

Quaternary Evolution of Fluvial Terraces in the Shing Mun River Valley of Hong Kong

Ki Him Lawrence So

Department of Earth and Planetary Sciences, The University of Hong Kong, Hong Kong SAR, China

Abstract

This study investigates the distribution, characteristics, and preservation of fluvial terraces in Shing Mun Valley. Through aerial photograph interpretation (API), field surveys, and borehole data analysis, two terrace stages were identified. Anthropogenic impacts were assessed, and terrace evolution was interpreted in relation to climate and sea level changes. The results align with regional geological studies and provide a further line of evidence supporting the existence of two fluvial terrace stages in the Quaternary.

1 Introduction

Fluvial terraces are relict floodplains formed by alternating river deposition and erosion, influenced by tectonics, climate, and sea level changes (Huggett, 2017). In Hong Kong, Quaternary sea level fluctuations shaped these terraces. The Shing Mun River, originating from Tai Mo Shan, flows through fault-controlled valleys, notably the Tolo Channel Fault. Urban development, including reservoir and channelisation projects, has altered much of the original landform. However, the lower valley retains gentle relief and potential terrace remnants. This study investigates terrace distribution and age in the lower Shing Mun Valley using aerial photograph interpretation, field surveys, and borehole data. The aim is to reconstruct the valley's Quaternary evolution revisiting the hypothesis of Middle to Late Pleistocene terrace formation proposed by Li (1998), where two stages (Stage 1 and Stage 2) of Quaternary fluvial terraces exist.

2 Literature Review

Hong Kong's Quaternary onshore superficial deposits, shaped by glacial-interglacial sea level fluctuations, consist mainly of colluvium and alluvium. Lai (1997, 2011) identified two fluvial terrace stages in Lam

Tsuen Valley, distinguished by elevation, soil colour, grain size, and organic content. The dating results from Lai (1998) show that the terraces were formed in the Middle to Late Pleistocene. Li (1998) proposed similar terraces in the Shing Mun River Valley, identifying Stage 1 and Stage 2 terraces through API, field observations and borehole logging. Stage 2 terraces, at higher elevations, comprise reddish brown silty clayey sand, while Stage 1 terraces, adjacent to the modern river, contain gravelly sand with cobbles. Li (1998) suggested that the geological ages of the Shing Mun River terraces correlate with the dating results obtained by Lai (1998) in the Tai Po – Lam Tsuen River, as both rivers share similar fluvial and soil characteristics.

On the published Sha Tin geological map (GEO, 2008), Holocene alluvium and Pleistocene colluvium were recorded in the valley, aligning with the NE-SW trending Tolo Channel Fault.

3 Method

This study integrates API, field surveys, and borehole data analysis to investigate the fluvial terraces in the Shing Mun River Valley. Historical aerial photos taken in 1963 and topographic maps were georeferenced using Geographic Information System (GIS) to identify terrace boundaries. Field surveys were conducted to assess the preservation or removal of the terraces, confirming current site conditions and allowing for a comparison with historical borehole records. Borehole logs from the Geotechnical Information Infrastructure (GInfo) (GEO, 2019) were screened and interpreted based on soil colour, grain size, organic content, and the relative position of different layers (Lai, 1997). LiDAR data, historical topographic data and 3D geological modelling software (Leapfrog Works) were used to construct 3D geological models and cross-sections, allowing visualisation of terrace evolution in the study area.

