Initial Report on OSL Dating from Pailin Beach Ridge Plain, Trat Province, Eastern Gulf of Thailand with Special Highlight to Record of the Holocene Sea Level Change

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Abstract

A long and narrow Pailin Beach is located in Trat province, the eastern coast of the Gulf of Thailand. The area is dominated by beach ridge plain that is preserved well with no anthropogenic disturbance. This area is appropriate for relating beach evolution with sea-level change. The coastal geomorphology is classified into 4 units including the former sand beach, recent sand beach, old lagoon, upland and mountain. The physical properties of the beach ridge sediments are composed of fine sand, moderately well to well-sorted, and high quartz content. Age determination by optically stimulated luminescence (OSL) dating reveals the formation of beach ridges related to sea-level changes from middle to late Holocene. The beach ridge began to form around 3,230 ± 250 years ago to 1,750±150 years ago. The decreasing age reflects the gradual fall of the sea level during that time.

Keywords: Beach ridge, OSL dating, Sea level change, Holocene

1. Introduction

The sea level has changed frequently in the Holocene, both rising and falling. It is well known that the cause of this change is climatic factors inducing the global sea level fluctuations. In Thailand, the sea level maximum highstand of about 4 m above the present mean sea level occurred approximately 6,000 years ago (Sinsakul et al., 2002). The rising sea level at that time had a profound impact on the evolution, development of terrain, and the formation of coastal sediment deposition (Choowong, 2002). Understanding the history of sea level change is significant as a basis for evaluating the local or regional causes of sea level fluctuations. These data sets, more or less, can be helpful for making people awareness of the coastal hazards and can be inspiring to reduce the problem in the coastal environment.

Pailin beach is located in Trat province, on the eastern coast of the Gulf of Thailand (Figure 1). The satellite images interpretation shows that the coastal zone includes long and narrow beach ridge plains. As beach ridge is one of good indicators of sea-level change, straight beach ridge here appears to preserve the transgression and regression during the Holocene. The main objective of this paper is to present the result of our investigation in sediment characteristics of the beach ridge plain and to determine the absolute age in relation to sea-level changes.

2. Materials and Methods

The methodology can be divided into 3 steps. The first step was pre-field work. This step started with the interpretation of satellite images for the identification of coastal geomorphology and planning for field survey to determine the location for collecting sediment samples.

Fieldwork was performed to check the interpreted geomorphological units. It was not only intended to verify the correctness of the interpretation, but also to conduct a detailed topographic survey of beach ridge plains by Real-Time Kinematic Global Navigation Satellite System (RTK GNSS). Then, the fieldwork included the study and description of the stratigraphy of the beach ridge sediment as well as collecting sediment samples. The samples were collected in vertical pits deeper than the topsoil to prevent disturbance and contamination in the beach ridge. The last step was the laboratory analysis, bringing the samples to age determination using optically stimulated luminescence (OSL) dating.

