# DALLOL DOME MINERAL MAPPING USING LANDSAT MULTISPECTRAL DATA

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## ABSTRACT

The Dallol hydrothermal dome is located at the Danakil plain of Ethiopia, in the Afar triangle depression. The region is structured by three rifts, the Red Sea oceanic ridge, the Gulf of Aden oceanic ridge, and the Main Ethiopian Rift which is at a continental stage of extension. The Red Sea and Gulf of Aden rifts split the African and the Arabian plates in two perpendicular directions and meet in the Strait of Bab-el-Mandeb. However the oceanic extension is not exactly linear since the ridge of the Red Sea is displaced further west into the land [1], parallel to the initial extension direction of the rift, along an axis aligning a volcanic chain in the Danakil plain and the Dallol dome. The creation of this dome is associated with halo-volcanic activity [2]: spatially and temporally variable sub-surface hydrothermal events [3], controlled by a magmatic chamber at depth [4]. In the long run, this magmatic activity at depth could lead to the emergence of volcanic activities on the surface in an active or passive way. Thus, the dome of the Dallol can be a possible manifestation of the first stages of transition from continental to oceanic extension [2]. To study this interesting geological object, we propose a method to instantaneously determine local geology.

Our method is based on time-series multispectral remote sensing data analysis. The data were acquired from Earth's orbit using NASA's Operation Land Imager (OLI) spectro-imager onboard Landsat 8. Comparing orbital dataset with in-situ chemical analyses from previous field campaigns [2], we were able to determine the minerals which are potentially present at the Dallol area. The reference spectra of these minerals were subsequently selected from the USGS spectral library. Then, by comparing the library spectra with OLI spectral data, we were able to perform mineral classifications on several spectral image cubes acquired from 2016 to today. To verify the obtained classifications, we also generated decorrelation stretch maps in order to determine with more precision the edges of the different spectral units. By combining the classification and decorrelation stretch approaches, we obtain time-series mineralogical maps showing the geology of the dome overcoming the temporal and spatial variability of its activity. However, these mineralogical maps are first-order estimates since we use multispectral data with only 7 bands in the visible near-infrared domain. Coupled with hyperspectral data, our results would be more accurate and our maps more reliable [5]. Unfortunately, no hyperspectral data is available for our study area.

The results of this study show that the mineralogical diversity can be captured and mapped using our method, even salt diversity in Danakil plain around Dallol dome. In that way, it is possible to locate with precision the active hydrothermal areas of the dome, which are especially recognizable due to the high concentration of native sulfur. Our final maps show that the dome's hydrothermal activity is variable at least on a seasonal scale, although it seems that punctual events considerably and suddenly change the intensity and the location of the activity. We made useful inferences about the mineralogy of Dallol from 2016 to today using the data from the OLI instrument. Our method and results will allow a better understanding of the formation and the fate of the Dallol. More in-depth work, whether through other remote sensing data and processes or additional in-situ analyses allowing the integration of additional minerals into the classification, could complete these classification maps made in this study.

***Index Terms –*** remote sensing, OLI, Landsat 8, Dallol dome, rift, halo-volcanic activity, mineral mapping, visible near-infrared spectra.

## REFERENCES

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