Journal of
*Marine Science and Engineering*

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# Detrital Zircon Provenance in the Sediments in the Southern Okinawa Trough

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**Abstract:** The provenance of sediments in the Southern Okinawa Trough since the late Holocene has been a controversial scientific issue during the past 20 years. Previous studies based on isotope proxies generally indicated Taiwanese rivers as the primary source in the Southern Okinawa Trough since the late Holocene. Based on the zircon U-Pb geochronology, this study identified how sediments from the Yangtze River/East China Sea shelf had contributed significantly to the Southern Okinawa Trough in the past 624 a BP. Notably, this study found two Paleoarchean zircon grains, which indicated they originated from older orogenic belts. These data shed new light on the provenance of sediments, and a partial supply from the mainland of China cannot be excluded.

**Keywords:** detrital zircon; sediment provenance; Okinawa Trough

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**Citation:** Zhu, B.; Zeng, Z. Detrital Zircon Provenance in the Sediments in the Southern Okinawa Trough. *J. Mar. Sci. Eng.* **2022**, *10*, 142. https://doi.org/10.3390/jmse10020142

Academic Editor: Antoni Calafat

Received: 2 December 2021
Accepted: 18 January 2022
Published: 21 January 2022

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## 1. Introduction

As a momentous "sink" in the East Asia continental margin, the Okinawa Trough is a crucial area to study continental-oceanic interactions and "source-to-sink" processes. Sediments in the Okinawa Trough record the evolutionary history of sea level, ocean circulation, East Asian monsoon, and human activities since the late Pleistocene [1,2]. During the Holocene, terrigenous sediments from various sources were deposited in the East China Sea (ECS) shelf and Okinawa Trough, such as large rivers on the Chinese mainland (the Yangtze River and Yellow River), the "mountain stream type" small and medium rivers on Taiwan Island, and small rivers on the Korean Peninsula and the Ryukyu Island Arc [2–7]. Owing to the sudden change in the Kuroshio Current to reach its present position approximately 7.1 ka [4], sediments in the Southern Okinawa Trough (SOT) record continuous climate and ocean signals, which provides geological evidence for tracing the sedimentary response of the evolution of Kuroshio Current. Simultaneously, the rapid deposition rate in the SOT indicates high sediment supply [8–11]. Therefore, defining the provenance of sediments in the SOT is essential to reveal the evolution of sedimentary environment.

In the last two decades, there have been several research projects conducted on provenance of sediments in the SOT. However, these have not yet led to decisive results. Due to the different research indicators, previous studies have obtained inconsistent conclusions on the provenance of the SOT since the Holocene. For example, records of Sr-Nd isotopic compositions indicate that the provenances of ODP-1202B and H4-S3 were mainly derived from Taiwanese rivers during the past 3.0 ka BP [5,10]. However, a study based on the Sr-Pb isotopic composition of the sediments of RC14-91 core argued that loess and the sediments from the Yangtze River account for 40% of the total [12]. Moreover, the compositions of the total organic carbon (TOC) and total nitrogen (TN), hydrocarbons, long-chain n-alkanes, and fatty acids in surface sediments from the SOT are different from Taiwan river sediments [13,14], indicating that there may be other potential sources in the SOT. Notably, under the ocean circulation system of the Western Pacific since the Holocene, it seems improbable for the sediments from the Yangtze River or the ECS to enter the SOT. Therefore, it is necessary to use more accurate provenance fingerprints to determine whether the Yangtze River or the East China Sea are potential sources for the sediments of the SOT.

The detrital zircon geochronology, which has been used in the ECS [6], the South China Sea [15,16], and the Yellow Sea [17], has become one method used to trace the provenance of sediments in the Chinese marginal seas. In this study, we also reconsidered previous hypothesis, and report detrital zircon U-Pb age distributions from H4-S2, aiming to identify the sediment provenance in the SOT since 624 a BP.

## 2. Regional Setting

The ECS has a wide continental shelf with complex terrain and hydrological conditions, so sediments are commonly affected by two sources: large and medium rivers in the southeastern China mainland (such as the Yangtze River, Oujiang, and Minjiang) and small and medium rivers (such as Zhuoshui river) in Taiwan [18]. The sediment discharge of the Yangtze River has reached 680 Mt/a historically [19], but with the construction of the Three Gorges Dam, this amount has reduced to 100 Mt/a [20]. At the same time, Minjiang and Oujiang, along the southeastern coast of the Chinese mainland, also have significant sediment loads, contributing 17–20 Mt of sediments per year [21]. On the other side of the Taiwan Strait, Zhuoshui river, the longest river in Taiwan, carries 54 Mt of sediments per year into the ECS [22]. As an essential provenance area of SOT, Lanyang river in northeastern Taiwan can transport 6–9 Mt of sediments to the SOT every year [23–25]. The above rivers are the potential provenance areas of sediments in this study.

Ocean currents affect the transport of sediments in the ECS. For example, sediments from the Yangtze River, under the action of the Zhejiang-Fujian Coastal Current (ZFCC) and Changjiang Diluted Water, affect the composition of sediments in most areas of the East China Sea [26]. Meanwhile, most of the sediments from the Changjiang are confined to the East China Sea shelf by the Taiwan Warm Current, forming the mud wedge, and are difficult to transport to the area east of 123° E [26,27].

The area around SOT has developed complex topography characterized by the ECS slope, the North Mien-Hua Canyon, the Mien-Hua Canyon, Keelung Valley, and I-Lan Ridge (Figure 1). The hydrologic environment in this region is influenced by ocean large-scale and mesoscale ocean dynamic processes, including the Kuroshio Current, internal tides, upwelling, and cyclonic eddies (Figure 1b) [28–32].

