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BREATHING NEW LIFE INTO OLD DATA: COLOUR IMAGES FROM THE CORRECTED, REGIONAL AEROMAGNETIC DATASET FOR INSULAR NEWFOUNDLAND

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ABSTRACT

Regional aeromagnetic data for insular Newfoundland have been corrected and levelled and are now available by NTS map area, as a series of digital Open Files, at a grid-cell interval of 200 m. The data are released as individual grids, for each 1:250,000-scale NTS map area, in order to accommodate their easy storage and retrieval, as well as to maximize data access speed. Gridded datafiles for adjacent NTS map areas may be joined successively to generate a single grid for all of insular Newfoundland. The gridded dataset is available in two commonly used grid-storage formats. A conversion utility is provided to allow any portion of the data to be output to a text file.

INTRODUCTION

Data from regional potential-field surveys have historically been presented as contour maps, from which, either features have been interpreted by correlation with surface geological information or profiles have been extracted as input to various types of quantitative modelling techniques. With the common use of the personal computer (PC) during the 1980's, image-processing techniques have been applied with increasing frequency to extract textural information, as well as to enhance the more subtle but often large-scale linear features contained in these data. Increasingly, the published literature contains examples of subtle, linear features (on the scales of a country (cf. Lee *et al.*, 1990) to a continent cf. O'Driscoll, 1986), identified from gravity and aeromagnetic data, which have been correlated with megascopic structural trends and related to the locations of major-ore deposits.

In order to extract subtle spatial features from aeromagnetic data through image analysis and enhancement techniques, the data must first be relatively error free and interpolated to a regular grid. Many of the various types of errors that may exist in the data, may be of sufficient magnitude to overshadow or at least distort the geometry of the subtle magnetic expression of important structural features. The methods for identification and correction of the many errors and inconsistencies that exist in the digitized profiles, which comprise the regional aeromagnetic dataset, have been previously discussed (Kilfoil, 1990a). Although the reader will be briefly updated as to any changes to the processing sequence, the objective of this report is to present a portion of the data as colour, shaded-relief plots and to show, through these examples, how subtle features in the corrected aeromagnetic dataset may be interpreted.

This project was undertaken to provide a corrected and levelled aeromagnetic dataset for the Island of Newfoundland, as a series of levelled digital data grids for 1:250,000-scale NTS map areas, which can be joined to form a seamless, contiguous grid for the whole of the province. The project was initiated because of the strong interest, both within and outside the Newfoundland Department of Mines and Energy, to acquire quality-gridded geophysical data. The gridded datafiles that result are particularly designed for input to image analysis and display systems.

The first phase of the project involved correction of positional errors, contour–flight-line intersection labelling errors, and the digitizing of flight-line segments omitted from the data. Flight-line segments from adjoining map sheets were then merged interactively on a PC to reconstruct, as closely as possible, the original recorded database. Inter-survey levelling errors were then effected and the corrected profile data were gridded to a 200-m grid interval. The grid-cell size was selected to retain as much as possible of the detailed information, while at the same time making the overall gridded dataset no larger than necessary. Much of the levelling error that exists between adjacent flight lines was efficiently removed by subsequent application of wavenumber domain filtering. Finally, smaller gridded datafiles were joined to yield a single, corrected and levelled grid for insular Newfoundland. The entire dataset is presented as a colour map in Plate 1. At the scale used to plot this plate, the outlines of major bodies of water, geological contacts and faults added in increasing respective line weights for reference, mask much of the local detail in the dataset. However, Plate 1 is useful for correlating regional zones and trends in the aeromagnetic data with the geology from surface mapping.

The gridded dataset for insular Newfoundland was subdivided into a series of individual gridded datafiles of manageable size by extracting only the grid cells that lie within each 1:250,000-scale NTS map area. The entire dataset or any of the component datafiles are available on floppy diskette at nominal cost, in the grid formats of two PC-based software systems in common use: GEOSOFT™ Inc. and GEOPAK™ Systems (Kilfoil and Bruce, 1990). Alternatively, the contents of a gridded datafile can be dumped to an ASCII file for input to other systems. This basic corrected, levelled and gridded version of the standard Geological Survey of Canada aeromagnetic data can be very rapidly and easily re-gridded on a PC to any interval size that meets the user's objectives. Similar processing is underway on the aeromagnetic dataset for Labrador.

JOINING FLIGHT-LINE PROFILE SEGMENTS

Aeromagnetic data for Newfoundland were originally collected by the Geological Survey of Canada (GSC) in four major surveys, flown between 1953 and 1971 (Kilfoil, 1990a, Figure 1, survey blocks 1 to 4). The data, collected by analog methods at 300 m (1000 ft) altitude along generally east-oriented flight-lines spaced at 0.8 km (0.5 miles), were transcribed to 1:63,000 (1"=1 mile) paper plots and hand-contoured. During the 1980's, the data were captured in digital form by digitizing the points along each flight line of the intersection of contours on these paper contour maps of the province. In July 1988, these digital aeromagnetic data, covering the whole of Newfoundland and Labrador, were received (Geological Survey of Canada, 1988).

