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Next-generation Geotectonic Data Analysis: Using pyGPlates to quantify Rift Obliquity during Supercontinent Dispersal

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Fragmentation of a supercontinent by rifting is an integral part of plate tectonics, yet the dynamics that govern the success or failure of individual rift systems are still unclear. Recently, analytical and thermo-mechanical modelling has suggested that obliquely activated rifts are mechanically favoured over orthogonal rift systems. Hence, where two rift zones compete, the more oblique rift proceeds to break-up while the less oblique one stalls and becomes an aulacogen. This implies that the orientation and shape of individual rift systems affects the relative motion of Earth's continents during supercontinent break-up.

We test this hypothesis using the latest global plate tectonic reconstructions for the past 200 million years. The analysis is performed using pyGPlates, a recently developed Python library that allows script-based access to the plate reconstruction software GPlates. We quantify rift obliquity, extension velocity and their temporal evolution for all small-scale rift segments that constituted a major rift system during the last 200 million years. Boundaries between continental and oceanic crust (COBs) mark the end of rifting and the beginning of sea floor spreading, which is why we use a global set of updated COBs in order to pinpoint continental break-up and as a proxy for the local trend of former rift systems.

Analysing the entire length of all rift systems during the last 200 My, we find a mean obliquity of $\sim$40° (measured as the angle between extension direction and local rift trend normal), with a standard deviation of 25°. More than 75% of all rift segments exceeded an obliquity of 20° highlighting the fact that oblique rifting is the rule, not the exception. More specifically, East and West Gondwana split along the East African coast with a mean obliquity of 45°. While rifting of the central and southern South Atlantic segment involved a low obliquity of 10°, the Equatorial Atlantic opened under a high angle of 60°. The separation of Australia and Antarctica involved a protracted extension history involving two stages with $\sim$25° prior to 100 Ma followed by more than 50° obliquity. In many cases both obliquity and extension velocity increase during rift evolution (e.g. South Atlantic, India-Antarctica, Australia-Antarctica, Gulf of California), suggesting an underlying geodynamic correlation. Considering that most conceptual models of rift evolution assume 2D deformation, we here quantify the degree to which 2D rift models are globally applicable, and highlight the importance of 3D models where oblique rifting is the dominant mode of deformation.