by Liangshu Shu[1], Michel Faure[2], Shaoyong Jiang[1], Qun Yang[3], and Yujing Wang[3]

SHRIMP zircon U-Pb age, litho- and biostratigraphic analyses of the Huaiyu Domain in South China

— Evidence for a Neoproterozoic orogen, not Late Paleozoic-Early Mesozoic collision

1 State Key Laboratory for Mineral Deposits Research, Department of Earth Sciences, Nanjing University, Nanjing 210093, China.
2 ISTO, Université d'Orléans, B. P. 6759, 45067 Orléans, Cedex 2, France.
3 Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China.

In the last few decades, the Late Paleozoic–Early Mesozoic tectonic evolution of South China has been quite controversial. The focus of debate is on both the age of ophiolites and the Late Paleozoic–Early Mesozoic geological and geodynamic environment. The Huaiyu Domain is located in the NE part of South China and exposes numerous significant geological features that are keys to understand the tectonics of South China. In this paper, we present some new evidence on stratigraphy, petrology and SHRIMP zircon U-Pb geochronology, and together with other geological and geochemical data available in the literature, and the following conclusions are suggested: 1) The eastern Jiangnan ophiolites belt, dated at 858±11 Ma by SHRIMP zircon U-Pb method, was generated during the Neoproterozoic, but not the Late Paleozoic; 2) The sedimentary rocks associated with these oceanic rocks do not contain radiolarians but Neoproterozoic acritarchs; 3) During Permian–Early Triassic times, the Huaiyu Domain was dominantly characterized by a shallow sea depositional environment since deep sea sediments are absent; and 4) The pre-Devonian tectonics of South China has been reworked by late polyphase tectonism through the Triassic and the Cretaceous periods. A Late Paleozoic–Early Mesozoic deep marine domain floored by oceanic crust never existed in the study area. The geochronological and structural data do not comply with a Late Paleozoic–Early Mesozoic South China Ocean.

Introduction

The Huaiyu Domain occupies an area larger than 4000 km^2, in NE Jiangxi, NW Zhejiang provinces and a part of southern Anhui Provinces. In this large area, numerous significant geological features such as ophiolitic mélange, blueschist metamorphic rocks, arc-type volcanic rocks, various types of granitic rocks, ductile and syn-metamorphic structures and complete Phanerozoic sedimentary sequences are well preserved. Thus the Huaiyu Domain is a key area for understanding the tectonics of South China.

However, in the last few decades, the tectonic evolution of this region has been quite controversial. In the 1990's, the Huaiyu Domain was interpreted as either a Neoproterozoic active continental margin or an Early Mesozoic collisional orogenic belt (Hsu et al., 1988; Rowley et al., 1989; Rodgers, 1989; Guo et al., 1989; Ren et al., 1989; Chen et al., 1991; Li, 1993; Shi et al., 1994; Charvet et al., 1996; Shu et al., 1990, 1994, 1996). Zhao et al. (1995) claimed that they had found Carboniferous–Permian radiolarians associated to the ophiolitic blocks in the NE part of the Jiangxi Province. Thus these authors concluded that the ophiolitic magmatism was generated in a Late Paleozoic oceanic basin. Since then, a new controversy has arisen concerning the nature and origin of the radiolarian-bearing cherts (He et al., 2000; Li, 2000; Wang and Shu, 2001; Yang et al., 2005). The debate on the Proterozoic tectonic nature of SE-margin of Yangtze block hasa been extended to the western part of the Jiangnan orogenic belt (Zhou et al., 2002; Li et al., 2003; Zhou et al., 2004). Some researchers have emphasized that in South China the Jiangnan Orogenic Belt was formed by the closure of a Paleozoic ocean, called the "Banxi ocean", during Late Paleozoic to Early Mesozoic (Zhao et al., 1995; He et al., 2000). According to this view, a Late Paleozoic deep sea environment and a Late Paleozoic-Early Mesozoic ocean-continent paleogeographic framework are suggested for the South China Block (Xiao and He, 2005).

The age of the ophiolite and the Late Paleozoic-Early Mesozoic stratigraphic sequence in the Huaiyu Domain is still poorly understood, leading to various interpretations on the tectonic evolution and geological environment of the South China Block. Therefore, it appears necessary to precisely determine the age of the ophiolitic rocks, and to clarify the Phanerozoic strata sequence and corresponding sedimentary environments. In this paper, we present new stratigraphic information and new SHRIMP zircon U-Pb dating of ophiolitic rocks, in an attempt to clarify the age of the ophiolitic rocks and to better constrain the depositional environment of the Late Paleozoic-Early Mesozoic rocks in the study area.

Geological setting

Tectonic outline

The Huaiyu Domain is situated in the eastern segment of the NEE-NE-trending Jiangnan Neoproterozoic orogenic belt. This domain separates the Jiuling Proterozoic terrane to the northwest by the NE Jiangxi fault, from the NE-trending Early Paleozoic Cathaysian Orogenic Belt to the south by the Shaoxing-Jiangshan fault (Figure 1). The NE Jiangxi and the Shaoxing-Jiangshan faults are considered to be very important tectonic suture zones (Guo et al., 1989; Gilder et al., 1991; Shi et al., 1994; Faure et al., 1996; Shu and Charvet, 1996; Charvet et al., 1996; Yang et al., 2005).

The Huaiyu Domain can be divided into three lithological and tectonic units: 1) the ophiolitic mélange zone (or northern zone); 2) the Precambrian volcanic rock zone (or central zone); and 3) the sedimentary cover zone (or southern zone). The northern and central

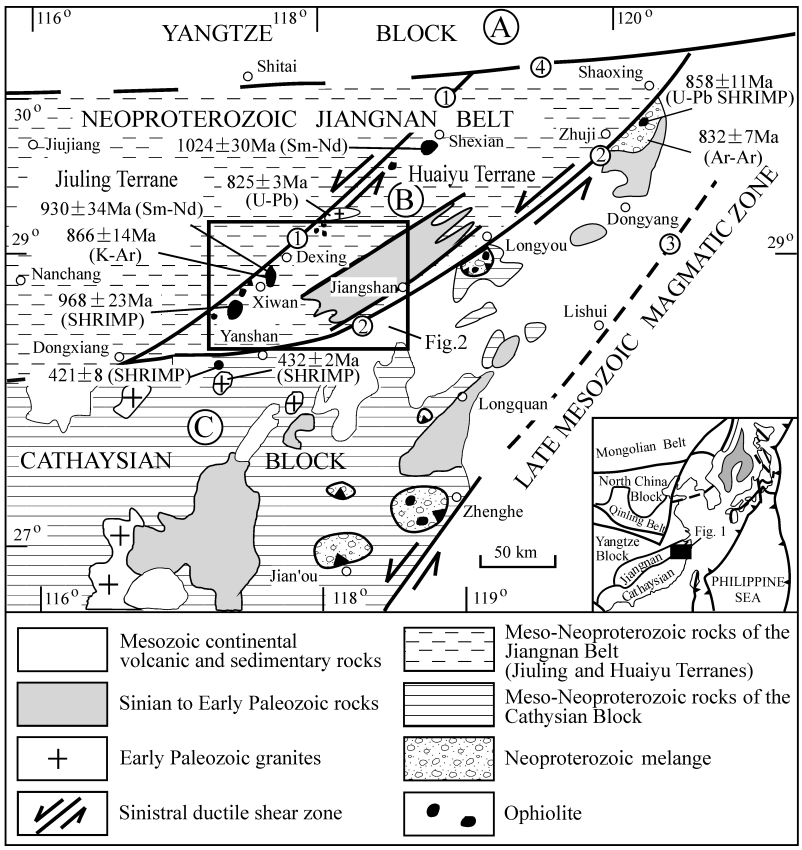


Figure 1 Simplified tectonic map of the Huaiyu Domain, South China.

zones have been subjected to a regional-scale lower-greenschist facies metamorphism and ductile shear deformation.

The northern zone is distributed along the NE Jiangxi fault, about 2–4 km wide and 200 km long, where exist more than 200 exposures of fault-bounded mafic or ultramafic blocks. The ophiolitic blocks consist of various lithologies such as serpentinite, peridotite, orthopyroxenite, gabbro, diabase, pillow basalt, tuffaceous flysch, limestone, chert, andesite and vocalnoclastic rocks. In outcrop, the size of a single block varies from 2 km^2 (e.g. in Zhangshudun and Xiwan, Figures 1, 2) to less than 100 m^2. In Shiershan near Kaihua County, the ophiolitic mélange was intruded by a S-type cordierite-bearing granite dated at 825±3 Ma by U-Pb on zircon (Liu et al., 1995) and is overlain unconformably by Lower Sinian conglomerate and coarse-grained sandstone (Ren et al., 1989; Shi et al., 1994; Shu and Charvet, 1996).

