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**APPLICATION OF MULTIVARIATE STATISTICS TO STUDY STREAM SEDIMENT DATA FROM THE VICINITY OF LEAD-ZINC OCCURRENCES AT GABAL-RUSAS AREA, EASTERN DESERT, EGYPT**

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**ABSTRACT**

Sixty-seven stream sediment samples were collected in the vicinity of the Miocene Lead-Zinc occurrences near Gabal El-Rusas Area, and analyzed for their Pb, Zn, Cu, Ni, Co, Mn and Fe contents. In the present study, statistical cluster and factor analyses revealed useful simplification of the given data. Cluster analysis classifies samples into two main groups: the first contains the background samples, while the second shows probably mineralized sample group. R-mode factor analysis revealed three dominant factors (R1: Pb-Zn; R2: Co-Mn-Ni-Fe; R3: Co-Mn-Ni) which explained 86% of the total information contained in the original geochemical data. Factor R1 is closely related to the lead-zinc occurrences in the area and can be termed the mineralized factor. Factor R2 and R3 are probably the result of adsorption and coprecipitation of cobalt and nickel in manganese iron hydroxides (in the second and third factors). These two factors may account for the main background population, which is affected by secondary adsorption effects.

**1 INTRODUCTION**

Geochemical surveys using multielement regional stream sediments are important in mineral exploration. Such surveys have not only yielded data economic significance but have also provided much information of more fundamental interest. So, the sampling of stream sediments is preferred to rock or soil sampling as the latter is representative only a relatively small area close to the sample site. The stream sediments are generally composed of weathering products introduced into the stream. The interpretation of the minor element content within these stream sediments must take into account the fact that the data are frequently related to a number of geochemical populations, each of which represents geological or geochemical features in the environment.

As the minor element contents of the stream sediment samples are attributable to the features of bedrock, mineralization or secondary environment, it is frequently apparent that many stream sediment samples are displaying similar patterns, which indicates considerable repetition of information or data, Garrett and Nichol (1969). Cluster and factor analyses are powerful techniques, which overcome the above difficulties and are useful in evaluating multivariate geochemical data of various types.

This paper illustrates the application of cluster and factor analyses as methods of classifying and expressing the relationships of the minor element distributions in terms of dominant geochemical controls operating in the environment with reference to a multielement drainage survey in Gabal El-Rusas area, Eastern Desert, Egypt.

**2 GEOLOGICAL SETTING OF THE AREA**

Numerous geological and geochemical investigations were carried out in the area including Sabet et al. (1976), Sabet and Hassan (1978), Morsy (1981 a, b) and Morsy and Hassan (1982). The geological section of the Red Sea coastal plain to the south of El Quseir to Mersa Alam is made up of sedimentary rocks of Upper Cretaceous, Middle Miocene, Plio-Pleistocene and Quaternary ages lying unconformably over late Proterozoic basement rocks. The middle Miocene is well represented in the Gabal El-Rusas area. This sequence overlies unconformably the basement complex; the latter is composed mainly of igneous and metamorphic rocks in the western part of the area.

### 3 SAMPLING AND ANALYTICAL PROCEDURES

In the investigated area, 67 stream sediment samples were taken during a geochemical survey study. Sample spacing was 100 m to 200 m. Each sample consisted of some 100 g of stream sediment. Orientation tests revealed that the -1 mm sample fraction and hot extraction with dilute (1:1) hydrochloric acid yielded the best analytical results, Morsy (1981a). Analyses of Pb, Zn, Ni, Cu, Co, Mn and Fe were carried out by means of Atomic Absorption Spectrometry (Perkin Elmer model 300). Analytical precision for all the studied elements is between 14 and 17%.

### 4 STATISTICAL TREATMENT OF DATA

The data obtained were statistically treated, where the calculations of the cluster and factor analyses were carried out by using of the SPSS 1986 (Statistical Package for Social Science). The cluster analysis was represented by a dendrogram, in which the endpoints of the branches represent the samples, and the height at which the branches join corresponds to the sample similarity level for admission to pre-existing group. The higher the branches, the more similar are the samples. The constructed dendrogram for all the studied samples at Gabal El Rusas area was based on inverse distance (d) between these samples. It is evident from this dendrogram that partitioning has separated eight samples with anomalously high values for Zn, Pb, Fe, Mn and Ni from the rest samples, which themselves form a relatively homogenous group, having essentially background values. From the study of the scatter diagrams between zinc versus manganese and iron, it is shown that samples (Nos. 31,32,33) form a mutual group, which is unlike that of the other samples in composition, since it lies a long distance away from them. The second group includes samples (Nos. 29,30,58), which are more similar in terms of their zinc and manganese, while the third group includes samples (Nos. 51,52), which are close in terms of their high manganese and iron contents.

