Lithofacies analysis, ichnofacies analysis and depositional environment of Jatiluhur Formation in Cipamingkis area

W Imanda, B Ramadhan, I Aulia, R A Y Harahap and R Aditiyo
Geoscience Study Program, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia

Corresponding author's email: rezkyaditiyo@sci.ui.ac.id

Abstract. Depositional environment of Jatiluhur Formation is a very interesting research object to study, especially from the geological and biological aspects. This formation is very well exposed in several rivers in Bogor, especially in the Cipamingkis River. Field studies were carried out by measuring section method and ichnofossil description along the section. Stratigraphy log data shows the overall upward coarsening with a length of 66 meters. There are 4 facies associations from stratigraphy log data and the description of ichnofossil, FA1 is interpreted as a classical turbidite deposition process seen from alternating pattern of thin carbonate sandstones with carbonate siltstone in relative depths in the bathyal to sublittoral zone seen from Scleria, Thalassinoides, and Opiomorpha seen in this section, FA2 is interpreted as a turbidite deposition process in the upper-fan section seen from the lithology of thick carbonate claystone and carbonate sandstones in the form of inserts at a relative depth in the sublittoral zone seen by ichnofossil found in the form of Circulishnis, FA3 is interpreted as an upper fan or channel fill seen from the structure The slump in this section that occurs at a sublittoral depth is seen from its ichnofossils, namely Rhizocorallium and Thalassinoides, and FA4 is interpreted as shallow marine seen from the lithology dominated by carbonate sandstones with tires. Depositional environment of the Jatiluhur Formation shows that depth at bottom of section is deeper than upper section and deposition process from turbidite to shallow marine.

Keywords: Depositional environment, Jatiluhur Formation, lithofacies, ichnofacies

1. Introduction
Jatiluhur Formation outcrops are spread along Cipamingkis River, Cileungsi River, and Cihoe River. Jatiluhur Formation outcrop in the northern part of the Bogor Basin, for example in Cipamingkis River, is often used as a reference for the reservoir rock analogy of Cibulakan Formation in the North West Java Basin [1]. Many studies have been done in this section regarding paleobathymetry by Fauzielly [2], and lithofacies by Abdurrahman [1] in Jatiluhur Formation. This research was conducted in detail to determine the depositional environment in area with the addition of ichnofossil data. Ichnofossil is the biological activity of organisms that have become fossilized, but the bodies of animals or plants are not preserved. Ichnofossil study discusses depositional environment in detail from depth zone called ichnofacies. Therefore, this study was conducted to determine depositional environment of Jatiluhur Formation based on lithofacies and ichnofacies.
2. Geological setting
The research is located in Cipamingkis river at Jonggol District, Bogor, West Java Province (figure 1). Jatiluhur Formation, which is well exposed along Cipamingkis River, is oldest exposed rock formation in northern part of the Bogor Basin [3]. Jatiluhur Formation consists of limestone-inserted limestone claystone and limestone sandstone with limestone claystones ranging in age from Early Miocene to Middle Miocene [4]. The lower boundary of this formation is not exposed while the upper boundary is deposited with Klapanunggal Formation, Cantayan Formation, and Subang Formation which overlap in line with the Jatiluhur Formation (figure 2) [5]. This formation also contains several trace fossils that can support data from the depositional environment process [1]. The condition of the outcrop in Cipamingkis River lies along with the river flow from north to south with at several points there are burrows indicating faults in the area.

3. Data and methodology
The method used is measurement of stratigraphic sections and descriptions of ichnofossils contained in the outcrops. After that, we identified the ichnofossil found based on existing literature and correlated it based on the measuring section results. This is data that has been taken from the field with a section length of 66 meters, has a lithology of calcareous claystone, calcareous sandstone, and calcareous siltstone. In-addition there are ichnofossils in several layers along the section (figure 3).

Figure 1. Map of study area
Figure 2. Cenozoic stratigraphic sequences in Bogor Basin and North West Java Basin [6].

4. Discussion
Stratigraphy log data along 66 meters divided into 4 facies associations based on ichnofossil and lithofacies. Identification of lithofacies in the section refers to submarine-fan model by Walker [6]. Meanwhile, identification of ichnofacies is divided based on distribution of trace-making organisms, which can determine depth when deposition process occurred by Saitacher [7].

4.1. Facies association 1
FA1 consists of alternating carbonate claystone with carbonate sandstones and thickening at the top (upward coarsening) and repeating (figure 3). The thickness of these facies is 23 meters. The lithofacies consist of massive mudstone to siltstone (Fm), bioturbated sandstone (Sb), and massive sandstone (Sm) (figure 4). Ichnofossil found at the bottom of the section contained ophiomorpha, thalassinoides, and scolia (figure 5). While the upper part is thalassinoides and planolites. These ichnofossils are interpreted as changing ichnofacies from zoophycos (bottom) to cruziana (upper).

These characteristics are interpreted in the vertical model of submarine-fan by Walker [6] to be on lower-fan. From lithology and submarine-fan model, it can be concluded that the association of lithofacies is turbidite [6]. The ichnofacies were in the bathyal zone to the sublittoral zone [7].

4.2. Facies association 2
FA2 consists of calcareous claystone and calcareous sandstone with thickness is 17 m. Calcareous sandstone has a parallel lamination. Lithofacies consist of massive mudstone to siltstone (Fm) (figure 6) and horizontally laminated sandstone (Sh). Ichnofossils found on these facies are Circulichnis (figure 7) at the bottom of the section and Thalassinoides at the top of the section which is exactly in the lower of FA3.