The central zone is a NE-trending volcanic belt, 10–15 km wide that consists of a 4000 m-thick pile of spilite, keratophyre, andesite, rhyolite, tuffaceous rock and graywacke. The U-Pb dating on zircon from quartz-keratophyre in Kaihua County (Figure 1) yields an age of 846±4 Ma (Liu et al., 1995).

The southern zone belongs to an unmetamorphosed Sinian and Phanerozoic sedimentary cover, distributed mainly in the southeastern part of the Huaiyu Domain. The deposits of southern zone cover partly the Jiangshan–Shaoxing Neoproterozoic suture between the Yangtze block and the Cathaysian block. Along the suture, several ophiolitic mélange blocks are exposed, dated at around 900 Ma, a Neoproterozoic age (Zhou and Zhu, 1992). From the Sinian Period (equivalent to the Ediacaran Period of 630–540 Ma, Gradstein et al., 2004) to the Early Triassic, the whole domain was a passive continental margin. Except for short-lived magmatism coeval with a rifting event around 825 Ma (Gilder et al., 1991; Li et al., 1996), any other regional-scale volcanism is lacking from Cambrian till Early Triassic times in the Huaiyu Domain.

Stratigraphic sequence

Pre-Sinian basement. Metamorphic and plutonic rocks of pre-Sinian age crop out widely in the Jiangnan belt. These basement rocks consist of Meso- to Neoproterozoic granitoids, volcanic rocks (bedded tuff, basalt, spilite) and turbidite strata including argillite, sandstone and mudstone. The mafic-ultramafic blocks assigned to a dismembered ophiolitic mélange. Sinian sedimentary rocks devoid of ductile deformation and metamorphism overlie unconformably the pre-Sinian basement (JBGMR, 1984; ABGMR, 1985; FBGMR, 1985; ZBGMR, 1989; Rodgers, 1989; Rowley et al., 1989; Shu and Charvet, 1996; Chen et al., 1997).

Sinian System. This consists of four formations, namely, the Zhitang Formation (Z_1z), Leigongwu Formation (Z_1l), Doushantuo Formation (Z_2d) and Dengying Formation (Z_2dy). The Zhitang Formation (Z_1z), with thicknesses ranging from 100 m to 1500 m, is composed of red colored conglomerate, graywackes, quartz-sandstone with southward current indicators, toward upper siltstone and shale. These terrigeneous rocks with coarse fragment overlie unconformably the volcanic rock series of the Neoproterozoic Shangshu Formation. Numerous pebbles of slate, schist and orthogneiss are preserved in the conglomerates. The Leigongwu Formation (Z_1l) is composed of 5–60 m thick glaciofluvial sediments. The Doushantuo Formation (Z_2d) is a phosphorus-bearing dolomite and pyrite-bearing dolomite-limestone formation of 5–80 m thick. The Dengying Formation (Z_2dy) is mainly composed of chert with intercalated limestone and dolomite. The Lower Sinian rocks correspond to a post-collisional foreland basin. The study of paleocurrent direction during the Early Sinian Period shows that the Early Sinian detrital rocks were supplied from two sedimentary sources on both NW and SE sides of the foreland basin (ZBGMR, 1989; Shu et al., 1990, 1996).

According to Zhang and Yan (2006), the Zhitang Formation and the Leigongwu Formation were considered to be a Pre-Sinian sequence, called the Nanhua System, and the Doushantuo Formation and the Dengying Formation belong to the Sinian System. Unfortunately, they didn't provide dating evidence on the ages of the Zhitang and Leigongwu Formations.

Early Paleozoic. During this period, a shallow sea occupied the whole domain. The 200–400 m thick Cambrian System is in conformable contact with the Sinian System. It is composed of pyrite-phosphate-uranium-vanadium-bearing black shale or mudstone with some coal seams, bedded limestone, marlite and dark colored chert, in which abundant trilobite and brachiopoda are preserved. The 800–2000-m-thick Ordovician System consists of nodular limestone, nodular marlite, black chert and sandstone-siltstone-shale turbidite with Bouma sequences. These rocks contain numerous fossils of graptolite and cephalopoda. The 1800–3000-m-thick Silurian System is composed of interbedded sandstone, siltstone and shale or mudstone with limestone and marlite intercalations, containing brachiopoda and a few graptolite fossils. The strata of the above mentioned three systems deposited continuously in the stratigraphic succession (JBGMR, 1984; ZBGMR, 1989).

Late Paleozoic. In the study area, the Lower and Middle Devonian Series are absent. Only the 80–300 m thick Upper Devonian Series called Wutong Formation is preserved. It is composed of red and gray conglomerate, quartz-conglomerate and coarse-grained sandstone with siltstone containing plant fossils of *Leptophloeum rhombicum* Dawson (JBGMR, 1984; ZBGMR, 1989). These rocks deposited in an intra-continental marine basin in a littoral depositional environment. The Upper Devonian (Wutong Formation, D_3) overlies unconformably the folded Upper Ordovician or Upper Silurian Series (Figure 2), indicating the existence of an Early Paleozoic tectonic event.

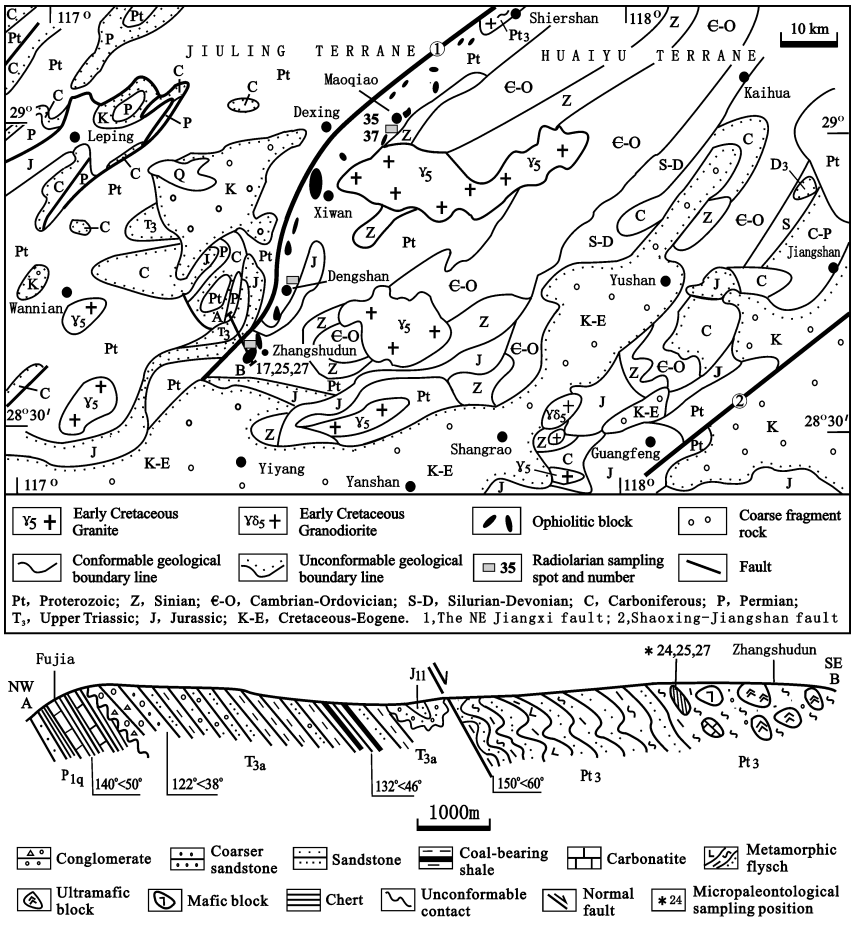


Figure 2 Geological map insetting a geological section of Huaiyu Domain, South China.

The Carboniferous System belongs to a stable platform setting of shallow sea in which were deposited 110–200-m-thick carbonates, with various fossils of fusulinaceans, coral and brachiopoda. The 40–50 m thick siltstone, marlite and shale intercalated with coal seams form the Lower Carboniferous Series (Zhishan Formation, C_1z). Frequently, the basal part of the Lower Carboniferous Series consists of coarse terrigeneous rocks (conglomerates, sandstones) that unconformably cover the Lower Paleozoic rocks.

