Integration of Geology, Geophysics, Geochemistry and Imagery for Mineral Exploration Applications

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Today's geologists have unprecedented access to multi-disciplinary geoscientific data and information. The problem in this "data- and information- rich" environment lies in implementing efficient approaches for verifying and integrating all available data and information. Effective integration leads directly to increased success potential and reduced exploration risk. Data verification is particularly important with historical data where data origins and quality can vary significantly, and additional information helps increase the accuracy and completeness of interpretation.

This short example reviews the integration of historical geochemistry, geology, geophysics, and Landsat imagery from the Broederstroom 2527DD map sheet, South Africa. It also demonstrates the application of a commercial software system (i.e. Geosoft's OASIS montaj) in performing end-to-end verification, processing, analysis, integration and interpretation. Geosoft was also used to integrate imagery using a built-in ER Mapper imaging plug-in.

The final result comprises a geological interpretation based on all multi-disciplinary data, a subset area for detailed investigation, and digital output of sample locations that can be input directly into a GPS system for ground follow-up and sampling.

REGIONAL EXPLORATION PROBLEM

The regional data used here were obtained as part of an ongoing mapping programme by the Council of Geosciences (Geological Survey of South Africa). Programme objectives include mapping regional geochemical trends as well as to allow for the identification of most small to medium sized outcropping ore bodies. As this area is most prospective for base metals, the geochemical study focuses on As, Co, Cr, Mo, Ni, Pb, Sn, Zn and Zr. Airborne geophysical surveys have been flown as part of regional mapping initiatives. Images and orthophotos for this area are also easily accessed from various sources.

Based on the objective of identifying base metal targets, we focus on the application of end-to-end quality control, integration and interpretation for identification of prospective targets for ground follow-up.

QUALITY CONTROL, DATA PROCESSING AND ANALYSIS

Historical data was provided for this study by the Council of Geosciences, South Africa. Data included unprocessed multi element geochemical data, geophysics (variety of unprocessed data and grids), AutoCAD files, bitmap file, Geosoft grid file and Landsat image. This information package represents a fairly typical scenario for today's geologist responsible for performing regional project work.

A key task in working with historical data is to verify the information before proceeding. In this case, geochemical assay data required detailed verification. Quality control steps included visual examination of data, removing standards and duplicates, merging assay data with locations, and performing statistical analysis. These steps — as well as geochemical data analysis — were accomplished entirely from within the Geosoft environment using specialized application software designed for exploration geochemistry data.

Geochemical and geophysical processing was also performed within Geosoft. Geochemistry data were gridded to facilitate rapid visual analysis and symbol maps were created. Geophysical processing consisted of verifying and gridding magnetic and radiometric airborne survey data using a variety of software algorithms. In this case, data quality problems were identified in the magnetics as indicated by high-amplitude, "blotchy" results that could not be corrected using further processing. These represent artifacts from the original acquisition process.

INTEGRATION OF MULTI-DISCIPLINARY DATA AND INFORMATION

The value of integration lies in being able to rapidly display many types of processed, located earth science data for comprehensive interpretation. The geologist can then make informed exploration decisions based on all available results.

In this example, we show integration of geology, geochemistry, geophysics and imagery in a single software environment. As described previously, geochemical and geophysical data were processed in the Geosoft environment to enable information sharing between geologists, geochemists and geophysicists. All data types were linked dynamically using a georeferenced cursor to further facilitate comparison of results.

As a further interpretational aid, Landsat imagery was imported into the Geosoft environment using an integrated ER Mapper' plug-in. The ER Mapper image was then masked dynamically to the geochemistry sample region to enable examination of the data from the prospective map sheet.

INTEGRATION OF DATA AND INFORMATION IN DIFFERENT PROJECTIONS

A common problem in integrating exploration results is working with results provided in different projections. The software used in this example provides on-the-fly capabilities for accomplishing this task and keeping track of historical projection information. Access to this type of dynamic projection capability further streamlines the compilation and interpretation of results.

In this example, we show Landsat data from UTM zone 35S. The ER Mapper *.alg. file was imported via the integrated plug-in available within Geosoft. Working with the *.alg file is much more efficient than the working with the *.ers file which is significantly larger in size. Geological information was scanned from the 1:250000 geological map, and then georeferenced using a quadrilateral warp. The projection for the geology map was the South African LO System central meridian 27.

GEOLOGIC INTERPRETATION AND PRESENTATION

After geology, geochemistry, geophysics and imagery is integrated, the geologist can proceed with interpretation using all information — using a single map. In this example, we show a final interpretation generated using onscreen CAD tools and the area selected for detailed follow up (Figure 5). Final maps can be prepared for all data sets and geological interpretations using OASIS montaj or results can be exported to a variety of software formats including ArcView, ER Mapper. Grids are exported at true pixel size for final presentation to management.