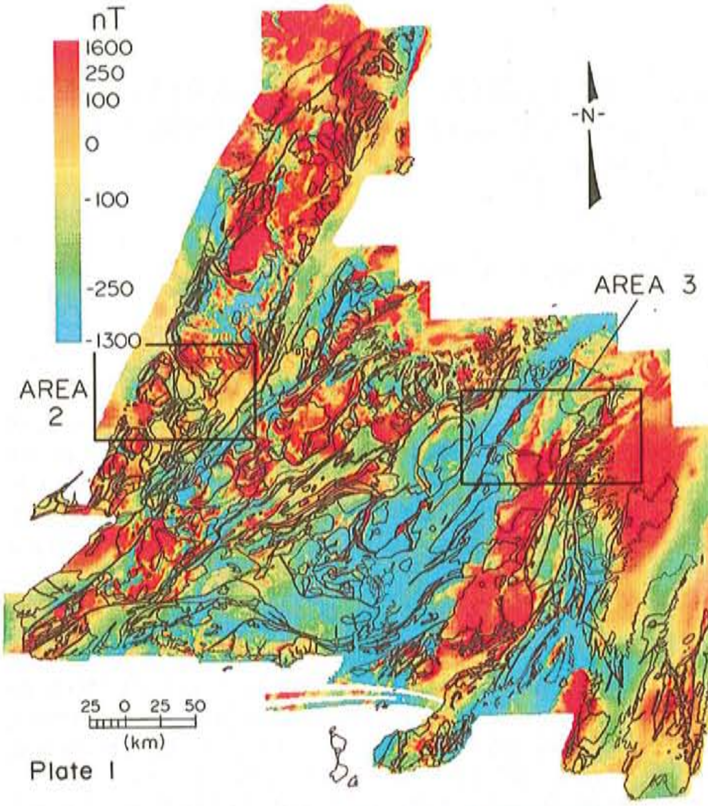


Plate 1

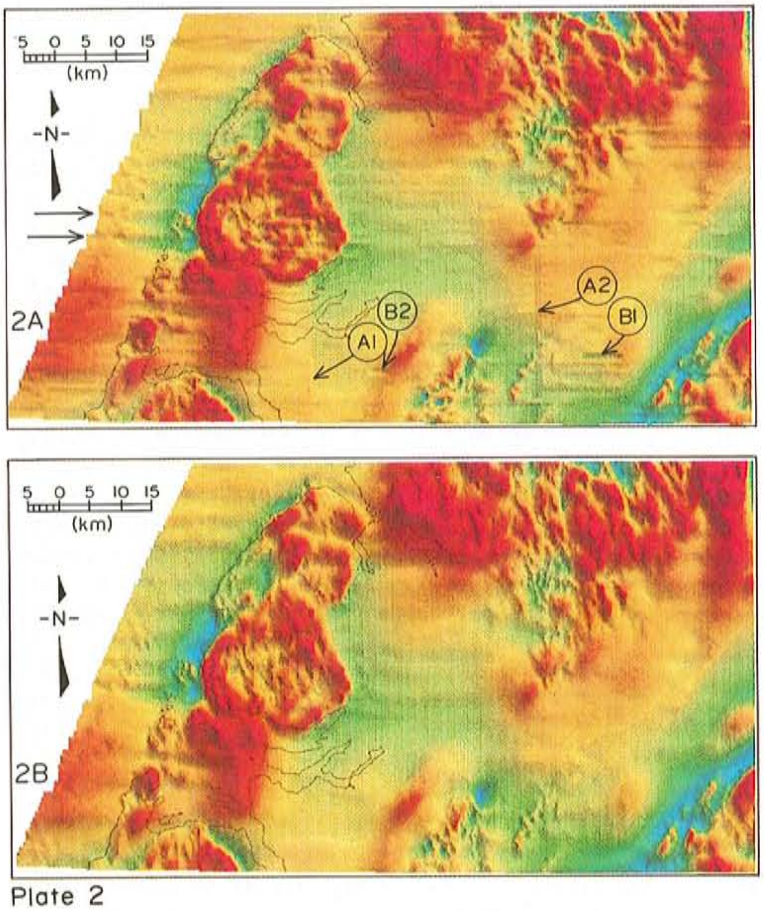


Plate 2

Plate 1. *Colour map of levelled and corrected GSC aeromagnetic anomaly data for insular Newfoundland. Black lines, in order of increasing line weights, trace the coastline, geological contacts and major faults (from Colman-Sadd* et al., *1990), respectively. The colour spectrum is linearized by the histogram of magnetic anomaly values to give equal distribution throughout the map (note values along scale bar). Locations for Plates 2 and 3 are outlined in white and are denoted as Areas 2 and 3, respectively.*

Plate 2. *Colour, shaded-relief maps of regional aeromagnetic data for parts of NTS 12G and 12H, western Newfoundland, a) before and b) after data editing and removal of flight-line levelling error. Black line is digital coastline extracted for reference from EMR Surveys and Mapping Branch's vector topographic data. Shading is created by introduction of a false light source from the northeast, inclined at 45° to the horizon. Marked features are discussed in the text.*

Upon initial attempts at gridding, filtering and displaying the data as images, several types of errors became apparent in the data. Digital images derived from uncorrected digitized profile data exhibit distinct features that result from: levelling errors that exist at boundaries between different survey blocks, discontinuities along individual map-sheet boundaries within survey blocks incorrectly labelled contour intersections, and the levelling errors among adjacent flight-line profiles. In addition, the quality of the digitized product was found to vary somewhat with the survey area. An interactive computer program, MAPJOIN, was written to join and effect corrections to the data from individual map plots as a means of restructuring the dataset within individual survey blocks.