During the Permian Period, as presented below, various depositional environments occurred in the Huaiyu Domain and its neighboring areas. In the Huaiyu Domain, the 400–450 m thick Permian System is composed of: 1) black limestone intercalated with nodular chert with abundant fusulinids (Qixia Formation, P_1q); 2) thin-bedded chert intercalated with sandstone (Gufeng Formation, P_1g), 3), coal-bearing siltstone and feldspar-sandstone with plant fossils such as *Pecopteris* and *Gigantopteris* (Longtan Formation, P_2l), and 4) siliceous shale and sandy shale containing numerous fossils of ammonoidea, brachiopoda and a few fusulina (Dalong Formation), indicating a littoral-shallow sea environment.

The Lower Triassic deposits are generally in conformity with the underlying Permian strata. But in several areas, there are disconformities (Yang et al., 1982). Conversely, Upper Triassic red conglomerates and quartz-sandstone overlie regionally the Paleozoic strata by an angular unconformity (Figure 2). The lithological features of the Mesozoic strata will be described in the following sections.

Age of ophiolitic mélange in the Huaiyu Domain

Two ophiolitic mélange zones, namely the NE Jiangxi zone and the Jiangshan-Shaoxing zone, are distributed along the two boundaries of the Huaiyu Domain. The mélanges are interpreted as two sutures located between the Proterozoic Huaiyu and the Jiuling terranes and between the Yangtze and Cathaysian continental blocks, respectively (Shu and Shi, 1990; Shi et al., 1994; Shu and Charvet, 1996; Charvet et al., 1996).

The Jiangshan–Shaoxing ophiolitic mélange that outcrops in the Zhuji and Longyou areas consists of serpentinized peridotite, orthopyroxenite, sheared gabbro, diabase, basalt, chert and a few limestone. These rocks experienced a regional lower greenschist facies metamorphism coeval with ductile shearing. The radiometric ages of these ophiolitic rocks were up to now poorly studied. Only two dating ages of ophiolite were obtained, that is, 889±10 Ma by K-Ar on amphibole grains of diorite in Zhuji (Zhou et al., 1992), and 832±7 Ma by $^{40}Ar/^{39}Ar$ on amphibole grains of mafic schists near the gabbro (Kong et al. 1995), respectively. These ages for the ophiolite are considered not as precisely as the SHRIMP zircon U-Pb ages. Therefore, in this study we carried out a SHRIMP dating on a fresh gabbro rock (Sample 407) sampled in Huaquan of Zhuji.

The sample preparation and SHRIMP U-Pb dating of 14 zircon grains from gabbro were done in the Beijing SHRIMP Center, Chinese Academy of Geological Sciences. The results are listed in Table 1 and the representative cathodoluminecence images of zircon grains from the gabbro are presented in Figure 3. Weighted mean $^{206}Pb/^{238}U$ ages with 1 σ error are in 95% confidence. Most analyses are concordant, with $^{232}Th/^{238}U$ ratios 0.68–1.11, and MSWD 1.60. From the U-Pb concordia diagram (Figure 4), Sample 407 yielded a mean

Table 1 Analytical data from SHRIMP U-Pb dating for zircon grains from the Huaquan ophiolitic gabbro, Zhuji area.

Sample Number	% $^{206}Pb_c$	ppm U	ppm Th	$^{232}Th/^{238}U$	ppm $^{206}Pb^*$	$^{206}Pb/^{238}U$ ± 1σ (Ma)		$^{207}Pb/^{206}Pb$ ± 1σ (Ma)		$^{207}Pb^*/^{206}Pb^*$	±%	$^{207}Pb^*/^{235}U$	±%	$^{206}Pb^*/^{238}U$	±%
407-1	0.37	84	77	0.95	10.00	841	25	855	79	0.072	3.2	1.378	4.2	0.1393	2.7
407-2	0.69	73	67	0.95	8.88	857	25	800	86	.074	3.3	1.44	4.2	.1421	2.7
407-3	1.23	53	35	0.68	6.50	860	26	785	196	.071	4.1	1.40	5.0	.1428	2.9
407-4	0.12	66	71	1.11	7.77	829	26	826	135	.069	5.9	1.30	6.5	.1373	2.7
407-5	0.43	80	74	0.95	10.2	886	25	680	93	.065	3.4	1.31	4.2	.1473	2.6
407-6	0.37	80	72	0.92	9.80	856	24	825	81	.069	3.3	1.35	4.2	.1420	2.6
407-7	0.00	78	66	0.87	9.85	878	25	946	67	.065	3.6	1.31	4.4	.1459	2.6
407-8	0.98	99	88	0.91	12.9	898	21	649	131	.072	2.7	1.50	3.7	.1515	2.5
407-9	0.43	154	132	0.89	18.4	*837*	*18*	749	60	.069	2.3	1.33	3.3	.1394	2.3
407-10	1.93	58	41	0.72	7.18	*846*	*24*	621	330	.076	3.7	1.49	4.6	.1429	2.8
407-11	1.16	49	39	0.83	6.35	897	25	986	221	.054	6.1	1.08	6.8	.1458	2.9
407-12	0.28	111	102	0.95	13.5	*849*	*20*	755	87	.069	2.8	1.35	3.7	.1416	2.5
407-13	0.49	81	72	0.93	9.48	*824*	*20*	718	99	.068	3.3	1.29	4.2	.1371	2.6
407-14	0.65	104	92	0.91	13.4	899	21	725	146	.070	5.1	1.45	5.6	.1507	2.5

Errors are 1-sigma; Pbc and Pb* indicate the common and radiogenic portions, respectively.
Error in Standard calibration was 1.86%(not included in above errors but required when comparing data from different mounts).
(1) Common Pb corrected using measured 204Pb; (2) Common Pb corrected by assuming 206Pb/238U-207Pb/235U age-concordance;
(3) Common Pb corrected by assuming 206Pb/238U-208Pb/232Th age-concordance

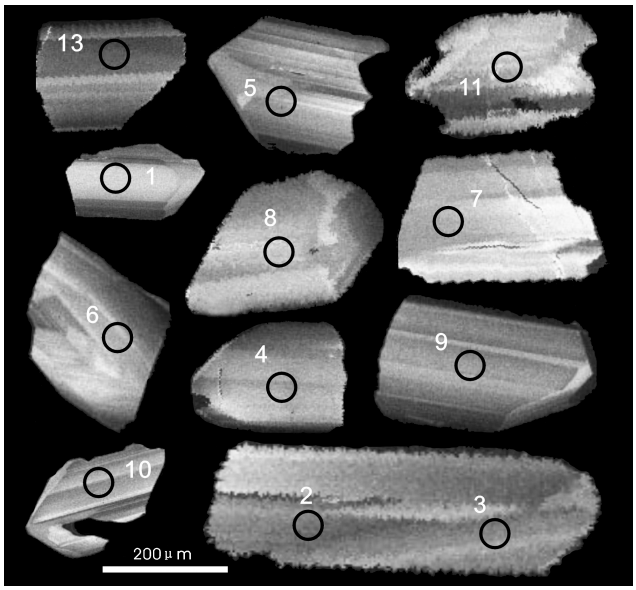


Figure 3 Representative cathodoluminescence images of zircon grains from the gabbro sample 407. Circles indicate analyzed spots.

$^{206}Pb/^{238}U$ age of 858±11 Ma. This age demonstrates that a strong tectono-thermal event took place during Neoproterozoic in the region.

These ophiolitic mélanges were likely reworked by late tectonic events during Early Paleozoic and Early Mesozoic times. For example, an Early Paleozoic sinistral transpressive ductile shearing has been documented by $^{40}Ar/^{39}Ar$ dating on syn-kinematic metamorphic minerals of muscovite (391±3 Ma) and biotite (421±8 Ma), respectively (Shu et al., 1999). In addition, a 432±2 Ma SHRIMP zircon U-Pb age is obtained for a sheared granodiorite in the SW side of Yanshan (Figure 1) (Sun, 2005). In the study area, large-scale ductile deformation, younger than Silurian, had not been found. However, several metamorphic core complexes around Mesozoic granitic domes or ductile shear zones coeval with the thermal aureole that surrounds the Mesozoic granitic plutons are documented in several places in South China (e.g., Faure et al., 1996, Faure et al., 1998; Lin et al., 2000, 2001). Since the Late Devonian, brittle deformation structures such as faults, joints, cataclasite, breccia and gentle upright folds are widely developed, possibly in relation with transpressional tectonics.

