Geophysical Research Abstracts
Vol. 21, EGU2019-14273, 2019
EGU General Assembly 2019

A global plate model including lithospheric deformation along major rifts and orogens for the last 240 million years

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Two fundamental assumptions of the plate tectonic paradigm are that tectonic plates are rigid and that they are separated by narrow boundaries. The rise of space geodesy has allowed the construction of present-day deforming plate models with applications such as modelling ongoing crustal deformation in broad, complex continental plate boundary zones. Despite the enormous advances in understanding present-day plate deformation, to date there is no global plate model incorporating diffuse deformation for the geological past. We present a global Mesozoic-Cenozoic deforming plate motion model, constructed using the GPlates software (www.gplates.org) that captures the progressive extension of all continental margins since the initiation of rifting within Pangea, starting with the Triassic extension between Africa and North America (∼240 Ma). The model includes major failed continental rifts, and the progressive compressional deformation along collision zones. The outlines and timing of distributed deformation episodes are reconstructed from a wealth of published regional tectonic models and associated geological and geophysical data. We reconstruct absolute plate motions in a mantle reference frame using a joint global inversion of multiple constraints including hotspot tracks for the last 80 million years, global trench migration behavior and estimates of net lithospheric rotation. In our optimized model net rotation is consistently below 0.25º/Myr (using a 5 Myr median filter), and trench migration scatter is substantially reduced, particularly for the Jurassic and Triassic periods. Distributed plate deformation reaches a Mesozoic peak of 30 million km2 in the Late Jurassic (∼160-155 Ma), driven by a vast network of rift systems. The deforming area dropped to about half this size in the mid-Cretaceous (∼100 Ma), reflecting the onset of seafloor spreading along many rift systems. Diffuse deformation reaches a high of 48 million km2 in the Late Eocene (∼35 Ma), driven by the progressive growth of plate collisions and the formation of new rift systems. About a third of the continental crustal area has been deformed since 240 Ma, partitioned roughly into 65% extension and 35% compression. This community plate model provides a framework for building detailed regional deforming plate networks and forms a constraint for models of basin evolution and the plate-mantle system. The model can be used to compute a variety of quantities, including the evolution of finite strain, crustal thickness, lithospheric temperature, isostatic topography and heat flux. Higher precision plate motion models, including deformation and assimilating many more constraints from regional geology than previously possible, will have a range of benefits to different communities, including the study of crustal and lithosphere structure and dynamics, basin analysis, resource exploration, and regional geodynamic models. In the future, deforming plate models will provide a basis for creating global paleotopography models, useful for surface process and paleoclimate models. Future improvements of regional deforming plate models will benefit from more detailed regional data sets on basin scales being made available by industry and government organisations, including structural and stratigraphic data.