# Experimental Study on Rock Mechanics Parameters-A Case of the Sand Conglomerate Reservoir in M2 Well Area

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**Abstract:** This paper presents the acoustic characteristics tested on 20 groups of cores (20 vertical samples and 60 horizontal samples) from the sand conglomerate reservoir in Baikouquan and lower Wuerhe Formation (two wells in the M2 well area). The average values of dynamic modulus of elasticity and Poisson's ratio of rocks from Baikouquan Formation are 32.1 GPa and 0.2055 respectively, and those of lower Wuerhe Formation are 28.4 GPa and 0.2425 respectively. The three axis rock mechanics test device is used to test the stress-strain curves of the corresponding rock samples. The sand-conglomerate samples in this area generally have good brittleness characteristics; the static modulus of elasticity and Poisson's ratio of the corresponding rock samples are 13.7GPa and 0.2858 respectively, and those of rocks from lower Wuerhe Formation are 14.9GPa and 0.2565, respectively. In general, there is a good correlation between P& S wave velocity, and poor correlation in the dynamic and static mechanical parameters.

#### 1 Introduction

The development test of sand-conglomerate tight oil reservoir in Mahu depression of Junggar Basin has achieved good results <sup>[1]</sup>, but many unknowns need to be further studied. In view of the important role of rock mechanics parameters in drilling engineering and fracturing engineering <sup>[2-3]</sup>, and different acoustic and mechanical characteristics in different regions and lithologic reservoirs <sup>[4]</sup>, so it arouses highly attention in the industry. At present, the main methods to obtain rock mechanics parameters are indoor single or three axis stress test

method <sup>[5-6]</sup>, acoustic characteristic calculation method <sup>[7-8]</sup> or log interpretation method <sup>[9-11]</sup>. The static modulus of elasticity and static Poisson's ratio obtained by the core test are better to reflect the rock deformation, and have been widely used in the field of petroleum engineering <sup>[12-14]</sup>. The logging interpretation method is essentially a method of calculating the acoustic characteristics of dynamic modulus of elasticity and dynamic Poisson's ratio according to P& S wave logging data, while it needs to be adjusted from the dynamic value to the static one for application in the engineering practice <sup>[15]</sup>.

There are 20 groups of  $\phi$ 25, 80 rock samples (1 vertical sample and 3 horizontal sample every 45° in each group) from sand conglomerate reservoir in Baikouquan and lower Wuerhe Formation (M20001 and M21008 wells). First, P& S wave velocity of rock

samples is tested by experiments to calculate the dynamic modulus of elasticity and dynamic Poisson's ratio, and then the static mechanics parameters under the triaxial condition are tested. The characteristics of static and dynamic mechanics parameters and transformation relation thereof are established to comprehensively and effectively evaluate the characteristics of rock mechanics parameters, which provide technical support for the oil exploration and development engineering in this area.

## 2 P& S wave velocity testing and dynamic mechanics parameters

#### 2.1 Experiment on P& S wave velocity of rocks

The SCMS-E high temperature and pressure core multi-parameter tester is used to measure P& S velocity of rocks based on the transmission principle. The core specimen is installed into the core clamp. The two ends of the specimen are connected with the acoustic wave generator and the acoustic oscilloscope respectively. The acoustic generator is excited 1 times, corresponding to 1 set of waveforms collected by the acoustic oscilloscope. By measuring the arrival time of the head wave of P& S wave, the propagation speed of P& S wave in the core specimen will be calculated.

The formula for calculating the P& S wave velocity is as follows:

$$V_p = \frac{L}{\Delta t_p - \Delta t_{p_0}} \times 10000$$

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$$V_s = \frac{L}{\Delta t_s - \Delta t_{s_0}} \times 10000$$

Where

Vp, Vs—P& S wave velocity, m/s;

L—Sample length, cm;

 $\Delta t_p$ ,  $\Delta t_s$ —Travel time of testing P& S wave,  $\mu s$ ;

 $\Delta t_{p0}$ ,  $\Delta t_{s0}$ —Time in probes for P& S wave,  $\mu s$ . The experiment was performed to measure P& S wave of 80 samples from the two wells, an example of the measured wave form is shown in Fig.1.



 $\begin{array}{c} \mbox{Time (us)} \\ \mbox{(b) Ma21008 (90^{o} sample)} \\ \mbox{Fig.1 Graphs on P& S wave form of $P_2w_2^{2-2}$ cores from $M21008$ well} \end{array}$ 

The measured results of P& S wave velocity of rocks from M20001 and M21008 wells are shown in Fig.2. There is a good correlation between P& S wave velocity of sand conglomerate in M2 well area but difference in the correlation for the 2 wells.



