Integrated Presentation and Interpretation of Geochemical Data and Multi-disciplinary Information: Regional and Local-Scale Approaches

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Today’s geoscientists have unprecedented access to multi-element geochemical data and multi-disciplinary information – from large-scale regional programmes to local programmes on a single property. The challenge in this “data- and information-rich” environment is to identify and remove problematic results and use the remaining high-quality data and information to identify exploration targets.

In regional programmes, “identifying targets” refers to the process of initiating exploration in often unfamiliar countries or regions and recommending areas for grassroots follow up. Data volumes are large with tens of thousands of samples assayed for 30 or more elements – from various sources and often in different digital formats. In this context, success depends on effectively presenting and interpreting results, especially during the key data verification and target identification stages.

In local programmes, target identification focuses on acquiring, verifying and interpreting relatively low-cost assay data and identifying drill targets. With fewer samples than regional programmes, data volumes are more compact but there are still many elements with which to work. Local project data also change frequently as data are returned from the laboratory. Here, success also depends on effective presentation and interpretation of results with the caveat that certain formats and methods may be more appropriate for local projects.

This paper is intended to compare regional and local presentation and interpretation methods – focusing on their application for quality control and target identification. The ultimate purpose is to provide examples of a cross-section of techniques to help navigate the large volumes of data and multi-disciplinary information available.

Presentation and Interpretation of Regional Data

The regional scale study portion of this paper considers presentation and interpretation methods in the context of specific exploration problems. We start with a brief review of the regional data available for study.

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Overview of Regional Data

The regional data used here were obtained as part of an ongoing geochemical mapping programme on a 1 km grid by the Council of Geosciences (Geological Survey of South Africa). The sampling density was designed to map regional geochemical trends as well as to allow for the identification of most small to medium sized outcropping ore bodies. Elements comprised a subset of the regional data including As, Co, Cr, Mo, Ni, Pb, Sn, Zn and Zr.

The study used digital data for the 1:50,000 scale 2527DD Broederstroom map sheet. Samples were primarily from first order stream sediments although soil samples were substituted in some areas of poor drainage. The sample size was approximately 5 kg and was taken from the top 20 cm of river bed sediments or the soil profile. Samples were dry sieved to the ~75 um fraction, pressed into a powder briquette and analyzed for 24 elements using a simultaneous X-ray fluorescence spectrometer.

Regional Quality Control

At the regional project scale, there are two types of quality control scenarios or problems to consider:

• If the project relies on historical data, data often come from different sources. A key goal is to recognize effects from different field sampling techniques, laboratories and assaying technologies.

• If the project relies on a combination of historical data and ongoing sampling results, the geoscientist must also consider how to effectively handle standards (reference samples) and duplicates.

Based on the data available for this study, we focus on verification of historical data only. Handling of ongoing results is considered in the local project study.

Verifying Historical Data

When verifying historical data, an initial task is to determine data origins. This information is especially useful if the project calls for merging of data from multiple surveys. Provided that suitable documentation is available, the geoscientist can then develop strategies for dealing with differences in data acquisition and assaying methods.

Based on the documentation provided for this data set, we were not required to merge data from multiple surveys. Even with an apparently well-behaved data set, however, it is essential to perform due diligence. With this objective in mind, we include examples of visual quality control and spatial verification methods that can assist in recognizing problems early in the exploration process.

Performing Visual Quality Control

As part of an initial data orientation, we tabulated all data and information provided. The data package included two AutoCAD files (2527dd.dxf and geology.dxf), bitmap file (geology.bmp), Geosoft grid file (m5277dd.grd), and three ASCII files (standard.txt, location.txt and assays.txt).

The assay file was first opened in a text editor to quickly determine the volume of data and to detect obvious problems such as missing samples. Assay, standard and location files appeared to be complete.

The next step was to merge data. Since this process is time-consuming with text files, the approach was to import assay, standard and location data into a commercial software system designed for processing, analysis and visualization of high-volume earth science data.

