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Depth-weighted Inverse and Imaging methods to study the Earth's Crust in Southern Italy

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Inversion means solving a set of geophysical equations for a spatial distribution of parameters (or functions) which could have produced an observed set of measurements.
Imaging is instead a transformation of magnetometric data into a scaled 3D model resembling the true geometry of subsurface geologic features. While inversion theory allows many additional constraints, such as depth weighting, positivity, physical property bounds, smoothness, focusing, imaging methods of magnetic data derived under different theories are all found to reduce to either simple upward continuation or a depth-weighted upward continuation, with weights expressed in the general form of a power law of the altitude, with the half of the structural index as exponent. Note however that specifying the appropriate level of depth weighting is not just a problem in these imaging techniques but should also be considered in standard inversion methods. We will also investigate the relationship between imaging methods and multiscale methods. A multiscale analysis is well suitable to study potential fields because the way potential fields convey source information is strictly related to the scale of analysis. The stability of multiscale methods results from mixing, in a single operator, the wavenumber low-pass behaviour of the upward continuation transformation of the field with the enhancement high-pass properties of n-order derivative transformations. So, the complex reciprocal interference of several field components may be efficiently faced at several scales of the analysis and the depth to the sources may be estimated together with the homogeneity degrees of the field.
We will describe the main aspects of both the kinds of interpretation under the study of multi-source models and apply either inversion or imaging techniques to the magnetic data of complex crustal areas of Southern Italy, such as the Campanian volcanic district and the Southern Apennines. The studied area includes a Pleistocene volcanic structure (Mt. Vulture) whose intense dipolar anomaly is superimposed on a longer wavelength regional anomaly. In the Southern Apennines the aeromagnetic field presents smooth and extended anomalies, with wavelength of the order of tens of kilometres, which are aligned along the external border of the Apennine overthrusts. Their origin is rather uncertain, some possible causes including the diffuse presence of intrasedimentary volcanic bodies proven by several exploratory wells, as well as deep seated intrusions. Application of either imaging or inversion techniques allows recognition of at least three distinct sources between about 5 km and 20 km depth. Their interpretation is discussed in light of borehole data and other geophysical constraints.