DETERMINATION OF BASIC HYDROGEOLOGICAL WATER TYPES AND THEIR FRACTIONS IN MIXED SAMPLES OF MINE WATERS IN THE CZECHOSLOVAK PART OF THE UPPER SILESIAN BASIN

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ABSTRACT

The present paper deals with selecting of representative samples to be used for mathematical-statistical evaluation of mine waters in the Ostrava-Karviná Coal District. Further, conditions and possibilities for applying methods of the hierarchical cluster factor analysis are given. Seven variables (concentration of basic ions and salinity of samples) are enough to settle the proper distribution of the hydrogeochemical data file of mine water samples. According to the basic hydrogeochemical characteristics, which in analytical tests are usually available, the cluster analyses enable us to define basic waters types. The types mentioned above together with process waters at the same time represent the basic scale of waters influent in the mine workings. Applying computing program KYBL the percentage of individual etalons in mixed samples of mine waters is determined. The present subjective mine waters evaluation can be complemented by this mathematical-statistical method.

To the targets of the hydrogeological service belongs - among others - also the quantification of the evoked rock massif. These data are necessary for both judging the dewatering efficiency and solving hydrogeological problems by the hepl of modelling.

In conditions of the Czechoslovak part of the Upper Silesian Basin the overall mine influents consist of the following five types of basic water types :

1. Quaternary water-bearing systems, from which waters percolate through fissures into mining space,
2. Basal clasts of the Miocene spread out in depressions on the Carboniferous relief (detritus),
3. Sandy layer in Upper-Carboniferous calcerous clays (especially the so called upper and lower sandy horizons),
4. Waters from the Carboniferous and deeper Carboniferous underlyings,
5. Operating waters taken into the mine through piping.

Geological and especially hydrogeological prospectings of the water-bearing basal clasts of the Miocene is in the Czechoslovak part of the Upper-Silesian Basin rather poor and uneven in spite of the fact that in the near future it will represent the main problem for an effective exploitation of coal supplies in the Ostrava-Karviná Coal District. The water-bearing system of the detritus and sandy layers in calcerous clays represent an elastopressure drive in which also the dissolved-gas component plays an important role. The water-bearing system of the Carboniferous as well as the systems from the deeper Carboniferous underlying are subsidiary if seen from the viewpoint of the underground geology.

The problems of utilizing the hydrogeochemical analyses to classify mine waters in the Ostrava-Karviná Coal District and to answer the question of their origin have been solved at the University of Mining and Metallurgy of Ostrava since the year 1980. These problems are solved now at four fundamental levels :

1. Building up a data bank containing hydrogeochemical data of mine waters in the Ostrava-Karviná Coal District,
2. Assembling fundamental evaluating programs for computers,
3. Building up fundamental etalons of the mine water sources for individual parts of mines,
4. Dividing the mixed samples into individual sources.

The aim of this is partly to objectify the hydrogeochemical data of mine waters applying methods of mathematical-statistics and partly to zone the fundamental sources of mine waters, to find the mine source of an indefinite mine waters sample and the composition of the mine waters.

Most of the hydrogeochemical analyses of mine water occuring in the Ostrava-Karviná Coal District is processed in such a way that the resulting classification of samples and data concerning the ground-water body position are of a descriptive character only. Based on these - to a great extent subjective and routine-conclusions, important resolutions securing people´s health and protection are adopted. The evaluation of the results was - only sporadically - carried out by the help of special hydrogeochemical graphs and prophiles which gave us information on distribution, or zonality of various types of mine waters, respectively. Hundreds of hydrogeochemical analyses collected at geological departments of mining plants of the Ostrava-Karviná Coal district and at organizations carrying out investigations of this kind represent a data collection to which the methods of mathematical-statistical analysis may be suitably applied.

Chemism of mine waters is strongly effected both by miking of individual types of waters and by rock environment (lithology of layers), the very underground environment (oxidation of minerals, artificial powdering of openings, use of various substances in mine spaces, etc.). Sometimes sampling is carried out far from the own ground-water body and after passing through examinable routes so that the natural vertical and horizontal zonality is often disturbed. Also analyses carried out formerly do not quite correspond - because of the dynamics of the environment - to the present state of hydrogeological conditions in a ground-water body. All the

effects on forming the hydrochemistry of a mine sample mentioned here had to be taken into account when the fundamental etalons were formed. Some parameters found out proved to be quite unsuitable, some show this effect only in certain depression variances of values being attained, which - in fact - is accepted as the measure of accuracy.

