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the role of magmatism and segmentation in the structural evolution of the Afar Rift

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A common issue at volcanic passive margins (VPM) is the lack of observation of the structures that accommodate stretching and thinning. Indeed, the most distal parts and the Ocean-Continent Transition is often masked by thick seaward-dipping reflectors (SDR) sequences. Some current challenges are then to know if the observed thinning fit the divergence (thinning vs dyking); and what is the rheological effect of magma supply that re-thickens the crust during extension?

In the Central Afar magmatic rift (Ethiopia), the structures related to rifting since Oligocene are cropping out onshore and are well preserved. We present here a new structural model based on field data and lavas (U-Th/He and K/Ar) datings along a balanced cross-section of the Central Afar Western Margin. We mapped continent-ward normal fault array affecting highly tilted trapp series (29-30 Ma) unconformably overlain by tilted Oligo-Miocene (25-7 Ma) acid series. The main extensional and necking/thinning event took place during the end of this Miocene magmatic episode. The Pliocene flood basalt (Stratoid series) is erupted over an already thinned crust. The bulk extension for the Afar Western Margin is ß $\sim$ 2.50. Our main findings are:

- Oligo-Miocene deformation in Central Afar appears to be largely distributed through space and time ("magmatic wide rift"). It has been accommodated in a 200-300 km wide strip being a diffuse incipient plate boundary during the whole rifting history until the formation of present-day magmatic segments. There is a period of tectonic quiescence accompanied with few magma erupted at the surface between 25 Ma and 7 Ma. We suggest that tectonic and magmatic activity was focused at that time on the highly faulted Danakil block and Southern Red Sea, away from our study zone.

- ß $\sim$ 2.50 is higher than the thinning factor of $\sim$1.30 observed in geophysical studies. We propose that the continental crust in Central Afar has been re-thickened during extension by the syn-rift magmatic supply. The difference in tectono-magmatic style between Central Afar (distributed extension and thick crust) and Northern Afar Erta Ale segment (narrow graben, thin crust) may be explained by the difference of magma volume (extruded & underplated) brought to the crust during extension. Magma supply in Central Afar thus allows the crust to be stretched without extreme thinning despite high degree of divergence. Thus, break-up may occur in both Central and Northern Afar, not depending on the apparent thickness of the crust but rather on the ability of the system to localize deformation.

- There appears to be a link between early-rift transform zones and distribution of magmatic activity that affects in turn the structural style. We suggest that the closest feature from the SDR at mature VPM is the Stratoid series. The difference of volume between the Stratoid and the enormous volume of SDR imaged in seismic studies (e.g South Atlantic) is probably best explained by an initial low mantle potential temperature in Afar.

Contrasted structural styles in Afar are the product of magma supply and segmentation, controlling thinning and extension distribution in the rift.