Yangtze River as a major sedimentary source to Taiwan Neogene Formations: Is this real?

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ABSTRACT

Many studies suggested that the sediments of Taiwan Neogene strata were transported from the East China Sea Shelf Basin (ECSSB), and the ECSSB sediments mainly came from the Yangtze River, so the sedimentary sources of Taiwan Neogene strata and Yangtze River sediment have strong similarity. However, according to the geographic affinity, the Taiwan sediments should be sourced from the East Cathaysia Block. Because most studies were based on the detrital zircon age analysis, we compiled zircon age data from the Yangtze River, Yangtze Gravel, Taiwan, ECSSB and the East Cathaysia Block to identify the source aera of Taiwan sediments. Data were reanalyzed and compared via Kernel Density Estimation (KDE) and Multi-dimensional Scaling (MDS) plots. The MDS plot shows a close relationship between sediments of the East Cathaysia, Taiwan Neogene formations and Xihu Sag Miocene formations (part of ECSSB). As indicated by the MDS plot, Yangtze River is most likely not the main source of ECSSB and Taiwan in Early Miocene, instead, the East Cathaysia should be the main source of ECSSB and Taiwan. This result suggests the paleo-Yangtze River might not have reach the present Yangtze River mouth. Furthermore, East Cathaysia should be the main sedimentary source of Taiwan and ECSSB.

GEOLOGICAL BACKGROUND

East Asia is composed of many tectonic units, including the Cathaysia Block, Yangtze Craton, North China Craton and others. By analyzing the detrital zircon geochronologic data, a series of important zircon growth peak periods in Earth history can be obtained. Seven major crustal growth events are the Wutai orogeny (2498 Ma), Luliang orogeny (1855 Ma), Jinning orogeny (828 Ma), Caledonian orogeny (444 Ma), Indosinian orogeny (249 Ma), Yanshanian orogeny (131 Ma), and Himalayan orogeny (58 Ma, Wu et al., 2020).

Taiwan is situated at the boundary between the Eurasian and Philippine Sea Plates, which has become passive continental margin since Neogene and received sediments from East Asia (Lin et al., 2003).

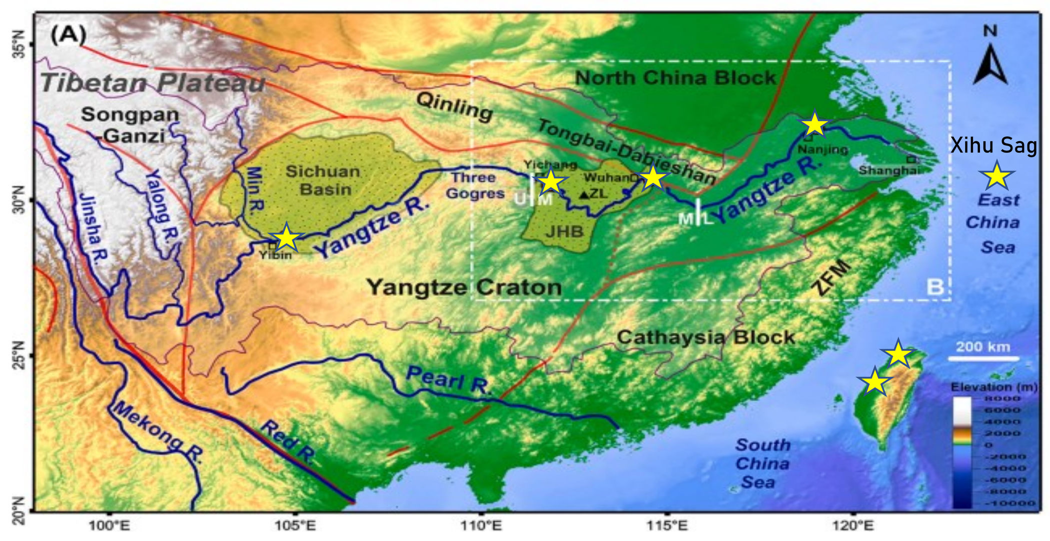

Fig. 2. Tectonic units of East Asia. The Yangtze River is divided into the upper (U), middle (M) and lower (L) reaches by white lines. The dashed brown line divides the Yangtze Craton into eastern and western regions. JHB - Jianghan Basin. ZFM - Zhejiang-Fujian Mountain. (from Zhang et al., 2021)

