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The relations between magmatism and deformation during continental rifting: examples from the Main Ethiopian Rift, East Africa

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The Main Ethiopian Rift in East Africa is a natural laboratory for studying continental rifting; all the different stages of the rifting process -from rift initiation to continental break-up- can be identified in this rift system and thus it represents an ideal place to investigate the relations between deformation and magmatism and their evolution with time. Rift evolution started with an early continental rifting stage (Mio-Pliocene) characterised by displacement along large boundary faults, whose location and evolution was connected to the reactivation of a Pan-African weakness zone, and diffuse magmatic activity. In this initial phase, magmatism encompassed the whole rift, with volcanic activity affecting both the rift depression and the major boundary faults. Off-axis volcanic chains developed on the rift shoulders during this rift stage, owing to a lateral magma migration and upraising in correspondence to pre-existing basement structures. Progressive extension led to a riftward narrowing of the volcano-tectonic activity: in the Pleistocene both faulting and magmatism shifted along en-echelon deformation segments obliquely affecting the rift floor (Wonji magmatic segments). This shift occurred because progressive displacement on boundary faults in response to increasing extension accumulated stresses that oppose further movement; extension then occurred at lower applied stresses along new high-angle normal faults in the weakest parts of the lithosphere (i.e. within the thinned rift depression) giving rise to en-echelon oblique regions of faulting and lithospheric thinning. Warm mantle material uprose below these en-echelon segments of strong thinning, as imaged in the segmented, NE-trending low-velocity zones in the mantle beneath the Wonji mag-

matic segments, interpreted as discrete zones of enhanced melt production. Ascending magmas were then focused by the Wonji segments, resulting in the imaged right-stepping, along-axis segmentation in magmatic intrusions below the rift; at surface, magma eruption preferentially occurred along the oblique Wonji faults. At this stage, a strong feedback between deformation and magmatism develops: within the Wonji segments, the thinned lithosphere is strongly modified by the extensive magma intrusion and extension is facilitated and accommodated by a combination of magmatic intrusion, dyking and faulting. Focused melt intrusion allows the rupture of the thick continental lithosphere and the magmatic segments act as incipient slow-spreading mid-ocean spreading centres sandwiched by continental lithosphere.