Progress Report – June 2005
Geoinformatics and RFI
Pioneer Tenement Work

Compiled for June 2005 by Dan Core and Amanda Buckingham of Geoinformatics Exploration Australia

1.0 Introduction

During May and June, geophysical, topographic, and geochemical data covering the Haezlewood (EL31/2003) and Corinna (EL36/2003) tenements were processed to provide a framework for interpretive work in those areas. Major tasks included

- Obtained detailed magnetic surveys from Mineral Resources Tasmania and downloaded gravity data from Geoscience Australia,
- Subsetted existing topography and stream sediment data for tenement areas,
- Processed geophysics and topography using a variety of filters to enhance features potentially related to mineralization
- Wormed gravity and magnetic data to provide constraints on deep structures.
- Inverted new magnetic data to provide 3D constraints on units
- Processed stream sediments to highlight anomalous areas.

2.0 Data Collection, Cataloging, Capture, and Validation

New magnetic surveys covering northwestern Tasmania were downloaded from the MRT website. These surveys are 2001 West Tasmania (WTRMP Area C) and P652 Arthur Pieman (1996). The data in these surveys were not leveled properly so the grids were smoothed to remove noise. The surveys were then stitched together and windowed for the area encompassing both tenements. Gravity data was downloaded from the Geoscience Australia website. DEM data were taken from the Geoinformatics database for the PMD*CRC Tasmania regional project. A detailed helimag survey over the Corinna tenement was downloaded but not used because of decorrugation issues.

All original and processed data were loaded into our IFS database with appropriate metadata. All data were also loaded into a FracSIS database.

3.0 Processing of Geophysical and Topographic Data

3.1 Aeromagnetic and Ground Gravity Data

ENHANCEMENT FILTERING

Potential field data (magnetic and gravity data) can be manipulated in the frequency domain to emphasize features of interest such as deep and shallow sources, pertinent structures and discontinuities, and locations of unit edges. GXL has developed a suite of enhancement filters specifically designed to highlight such features in magnetic data, to assist in the interpretive process.

Several different types of filtering (both linear and non-linear) have been applied to the RTP (Reduced to the Pole) magnetic and Bouger gravity grids covering the project area (Pioneer tenements). Appendix 1 details the various filters used, the purpose of each filter and a snapshot of the geo-referenced images created for each filtered grid. Due to the coarseness and quality of the gravity data, only a few of the filtered images were useful.

WORMING

In addition to enhancement filtering, magnetic and gravity data were wormed. Worming is edge detection on upward continued data and is used to locate boundaries between long wavelength features that may not be apparent in the original data. Such boundaries often correspond to deep structures.

INVERSIONS

Magnetic data over the Haezlewood tenement was inverted to better understand the 3D distribution of units. The data over the Corinna tenement could not be inverted. The gravity data was not inverted because it is too coarse.

3.2Topographic Data

ENHANCEMENT FILTERING

Many of the filters originally designed for potential field data can be suitably applied to gridded topographic data, with the same goal of emphasizing features of interest, pertinent structures and discontinuities. For example the upward continuation operator when applied to magnetic data approximates the field that would be observed if the sensor were placed at a 'higher' elevation above ground; when applied to topographic data, the operator acts as a tapered smoothing filter, highlighting dominant (longer wavelength) variations in elevation. The GXL suite of enhancement filters has been applied to the 100m topography grid covering the Pioneer tenements.
Appendix 1 details the various filters used, the purpose of each filter and a snapshot of the geo-referenced images created for each filtered grid.

4.0 Processing of Stream Sediment Data

Stream sediment data were sent to IO Geochemistry for leveling and gridding. For details of the processing, see the Power Point presentation provided by IO Geochemistry. The data distribution is irregular but a few anomalies stand out. The only anomalies in the Pioneer tenements are high Zn, Ag and Cr in the Cambrian ultramafics in the Haezlewood tenement (Figure 1). There is a large Au and minor Cu anomaly just to the west of Haezlewood in the Permian sediments. There is a large Cu anomaly southwest of the Haezlewood tenement in early Cambrian volcanics and sediments. Northwest of Corinna is a minor Cu anomaly in Permian sediments.

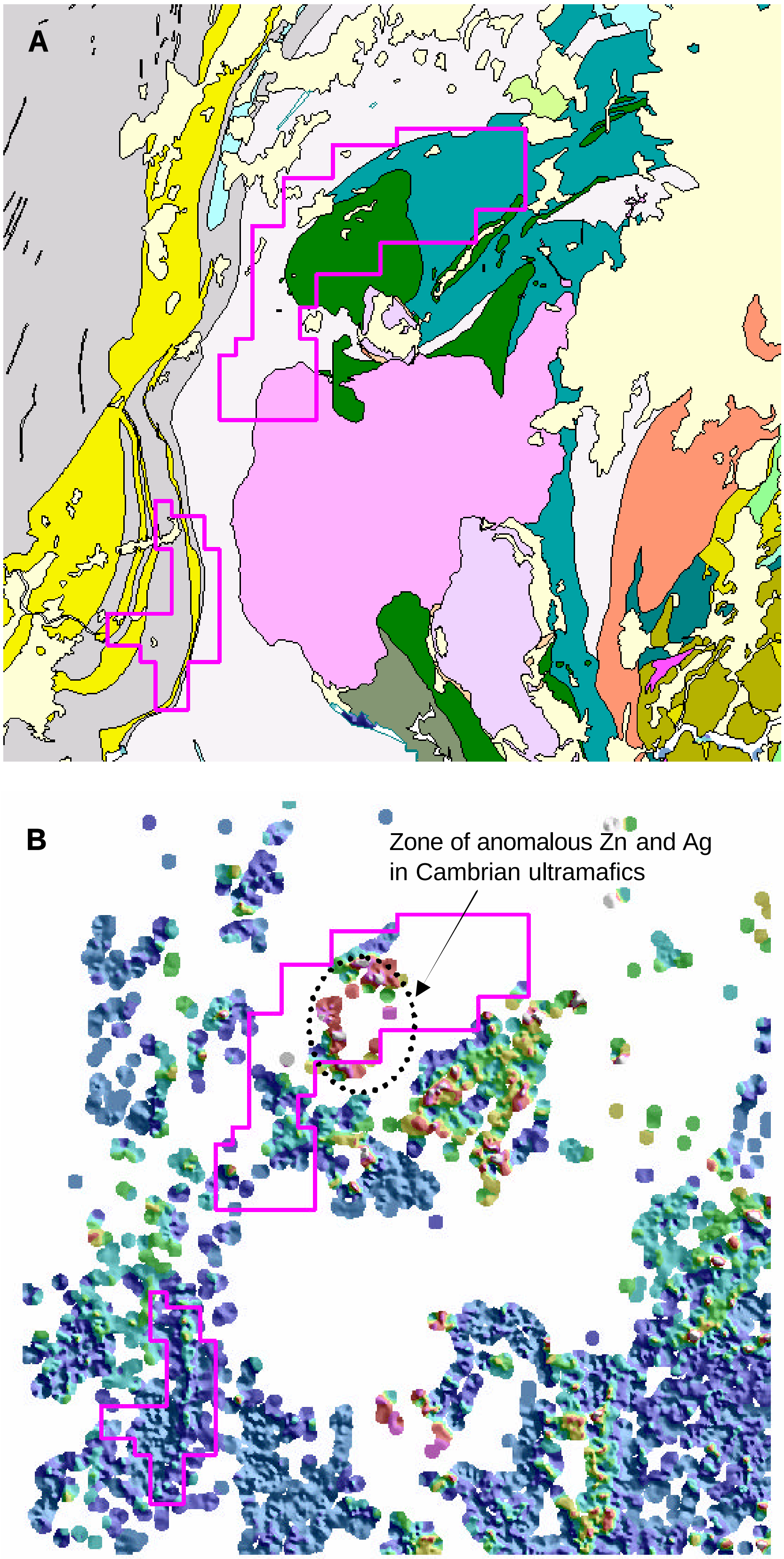


Figure 1 A. 250 K geology map of the region encompassing the Haezlewood and Corinna tenements. B. Zn in stream sediments showing an anomaly in the Haezlewood tenement.

5.0 Work Details

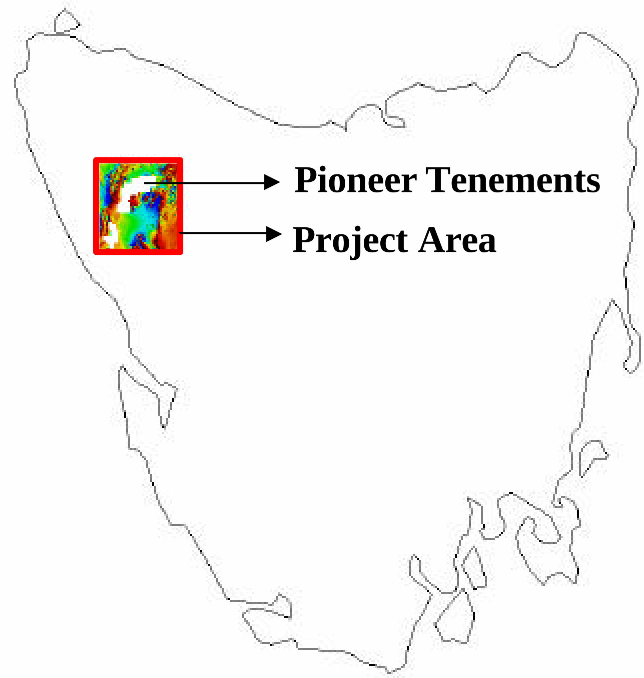
Summary of tasks and hours by Geoinformatics Personnel for May and June, 2005

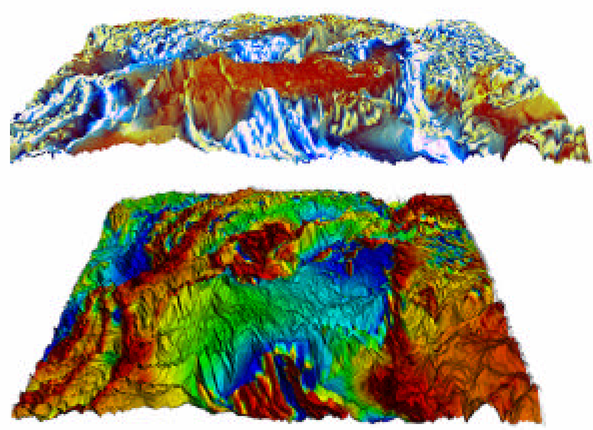
Name	Hours	Description
Amanda Buckingham	12	Geophysical/image processing work; report writing
Rob Stuart	28	Geophysical/image processing work; data capture
Dan Core	22	Geophysical/image processing work; data capture; report writing; database management
Darren Holden	2	Business development
Patricia Laidlaw	1	Entering data into library system
TOTAL	**65**	

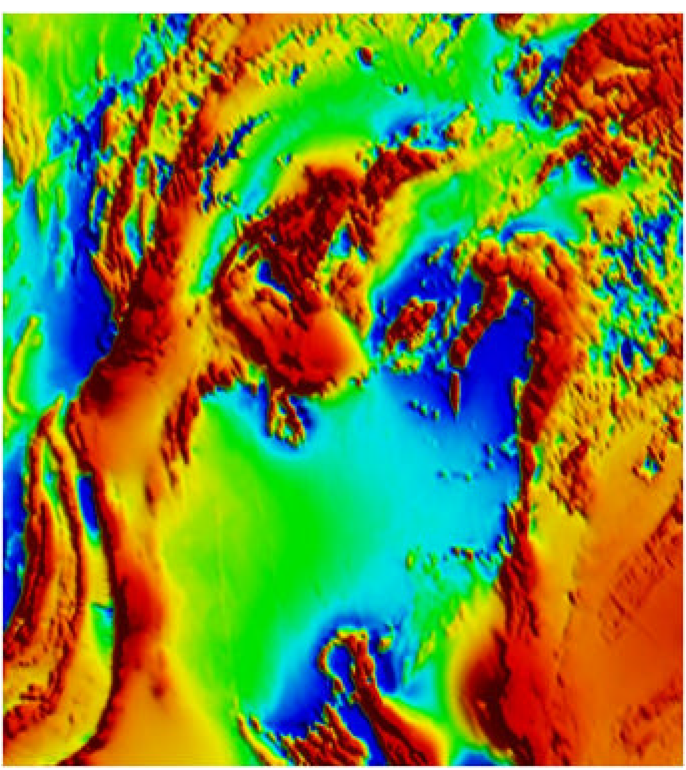
Summary of outsourced tasks for May and June, 2005

Processing of stream sediment data by IO Geochemistry – $2775

Appendix 1
Enhancement filtering of Aeromagnetic, Gravity and Topography data over the Pioneer Tenements