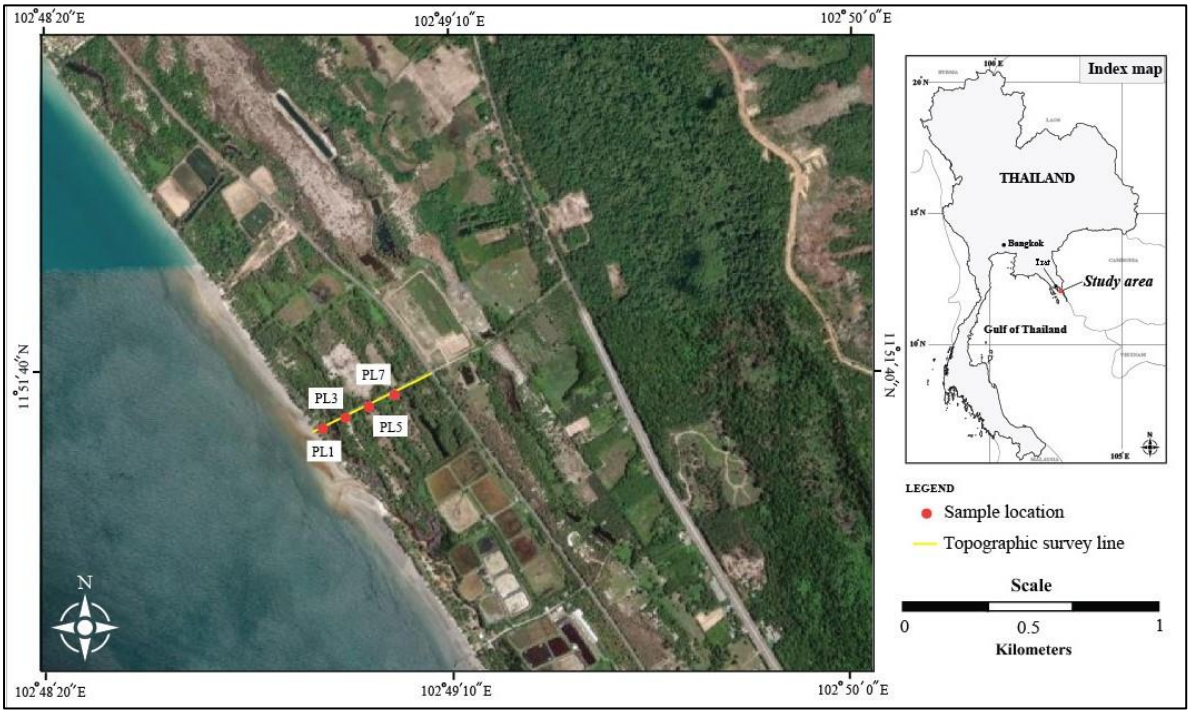

Figure 1. Pailin Beach is located in Trat province, on the eastern coast of the Gulf of Thailand.

3. Results

3.1 Classification of geomorphological units

The geomorphology of Pailin Beach can be divided into 4 units, consisting of former sand beach, recent sand beach, old lagoon, and upland and mountain (Figure 2). The former sand beaches are a geological indicator to sea-level change (Choowong, 2002). The former beach was located away from the present shore and was approximately located 3 m above the present MSL. The sediment of the former sand beach is composed of fine sand, moderately well to well sorted with high content of quartz minerals. The recent sand beach is represented as long and narrow line at the present shoreline. It is an area that has been disrupted by natural processes and human activities. The sediment is composed of fine sand, moderately well to well sorted, and most of the composition is quartz minerals. Moreover, the old lagoon is located between the former sand beach or behind the barrier beach which developed after the sea-level regression (Chaimanee, 2001). The old lagoon is generally composed of fine-grained sediment, such as fine sand, silt, mud or clay, and organic matter. The upland and mountain are composed of rock and sediment. The sedimentary rock is of Jurassic period and sediment is of Quaternary period (DMR, 1985). At present, most of the areas are related to residence, agriculture, and tourist attractions.

3.2 Lithostratigraphic description

The stratigraphic column shows the vertical sequence of the beach ridge sediment (Figure 3). The sediment sequences are a record of the history and changing environments, including sea-level changes (Larson et al, 1997). The description of the sediment was recorded during the fieldwork using sediment visual physical properties. The lithostratigraphic description consists of 4 columns (Figure 1 and 3). Site PL1 is the location of the recent beach ridge (UTM grid of 261913 E 1312066 N). The total depth of this column is about 82 cm. It can be classified into 3 layers as shown in Figure 3A. Moreover, site PL3 is located on the old beach ridge (UTM grid of 262030 E 1312070 N), situated approximately 120 m to the northeast of the present shoreline. The total depth of this column is about 160 cm. It can be classified into 2 layers as shown in Figure 3B. Site PL5 is the location of the old beach ridge (UTM grid of 262102 E 1312161 N) and it is approximately situated 220 m to the northeast of the present shoreline. The total depth of this column is about 60 cm. It can be classified into 3 layers as shown in Figure 3C. Site PL7 is the location of the last old beach ridge (UTM grid of 262184 E 1312193 N). The location is approximately 310 m from the present shoreline in the northeast direction. The total depth of this column is about 60 cm. It can be classified into 2 layers as shown in Figure 3D.

3.3 Age determination of old beach ridges

Four sediment samples from the old beach ridge plains located at a distance from the present shoreline were analyzed by the optically stimulated luminescence (OSL) dating method. The result of OSL dating reveals an age of old beach ridges beginning from 3,230±250 years ago to 1,750±150 years ago (Figure 4).

