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Extensional strain accommodation by diking in the transitional Main Ethiopian Rift

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Strain localizes as rifting proceeds to continental breakup, but the partitioning of strain between faults and magmatic intrusion remains controversial. We integrate new local seismicity data with structural, geophysical and geodetic data from the volcanically active Main Ethiopian Rift (MER) to evaluate strain partitioning in a rift transitional between continental and oceanic in style. Geodetic data show that strain has localized to ˜20 km-wide, 60 km-long 'magmatic segments' marked by aligned eruptive centers, dikes, and small offset normal faults within the central MER (Bilham et al, Geophys. Res. Lett., 27, 1999). From October 2001 to February 2003 over 2000 local earthquakes were recorded on 170 broadband seismic instruments deployed within the Northern MER and its uplifted rift flanks. Earthquake locations are estimated with the best 1-D and 3-D velocity model obtained from local earthquake tomography. The catalogue of earthquakes is complete above Ml ˜ 2. Earthquakes cluster within the magmatic segments and the majority of events occur at depths of 6-10 km. Epicentres of small magnitude events ($Ml < 4$) parallel faults that cut Quaternary - Recent lavas and aligned eruptive centres within the magmatic segments. Large offset border faults bounding the MER are inactive, excluding a dense cluster of events concentrated at the intersection of the ˜29 My Red Sea Rift and the ˜11 My MER, where the older Red Sea Rift flank is flexing into the younger MER. Historical events follow the same spatial patterns: seismicity is concentrated in magmatic segments and the MER-Red Sea Rift intersection near Ankober. Fault plane solutions show predominantly normal slip, with oblique and strike slip events beneath active volcanoes. Inversion of focal mechanisms for the stress tensor shows N109 directed extension, within errors of geodetic and plate kinematic models. The distribution and mechanism of local and historical seismicity, as well as existing geodetic data show that strain is concentrated within the

narrow magmatic segments, and not along Miocene border fault ‘detachments’. Local earthquake tomography shows ~20 km-wide high velocity zones extending to the base of the seismogenic layer beneath magmatic segments, which we interpret as basaltic intrusions that feed dikes, fissures, and shallow magma chambers. Seismic swarms are clustered above zones of magma intrusion and may be triggered by dike injection. This integrated study shows that strain is accommodated by a combination of magmatic intrusion in the mantle lithosphere to mid-crust, and by small displacement faults in the brittle upper crust above the intrusions.