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Application of factor analysis to determine factors affecting the iron grade in Precambrian BIF deposits

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SUMMARY

Factor analysis can be viewed as a complex statistical method for solving geological problems. This is the reason for its wide application in geological sciences. The method of factor analysis was used in the work to determine the reasons that are initial for the ore grade and it helps to plan and optimize mining operations on a long-term basis.

The studies were carried out at the example of Ukrainian BIF deposits that form the basis of the iron ore mineral resource base of Ukraine – deposits of Inguletsky, Pivnychny, Novokryvorizhsky, Central, Pivdenny, Poltava mining and processing plants. The iron grade of the deposits exploited by these enterprises was analyzed. Deciphering the factorial structure of deposits made it possible to identify factors that determine about 65% of the variability of the iron grade. These are primarily the conditions of sedimentation of ferruginous-siliceous formations containing deposits. The highest iron concentrations were formed in the central parts of synclinal deposits. Then wider and deeper the sedimentation basin was developed than richer ferruginous quartzites were created. Therefore, the Skelevatske and Ternivske deposits are characterized by the highest iron grade. They are located in the frame of the largest granite-gneiss domes on the Ukrainian shield (Saksaganskiy and Demurinskiy), and their general structure is inherited from the most influential greenstone belts of the Central Dnieper region (Shirokovsky and Verkhovtsevsky).

Introduction

The idea of factor analysis lies in the assumption that the presence of groups of correlated quantities is determined by the fact that the variability of these quantities is influenced by some common cause-factors. It is natural to consider the number of factors less than the number of output quantities since each individual factor and all of them together affect not one, but several measured quantities. The peculiarity of the problem is that in the process of experiment or observation, the values of the factors cannot be measured, and the factors themselves are unknown to us in advance: they turn out to be by analyzing the correlation matrix. Therefore, the method itself is called the method of factor analysis. Factor analysis solves the following tasks:

- Identification of generalized variables (factors) that determine the variability of the output variables. By analyzing the influence of factors on certain initial values, the geological content is provided to the factors.
- Replacing m output variables with new "p" variables ($p \langle\langle m$) decreases the dimension of the feature space, simplifies the analysis of multidimensional input data.
- Assessment of the values of factors in individual objects or observations. According to the value of the factors, it is possible to classify objects (observations).
- Highlighting on geological plans, sections of areas with different values of factors: the transition to the task of mapping factors is carried out.

Thus, factor analysis can be viewed as a complex statistical method for solving geological problems. This is the reason for its wide application in geological sciences.

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Results and discussion

The studies were carried out at the example of Ukrainian BIF deposits that form the basis of the iron ore mineral resource base of Ukraine – deposits of Inguletsky, Pivnychny, Novokryvorizhsky, Central, Pivdenny, Poltava mining and processing plants. The iron grade of the deposits exploited by these enterprises was analyzed (Plotnikov, 1994; Rudko et al., 2010). Deciphering the factorial structure of deposits made it possible to identify factors that determine about 65% of the variability of the iron grade (Figure 1).

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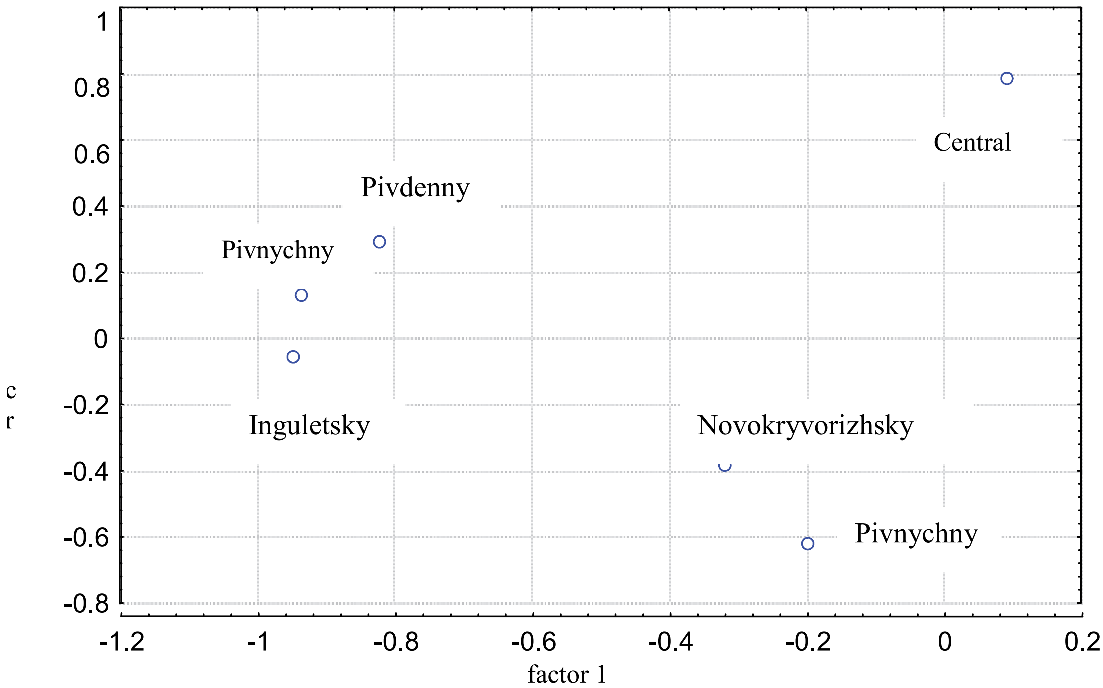