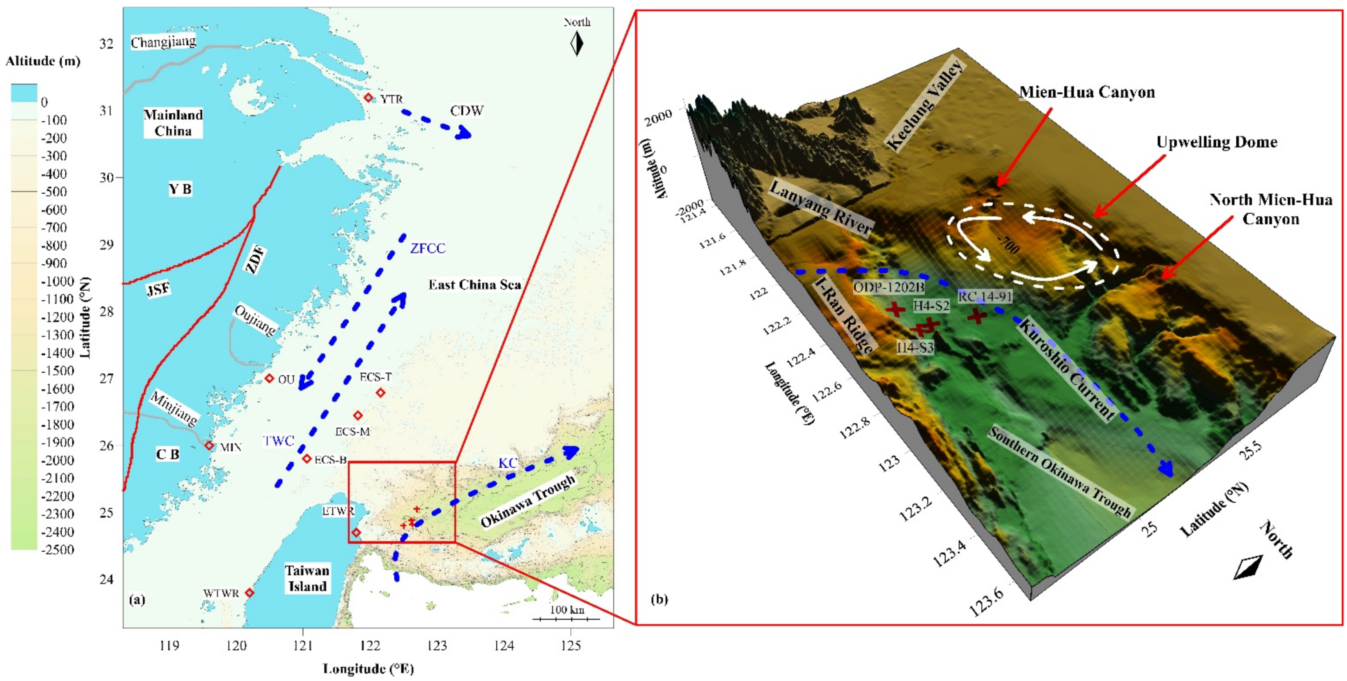


**Figure 1.** (**a**) Currents, cores, and potential provenance areas distribution in the East China Sea (modified from references [5,8,26,33–35]), and (**b**) the location of cores in the Southern Okinawa Trough. YTR, the Yangtze River (Changjiang) mouth; OU, Oiujiang; MIN, Minjiang; ECS-T, ECS-M, and ECS-B, East China Sea shelf; WTWR, Zhuoshui river mouth; ETWR, Lanyang river mouth. CDW, Changjiang Diluted Water; ZFCC, the Zhejiang-Fujian Coastal Current; TWC, the Taiwan Warm Current; KC, Kuroshio Current. Y B, the Yangtze Block; C B, the Cathaysia Block; JSF, Jiang-Shao Fault; ZDF, Zhenghe-Dapu Fault. The location of upwelling dome, valley, ridge, and canyon modified from reference [8]. The pathways of currents and upwelling dome in this figure are not a representation of the actual location. The potential provenance areas are represented by red diamonds, with specific latitude and longitude from the references [6,33,36,37]. Cores in the Southern Okinawa Trough are represented by red crosses, with specific locations from the references [8,10,12]. Topographic data comes from https://www.gebco.net/ (accessed on 2 December 2021).

## 3. Materials and Methods

### 3.1. Samples and Age Model

H4-S2, a 477 cm core on the ocean floor at 1505 m in depth, located in the SOT (Figure 1b). This study focused on the detrital zircon from five layers in H4-S2 (26–66 cm, 112–152 cm, 192–232 cm, 332–372 cm, and 402–442 cm) (Figure 2). The depositional age at 477 cm is 624 a BP (Figure 2).

### 3.2. Methods

#### 3.2.1. Detrital Zircon U-Pb Age and Th/U Analysis

We collected five samples from H4-S2 (Figure 2) to investigate the provenance of the detrital zircons. The details of the samples are provided in Table S2. Since samples are rare, only 400 g of sediment for each sample were processed. Zircon grains were extracted from the sediments by using conventional heavy liquid and magnetic separation procedures.

For detrital zircon U-Pb age analysis samples, more than 1000 grains were selected. A subset of 400 grains was randomly selected under a binocular microscope, fixed, transferred to an epoxy mount, and polished to expose the midsection. Cathodoluminescence (CL) images were used to obtain the internal structure of grains and aid in selecting dating points. The above work was completed at the Institute of Resources of the Chinese Academy of Geological Sciences.

