



Heavy Oil Seepage Characteristic in Cipari Area, Banyumas Central Java

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ABSTRACT - Oil seepage in Cipari, Banyumas, Central Java, has long been known. Although, Its occurrence had been reported in several publications, it's properties and characteristic, have not been explained in detail. Therefore, through field geology observation and laboratory analysis, this paper attempts to describe the oil seep characteristic, possible source rock origin, and its relationship with geological features in the surrounding area. Picnometer analysis resulted that this oil seep can be classified as heavy oil with 12π API Gravity. Gas Chromatography (GC) & Gas Chromatography Mass Spectrometry (GCMS) analysis revealed that Cipari oil seep is heavily biodegraded. Possible source rock of the oil seep was interpreted based on bicadinane and oleanane biomarkers, which indicated that source was deposited in fluvio-deltaic/transitional environment. Based on regional geology reference of Banyumas sub-Basin, it is inferred that the source rocks possibly shale or claystone of Paleogene sediment which was thermally mature, and deposited in transition to marine environment. Deep seated fault that extent from Majenang to Karangbolong areas is probably the main migration pathway of the oil seepage from the kitchen or deep reservoir to the surface. The Cipari anticline outcrop, which associated with faults and fractures, become the place where the oil seep occurs in the surface. Heavy biodegradation of the oil seep may possibly be accelerated by hydrothermal system during migration from the reservoir/kitchen area to the surface.

Keywords: Oil Seep Cipari, Banyumas Sub-basin, Heavy Oil.

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INTRODUCTION

Oil seepage in Cipari, Banyumas, Central Java (Figure 1), based on local information, has long been known since Dutch colonialism. Local people call this oil seep as “oli”, probably came from Dutch language “olie” which means oil. Several authors had reported and published studies regarding to this oil seep (Mulhadiyono, 1973; Subroto, et al., 2008; Armandita, et al., 2009, Rizal, et al., 2018). However, none of them described in detail about the oil seep properties and characteristic. Therefore, this paper

attempts to explore this oil seep properties and characteristic based on geological field observation, API gravity analysis, geochemical finger printing analysis Gas Chromatography (GC) & Gas Chromatography-Mass Spectrometry (GCMS), and its relationship with geological feature in the surrounding areas.

The oil seep area is located near hot spring in Segaralangu Village, which belongs to Cipari Subdistrict, Cilacap Regency, Central Java Province (Figure 2). The oil seep location is about 60 km to

the West from Purwokerto City, or about 50 km to the Northwest from Cilacap City.

DATA AND METHODS

In general, method used in this study is the integration between field geology and laboratory analysis. The method begins by collecting several related published references and reports. The next step is to visit oil seep location, collection of oil seep sample, while conducting short field geological observation around the area. The oil seep sample is then submitted to the laboratory for physical properties and finger printing (GC & GCMS) analyses. The laboratory results integration with geological regional knowledge and field geology observation are then used to interpret the possible source rock depositional environment and present oil seep occurrence related to geological feature in the area.

RESULTS AND DISCUSSION

A. Field Geology

Banyumas Sub-Basin is a small Tertiary basin located in the west southern part of Central Java. This

basin as described by Bolliger & De Ruiter (1975), is a transition zone between the active volcanic arc of Java and the outer arc basin. Purwastriya, et al. (2018) stated that, based on paleo magmatic arc alignment, the Banyumas Sub-basin tectonic setting during Oligo-Miocene was back-arc basin, then after Plio-Pleistocene became fore-arc basin setting. This sub-basin was filled by transition to marine sediments which was influenced by volcanic material (Figure 3). The oldest sedimentary rocks are Paleogene sediment Karangsembung shale and Jatibungkus limestone followed by Oligo-Miocene Gabon volcanic and marine sediment that deposited during Middle Miocene to Pliocene. The last regional tectonic in Plio-Pleistocene time uplifted the whole area followed by sedimentation of Quaternary Alluvium deposit and deposition of erosional sediment from the oldest rocks. Several exploration well had been drilled within the basin, however none of them found commercial hydrocarbon accumulation (LEMIGAS, 2010).