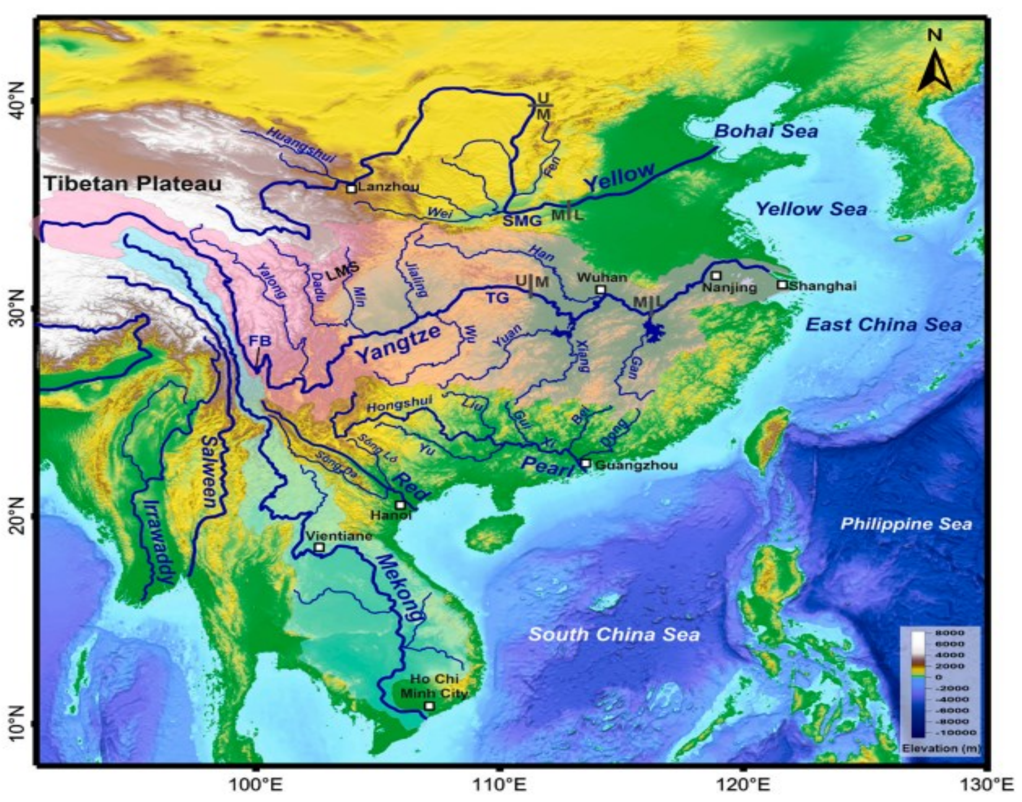

Fig. 3. the major fluvial systems draining eastern Asia and their major tributaries. The Yangtze and Yellow Rivers are divided into the upper (U), middle (M) and lower (L) reaches by grey lines. LMS = Longmenshan; FB = First Bend; TG = Three Gorges; SMG = Sanmen Gorges. (from Zhang et al., 2022)

METHOD

Detrital zircon geochronology relies on compiling individual zircon grain ages from a sedimentary sample and is most often used to link the sediments or sedimentary rocks to potential source regions. Data were reanalyzed and visualized through the KDE plots and the MDS plots. The KDE plots group data by bandwidth as a smooth curve which allow visual comparison of potential sedimentary source, while the MDS plots utilize goodness-of-fit and closeness criteria to evaluate similarities and differences among samples (i.e. suggest the similarity through distance and present most and second similar through solid and dashed line) (Vermeesch, 2013).

