IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 05, Issue 04 (April. 2015), ||V2|| PP 59-64

Prediction of volcanic rock fracture in Yingcheng Formation, Songliao basin

Zhiming Zhang [1], Mingxue Zhang [1], Yushuang Hu [1], Shiqin Zhang [1], Xiaoyu Yang[1], Ziqi Zhou[2]
1. Northeast Petroleum University, Daqing, Heilongjiang, China, 163318
2. Well Testing Company, Daqing Oilfield co., LTD. Daqing, Heilongjiang, China, 163412

Abstract: With the feature of complex types, unbalanced regional distribution, lithology lateral change fast, compact physical, the exploration of volcanic rock reservoir is difficult. Affected by factors such as tectonic transformation, volcanic rock formation of epigenetic cracks can improve the permeability of volcanic rock conditions, modified volcanic rock class can become a good reservoir of oil and gas, formed fracture reservoir. This type of reservoir always reserves abundant oil and gas, has a broad prospect of exploration and development. In the study area, optimizing the properties of post-stack seismic data, coherence, ants and curvature attribute to predict fracture of yingshan area, found three groups fault zone with the trend of NNE, NE and nearly NS. Comparing the prediction results with drilling data, interpretation results, production data and FMI showed that the prediction result is good.

Keywords: *ants; curvature; fracture prediction; volcano rock; Yingshan region*

I. INTRODUCTION

With the development of oil and gas exploration, the volcanic rock reservoir has become an important part of oil and gas exploration. With the feature of complex types, unbalanced regional distribution, lithology lateral change fast, compact physical, the exploration of volcanic rock reservoir is a key problem for exploration research [1-3]. Structure and volcanic activity generated multiple effects on the original reservoir, such as damage, transformation [4].

Compact physical of volcanic rock set back the distribution regularity of reservoir prediction. However, the brittle property of volcanic led to produce large amounts of fracture during tectogenesis period, which expand the reservoir space to increase the porosity, and improve the original pore permeability. Thus, the volcanic rock reservoir exploration guided by the fissured thought [5]. Reservoir fracture show diversity, strong anisotropy and controlled by many factors. In addition, it also controls the distribution of reservoirs. Therefore, researching on fracture is vital to reservoir exploration, migration, and monitor [6].

To predict volcanic fracture, predecessor apply the finite deformation method, image logging method, the tectonic stress field numerical simulation prediction method, correlation analysis, seismic attributes, pre-stack and post-stack inversion method to volcanic fracture reservoir, etc. In this paper, post-stack seismic data of target volcanic rocks of yingshan area in the songliao basin was used to predict and analyze the distribution of fracture. This method effectively predicts the fracture belt, and has guiding significance for the further exploration.

II. GEOLOGICAL SURVEY

Yingshan fault depression is located in the southeast fault depression of the northern of songliao basin (figure 1), Yingcheng formation mainly develop volcanic rocks in the Yingshan fault depression. The formation is divided into three cycles according to the features of the volcanic eruption cycle and seismic reflection. This formation's volcanic erupt polycyclic superimposed; volcano rock basically covers the entire area, the maximum thickness up to 1250 m. The volcanic are acid rhyolite, tuff and volcanic breccias in composition and a few andesite and dacite in some areas. Drilling show that pore space are filled by Quartz, carbonate (figure 2) and so

on. The volcanic lithofacies are mainly erupting facies and flowing facies. However, diagenesis, epigenesis and reformation improve the poor connection of the fractures in part of Yingshan region.

Shahezi formation are mainly composed of mudstones intercalated with fine conglomerate, fine-grained sandstone and shale interbed, high abundance of organic matter, belong to Yingshan Area, Songliao Basin, which is a set of limnetie facies, fan-delta facies and subvolcanic rock facies. Its average thickness of source rock is about 500m, approximately 350 km^2.The volcanic rock of Yingshan formation directly covered on the source rocks of shahezi group. Moreover, a set of stable thickness, widely spread sedimentary rocks exist on both of them. This kind of structure forms the lower product and upside reservoir Accumulation models, which determines the volcanic reservoirs in the area are predominantly fracture-pore type double-medium low porosity and permeability heterogeneous reservoir.

