GEOCHEMICAL MAPPING USING GEOCHEMISTRY FOR ARCGIS

S. Karunakar Rao [1], Alice Deepika [2], Nigel Halsall [3]

[1] President, Datacode

[2] Junior Geologist, Datacode

[3] Technical Analyst, Geosoft Europe

Datacode, K-26, 2nd Floor, Kinkhede Layout, Opp LIT, Bharat Nagar, Nagpur 440033, Maharashtra, India

Abstract:

Geochemistry for ArcGIS enables explorers to analyze geochemical data within their Esri ArcGIS Environment. Geochemical mapping/ exploration require the ability to process and analyze all components of geochemical data in context with the geology, structure and geomorphology. Using Geochemistry for ArcGIS, geoscientists can effectively examine multivariate relationships; uncover underlying structures and present results with visually impactful maps.

Supported data imports include ASCII, excel, access, ODBC, geodatabase and feature class file types. Geologists can visualize their multi-element geochemical data in histograms, scatter plots, Pearson's correlations (R), probability plots, box plots and ternary plots. Geosoft's advanced gridding options, including Kriging and inverse distance weighted de-cluster and reduce spatially bias data, displaying it as 2D grids or contours. With Geosoft's built in 3D viewer, geochemical data can also be visualized in 3D as surfaces, relief surfaces and symbols. ArcMaps powerful spatial and attribute table selection tools enable users to split subset and refine geochemical data for specific statistical analysis, based on regional geological differences, analytical techniques or sampling types. Powerful quality control functions recognize and extract both standards and duplicates within geochemical datasets, which are then represented graphically.

Geosoft's Geochemistry for ArcGIS extension has been implemented successfully by many companies exploring around the world. In Burkina Faso, Etruscan has been successfully using Geosoft's extensions as their principal exploration platform at their Youga gold mine. The Ontario Geological Survey has used Geochemistry for ArcGIS to analyze tens of thousands of geochemical samples in a multi-year lake sediment sampling program, building a geochemical picture of northern Ontario, Canada. Actlabs in Canada has also applied Geochemistry for ArcGIS in their exploration to analyze organic chemistry in the search for ore bodies.

In this short communication, Geochemical mapping using 34 elemental analyses is being assessed The Objective of the project was to generate Geochemical Map and identify the anomalous zone. Though the project was initially envisaged for mineral exploration however with kind of data set available it can be further used for environmental and other studies including soil classification and creation of a 'geochemical baseline data'. These additional studies will further be used for planning be it agriculture or delineate environmental sensitive industrial setup.

About the Author:

MR. S.KARUNAKAR RAO

Mr. S. Karunakar Rao is Company President at Datacode, Nagpur. He has 15 years of experience in marketing and training Geoscientific software in India. He holds command in earth science software like Geosoft's Target, Oasis Montaj Geochemsitry, DAP; Rockworks, Logplot, Surfer, Mapinfo & Discover.

Datacode is a pioneering Geoscientific Software Company offering strategic solutions that leverage technology in the fields of mineral exploration and mining.

E mail ID: kk@datacodeintl.com

Contact No: +91 – 0712-2530092/93

Introduction

Geochemical Mapping is an essential part of Geological studies and Soil classification for agriculture and environmental management. The project was defined with objective to identify regional mineralization zone and geological formation using geochemical data. Target for Geochemistry of Geosoft (www.geosoft.com) is an important addon tool to ARC GIS to effectively utilization of geochemical data. The addon was used at every stage of project starting from planning of survey grids on toposheet, acquisition of data and plotting location maps, QA/QC of data in terms standard duplicates and invalid data, merging and checking of laboratory assay data with location data. Identify of outliers and masking them during generation of Maps and contours. Apart from mapping, the data was further analyzed for correlation between various elements and other statistical techniques was applied on the data set to see if any specific productive inference can be drawn. The project was divided into following stages.

1. Planning and Acquisition of Data.
2. Chemical Analysis at Labs
3. Generation of Geochemical maps of single elements and combination of multiple elements.
4. Interpretation of geochemical anomaly map.

This study will demonstrates the value of visualizing data in 2D and 3D and illustrates how data integrity can be maintained by dynamic data linking to the original data in 1D space and 2D sections

Overview of the Regional Data

The regional data used in this study was obtained as part of an ongoing geochemical mineral exploration program. Nearly 600 samples were collected during the survey. The Co-ordinates of the survey lines lies in the region between 74°E and 25°N (State Highway 56, Rajasthan). The location map was plotted on 1: 1000000 m using Geosoft Target for Geochemistry. 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 V, Cr, Ni, Cu, Zn, Y, Zr, Nb, Rb, Sr, Ba, Au, Th, U, Cu, Pb, Ni, Co, V, Ga, Sc, SO_3 in ppm and percentage analysis of SiO, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, MnO, TiO_2, P_2O_5 . The samples were analyzed for the elements using various analytical methods including XRF, Flame AAS, GF AAS, etc.