Morphology of the Cipari area and surrounding is hilly area that formed by faulted anticline which bordered to the south by flat area which represents a depression. This anticline associated with NW-SE regional deep seated fault which extent from northern area of Majenang to Karangbolong. This fault probably

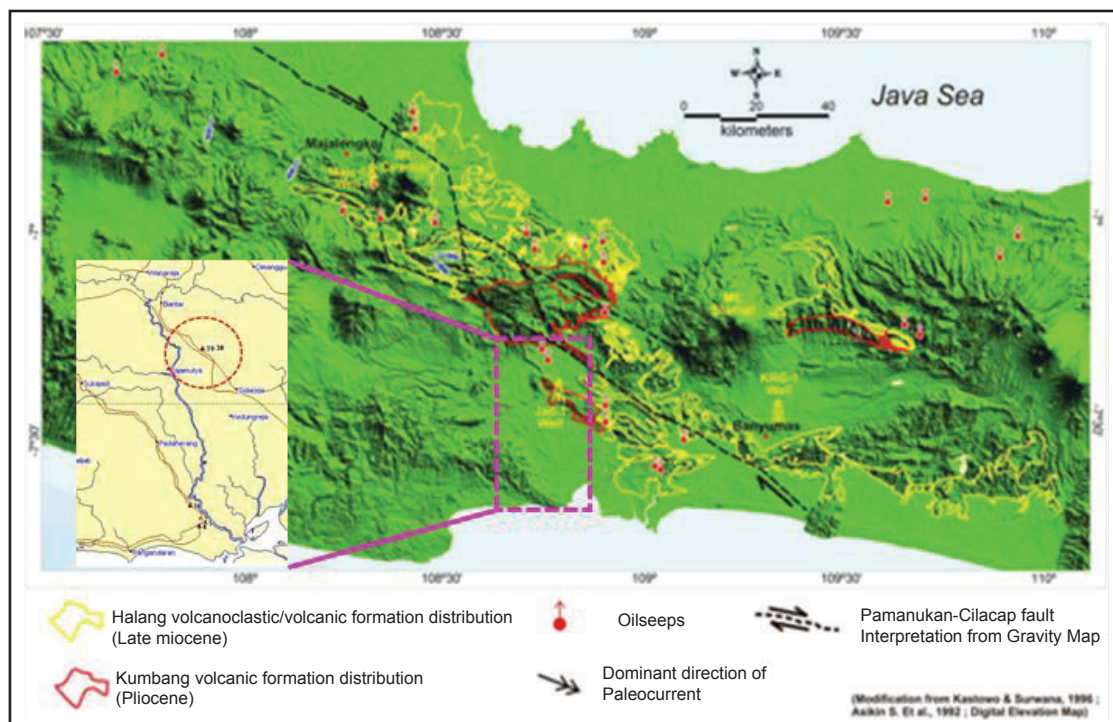


Figure 1
Oil seep distribution in South Central Java and index map of Cipari oil seep location (modified from Armandita, et al., 2009).

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Figure 2
Location map of Cipari oil seep within topographic map of Cipari - Cilacap - Banyumas area.

