Paleozoic to Early Mesozoic Tectonics of North China Craton

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Abstract

The North China Craton (NCC) started its Paleozoic evolution from ca. 520 Ma when Gondwana assembled in its peak tectonism. The Middle Cambrian developed in margins of the NCC on older strata or basement rocks. Then the marine environment expansion and its extensive invasion led to the late Middle Cambrian marine deposits, the Mantou Formation and afterwards occurred throughout the NCC. New results of the Bainaimiao arc belt, north to the northern NCC indicated that the arc was active from 520 Ma and lasted to 420 Ma, which could extend to east Siping in NE China. Along the southern edge of the NCC the northward subduction of the Shangdan Ocean was operated during ca. 514–420 Ma. Marine regression occurred postdated the Majiagou phase in Middle Ordovician in most parts of the NCC. Recently in the northern NCC some Devonian plutons and volcanic rocks were recognized. The Late Carboniferous sedimentary sequence with the 'G' layer of bauxites at its bottom is overlain disconformably upon the Middle Ordovician limestone. The bauxites were derived mainly from ashes produced by volcanism mainly in the Inner Mongolia Paleo-uplift (IMPU) during Paleozoic period, particularly in latest Early Carboniferous to Early Permian when the northern margin of the NCC evolved as an Andean-style active continental margin. The sequence is mainly clastic formations, composed of coal-bearing sandstones and siltstones interlayered with marine limestone and volcanic ash, which demonstrates that they formed in terrestrial–marine transitional or terrestrial environment with volcanic arc settings. After late Early Permian a terrestrial environment was dominant in the NCC. In the southern NCC and the Qinling Orogenic Belt (QOB) spreading of the Mianlue Ocean between the South China Craton (SCC) and South Qinling Block (SQB) was sustained in Late Paleozoic and the northward subduction–accretion of the Mianlue Ocean was active in Late Paleozoic. In Triassic, the collision between the SCC and SQB along the Mianlue suture resulted in intense shortening and uplift of QOB and HP/UHP metamorphism documented in Hong'an-Dabie-Sulu terranes.

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Meanwhile in the northern NCC, significant changes in tectonic deformation and magmatism occurred in Late Triassic. In the Panshan region, the northern NCC, intensive regional folding and thrusting took place around 210 Ma, which shows that the NCC underwent into its initial decratonization.

Keywords
Tectonics • Paleozoic • Early Mesozoic • North China Craton

18.1 Introduction

The North China Craton (NCC) is one of the oldest cratons in the world and is characterized by complex evolution history from Early Precambrian (e.g., Zhai and Santosh 2011; Zhao and Zhai 2013; Zhai 2014). Evolving into Phanerozoic, from earliest Paleozoic to Early Mesozoic periods, the NCC underwent its typical craton stage in Early Paleozoic, in which extensive transgression occurred throughout the NCC in Middle Cambrian after an unexpected ca. 800 Ma long gap, and then typical craton sequences developed. The tectonic events of the NCC in Early Paleozoic appeared well known. But their global settings and their relationships with tectonic events of adjacent orogenic belts remained poorly understood. Recently, great progress was made not only in the NCC but also in the neighbouring Qinling Orogenic Belt (QOB) and Central Asian Orogenic Belt (CAOB) on Paleozoic to Early Mesozoic geology and tectonics can draw some veils over the issues. They are Early Paleozoic extensive transgression and regression, regional minerals, Late Paleozoic tectonic events and Early Mesozoic regional deformation and magmatism, and their relationship with tectonic events of adjacent orogenic belts and global significant tectonic events. This review paper will address the above issues.