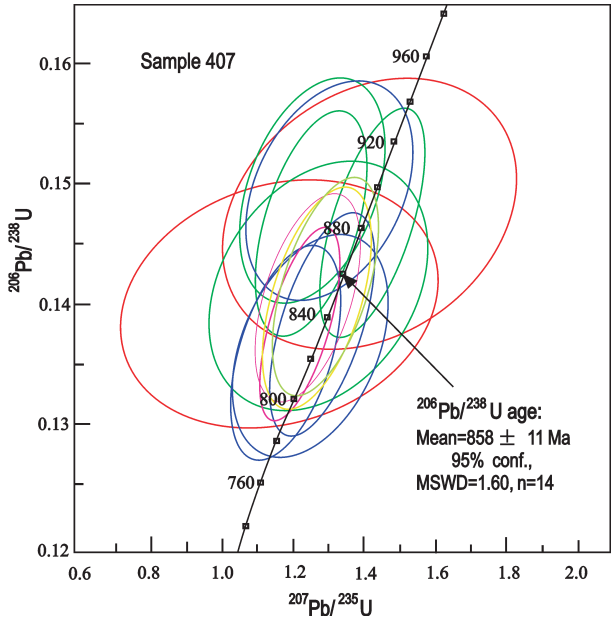


Figure 4 SHRIMP U-Pb age on zircon grains from the Huaquan ophiolitic gabbro, sampled near Zhuji.

Regional-scale sedimentary environment around the Huaiyu Domain during the Late Permian to the Early Triassic

In the past thirty years, many geologists paid attention to biostratigraphy and paleogeography of the Paleozoic and Mesozoic sedimentary deposits of South China (JBGMR, 1984; ABGMR, 1985; FBGMR, 1985; ZBGMR, 1989). Eight synthetic lithostratigraphic columns for the Permian to Triassic interval are established all around the Huaiyu Domain (Figure 5).

The Early Permian strata consist of nodular-chert-bearing limestone, bioclastic limestone and chert. Brachiopods and fusulinids are abundant. The strata thickness varies, from 160–210 m in Xuancheng and Anqing (Figures 5-1, 4) to 1000 m in southern Fujian (Figures 5-7, 8). The Early Permian Series was deposited in a shallow sea environment in continuity with the Late Carboniferous strata. The Late Permian strata, including the Changxing Formation in NW Zhejiang, are mainly composed of feldspar-sandstone, coal-bearing siltstone, shale, carbonaceous shale, coal seams, calcareous-shale, muddy siltstone and siliceous shale with intercalated lenses of limestone containing numerous fossils of *Pecopteris, Gigantopteris,* cephalopoda and pelecypoda. The thickness of this series ranges from 100–200 m in the Zhejiang and Anhui Provinces (Figures 5-1, 2, 3, 4) to 200–500 m in Jiangxi Province (Figures 5-5, 6), and up to 700 m in Fujian Province (Figures 5-7, 8).

The stratigraphic characteristics of Late Permian to Early Triassic deposits are summarized in Table 2. Obviously, the decreasing in grain size of the deposits from the NW (Figures 5-1, 2, 3, 4) to the SE (Figures 5-5, 6, 7, 8) indicates a SE-dipping slope during the Late Carboniferous to the Middle Triassic. However, both lithological characteristics and fossil assemblages in these eight areas document only variations of sea level that reflect various paleo-environments such as shallow sea, littoral, swampland and land, but not deep sea environment. This view is further supported by the occurrence of three coal-forming periods in this region during the Late Permian (Figures 5-2, 3, 5, 6, 7, 8), the Middle Triassic (Figures 5-5, 6) and the Late Triassic (whole region). In the eight areas, there are abundant Late Paleozoic shallow sea animal fossils such as brachiopoda, pelecypoda, cephalopoda, fusulinids and coral, and terrestrial plants such as *Pecopteris* and *Gigantopteris*, indicating an environment ranging from continental shelf to land. The Lower Triassic Series corresponds to shallow sea facies sediments, including mudstone, dolomitic limestone, marlite and oolitic limestone, rich in pelecypoda and brachiopoda (Yang et al., 1982). The thickness varies in different sections, from 160–280 m (Figures 5-1, 4) to 500 m (Figures 5-2, 3), and even up to 600–700 m (Figures 5-5, 6, 7, 8). The Middle Triassic Series with a thickness ranging from 670 m (Figures 5-7, 8) to 1000 m (Figures 5-4, 5, 6) is deposited in the southern part of the study area, composed of shallow sea and littoral facies calcic siltstone, siltstone and limestone including pelecypoda, brachiopoda and plants. However, in the northern part of the study area, Middle Triassic Series is lacking (Figure 5-1). The Upper Triassic Series consists of red colored coarse clastic rocks (sandstone and conglomerate) and coal-bearing siltstone, which unconformably overlie the older strata.

On the basis of the above mentioned stratigraphic and sedimentologic lines of evidence, we conclude that during the Late Permian

Table 2 Lithostratigraphic features from the Upper Permian to the Lower Triassic in areas around the Huaiyu Domain.

Region	Formation	Features of lithostrata	Fossil	Environment
Xuancheng	**T1d**	Calcic mudstone,sandstone, marlite, limestone, oolitic limestone	brachiopods,ammonoids	Shallow sea
	P2c	Bituminous limestone, intercalated thin-bed of siliceous rock	brachiopods, fusulinids, ammonoids	Shallow sea-slope
	P2w	Lower part: conglomerate,feldspar-quartz sandstone, shale, coal Upper part: sandstone, carbonaceous shale, intercalared limestone	Lower part: *Pecopteris, Gigantopteris* Upper part: brachiopods, fusulinids	Early stage: land Late stage: littoral
Changhsing	**T1n**	Limestone, nodular limestone,dolomite, oolitic limestone	ammonoidea, bivalves	Shallow sea-littoral
	T1h	Limestone, dolomitic limestone	bivalves	Shallow sea
	T1y	Mudstone, marlite, calcic mudstone, limestone	bivalves, ammonoids	Shallow sea
	P2c	Bituminous limestone, intercalated thin-bed of siliceous rock	brachiopods, fusulinids, ammonoids	Shallow sea-slope
	P2l	Lower part: conglomerate,feldspar-quartz sandstone, shale, coal Upper part: sandstone, carbonaceous shale, intercalared limestone	Lower: *Pecopteris, Gigantopteris* Upper: brachiopods, fusulinids, corals	Early stage: land Late stage: littoral
Jiangshan	**T1z**	Calcic siltstone,siltstone,intercalated limestone	brachiopods, bivalves, ammonoids	Shallow sea-littoral
	P2d	5m thick conglomerate , sandstone,then siliceous shale, siltstone	brachiopods, ammonoids	Shallow sea
	P2w	Quartz-sandstone, siltstone, shale, silt-mudstone, coal, alumyte	Plant: Compsopteris cf. *contracta* Gu et Zhi	Littoral-swampland
Anqing	**T1n**	Limestone, nodular limestone, oolitic limestone,breccia limestone	ammonoids, bivalves	Shallow sea-littoral
	T1h	Limestone, nodular limestone, intercalated shale	bivalves, ammonoids	Shallow sea
	T1y	Calcic mudstone, marlite, intercalated bed of limestone	brachiopods, ammonoids	Shallow sea
	P2c	Bituminous limestone, intercalated thin-bed of siliceous rock	brachiopods, fusulinids,ammonoids	Shallow sea
	P2w	Lower part: carbonaceous shale, sandy shale, siltstone, coal beds Upper part: limestone, chert-nodular limestone	Lower: *Pecopteris, Gigantopteris* Upper: brachiopods, fusulinids, bivalves	Land-swampland, littoral-shallow sea
East Jiangxi	**T1d**	Interbedding marlite and limestone, mudstone	bivalves, Ammonoids	Shallow sea
	P2c	Limestone, intercalated siliceous rock and siliceous limestone	brachiopods, fusulinids	Shallow sea
	P2lp	Lower part: feldspar-quartz sandstone, sandstone,shale, coal beds Upper part: limestone,siliceous limestone, mudstone, siltstone	Lower: *Pecopteris, Gigantopteris* Upper: brachiopods, ammonoids	Land-swampland, littoral-shallow sea
West Jiangxi	**T1d**	Shale, limestone, dolomite, mudstone	bivalves, ammonoids	Shallow sea
	P2d	Limestone, siliceous limestone	Palaeofusulinids, Corals	Shallow sea
	P2wl	Feldspar-quartz sandstone, silty shale, mudstone, coal beds	Plant: *Compsopieris* cf. *contracta* Gu et Zhi	Land and marsh
Central Fujian	**T1xw**	Red siltstone, mudstone, intercalated beds of fine grain sandstone	bivalves	Land to littoral
	T1xk	Siltstone, mudstone, intercalated beds or lens of limestone	bivalves	Littoral
	P2d	Mudstone, siltstone. bottom part: fine grain sandstone	brachiopods, bivalves, ammonoids	Shallow sea
	P2cp	Bottom part: quartz-sandstone and coarse sandstone containing pebbles. Main part: sandstone, shale intercalated coal beds	bivalves, brachiopods Plants: *Gigantopteris*	Land to swampland and littoral
SE Fujian	**T1xw**	Red siltstone, mudstone, intercalated beds of fine grain sandstone	bivalves	Land to littoral
	T1xk	Siltstone, mudstone, intercalated beds or lens of limestone	bivalves	Littoral
	P2d	Mudstone, siltstone. bottom part: fine grain sandstone	brachiopods, bivalves, ammonoids	Shallow sea
	P2cp	Bottom part: quartz-sandstone and coarse sandstone containing pebbles. Main part: sandstone, shale intercalated coal beds	bivalves, brachiopods *Plants: Gigantopteris*	Land to swampland and littoral