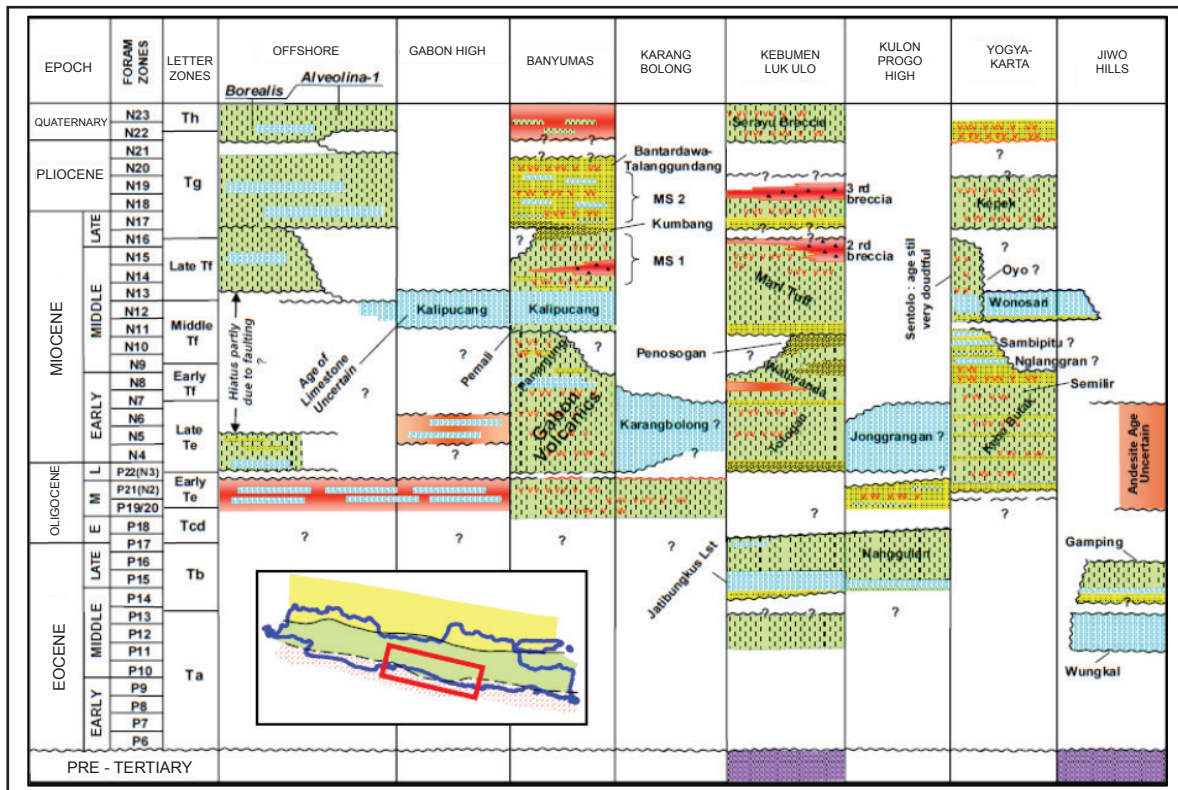


Figure 3
General stratigraphy of Banyumas and Southern Java area (Satyana, 2005).

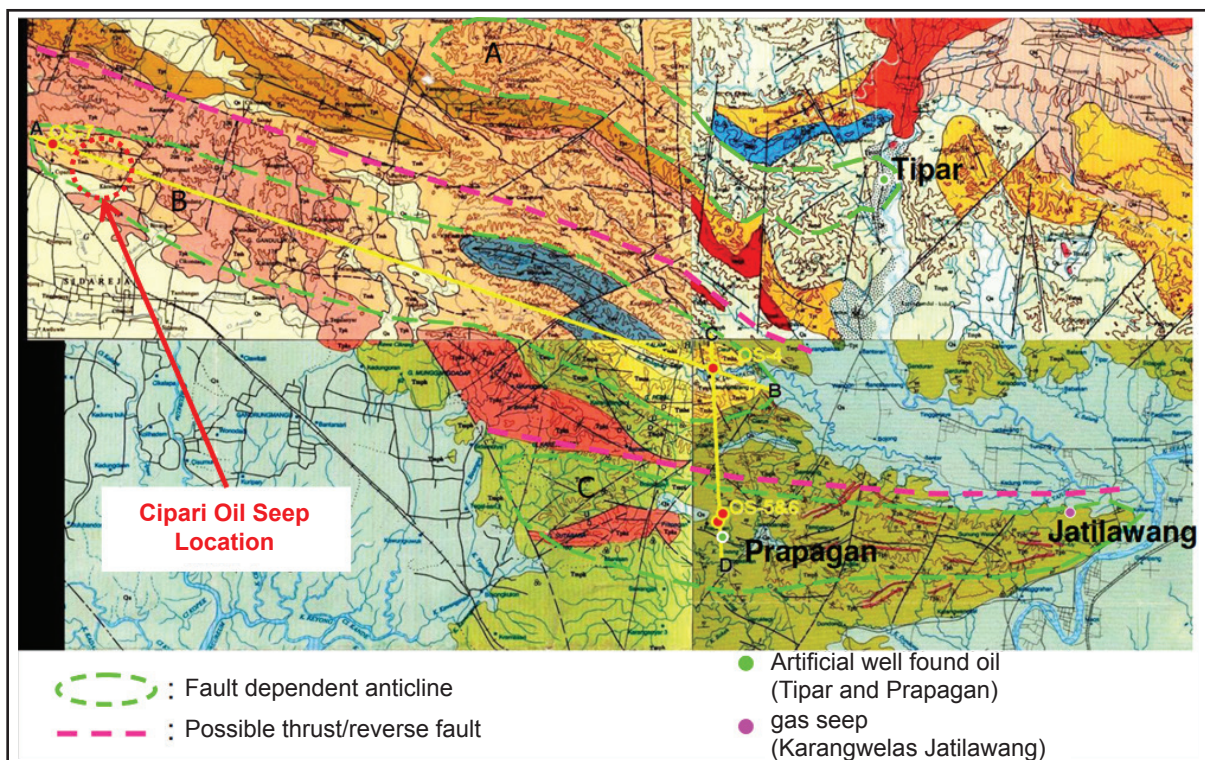


Figure 4
Geological map showing the occurrence of anticline and fault which associated with several oil & gas seepages (modified from Purwasatriya & Waluyo, 2012).