DIGITAL OUTPUT OF DATA FOR GPS NAVIGATION

Another traditional exploration problem is planning follow-up surveys and laying out a survey grid. This process can be accomplished effectively using current software tools. In this case, the result was a survey plan based on line directions perpendicular to geological strike and a station spacing of 25 metres (Figure 6). The process is based on:

- Definition of a survey boundary file based on geological interpretation. Survey boundaries can also be imported directly from MapInfo, ArcView, AutoCad DXF or ASCII file.

- Import orthophoto for better definition of ground positions.

- Set-up of a survey plan for the defined polygon area using Geosoft survey planning capabilities. In this case the line spacing = 25m and azimuth = 30 degrees. Stations were incremented by 25m and saved to an OASIS database (Figure 7).

- Output geographic coordinates in WGS84 datum from the X, Y locations in Cape datum using an automated projection wizard directly to an OASIS database (Figure 7). This data was then exported to an ASCII waypoint file (not shown) for GPS navigation.

SUMMARY

Integration of multi-disciplinary results is a prerequisite in today's highly focused exploration environment. Integration provides a number of real benefits including faster evaluation and turnover of prospective regional data, decreased risk and improved geologic interpretation using all available information.

In this short example, we have demonstrated the end-to-end process encountered by many geologists. This process includes verifying historical data from different origins, processing (or partially processing geochemical and geophysical data), analyzing results, integrating results and finally, developing geologic interpretations on which follow-up surveys can be planned. The final result from this exercise is an output file of sample locations that can be input directly into a GPS for follow up.
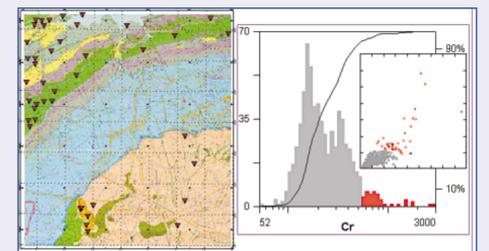
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Figure 1: Histogram analysis presentation showing subsetted population (middle), scattergram representation of selected samples and samples overlying geological map.
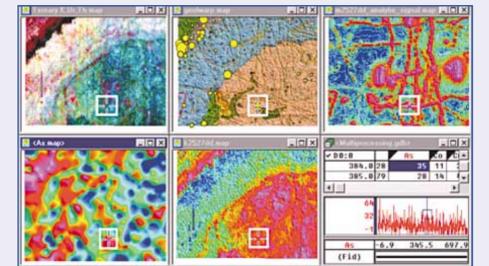

Figure 2: Integrated presentation showing ternary K/U/Th image, shaded geology map with proportional As symbols, processed magnetic data (analytic signal), As grid, Potassium grid and original As geochemical data with graphical view.
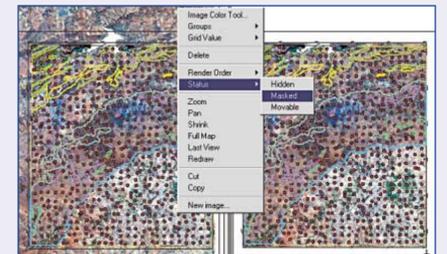

Figure 3: Landsat imagery was added to interpreted geology using the ER Mapper plug-in provided within Geosoft's OASIS montaj software. Imagery was clipped to the Broederstroom map area to create an integrated compilation of geochemistry, geology and imagery.

Figure 4: Landsat imagery accessed in Geosoft via ER Mapper plug-in and corresponding geology map. The cross-hair symbol represents a dynamic link between datasets in different projections. Projection information is shown below.
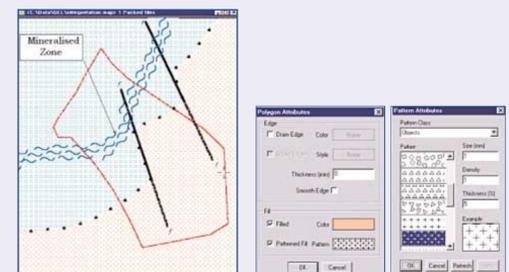

Figure 5: Geological Interpretation compiled with Geosoft CAD tools. Survey boundary indicated in red. The software screens show some of the control settings available for interactive interpretation within the software environment.

Figure 6: Orthophoto with prospective area showing proposed sampling region with survey grid created with Geosoft survey plan wizard.

Figure 7: Geosoft database showing sampling locations in projected and geographic coordinates with ASCII waypoint file (overlay) for GPS navigation from Geosoft export wizard. The start and end of each line in the waypoint file is indicated with an asterisk (*) in the station column.