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Editorial

Precambrian tectonics of East Asia and relevance to supercontinent evolution

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We wish to dedicate this volume to the late Professor C.McA. Powell, a past co-leader of IGCP 440, whose leadership and inspiration benefited many who contributed to this volume.

1. Introduction

East Asia, as part of the Eurasia continent, has been the locus of convergence of continents large and small since late Palaeozoic time. This growth is still continuing today, and as predicted by Hoffman (1999), East Asia could become the centre of a future supercontinent, Amasia. Vastly different geological histories among various blocks prior to their amalgamation hint at their diverse origins. If the Earth's evolution was indeed dominated by the formation and breakup of supercontinents such as Pangaea, Gondwanaland (e.g. Veevers, 1990) and Rodinia, the East Asian blocks may hold key information about the configuration of these supercontinents and the kinematics of their assembly and disintegration.

This volume summarizes some of the latest research results by members of IGCP Project 440: "Rodinia assembly and breakup," on the Precambrian tectonic history of various East Asian blocks, and their significance to supercontinent evolution. These papers either present new, high-quality geochronological, geochemical, structural, or petrological results, or offer reinterpretations of available data. The substantial volume of new data presented in this volume will remain a fundamental dataset for verifying various tectonic and supercontinent models for a long time to come.

2. Basement characteristics of the Indochina Block

The field regions covered by this volume range from Indochina to southern Siberia (Fig. 1). We thus organized the papers following this geographic trend. The first paper, by Lan et al. (2003), reports new geochemical and Sr–Nd isotopic data from the Kuntum Massif, previously thought to have an Archaean crystalline basement. Recent high-quality geochronology (e.g. Carter et al., 2001; Nagy et al., 2001; Nam et al., 2001) demonstrated that strong Paleozoic (ca. 450 Ma) magmatic (and metamorphic?) events, and Permo-Triassic intermediate to high-grade metamorphism/magmatism, have obscured the Precambrian record of the massif. Lan et al.'s work demonstrates

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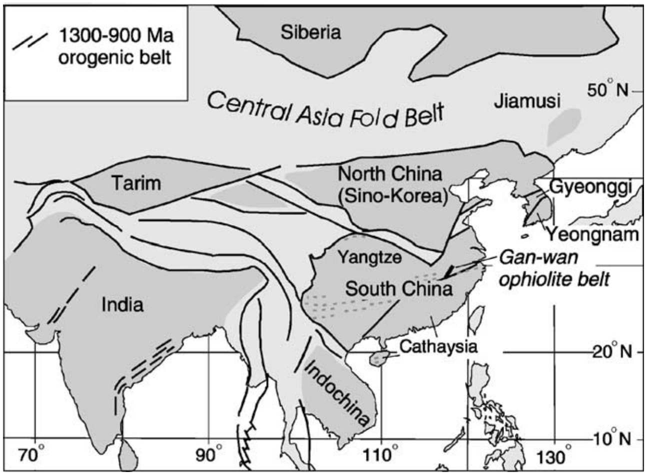

Fig. 1. Major Precambrian crustal blocks in East Asia.

that crustal formation within the Indochina Block occurred mainly during the Palaeoproterozoic to Mesoproterozoic, not during the Archaean as previously thought.

3. South China in Rodinia: 970 Ma adakitic granite during Rodinia assembly, widespread Neoproterozoic magmatism and rift basins during Rodinia breakup, and a possible Rodinian superplume

This group of five papers deals with major magmatic and rifting events in the South China Block which may reflect the dynamic changes in tectonic environment between the assembly of Rodinia in late Mesoproterozoic to earliest Neoproterozoic time (≥900 Ma), and breakup of the supercontinent from ca. 825 Ma (magmatism starting as early as 850 Ma?) to ca. 750–700 Ma.

The paper by Li and Li (2003) reports geochemical and Nd isotopic analyses of ca. 970 Ma albite granites within the NE Jiangxi ophiolite complex, part of the Gan-wan ophiolite belt located between the Yangtze and Cathaysia blocks (Fig. 1). The authors suggest an adakitic nature for the granite and argue for its generation by low-degree partial melting of subducted oceanic crust. If correct, this would imply that the SHRIMP U–Pb zircon age of 968 ± 23 Ma (Li et al., 1994) for the adakitic granite represents the time of oceanic subduction rather than formation of oceanic crust as previously thought.

