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An outline of the tectonic evolution of China

Tectonically China is composed of three Precambrian continental platforms, Sino Korea, Yangtze, Tarim, and possibly also Cathaysia. With their interstitial fold belts, they were incorporated together to form part of the Eurasian Supercontinent through the Indosinian orogeny in the late Triassic. In addition, there are the northern border of the Indian Platform, the Himalayas and the northern massifs of Gondwanan affinities, which were accreted or collaged successively onto the Eurasian Supercontinent in post-Indosinian times. Nine tectonic domains are recognised, which are delimited by major geosutures called convergent crustal consumption zones. The tectonic development was in five megastages during which were formed: firstly, continental nuclei (c. 2.8 Ga); secondly, the proto-platforms (c. 1.8 Ga); thirdly, the platforms (c. 800 Ma); fourthly, the Eurasian supercontinent (c. 210 Ma), and fifthly, the present frame of China. Among these, the platform formation at the end of the Jinningian orogeny (800 Ma) and the supercontinent formation at the end of the Indosinian orogeny (210 Ma) are the main landmarks.

The tectonic frame and crustal development of China

Terminology of tectonic units

A tectonic unit of the first rank, here called a tectonic domain, is a plate of composite structure and prolonged history of development. The boundaries between plates, here called convergent crustal consumption zones, are the main geosutures. The recent loose usage of the very useful term 'terrane' to cover tectonic units from continental platforms to single thrust masses has caused some confusion. In order to make the tectonic terminology more systematic, we use a four-rank hierarchy in the hope that ambiguity may be avoided:

- 1 Tectonic domains composed of a continental platform and its surrounding fold belts, or of a group of Precambrian massifs interconnected by Early Palaeozoic fold zones so as to form a more or less integrated whole (Wang, 1981, 1986). The tectonic domains are delimited from each other by convergent crustal consumption zones (CZ) that mark the final convergence of the opposite continental margins.
- 2 Platforms (cratons) and mobile belts.
- 3 Units within a platform that comprise ancient continental nuclei and Precambrian basement of various ages, and those within a mobile belt attributable to a single continental tract, made up of fold zones of various ages with or without median massifs. The fold zones and massifs originate from successively accreted island arcs and fragments split from the continent; they are usu-

ally bounded by subduction zones (here called accretional crustal consumption zones, or AZ).

- 4 Terranes within the fold zones. These might be regarded as special cases of the third rank.

Three ranks of tectonic stage may be discerned (Wang, 1982). The first is mainly of a global nature and denotes profound changes in the geospheres and in world tectonic frames. The second is the traditional tectonic stage, in which there were important changes in tectonic frames or patterns. The third refers to epochs of intense orogenic deformation and magmatic activity. Five megastages are recognised, which led to the formation of

- 1 continental nuclei (c. 2.8 Ga);
- 2 continental protoplatforms (c. 1.8 Ga);
- 3 continental platforms (c. 800 Ma);
- 4 supercontinents (c. 210 Ma), and
- 5 disintegration of the supercontinent to form the present earth frame.

The main features and geological events in the different tectonic stages of China are summarised in Table 1. For convenience of discussion, we have specially included Korea in Figures 1 and 2.

Nine principal tectonic domains may be recognised in China (Wang et al., 1990). They are from north to south (Figure 1):

- 1 The Altai–Hingan Belt (AHB), which is the southern part of the Siberia–Mongolia Domain.
- 2 The Junggar–Tianshan Belt (JTB), which is the eastern part of the Kazakhstan Domain (KZD).
- 3 The Bureya–Jiamusi Belt (JBB), which is the southern part of the North-east Asian Domain. All the three domains are composed of small massif groups interconnected by Early Palaeozoic fold zones and are delimited from each other by Early Hercynian convergent zones, the Ertix–Kalameili (EKCZ) in the west and the Hegen (HGCZ) in the east.
- 4 The Tarim Domain (TAD), which includes the unusually mobile platform and surrounding Palaeozoic fold belts.
- 5 the Sino-Korea Domain (SKD) is surrounded mainly by Early Palaeozoic fold belts with several detached Precambrian massifs in the south. The boundary between the TAD and the SKD is controversial, as the Qaidam (Qd) and the Alxa (Ax) massifs seem to be closely related to both domains. A recent study (Wang, T., 1994) has discovered an ophiolite zone, the Enger Usu (EUCZ), which may be a convergent zone effectively delineating a southern (SKD) and a northern (KZD) faunal province during the Palaeozoic. This boundary between the SKP and the KZD is truncated by the Altun transcurrent fault in its western segment (Figure 1). The southern boundary of the platform in Korea is also problematic, because the cratonic area south of the Imjingang and north of the Ocheon Belt belongs certainly to the SKP not the YZP as generally believed (Yin et al., 1993). This interpretation seems to be supported by the indentation of the north-eastern part of the YZP into Korea along the Imjingang River during or after the Indosinian Stage (Figure 1). The northern boundaries of the TAD and the SKD are marked by the South Tianshan–Mazongshan convergent zone (TMCZ) and the Suolun–Linxi convergent zone (SLCZ) respectively, both of Late Hercynian age. Evidence for collision is not manifest for the SLCZ, but biogeographic evidence seems to be convincing (Huang, B., 1991; Li et al., 1992).
- 6 The Yangtze–Qiangtang Domain (YQD) includes the Yangtze Platform in the east and a group of massifs in the west, comprising the North Qiangtang (QT), the Qamdo (Qm) and the Lincang–Simao (Ls), which were probably parts of the YZP that

Table 1 Tectonic stages in the crustal evolution of China.

Eon	Era	Megastage	Stage	Orogenic epochs and geological events	Main regimes	
Ph Phanerozoic	Kz	V Intracontinental development	Himalayan	Upheaval of Quinghai–Tibet Plateau —— Himalayan orogeny 30 Close of YZAZ northward indentation of NE India onto Tibet–Yunnan foreland basins (W) rift basins and marginal seas (E)	Compression dominant (W) extension dominant (E)	
	65		90	Yanshanian orogeny		
	Mz	208	Yanshanian	Formation of circum-Pacific magmatic belt Indentation of NE YZP onto Korea Close of QNAZ		
	250		Indosinian	Indosinian orogeny Collision of TZD, TBD, TAD and YQD to form Eurasian Supercontinent close to PAO and PTO Opening of TEO mixing of GWF, CAF, ANF	Compression dominant	
				270	L Hercynian orogeny	PANGAEA III
			Pz ₂	IV Supercontinent formation	Hercynian	Separation of Qt and Qd from YZP aulacogens on platforms and fold belts —— E Hercynian orogeny 300
	408		Collision of AHB, KZD, JBD and SKD —— L Caledonian orogeny			
	Pz ₁		Caledonian	Convergence of YZP and CAD collision of Ax and Qm —— E Caledonian orogeny 440		
	570			Opening of S Tianshan, Opening of Qilian, Qinling		
	Pt ₃	L Jinningian orogeny		Extension dominant		
	Pt Proterozoic	1000	III Platform formation	Jinningian	Formation of platforms: SKP, TAP, YZP —— E Jinningian orogeny	Compression dominant PANGAEA II
Pt ₂		Formation of aulacogens: Yanshan, Xionger Chaltai			Extension dominant	
1800		II Protoplatform formation	Lüliangian	Lüliangian orogeny	Compression dominant PANGAEA I	
Pt ₁				Formation of protoplatforms: KD, TAD YOD, CAD. Formation of protoaulacogens: Hutuo, Liaohe, Dahongshan —— Wutaian orogeny	Extension dominant	
2500			Wutaian		Increase of continental crust	
Ar Archaean	2800	I Continental nuclei formation	Fupingian	Fupingian orogeny	Compression dominant Aggregation and convergence	
	Ar ₃		Continental nuclei: Or, JI, Th, Ts, Ch			
	3200		Qianxian	Protonuclei: Caozhuang, Ansham	Primary continental crust	
	Ar ₂					
	3200					
	Ar ₁					
3900						
HD	HADEAN					