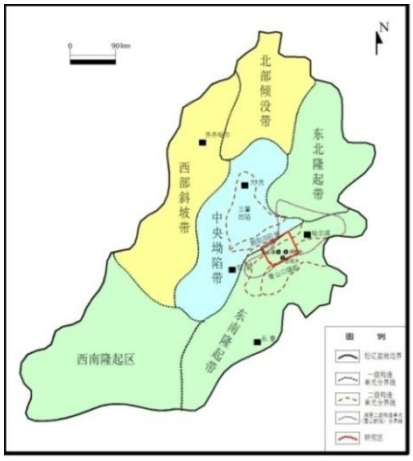

Fig 1 tectonic locations of Yingshan area

Fig 2 fracture filled by secondary quartz and carbonate

III. RESEARCH ON PREDICTION OF VOLCANIC ROCK FRACTURE

2. The post-stack seismic data for fracture prediction

Generally, as for tight volcanic reservoir, the function of multi-scale fracture network is not only supplying reservoir pore space but also supplying migration pathway for oil and gas. Fracture zone often cause seismic anomalies (such as amplitude, frequency, phase characteristics change).Seismic data with high lateral resolution, and clearly macroscopic distribution rules was used to detect the abnormal area, to select sensitive mathematical methods, to predict the fracture region. Those changes usually indicate the development of reservoirs.

2.1 Coherence technology to identify cracks

The coherence technique reflects the comparability channel to channel by calculating the similarity of waveform among. This kind of displaying and highlighting seismic data transversal changes related to geological anomalies, where the coherent value is low, usually related to the reflection wave form discontinuity. Influence factors of low correlation value are summarized, including noise of seismic data processing, stratigraphic dip, lithology changes, fracture, igneous rocks, reefs, salt dome and rock mass stab, etc. At present, many popular coherence algorithms are mostly based on energy normalization of multi-channel cross-correlation calculation. There are three kinds of method to generate seismic coherent data volume. The first generation coherence algorithm based on cross-correlation (C1), the second based on multi-channel similarity (C2), the third based on the characteristics of the structure (C3).

C1 algorithm is cross-correlation calculation after energy normalized, which is not suitable for seismic data with coherent noise but high quality seismic data; C2 has better anti noise capability, but the resolution is poor.C3 has advantages of high resolution, strong anti-noise ability, because more seismic information is

introduced in the algorithm. Coherence slices along the layer (Fig 3, cycle Ⅲ) show us that large shadow zone (poor correlation) in southern and central of the study area, which means the possible fracture development zone. White and dark bands appear on the angle detection of cycle Ⅲ(Fig 4), where occur mutation of the angle value, the crack development area. This phenomenon verifies the rationality of the prediction of fracture distribution by coherence body.

