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Analysis of influencing factors on the brittleness of rocks and minerals—Well A in the Permian Lucaogou Formation of J depression as an example

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Abstract: Rock brittleness is one of the key parameters to be considered in the exploration and development of unconventional oil and gas reservoirs. The Young's modulus and Poisson's ratio method based on rock elastic parameters of normalized is currently widely used for seismic prediction of brittle rock evaluation technology, but the results could be severity affected by parameters of normalized. The Young's modulus and Poisson's ratio as the evaluation index of brittleness, and the scale of large quantity of rock mechanics experiment, has increased the reliability of brittle rock discrimination, this paper re-division of brittle category, focusing on analyzing the effects of minerals and rocks on the brittle zone, and explore the brittleness index calculation method and formula, to play a reference role for the number of period of J depression Permian Lucaogou Formation compact rock brittle prediction.
Keywords: tight oil, brittleness, J depression, horizontal well.

INTRODUCTION

Chinese tight oil exploration started late, China is abundant in tight oil and gas resource, widely distributed in Sichuan Basin in the Jurassic, Junggar basin Permian Lucaogou Formation, Ordos Basin in Triassic Yanchang formation, Songliao Basin Cretaceous Qingshankou--Quantou Formation and so on, Bohai Bay, Tarim and Qaidam basin also contain varying degrees of tight oil resources [1]. Brittleness evaluation of rock reservoir is one of the important evaluation contents of reservoir fracturing before modification. Brittle rock can reflect the ability of rock under certain conditions in the form of cracks, with the rock is more brittle, the fracturing response more sensitive, cracks in the formation is more complex, so as to effectively modify the reservoir and get a higher single well yield [2]. In this paper, based on the research results of previous studies [2-4], with focusing on reservoir microscopic characteristics of mineral and rock, analyze the tight oil reservoir layer brittle characteristics and influence factors, In order to provide an important reference to predict the brittle rocks and to guide horizontal wells deployment.

Geological Survey

Located in the southwest margin of the eastern Junggar Basin, Jdepression is a relatively independent half graben. There are two tight oil reservoirs physical propertyin target layer is relatively favorable, and distribute in Lateral large area stablable, called "sweet spot". The reservoir lithology of the upper sweet spot is mainly dominated by dolomite, contains dolarenite dolomite, micritic dolomite as well. In the lower sweet spot, the lithology of the reservoir is mainly dolomite, other kinds of rocks is few, only some dolomicrite is visible in random.

Classification of brittleness

Tight sandstone oil and gas are widely distributed in China and have great potential, while because of tightness of reservoir and complexity of lithology, fracturing is needed to obtain industrial production capacity, therefore, the evaluation of compressibility has important significance for the optimization of fractured wells. In this paper, through the study we found that the range of rock elastic mechanics parameters with better brittleness is:$Es \geq 15000MPa$, $vs \leq 0.2$; The range of rock elastic mechanics parameters with medium brittleness is: $Es \geq 10000MPa$, $0.2 <$

vs≤0.23 or 10000≤Es＜15000MPa, 0.2＜vs≤0.23; The range of rock elastic mechanics parameters with poor brittleness is: Es＜10000MPa, vs＞0.23. According to the brittle rock category and range of rock elastic mechanics parameters we form a brittle rock classification standard of J depression Permian Lucaogou Formation dense oil reservoir layer (Figure 2).

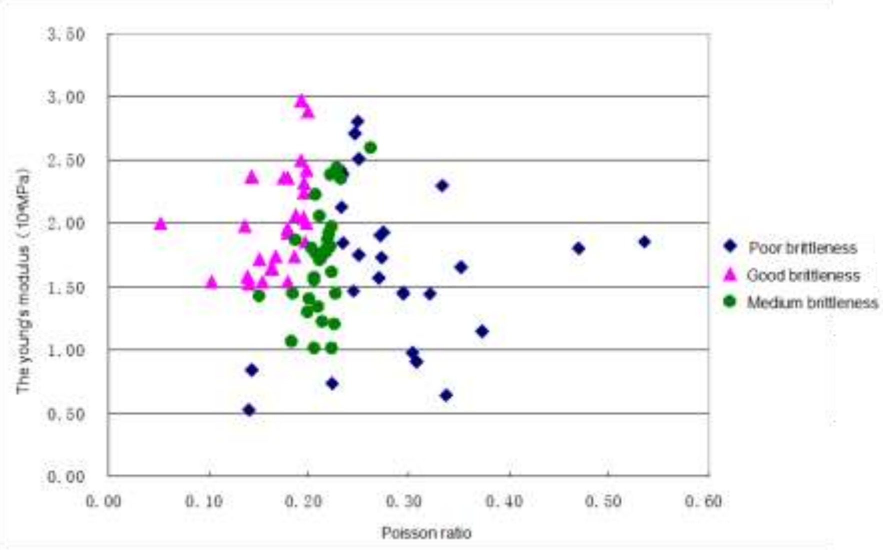

Fig. 2: the static elastic parameters of rock mechanics in X well

On the basis of the above research, according to the rock mechanical parameters of 85 samples, on the basis of the existing classification we divided each kind of samples (good, medium and poor) into three segments, from good to poor the samples is placed in more detailed classification of A1. The smaller the Poisson ratio, better the rock's brittleness is; the bigger the elastic modulus, the better the rock is.

