Source to Sink Evolution During the Oligocene-Miocene Rift-drift Transition in Northern Taiwan: A Preliminary Detrital Zircon Study

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Abstract

The detrital zircon geochronology not only can reflect the sedimentary provenance, tectonic setting, and drainage system evolution, but also can reveal the intrapltae basin evolution in syn-rift, transition, and post-rift stages. The early Tertiary Hsuehshan trough was reconstructed by the outcrops as well as borehole data, and the detailed rift-drift transition was analyzed. In this study, the detrital zircon data from rift to drift sedimentary sequences of Hsuehshan trough can fit the general age spectra patterns of basin evolution from rift to drift within the intraplate basin. Furthermore, the detrital zircon age spectra may imply a slightly different result to the four-stage evolution scenarios of Hsuehshan trough as previously suggested.

Introduction

Detrital zircons, measuring approximately 100 µm in size, primarily originate from the granitic or felsic rocks (Sun, 2006; Fig. 1a) through processes of erosion and transportation. By integrating data regrading the distribution of different age igneous rocks of varying ages and incorporating detrital zircon age data collected from contemporary river systems, it becomes possible to reconstruct the sedimentary provenance and the historical drainage network. The various tectonic settings, arising from magmatic activity at convergent, collisional, and extensional margins, are discernible through the corresponding detrital zircon age spectra and cumulative curves (Cawood et al., 2012). Furthermore, the detrital zircon age spectrum can unveil the evolution of intraplate basins, with the spectra exhibiting increasingly intricate patterns from the syn-rift to post-rift stage (Song et al., 2022; Fig. 1b).

Based on the several outcrops and drilling data, the concept of early Tertiary Hsuehshan trough was proposed, and the wedge-like Paleogene sequences suggest that the Hsuehshan trough was a half-graben located on passive margin setting (Teng et al., 1991). The continuous Waimushan profile in northern Taiwan with little structural disturbance recorded the rift-drfit transition of Hsuehshan trough development and can be divided into four stage, which are late syn-rift, initial early post-rift, late early post-rift, and late post-rift stages (Yu et al., 2013; Fig. 1c).

In this study, we will compare the detrital zircon age spectrum patterns of both intraplate basins and the Hsuehshan trough. Our objective is to assess whether the data from passive margin settings can align with the detrital zircon age patterns observed in intraplate basins.