Standards were removed and assay data were merged with location data as a prerequisite for further evaluation. Standards were not examined in detail since we were not working with “live” (i.e. dynamically changing) results.
After data import, a subsequent step was to evaluate each element using simple statistics. The objective was to confirm correct labeling of assay fields and ensure that there were no obvious discrepancies in analytical techniques, detection limits and acceptable data ranges.

As shown in Figure 2, simple statistics were calculated and used to determine mean and standard deviation values as a prerequisite to establishing confidence intervals. An examination of data ranges indicated the data was within an acceptable range.

Data were then displayed in profile format. Profile presentation is not a traditional method for randomly sampled regional data. However, this method can provide a quick visual means of assessing background, identifying extreme high and low values, and examining relationships between different elements.

The example in Figure 3 shows several quality control problems. Specific Cu, Pb and Sn samples had very high amplitudes, suggesting the need for more detailed evaluation to assess their significance. In contrast, a large number of Sn samples were clustered near the detection limit and the noise envelope (i.e. variation about the mean) was significant in comparison with other elements.
Additional profiles were plotted and proved to be effective for identifying different types of variability as indicated in Figure 4. Specifically, the Cu and Ni data were well-behaved with only a few extreme high and low values. A strong covariance between Cu and Ni was also exhibited. In contrast, Mo data had more high- and low-end variability as well as a distinctly different “profile fingerprint”. Recognizing these types of Cu / Ni and Mo groupings can assist in identifying unique geologic relationships at an early stage.

Histogram Analysis was performed to evaluate some of the findings from profile presentations in more detail. This follow-up indicated that As, Co, Cr, Ni and Zr values exhibited well behaved lognormal distribution patterns with indication of multiple populations. As indicated in Figure 5, Sn exhibited severe effects at the lower end of the sample range likely related to detection limit problems. Mo, Pb and As also exhibited detection limit problems to varying degrees.

Performing Spatial Verification

A remaining quality control task was to verify and evaluate the spatial distribution of samples. This type of verification can help:

- Identify sample clustering patterns that can affect interpretation
- Evaluate the spatial distribution of problematic elements identified during the previous quality control exercise (detection limit problems in Sn, Pb, Mo and As, and high Cu and Zn values).
- Identify whether background effects (i.e. background shifts related to different batches of assays or different laboratories) are present.
All of these potential quality control problems can be followed up via spatial quality control presentations. It is up to the geoscientist to determine which methods may be appropriate to their particular data set or worthwhile from a time perspective.

Here, we started with a quick analysis of sample locations to evaluate the sampling pattern.

The pattern shown in Figure 6 indicates a random, relatively uniform distribution. The data set does not exhibit any clustering effects that could affect analysis and interpretation. This type of clustering is more typical of stream-based sampling programmes.

Another spatial check is to determine the distribution of samples with specific problems such as a high incidence of samples at the detection limit. The purpose is to recognize laboratory batches or groups of samples with problems such as those in Figure 7.

This distribution may be related to survey methods. As described in the review of regional data, samples were primarily from first order stream sediments although soil samples were substituted in some areas of poor drainage. This discrepancy may explain the distribution in Figure 7. Depending on time and rigour, the interpreter may want to consider whether they represent a significant problem and should be removed from the data set prior to further processing and analysis.
Another check was to evaluate the distribution of samples with extreme high values. These values may represent laboratory problems, cultural influences or geologically significant anomalies. Here, we used Scatter Analysis to quickly select and plot co-varying Cu and Pb anomalous values (as identified previously through profile-based quality control).

The two anomalous values to the northeast of Figure 8 likely correspond to anthropogenetic contamination as identified in a regional geochemical follow-up report (Szczesniak et al. 1997). The significance of the other anomaly is unknown. This type of approach is recommended as a standard method for regional data. As a final verification exercise, we gridded the data. Gridding (i.e. geospatial interpolation of samples to produce a colour-coded image) and onscreen grid visualization techniques are becoming widely accepted in exploration geochemistry as a means of effectively handling increasing data volumes.

In regional surveys, gridding can help quickly identify problems such as systematic background shifts (i.e. level problems) in geochemical data. These shifts can be related to different sampling methods, detection limits or laboratory preparation problems and are recognizable from abrupt “steps” as well as “striping” patterns in the gridded image.