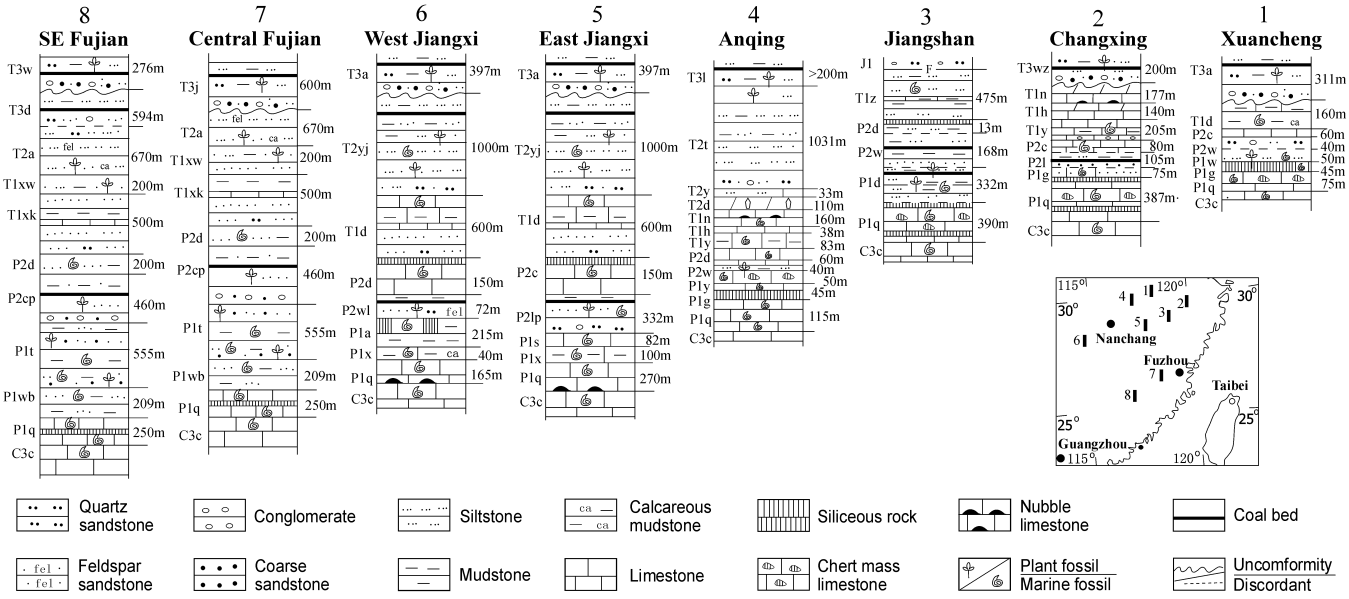


Figure 5 Carboniferous-Triassic stratigraphic columns of Zhejiang-Jiangxi-Anhui and Fujian Provinces, South China.

Symbols of strata: J1, Lower Jurassic Series; T3, Upper Triassic Series; T2, Middle Triassic Series; T1, Lower Triassic Series; P2, Upper Permian Series; P1, Lower Permian Series; C3, Upper Carboniferous Series. T3a, Anyuan Formation; T3d, Dakeng Formation; T3l, Lalijian Formation; T3j, Jiaokeng Formation; T3w, Wenbinshan Formation; T3wz, Wuzhao Formation; T2a, Anren Formation; T2d, Dong maanshan Formation; T2t, Tongtoujian Formation; T2yj, Yangjia Group; T2y, Yueshan Formation; T1d, Daye Formation; T1h, Helongshan Formation; T1n, Nanlinhu Formation; T1xw, Xiwei Formation; T1xk, Xikoi Formation; T1y, Yinkeng Formation; T1z, Zhengtang Formation; P2c, Changxing Formation; P2cp, Cuipingshan Formation; P2d, Dalong Formation; P2l, Longtan Formation; P2lp, Leping Formation; P2wl, Wulinshan Formation; P2w, Wujiaping Formation; P1a, Anzhou Formation; P1g, Gufeng Formation; P1q, Qixia Formation; P1s, Shizixing Formation; P1t, Tongziyan Formation; P1wb, Wenbishan Formation; P1w, Wuxue Formation; P1x, Xiaojiangbian Formation; P1y, Yinping Formation.

to Early Triassic interval, the Anhui-Zhejiang-Jiangxi-Fujian areas corresponded to a shallow marine environment instead of a deep sea one.

The radiolarians in the NE Jiangxi zone: their age and paleogeographic significance

Radiolarians are planktonic protozoa that currently live both in the continental shelves (e.g. Fjords of Norway or East China Sea) and in deep water environments (e.g. offshore of Japan). In shallow sea environments, after their death, the shells of micro-organisms were accumulated and sometimes may have been partly transported to a deep sea basin. In a deep sea setting, the preservation is sometimes more difficult because of the dissolution of the shell on the way down to the sea floor. Thus, the occurrence of radiolarian in chert is not an unequivocal criterion to assess the water depth and the sedimentary environment. Geochemical criteria such as REE patterns, especially Ce anomaly of radiolaria-bearing chert, are also widely used (Shimizu et al., 1977; Murray et al., 1990; Kozur, 1993).

On the basis of previous work, the two ophiolitic zones mentioned above were considered to have been generated by the closure of the paleo-South China ocean during the Neoproterozoic (e.g. Shi et al., 1994; Shu and Charvet, 1996). However, the Late Paleozoic radiolarians found by Zhao et al. (1995) and He et al. (2000) around the Neoproterozoic NE Jiangxi ophiolitic zone have challenged this viewpoint. For example, Xiao and He (2005) proposed that the occurrence of Late Paleozoic radiolarians in the NE Jiangxi ophiolitic mélange zone reflects the development of a synchronous deep sea.

In order to fix the timing of the tectonic evolution of South China and to clarify the significance of the Late Paleozoic radiolarian, we made four surveys of the field area and collected numerous chert samples from the NE Jiangxi area (Figure 2). Particularly, all the locations where radiolarians had been previously reported by Zhao et al. (1995) and He et al. (2000) were repeatedly visited and sampled by us. A total of 306 samples of chert (191 sets) and siliceous slate (115 sets) were analyzed by Prof. Y.J. Wang at the Micro-Paleontological Laboratory of Nanjing Institute of Geology and Palaeontology, and none were found to contain radiolarians. However, 74 samples yielded acritarchs, dated to the Mesoproterozoic and Neoproterozoic (Yang et al., 2005). It is worth noting that the Proterozoic acritarchs were recovered from both chert and siliceous slate in Zhangshudun, Dengshan and Maoqiao is exactly the same places where putative radiolarian-bearing Late Paleozoic cherts has been reported (Zhao et al., 1995; He et al., 2000). Furthermore, these rocks show similar level of crystallinity and deformation as the surrounding Proterozoic slates, suggesting that Neoproterozoic cherty rocks have experienced the same pre-Sinian regional tectonics.

Table 3 The REE concentrations of radiolarian-bearing cherts in the NE Jiangxi (in ppm).

Sample No.	17	25	27	35	37
La	1.54	17.01	18.17	31.96	47.08
Ce	2.411	51.4	40.19	63.33	73.65
Pr	0.3153	4.994	4.838	7.398	8.634
Nd	0.8465	19.3	17.82	29.05	34.28
Sm	0.1475	4.083	3.652	5.434	6.791
Eu	0.042	0.7936	0.7443	0.9.54	1.107
Gd	0.2519	4.625	3.535	4.977	6.819
Tb	0.026	0.6484	0.4952	0.7323	0.966
Dy	0.2893	4.22	3.225	4.992	6.137
Ho	0.0633	0.8784	0.6533	1.224	1.293
Er	0.1524	2.217	1.651	2.98	3.368
Tm	0.0268	0.3466	0.2618	0.4908	0.5377
Yb	0.1632	2.447	1.734	3.434	3.761
Lu	0.0266	0.3983	0.2658	0.5446	0.592
Y	1.983	20.96	15.74	28.21	33.18
Ce/Ce*	0.8193	1.5909	1.1438	1.0502	0.8847

Ce/Ce* =Normalized Ce/((La+Pr)/2);
Normalized (n) to chondrites for REEs after Sun and McDonough (1989).
REE analyses were carried out by ICP-MS at the Modern Analysis Center, Nanjing.