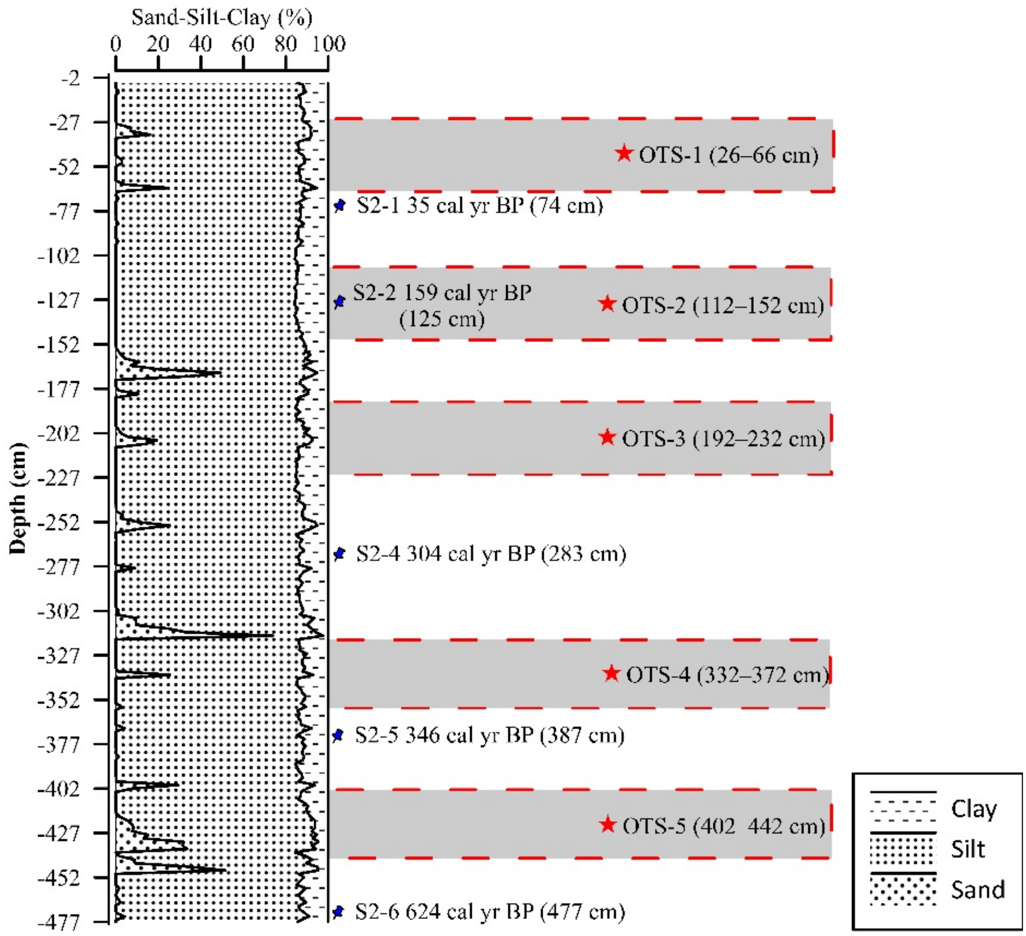


**Figure 2.** The sedimentological column of the H4-S2. The level of detrital zircon sample is marked by red stars and gray rectangles with red boundaries, and its depth placed on the right. The grain size and dating data of H4-S2 are sourced from reference [38].

Zircon U-Pb dating and Th/U analysis were conducted using the LA-ICP-MS instrument in the Mineral and Fluid Inclusion Microanalysis Laboratory of the Institute of Geology, Chinese Academy of Geological Sciences, Beijing. The NWR 193UC laser ablation system (Elemental Scientific Lasers, Omaha, NE, USA) is equipped with a Coherent Excistar 200 excimer laser and a Two Volume 2 ablation cell. The ablation system was coupled to an Agilent 7900 ICP-MS (Agilent, Santa Clara, CA, USA). An external energy meter was used to ensure that the input laser fluence value matched the actual energy of the sample well before analysis. The zircon mounts were cleaned ultrasonically in ultrapure water. Before analysis, the mounts were cleaned again using AR-grade methanol, and each spot was preablated for five shots (~0.3 μm in depth) to remove potential surface contamination. The analyses were performed using a 25 μm diameter spot size at 5 Hz, 2 J/cm$^2$ laser fluence.

The Iolite software package was used for data reduction. Zircon 91500 was used as the primary standard, and GJ-1 and Plešovice were used as secondary standard. The 91500 standard was analyzed twice, and both GJ-1 and Plešovice were analyzed once every 10–12 analyses for the sample. Typically, 35–40 s of the sample signals was acquired after 20 s of gas background measurement. The exponential function was used to calibrate the downhole fractionation. NIST 610 and 91Zr were used to calibrate the trace element concentrations as external reference materials and internal standard elements, respectively. The measured ages of the reference materials in this batch are listed as follows: 91500 (1061.5 ± 3.2 Ma, 2σ), GJ-1 (604 ± 6 Ma, 2σ), and Plešovice (340 ± 4 Ma, 2σ), which agreed with the nominal values well within uncertainty.

ICPMSDataCal9.2 was used to process the experimental data obtained through the above method [39]. For detrital zircon with a $^{207}Pb/^{206}Pb$ age less than 1400 Ma, $^{206}Pb/^{238}U$ ages with a degree of concordance greater than 90% were selected, and for detrital zircons with a $^{207}Pb/^{206}Pb$ age greater than 1400 Ma, $^{207}Pb/^{206}Pb$ ages greater than 90% were selected [40–42].

### 3.2.2. Visual Analysis of the Detrital Zircon Age Distribution

The detrital zircon U-Pb age distribution was visualized as kernel density estimation (KDE) plots with an adaptive bandwidth of 30 Ma, and multidimensional scaling (MDS) map by using an R package for statistical provenance analysis [43]. The above method can transform the differences in age distribution into the shape of the curve and the distance in two-dimensional space. The more similar the distribution is, the more similar the shape will be and the smaller the distance will be.

## 4. Results

### *4.1. Detrital Zircon Grain-Size and U-Pb Age Distribution of the Southern Okinawa Trough over the Past 700 Years*

Most zircon grains are igneous in origin according to oscillatory zoning (Figure 3a) and Th/U > 0.1 (Figure 3b) [33,44,45]. Thus, 75–93 valid ages (427 in total) were obtained for each sample (Table S1).

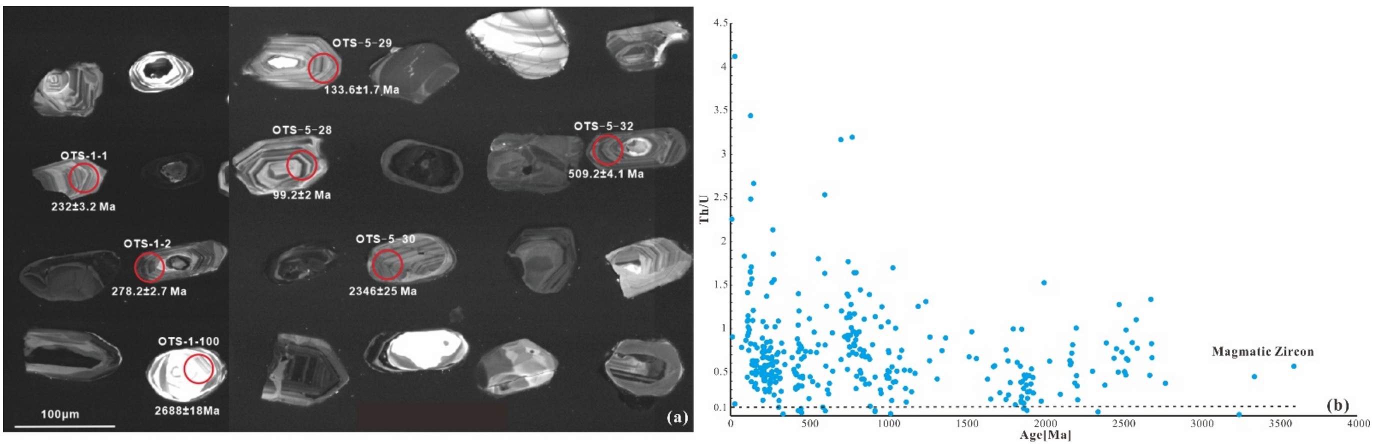


**Figure 3.** Cathodoluminescence images and U-Th ratios of detrital zircon grains from sediments in H4-S2. (**a**) Cathodoluminescence images; (**b**) U-Th ratios. Red circles indicate the dating points.

