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Long-term sea level and the cycle of supercontinent formation and dispersal

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The main drivers of global long-term sea level fluctuations include changes in seafloor spreading, mid-ocean ridge length, continental area, sedimentation and large igneous provinces, which contribute to defining the volume of the ocean basins. Changes in the volume of ice-sheets affects the amount of water available to fill the ocean basins through time but its effect is smaller. In order to quantify the contribution of ocean volume change to global sea level, we build a plate motion model back through time based on the present day preserved seafloor spreading record, an interpretation of the spatio-temporal record of plate boundaries, simple assumptions regarding spreading symmetry and triple junction closure. We reconstruct the now subducted portions of oceanic lithosphere and compute grids of the age-area distribution of ocean lithosphere from the time of Pangea assembly to supercontinent break up and dispersal (200-0 Ma). Our model includes a merged moving hotspot and true polar-wander corrected reference frame, a revised history for the formation of Panthalassa, a model for the break-up of the Ontong Java-Manihiki-Hikurangi plateaus between 120-86 Ma and includes the seafloor spreading history in the Tethys and Mongol-Okhotsk Ocean. We estimate the contribution of deep-sea sedimentation to ocean basin volume using a predictive age-latitude-sedimentation relationship. The eruption and subduction/accretion of large igneous provinces based on a newly compiled age-coded large igneous province data set is incorporated in our workflow to estimate their relative input to sea level change.

A similar approach was successfully applied to predict the magnitude and pattern of eustatic sea level change since the Cretaceous (Müller et. al. 2008) but this study was unable to capture the full cycle of supercontinent amalgamation and dispersal. Our results suggest that old mid-ocean ridge flanks in the proto-Pacific and the Tethys oceans were gradually destroyed during the early stages of supercontinent break-up (200-150 Ma) and replaced by new mid-ocean ridge systems. This cycle led to a substantial younging of the ocean basins from the Jurassic to the Cretaceous period, followed by a gradually ageing of the oceanic lithosphere from the Cretaceous seafloor spreading pulse to the present day. Our age-area distribution of oceanic lithosphere from 200 Ma to the present day produces a record of long-term sea level change that agrees extremely well with independently computed estimates for eustasy over the same time period and may be linked with the cycle of supercontinent formation and dispersal.