因子图解法预测雅克拉构造含油气性及图形数据再处理[1]

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雅克拉构造位于中国新疆塔里木盆地东北部，沙雅隆起的中段，为一高断块，地处南北侧两个生油拗陷油气运移指向的聚集地带。布于构造上的沙参2井于奥陶系获高产工业油气流。在油气化探工作中，土壤气体测量法属多指标找矿法。在数学地质领域内，因子分析(R型或Q型)是一种多元统计方法，是用以进行系统分类和成因分类的重要手段。

本文通过对雅克拉工区195个土壤样品、13个气测指标(烃类气体12个，稀有气体1个)进行R型因子分析，根据因子图解特征，划分因子得分异常区带，以预测该区含油气性。随着地质资料的日益丰富，为进一步对比研究地表异常划分和异常分布特征，作者于1993年再次对图形数据进行处理，采用电子计算机成图，对工区异常区带的划分作了修改。

PREDICATIONS OF OIL AND GAS POTENTIAL BY FACTOR DIAGRAM METHOD AND REPROCESSING DIAGRAM DATA IN YAKELA STRUCTURAL AREA

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ABSTRACT

Geochemical survey was made in Yakela structure area in 1987. 195 soil samples were taken for measurement and 13 gaseous geochemical indicators were made for R-type factor analysis. According to the characteristics of factor loading, the author divided the 13 indicators into 4 types and predicated 4 oil and gas potential zones with 12 high geochemical anomalies. Three producing wells (Shacan-2, Sha-4 and Sha-7) are located within the two geochemical anomalies. 10 prospective oil land have been predicated by this method. 8 anomalous zones from these favorable areas have higher factor score than that from well Shacan-2 area. Note that there is a

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❶ 本文资料系“七五”国家重点科技攻关项目75-54-03-05-04阶段性研究成果之一。

single and circular geochemical anomaly with the coverage about 6km^2 at the well Shacan-2 area. This is not shown from other geochemical map in the same area. In order to comparing the distribution character of the surface geochemical anomalies determined, the author reprocessed the diagram data in 1993 by computer mapping procedure and solved rationally the problem of the origin for several higher factor scores resulting in the correction of originakl geochemical anomalous zones in the studied area.

INTRODUCTION

Yakala structure is situated in the north-eastern part of the Tarim Basin in Xinjiang and middle part of Shaya uplift. It belongs to a high structual block between Aman oil-bearing depression (in the south) and Kuche (in the north) oil-bearing depression. There are 5 producing wells Shacan-2, Sha-4, Sha-5, Sha-6 and Sha-7. Well Shacan-2 is a commercial oil well just to be located within the structural area. Producing formation from the Ordovician has the depth of over 5000m.

Soil gas survey method is one of the most effective survey techniques in geochemical prospecting for petroleum at home and abroad. There are three types of gases detected: (1)hydrocarbon gases, (2)nonhydrocarbon gases, and (3) rare gases. Single and combined components from the same gas type or different gas types related to the oil and gas pools are all regarded as geochemical indicator (direct or indirect) for finding petroleum. Therefore, soil gas survey method is a multi-indicator technique in hydrocarbon prospecting.

In mathematical geology, factor analysis (R-type or Q-type) is a multivariate statistics. It is an important tool for data classification of system or origin. The function of the factor analysis is based on th relationship between original data. The complex and multiple variates can be transformed into a few new independent variate-factor by mathematical method. The new variares are used to indicate the factor playing a main role in observational data and finding their inner relationship. It is useful for expressing and interpreting an essential phenomenon of geology. R-type factor analysis is to study the relationship between variates and Q-type factor analysis is to study the relationship between samples. The character of R-type factor analysis is to express the relationship between P variates by m factors. In general, the number of factor m is less than the number of variarte P. The mathematical model of factor analysis is to express the variate (or sample) as linear combination of a common factor. We finally obtain a factor loading matrix and a varimax rotation matrix. On the contrary, the common factor can be expressed a linear combination of the variate (or sample) to calculate common factor score. In fact, factor score is a comprehensive indicator. It allows the information of common factor in original data to collect. If the factor number is two and the variate of each sample is P, the factor score (F1 and F2) would be calculated by corresponding formula. A 2-dimensional map can be done by using F1 and F2 for geochemical classification and geological interpretation.