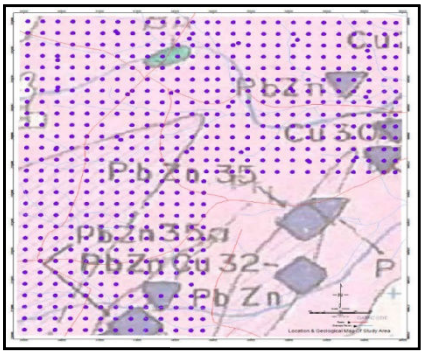

Figure 1: Location and Geology of the Study Area

Stage I : Planning & Acquisition of Data.

This geochemical mapping work was initiated at 1:50,000 Survey of India toposheet level in parts of east central Rajasthan which exposes Precambrian rocks hosting sporadic large deposits of lead and zinc. The medium of sampling was stream sediment (1st & 2nd order) collected at every 1 km interval. These gridlines were plotted on toposheet using the base map option (GeochemMap >> BaseMap) now in these grid specific location of sample pick-up was defined digitizing point based on drainage pattern of toposheet.

The digitized LAT/Long files were uploaded in GPS (Mobile mapper). Surveyors used the GPS to locate the point however at some times the actual sample collection was not exactly at the point identified by GPS since the drainage has changed the course or many other reasons. So the sample was picked up from a location and the point was captured by GPS.

A location map was generated and deviation in planned and actual was also identified. Any specific issues related to sample acquisition were also marked on location plot, like any local factors effective the sampling or subsequent process.

Stage II : Chemical Analysis at Labs

This stage was mainly consisting of laboratories sample analysis. The results from various instruments like XRF and other methods were directly imported in to software as digital data. Or was prepared as tables in Excel sheets and imported in software. For this import of Assay values option GeochemImport-> Import Assays was used.

Once both assay and survey data was imported in database. Merge and verify option was used to do QA/QC of the basic field and assay data. The aspects which was checked for;

1. Sample which have no location data but assay values are there
2. Sample for which location are there but no assay is there.
3. Duplicate sample points.

The assay attributes (Laboratories attributes) where updated to define the limits of each elements. The various detection limits and minimum cutoff and maximum cutoff for particular element were defined here. Standards and Duplicates where extracted out of the merged database where ever necessary. Once the data base was merged, the data was cleaned and ready to be used. Here each element was viewed, using profile option to visually identify any abnormality in data without going into value of each and every data point.

Stage III: Generating Geochemical Elemental Map, using Cr and Au assay values

The above two stages mainly focused on generation of data and data quality aspects. Once the data was to the acceptable standard of project it was brought into main database. Some of the highlights of Oasis Montaj™ database are.

1. It can handle large volume of data almost upto 64 Terrabyte.
2. The Database is dynamically linked to map and profile. So one can identify specific datapoint even in large size data bases having millions of Datapoints.
3. Seamless Interoperability to work with more than 50 supported data types and formats like CAD, GIS, mine planning and modeling formats.
4. Complete ESRI integration including ARCGIS layer support.
5. Easily combines data and keep multiple profile windows open for comparison with maps. Works with collection of data points or treat individual data points

Elemental Maps

For every important element an elemental map was generated and location points were also plotted along with assay value.

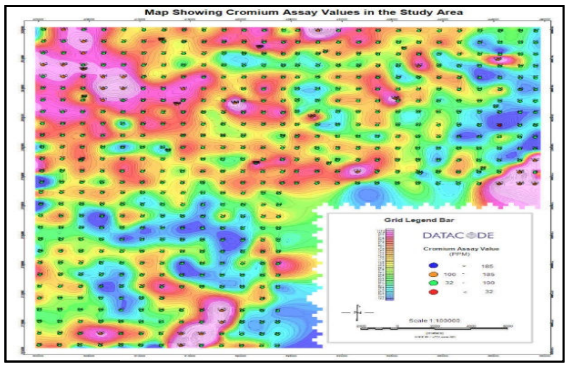

Figure 2: Map showing Chromium Assay Values in the Study Area

Histogram Analysis

For some specific elements histograms analysis was carried out to find the data point lying in band of values. These points were selected highlight the area on Histogram Chart and than those data points which were in the specified range were masked using channel mask. This data was gridded and mapped along with contours

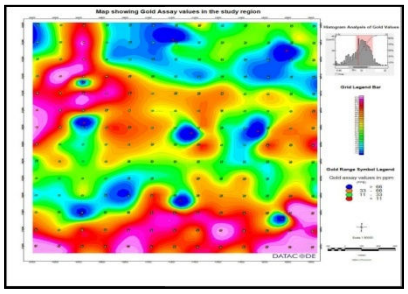

Figure 3: Map showing Gold Assay values with Histogram Analysis

Triplot Analysis

The Triplot analysis was used to plot ternary plot using three channels. Each corner of the triangle represents 100 percent for one of the channels, and at any point in the plot the sum of all three components sums to 100. The values for any point are summed, and then normalized to give fractions from 0 to 100 percent.

