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Assessment of the Effects of Temperature, Confining Pressure, and Loading Rate on the Geomechanical Behavior of Caprock of Asmari Reservoir in Iranian Oil Fields

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INTRODUCTION

Casing collapse is one of the main troubles of oil industry worldwide, as well as southwest Iranian oil fields, where these incidents mostly occurred in Gachsaran formation which is underlain by the giant reservoir, Asmari. The first member of the Gachsaran consists of anhydrite type of rock, the geomechanical characteristics of which at various temperatures, confining pressures and strain rates are specified in this study. Because it is the first step to evaluate the possible scenarios of casing collapse in this layer.

According to the previous studies, the rock strength increases often by adding up the confining pressure, which causes that the rock behavior changed from brittle to ductile [1, 2 , 3 , 4 , 5, 6]. Meanwhile, most rocks lose their strength and become more ductile by temperature increment [1, 7]. Moreover, as the loading rate increases, the strength of rock increases too [1].

At the same time, there are some exceptions for each of these scenarios. Additionally, there are few studies about the behavior of anhydrite rock type at reservoir conditions. Figure 1 shows the results of one study in the regard [8].

As shown in Figure 1, it seems that the strength anhydrite among the rock types decreases by temperature, so that at temperatures higher than around 150 °C, its strength loses considerably.

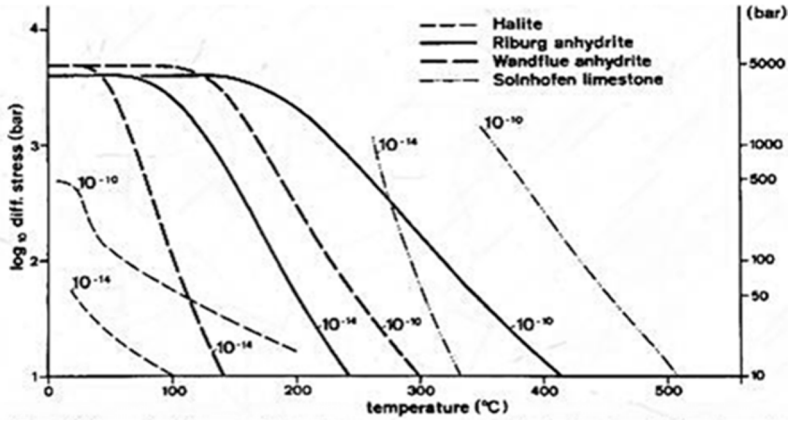

Figure 1. Variations of shear strength vs. temperature for some types of rock including anhydrite [8]

This finding depicts the importance of specifying the geomechanical properties at in-situ conditions of temperature and confining pressure. In the following, the geomechanical propertires of the caprock anhydrite are specified experimentally at various values of temperature and confining pressure.

EXPERIMENTAL PROCEDURES

A number of uniaxial and triaxial compression tests are conducted at the elevated confining pressures up to 48 MPa and the elevated temperatures up to 90 °C to include the in situ conditions of the caprock which are at real depths. Figure 2 shows the experiment set up used for conducting the experiments. The samples were processed into cylinders with a height/diameter ratio of around 2.

All tests were performed according to the methods suggested by International Society of Rock Mechanics (ISRM).

RESULTS AND DISCUSSION

Figure 3 shows the stress-strain curve of some samples. As shown, for all cases, adding up the temperature reduces the strength. Also, the caprock shows the hardening behavior for all the proposed results. Additionally, an increase in temperature reduces the rock stiffness, while the stiffness value rises by an increase in confining pressure.

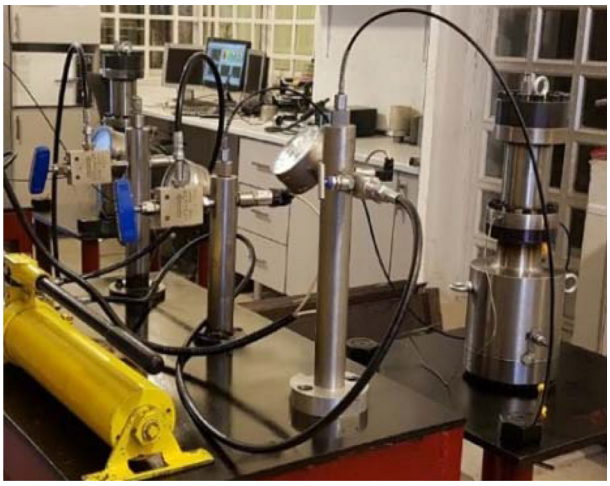

Figure 2: The experimental apparatus.

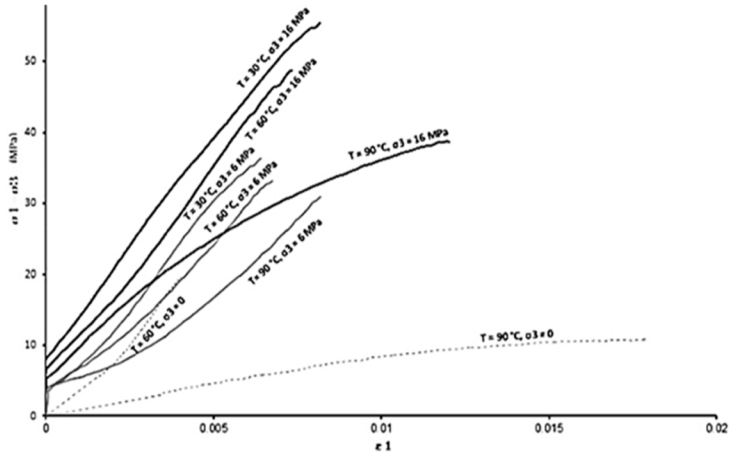

Figure 3: Stress-strain curves of the caprock anhydrite samples.

It must be noted that it is essential to express the in-situ conditions where the geomechanical properties are to be presented. For example, the elasticity modulus of the caprock strength is 8.36 GPa at 90 °C, strain rate of 4μ, and confining pressure of 16 MPa, while the corresponding parameter is 19 GPa at 30 °C, strain rate of 4μ, and confining pressure of 16 MPa.

CONCLUSION

In this study, the effects of temperature, confining pressure, and strain rate on the geomechanical properties of the anhydrite caprock in Iranian oil fields were studied. The results show that:

- Incensement of confining pressure causes the caprock stiffness to rise, especially at ambient temperature.
- An increase in temperature causes that the caprock strength envelope to be reduced. That is equal to decease in cohesion, while the friction value does not change considerably.
- With increasing strain rate, the caprock strength rises under constant temperature and confining pressure.
- The trends of strength variations of the anhydrite caprock with temperature and confining pressure are compatible with the previous studies conducted on anhydrite rock type in other parts of the world.

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