(a) Complete experimental data



(b) Data as per well Fig.2 Correlation of P& S wave for M2 well area

### 2.2 Analysis on dynamic mechanics parameters of rocks

Assuming that the rock is a homogeneous and isotropic linear elastic body, the formula for calculating the dynamic mechanical parameters of rock samples based on the P& S wave velocity of rocks is as follows [6,7]

$$E = \frac{\rho V_s^2 (3V_p^2 - 4V_s^2)}{V_p^2 - V_s^2} \qquad \qquad \mu = \frac{V_p^2 - 2V_s^2}{2(V_p^2 - V_s^2)}$$

where:

 $\rho$ —bulk density of rocks, kg/m<sup>3</sup>;

*E*—Dynamic modulus of elasticity of rocks, Pa;

 $\mu$ —Poisson's ratio of rocks, dimensionless.

The calculated dynamic modulus of elasticity and dynamic Poisson's ratio are shown in Fig.3. The dynamic modulus of elasticity dynamic and Poisson's ratio of rocks from Baikouquan Formation are respectively 23152~42242MPa (mean 32146MPa) and 0.077~0.318 (mean 0.2055), while the dynamic modulus of elasticity dynamic and Poisson's ratio of rocks from lower Wuerhe Formation are 12728~42562MPa (mean28401MPa) and 0.095~0.357 (mean0.2425).



Fig.3 Test results of dynamic mechanical parameters of rock samples from M2 well area

#### 3 Experimental test on static mechanics parameters of rocks

The high temperature & pressure triaxial rock mechanics test device was used to measure static mechanics parameters of 80 rock samples as per the national standard <sup>[5]</sup>. The experimental curves of some rock samples were shown in Fig.4 and 5. Judging from the curve, the sand conglomerate in M2 well area is generally characterized by good brittleness. The experimental test results are given in Fig.6 with the static elasticity 7885~16770MPa modulus of (average 13745MPa) static and Poisson's ratio 0.193~0.443(average 0.2858) of rocks from Baikouquan Formation, and the static modulus of elasticity 8601~21042MPa (average 14884MPa) and static Poisson's ratio 0.111~0.396 (average 0.2565) of rocks from low Wuerhe Formation



Fig.4 Stress-strain curve from the triaxial mechanics test on 8# core samples from M21008 well



Fig.5 Stress-strain curve of rock samples from M2 well area (Partial)



Fig.6 Experimental results of static mechanics parameters of rocks from M2 well area

## 4 Relations between dynamic and static mechanics parameters of rocks

The dynamic elastic parameters of rocks are calculated by using P& S wave velocity of rock samples based on static mechanics parameters of rocks obtained by the triaxial experiment. The relationship between dynamic and static Young's modulus of elasticity and Poisson's ratio of rocks from M2 well area and stratification is established as shown in Fig.7, and the conversion relationship is shown in Fig.8.





Fig.7 The conversion relationship between dynamic and static parameters of rocks from M2 well area



Fig.8 Diagram on the fitting relation on dynamic modulus of elasticity of rocks from M20001 well

#### **5** Conclusions

The following conclusions are obtained from the analysis on experimental testing on 80 rock samples from 20 groups (80 samples) of Baikouquan and lower Wuerhe Formation in M2 well area.

(1) In general, there is a good correlation between P& S velocity of rock samples with poor correlation for M20008 well than that for M2000 well. The fitting relation between P& S wave velocity in pay zone is: Vs=0.3692Vp+851.3.

(2) The dynamic modulus of elasticity dynamic and Poisson's ratio of rocks from Baikouquan Formation are respectively 23152~42242MPa (mean 32146MPa) and 0.077~0.318 (mean 0.2055), while the dynamic modulus of elasticity dynamic and Poisson's ratio of rocks from

lower Wuerhe Formation are 12728~42562MPa (mean28401MPa) and 0.095~0.357 (mean0.2425)

(3) The test on the sand conglomerate in M2 well area under the triaxial condition is generally characterized by good brittleness. The static modulus of elasticity and Poisson's ratio of rocks from Baikouquan Formation are respectively 7885~16770MPa (average 13745MPa) and 0.193~0.443(average 0.2858), and while that from low Wuerhe Formation are 8601~21042MPa (average 14884MPa) and 0.111~0.396 (average 0.2565) respectively.

(4) The correlation between dynamic and static mechanical parameters of the sand conglomerate in M2 well area is not generally high, which may be related to the content and distribution of the sand conglomerate.

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