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Factors of Fault Sealing Ability

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Abstract: Fault plays an important role in petroleum exploration, especially the fault sealing ability which is the key during the formation of the reservoir. The research analysis the controlling factors on fault sealing ability based on the throw, fault filling and fault section pressure. Throw controls the fault types by influencing the contact status of the sand stratum in both sides of the fault; Fault filling decides the sealing ability on vertical and lateral directions and it is also the key of the membrane sealing in lateral fault seal. The pressure on the fault section controls the vertical sealing ability directly, which means the higher the pressure is, the stronger the sealing ability is.
Keywords: Fault sealing ability, throw, fault filling, fault plane pressure.

INTRODUCTION

Fault sealing study began from 1980s and the research made a great process from qualitative to quantitative study. The accurate knowledge of fault controlling ability on fluid always plays the key role in the history of the petroleum exploration. Faults could be the pass way for the fluid, and also be the seal of the hydrocarbon accumulation [1]. So the fault is the key factor during the formation of the oil and gas trap [2, 3].

Here is the controlling factors on fault sealing: earth stress direction and intensity, fault strike and dip, matching relation between the faults and stratum, fault depth, throw and activity rate, cross-sectional geometry and width of the fault zone, fault type or systems, ways of fault activities, the contact status of the sand stratum of both sides of the fault, the thickness of mudstone, shale content and frequency of occurrence, matching relation between fault activity and hydrocarbon migration or accumulation period. We mainly analyzed the fault sealing ability from three factors, which were the throw, fault filling and pressure section. The fault sealing is divided into two types, and they are called capillary seal and hydraulic seal [4, 5]. The capillary seal is common. The fault sealing ability is depending on the capillary pressure of the fault zone and the lithology of on both sides of the fault zone.

THROW

Stratum deposited in different ages contact with each other as the continuing stratum are faulted and dislocated. If the throw exactly make the sand stratum contact with the shale from the other side of the fault, the hydrocarbon migrated into the footwall will be sealed by the shale from hanging wall which means the lateral sealing ability of the faults. If the throw continues to grow and the stratums of the both sides are totally deposited in different ages, there will be 2 situations about the sealing of the faults. If there is no lateral sealing from stratum with high displacement pressure on the footwall, the lateral pass way opens. While if the stratum contacting with the footwall contains high displacement pressure, the fault block sealing forms. The throw decides the contact of both section from 2 sides of the fault and the material mixture degree in fault zones. In another word, it controls the fault sealing effectiveness (Fig.1).

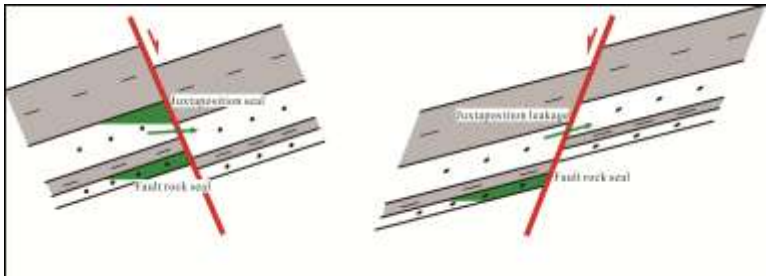

Fig-1: Throw controls the fault types by influencing the contact status of the sand stratum in both sides of the fault

"Allan" [6] figure takes the fault plane as the base plane and all figures like stratum geometry and lithology are covered on the same plane (Fig.2). In this way we can clearly find out the contact relation between lithology and fault strike or tendency base on the throw and fault plane lithology. "Allan" has been widely used in fault sealing analysis. But "Allan" is a qualitative way in fault analysis and it can only be used in fault lateral evaluation.

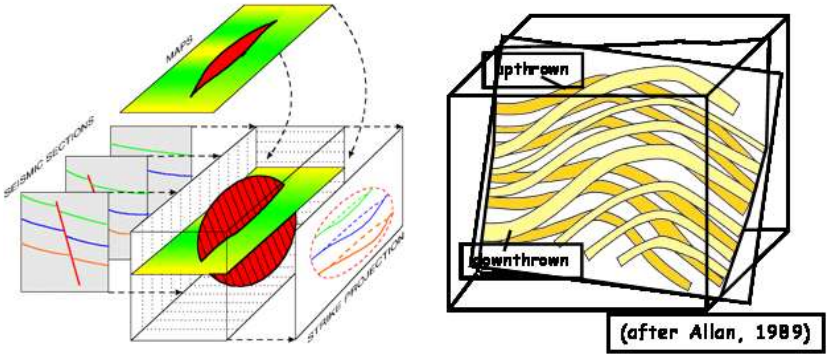

Fig-2: Allan diagram. The Allan diagram directly reflects the status of juxtaposition at any point in the plane