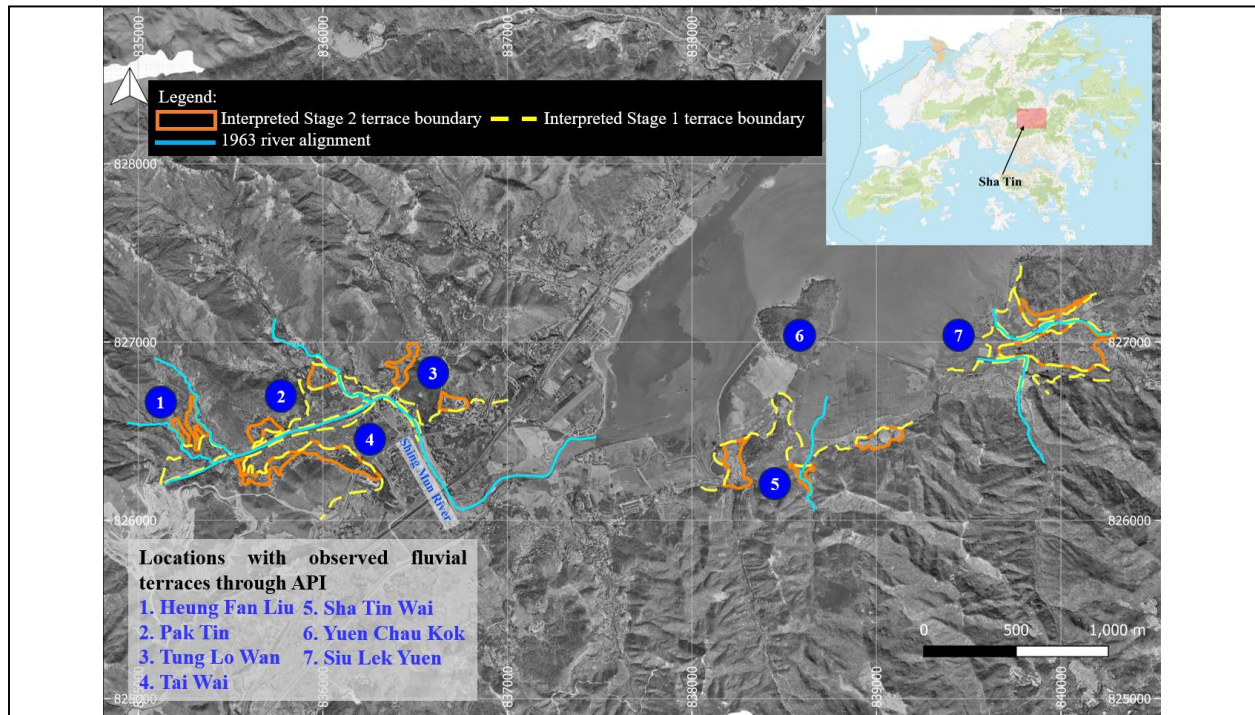


Fig. 1. Map plan showing the distribution of fluvial terraces in Sha Tin – Shing Mun Valley, overlain on the 1963 orthophoto from GInfo (GEO, 2019).

4 Results of Aerial Photograph Interpretation and Field Visits

Two terrace stages, Stage 1 and Stage 2, were mapped using the 1963 aerial photos of the Shing Mun River Valley based on elevation, terrain gradient, and geomorphological features. Stage 1 terraces are extensive, abandoned floodplains close to the modern river channel that were mainly occupied by agricultural lands in 1963. In contrast, Stage 2 terraces are scattered terrace remnants distributed along the

valley foot slopes at higher elevations (see **Figs. 1 and 2**). Nevertheless, anthropogenic disturbances from urban development, including housing and road construction, have significantly removed or buried many terrace features, especially in the Tai Wai area. Comparisons between historical topographic maps and modern LiDAR data revealed elevation changes due to terrace removal. Some segments were identified as likely preserved terrace remnants, forming the basis for reconstructing the valley's Quaternary geomorphological evolution.