Tas_Pioneer_RTP.tif

TMI
Reduced to the Pole

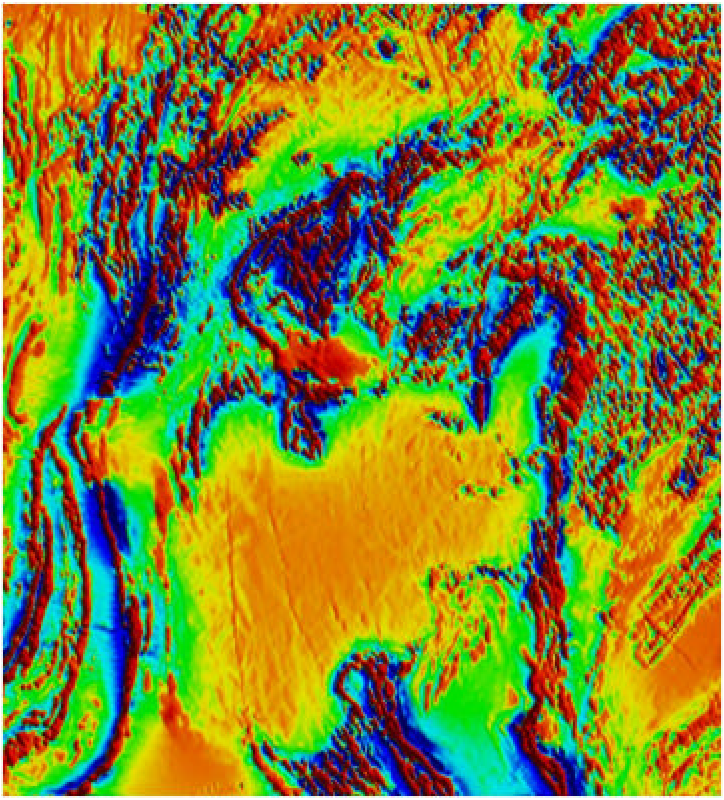
Filtering

The result of the reduction to the pole operation is a field which would be observed if the given field had been observed with vertical polarization, that is, as though observed at the Earth's magnetic pole. If strong remnant magnetization is present in directions other than that of the Earth's ambient field, the transformed field will be in error.

Purpose

TMI data are reduced to the pole to shift anomalies directly over their source and produce symmetric anomalies.

The location of sources, particularly source edges, can more readily be determined when the magnetic data has been reduced to the pole.



Tas_Pioneer_1vd.tif

RTP
First Vertical Derivative

Filtering

The first vertical derivative filter has been applied.

Purpose

The first vertical derivative filter enhances near surface contrasts in susceptibility by amplifying the high frequency component of the spectrum (linear increasing filter).
Noise and merging artifacts are also enhanced in this process.

Tas_Pioneer_2vd.tif

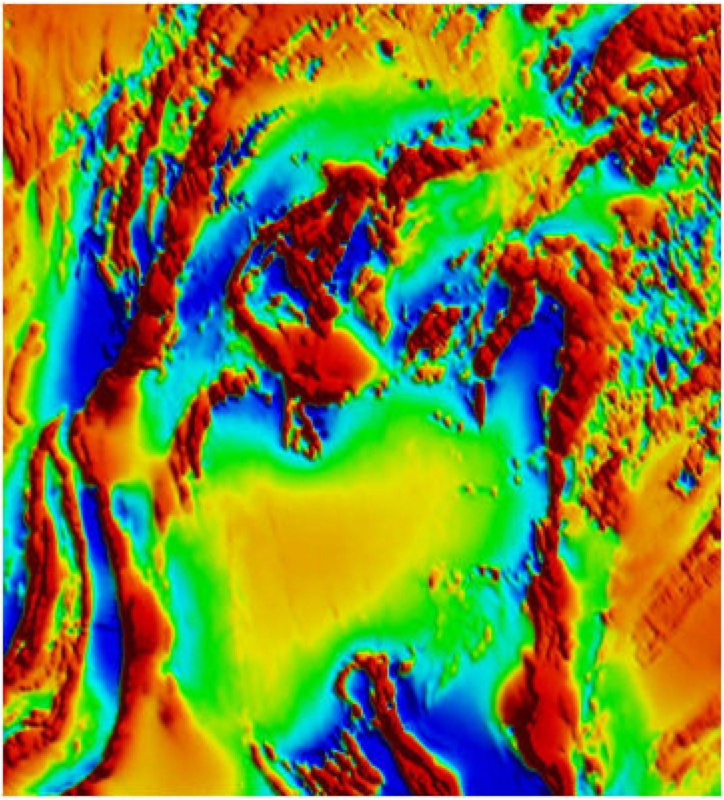
RTP
Second Vertical Derivative

Filtering

The second vertical derivative filter has been applied.

Purpose

The second vertical derivative transform, based on Laplace's equation, has the effect of accentuating the shorter wavelength (shallower source) components at the expense of longer wavelength (generally deeper) features. The zero contour of the second vertical derivative 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.



Tas_Pioneer_RTP0-2km.tif

RTP Shallow Residual (differential upward continuation) 0m to 2km

Filtering

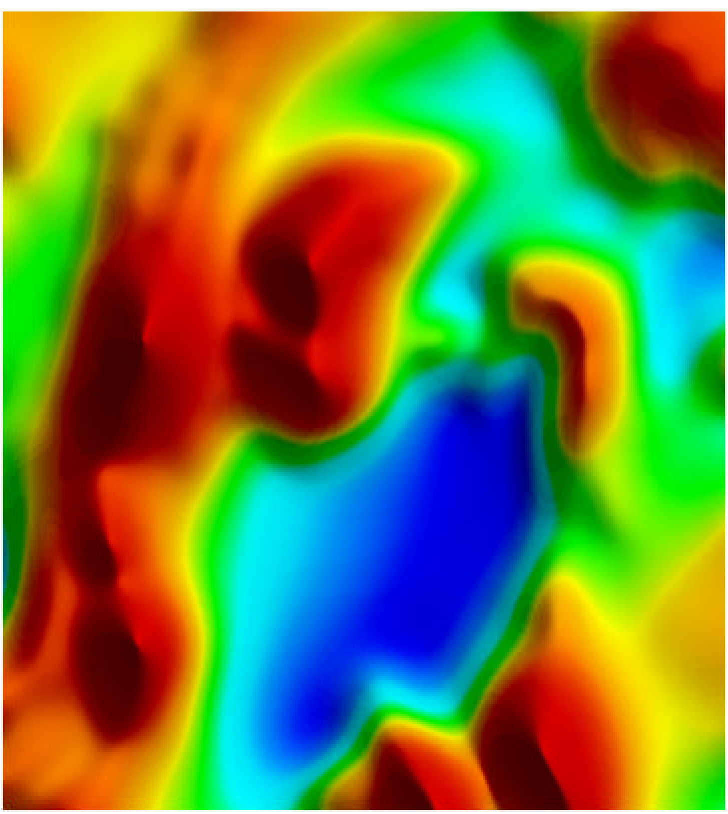
Separation filtering using differential upward continuation can be used to approximate the magnetic response arising from different depth intervals below surface. Complete separation of responses is not possible, however, the method is useful for discerning “shallow” from “deep” sources.

In effect, band-pass filters (with a physical meaning) are being applied to the data.

Residual = original – field upward continued 2km

Purpose

To highlight (as best possible) only the shallow (surficial) sources.

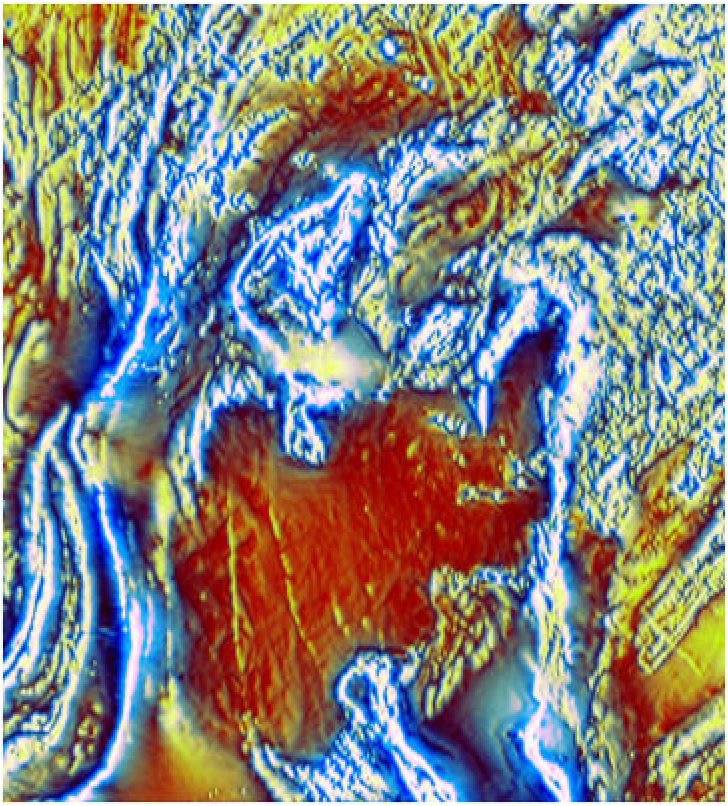


Tas_Pioneer_RTP2-10km.tif

RTP Intermediate Residual (differential upward continuation) 2km to 10km

Purpose

To highlight intermediate depth sources.



Tas_Pioneer_Ternary_Residual.tif

RTP
Ternary Representation

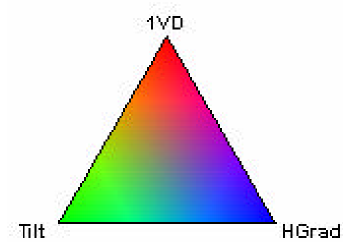
Filtering

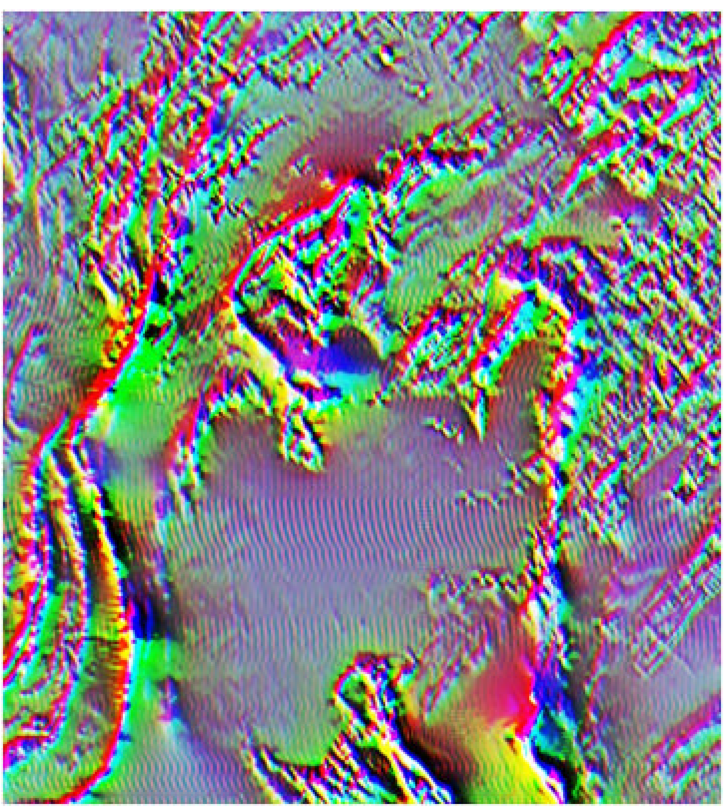
This representation of the magnetic field combines three of the best known approaches to highlighting source edges and structure.

Cyan = First vertical derivative
Magenta = tilt angle filter
Yellow = horizontal gradient magnitude

Purpose

To highlight pertinent structures, emphasize breaks in continuity and enhance the textural character of units.





