Dominion Range
18242, 18244, 18262, 18509, 18543, 18545, 18666, 18678

Polymict regolith breccia

140.85 g

Figure 1: DOM 18666 (left) as recovered and interior of DOM 18545 (right).

<u>Introduction:</u> The 2018-19 season ANSMET team recovered eight lunar meteorites (**Figure 1**), reported in three different newsletters (Satterwhite and Righter, 2019, 2020, 2022). All were found near the northern edge of the blue ice tongue or at the edge in the moraine (**Figure 2**). The largest mass is 45.87 g, ranging down to lowest mass of 5.46 g (**Figure 3**; **Table 1**).

Petrography and Mineralogy: All of the DOM lunar masses have greyish olive fusion crust, with gabbroic and feldspathic lithic clasts up to 0.5 cm in size. In addition to the lithic clasts are mineral (mostly pyroxene and plagioclase feldspar) and glass spherules (Zeigler et al., 2020; Hayden et al., 2022a). Both the mineral and lithic clasts can be seen in interior images of the meteorites (**Figure 4**). The matrix is coherent and fine grained, dark in color, and comprises most of the mode of the sample. DOM 18242 (and pairs) is a polymict regolith breccia that is dominated by basaltic material, but also contains anorthositic clasts and plagioclase fragments. (**Fig. 5 and 6**). Most components are mineral clasts of plagioclase feldspar and pyroxene, but there are also significant modes of gabbroic clasts and symplectitic clasts that are up to 3 mm in size (Figs. 5 and 6; see Gross et al., 2020; Hayden et al., 2022a; Ireland et al., 2021, 2022; McLeod et al., 2020; Schweitzer et al., 2022; Zeigler et al., 2021). There are also more feldspathic clasts such as quartz monzodiorites (Hayden et al., 2022a). Pyroxenes in the various paired masses exhibit a wide range of Mg# from 0 to 80 (**Figure 7**) with extensive overlap in composition between the various samples within the group (Gross et al., 2020; Hayden et al., 2022a).

Table 1: Samples in the DOM lunar pairing group (total mass = 140.85 g)

sample	DOM 18242	DOM 18244	DOM 18262	DOM 18509	DOM 18543	DOM 18545	DOM 18666	DOM 18678
Mass (g)	15.92	25.07	6.78	16.52	13.59	5.46	45.87	11.64
Log X	4.28	4.2	4.48	4.13	4.22	4.01	4.16	4.42