We also analyzed chert and siliceous mudstone samples gathered by L.S. Shu, G.B. Chen, and K.Z. He. All these samples are also devoid of Paleozoic radiolarians (Yang et al., 2005). A similar investigation was carried out by A. Yao and his group from Osaka City University, Japan, and their results were also negative (personal comminication, 2001). None of the putative radiolarian-bearing rocks yield any radiolarian remains. Moreover, in southern Jiangsu, southern Anhui and northern Jiangxi areas, the cherts interlayered with fusulina-bearing limestone, contain an abundance of Permian radiolarians (ABGMR, 1985; JBGMR, 1984; Wang and Shu, 2001; Yang et al., 2005). There, we collected five samples of Permian radiolarian-bearing chert for a geochemical study. All chert samples show a slightly LREE enriched pattern with positive Ce anomaly (Figure 6, left). In agreement with previous studies (Figure 6, right; Shimizu et al., 1977; Murray et al., 1990; Kozur, 1993), these geo-

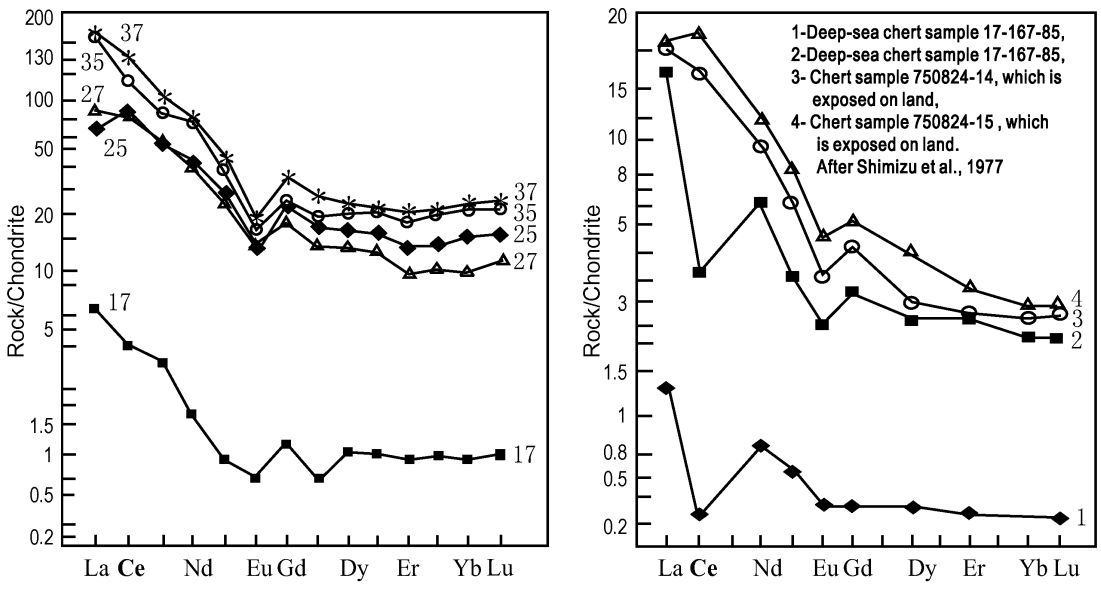


Figure 6 The chondrite-normalized REE patterns of cherts. Left: so-called Late Paleozoic radiolarian-bearing cherts in the NE Jiangxi fault zone; Right: cherts from various environments for comparison.

chemical characteristics demonstrate that the chert was deposited in a shallow marine environment on a continental margin. Therefore, micropaleontology and geochemistry do not support the idea of a "Late Paleozoic to Mesozoic deep sea".

Discussion

Proterozoic or Permian-Triassic age of the ophiolites

Various radiometric ages have been reported from the ophiolitic mafic pods of the NE Jiangxi zone (Figures 1, 2), including a 968±23 Ma SHRIMP U-Pb age on zircons from plagiogabbro in Zhangshudun (Li et al., 1994); a 930±34 Ma Sm-Nd isochron age on gabbro rocks in Xiwan (Xu and Qiao, 1989); a 1034±24 Ma Sm-Nd isochron age on whole gabbro rocks and mineral separates of feldspar and pyroxene in Zhangshudun (Chen et al., 1991); a 1024±30 Ma Sm-Nd isochron age on whole rock and pyroxene-apatite-plagioclase minerals in Shexian (Zhou et al., 1989); and a 866±14 Ma K-Ar age on glaucophane grains in Xiwan (Shu et al., 1994). The Shiershan granite that cuts across the ophiolitic mélange yielded a zircon U-Pb age of 825±3 Ma, providing an upper limit for the ophiolitic mélange (Liu et al., 1995). We conclude that both the NE Jiangxi and the Jiangshan–Shaoxing ophiolitic mélange zones were formed in the Neoproterozoic period. The ophiolites involved into the mélange should represent two Neoproterozoic oceanic lithospheres, which cannot be Late Paleozoic to Early Mesozoic in age.

Comparison of Sinian to Early Paleozoic strata with neighboring regions

Regional stratigraphic data show that the South China Block might be divided into three regions by the Shitai–Jiujiang and Shaoxing–Jiangshan–Pingxiang faults, namely the Yangtze continental block, the Jiangnan orogen and the Cathaysian continental block, A, B and C in Figure 1 respectively (JBGRM, 1984; ZBGRM, 1996). From Early Sinian to Late Silurian, both the lithological and paleontological features are gradually transitional among the three regions (Figure 7). The Yangtze one was a carbonate platform characterized by bioclastic rock, nodular limestone, massive carbonate and rare chert; the Cathaysian region belongs to a deep-water environment represented by *Graptolithic* facies sandstone-shale and lava-volcanoclastic rock. Finally, the Jiangnan region situated between the Yangtze and Cathaysian regions was a transitional sedimentary area both in lithological facies and in biological assemblages, belonging to a marginal platform environment. In the Devonian, this paleogeographic framework was partly destroyed due to the Caledonian folding. Each Formation and Member of the Paleozoic stratigraphic sequence in the NE Jiangxi-NW Zhejiang areas are well constrained by various standard mega fossils typical of shallow sea and land origin. Therefore, in this area, there is no paleontological or sedimentological evidence to support the existence of a Paleozoic ocean.

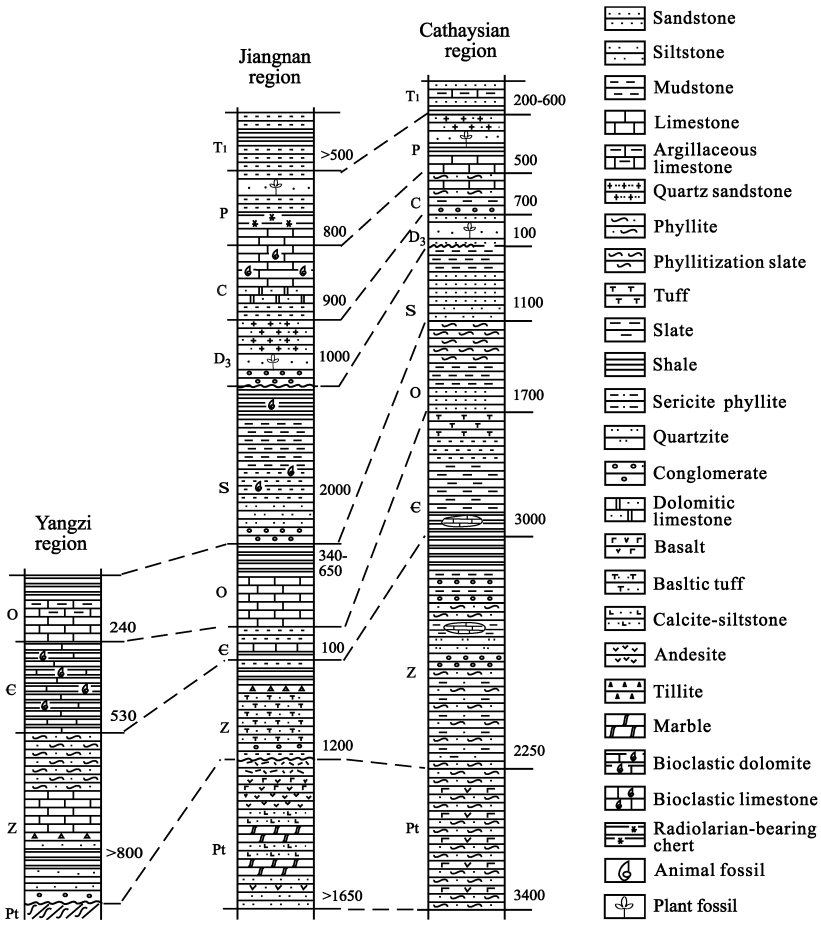


Figure 7 Stratigraphic columns from Neoproterozoic to Triassic in Yangtze, Jiangnan and Cathaysian regions.