Ar₁ *Eoarchaeon*
Ar₂ *Palaeoarchaeon*
Ar₃ *Mesoarchaeon*

Ar₄ *Neoarchaeon*
Pt₁ *Palaeoproterozoic*
Pt₂ *Mesoproterozoic*

Pt₃ *Neoproterozoic*
PAO *Palasian Ocean*
PTO *Palaeotethys Ocean*

TEO *Tethyan Ocean*
GWF *Gondwana flora*
CAF *Cathaysian flora*
ANF *Angaran flora*

For others see Figure 1

were detached and disseminated in the Late Palaeozoic (Wang et al., 1990). The YQD is demarcated from the northern domains by the Indosinian convergent zones, the Xiugou-Maquin (XMCZ) in the western, and the Fengxian-Tongcheng (FXCZ) in the eastern segment, but it is not clear how they were joined with each other in the south Qinling region. The position of the southern boundary of the YQD in northern Tibet has remained unclear, but recent studies have revealed that an oceanic basin, beginning

in the Devonian or earlier and closed in the Late Permian, may be represented by the Longmuco-Shuanghu convergent zone (LSCZ) (Li, 1987). The Changning-Menglian (CMCZ) zone to the west of the Lancang River in western Yunnan represents the southern continuation of the LSCZ and is proved to have closed at the end of Indosinian Stage (Liu et al., 1994). These convergent zones mark the southern limit of the Eurasian Supercontinent formed at the end of Indosinian Stage (Chang et al., 1992).

Figure 1

1 Continental nuclei, 2800 Ma (Ar ₃)	Tectonic units:	Jl Jiliao Nucleus	Ln Lingnan Massif	AZ Accretional zones:
2 Protoplatforms, 1800 Ma (Pt ₁)	AHB Altai-Hingan Belt:	Hh Hehuai Nucleus	Hn Hainan Massif	(a) OSAZ Ondor Sum (C)
3 Platform and massifs 800 Ma (Pt ₃)	Ag Arguna Massif	Th Taihua Nucleus	Ss South China Sea Massif.	(b) AXAZ Aibihu-Xingxingxia (H)
4 Caledonides	Hg northern Hingan Massif;	Ax Alxa Nucleus	TBD Tibet-Burma Domain:	(c) QQAZ North Qilian-North Qinling (C)
5 Hercynides	Tt Tuotuoshan Massif	Qc Central Qilian Massif	Gd Gangdise Massif	(d) KWAZ West Kunlun (J)
6 Indosinides	JBB Jamus-Bureya Belt:	Lx Longxi Massif	Hm Himalaya Massif	(e) KEAZ East Kunlun (J)
7 Yanshanides and Himalayides	Jm Jamus Massif	Qd Qaidam Massif.	Bt Baoshan-Tengchong Massif.	(f) LHAZ Longmenshan-Honghe (J)
8 Permian basalts	Sn Songnen Massif	YQD Yangtze-Qiangtang Domain:	CPD Circum-Pacific Domain:	(g) SCAZ Shexian-Changsha (J)
9 Jinningian (Pt _{2.3}) granitic zones (J)	Xl Xilinhote Massif.	YZP Yangtze Platform:	Xk Xingkai Massif.	(h) WYAZ Wugong-Yunkai (C)
10 Caledonian (Pz ₁) granitic zones (C)	KZD Kazakhstan Domain:	Ch Chuanshong Nucleus	CZ Convergent zones:	(i) SBZ Sibao (J)
11 Hercynian (Pz ₂) granitic zones (H)	Yn Yinnin Massif	Kd Kangdian Region	1 EKCZ Ertix-Kalameili (H)	(j) JTAZ Jinshajiang-Tengtiaohe (I)
12 Hercynian-Indosinian (P-T) granitic zones	Jg Junggar Massif	Kd Jiangnan Region	2 HGCZ Heganshan (H)	(k) BNAZ Banggong-Nujiang (YH)
13 Accretional crustal consumption zones (AZ)	Tm Turpan-Hami Massif.	Dt Dabie-Tongbe Massif	3 TMCZ South Tianshan-Mazongshan (H)	(l) YZAZ Yarlung Zangbo (YH).
14 Convergent crustal consumption zones (CZ)	TAD Tarim Domain:	Do Douling Massif	4 SLCZ Soulun-Linxi (H)	
15 Pt _{2.3} aulacogens and rifts	TAP Tarim Platform:	Fp Fuping Massif	5 EUCZ Enger Uzu (H)	
16 Z-O aulacogens	Ts Central Tarrim Nucleus	Qt Qiangtang Massif	6 XMCZ Xiugou-Maqin (I)	
17 D-T aulacogens	Sw South-western Region	Qm Qamdo Massif	7 FTCZ Fengxian-Tongcheng (I)	
18 Strike-slip faults, mostly post-Indosinian.	Mj Manjyar Region	Bg Batang Massif	8 SSCZ Shaoxing-Shaoguan (C)	
	Qu Quruktagh Region	Sb Songpan-Bikou Massif	9 LSCZ Longmucuo-Shuanghu (I)	
	At Altun Region	Ls Lincang-Simao Massif	10 MCZ Changning-Menglian (I).	
	Bb Bayanbluk Massif	Wg Wugong Massif		
	Mz Mazongshan Massif.	Zg Zhuguang Massif		
	SKD Sino-Korea Domain:	Yk Yunkai Massif.		
	SKP Sino-Korea Platform:	CTD Cathaysian Domain:		
	Or Ordos Nucleus	Cc Chencai Massif		
		Jo Jianou Massif		
- (J) Jinningian; C Caledonian; H Hercynian; I Indosinian; YH Yanshanian-Himalayan)
- SF Strike-slip faults:**
(I) Altun;
(II) Tanlu.