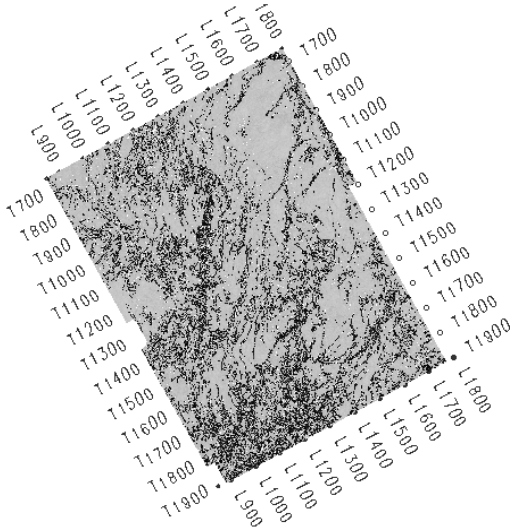

Fig 3 coherence slices of cycle Ⅲ

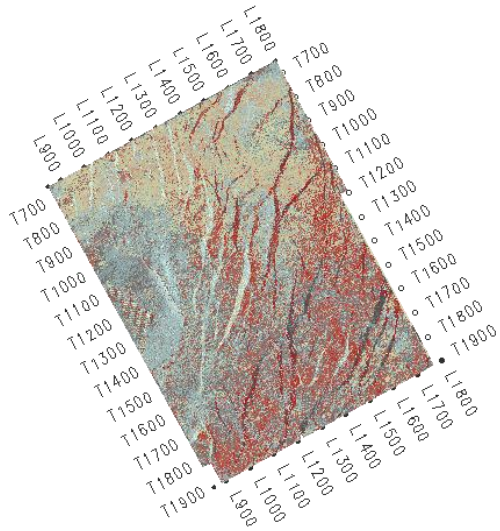

Fig 4 Angle detection of cycle Ⅲ

2.2 Ants technology to identify fracture

Ant colony algorithm (ACA) is a new kind of simulated evolutionary algorithm. It is proposed by Italian scholar Macro Dorigo [7]. It's a kind of post-stack technology that is effective for mini-faults recognition. Ant algorithm is a bionic-optimization method, which has a capacious application foreground because of its properties of positive feeding-back, coordinating and implicating parallelism. In seismic survey, spreading electronic ants in the seismic data volume or discontinuity (coherence, variance), set up fracture condition, and satisfy a single ant along the track conditions and release pheromones, to attract other ants tracking until conditions change.

According the features of initial ant cube and region tectonic stress field, the shape of the igneous rock and it space extending rules in Yingshan area has been determined. Through the attitude control and so on, the final prediction results are obtained. The profile of ant body shows the distribution of fractures clearly. Fractures are mainly vertical ones. On the ants body section (figure 5, cycle II), fractures distribute clearly. These faults contain three groups of NNE trending, NE trending and NS trending.

2.3 Curvature Attribute recognition cracks

The relationship between the crack and curvature properties reflects the stress process of formation fold or bending deformation [8]. It's an effective method to study the brittle strata deformation cracks by structure curvature. It can accurately reflect and predict the development of structural fracture. Two-dimensional curvature attribute can reflect part of the structure information. Nevertheless, it's hard for identifying and interpreting faults with high resolution seismic exploration. Only based on the two-dimensional isochronous tectonic curvature attribute is affected by many factors. Lack using of azimuth information leads to that the result is sensitive to noise. Influenced by many factors, the structure map is prone to horizon disclosure phenomenon. So, the curvature attribute we got is not accuracy and precision limited, or even creates a false impression [9].

Three-dimensional curvature attribute is obtained through the calculation of the azimuth information of seismic data. It is directly extracted from post-stack seismic data, also can depict geological tectonics, the degree

of bending formation interface, research stress field distribution and so on. In seismic exploration, horizontal or inclined layer of curvature is defined as zero, the anticline is defined as positive, and syncline is defined as negative. The absolute value of both increased with the increase of bending degree increase. Curvature attribute quantify the angle of curve offset linear, help to dilute local angle effect and emphasis on the linear features related to mini-faults and sedimentary characteristics. Based on the research of the curvature attribute, faults and tectonic geometry can be defined. In addition, it can also reflect the local features of valley, flat, ridge, dome