Tas_Pioneer_DDeriv.tif

RTP
Directional Derivatives

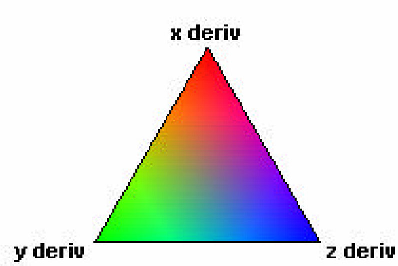
Filtering

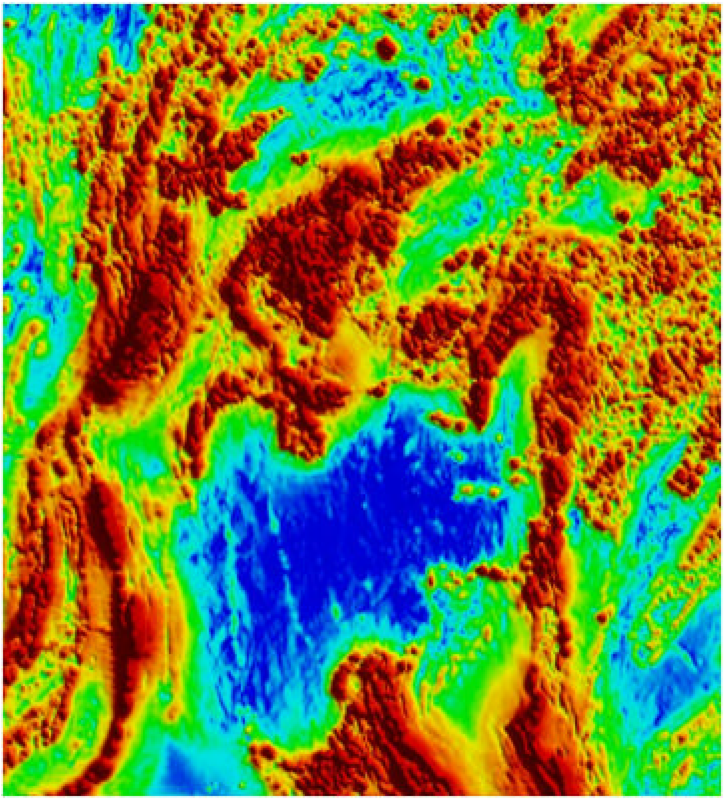
The three orthogonal derivatives are combined in a ternary display where:

Red	= X derivative of the field
Green	= Y derivative of the field
Blue	= Z derivative of the field

Purpose

To highlight changes in gradient in all three directions.



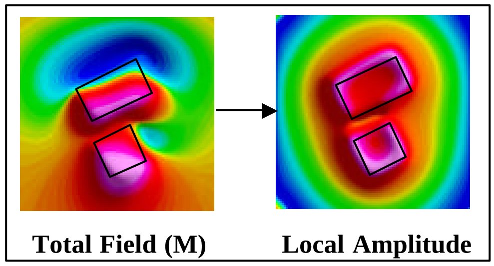


Tas_Pioneer_ASig.tif

RTP
Analytic signal amplitude

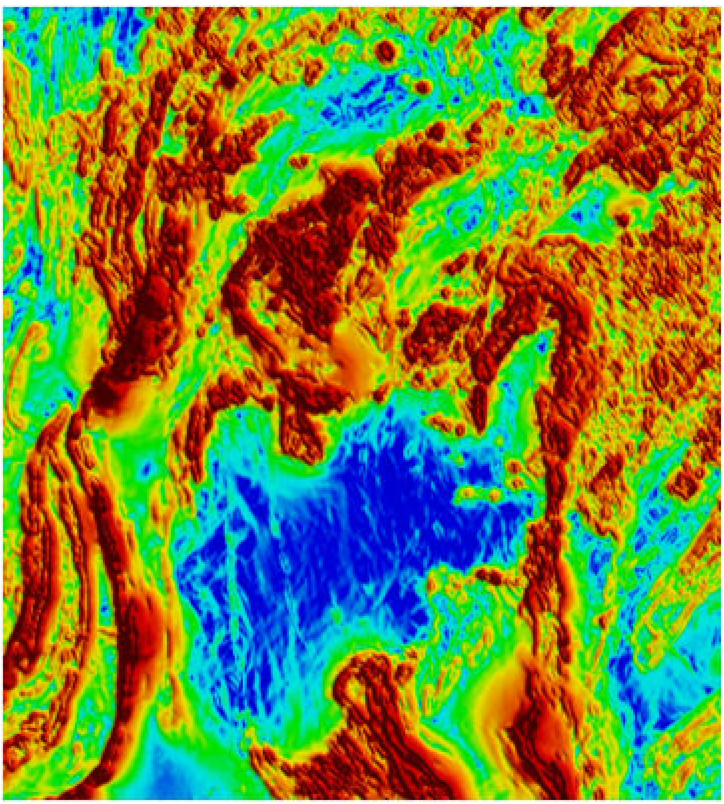
Filtering

The analytic signal amplitude, also known as the total gradient, is calculated from the three orthogonal derivatives of the magnetic field (x,y and z).



Purpose

The analytic signal peaks over the edges of wide bodies and over the centre of narrow (dyke-like) bodies. Source body edges can be located by tracing the peaks in the analytic signal amplitude. The analytical signal is independent of remanence.



Tas_Pioneer_HGrad.tif

RTP
Horizontal Gradient Magnitude

Filtering

The Horizontal Gradient Magnitude (HGM) is calculated from the orthogonal *x* and *y* derivatives of the magnetic field.

Purpose

The horizontal gradient magnitude (HGrad) filter highlights the location of contrasts in susceptibility (source body edges), assuming vertical sided sources.

Note however, that this filter is not independent of the direction of magnetization, as is the case for the analytic signal filter. Additionally, the location of a peak (ridge) in the HGM image will be offset in the down-dip direction, if the source body is dipping.

RTP
Tilt Angle Filter

Filtering

The tilt angle filter is defined as the arctangent of the ratio of the vertical derivative to the horizontal gradient magnitude, of the field. For isolated sources, the tilt angle is positive over the source, crosses through zero at or near the edge of a vertical sided source, and is negative outside the source region.

Purpose

The tilt angle filter is excellent for highlighting structure in magnetic data. It responds equally well to shallow and deep sources.

Tas_Pioneer_Tangle.tif

RTP
Positive tilt pseudocolour

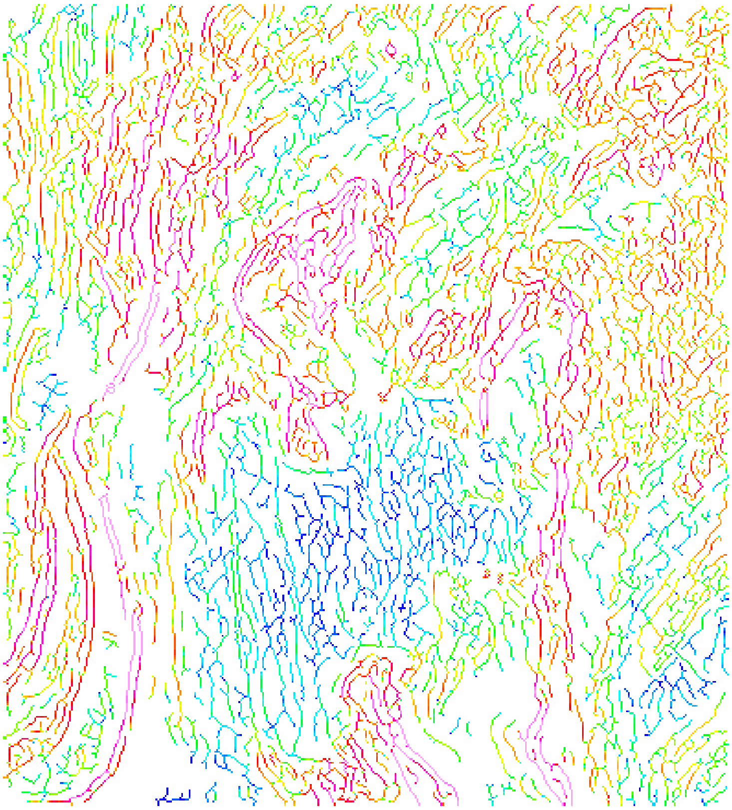
Filtering

Positive tilt regions have been pseudo-coloured by the residual RTP amplitude

Purpose

The tilt angle filter is excellent for highlighting structure in magnetic data. It responds equally well to shallow and deep sources.

Tas_Pioneer_STilt.tif



RTP Automated edge detection Edge Strength

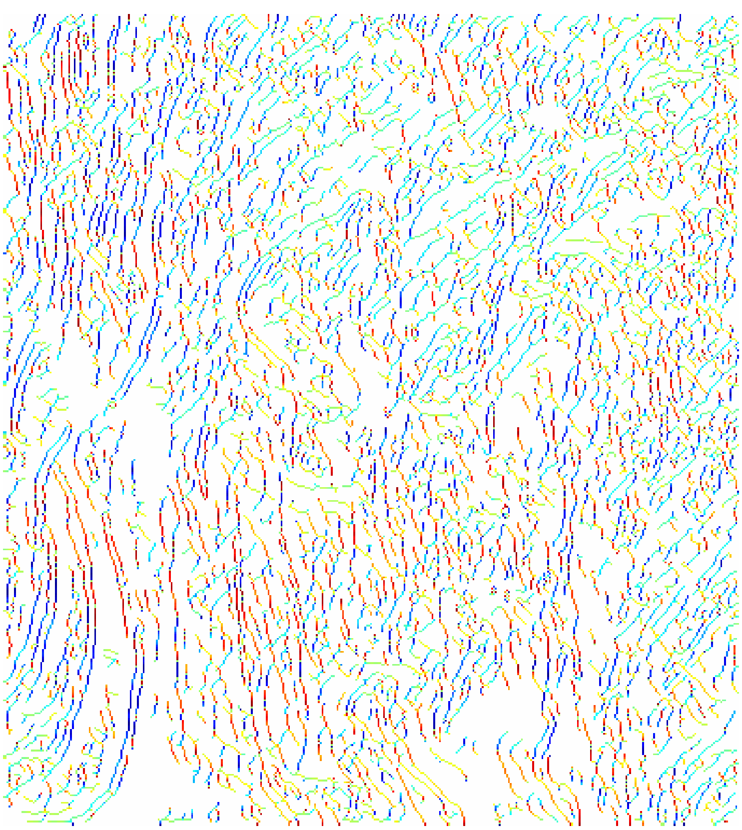
Filtering

Automated edge detection using the height ridge algorithm (Buckingham 2003 method) has been applied to the total horizontal gradient of the RTP grid. Crests in the HGM RTP occur over the edges of wide bodies and the centre of narrow bodies.
The strength of the edge has been highlighted here, where strength is defined as the difference between the minimum and maximum principal curvature of the ridge.

Purpose

To highlight the locations of magnetization contrasts that may represent lithological contacts, faults, alteration, internal fabric. This representation of the data allows the interpreter to readily identify pertinent structures of interest, that may be overlooked in the original RTP data.

Tas_Pioneer_RTP_edge_str.tif



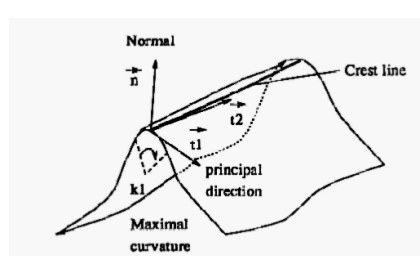
RTP Automated edge detection Edge Orientation

Filtering

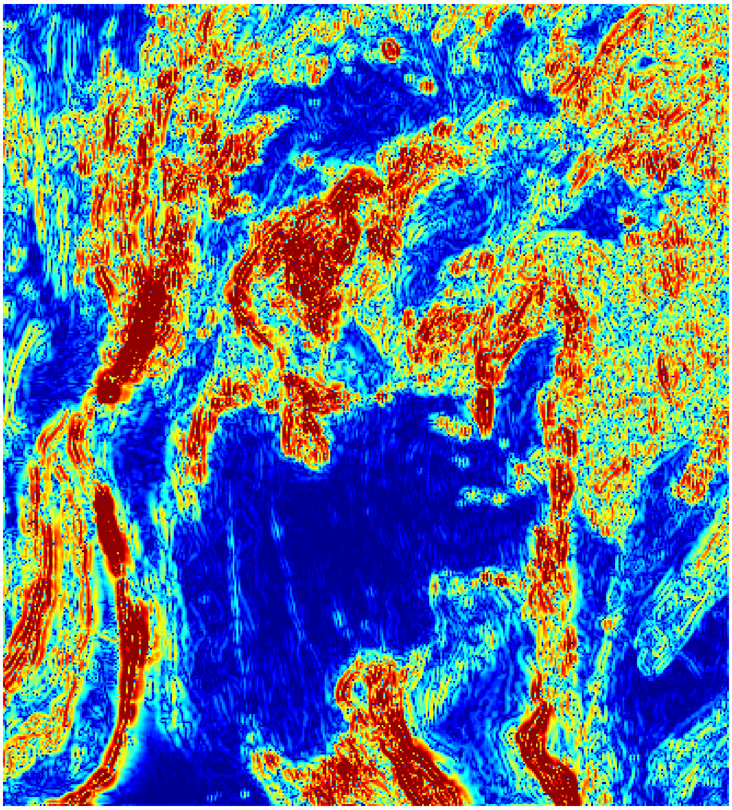
The orientation of the edge has been highlighted here, where orientation is defined as the minimum principal curvature direction (the direction along the crest of the ridge).

Purpose

To highlight patterns in orientation of structures and to delineate structures having an orientation of predetermined importance.