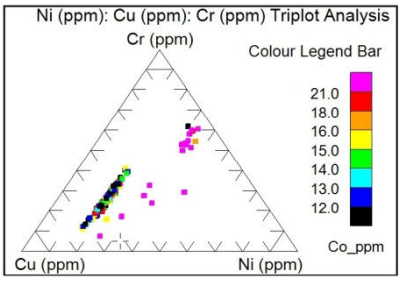

Figure 4: Triplot Analysis of Ni,Cu and Cr (ppm)

Muilti element cross correlation

Correlation is a geochemical analysis tool which calculates the Pearson's correlation between data channels and plot results in a correlation table on a map. Significance level of calculating correlation strength can be selected from 0.90, 0.95, 0.975 or 0.99 (usually 0.95).
The correlations are calculated using Pearson's correlation:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2} \sqrt{\sum (y_i - \bar{y})^2}}$$

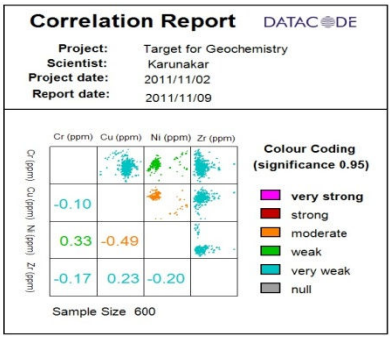

Figure 5: Correlation Plot of Cr, Cu, Ni and Zn values in ppm

Probability Analysis

Probability Analysis is used to determine normal distribution of geochemistry data and have the added benefit of providing a visual representation of the data in which:

- Total data range for a particular element
- Modes can be easily recognized
- Distribution of data can be estimated rapidly
- The general form of the distribution of data is apparent

They are also useful for distinguishing between background and anomalous values (i.e. quality control), or for recognizing a bimodal data distribution (i.e. interpretation).

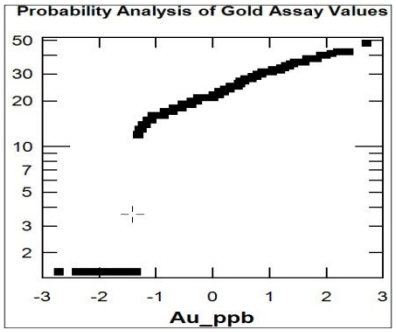

Figure 6: Probability Plot of Gold Assay values in log scale

Interpretation

Some of the basic steps of multi-element data interpretation are:

- Basic Statistics including calculation of mean, median, SD, min. value, max value, 1st quartile, 3rd quartile
- Log transformation of values for those elements not distributed 'normally'
- Correlation Matrix
- Bi-polar plots to see the trends in correlation of element pairs with intermediate 'R' values
- 'R' mode (rotation) Factor Analysis to form 'element groups/ associations' suggestion either rock types, alteration process or mineralization etc.
- Plot the Factor Maps to spatially depict the above associations

Table 1: Descriptive Statistics of the Elements used in the case study

Elements	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Range	Std.Dev.
SIO2%	600	58.66786	59.01	43.94	69.75	56.455	61.05	4.595	3.758219
AL2O3%	600	14.0961	14.19	9.96	19.52	13.095	15.26	2.165	1.617022
FE2O3%	600	6.28181	6.13	3.52	13.87	5.36	6.97	1.61	1.308011
MGO%	600	2.601352	2.47	1.2	6.21	2.13	2.96	0.83	0.651812
CAO%	600	3.174967	2.85	1.16	16.65	2.16	3.745	1.585	1.594264
NA2O%	600	1.41692	1.38	0.08	3.86	1.15	1.63	0.48	0.470962
K2O%	600	2.3858	2.38	0.21	4.47	2.115	2.67	0.555	0.427279
MNO%	600	1.0174	0.94	0.08	4.81	0.84	1.135	0.295	0.356117
TIO2%	600	0.1668	0.115	0.04	1.37	0.09	0.18	0.09	0.17049
P2O5%	600	0.089277	0.08	0.017	0.94	0.071	0.0935	0.0225	0.062819
SO3PPM	600	535.1667	422.5	160	4081	331	595.5	264.5	371.5317
VPPM	600	106.7667	103.5	27	211	93	119	26	22.47757
CRPPM	600	73.66	71	32	185	61	81	20	20.42522
NIPPM	600	103.0367	99	11	307	86	119.5	33.5	28.56113
CUPPM	600	161.6217	153	13	578	128	182	54	61.26988
ZNPPM	600	431.3267	421.5	67	1015	377.5	477.5	100	106.593
YPPM	600	46.975	41	21	462	34	49	15	31.71931
ZRPPM	600	471.345	440	151	2086	359	543	184	185.1884
NBPPM	600	23.51333	20	6	112	17	27	10	11.86625