R-type factor analysis was conducted with 195 soil samples and 13 gas indicators in Yakala structure. According to the factor loading character the geochemical anomalous zones have been divided for predications of oil and gas potential in studied area. With the geochemical data increasement and in order to further research the chafacteristics and distribution of geochemical anomalies, the author reprocessed the diagram data by computer mapping procedure. It has rationally classified several anomalous sites of factor score and leaded to correct the original geochemical anomalous zones.

EVALUATION OF GEOCHEMICAL INDICATOR

Following 13 soil gas indicators were sellected for R-type factor analysis in order to forecast the oil potential of the area. They are: (1)methane (C1), (2)ethane (C2), (3) propane (C3), (4)iso-butane(iC4), (5)n-butane (nC4), (6)n-pentane (nC5), (7)iso-pentane (iC5), (8)heavy hydrocarbon (C2+), (9)total hydrocarbon (Ct), (10)C1/C2+, (11)iC4/nC4, (12)C3/nC4, (13)helium (He).

The main results of computer processing iifcludes: (1)correlation matrix, (2)factor variance, (3)principal factor loading, (4)principal factor score, (5)factor loading of varimax rotation, (6)factor score of varimax rotation, (7)factor secore of oblique rotation, (8)correlation matrix of oblique rotation factor, (9)structural matrix of oblique rotation factor.

The main characters of the part of above processing results are:

1. The character of the correlation coefficient indicates that correlation coefficient of methane (showing gas indicator) vs. heavy hydrocarbn (showing oil indicator) is 0.5196, but methane vs. total hydrocarbon is 0.9286. Large difference correlation coefficience (about 1/2) of the two indicates that methane is important in the area. The correlation coefficience of C1, vs. C2, C4, C3, C5 are respectively 0.5555, 0.4904, 0.4443 and 0.4322. It shows that with the inerease of carbon number of composition the correlation coefficience decrease. All above indicators present a positive correlation coefficience. The rare gas He might be come from deep depth. Helium vs. iC4/nC4, C3/nC4, iC4 has positive correlation coefficience, 0.0530, 0.0399, 0.0033 respectively. It suggests that He and iC4/nC4 have more closely relationship than the other two.

2. Sellection of principal component is necessary for reducing variate number. The criterion of sellection is to make the percentage of variance contribution in the former of m principal components above the reach of 80%. The characteristic value, percentage and accumulated percentage of the variance contribution from 13 geochemical indicators in Yakela structure area were calculated. The data indicate that the accumulated variance contribution in the first to third principal factors (F1—F3) is 86.84%, 75.74% in the F1 and F2, 59.84% in the F1. It represents the majority of information of gas indicators. Thus, C1, C2 and C3 are important indicators for finding petroleum in studied area.

3. The factor loading is a correlation coefficient between variate (sample) and common factor. It can be interpreted how much proportion of the principal factor occupies in variance. The character of factor loading of gas indicators in Yakela area are described. According to the factor loading character, the author divided the 13 indicators into 4 types. The first type consists of C2, C3, nC4, iC4, nC5, iC5 and C2+, the second type of C1 and Ct, the third type of iC4/nC4 and He, and the fourth type of C1/C2+, C3/nC4. In the first factor axis(F_1), it has the factor loading 0.8～1.1, 0.6～0.8, 0～0.03 and －0.4～－0.1 respectively from the first type to the fourth type. In the second factor axis (F2), it has the factor loading －0.1～0.2, 0.8～0.9, －0.2～0 and 0.2～0.9 respectively from the first type to the fourth type. Note that the second type of indicator has larger factor loading in the F1 and F2 factor axis and the first type has larger factor loading in the F1 factor axis. The first and second type are the main indicator for finding oil and gas pools in the area, then the third but the fourth type is according to their factor loading magnitude (see Fig. 1).

