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Characteristics of Eritrean Seismicity in 2011-2012: Implications for Rifting Dynamics

Berhe Goitom (1), J-Michael Kendall (1), James O.S. Hammond (2), Ghebrebrhan Ogubazghi (3), Derek Keir (4), and Finnigan Illsley-Kemp (4)

(1) University of Bristol, School of Earth Sciences, Bristol, United Kingdom (bg12363@bristol.ac.uk; gljmk@bristol.ac.uk), (2) Birkbeck, University of London, Department of Earth and Planetary Sciences, UK (J.hammond@ucl.ac.uk), (3) Eritrea Institute of Technology, Department of Earth Sciences, Eritrea (ogubazghi_ghebrebrhan@yahoo.com), (4) University of Southampton, National Oceanography Centre Southampton, UK (D.keir@soton.ac.uk; f.illsley-kemp@soton.ac.uk)

Eritrea hosts the final stages of on-land rifting in the East African Rift System (EARS), yet questions remain about how rifting transitions from the Afar Depression to the Red Sea, the final stage of which happens in Eritrea. We use data from recent deployments of seven broadband seismometers in Eritrea, together with deployments in Ethiopia, to locate seismicity and determine the current focus of strain in Eritrea. Over 1100 events have been located with local magnitudes, ML 0.5-5.0. We use double difference relocations to improve relative relocation accuracy and show two main trends in seismicity. One oriented NW-SE along the Alid-Dallol axis along the northwestern boundary of the Danakil microplate and another, NE-SW, following the trend of the Dubbi-Nabro axis. Two clusters of seismicity stand out: July 1, 2012 and December 25, 2011. The July 1 cluster is located around Nabro volcano, the largest event of ML 5.0 preceded by 38 events in the previous two days and is likely related to magma movement below Nabro. The December 25 cluster of seismicity includes an earthquake of ML 4.2 with 13 other events on the same day. The later cluster is located around the previously unreported Hayli Gubbi and Ale Bagu volcanoes and could be related to magmatic activity around these volcanoes. The new estimates of seismicity demarcate the boundary of the Nubia and Somalia plates with the Danakil microplate, which suggests that the Danakil microplate may be broken in two along the Dubbi-Nabro axis. We estimate b-values for the different clusters of events and show that close to the major border faults near Massawa, average b-values are lower (0.8 ± 0.09) than those found near the volcanic centres (1.1 ± 0.16 – Dubbi-Nabro). This suggests that the stress is less along the rift axis and strain is accommodated by the injection of magma or due to rocks that are hotter and more ductile. In contrast the earthquakes around Massawa occur in relatively strong rocks suggesting strain may be accommodated by movement on larger faults. The present study shows that: (i) there are five clusters of seismicity in this time period within Eritrea, (ii) Nabro volcano is seismically active, (iii) there is seismic activity about 35 km SE of Alid close to a small village, Regali that tends to migrate towards SE, (iv) the Danakil microplate splits into two along the Dubbi-Nabro axis, and (v) rifting transitions from Afar depression towards the Red Sea through both the Dubbi-Nabro and Massawa axes.