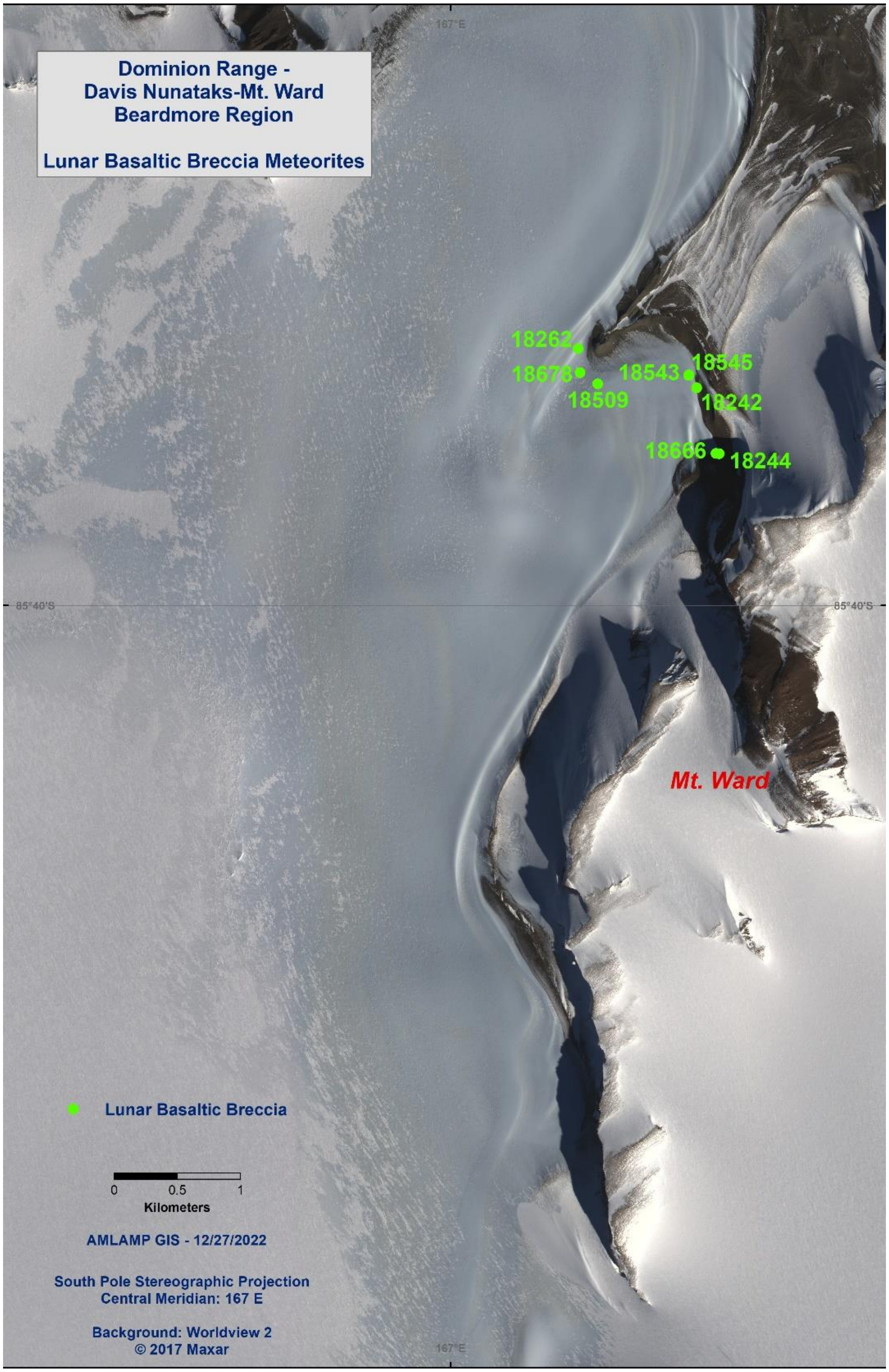


Figure 2: *Location of the 8 lunar meteorites from the Dominion Range 2018-19 ANSMET season. Worldview 2 image – 19 January 2017 (Copyright 2017 Maxar). All Maxar Worldview satellite imagery was acquired through Polar Geospatial Center. Support for this work provided by the Polar Geospatial Center under NSF-OPP awards 1043681 and 1559691.*

Figure 3: *Field photos of the eight DOM lunar meteorites from lowest number in upper left to highest in lower right (242, 244, 262, 509, 543, 545, 666, 678). Field photo image(s) courtesy of the **ANSMET** Program, Case Western Reserve Univ. and the Univ. of Utah.*

