SM-ND, LU-HF AND MN-CR COMPOSITIONS OF EUCRITE, DIOGENITE AND UNGROUPED ACHONDRITES: IMPLICATIONS FOR THE FORMATION AND SOURCES OF DIFFERENTIATED PLANETESIMALS

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Introduction: Achondrites are formed by igneous melting and single or multi-stage crystallization within planetary crusts. While the Howardite-Eucrite-Diogenite (HED) meteorites are the most abundant achondrites and are proposed to originate from the asteroid 4-Vesta [1], more than 80 ungrouped achondrites highlight the diversity of meteorite parent bodies. As chondrites, achondrites have a dichotomy in their O-Cr-Ti isotopic compositions [2] which can be used to establish genetical links between planetary objects, and compared with the timing of their formation. The HED belong to the non-carbonaceous (NC) clan, while the ungrouped achondrites NWA 2976, NWA 6704 and Tafassasset are affiliated with the carbonaceous (CC) clan, and linked to the CR chondrites [2]. To gain further constraints on planetary formation and differentiation and their reservoirs, we carried out geochemical analyses and isotopic analyses for short-lived and long-lived radiogenic systems ^{53}Mn-^{53}Cr, ^{147,146}Sm-^{143,142}Nd and ^{176}Lu-^{176}Hf (including their stable isotopes) in selected achondrites from both clans.

Samples: Bilanga and NWA 7977 are diogenites, while NWA 11001 and Tirhert are both unbrecciated gabbroic eucrites. NWA 12338 is an ungrouped achondrite with eucrite-like elemental composition but distinct isotopic and petrological features [3]. Literature ages of Bilanga [4], NWA 6704 [2], NWA 2976 [5] or Tafassasset [6] indicate that their crystallization occurred contemporaneously within 5 Ma after Solar System formation, while eucrites may have formed over a more protacted history [7]. Whole-rock powders for each meteorite ranging from 1.1g to 2.8g were prepared from individual interior chips or fragments without fusion crust. Plagioclase-rich and pyroxene-rich fractions were separated for NWA 11001, NWA 12338 and Tirhert.

Methods: LA-ICPMS analyses of minor and trace elements for minerals of NWA 6704, NWA 11001, NWA 12338 and Tirhert were obtained using a NWR193UC laser coupled with an Agilent 7900 qICP-MS at the University of Toronto. For Sm-Nd and Lu-Hf analyses, all samples including whole-rock and mineral separates were processed for analyses as described in [8]. Whole-rock compositions for minor and trace elements were obtained using a qICPMS iCAP at Western. Sm-Nd and Lu-Hf spiked isotopic dilutions, and unspiked Hf isotopic compositions were carried out using a Thermo Neptune Plus MC-ICPMS at UCA. Unspiked isotopic analyses of Sm and Nd by Thermo Triton Plus TIMS are ongoing at UCA. Cr isotopic data were obtained by Triton TIMS at Carnegie IW.

Results and Discussion: *LA-ICPMS* data shows Eu/Eu* anomalies of plagioclase are variable (17.0-32.7) for NWA 11001, NWA 12338 and Tirhert, while as low as 2.5 for NWA 6704; while for pyroxene, Eu/Eu* anomalies are absent. The whole rock have Eu/Eu* of 0.2-0.4 for diogenites, 1.3-1.8 for NC achondrites, and 0.6 to 2.4 for CC achondrites. Their compositions indicate various degrees of silicate partial melting and crystallization processes, and thus differentiation histories.

Mn-Cr systematics: NWA 6704 has a WR ε^{54}Cr of 1.63±0.10 similar to the report in [2]. NWA 11001 has a WR ε^{54}Cr of -0.26±0.08 which is on a lower end of the range reported for eucrites and suggests a formation towards a more inner region of the disk (e.g. [2]). The ε^{53}Cr of mineral fractions do not have a strong correlation with Mn/Cr ratios, which indicates that NWA11001 formed relatively late at 4543.9±12.3 Ma (when anchored to LEW 86010).

Whole-rock isochrons: When regressed with literature data on eucrites and angrites [7,9-11], we obtain a ^{176}Lu-^{176}Hf age of 4614±53 Ma for achondrites and ^{147}Sm-^{143}Nd age of 4538±58 Ma for eucrites consistent with their early formation (e.g. [4]). We do not find an anomalous λ^{176}Lu for Lu-Hf WR isochron. A deficit in μ^{178}Hf = -43±5 ppm in Bilanga, while other achondrites are similar to our standard. The stable Sm and Nd isotopic compositions are ongoing and will be presented at the meeting.

Ackwledgements: We thank the Smithsonian Institution, and Sean Tutorow and Adam Aaronson for meteorite loans and donations. **References:** [1] McSween H. Y. et al. (2013) *Meteoritics & Planet. Sci.* 48: 2090–2104. [2] Sanborn M. E. at al. (2019). *Geochim. Cosmochim. Acta*, 245, 577-596. [3] Guo Z. et al. (2019) 50th *LPSC*, Abstract #1583. [4] Hublet G. et al. (2017) *Geochim. Cosmochim. Acta* 218: 73–97. [5] Bouvier A. et al. (2011). *Geochim. Cosmochim. Acta* 75: 5310-5323. [6] Göpel C. et al. (2015). *Geochim. Cosmochim. Acta* 156: 1-24. [7] Bouvier A. et al. 2015. *Meteoritics & Planet. Sci.* 50: 1896-1911. [8] Bouvier A. and Boyet M. (2016) *Nature* 537: 399-402. [9] Bast R. et al. (2017) *Geochim. Cosmochim. Acta* 212: 303–323. [10] Blichert-Toft J. et al. (2002) *Earth & Planet. Sci. Lett.* 204: 167-181. [11] Sanborn M. E. at al. (2015). *Geochim. Cosmochim. Acta* 171: 80-99.