Report for CAGS visiting project in CO2CRC in the University of Adelaide

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1. SUMMARY OF STUDIES AND WORK

❖ Reading and review

During my visit in CO2CRC in the University of Adelaide, I keep on reading relevant papers and books on geomechanics and Gippsland basin. I have finished reading two books, one is <Reservoir Geomechanics> by Mark Zoback and the other is <Stress Field of the Earth's Crust> by Arno Zang and Ove Stephansson.

Geological structures, sedimentation and stratigraphy, geomechanics and potential for CO_2 sequestration in offshore Gippsland basin has been reviewed based on the papers and books.

❖ Technical Training

(1) Technical training on geomechanics during my visit, including the method for calculating stress magnitude, the method for determining stress orientation, and so on.

(2) Trained for using the geomechanical software for stress orientation determination, that is, the image interpretation of JRS suite.

(3) Training for the use of Poly3D, a boundary element numerical code modelling stress and strain associated with tectonic stresses and faults

(4) Data transfer from seismic interpretation package to boundary element code

❖ The work that I undertook

(1) Review for the geological structure, in situ stress field and its implications for the site characterisation and long-term safety for CO_2 sequestration in offshore Gippsland basin.

(2) Build a database for the offshore wells in Gippsland basin: the database for the wells with interpretation possibility of stress magnitudes and orientations.

(3) Determination of the in situ stress magnitudes and stress orientations in Gippsland Basin based on the well logs, borehole testing data, well completion reports and borehole image data, and so on.

(4) Plot the stress profile versus depths and the stress gradient map in offshore Gippsland Basin

(5) Fault stability model for a segment of the Rosedale fault system

- Achievements

(1) Database

A database has been established to show the interpretation possibility of stress magnitudes and orientations. All the wells are based on the updated well data from DPI of Gippsland Basin except the published wells in which the in situ stresses have already been interpreted. In all, there are 53 wells available for vertical stress magnitudes, 38 wells for the minimum and maximum horizontal stresses. And there are 7 wells which are available for calculating all three stress magnitudes.

(2) Stress magnitude

Based on well logs and well completion report, vertical stress (Sv) magnitudes for 53 wells, and the minimum (Shmin) and maximum horizontal stresses (SHmax) for 38 wells have been calculated. The stress profiles versus depths and stress gradient map have been plotted for all the wells.

(3) Stress orientation

The SHmax orientation of West tuna-42 has been determined by 11 Breakouts (BOs). The SHmax orientation for the well of West tuna-42 is NW-SE with the azimuth of 120°~150°. The stress orientation by rose diagram and azimuth versus depth has been plotted. The stress orientation in West Tuna-42 is generally consistent with other wells in offshore Gippsland Basin. The stress orientation of other two wells, East Pilchard-1 in Gippsland Basin and the CRC-1 in Otway Basin, has also been determined.

2. LEARNING/ BENEFITS

- Methods for Calculating Stress Magnitudes

(1) The magnitude of the vertical stress is the pressure exerted by the weight of overlying rocks at a given depths. It is calculated by integrating sedimentary rock densities from the surface to the target depth. The density logs and Check shot data (One-Way Time) are needed for calculating vertical stress (Sv).Three issues must be addressed here: a) logging depths should be converted to true vertical depths subsea (TVDSS); b) removing poor quality data from the density log (RHOB data); c) estimation of the average density from the surface to the top of the density log.

(2) The minimum horizontal stress (Shmin) is generally determined by the Leak-Off Test (LOT) or Formation Integrity Test (FIT). It is better to use the pressure versus volume pumped curves for LOT or FIT. The Shmin can be calculated by the combination of

LOPs (or FIPs), mud weights (Pw) and the pore pressure from RFT tests. But most Leak-off pressures (LOPs) or formation integrity pressures (FIPs) are only recorded as the equivalent mud weights (EMW) in Well Completion Report or in daily drilling reports. And the EMW is assumed to include the mud weights, LOPs and pore pressures (Pp).

(3) The maximum horizontal stress (SHmax) magnitude can be calculated by the Shmin, Pp, Pw and Tensile strength (T) or Compressive strength (Co). And when occurrence of DITFs, we can use the tensile strength; when occurrence of breakouts, we can use the compressive strength. In addition, frictional limits theory is often used to constrain the upper bound of the SHmax.

(4) All the vertical and horizontal stress profiles should be plotted and the stress gradients need to be calculated. Sometimes we can also plot the stress gradient plots.

❖ Determining SHmax Orientation by Breakouts (BOs) and DITFs

Breakouts (BOs) and drilling-induced tensile fractures occur where the stress concentration happens in the wellbore during drilling. The borehole breakouts are compressive failure while the DITFs are tensile failure. The BOs and DITFs are usually recorded by image logs such as FMI, FMS or STAR, and so on.

In general, we only choose those vertical BOs and DITFs observed in FMI or FMS image logs, because they can directly reflect the orientation of the horizontal stresses. Pairs of Breakouts (BOs) reflect the Shmin orientation and pairs of vertical DITFs indicate of the SHmax orientations. When we check all the BOs and DITFs in FMI or FMS logs, we can plot the rose diagram and azimuths.

❖ Plotting the stress profile versus depths and stress gradient

❖ Import seismic interpretation of the Rosedale fault system into numerical modeller (Kubrix)

❖ Fault stability model (Poly3D)

3. FUTURE PLAN FOR CCS RESEARCH

❖ Geomechanical stability for caprocks

(1) Numerical simulation for caprock stability in the context of CO2 injection, including fracture propagation and fault reactivation.

   a. Poly 3D (started – to be continued in collaboration with G. Backé in 2012)
   b. Flac3D model (initiated – to be continued in collaboration with M. Rahman in 2012)

(2) Rock fracture toughness tests and failure modes of caprcoks in laboratory while CO_2 injection.

❖ MICP sealing capacity of caprocks

(1) Evaluate the seal capacity by MICP method, and reveal the capillary failure mechanism of caprcoks.