Influence of the Indosinian tectonic event

Undoubtedly, the influence of the Permian-Early Triassic (Indosinian) event is well developed in the Huaiyu Domain. The preserved records include structural evidence, namely, a) the angular unconformity of the Late Triassic Anyuan Formation (T_3a) upon the pre-Triassic strata; b) the regional scale folding of the pre-Triassic strata; c) the conspicuous pre-Late Triassic thrusting or normal faulting developed in brittle conditions. For example, to the north of Zhangshudun, Proterozoic metamorphic rocks thrust at a high angle on Permian coal-bearing strata. On the southern slope of the Jiuling Mountains, the Proterozoic metamorphic slabs glided to the south upon the Late Paleozoic rocks of the Pingxiang basin, or the Permian carbonate or chert slabs were folded and collapsed upon pre-Cambrian rocks (e.g. Faure et al, 1998; Lin et al., 2001). Thus it is not impossible that during the Indosinian tectonism, Permian limestone and radiolarian cherts were placed in close contact with Neoproterozoic ophiolitic blocks. However, these cherts are not representative of an oceanic setting.

Conclusions

The petrological, structural and geochronological study of the Huaiyu Domain allows us to conclude the following:

(1) Ophiolites and ophiolitic mélange are recognized in the Huaiyu Domain for a long time. Geological and geochronological data confirm that these rocks are Neoproterozoic in age, and neither Permian nor Triassic.

(2) In contrast to previous statements, the sedimentary rocks associated with the Neoproterozoic oceanic rocks in the Huaiyu Domain do not contain any Late Paleozoic radiolarians, but contain abundance of Neoproterozoic acritarchs.

(3) Radiolarian-bearing cherts are widespread in the Lower Permian Gufeng Formation of South China. Nevertheless, this does not demonstrate that Permian rocks were deposited in a deep sea environment. Instead, our study suggests that during Permian to Early Triassic times, the Huaiyu Domain was occupied by a shallow sea. Deep sea sediments, such as turbidite or chert are absent.

(4) The South China Block experienced a complex polyphase tectonic evolution. The pre-Devonian tectonics has been reworked by polyphase geological events such as Indosinian folding and Yanshanian magmatism. The post-Devonian events mainly develop brittle structures, possibly related to transpression. In any case, the structural data do not comply with an Early Mesozoic collision. The idea that the Early Mesozoic tectonics of South China is due to continental collision is not supported by sedimentology, petrology and structural analysis.

Acknowledgements

This study is financially supported by grants from the National Natural Science Foundation of China (grant nos. 40221301, 40634022, and 40572118) and Ministry of Education in China (grant nos. 306007 and 20060284008).

References

ABGMR (Anhui Bureau of Geology and Mineral Resources), 1985, Regional geology of Anhui Province: Beijing, Geological. Publishing House, 721 p. (in Chinese with English abstract)

Charvet, J., Shu, L.S., Shi, Y.S., Guo, L.Z., and Faure, M., 1996, The building of South China: collision of Yangzi and Cathaysia blocks, problems and tentative answers: Journal of Southeast Asian Earth Sciences, v.13, p. 223–235.

Chen, J.F., Foland, K.A., Xing, F.M., and Zhou, T.X., 1991, Magmatism along the southeast margin of the Yangzi block: Precambrian collision of the Yangzi and Cathaysia blocks of China: Geology, v. 19, p. 815-818.

Chen, X., Rowley, D.B., Rong, J.Y., Zhang, J., Zhang, Y.D., and Zhan, R.B., 1997, Late Precambrian through Early Paleozoic stratigraphic and tectonic evolution of the Nanling region, Hunan Province, South China: International Geological Review, v. 39, p. 469–478.

FBGMR (Fujian Bureau of Geology and Mineral Resources), 1985, Regional geology of Fujian Province: Beijing, Geological Publishing House, 671 p. (in Chinese with English abstract).

Faure, M., Sun, Y., Shu, LS., Monié, P., and Charvet, J., 1996, Extensional tectonics within a subduction-type orogen. The case study of the Wugongshan dome (Jiangxi Province, SE China): Tectonophysics, v. 263, p. 77–106.

Faure, M., Lin, W., Sun, Y. 1998, Doming in the southern foreland of the Dabieshan (Yangtse block, China): Terra Nova, v.10, p.307–311.

Gilder, S.A., Keller, G.R., Luo, M., and Zhao, X.X., 1991, Eastern Asia and the western Pacific timing and spatial distribution of rifting in China: Tectonophysics, v.197, p.225–243.

Gradstein, F.M., Ogg, J.G., Smith, A.G., Bleeker, W., and Lourens, L.J., 2004, A new geologic time scale with special reference to Precambrian and Neogene: Episodes, v.27, p. 83–100.

He, K.Z., Nie, Z.T., Zhao, C.H., Ye, N., Zhou, Z.G., Yue, C.S., and Tai, D.Q., 2000, Discovery of the Late Paleozoic radiolarian fossils in northeastern Jiangxi: Geoscience, v. 14, p. 1–10.

JBGMR (Jiangxi Bureau of Geology and Mineral Resources), 1984, Regional geology of Jiangxi Province: Beijing, Geological. Publishing House, 921 p. (in Chinese with English abstract).

Kong, X.S., Li, Z.F., Feng, C.G., Gu, M.G. and Ma, J.P., 1995, The Precambrian geology of Chencai region in Zhejiang Province: Beijing, Geological. Publishing House, 136 p. (in Chinese with English abstract).

Kozur, H., 1993, Upper Permian Radiolarians from the Sosio Valley area, Eastern Sicily (Italy) and from Upper Most Lamar Limestone of West Texas: Geology and Paleontology, v. 136, p. 99–123.

Li, Jiliang, 1993, Tectonic framework and evolution of southeastern China: Journal of Southeast Asian Earth Sciences, v. 8, p. 219–223.

Li, X.H., Zhou, G.Q., Zhao, J.X., Fanning, C.M., and Compston, W., 1994, SHRIMP ion microprobe zircon U-Pb age and Sm-Nd isotopic characteristics of the NE Jiangxi ophiolite and its tectonic implications: Chinese Journal Geochemistry, v. 13, p.317–325.

Li, Z.X., Zhang, L., and Powell, C. McA., 1996, Positions of the East Asian Cratons in the Neoproterozoic supercontinent Rodinia: Australian Journal of Earth Sciences, v. 43, p.593–604.

Li, Z.X., Li, X.H., Kinny, P.D., Wang, J., Zhang, S., and Zhou, H., 2003, Geochronology of Neoproterozoic syn-rift magmatism in the Yangtze Craton, South China and correlations with other continents: evidence for a mantle superplume that broke up Rodinia: Precambrian Research. v.122, p.85–109.

Liu, B.G., Zheng, G.C., Chen, S.M., and Tang H.F., 1995, The breakup of the Songmuwu Group in western Zhejiang: evidence from isotope dating: Geological Review, v.41, p. 457–462.

Lin, W., Faure, M., Monié, P., Schäerer, U., Zhang, L. and Sun, Y., 2000, Tectonics of SE China, new insights from the Lushan massif (Jiangxi Province): Tectonics, v.19, p.852–871.

Lin, W., Faure, M., Sun, Y., Shu, L., 2001, Compression to extension switch during the Early Triassic orogeny of E. China: The case study of the Jiu lingshan massif in the southern foreland of the Dabieshan: Journal of Asian Earth Sciences, v.20, p.31–43.

Murray, R.W., Brink, M.B.,Jones, D.L.,Gerlach, D.C., and Russ III, G.P., 1990, Rare earth elements as indicators of different marine depositional environments in chert and shale: Geology, v.18, p.268–271.

Ren, J.S. and Chen, T., 1989, Tectonic evolution of the continental lithosphere in eastern China and adjacent areas: Journal of Southeast Asian Earth Sciences, v. 3, 17–27.

Rodgers, J., 1989, Comment on "Mesozoic overthrust tectonics in South China": Geology, v. 17, p. 671–672.

Rowley, D.B., Ziegler, A.M. and Gyou, N., 1989, Comment on "Mesozoic overthrust tectonics in South China": Geology, v. 17, p. 384–386.