Since the plot of 25 μm was selected, the size of the zircon grains was relatively fine. The equivalent spherical diameter (ESD), which is the cube root of the product of lengths of the three axes [46], was distributed from 36.21–89.18 μm and mainly distributed from 36.21–62.92 μm. The mean ESD of analyzed zircon grains in OTS-1 to OTS-5 are 50.83, 48.89, 52.47, 53.07, and 61.08 μm, respectively (Table S2).

All samples show seven primary groups: 200–100 Ma, 300–200 Ma, 500–400 Ma, 900–700 Ma, 1.1–1.0 Ga, 2.0–1.8 Ga, and 2.7–2.5 Ga (Figure 4). However, there are some differences between each sample; for example, the main peaks in OTS-1 and OTS-5 appear in the 200–100 Ma group, while peaks in OTS-2 and OTS-4 lie from 300 to 200 Ma, and the peak of OTS-3 is older than others and falls in the 900–700 Ma group. Moreover, OTS-4 has more grains distributed in the range of 1.2–1.0 Ga, while other samples did not show a similar situation. Furthermore, Cenozoic grains all appear in five samples, including OTS-1-92 (28.53 ± 0.86 Ma), OTS-2-94 (29.12 ± 0.3 Ma), OTS-3-83 (58.6 ± 1.6 Ma), OTS-4-83 (9.73 ± 0.43 Ma), and OTS-5-65 (13.75 ± 0.64 Ma) (Table S1). Paleoarchean grains are only found at OTS-2-31 (3597 ± 16 Ma), and OTS-4-51 (3282 ± 12 Ma) (Table S1).

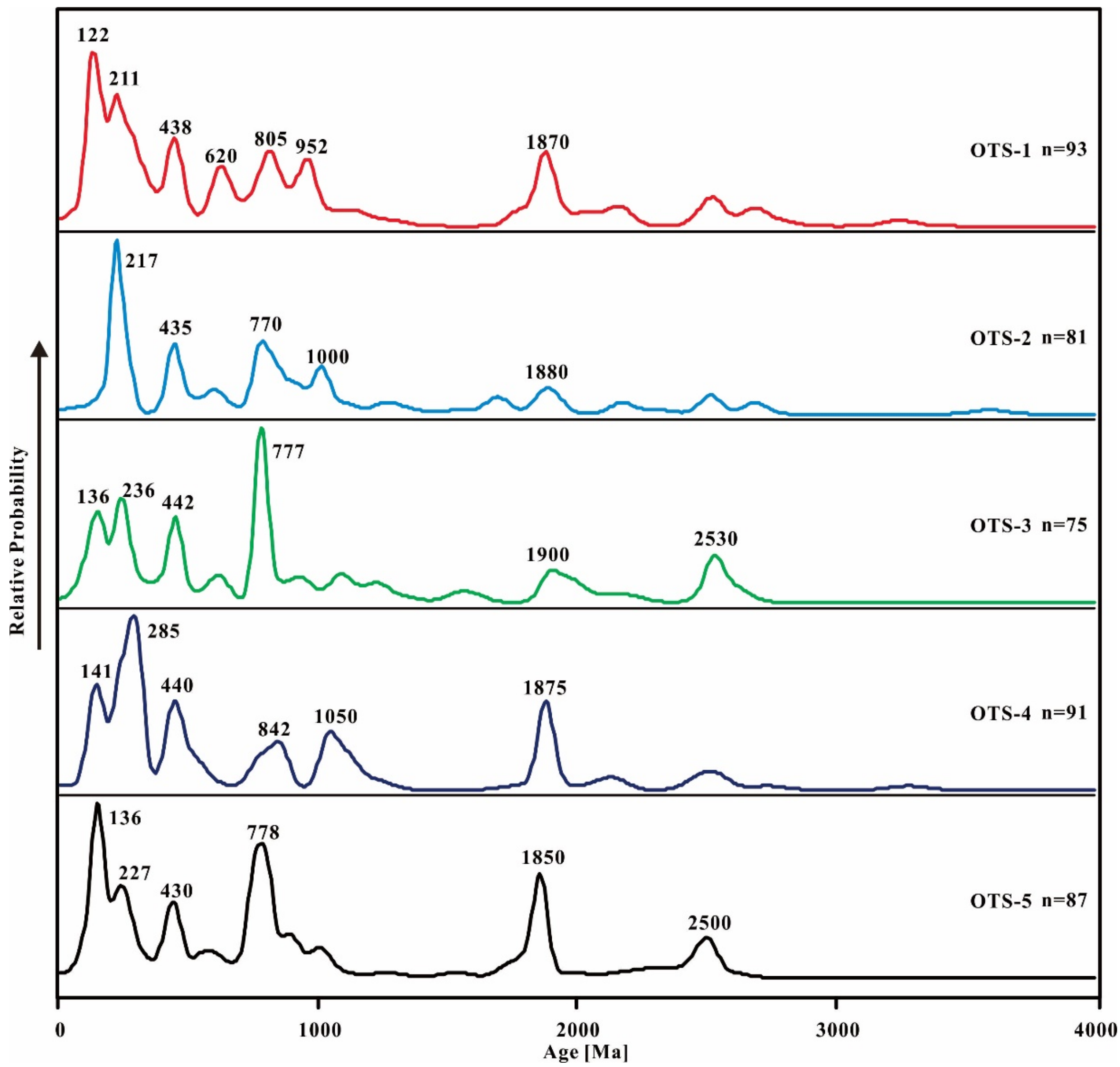


**Figure 4.** Kernel density estimation (KDE) plots for detrital zircon U-Pb ages of OTS-1 to OTS-5 in H4-S2. Please refer to Table S1 for detailed data. The results of OTS-1 and OTS-2 are reprocessing of the previous data [47]. The values of major age peaks are marked in this figure.