CORRECTING DIGITIZING ERRORS

A comprehensive description of the digitized aeromagnetic profile data and a rigorous account of the digitizing-error correction procedure applied to the flight-line profiles are contained in Kilfoil (1990a). Most of the digitizing errors located along map boundaries were corrected during the profile joining process. However, many of the errors located within map sheets, such as mis-labelled contour intersections, still remained. Considerable effort has been expended in locating and correcting these errors.

The effects that digitizing errors may have on gridded datasets, and the images produced from them, is illustrated by Plate 2, which are a pair of images produced from a portion of the gridded data for NTS map areas 12G and 12H. Plate 2a is a colour, shaded-relief image (false illumination from the northeast) of the gridded datafile produced from uncorrected aeromagnetic profiles. Plate 2b is the equivalent image derived from profile data after correcting for digitizing and flight-line levelling error. For the purpose of referencing these images, the thin black line that traces the coastline near the Bay of Islands, was extracted from 1:250,000-scale digital topographic data (Energy, Mines and Resources, 1990) and added to these plots. The roughly circular features having high-magnetic relief (reds) located in the west-central region of these images, are an expression of the more magnetic units within the Bay of Island ophiolite complexes. The locally variable magnetic field, giving these features a mottled texture on Plate 2, is characteristic of the occurence of variable magnetic rocks in outcrop or at shallow depth.

The north-oriented features marked by 'A1' and 'A2' on Plate 2a are expressions of the discontinuities that may occur at the boundaries of adjacent 1:50,000-scale map boundaries before the profile merging process. This type of error is usually the result of improper registration during the data digitizing stage and can be remedied by applying a least-squares stretching to profile positional data within each distorted map sheet (see Kilfoil, 1990a). The westernmost of the errors, marked by 'A1' on Plate 2a, locates the boundary between map areas NTS 12G and 12H, and the upper halves of these images are the colour equivalents to the profile line drawings (Kilfoil, 1990a, Figure 2). The error at this boundary is less prominent on these images than the map boundary to the east (feature 'A2') due to lesser enhancement from the northeast illumination direction. The feature marked by 'A2' is more prominent in the lower half of Plate 2a, where the error located along the boundary between NTS 12H/4 and NTS 12H/3 map areas is particulary well enhanced. Note that these apparent seams caused by discontinuities along map boundaries have been virtually eliminated in the image of Plate 2b.

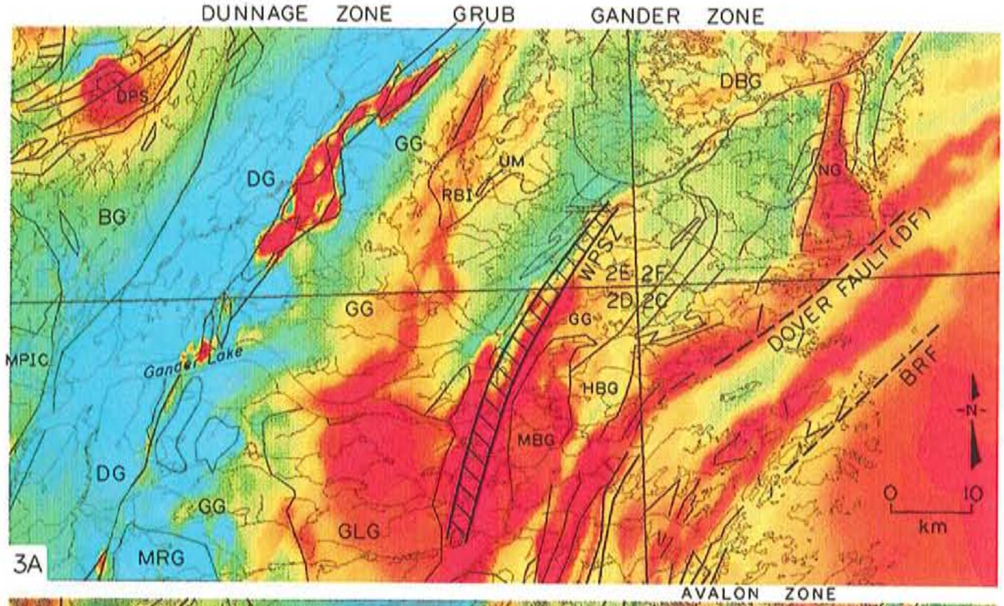
Mis-labelled contour intersections along profiles located within map sheets are expressed as anomalous features in gridded data, such as those indicated by 'B1' and 'B2' on Plate 2a. If several consecutive contour intersections are mis-labelled along a single digitized flight profile, these errors are easily detected on shaded-relief images as relative highs (bumps) or lows (troughs) elongated in the profile direction. The feature marked by 'B1' on Plate 2a provides an excellent example; here, five consecutive contour intersections were assigned magnetic values that were low by 100 nT, creating a suspiciously anomalous trough. The trough marked by 'B2' resulted from three low-contour label assignments along an east-oriented profile. Single, mis-labelled contour intersections are expressed as point anomalies in the gridded data. Although isolated occurrences of mis-labelled contours are more common in the digitized data, they are much more difficult to detect than errors spanning several contours, particularly when located within a region of highly variable magnetic field strength (such as near the northern margins of the images on Plate 2).