Tas_Pioneer_RTP_edge_ori.tif



Tas_Pioneer_RTP_str_p_1_log.tif

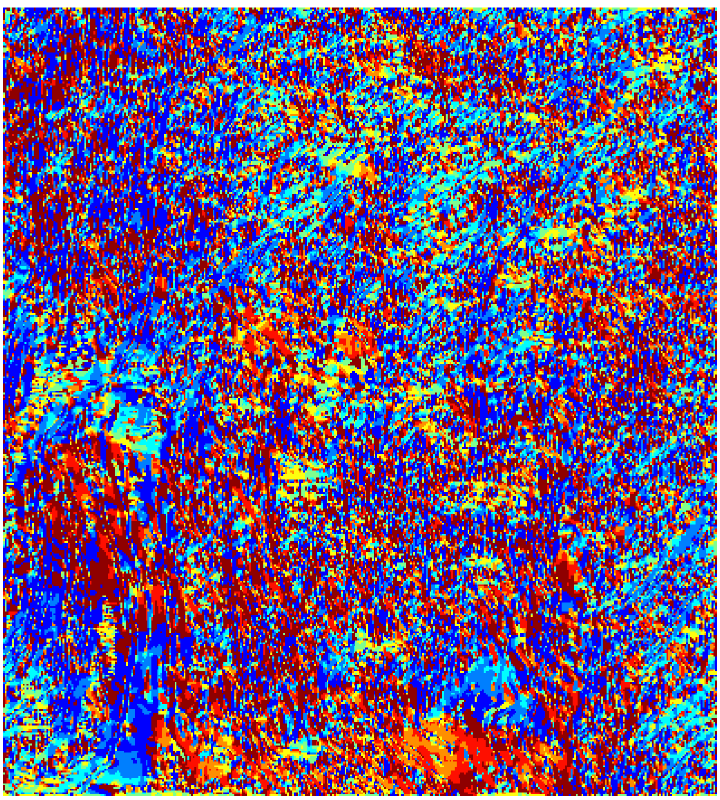
RTP Strength

Filtering

The strength at every grid cell has been highlighted here, where strength is defined as the difference between the minimum and maximum principal curvature of the surface calculated over a 5 x 5 window.

Purpose

To highlight pertinent structures and contrasts in susceptibility.



Tas_Pioneer_RTP_ori_grouped.tif

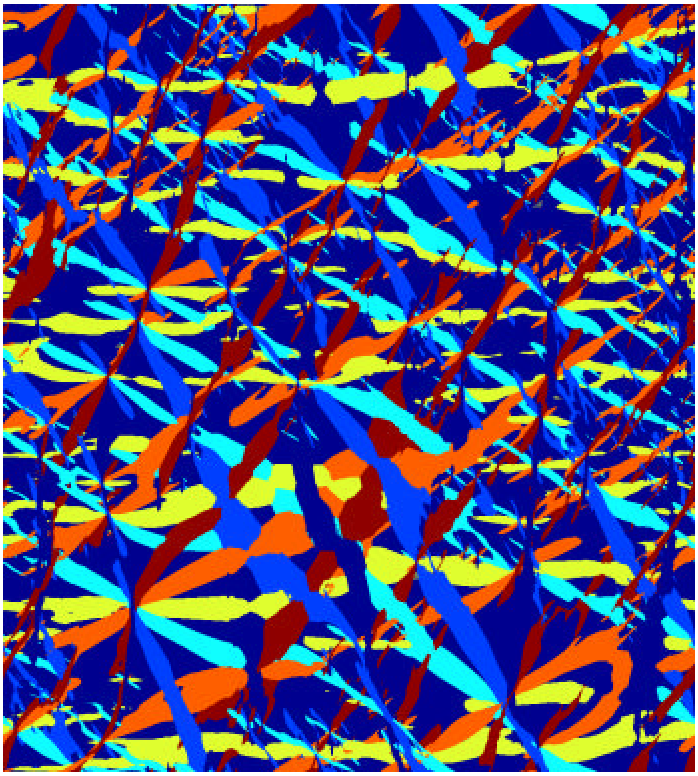
RTP Orientation

Filtering

The orientation at every grid cell has been highlighted here, where orientation is defined as the minimum principal curvature direction.

Purpose

To assist in the identification of textural patterns associated with variations or similarity in magnetic character based on orientation.



Tas_Pioneer_RTP_sm_phOri.tif

RTP
Phase Congruency
Orientation

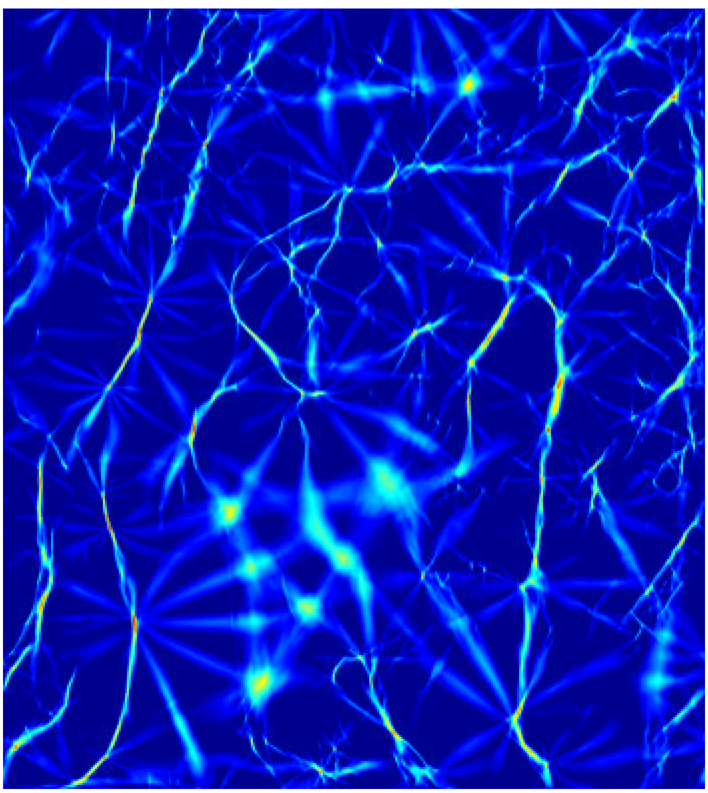
Filtering

The Phase Congruency method is a type of multi-scale feature detection which attempts to extract dominant breaks in continuity from a grid. Such features are often detected by the human eye, but it is difficult to determine their extent and intensity from the original data alone.

Pertinent features in a grid such as step edges, ridges and lines (boundaries or axes of magnetic units) result in strong local phase coherence structures in the frequency domain (across scale and space).

Phase congruency is a dimensionless quantity - and is independent of any frequency domain amplitude filtering that has been applied (for example upward continuation).

Different descriptors cam be extracted from the filtered data including the orientation of the features and the degree of symmetry (in the phase domain).

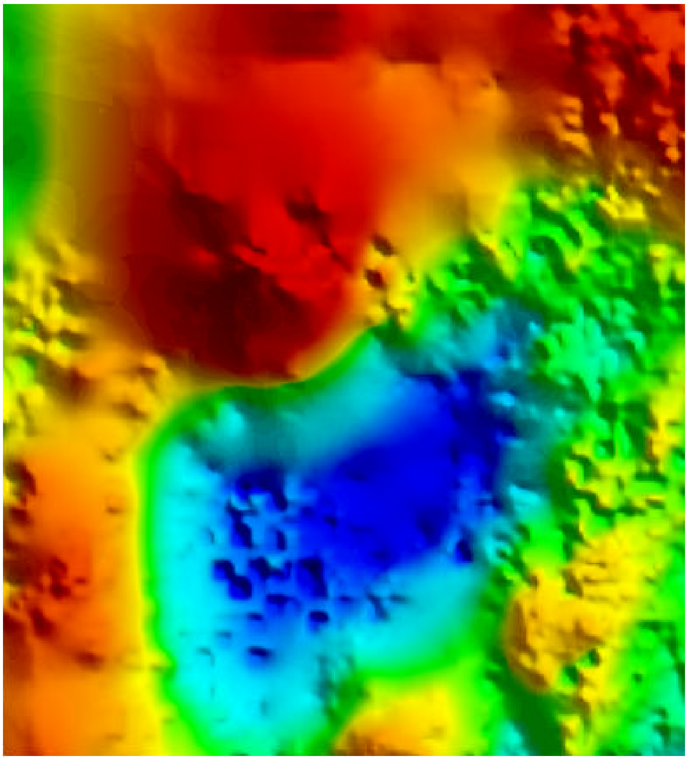


Tas_Pioneer_RTP_sm_phSym.tif

RTP
Phase Congruency
Symmetry

Purpose

To highlight pertinent features in a grid independent of scale.



Tas_Pioneer_Grav_boug.tif

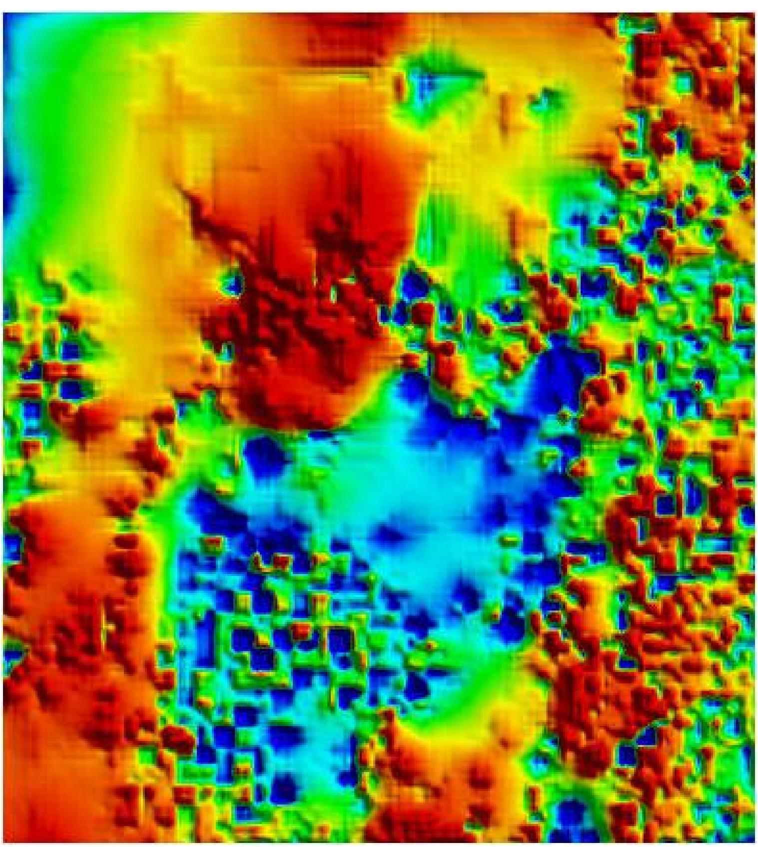
Bouguer Gravity

Filtering

Free air gravity data is reduced to Bouguer gravity by the calculation and removal of the effects topography (rock/water or rock/air interface) on the gravity anomaly.

Purpose

It is the lateral density variations in the middle to upper crust that allow characterization of the structure, geometry and character of the basement.



Tas_Pioneer_Grav_boug_1vd.tif

Bouguer Gravity
First Vertical Derivative

Filtering

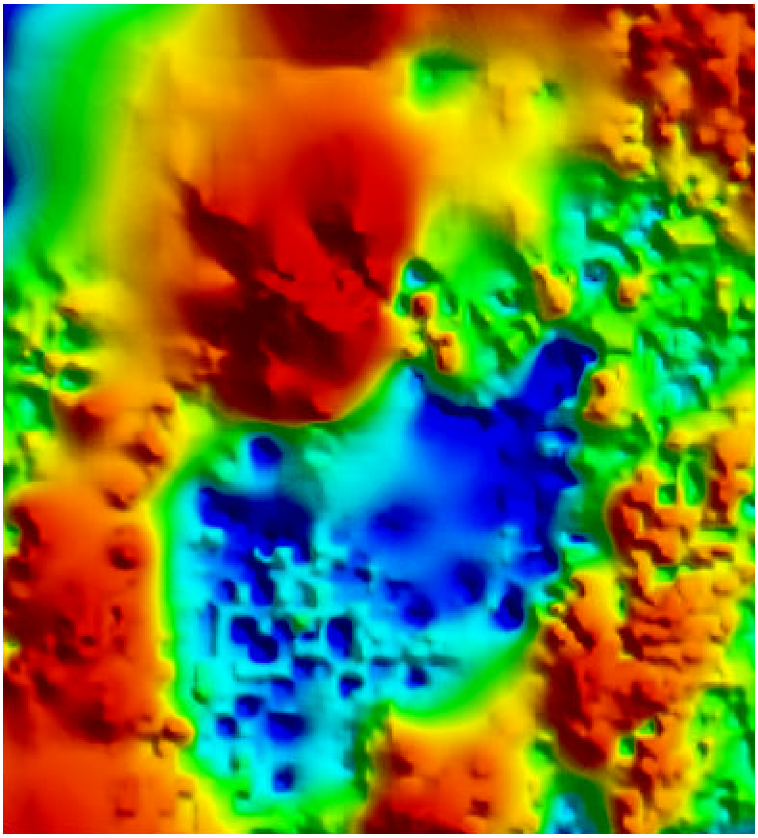
The first vertical derivative filter has been applied.

