analyzed here, Birt E has morphological characteristics that strongly suggest a pyroclastic origin: (1) irregular depression that could be a vent, (2) almost circular pattern of the dark albedo deposit that is consistent with Birt E as the source, and (3) a low albedo at 0.75 μm that is readily visible in the M^3 images (Figure 6a).

Although mare units west and east of Birt E are readily separated in two units based on the IBD1000 (Figure 6b, yellow outline), the DMD resembles the western mare unit and this parameter alone does not serve to isolate the DMDs. However, Figure 6c clearly captures the extent of the DMDs by mapping the band depth at 1.25 μm (i.e., the blue channel of the color map), and this suggests that the 1 μm band center of the DMD is near that longer wavelength. As it can be seen in Figure 6f, the 1 μm band for the DMD is also slightly wider than in the mare unit spectra, suggesting that a component such as volcanic glass or olivine may be present. The spectra in Figures 6e–6f do not show strong variations of the band position at 2 μm but do show band centers near 2.1 μm (although the one from the DMD is shifted to slightly shorter wavelengths). It is clearly the wider 1 μm absorption band that characterizes the uniqueness of possible Birt E DMDs. Color ratio (i.e., ultraviolet-visible slope) using Clementine observations can also isolate the dark deposits suggesting a lower titanium concentration than the surrounding mare basalts [see *Gustafson et al*., 2012, Figure 14b]. It is not unusual to have strong variations of the titanium level in the DMDs [*Gaddis et al*., 2003], and in mare basalts as well [*Staid et al*., 2011]. Although the shape and position of the 1 μm absorption band of the DMDs could be consistent with olivine, the position of the 2 μm band and its strength relative to the 1 μm band is more consistent with the presence of volcanic glass, and in particular orange glass.

From the M^3 observations, the Birt E DMDs candidates are not only distinguishable from the surrounding mare basalts in terms of albedo but they also exhibit different mineralogy. The change in position and shape of the absorption is also consistent with the presence of volcanic glass. Coupled with the morphological evidence, Birt E could be considered as a likely DMD. It is noted that the DMDs do not show darker reflectance at 2.94 μm as seen for Schluter. This could be due to the presence of mare basalt materials that are already very dark, thus making the identification of DMDs more difficult at this location and at the M^3 wavelengths.

4.5. Walther A

Walther A is a small crater (diameter of 11 km) located within the crater Walther (135 km diameter), itself located in the highlands ~450 km northeast of Tycho and southeast of Mare Nubium (Figure 1). The dark deposits associated with possible DMDs are located north of Walther A, which is itself north of the central peak of Walther. The terrain in the crater floor around Walther A appears rougher with some topographic features that could be part of a central peak complex.

From Figure 7a, several deposits appear darker in the region. However, only the deposits around Walther A display 1 μm mafic absorption bands (Figures 7b and 7c) and lower reflectance at 2.94 μm (Figure 7d). The mafic signatures match spatially with the lower reflectance of Figure 7d and the outline of the DMDs proposed by *Gustafson et al*. [2012]. The low-albedo deposits are mainly concentrated around the impact crater Walther A and are potentially related to ejected materials from the impact itself. However, some of the dark material is found inside the Walther A impact crater. Examination of LROC-WAC data (Figure 7e) shows that the dark deposit inside the crater (highlighted by black arrows) could also be related to ejecta from a smaller impact crater (highlighted by a white arrow). The low-albedo feature south of Walther A at 0.75 μm (i.e., location of spectrum W-S) still appears darker in the albedo map at 2.94 μm (Figure 7d), although it is lighter than the deposits around Walther A. However, as seen in Figures 7b and 7c, and also in the spectra of Figures 7e and 7f, these deposits do not exhibit mafic absorptions. Investigations of spectral characteristics as a function of distance from Walther A are plotted in Figure 7f with a continuum removal (W-Cs, W-Cm, and W-Cn). The only notable spectral variation observed is a change in the depth of the absorption for the 1 and 2 μm bands. No shift of the band position, as was seen in the case of Alphonsus where the band position changed with distance from the source [*Jawin et al*., 2013], was observed. This change in band depth is more likely related to the thickness of the deposits as a function of distance from the impact crater and/or a mixing with more feldspathic material from the floor. However, like the spectra from Schluter and Birt E, the band positions at 1 μm are shifted to longer wavelengths and the band position at 2 μm to shorter wavelengths relative to pyroxenes. This also indicates the presence of volcanic glass, which is a common component of DMDs [e.g., *Gaddis et al*., 1985]. The position of the 1 μm band and the relative intensity between the two bands is more consistent with the presence of orange glass. In the case of the Walther A dark deposit, no olivine signature could be observed in the deposits associated with the DMD.