Satellite Gravity and Geoid Studies Reveal the Formations Underlying Large-Scale Basin Structures

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Abstract

We compare results from studies of the global large-scale basins. Such large-scale basins are often referred to as cratonic or intracratonic basins. Detailed study of satellite derived gravity anomalies, geoid undulations and the isostatic state of large-scale basin structures shows that these basins show a series of distinctive features: the basins show in general the presence of volcanic material and a thick sedimentary succession, even with large variations in absolute thickness and areal extent. Most striking, however, is that for the majority of the basins we find evidence for high-density material in the lower crust and/or upper mantle. These high-density structures compensate at least partly for the low-density sedimentary infill, while crustal thickness variations and Moho topography cannot be considered solely as mechanisms of compensation of the sedimentary loading. This is in clear contrast to rift-type basins, and formation of large-scale basins is apparently inked to large-scale lithospheric processes. The global comparison allows us also to test mechanism models, which might be valid for less well known basins; e.g., the Congo basin.
Introduction

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Satellite data and earth gravity models

New data acquired by the GRACE and recently Launched GOCE satellite gravity mission greatly improved accuracy and spatial resolution of the determination of the global earth gravity field e.g., Tapley et al. (2005). Studies of the Earth’s geophysical field e.g., Dziewonski et al. (1981), Dziewonski & Anderson (1981) combine these satellite data with terrestrial data sets and enable global studies of the gravity and geoid field over geologically interesting foreland Chains. Continental basins, ocean basins, or geocentric tectonic units on the Earth's surface are geophysical structures that can be studied with a global satellite mission. The task of these missions is to derive the spatial variation of the Earth's gravity field.

Earth gravity models

Earth gravity models are used to recover the spatial variation of the Earth's gravity field from satellite measurements. These models include the main sources of the gravity field, such as the mass distribution of the Earth, the oceans, and the atmosphere. They also account for the effects of the rotation of the Earth and the Earth's oblateness. The models are typically represented in a spherical harmonic series, which allows them to be used in a wide range of applications, such as the study of the Earth's interior, the determination of the Earth's mass distribution, and the estimation of the geoid.

Intracratonic basins of South America: Paraná basin (A) and Paraná basin

The Paraná basin is filled with sedimentary and volcanic rocks that range in age from Middle Ordovician to Cretaceous with a mean age of about 12 km. The Paraná basin contains a large number of sedimentary basins, each with a thickness ranging from about 1000 meters to over 10,000 meters. The variation in thickness is due to the presence of volcanic rocks, which are more dense than sedimentary rocks. The thickness of the sedimentary rocks is also affected by the tectonic activity of the region, which has caused uplift and subsidence over geological time.

The selected large-scale basins

The selected large-scale basins are shown in the table below. They are organized by age from oldest to youngest. The age range of each basin is given in the Notes column. The thickness range is also provided, along with the number of sites used to estimate the thickness.

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At least two classes of intracratonic basins can be found: E.g. E- Erecta Sea basins, Paraná basin, Congo basin. Gravity anomaly reflects crustal thick in E- Erecta Sea basins, Paraná basin. Gravity anomaly reflects crustal thick in Congo basin.

Conclusions

Satellite gravity and geoid are ideal tools to study large-scale basins:

- Gravity anomalies can reveal residual, thick crust.
- Geoid anomalies reflect crustal thickness.

A third class contains the basins not fitting to these characteristics: Paraná basin, Tarim basin.