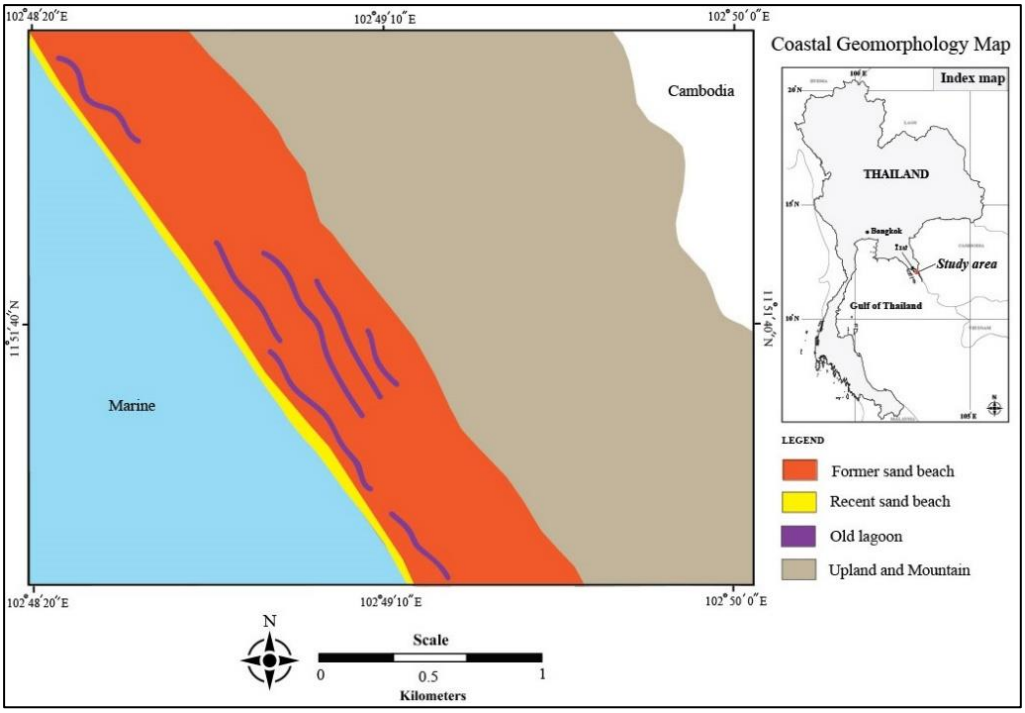

Figure 2. Coastal geomorphological map of the study area.