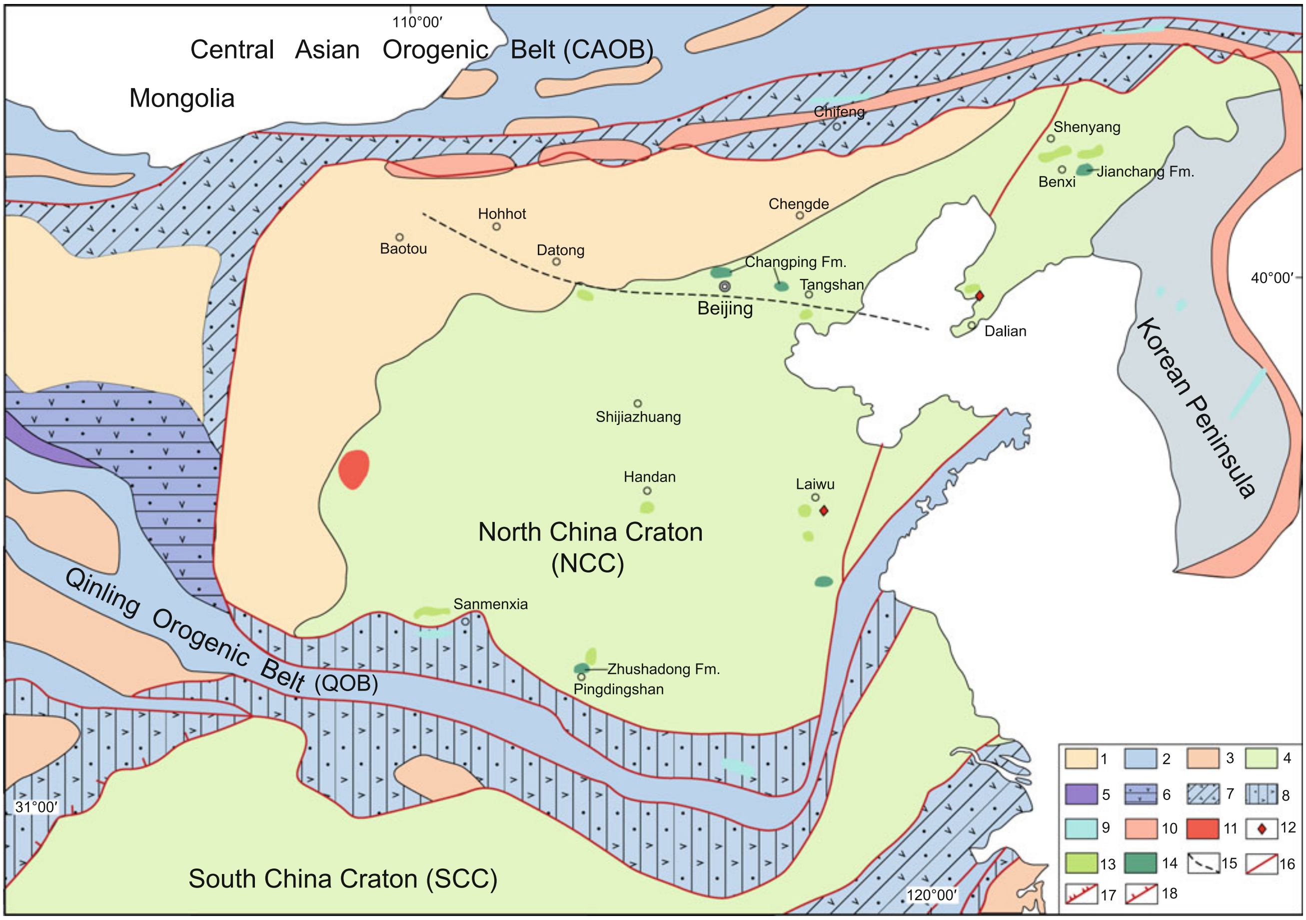
18.2 Early Paleozoic Tectonics

18.2.1 Main Regions of the NCC

The northern NCC restarted its geological documents in Paleozoic period after a long gap probably from ca. 1320 Ma to ca. 515 Ma. The Middle Cambrian marine deposits, the Jianchang Formation in Liaoning, the Changping Formation in Beijing and the Fujunshan Formation in Tianjin, the Liguan Formation/Xinji Formation and Zhushadong Formation in Henan, the Xinji Formation and Zhushadong Formation in Shaanxi (Figs. 18.1 and 18.2) developed in the margins of the NCC on older strata or basement rocks when Gondwana assembled in its peak tectonism. Then the marine environment expanded to almost the whole NCC, from the Mantou phase and thereafter up to the Middle Ordovician Majiagou phase. The Middle Ordovician marine regression and regional uplift of the NCC occurred after deposition of the Majiagou Formation and led to the paleogeographic change of the NCC, especially in the eastern Ordos basin and potash formation (Zhang et al. 2015), which coincided with diamondiferous kimberlite magmatism in the eastern and northeastern NCC at ca. 463–470 Ma (Zhang and Yang 2007; Yang et al. 2009). There was hidden magmatic event in deep of the NCC at 520 and 430 Ma as indicated by the inherited zircons from the basalt of the Nandaling Formation in western Beijing (Zhao et al. 2006a), the latter simultaneous with the final closure of the Iapetus Ocean as Baltica collided with Laurentia to form Laurussia and the Caledonian Orogeny (Lawver et al. 2011), suggested that the uplift of the NCC in late Early Paleozoic was related to the concurred deep and global tectonism. The regional uplift and stratum hiatus lasted until Late Carboniferous.

18.2.2 Northern NCC and the Southern CAOB

The northern NCC is bounded with the Bainaimiao arc belt by the east-west-trending Bayan Obo–Duolun–Chifeng–Kaiyuan fault zone (Fig. 18.3a). Although previous researchers considered the northern margin of the NCC as an active continental margin during Ordovician to Silurian (e.g. Zhang et al. 1986; Wang and Liu 1986; Hu et al. 1990; Wang et al. 1991; Tang 1992; Chao et al. 1997; Xiao et al. 2003), sedimentary and magmatic evidence show that the northern margin of the NCC remained as a passive continental margin during Early Paleozoic period (e.g. Li et al. 2009; Zhang et al. 2014a). The Early Paleozoic magmatic rocks with zircon U–Pb ages of 520–420 Ma are only distributed in the Bainaimiao arc