Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 102 (2016) 159 – 162

Procedia Computer Science

12th International Conference on Application of Fuzzy Systems and Soft Computing, ICAFS 2016, 29-30 August 2016, Vienna, Austria

Clustering of geological objects using FCM-algorithm and evaluation of the rate of lost circulation

G. M. Efendiyev[a], P. Z. Mammadov[b], I. A. Piriverdiyev[a], V. N. Mammadov[a]*

[a] *Institute of Geology and Geophysics of Azerbaijan National Academy of Sciences, H.Javid Av., 119, Baku AZ1143, Azerbaijan*
[b] *Azerbaijan State Oil and Industry University, Azadlig av., 34, Baku AZ1010, Azerbaijan*

Abstract

The report is devoted to assessing the impact of petrophysical properties of rocks on the rate of drilling mud lost circulation. The cluster analysis by FCM-method has been performed, 5 clusters have been established, and appropriate fuzzy rules have been formulated. To evaluate the effect of geological conditions on the nature of lost circulation in terms of lack of information, mutual correspondence between indicators of petrophysical properties of rocks and rate of lost circulation has been reached on the basis of fuzzy cluster-analysis, that is very important for the early diagnosis of lost circulation and assessment of their risk.

Peer-review under responsibility of the Organizing Committee of ICAFS 2016

Keywords: membership function; cluster-analysis; lost circulation; drilling mud; porosity; permeability

1. Introduction.

Currently, cluster-analysis or automatic classification problems are widely used in various fields, in particular economics, sociology, medicine, geology, and other sectors, where there are sets of arbitrary kind of objects to be automatically divided into groups of similar objects based on their "similarities-differences" features. In recent years, these methods have been widely used in data analysis problems. Conventional methods of cluster-analysis suggest a clear partition of the original set into subsets, in which each point is included only in one cluster after the partition. However, as it is well known, such a restriction is not always true. It is often necessary to make such kind of partition, which allows determining the degree of membership of each object for each set. In this case it is advisable to use fuzzy cluster-analysis methods. Problems in this formulation arouse interest of specialists dealing

* Corresponding author, Tel.: +994125393471
E-mail address: galib_2000@yahoo.com*, igorbaku@yandex.ru***

Peer-review under responsibility of the Organizing Committee of ICAFS 2016
doi:10.1016/j.procs.2016.09.383

with geology, geophysics, oil- and gas-well drilling and oil and gas production. One of the most important results of the study of lost circulation zones is determination of the coefficient of lost circulation intensity.

Usually work on the definition of this coefficient is performed for each well. The intensity of lost circulation is influenced by a number of factors, including litho logic and petro physical characteristics of the reservoir. The forecast of the expected lost circulation intensity values during the design of wells according to the results of studies of previously drilled wells is a reserve for further reducing of the well wiring cost in the areas, folded by layers which tend to lost circulation. Lost circulation can have varying rate, which can be estimated by using cluster-analysis. Accordingly, the purpose of the present report is the use of fuzzy cluster-analysis for the assessment of rate for this kind of complications in drilling, which include lost circulation of drilling mud. Data about drilling was collected, that also contains measurements, which allowed determining the intensity of lost circulation. Depending on the nature of the original information, two approaches were suggested: statistical and based on fuzzy-cluster analysis[1]. The data was subjected to statistical and fuzzy cluster-analysis using c-means algorithms and an appropriate program. This report presents the results of fuzzy cluster-analysis. As a result of cluster-analysis five classes were produced, and each of them is characterized by the relative rate of lost circulation, the relevant characteristics of layers and intensity of lost circulation.

2. Results of the analysis

A cluster analysis was carried out using the c-means method[2] based on two signs, influencing the intensity of lost circulation: porosity and permeability. These input signs were set in accordance with the intensity of lost circulation. Each class corresponds to certain degree of rate (catastrophic, serious, intensive, partial and minor).

However, the desired result of clustering can be also obtained by using hard c-means algorithm, if a set of objects consists of compact clusters and each cluster is noticeably separated from others. At the same time, in practical problems, particularly in geology, oil and gas business, such kind of sets of objects are rare. A set of objects often contains several un prototype objects, which can lead to poor results of clustering due to the shift of cluster centers[2].To overcome such undesirable property of clear algorithm, FCM-algorithm (fuzzy c-means algorithm) using weighting factors (membership function) to monitor the contribution of the objects into the cluster centers definition, should be applied. FCM-algorithm gives adequate results of clustering if a set of objects contains overlapping clusters[3,4]. The results of clustering are based on fuzzy membership function, using the relative distances of objects relative to the centers of clusters. For example, an object that is far away from the cluster center, makes a smaller contribution to the clusters centers search process, than objects which are close to the center of the cluster.