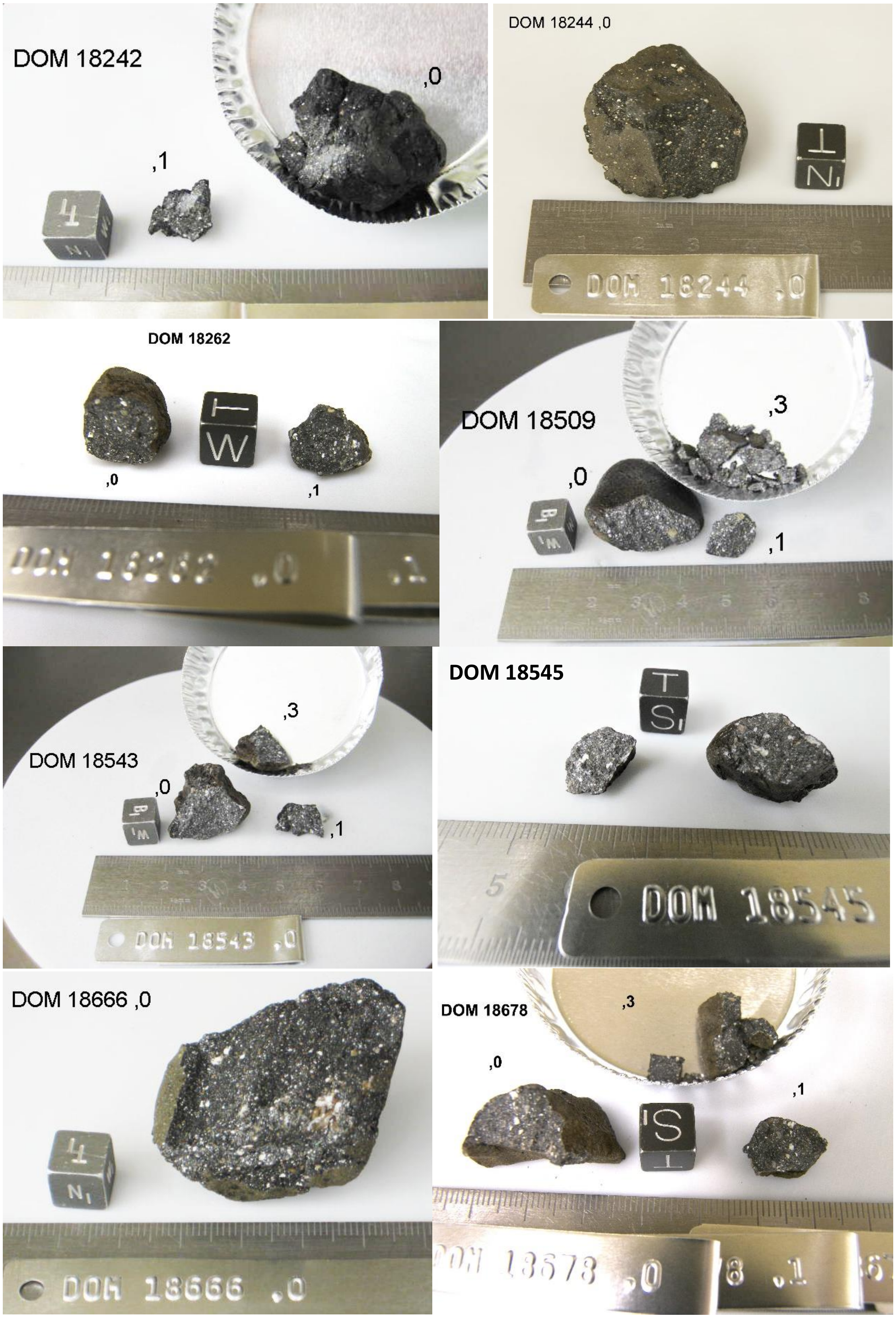
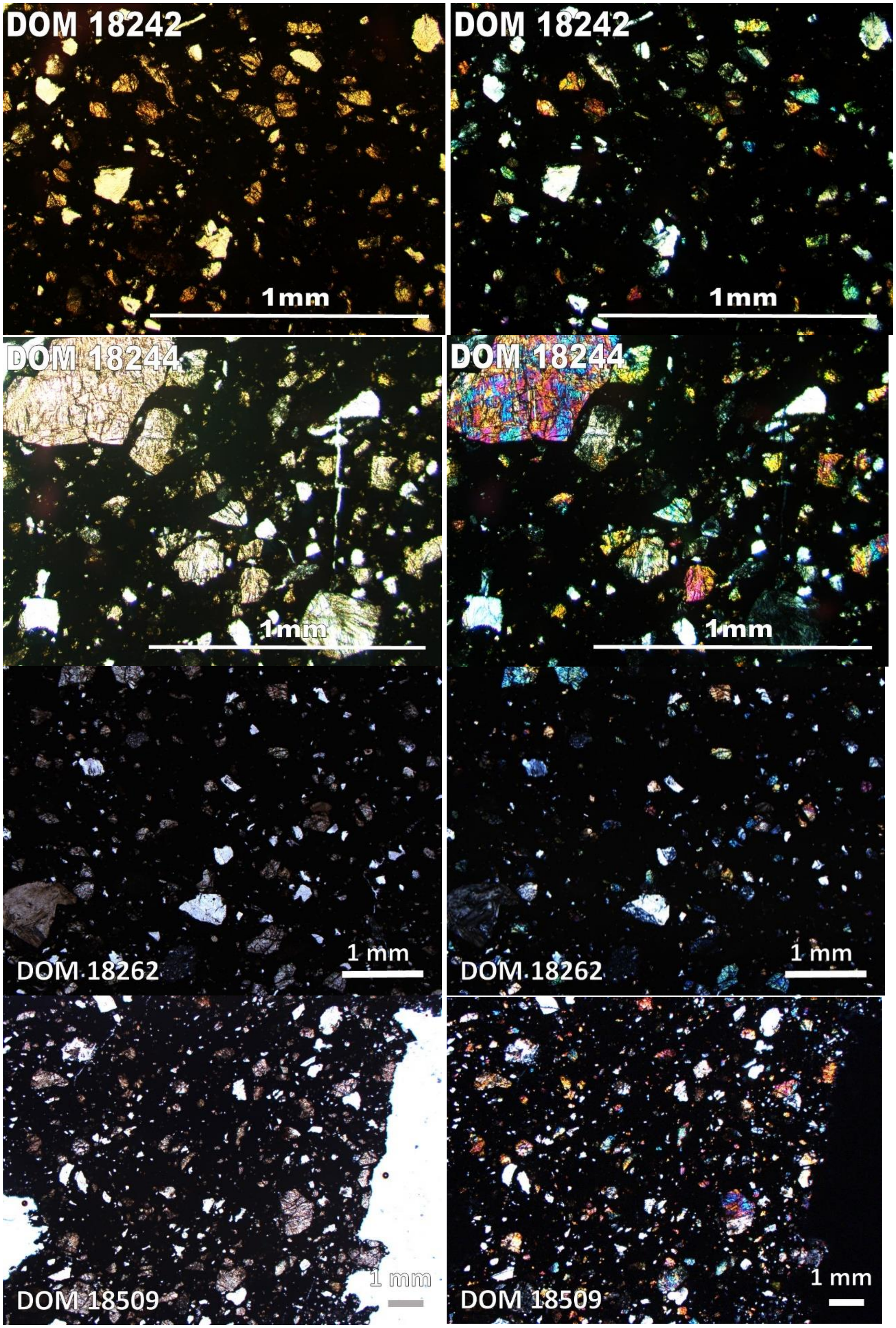


