Cone penetration test for facies study: a review

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Abstract. Engineering geology investigation through Cone Penetration Test (with pore-pressure measurements) approach is one of the most effective methods to find out sub surface layer. This method is generally used in Late Quaternary and typical deposit and can also be used for sedimentological purposes. CPTu and drilling core for high-resolution stratigraphy sub surface have been done in many research. These combined data can also be used to detail correlations of sub surface stratigraphy, to identify facies change and to determine the interpretation of sequence stratigraphy. The determination facies distribution research based on CPTu profile, which was included in quantitative data, is rarely done especially in Indonesia which has a different climate. Whereas drilling core description using grain size analysis will provide information on validation about physical lithology characteristics which are developed in research area. The interpretation is given using CPTu curve pattern and cone resistance parameter of CPTu’s data correlated with physical characteristics of drilling core. The cone resistance will provide the strength of the sediment layer which also gives the range of data between clay and sand. Finally, the review will show that each of developing facies characteristic provides a specific curve pattern and every sediment deposit facies can be determined by the transformation of CPTu curve profile. Despite the fact that the research using those methods are quite comprehensive, a review is presented on each of these methods related with the chronologic factor seen by the geological time and different characteristics sediment of different location.

1. Introduction
Cone Penetration Test with pore-pressure measurements (CPTu) is the main equipment which is mostly used in geotechnical investigation activity. This tool is a method used to determine geotechnical and describe sediment characteristics [1]. CPTu generates a continuous sub surface profile which is visualized on the computer screen. This test does not produce a physical sample, but it can be used to interpret the engineering and stratigraphy aspects in more detailed. The interpretation that can be done consists of lithology, sediment classification, and boundaries change the identification of sediments stratigraphy [2] (Figure 1). If the engineering aspects are combined with geologic interpretation, they will provide high resolution of stratigraphy interpretation, specifically facies and stratigraphy correlation. (Figure 2, 3) [1-5].

The discussion covers whether CPTu method can be combined with chronostratigraphy, such as grain size, and granulometric method in which it only measures rocks layer. In addition, facies is a body of rock with specified characteristics, which can be any observable attribute of rocks such as their overall appearance, composition, or condition of formation, and the changes that may occur in those attributes over a geographic area [6]. It is the sum total characteristics of a rock including its chemical, physical, and biological features that distinguishes it from adjacent rock [7-8]. Analysis of grain size, granulometry and fossil description will provide more detailed information about the diagenesis of the facies.
Figure 1. An example of sediments type interpretation based on CPTu using CPT-It software.

Figure 2. Facies interpretation based on CPTu [1].

2. Methods
Wireline log is one of the methods aim to improve the visualization of inter-well-scale lateral continuity (and discontinuity) of strata and to demonstrate the reliability and potential pitfalls of sub surface wireline log correlations [9]. It is also generally used to interpret geology aspect in the petroleum industry.

In the description, gamma ray log is one of petroleum log which is used to interpret lithology of rocks, and the principles are evaluation of shale content (V-shale) or fine fraction and recording grain size change of a sediment through certain curve pattern. CPTu is a geotechnical tool which is used to determine geotechnical sediment characteristics and describe sediment stratigraphy. The principle of CPTu is to measure cone and sleeve friction to interpret lithology. From this condition, two of these tools can be correlated to lithology and geology interpretation (Figure 4).
The facies is a body rock which has characteristics and feature combination related to physic, biology, or chemical aspects compared to lithology, sediment and biology structure that differ from upper, lower, or parallel layer that occur at the same time [9]. Moreover, one time plane is reflected by bedding plane which is shown by grain size difference, mineral content, texture, and structure. The difference between one facies to another will provide an ideal model which shows different deposition and environment conditions [9].

Facies determination is strongly influenced by several factors including chemical, biology and physic condition in a body of rock. This matter requires us to analyze them appropriately so that it will provide an ideal description of how facies is formed. Nevertheless, this research does not analyze the biological aspect (e.g., fossil or granulometric analysis) that will give uncertainty about the compatibility of sediment deposition formation of a facies.

3. Summary
This research has reconstructed facies based on CPTu data to determine its deposit pattern. On the other hand, this research only determines deposit environment based on lithostratigraphy without analyzing the sample using the grain size method. With this method at least the environment of the facies can be obtained clearly. It seems contradictory that every layer of soil/rocks consists of a fossil representing the age of a rock. Furthermore, the fossil also specifically provides types of deposit sediment environment.

One of important point in this paper is that it does not criticize the application method which is used in sub-tropic climate such as in Indonesia. This condition will influence some factors related to weathering and sedimentation rate, grain size and shape, fossil content type, and diagenesis of sediment environment condition in the area. Similarity in grain size and shape will be provided, but it will be different in the weathering process (in this case time process and morphological factors) is not calculated.
| Silindris | Funnel shape | Bell shape | Simetris | Cressentik |
|----------|-------------|------------|----------|------------|
| Braided fluvial channel | Barrier island distributary mouth bar | Fluvial point bar tidal point bar transgressive shelf sand | Transgressive shelf sand | Flood plain |

**Figure 4.** Correlation between CPTu and gamma ray log (James and Walker, 1992; Amorisi and Marchi, 1999).

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