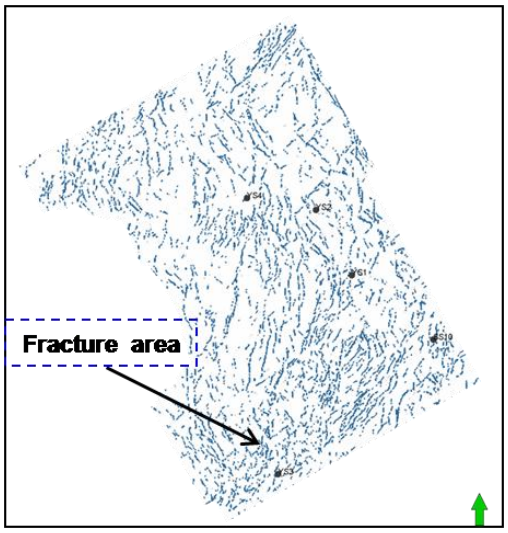

Fig 5 ant cube slices of cycle II

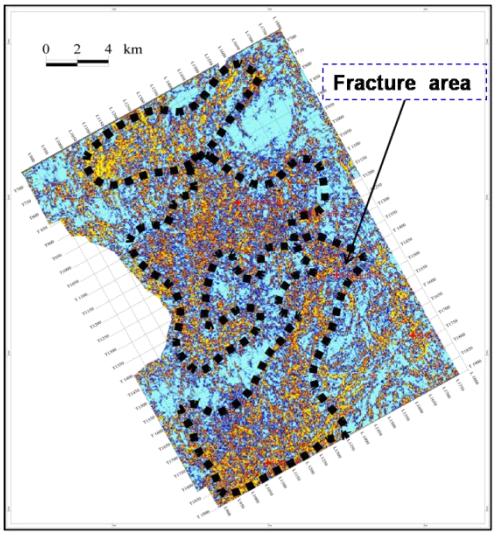

Fig 6 curvature cube slices of cycle II

and strengthen the small faults and other bedding characteristics identification, etc. Different curvature algorithms and parameter can reflect the local features of the fault to varying degrees. The forecast has been carried out using the structure curvature method to the fracture parameters. Let's set the cycle 2 as an example. According to the curvature cube along interest horizons (Fig.6), in the northern, central and southern sections of the study area show yellow-blue features (large curvature values). This characteristic is considered the Fracture development belt. It is in line with other properties prediction results.

IV. THE ANALYSIS AND APPLICATIONS OF FRACTURE PREDICTION RESULTS

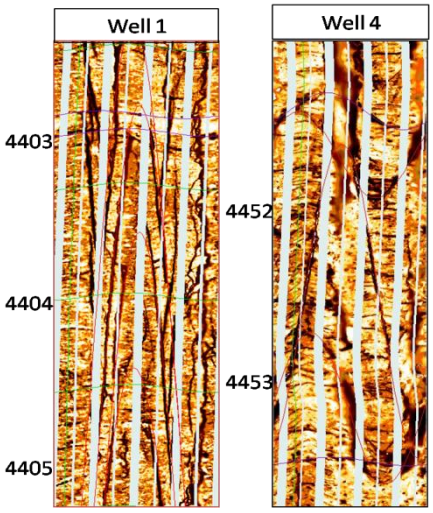

Fig 7 FMI image of well1(right) and well4 (left)

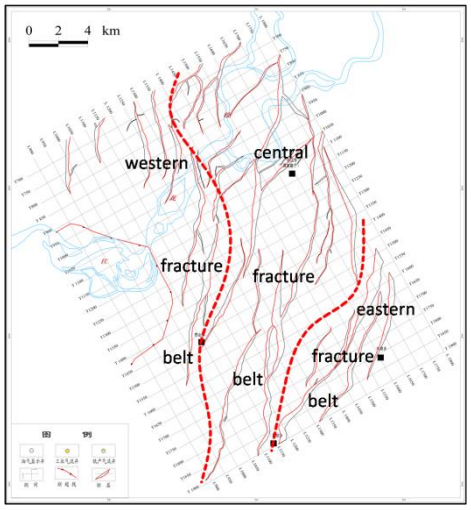

Fig 8 the planar distribution of fracture

Yingcheng group is divided into three cycles by seismic interpretation in the study area. Utilization of conventional seismic data cube, coherence cube, curvature cube, ant cube properties, volcanic facies and interpretation result predicts the distribution of fracture development zone of every cycle. In cycle Ⅰ, fracture distribute in the south and north, mainly high conductivity fracture, poor developed in central depression. In cycle Ⅱ, there are two fracture development zone near the well4-well3-well10 controlled by crater and tectonic. In cycle Ⅲ, continuous fault development and micro cracks are controlled by volcanism.

