ISSN: 2186-7631 (SEATUC)
ISBN: 978-1-5386-5092-9 (IEEE)

PROCEEDINGS

SEATUC 2018

SOUTH EAST ASIAN TECHNICAL UNIVERSITY CONSORTIUM

In Conjuction with

InAES 2018

"the 8th International Annual Engineering Seminar"

The 12th SEATUC Symposium

Engineering Education and Research for Sustainable Development

OS01. Green Energy System
OS02. Sustainable Building and Infrastructure
OS03. Information Technology, Smart System and Automation
OS04. Hazard and Risk Management
OS05. Earth Science and Geomatics
OS06. Green and Smart Transportation System
OS07. Green Advanced Materials
OS08. Sustainable Industrial Process and Manufacturing System
OS09. Sustainable Environment
OS10. Sustainable Urban and Regional Planning & Development
OS11. Biotechnology and Life Science
OS12. Engineering Education
OS13. IEEE

March 12 - 13, 2018
Graduate School Building UGM
(Gedung Pascasarjana)
Yogyakarta, Indonesia

http://seatuc2018.ugm.id
seatuc2018@ugm.ac.id

UNIVERSITAS GADJAH MADA
FAKULTAS TEKNIK

South East Asian Technical University Consortium

IEEE
Advancing Technology for Humanity

In Conjuction with
InAES 2018
"the 8th International Annual Engineering Seminar"

TABLE OF CONTENT

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 0,25<R<0.
6. Pure compressive, if σ3 vertical (white circle) and 0,25<R<0,75 and
7. Radial compressive, if σ3 vertical (white circle) and 0,75<R<1,0

Diagrammatic of these 7 type of stress regime is shown in fig 2.

Stress ratio R can be calculated using this formula (Angelier, 1975)

$$R = (\sigma_2 - \sigma_3) / (\sigma_1 - \sigma_3) \quad (1)$$

Processing of shear fracture using software Win Tensor 5.0.7. with optimization rotation method to interpret the stress tensor and stress regime.

Secondary data from literature used to obtain the tectonic event in geological time, such as Bolliger & 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 subaqueous 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

ACKNOWLEDGMENT

I would like to thank to Department of Geological Engineering Universitas Gadjah Mada, Geological Engineering Jenderal Soedirman University and Geological Engineering UPN "Veteran" Yogyakarta.

REFERENCES

Angelier, J., Sur l'Analyse de Measures Recueillies Dans des Sites Faille's: l'utilite D'une Confrontation Entre les Methods Dynamiques et Cine'Matiques., *Comptes Rendus de l'Acade'mie des Sciences*, 1975.

Asikin, S., Handoyo, A., Prastistho, B., dan Gafoer, S., Peta Geologi Lembar Banyumas, *Pusat Penelitian dan Pengembangan Geologi*, Bandung, Indonesia, 1992.

Bolliger, W. and Ruiter de, P.A.C., Geology of The South Central Java Offshore Area, *Proceeding Indonesian Petroleum Association, Fourth Annual Convention*, Jakarta, 1975.

Condon, W.H., Pardyanto, L., Ketner, K.B., Amin, T.C., Gafoer, S., Samodra, H., Peta Geologi Lembar Banjarnegara dan Pekalongan, *Pusat Penelitian dan Pengembangan Geologi*, Bandung, Indonesia, 1996.

Delvaux, D., Moeys, R., Stapel, G., Paleostress Reconstructions and Geodynamics of the Baikal Region, Central Asia, Part II: Cenozoic Tectonic Stress and Fault Kinematics, *Tectonophysics*, 1997.

Husein S., Jyalita J., Azis M., Kendali Stratigrafi dan Struktur Gravitasi pada Rembesan Hidrokarbon Sijenggung, Cekungan Serayu Utara. *Proceedings of Seminar Nasional 6th Jurusan Teknik Geologi Fakultas Teknik UGM*, Yogyakarta, 2013.

Purwasatriya, E.B., Tinjauan kembali potensi hidrokarbon Cekungan Banyumas berdasarkan data geologi dan geofisika, *Proceeding Seminar Kebumian Ke-7,* Yogyakarta, 2014.