### *4.2. Detrital Zircon U-Pb Age Distribution from the Potential Provenance of the Southern Okinawa Trough*

Recent studies have shown that detrital zircon from sediments in modern rivers may well reproduce the expected age distribution of the zircon-bearing bedrock source area [33,48]. To better define the provenance of detrital zircon grains in the southern Okinawa Trough, we consider the East China Sea shelf, Yangtze River, Lanyang river, Zhuoshui river, Minjiang, and Oujiang as potential provenance areas (Figure 1a).

The U-Pb age distribution of the detrital zircon in the potential provenance areas is mainly characterized by the following characteristics (Figure 5): (1) The detrital zircon in the sediments of the Lanyang river and Zhuoshui river is represented by seven main age groups: 200–100 Ma, 300–200 Ma, 550–360 Ma, 850–700 Ma, 1.1–0.9 Ga, 2.0–1.8 Ga, and 2.6–2.4 Ga. The age distribution of the Zhuoshui river is relatively simple, with a higher proportion of Phanerozoic zircons, but the Zhuoshui river has a more complex age composition and more Precambrian zircons [33]. (2) The detrital zircon of Changjiang-derived sediments shows five major age groups: 300–100 Ma, 600–400 Ma, 900–700 Ma, 2.0–1.7 Ga, and 2.6–2.2 Ga [36,49]. The distribution characteristics of Changjiang-derived and Huanghe-derived sediments are completely different, with four main age groups: 500–200 Ma, 1000–800 Ma, 2.0–1.5 Ga, and 2.8–2.2 Ga [50]. In addition, the age peak of the Huanghe-derived sediments appeared in the Paleoproterozoic, which is also an important signal to distinguish the two provenance areas (Changjiang and Huanghe). (3) The age distribution of the detrital zircon in Oujiang is simple, distributed in the ranges of 200–60 Ma and 2.4–1.8 Ga; (4) Minjiang is mainly distributed in the range of 1.0 Ga–60 Ma, and the remaining particles were distributed in the range of 3.3–1.2 Ga [36,37,51]. The age ranges of Oujiang and Minjiang are obviously younger than those of Changjiang and Huanghe, which also provides a basis for distinguishing different provenance areas for this study. (5) Due to the different locations, the age distribution of the East China Sea shelf is different. ECS-B has four main age groups: 600–60 Ma, 1.2 Ga–700 Ma, 1.9–1.6 Ga, and 2.7–2.4 Ga; ECS-M has two main age groups: 500–3 Ma and 1000–600 Ma; and ECS-T has three main age groups: 1.2 Ga–100 Ma, 2.1–1.8 Ga, and 2.6–2.4 Ga [6].

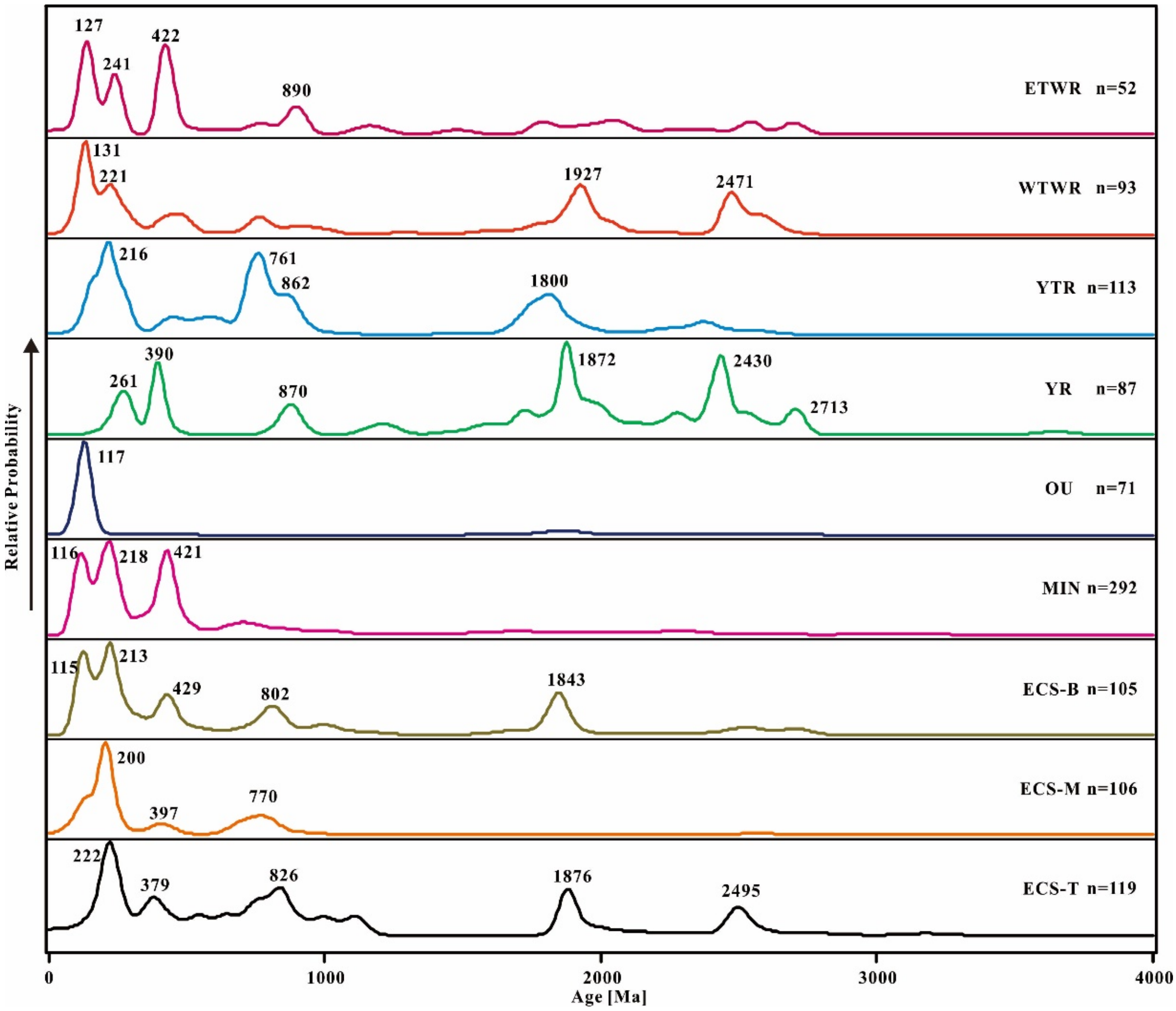


**Figure 5.** Kernel density estimation (KDE) plots for detrital zircon U-Pb ages of Lanyang river mouth [33], Zhuoshui river mouth [33], the Yangtze River mouth [36], Yellow River mouth [50], Oujiang mouth [34], Minjiang mouth [37], and the East China Sea shelf [6]. Please refer to Table S1 for detailed data. The values of major age peaks are marked in this figure.