- 7 The Cathaysian Domain (CTD), formed of Precambrian massifs incorporated in the Early Palaeozoic, and thus comparable with the KZD, was probably a part of the South-east Asian palaeocontinents. The relation between the YZP and the CTD has long been discussed (Guo et al., 1989). It seems doubtless that a widespread Precambrian basement existed in south China to the south of the YZP in Proterozoic time, which became somewhat dissociated and collided with the YZP in the Early Palaeozoic. The convergent zone between the YZP and the CTD is tentatively drawn from Shaoxing to Shaoguan (SSCZ). It continues further to the south.
- 8 The Tibet–Burma Domain (TBD), occupying the northern border parts of the Indian Platform, consists of the Himalayas Massif (Hm), the Gangdise Massif (Gd) and the southern Qiangtang area, which are demarcated by the Yarlung Zangbo (YZAZ) and Bangong–Nujiang (BNAZ) ophiolite zones. The Indosinian Massif seems to be related to both the YQD and CTD, and the South China Sea Massif (Ss) may bear a closer relationship with Australia.
- 9 The Circum-Pacific Domain (CPD), which includes the Xingkai Massif (Xk) and the Yanbian area of north-east China, both came probably from the western Proto-Pacific and became collaged to east Asia in the Indosinian and later stages.

China in Presinian times — the formation of continental nuclei, protoplatforms and platforms

Continental nuclei

Continental nuclei of considerable size formed prior to 2.8 Ga and occur in the Sino-Korea, the Yangtze and possibly the Tarim platforms. The oldest rocks are in the Jiliao Nucleus (Jl) in eastern Hebei and Liaoning, where detrital zircon, with a U–Pb age of over 3.6 Ga, was obtained from the Huangbaiyu Quartzite, Jixian, and ancient granitic continental crust, 3.8 Ga old, was reported from Anshan, Liaoning (Liu et al., 1992; Cheng, 1994), both of Eoarchaean (Ar₁) age (Table 1). Near Anshan, banded ironstone formations (BIF) of Algoman type were found unconformably overlying granites 2.8 Ga in age. The Hehuai Nucleus (Hh) contains the Taishan Group representing a granite–greenstone terrain, and the Taihua Nucleus (Th) contains both the Dengfeng granite–greenstone terrain and the Taihua trondhjemite–tonalite–granodiorite (TTG)-type high grade terrain. Both of them contain rocks older than 2.8 Ga. The major part of the Ordos Nucleus (Or) subsided, but aeromagnetic data denote its ancient nature, and a latitudinal Mesoarchaean (Ar₃) granulite belt is distributed all along the Yinshan Range in the north. Another nucleus may be recognised in southern Alxa, where the basement contains granulites of presumably Mesoarchaean age. These nuclei formed the main grain of the ancient frame of north China and later coalesced to form the Sino-Korea protoplatform (Cheng et al., 1984).

The Central Tarim Nucleus (Ts) occupies a central position in the Tarim Basin. An isotopic age over 2.8 Ga was recently reported from Archaean rocks in Quruktagh. On the Yangtze Platform the oldest rock is the Kongling TTG gneiss in the Gorges region which has an age of 2.8 Ga. This represents the upwarped border part of the Central Sichuan Nucleus (Sc), the Mesoarchaean age of which is suggested by the presence, in the Sanjiang area in south-eastern Guizhou, of detrital zircon, aged 2.8 Ga and evidently of northern provenance. As indicated by the pronounced geochemical differences between the Taihua and Kongling rocks (Zhang et al., 1994) that constitute respectively the nuclei Th in the SKP and Sc in the YZP, these two platforms were probably rather far apart from each other in the Archaean. On the whole, it seems reasonable to assume

that they originated separately and were later aggregated together to form the protoplatforms.

Protoplatforms

The Neoarchaean (2.8–2.5 Ga, Ar₄) in north China includes the Wutai, Luliang and Jiangxian groups in Shanxi and possibly the Dantazi Group in eastern Hebei, forming the so-called Eparchaean interval on the SKP. It is absent in many other areas. These rocks represent greenstone belts probably of extensional origin, and were intensely folded by the Wutaian orogeny and metamorphism (2.5 Ga), which marked a conspicuous cratonisation of north China. The succeeding Palaeoproterozoic (Pt₁) rocks comprise two tectono-sedimentary types, a rift-geosyncline type (Milanovsky, 1985) or protoaulacogen type (Wang and Qiao, 1984) and a semi-stable marine basin type. The first is represented by the Hutuo Group and its equivalents, containing clastics and argillites with metabasic rocks of bimodal pattern. The second is represented by the Songshan Group containing well-sorted clastics and carbonates. Both were folded and metamorphosed during the Luliangian orogeny (Wang and Qiao, 1984). Contemporaneous rocks in Liaodong of north-east China include Mg carbonates and turbidites, sometimes attaining huge thicknesses. The Wutaian and Luliangian orogenies caused the separated nuclei in north China to coalesce and led to the final formation of the SK protoplatform. The southern boundary of the protoplatform was along the southern border of the Qinling zone, which was probably split and shifted to the south in the Mesoproterozoic (Pt₂).

In northern Tarim, the Pt₁ Hinditag Group is variable in lithology and is in some places strongly folded and metamorphosed, partly to amphibolite facies. Contemporaneous rocks in Altun and west Kunlun show even stronger metamorphism. This represents the Luliangian orogeny which led to the formation of the Tarim protoplatform including the Yining (Yn) and Bayinbluk (Bb) massifs in central and south Tianshan. It is to be noted that the Meso- and Neoproterozoic sequences and lithology in northern Tarim, Alxa, Qaidam and north China are all similar to each other, and the Sino-Korea and Tarim protoplatforms may have been then interconnected, or at least close together.

Ancient crystalline basement in the Yangtze region is confined to the north of the Jiangnan Region (Jn), but the Dabie–Tongbai Massif (Dt) was probably a part of Yangtze in Pt₁ time. The Dahongshan Group in central Yunnan is a sodic alkali volcanic series and may represent a protoaulacogen formed on thin sialic crust on the inner side of the Kangdian Region (Kd). The Sibao Group, formerly thought to be Pt₂ but recently proved to be Pt₁ in age, marks the south-eastern boundary of the Yangtze protoplatform, although its metabasic content denotes a crust of transitional nature. In the CTD in south-east China (Figure 1), isotopic ages over 2.5 Ga are known from Zhejiang and Fujian, and Pt₁ basement rocks (Badu and Jianou groups) reaching amphibolite facies are well known (Dong et al., 1986), indicating the presence of an extensive ancient basement at that time. It is probable that at the end of Pt₁ (1.8 Ga) the protoplatforms formed in China through the Luliangian orogeny had a wider extent than the present platforms. In fact, around 1.9–1.8 Ga, a pronounced increase of continental crust and a widespread cratonisation may have occurred, in China and probably all over the world, and the extensive protoplatforms that were formed may have joined with each other to form Pangaea (Pangaea I in Table 1). This is partly the reason why we prefer to put the lower boundary of Mesoproterozoic at 1.8 instead of 1.6 Ga (Wang, 1986).