There were several types of fractures in volcanic rock sections, including high conductivity fracture, induced fractures, high resistance fault and micro crack. By FMI logging data interpretation results, we can get the quantitative parameters of cracks and holes. Near borehole geological conditions will be evaluated quantitatively and directly, which provide an effective method for the study of wellbore in the reservoir fracture [7]. Thoughtfully analysis and investigation on FMI data discovery that well1 and well4 (Fig.7) mainly develop high conductivity fracture, formed a nearly EW strike, dip N, High resistance seam not development.Well2 mainly develop high conductivity and micro fracture. Well3 and well10 locally developed cracks.

To my mind, the igneous rocks of the Yingcheng group formation include two primary types of fracture: high conductivity controlled by structural processes and micro cracks associated with volcanism. Fractures are mainly vertical ones, with few middle, low angle extensional fractures and micro cracks. Generally speaking, the tectonic trend in the yingshan region is NW-ES. It mainly develops three groups of NNE, NE and nearly NS-trending tensile fault. They are differently corresponding west fault zone, central zone and eastern zone (Fig.8). The effectiveness of the multiple methods is demonstrated by the production data. Well2 is high yield well. Well1 and well4 are low production ones. The prediction result obtained is well coincident with the actual showing of oil and gas.

Effective porosity controls gas distribution, while fracture controls gas production rate. Fractures geometry and density are the main factors controlling oil and gas productions of fractured reservoirs, the determination of which is of great importance in fractured reservoir. Those results are very helpful for us to explore hydrocarbon accumulation area.

V. CONCLUSION

5.1 Based on post stack seismic data, combined with the coherence, curvature, ants and other methods to predict the distribution of volcanic reservoir fracture is relatively reliable, better prediction effect in yingshan area.

5.2 The tectonic trend in the yingshan region is NW-ES. It mainly develops three groups of NNE, NE and nearly NS-trending tensile fault (west fault zone, central zone and eastern zone). Fractures are mainly vertical ones, with few middle, low angle extensional fractures and micro cracks.

5.3 FMI data can accurately identify the types of cracks and determine the distribution of structural fractures, as well as an effective method to test the other prediction means.

VI. ACKNOWLEDGEMENTS

Thanks for the sponsorship of the graduate research projects of Northeast petroleum university (NO.YJSCX2014-006NEPU).

REFERENCES

[1] Wei Sun, Yanchun Wang, Mei Li, et al. The detection of fractures in the volcanic reservoir with pre-stack seismic data [J].Geophysical and geochemical exploration, 34(2), 2010: 229-232.

[2] E H Zhang, X W Guan, Y G Zhang. Support vector machine in volcanic reservoir forecast: East slope in Xujiaweizi depression [J].Chinese Journal of Geophysics,54 (2), 2011:428-432.

[3] C J Jiang, X Y Feng. Seismic Inversion Approach on Volcanic Rock Reservoir Prediction [J]. Petroleum

Geology and Oilfield Development in Daqing, 28 (6), 2009:304-307.
[4] Q Jin, L Xu, C L Wan. Interactions between basalts and oil source rocks in rift basins: CO2 generation [J]. Chinese Journal of Geochemistry, 2007, 26:58-65.
[5] Zhichao Sun, Liguo Han, Gaocheng Feng. Prediction of volcanic rock fracture in Wichian Buri Formation, central Thailand [J]. JILIN Geology, 33 (1), 2014:78-82.
[6] Zhen J J, Liu Y. Review over physical model of fractured rock medium [J]. Progress in Geophysics. (in Chinese),26(5), 2011: 1708～1716.
[7] Colorni A; Dorigo M; Maniezzo V Distributed optimization by ant colonies 1991.
[8] Yong Wang, Xueguo Chen, Yuelei Wang, et al. Application of multiple post-stack seismic attributes in the prediction of carboniferous fracture in West Hashan [J]. Progress in Geophysics (in chinese), 29(4) .2014: 1772-1779.
[9] W Yang, Z H He, X H Chen. Application of three-dimensional volumetric curvature attributes to fault identification [J]. Progress in Geophysics. (in Chinese), 26(1), 2011: 110～115.