become the main migration pathway for the several oil seepages in the Majenang and Banyumas regions (see Figure 1). Geological map of Cipari

- Jatilawang areas in Banyumas describe several NE-SW trending anticlines, which associated with faults (Figure 4) such as Cipali Anticline trend and

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Banyumas anticline trend. The southern part of the Cipari Anticline is a depression, which is known as Citanduy Basin (Lunt, et al., 2009). The anticlines were dissected by several normal faults and the northern part possibly bounded by thrust fault.

The Cipari oil seep occurs within the Cipari anticlinal trend. It slowly flows from a fracture within

cliff of a creek in Segaralangu village (Figure 5). The oil has brownish to greenish black colour, strong smell, and relatively viscous. It flows mixed with water. It is possible that the oil flows out by water driving mechanism, especially during rainy session. Near the oil seep location, about 200 m to the Southeast, there is a hot spring that is utilized for tourism purposes (Figure 6).



Figure 5

Oil seepage location in Segaralangu village, Cipari Sub-district, Cilacap regency. GPS location: 108°45'54 E, 7°25'41.63 S. Oil seep slowly flows from cliff of the creek (A) and accumulated into a small pond (B). The oil seep sample is taken from this small pond.



Figure 6

Cipari hot spring tourism area.

Figure 6 Oil Seepage location in Segaralangu Village, Cipari Sub-district, Cilacap Regency. GPS location : 108°45'54 E, 7°25'41.63 S. Oil seep slowly flows from cliff of the creek (A) and accumulated into a small pond (B). The oil seep sample is taken from this small pond.

B. Laboratory Analysis Result

The oil sample was analysed at LEMIGAS Laboratory facility (LEMIGAS, 2020) for oil properties and finger printing analysis. Picnometer analysis of the oil samples resulted in 12° API gravity, which means that the oil seep sample can be classified as heavy oil (Meyer, et al., 2007). The result of Gas Chromatography (GC) analysis reveals that the Cipari oil seep sample have lost all their alkane fraction including isoprenoid pristane and phytane (Figure 7), which indicate that the oil had been biodegraded.

Chromatogram of GCMS analysis (Figure 8) describes triterpana distribution (m/z 191) of oil seep sample appears to be dominated by bicadinane resins whereas the hopane compounds are not well detectable. This condition indicates that there has been a very intensive degradation of the oil that is predicted to be due to biodegradation or thermal. The result of the process causes those left in the oil are only high

resistance compounds to the degradation process, such as bikadinana resin (W,T) and oleanane (OL). Oleanane in crude oils is a marker for both source input and geologic age. The oleananes originates from betulins that are produced by *angiosperms* (flowering land plants). *Angiosperm* first became prominent in the Late Cretaceous (Peters & Moldowan, 2005). Oleanane and related compounds are best preserved in deltaic rocks. The Sterane chromatogram (m/z 217) show diasteranes and regular sterane distribution pattern with interference of bicadinanes compounds, which in turn was difficult to identify (Figure 9). These compounds are typical of terrigenous higher plant organic matter deriving from *dipterocarpaceae* species. In the m/z 217 sterane ion chromatograms, they predominantly appear as four distinctive peaks labelled W, T, T' and R.

The occurrence of bicadinane (W, T) and oleanane within the oil sample indicated that the biomarkers derived from higher plant, which was probably deposited in deltaic/transition environment. Ternary diagram based on the composition C27-C28-C29 sterane (Figure 9) indicates that the hydrocarbons in Cipari oil sample originated from fluvio-deltaic depositional environment where the main organic matter influx was dominated by higher plants.