Figure 1 *Diagram of factor loads on the axis of the first two factors of the iron grade of BIF deposits of mining and processing plants in Ukraine*

Synclinal troughs are passive structural-tectonic elements (Plotnikov, 1994; Rudko et al., 2010), their shape and size are determined by the shape, relative position, and development of granite-gneiss domes. The rocks that compose the interdome of the troughs border the dome structures in an arc-like manner. Precambrian ferruginous-siliceous formations are confined to interdome structures and overlap greenstone formations, inheriting both the general structure of greenstone belts and their individual features.

The structure inheritance of greenstone belts in the Krivyi Rih ore region is manifested primarily in the nonlinearity of the eastern region border (Figure 2). It has the form of a series of arcs convex to the west, located en-echelon conformable with the general strike of the region. The southern arc with a length of more than 20 km is a framing of the Miloradovsky dome rise. The rocks of the Kryvyi Rih group form here the so-called Likhmanyvske synclines. The strike azimuth of the rocks of this syncline, almost throughout its entire length it is represented only by the eastern wing, varies from 320° in the south to 10° in the central and 30° in the northern parts.

The second arc of the eastern border of the Krivyi Rih ore region is due to the framing of the Saksagansky dome. The rocks of the Krivyi Rih group here form the Saksaganskiy monocline, the strike azimuth of which varies from 10° in the south to 55° in the north. The arc is over 32 km long. In the frame of the Demurinsky dome, the rocks of the Krivyi Rih group make up the East Hannivska structure more than 25 km long, the strike of which varies from 315° in the southern part to 10° in the northern part.

Folded nodes develop on the continuation of greenstone zones within the Krivyi Rih ore region.

