# GEOCHEMICAL AND OPTICAL CHARACTERIZATION OF THE LUNAR METEORITE TOUAT 005

M. S. Soukup[1], T. S. Hayden[1], G. R. Osinski[1] and L. Loiselle[1], [1]Department of Earth Sciences, University of Western Ontario, London, Canada (msoukup2@uwo.ca)

**Introduction:** The lunar meteorite Touat 005 is classified as a fragmental breccia, and was found in two pieces between the Erg Chech 002 achondrite locality and Tabelbala, Algeria. Collected in 2020 by meteorite hunters, the two fragments have a mass of 2035 g and 1675 g (total mass 3.71 kg). The two stones have been described as having a dark, shocked matrix with white euhedral anorthositic-noritic megacrysts and other lithic clasts, glass, and lack fusion crusts [1]. The megacrysts are cross-cut by filled fractures, and exhibit mosaicism and twinning. Previous scanning electron microscope (SEM) and imaging analyses have indicated geochemical affinities to the ferroan anorthosite (FAN) suite based on the composition of olivines and pyroxenes [1,2]. This study provides the initial results of the first detailed characterization of Touat 005.

**Methods:** Three polished thin sections of Touat 005 were analyzed via optical microscopy using an Olympus DSX 500 and a Nikon Eclipse LV100POL microscope (Fig. 1). These were prepared from a 55.5 g mass sample. The broad-scale geochemistry of the thin sections was collected via X-ray fluorescence (XRF) using a Bruker M4 micro-XRF with a voltage of 50 kV and beam current of 600 µA. All instruments used are at The University of Western Ontario Earth and Planetary Material Analysis Laboratory.

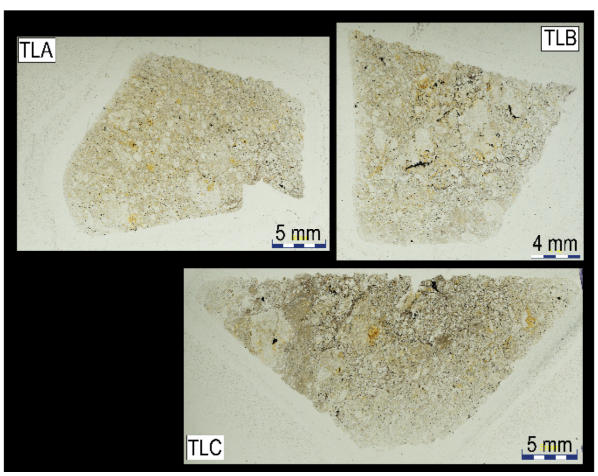


Fig. 1. Plane polarized light (PPL) maps of TOUAT 005 thin sections.

**Results**: *Petrography/Mineralogy:* The matrix of this polymict breccia is poorly sorted, dominated by mineral grains of low-calcium pyroxene (LCP), olivine, and plagioclase. Clasts (0.5-2.5 mm) are predominantly anorthosite, norite, and minor troctolite (Fig. 2). These clastic components are generally subrounded to sub-angular, highly fractured, and exhibit some form of shock deformation, including mosaicism, twinning, and fractured twinning. Glasses with flow banding are commonly observed, and usually exhibit entrained clasts, and rare vesicles (Fig. 2). Accessory minerals, opaque oxides, and similar components represent a minor percentage of the sample. Thin section TLA is dominated by the fragmental breccia matrix (Fig. 1), while TLB has the greatest abundance of opaque oxides, and a generally larger (>2 mm) clastic component than TLA. TLC also contains a large (>2 mm) clastic component, and has the greatest abundance of glass; glass is observed in all three sections, however.