The digitizing errors that result from mis-labelled contours were especially prevalent in areas where a variable magnetic field occurred near contour map boundaries. Near map boundaries, these contour levels are not always clearly labelled on the original paper-copy plots. Errors of this type were readily detected during the profile end-point matching process of the merging phase or, following subsequent gridding, as isolated discontinuities along map boundaries on images derived from the gridded files.

The more obvious errors resulting from incorrect contour assignment were easily detected and remedied. However, the more subtle errors that result from only minor contour mis-labelling or from minor positional errors may still exist in the data as these are not readily distinguishable from genuine magnetic anomalies.

PRE-GRIDDING DATA PREPARATION

The procedure employed in survey-block levelling to create a contiguous gridded dataset for Newfoundland has previously been described in detail (Kilfoil, 1990a; Kilfoil and Bruce, 1990). To summarize, data within older survey blocks were corrected by adding differential offsets of magnitudes defined by least-squares polynomials, (Gangi and Shapiro, 1977) which were fitted to offsets along survey boundaries. The aeromagnetic profile data for NTS map areas 12B, 12A, 2D and 2C (Kilfoil, 1990a, survey blocks 1 and 3 of Figure 1) were levelled to the data for surrounding survey blocks by this method. The efficiency of the method is attested to by the continuity of the magnetic field across survey-block boundaries. Plate 3 (to be discussed in more detail later),


DUNNAGE ZONE
GRUB
GANDER ZONE
DPS
DBG
GG
UM
DG
RBI
NG
BG
WPSZ
2E
2F
2D
2C
GG
GG
DOVER FAULT (DF)
MPIC
Gander Lake
HBG
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MBG
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km
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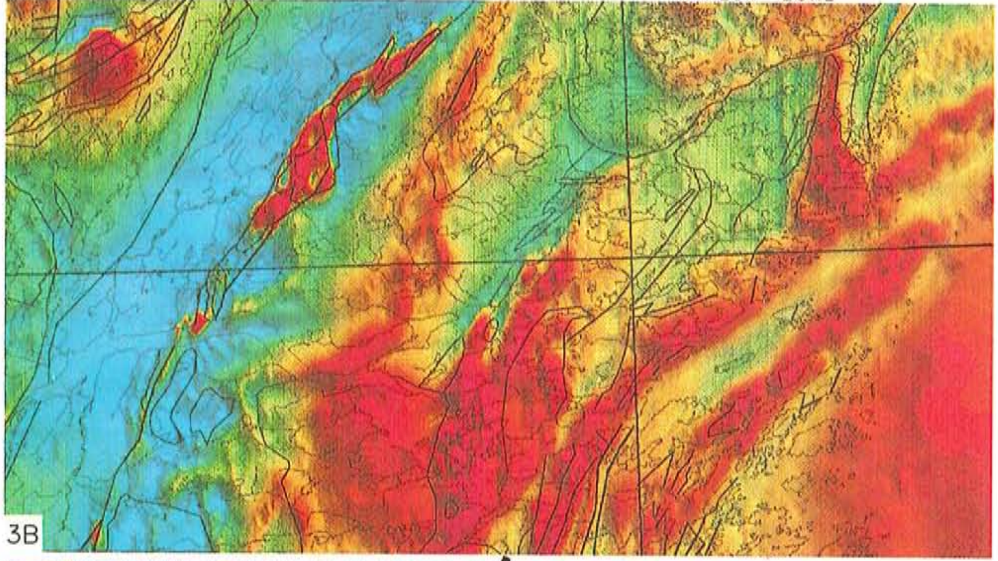
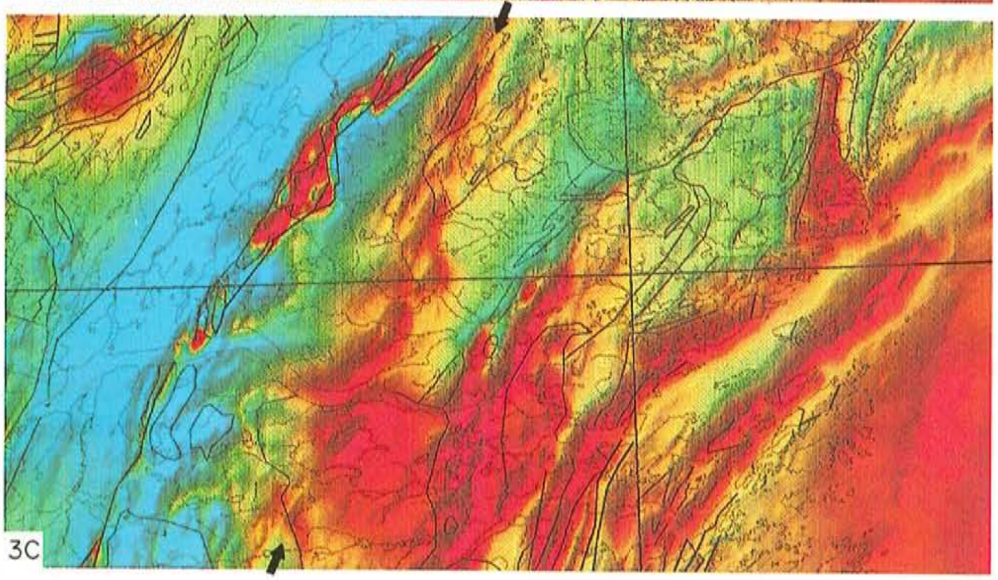
GLG
MRG
AVALON ZONE

3A



3B



3C

provides a representative example of the results from survey block levelling.

