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SUPPRESSING VARYING DIRECTIONAL TRENDS IN AEROMAGNETIC DATA

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ABSTRACT

Both qualitative and quantitative interpretations of aeromagnetic data can be hindered by the presence of magnetic anomalies due to mafic dykes. Such anomalies obscure the magnetic signatures due to basement lithology and structure, and their effects will often dominate when automated interpretation methods are applied to gridded data sets. Since dyke swarms are often nonparallel, simple frequency-domain strike-sensitive filtering based on a single directional trend is not a viable method for removing their signatures. Here, we use a co-ordinate transformation to project anomalies of various strikes onto one direction which is then suppressed using a standard decorrugation method. The resulting grid is then transformed back to the original projection. This approach is illustrated by removal of the magnetic signature of the Proterozoic Mackenzie dyke swarm occurring in the Slave structural province, Northwest Territories, Canada.

INTRODUCTION

Mafic dyke swarms are found in many different geological environments on earth, including volcanic centres, compressional plate boundaries, spreading centres and ophiolite complexes, continent-continent collision zones and in radial swarms originating from the sites of mantle plumes (Ernst et al., 1995a). Approximately 70 giant swarms have been identified worldwide that extend over distances of >300 km (Ernst et al., 1995b). Most dykes are tholeiitic in composition and therefore magnetic. Schwarz et al. (1987) estimate those outcropping mafic dykes wider than 5 m should be detectable in regional aeromagnetic data. Indeed, aeromagnetic data have helped considerably to improve the continuity of previous geological mappings of individual swarms (e.g., West and Ernst, 1991).

However, linear magnetic anomalies caused by mafic dykes can conceal useful lithological and structural information that could otherwise be determined in their absence. Such linear trends often truncate and interrupt magnetic anomalies due to magnetization contrasts, making the tracing of such features ambiguous. Similarly, any subtle magnetic texture within lithological units may be obscured by the presence of dyke anomalies. Since detectable dyke anomalies are generally caused by sources at or near the ground surface, any enhancements (e.g., calculating gradients) of the measured field are likely to exacerbate the problem. In addition, automated methods for source parameter estimation may respond preferentially to the dyke sources at the expense of other, perhaps more useful, source information.

Thus, to improve the utility of magnetic data where the obscuring effects of dykes are significant, some method to remove their signature is needed. Directional filtering either in the spatial or frequency domain is one option that allows all spectral components within some range of azimuths to be removed from the data (Fuller, 1967; Geosoft, 1994). Such filters should be designed to reject only those trends that are unwanted, with little effect on anomaly components in other directions. Nevertheless, some distortion is to be expected since the rejection band in the frequency domain must be smoothly tapered off and wide enough to avoid ringing effects in the filtered data.

Many dyke swarms are parallel or subparallel (especially at small scales) so that standard directional filtering is appropriate for removing their signature. However, fifty percent of swarms in North America exhibit a fanning pattern (Ernst et al., 1995a) over large enough angles that applying directional filters with such a large rejection band will undoubtedly remove useful source information along with the unwanted anomalies. Furthermore, the removal of trends over a wide range of angles distorts the remaining anomaly distribution and possibly introduces new, false directional information.

Overcoming these difficulties can be achieved by a co-ordinate transformation that can reproject the varying dyke directions onto a single azimuth. Anomalies along this single trend can then be removed by standard directional filtering. First, the focal point of the swarm

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(latitude α°, longitude β°) is estimated from the dyke trends. The data grid is then rotated an angle of 90-α° moving the focal point to the north pole and causing the dykes to lie on lines of longitude. If the data are then regridded onto a cylindrical projection (e.g., Mercator), then lines of longitude are oriented vertically along the columns of the grid, the focal point now being at infinity. So, with the dyke anomalies now vertical, their effects can be removed with standard decorrugation techniques (e.g., Urquhart, 1988; Minty, 1991) developed for levelling grids, i.e., those grids containing striping due to residual flight line problems. The need for filtering over a range of azimuths has been removed. Once the grid is decorrugated in the transformed co-ordinate system, the opposite rotations can be applied and the data values regridded at the original grid location and orientation.

Using a co-ordinate transformation with unidirectional filtering results in a more selective removal of specified anomaly components. In contrast to the effects of frequency-domain directional filtering that are spatially invariant, this approach is location-dependent in that a given trend will only be removed if it passes through the specified focal point. Trends along a given direction in different areas will be affected according to their location.

REMOVAL OF MACKENZIE DYKE SWARM EFFECTS

We use the co-ordinate transformation approach to suppress the anomalous effects of the Mackenzie dyke swarm that contributes significantly to the magnetic field over the Slave structural province, Northwest Territories, Canada. The Mackenzie dykes constitute the largest dyke swarm known on earth, and likely originated from a mantle plume whose location has been estimated at 70° N, 118° W. Most of the Mack-