belt and haven't been identified from the northern margin of the NCC (Zhang et al. 2014a and references therein). New zircon U–Pb and Sr–Nd–Hf isotopic results on the magmatic and metasedimentary rocks indicate that the Bainaimiao arc belt is an ensialic island arc characterized by very different tectonic history and basement compositions than the northern NCC (Fig. 18.3b; Zhang et al. 2014a). Similar to most of the microcontinents



1. Craton uplift 2. Ocean basin 3. Displace block 4. Carbonate platform 5. Continental margin magmatic arc 6. Back-arc basin 7. Passive continental margin basin 8. Continental margin depressed basin 9. Outcrops of Silurian (S) 10. Silurian sediments distribution inferred 11. Potash saline 12 Kimberlites at ~ 470 Ma 13. Fengfeng Formation (Late Ordovician) 14. Outcrops of Early Cambrian (Є$_1$) 15. Northern margin of Fengfeng Formation (O$_3$) 16. Fault 17. Subduction zone 18. Boundary fault on depressed basin margin

Fig. 18.1 Early Paleozoic paleogeographical map of the NCC. For explanation, see text

in the CAOB (e.g., Wang et al. 2001; Zhao et al. 2006b; Demoux et al. 2009; Levashova et al. 2010, 2011; Kozakov et al. 2012; Kröner et al. 2011, 2014), the Bainaimiao arc belt has a tectonic affinity to the Tarim or Yangtze (South China) cratons and was developed upon some crustal fragment with affinity to the Tarim or Yangtze (South China) cratons during Early Paleozoic (Zhang et al. 2014a). The Bainaimiao arc belt was accreted to the northern margin of the NCC during the Late Silurian-earliest Devonian by arc-continent collision, which was followed by sedimentation of the latest Silurian-Early Devonian molasse or quasi-molasse of the Xibiehe Formation (e.g., Zhang and Tang 1989; Tang 1990; BGMRIM 1991; Su 1996; Xu et al. 2003; Wang 2005; Chen and Boucot 2007; Zhang et al. 2010b) and emplacement of the Early-Middle Devonian alkaline rocks in the northern NCC and southern CAOB (e.g., Luo et al. 2001; Zhang et al. 2007a, 2009a, 2010a; Shi et al. 2010; Wang et al. 2012). The latest Silurian arc-continent collision between the Bainaimiao island arc and the NCC was very likely responsible for Paleozoic reversal of arc polarity and transitions of the northern NCC from passive to active continental margin (Fig. 18.3c) as suggested in other places such as the Cenozoic Taiwan, northern New Guinea, Northwest Pacific and the Irish Caledonides (e.g., McKenzie 1969; Johnson and Jaques 1980; Konstantinovskaia 2001; Clift et al. 2003).

