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C Prasetyadi, B Prastistho, A Rodhi, P Pratiknyo, M G Rachman, Y Rizkianto, Arhananta, I Arina, A Nugraha. "Conservation of groundwater in Nglanggeran Area, Gunung Kidul District, Yogyakarta", IOP Conference Series: Earth and Environmental Science, 2018

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.... iii iv v vi vii xi xiv xvi xxxv i1ii Paper ID Paper Title Authors with Affiliation and Country Page OS05 - 06 OS05 - 07 OS05 - 08 OS05 - 09 OS05 - 10 OS05 - 11 OS05 - 12 OS05 - 13 OS05 - 14 OS05 - 15 OS05 - 16 OS05 - 17 OS05 - 18 OS05 - 19 OS05 - 20 OS05 - 21 Effect of Earthquake Vibration on Shear Strength of Sandstone Fractures Effects of Cyclic Loading on Frictional Behavior of Fractures in Sandstone Effects of Mine Subsidence on Mechanical Integrity of Cement Seals in Nearby Boreholes Permeability of Phu Phan and Sao Khua Sandstones Under High Confinements Consolidation of Crushed Salt Mixed with Saturated MgCl2 Brine Strengths of Rock Mass Models Under Confinements Shear Strengths of Fractures in Saturated Sandstone Effects of Cyclic Loading on Tensile Strength of Rock Salt The Detection of Concrete Bridge Structure Movement Using Global Positioning System Static Technique - Overview on Traffic Flow Mechanical Properties of Compacted Bentonite-Aggregate Mixtures as Backfill in Salt and Potash Mine Openings Tectonostratigraphy of Banyumas Basin and Its Correlation to Petroleum Potential Petroleum System of Matarombeo Basin, South-East Arm Sulawesi, Indonesia Potential Influence of Secondary Aerosols on Atmospheric Visibility in Eastern Thailand Shale Reservoir Characterization and Applying Hydraulic Fracturing to Shale Oil Well XX-3P Application of Nanomaterials in Water Based Mud Towards Shale Swelling Integrating Fracture Height Calculation into Hydraulic Fracturing Procedure by Unified Fracture Design Method xL Khanapot Boonyord (Suranaree University of Technology, Thailand) Narudon Patitung (Suranaree University of Technology, Thailand) Sujitra Lahib (Suranaree University of Technology, Thailand) Sawarin Champanoi (Suranaree University of Technology, Thailand) Worawat Suwannabut (Suranaree University of Technology, Thailand) Kiattisak Sripun (Suranaree University of Technology, Thailand) Pittawat Liapkrathok (Suranaree University of Technology, Thailand) Thanapon Kaewpuang (Suranaree University of Technology, Thailand) Masreta Mohd@Basri (University Technology of Malaysia, Malaysia) Laksikar Sitthimongkol (Suranaree University of Technology, Thailand) Eko Bayu Purwasatriya (Universitas Jenderal Soedirman, Indonesia); Sugeng Surjono (Universitas Gadjah Mada, Indonesia); Hendra Amijaya (Gadjah Mada University, Indonesia); Hendaryono Mr and Salatun Said (UPN Veteran Yogyakarta, Indonesia) Saptono Samodra and Sugeng Surjono (Universitas Gadjah Mada, Indonesia) Nishit Aman (KMUTT & JGSEE, Thailand); Kasemsan Manomaiphiboon (King Mongkut's University of Technology Thonburi, Thailand) Dung Ta (Ho Chi Minh City University of Technology, Vietnam); Nhan Danh Ha (Ho Chi Minh City University of Technology - VNU-HCMC, Vietnam) Rafat Abdul-Razzaq, Abdul Razak Ismail and Mohd Zaidi Jaafar (Universiti Teknologi Malaysia, Malaysia) Khanh Nguyen (Bach Khoa University, Vietnam) 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 OS05-16 TECTONOSTRATIGRAPHY OF BANYUMAS BASIN AND ITS CORRELATION TO PETROLEUM POTENTIAL *Eko Bayu Purwasatriya(1), Sugeng Sapto Surjono(2), D. Hendra Amijaya(2), Fauzan Eka Saputra(3), Hendaryono(4), Salatun Said(4) (1)Geological Engineering Jenderal Soedirman University, Purwokerto and Doctoral program Department of Geological Engineering Universitas Gadjah Mada, Yogyakarta (2)Department of Geological Engineering Universitas Gadjah Mada, Yogyakarta (3)dr Bumi Research Group (dBRG) Geological Engineering Jenderal Soedirman University, Purwokerto (4)Geological Engineering UPN "Veteran", Yogyakarta *Corresponding author: bayusatriya@yahoo.com; sugengssurjono@ugm.ac.id ABSTRACT Objective of this research is to understand tectonic event and stratigraphy in order to know better about petroleum potential of this area. Method used in this research is taking primary field data and combine with secondary data to interpret the results. The primary data of 841 shear fractures had been measured from the field in Banyumas basin, from various lithological formation such as Karangsambung Formation as the oldest, then Gabon Formation, Halang Formation, Kumbang Formation and Tapak Formation. The result is, there are 3 (three) paleostress from after Eocene to Pliocene age: (1) Paleostress NW-SE with transpressive or compressional strike-slip regime at after Eocene to Late