Figure 4: *Macroscopic images of lunar meteorites from lowest number in upper left to highest in lower right (242, 244, 262, 509, 543, 545, 666, 678), illustrating the basaltic (dark) and feldspathic (white) clasts and the dark matrix.*


DOM 18242
1mm
DOM 18242
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DOM 18244
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DOM 18244
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DOM 18509
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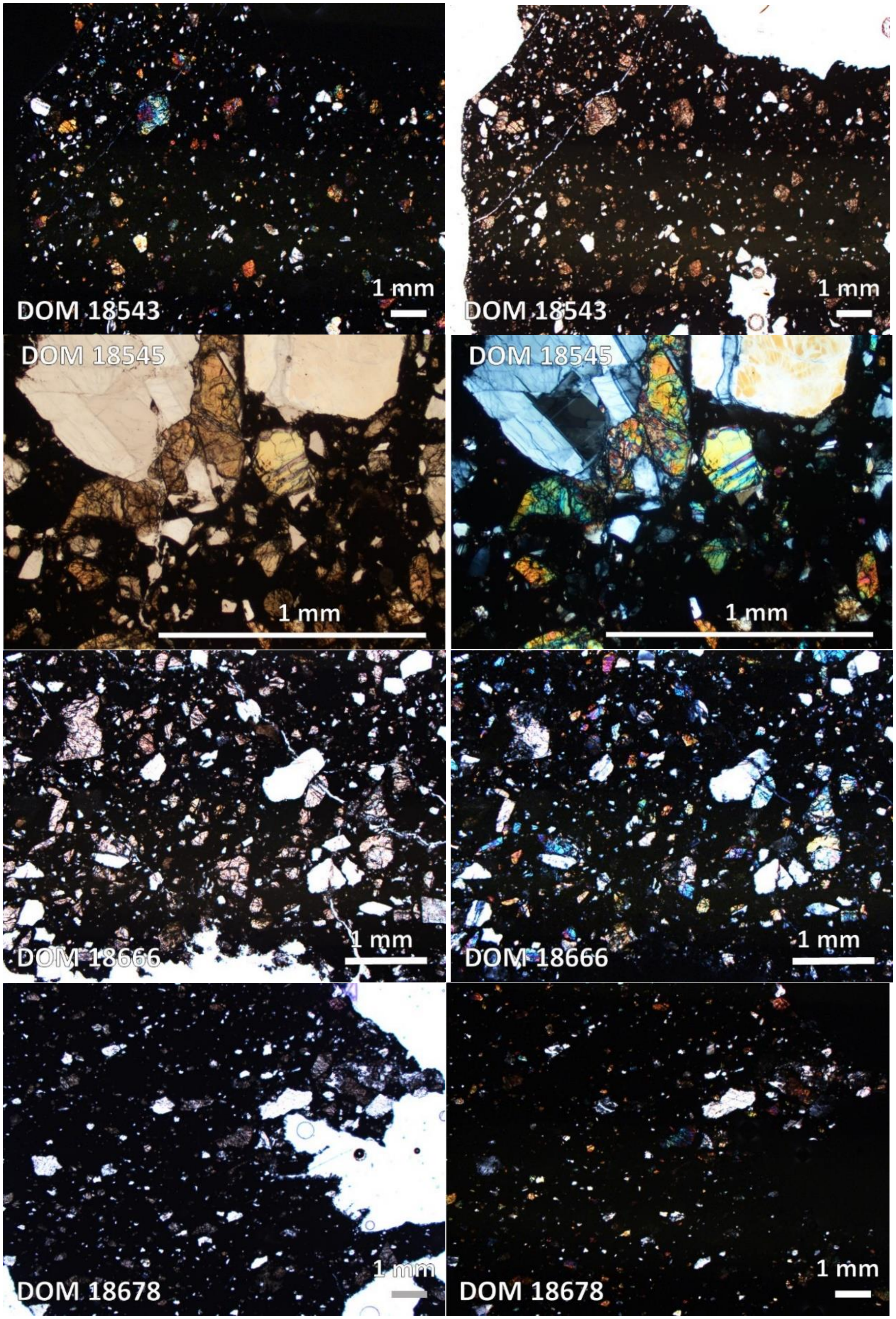

Figure 5: *Microscopic images of the eight DOM lunar meteorites, illustrating the basaltic clasts and fragmental brecciated texture. Left hand column of images is plane polarized light while the right hand column of images are cross polarized light.*