18.2.3 Southern Edge of the NCC and QOB

Along the southern edge of the NCC in QOB series of tectonic events took place in Early Paleozoic. The Erlangping back-arc basin was spreading and closed; the Shangdan Ocean was subducted northward beneath North Qinling Block (NQB). The latter was active from ca. 514 Ma or slightly later to 420 Ma (Fig. 18.4) (Liu et al. 2012a; Wu and Zheng 2013; Dong and Santosh 2016), which are based upon the geochronological data of metamorphic rocks (ca.

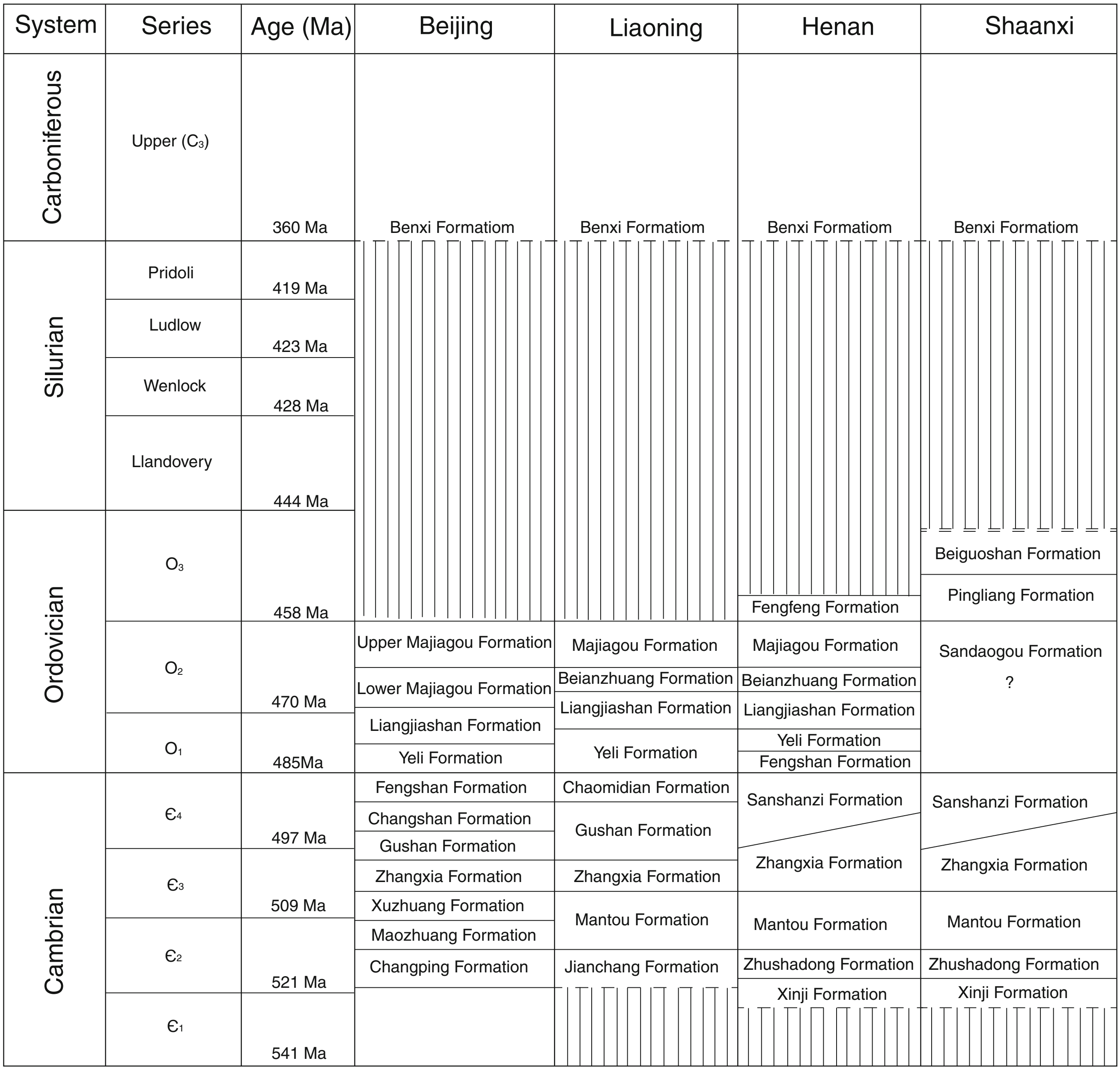


Fig. 18.2 Diagram showing the Lower Paleozoic strata of the NCC. For explanation, see text

510–400 Ma) and magmatic rocks in the NQB (ca. 514–420 Ma), as well as the anatexis and migmatization at 517–445 Ma (Dong et al. 2011). While the Erlangping back-arc basin opened between northern NQB and NCC at around 508 Ma, was spreading and then closed at ca. 450 Ma or slightly later, which resulted in the collision between the NQB and NCC and the S-type granitoids in the northern NQB (Liu et al. 2012a; Wu and Zheng 2013; Dong and Santosh 2016). However, the Kuanping Group developed on/in the margin of NCC remains to debate for its age and tectonic environment (Wang et al. 2009; Liu et al. 2012a; Wu and Zheng 2013; Dong and Santosh 2016).

18.3 Late Paleozoic

18.3.1 Main Regions of NCC

The change of its tectonic settings of the NCC in Late Paleozoic was a volcanic arc emerging on the northern margin of the NCC. From at least Late Carboniferous period, the northern margin of the NCC evolved as an Andean-style active continental margin due to southward subduction of the Paleo-Asian Ocean (Fig. 18.5), which resulted in deposition of the first sedimentary layer of the NCC in Late Paleozoic, known as the 'G' layer bauxite. The 'G' layer