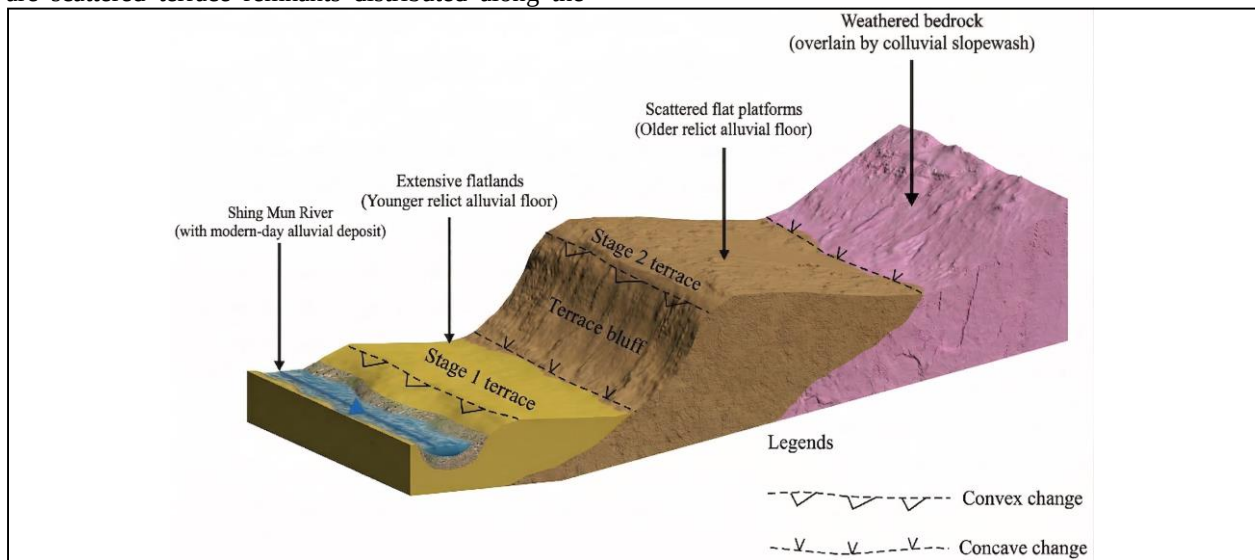


Fig. 2. Schematic diagram of the Stage 1 and 2 terraces identified based on terrain gradient and geomorphology.

5 Analysis of Existing Borehole Logging Records

711 ground investigation logs retrieved from GInfo were reviewed to assess the subsurface characteristics of fluvial terraces in the Shing Mun River Valley. Boreholes were selected based on the availability of detailed logging descriptions and photographic records and were interpreted using six key criteria: soil colour, organic content, geomorphological context, stratigraphic relationships, grain size, and clast roundness.

Stage 2 alluvium typically occurs at higher elevations and is characterised by reddish or orangish brown silty clayey sand with subangular gravel and occasional cobbles. The reddish or orangish brown colour of these deposits indicates oxidation of the minerals in the soil, due to prolonged exposure in a warm and humid palaeoclimate. Stage 1 alluvium is generally finer-grained, yellowish to greyish brown, and contains more organic matter. It is found closer to the modern river channel and often overlies Stage 2 deposits (See **Table 1**).

The borehole data revealed that many alluvial deposits have been significantly altered by urban development. In areas such as Pak Tin and Tai Wai, site formation works have removed or buried original terrace materials, replacing them with fill. In contrast, locations like Siu Lek Yuen and Sha Tin Wai retain buried alluvial deposits beneath infrastructure. Nevertheless, some remaining alluvial deposits were recovered by historical boreholes and the relevant log descriptions could still be interpreted from ground investigation reports.

Some deposits previously logged as colluvium were reinterpreted as fluvial alluvium based on their soil colour, organic content, stratigraphic relationship, grain size and clast roundness (See **Table 2**). The reinterpretation was reviewed against the API model for consistency checking. Overall, the results provide an alternative interpretation of the alluvial deposits where historical terrace height were significantly higher than modern levels.

Table 1. Characteristics of Stage 1 and 2 fluvial terraces and associated fluvial deposits (Tai Wai).