Oligocene, (2) Paleostress NNW-SSE with pure strike-slip regime in Miocene and (3) Paleostress NNE-SSW with pure compressional regime in Pliocene. Generally, the paleostress is rotating clockwise, and stratigraphy of every tectonic events show an opportunity to the petroleum potential of this basin. Keywords: Tectonostratigraphy, Banyumas basin, Petroleum potential 1. INTRODUCTION This study is attempt to reconstructing the paleostress evolution related with tectonic event, stratigraphy and the petroleum potential. Primary data obtained in the field are shear fractures and geological mapping for stratigraphic study. Tectonic events was compiled from several previous researcher to match it with the paleostress analysis. 841 shear fractures had been measured spreading in Banyumas basin for paleostress analysis. Although shear fractures is not the main data to determine stress condition, but the result of stress inversion and kinematic analysis can be used to interpret the stress condition. 4 (four) principle parameters for shear fracture are σ1, σ2, σ3 and stress ratio (R). Inversion of shear fracture can produce stress index (R'), Maximum horizontal sharpness (Shmax) and Minimum horizontal sharpness (Shmin), that can be used to interpret the stress regime (Delvaux, et al. 1997). 2. DATA AND METHOD 2.1 Data Data obtain from 15 location representing various lithological formation from the oldest to the youngest. The coordinate of these location is show on table 1 and displayed on geological basemap (fig.1). Total data obtain is 841, but need to validate base on stress tensor produced by each data and considering local and regional geological condition. After selecting and grouping all the data, only 498 data valid to be used on interpretation which are consistent determining 4 principle parameter of stress. Stratigraphic data obtain from geological mapping and display as geological map on fig.1. 2.2 Method Method using in this research is field observation combine with secondary data from literature to analyze and interpret the result. Field observation comprise measure of shear fracture and geological field mapping. Shear fractures selected to get valid data and then grouping into same stress tensor type. Delvaux (1997) divide the stress regime into 7 type : 1. Radial extensive, if σ1 vertical (black circle) and 0<R<0,25 2. Pure extensive, if σ1 vertical (black circle) and 0,25<R<0,75 3. Transtensive, if σ1 vertical (black circle) and 0,75<R<1,0 or σ2 vertical (black dot) and 1,0>R>0,75 4. Pure strike-slip, if σ2 vertical (black dot) and 0,75>R>0,25 5. Transpressive, if σ2 vertical (black dot) and 0,25>R>0 or σ3 vertical (white circle) and 0,250,25<R<0,75 and 7. Radial compressive, if σ3 vertical (white circle) and 0,75Bolliger & de Ruiter (1975), Sribudiyani, et al. (2003) and Husein, et al. (2013). Next process is to matching the stress tensor and stress regime into tectonic events and stratigraphic events to create the tectonostratigraphy of Banyumas basin and correlate it to petroleum potential of the basin. 3. ANALYSIS Analysis of valid shear fracture data resulting 3 (three) group of paleostress. Geological age determination of paleostress is controlled by the stratigraphy of Banyumas basin. Older lithological formation will have almost all of paleostress, but younger lithological formation will only have young paleostress. 3 (three) group of paleostress as follow : 1. Paleostress NW-SE Shear fractures data that formed by the stress with NW-SE orientation found in Sempor (Sempor, Banyumas) is located in Karangsambung Formation, and Strati (Karangbolong, Kebumen) is located in Gabon Formation. Based on the analysis of all NW-SE stress data, the maximum stress direction (σ1) averages is 28o / N 336o E, intermediate stress (σ2) 62o / N 149o E, and minimum stress (σ3) 3o / N 245o E. The stress ratio R is 0 and stress index R' is 2,00. Therefore, the stress regime of NW-SE is Transpressive or compressional strike-slip (R' 2,00) with 156o Shmax 2. Paleostress NNW-SSE Shear fractures data that formed by the stress with NNW-SSE orientation found in the location of the Banaran (Jatilawang, Banyumas) is located in Halang Formation, Kedungwringin (Jatilawang, Banyumas) is located in Halang Formation, Darmakradenan (Ajibarang, Banyumas) is located in Halang Formation, Sawangan (Patikraja, Banyumas) is located in Halang Formation, Sanggreman (Rawalo, Banyumas) is located in Halang Formation, and Sempor (Sempor, Banyumas) is located in Karangsambung Formation. Based on the analysis of all NNW-SSE stress data, the maximum stress direction (σ1) averages is 3o / N 177o E, intermediate stress (σ2) 80o / N 68o E, and minimum stress (σ3) 10o / N 268o E. The