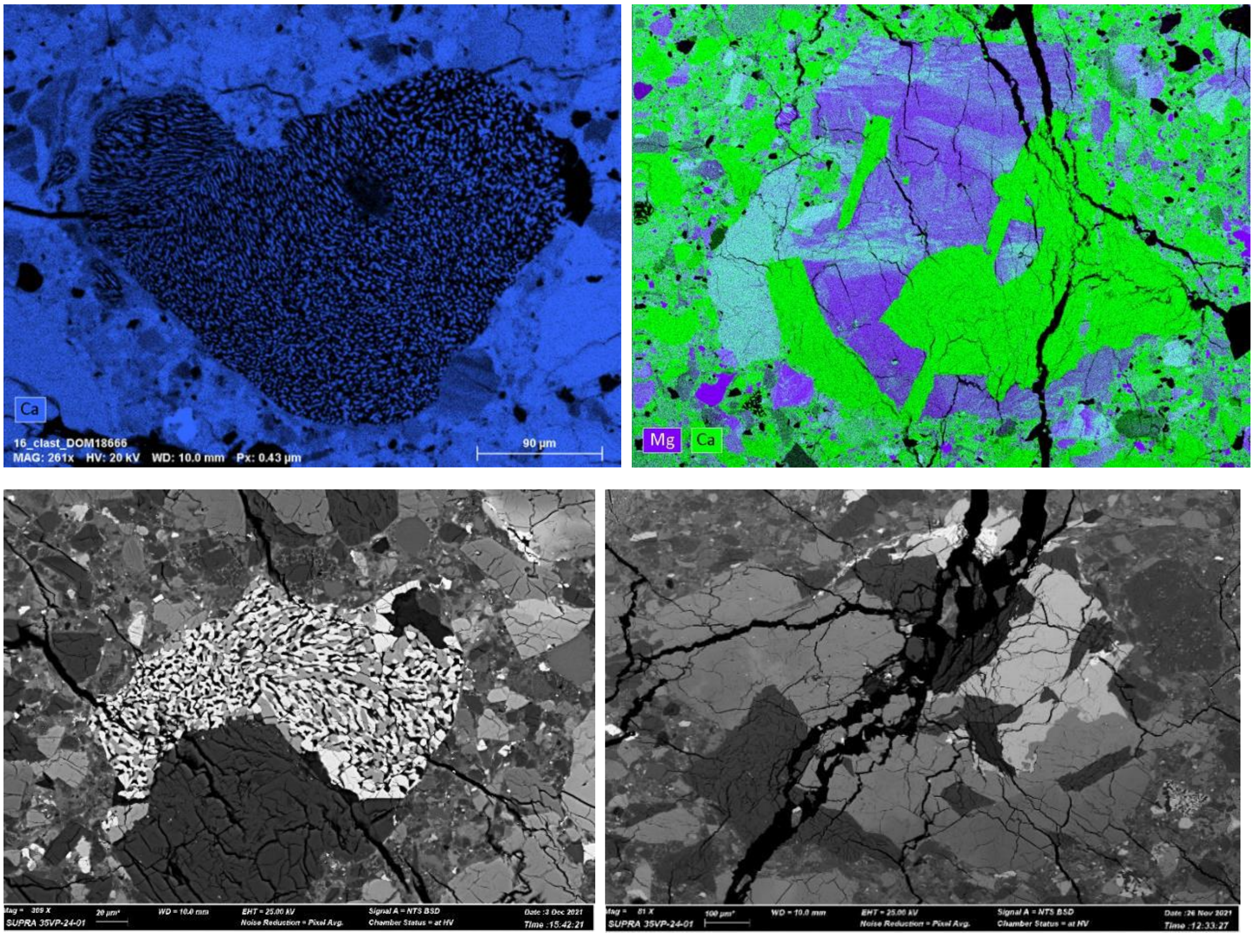

Figure 6: *Images of lithic clasts in DOM 18666 and DOM 18543. Top Left: Ca elemental map of a symplectite (from Ireland et al., 2022). Top Right: Elemental map of a gabbroic clast in DOM 18666 (from Ireland et al., 2021). Bottom left: Backscattered electron image of a symplectite from DOM 18543 (from Schweitzer et al., 2022). Bottom right: Backscattered electron image of a gabbroic clast from DOM 18543 (from Schweitzer et al., 2022).*