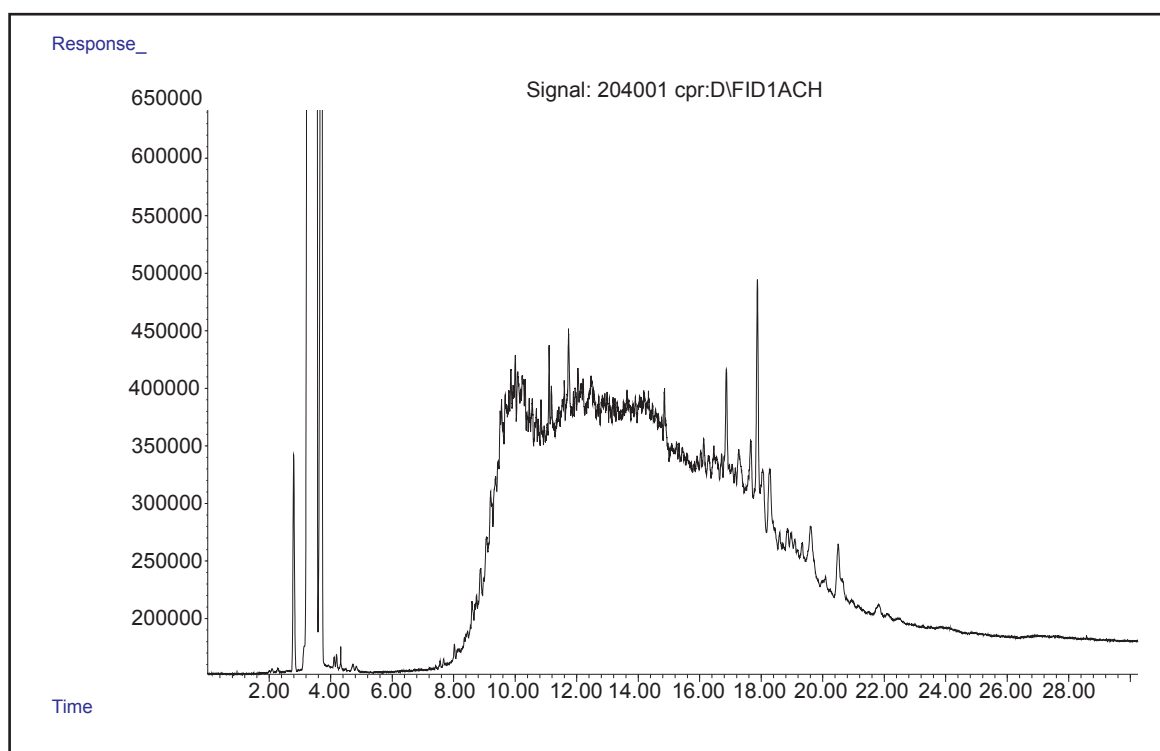


Figure 7
Chromatogram of GC analysis of Cipari oil seep describing that all alkanes fraction has been lost.