In this case, the level shift was subtle and reflects the inclusion of samples near the detection limit. In viewing the positioning cross mark in the bottom left corner in Figure 9, it can be seen that two values create an artificial “low” in the grid. As samples near the detection limit are discarded (i.e. as a correction process is applied), this low is eliminated and a northwest to southeast trend becomes apparent. In addition, as indicated by the simple line drawn in the image to the right, removal of selected samples enables resolution of a general region of low As values not observed in the original grid.

Summary of Regional Quality Control
A combination of visual and spatial quality control presentations were effective in illuminating problems in regional data sets related to a number of different sources.

Application of basic statistics, profile display and histogram display helped identify isolated elements with detection limit problems and elements with extreme high values requiring further study. These methods also provided initial insight into possible geologic relationships between elements including Cu and Ni.
Spatial methods were effective for isolating specific samples and groups of samples that potentially require correction. Gridding helped identify geochemical “leveling” problems. Used in combination, these methods can help the geoscientist develop strategies for correcting or working with data as a prerequisite to target identification.

**Regional Target Identification**

At the regional scale, we considered three types of target identification scenarios:

- Implementing appropriate techniques for processing and analyzing data
- Applying classification techniques
- Integrating data and results with multidisciplinary data and information, and selecting prospective areas for follow-up

**Processing and Data Analysis**

After performing quality control, an important consideration is how to best process and visually display data to extract meaningful information while maintaining data validity. Some approaches include:

- Preparing symbol plots
- Calculating ratios and preparing contour plots
- Using gridding to emphasize coherent patterns
- Preparing other advanced presentations including ternary images
- Comparing processed and original data using dynamic links

Preparing symbol plots and grids for all elements in a data set is a desired starting point in regional exploration. In the past, this was a major task requiring much patience. With advances in computer software, however, these types of processing have moved into the realm of reality. The following figures provide some examples of products that can be produced either manually or automatically in today’s commercial software systems.

Geoscientists have a wide variety of methods of producing and applying symbol plots. Traditional methods include proportional symbols and range-classified symbols. As indicated in earlier profile-based quality control, specific sample groups were evident. In Figure 10, we show Mo proportional symbols as well as As symbols which – through “profile fingerprints” – were identified as potentially mapping different geologic units. This hypothesis is confirmed here.

*Figure 10: Regional presentation showing proportional symbol plots overlying geology for Mo (left) and As (right).*
In addition to traditional symbol element plots, new technologies are enabling other applications as shown in Figure 11.

![Figure 11: REGIONAL PRESENTATION SHOWING Cu SAMPLE LOCATIONS WITH GEOLOGICAL MAP AND SCATTER ANALYSIS TOOL USED TO SELECT SAMPLES.](image)

In this case, we plotted a Scattergram of Cu and Ni results to view their interrelationship. It was apparent that there were two population groups. Using an interactive software-based method, we then selected all samples from one population and displayed them automatically on a map. This technique showed the correlation of Cu (and inverse correlation of Ni) within granites to the southeast of the map area and within northern east-west trending shale units.

Although not performed in this study due to a lack of appropriate data, an important processing and analysis technique is the calculation and presentation of ratio data. Examples include calculating ratios such as Cs/Rb, K/Ca and summing elements such the Rare Earths (Total REE) or high field strength elements (Total HFSE). Results can then be quickly contoured and plotted, with or without an underlying grid.

![Figure 12: REGIONAL PRESENTATION SHOWING CONTOURED Cu DATA WITH UNDERLYING Cu GRID.](image)

Gridding is gaining acceptance as a geochemical technique for regional programmes. Here, the gridding algorithm used was designed to reflect precisely the original assay values without smoothing. This is critical to data interpretation in grid and regional stream sediment geochemistry (Chris Oates, 1998, personal communication).
Another technique shown in Figure 14 utilized a “visual querying” technology called dynamic linking. This method enables the geoscientist to evaluate specific samples using database, spreadsheet and map views on an interactive basis – with the goal of providing a multidimensional representation of specific anomalies orprospective targets.