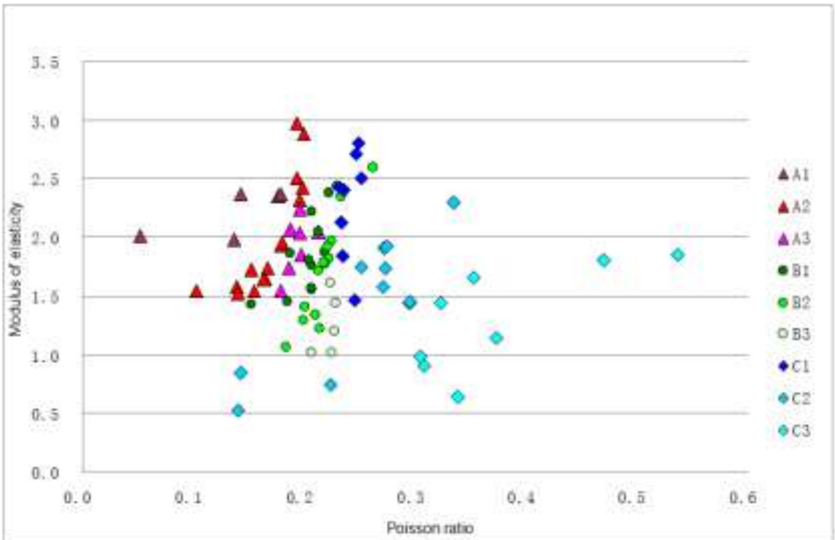

Fig. 3: Nine classification of rock brittleness

THE ESTABLISHMENT OF MAIN BRITTLE MINERALS AND THE CALCULATION OF BRITTLE INDEX

Study on brittleness index of mineral composition

The brittle mineral content is an important factor that influences the development degree of the rock matrix porosity and micro fracture, the gas bearing and the effect of fracturing, The higher content of brittle minerals, the stronger the brittleness of rocks are, and natural fractures or induced fractures can be easily formed under the action of tectonic stress or hydraulic fracturing. When the clay mineral content is high, it usually makes the rock layers show strong plasticity, absorbing energy during fracturing, in order to form the plane crack as main cracks which are not conducive to the volume transformation. When North American scholars' evalues the brittleness of shale reservoir, they use the ratio of quartz mineral content to the total mineral content as the shale of the mineral brittleness index. Compared with the mineral composition of the North American shale, the content of quartz in the tight oil reservoir is lower in China; on the contrary, the carbonate content is higher. Some scholars believe that for the shale reservoir with a high content of carbonate minerals, and the mineral composition is used to calculate the brittleness index, the dolomite and calcite and other carbonate rocks should be included in the brittle mineral. After the research, the mineral fragility index of the study area is expressed as follows:

$$\text{Bquartz}=\frac{\text{Vquartz}}{\text{Vquartz}+\text{Vcarbonate}+\text{Vclay}}$$

$$\text{Bcarbonate}=\frac{\text{Vcarbonate}}{\text{Vquartz}+\text{Vcarbonate}+\text{Vclay}}$$

$$\text{Btotal}=\frac{\text{Vquartz}+\text{Vcarbonate}}{\text{Vquartz}+\text{Vcarbonate}+\text{Vclay}}$$

Bquartz indicates quartz brittleness; Bicarbonates show brittle index of carbonate rocks; Btotal indicates the index of total brittle mineral. The role of the brittle index of quartz and carbonate rocks in the total brittleness index is as follows:

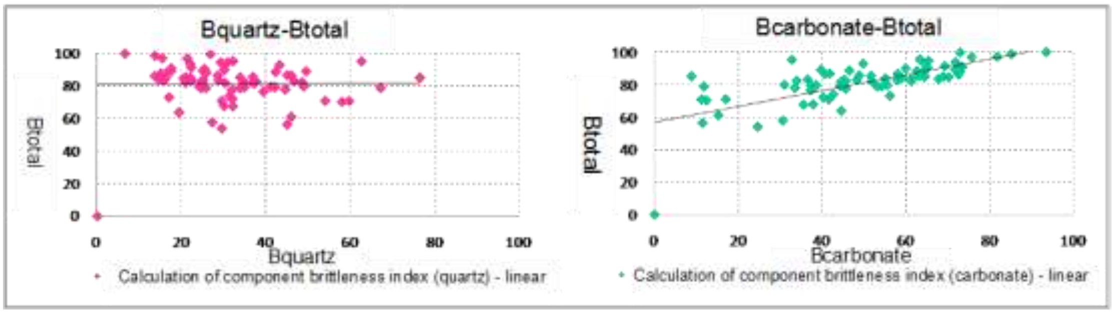

Fig. 4: the relationship between the degree of quartz brittleness and total brittleness (a)

Fig. 4: the relationship between the degrees of carbonates brittleness and total brittleness (b)

The total brittleness of tight sandstone reservoirs in the study area of J depression rose with the increase of the carbonate content, and the correlation with the quartz content is poor. Therefore, in the reservoir of J depression in the study area, the leading role of brittle minerals is carbonate rock. This shows that in the Permian Lucaogou Formation of tight reservoir in J sag, the carbonate minerals is the main constituent of brittleness.

