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Drainage evolution of the transcontinental Cenozoic paleovalleys of Western Australia

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Large parts of the paleodrainage networks preserved across the arid/semi-arid Western Australia (WA) formed after the emergence of the Canning-Officer Basin at the end of the Lower Cretaceous. They owe their preservation to long-term tectonic stability of the continent, relatively low relief, limited erosion/burial, and an overall drying climate since the Late Eocene. Epeirogenic uplift within a context of large amplitude eustatic sea level variations subsequently drove incision of this drainage within the underlying sediments and basement rocks. Spatial variations in surface uplift triggered drainage rearrangements in the Cenozoic. Incision and drainage reorganization determined the fluxes of terrigenous sediments delivered to the North West Shelf of Australia and to the Great Australian Bight in southern Australia. Aridification of the continental interior initiated between the Late Eocene and the Late Miocene. It induced a decrease in the delivery of terrigenous sediment and freshwater to the shelves, with sediment retention on land, before complete drying out of the valleys in the Late Pliocene to Early Quaternary. This evolution has influenced the formation of potential hydrocarbons traps and seals in the Cenozoic series on the shelves, the accumulation of heavy mineral placers along paleo-shorelines, as well as the retention of gold, uranium, boron and lithium in paleovalleys.

We use the integrative power of Badlands, a landscape evolution model, to inform poorly understood aspects of this evolution. These paleovalleys debouched at their downstream ends at well-dated paleo-shorelines, which provide age constraints and firm milestones of their temporal and spatial evolution. Drainage network evolution and valley long profiles constrain the timing of long ($\sim$1,000 km) to intermediate wavelength ($\sim$200 km) variations in uplift and subsidence rates over the continental interior. This chronology of deformation and drainage evolution is used to constrain our numerical modeling. The modeling comprises two main consecutive steps. Firstly, we simulate drainage incision during the period of highly positive water balance (110 - 43 Ma), under the effect of lowering, fluctuating sea level and slow, generalized surface uplift (average of 3.8 m/My). The aim is to constrain the erodibility of the sediment cover (Carboniferous, Permian, and Cretaceous sediments of the Canning and Officer basins) and that of the underlying basement rocks. Secondly, we implement algorithms to simulate water evaporation and hyporheic infiltration along the drainage network. The goal is to explore the consequences of a diminishing water balance on river incision, sediment deposition, and the size of lakes produced over time, in an attempt to reconcile apparently conflicting paleoenvironmental records of aridification.