NON-TRADITIONAL STABLE ISOTOPE CONSTRAINTS ON THE EVOLUTION OF MOON. T. Magna[1] and C. R. Neal[2], [1]Czech Geological Survey, Prague, Czech Republic (tomas.magna@geology.cz), [2]University of Notre Dame USA (cneal@nd.edu).

Introduction: Past applications of less traditional stable isotope systems in Earth and planetary science were hampered by the lack of sensitive instrumentation that would allow a variety of interior and surficial processes to be distinguished. The development of MC-ICPMS has overcome many analytical issues and investigations of lunar materials have produced important observations concerning the provenance of lunar building materials [1,2], pre-impact status of the Earth [3], and differentiation of the lunar mantle [4,5]. But other isotope systems have also gained their importance in disentangling the processes of the lunar differentiation, degassing process, and the hydrous versus anhydrous nature of the Moon [6–10]. This contribution highlights the unique information that can be obtained from such isotope systems.

Major elements. *Oxygen.* A seminal study by [11], reconfirmed by [12], has provided the high-resolution data needed to demonstrate O isotope homogeneity between Earth and Moon. These data show that they formed from common materials homogenized as a consequence of the energetic Moon-forming impact. Systematic investigations of lunar maria also indicate a mineralogy-mediated O isotope dichotomy, manifested for low- and high-Ti basalts [13].

Magnesium. Although Mg is present in a significant proportion of lunar mantle, little attention has been made in characterizing Mg isotope systematics of various lunar reservoirs but recent analyses further confirm heterogeneous sources for mare basalts [7].

Iron. Fe isotope systematics also indicate a heterogeneous mantle but some sample-related inconsistencies resulted in different interpretations of the data [4,5], requiring further targeted studies. Computational evidence [3] suggests a unique character of the Earth–Moon tandem but careful experiments may produce important information on metal–silicate equilibration as well as effects of late-stage ilmenite accumulation from the lunar magma ocean on Fe isotopes.

Silicon. Conflicting results [2,14,15] exist for Si isotopes but preliminary results indicate small differences between anorthositic crust and mafic silicates [15]. It remains to be tested whether Si isotopes may be fractionated during magmatic differentiation.

Trace elements. *Lithium.* Although its geochemical nature is most applicable to low-temperature hydrous environments [16], available data show the lack of loss through any volatilization (as suggested by Fe and Mg data with similar condensation temperatures). Moreover, Li was among the first non-traditional stable isotope systems [6] to support the heterogeneous nature of lunar mantle sources for low- and high-Ti basalts [17], and to document implantation of Solar Wind into the very surface of lunar soils [6,18]. Also, the lunar anorthositic crust may be unique across the Solar System given its Li elemental and isotope systematics [6]; tracing dissemination of KREEP in lunar rocks may be possible using Li systematics.

Zinc, Copper. Volatile loss from the lunar interior in the aftermath of the Moon-forming impact has been assessed by Zn and Cu analyses of lunar soils and crystalline samples [8,9,19]. Large-scale depletion in Zn and Cu is explained through a Moon-forming impact event while volatile-rich reservoirs may locally exist, as exemplified by pyroclastic glass beads (but note enrichments in other, less volatile elements).

Chlorine. Hydrous versus anhydrous character of lunar volcanism has been contested with Cl isotopes in crystalline samples [10], showing a spectacular range of Cl isotope compositions far beyond other Solar System materials. The presence of specific Cl compounds in an H-poor environment have been proposed.

Conclusions: Several novel stable isotope systems explored in the last decade attested to source mantle heterogeneities that appear to be the major impetus in stable isotope dichotomy of lunar effusive volcanism. These major and trace element systems have gained considerable attention and are providing further constraints on the origin and evolution of the Moon.

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