Gravimetric Investigation of Volcanic Structures

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Volcanic structures of various origin usually represent an anomalous feature in the country rocks setting. Diatremes, calderas, linear lava flows, stratovolcanoes, maars, craters etc. may be studied, besides geological and geochemical methods, by various geophysical techniques. Gravimetry can be very effective for the location of the structures, detailed description of the density distribution related to different rock materials and for density modelling resulting in a schematic density/geological model. Problems are caused by the topography, as volcanoes normally form complicated morphological elements and terrain correction must be applied in the gravity data processing. Extremely different rock textures do not allow to set a common investigation procedure just as well, and a specific approach must be designed for each particular case. Three different examples are presented:

1) A small volcanic body in the crystalline complex environment
2) A complex polyphase structure in a volcanic region
3) A large crater with a volcanic funnel

1) During the gravimetric survey of the West Bohemian Upper Proterozoic formations (the Teplá complex) an intensive negative gravity anomaly was identified near the village of Dobrá Voda (Mrlina 1989). As a routine, detailization of measurements was carried out to confirm the anomaly. With respect to its extreme amplitude, a detailed survey was performed along profiles using gravimetry, magnetometry and gamma-ray spectrometry, supported by petrophysical and petrological investigations. An unknown volcanic structure of an exceptional composition consisting of olivine basalt – basalt – trachybasalt – trachyte succession was discovered.

   Porous trachyte was recognised as the main source of the gravity anomaly with bulk density less than 2.00 $g.cm^{-3}$ and natural (wet) density of 2.15 $g.cm^{-3}$. Contributing source is a strongly disintegrated crystalline complex (breccia) within the structure. The comparison of surface magnetometry and gamma-ray spectrometry enabled to define the spatial distribution of basic and acid rock material. Trachyte samples showed even higher content of radioactive elements (5 ppm U, 25 ppm Th and 4.6 % K) than other trachytes studied previously in the same region. The polyphase character also distinguishes this structure from the other monotype ones. There is one more striking feature: while all other volcanoes form a morphological elevation, this structure is located in a depression, surrounded by hills from three sides.
2) The aim of the geophysical investigations of the volcanic centre of the České středohoří Mts. was to explain a distinct gravity low obviously related to this structure. Gravity modelling was based on rock density data and rough geometry estimation, using the Pd-2 borehole (600 m) data and rock samples. A model consisting of a few bodies of relatively decreased block density (in comparison to surrounding sediments and basement), relevant to the breccia filling, was calculated. The model provided a certain idea on the caldera extent and depth, and confirmed the presence of such anomalous geological structure (Mrlina 1986).

   In the second step, a complex geophysical survey was proposed and performed in two stages - in the central area as a testing site and then in almost the whole area of the structure. Rocks or zones of different content of magnetic minerals and K-U-Th elements were localized, as well as indications of mineralization (sulphides) and faults.

   The gravity survey was applied in the form of an irregular net depending on accessibility and morphology. The final data enabled to construct a detailed gravity map providing new information on unknown hidden bodies of essexite, separating the gravity low into two parts and defining the extent of the main intrusion (rongstockite) and of the whole structure. A scheme of gravimetric indications was constructed to define low and high rock density areas, axes of gravity highs and lows and tectonic indications. More detailed gravity modelling sections were calculated with tentative geological explanation of the models.
3) Double-phase gravity survey constituted a substantial part of the geophysical exploration in the Coastal Mts., NW Syria (Mrlina 1993). In a regional scale the general knowledge of the structures was obtained including a quantitative estimation of formation thickness in the Al Ghab Graben tectonically related to the mountains. Detailed investigation at the bottoms of large craters produced by explosive volcanic processes, Cretaceous to Quaternary in age, enabled to localize volcanic chimneys and define the extent of volcanic material (tuff, lava). Geometries of these parts of the crater bottoms and fillings were modelled being supported by other geophysical methods (geoelectrics, magnetometry).

References

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