As a result of the applying of algorithm, as already mentioned, five clusters were obtained, and each of them is characterized by petrophysical characteristics matched rate of lost circulation of rocks as following fuzzy rules:

IF the rock is dense and impermeable, THEN lost circulation is minor.

IF the rock is low-porous and moderately permeable, THEN lost circulation is intensive.

IF the rock is moderately porous and low-permeable, THEN lost circulation is partial.

IF the rock is porous and highly-permeable, THEN lost circulation is catastrophic.

IF the rock is highly-porous and permeable, THEN lost circulation is serious.

Term-sets of input and output variables are shown in Figures 1-3.

3. Conclusion

Thus, to evaluate the effect of geological conditions on the nature of lost circulation in terms of lack of information, mutual correspondence between indicators of petrophysical properties of rocks and rate of lost circulation has been reached on the basis of fuzzy cluster-analysis, that is very important for the early diagnosis of lost circulation and assessment of their risk.

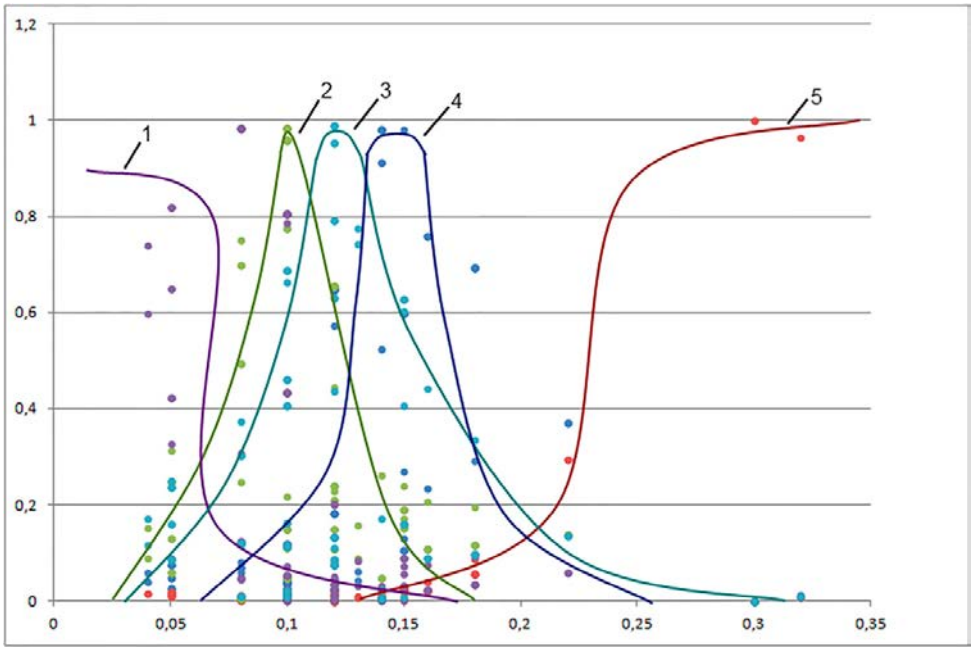

Fig.1. Term-sets of porosity:
1 – dense; 2 – low-porous; 3 – moderately porous; 4 – porous; 5 – highly-porous.

