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Tectonomorphic evolution of Marie Byrd Land – Implications for Cenozoic rifting activity and onset of West Antarctic glaciation

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The West Antarctic Rift System is one of the largest continental rifts on Earth. Because the West Antarctic Ice Sheet mostly covers it, its evolution is still poorly understood. Here we present the first low-temperature thermochronology data from eastern Marie Byrd Land, an area that stretches ∼1000 km along the rift system. Furthermore, we petrographically analysed glacially transported detritus deposited in the marine realm offshore Marie Byrd Land. Our data provide information about the subglacial geology, and the tectonic and morphologic history of the rift system. Dominant lithologies of coastal Marie Byrd Land are igneous rocks that intruded (presumably early Paleozoic) low-grade meta-sediments. No evidence was found for un-metamorphosed sedimentary rocks exposed beneath the ice. According to the thermochronology data, rifting occurred in two episodes. The earlier occurred between ∼100 and 60 Ma and led to widespread tectonic denudation and block faulting over large areas of Marie Byrd Land. The later started during the Early Oligocene and was confined to western Pine Island Bay area. This Oligocene structure may kinematically be linked to previously described rift structures reaching into Bellingshausen Sea and beneath Pine Island Glacier, which were also assumed to be of Cenozoic age. However, our data provide the first direct evidence for Cenozoic tectonic activity along the rift system outside the Ross Sea area. Furthermore, our data suggest that uplift of the Marie Byrd Land dome only started at ∼20 Ma; that is, nearly 10 Ma later than previously assumed. The Marie Byrd Land dome is the only extensive part of West Antarctica elevated above sea level. Since the formation of a continental ice sheet requires a significant area of emergent land, our data imply that initiation of extensive glaciation of this part of West Antarctica may only have started since the early Miocene.