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Separation of sources and 3D potential field data inversion for the Thuringian Basin

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We suggest a new mathematical theory, numerical algorithms and computer programs for separation of potential field sources and its 3D inversion. New approaches are developed to separate sources: i) in depth using upward and downward continuation; ii) in the lateral direction by means of approximation with a field of 3D line segments; iii) according to density and magnetization contrast on the basis of pseudo-gravity calculation. Our original inversion algorithms allow retrieving unknown 3D geometry of an anomalous object both for a restricted body of arbitrary shape and for a contact surface. We apply our algorithms to gravity and magnetic data for the Thuringian Basin in Mid-Germany.

While upward continuation, we make integration along the investigation area only. It is possible, because we subtract from the observed field prior to upward continuation a model of the regional field, which is assumed to satisfy 2D Laplace equation in the area of investigation and to have the same values at the boundary of the area, as the observed field. The problem of downward continuation is a linear ill-posed inverse problem, therefore we must use some regularization. Since the integral operator is self-adjoint and positive, we apply the Lavrent'ev's approach. Inversion problems both for a restricted body and for a contact surface are reduced to nonlinear integral equations of the 1st kind, which we solve by the original method of local corrections. It leads to decomposition of the inverse problem and reduction of time expenditures to solve it approximately by an order of magnitude. For restricted star convex objects, we apply new integral equations of gravity and magnetic inverse problems. Their integrands are algebraic relative to the function sought and do not contain its derivatives.

We have separated sources based on upward and downward continuation of gravitational and magnetic field into shallow (above 5 km), intermediate (between 5 and 20 km) and deep ones (below 20 km). It is revealed that anomalies are caused partly by different objects. For instance, a component of gravity corresponding to deep sources is caused by an uplift of Moho, meanwhile the same component of the magnetic field is generated by the Mid-German Crystalline High. We have inverted gravity and magnetic data for the main shallow, intermediate and deep sources. 3D model for the main intermediate sources includes a restricted body (a granitic intrusion) above a density interface with topography. Among effects generated by shallow objects, the most discernible is an arc-shaped anomaly, clearly visible both in gravity and in magnetic data. We have inverted the magnetic anomaly for 3D topography of a contact surface (an uplift of crystalline). We calculate the gravitational effect of the magnetic topography and subtract it from the given gravity. After subtraction we obtain quite small gravity anomalies which are attributed to topography of the near-surface layers. The next goal is a 3D model for the whole area of the Thuringian Basin.