Platforms

The Pt₂ and Pt₃ rocks constitute paracover strata on a consolidated Sino-Korea protoplatform. The Pt₂ (1.8–1 Ga) includes the Changchengian (1.8–1.4 Ga) and Jixianian (1.4–1.0 Ga) systems. The former comprises in the basal part aulacogen fluvialite deposits followed by clastics and carbonates containing some K-rich volcanics in the Yanshan region, while the latter includes carbonates of wide transgression in the lower and of limited marine basin in the upper

part (Sun et al., 1990). The lower part of Pt_3 (Qingbaikouan 1000–800 Ma) represents true cover strata, but local deep trough filling reaching huge thicknesses occurs in Liaoning Province. At the close of the Qingbaikouan Period, general uplifting, coeval with the Jinningian orogeny, occurred and the Sino-Korea Platform was finally consolidated. Subsiding belts receiving marine deposits of Sinian (younger Pt_3) age still lingered in the eastern part of the SKP.

Both the southern and the northern margins of the Sino-Korea protoplateau underwent a complicated history in Pt_2 and Pt_3 times. The Xionger aulacogen, with calc-alkali bimodal volcanics, may have been the interior failed arm of an tripartite rifting system brought about by the southward splitting and shifting of the Qinling zone. The resultant Kuanping marginal marine basin received sediments from both the northern passive margin and the southern Qinling island chain. It was the Jinningian orogeny that brought about the closure of the Kuanping basin and the northern accretion of the Qinling zone through an arc-continent collision (Zhang et al., 1994). The northern margin of the SKP was characterised by development of the mainly Pt_2 marginal aulacogens, the inner Chertai belt and the outer Baiyun–Obo belt. Disseminated minor massifs recently designated in Nei Mongol such as Xilinhot (XI) may represent border fragments that split off and moved to the north in the Neoproterozoic.

The northern margin of the Tarim protoplateau has had a complicated history. In the western segment, the Yn Massif which was then still a part of the protoplateau, might have rifted away and reaccreted to the TAP again in the Jinningian, as is manifested by the presence of a blue schist 700–900 Ma in age in the Aksu Group in northern Tarim (Xiao et al., 1992). In the southern part of east Tianshan, the Pt_2 Kawabulak Group may have been deposited on the northern passive continental margin facing an ancient ocean to the north. Along the northern border of the TAP a trough-like basin developed receiving very thick Pt_2 and Pt_3 clastics and carbonates almost devoid of volcanics, upon which was superimposed the Sinian Quruktagh aulacogen bearing volcano-sedimentaries and glaciogenic deposits. In the Tieklik region north of west Kunlun, the Pt_2 and Pt_3 strata are of a stable cover type, which marked the southern limit of the platform. They seem to overlie the crystalline basement Karakash Group, although the contact relation has not been found. In west Kunlun, along the southern border of the TAP, Pt_3 granites of I-type are often met with, probably along the northern side of the West Kunlun Accretional Zone (KWAZ) of Jinningian age. Pt_3 granites are also known in east Kunlun to the south of the Qaidam Massif (Jiang et al., 1992), probably related to the east Kunlun Accretional Zone (KEAZ) (Figure 1). It seems that there was a northward subduction of oceanic crust on the southern side of the TAP and SKP during the Jinningian Stage.

In the Shennongjia region, near the northern margin of the YZP, thick clastics and carbonates of Pt_{2-3} age are developed. These represent aulacogen-type sediments indicating a rifted origin. The Dabie–Tongbai Massif (Dt) of Ar_4 – Pt_1 age and the Douling Massif (Dl) of Pt_1 age were probably rifted away from the Yangtze in Pt_2 , and the Wudang volcano-sedimentaries and its equivalents to the east may represent the rocks formed in the rifted troughs. To the west, the Precambrian Fuping Massif (Fp) may have been split from the Hannan region, the present northern border of the YZP. The newly generated oceanic crust was subducted southward under the YZP, and a clear subduction sequence of geochemically different granite zones has been observed in the Xixiang area (Gao et al., 1990). This evidently resulted from the Jinningian orogeny, after which the northern margin of the YZP became passive. Along the western margin of the YZP, from Longmenshan to Honghe, the Neoproterozoic Kangding Group and its equivalents, composed of amphibolites and migmatized gneiss of TTG type, and the Pt_1 Dahongshan Group of metavolcanics and metasediments make up the western margin of the present platform. Further to the west, the Lingcang Simo Massif (Ls), bearing a basement formed of the Lancang Group of Pt_{1-2} age, was probably rifted away from the western (present orientation) margin of the YZ mother continent in Pt_2 time. The subsequent eastward subduction of the newly formed oceanic

crust resulting from this rifting, is indicated by the presence of Pt_3 ophiolites near Ailaoshan (LHAZ) in the Honghe Valley on the western margin of the YZP. Meanwhile, in the eastern part of the Kangdian Belt, a deep aulacogen developed receiving very thick volcano-sedimentaries, the Kunyang and Yanbian groups of Pt_2 age. These were intensely folded, and granites were extensively emplaced as a result of the Jinningian orogeny. Along the south-eastern margin of the YZP is the Jiangnan Region (Jn), which comprises a Pt_{2-3} arc and basin system that indicates a general eastward growth of continental crust (SCAZ and SBAZ). The north-eastern segment of the Jn is complicated and Palaeozoic rocks were involved in a metamorphic belt generally designated as Pt_{2-3} . Nevertheless, there can be no doubt about the Proterozoic southern boundary of the platform, as Jinningian granites are extensively developed along the southern border of the YZP from southern Anhui to western Jiangxi.

The CTD, as pointed out previously, is comparable with the KZD, but, unlike the latter, no Late Proterozoic and Early Palaeozoic ophiolite zones have thus far been found. Pt_{2-3} metasediments and metavolcanics overlying the Ar – Pt_1 basement are widespread, but carbonates rarely occur. The Pt_{2-3} Baoban Group was recently found on the Hainan Massif (Hn) and in central and western Guangdong. Jinningian granites are reported from northern Zhejiang, and are evidently the southern counterpart of the Jinningian collision granites along the southern border of YZP. It seems that during the Proterozoic, the YZP and CTD were probably separated from each other, although they became partly connected at their eastern parts through collision at the end of the Jinningian Stage.