stress ratio R is 0,58 and stress index R' is 1,42. Therefore, the stress regime of NNW-SSE is pure strike-slip (R' 1,42) with 177o Shmax 3. Paleostress NNE-SSW Shear fractures data that formed by the stress with NNE-SSW orientation found in the location of the Gunungwetan (Jatilawang, Banyumas) is located in Halang Formation, Kedungwringin (Jatilawang, Banyumas) is located in Halang Formation, Kaliputih (Purwojati, Banyumas) is located in Halang Formation, Karangkemiri (Wangon, Banyumas) is located in Halang Formation, Darmaji (Lumbir, Banyumas) is located in Tapak Formation, Panimbang (Cimanggu, Cilacap) is located in Tapak Formation, Cipari (Cipari, Cilacap) is located in Halang Formation and Sanggreman (Rawalo, Banyumas) is located in Halang Formation. Based on the analysis of all NNE-SSW stress data, the maximum stress direction (σ1) averages is 18o / N 23o E, intermediate stress (σ2) 40o / N 129o E, and minimum stress (σ3) 45o / N 274o E. The stress ratio R is 0,55 and stress index R' is 2,55. Therefore, the stress regime of NNE-SSW is pure compressive (R' 2,55) with 15o Shmax Summary of these result analysis is shown in Table 2. 4. RESULTS AND

DISCUSSION 4.1 Tectonostratigraphy Tectonic events from previous researcher used to matching the direction of paleostress that had been analyze. Tectonostratigraphy of Banyumas Basin describe as follow : - From Eocene time (or probably from Cretaceous) to Late Oligocene time, the Paleostress is NW-SE and the stress regime is transpressive. This stress direction is Meratus pattern, that still exist before docking of East Java microcontinent in Karangsambung area. The stratigraphy from Late Cretaceous to Paleocene is a melange complex named Luk Ulo complex. After the docking of East Java microcontinent at Paleocene (Sribudiyani, 2003), the subduction of Meratus pattern starting to stop and slowly change to Java pattern. At this phase, Karangsambung Formation and Totogan Formation as olistostrome deposited. Karangsambung Formation lithology is dominantly black shale with high organic content, that potential as petroleum source rock for Banyumas basin. At Late Oligocene, the pattern of subduction finally change to Java pattern that almost east-west, indicating by orogenic phase of Southern Mountain along Java Island. The stratigraphy in Banyumas basin is the deposition of Gabon Formation and Waturanda Formation with dominantly volcanic breccia, lava and intrusion. At this stage, the tectonic event is rifting and volcanism (Bolliger & de Ruiter, 1975) and Husein, et al. 2013 adding the rifting event on North Serayu Basin. - From Late Oligocene to Late Miocene, Paleostress direction is become NNW-SSE. Rotation of the stress is clockwise, and the stress regime become pure strike-slip. The stratigraphy from Early to Late Miocene are Kalipucang Formation, Rambatan Formation and Halang Formation. Kalipucang Formation compose of carbonate rock that spreading in the high part of subaquaeous inactive volcanic body (Asikin, et al. 1992). Rambatan Formation compose of carbonate sandstone, conglomerate, intercalating with shale, marl and tuff (Condon, et al. 1996) Halang Formation compose of intercalating turbiditic tuffaceous sandstone and claystone with tuff, marl and siltstone. Tectonic events are rapid subsidence, volcanism-faulting and also uplift in Middle Miocene (Bolliger & de Ruiter 1975). Husein, et al. 2003 state this phase is volcanism of South Serayu and inline with this, Purwasatriya, et al. 2017 delineate Mio-Pliocene magmatic arc during this stage using residual gravity data. The “keyword” that we can capture from this stage are : abundant sediment supply and rapid sedimentation. Abundant sediment supply comes from erosion of inactive volcanic body in the south and orogenic of Mio-Pliocene magmatic arc. Rapid sedimentation fill the accomodation space of basin flexure that already formed previously. Abundant sediment supply and rapid sedimentation creating very thick sediment with overpressure inside it. - From Pliocene to Pleistocene age, the paleostress is NNE-SSW, still continue rotating clockwise and the stress regime is pure compressive. Tectonic events are uplift, folding, volcanism (Bolliger & de Ruiter) and volcanism of North Serayu (Husein, et al. 2013). Plio-Pleistocene magmatic arc are formed (Purwasatriya, et al. 2017) and the stratigraphy are Kumbang Formation representing the volcaniclastic rock such as breccia, lava and tuff. Tapak Formation representing transitional sediment, compose of greenish sandstone intercalating with marl and lenses of limestone. The sedimentation environment has changed from deep marine with volcanic mountain in subsea into shallow marine. Compressive regime of stress made reactivation of previous structure and create folding in this area. Probably, this compressive regime is also reactivate the strike-slip structure across Karangsambung area and creating positive flower structure in Karangsambung that responsible to exposing the old age rock into the surface. Tectonostratigraphy of Banyumas Basin compiled from previous researcher and result of this research is shown in fig 3. 