Stage	Top level	Thickness	Composition
Stage 2 terrace	+13 to +27 mPD	2m to 16m	Reddish or orangish brown, silty clayey fine to coarse sand with some gravel and boulders
Stage 1 terrace	+8 to +15 mPD	1m to 9m	Greyish or yellowish brown silty fine to coarse sand with much gravel, cobbles and boulders

Table 2. Summary of criteria for interpreting and classifying superficial deposits in this study.

Criteria	Key Features
Soil Colour	Stage 2 alluvium: Darker (reddish/orangish brown) due to oxidation Stage 1 alluvium: Paler (yellowish brown) (Lai, 2011)
Organic Content	Younger Soil (Stage 1): Higher organic content (Lai, 1997)
Stratigraphic Sequences	Stage 1 alluvium overlies Stage 2 alluvium
Grain Size	Stage 2 alluvium: Finer Stage 1 alluvium: Coarser (Lai, 1997)
Clast Roundness	Colluvium: Angular to subangular Alluvium: Subangular to subrounded (due to longer transport distance)

6 Geological Cross-sections and Long Profiles

The geological sections revealed terrace remnants in various states—buried, removed, or exposed—

highlighting the impact of urban development (see **Fig. 3**). Stratigraphic relationships and elevation differences between terraces were also illustrated. These visualisations provide a spatial understanding of terrace distribution and thickness.

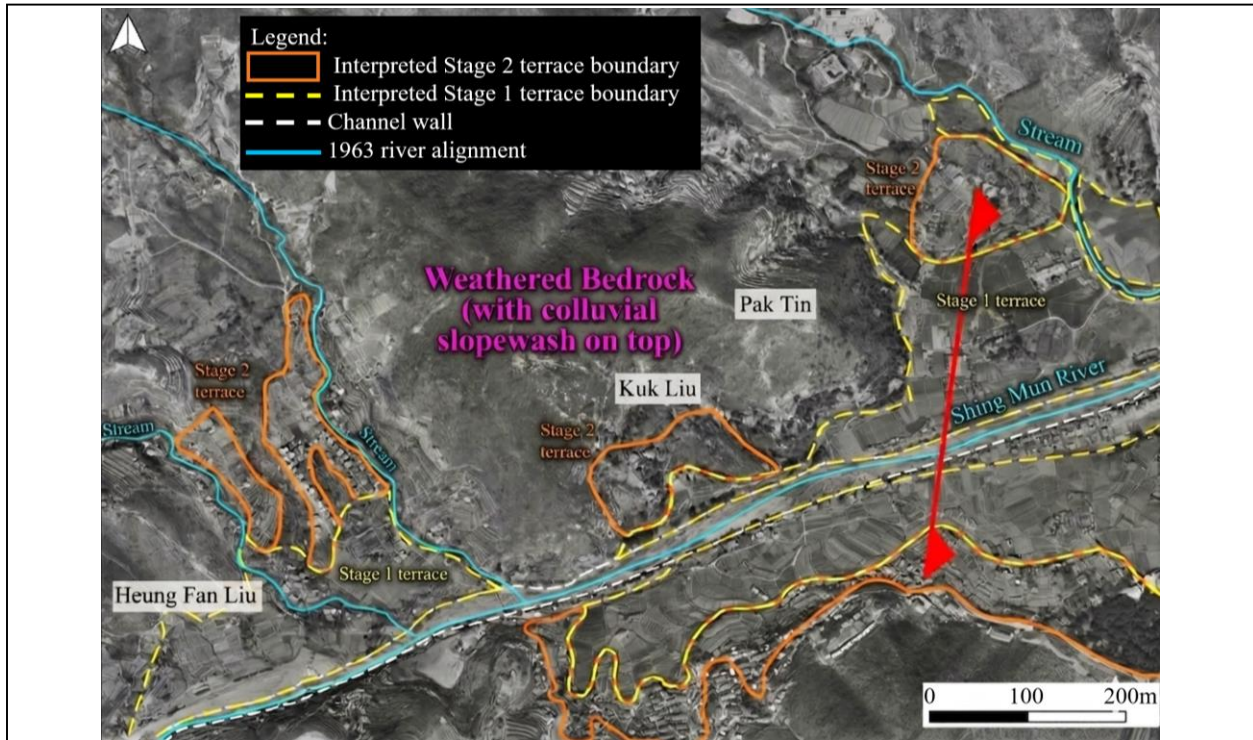


Fig. 3. Map plan showing the distribution of fluvial terraces and cross section location in Tai Wai, overlain on the 1963 orthophoto from GInfo (GEO, 2019).