Summarising, at the close of the Jinningian Stage (800 Ma), the SKP was probably more extensive than nowadays both to the north and south, and the northern margin was mainly of a passive and rifted nature. The Qd, Qc and Lx massifs in the south-west were still connected with the Alxa region in the north, but the southern margin of Qd was probably faced by an ancient ocean. The Qinling arc zone had reaccreted to the SKP through an arc–continent collision. To the east of the Tanlu strike slip fault, the boundary between the SKP and YZP in Shandong is marked by the Jinningian granite zone. They probably collided with each other along this part of the boundary. The TAP was still connected with Yn in the north, but there were ancient oceans both to north of Kawabulak and to the south of Kunlun. The relationship between the SKP and TAP is difficult to judge. The similarity of Pt_{2-3} stratigraphical sequences would put them together, but immediately after the Jinningian orogeny, in the Early Sinian, they seemed to have separated from each other, as manifested by palaeomagnetic data and by the different stratigraphical development in the Sinian. On the whole, at the close of the Jinningian Stage, the main platforms in China seemed not to be far apart from each other. This is supported by palaeomagnetic studies recently carried out by Zhang et al. (1985 and afterwards), and an investigation of the global palaeomagnetic data seems to favour the idea of a Pangaea around 800–900 Ma (Pangaea II in Table 1) in the Early Neoproterozoic.

China from the Sinian to the Triassic—the formation of supercontinents

This megastage contains three tectonic stages, the Caledonian, the Hercynian and the Indosinian, the latter two usually not separable from each other, especially in south China. In the beginning of the Sinian, the principal platforms of China began to drift away from each other, and in the Cambrian and Ordovician the tectonic regime was essentially extensional. The close of the Caledonian Stage brought about the reaccretion of the Qd to the SKP and the collision of the YZP with the CTD, but other intercontinental oceanic basins still remained. During the Late Hercynian and Indosinian orogenies the platforms and massifs were assembled together to form the Eurasian Supercontinent, which constituted the northern part of Pangaea III (Table 1).

The Caledonian Stage

The Sino-Korean Platform was mostly exposed in the Early Sinian, only the eastern part being subsided. The Late Sinian glaciogene deposits are distributed along the southern and western border of the platform, and are also known in northern Qd and northern TAP, indicating that these massifs were not far from each other at that time. Qd began to split away from the SKP in the Cambrian, first forming the north Qilian and then, in the Ordovician, the south Qilian oceanic basins. Ophiolite and ophiolitic melange zones are well developed in north Qilian. The oceanic basins began to shrink in the Late Ordovician and closed in the Late Silurian. Early Palaeozoic arc type volcanism is frequent and granites of both subduction and collision type are known on both sides of the Accretional Zone (QAZ) from northern Qaidam in the south to southern Alxa in the north. The north Qilian Caledonides continue south-eastwards to north Qinling, where the oceanic basin was subducted under the SKP after the Ordovician (Zhang et al., 1988). Continental collision does not seem to have occurred, as only a few subduction-type Caledonian granites are found in north Qinling, and south Qinling regions. The complicated and rifted passive margin of the YZP, had mostly remained.

The SKP is bordered in the north by a narrow strip of Caledonides which contains Cambro-Ordovician island arc volcano-sedimentaries, unconformably overlain by Late Silurian clastics and carbonates near the Ondur Sum accretional zone (UAAZ) (Tang et al., 1993). The south Tianshan oceanic trough to the north of the TAP was probably initiated in the Ordovician and persisted into the Late Palaeozoic. Partial subduction may have occurred in Silurian–Devonian time, which had caused the uplift of the TAP after its rifting and subsidence in the Cambrian and Ordovician, especially in the Manjyar region (Mg) (Figure 1). The narrow Caledonides belt bordering the Junggar and other massifs in northern Xinjiang is characteristic of the KZD. As the Silurian Tuvaelia fauna was found both in the AHB of the Siberia–Mongolian Domain and in eastern Junggar of the Kazakhstan Domain, these two domains were probably not separated by wide oceans in the Early Palaeozoic.

As noted previously, the Jinningian orogeny brought about a partial collision of the YZP and the CTD in western Zhejiang and northern Jiangxi. Pan (in Liu et al., 1993) thinks that these two massifs collided all along their margins, but later, oceanic troughs and basins formed between them by rifting in the Sinian, probably the result of strike slip faulting. He has drawn the boundary between the YZP and the CTD along the Qinfang residual seaway to the west of the Yunkai Massif (Yk). We, on the contrary, have interpreted the Yk and the Wg (via Yingyanguan) as marking the eastern margin of the YZP from the presence of Sinian arc-type volcano-sedimentaries, and Lower Palaeozoic continental slope sediments found to the east of that line. This places the convergent zone (SSCZ) east of the Yk (Figure 1). In fact, the central Hunan–eastern Guangxi region was a back-arc basin with a transitional basement crust, and was not strongly folded in the Caledonian orogeny. The main belt of strong Caledonian magmatism and metamorphism runs from Wuyishan south-westwards to northern Guangdong. The Hainan Massif (Hn) was a constituent part of the CTD, but the South China Sea Massif (Ss) with an Australian affinity of Cambrian trilobites, was at that time still far away to the south. The Caledonian fold zone in northern Vietnam may indicate a closer relationship between the Indosinia Massif and the YZP, but that between the Indosinia and the South China Sea massifs remains unclear. Guo et al. (1989) and Chen et al. (1992) have both discussed the plate tectonics of south China in the Early Palaeozoic.

The Early Palaeozoic tectonic pattern in the Tibet–Yunnan Domain (TYD) is obscure. An analysis of the Ordovician and Silurian biogeography seems to indicate that the separated massifs (Hm, Gd, Bt) constituted an integrated whole and show close affinities with the YZP, but the Ordovician faunas show also similarities with those of the SKP. They were on the whole of Australian (Gondwanan) affinities (Yin et al., 1994).

The Hercynian and Indosinian stages

In the Late Palaeozoic, a major part of the SKP remained exposed from the time of its upheaval in the mid-Ordovician, until the Middle Carboniferous, when epicontinental seas began to inundate the east-

ern and central part of the platform. Stable marine sediments prevailed up to mid-Permian time, when paralic and terrestrial deposits became predominant. The SKP had a passive northern margin in the Devonian, though Devonian deposits are absent inside the platform. An oceanic basin existed further to the north, which was consumed in the Early Carboniferous. This is manifested by the Hegenshan ophiolite zone (HGCZ), which marks continental collision between the SKD and the Siberia–Mongolia Domain for the first time. In the meantime, sea ways and marine basins still existed in the Soluon–Linxi belt, on the evidence of Permian turbidites and possible ophiolites, reported in the Linxi area near the SLCZ (Wang et al., 1991). Strong support for this view comes from biogeographic evidence. Not only were the Early Permian cool–warm water fauna and the Tethyan warm water fauna demarcated by this belt, but the line between Cathaysian and Angaran flora may also be traced from Daqingshan in the west to the Yanbian area in the east. The barrier disappeared in Late Permian, when the palaeocontinents finally collided. Both the early Hercynian HGCZ and the late Hercynian SLCZ are significant, as the former marks the boundary between the AHB and JBB and the latter between the JBB and SKD.

In northern Xinjiang, collision between Altai and Junggar occurred along the EKCZ (Li et al., 1982). The convergent zone here has a complicated history and several *en échelon* ophiolite zones, the Almantai and the Kalameili, have been found (Xiao et al., 1992). The merging of Euamerican, Angaran and Cathaysian floras in northern Xinjiang in the Late Permian denotes the final assembling of the AHB, KZD and TAD into the Eurasian Supercontinent in the Late Hercynian.