## 5. Discussion

### 5.1. Detrital Zircon Provenance of the Southern Okinawa Trough in the Past 700 Years

A recent study suggested that the detrital zircon may not be representative of the provenance of bulk sediments [52]. Therefore, the provenance identification results of our study may only indicate the provenance of detrital zircons.

The 700–900 Ma age component, especially the peak at ~761 Ma, is the diagnostic characteristic of the Yangtze River [36]. This identification sign of the Yangtze River is of great significance to distinguish other potential provenance areas of SOT, since there is no significant peak at ~761 Ma in other provenance areas except the Yangtze River (Figure 5). This component and peak prevail in OTS-3 and OTS-5 (Figure 4), indicating that sediments from the Yangtze River and southern Okinawa Trough are of the same origin. In addition to the 700–900 Ma age group, 100–200 Ma, 200–300 Ma, and 400–500 Ma are also the primary age components in H4-S2 (Figure 4). These groups cannot be used to accurately determine their sources since they coexist in the Lanyang river, Zhuoshui river, Minjiang, and the East China Sea shelf (Figure 5). The same feature is also present in the 1.8–2.0 Ga and 2.5–2.7 Ga age groups. However, it is simpler due to the fact that only the Zhuoshui river, the Yangtze River, and the East China Sea shelf provide for these groups. Although the age distribution characteristics of the Yellow River and Oujiang are listed in this study (Figure 5), they are not potential provenance areas for the following reasons: (1) Oujiang-derived sediments only contain Mesozoic grains, which are not similar to any H4-S2 samples; (2) the modern Yellow River estuary is so far away from the southern Okinawa Trough that there is no evidence of sediments migrating to this region; and (3) sediments from the Yellow River are characterized by high concentrations of Archean zircon, which are completely different from H4-S2 (Figures 4 and 5). The MDS maps more clearly show the source-sink relationship between H4-S2 and provenance areas (Figure 6). OTS-2, OTS-3, and OTS-5 were close to YTR and ECS-T. OTS-1 and OTS-4 were closer to ETWR (Figure 6). The results of MDS indicated that Lanyang river may be the source of detrital zircon grains in OTS-1 and OTS-4. Grains in OTS-2, OTS-3 and OTS-5 may be derived from the East China Sea shelf and Yangtze River. All of the provenance analyses indicated that the detrital zircon, which was found in H4-S2 in the past 624 a BP, originated from a mixture of sediment supplies from Taiwanese rivers, the East China Sea shelf, and the Yangtze River. This understanding is consistent with previous provenance identification results of geochemistry and mineralogy in this region [8,12,53,54]. Thus, it is believed that detrital zircons in the SOT have consistently recorded sediment supplies from the Yangtze River and the East China Sea shelf since 624 a BP.

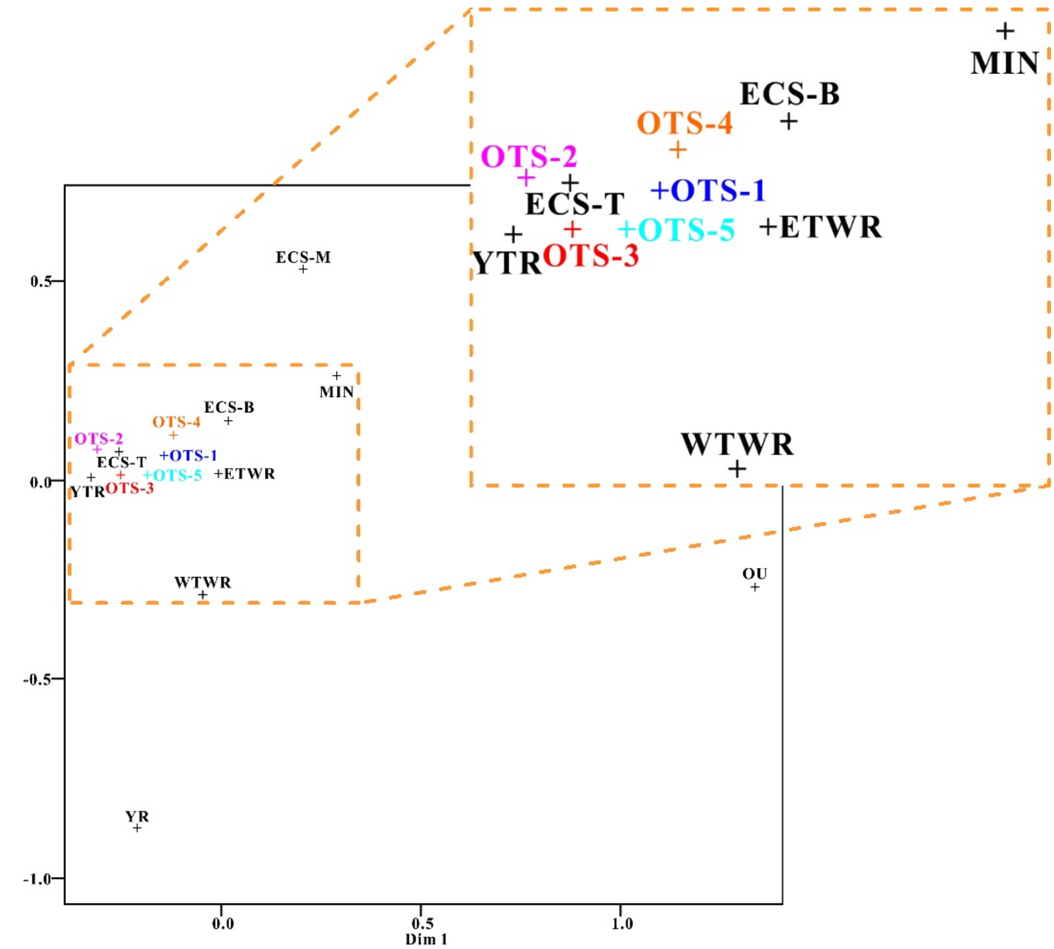


**Figure 6.** Multidimensional scaling (MDS) plot for detrital zircon U-Pb ages of H4-S2 and potential provenance areas. The orange dotted line shows an enlargement of part of this figure.