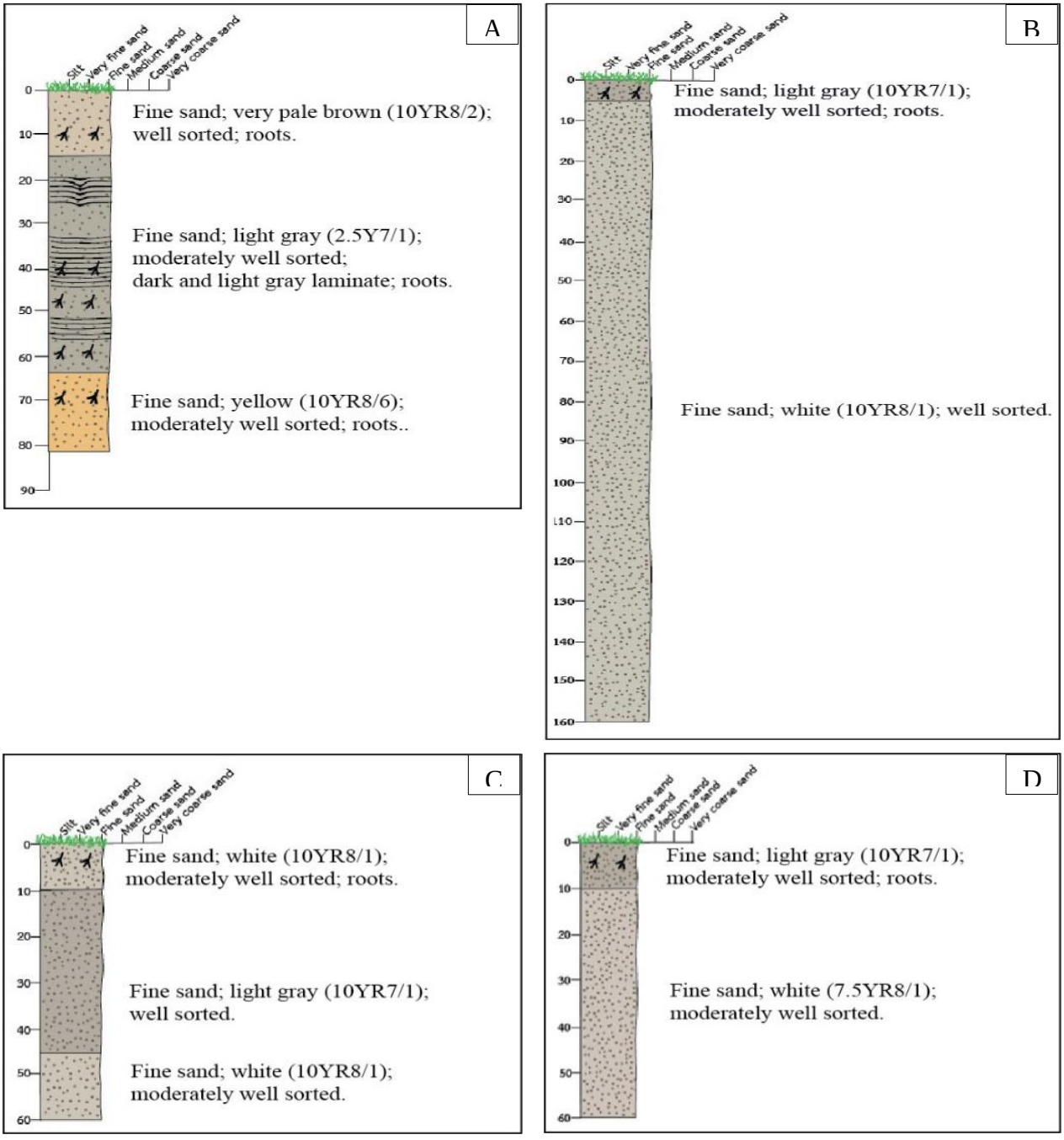

Figure 3. Stratigraphic column and description of beach ridge plain at Pailin Beach. (A) Site PL1 (B) Site PL3 (C) Site PL 5 and (D) Site PL7.