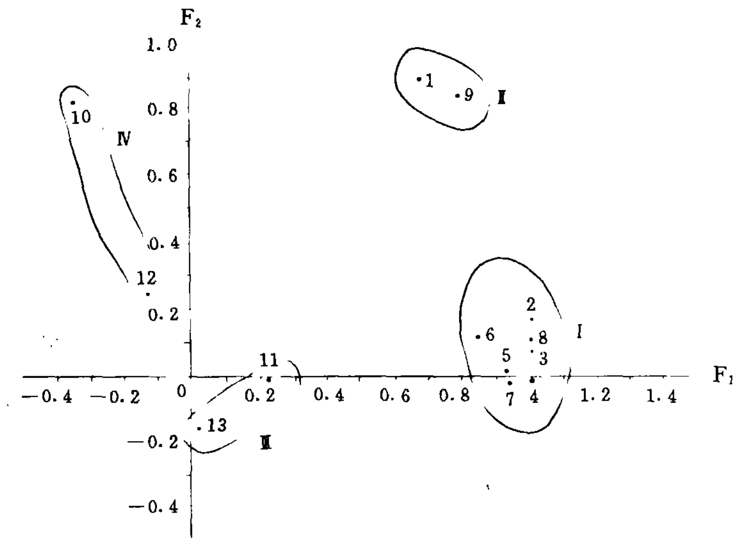

Fig. 1 The factor loading of 13 gas indicators in Yakela survey area

F1. The first factor axis; F2. The second factor axis

1＝methane; 2＝ethane; 3＝propane; 4＝i-butane; 5＝n-butane; 6＝n-pentane; 7＝i-pentane; ＝heavery hydrocarbon; 9＝total hydrocarbon; 10＝methane/heavy hydrocarbons; 11＝i-butane/n-hutane; 12＝propane/n-butane; 13＝helium

DETERMINATION AND PREDICATION OF ANOMALOUS ZONES

Four anomalous zones were determined based on the character of the factor score and the threshold 0.5. Three producing wells Shacan-2, Sha-4 and Sha-7 are located within the two geochemical anomalies. 10 prospective oil lands have been predicated by the methods. 8 anomalous zones from these favorable areas have higher factor score than that from well

Shacan-2 area. Note that there is a single and circular geochemical anomaly with a coverage of $6km^2$ at the well Shacan-2 area. This is not shown from other geochemical map in the same area.

The original 4 anomalous zones were determined by hand mapping. The first anomalous zone is situated in well Shacan-2 area. The largest factor score is 1. 17. The second anomalous zone is situated in the southeast part of the area. Sha-4 and Sha-7 are within the zone. Wells Sha-4 and Sha-7 have the factor scores 1. 17 and 1. 60 respectively. The third anomalous zone is situated in the north part of the area. It consists of two anomalies. The highest factor scores are 2. 55 (in the east) and 6. 39 (in the west). The well Sha-6 is in the middle part of the two anomalies. The fourth anomalous zone is situated in the west part of the area and consists of four anomalies. the highest factor score is 2. 61. The well Sha-5 is at the side of the north of the anomalous zone. According to the statistics, there are 12 higher geochemical anomalous zones in Yakela if the threshold of the factor score is 1. Among them one is in the first anomalous zone, two in the second zone, five in the third zone and four in the fourth zone (see Fig. 2).