The final step in preparing the profile data for gridding involved removal of the Definitive Geomagnetic Reference Field (DGRF) (Regan, 1983) and conversion of the positional data to the Universal Transverse Mercator (UTM) projection (Snyder, 1982; McDonnell, 1979), referenced to the Clarke 1866 geodetic ellipsoid. Profiles of total-field aeromagnetic data are reduced to magnetic anomaly values by reference to the DGRF, the values of which can be calculated at each unique geographic location by interpolation from a series of published (Barraclough, 1988) spherical harmonic coefficients that reflect both spatial and temporal changes in the reference field. Since most of insular Newfoundland is situated in UTM Zone 21 (54° to 60°W longitude), the profile data situated within UTM Zone 22 (comprised largely of the Avalon Peninsula) was converted to Zone 21 before gridding to maintain continuity with only minimal distortion (McDonnell, 1979).

GRIDDING AND POST-PROCESSING

Gridding refers to the transformation of irregularly spaced, spatially referenced data onto a two-dimensional matrix or grid, of uniform spacing in each of the X and Y dimensions. Individual elements comprising the grid are referred to as grid cells or, if the grid is converted to a visual image, pixels. A grid is usually produced by some form of weighted averaging of the data when data points are randomly distributed, or by a line or surface interpolation in the case of data organized into profiles (such as the aeromagnetic data). Interpolating data to a regular grid is advantageous in terms of the ease and speed in which later computation-intensive operations (such as contouring, filtering, plotting) can be applied. Of particular importance is the ease of application of digital filters. The organizational similarity of data in a regular matrix to pixels referenced on a computer monitor enables images to be very efficiently generated from gridded datasets.

DESCRIPTION OF GRIDDING PARAMETERS

All gridded datafiles were generated by the GEOSOFT™ routine, BIGRID, which takes advantage of the organized format of profile data to efficiently interpolate gridded data (Geosoft Inc., 1989a). Following several experiments with grid-cell intervals and discussions of the results, an interval of 200 m was chosen as the best balance between that which contains nearly all of the detail contained in the digitized profile data (even in regions of high magnetic variability) and considerations of data storage and access efficiency. The density of contours in the digitized profile data limits the resolution attainable and ultimately restricts the possible uses of the data. In order to ensure that adjacent grids would be continuous, the grid extremes were chosen as those which expand the areal extent of each grid to that with an approximate 10 percent margin beyond the boundaries of each 1:250,000-scale NTS map area.

As the name suggests, BIGRID is a bi-directional interpolation routine, which interpolates profile data by first interpolating values equispaced (at grid-cell interval) along the flight-line direction, then interpolates the grid-cell nodes between adjacent profiles from these values. Bi-directional interpolation of data organized into profiles is much more efficient than any random gridding, which must sort the data and search the immediate vicinity of each grid cell for neighbouring data points. The user can select the interpolation technique for either of the two directions independently, as linear, cubic spline (Forsythe *et al.*, 1977) or minimum curvature (or akima) (Akima, 1972; Briggs, 1974; Swain, 1976).

The aeromagnetic data grids were created by an initial cubic spline oriented along data profiles, followed by akima interpolation applied in the cross-profile (south to north) direction. This combination was found to be the most effective as the cubic spline preserved detail and ensured smoothness of the digitized data in the profile direction, while the minimum curvature eliminated unwanted 'bumps' in the cross-profile direction, where much less detail was present and subsequent flight-line levelling error removal was planned. An example of the effects of different gridding schemes is shown in Plate 2. The gridded data from which Panel 2a as derived, was created from uncorrected profile data using BIGRID with the along-profile interpolation method set to linear. Note the small irregularities that result, situated near the centre of Plate 2a, in a region of otherwise featureless magnetic field. These subtle irregularities were eliminated by the spline interpolation used to produce the final gridded datafiles (Plate 2b).