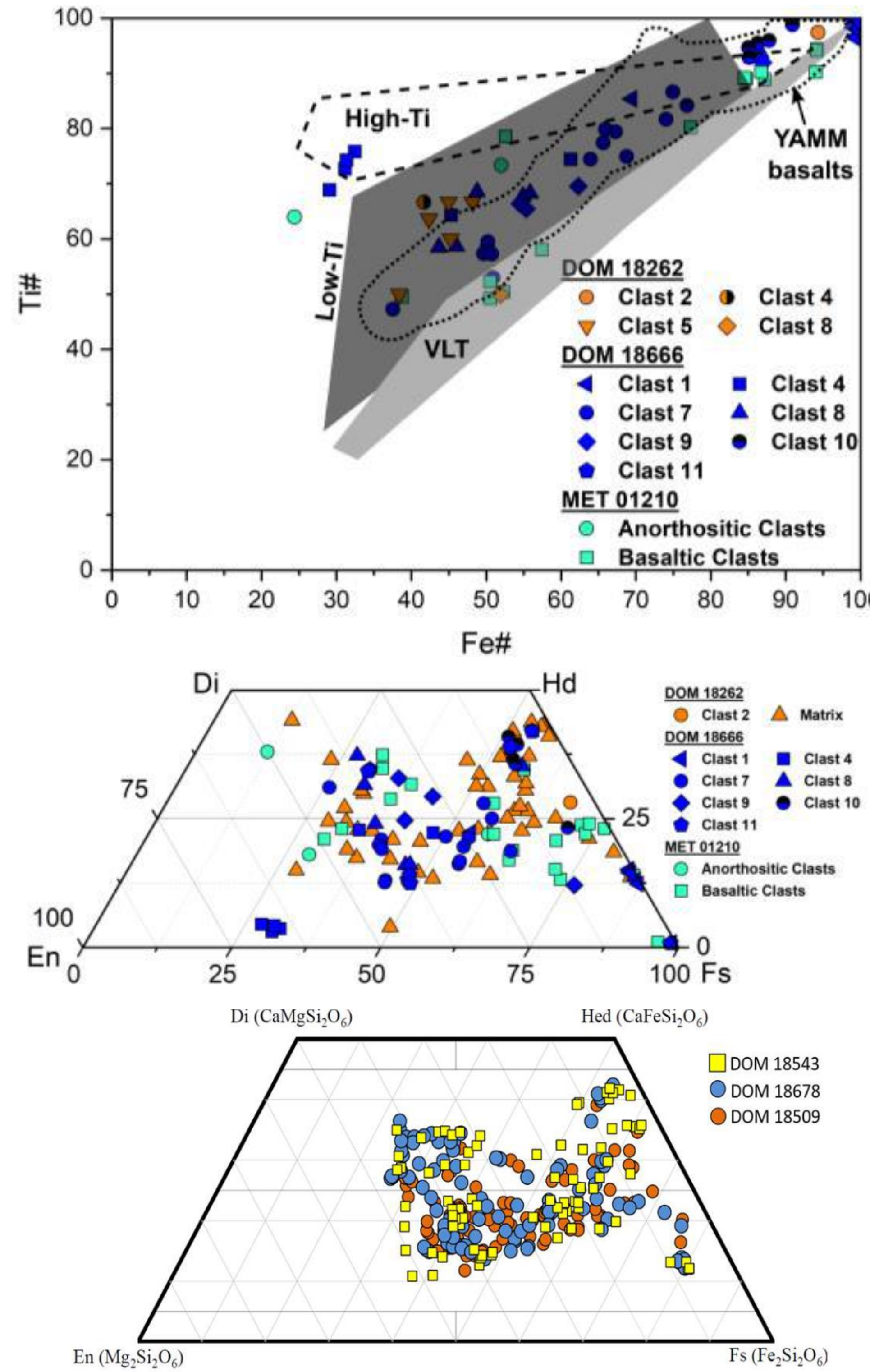

Figure 7: *Pyroxene compositions from several of the paired masses from the DOM lunar meteorites. Top: Ti# versus Fe# for DOM 18262 and DOM 18666 compared to MET 01210 and Apollo basaltic pyroxenes (from Hayden et al., 2022a). Middle: Pyroxene quadrilateral diagrams for DOM 18262 and DOM 18666 compared to MET 01210 (from Hayden et al., 2022a). Bottom: Pyroxene quadrilateral diagrams for DOM 18509, DOM 18543, and DOM 18678 (from Gross et al.. 2022).*

Measurements of magnetic susceptibility were made with an SM30 handheld magnetic susceptibility meter, used routinely at JSC as a non-destructive characterization technique. All 8 have a range from 4.01 to 4.5 (**Figure 8**). Comparison of magnetic susceptibility values for the DOM lunars to other lunar meteorite types shows they are somewhat unique among the lunar meteorites. The values range between 4.01 and 4.48, similar in magnitude to two other lunar meteorites – the basaltic fragmental breccias MET 01210 and NWA 3136 (**Figure 8**).