Applying Classification Techniques

After performing data processing and analysis, another visual technique implemented was classification. With this method, the objective is to isolate regional trends and subset specific groups or areas for further investigation. For example, if geochemical data are clearly mapping geology, it may be appropriate to isolate all sediments and remove granites and other less prospective rock types.

Depending on the data and information available, classification can take several forms, including subsetting on:

- Region (i.e. select an area on the map and extract all samples for that area)
- Lithology (i.e. rock and other geologic codes defined in a database)
- Groups on a map (i.e. use existing digitized geologic map layers to extract samples)

The example in Figure 15 was constructed by interactively defining a polygonal area on a digital geology map. Software was used to subset all samples in the area into a separate database. This method facilitates detailed examination of specific prospect areas.
Integrating Multi-disciplinary Data and Information

Geoscientists currently face an environment in which margin for error, risk tolerance and project resources are declining. These trends are creating demand for methods capable of efficiently integrating multi-disciplinary data and information from various sources. Here, we show one type of integrated presentation and suggest methods for applying “visual querying” (i.e. dynamic linking) methods to the various types of data and information available for the Broederstroom 2527DD area.

The presentation in Figure 16 integrates many types of multi-disciplinary data and information. All components are linked interactively using a dynamic linking mechanism (indicated by cross). This mechanism enables the geoscientist to select any point on a spreadsheet, profile or map, and see the same location in all other views. From an interpretation perspective, we suggest that dynamic linking can be effective for a variety of applications including:

- Evaluating geologic structures, for example, by tracking some of the dykes evident in the magnetics to similar features in the ternary radiometric image.
- Correlating geologic boundaries between different rock types based on a comparison of radiometric images, geochemical grids and geology.
- Examining individual anomalies. In Figure 15, the dynamic link cross is centred on an As anomaly which on examination of the analytic signal grid (magnetics) coincides with a single anomaly. This could represent a potential base metal target requiring further follow-up, and evaluation.

Summary of Regional Target Identification

After verification, the remaining statistically meaningful data was ready for target identification. Key steps include determining optimal presentation methods, performing classification, and integrating geochemical data with multi-disciplinary information.

On examining the Broderstroom data and information, key results were:

- Recognition of specific elemental patterns corresponding to geologic units (including Mo, As and Cu)
- Definition of at least one individual target defined by coincident As, Cu and magnetic (analytic signal) anomalies that may represent an area for follow-up for base metal potential.
- Recognition of anomalous samples from human activities that should be excluded from further investigation.

Presentation and Interpretation of Project Data

The objective in including this study was to compare and contrast some of the quality control and target identification approaches applicable to project data. It also provided an opportunity to provide an additional example of multidisciplinary integration using geochemical, geological and geophysical data and information. As in the regional study, we start with a brief review of the project data.
Overview of Project Data

Digital geochemical, geophysical and geological were obtained for the 1:25,000 scale map sheet from an unspecified gold exploration project in the Kalgoorlie greenstone belt, Western Australia.

Geochemical data were from first order soil samples taken from the C-horizon. Other characteristics such as sample size, depth, sieve size were not known. Elements available for the study included ICP data for As, Au, Cu, Pb and Zn. This subset of the assay package was provided to enable a basic characterization of gross lithological variations and mineralization.

Geophysical information comprised a regional airborne magnetic grid. The magnetic grid was Laplace-filtered to derive a grid that showed near surface variation (as opposed to the original magnetic grid that showed mainly regional features).

Geological information included a regional geologic map with basic lithologic codes and geologic structures.

Local Quality Control

The importance of quality control for local scale projects has been emphasized recently by events such as the Bre-X scandal. The scandal had major effects on the mineral exploration industry as a whole and opened the industry to higher levels of scrutiny than ever before. This trend, combined with the growing downstream uses of assay results – in mine feasibility studies for instance – means that these data have assumed a greater significance.

In this study, the objective was to discuss basic quality control challenges at the project level and suggest some presentation methods to help address these problems. Specifically, we focused on the following scenarios:

- Identifying basic problems in field sampling techniques
- Identifying basic problems in laboratory assaying
- Evaluating whether the laboratory product (assay package) works for the geology

For the geoscientist, the ability to answer these types of questions can help make key decisions including modifying field procedures, selecting alternate laboratories and choosing the optimal assay product.