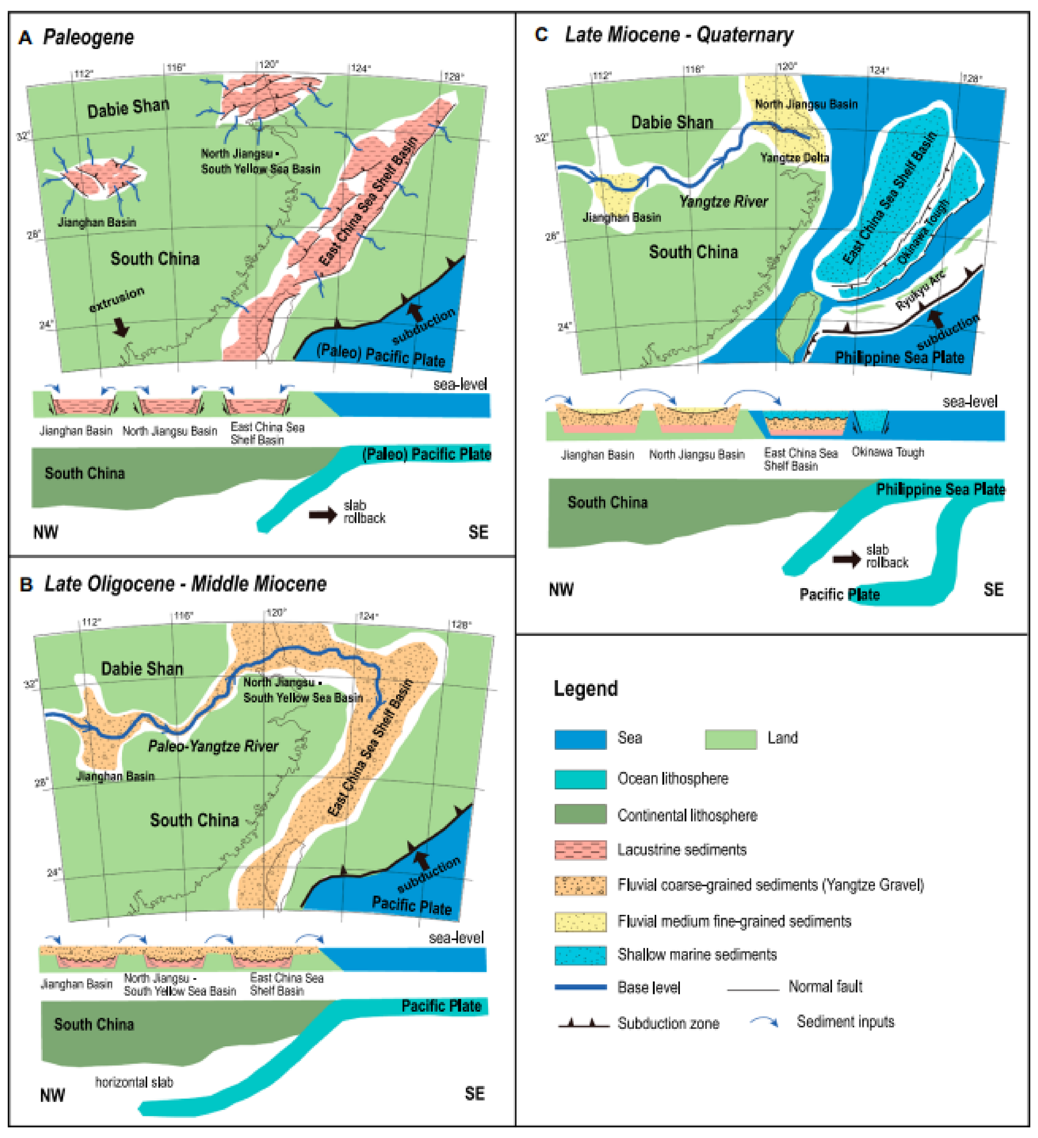

Fig. 1. Tectonic control on the evolution of the Lower Yangtze River in southeast China. (A) During the Paleogene the Jianghan Basin, North Jiangsu-South Yellow Sea Basin, and East China Sea Shelf Basin were isolated and structurally controlled by normal fault with well-developed grabens or half grabens. Basin infills are characterized by red-colored lacustrine, deltaic, and especially evaporite deposits of local provenance. (B) During the late Oligocene to Early Miocene, the ongoing subduction of the Pacific Plate produced the horizontal stagnant slab, which triggered the post-rift board depression and opened a path to a thoroughgoing fluvial system (paleo-Yangtze River). The three basins were connected and filled by gray and yellow-colored, coarse-grained fluvial deposits of Yangtze Gravel. (C) During late Miocene to Quaternary, the Philippine Sea Plate moved northward and collided with the SW Japan-Ryukyu margin in the Miocene, causing the replacement of the Pacific Plate subduction with the Philippine Sea Plate subduction. As a result, the subsidence center migrated eastward from the East China Sea Shelf Basin to the Okinawa Trough, accompanied by the inception of the marine deposition in the East China Sea Shelf Basin. (from Wang et al., 2022)