Purpose

The first vertical derivative filter enhances near surface contrasts in density by amplifying the high frequency component of the spectrum (linear increasing filter).
Noise and merging artifacts are also enhanced in this process.

Note the irregular sample spacing and gridding problems have been amplified.

Poor results due to irregular sample density and gridding artifacts



Tas_Pioneer_Grav_boug_0-2km.tif

Bouguer Gravity (differential upward continuation) 0m to 2km

Filtering

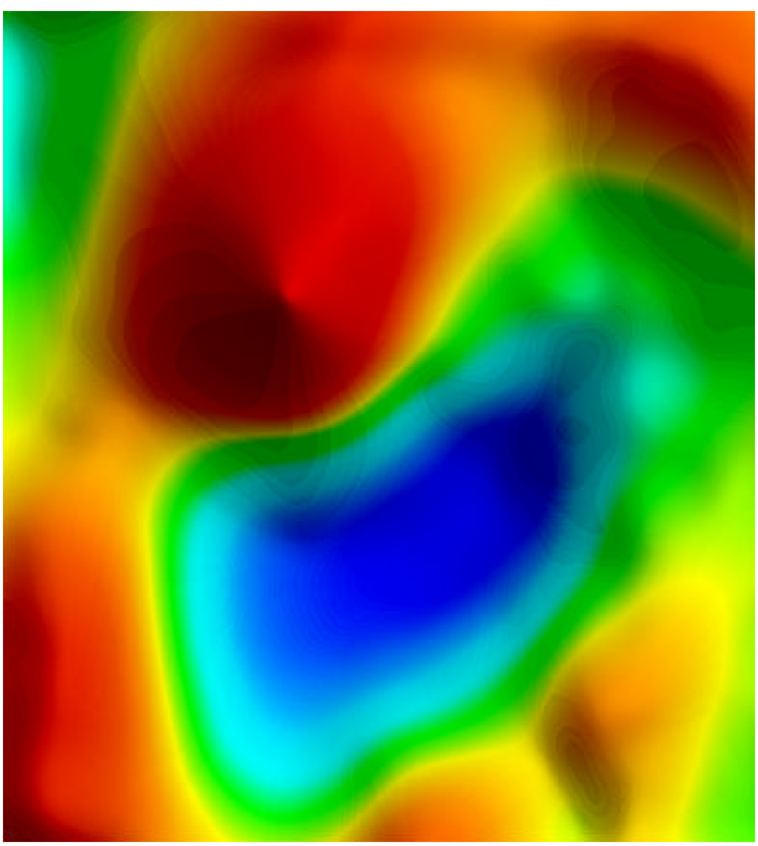
Separation filtering using differential upward continuation can be used to approximate the gravitational response arising from different depth intervals below surface. Complete separation of responses is not possible, however, the method is useful for discerning "shallow" from "deep" sources.

In effect, band-pass filters (with a physical meaning) are being applied to the data.

Residual = original – field upward continued 2km

Purpose

To highlight (as best possible) only the shallow (surficial) sources.

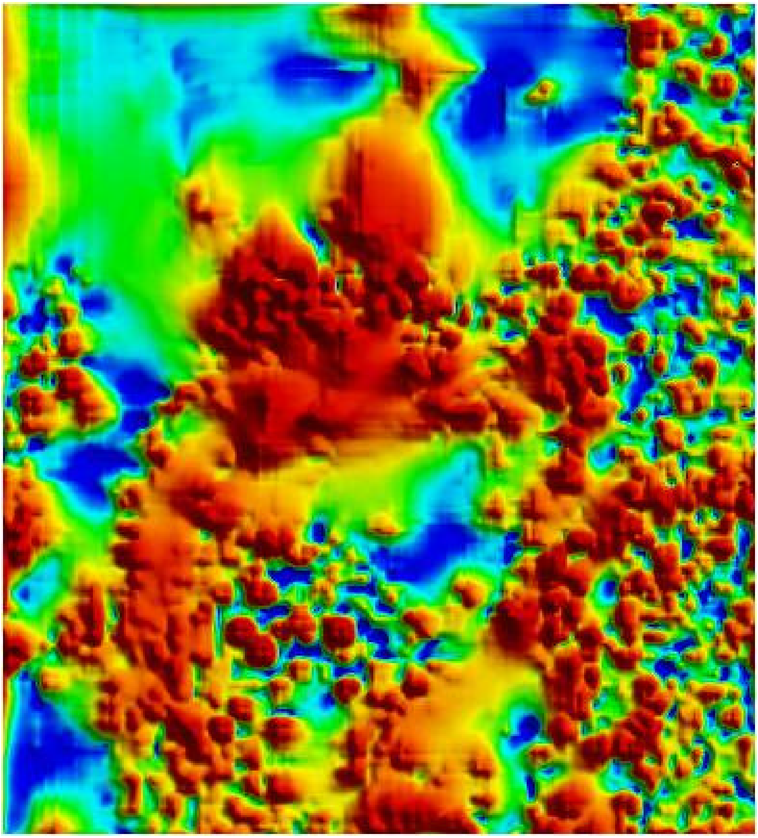


Tas_Pioneer_Grav_boug_2-10km.tif

Bouguer Gravity (differential upward continuation) 2km to 10km

Purpose

To highlight deeper sources.

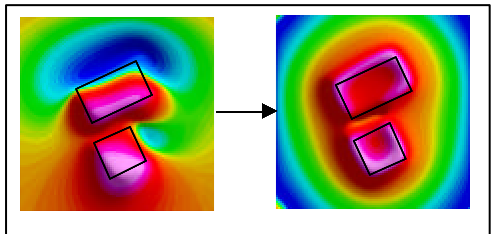


Tas_Pioneer_Grav_boug_ASig.tif

Bouguer Gravity
Analytic signal amplitude

Filtering

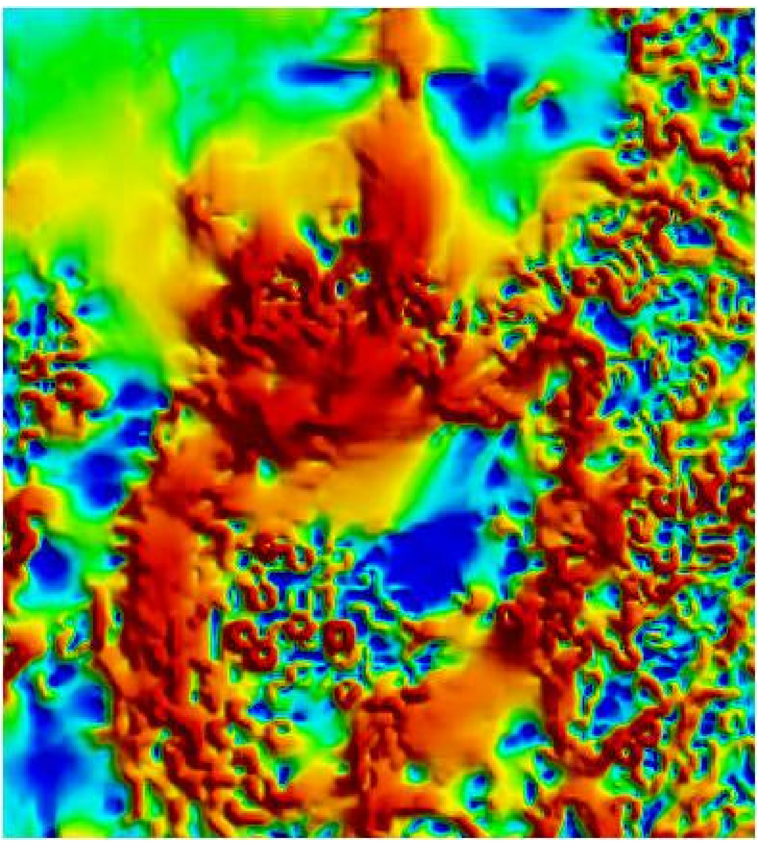
The analytic signal amplitude, also known as the total gradient, is calculated from the three orthogonal derivatives of the potential field (x,y and z).



Purpose

The analytic signal peaks over the edges of wide bodies and over the centre of narrow (dyke-like) bodies. Source body edges can be located by tracing the peaks in the analytic signal amplitude.

Poor results due to irregular sample density and gridding artifacts



Tas_Pioneer_Grav_boug_HGrad.tif

Bouguer Gravity
Horizontal Gradient Magnitude

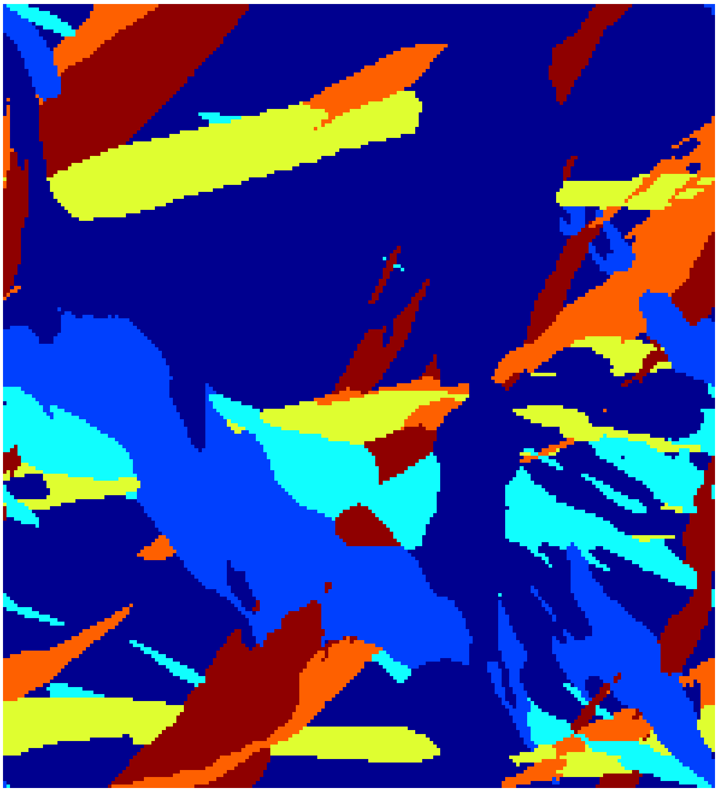
Filtering

The Horizontal Gradient Magnitude (HGM) is calculated from the orthogonal *x* and *y* derivatives of the potential field.

Purpose

The horizontal gradient magnitude (HGrad) filter highlights the location of contrasts in density (source body edges), assuming vertical sided sources.

Poor results due to irregular sample density and gridding artifacts



Tas_Pioneer_Grav_boug_phOri.tif

Bouguer Gravity Phase Congruency Orientation

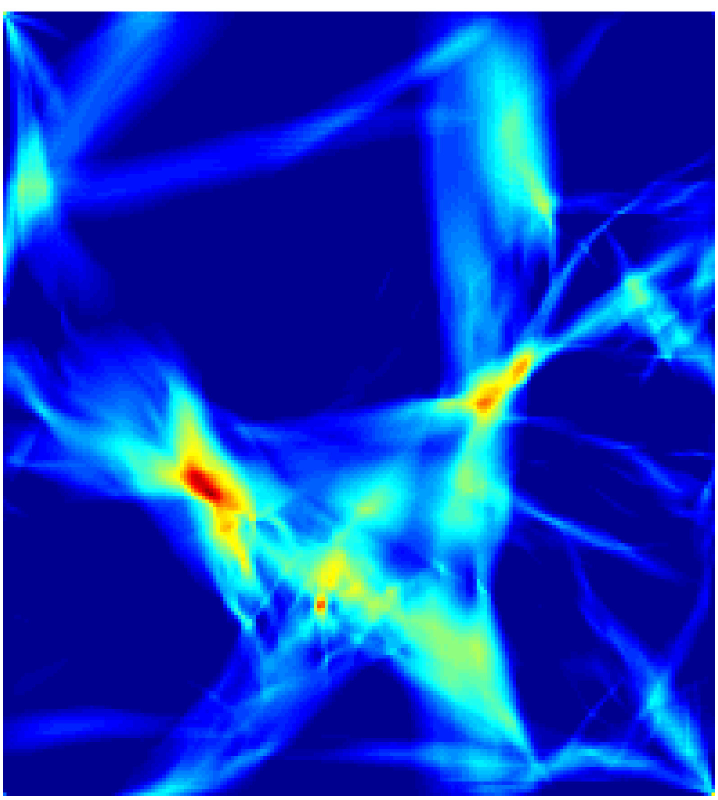
Filtering

The Phase Congruency method is a type of multi-scale feature detection which attempts to extract dominant breaks in continuity from a grid. Such features are often detected by the human eye, but it is difficult to determine their extent and intensity from the original data alone.

