COMPOSITIONAL AND MORPHOMETRIC EXPLORATION OF VAN DE GRAAFF CRATER ON THE LUNAR FARSIDE. D. R. Hood[1], P. James[1], J. Lee[1] 1: Baylor University, Department of Geosciences. (Don_Hood@baylor.edu)

Introduction: In a report produced by NASA's Constellation program, Van de Graaff (VDG) crater was identified as a site of significant fundamental science interest [1]. This crater likely formed in a rare doublet impact event, which represent 2-10% of known impact craters [2] and overlapping "peanut" doublets likely represent <10% of doublet impact scenarios [3]. In addition to the unique formation event, VDG crater has been proposed to host ancient volcanic deposits (cryptomaria) in its floor [4] which are partially covered by debris from the nearby Birkeland crater (Fig. 1). Potential post-impact volcanism as well as uncertainties of the mechanics of doublet impacts make it unclear whether some of the topographic features within the crater (ROI 1, 2, Fig. 1) are of impact or volcanic origin.

The craters of VDG and neighboring Birkeland (Fig. 1) are also poised on the edge of the South Pole Aitken (SPA) impact basin, the largest universally-recognized impact basin on the lunar surface [5]. Hydrocode models of large lunar impacts provide predictions for the excavation of mantle material, as well as the crustal structure near such large basins [6]. These models predict that excavated mantle material will cover large areas within the basin, in part due to central uplift materials being thrust over inward-collapsing crater rim materials [6].

Current observations of VDG and Birkeland craters yield interesting questions about their formation as well as the crustal structure beneath them: 1) Is the large massif in the SW basin of VDG an uplifted central peak? 2) Are the topographic features in the NE basin of VDG a central peak cluster? 3) What can the central uplifts of Birkeland and VDG tell us about the deeper structure of the crust in proximity to the SPA basin? 4) Did the VDG impactor excavate material from below the SPA melt sheet [7]?

Proposed Investigation: To better understand the impact processes that formed VDG crater, and to probe the subsurface structure in the vicinity, we propose an investigation of local mineralogy and morphometry. This exploration is expected to clarify the origin of uplifted materials in the two basins, the thickness of floor deposits in VDG, and better constrain the pre-volcanic topography of VDG.

We will primarily use data from the Moon Mineralogy Mapper (M3) instrument [8] to identify the mineralogy of surface materials within the craters. Primary sites of investigation will be topographic

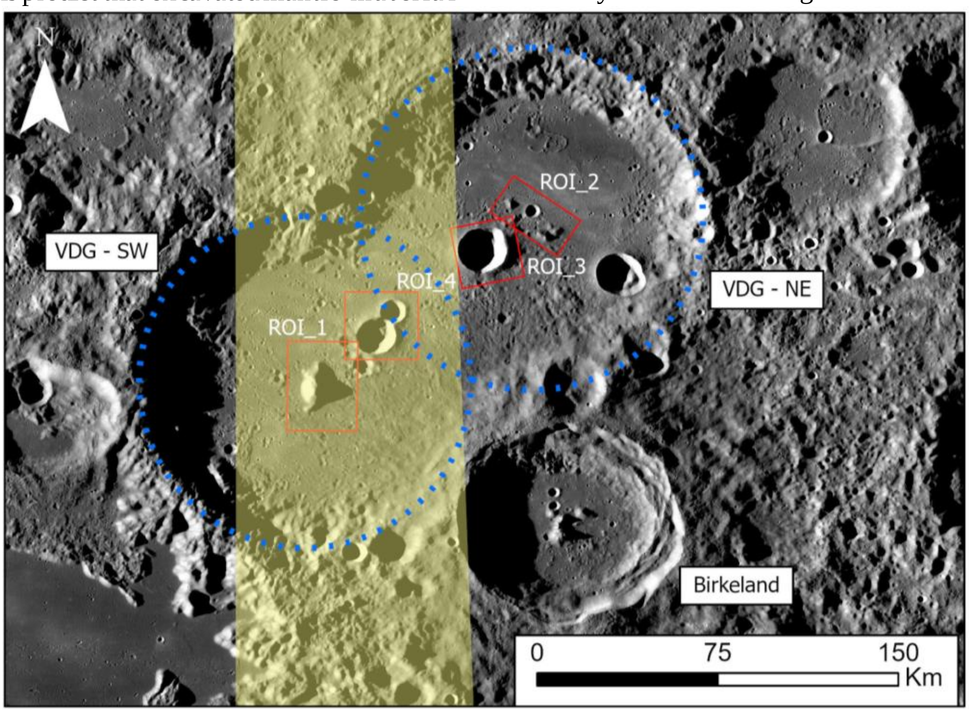

Figure 1. *LRO Wide Angle Camera mosaic and regions of interest (ROIs) in the vicinity of Van De Graaf crater including Birkeland Crater to the SE. Five M3 images intersect VDG crater, with the footprint of the image used in Fig. 2 shown in yellow.*