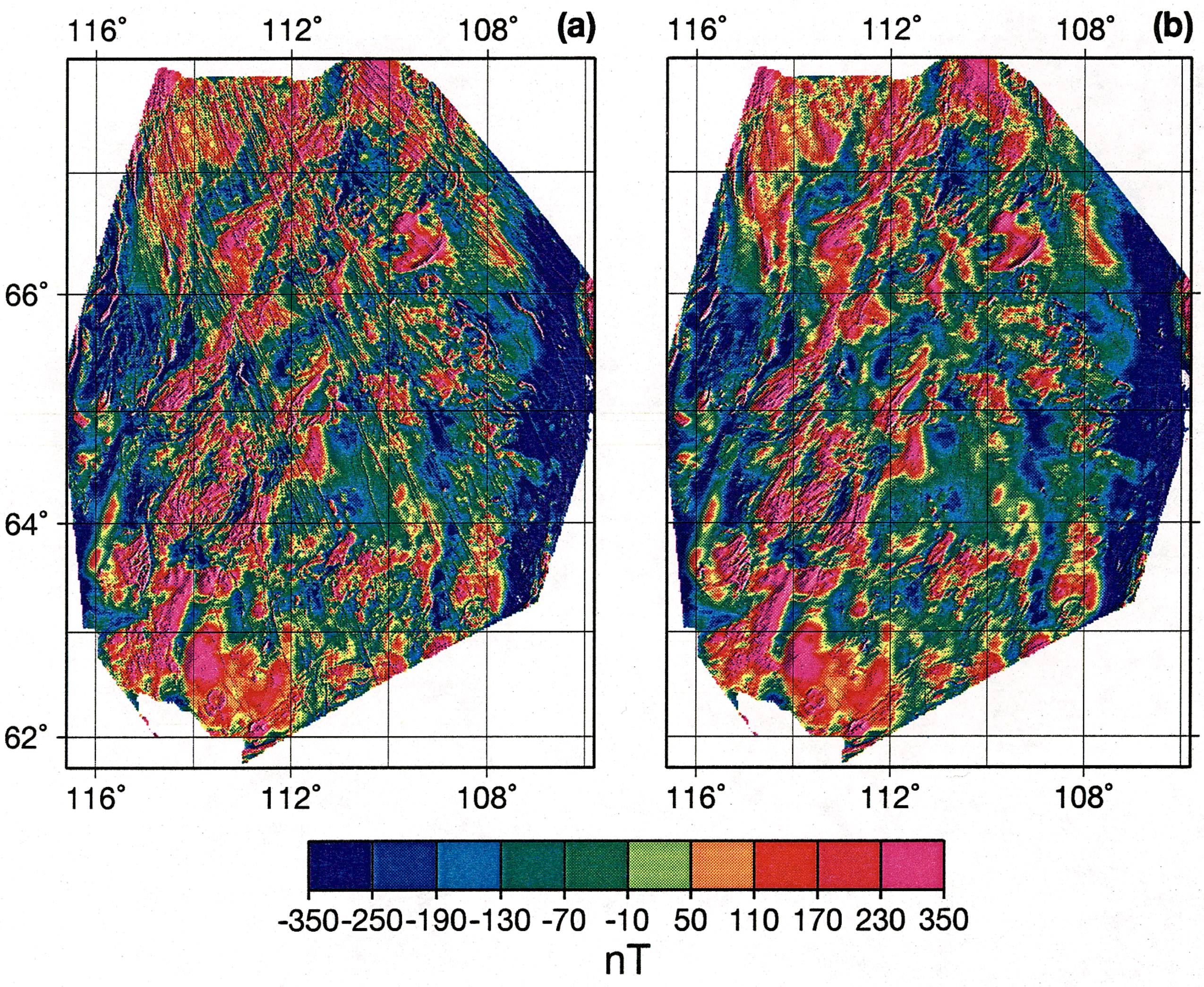

Figure 1: *(**a**) Observed magnetic field over the Slave province showing the presence of numerous Mackenzie dyke anomalies. (**b**) Processed grid after projection and filtering and regridding with the dyke anomalies now suppressed.*

enzie dykes have a quartz-tholeiitic composition and are clearly magnetic, with maximum amplitudes of over 100 nT. The average dyke width is ~30 m, but some reach thicknesses of >100 m (Fahrig, 1987).

Figure 1a shows the observed magnetic field over the Slave province and the ubiquitous nature of the Mackenzie dykes. Within this area, the swarm radiates over an angle of >60° with an average north-northwesterly trend. The grid is first rotated 20° northwards so that the focal point is now at 90°N and the dykes are oriented north-south along lines of longitude. We then regrid the data on a Mercator projection where the meridians are now vertical and coincident with the columns in the grid. The transformed grid is then decorrugated using a directional cosine filter of degree one (Geosoft, 1994, p.23) and a low-pass Butterworth filter of order 8 and cut-off wavelength of 20 km. This processed grid is then rotated back to the true grid position and orientation and regridded at the original grid interval of 400 m (Figure 1b).

CONCLUSIONS

The suppression of variable directional trends in aeromagnetic maps has been accomplished by use of a simple co-ordinate transformation. A combination of rotations on a sphere can be devised to position the unwanted trends onto meridians which, after regridding with a suitable map projection, can be made to coincide with the columns in the grid. In this fashion, techniques that exist for decorrugating gridded data sets may be used to remove the trends.

The example of the radiating Mackenzie dyke swarm shows that this type of approach has advantages over standard directional filtering methods. When trends exist over a large range of azimuths, too much useful, non-dyke, magnetic source information is lost using the latter technique. Additionally, this type of filtering is spatially invariant and rejected frequency components are removed similarly from all points in the gridded data. The co-ordinate transform is, on the other hand, location-dependent, removing only those trends passing through a specified focal point.

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