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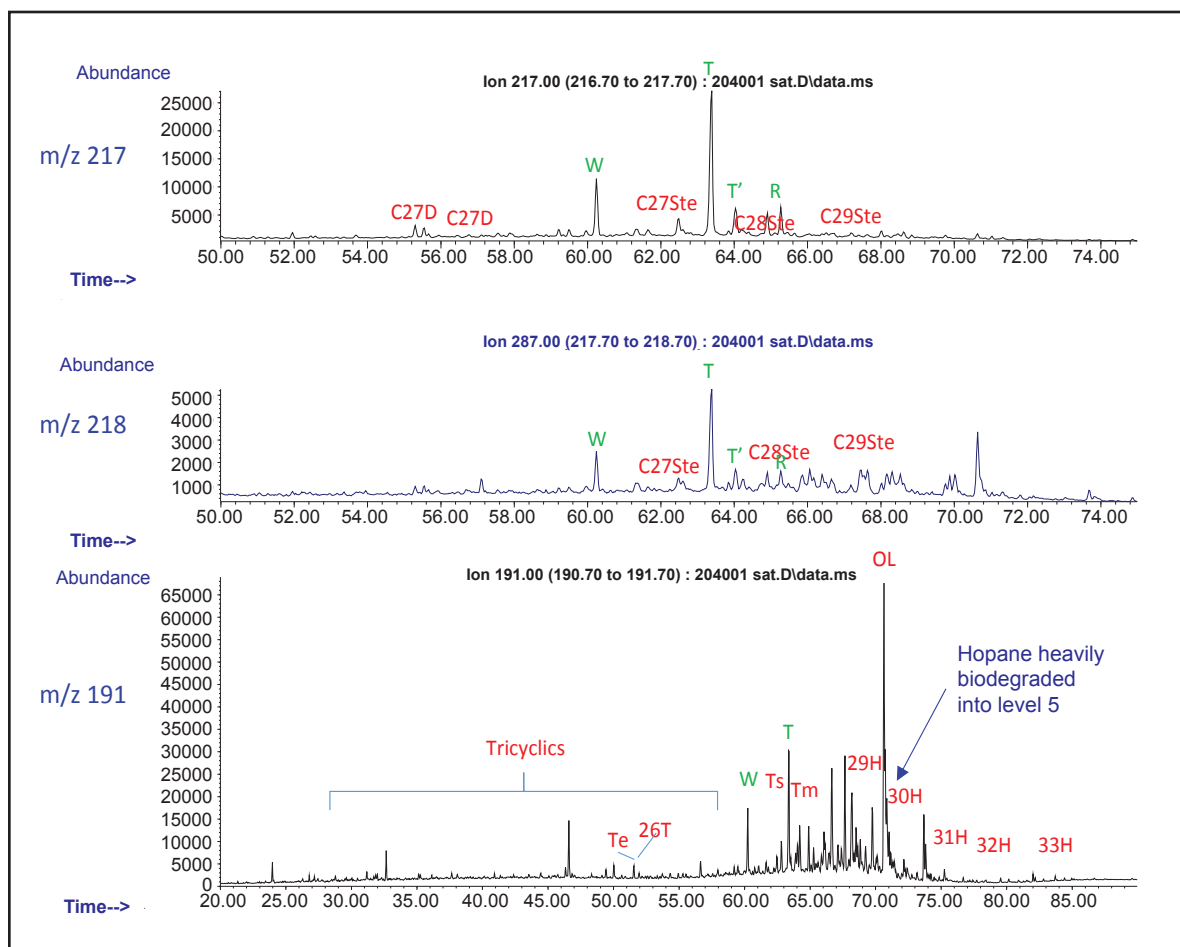


Figure 8
Chromatogram of Gas Chromatography Mass Spectrometry (GCMS) of Cipari oil seep shows high resistance compounds to the degradation process, such as bikadinana resin (W,T) and oleanane (OL).

C. Discussion

Oil seepage in Cipari based on laboratory analysis can be classified as heavy oil (12° API gravity) and also severe biodegraded (level 5-6) based on the table conducted by Head, et al. (2013). The 5-6 levels biodegradation describes that all alkanes and isoprenoid pristane phytane are lost, while Hopane compounds from the triterpane chromatogram are depleted. However, it is unknown whether the heavy oil is entirely produced by biodegradation or there was also thermal influence (hydrothermal) which accelerated the degradation process. With regard to the fact that the oil seep location is near a hot spring associated with regional *deep seated fault* NW-SE from North Majenang to Karangbolong offshore, it was possible that during migration through the fault, the oil also contacted or was affected by hydrothermal which led to thermal degradation of the oil.

Biomarker finger printing results have also revealed that the Cipari oil seep probably originated

from higher plant organic matter which deposited in fluvio-deltaic/ transition sedimentary environment. Unfortunately, this study did not cover collection of rock samples for oil to source correlation due to limited time during fieldwork. Previous correlation study of oil from DST of Jati-1 Well and several seepages in Banyumas Region also indicate fluvio-deltaic characteristic rather than marine characteristic. The biomarkers distribution (tricyclic and pentacyclic triterpanes) of the equivalent Karangsambung sediment (from shallower marine) shows relatively identical with that of the crude oil indicating that they have a good correlation (Subroto, et al., 2008). The other source candidate, the Penosogan shale (Middle Miocene) is still in immature stage. Therefore, it is suggested that the crude oils found as seeps and a DST sample in the Banyumas Sub-basin might be derived from equivalent Eocene Karangsambung Formation (Paleogene) whose depositional environment was shallow marine. However, it is also possible that deltaic sediment of Nanggulan

