Short Note

The Accuracy of Dip Estimation by an Automated Magnetic Interpretation Technique

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Abstract

Statistical studies of a computerised automatic interpretation technique based on the method of Koulomzine *et al* (1970) are extended to the evaluation of the dip parameter for semi-finite magnetized dykes. Results show that dip estimates are in general very good (within 5%) with some deterioration in accuracy for small depth to width ratios on more asymmetric anomaly shapes.

Introduction

The performance of an automated interpretation technique based on the method of Koulomzine *et al* (1971) has been previously evaluated with regard to the accuracy of depth and width estimation for semi-infinite dykes. (Long and Whiteley, 1974). The aim of these studies is to provide the practising geophysicist with an automated interpretation tool whose accuracy and limitations are well known. The method of Koulomzine *et al* (ibid) was chosen because of its inherent simplicity and suitability to both mini and main-frame computers.

The interpretation technique requires only that the geomagnetic field parameters and strike of the dyke be specified. The same statistical approach which was used to establish the accuracy of this technique for both depth and width estimates has again been used for the evaluation of dip estimate accuracy.

Statistical studies

The application of Koulomzine *et al*'s method has been briefly discussed in a previous paper (Long & Whiteley, ibid). In order to make an estimate of the geometric parameters of a semi-infinite dyke by this method the magnetic anomaly profile (total or vertical field) must be broken down numerically into its symmetric and asymmetric components. These can be simply calculated. The ratio of the amplitudes of these two components in conjunction with characteristic estimators from the individual components determines a dip parameter.

This dip parameter is a complex angle dependent on dyke dip and its strike, the field inclination and its declination. (Koulomzine *et al*, Equation 65, ibid). Separate estimates of the dip parameter are obtained from both anomaly components and the automatic interpretation procedure which has been developed uses the criteria of individual component amplitudes to determine the most reliable estimate. In cases where component amplitudes are similar, a simple average is taken of the two individual estimates.

To carry out the statistical study approximately 400 different depth and width combinations for semi-infinite dykes were randomly generated by computer and constrained to lie within a range of depth-to-width ratios ($d/_w$) from 0.02 to 2.0. This range was considered geologically adequate for an initial study of thick dykes.

A variety of anomaly shapes for each set of geometric model parameters was generated. Theoretical total field magnetic profiles in a north-south direction over east-west striking vertical dykes were calculated using the Talwani and Heirtzler (1964) two dimensional polygon method at three separate field inclinations (I = 90, 75, 60 degrees). This resulted in dyke anomalies from perfectly symmetric at an inclination of 90 degrees to considerably asymmetric at an inclination of 60 degrees.

It should be noted that symmetric anomalies can be produced in the following circumstances for inducely magnetised dykes, (i) vertically dipping dykes of any strike at the pole (ii) north-south striking vertically dipping dykes at any inclination and (iii) dykes whose dip is in the same plane as the magnetisation vector.

Asymmetric anomalies occur in all other situations with the degree of asymmetry dependent on the dip of the dyke, field inclination and strike of the dyke.

The theoretically generated profiles were interpreted by the automated technique which evaluated the dip parameter. From this, estimates of the dip of the dyke were obtained. Percentage errors in these estimates for each model were recorded along with actual depth-to-width ratio of the model. These were then computer plotted.

The results for each of the cases studied are shown in figures 1 to 3. Figure 1 shows the results for perfectly symmetric anomalies (I = 90°) with Figures 2 (I = 75°) and 3 (I = 60°) for asymmetric anomaly shapes. Each model is shown as a small cross plotted as the co-ordinate of the true depth-to-width ratio and a percentage error of the estimated dip. The horizontal axis represents depth-to-width ratios with a maximum value of 2.0 while the vertical axis is the dip percentage error with limits of ± 5%.

Discussion

For all the models evaluated only very few at the highest level of anomaly asymmetry have a dip estimate error greater than ± 5%.

For the perfectly symmetric anomaly profiles (Figure 1) there is negligible error over the entire range of depth-to-width ratios studied. This error result is to be expected for these anomalies since the dip parameter evaluated by Koulomzine technique is dependent on the ratio of the individual anomaly component amplitudes which is infinite in this case i.e. no asymmetric component.