Identifying Problems in Field Sampling Techniques

Field sampling techniques are a major source of uncertainty in exploration geochemistry. Potential problems include discrepancies in sampling specific horizons – either by non-recognition, by sampling bias, or by other field related factors such as topographic slumping or wind-borne transport of surface sediments.

A basic technique for dealing with these problems is using duplicate samples – samples taken within 5m or less of each other. These can then be evaluated to look at variations in sampling methods or local sample bias problems. High variability in closely spaced samples can indicate possible sampling problems or high intrasite variability.

As indicated in Figure 17, one approach to evaluating this type of problem visually is to use Scatter Analysis to compare pairs of duplicates. Ideal pairs exhibit a linear relationship. If samples deviate significantly, they can be quickly selected and plotted to a map using the method described in Figure 8. If a systematic trend is apparent, the geoscientist can then determine whether the problem is related to field procedures, or other geologic bias.
Identify Problems in Laboratory Assaying

Some basic problems in laboratory assay procedures include:

- **Instrumentation drift.** This problem can be evaluated by looking at variations in similarly analyzed values over time (i.e. by plotting samples in analytical order to see whether there is any systematic variability).

- **Contamination.** This problem can be evaluated through methods described in the Basic Quality Control section in the regional study.

- **Extreme low values.** These can be due to detection limits. Methods for verifying these data are described in the Basic Quality Control section in the regional study.

- **Extreme high values.** These can be related to field, laboratory or geologic (i.e. “real”) sources. Standards (reference samples) are typically used to numerically evaluate these types of problems. Standards are samples with well-understood assay values that are inserted randomly prior to analysis. Since standards were unavailable for this study, we focused on using visual methods for due diligence. A visual approach is a practical alternative especially in the context of an ongoing field programme where decisions must be made to continue sampling or drilling. Methods included:
  - Plotting profiles to recognize obvious problems.
  - Performing a basic statistical analysis to establish mean and standard deviation values.
  - Sorting data to evaluate extreme values.
  - Performing histogram analysis to look for the mean +/- 2 standard deviations. This 95% confidence limit establishes a reliable upper limit for quality control and further processing such as gridding. It also helps to establish natural breaks in data and percentiles that can be used for symbol plotting.
  - Gridding data to look at gross trends such as leveling effects and to ensure that all prospective areas were completely sampled.

To avoid duplication with the regional study, we include selected results.

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**Figure 17.** 
QUALITY CONTROL PRESENTATION SHOWING SCATTERGRAM PLOTTED USING DUPLICATE SAMPLES FOR Cu.

**Figure 18.** 
QUALITY CONTROL PRESENTATION SHOWING LOGARITHMIC PROFILES OF Cu DATA FROM CURRENT, PREVIOUS AND FOLLOWING LINES.
The profile plots in Figure 18 show the continuity of Cu anomalies across lines. In addition, we see evidence of some differences in background, mean and “high” values on a line-to-line basis that may indicate either field or laboratory problems. This type of problem is covered in more detail in the gridding results.

In Figure 19, the Cu grid exhibited leveling effects as shown by linear “stripes”. Specifically, there are six lines with an East-West striping or “smearing” along the sample lines – possibly indicating that field or assay methods changed during the survey programme.

One way to correct the data is to assess the background from adjacent unaffected lines and compare the background with that for affected lines. In this case, we determined that Cu background was 40 ppm approximately on unaffected lines and 55 ppm or higher on affected lines. The average correction to apply is 15 ppm.

With the commercial system employed in this paper, corrections can be applied as follows:

- Select the affected line
- Use the mathematical expression capability to subtract the correction
- Re-grid

A more automated approach to use with a larger data set is to “remove” affected lines from the database to a subset database and assess the statistics for each removed line. Then compare the background values of removed lines with those of the unaffected lines and determine a correction value. Lastly, correct the lines and merge them back with the unaffected lines.