Neoproterozoic granitic and mafic–ultramafic intrusions are widespread in South China and have been attributed to continental collision between the Yangtze and Cathaysia Blocks (e.g. Chen et al., 1991), arc magmatism (e.g. Zhou et al., 2002a), and crustal melting above a mantle plume (e.g. Li et al., 1999). Contradictory tectonic interpretations result partly from poor age constraints for both orogenic and magmatic events and the often non-uniqueness in geochemical interpretations. In this volume, new SHRIMP ages and geochemical data are presented for both pre-rift (830–820 Ma, Li, X.-H. et al., 2003) and syn-rift (820–750 Ma, Li, X.-H. et al., 2003) magmatic rocks. Li et al. (2003) argue that because the pre-rift granitoids intruded dominantly within a ∼5 Ma interval at ca. 825–820 Ma, over an area of > 1000 km × 700 km, and show a variety of geochemical characteristics, they can best be explained by extensive crustal melting above a mantle plume. Li, Z.-X. et al. (2003), on the other hand, demonstrate that there were two major episodes of widespread bimodal magmatism in South China during the Neoproterozoic: one at ca. 830–795 Ma (peaked at ca. 820 Ma), and another at ca. 780–745 Ma. Moreover, both episodes were accompanied by continental rifting, and some co-magmatic mafic dykes show geochemical characteristics of continental flood basalts. Considering the similar records in other Rodinian continents, these authors speculate on the existence of a Rodinian superplume that led to anorogenic magmatism, continental rifting, and eventually to the breakup of Rodinia. The authors of both papers interpret the arc signature reported by Zhou et al. (2002a) as reflecting inheritance from pre-existing arc materials.

The next paper, by Ling et al. (2003) documents the transition of tectonic regimes at the northern margin of the Yangtze Block, from an arc setting at ca. 950–900 Ma (the Xixiang Group) to a plume-related continental rift setting at ca. 820 Ma (the Tiechuanshan Formation), in which E-MORB type tholeiitic basalts, OIB-like alkaline basalts, and rhyolites and dacites with significant contributions from crustal components were developed. This result is compatible with events observed along the southern margin of the Yangtze Block and exemplifies that (1) the convergent tectonic regimes surrounding the Yangtze Block persisted until ca. 900 Ma; and (2) an extensional regime, possibly plume induced, began by at least ca. 820 Ma. The rock units studied by Ling et al. (2003) are the same as those discussed by Zhou et al. (2002b). Both Li et al. (1999) and Ling et al. (2003) interpret the ca. 820 Ma Tiechuanshan Formation and the ca. 820–780 Ma bimodal igneous intrusions in the region as being developed in a plume-induced continental rift. Zhou et al. (2002b), however, suggested that they were part of the Xixiang arc which is at least 80 My older. Some of the arc-compatible geochemical signatures reported by Zhou et al. (2002b) from the younger group of rocks clearly need to be verified and satisfactorily explained.

The last paper in this group, by Wang and Li (2003), provides a synthesis on the development of a continental rift system in South China during the Neoproterozoic. Although a rift model for the Neoproterozoic volcaniclastic rocks in South China has long been suggested (e.g. Liu, 1991; Li et al., 1995, 1999), the same rock successions were alternatively interpreted by others to have formed in arc environments (see previous discussions), and cross-continental correlations based on both reliable age determinations and sequence stratigraphy are lacking. Wang and Li demonstrate here that the ca. 820–700 Ma rift history of South China can be well correlated with that in eastern Australia and thus argue for the palaeogeographic proximity of the two continents in Rodinia.

4. Precambrian of North China and correlations with other continents

Three papers in this group focus on the North China Block. The first, by Wang et al. (2003), provides new structural and $^{40}Ar/^{39}Ar$ data documenting the tectonic evolution of the Zanhuang dome in the central metamorphic zone of the North China Block, a zone touched on by all three papers. The authors argue that the tectonic setting in the study region evolved from a collisional stage at 1870–1826 Ma to an orogenic collapse stage at 1826–1793 Ma and, finally, to cooling and localized extensional shearing during the early Mesoproterozoic. The review paper by Zhai and Liu (2003), while recognizing the existence of major magmatic-metamorphic peaks over the North China Block at both ca. 2500 and 1900–1800 Ma, highlights the controversy over what occurred between these two events, and whether the younger event could be attributed to a collisional orogeny or to a mantle upwelling beneath a Palaeoproterozoic supercontinent. Clearly more work is needed to understand this complex, mostly still poorly studied region. The last paper in this group, by Zhao et al. (2003), provides a review of Archaean to Palaeoproterozoic tectonostratigraphic records in both the eastern North China Block (they refer to it as the Eastern Block) and the South Indian Block. The authors argue that these two blocks could have been together from Archaean until early Mesoproterozoic time. Although their palaeogeographic reconstructions await further tests, particularly using palaeomagnetism, the remarkable similarities in geological records between these blocks deserve further attention.

5. Basement history and tectonic affinities of crustal blocks in the Korean Peninsula

The tectonic affinity of the Korean Peninsula has been an enigma for a long time. The entire peninsula was traditionally regarded as an extension of the North China Block (also called the Sino-Korea Craton/ Block). However, the existence of faunal assemblages of both South and North China types in different parts of the Korean Peninsula led to the speculation that the Gyeonggi Massif belonged to the South China Block (Fig. 1; see references in Cluzel et al., 1991).