Purwasatriya, E.B., Surjono, S.S., Amijaya, D.H., Oligocene-Pleistocene Paleogeography within Banyumas Basin and Implication to Petroleum Potential, *Proceeding of 3rd International Conference on Science and Technology (ICST),* UGM, Yogyakarta, 2017

Sribudiyani, Muchsin, N., Ryacudu, R., Kunto, T., Astono, P., Prasetya, I., Sapiie, B., Asikin, S., Harsolumakso, A.H, Yulianto, I., The Collision of East Java Microplate and Its Implication for Hydrocarbon Occurences in the East Java Basin, *Proceeding of Indonesian Petroleum Association, 29th annual convention and exhibition*, Jakarta, 2003 .

NOMENCLATURE

σ1	:	Maximum stress axes
σ2	:	Intermediate stress axes
σ3	:	Minimum stress axes
R	:	Stress ratio
R'	:	Stress index

Subscripts

NW	:	Northwest
SE	:	Southeast
NNW	:	North Northwest
SSE	:	South Southeast
NNE	:	North Northeast
SSW	:	South Southwest

PHOTOS AND INFORMATION

Eko Bayu Purwasatriya received the S.T. (2002) from Universitas Gadjah Mada, M.Si. (2008) from Universitas Indonesia, and now study in doctoral program Department of Geological Engineering, Universitas Gadjah Mada. He is a Lecturer in Geological Engineering, Jenderal Soedirman University. His Current interests include petroleum play of Banyumas Basin.

Table 1. Data location

No	Data Location			Latitude			Longitude			Formation
	Village	Sub-district	District	deg	min	sec	deg	min	sec	
1	Darmakradenan	Ajibarang	Banyumas	7	24	25,3	109	0	34,38	Halang
2	Kracak	Ajibarang	Banyumas	7	24	53,92	109	3	1,47	Tapak
3	Kunci	Sidareja	Cilacap	7	27	13,5	108	48	54,6	Kumbang
4	Cipari	Cipari	Cilacap	7	25	47,56	108	46	21,46	Halang
5	Sawangan	Patikraja	Banyumas	7	28	18,19	109	10	7,9	Halang
6	Sanggreman	Rawalo	Banyumas	7	29	53,8	109	8	42,1	Halang
7	Sempor	Sempor	Kebumen	7	32	3,26	109	27	8,71	Karangsambung
8	Srati	Karangbolong	Kebumen	7	45	33,9	109	25	17,6	Gabon
9	Banaran	Jatilawang	Banyumas	7	33	29,7	109	4	24,63	Halang
10	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

1. NW-SE PALEOSTRESS

No	Stopsite			Subset	n	σ1	σ2	σ3	R	R'	Tensor Type	Formation	Shmax	Shmin	Azimuth Shmax
	Village	Sub-District	District												
1	Sempor	Sempor	Banyumas	1	30	30/335	50/108	24/230	0.9	1.1	*extensional STRIKE-SLIP*	Karangsambung	141	51	NW-SE
2	Srati	Karangbolong	Kebumen	1	41	16/343	70/199	11/076	0.46	1.54	*pure STRIKE-SLIP*	Gabon	164	74	NW-SE
					71	28/336	62/149	03/245	0	2	*compressional STRIKE-SLIP*		156	66	NW-SE

2. NNW-SSE PALEOSTRESS

No	Stopsite			Subset	n	σ1	σ2	σ3	R	R'	Tensor Type	Formation	Shmax	Shmin	Azimuth Shmax
	Village	Sub-District	District												
1	Banaran	Jatilawang	Banyumas	1	30	05/173	77/283	12/082	0.38	1.62	*pure STRIKE-SLIP*	Halang	173	83	NNW-SSE
2	Kedungwringin	Jatilawang	Banyumas	2	20	31/178	59/342	07/084	0.13	1.87	*compressional STRIKE-SLIP*	Halang	177	87	NNW-SSE
3	Darmakradenan	Ajibarang	Banyumas	1	24	42/356	48/182	03/089	0.27	1.73	*pure EXTENSIONAL*	Halang	177	87	NNW-SSE
4	Sawangan	Patikraja	Banyumas	1	10	27/170	60/019	12/267	0.64	1.36	*pure STRIKE-SLIP*	Halang	174	84	NNW-SSE
5	Sanggreman	Rawalo	Banyumas	1	15	29/153	44/031	32/264	0.91	1.09	*pure COMPRESSIVE*	Halang	172	82	NNW-SSE
6	Sempor	Sempor	Banyumas	3	11	30/155	34/043	41/276	0.82	2.82	*pure COMPRESSIVE*	Karangsambung	179	89	NNW-SSE
					110	03/177	80/068	10/268	0.58	1.42	*pure STRIKE-SLIP*		177	87	NNW-SSE

