A Grip on Geology with GOCE

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The development of today's emerging countries of Africa requires the retrieval of the sufficient funds to build the necessary governmental structures and institutions. An important source of wealth is given by mineral and underground fossil energy resources, but must yet be explored and discovered. More developed countries have invested in geological surveys, which have had the time of decades to geologically map the country and commission terrestrial geophysical soundings. The greater geological context is therefore known in general terms, and it is clear in which areas natural resources can be expected and where further detailed investigations are necessary. In emerging countries the geological surveys are at the start of the complex work of investigating the entire territory. The discovery of deposits is greatly accelerated if there is the possibility to guide detailed investigations to the right place, based on the regional knowledge of the geologic history, the recognition of main crustal structures, and the identification of potentially productive geological units. Density is a fundamental rock parameter that distinguishes different rock types due to their compactness and chemical or mineralogical composition.

The link between the presence of natural resources and the density variation of the rock is not necessarily that of direct cause and effect, but is based on the correlation of processes that can produce the subsurface deposit. Diamonds are found in the extremely dense kymberlite pipes, because they are transported by dense mantle rocks that quickly move upwards through the less dense crust to the surface. It is an example of a situation in which the presence of the high-density rocks guides the exploration to the limited area in which there is a higher probability to find the mineral or hydrocarbon resource. The new satellite GOCE gives the first time opportunity to map such structures from space, under the condition that their extent is sufficiently big. This is due to the highly precise observation of the gravity gradient tensor in space at low altitude.

After making some reductions to the data for the deeper lying density sources and the obvious mass effect of topography, the geological signal is enhanced. The residual gradient map from GOCE defines the large scale geologic structures over their entire extent, revealing a relatively orderly alignment of subparallel lineaments that flank the African hardcore, the Congo craton. The Congo craton carries on the surface the Congo basin, and extends down to 400km with the cratonic root, signalized by an increased seismic velocity. It's age is estimated to be 3300 Ma, that is two third of Earth's history. The geometry of this rigid and deep reaching core which has moved since 200Ma from the South Pole to the present equatorial position has determined the directionalities of the orogenic belts, the rifts and the shear zones, that were formed by the forces acting on the crust being pushed against the rigid core. An important fact for mineral exploration is, that existing planes of weakness along which the mineral rich fluids can percolate and accumulate in mineral veins, are preserved during Earth history, increasing the deposit with time. Such a situation is recorded along the borders of the craton, as the same lineaments that were formed in an orogen at some time in earth history are reused as planes for rifting or shearing, as they present stable zones of weakness. The GOCE observations show the alternation of high and low density rock- alignments of different ages, demonstrating that the directionalities are long lasting and span over 1000Ma. Partial correlation of these density lineaments with the surface geology is demonstrated by geospatial analysis.

The geologic units are identified unequivocally by the gravity and gradient signals, directly linked to the different characteristic rock densities. Relevant for the geodynamical context of Gondwana is the western series of high and low density belts that run parallel to the African coast, presumably defining the weakness line along which the South American continent was separated through rifting from the African plate.