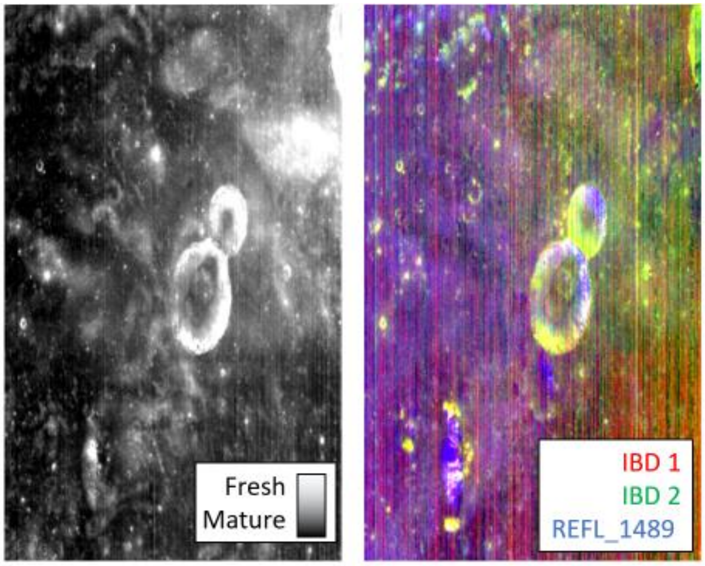

Figure 2. *Optical maturity (OMAT, Left) and mafic mineral composite (R: 1µm Integrated Band Depth (IBD 1), G: 2 µm IBD, B: Reflectance at 1.489 µm, after [4]) in the SW basin of VDG Crater covering ROIs 1 & 4 (Fig. 1). A pair of craters in the current floor of VDG (image center) expose fresh, mafic material (yellow-orange in composite, white in OMAT). Notably, the edifice in the lower left does not appear mafic at the peak.*

features in each basin (ROI-1, 2, Fig. 1) and crater walls within the basin-filling material (ROIs 3-4). We will examine the mineralogy of topographic features in ROI 1 and 2 to determine if they are exposed crater central peaks or volcanic edifices that formed post-impact. This analysis may also determine how deeply the VDG impactor(s) excavated during impact, as the uplifted material may be typical lunar highlands material or lower crustal material originally excavated in the Aitken Basin impact. ROIs 3 and 4 will be examined to constrain the thickness of basin-filling material, informing pre-volcanic basin topography. Craters in the current floor of VDG exceed 1.5 km in depth and may penetrate the volcanic infill, exposing VDG floor materials. These analyses will be supported by other compositional data (e.g. LP GRS, Clementine, SIR-2) as needed.

Methods: We will use a variety of established methods to analyze the M3 data, including the techniques used to identify cryptomaria in VDG [4] and estimations of iron abundance [9,10]. Images and spectra will be analyzed using PyHAT [11] and WISER [12].

Preliminary Results: Initial investigation with M3 images (Fig. 2) suggest distinct compositions of the VDG edifice (ROI 1, VDG SW Peak), VDG basin material (ROI 4) and the Birkeland central peak (Fig. 3). Most ROIs have a mafic signature with deep 1- and 2-µm absorptions, but the central peak of the VDG SW Basin has much smaller absorptions in these bands.

Mafic material appears to be exposed in the areas flanking the peak (Fig. 2,3) despite relatively shallow absorptions in the 1- and 2-µm. This could be mafic material excavated from depth, debris from the Birkeland impact, or material originating from the volcanic event that filled the floor of VDG.

These preliminary results support the interpretation of the topographic feature in the SW basin as a central peak that may excavate feldspathic highlands-like material, most likely originating from crust that was buried under SPA-excavated mantle material [6]. However, more detailed and quantitative work will be required to determine a more precise origin of this feature as well and answer the other proposed questions regarding the development of this unique binary crater.

References: [1]: Gruener, J. E. (2009). NASA, **[2]**: Bottke, W. F., & Melosh, H. J. (1996). *Icarus*, **[3]**: Miljković, K., et al., (2013). *EPSL*, **[4]**: Whitten, J. L., & Head, J. W. (2015). *Icarus*, **[5]**: James, P. B., et al., (2019). *GRL*, **[6]:** Miljković, K., et al., (2015). *EPSL*, **[7]**: Vaughan, W. M., & Head, J. W. (2014). *Planetary and Space Science*, **[8]**: Green, R. O., et al., (2011). *JGR: Planets*, **[9]**: Wöhler, C., et al., (2014). *Icarus*, **[10]**: Bhatt, M., et al. (2018). *Icarus*, **[11]:** Laura, J. R., et al., (2022). In *Machine Learning for Planetary Science* (pp. 55–90). Elsevier. **[12]:** Greenberger, R. N., et al.,(2022). *LPSC* 2022 Abstract #2381.

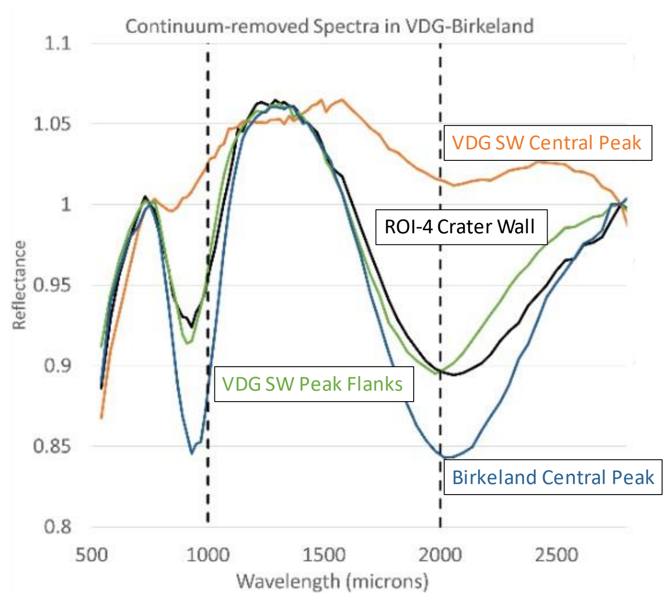

Figure 3. *Continuum removed spectra from several areas of interest in VDG and Birkeland craters.*