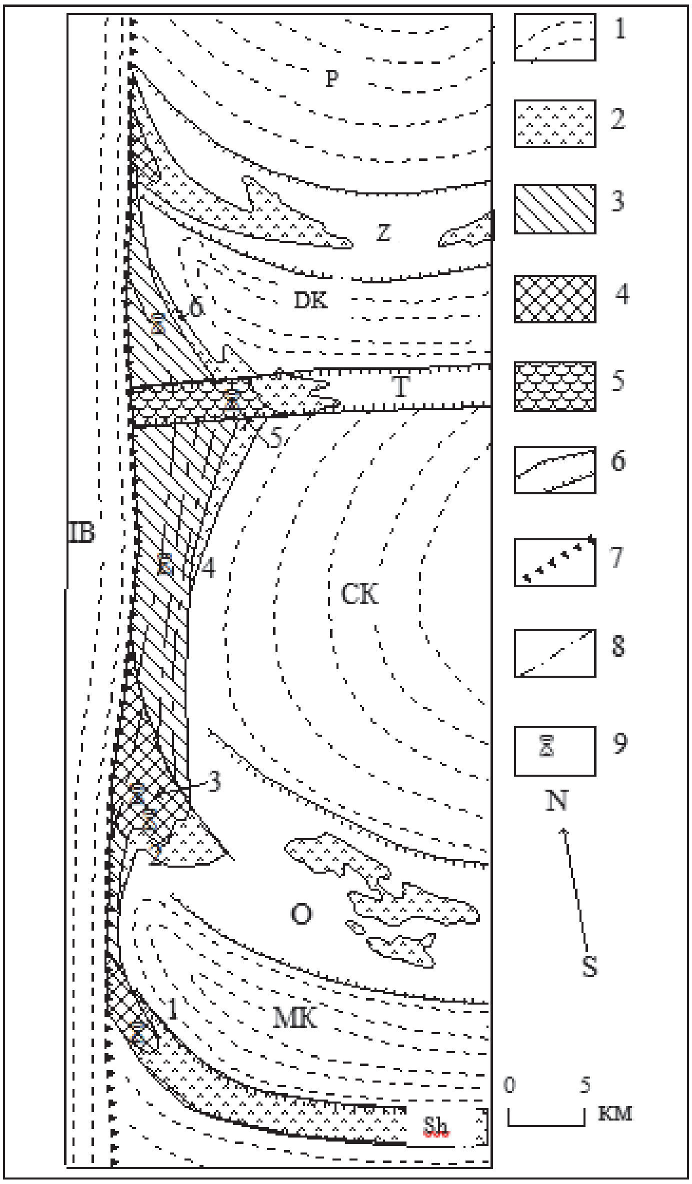

Figure 2 *Scheme of the location of BIF deposits in the structure of the Krivyi Rih ore region and the western part of the Dnieper granite-greenstone region.*
1 - granite-gneisses domes: MK - Miloradovsky, CK - Saksagansky, DK-Demurinsky, P - Pyatikhatsky swell, IB - Inguletsky swell; 2 - amphibolites of the Konksky-Verkhovtsevsky series; 3-5 - rocks of the Krivyi Rih series, 3 - areas of monoclinal occurrence, 4 - folded areas, 5 - areas with a block structure; 6 - greenstone structures: Sh - Shirokovska, O - Oleksandrivska, T - Ternivska, Z - Zheltorechensky; 7 - Western fault; 8 - faults in the Krivyi Rih ore region; 9 – BIF deposits: 1 - Inguletske, 2 - Skelevatske, 3 - Valyavkinske, 4 - Gleevatske, 5 - Ternivske, 6 - Hannivske

Thus, a complex zone of rocks crumple of the Krivyi Rih group is formed in the core of the Likhmanovsky syncline (Inguletskoe deposit), located on the continuation of the Shirokovsky greenstone zone. On the continuation of the Oleksandrovska greenstone zone, a complex folded knot of the closure of the Main syncline appears (Skelevatske deposit). On the continuation of the greenstone zone within the Kryvyi Rih ore region, there is also a complex Zheltorechensky structure. Somewhat different from other Ternovska synclines (Ternivske deposit), within which the folding of higher orders is poorly developed. This is due to the influence of the sublatitudinal Devladovsky fault, due to which the discharge of tectonic stresses manifested itself in the formation of ruptured structures.

The peculiarity of the inherited structures of ferruginous formations is also that their orientation corresponds to the axes of greenstone troughs and is not parallel to the general strike of the Krivyi Rih -Kremenchuk ore belt. This leads to an arcuate plan of the axes of the main folds. Thus, the axis of the Likhmanovskaya syncline in its southern closure arches towards the Western fault. At the closure of the Main Syncline, the angles between the main strike of the Krivyi Rih -Kremenchuk ore belt and the fold axes decrease from 45° in the south to 30° in the north, where the fold axes are adjacent to the Tarapakiv fault. The Ternovsky greenstone trough runs almost at right angles to the zone of the Krivyi Rih-Kremenchuk ore belt, and accordingly, the rocks of the Krivyi Rih series create a transverse open fold here - the Ternovsky synclines.

These features determine the iron content in the original ore of ferruginous quartzite deposits. For example, the southern parts of the Inguletsky and Poltava mining and processing plants, which are characterized by common synclinal structures, have high levels of iron grade. When they were worked out (1977) and these mining and processing plants began to develop monoclinal northern parts, the iron grade began to drop sharply. At the time when the Central mining and processing plant was developing monoclinal deposits of the Saksagansk region of Krivyi Rih (Gleyevatsky), the iron grade did not exceed 33%, and when the development of the Petrovsky deposit with a general synclinal structure began in 1981-1988 the average iron content in the ore increased to 34%.

In general, all deposits tend to decrease the iron content in the ore and if the mining enterprises do not commission new deposits, this trend will continue.

Conclusion

The method of factor analysis makes it possible to determine geological factors affecting the iron grade in Precambrian BIF deposits. The processing of significant factual material on iron ore deposits that form the basis of the mineral resource base of Ukraine Inguletsky, Pivnychny, Novokryvorizhsky, Central, Pivdenny, Poltava mining, and processing plants made it possible to identify factors that determine about 65% of the variability of the iron content in iron ore deposits. These are primarily the conditions of sedimentation of ferruginous-siliceous formations containing BIF deposits. The highest iron concentrations were formed in the central parts of synclinal deposits.

References

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