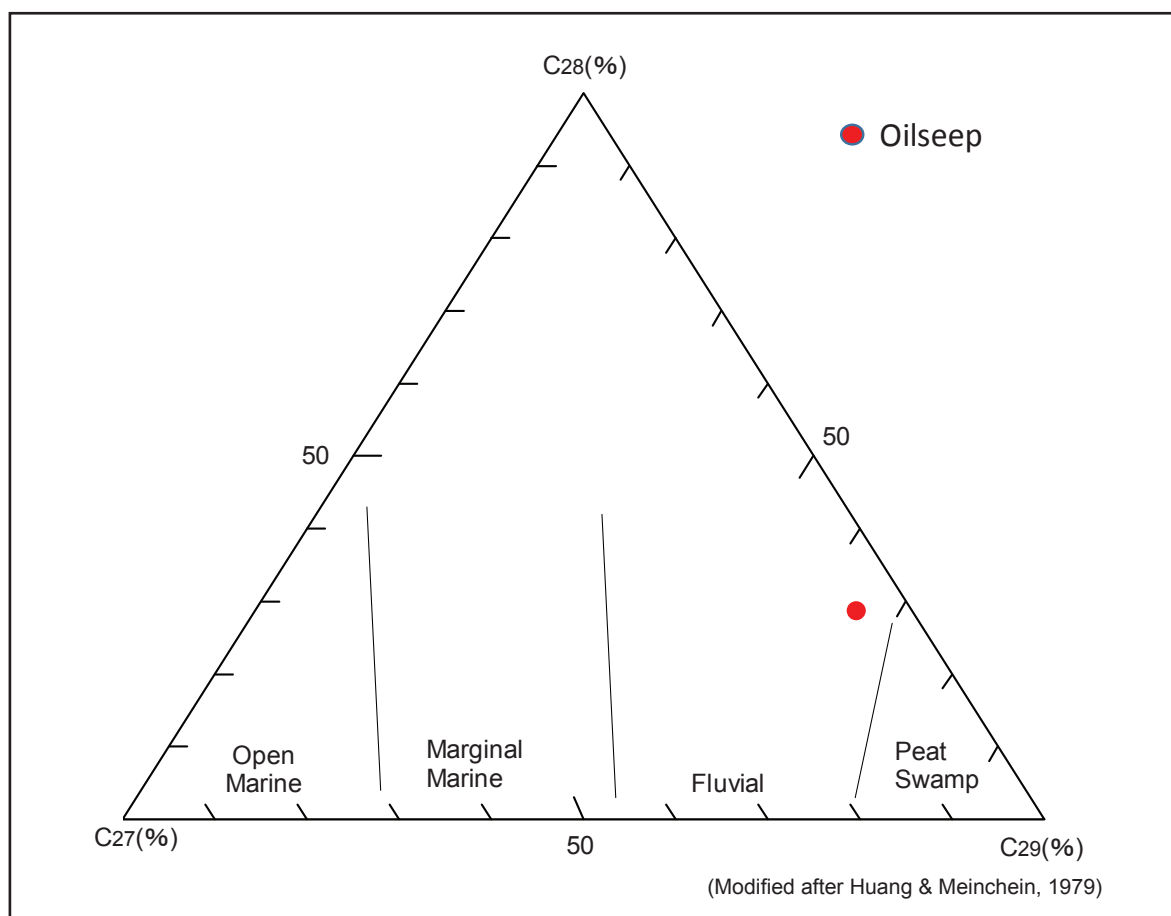


Figure 9
Ternary diagram based on the composition of C27 - C28 - C29 sterane, which indicates that the organic matter of Cipari oil sample possibly came from fluvio-deltaic environment.

Formation (Eocene) could be source for oil in the basin (KIGAM - LEMIGAS, 2011).

Purwasatriya, et al. (2018), described that during Paleogen time, Banyumas sub-basin occurred as back-arc basin setting which more suitable paleogeography for petroleum potential. In the back-arc setting, fine grained sediments with high organic matter content can be deposited and well preserved. During burial history of the basin, the source rocks were thermally mature and the organic matter converted into hydrocarbon. The generated hydrocarbon was expelled and migrated through all available faults and fractures to the reservoirs and some even escaped to the surface as seepages. When the oil associated or contacted with fresh water, it would be biodegraded by micro-organism (bacteria) and resulted in losing of lighter fraction became heavy oil (Head, et al., 2003; Pannekens, et al., 2019).