Pertinent features in a grid such as step edges, ridges and lines (boundaries or axes of magnetic units) result in strong local phase coherence structures in the frequency domain (across scale and space).

Phase congruency is a dimensionless quantity - and is independent of any frequency domain amplitude filtering that has been applied (for example upward continuation).

Different descriptors cam be extracted from the filtered data including the orientation of the features and the degree of symmetry (in the phase domain).

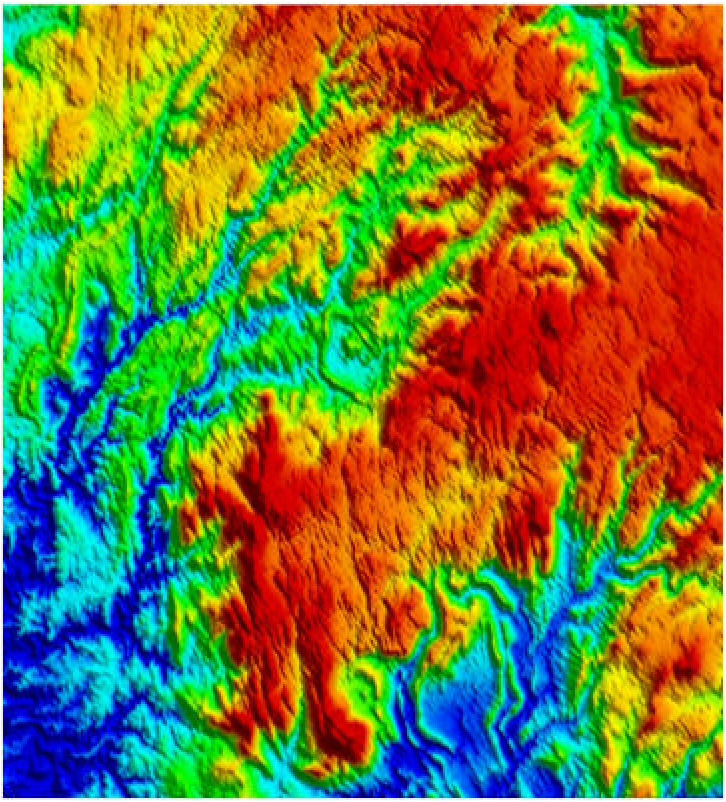


Tas_Pioneer_grav_boug_phSym.tif

Bouguer Gravity Phase Congruency Symmetry

Purpose

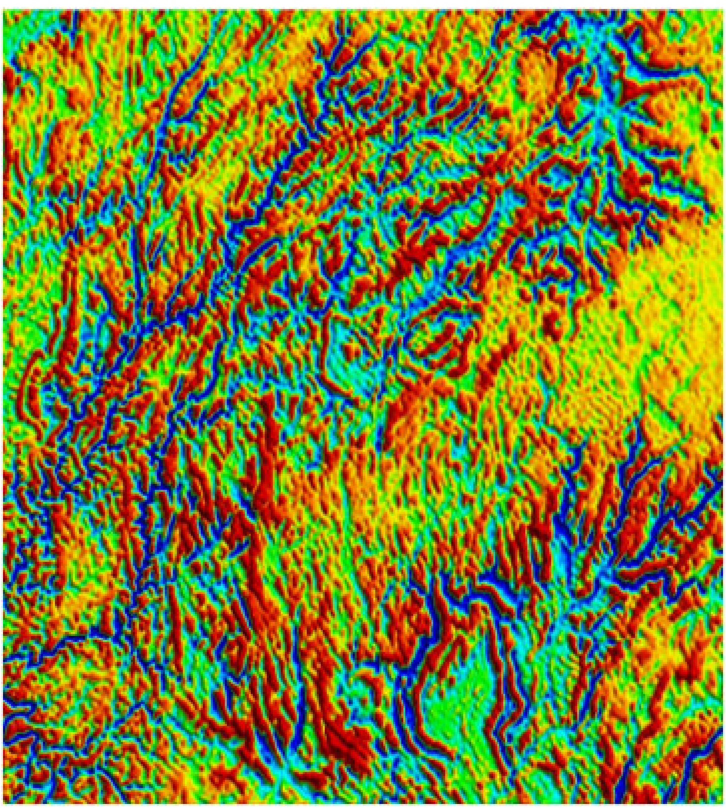
To highlight pertinent features in a grid independent of scale.



Tas_Pioneer_topo.tif

Topography

The 100m DTM grid covering the Pioneer Tenements has been imaged.

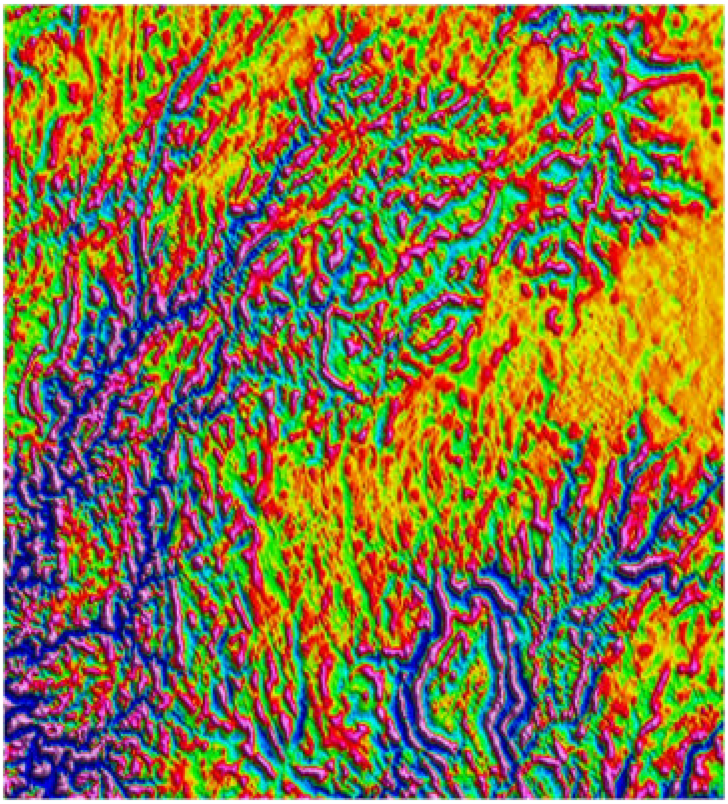


Tas_Pioneer_topo_1vd.tif

Topography
First Vertical Derivative

Filtering
The first vertical derivative filter has been applied.

Purpose
To highlight regions of significant change in slope and valley/ridge patterns.

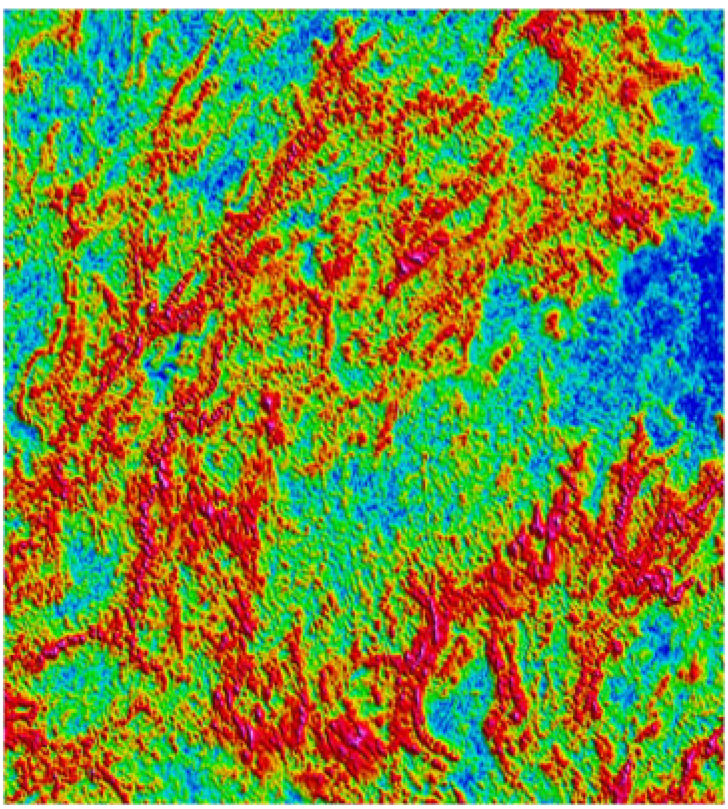


Tas_Pioneer_topo_AGC.tif

Topography
Automatic Gain Control

Filtering
The automatic gain control (AGC) filter equalizes the range of amplitude variations across the grid. The local amplitude has been used here.

Purpose
Subtle features in the data may be obscured or overwhelmed by the amplitude variations due to large changes in elevation. This filter gives equal emphasis (in terms of amplitude) to ‘anomalies’ of all frequencies, allowing the interpreter to notice subtle responses.

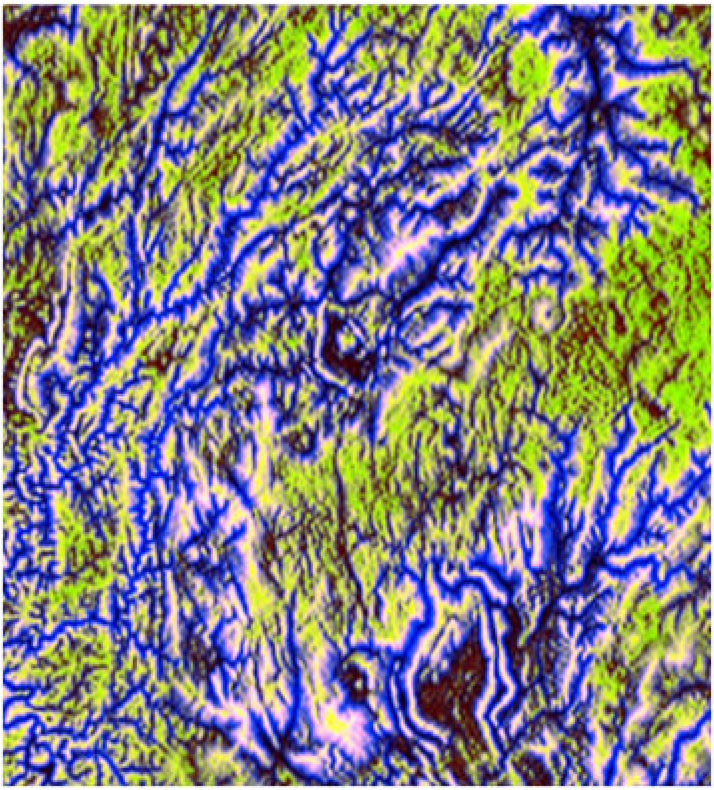


Tas_Pioneer_topo_ASig.tif

Topography
Total Gradient
(Analytic Signal)

Filtering
The total gradient filter has been applied.

Purpose
To highlight pertinent features and patterns.



Tas_Pioneer_Topo_Ternary.tif

Topography
Ternary Representation

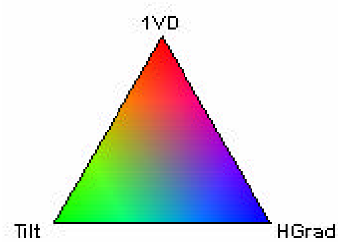
Filtering

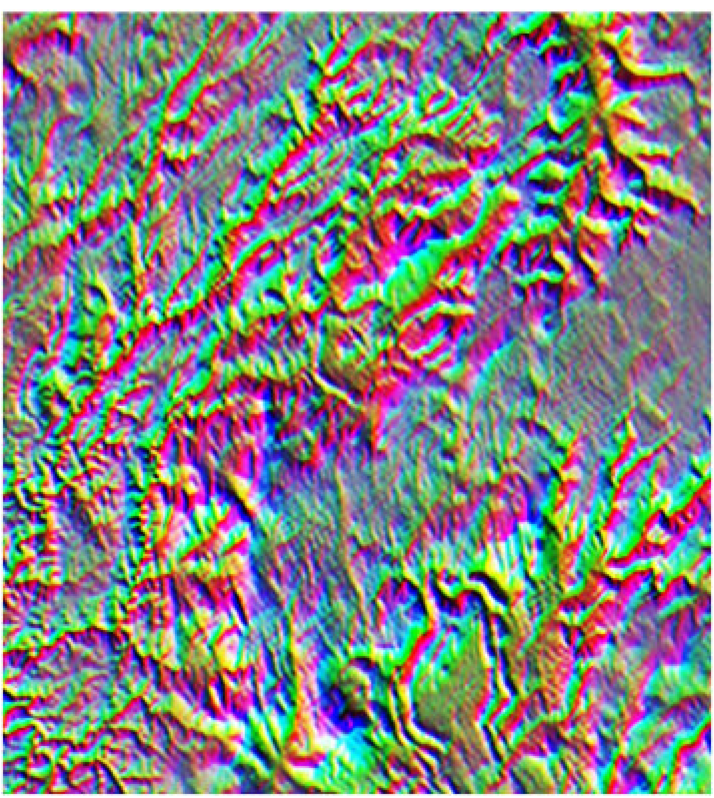
This representation of the topography combines three of the best known approaches to highlighting significant gradients and structure.