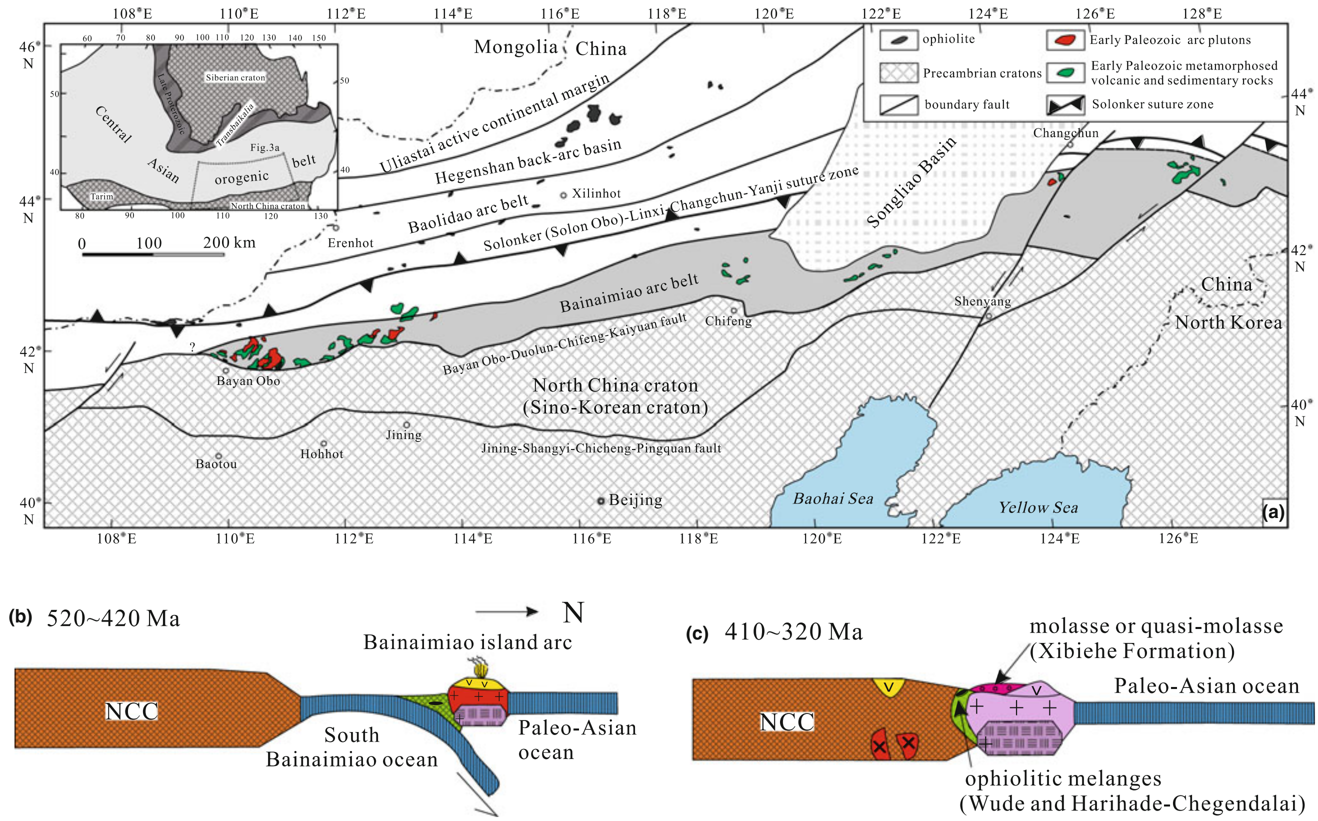


Fig. 18.3 **a** Sketch tectonic map of the southern CAOB and the northern margin of the NCC (modified after Zhang et al. 2014a; *inset* figure is modified after Jahn et al. 2000); **b**, **c** schematic cartoons showing evolution of the northern NCC during Early Paleozoic to Devonian period (modified after Zhang et al. 2014a). See text for discussion. Not to scale

bauxite, which is disconformably overlying upon the Middle Ordovician Majiagou limestone, is widespread throughout the northern and central parts of the NCC (Fig. 18.6) and can become bauxite deposits, the most important bauxite deposits in China (Meng et al. 1987).

The 'G' layer bauxites, bauxite deposits, known as the 'G' layer bauxite deposits, are widespread throughout the northern parts of the NCC, above a disconformity between Middle Ordovician limestones and Late Carboniferous clastic sedimentary rocks, was traditionally thought to be mainly derived from residuals of long-term weathering. But the underlying Middle Ordovician Majiagou limestone is lack of aluminium. Recent studies (Zhao et al. 2010; Wang et al. 2010, 2016; Liu et al. 2014) demonstrated that one of its most important heavy minerals from