Shi, Y.S., Shu, L.S., Brewer, R.C., Charvet, J., and Guo, L.Z., 1994, Late Proterozoic terrane tectonics in the central Jiangnan belt, Southeast China: Journal of Southeast Asian Earth Sciences, v. 7, p. 367–375.

Shimizu, H., Masuda, A., 1977, Cerium in chert as an indication of marine environment of its formation: Nature, v. 266, p.346–348.

Shu, L.S., and Shi, Y.S., 1990, A study of the Middle–Late Proterozoic terrane tectonics in North Jiangxi, Eastern China, *in* T.J. Wiley, D.G. Howell and F.L. Wong, eds., Terrane analysis of China and the Pacific Rim: The Circum-Pacific Council for Energy and Mineral Resources, v. 13, p.301–304.

Shu, L.S., Zhou, G.Q., Shi, Y.S., and Yin, J., 1994, Study of the high-pressure metamorphic blueschist and its Late Proterozoic age in the Eastern Jiangnan belt: Chinese Science Bulletin, v.39, p.1200–1204.

Shu, L.S., and Charvet, J., 1996, Kinematics and geochronology of the Proterozoic Dongxiang–Shexian ductile shear zone: With HP metamorphism and ophiolitic mélange (Jiangnan Region, South China): Tectonophysics, v. 267, p. 291–302.

Shu, L.S., Lu, H.F., Charvet, J., and Faure, M., 1997, Kinematic study of the northern marginal fault zone of Wuyishan, South China: Geological Journal of China Universities, v. 3, p. 282–292.

Shu, L.S., Lu, H.F., Jia, D., Charvet, J., Faure, M., 1999, Study of the $^{40}Ar/^{39}Ar$ isotopic age for the early Paleozoic tectonothermal event in the Wuyishan region, South China: Journal of Nanjing University, v. 35, p. 668–674. (in Chinese with English abstract).

Sun, S.S. and Mc Donough,W.F., 1989, Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes, *in*: A.D. Saunders and M.J. Norry (Editors), Magmatism in the Ocean Basins Geological Society of London, Spec. Publ. 42:313–345.

Sun, T., 2005, The Mesozoic magmatic rock assemblages and their petrogenesis, South China: Nanjing, Postdoctoral report of Nanjing University, 41p. (in Chinese with English abstract).

Wang, B., and Shu, L.S., 2001, Notes on Late Paleozoic radiolarians of Northeastern Jiangxi Province: Geological Review, v. 47, p.337–344. (in Chinese with English abstract).

Wang, X.L., Zhou, J.C., Qiu, J.S., Zhang, W.L., Liu, X.M., and Zhang, G.L., 2006, LA-ICP-MS U-Pb zircon geochronology of the Neoproterozoic igneous rocks from Northern Guangxi Province, South China: implications for the tectonic evolution: Precambrian Research. v. 145, p.111–130.

Xiao, W.J. and He, H.Q., 2005, Early Mesozoic thrust tectonics of the northwest Zhejiang region (Southeast China): Bulletin of Geological Society of America, v. 117, p.1–17.

Xu, B., and Qiao, G.S., 1989, Sm-Nd isotopic age and tectonic setting of the Late Proterozoic ophiolites in Northeastern Jiangxi Province: Journal of Nanjing University (Earth Science), v.3, p.108–114 (in Chinese with English abstract).

Yang, Q., Wang, Y.J., Yin, L.M., Shu, L.S., Lou, F.S., and Wang, B., 2005, On the age of the ophiolitic complexes in northeastern Jiangxi: a micropaleontological analysis: Acta Geologica Sinica, v.79, p. 801–805.

Yang, Z.Y., Li, Z.S., Qu, L.F., Lu, Z.M., Zhou, H.Q., Zhou, T.S., Liu, G.F., Liu, B.P., and Wu, R.T., 1982, The Triassic of China: Acta Geologica Sinica, v. 56, p.1–20.

ZBGMR (Zhejiang Bureau of Geology and Mineral Resources), 1989, Regional geology of Zhejiang Province: Beijing, Geological. Publishing House, 688 p. (in Chinese with English abstract).

ZBGMR (Zhejiang Bureau of Geology and Mineral Resources), 1996, Stratigraphy (lithostrata) of Zhejiang Province: Beijing, China University of Geosciences Press, 236 p. (in Chinese with English abstract).

Zhang, S.G. and Yan,H.J., 2006, A brief introduction to International Stratigraphic chart and global stratotype section and point: Journal of Stratigraphy, v. 29, p. 188-204.
Zhao, C.H., He, K.Z., Mo, X.X., Tai, D.Q., Ye, D.L., Ye, N., Lin, P.Y., Bi, X.M., Zheng, B.R., and Feng, Q.L., 1995, The discovery of the Late Paleozoic radiolarian chert in the ophiolitic mélange along the NW Jiangxi fault and its implications: Chinese Science Bulletin, v.40, p. 2161–2163.
Zhou, G.Q., and Zhao, J.X., 1990, The Sm-Nd isochron age of the northeastern Jiangxi ophiolite in the SE margin of Yangzi craton, South China: Chinese Science Bulletin, v.35, p.129–132.
Zhou, J.C.,Wang, X.L., Qiu, J.S.,and Gao, J.F., 2004, Geochemistry of Meso- to Neoproterzoic mafic-ultramafic rocks from northern Guangxi, China: Arc or plume magmatism?: Geochemical Journal, v.38, p.139–152.
Zhou M.F., Yan D.P., Kennedy, A.K., Li, Y., and Ding J., 2002, SHRIMP U-Pb zircon geochronological and geochemical evidence for Neoproterozoic arc-magmatism along the western margin of the Yangtze block, South China: Earth and Planet Science Letters, v.196, p.51– 67.
Zhou X.M., Zhou H.B., Yang J.D., and Wang Y.X., 1989, Sm-Nd isochron age of the ophiolite suite in Shexian County, Anhui Province and its geological significance: Chinese Science Bulletin, v.35, p.208–212.



Michel Faure *is professor of structural geology in Orléans University. His scientific work is dedicated to the geodynamic evolution of mountain belts. More particularly, he investigates the tectonic setting of metamorphic and magmatic roots of orogens from lithospheric convergence to collision, exhumation of High Pressure and Ultra-High Pressure tectonic units and crustal melting. Since 1985, when he obtained his Ph. D. degree in Orléans University, he worked in several places of Eastern Asia, from Sikhote Alin to the Philippines, but mainly in SW Japan, and China. He is also studying the tectonic evolution, magmatisme and ore deposits of the Paleozoic Variscan Belt of Western Europe.*



Liangshu Shu *is professor of structural geology in Nanjing University, China. He obtained his Ph. D. degree in Nanjing University in 1990. His major interests have been on geotectonics and structural geology, especially the deformation and evolution of crustal rocks. Since 1980's, he has been studying the plate tectonics and evolution of the Jiangnan orogenic belt and then the Tianshan orogen, and has published the 5 scientific monographs and 120 papers by the name of 1st and 2nd author in Chinese and international journals.*



Shaoyong Jiang *is professor of geochemistry in Nanjing University, China. He got his B.Sc. and M.Sc. degrees in Peking University (China) in 1984 and 1987. He obtained his Ph. D. degree in Bristol University (UK) in 1995. His scientific interests are mainly on geochemistry of crust-mantle evolution and hydrothermal mineralization, especially in the field of isotope geochemistry and geochronology. Up to now he has published more than 100 papers in peer-reviewed Chinese and international journals.*

CALL FOR PAPERS

Episodes is the quarterly science and news journal of the International Union of Geological Sciences (IUGS). It focuses on the publication of results of scientific research and other information addressing issues of interest to the global earth-science community. Special emphasis is given to topics involving geological aspects of population growth and economic development and their resulting impacts on or implications for society. As the principal publication of the IUGS, *Episodes* also carries information about IUGS scientific programs and activities to the extent necessary to communicate effectively with the worldwide IUGS constituency.

Contributions of the following types of manuscripts are here solicited:
- review papers
- scientific articles
- conference reports
- news and views
- letters to editor
- book reviews
- information on training courses (especially those geared to participants from developing countries)
- noteworthy new publications, including national or regional geologic maps

Episodes also invites photos or other images for the front cover. Photos must be of high technical quality and tell an interesting geological story. A color transparency and one color print (at least 9 cm × 12.6 cm) are required for submission, which should be supplemented with a short explanatory paragraph (no more than 100 words).

Please address all contributions to:

The Editor
Episodes
P. O. Box 823, 26 Baiwanzhuang Road
100037 Beijing, CHINA
Tel: +86-10-68320827, +86-10-68329084
Fax: +86-10-68328928
E-mail: episodes88@yahoo.com