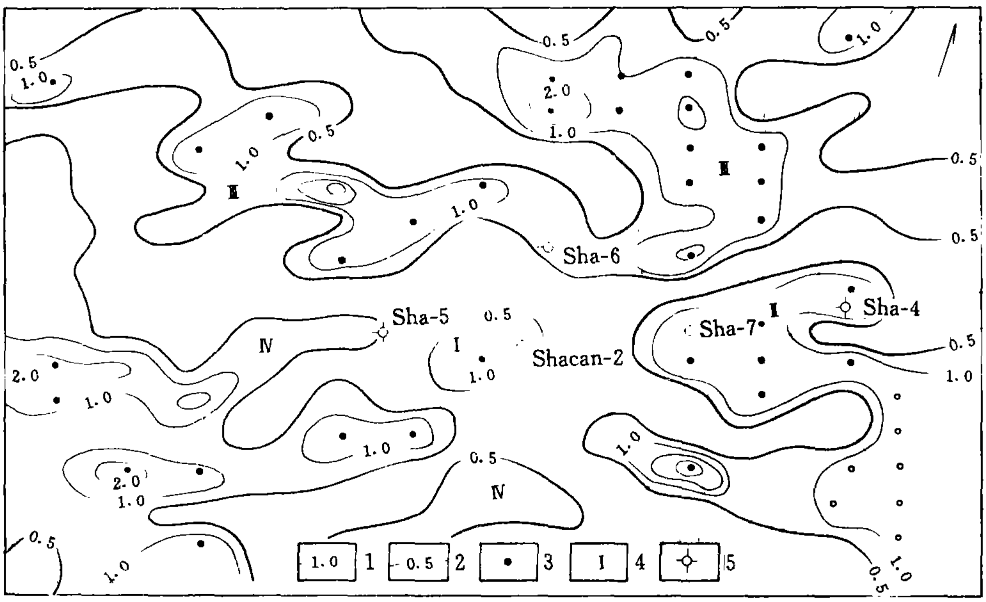

Fig. 2 Geochemical anomaly map showing the factor scores of varimax rotation in Yakela survey area (mapped by hand in 1988)

1=anomalous contour; 2=contour of the threshold; 3=anomalous site; 4=number of the anomalous zone; 5=well

The aim of this geochemical survey is to extend the area of oil-bearing structure and search for new hydrocarbon potential. Above results indicate that producing wells Shacan-2, Sha-7 and Sha-4 are within the range of two geochemical anomalies among four anomalies to be predicated and suggests that the geochemical survey data are reliable. The new predictions of petroleum potential by this method might be prospective. It is shown that the contour of the score 0.5 are widely distribution but only exists at the well Shacan-2 area in small trap. However, the contour of the score 1.0 can make more anomalous zones. It is probable caused by apical effect over oil and gas pools in Qian Shan type. One must pay attention to the anomalous zones at which the score contour are equal or more than 1.0. The author proposes that the geochemical anomalies should be proven by drilling in conjuction with research of geological and geophysical data. Geochemical results might be effective because of less pollution in the desert region of the Tarim Basin.

RESULTS OF REPROCESSING DIAGRAM DATA

With the increase of geological data, the author reprocessed the diagram data in 1993 by computer mapping procedure in order to further study and compare the relationship between the distribution characteristic of surface geochemical anomaly and subsurface geology. It has shown the following results: (1) verify well Shacan-2 area to be a separated geochemical anomaly, (2) divide reasonably some geochemical anomalies, for example, wells Sha-4 and Sha-7 areas belong to two neighbouring anomalous zones respectively, and (3) reveal the key sites to play an important role in correcting and interpreting anomaly and provide a new reliable basis for oil and gas prospecting and predicating in Yakela structure area. For example, the original anomalous zones (the second and third) are merged together to form rationally the second anomalous zone known as the northeast anomalous zone by correcting several anomalous sites in the survey lines Y-19 and Y-21. It changes the original anomlous zones from 4 to 3 (see Fig. 3).

RECOGNIZATION AND DISCUSSION

Some recongnization and discussion are made through studying the data of factor diagram analysis in Yakela structure area.

1. The geochemical data indicate that surface geochemical anomalies are related closely with deep hydrocarbon accumulations. Three anomalous zones determined by factor analysis include producing wells Shacan-2, Sha-4, Sha-5 and Sha-7. It is proven that the Yakela structure is a target for oil and gas prospecting. It is expected that more and better results could achieve at the third anomalous zone (Ⅲ) southwest of the well Sha-5 and the anomalous zone west and east of the well Sha-6 if drilling in these favorable areas. It is an important oil and gas discovery for well Shacan-2 from Paleozoic formation. In addition, the wells Sha-7, Sha-4 and Sha-5 have provided an information that a good prospect of petroleum perhaps occurs in Mesozoic time. One must therefore pay attention to searching for hydrocarbon accumulations from Mesozoic and Cenozoic time in favorable places (west and east slope) of Paleozoic in conjuction with the distribution characters of geochemical