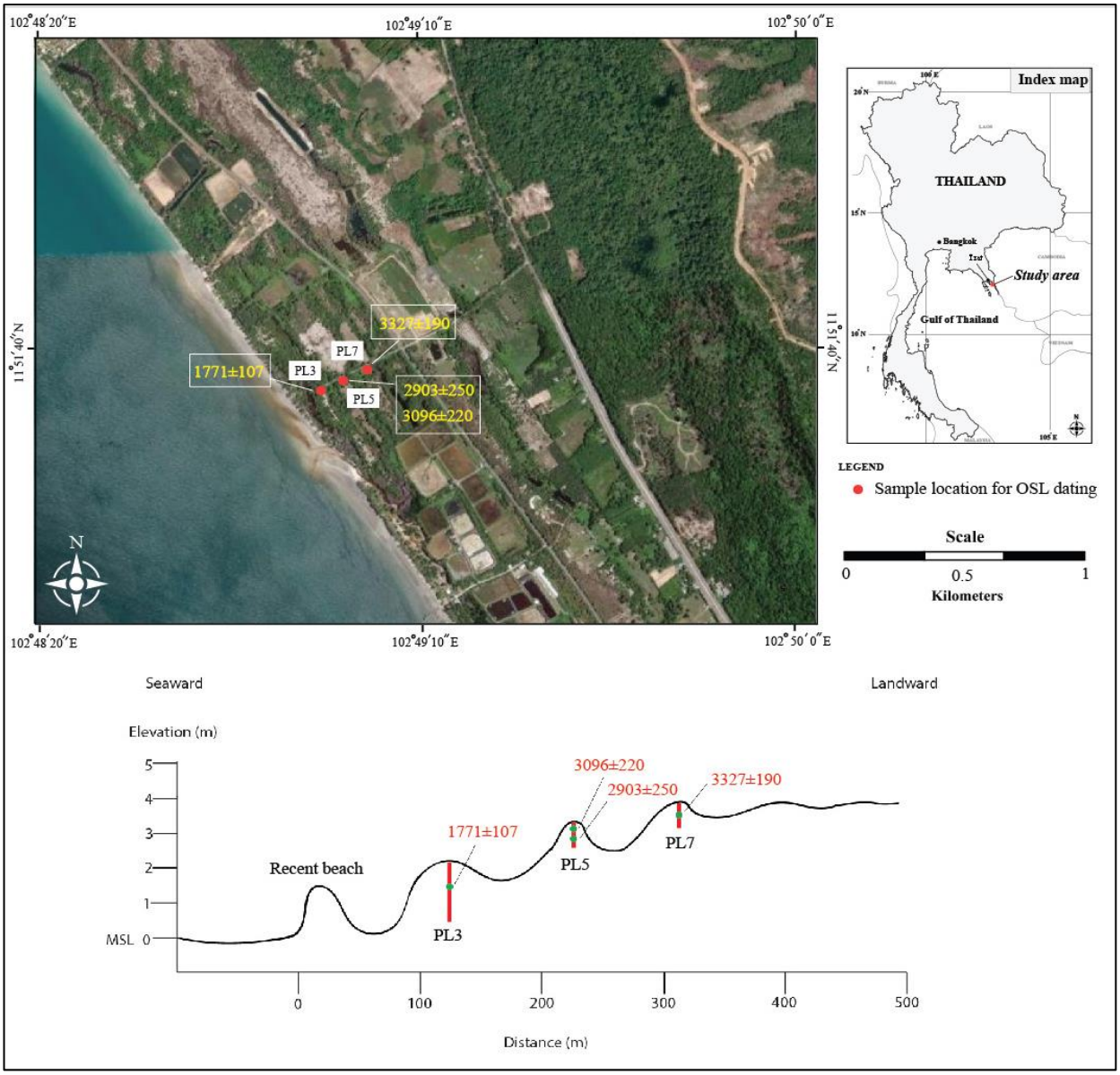

Figure 4. Topographic profile and age of beach ridges at Pailin Beach.

4. Discussion

4.1 Sediment characteristics of beach ridge

The physical properties of sediments can explain the environment of deposition. The size of particles depends on the type of environmental setting, transporting agent, length and time during transport, and depositional conditions (López, 2017). Sediment samples of Pailin beach show a small particle of fine sand indicating low energy conditions and low velocity during the transportation (Baiyegunhi et al, 2020). The sorting provides data of distribution and represents the waving pattern of energy conditions of the depositional environment (Folk and Ward, 1957; Baiyegunhi et al., 2017; Nagalakshmi et al., 2018). The sediment samples are moderately well to well-sorted, indicating depositional environment in low energy and constant current.

4.2 Age determination

Optically stimulated luminescence (OSL) dating method is beneficial for determining age in the late Quaternary, especially the study

of beach ridge environment. In this study, the uncertainty of OSL dating is less than 10%, which is acceptable for the beach ridge plain. The result of age shows the relationship of the beach ridges formation with sea-level change during the Holocene. The formation of the beach ridge likely occurred after the highest sea-level rise in the mid-Holocene. The gradual decline of age from the innermost beach ridge located on land to the outermost beach ridge adjacent to the sea reflects the gradual regression in sea level during that time.

4.3 Beach ridge plain

There is abundant evidence that indicates sea-level changes, both geological and biological evidences. Pailin Beach has a dominant landform of beach ridge plain. Beach ridges are formed by the deposition of sediment. The relict and prograded beach ridge are good evidence that represents the sea-level change in the past. In addition, their locations are useful in dividing the boundary of marine and non-marine deposits, including determining the position of paleo-shoreline (Choowong, 2002).

Precautions for using beach ridge as an indicator of sea-level change include: (a) the age determination by OSL dating method should involve careful sediment sample collection, since, sometimes, the sediment does not preserve the real age of deposition because there may be bleaching or reworking; (b) order of samples while drilling, if samples are incorrectly sorted according to their occurrence, there will be misinterpretation; (c) age determination should be repeated multiple times in a sample to increase precision.

4.4 History of sea-level change

The last sea-level change occurred during the Quaternary period. The melting of ice sheets during the last ice age caused sea levels to rise rapidly worldwide and affected the deposition of coastal areas. Previous studies on sea-level change in Southeast Asia and Thailand based on various evidence provide 2 different groups of sea-level record data. The first group found that the sea level has fluctuated at least 3 times. The sea-level maximum highstand occurred about 6000, 4000, and 2700 years ago, including the research of Sinsakul et al. (1985) and Tjia and Fujii (1992). Another group found that the sea level rose rapidly to the maximum highstand around 6,500 years ago (middle Holocene) and then gradually fell to the present MSL. This group has no evidence of sea-level fluctuation and second highstand, including the research of Choowong (2002), Nimnate et al. (2015), and Surakiatchai et al. (2018). The result of the study of beach ridge plain at Pailin Beach, Trat Province can be brought to explain the history of sea-level change. The results showed that the innermost beach ridge likely to be deposited during the sea transgression in the middle Holocene period. After the sea has risen maximum highstand, the sea regression caused beach ridge formation. Until the recent beach ridge was probably started to form in the late Holocene when the sea level is almost equal to the present MSL. The regression of the sea level from 3500 to 1600 years ago has no evidence showing the sea fluctuation.

5. Conclusion

1) The geomorphological classification of coastal landform at Pailin Beach consist of former sand beach, recent sand beach, old lagoon, and upland and mountain.
2) The sediment characteristics of beach ridge are fine sand and show moderately well to well-sorted, indicating the depositional environment in the low energy.
3) OSL dating reveals that the formation of beach ridge plain around 3,230±250 years ago to 1,750±150 years ago. The age relates to the sea-level change during the Holocene period.
4) Location and presence of old beach ridge indicate sea-level changes in the past.

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