Most grains analyzed in this study have a size of 36.21–89.18 μm and are mainly concentrated in the silty fraction, which is common in H4-S2 (Figure 2). In previous studies, the grain-size effect on the detrital zircon age distributions was mentioned [55]. For the case of this study, although the median grain size distributions of detrital zircon in OTS-1, OTS-2, OTS-3, and OTS-4 are relatively finer than OTS-5, no specific correlation of zircon age and grain size was noted (Figure 7). There was also no correlation between the grain size and zircon age in the same sample, meaning that older zircon grains were not necessarily finer (Figure 7).

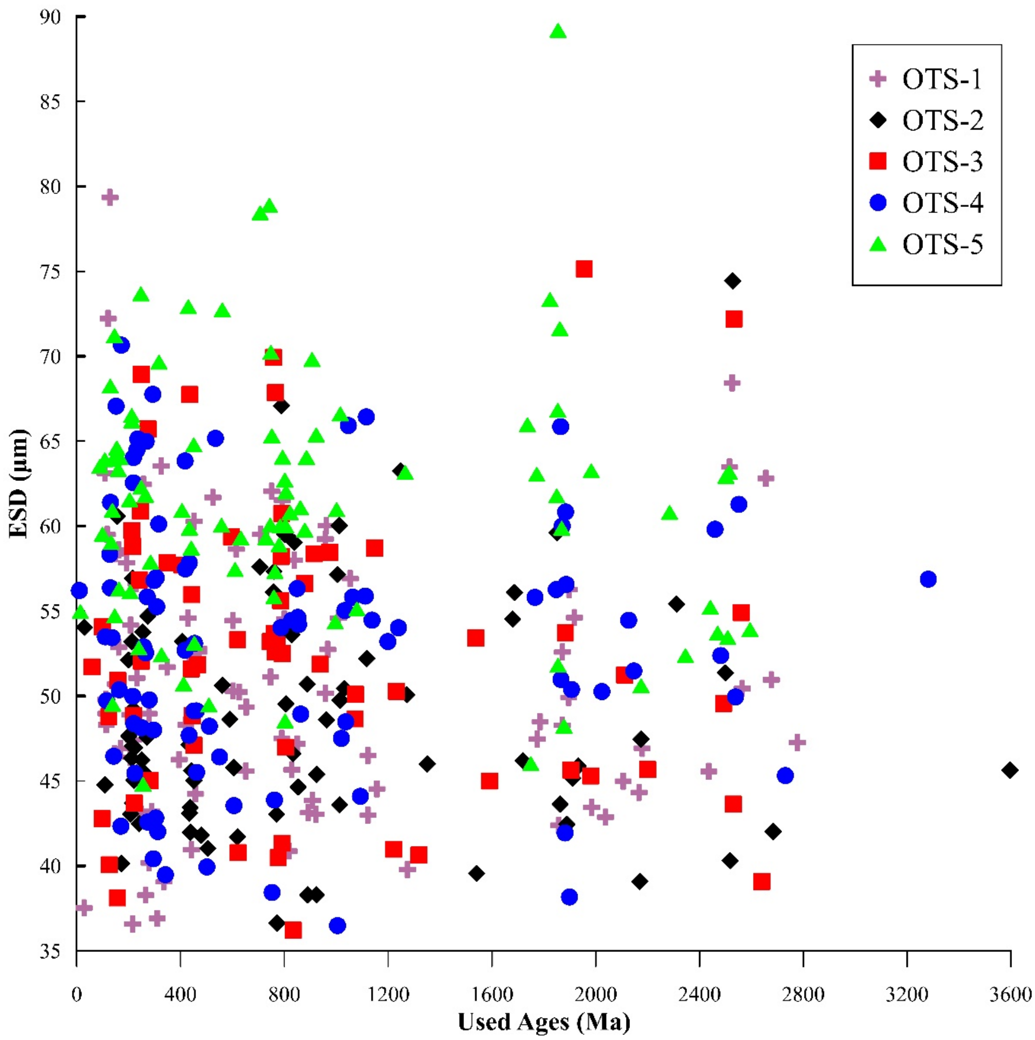


**Figure 7.** Distribution plots of detrital zircon U-Pb ages and ESD which be used in this study. Please refer to Table S2 for detailed data.

*5.2. Paleoarchean Detrital Zircon: Singal or Noise?*

Although there are only two Paleoarchean detrital zircon grains (OTS-2-31: 3597 ± 16 Ma and OTS-4-51: 3282 ± 12 Ma), they may be important provenance indicators since the provenance areas around the southern Okinawa Trough could not provide such old grains. In order to find the source of these two grains, we collected the reported Paleoarchean grains from the south China (the Yangtze Block and Cathaysia Block). Detailed locations, data, and references are listed in Table S3. As shown in Figure 8, Paleoarchean zircon grains appear to be distributed in various regions throughout the south China. Grains of similar age exist in the sediments of the middle and upper reaches of the Minjiang river [37], which should be direct evidence that Paleoarchean grains from the south China could through the Minjiang river to the East China Sea. Another evidence is that Paleoarchean detrital zircon has been found in the main stream of the Yangtze River (Hukou, Shigu and Panzhihua) and its tributaries (Hanjiang and Ganjiang) [36,49].

Therefore, the two Paleoarchean grains in this study may not be noise, but weak signal to indicate provenance. Although sporadic detrital zircon data from the East China Sea do not contain such old zircons [6], ancient grains from the Yangtze River, Yangtze Block, and Cathaysia Block may all be sources of OTS-2-31 and OTS-4-51.

