WAVELET BASED INVERSION OF POTENTIAL FIELD DATA

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ABSTRACT

By analysing potential field data in the wavelet domain and performing a multi scale edge detection we can automate what is commonly called 'worm analysis', i.e., the traditional visual inspection of gravity and aeromagnetic data in order to detect shallow faults, lineaments, contacts etc. More importantly, with the use of an appropriate wavelet, defined by the physics of the problem, information about the depth extent of major geological features can be obtained.

PURPOSE OF THE WORK

The collection and analysis of potential field data represents one of the cheapest forms of geophysical exploration. By the use of airborne surveying, it also has the advantage of allowing a relatively easy exploration on remote and hardly accessible areas. For these reasons it has been the object of extensive research for many decades.

Currently the techniques used in potential field analysis may be broadly divided into two classes. The first is represented by the visual inspection of aeromagnetic/gravity maps by geoscientists. More or less sophisticated image processing tools and different kinds of enhancements (first/second derivatives, sun-angle illumination, map colouring) are used in order to allow human analysts to better discriminate geometrical features present in the data. The targets of this kind of analysis are mainly shallow geological lineaments such as faults, folds, geological contacts, and, more rarely, broad information about the extension and depth of the main causative bodies. This approach has the flavour of an art and requires specific training and experience. As such, it has the disadvantage of being partly subjective, being influenced by the specific background and field of expertise of the analysing geoscientist.

The second kind of approach can be generically defined as inversion. Here more or less sophisticated algorithm are employed in order to determine the geological setting(s) that may be responsible for a particular data set. The target of this kind of analysis is typically the location and depth extension of main geological bodies.

We developed a technique that attempts to unify the visual and inversion approach mentioned above into a single procedure by the use of wavelet analysis.

METHOD

The location and characteristics of irregularities often carry most of the information found in signals. In image processing for example, it is known that the detection of main irregularities is crucial to recognise and discriminate large object and main patters in the data (Mallat and Zhong, 1992). In the visual inspection of potential field data, irregularities correspond to geological contacts, faults, lineaments that are indeed the main target of the analysis.

Edge detection algorithms applied to the analysis of potential field data have already been proposed in the literature (e.g., Blakely and Simpson, 1986). However, an analysis in the wavelet domain offers a crucial advantage in that fact that it implicitly contains the analysis of data at different scales. In potential field data it can be shown that from this information, and by the use of an appropriate wavelet, quantitative information on the position and strenght of contrasts in potential field sources can be obtained. Consequently this approach can be seen as a form of 3-D inversion.

RESULTS

The method has been applied to regional scale aeromagnetic data. Figure 1a shows an example of an aeromagnetic map while in Figure 1b the corresponding automatic 'worm diagram' is shown. It can be seen that all the main features are detected and that an unbiased reconstruction is achieved also on features that would be hardly seen by simple visual inspection. Figure 1c shows the 'worm diagram' at a larger scale. This information is used in the 3-D inversion in order to recover the depth of the main causative bodies.

CONCLUSIONS

The main advantage of this approach is that it formulates an inversion strategy in a framework ('worm diagram') that is in common use for geoscientists and consequently is easily interpretable from a geological point of view. It also allows a fast, fine resolution analysis of maps many order of magnitude larger than what is possible for traditional, voxel based, inversion algorithms. The algorithm will form the basis of both an interactive visualisation environment designed for hands-on use by field geologists and geophysicists and a 3-D full inversion procedure.

REFERENCES

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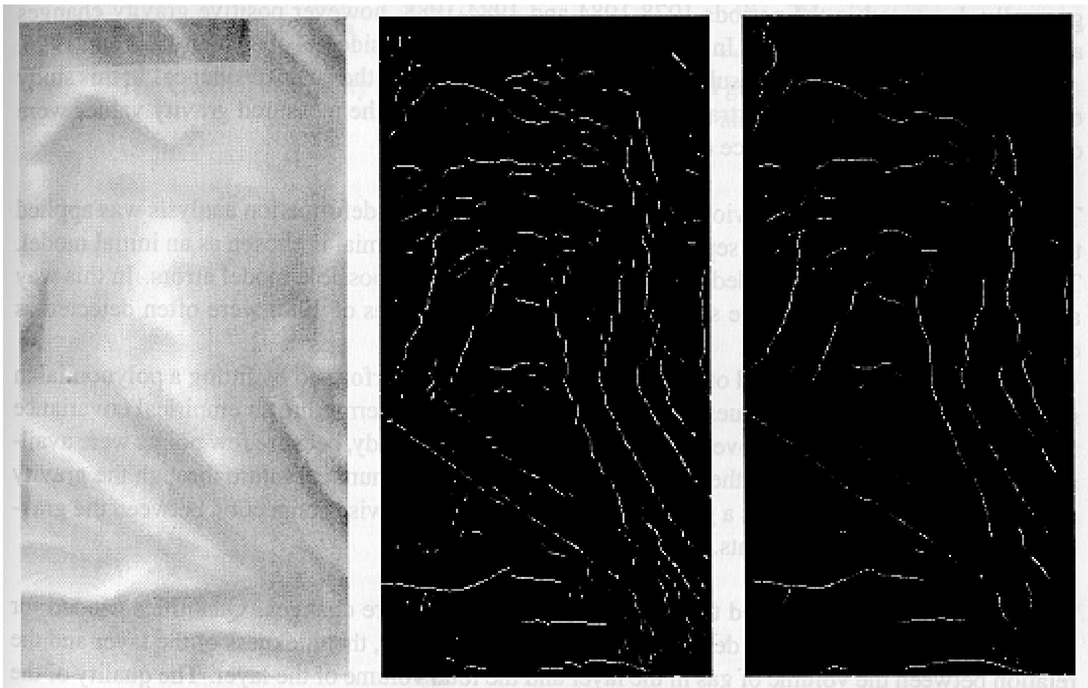

Figure 1a 1b 1c