3. NNE-SSW PALEOSTRESS

No	Stopsite			Subset	n	σ1	σ2	σ3	R	R'	Tensor Type	Formation	Shmax	Shmin	Azimuth Shmax
	Village	Sub-District	District												
1	Gunungwetan	Jatilawang	Banyumas	1	15	39/009	51/185	02/277	0.24	1.76	*pure STRIKE-SLIP*	Halang	8	98	NNE-SSW
2	Kedungwringin	Jatilawang	Banyumas	1	26	49/189	41/004	03/096	0.57	0.57	*pure EXTENSIONAL*	Halang	7	97	NNE-SSW
3	Kaliputih	Purwojati	Banyumas	1	12	17/189	63/317	20/093	0.93	1.07	*extensional STRIKE-SLIP*	Halang	3	93	NNE-SSW
4	Karangkemiri	Wangon	Banyumas	2	11	16/181	51/065	28/281	0.86	1.14	*extensional STRIKE-SLIP*	Halang	8	98	NNE-SSW
5	Darmaji	Lumbir	Banyumas	2	12	06/188	72/298	17/097	0.49	1.51	*pure STRIKE-SLIP*	Tapak	7	97	NNE-SSW
6	Panimbang	Cimanggu	Cilacap	1	44	04/193	59/289	31/101	0.91	1.09	*extensional STRIKE-SLIP*	Tapak	11	101	NNE-SSW
				2	6	30/114	07/021	59/279	0.95	2.95	*radial COMPRESSIVE*	Tapak	6	96	NNE-SSW
7	Cipari	Cipari	Cilacap	1	21	17/159	18/063	64/289	0.92	2.92	*radial COMPRESSIVE*	Halang	8	98	NNE-SSW
8	Sanggreman	Rawalo	Banyumas	3	12	20/359	21/260	60/128	0.23	2.23	*compressional STRIKE-SLIP*	Halang	1	91	NNE-SSW
					159	18/023	40/129	45/274	0.55	2.55	*pure COMPRESSIVE*		15	105	NNE-SSW