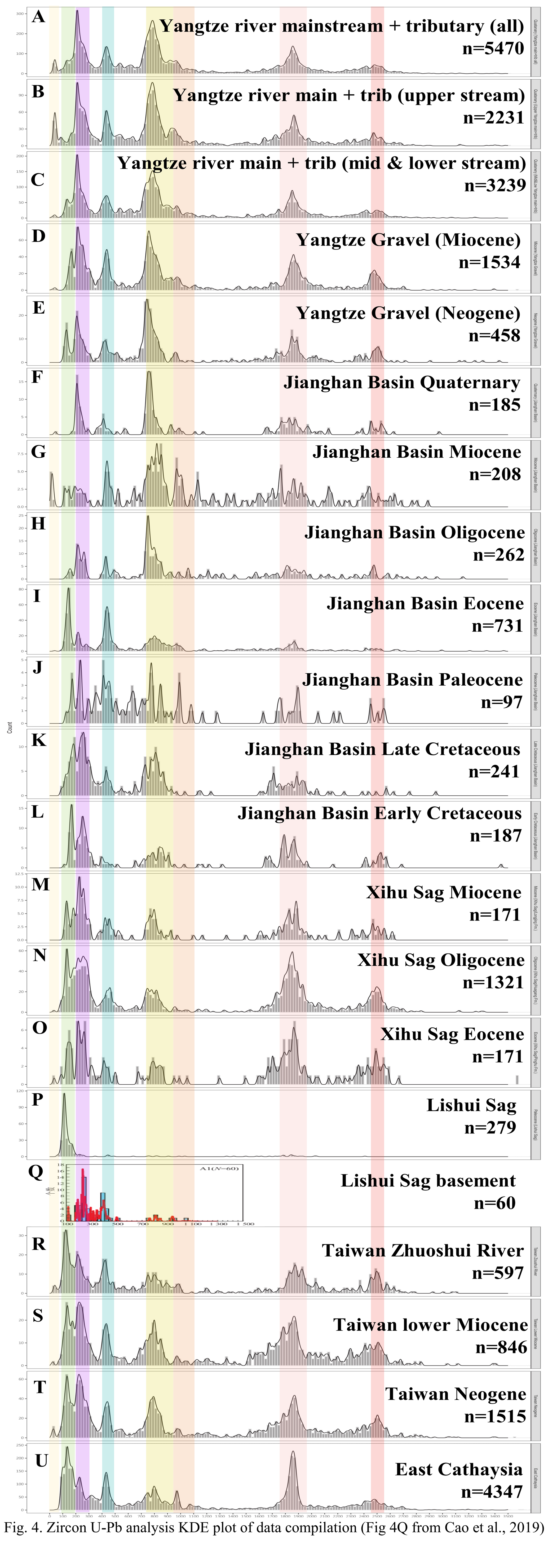

Fig. 4. Zircon U-Pb analysis KDE plot of data compilation (Fig 4Q from Cao et al., 2019)

ANALYSIS

1. Yangtze Craton

The zircon age distributions of sediments from the Yangtze River (Fig. 4A-C) shows a wide peak of Luliang, two strong peaks in Jinning and Indonesian, and a weaker peak in Caledonian. Notably, the middle to lower stream (Fig. 4C) have stronger Caledonian and Luliang peaks than the upper stream (Fig. 4B). On the other hand, Yangtze Gravel also have the same pattern as Yangtze River (Fig. 4D).

1. Yangtze Craton-Jianghan Basin

In Jianghan Basin, Luliang, Jinning and Indonesian seems to have no obvious pattern (Fig. 4E-K). However, Quaternary and Miocene strata share similar pattern age spectra during the Yanshanian, Indonesian, Jinning, and Sibao periods (Fig. 4E-F).