Cyan = First vertical derivative
Magenta = tilt angle filter
Yellow = horizontal gradient magnitude

Purpose

To highlight pertinent structures, emphasize breaks in continuity and enhance the textural character of regions.





Tas_Pioneer_Topo_DDeriv.tif

Topography
Directional Derivatives

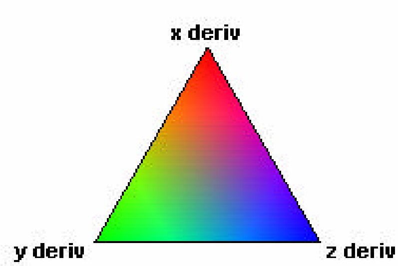
Filtering

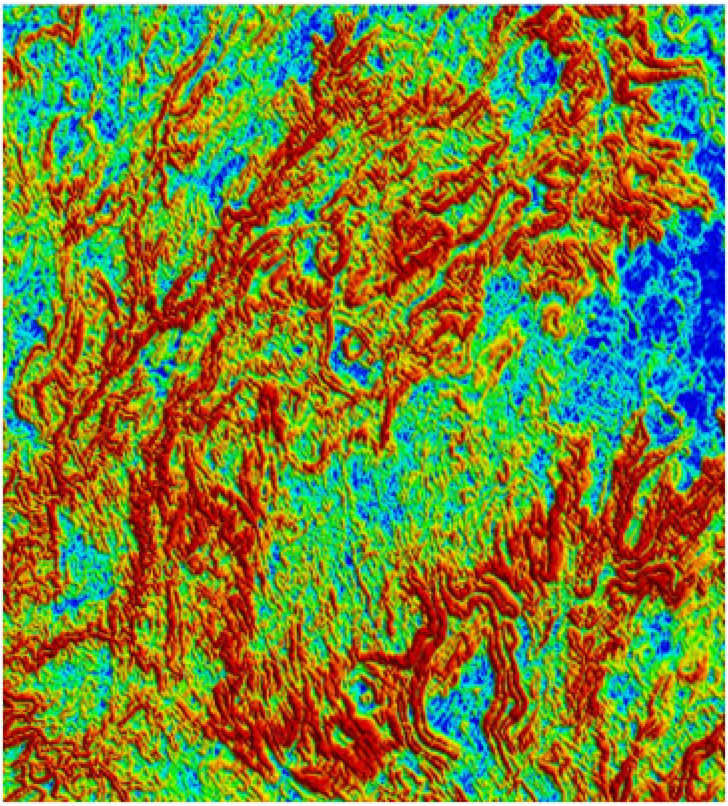
The three orthogonal derivatives are combined in a ternary display where:

Red	= X derivative of the field
Green	= Y derivative of the field
Blue	= Z derivative of the field

Purpose

To highlight changes in gradient in all three directions.





Tas_Pioneer_Topo_HGrad.tif

Topography
Horizontal Gradient Magnitude

Filtering
The Horizontal Gradient Magnitude (HGM) is calculated from the orthogonal *x* and *y* derivatives of the magnetic field.

Purpose
The horizontal gradient magnitude (HGrad) filter highlights the location of contrasts in susceptibility (source body edges), assuming vertical sided sources.

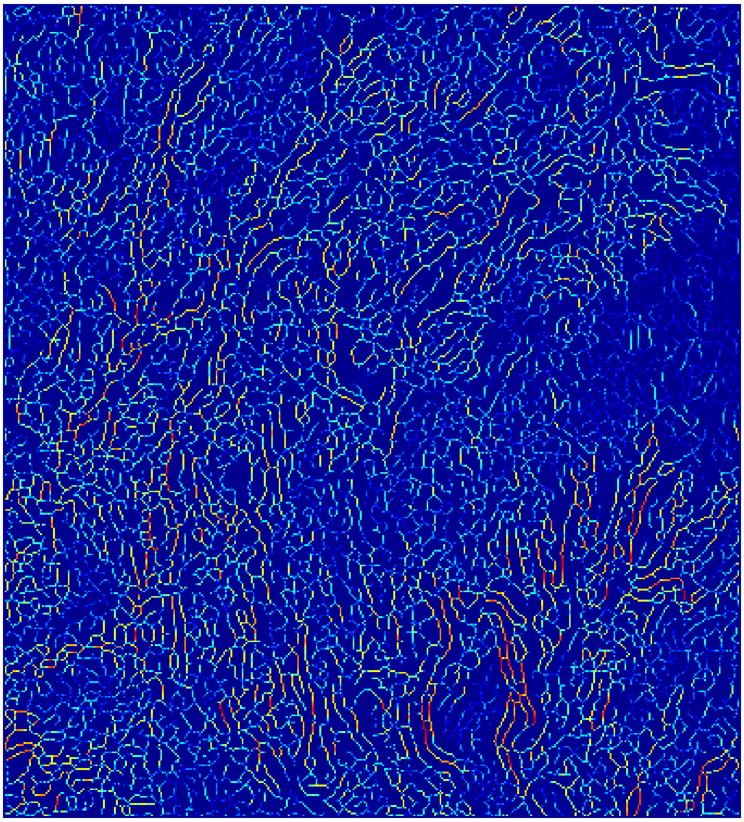
Note however, that this filter is not independent of the direction of magnetization, as is the case for the analytic signal filter. Additionally, the location of a peak (ridge) in the HGM image will be offset in the down-dip direction, if the source body is dipping.

Tas_Pioneer_Topo_Tangletif

Topography
Tilt angle filter

Filtering
The tilt angle filter is defined as the arctangent of the ratio of the vertical derivative to the horizontal gradient magnitude of a grid.

Purpose
The tilt angle filter is excellent for highlighting structure in topography data, independent of absolute change in elevation.



Topography
Automated edge detection
Edge Strength

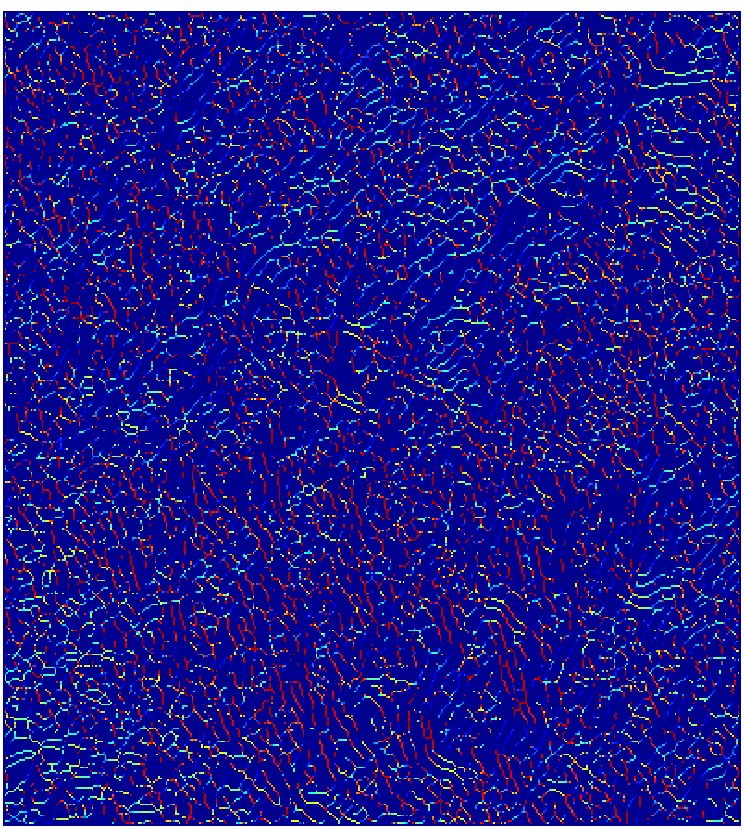
Filtering

Automated edge detection using the height ridge algorithm (Buckingham 2003 method) has been applied to the horizontal gradient magnitude topography grid.

The strength of the edge (inflection point:: inflection curve on 2D topographic surface) has been highlighted here, where strength is defined as the difference between the minimum and maximum principal curvature of the ridge.

Purpose

This representation of the data allows the interpreter to readily identify pertinent structures of interest



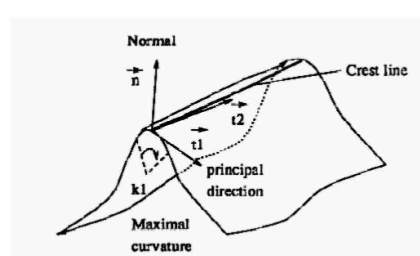
RTP
Automated Edge detection
Edge Orientation

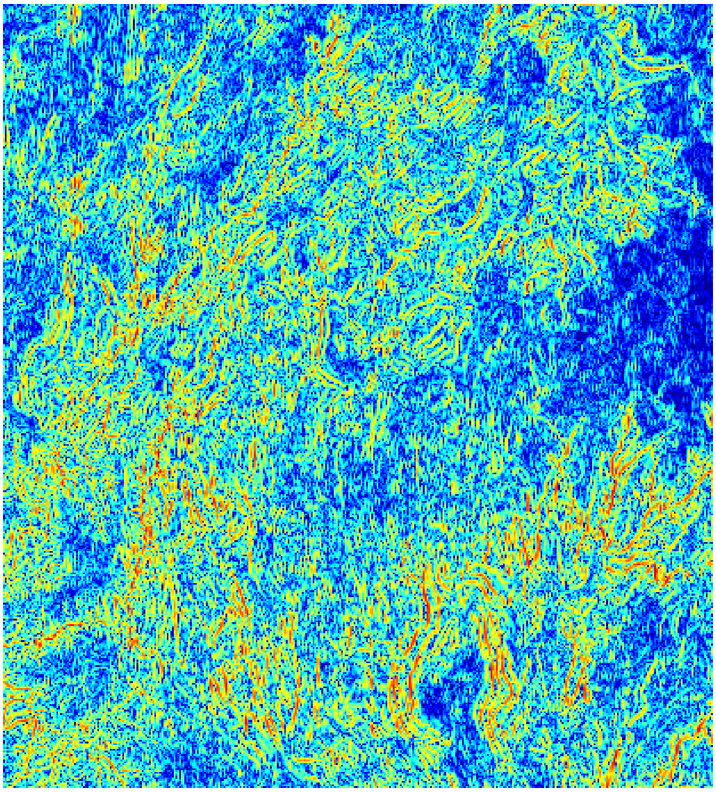
Filtering

The orientation of the edge has been highlighted here, where orientation is defined as the minimum principal curvature direction (the direction along the crest of the ridge).

Purpose

To highlight patterns in orientation of structures and to delineate structures having an orientation of predetermined importance.





Topography Strength

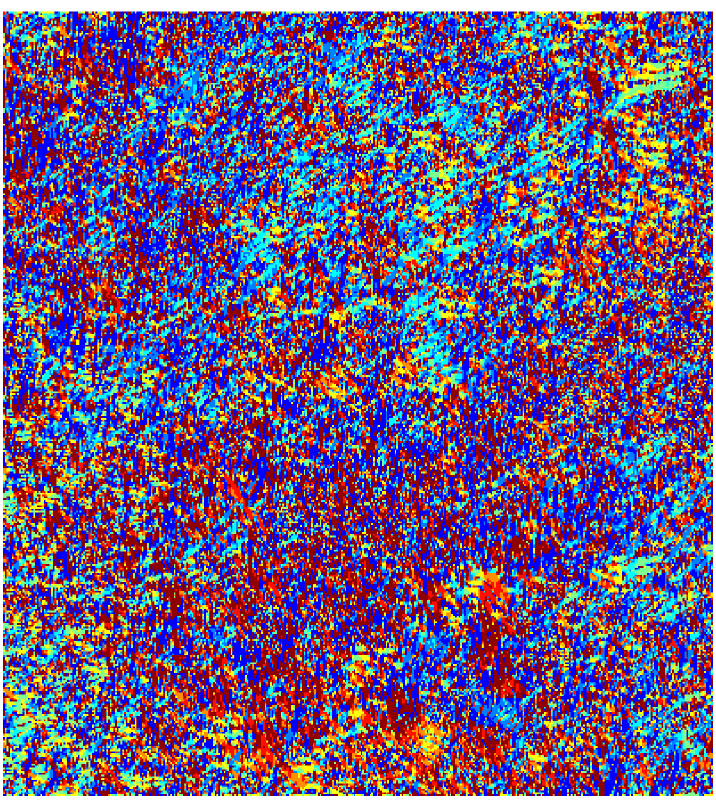
Filtering

The strength at every grid cell has been highlighted here, where strength is defined as the difference between the minimum and maximum principal curvature of the surface calculated over a 5 x 5 window.

