Stress evaluation of shallow formation in Nankai Trough area by the data of METI Exploratory Test Wells Tokai-oki to Kumano-nada

Koji Yamamoto[1]

[1] JOGMEC

http://www.mh21japan.gr.jp/

In 2004, about 30 wells were drilled in a drilling campaign named METI Exploratory Test Wells Tokai-oki to Kumano-nada for the exploration of ocean subsurface methane hydrate (MH) resource. During this campaign, the earth stress of the shallow formation below seabed was evaluated using well logging and a downhole in-situ testing. The sea depth varies from 800m to 2000m, and each hole covers the interval from sea bottom to below BSR.

Data acquisition were performed using Logging While Drilling (LWD) and wireline conveyed tools, whole interval coring and spot coring of hydrate bearing samples using a Pressure-Temperature Core Sampler (PTCS), formation temperature measurements using Distributed Temperature Sensors (DTS), and in-situ stress and pressure measurement using Cased Hole Dynamics Tester (CHDT)∗. The drilled formations are unconsolidated or weakly consolidated turbidites.

The following information were obtained using such data acquisition items:

(1) Maximum horizontal stress direction

LWD and wireline resistivity wellbore imaging tools detected hole breakout, a compressional failure of the wellbore caused by high horizontal stress, and gave the information of the maximum horizontal stress direction.

The derived stress direction varies with locations, but the basic trend is East-West compression rather than Northwest-Southeast compression anticipated by the tectonic plate motion. However, the locality is high, and effect of local structure and topography should be significant (see the attached figure). The existence of obvious breakout suggests that the stress anisotropy in the horizontal plane is also significant. Such high anisotropy is also implied by the anisotropy of the S-wave velocity observed in the elastic wave logging.

In MH bearing boreholes, breakout occurrence is significant in the layers below hydrate bearing zones.

(2) Magnitude of the minimum horizontal stress and pore pressure

CHDT is a device to inject or extract fluid through a mechanically drilled hole in casings. Using this device, we can measure the pore pressure and minimum principal stress based on the principle of the hydraulic fracturing.

Together with other information such as observed cement loss, the measured data suggests that the minimum horizontal stress is low value of 1.15 to 1.2 times hydrostatic pressure.

(3) Discontinuity of the formation

Same as the breakout, formation discontinuities such as faults, and unconformity are detectable by borehole imaging tools. Even by the relatively low resolution of LWD tool, we could observe many discontinuities. Many of them show the character of fault.

Such faults can work as the fluid path or seal, and then they are interesting in the view of gas migration and MH accumulation. Also the condition of such discontinuities reflects the local stress condition.

From such results, we can conclude that the logging and well test devices designed for rock formations in hydrocarbon reservoirs can work in shallow unconsolidated sediments. However, the difference of physical processes and responses between rock and soft sediment should be taken into account for the interpretation of data. Specifically, high permeability and existence of the well is important for the pressure analysis of the hydraulic fracturing.

The observed stress orientation and the fault density vary widely with locations. There is no evidence that such observations in the shallow formation are common in deeper zones, but the trend is uniform in entire logged interval.

For the further study, other information such as focal mechanism and surface distribution on land will be compared with this measurement, and investigate the local and global stress states that are important for MH resource development.

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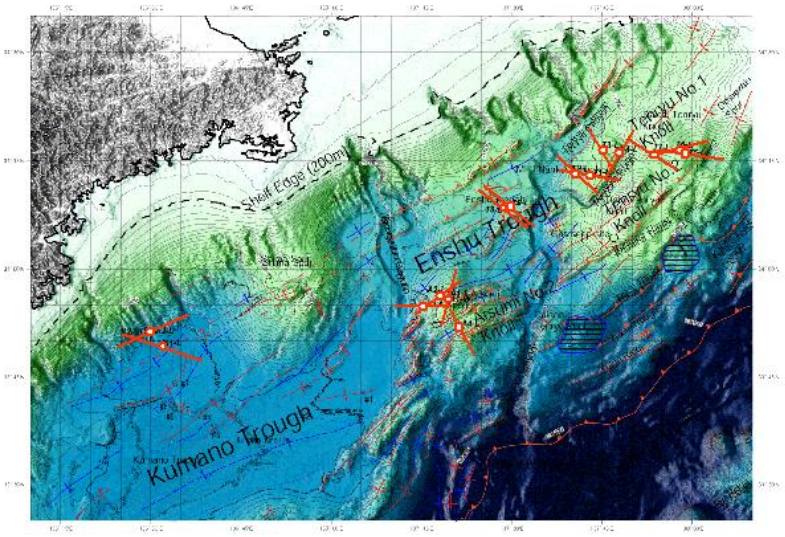
∗Mark of Schlumberger


Shelf Edge (200m)
Enshu Trough
Kumano Trough
Tenyu No.1
Kmb0
Tenyu No.2
Kmb1
Atsumi No.2
Kmb2