### 5 FACTOR ANALYSIS AND DISCUSSION OF RESULTS

In recent years many geochemical studies have used factor analysis for reconnaissance and exploration work in Egypt, Morsy (1993 & 1997). In the present study, R-mode factor analysis has shown the existence of three important factors that can broadly explain the observed variations and distribution of elements in the stream sediments of Gabal El Rusas area. Table 1 shows the results of this factor, which is concerned with interrelations of among variables, each variable attributes a certain loading to each of the extracted factors, which is expressed in the matrix of factor loading. The variance indicates the amount of total information contained in each factor. The cumulative variance or total explained variance of the three-factors in the area is 86%.

Table 1. R-mode variomax rotated factor matrix

Communality	Factor 3	Factor 2	Factor 1	Variable
0.9771	0.1181	0.0966	0.9624	Zn
0.9792	0.1472	0.1259	0.9803	Pb
0.7940	0.5587	0.6801	0.1388	Ni
0.8448	0.0391	0.0086	0.0064	Cu
0.8130	0.7431	0.8504	0.0642	Co
0.8127	0.7042	0.8124	0.3139	Mn
0.8001	0.4509	0.5894	0.1213	Fe
	14.77	25.86	45.27	Variance

The communality for each element expresses the proportion of the total variability of that element that is contained in the factors. The first factor is dominated by zinc and lead, which accounts for 45.4% of total variance, while the second is Co, Mn, Ni, Fe factor, which explained 25.8%, and the third is Co, Mn, Ni factor, which explained 14.8% of the total information. The remaining 14% of the variance are explained by factors, which make small contribution. The importance of factor scores, which contain informations about more than one element with respect to the extracted factors, should be taken in consideration within multi-element geochemical exploration. The following observations can be made about the factor scores for Gabal El Rusas area. Regarding factor 1, which is a zinc and lead factor, thirty six samples have scores below or equal to the mean value, while five samples have scores above 1.0 and less than 2.0. Moreover only three samples exceed 2.0. Factor 2 which is a Co-Mn-Ni-Fe, where fifty and nine samples have scored below or equal to the mean value, while two samples are above 1.0 and less than 2.0 and three samples exceed 2.0. Factor 3 is a Co-Mn-Ni factor, in which the distribution of factor scores is nearly centered at zero and is almost bell-shaped with two extreme values, which represent two samples, one having the highest and the other the lowest iron contents. Thirty-seven samples have scores below or equal to the mean value, while seven samples have scores above 1.0 and less than 2.0, and only three samples exceed 2.0. Both factors 2 and 3 are probably a result of adsorption and co-precipitation of Co and Ni in manganese iron hydroxides. The areal distribution of the three factor score values indicates that the samples with high factor 1 scores correlate with the known Pb-Zn occurrence in the area. Actually, all anomalous samples on the two Pb and Zn maps of single variables are shown in a single map. The samples with higher absolute scores on factor 2 and 3 may represent false anomalies and the higher values appear in their lead and zinc contents probably result from co-precipitation and scavenging of these elements within the iron and manganese hydroxides, which characterize these two factors.

## 5 CONCLUSIONS

The applicability of both cluster and factor analyses as an aid in the interpretation of reconnaissance stream sediment data from Gabal El Rusas area has shown. Clustering of data and its representation by a dendrogram provides relatively a simple and direct way to classify the samples into anomalous and background groups. The use of R-mode factor analysis made it possible to reduce the seven initial variables (Pb, Zn, Cu, Ni, Co, Mn and Fe) into three: Factor 1, a Pb-Zn factor; Factor 2, a Co-Mn-Ni-Fe factor; and Factor 3, a Co-Mn-Ni factor. Factor 1 is largely explained by the ore-related elements and reflects readily all the anomalies in the stream sediments related to lead-zinc occurrences. Factors 2 and 3 probably explained in terms of geological and surface processes caused by the effects of co-precipitation of trace elements in manganese and iron hydroxides. Also, factor analysis helps in compressing of the anomalous samples indicated by two single variable maps into a single map.

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