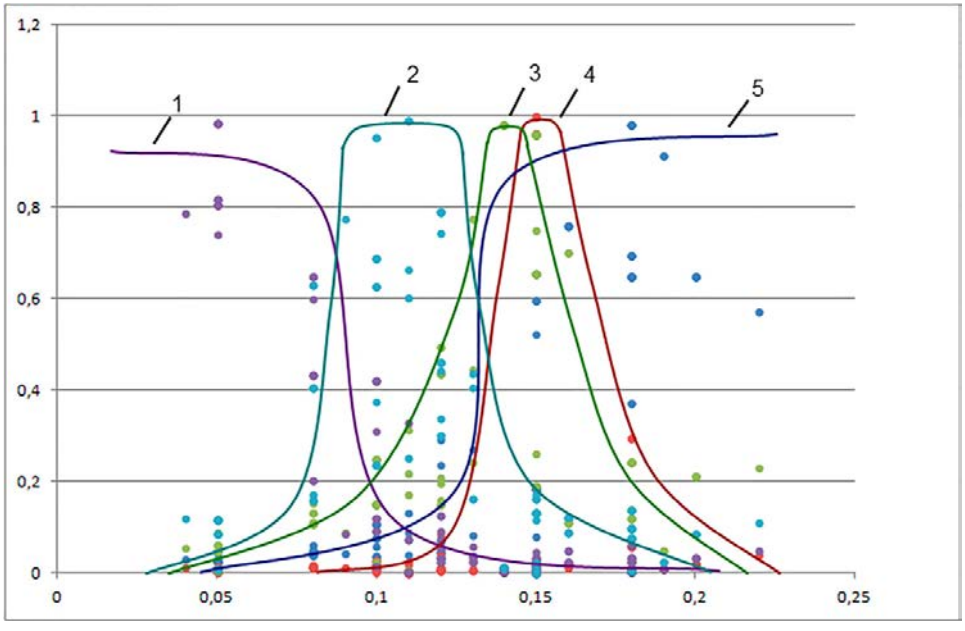

Fig.2. Term-sets of permeability:
1 – impermeable; 2 – low-permeable; 3 – moderately permeable; 4 – permeable; 5 – highly-permeable.

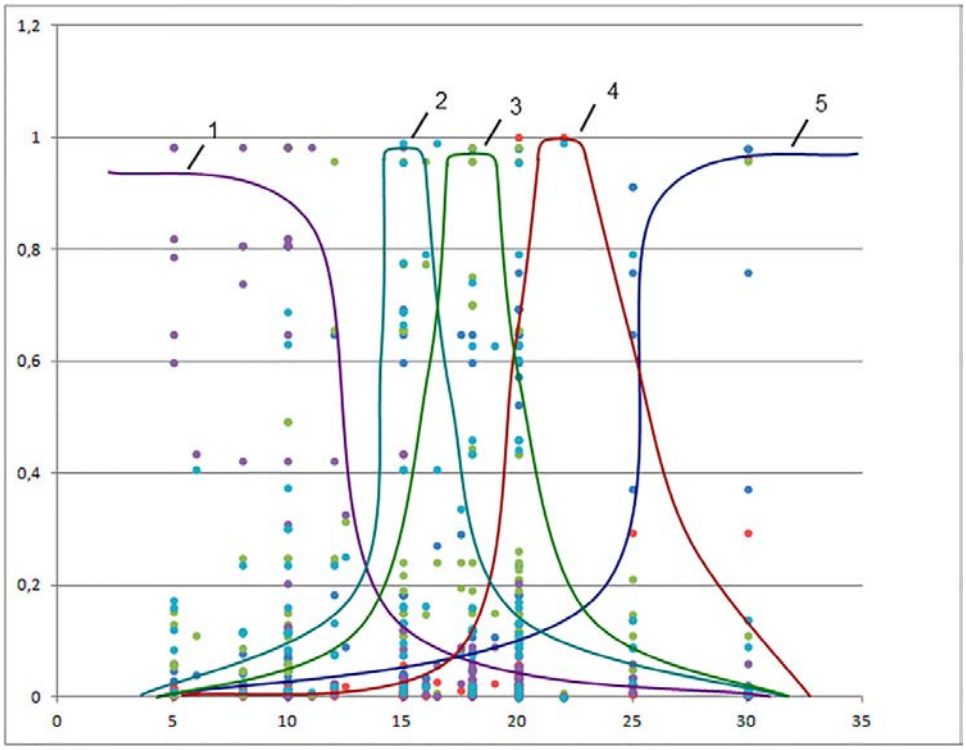

Fig.3. Term-sets of lost circulation:
1 – minor; 2 – partial; 3 – intensive; 4 – serious; 5 – catastrophic.

References

1. Efendiyev GM , Rza-zadeh SA , Kadimov AK, Kouliyev IR. Forecast of drilling mud loss by statistical technique and on the basis of a fuzzy cluster analysis. *Seventh International Conference on Soft Computing, Computing with Words and Perceptions in System Analysis, Decision and Control*. Turkey, Izmir, 2013, p. 319-322.
2. Demidova LA, Konyaeva EI. Clustering of objects using FCM-algorithm on the basis of type-2 fuzzy sets and genetic algorithm. *Vestnik of RSREU*, **№4** (Issue 26). Ryazan, 2008.
3. Aliev RA, Guirimov BG. *Type-2 Fuzzy Neural Networks and Their Applications.* http://www.springer.com/us/book/9783319090719
4. Turksen I.B. Full Type 2 to Type n Fuzzy System Models. *Seventh International Conference on Soft Computing, Computing with Words and Perceptions in System Analysis,* Decision and Control. Turkey, Izmir, 2013, p. 21.