Transforms

Transforms are grid-based mathematical operations performed on the primary magnetic anomaly and Bouguer gravity datasets.

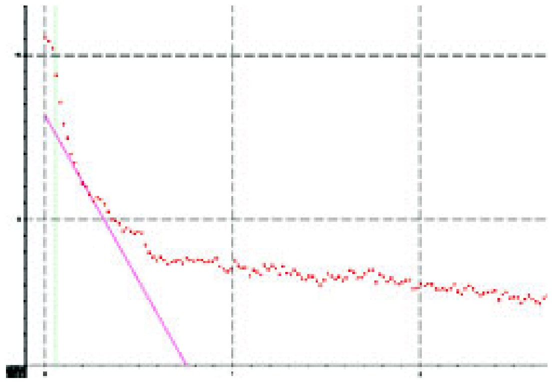
These operations highlight more detailed features or correct the data for known effects within these datasets and help to increase the ease and accuracy of the interpretation.

Transform maps can be of particular use to seismic interpreters, as they provide information on faults and lithological boundaries.

Spectral analysis

Spectral analysis is not a transform process in itself, but may precede and be used to guide particular transforms, especially regional-residual separation.

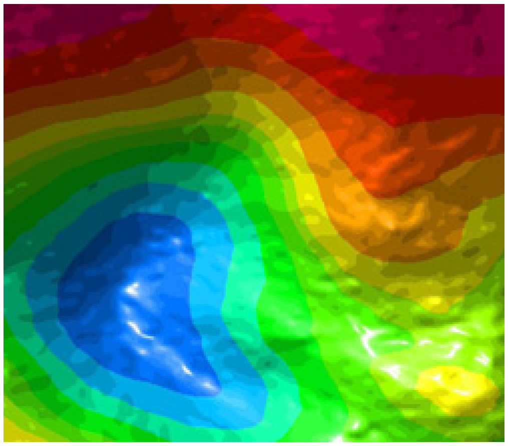
The power spectrum derived from a two-dimensional dataset such as a grid of Bouguer gravity data, also has inherently a two-dimensional form. For ease of interpretation an azimuthal average of the two-dimensional power spectrum is taken to produce a simplified one-dimensional output as shown in figure 1. Sometimes the power spectrum can be divided into two or more straight line segments. The gradient of each segment may be related to the depth to an ensemble of anomalous sources which are within the range of spatial frequencies defined by the segment. The 'break points' (intersections of the straight line segments) provide suitable estimates of cut-off wavelengths for regional-residual separation.



The azimuthally-averaged power spectrum of Bouguer gravity can also be used to derive regional depth estimates. (Spector and Grant, 1970).

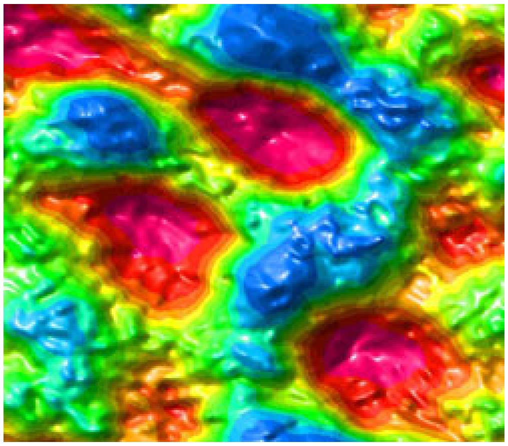
Regional-Residual Separation

A Bouguer gravity or magnetic anomaly grid can be thought of as being composed of several components. Large scale structural elements cause very long wavelength anomalies referred to as the 'regional'. Superimposed on these are smaller localised perturbations, the 'residual', caused by smaller scale structures or bodies. Superimposed on both will be a degree of short wavelength noise. The distinction between the regional and residual is somewhat arbitrary but the regional component can be thought of as the response of bodies large and/or deep compared with respect to the study area and, therefore, not readily interpretable within the bounds of the study area.



Before

As stated above, an initial selection of the cut-off wavelength may be made on the basis of spectral analysis. Additional trials shall, in any case, be made to determine the most appropriate value to use on any dataset.



After

Vertical Derivatives

Vertical Derivative transforms are intended to facilitate the interpretation of gravity and magnetic RTP (or RTE) maps. They are enhancement techniques which amplify the shorter wavelength features relatively to those with longer wavelengths.

The second vertical derivative (SVD) transform is a mathematical transform based on Laplace`s equation. It has the effect of accentuating the shorter wavelength (shallower source) components at the expense of longer wavelength (generally deeper) features. This data enhancement technique was first expounded by Elkins (1951).