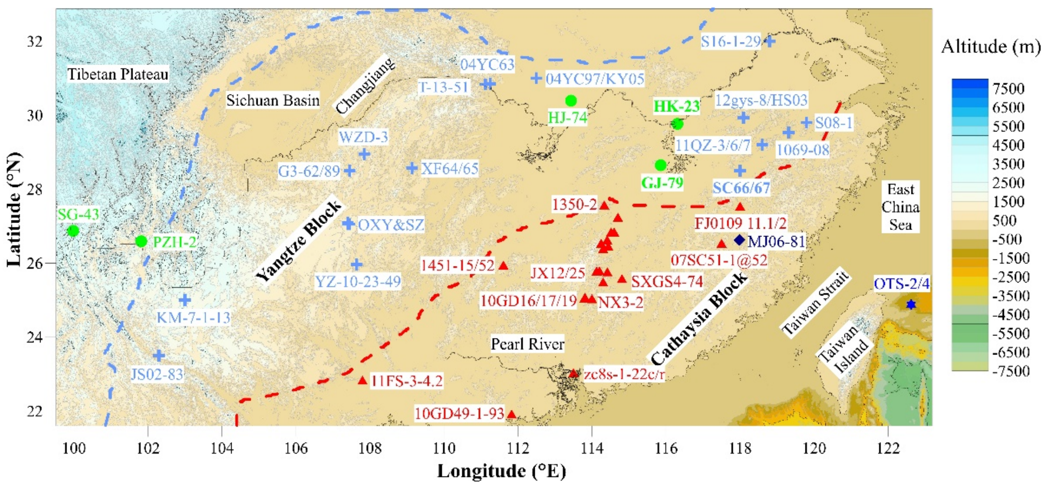


**Figure 8.** Distribution of Paleoarchean detrital zircon grains in the south China and East China Sea. Grains in the Yangtze Block, Cathaysia Block, Yangtze River Basin, and Minjiang are marked by light blue cross, red triangle, green circle, and dark blue diamond, respectively. The location of the Yangtze Block and the Cathaysia Block modified from references [33–35]. Please refer to Table S3 and references therein for detailed data of ages and location. The light blue and red dotted lines roughly define the position of the Yangtze Block and the Cathaysia Block, respectively. Topographic data comes from https://www.gebco.net (accessed on 1 December 2021).

### *5.3. Why the Yangtze River Zircons Appear in the Souerhtern Okinawa Trough?*

Previous studies on the sediment sources of ECS indicated that ECS shelf received a large number of materials from the Yangtze River, and the contribution rate of the Yangtze River could reach 72% and even higher [6,56]. Similarly, physical oceanography and heavy mineral studies have shown that the Yangtze River sediments can be transported southward to the East China Sea Shelf via the ZFCC and transported further east by the puncture front [26,57,58]. Moreover, the ECS shelf is characterized by the extensive development of residual deposits [59]. With increasing offshore distance, the grain size of surface sediments in the ECS shelf is gradually enhanced [26], and the content of stable minerals increased significantly [60], indicating a large amount of Pleistocene residual sand accumulation on the outer shelf and slope of the East China Sea. Hence, the sediments from the ancient and modern Yangtze River may be jointly preserved in the outer shelf and slope of the ECS and become the source for sediments in the SOT.

Previous studies have suggested that mass wasting and density currents caused by occasional events, such as earthquakes, typhoons, and heavy floods, in the hinterland resulted in the transport of sediments on the slope to the seafloor [23,61]. In addition, the widely developed submarine canyon at the junction of the East China Sea shelf and Okinawa Trough is a natural channel for sediment transport [62]. Particles from the shelf are transported by grain flows through submarine canyons into the Okinawa Trough [63]. Many coarse-grained layers in H4-S2 record the extensive development of turbidity current events in the past 624 a BP [38]. Therefore, the detrital zircons in H4-S2 are derived from the sediments of the modern Yangtze River and the residual deposits on the ECS. ZFCC may be an important mechanism for the transport of sediments from the Yangtze River to the ECS shelf. Gravity flow may be the transport mechanism of sediment from the ECS to the SOT. This could also explain the presence of Paleoarchean detrital zircons in H4-S2. Since this study only reported zircon data from five layers, it is hard to verify whether this transport process is continuous, especially with gravity flow.

## 6. Conclusions

Based on detrital zircon U-Pb geochronology provenance identification, our study provides direct evidence that sediments from the Southern Okinawa Trough recorded sediments from Taiwan rivers, the East China Sea shelf, and the Yangtze River in the last 700 years. At the same time, two Paleoarchean detrital zircon grains probably originated from the Cathaysia Block and Yangtze Block in the south China and were transported into the East China Sea by the Yangtze River or Minjiang river. Detrital zircon grains in this study are mostly in the silty fraction and may only indicate the provenance of the silt in the sediments or only the provenance of the detrital zircon. Detrital zircons from the modern Yangtze River were transported by the Min-Zhejiang coastal current, and settled on the East China Sea shelf. They and residual sediments in the East China Sea shelf were transported by gravity flow through submarine canyons and eventually deposited in the Southern Okinawa Trough.

Detrital zircon U-Pb geochronology is a powerful tool for distinguishing the sediments from Taiwan rivers, the East China Sea shelf, and the Yangtze River. A deep understanding of the quantitative provenance analysis and marine dynamics evolution in the Southern Okinawa Trough may be improved by the availability of longer time-scale cores and more grains of detrital zircon.

**Supplementary Materials:** The following are available online at https://www.mdpi.com/article/10.3390/jmse10020142/s1. Table S1: Isotopic data and U-Pb ages of detrital zircon in H4-S2 and potential provenance areas; Table S2: ESD compositions of detrital zircon grains in H4-S2; Table S3: Locations, ages, and references of Paleoarchean detrital zircon grains in the south China.

**Author Contributions:** Methodology, B.Z.; software, B.Z.; validation, B.Z.; investigation, B.Z.; resources, Z.Z.; data curation, B.Z.; writing—original draft preparation, B.Z.; writing—review and editing, B.Z.; visualization, B.Z.; supervision, Z.Z.; project administration, Z.Z.; funding acquisition, Z.Z. All authors have read and agreed to the published version of the manuscript.

**Funding:** This work was funded by the National Natural Science Foundation of China (Grant No. 91958213), the International Partnership Program of Chinese Academy of Sciences (Grant No. 133137KYSB20170003), the Special Fund for the Taishan Scholar Project of the Shandong Province (Grant No. ts201511061), the National Special Fund for the 13th Five Year Plan of COMRA (Grant No. DYI35-G2–01–02), and the National Basic Research Program of China (Grant No. 2013CB429700), the Natural Science Foundation of Shandong Province (Grant No. ZR2019QD016).

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** All data and references involved in this study are listed in the Tables S1–S3.

**Conflicts of Interest:** The authors declare no conflict of interest.

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