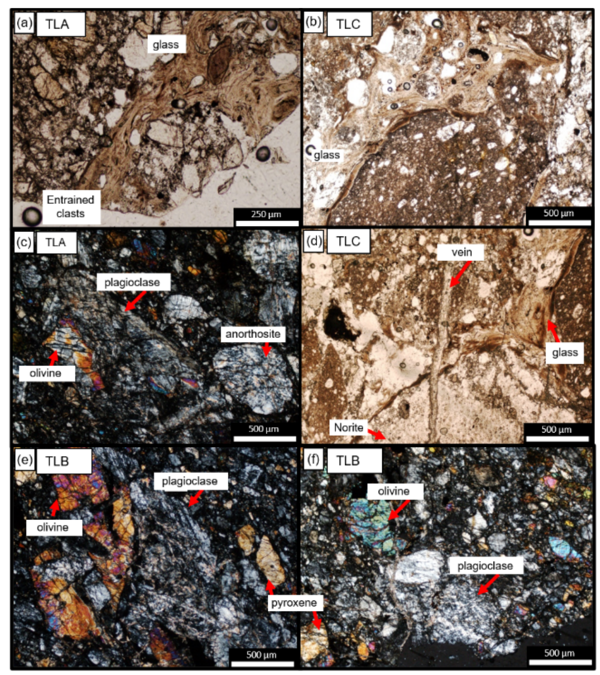


Fig. 2. Plane-polarized and cross-polarized images of impact melt, norite, and troctolite grains in a fragmental breccia are found throughout the TOUAT 005 sections.

The meteorite fragment has common veins that exhibit high relief in PPL (Fig. 2) and have high birefringence in XPL. XRF results indicate the veins have a calcium-rich fill. Cross-cutting relationships of the fractures with material in section suggest that the fractures are the youngest component.

XRF results (Fig. 3) indicate a high signal of Fe, Ca, Al, and Mn. This is consistent with optical observations of mafic silicates (including olivine and low-Ca pyroxene-rich lithologies). Variation in Al signal across the thin sections are indicative of variation in abundance of anorthosite, versus other more plagioclase-poor lithologies (e.g., norite, troctolite). There is a high K signal in isolated clasts, and a lower Mg signal that could indicate an absence of Mg-rich olivine and pyroxene across the thin sections.

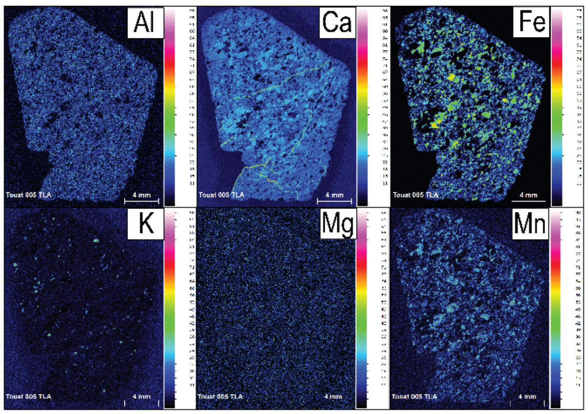


Fig. 3. XRF whole-rock image of Touat 005 mount TLA displaying geochemical differences between clastic and groundmass components.

**Discussion:** One of the most surprising findings of this study is the abundance of glass in Touat 005. The glass is present in all three studied thin sections, and shows flow textures and contains entrained clasts (< 20 μm) that are predominantly accessory minerals, LCP, and olivine (Fig. 1). Glass in lunar samples could be formed via either meteorite impact or from volcanic processes [3]. The properties of the glass and its spatial relationship with the mineral and lithic phases (Fig. 2) is most consistent with an impact melt origin. It is noteworthy that glass was not previously identified in this meteorite [1]. Backscattered electron (BSE) imaging would confirm the presence of crystallites and can be compared to other lunar glasses to constrain the textural nature of the Touat 005 glasses. Whether this glass is whole rock impact melt glass, mineral glass, or represents an agglutinate remains to be determined. As lunar meteorites can be sourced from anywhere on the lunar surface, the geochemistry of Touat 005 and its constituent components could broaden our understanding of the lunar crust and regolith outside the Apollo sample region and the effects of impact processing across a broad range of impactor sizes. As this meteorite was found near the same location as Erg Chech 002 achondrite [1], they may be sourced from the same parent meteorite.

**Conclusion:** Interpretation of the lunar meteorite Touat 005 indicates that it consists of a fragmental matrix with euhedral anorthositic-noritic megacrysts and other lithic clasts. Glass is distributed non-uniformly throughout the sample and is a significant new observation in this meteorite. Work on the texture and geochemistry of Touat 005, including electron probe microanalysis will also provide insight into the effects of impact melting at a small scale, which can be compared to a range of lunar impact melts to better understand melting processes at the lunar surface.

**References:** [1] Gattacceca, J. et al. (2021) *MaPS 56(8),* 1626– 1630. [2] Hayden, T. S. and Osinski, G. R. (2023) *NESF 2023* [3] McKay, D. S. et al. (1972) *LPSC III*, 983-994.