Determining Geologic Suitability of Laboratory Products

With advances in technology, laboratories are now combining many elements into “products” for mineral exploration. A basic starting point on a project is to determine whether the laboratory assay product is suited to the geology. In practice, this verification process can be time consuming since there may be many elements to evaluate. In addition, the geoscientist may want add other key values, such as ratios, to the evaluation.

One solution is to implement standard procedures and presentations for performing this type of verification quickly. With the project data in this study, we were not able to perform a comprehensive evaluation due to the limited set available. Instead, we implemented a basic method that can help evaluate a laboratory product.

We started by examining statistics for each element in the data set. The next step was to create range-classified sample plots for comparison with other elements and the existing geological map. These plots then enabled us to assess the effectiveness for specific elements in mapping mineralization and lithology.
In the sample Figure 20 above, the range-classified colour plot indicates several distinct populations including a northwest trending feature in the west and centre of the map and a northeast trending feature in the eastern portion.

Comparison with geology maps indicated that the former feature corresponded to structures (i.e. faults) whereas the latter feature is indicative of Cu mapping a specific lithology (map coverage did not extend to this area). As, Au and Pb results were also evaluated and showed similar patterns in the vicinity of the main northwesterly oriented structure. Elsewhere, each element also showed mapped certain lithologic units.

**Summary of Local Quality Control**

The project study examined a cross section of quality control methods for evaluating field and laboratory problems as well as assessing the suitability of laboratory products for local exploration.

Duplicate plotting using a Scatter Analysis tool was an effective means of identifying anomalous sample locations for rapid visualization and plotting.

Various methods were effective for assessing laboratory problems. Gridding had certain advantages in detecting leveling problems on a local project basis. After recognizing these problems, the geoscientist can then develop a systematic method for correcting or adjusting values as required.

Lastly, symbol plotting showed the abbreviated assay product available to be adequate for mapping both mineralization and lithology in this study. Another method that could be used for this type of verification is gridding. This process can be automated to enable rapid evaluation of laboratory products with even a large number of elements.

**Local Target Identification**

At the local project scale, we considered three types of target identification goals:

- Implementing appropriate techniques for processing and analyzing data
- Integrating data and results with multidisciplinary data and information
- Selecting drill targets

**Implementing Processing and Data Analysis Methods**

Following verification, the geoscientist must determine how best to process and analyze results. In this study, we focused on visual methods that would maintain true representations of the original data. Methods included performing:

- Basic statistical analysis to determine processing parameters (i.e. percentiles that apply to all data such as the mean +/- 2 standard deviations)
- Histogram analysis to evaluate populations and processing parameters (i.e. percentiles that apply to specific elements based on population “breaks”)
- Scatter Analysis to evaluate interrelationships between elements.
Following application of these methods, we were then able to determine ranges for preparing colour symbol plots. Ranges can also be used for gridding – a particularly effective interpretation method. However, if the goal is to select specific samples for drilling targets, symbol plots may provide more precise positioning than grids.

Scatter Analysis is a basic starting point for looking at interrelationships. In Figure 21, there are three Au and As populations. We plotted the middle population on a map as shown in Figure 22.

Review of Figure 22 indicates a strong spatial relationship for Au and As. This relationship corresponds to a major northwest trending structure. In other map areas, Au and As are only weakly correlated – indicating different types of mineralized behavior in the project area.

**Integrating Results with Multidisciplinary Data and Information**

From a target identification perspective, our approach relies on integrating all available data and information, examples of which can include:

- **Topography.** Topography can affect interpretations significantly. One of the challenges is to determine the most effective means of integrating topography with data. A suggested presentation method is to create a pseudo-3d topography grid (i.e. shaded relief) and add symbols to the map.

- **Geology.** At the project scale, the geoscientist is intimately familiar with the geology (in comparison with regional programmes). The challenge is to apply this knowledge. A suggested presentation method is to integrate surface assay results with the geology and detailed interpretation as a precursor to identifying drill targets.

- **Geophysics.** Geophysics adds a different perspective to the exploration programme. A key challenge is to assess any available data and information to confirm knowledge gained from geochemistry and geology. A suggested presentation is to add symbol plots of key elements directly to the geophysical maps.