Vertical derivatives of any order may be prescribed. The higher the order the greater is the relative amplification of higher frequencies and greater too is the risk of accentuating noise to an unacceptable degree. For this reason vertical derivatives of order three and above are hardly ever calculated. Thus the First Vertical Derivative (FVD) and second vertical Derivative (SVD) transforms are the only transforms of this type that are routinely generated.

The primary property of the SVD transform is that the ZERO CONTOUR represents the point of inflexion on the original anomaly curve which approximates the locations of edges of the causative bodies, providing that the bodies are shallow and have vertical sides.

The first vertical derivative can be used as an alternative to a residual display.

The SVD or FVD is calculated using a filtered and unmasked grid of the Bouguer gravity or RTP/RTE magnetic anomaly.

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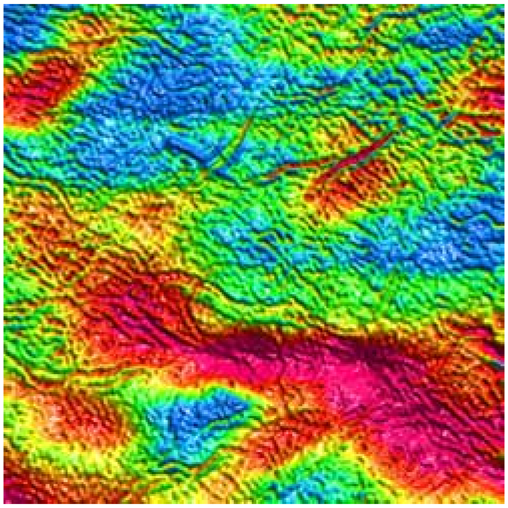


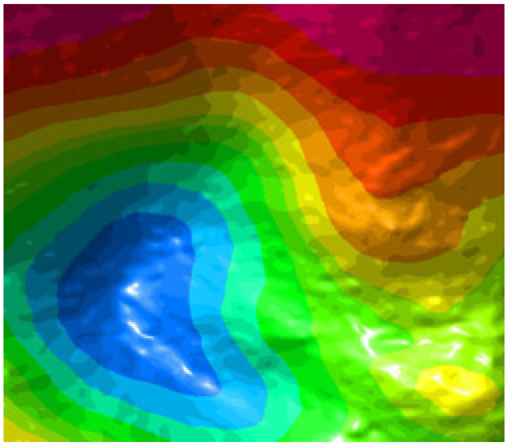
After

Terracing

Terracing is an iterative process which converts an undulating surface grid into a terraced surface of plateaux and plains, producing something analogous to a physical property map akin to a solid geology map. The algorithm compares each point in a grid to its north, south, east and west neighbours and either leave the point value unchanged, sets it to the highest value of the five points or sets it to the lowest depending on the value of the local curvature at that point.

The grid so produced contains large homogeneous areas of little variation bounded by sharp changes. However, a quirk of the algorithm tends to produce squared of boundary edges. An alternative method of boundary delineation involves the amplitude-of-horizontal-gradient method. Boundaries between relatively homogeneous areas in a normal grid are marked by a peak or ridge in the horizontal gradient. These boundaries may be picked out by automated processes.

Terracing is usually applied to the Bouguer gravity and magnetic anomaly grids.



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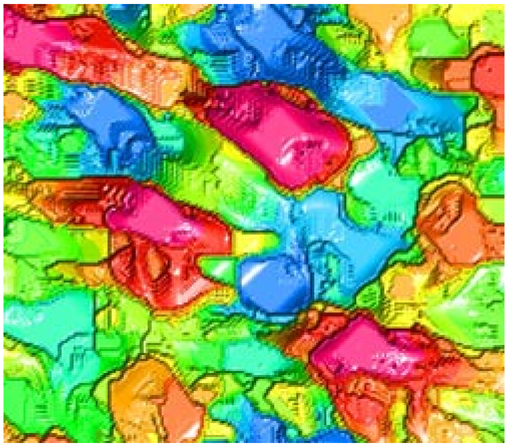
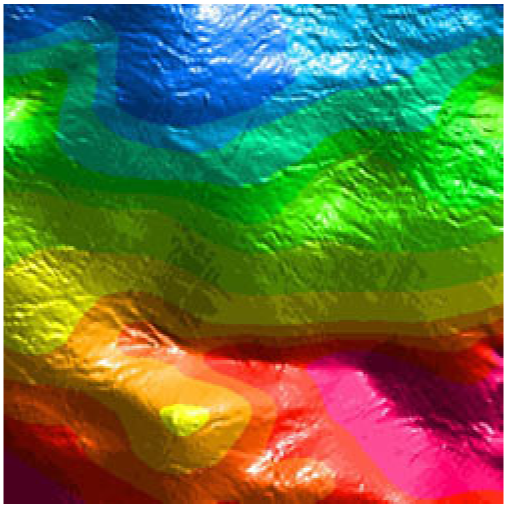


After

Reduction to Pole or Equator of magnetic data

The purpose of the Reduction-to-Pole (RTP) operation is to provide an additional magnetic data set which, (assuming the frequently correct situation of sub vertical interfaces) depicts the magnetic field in a simplified form transformed to its equivalent response at the geomagnetic pole.



