Luxuriae are superimposed on the northern portions of both Areas 1 and 2. Given the depth of the largest crater in Lacus Luxuriae (LL-C in Figure 3a, left side of Area 1), it is most likely that the crater has punched through the older volcanic layer, which exhibits a different mineralogy and especially a weaker 2 μm band (Area 1). The ejecta from the impact cover a portion of Area 2 that extends further east. They define Area 1 and have the same composition as a portion of the proposed DMDs covering the southern part of Buys-Ballot (orange color, Area 1) and could therefore explain the mantling description given by *Gustafson et al*. [2012] if they correspond to ejecta. The deposits extending further southwest have stronger absorption bands that are consistent with small spots within Anderson E and F (green color, Area 2). It is noted that the deposits in Buys-Ballot Q also exhibit two different compositional units, which are consistent with Area 1 and also are associated with a crater that could have excavated a deeper layer with different mineralogy.

Individual spectra, specifically LL-Ce and LL-Ne, (Figures 3e and 3f), confirm that the Area 1 unit has weak absorptions, characteristic of mature soils. The spectrum LL-C has stronger absorptions because it is associated with a fresh crater. The 2 μm absorption band of LL-C is shallow, but the 1 μm absorption band is quite strong, broad, and characteristic of an olivine-rich composition. The LL-C spectrum can be compared with other fresh craters in the Area 2: LL-S, LL-Nw, and BB-C, which all have strong 1 and 2 μm absorptions indicative of the presence of a mafic mineral such as high-calcium pyroxene, supporting a mare volcanic origin for many of these deposits. However, the 1 μm absorption in the spectrum of LL-C is both broad and occurs at longer wavelengths than the other fresher craters indicating a strong enrichment of olivine in Area 1. Thus, olivine content likely is the main difference between the two clearly defined mafic units within the proposed DMD of Lacus Luxuriae. From Figures 3e and 3f, it can be seen that the mafic signatures within Anderson E and F are more consistent with an olivine-poor mafic composition as seen also in the spectra of Ae-S and Ae-N. None of the individual spectra exhibit band position and asymmetry that could be associated with volcanic glass.

Based on the mineralogy, if the deposits at Lacus Luxuriae are pyroclastic in origin, they must be divided into two distinct deposits of roughly equal size. This would imply that two distinct volcanic episodes have emplaced pyroclastic deposits adjacent to each other. Another explanation could be that part of the DMDs is covered by the ejecta of the fresh crater in Lacus Luxuriae; however, this does not explain why the ejecta have the same albedo. From the albedo maps at 0.75 μm (Figure 3a) and at 2.94 μm (Figure 3d), the proposed DMDs do not appear darker in the M^3 images as is typical of other likely DMDs (see sections 4.3 and 4.5). Together with the spectral characteristics, this makes the Buys-Ballot dark deposits less likely than Anderson E and F craters to be a DMD because its emplacement would need to have been very complicated. We propose a basaltic origin of these deposits that is comparable to that of other basaltic deposits in Freundlich-Sharonov basin as proposed by *Gustafson et al*. [2012]. Anderson E and F craters do not show specific mineralogical signatures (e.g., volcanic glass) that would clearly indicate pyroclastic origin. However, morphological evidence from *Gustafson et al*. [2012], including the presence of possible low-relief vents in association with floor fractures, still argues in favor of a pyroclastic origin for the dark deposits in Anderson craters E and F.

4.2. Kopff

Kopff is a crater (41 km diameter) located in the eastern portion of the Orientale basin. The floor of the crater is dominated by numerous fractures, which are more concentrated in the southern part. The northern part of the crater is slightly elevated with isolated massifs. *Gustafson et al*. [2012] proposed that the entire floor of Kopff and a small extent to the south (i.e., spectra K-S in Figure 4) are covered with possible DMDs.

From Figure 4b, a map of the strength of absorption bands at 2 μm, it appears that most of the crater floor shows a general mafic enhancement, but that fresh mafic signatures (with stronger and deeper absorption bands) are limited to small features that are either fractures or impact craters. A limited number of these mafic signatures are also located in the walls of the crater. Note that some portions of the floor show very weak mafic signature; they are outlined in white for the Area 1 in Figures 4a–4d and correspond to bright crater rays derived from large craters outside the scene and superposed on the floor. Units with low reflectance at 2.94 μm (arrows in Figure 4d), located close to the inner rim, are also associated with strong mafic absorptions. Figure 4c shows similar results, with strong absorptions (i.e., bright features) associated with small, fresh craters, fractures, and low reflectance at 2.94 μm. The black outline in each image of Figure 4 corresponds to the spatial extent of the ejecta of the larger fresh crater on the eastern portion of the floor. The proposed DMDs that extend south of the crater are slightly distinguishable in Figure 4c with a bluer color.