A major part of the TAP underwent uplift after the Silurian. Devonian clastic terrestrial deposits were widespread on the platform and rifting and subsidence again prevailed in the Carboniferous. A marginal aulacogen, of Carboniferous age, was developed along the Kudi zone in north Kunlun and a strongly subsiding belt was formed in the south-western part of the platform (Figure 1). The collision between the south-eastern border of the TAP and the western border of the SKD, including Qd in the south and Alxa in the north, (Figure 1), probably occurred along the Altun transcurrent fault and along the EUCZ, also in the Late Hercynian. In short, at the end of the Hercynian Stage, the oceanic basins between the northern continental masses, usually collectively known as the Palasian Ocean, had all disappeared, and the main oceanic basins in the south were part of Palaeotethys.

At the beginning of the Devonian, the northern marginal massifs of the south Qinling region were quite near to the southern border of the SKP, and the marine basins in south Qinling actually received sediments partly from the north. The seas were shallow and narrow, as exactly the same Devonian fish remains were found in Yunnan and Ningxia, north of the Gansu Corridor. The Late Palaeozoic seaways on both sides of the northern marginal massifs of south Qinling were opened to the wide ocean in west Qinling, and extended eastwards along the southern border of the SKP (Wang, 1981), as proved by the recent discovery of Early Triassic open sea radiolarians to the north of the Tonghai Massif (Tb). This Late Palaeozoic and Triassic marine trough along the southern border of the SKP was finally closed during the Indosinian orogeny (FTCZ) (Wang, 1986).

At the end of Silurian, the YZP and the CTD had united in south China, and the only residual seaway was along the Qinfang belt, which was probably connected with the south-western oceans. In Devonian time, extensional conditions prevailed in the marginal parts of the YZP, especially in its western and south-eastern marginal tracts. The northern Qiangtang and Tangla massifs began to depart from the YZP, and rifting frequently occurred to form 'microaulacogens' in the Hunan–Guizhou–Guangxi region. Extensional processes were strengthened by Permian time, leading to profuse eruption of Permian and Triassic continental and submarine basalts and to the formation of rift- and arc-type volcanism in the limited oceanic basins in the triangular region of Songpan–Garze (Huang and Chen, 1987; Chang et al., 1992). To the west of the Jinshajiang, oceanic basins of considerable width existed on the eastern

TECTONIC OUTLINE MAP OF CHINA

Mainly post-Indosinian and later

0 250 500 750km

Figure 2

- 1 Continental platforms and massifs
- 2 Triassic-Cretaceous basins/foreland basins
- 3 Early Cretaceous (including Late Jurassic) basin group
- 4 Cretaceous basins
- 5 Late Cretaceous-Palaeogene basins
- 6 Palaeogene-Quaternary basins
- 7 Indosinian granites (I-type/S-type)
- 8 Early Yanshanian granites (I-type/S-type)
- 9 Late Yanshanian granites (I-type/S-type)
- 10 Late Yanshanian-Himalayan granites (I-type/S-type)
- 11 Indosinian calc-alkaline volcanic rocks
- 12 Yanshanian calc-alkaline volcanic rocks (andesite-dominant/rhyolite-dominant)
- 13 Yanshanian high-K volcanic rocks
- 14 Cenozoic volcanic rocks (high-K type basalts)
- 15 convergent zones/accretional zones
- 16 thrusts and nappes
- 17 strike-slip faults
- 18 faults in general.

JGB Junggar Basin
YLB Yili Basin
TMB Tarim Basin
THB Turpan-Hami Basin
QDB Qaidam Basin

JQB Jiuquan Basin
ORB Ordos Basin
SCB Sichuan Basin
SLB Songliao Basin
BHB Bohaiwan Basin
JHB Jiangnan Basin
YGB Yinghai Basin
SYB South Yellow Sea Basin
ECB East China Sea Basin
PRB Pearl Basin
OKB Okinawa Basin.

CZ Convergent Zones (open circles):

- 1 XMCZ Xiugou-Maqin
- 2 FTCZ Fengxian-Tongcheng
- 3 LSCZ Longmucuo-Shuanghu
- 4 CMCZ Changning-Menglian.

AZ Accretional Zones (black circles):

- 1 JTAZ Jinshajiang-Tengtiaohe
- 2 BNAZ Bangong-Nujiang
- 3 YZAZ Yarlung Zangbo.

SF Strike-slip faults:

- (I) ATSF Altun; (II) TLSF Tanlu; (III) HHSF Honghe.

side of the Qm and Ls massifs. The closure of these oceanic basins and the formation of Indosinian convergent zones (LSCZ and CMCZ) to the south and west of Qt, Qm and Ls, marked the northward accretion of these massifs and the southern boundary of the newly formed Eurasian Supercontinent.

As mentioned previously, the major geosuture demarcating the Eurasian Supercontinent in the north and the Tibet–Burma Domain in the south has long been controversial. Early Permian tillites and cold water faunas indicating a Gondwanan origin are not found north of Longmucuo and Shuanghu. Typical Viséan faunas occur to the north of Gerze and a south Cathaysian flora of Late Permian age is found in Shuanghu. There seems little doubt about this main boundary, although the oceanic basin to the south of it may not have been so wide as previously thought (Wang, 1986). It may be noted in this context that, from a biogeographical and palaeomagnetic viewpoint, Palaeotethys, between the northern and the southern continents, seems not to have been wide enough for the palaeocontinents to be globally reconstructed. The presence of a Cathaysian flora in south-western USA is also difficult to reconcile with our present knowledge of palaeophytogeography and palaeocontinent reconstruction.

China in post-Indosinian times — intracontinental development

The tectonic framework at the close of the Indosinian Stage

The close of the Indosinian Stage marks an important turning point in the tectonic evolution of China and led to the final formation of the Eurasian Supercontinent (Chang et al., 1988). The closure of Palaeotethys in the Late Triassic had left several convergent and accretional crustal consumption zones marked by ophiolite and ophiolitic melange zones of Indosinian age. The convergent zones include the Xiugou–Maqin (XMCZ), the Fengxian–Tongcheng (FTCZ) and its eastward extension in southern Shandong, the Longmucuo–Shuanghu (LSCZ) and the Changning–Menglian (CMCZ). The accretional zones comprise the Jinshajiang–Tengtiaohu (JTAZ), the Garze–Litang in Tibet and Yunnan. Almost every zone is accompanied by a magmatic belt, consisting of subduction- and collision-type volcanic and granitic rocks aged from Late Permian to Late Triassic. These may be called coupled ophiolite-magmatic arcs (Mo et al., 1994). The formation of foreland type sediments in the western border parts of the Ordos and Sichuan basins in Late Triassic was also a manifestation of the Indosinian convergence events in the East Palaeotethys region (Figure 2).