Table 2: Factor Loadings (Varimax normalized), Extraction: Principal components

Elements	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
SIO2%	**-0.89**	-0.06	-0.16	-0.05	0.13	0.07
AL2O3%	**0.62**	**-0.63**	0.12	0.14	-0.07	-0.11
FE2O3%	**0.86**	-0.01	0.05	0.06	0.36	-0.07
MGO%	**0.87**	0.13	-0.08	0.01	-0.10	-0.07
CAO%	0.30	**0.73**	0.18	0.02	-0.24	0.11
NA2O%	-0.11	0.21	0.29	**0.67**	0.03	-0.21
K2O%	0.10	**-0.87**	0.08	-0.05	-0.25	0.09
MNO%	0.34	0.27	**0.54**	-0.11	**0.49**	-0.24
TIO2%	0.40	0.00	-0.18	**0.77**	0.13	0.07
P2O5%	0.10	0.07	-0.10	0.09	**0.64**	0.11
VPPM	0.46	0.20	**-0.60**	-0.28	0.19	-0.05
CRPPM	**0.70**	-0.27	-0.01	0.04	0.22	0.18
NIPPM	0.08	**-0.73**	0.07	-0.45	-0.27	0.01
CUPPM	0.12	0.41	**0.65**	0.19	-0.27	-0.08
ZNPPM	0.12	-0.19	**0.86**	-0.12	0.04	0.02
YPPM	0.11	-0.06	0.01	0.07	-0.08	**-0.92**
ZRPPM	-0.18	0.16	0.42	0.22	0.45	-0.39
Expl.Var	***3.86***	***2.70***	***2.22***	***1.47***	***1.37***	***1.20***
Prp.Totl	***0.23***	***0.16***	***0.13***	***0.09***	***0.08***	***0.07***

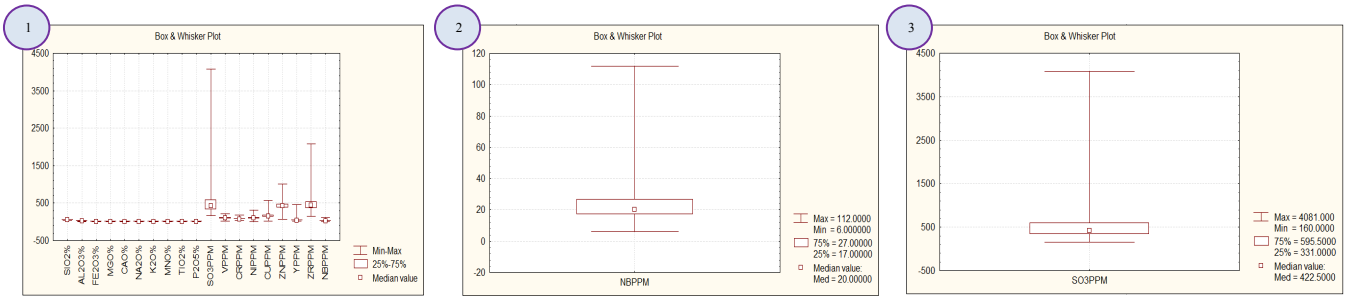

Figure 7: Box and Whisker Plots of 19 elements

Figure 8: Box and Whisker Plot of Nb(ppm)

Figure 9: Box and Whisker Plot of SO_3(ppm)

Conclusion

Geosoft's Geochemistry for ArcGIS software was effectively utilized for not only data management and mapping which was primary objective of the project. However the overall capability of software which covered other aspects of data analysis namely

(1) Data import and QA/QC, the software allowed various form of Data Import ranging from ASCII files, binary or from any other RDBMS database. The Software allows defining various levels of filter and control to perform on large (terabyte) scale database. A national level data can be easily managed.

(2) The easiness of gridding and generation of maps in various projections, various scale with different layers of data and integrates the same with ARCGIS as layer.

(3) The analytical tools of software is highly versatile and allows an user to do multiple form of statistical analysis be it uni-variate , bi-variate , multivariate , PCA or classification of data by various attributes.

(4) The user friendliness and tight integration with ESIR platform is key advantage.

(5) Generation of ARC MXD allows you to integrate further on web solutions.

The objective of project being mapping, there was not a specific defined conclusion but for generation of various maps

References

- www.geosoft.com
- Integrated presentation and Interpretation of Geochemical data and Multi Disciplinary Information: Regional and Local Scale Approaches- an Anglo American Case study by Geosoft team, Greg M Hollyer, Tracey Minton, Andrews Daniels.