Plate 3. *Corrected and filtered GSC aeromagnetic data for portions of NTS map areas 2D, 2C, 2E and 2F, (location on Plate 1) presented as a) standard colour intensity map, b) colour, shaded-relief map; false illumination from azimuth 135°, inclination 45°, and c) colour, shaded-relief map; false illumination from azimuth 45°, inclination 40°. In increasingly heavier line-weights, the solid black lines trace selected digital topography (lakes, streams and coastline from 1:250,000-scale EMR datafiles), geological contacts, faults and map area boundaries. Geological features marked in a) are: BG—Botwood Group; BRF—Bloody Reach Fault; DBG—Deadman's Bay Granite; DPS—Dildo Pond Stock; DF—Dover Fault; GG—Gander Group; GRUB—Gander River Ultrabasic Belt; HBG—Hare Bay Gneiss; MBG—Middle Brook Granite; MPIC—Mount Peyton igneous complex; MRG—Middle Ridge Granite; NG—Newport Granite; RBI—regional biotite isograd (dashed line in NTS map area 2E); TL—topographic lineament; UM—ultramafic outcrop; WPSZ—Wing Pond shear zone. Outlines of geological features were digitized from the regional geological map of insular Newfoundland (Colman-Sadd* et al., *1990) and, locally, selected from 1:50,000-scale maps (O'Neill, 1987, 1990). Features are discussed in the text.*

The GSC advocates use of a minimum curvature surface-fitting routine (Akima, 1974) for interpolating a smooth surface through unequally spaced data values. However, bi-directional gridding is much more efficiently applied to profile data and very closely approximates minimum curvature surface-fitting, where the gridding interval relative to profile spacing is small.

The other gridding parameters that were fine-tuned to specific areas were the minimum and maximum interpolation distances and the parameter, NEX, which controls interpolation of N cells extending beyond the end of data profiles. NEX was set to zero for most NTS map areas; the exceptions were NTS 12B and 12P, where profiles extend only to the shoreline or barely overlap. For these map areas, NEX was set at 1 to ensure complete grid coverage. The minimum and maximum gridding distances refer to the extremes of interpolation between profiles; values from profiles that are closer than the minimum distance are averaged whereas cross-line interpolation is not carried out between profiles whose separation exceeds the maximum distance, resulting in a data gap in the grid. The minimum and maximum interpolation distances were set to 100 m and 2500 m, respectively, for most NTS areas. The exceptions to this were NTS 12B and the southeast-oriented flight profiles in NTS 12P, which bridge the Newfoundland data with that for Labrador; in both cases, the maximum gridding distance was increased to 3500 m to avoid gaps in these grids.

REMOVAL OF FLIGHT-LINE LEVELLING ERROR

A final processing step was taken to correct the aeromagnetic database by removing any systematic error that existed in the data subsequent to gridding, the largest source of which is the relative level shifts between adjacent flight lines (Kilfoil, 1990a). Removal of this error is commonly referred to as decorrugation filtering. Much of the flight-line levelling error was determined by first transforming data grids to the spatial frequency or wavenumber domain using a computationally efficient Fast Fourier Transform (FFT), applying digital filtering techniques, then transforming the result back to the spatial domain. All FFT transforms and filtering operations were performed by the GEOSOFT™ Magmap software package (Geosoft Inc., 1989b).

Filtering was accomplished by applying a combination of Butterworth and directional filters (Kulhànek, 1976) tuned to the consistent orientation and the regularity of average line spacing of the original aeromagnetic survey. An 8th order Butterworth filter, with a central wavenumber corresponding to four times the 0.8-km average flight-line spacing, was found to be the most effective in isolating the levelling error without sacrificing the detail contained in the aeromagnetic data. Directional filters were designed to take advantage of the average east-west flight-line orientation. The outputs from the wavenumber filtering stage were gridded datafiles, the contents of which consisted largely of the aeromagnetic flight-line levelling error. The actual correction was applied by subtracting the levelling error grid from the original grid to yield a corrected grid.

The panels of Plate 2 illustrate the effectiveness of decorrugation filtering on the aeromagnetic data grids for NTS map areas 12G and 12H. The east-oriented features due to flight-line levelling error (indicated by arrows on Plate 2a) have been virtually eliminated in the corrected version of Plate 2b. The levelling error filtering and removal causes some smoothing locally in the cross-profile direction, particularly in areas where features are oriented along the flight-profile direction and are of wavelengths comparable with flight-line spacing. Although filtering parameters were selected conservatively in order to keep smoothing of detail to a minimum (note that some apparent east-west corrugation remains evident in Plate 2b), unfortunately some detail may be lost in certain areas and should be considered when interpreting filtered grids. The removal of flight-line noise significantly improves the appearance and continuity of features on images produced from the gridded data. One should bear in mind, during interpretation, the anisotropy in detail caused both by directional filtering and the much denser data detail along flight lines than that (limited by the flight-line spacing) in the cross-line direction.

FINAL GRID PREPARATION

Once the digitally filtered aeromagnetic data grids for Newfoundland were created in piecemeal form, the data required some cleanup and reformatting before it was deemed acceptable for release. The following sections describe the final steps taken to cleanup the data for release.

GRID TRIMMING

As noted above, in order to ensure continuity of data across adjacent gridded datafiles, all data that lie within a margin that surrounds each NTS map area are included during gridding. After filtering, each gridded datafile extended beyond its NTS map boundaries. For the purpose of referencing, the grids were then trimmed by first nulling out all grid cells whose coordinates did not lie within the respective NTS map sheets, and eliminating any null columns or rows, which were marginal to the grids to reduce grid file-size. As a result, each grid value in the entire gridded dataset for Newfoundland was represented only once; that is, no grid cell appears in both of two adjacent grid files. A routine designed to join spatially referenced grids, program MERGEO, was written to provide clients the ability to merge gridded datafiles from adjacent NTS areas.

