Flume tank experiment: An approach in replicating sequence stratigraphy in a laboratory scale

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Abstract. Sequence stratigraphy was a study of layered rocks that form in some period of time. It was proven to be a useful tool in industry, especially oil industry. Yet, sequence stratigraphy most people have seen was the result, not the process. Of which, this study wanted to replicate the process that was taken place in sequence stratigraphy in a smaller scale of a laboratory.

To replicate sequence stratigraphy, this study used a flume tank device filled with sand and water flowing with controlled rate. This study makes changes in water level in the flume tank to affect accommodation space, on which sedimentation happens, thus, making some morphological change known as progradation and retrogradation. Changes were recorded using time lapse camera and measured using laser distance meter to see how much the morphology had changed after some period of time. Result of this study showed that transgression and regression could be replicated inside the flume tank by changing the height of water level. Though the time scale could not be made close to real condition, but the process and the result could. This would help understanding sequence stratigraphy not only from the outcrop but also from the series of the process that made it.

Keywords: Sequence stratigraphy, flume tank, progradation, retrogradation

1. Introduction
Sequence stratigraphy is based on the premise that sedimentary succession that could be divided into unconformity-bounded units (sequence) that form during a single, mayor cycle of sea level change [1, 2]. Several terms that are commonly used in sequence stratigraphy are progradation, retrogradation, aggradation, transgression and regression. Progradation is a condition when accommodation space is lower than sediment rate, while retrogradation is a condition when accommodation space is higher than sediment supply rate [3]. Accommodation space is a space on which sediment can freely accumulates at any point of time, the space is placed so well that sediment can only be deposited not eroded [1-3]. Transgression is a condition of sea level rising, while the regression is a condition of sea level sinking [3].

Being widely used in industry, especially in oil industry, sequence stratigraphy was one of the most reliable method of correlating oil reservoir [4]. Most of industrial use of sequence stratigraphy were just the result of the combined process of many sedimentation patterns. Aim of this study is to replicate sequence stratigraphy into a much smaller scale in a laboratory using flume tank to see how sequence stratigraphy really works.
The main focus of this study would be on using constant sediment supply and manipulating accommodation space inside the tank to affect the sedimentation pattern. To manipulate water level, inlet and outlet had to be set specifically as it was in the real condition of transgression and regression. It was expected to affect sedimentary process so that retrogradation and progradation happen.

2. Data and method

2.1. Experimental facility
Device used in this study was a flume tank with dimension of 3 x 1 x 0.5 m (figure 1). The flume tank was made of metal plate and glass so that it could withstand the weight of sand and water filled in. It has two water pumps as an inlet and outlet. Both inlet and outlet are connected with flow meter to measure how much of water is in and out. The tank stands 0.7 m above the ground with metal feet. Attached to the feet are two hydraulic jacks to lift up the tank into certain angle so that it created slope on the surface of the tank. The walls of the tank, which made of glass, were attached with a ruler to measure quantitative change of the morphology formed inside.

To create initial morphology inside the tank, the sand was formed to replicate transitional zone between channel and shoreline. It was then measured using laser distance meter, to create Digital Elevation Model (DEM). Time lapse camera were used to observe the morphological change gradually.

Water used to fill the tank was a fresh water which pumped using specific flow measured by flow meter to ensure that the flow and the time was scaled as it was in the real condition. Sediment particles used in this study were fine to very fine sand (90 Quartz), to be able to be transported and deposited in a flume tank condition. Sediment particles were taken from Sawarna Beach, Banten.

2.2. Changing water level
Water level was set to mimic the condition of transgression and regression. To begin the study, water level was set at the height of 31 mm, due to the capacity limit of the flume tank. This was normal height of water level before transgression or regression happened. Sediment supply was set to be constant to maintain the aggradation. Water level then modified to 7 mm higher to simulate transgression and 3 mm lower to simulate regression. Reynolds scaling down method was not applied because the water level was not considered. Time dependent transgression and regression were diminished because the scaling down the million years event was not applicable in this study [5, 6].

It was expected to have some changes in the morphology formed inside the tank, like the position and size of delta, after transgression and regression happened. To get clearer result, each morphology of the progradation, aggradation, and retrogradation were scanned using laser distance meter to create DEM afterward.

![Figure 1. Flume tank design used in this study. The dimension is 3 x 1x 0.5 m.](image)
3. Results and discussion
At the beginning of this study, flume tank condition was set to normal condition (figure 2) and shown to form delta at the end of the channel, water level was at the height of 31 mm. Delta was normally formed on the downstream of a channel that connected to sea. After the water level was made to be risen from 31 mm to 38 mm, morphology inside the tank changed into retrogradation (figure 3). Delta formation was drawn back into the channel because the water level rose, and the accommodation space was reduced. This represented transgression in a real depositional setting.

![Figure 2](image1.png)
![Figure 3](image2.png)

**Figure 2.** Normal condition of the morphology inside tank, water level in this condition was normal, (a) map view, (b) 3D view and (c) photo from the experiment. Red line indicates the initial condition of the morphology.

**Figure 3.** Retrogradation condition of the morphology inside tank after water level had been risen, (a) map view, (b) 3D view and (c) photo from the experiment. Yellow line indicates the retrogradation condition.
Figure 3 (continued). Retrogradation condition of the morphology inside tank after water level had been risen, (a) map view, (b) 3D view and (c) photo from the experiment. Yellow line indicates the retrogradation condition.

Figure 4. Progradation condition of the morphology inside tank after water level had been sunk, (a) map view, (b) 3D view and (c) photo from the experiment. Green line indicates the progradation condition.

When water level was made to be sank from 31 mm to 28 mm, the delta formed further from the channel and the morphology changed to progradation (figure 4). This happened because as the water level sank, the accommodation space was getting larger and wider, therefore allowed delta to form further from the channel. The process of the sea level sinking was called as regression.
4. Conclusion

After some tests, transgression and regression can be replicated in the flume tank by changing the water level 7 mm higher to make transgression and 3 mm lower to make regression. In this study, normal height of water is 31 mm. Water level rising made accommodation bigger and sedimentation pattern changes into retrogradation. Water level sinking made accommodation smaller and sedimentation pattern changes into progradation.

Stratigraphic sequence could be replicated into a laboratory scale using flume tank albeit the scaling down of the processes could not be made close to the real condition. Still, it is a helpful tool to understand the subject in a process-based understanding. It means that using this experiment, stratigraphic sequence can be understood not only from outcrop but also from the series of the process that made it.

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