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Investigating automated depth modelling of archaeo-magnetic datasets

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Magnetic surveying is a commonly used tool for first-pass non-invasive archaeological surveying, and is often used to target areas for more detailed geophysical investigation, or excavation. Quick and routine processing of magnetic datasets mean survey results are typically viewed as 2D greyscale maps and the shapes of anomalies are interpreted in terms of likely archaeological structures. This technique is simple, but ignores some of the information content of the data.

The data collected using dense spatial sampling with modern precise instrumentation are capable of yielding numerical estimates of the depths to buried structures, and their physical properties. The magnetic field measured at the surface is a superposition of the responses to all anomalous magnetic susceptibilities in the subsurface, and is therefore capable of revealing a 3D model of the magnetic properties. The application of mathematical modelling techniques to very-near-surface surveys such as for archaeology is quite rare, however similar methods are routinely used in regional scale mineral exploration surveys.

Inverse modelling techniques have inherent ambiguity due to the nature of the mathematical “inverse problem”. Often, although a good fit to the recorded values can be obtained, the final model will be non-unique and may be heavily biased by the starting model provided. Also the run time and computer resources required can be restrictive. Our approach is to derive as much information as possible from the data directly, and use this to define a starting model for inversion. This addresses both the ambiguity of the inverse problem and reduces the task for the inversion computation.

A number of alternative methods exist that can be used to obtain parameters for source bodies in potential field data. Here, methods involving the derivatives of the total magnetic field are used in association with advanced image processing techniques to outline the edges of anomalous bodies more accurately. When combined with the use of methods such as downwards continuation, Euler deconvolution and pseudo-gravity transformations, which can reveal information concerning depth and susceptibility parameters, a rapidly obtained initial model may be devised allowing subsequent inversion of data to be achieved more efficiently and with increased confidence in the final result.

The long-term objective is to devise a procedure which will lead to models of the 3D subsurface materials with minimal user control, and short computing time, however retaining confidence in the final result. Such methods would be applicable to a variety of other near-surface magnetic data, such as brownfield sites.