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The Weddell Sea Rift System: recent interpretations, unresolved issues and future outlook

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The Weddell Sea Rift System (WSRS) is one of the largest but least understood Antarctic continental rift systems. The prevailing view is that the WSRS formed in the Jurassic, perhaps synchronously or in parts prior to the emplacement of the ca 180 Ma old Ferrar Large Igneous Province. The WSRS appears to be located in a back arc position with respect to long-lived subduction along the Paleo-Pacific margin of Gondwana, and may have been active at least till ca 160 Ma, when sea floor spreading is thought to have commenced in the northern Weddell Sea. The width of the WSRS resembles typical wide mode rifts/Highly Extended Terranes, such as the Basin and Range Province. However, magnetic and gravity anomalies also suggest the existence of superimposed narrow rifts, indicating the occurrence of localisation processes that are often linked in other rift systems and in numerical models with post-rift lithosphere strengthening and with changes in rift kinematics.

Notably, recent compilations of aeromagnetic and airborne gravity datasets have indeed been interpreted by Jordan et al. (2017, Gondwana Res.) as suggestive of two different directions of extension in the WSRS, a ca E-W oriented one, followed by a ca N-S oriented one. Alternatively, more complex strike-slip and oblique rifting models may also be permissible, based on the newly recognised horsetail-like geometry of inferred fault systems in the northern WSRS, and on previously proposed strike-slip fault arrays along the south-eastern edge of the WSRS. Regardless of which of these kinematic scenarios holds true, the potential field interpretations of Jordan et al. (2017) remain difficult to reconcile with widely accepted paleomagnetic and geological interpretations that favour major Jurassic microplate movement and ca 90 degrees of block rotation of the Ellsworth-Whitmore (EW) crustal block in the WSRS region. However, a recent re-interpretation of the only wide angle seismic line available in the region (Jokat & Herter, 2016, Tectonophys.) suggests the existence of crust with oceanic affinity or rift-related underplated igneous crust, at least in the northern WSRS. This finding, if truly representative of the wider WSRS region, could in principle enable more substantial microplate movement than simple stretching models would appear to allow.

Overall, we conclude that new 3D geophysical and plate kinematic modelling, ideally aided by the acquisition of: a) higher resolution aerogeophysical observations over key parts of the WSRS and its boundaries; b) new seismic data in particular over the Ronne-Filchner ice shelf and; c) new structural geology and paleomagnetic studies extending from the EW block across the Pensacola Mountains and Coats Land are required to better comprehend the structure and evolution of the WSRS. This is a pre-requisite to establish more firmly the linkages between the WSRS and early Gondwana break up, as well as better constraining its pre-rift history, including defining the extent, development and subsequent role of the Gondwanide Fold Belt during rifting and inferred microplate motion stages.