7 Discussion of Geological Evolution

The Quaternary superficial geology of the Sha Tin–Tai Wai area is characterised by a two-stage alluvial terrace sequence. Stratigraphically, the older terrace

(Stage 2) underlies the younger terrace (Stage 1), reflecting distinct phases of fluvial deposition and subsequent local incision (see **Fig. 4**). The vertical transition from fine to coarse material indicates a shift from a lower-energy to a higher-energy depositional environment.

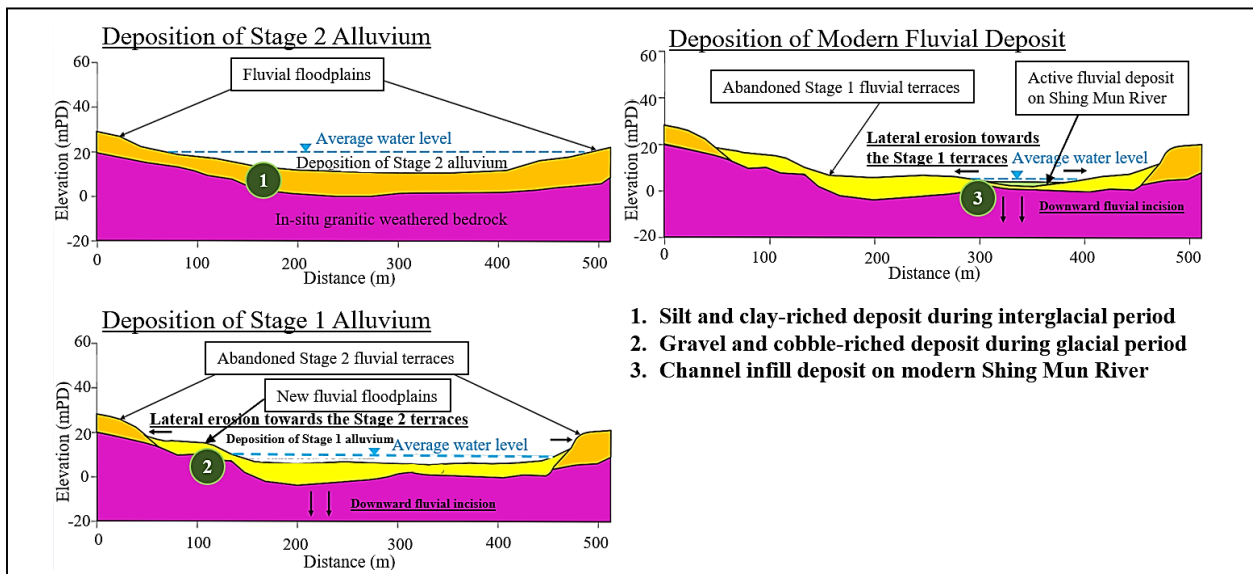


Fig. 4. Diagram of the interpreted Quaternary evolution of fluvial terraces in Lower Shing Mun Valley (Sha Tin – Tai Wai area).

Following the formation of the Stage 1 terrace, subsequent channel incision and fluvial reorganisation shaped the present-day valley morphology. As observed in pre-urbanisation aerial imagery from 1963, the modern Shing Mun River channel and its active alluvial deposits occupy a lower elevation of about +8 mPD. The approximately 7-meter elevation difference between the Stage 1 terrace surface and the modern channel can be interpreted as a local geomorphic response, reflecting incision during the late Quaternary.