In Figure 2 at the lesser anomaly asymmetry (ratio of anomaly maximum to minimum amplitude approximately 10 to 1) there is constant underestimation of dip by 0.5% within an average deviation of ± 0.2%. At the lower depth-to-width ratios (less than 0.5) a systematic tendency for further underestimation is evident. The slight functional appearance of the dip estimate errors in Figure 2 becomes very pronounced as the asymmetry increases (Figure 3) (ratio of anomaly maximum to minimum amplitude approximately 3 to 1). The automatic procedure in this case estimates the dip parameter from both anomaly components and averages the results. This averaging together with the constant profile length used for all models regardless of depth-to-width ratio seems to be the cause of this behaviour. Errors in interpretation resulting from parameter estimates based on the two anomaly components and using finite profile lengths are not yet fully known.

Conclusions

In general, the automatic interpretation technique developed, based on the method of Koulomzine *et al* (ibid) produces very reliable dip estimates over a large range of depth-to-width ratios. A slight decrease of accuracy in dip estimation occurs for more asymmetric anomaly shapes, however, errors remain within approximately ± 5%. This study is currently being extended to evaluate errors due to limited profile lengths and individual anomaly component estimates.

References

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TALWANI, M. and HEIRTZLER, J.R. (1964) Computation of magnetic anomalies caused by two dimensional structures of arbitrary shape. Computers in the Mineral Industries. Stanford University, Stanford, California, pp. 464-480.

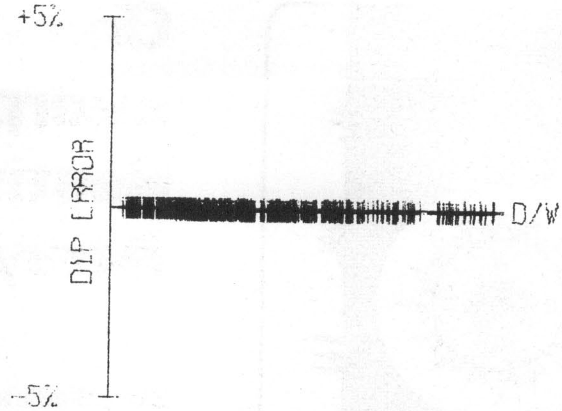

Figure 1. Symmetric Anomalies

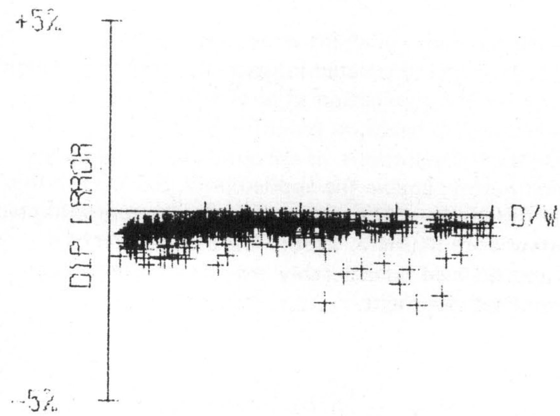

Figure 2. Asymmetric Anomalies (I = 75°)

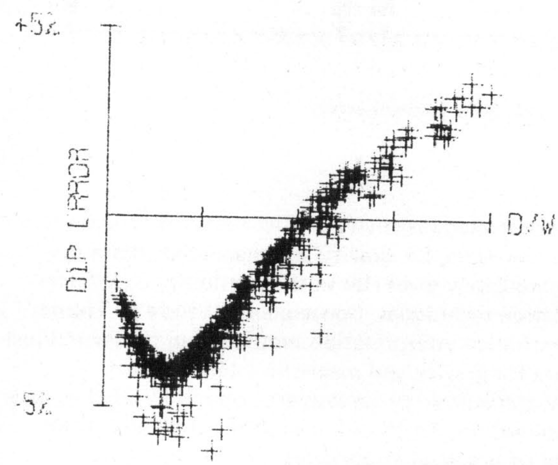

Figure 3. Asymmetric Anomalies (1 = 60°)