INCLUDING A HISTOGRAM

In order that the user better understand the distribution of data contained within the gridded dataset, a frequency histogram of grid values was incorporated into each aeromagnetic data grid. The histogram consists of 32 integers representing the numbers of non-null grid cells with magnetic values that fall within 32 intervals. The 32 intervals are equispaced between the grid minimum and maximum Z-values, two parameters that are normally stored in the grid headers.

Since the grid header of GEOSOFT™ Version II grids is 512 bytes in length (GEOSOFT, 1989c), there is plenty of previously unused space in which to store the 128 bytes required for the histogram. However, the 128-byte total size of Geopak™ and GEOSOFT™ Version I grid headers make it impractical to store the histogram; instead a flag is set in the header, which indicates the presence of a 128-byte histogram appended as a footer to these grid types. When present in a gridded datafile, the histogram is used by the program DISPLAY (Kilfoil, *this volume*) to calculate histogram equalized colour scaling during image generation. Note that if later processing, such as filtering or data transfer operations, is performed on these grids, there is no guarantee that the histogram will be transferred to the newly created grids or that the histogram will be representative of the distribution of new grid values.

AVAILABLE GRID FORMATS

The gridded datafiles comprising this release are available in two storage formats: GEOSOFT™ or GEOPAK™. GEOSOFT™ has two storage formats: a pre-July 1989 (Version I) sequential access binary file and an updated (Version II) random access binary file. All three formats share a common style, consisting of a single header record, containing the grid dimensions and other descriptor variables, followed by lines of gridded data scaled to the available range of 2-byte signed integers. The gridded, aeromagnetic datafiles are stored as grid lines arranged in increasing X (west to east) within lines and are sequential in Y (south to north) within the grid. Thus, the first grid value stored corresponds to the southwestern-most grid cell.

Header lengths are 512 bytes for GEOSOFT™ Version II gridded datafiles and 128 bytes for GEOSOFT™ Version I and GEOPAK™ files. Thus, GEOPAK™ grids differ from GEOSOFT™ Version I grids only by the descriptor variables and their arrangement as contained in the respective grid headers. Should these formats be found to be incompatible with the user's software, a program is provided that will dump the contents of a binary gridded datafile to an ASCII character file, irrespective of the gridded datafile format purchased. The data are available in either of two IBM-compatible diskette formats: 5-1/4 inch, 1.2 Mb or 3-1/2 inch, 1.4 Mb diskettes.

ADDING SHADED RELIEF TO ENHANCE AEROMAGNETIC COLOUR IMAGES–AN EXAMPLE

The addition of shaded relief to colour images is not only useful for locating errors in a gridded geophysical dataset, but can be a very powerful tool for interpretation of the corrected data. Plate 3 consists of three printed images from the merged aeromagnetic dataset for NTS map areas 2D, 2C, 2E and 2F. This plate is included to illustrate how false illumination can be applied to a portion of the gridded aeromagnetic dataset for insular Newfoundland to enhance the features of interest. Here, the area near Gander was chosen because it represents an area of active geological and geophysical investigations that encompass data from three survey blocks. In regard to the latter, note the continuity of the aeromagnetic features in the data across the NTS map area boundaries, in particular those situated astride the NTS 2D/2E and NTS 2D/2C boundaries. The area encompassed by Plate 2 contains some of the highest and the lowest magnetic anomaly values found in the gridded data for insular Newfoundland.

The light-weight black lines on all three panels of Plate 3 are the outlines of rivers, lakes and coastlines drawn from digital vector files derived from computer-scanned, 1:250,000-scale topographic maps (Energy, Mines and Resources, 1990). The outlines of the major geological contacts and faults, in increasingly heavier respective line-weights, were digitized from the 1:1,000,000-scale geological map of Newfoundland (Colman-Sadd *et al.*, 1990), with the exception of certain local geological units digitized from 1:50,000-scale maps of NTS 2D/15, 2D/16 and 2E/1 (O'Neill, 1987, 1990). The dashed line within the Gander Group (GG) of map area NTS 2E/1 traces the biotite isograd. Dashed lines were also added to trace the offshore continuation of the Dover and Long Reach faults. The heaviest line-weights were used to trace the outlines of the NTS map areas. The colour scheme for this plate is a rainbow arrangement of 37 colours ranging from deep blue for magnetic lows to deep red for high magnetic anomalies. The magnetic anomaly range for each colour was determined by linearizing the histogram of magnetic values from the gridded dataset for all Newfoundland (used to generate Plate 1).

The colour panel of Plate 3a exemplifies a typical 'flat' colour magnetic map. Many of the magnetic features on this map closely correlate with major geological boundaries. Examples are the characteristically non-magnetic Davidsville Group (DG) sediments; the distinctly magnetic ultramafic units within the Gander River Ultrabasic Belt (GRUB); and the magnetic high associated with outcrop of the Newport Granite (NG). Other geological units do not show such a strong correlation to magnetic field strength alone; examples are the Gander Lake Granite (GLG), the Mount Peyton intrusive complex (MPIC) and the Deadman's Bay Granite (DBG). The magnetic expression of certain geological units, such as the Dildo Pond Stock, would suggest that these units are more extensive at depth than indicated by the area of surface outcrop mapped.

