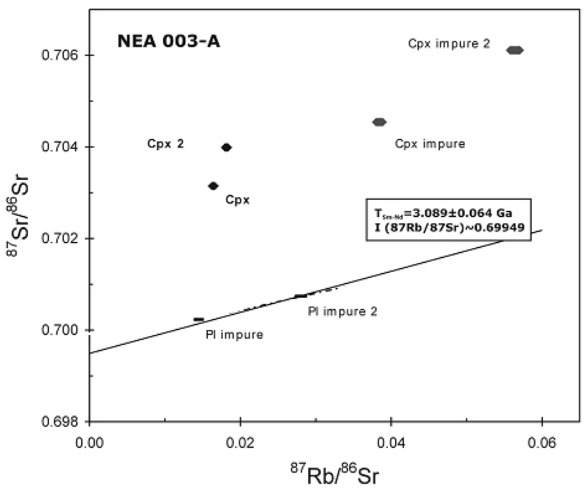

Fig. 2.: Rb-Sr isotopic data for mineral fractions of NEA 003-A shown as an isochron diagram.

Isotopic constrains on petrogenesis: The discrepancy in Sm-Nd age could be explained by partial disturbance or re-setting of the Sm-Nd system during the shock processes which converted plagioclase into maskelynite. However, a recent study of [4] suggests no or very little effect of shock metamorphism on the Sm-Nd systematics of lunar basalt samples. Furthermore, the shock event(s) forming maskelynite was fast with little heating, since there is no petrographic evidence of recrystallization. The supposed post-shock temperature of 200–250˚C [5] would have been insufficient to cause Sm-Nd diffusion since the closure temperatures for pyroxene and plagioclase are much higher.

Alternatively, the Sm-Nd system could be influenced by terrestrial contamination due to weathering processes taking place in the hot desert environment where the meteorite was found [1]. Study of individual mineral phases under SEM and using EMPA revealed the presence of large numbers of shock fractures filled with secondary weathering products, particularly in the outer part of olivine and pyroxene grains. This is in contrast to maskelynite where the fractures are almost absent. The Fe-rich pyroxene rims represent the most affected region of the pyroxene grains and slight disturbance in Sm-Nd data can be explained by the presence of terrestrial contamination in this separate. Therefore we consider the age of 3.089±0.064 Ga, $(^{143}Nd/^{144}Nd)_i$ = 0.50861±0.000095, ε_{Nd3089} = -0.4±0.3, and MSWD = 1.01 to best represent the crystallization age of NEA003-A.

Previous studies [1,2] shows that there is a strong geochemical affinity of NEA 003-A to Apollo 15 olivine-normative basalts and we can assume that a slightly more evolved source magma of Apollo 15 olivine-normative basalts could be derived by fractional crystallisation from a magma source having a similar composition to NEA 003-A. In contrast, the geochemically similar olivine-normative basalts 15555 and 15016 from Apollo 15 suite were derived from isotopically more depleted source than the near-chondritic NEA 003-A (Fig. 3). Most likely, the magma source of these rocks evolved separately in isolated geochemically similar reservoirs [6].

The Sm-Nd crystallization age (3.089±0.064 Ga) corresponds to the period of lower Eratosthenian lunar volcanic activity. Older crystallization ages of geochemically similar Apollo 15 olivine-normative basalts (~ 3.3±0.02 Ga) suggest that NEA 003-A can be a product of younger low-Ti mare basalt volcanism within the Apollo 15 olivine-normative basalt suite. The near-chondritic ε_{Nd} value of –0.4±0.3 indicates that NEA 003-A could also be derived from a mantle source similar to the Apollo 15 green glass which is also characterized by very low and unfractionated REE abundances and near-chondritic Sm/Nd evolution [7].

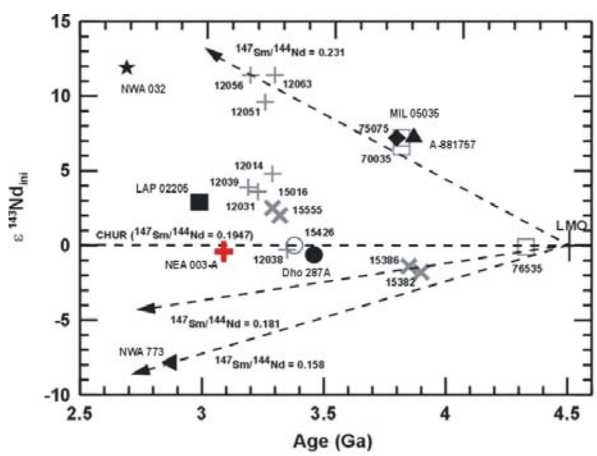

Fig. 3.: Initial Nd isotopic composition ε_{Nd} vs age plot for NEA 003-A, lunar mare basalt meteorites and selected Apollo 12, Apollo 15 and Apollo 17 basalts.

References: [1] Haloda J. et al. (2006) *LPS XXXVII,* Abstract #2269. [2] Haloda J. et al. (2007) *LPS XXXVIII,* Abstract #1768. [3] Haloda J. et al. (2007) *Eos Trans. AGU 88,* Abstract #V23B-1440. [4] Gaffney A. M. et al. (2007) *LPS XXXVIII,* Abstract #1424. [5] Stöffler D. and Grieve R. A. F. (2007) Impactites. In *Metamorphic rocks - a classification and glossary of terms* (editors: Fettes D. and Desmons J.). [6] Nyquist L. E. and Shih C. Y. (1992) *GCA* 56, 2213-2234. [7] Lugmair, G. W. and Marti, K. (1978) *EPSL* 39, 3349-3357.