Satellite Gravity Data in Continental Geology and Resource Exploration

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Carla Braitenberg , University of Trieste, Trieste, Italy

Continents are made of older pieces of Earth's crust welded together. Most of today's seismic and volcanic activity occurs along the lines of amalgamation that form weakness zones. Throughout Earth's evolution these crustal borders have been the preferred interaction path between the hotter mantle and the crust, where the chemical composition of rock is altered. Particularly compact and resistant crustal pieces have maintained their extension from early in Earth’s history, focusing deformation along their borders. These focus areas are particularly rich in mineral resources. Density variations produce heat and increase pressure on the rocks in the boundary areas. The gravity field is an excellent proxy for the borders of the continental fragments, due to the existing density variations.

With GOCE, for the first time, these borders can be traced continent-wide, because the field is global and the resolution is adequate. Previous satellite missions delivered fields too coarse to be useful in this context. GOCE has considerably higher resolution and detects finer details. Conventional gravity measurements suffer from inhomogeneous data coverage, varying data quality, and a large time span in which data were acquired. Regular grids are produced by averaging the available data, but the inherent problems in the data acquisition make data error assessment difficult. Grids produced from satellite observations have homogeneous precision and resolution, as they are independent of the Earth terrain.

The classical way to identify crustal lineaments and units is by rock sampling resulting in geological mapping. Vegetation and sedimentation can obscure and block identification of the full extension of the features. Large sediment basins are completely flat, but the compact rock a few kilometers beneath the surface may have considerable depth variation and form the boundary between crustal pieces of different ages and compositions. With gravity, the lineaments can be identified regardless of the concealing cover. The usefulness is illustrated in the African continent. Here seemingly unconnected geologic units associated with rich mineral findings correspond to continent-wide lineaments identified by GOCE. The outcrops are linked to the much larger and deeper crustal inhomogeneity that presumably contributed to the differentiation of the minerals. In some places these focus lines connect between Africa and South America, recalling the once united continent Gondwana. This approach is a new tool for resource exploration and risk assessment.