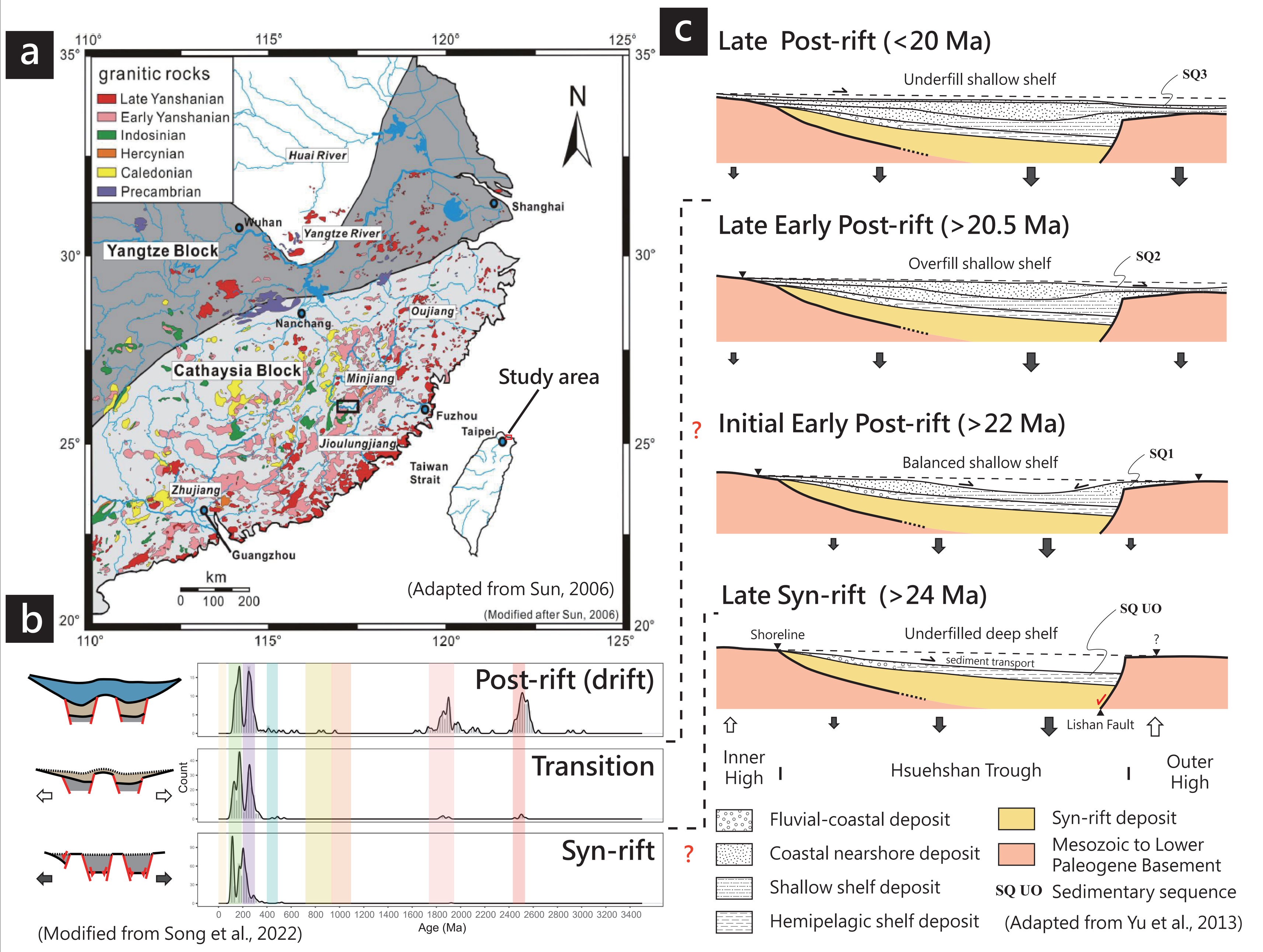

Fig. 1. (a) Simplified geological map of South China displaying the distribution of granitic rocks with different ages (adapted from Sun, 2006). (b) The general patterns of detrital zircon age spectra corresponding to the syn-rift, transition, and post-rift stages (from Song et al., 2022). (c) Four stages of basin evolution of the Hsuehshan trough (modified from Yu et al., 2013).

Data processing

The 9 outcrop sample data are compiled from Shao et al. (2010), Lan et al. (2016), Wu (unpublished), and 4 new samples will be dated (Fig. 2). The samples are labeled on the stratigraphic column by their field position (Fig. 3). The accepted ages were opted from a subset of ≤30% discordance and uncertainty (1σ). The dating ages used $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$ ages when the zircon is younger or older than 1000 Ma, respectively. The detrital zircon age spectra were displayed by histograms and kernel density estimation (KDE, adaptive bandwidth =20 Ma and binwith =10 Ma). The spectra and the cumulative proportion curves are plotted by using IsoplotR.