Rock mechanics parameter calculation brittleness index

Both elastic modulus and Poisson's ratio are the parameters to characterize the rock's brittleness. By combining these two arguments together is a more effective and accurate method to quantitative analysis rock brittleness characteristics. In this paper, the elastic parameter method is used to calculate the brittleness index, including the normalized Young's modulus and Poisson's ratio, rendezvous of Young's modulus and Poisson's ratio, Young's modulus / Poisson's ratio, Lame coefficient * density and some other parameter. The basic criterion for judging the brittleness of these parameters is that the higher the young's modulus and the lower the Poisson's ratio, the stronger the rock's brittleness is.

$$BI= (YM\_BRIT+PR\_BRIT)/2 \quad (1)$$

$$YM\_BRIT= (YMC-YMmin)/ (YMmax-YMmin) \times 100\% \quad (2)$$

$$PR\_BRIT= (PRC-PRmax)/ (PRmin-PRmax) \times 100\% \quad (3)$$

YMC and PRC are for the calculation of Young's modulus and Poisson's ratio; YMmax and YMmin is for the Maximum and minimum values of Young's modulus. Maximum and minimum values of PRmax and PRmin for Poisson's ratio, PRmax and PRmin for the Poisson's ratio of the maximum value and minimum value , YM_BRIT and PR_BRIT as the young's modulus and Poisson ratio counted brittleness. BI is for rock brittleness index.

By using the rule of brittle index and Poisson's ratio and elastic modulus, we have found that the brittleness index is obviously in inverse proportion to the Poisson's ratio, in direct proportional to the elastic modulus and the correlation is very good, which preliminary prove the formula is feasible (Figure 5).

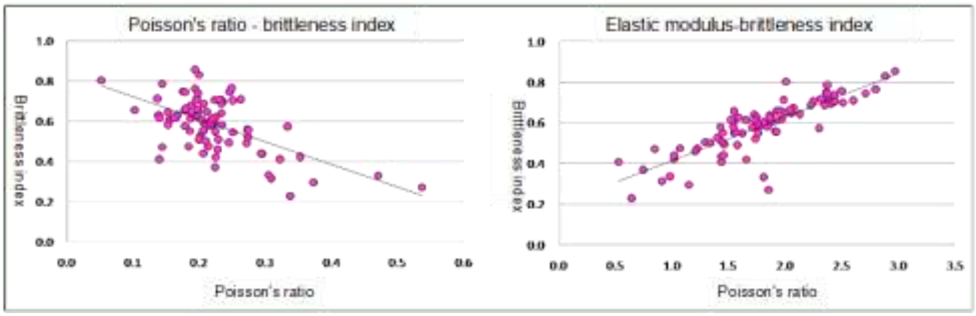

Fig. 5: brittleness index and Poisson ratio, elastic modulus of scatter

CONCLUSIONS

In this paper, we use the district of Lucaogou Formation of tight oil reservoir as an example, mainly use the mineral composition and mechanical parameters to research the brittle characteristics of the reservoir and calculate brittleness index. Conclusions are as follows:

The research area of J depression belongs to salty lacustrine deltaic depositional system which mainly is saline lakes, compared with the North American shale mineral composition, the quartz content is low, while the carbonate content is higher, and the brittleness of carbonate rocks is higher than quartz and clay minerals. Tight oil reservoir in China generally has low content of quartz; the carbonate content is relatively high. In this case, when the sedimentary environment of another area is similar to J depression, we can speculate that carbonate minerals are the best brittle mineral components.

REFERENCES

1. Caineng, Z., Zhi, Y., Zhang, G., Lianhua, H., Rukai, Z., Shizhen, T., Haibin, BI. (2014). Conventional and unconventional petroleum “orderly accumulation”: Concept and practical significance [J]. *Petroleum Exploration and Development*, 41(1), 14-30.
2. Xuguang, G., Zhijie, N., Zhenlin, W., Youlun, F., Kequan, Z., Yongcai, Z. (2015). Application in prediction of brittle rock geology and exploration of tight oil exploration in the J sag [J]. *Geology and prospecting*, 03:592-598.
3. Hongqiu, W., Yan, GL., Chunhui, X., Qiaofeng, Z., Xuguang, G. (2015). A new rock brittleness evaluation parameters and in dense oil reservoir prediction application [a].China Petroleum Institute of petroleum geophysical prospecting Professional Committee. China Petroleum Institute 2015 geophysical technology seminar paper set [C]. China Institute of petroleum geophysical prospecting for petroleum Professional Committee, 4.
4. Yu, W., Xiao, L., Yanfang, W., Yuxing, B., Dingshou, L., Jianming, H., Bo, Z. (2014). Connection between brittle rock crack force level and brittleness index discussion [J]. *Chinese Journal of rock mechanics and engineering*, 02:264-275.