This speculative model was further supported by the recent discovery of 756 Ma rift-related metavolcanics in the Ogcheon belt (Lee et al., 1998), which are similar in age to rocks in South China (see Li, Z.-X. et al., 2003; Wang and Li, 2003), and by palaeomagnetic studies (e.g. Uno and Chang, 2000). However, it is still unclear whether the entire lithosphere of the Gyeonggi Massif (e.g. Cluzel et al., 1991; Yin and Nie, 1993), or just its middle to upper crust (Li, 1994), is correlative with that of the South China Block. Further work on the basement may help to verify the proposed correlation between Korea and South China and, if proved correct, help to determine whether it is a thick-skinned, or a whole-lithospheric feature. It may also shed light on positions of the East Asian crustal blocks in supercontinents such as Rodinia.

The four papers included in this group express diverse opinions on the above-mentioned issues. Both Kim and Cho (2003) and Kwon et al. (2003) report ca. 1900 Ma granitic intrusions along northeastern Yeongnam Massif. Whereas the former suggests a possible correlation of this event with that in the North China Block, the latter argues otherwise because there are younger events at ca. 1400 Ma (published in Korean journals) and 617 Ma that have not been reported from the North China Block. However, neither work negates the possible connection between the Gyeonggi Massif and the South China Block. The third paper, by Sagong et al. (2003), reports paired Sm–Nd and U–Pb garnet ages from both the Yeongnam and Gyeonggi massifs. The authors find that although metamorphic ages between 1989 and 1835 Ma are common to the basement rocks of both massifs (comparable to that of the North China Block?), a strong late Permian metamorphic age is registered by supracrustal rocks in the Gyeonggi Massif, marking the collisional event between South and North China Blocks.

The strongest evidence supporting a South China affinity for the Gyeonggi Massif in central Korea is presented by Lee et al. (2003), who report a 742 Ma age for alkaline meta-granitoid in the Gyeonggi Massif that was possibly generated by buoyant asthenospheric mantle with the mixing of continental crust and mantle-derived basaltic magma. The authors argue that because Neoproterozoic rift-related magmatism was widespread in South China but was absent from the North China Block, the Gyeonggi Massif was likely an extension of the South China Block in Rodinia, possibly adjacent to Australia. It is interesting to note that the time range of ca. 860–750 Ma for the anorogenic magmatism in the Gyeonggi Massif matches well the ages of magmatic events in South China and some other Rodinian continents which are interpreted as products of a Rodinian mantle superplume (e.g. Li, Z.-X. et al., 2003).

6. Crustal blocks and ophiolitic belts in the Central Asia Fold Belt and Neoproterozoic dykes in southern Siberia

The final three papers focus on the Neoproterozoic to Cambrian tectonic history of the Central Asia Fold Belt and the southwestern margin of Siberia. The paper by Wilde et al. (2003) reports 525–515 Ma granitic intrusions in the Jiamusi Massif in northeastern China which underwent granulite-facies metamorphism at ca. 500 Ma. These granitoids were previously considered to be of Palaeoproterozoic age and were compared with basement rocks in the North China Block. The presence of such Pan-African magmatic and metamorphic events leads the authors to speculate on possible origins of the massif either along the southern margin of Siberia or as an extension of the Ross-Delamerian Orogen off northeastern Australia during the Cambrian. Khain et al. (2003), on the other hand, report the occurrence of, and age determinations for, numerous Neoproterozoic to early Palaeozoic ophiolites and metamorphic complexes in the central and western Central Asia Fold Belt and provide a set of palaeogeographic reconstructions illustrating the evolution of oceans (they refer to them collectively as the Palaeo-Asian ocean) between Siberia, Baltica, North China and Tarim during the breakup of Rodinia. The paper highlights the formation of arcs along the present western and southern margins of Siberia.

The final paper by Sklyarov et al. (2003) reports the occurrence and geochemical, petrological and geochronological data for Neoproterozoic dyke swarms along the southern margin of the Siberia Craton. These dykes are of either tholeiitic or subalkaline character, and the authors report an imprecise Sm–Nd isochron age of 743 ± 47 Ma and a $^{40}Ar/^{39}Ar$ age of 758 ± 4 Ma for the dykes. If the $^{40}Ar/^{39}Ar$ age is an accurate date for dyke intrusion, the event correlates well with the last phase of Neoproterozoic rifting and magmatism in South China, Australia, Laurentia, India, and southern Africa, which Li, Z.-X. et al. (2003; Fig. 8) use to support the existence of a Rodinian superplume. However, Sklyarov et al. (2003) speculate that Siberia may not have been connected to Laurentia in Rodinia as widely believed. Clearly, more geological and palaeomagnetic studies are needed to further examine possible connections between Siberia and other cratons during the formation and breakup of Rodinia.

Papers in this special issue are mostly by members of IGCP 440 East Asia Working Party. We note with profound sadness the sudden death of the late Professor Teruo Watanabe during a field trip on 9 May 2002. Professor Watanabe was a co-author of one of the papers in this volume and was also one of the coordinators for the IGCP 440 East Asia Working Party.

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