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Litho-tectonic mapping of the North Afar region from Sentinel-2A multispectral imagery and ALOS AW3D30 digital elevation data: Controls on Danakil-Nubia plate motion between the Erta'Ale ridge and the Gulf of Zula

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The Danakil Depression in the North Afar region of Ethiopia reaches elevations deeper than 120 m below sea level and contains a Pleistocene-Holocene evaporite sequence currently investigated for potash mineral deposits. Separated from the main Ethiopian escarpment by the Dogua horst mountains, the asymmetric half-graben is bordered on its western (Nubian) side by the active, normal Main Danakil Rift-border Fault (MDRF). Above the MDRF, a series of piedmont alluvial fans (bajadas) fringes the Dogua Horst, emanating from a series of wadi catchments between the larger perennial rivers (Ragali, Saba) that drain from the high (>2000 m) Ethiopian Plateau. On its eastern side, the Danakil block contains Proterozoic-Palaeozoic sequences correlated with similar units in the Dogua range, and forms a microplate rotating independently between the larger Nubian and Arabian plates (McClusky et al., 2010). An understanding of the sedimentary and tectonic evolution of the Danakil-Nubia (DA-NU) plate system is crucial to the beneficial development of fresh groundwater resources and to an assessment of seismotectonic and volcanic geohazards in the area.

Between the Mt Alid caldera in the Dandeiro graben and the Erta'Ale crater in the south Danakil, the rate of present-day DA-NU motion is 10.9 – 13.5 mm/yr, with direction azimuths N106E- N096E (after Schettino et al., 2016). DA-NU relative motion is focussed along the east-dipping MDRF in the Danakil but switches to an eastern (west-dipping) rift-border normal fault in the Dandiero, a northward extension of the Renda-Maglalla-Coma graben, separating the Dogua Horst from the main part of the NU plate. This change in rifting asymmetry occurs across a WNW/ESE-striking zone of basement faulting that terminates the Dogua Horst and functions as a left-stepping proto-transform fault zone, across the NNW direction of DA-NU proto-rift propagation.

From 13-channel multispectral data of the European Space Agency satellite Sentinel-2A, a false-colour composite image, centred about MDRF and covering a wide region across the Ethiopia-Eritrea border, was created by combination of selected spectral band-ratios. This Sentinel-2A-based lithological mapping is integrated with the new ALOS AW3D30 digital elevation model, providing geomorphometric analysis and morphotectonic interpretations that allow 1) revision of previous fault-zone mapping, 2) seismotectonic contextualization of the earthquake record, and 3) improved discrimination of volcanic units and centres, both basaltic and silicic, along the northward propagating DA-NU rift zone.

References

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