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The operation requires knowledge of the values of inclination and declination of the Earth's magnetic field appropriate to the survey. This is obtained by inputting the location and period during which the data were acquired. The height above sea level is also required, e.g. for a marine survey height = 0 and for an airborne survey typically height = 305m (1000ft).

In relatively low magnetic latitudes (up to 30-40° north or south of the magnetic equator), the RTP operator can become unstable, amplifying high frequency noise. Also beware of RTP calculations that cover large areas. Currently there is no option within the program to compote a variable latitude correction. This problem may be resolved by Reduction to the Equator (RTE).

NOTE: Magnetic latitude does not correspond to geographic latitude.

Any RTE requirement should be discussed for projects within 20° of the magnetic equator as the analytic signal transform might be more appropriate.

The RTP operation should be performed on the filtered magnetic anomaly grid.

The critical parameter in the RTP procedure is the M,N - the number of weights on a side of the filter. The M,N value should be such that the filter window is a minimum of 50km, bur preferably 100km. The M,N value must be an odd number.

Horizontal Derivatives

Gradient transforms are non-linear (so their order in relation to other processing steps such as frequency filtering will affect the final result) and are of two kinds. The Horizontal Gradient H[F] of an anomaly field F is calculated as the Pythagorean sum of the gradients in the orthogonal directions. Choosing the directions to be along the ones of the grids, the calculation becomes:

$$\sqrt{Gxz^2 + Gyz^2} = H[F]$$

This is thus the absolute value of the horizontal gradient at x, y, i.e. the value of the horizontal gradient in the direction of greatest increase.

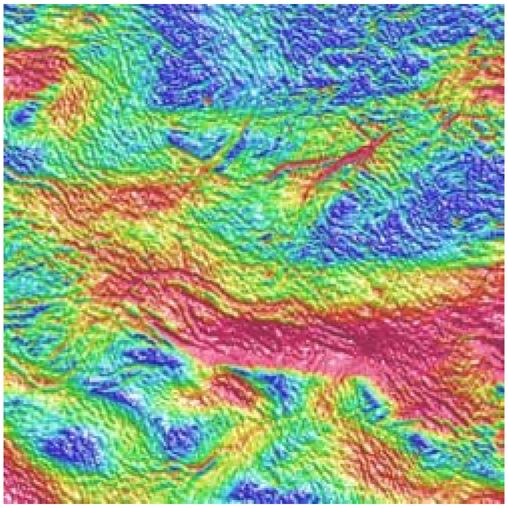
Generally when calculating the Horizontal Gradient, the primary option is to calculate H[F], though options also exist to calculate the direction of the greatest rate of change and the trend.

The ridges of maxima on the Horizontal Gradient of Bouguer gravity are recognised by the industry generally as being good locators of shallow, vertical body edges. The same is true of magnetic data which has been transformed to pseudogravity. However, current ARK practice is to use the magnetic anomaly RTP rather than pseudogravity.

The Total Gradient T[F(x,y)] of the field extends the Horizontal Gradient concept to three dimensions and is calculated thus:

For magnetic data the Total Gradient is the absolute value of a complex quantity known as the Analytic Signal and maxima also are indicators of body edges, independent of the Earth's magnetic field and direction of magnetisation in bodies. The advantages of calculating the Total Gradient for gravity, if any, are not known

Before



After

Vertical continuations

Upward and downward continuation will most commonly be used when merging together datasets from different sources, where the height of acquisition varies from one dataset to another. Aeromagnetic surveys frequently fall into this category.

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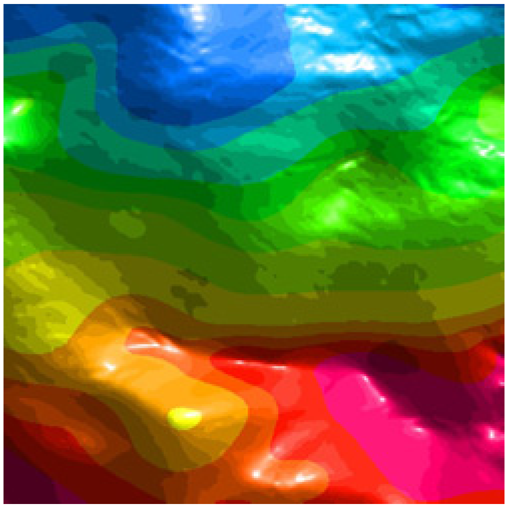

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