Geophysical Research Abstracts
Vol. 19, EGU2017-10857, 2017
EGU General Assembly 2017

The lithosphere of the Antarctic continent: new insights from satellite gravity gradient data

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The GOCE+Antarctica project, part of the Support to Science (STSE) program of the European Space Agency (ESA) is a new polar geosciences research initiative that aims to investigate the thermal and compositional structure of the Antarctic lithosphere by combing satellite gravity gradients (Bouman et al., 2016), airborne gravity data compilations (Scheinert et al., 2016), seismological (e.g. An et al., 2015) and petrological models in a forward and inverse manner. This approach promises to shed new light into the fundamental interplays between Antarctic lithospheric architecture, bedrock topography, ice sheet dynamics, and also its dynamic relations with Glacial Isostatic Adjustment (GIA).

Here we focus on the satellite gravity gradient signatures and superimpose these on major known tectonic and bedrock topography elements, as well as independent seismically-derived estimates of crustal thickness for the Antarctic continent. An ad hoc India up reference system was used to facilitate the initial interpretation of the satellite gravity gradient data images.

The GIU component clearly reveals the marked contrast between the thinner crust and lithosphere underlying the West Antarctic Rift System and also the Weddell Sea Rift System and the thicker lithosphere of East Antarctica. Notably, the new images suggests that more distributed wide-mode lithospheric and crustal extension affects the Ross Sea Embayment and continues under the Ross Ice Shelf, but this pattern is less clear towards the Bellingshousen Embayment. This suggests that the rift system narrows considerably as it reaches the southern edge of the Antarctic Peninsula, perhaps also in response to the relatively thicker crust and potentially relatively more rigid Precambrian lithosphere of the displaced Haag-Ellsworth block, which was originally located closer to East Antarctica, prior to distributed Jurassic lithospheric and crustal extension in the Weddell Sea Rift System.

In East Antarctica, the satellite gravity data arguably provides one the clearest large-scale views to date of the potential extent of the Archean to Mesoproterozoic Terre Adelie Craton, and clearly shows the contrast wrt to the crust and lithosphere underlying both the Wilkes Subglacial Basin to the east and the Sabrina Subglacial Basin to the west. This finding corroborates and also augments recent independent interpretations of aeromagnetic and airborne gravity data over the region, suggesting that the Mawson Continent is a composite lithospheric-scale entity, which was affected by several Paleoproterozoic and Mesoproterozoic orogenic events (Aitken et al., 2016). Thick crust is clearly imaged beneath the Transantarctic Mountains, the Terre Adelie Craton, the Gamburtsev Subglacial Mountains and also Eastern Dronning Maud Land, in particular beneath the recently proposed region of the Tonian Oceanic Arc Superterrane (Jacobs et al., 2015). The GIA and GIU components help delineate the edges of several of these lithospheric provinces, both in West and East Antarctica.

One of the largest and previously unknown lithospheric-scale features discovered in East Antarctica from the satellite gravity gradient images is a linear feature that appears to cut across East Antarctica, potentially extending from the area of the Lutzow Holm Complex on the Indian side of East Antarctica right across the continent to South Pole. We name this feature the Trans East Antarctic Shear Zone and propose that it represents a major lithospheric scale shear zone and possibly a major suture zone that separates the Gamburtsev Province from the Eastern Dronning Maud Land Province and also appears to form the southern boundary of the composite Recovery Province. We infer based on geological data in the Lutzow Holm Complex region and formerly adjacent segments of India and Madagascar and eastern Africa that it may represent a major hitherto unrecongnised Pan-African age suture zone related to the assembly of the Gondwana supercontinent. New aerogeophysical surveys in interior East Antarctica, between the Recovery region, the Gamburtsev Province and the southern edge

of the Eastern Dronning Maud Province are however required to investigate the detailed crustal architecture, evolution and also kinematics of this newly proposed shear/suture zone and to help understand its relationships with the previously proposed Gamburtsev and Shackleton Range suture zones.