The colour panels 3b and 3c of Plate 3 are colour, shaded-relief versions of the aeromagnetic data in panel 3a. The colour scheme used is identical to that used to print panel 3a but grey shadows have been added to the images of panels 3b and 3c by false illumination from the northeast and southeast, respectively. When compared to the colour map of panel 3a, the most striking features on these lower two panels are the linear and curvilinear patterns created by magnetic anomaly gradients, which are differentially enhanced by the shading. When properly chosen, two orthogonal directions of illumination are sufficient for identifying most of the subtle features in an aeromagnetic dataset (Lee *et al.*, 1990).

The northeast shading direction of Plate 3b gives maximum emphasis to any of these features that strike approximately southeast (perpendicular to the false illumination). The southwestern mapped boundary of the DBG and the northeastern boundary of the MPIC, approximately coincide with magnetic features that are particularly enhanced on this panel. A roughly circular magnetic feature located within the DBG (just west of the NTS 2E/2F map boundary) is also enhanced by this illumination. This relative magnetic high is probably an expression of a later, more mafic phase of granite intrusion. Two north-northwest oriented magnetic linears, which obliquely intersect the GRUB, are enhanced in the region between the Middle Ridge Granite (MRG) and the GLG near the southern border of this map. The orientation of these linears at an oblique angle to the northeast structural grain and their situation in proximity to the granitic intrusions would suggest that these two granites may be locally fault bounded. It is noteworthy that all features, even subtle linear magnetic features that trend northeast-southwest, are given a sense of relief in Plate 3b (compare with Plate 3a) by the false illumination from 045°.

In contrast to Plate 3b, all northeast-oriented magnetic features are brought out by the southeast illumination on Plate 3c. Such linear features as the Bloody Reach and Dover faults correspond to prominent magnetic linears, as are several of the minor faulted contacts associated with the GRUB. Several of the intrusive contacts are expressed by curvilinear magnetic patterns, particularly the southeast contacts of the DBG and the MPIC. A subtle, magnetic linear is situated within the Ordovician volcanic-rich sediments of the DG, near the southwest corner of Plate 3c. The orientation of this linear, parallel to the bedding of sediments within the DG, and the fact that the linear pinches out to the northeast suggests that it results from a slightly more magnetic mafic volcanic unit within the sediment package.

Of particular note on Plate 3c are several subtle, sub-parallel northeast-oriented linears (between arrows), which can be traced across the entire north-south extent of the map area, over 70 km in length. These linears are continuous north-northeastward to the intersection with the trace of the GRUB just off the map to the north. The sharpness of these features would suggest that they arise from sources near the surface. The westernmost linear, located just east of Weir's Pond, coincides with a mapped topographic lineament in which highly strained rocks are locally exposed (Goodwin and O'Neill, *this volume*). Several small granitic bodies have been identified in outcrop in the region just east of the linears (O'Neill, 1987); these may be the exposed portions of a larger granitic body at depth.

The fact that at least one of these linears can be traced through the GLG, a posttectonic granite of probable Devonian age, and their straightness suggests that they are due to steeply dipping to vertical faults or mega-fractures along which final movement postdates most tectonic elements in the area. The linears correlate with a region of higher magnetic relief of the Gander Group pelites, semipelites and psammites, which may be at least locally related to higher metamorphic gradient, as shown by the biotite isograd in NTS area 2E. However, on the scale of the Gander Lake Subzone, there is not a consistent relationship with high-grade metamorphic rocks. The magnetic anomalies associated with the Wing Pond shear zone (WPSZ) in the Gander Group do not exhibit such a clearly defined linear magnetic expression. Although situated a few kilometres to the east of the trace of these aeromagnetic linears, a lenticular body of ultramafic rocks (UM) identified in outcrop (O'Neill, 1987) gives credence to the notion that the linears are indicating the presence of faults in the area.

On the basis of the above discussion, these magnetic linears indicated by arrows on Plate 3c are interpreted as due to steeply dipping faults. If such extensive faulting exists within the Gander Subzone, implies that the Gander Group may be structurally repeated across the width of exposure. The origin of the linears are the subject of ongoing investigations in the area.

CONCLUSIONS

The application of shaded relief to gridded potential field data has proven very useful for enhancing subtle trends and features that would otherwise be overlooked in the data. Of equal importance, however, the production of colour, shaded-relief images from the gridded aeromagnetic datafiles has provided an invaluable means for the identification of the systematic and nonsystematic errors that were present in the digitized profile data. The ability to interactively vary the shading direction for colour image enhancement on a personal computer (Kilfoil, 1990b, *this volume*) has expedited the error identification and correction phase.

The rigorous correction of digitizing errors in the profile data and subsequent removal of the systematic flight-line levelling errors through digital filtering have eliminated many of the inconsistencies in the data that could mistakenly be interpreted as real magnetic features. The error corrections followed by levelling applied along the aeromagnetic survey-block boundaries has resulted in a relatively error-free and seamless, gridded aeromagnetic dataset for insular Newfoundland. The continuity of magnetic features across magnetic survey-block boundaries and the identification of very subtle magnetic linears on colour, shaded-relief images created from the dataset attest to its quality.

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