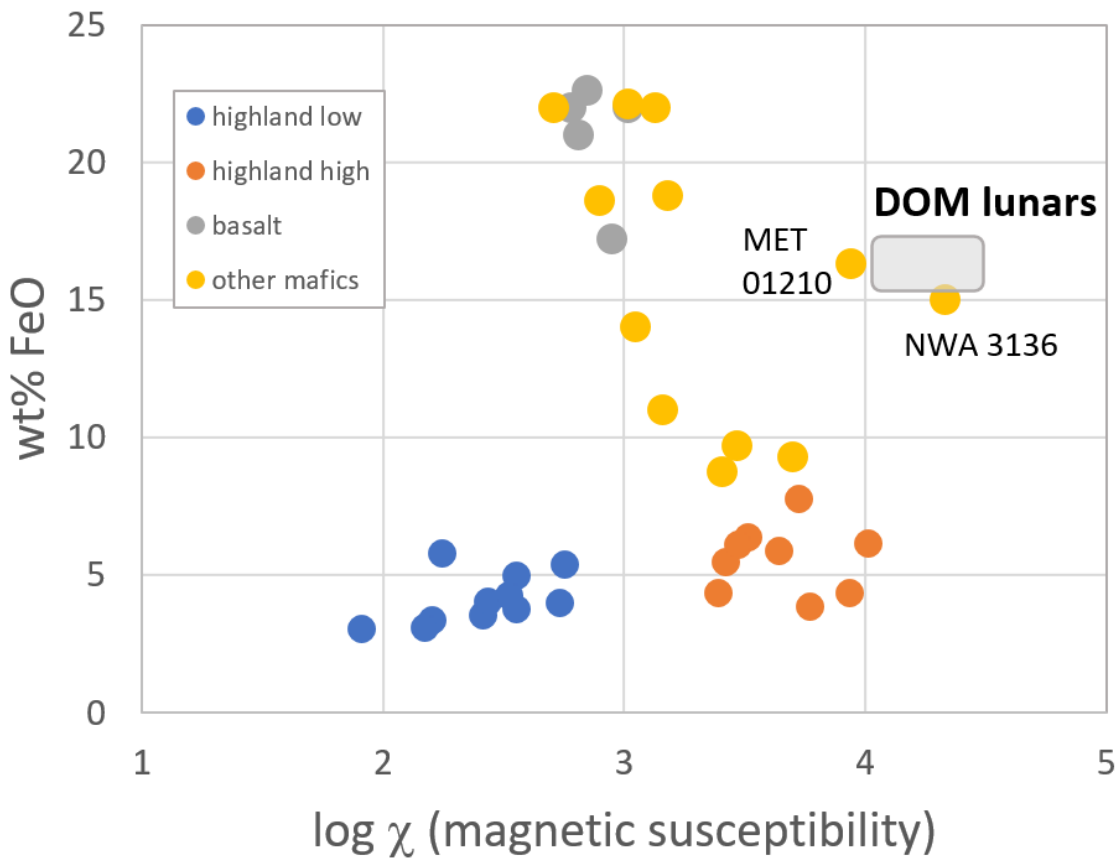

Figure 8: *Magnetic susceptibility (logχ) vs. bulk FeO (wt%) for lunar meteorites. Data from Rochette et al. (2010) (highland, basalt, and other mafics), and from this study. "DOM lunars" field is based on our magnetic susceptibility measurements combined with bulk FeO content measured on fusion crust reported by Gross et al. (2020).*

Chemistry

All three meteorites contain glassy fusion crust that is highly vesicular, high in FeO and Al_2O_3 (15-17 wt% each), ferroan (Mg# of 23-24), and moderately rich in TiO_2 (1.4-1.8 wt%). The composition of the fusion crust can serve as a proxy for the bulk meteorite composition and is identical within error for all three meteorites.

Measurements of volatile elements in apatites from a few of the DOM lunars have allowed a better understanding of their volatile content (H, Cl, F, S) (Hayden et al., 2021, 2022b), and have indicated the possibility of heterogeneous volatile contents of the lunar interior (**Figure 9**).

