Overpressure Characteristic in the Langkat Field, North Sumatra Basin, Indonesia

Hazmanu Hermawan Yosandian¹, Hengki Irawan¹, Binti Wasik Atul Ulum¹, Irawan Youdha Tribuana¹ and Patra Embara¹⁺

¹ Geological Engineering Department, Institut Teknologi Bandung

Abstract. The North Sumatra Basin is an overpressured and productive basin in Indonesia. Top overpressure in the basin is found in Lower Keutapang Formation, just above Baong Formation. In The Aru and Kuala Simpang Field, Baong Formation is shale dominated and forming mud volcano, which is a strong evidence of overpressure occurrence in the basin. In the Langkat Field, top overpressure is also detected in Lower Keutapang and Baong Formation, meanwhile, its distribution and generating mechanism related to geological environment are still unknown. The methods used in this study are analyzing drilling parameters and wireline logs with additional data from geochemical analysis which are vitrinite reflectance (Ro), Tmax, and Total Organic Carbon (TOC). After analyzing drilling parameters and wireline logs, top overpressure in the research area detected in Lower Keutapang and Baong Formation. Then, the pressure versus depth profiles show that overpressure condition decrease until Middle Baong Sandstone and increase again until becoming normal hydrostatic condition in Belumai Formation. So, it can be concluded that overpressure condition in the research area characterized by shale prone formation (Upper and Lower Baong Formation), rather than sand prone formation (Middle Baong Sandstone and Belumai Formation). Results reveal that the overpressure generating mechanisms at the research area are compaction-related (loading) and fluid expanding-related (unloading). The loading mechanism is caused by rapid sedimentation rate of the basin and the unloading mechanism is caused by clay diagenesis, hydrocarbon generation, and vertical transfer. Therefore, this research conclude that overpressure is related to geological environment and history at the research area.

Keywords: Overpressure, Baong formation, compaction.

1. Introduction

The North Sumatra Basin is a well-known overpressured basin in Indonesia [1]. One of Pertamina’s fields in the basin, the Langkat Field, has overpressure condition detected in Lower Keutapang and Baong Formation [2]. However, the overpressure characteristics of the Langkat Field, which are the distribution and generating mechanisms related to its geological environment, are still unknown.

This research uses four wells data at the Langkat Field which will be analyzed to find the characteristics of overpressure (Figure 1). It is highly important to know the characteristics because overpressure give heavy consequences in oil and gas industry. For example, overpressure drives hydrodynamics movement of oil and gas. Meanwhile, it will cause many financial and safety problems while drilling, such as kick and blow out if no or less accurate prediction is done. Therefore, overpressure characteristic and prediction are essential before drilling projects can be started at the research area.

2. Method

This research uses pressure measurements, mudweights, drilling events, and wireline logs to identify pore pressure trend at each wells. Those data are presented as pressure-depth and logs-depth profile. Then, the profiles will be analized to determine overpressure trend and its connection to the geological
Mudweight could be an indicator for the detection of overpressure marked by the increment of mudweight but not all increment of mudweight is caused by the increasing of pore pressure. The increasing of mudweight can be caused by geomechanical problem. Drilling event i.e kick, loss, blow out, pull/drag, hole fill, connection gas, etc, may be caused by overpressure. Another data that we use to analyze overpressure in this research is wireline log data. The wireline log data i.e sonic, bulk density, neutron porosity and resistivity log are often used for analyzing the overpressure [3]. After that, data processing will be conducted to discriminate between sand-rich and shale-rich value from wireline logs. The discrimination use crossplot density (RHOB) against the difference between neutron porosity and the porosity derived from density logs (PHIN-PHID) (Figure 2a) [4]. The...
responses of wireline log data will show two basic types of overpressure generating mechanisms, which are loading and unloading. Loading mechanism response will show constant trend of logs, caused by retention rate of pore fluid matching compaction rate of rocks (Figure 2b) [5]. Meanwhile, unloading mechanism will show opposite direction of log response from normal trend because the pore fluid expand faster than compaction rate (Figure 2c). Another method to analyze the mechanism is using crossplot between sonic and bulk density log, known as dutta crossplot (Figure 2d) [6]. Geochemical data also will be used to check hydrocarbon generation’s role.

3. Occurrence and Distribution

At typical well Tanjung Putus Barat-1 (TPB-1) well, top overpressure is detected in Upper Baong Formation at a depth of 1450 m (Figure 3a). Although overpressure condition occurs until the well reached Lower Baong Formation, sonic log shows a minor decrease of the trend while reaching Middle Baong Sandstone (MBS). That response might be caused by sand-rich intervals in MBS. Then, sonic log begin coming back to normal trend when the well reach Belumai Formation, which consist of sandstone, siltstone, and shale. The mudweight value might be overbalanced to anticipate high pore pressure, therefore, it does not show pressure decline. The trend keep going to normal, as it begins to reach dolomite and limestone of basement.

Sonic log and pressure profile of typical well Gohor Lama-1 (GHL-1) well shows top overpressure detected in Keutapang Formation at a depth of 900 m (Figure 4a). The Keutapang Formation consists of sandstone and siltstone interbedded with claystone and shale intercalations.

4. Generating Mechanism

Wireline log profiles show clear unloading responses at typical well TPB-1 (Figure 3b). Two
mechanisms possibly generate overpressure at the well are clay mineral transformation and hydrocarbon generation. Dutta Crossplot shows smectite transformation at 1200 – 1800 m (Figure 3c). The crossplot is confirmed by 73.58 °C/km of geothermal gradient, with 30 °C of surface temperature assumption, therefore, smectite can transform to illite at 1200 m. The maturity data (vitrinite reflectance and Tmax) show the mature source rock is detected at 2016 m (Figure 3d). Therefore, the overpressure generating mechanism at TPB-1 is unloading, which are clay mineral transformation and hydrocarbon generation, which assist generating pressure at 2016 m.

At GHL-1, log responses show loading response which is constant trend in sonic and resistivity log. Meanwhile, porosity and density log show minor unloading trend (Figure 4b). For solving the uncertainty, Dutta crossplot is made and shows no mineral transformation (Figure 4c). No indicator of unloading mechanism, so we may conclude GHL-1 has overpressure generated by loading mechanism.

5. Conclusion

At the Langkat field, overpressure occurrence and distribution is associated with shale lithology. The top overpressure is detected by wireline logs at shale dominated Upper Baong Formation (TPB-1). Generating mechanism analysis show that overpressure at the research area are fluid expanding-related (unloading) which is caused by clay diagenesis i.e smectite to illite and hydrocarbon generation. Another overpressure mechanism is loading mechanism.

6. Acknowledgment

Authors thank to INOV (Indonesia Overpressure Study) ITB and Pertamina E&P for the opportunity to study overpressure in The North Sumatra Basin.

7. References