One of the methods evaluating the files of hydrogeochemical data of mine waters are various procedures of mathematical-statistics enabling to work out data in such a way that their results are then comparable with traditional - especially graphical outputs. However, if traditional methods are used, a certain degradation of the information content resulting from the limited number of the characters in a multi-parametric file was observed.

The methods of multiparametric data processing belonging to the hierarchical cluster analysis eliminate the above mentionad degradation of the information content, as they compare the whole gamut of ascertainable characteristics of samples to be processed, and consider their mutual relations, relations and linkage between the particular sample and group of samples, etc. Classification procedures, on the other hand, go off exactly according to strictly given objective algorithms without being effected subjectively. By application of hierarchical clustering analyses we prowed the possibility and suitability of the process of numerical classification for fundamental etalons of mine-water sources and in cooperation with hydrogeologists at mining plants their evaluation was carried out. The most suitable for this numerical classification proved to be the basic analysed ions (Ca^{2+}, Mg^{2+}, $Na^{+}+K^{+}$, Cl^{-}, SO_4^{2-}, HCO_3^{-}) and the salinity of a sample.

Except for these basic analysed ions and the salinity of a sample also other variables may be used (e.g. I^{-}, Br^{-} and others), however, the condition must be kept that they will be determined analytically in all samples of the file and that their contents will be sufficiently higher then the sensitivity limit for their determination is. Recent analyses were carried out as enlarged (applying the analysis AAS the followihg ions were determined : K^{+}, Ni^{2+}, Cr^{3+}, Fe^{2+}, Zn^{2+},

Cu^{2+}, Sb^{3+}, Sr^{2+}, Ba^{2+}, Pb^{2+}, Al^{3+}, W^{2+} and others). However, these analyses are relatively rare in the given area and therefore they do not represent a statistically suitable file so that for the time being their results cannot be applied for drawing any results.

In fact, dissolved gases are not analysed at all. Only in extreme cases this analysis is carried out for samplings taken from the well from surface in investigation fields. Otherwise, the only component sometimes determined is carbon dioxide, however, it has to be pointed out that also these values are not in corespondence with the original contents, because CO_2 is determined a long time after sampling. Also the pH- and Fe^{2+} values must be considered prudently, because they are not determined in situs (neither the approximate values).

In this phase of processing the hydrogeochemical data of mine waters it is most important to appreciate the representability of individual inputs. The cores of etalons contain samples coming directly from the groundwater bodies being watched as well as samples retaining in the formed clusters even if the conditions were changed (e.g. if the standardization of variables has been changed).

Etalons of fundamental sources of mine waters for individual mining spaces or for winning blocks must be determined also according to the standpoint off a special appreciation of an hydrogeologist. The above given analyses of mathematical statistics of multiparametrical hydrogeochemical data only demonstrate the existing relations between parameters, however, the correct explanation is still missing. This is given in the known information on variables and it must be the specialist--hydrogeologist who will analyse and decipher them. Mathematical apparatus is here just for a correct understanding and objective transformation of existing relations, however, it must be proved to what extent it reflects the reality, to what extent it is utilizable for a predicting analysis, for genetic considerations, etc. From the mathematical methods classifying multiparametrical file there are programs CLUSTER and SHLU which are commonly used for hydrogeochemical data. Program CLUSTER (hierarchical factor analysis, according to J.M.Parks,