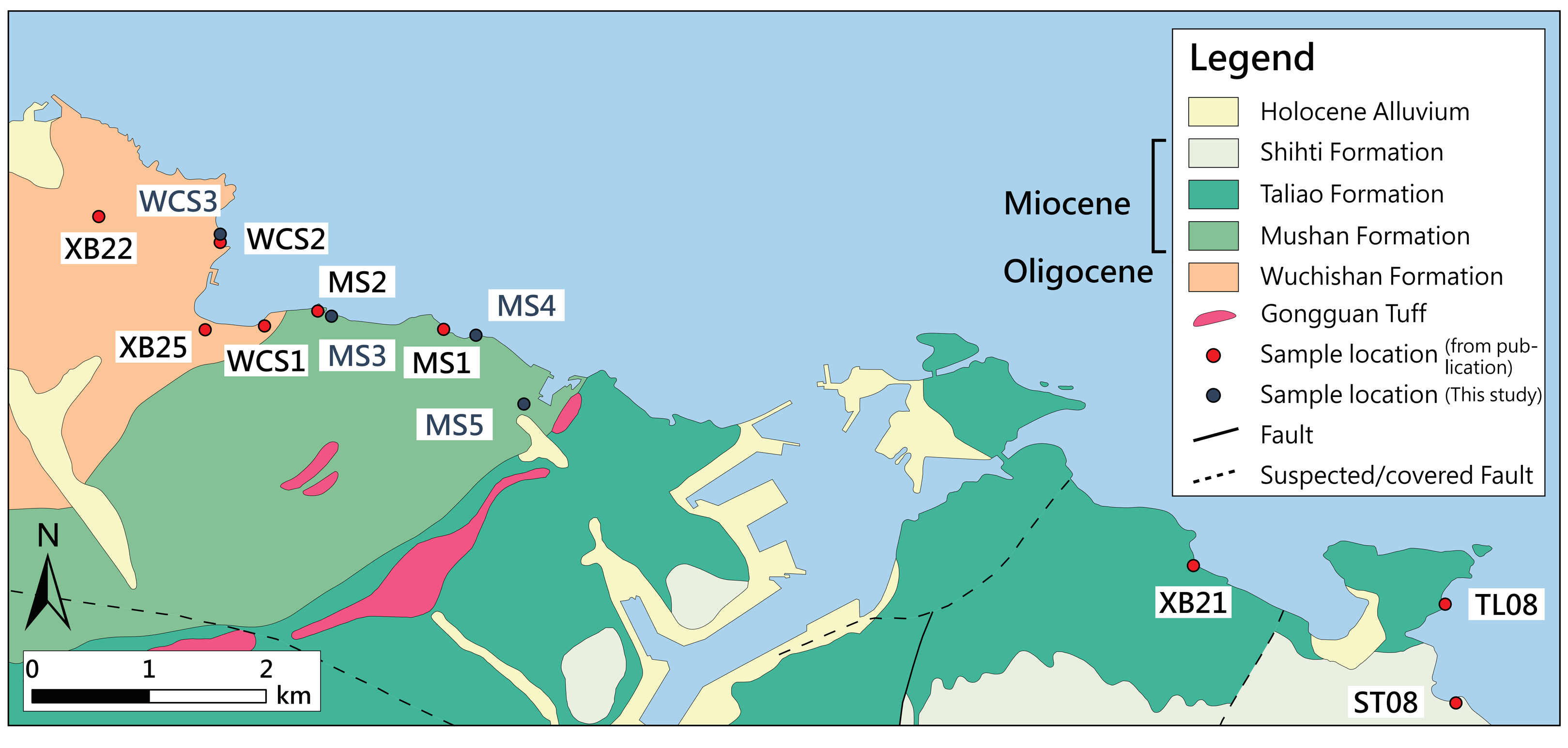

Fig. 2. The study area and the location of 14 samples (Modified from Central Geological Survey). The 6 samples in the Wuchishan Formation and Mushan Formation would correspond to the sequence stratigraphic column (Yu et al., 2013).

