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One third of Antarctica is not continental: Geophysical evidence for West Antarctica as a backarc system

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Antarctica has traditionally been considered continental inside the coastline of ice and bedrock since Press and Dewart (1959). Sixty years later, we reconsider the conventional extent of this sixth continent (Artemieva and Thybo, Earth-Science Reviews, 2020, https://doi.org/10.1016/j.earscirev.2020.103106).

Geochemical observations show that subduction was active along the whole western coast of West Antarctica until the mid-Cretaceous after which it gradually ceased towards the tip of the Antarctic Peninsula. We propose that the entire West Antarctica formed as a back-arc basin system flanked by a volcanic arc, similar to e.g. the Japan Sea, instead of a continental rift system as conventionally interpreted and tagged in the literature as "West Antarctica Rift System".

Globally, the fundamental difference between oceanic and continental lithosphere is reflected in hypsometry, largely controlled by lithosphere buoyancy. The equivalent (corrected for ice and water) hypsometry in West Antarctica (−580 ± 335 m on average, extending down to −1580 m) is much deeper than in any continent, since even continental shelves do not extend deeper than −200 m in equivalent hypsometry. However, an unusually deep equivalent hypsometry in West Antarctica corresponds to back-arc basins (with average values of equivalent hypsometry between ca −3000 m and −300 m) and oceans proper. This first order observation questions the conventional interpretation of West Antarctica as continental.

We present a suite of geophysical observations that supports our geodynamic interpretation:

- a linear belt of seismicity sub-parallel to the volcanic arc along the Pacific margin of West Antarctica;
- a pattern of free air gravity anomalies typical of subduction systems;
- and extremely thin crystalline crust typical of back-arc basins.

We calculate lithosphere density for two end-member scenarios to fit the calculated mantle residual gravity anomalies and seismic data on crustal thickness and demonstrate that it requires the presence of:

- (1) a thick sedimentary sequence of up to ca. 50% of the total crustal thickness, or
- (2) extremely low density mantle below the deep basins of West Antarctica and, possibly, the Wilkes Basin in East Antarctica.

Case (1) implies that for 25 ±6 km of the total crustal thickness, the crystalline basement is only 12-15 km thick, and such values are not observed in continental crust. Case (2) requires the presence of anomalously hot mantle below the entire West Antarctica with a size much larger than around continental rifts.

These results favor the presence of oceanic or transitional crust in most of West Antarctica and possibly beneath the Ronne Ice Shelf. Our model predicts that a granitic crustal layer with a high radiogenic heat production is almost absent in most of West Antarctica, which may affect heat flux at the base of the ice with potential important implications for models of ice melting. We propose, by analogy with back-arc basins in the Western Pacific, the existence of rotated back-arc basins caused by differential slab roll-back during subduction of the Phoenix plate under the West Antarctica margin.

Our finding reduces the continental lithosphere in Antarctica to 2/3 of its traditional area. It has significant implications for global models of lithosphere-mantle dynamics and models of the ice sheet evolution.