It is unknown the typical microorganisms that responsible for biodegradation process of the Cipari oil seep. Since there are many microorganisms

are present in oil reservoirs around the world (Pannekens, et al., 2019), the microorganism should be isolated from the Cipari oil and then identified by molecular technique to determines the specific genus or species of microorganisms. Chaillan, et al. (2004) based on their study on identification and biodegradation potential of tropical aerobic hydrocarbon-degrading microorganisms, have identified 33 distinct species of aerobic hydrocarbon (HC)-degrading microorganisms from Indonesia. The bacterial strains belonged to the genera *Gordonia*, *Brevi-bacterium*, *Aeromicrobium*, *Dietzia*, *Burkholderia*, and *Mycobacterium*. However, identification of typical bacteria responsible for biodegradation will led to estimation of possible biodegradation zone temperature and depth. This example demonstrated by Lemigas (Hadimuljono & Firdaus, 2021) which isolated and identified *Burkholderia multivorans* ATCC BAA-247 from oil seep sample taken from Central Sumatera Basin to determine biodegradation

zone in Central Sumatera Basin. Knowing the sub-surface biodegradation zone will help to identify reservoir or hydrocarbon traps that possibly preserve from biodegradation of microorganisms.

Oil seeps prove that the sedimentary rocks within a basin have generated oil and that a mature source rock is present (Link, 1952). As discussed above, the source rock of Cipari oil seep is inferred from Paleogen mature source rock that deposited in fluvio-deltaic environment. In exploration history, oil and gas seeps gave the first clues to most oil producing region. Many oilfields are drilled near or direct to the seepages. Unfortunately, seeps are not always located directly above accumulations. If the seeping hydrocarbons encounter a fault or permeable conduit, their vertical movement may develop a significant lateral component (Waples, 1985). The Cipari oil seep that associated with faults possibly migrated from subsurface reservoirs/ traps or kitchen area somewhere from the seep location. Therefore, it is need more geological and geophysical method to identify sub-surface oil accumulations/ traps within Banyumas sub-basin area.

CONCLUSIONS

Integrated works of field geology and laboratory analysis of Cipari oil seepage led to several main points that can be concluded:

The Cipari oil seep has 12° API Gravity, that can be classified as heavy oil. GC-GCMS analysis revealed losing of lighter fraction of oil, which indicated biodegradation. It is observed that the oil seep associated with fresh water, which led to biodegradation by bacteria during migration and accumulation in surface or shallow reservoir. It is also possible that degradation process accelerated by hydrothermal system near the oil seep location which led to severe biodegradation level.

Finger printing analysis interpreted that the Cipari oil seep probably derived from higher plant organic matter which deposited in fluvio-deltaic/ transition sedimentary environments. It is inferred that the source rock was Paleogen sediment since it has good source potential and enough maturity to generate hydrocarbon.

Oil seep Cipari give the clue for petroleum exploration that sedimentary rocks within Banyumas-subbasin have generated hydrocarbon. It is need more geological and geophysical method to identify

sub-surface oil accumulations/traps within the Banyumas sub-basin area.

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GLOSSARY OF TERMS

Symbol	Definition	Unit
Bacteria	Bacteria are small single-celled organisms. Bacteria are found almost everywhere on Earth and are vital to the planet's ecosystems. Some species can live under extreme conditions of temperature and pressure.	
Biodegradation	Biodegradation is the breakdown of organic matter by microorganisms, such as bacteria and fungi.	
GC	The process of separating compounds in a mixture by injecting a gaseous or liquid sample into a mobile phase, typically called the carrier gas, and passing the gas through a stationary phase. The mobile phase is usually an inert gas or an unreactive gas such as helium, argon, nitrogen or hydrogen	
GC-MS	Combination of gas chromatography with mass spectrometry to enhance its sensitivity. The separated components can be analysed by a mass spectrometric detector (GC-MS) for maximum sensitivity and selectivity.	

Symbol	Definition	Unit
Heavy Oil	Heavy oil is a crude oil that has a viscosity typically greater than 0.01 Pa. s [10 cP] and a high specific gravity. The World Petroleum Congress classifies heavy oils as crude oils that have a gravity below 22.3 degree API	
Oil seepage	a natural leak of crude oil that migrates up through the surface or seafloor	
Microorganism	an organism of microscopic size, which may exist in its single-celled form or as a colony of cells.	
Migration	Movement of bitumen, oil, and gas in the subsurface. Migration includes expulsion (primary migration), secondary migration, accumulation, and leakage.	
Source rock	a rock rich in organic matter which, if heated sufficiently, will generate oil or gas	

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