Discussion

The spectra of XB22 and WCS2 from Wuchishan Formation samples show the simplest pattern with almost only Yanshanian peak so that they are divided into group 1 (Fig. 3). The Yanshanian zircons are up to 60-75% (≤500 Ma) in these two samples, and the percentages of younger zircon are 74-77%. Comparing to the granitic rock distribution map (Sun, 2006), the two samples may indicate that sedimentary provenance came from the local sources during the late syn-rift stage. The XB25, WCS1, MS2, and MS1 from Wuchishan and Mushan Formation samples are divided into group 2 which shows more complicated patterns than group 1. The peaks of older zircons become observable, and the percentages of younger zircon (≤500 Ma) decrease to 57-65%. It is noteworthy that the MS1 is classified into initial early post rift stage by Yu et al. (2013), but its spectrum is similar to the other three samples, may indicate that they were in the source evolutionary stage for Hsuehshan trough. The group 3 age spectra of XB21, TL08, and ST08 from Taliao and Shihti Formation samples show the most complex patterns. The percentages of younger zircon (≤500 Ma) rapidly decrease to 23-36%. It is plausible that the overall thermal subsidence of Hsuehshan trough could have caused large drainage system reach into Hsuehshan trough so that the age spectra contain all different aged peaks.

The cumulative curve patterns of the Hsuehshan trough and the Songliao basin exhibit prominent similarities (Fig. 4). The unimodal, bi-modal, and multi-modal distributions observed in the Hsuehshan trough correspond to the syn-rift, transition, and post-rift stages of the Songliao basin, respectively. This alignment suggests that the detrital zircon age spectra can effectively unveil the evolutionary history of both intraplate basins and passive margin basins. While the main trends in detrital zircon age spectra pertaining to basin development are apparent, it is necessary that more samples should be analyzed. This expanded dataset will enable us to construct a more detailed chronicle of the changes occurring within the Hsuehshan trough.