- **Other Data and Information.** This can include satellite images and CAD files. The presentation approach is determined by the exploration problem and data quality.
In this study, we started by integrating range classified symbol plots with geology and airborne magnetics.

In Figure 23, we see a series of dynamically linked images (i.e. with cross indicating coincident points in each map). Using this type of presentation, it is possible to visualize many types of information as well as building new knowledge. For example, in this view, we observe different types of mineralization and relationships to geology, including:

• Strong coincidence of Au and As values along the northwest trending structure that dominates the centre of the map.

• Different relationships with geology on different parts of the project area. For example, As maps geology to the northwest of the area and Au maps geology to the northeast.

In addition, we observe that the geophysics does not reveal significant new information vis-à-vis the assay data and geology. This in part reflects the nature of the geophysics (i.e. an airborne survey rather than a detailed ground survey) and the fact that the magnetics may be responding to deeper targets than those under investigation. In the next section, we look at a processed magnetic product that reveals more information than the total field magnetics.

Selecting Drill Targets

In the current results-oriented exploration environment, it is essential to effectively evaluate and prioritize exploration targets with a high degree of reliability. Addressing this challenge requires building a comprehensive knowledge base, selecting the appropriate presentation methods, and integrating all available data and information.

As shown in Figure 24, a recommended area for follow-up drilling is in the vicinity of the intersection of two main structures near the centre of the map area. The northwest trending structure hosts many Au anomalies and traces the eastern limb of a volcanic unit defined by the Laplace-filtered magnetic grid. A second priority area is the north-south oriented group of gold anomalies that occur on the western flank of a magnetic unit defined in the Laplace-filtered grid.

Other less prospective areas include an area of elevated Au values to the east. Au anomalies appear to be hosted within a magnetic unit and they are therefore interpreted as mapping a lithologic unit for which we do not have geologic map coverage.
Summary of Local Target Identification

During the course of this local study, we moved from basic familiarity of the area to be able to recommend several areas for drilling. In addition, we were able to show through symbol plotting that the key prospective zones had been adequately covered with geochemical surveys.

The basic methodology in developing our project knowledge was to start with a basic assessment of geochemical data, adding geological information as the study progressed. This type of sequence mirrors the exploration process during which geologic results are added throughout the course of a project. We then added geophysical results and processed geophysical results. The final interpretation product was a combined geochemical, geological and geophysical map that led to the recommendation of several prospective drill targets.

Conclusions

This study focused on illustrating presentation and interpretation methods with emphasis on quality control and target identification in regional and local exploration programmes.

At the regional scale, an initial verification task is to evaluate the quality of data from different sources, survey types and analytical techniques. We illustrated a variety of techniques starting from an initial assessment of data origins and integrity. Following this basic evaluation, the geoscientist can implement a variety of visual presentations such as histogram and scatter analysis plots. Gridding is appropriate at the verification stage to rapidly identify background shifts from a variety of sources. The final result is a high-quality data set ready for further interpretation.

Interpretational methods shown included transforming data to a logarithmic scale and creating proportionally sized symbol plots. Interactive manipulation of colour symbol plots and visualization of geochemical grids also assisted in emphasizing coherent patterns in elemental data. Other important aids can include advanced map products, such as classified symbol plots, ternary maps, and integrated multidisciplinary presentations.

At the project scale, various verification methods were illustrated. Presentations described or shown included profile-based methods, basic statistics, histogram and scattergram methods, as well as symbol plotting. Gridding was recommended in certain cases to show background shifts on specific lines – a valid scenario in line-based geochemical surveys.

For target identification on a local project scale, a variety of presentations and interpretational methods were shown. Key presentations included range-classified symbol plots that facilitated rapid evaluation of mineralization and mapping of geology. Interpretational methods focused on integrating multidisciplinary data and information including geology, geochemistry and geophysics. In recommending drill targets, this methodology was further refined to integrate key combinations of gold assays, geologic structure and a processed geophysical product that effectively delineated the near-surface structures of interest from a local project scale.

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