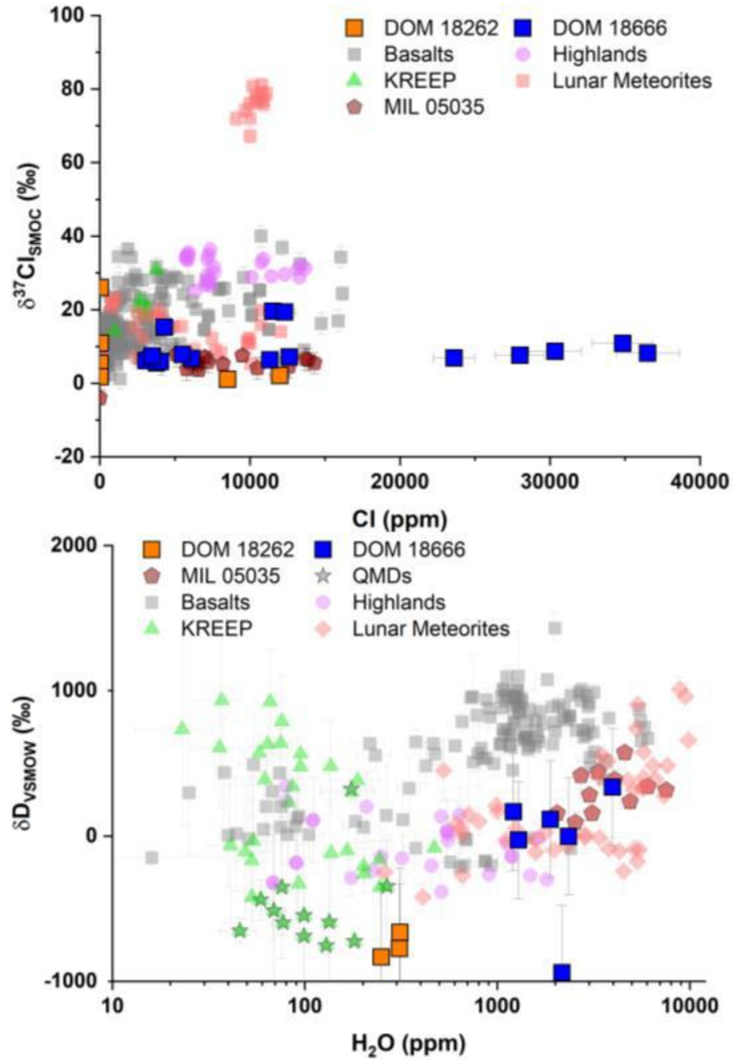

Figure 9: *Top: δ^{37}Cl (‰) vs. Cl (ppm) of DOM 18262 and 18666 apatite compared to literature data. Bottom: δD (‰) vs. H_2O (ppm) of apatite in DOM 18262 and 18666 compared with literature data. Both figures from Hayden et al. (2022b).*

Radiogenic age dating

Hayden et al. (2022a) report a Pb-Pb age of 3.86 to 3.96 for apatite grains from basaltic clasts in DOM 18262 and DOM 18666.

Summary

Studies of the petrology and geochemistry of the DOM lunar meteorites has shown they are indeed a mixture of basaltic and feldspathic materials and are polymict regolith breccias (Gross et al., 2020; McLeod et al. 2020; Zeigler et al., 2021; Ireland, et al., 2021). Petrologic similarities and similar (and somewhat unique) magnetic susceptibility values to the MET 01210 polymict breccia suggest that they could be launch paired (Gross et al., 2020; Hayden et al., 2022a). This could also be supported given the similarity in bulk composition of high FeO contents indicative of dominantly basaltic material. Finally, the ages of basalt clasts are similar to those reported for the YAMM group in general. All this evidence points to a connection to the YAMM launch paired meteorites, which are thought to have originated near a cryptomare basalt flow located in the Schiller-Schickard crater region where the regolith would be thicker than typical mare, and proximity to mare and highland material (Arai et al., 2010; Hawke et al., 2006). This location was suggested as a source crater based on the 3.8-3.9 Ga eruption age, basalt with ~ 2 wt% TiO_2, a mare:highland mixing ratio of 68:32, surface regolith composition of 16.4 wt% FeO and 0.9 ppm Th, a lack of pyroclastics, and an extremely young and small crater (Arai et al., 2010; Hawke et al., 2006).

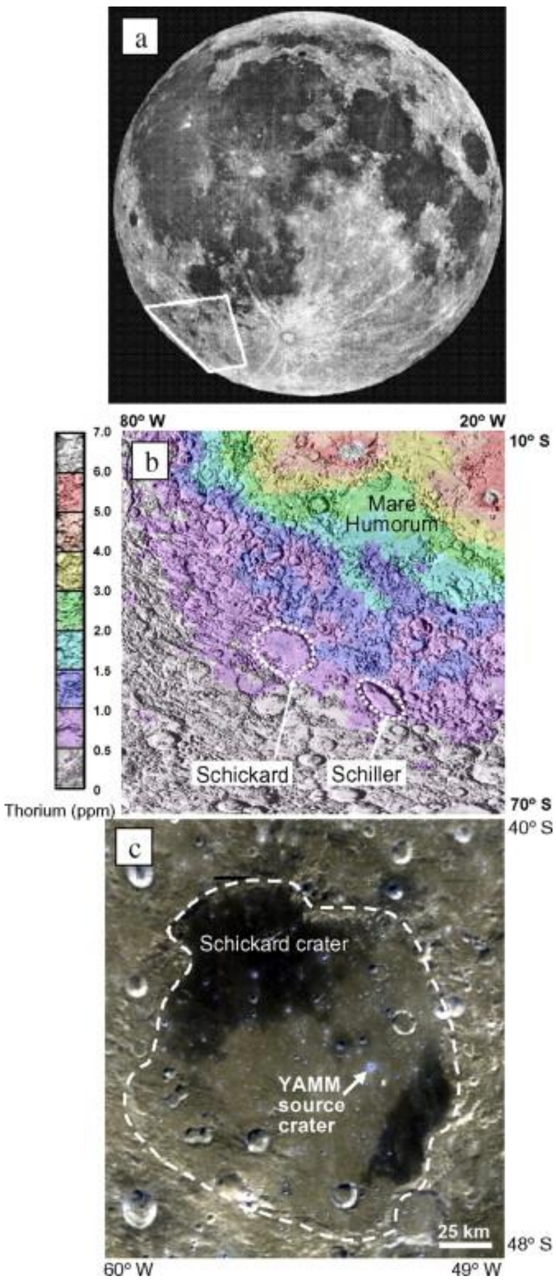

Figure 10: *Location of Schickard Crater and Schiller-Schickard cryptomare region (and low Th) on the nearside of the Moon, showing the potential source crater for the YAMM meteorites on the floor of Schickard Crater (Figure from Arai et al., 2010).*

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Kevin Righter, April 2024