Purpose

To highlight pertinent structures and contrasts in elevation

Tas_Pioneer_topo_str_p_1_log.tif



Topography Orientation

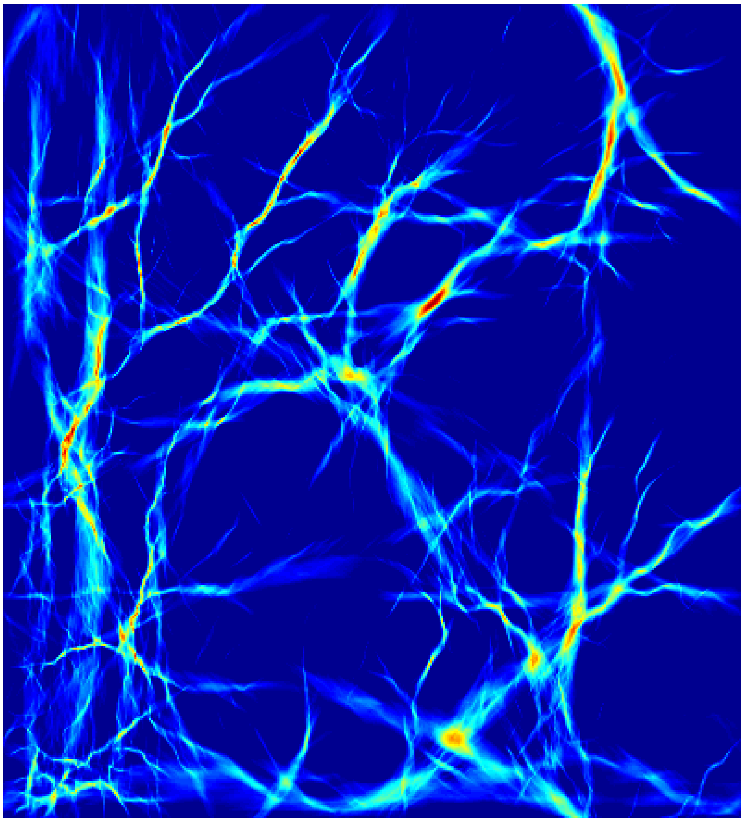
Filtering

The orientation at every grid cell has been highlighted here, where orientation is defined as the minimum principal curvature direction.

Purpose

To assist in the identification of textural patterns associated with variations or similarity in topographic character based on orientation.

Tas_Pioneer_topo_ori_grouped.tif



Tas_Pioneer_Topo_phOri.tif

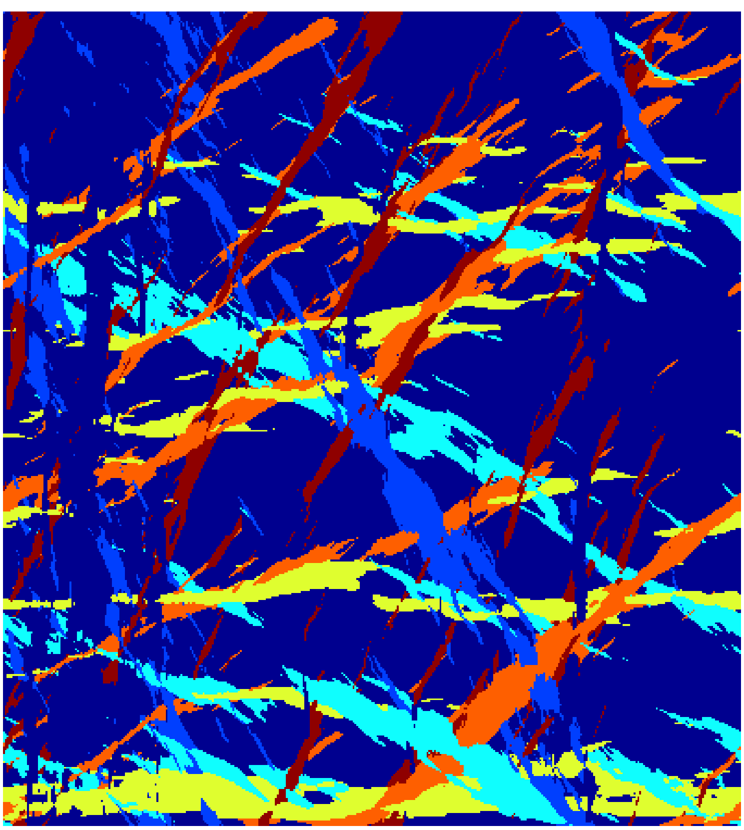
Topography Phase Congruency Orientation

Filtering

The Phase Congruency method is a type of multi-scale feature detection which attempts to extract dominant breaks in continuity from a grid. Such features are often detected by the human eye, but it is difficult to determine their extent and intensity from the original data alone.

Pertinent features in a grid such as step edges, ridges and lines (boundaries or axes of magnetic units) result in strong local phase coherence structures in the frequency domain (across scale and space).

Different descriptors cam be extracted from the filtered data including the orientation of the features and the degree of symmetry (in the phase domain).

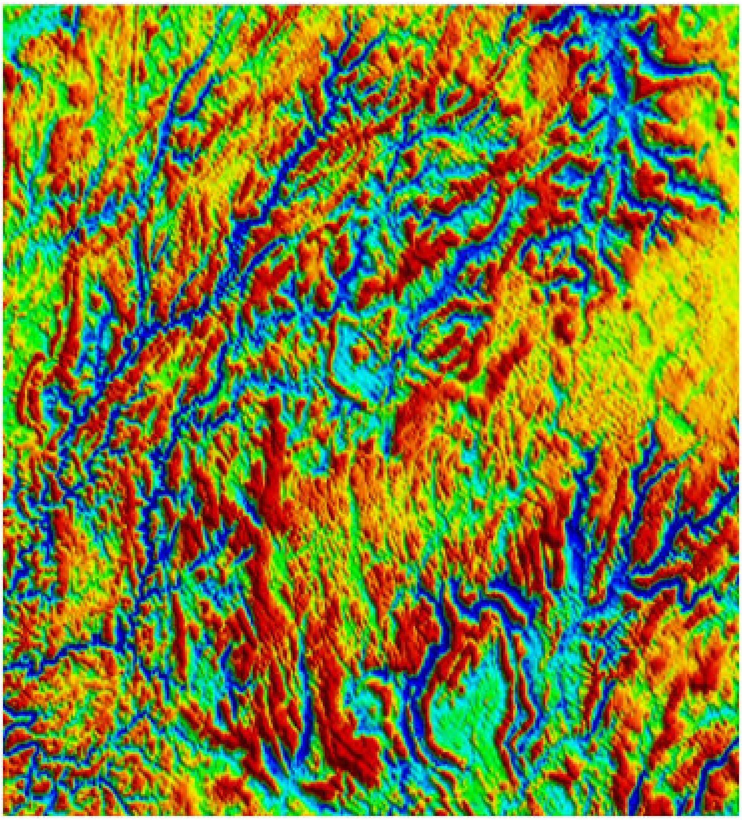


Tas_Pioneer_Topo_phSym.tif

Topography Phase Congruency Symmetry

Purpose

To highlight pertinent features in a grid independent of scale.



Tas_Pioneer_Topo_res0_200m.tif

Topography Shallow Residual (using the upward continuation operator) 0m to 200m

Filtering

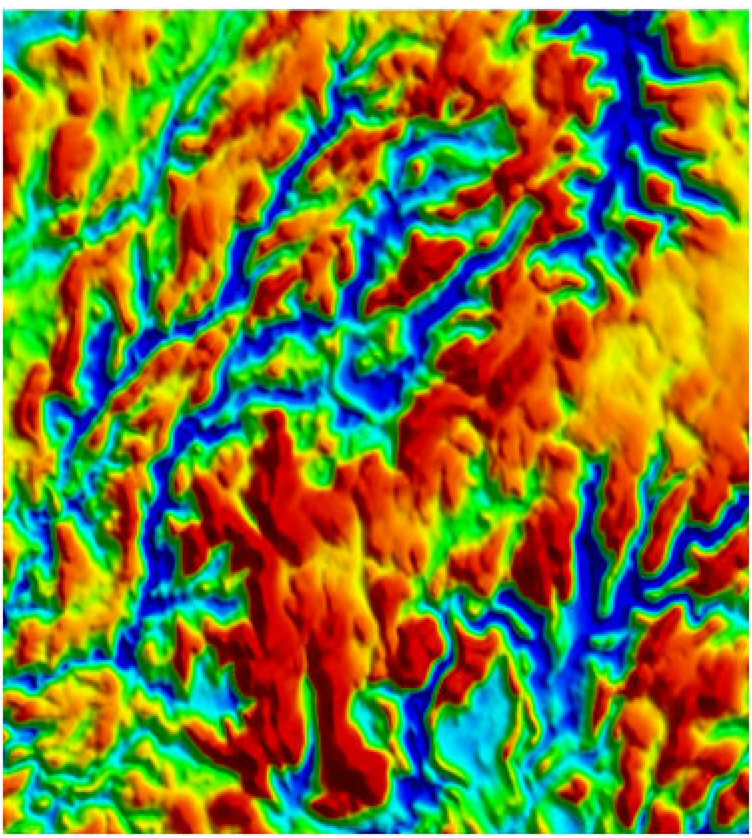
Separation filtering using differential upward continuation can be used to approximate the 'detailed' variations in the topographic surface.

Residual = original – field upward continued 200m

Note that while the upward continuation operator only had a 'physical meaning' when the input data is a potential field, the filter can readily be used as a 'smoothing' operator to separate frequency components of any data type.

Purpose

To highlight (as best possible) only the 'detailed' variations in the topographic surface.



Tas_Pioneer_Topo_res200_1km.tif

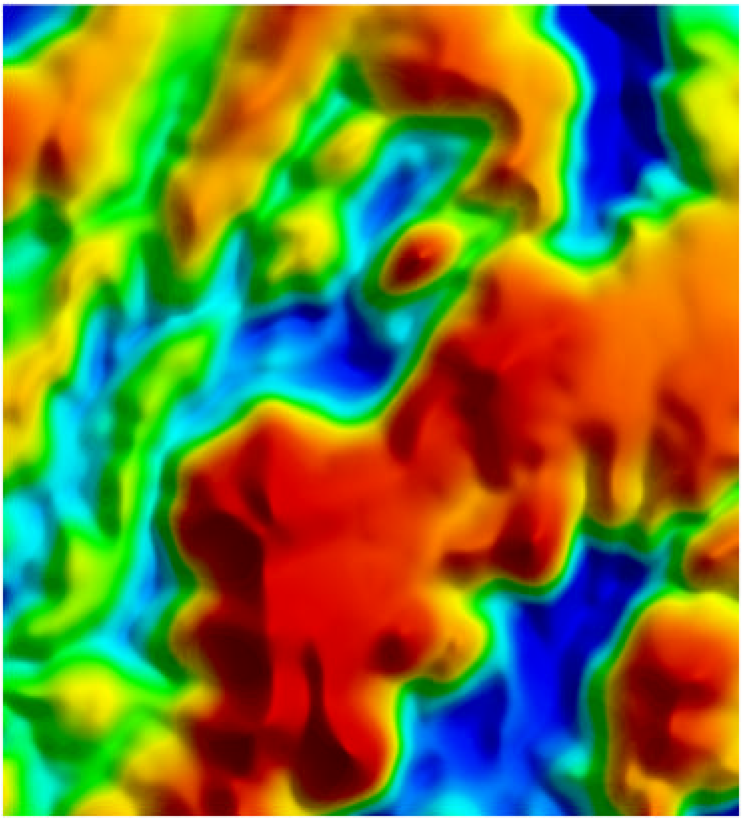
Topography Intermediate Residual (using the upward continuation operator) 200m to 1km

Filtering

Residual = field upward continued 200m - field upward continued 1km

Purpose

To highlight (as best possible) the dominant variations in the topographic surface.



Tas_Pioneer_Topo_res1_5km.tif

Topography Deep Residual (using the upward continuation operator) 1km to 5km

Filtering

Residual = field upward continued 1m - field upward continued 5km

Purpose

To highlight (as best possible) the long wavelength (regional scale) variations in the topographic surface.