Post-Indosinian tectonic development of east China

In the post-Indosinian, the tectonic development of the Chinese continent was chiefly controlled by interaction of the Siberian Plate from north, the Pacific Plate from east, and the Indian Plate from the south-west. The Palaeozoic tectonic regime was replaced and superimposed by the new regime which consists of a Circum-Pacific system in east China and a Tethys–Himalayan system in west China, the boundary lying roughly along longitude 105°E (Huang, 1978, Ren, 1990). With the exception of Tibet and western Yunnan and a few places including Taiwan (Juan, 1994) and the Nadezhda area of north-east China, where an ocean-arc-continent regime probably still existed, the major parts of China were under an intracontinental tectonic setting in post-Indosinian times.

The main post-Indosinian tectonic events in east China include the formation of the giant Circum-Pacific tectono-magmatic belt and of the extensive rift basin system. Intracontinental subduction and welding were also important, as the main platforms and most of the massifs had already been pieced together even before Indosinian time. Subduction is indicated by the development of Indosinian to

Yanshanian crust-derived muscovite-bearing granites in the Lower Yangtze region (Deng et al., 1992), and by the presence of diamond/coesite-bearing ultra-high pressure metamorphic rock belt in the Dabie region. The time of high pressure metamorphism is controversial, but it was probably formed by the rapid Indosinian lithospheric convergence, and was brought to the surface by the Yanshanian uplift on the collapse of the orogenic belt. The A-type granites in Jilin–Heilongjiang region of north-east China probably had the same origin through the Indosinian orogeny followed by collapse of the orogenic belt.

In east China, the Yanshanian Stage was characterised by intracontinental collision and further welding of the main platforms and massifs. Thrust zones have long been known from the Yanshan region within the SKP, and more extensive thrust and nappe zones have recently been discovered to the north of the Langshan Range in Nei Mongol. The giant Tanlu transcurrent zone (Figure 1), the imbrication slices formed of Proterozoic strata in northern Anhui and the various thrust zones found in the lower Yangtze and central Hunan, were probably all formed at this time. The Yanshanian volcanic rocks and granitic intrusives in east China were mainly formed by intracontinental convergence and subduction; probably resulting from the distant, inland influence of subduction of the Kola–Pacific Plate beneath the Eurasian Supercontinent. They are distributed in three belts striking in a NE–SW direction as follows:

- 1 The Hingan–Yanliao magmatic belt consists mainly of J₃–K₁ (145–110 Ma) terrestrial volcanic rocks and granites of both S- and I-type, 130–95 Ma in age, in the Daxinganling region, and of I-type, 138 Ma in age, in the Yanliao region. Volcanic rocks range from calc-alkaline basalt-andesite association to intracontinental extensional hawaiite-trachyte-peralkaline rhyolite association. This change in rock association was coeval with the conversion from compressional to extensional conditions in the regional stress field of east China, after which the rift basins of north China were extensively developed (Ma et al., 1987).
- 2 The Changbai–Lower Yangtze magmatic belt stretching from Zhangguangcailing in the north to Nanling in the south mainly consists of J₂ to K₂ (169–85 Ma) high-potassium calc-alkaline andesite-dacite-rhyolite and shoshonite-mugearite-trachyte volcanic assemblages. The granites are of S-type in the Nanling Range, and of S–I-type in north-east China. The volcanics seem to have been formed in an active continental margin with relatively thick crust, as they show clear compositional polarity across the magmatic arc in the lower Yangtze region. The arc volcanism ceased at the end of Cretaceous owing to collapse of the subduction zone and was followed by rift-related basaltic volcanism (Deng et al., 1992). The granites in north-east China and Nanling region show little relation with the subduction of the Pacific Plate.
- 3 The coastal belt contains volcanic rocks ranging in age from J₃ to E₁. They are K₁–E₁ in Okhotsk–Chukchi, K₂–E₁ in Sikhote–Alin–Laoyeling, K₂ in southern Korea, J₃–K₂ in south-east China, with an eruptive peak in K₁ (Tao et al., 1988). A few andesite-dominant calc-alkaline volcanic rocks and I-type to I–S-type granites occurred in a very early stage. The main stage (K₁) was dominated by rhyolite-dacite rocks and S-type granites. This is the well-known ‘rhyolite chain’ of the east Asian continental margin, which might have resulted from oblique subduction of the Kola–Pacific Plate against the Eurasian Supercontinent. Volcanism seems to have gradually shifted from south to north and from west to east with time. Bimodal volcanic associations and A-type granites formed in the Late Cretaceous indicate collapse of the orogenic belt and the beginning of intracontinental extension.

Since the Late Cretaceous, rifting and extension have prevailed in the eastern part of east China, which had led to the formation of rift basins and extensive eruptions of rift-related basalts. This seems to imply that an upwelling mantle plume was active beneath the continental lithosphere in east China. The principal rift basins in east China are mainly distributed in three belts:

- 1 A western belt including the Ordos and Sichuan basins which have a complicated history of development. They were cratonic sag basins in Permian to mid-Triassic, and became partly foreland basins in Late Triassic as a consequence of collision between the SKP and the YZP at the closure of the Palaeotethys. They had undergone alternating active and quiescent stages in the Jurassic and Cretaceous (Li et al., 1994), and came to an end at the close of the Mesozoic.
- 2 A central belt comprising the Songliao, north China (Huabei) and Jiangnan-Dongting basins, with filling ages ranging from Palaeogene to Quaternary, except the Songliao basin which was mainly Cretaceous. All these basins were formed under an extensional or transtensional regime and are characterised by rapid subsidence, thick basin-fill and relatively high heat flow. They show in general a superimposed architecture with an underlying rifting and an overlying thermal subsidence type of structure. The underlying thin crust (24–40 km) was probably coincident with an upwelling asthenosphere from depth. Hundreds of small fault-controlled basins are distributed along both the western and the central belts, which show to a certain extent similarities with the Basin and Range type of western North America.
- 3 A continental margin belt including the Yellow Sea and the East China Sea basins, and the marginal basins of South China Sea. Cretaceous basins with thick marine shales of pre-rifting age in the offshore area. The main rifting phase occurred in the Palaeogene, and was followed by the Neogene post-rift depression forming asymmetric sediment drapes. The Pearl Basin and the Qiongdongnan Basin are representative of this type, whereas the tectonic characteristics of the Beibuwan Basin and the Yellow Sea Basin formed on a continental basement show similar characteristics to onshore rift basins. The main continental marginal basins of China were developed on basement of either continental or transitional crust (Liu et al., 1992).

As mentioned above, Cenozoic magmatic events are characterised by rift-related basaltic eruptions, whereas granites seldom occur in east China. Palaeogene tholeiitic basalts are found beneath the sedimentary beds in most basins, and may imply a relatively fast spreading rate for the basins in the Palaeogene. On the contrary, the Neogene–Quaternary basalts are characterised by peridotite nodule-containing alkali basalt series. They occur usually as individual volcano or volcano clusters, and probably denote continental rifting with a relatively slow spreading rate (Chi, 1988).