This facies is interpreted in the submarine-fan model as a thin-bedded levee in upper-fan. From these characteristics, the association of lithofacies is included in turbidite [6]. Circulichnis is most frequent in bedded deep-sea sediment and more frequently from turbiditic deposits [8]. Thalassinoides enter into cruziana ichnofacies which have a depth in sublittoral zone [7]. Lithofacies and ichnofacies in FA2 show the process of turbidite deposition in sublittoral zone.
Figure 3. Stratigraphy log and Ichnofossil data from field.

Figure 4. Massive mudstone to siltstone lithofacies (Fm) outcrop and massive sandstone lithofacies (Sm) has a brown colour.

Figure 5. Scolicia has a diameter of 4 cm, length 10 cm, and horizontal subtract. Included in zoophycos ichnofacies, preserved in the bathyal zone.
4.3. Facies association 3

FA3 consists of layers of calcareous sandstones and calcareous siltstone with a thickness of 17 m. Lithofacies consist of massive mudstone to siltstone (Fm), bioturbated sandstone (Sb), slump sandstone (Ss) (figure 8). Ichnofossils found on these facies are *Rhizocorallium* and *Thalassinoides* at the bottom of the section (figure 9).

In this facies association, there is a slump in the middle section with a thickness of 3 m which indicates the deposition process occurs in the shelf margin and in the submarine-fan model including the upper fan channel fill [6]. Ichnofossils found on this facies fall into the cruziana ichnofacies indicating the depth of sublittoral zone [7]. FA3 shows the deposition process occurs in the upper fan, channel fill in the sublittoral zone.

**Figure 6.** Massive mudstone to siltstone lithofacies (Fm) outcrop.

**Figure 7.** Circulishnis has a circular shape, 5 cm diameter, and is horizontal to the substrate. Preserved in turbidite environment.

**Figure 8.** Slump Structure in Sandstone (Ss).

**Figure 9.** *Thalassinoides* has a sediment-filled tunnel with a diameter of 2 cm, horizontal to the substrate, penetration length > 15 cm. Include in Cruziana Ichnofacies, preserved in sublittoral zone.
4.4. Facies association 4
FA4 consists of calcareous sandstone and calcareous siltstone layers with a thickness of 9 m. Lithofacies consist of wavy laminated sandstone (Sw) (figure 10), trough cross-stratified sandstone (St), and massive siltstone (Fm). In the calcareous sandstone layer, there are several sedimentary structures. At the bottom of section, FA4 has a wave ripple that shows steady current conditions during the deposition process. In the middle of section, parallel laminations begin to appear, then cross laminations show a change in the direction of current (figure 3). Ichnofossils found in these facies are Planolites and Taenidium (figure 11) which are included in cruziana ichnofacies and skoolithos ichnofacies [7].

Existence of a sedimentary structure is influenced by ocean currents which indicate the deposition process occurs in shallow marine. It was also strengthened by two ichnofacies who concluded that its depth includes sublittoral to litoral zone. FA4 shows that the deposition process occurred in shallow marine based on lithofacies, ichnofacies, and added with sedimentary structures formed during deposition process.

5. Conclusion
Stratigraphy log data and ichnofossil are divided into 4 facies associations. Facies association gradually changed from the lowest one is FA1 showing the deposition process of turbidite to FA4 which shows the deposition process in shallow marine. Facies association 1 shows the classical turbidite process from bathyal to sublittoral, facies association 2 shows the turbidite environment in the sublittoral zone, facies association 3 shows the upper fan channel fill environment in the sublittoral zone, and facies association 4 shows shallow marine in the littoral zone. Overall depositional environment of Jatiluhur Formation is getting shallower. These results are inseparable from Lithofacies and Ichnofacies, which can continuously produce more detailed data about the depositional environment of the section.

Acknowledgments
We would like to express our special thanks of gratitude to Hibah Publikasi Terindeks Internasional Prosiding 2020 (Hibah PUTI PROSIDING 2020) Fiscal Year with contract number NKB-1034/UN2.RST/HKP.05.00/2020 for sponsoring this research.
References
[1] Abdurrokhim and Ito M 2013 *J. Asian Earth Sci.* 73 68-86
[2] Fauzielly L, Jurnaliah L and Fitriani R 2018 *Riset Geologi dan Pertambangan* 28 157-66
[3] Sudjatmiko 1972 *Peta Geologi Lembor Cianjur, Jawa Barat Skala 1: 100.000* (Bandung: Pusat Penelitian dan Pengenambangan Geologi)
[4] Martodjojo S 1984 *Evolusi Cekungan Bogor* PhD Thesis (Jawa Barat: Institut Teknologi Bandung)
[5] Suyono, Sahudi K and Prasetya I 2005 *Exploration in West Java: Play Concepts in the Past, Present, and Future Efforts to Maintain Reserves Growth* (IPA pp 267-81)
[6] Walker R G 1978 *American Association of Petroleum Geologists Bulletin* 62 932-66
[7] Seilacher A 1978 Use of trace fossil assemblage for recognizing depositional environments in *Trace Fossil Concepts* ed Basan P B (Tulsa: Society of Economic Paleontologists and Mineralogists) pp 167-81
[8] Pickerill R K and Keppie J D 1981 *Maritime Sediments and Atlantic Geology* 7 130-8