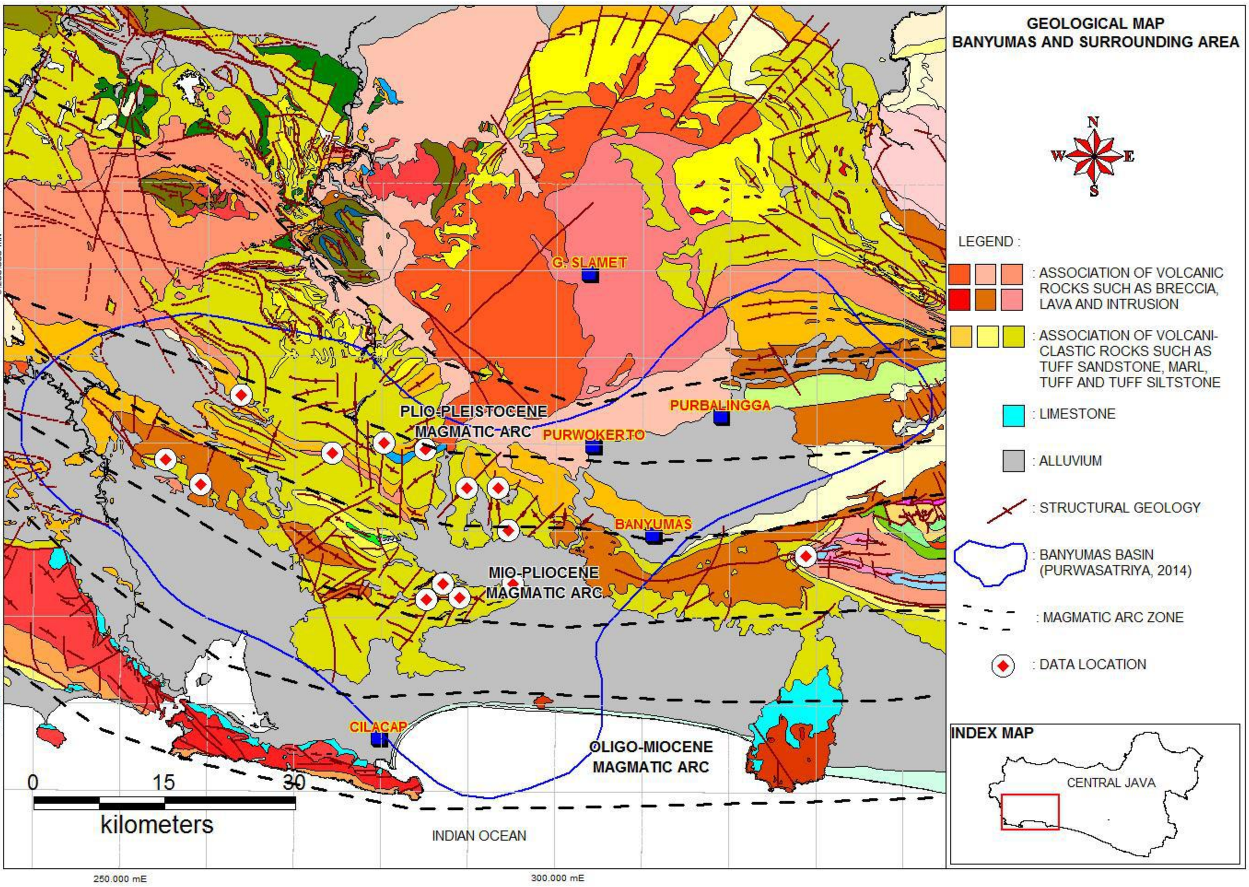

Fig. 1. Data location on geological basemap (modified from Purwasatriya, 2014)

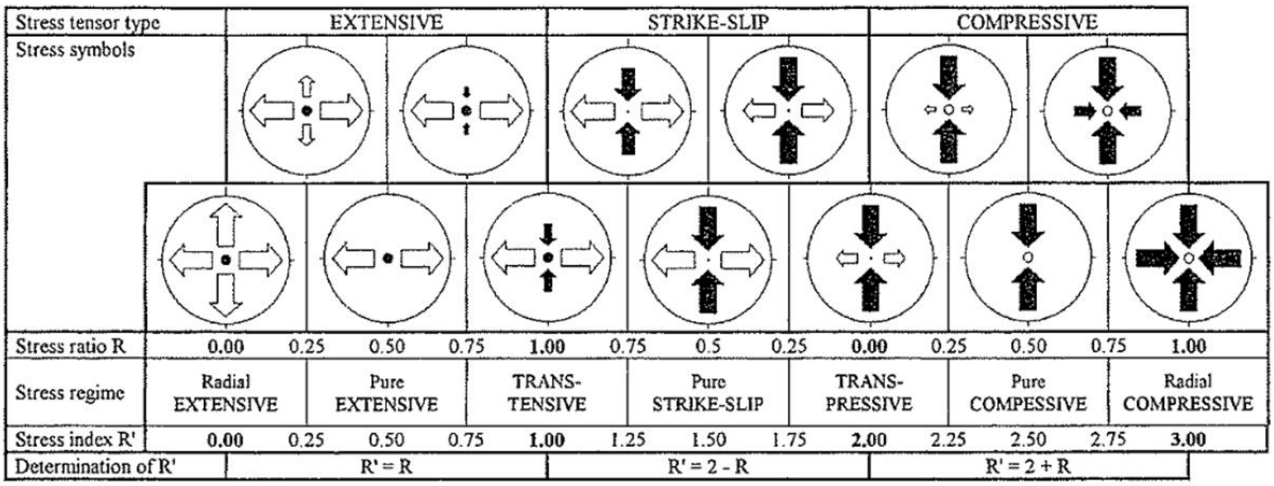

Fig. 2 Stress regime based on direction of principle axes and stress ratio R (Delvaux, 1997)