FAULT FILLING

Fault sealing ability is controlled by the contact between reservoir stratum and seal stratum or by the fault plane lithology development with high capillary pressure. Fault filling is a widely geological phenomenon, which can decrease the displacement pressure of the fault zone and develop it into a effective fault sealing. Fault rock is a typical fault filling, which is formed because of the rubbing between hanging wall and footwall. It can be divided into 3 types: Cataclasite sealing, fault rocks sealing with phyllosilicates framework and shale smears. Fault rock is the obstacle on the passing way of fluid. Fisher [7] believed the fault zone permeability was decreasing with the increasing clay content (Fig.3). Fault zone with shale could form better sealing easily, as the pore and throat are smaller due to the smaller particulate matter. So the fault shale content plays a key role in fault sealing ability. If the fault filling is sandstone, but the pores are filled by secondary minerals due to the mineralization of formation water latter, or by the degradation during migration of the hydrocarbon, fault sealing can also be formed. If the fault filling has the sealing ability already, and the contact stratum from the other side of the fault is also shale, it will decrease the possibility of lateral migration through the faults.

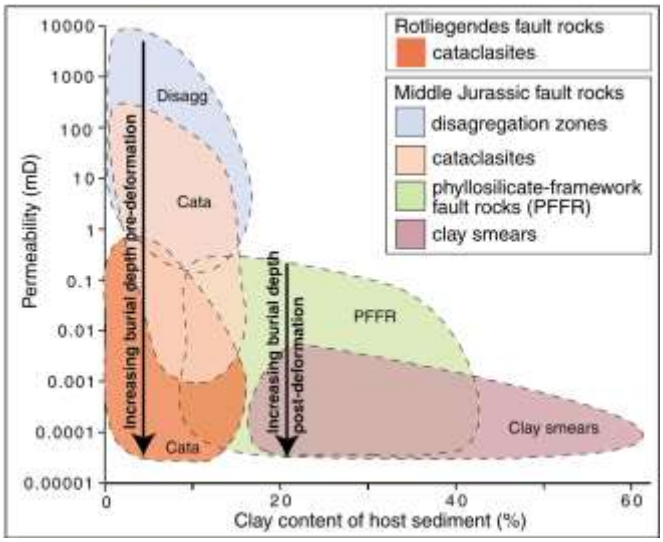

Fig-3: Permeability is against clay content for the various fault rock types [7]

FAULT PLANE PRESSURE

Faults can only have the sealing ability when the fault plane is closed. The stress on the fault plane influence fault sealing in vertical direction by horizontal tectonic stress and static stress which is decided by fault plane depth, dip, overburden rock matrix density, main region compressive stress and fault strike angle. The equation is:

$$p = H(\rho_r - \rho_w)g\cos\theta + \sigma\sin\theta\sin\beta \qquad (1)$$

Where p is positive pressure of the fault plane, MPa; H is fault plane depth, m; ρ_r is average density of the overburden formation, g/ cm^3; ρ_w is formation water

density, g/ cm^3; g is the gravitational acceleration, m/s^2; σ is horizontal stress, MPa; θ is fault dip, degree; β is angle between earth stress and fault strike, degree.

The deeper the fault plane is; the smaller the fault dip is; the larger the angle between main region compressive stress and fault strike; the stronger the pressure on fault plane is, the stronger the sealing ability is. Generally, extensional faults have weaker vertical sealing ability, and compression and transtension faults have stronger vertical sealing ability. Specially, it usually has stronger vertical ability where the fault plane dip dramatically decreases.

CONCLUSION

Throw influence the contact between the sandstone and shale from opposite sides of the faults, and controls the sealing types. The contact sealing or sandstone sealing by stratum in different age will form when the throw is more than the reservoir formation thickness; the sandstone contact in the hanging wall of the normal fault forms when the throw is smaller than the reservoir formation thickness, where we usually find leakage. It will be easier to form better sealing when the fault zone is filling of shale, as they contains smaller pores and throat due to the finer particulate matter. The stronger of total pressure on the fault plane, the stronger ability of the vertical sealing is.

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