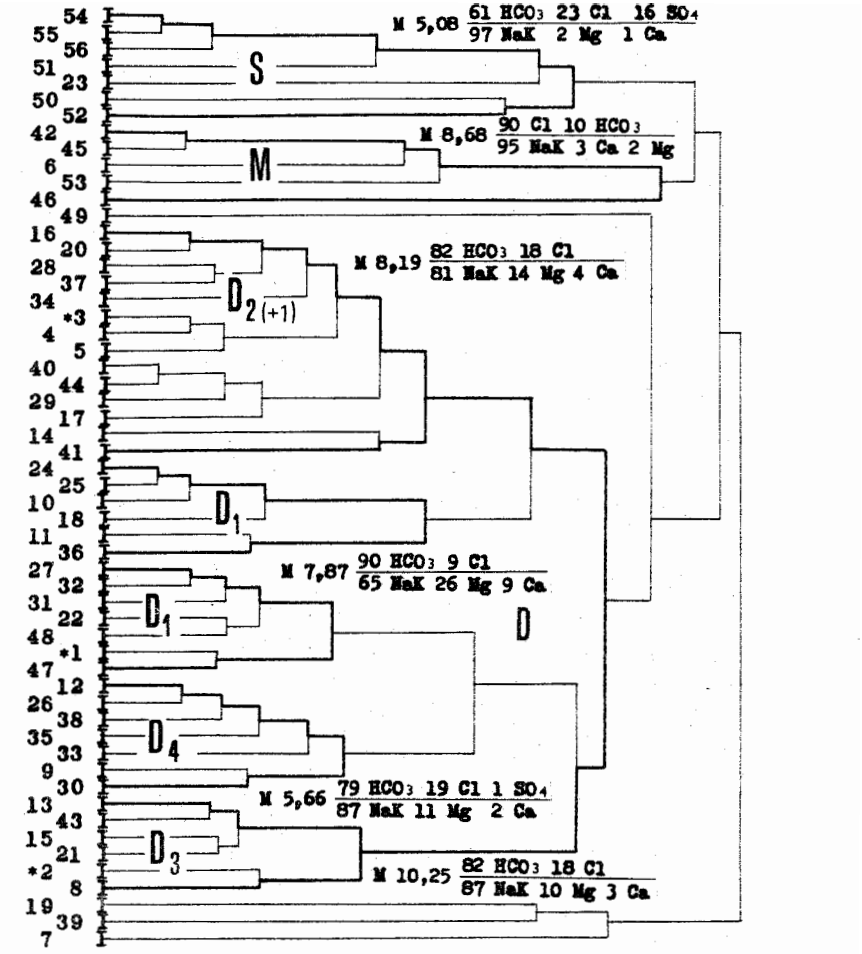

Fig. 1 Dendrogram for the hierarchical cluster analysis of the hydrogeological data file obtained from the mining space Odersky, "Jan Šverma"-Mine in Ostrava-Karviná Coal District. D-waters of detrital groundwater body (D_1-D_4 are types of detrital waters taken up), M-waters from sandy layers of the Miocene (cover beds), S-gob waters (mixture of processing, detrital, Miocene and Carboniferous waters), samples with asterisks denote waters originally taken for Carboniferous beds.

1970) elaborates the maximum file of 250 objects by the help of 25 variables. Program SHLU (the program system of the hierarchical cluster analyses - O.Hajkr et al.,1985 - elaborates the maximum file of 100 objects and 12 variables). Both programs have an orientation graphical output in the form of a dendrogram and a choosable standardization of variables. From the application of the programs given above to the conditions in the Ostrava-Karviná Coal District and from the evaluation of the time consumption of the calculation has followed that to evaluate the mine waters 4 factors (in case of the program CLUSTER the content of the information processed exceed 88 per cent) and 7 variables (basic ions concentration and salinity of a sample) are suffucient. It has been proved that using this method the following waters could be distinguished in the area under investigation :

- waters having their origin in detrital ground-water body,
- waters from sand layers of Miocene surficial deposits,
- waste waters and others

(see Fig. 1 - example from the Odersky-Mine - dendrogram). It was possible to eliminate objectively individual types of waters and to determine the dispersion variance of the individual characterizing parametrs.

Most of the samples, the origin of which was not given in the records were - using the cluster analysis - ordered to the formed clusters representing the main types of mine waters. For example, it was proved that most samples in the records identified as Carboniferous waters are, in fact, waters belonging to the detrital ground-water body which infiltrate through the joint system in Carboniferous rocks.

To solve the problems of the composition of mixed samples of mine waters occuring in the Ostrava-Karviná Coal District the program KYBL was laid out at the University of Mining and Metallurgy of Ostrava, which - on the basic of the known fundamental hydrogeochemical data of sources - enables to determine their percentage in mixtures. Mathematical solution of an overdetermined system of 7 equations with 5 unknowns - various dispersion of the input values being respected - was tested on some konwn laboratory mixtures. The results of a percentual

division had a deviation on average not greater than ± 7 per cent.

Even if at present the program is only on the stage when dispersion variables are tested, some results are surveyed here proving its applicability.

For the Rudý říjen-Mine the etalons of detrital waters (D), the etalon of Carboniferous water (K) and operating waters (P) were determined. By means of these etalons the mixed samples of collecting coffordams on the third, fourth and fifth levels in the Rudý říjen-Mine were determined. The results are as follows :

sample being tested	etalon D	etalon P	etalon K
3rd level-average	34.9 %	67.7 %	1.6 %
4th level-average	36.9 %	57.5 %	4.9 %
5th level-average	39.2 %	57.5 %	3.1 %

The determination of fundamental hydrogeochemical waters and their portion in mixed samples of mine waters was already carried out in practice in six mining plants. The results are in good correspondence with the assumptions and so the applicability of this method for an objective tracing of values of uncontrolled affluents into mines is supported.

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