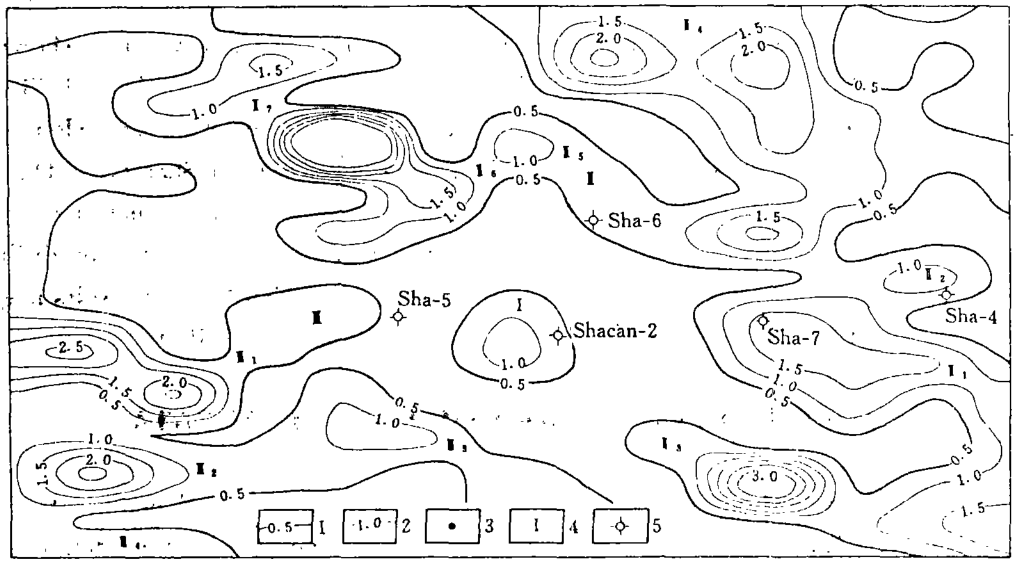

Fig. 3 Geochemical anomaly map showing the factor scores of varimax rotation in Yakela survey area (mapped by computer in 1993)

1=contour of the threshold; 2=anomalous contour; 3=anomalous site; 4=number of the anomalous zone; 5=well

anomalies.

2. The characteristics of factor loading diagram show that oil is the main production when oil and gas coexist and natural gas can exist as separated reservoir.

3. Helium is the characteristic of deep source information and related to iC4/nC4. It can become deposit alone in favorable geological conditions.

4. The geochemical anomalous zones divided by factor diagram method are more effective for evaluating prospective oil and gas potential. They also indicate that the separated geochemical anomaly is sometimes important for evaluating a favorable region. The geochemical anomaly in well Shacan-2 area is an example.

Because different geochemical time and different type of oil or gas pools repeat in the same vertical stratum column, it has probable influence on the formation and apparent character of the surface geochemical anomalies. The problem has to be solved in the further combined studies.

ACKNOWLEDGEMENTS

Many thanks to the following units for their energetic supports and fervent helps to this work. They are:

1. Computer Calculation Station, Comprehensive Geological Party, Southwest China Bureau of Petroleum Geology.

2. Computer Calculation Station, Geophysical Prospecting Party, Sichuan Bureau of

Geology and Mineral Resources.

3. Chengdu Institute of Technology.

4. Calculation Center of China University of Science and Technology.

5. Calculation Center of Anhui Bureau of Geology and Mineral Resources.

6. Computer Calculation Station, Geochemical Prospecting Party, Sichuan Bureau of Geology and Mineral Resources.

7. The Related Offices of Geochemical Prospecting Center, Bureau of Petroleum and Minal Geology, MGMR.

Thanks to Wu Xueming, Wu Chuanzi and Ge Yongyi for their help in this work, and thanks to the meeting to provide us a chance for academic exchange.

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