Post-Indosinian tectonic development of west China

The elimination of Palaeotethys and the formation of the Eurasian Supercontinent through the convergence of continental platforms and massifs, may imply that, in the Indosinian Stage, the vast region was controlled by a downward cold mantle flow in the deep part. In west China, the generation and evolution of Neotethys was the most important tectonic event in the post-Indosinian period. The Yarlung Zangbo oceanic basin, the main branch of Neotethys, was probably initiated in Late Permian or Early Triassic, and was fully developed by the Late Triassic. A good suite of MORBs accumulated along with mafic–ultramafic rocks and overlying radiolarian cherts, and together with peridotites. The Banggong–Nujiang oceanic basin, another branch of Neotethys, probably opened in the Early Jurassic and an ophiolite suite comparable to the oceanic crustal sequence has also been found. The general dispersion of lithosphere and the generation of new oceanic crust were pronounced in west China from the Late Triassic to the early Cretaceous, and may indicate that an upwelling hot mantle plume was in action in the deep part. In both the Yarlung Zangbo and the Banggong–Nujiang oceanic basins subduction started in the Late Jurassic, ending in the Late Eocene and Late Cretaceous respectively. To the north of the Yarlung Zangbo zone, along the southern border of the Gangdise Massif (Ga), a conspicuous magmatic belt developed, consisting of calc-alkaline volcanic rocks and granites as well as molasse deposits. The elimination

of Neotethys, the northward movement of the Indian Platform and its collision with the Eurasian Supercontinent in the Early Cenozoic marked a change from a divergent to a convergent tectonic condition in this region, and presumably a corresponding change from upward to downward, deep mantle convection.

The Cenozoic tectonic history of west China was essentially intracontinental convergence and subduction, and may be subdivided into two stages. The first stage is from Oligocene to Miocene and was dominated by strong horizontal compression and intracontinental subduction leading to the formation of the Himalayas and Gangdise mountain ranges and of the giant Siwalik and Indos–Yarlung Zangbo molasse zones (Li et al., 1986). The Main Central Thrust (MCT) and the large-scale nappe zone in the Himalayas were probably formed at this time. The remarkable crust-derived muscovite-bearing granite belts (aged 40–10 Ma, mainly 20–10 Ma) in the Himalayas and partly in southern Gangdise provide strong evidence of intra-continental subduction. In the second stage from Pliocene to Quaternary, the main event was the quick differential uplift of the Qinghai–Xizang (Tibet) Plateau. Intracontinental subduction took place on both the southern and the northern margin of the plateau, and brought about the formation of the Main Marginal Thrust (MMT) of the Himalayas and of the north Tibet–south Kunlun–Hoh Xil volcanic belt. The latter consists mainly of a shoshonite series as well as a few high- K_2O calc-alkaline volcanic rocks (Deng, 1991). The northward compression and upheaval of the plateau have given rise to the surrounding giant strike-slip faults such as the Altun and the Honghe (Figure 2). These processes have produced remarkable effects as far away as north-west China, including Late Mesozoic and Cenozoic molasse zones developed in the Qaidam Basin and along the northern piedmont zone of the Kunlun and Qilian mountains. The development of foreland thrust belts in northern Tarim and in the Junggar and Turpan–Hami basins in north Xinjiang was the result of compressive forces acting from either side of the Tianshan Mountains.

Concluding remarks

1. China is a composite continent consisting of nine tectonic domains that were sutured together in different stages. There have been five megastages of tectonic evolution, among which the end Jinningian and Indosinian stages mark the most important changes in the tectonic regime.
2. Primary continental crust formed scattered proto-nuclei in the Eoarchaean mainly in north China, which coalesced into separate continental nuclei at the end of Mesoproterozoic (2.8 Ga). The continental nuclei combined together, first at the end of Archaean and then in the Palaeoproterozoic (1800 Ma), to form extensive proto-platforms. The continental crust may have then attained its largest extent and formed a loosely united supercontinent, which might have been a part of Pangaea I (Table 1).
3. Extensional conditions manifested by aulacogens dominated in the Mesoproterozoic, and were followed by a mainly convergent regime in the Jinningian Stage, leading to formation of the mature platforms. The gathering of the platforms in China is consistent with the idea of a Neoproterozoic (c. 900–800 Ma) supercontinent Pangaea II. Up to this time the tectonic evolution of China had been mainly the increase and stabilisation of the continental crust.
4. From the Sinian to the Triassic the tectonic evolution of China consisted mainly of the complicated development of continental margins by rifting, splitting and reaccrion of marginal massifs. Generally known as the accretion model of continental margin development (Huang, 1984), this is to a certain extent consistent with Sengor's idea of crustal growth (1993) on the southern margin of the Siberian craton. On the whole, extension prevailed in the Caledonian, and compression in the Late Hercynian and Indosinian stages, bringing about formation of the Eurasian Supercontinent. A similar course may have occurred in most parts of the world resulting in the appearance of Pangaea III.

5. The close of the Indosinian Stage saw profound changes in the tectonic regime of China, and the latitudinal (present orientation) tectonic grain developed in the Palaeozoic was replaced by a Tethyan system in west China and a Pacific system in east China. The post-Indosinian was tectonically mainly intracontinental except in the Tibet-Burma Domain. Continental collision, subduction and indentation of the massifs prevailed as the three surrounding plates, India, Siberia and Pacific, interacted.

6. Analyses of the magmatism, tectonics and palaeomagnetism in post-Indosinian times seem to indicate that there was an alternating series of extensional and compressional regimes in time both in west China and in east China, and that in the same period, west China and east China were contrary in regard to their extensional or compressional conditions. This may mean that a convection system in the upper mantle was operating at depth below the Chinese continent, with alternating up- and down-welling current in space and time. Furthermore, from a macrocosmic point of view, the more-or-less periodical change between compressional and extensional conditions in China and the seemingly recurrent appearance of Pangaea may reflect a higher order periodic change engendered by processes in the interior of the earth which were under cosmological control.

7. In this paper, we have in general followed plate tectonics theory. However, there are problems for plate tectonics theory as it now stands. In particular:

- there is a comparative lack of evidence for ancient large oceans and deep ocean deposits prior to the Mesozoic;
- there are discrepancies in global reconstructions of palaeocontinents (the large gaps in eastern Tethys and between Siberia and north China in the Late Palaeozoic are well known) and
- there are difficulties in the biogeographical interpretation of Cathaysian flora in south-western North America.

Tomographic studies of the upper mantle (Woodhouse et al., 1984) have revealed the downward extension of seismic waveforms to over 300 km, which would put some constraints on plate motions. Therefore it is probably necessary to investigate the extent of free motion of the cratonic lithospheric plates and to determine whether the earth's radius has increased in the geological past (Owen, 1992). If the earth's radius has increased up to around 15%, presumably in an episodic pulsatory and asymmetric way (Milanovsky, 1983), the discrepancies mentioned above may be reconciled, at least to a certain extent.

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