4.2 Petroleum Potential Understanding tectonostratigraphy will help us to know better about petroleum potential of an area, because every element of petroleum system will be describe better in tectonostratigraphy events. Petroleum potential of Banyumas Basin based on tectonostratigraphy events is as follow : - Source rock potential source rock is black shale from Eocene Karangsambung Formation, because high organic content and the maturation also reasonable, because of thick and rapid sedimentation during Miocene age. The maturation will be good if there is a rifting event in Banyumas Basin, but, previous researcher only state about rifting in North Serayu Basin. As a substitution, thick burial sediment could generate enough heat to make source rock mature. - Reservoir Volcanic rock will be altered became clay mineral in subsurface, this condition make volcanic rock is hopeless as reservoir. But as show in the surface, the volcanic rock in Banyumas Basin had been fractured. Pure compressive regime in Pliocene to Pleistocene makes all the volcanic rock fractured and creates secondary porosity in reservoir rocks. Sandstone from Halang Formation, Penosogan Formation could be proposed as reservoir in Banyumas Basin. Limestone of Kalipucang Formation or member of Tapak Formation also possible as reservoir rock, although there is no indiation yet in seismic section show carbonate build up in subsurface. - Seal rock Marl, Tuff and siltstone is abundant and thick in Halang Formation and Tapak Formation. These rocks could be a good seal rock in Banyumas Basin. - Trap Based on tectonostratigraphy, it is possible for structural an stratigraphic trap in formed in Banyumas Basin. Compressive regime create structural trap such as anticline, fault or drag fold. Rapid sedimentation with abundant sediment supply could create diapiric trap, onlap or pinchout stratigraphic trap. - Migration Proper timing of migration is needed as critical time of a petroleum systems. Black shale from Eocene Karangsambung Formation had been burried with very thick sediment from Halang Formation and Rambatan Formation, crating enough heat temperature for maturation of source rock. Compressive regime in Pliocene age, create the petroleum traps to store the migrate petroleum. Need additional study to trace the migration path from kitchen to trap, in order to find the potential trap, because several well already spud in Banyumas Basin, but still not find the economic reserve of petroleum yet. Discussion of the petroleum potential in Banyumas Basin should be intensive on trapping and migration mechanism, because this elements of petroleum systems still need continous study to build the petroleum play of Banyumas Basin. 5. CONCLUSIONS The conclusions of this paper are : - There are 3 (three) group of paleostress in Banyumas Basin : (1) Paleostress NW-SE from Eocene (or probably Cretaceous) to Late Oligocen with transpressive regime, (2) Paleostress NNW-SSE from Late Oligocene to Late Miocene with pure strike-slip regime and (3) Paleostress NNE-SSW from Pliocene to Pleistocene with pure compressional regime - The paleostress is rotating clockwise - Tectonostratigraphy show that there is still an opportunity for petroleum potential in Banyumas Basin

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Kedungwringin Jatilawang Banyumas 7 33 16,1 109 8 1,4 Halang 11 Gunungwetan Jatilawang Banyumas 7 34 7,4 109 5 22,6 Halang 12 Kaliputih Purwojati Banyumas 7 27 38,3 109 7 41,2 Halang 13 Karangkemiri Wangon Banyumas 7 34 25 109 3 13,6 Halang 14 Darmaji Lumbir Banyumas 7 25 17,1 108 57 48 Tapak 15 Panimbang Cimanggu Cilacap 7 21 44,6 108 51 48,1 Tapak Table 2. Summary of shear fracture paleostress analysis in Banyumas Basin Fig. 1. Data location on geological basemap (modified from Purwasatriya, 2014) Fig. 2 Stress regime based on direction of principle axes and stress ratio R (Delvaux, 1997) Fig. 3 Tectonostratigraphy of Banyumas Basin (compile from Bolliger & de Ruiter, 1975; Sribudiyani, et al. 2003; Husein, et al. 2013, tensor and stress regime) The 12th SEATUC Symposium The 12th SEATUC Symposium The 12th SEATUC Symposium The 12th SEATUC Symposium The 12th SEATUC Symposium The 12th SEATUC Symposium The 12th SEATUC Symposium The 12th SEATUC Symposium