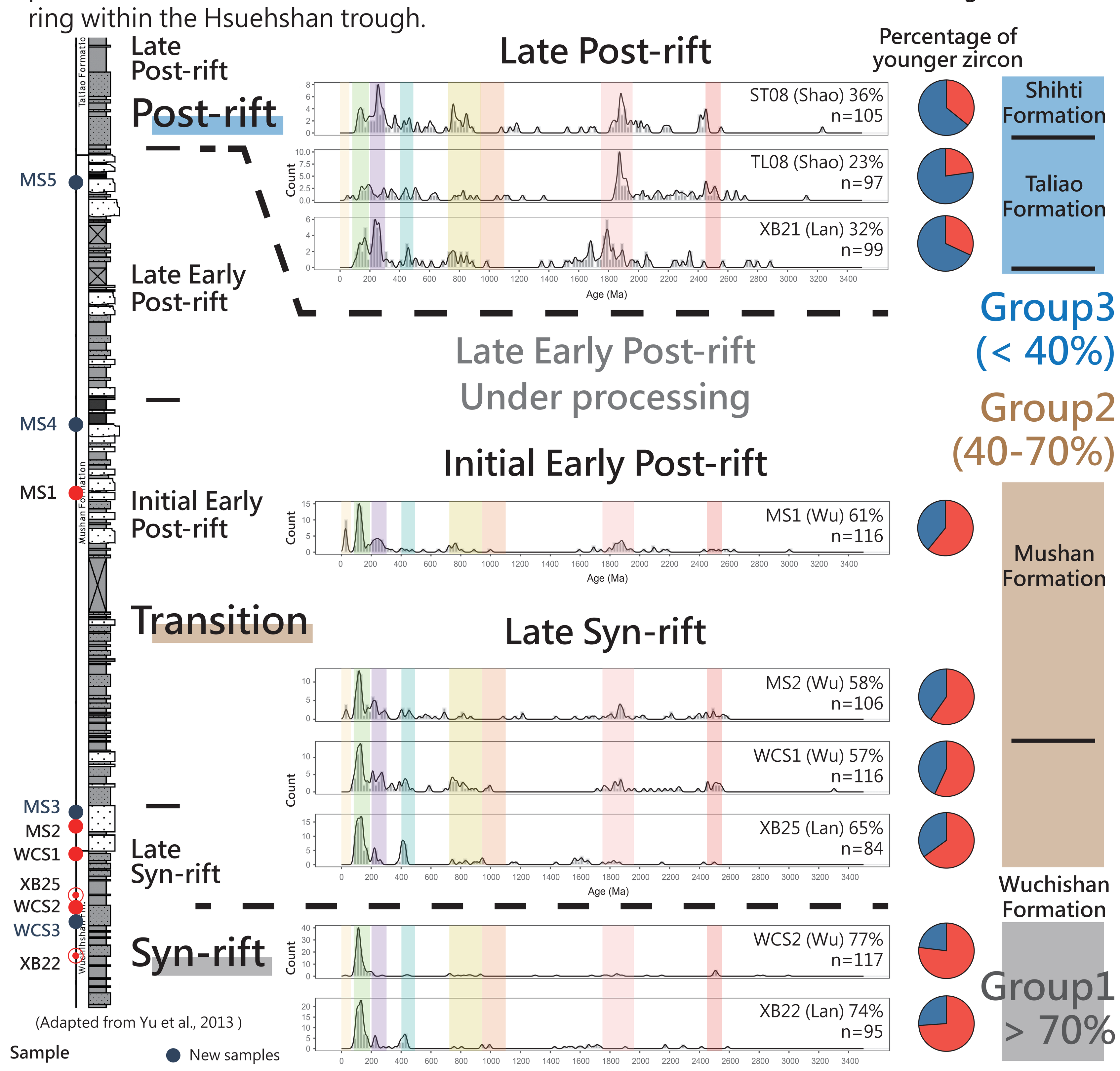

Fig. 3. The relationship between the detrital-zircon age spectra and the basin evolution during late Oligocene to early Miocene in the Hsuehshan trough. The percentage of younger zircon (≤500 Ma) decrease significantly in late post-rift stage, and the general pattern of detrital zircon age spectra become more complicated from syn-rift to post-rift stage.

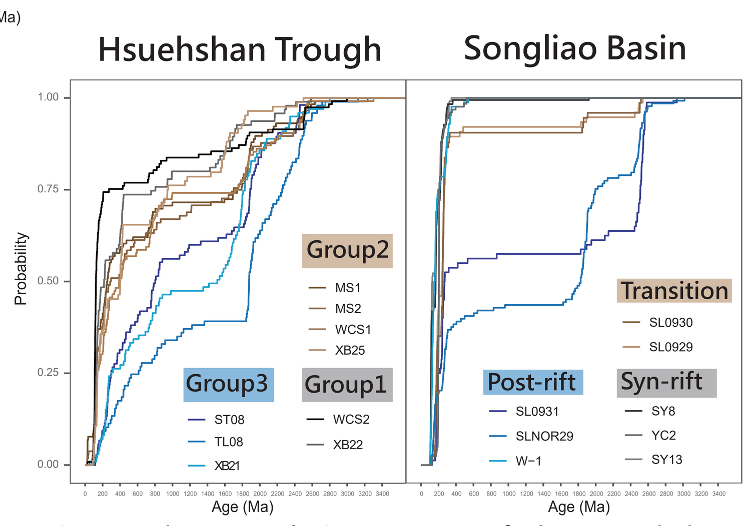

Fig. 4. The cumulative curves of the Hsuehshan trough and the Songliao basin. The curves can be divided into three groups which can be correlated to syn-rift, transition, and post-rift stages.

Summary

The detrital zircon age spectrum patterns within the Hsuehshan trough tend to grow in complexity as the basin evolved from the syn-rift to the post-rift stage within a passive margin setting. Similar variations are observable in intraplate basins. The application of detrital zircon geochronology data provides an innovative perspective on unraveling the enigmatic development of the Hsuehshan trough, which has remained nonconclusive thus far. Looking ahead, our plan involves processing of the four newly collected samples, with the goal of refining our comprehension of the source-to-sink relationship and providing greater constraints on the basin's evolution.

References

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