3. East China Sea Shelf Basin-Xihu Sag

The Eocene-Miocene formations of the Xihu Sag have main peaks of Yanshanian and Indonesian, minor peak of Calidonian and Jinning, and a broad peak of Luliang (Fig. 4L-O). Their age patterns are significantly different to Yangtze River, but similar to East Cathaysia.

4. East China Sea Shelf Basin-Lishui Sag

Paleocene formation of Lishui Sag has a single peak of 110 Ma, while the basement of Lishui Sag shows a Indonesian peak of 220 Ma and a minor Calidonian peak (Fig. 4P-Q).

5. Taiwan

Taiwan Neogene formation and Zoushui River sand have similar pattern of major peak in Indonesian and Yanshanian, minor peak in Calidonian, Jinging which is very similar to the pattern of East Cathaysia (Fig. 4R-T).

DISCUSSION

Previous researches on Taiwan Neogene sedimentary source have conflict summaries. The similarities of detrital zircon age distributions between the Yangtze River and the Neogene sediments of Taiwan suggest that the Yangtze River is the major sediment supplier to in the Miocene (Wang et al., 2018). Other researches suggested that Cenozoic sediments deposited in the Taiwan Strait may have been derived from the East Cathaysia by the incision of near-by river systems (Chen et al., 2002; Chen et al., 2018).

In this study, the MDS plot shows a close relationship between East Cathaysia, Taiwan Neogene formations and Xihu Sag Miocene formation. As Xihu Sag sits between Yangtze River mouth and Taiwan, the dissimilarity of Xihu Sag formation and present Yangtze indicates that paleo-Yangtze River sould be very different to present Yangtze River, which had not reached its present river mourh. Thus could not be the main sedimentary source of Taiwan during Neogene.

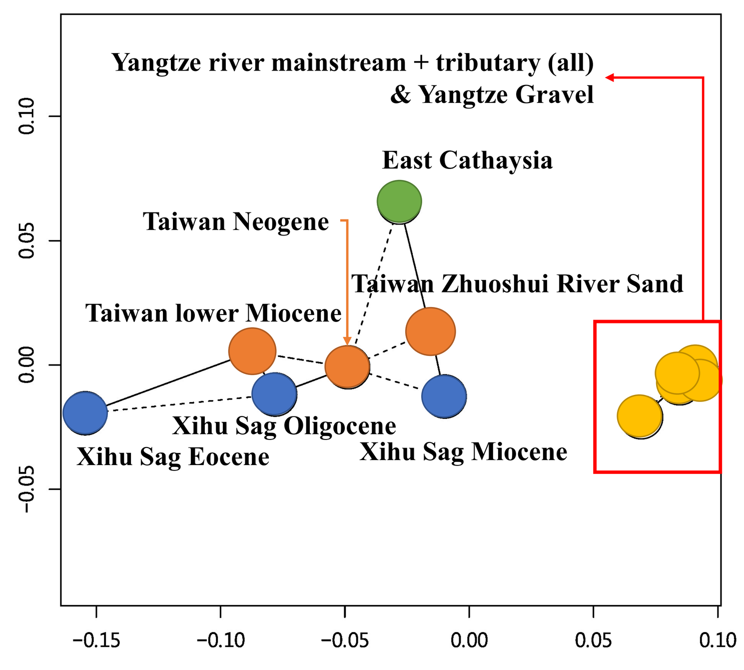

Fig. 5. Multidimensional scaling (MDS) plots of zircon U–Pb ages from the modern River sediments (Yangtze River and Cathaysia Block), the ancient sediments (Taiwan, Jianghan Basin, Xihu Sag and the East China Sea Shelf Basin).

CONCLUSION

After compiling 24447 detrital zircon U-Pb age analyses, the MDS plot shows Neogene sediments of Taiwan strata and river sand are all similar to East Cathyasia. Therefore, the Yangtze River could not have been the considerable sedimentary source of ECSSB nor Taiwan. Moreover, the Xihu Sag formations, sitting between the Yangtze mouth and Taiwan, have very distinct age patterns to the present Yangtze, which suggests the paleo-Yangtze River could be very different to present Yangtze River. Therefore, East Cathaysia should be the main sedimentary source of Taiwan during Neogene. This result is reasonable since Taiwan and ECSSB are both located on the East Cathaysia block.

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