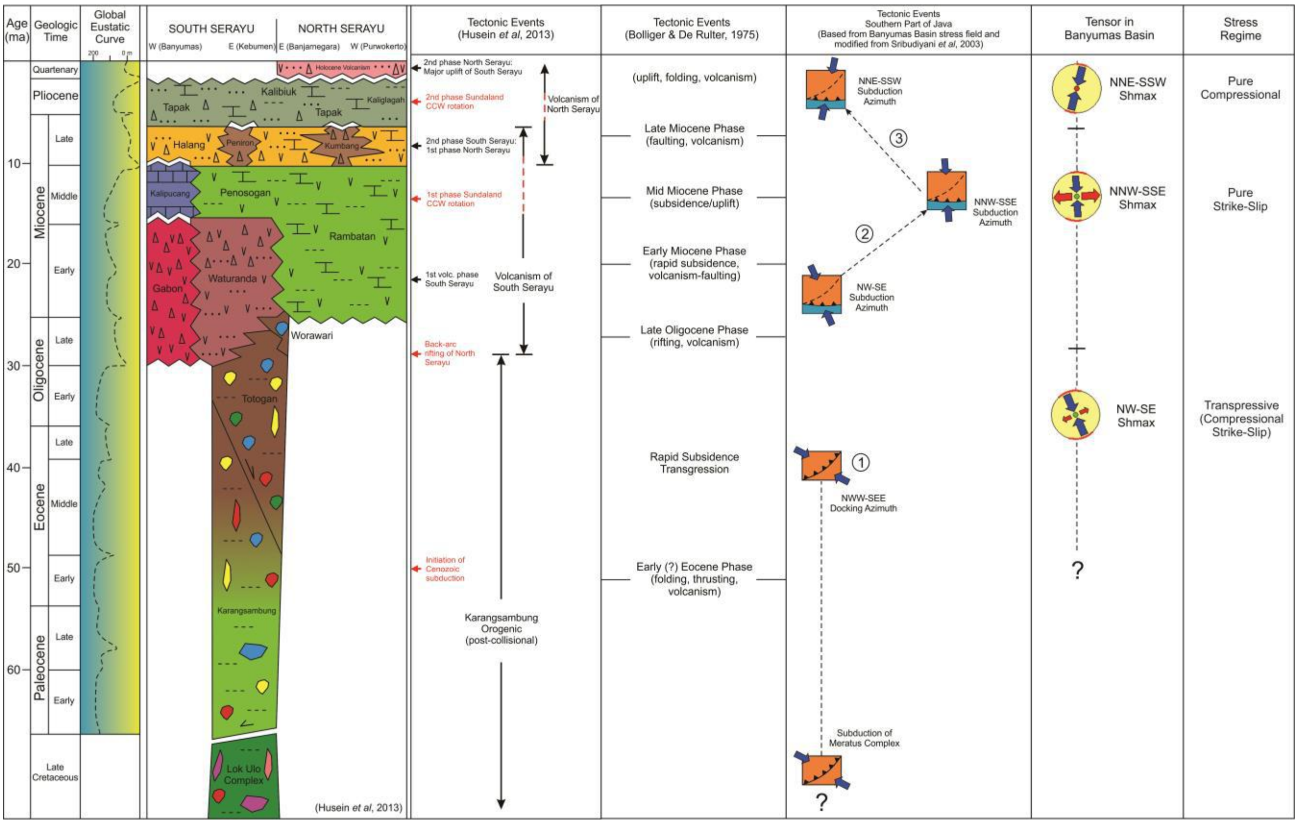

Fig. 3 Tectonostratigraphy of Banyumas Basin (compile from Bolliger & de Ruiter, 1975; Sribudiyani, et al. 2003; Husein, et al. 2013, tensor and stress regime)