Similar terrace stratigraphies and sediment characteristics have been documented across Hong Kong in catchments such as Lam Tsuen, Yuen Long, and Tung Chung (Fyfe et al., 2000). These parallel sequences suggest that valley evolution may have been modulated by broader Quaternary climate or eustatic base-level fluctuations. However, within the small, structurally confined Shing Mun River catchment, localised knickpoint migration or autogenic channel adjustments could equally drive such terrace-forming episodes independent of regional forcing.

8 Limitations

This study was constrained by project timelines and therefore focused exclusively on the fluvial terraces observed in Tai Wai, Sha Tin Wai, and Siu Lek Yuen. Other areas, including Fo Tan and regions inundated during Shing Mun Reservoir construction remain unexamined. Although API using 1963 imagery proved instrumental in terrace identification, limited GI data in key areas such as Pak Tin and Heung Fan Liu increased uncertainty regarding terrace thickness in these locations. Furthermore, because no new boreholes or absolute dating analyses were conducted as part of this study, the proposed geomorphological model relies heavily on previous findings and regional frameworks established by Lai (1998) and Fyfe et al. (2000). Without site-specific geochronological control or detailed, high-resolution sedimentological logging, the precise timing, duration, and primary drivers of the identified depositional-incisional phases cannot be resolved. Additionally, it should be noted that the interpretative criteria outlined in Table 2 are derived strictly from the localised ground investigation dataset and geomorphic setting. Variability in source material, post-depositional weathering, and overlapping facies boundaries introduces inherent uncertainty in deposit classification. Where multiple criteria yielded conflicting indications, interpretations were weighted toward stratigraphic and geomorphic evidence, and alternative classifications were acknowledged. The framework is not intended for generalised application beyond the site context without site-specific calibration.

9 Conclusion

Two Quaternary fluvial terrace stages are identified in the Shing Mun Valley. Their soil and geomorphological characteristics align with studies of other valleys in Hong Kong. Despite urban disturbance, remnants remain in areas like Heung Fan Liu and Siu Lek Yuen. Further geological dating is recommended to confirm terrace ages and enhance understanding of Hong Kong's Quaternary evolution.

Remark

This article is an abstract of the 2024 MSc thesis in Applied Geosciences of the University of Hong Kong, which can be accessed on HKU Scholar Hub. Erudite reviews by two editorial board members of the Geological Society of Hong Kong on early drafts of this article are gratefully acknowledged.

References

- Fyfe, J. A. (2000). The Quaternary geology of Hong Kong. Hong Kong Geological Survey.
- Geotechnical Engineering Office (GEO). (2008). Hong Kong geological survey – Solid and superficial geology sheet 7 “Sha Tin” (Edition 2).
- Geotechnical Engineering Office (GEO). (2019). Geotechnical Information Infrastructure. Retrieved May 18, 2024, from <https://www.ginfo.cedd.gov.hk/ginfont/>
- Huggett, R. J. (2017). Fundamentals of geomorphology (4th ed.). Routledge.
- Lai, K. W. (1997). Quaternary evolution of the onshore superficial deposits of Hong Kong. In N. G. Jablonski (Ed.), *The changing face of East Asia during the Tertiary and Quaternary: Proceedings of the 4th Conference on the Evolution of the East Asian Environment* (pp. 178–188).
- Lai, K.W. (1998). The Pleistocene alluvium and colluvium of Hong Kong. *Guangdong Geology* .13(1). 71-78.
- Lai, K. W. (2011). Geotechnical properties of colluvial and alluvial deposits in Hong Kong. In *Proceedings of the 5th Cross-Strait Conference on Structural and Geotechnical Engineering (SGE5)* (pp. 735–744).
- Li, X. Q. (1998). The terrace formed by river in the Tai Wai – Sha Tin Shing Mun River of Hong Kong (Unpublished manuscript).