the 'G' layer bauxite, zircon grain is magmatic in origin. Zircon crystals, the key component from the 'G' layer bauxite, yielded U–Pb ages mainly in Late Carboniferous and in situ Hf isotopes, which can also generate reliable information on the provenance of the rocks (e.g. Bodet and Schärer 2000; Kosler et al. 2002; Königer et al. 2002; Lizuka et al. 2005; Veevers et al. 2005; Boni et al. 2012). Zircon $\varepsilon_{Hf}(t)$ values range from 2.2 to −24.5 and are dominated by negative values, similar to those of Paleozoic magmatic rocks in the Inner Mongolia Paleo-uplift (IMPU), but distinct from those of Paleozoic magmatic rocks in the CAOB with positive $\varepsilon_{Hf}(t)$ values. The zircon ages are dominated by Paleozoic ages, especially Late Carboniferous to Early Permian, coeval with the Paleozoic subduction-related volcanism in IMPU on the northern NCC. Therefore, we consider that the bauxites were derived mainly from ashes produced by the Paleozoic, particularly Late Carboniferous to Early Permian, volcanism in the IMPU along the northern NCC (Liu et al. 2014).

The Late Carboniferous sedimentary sequence with the 'G' layer of bauxites at its bottom is composed of coal-bearing formations, with sandstones, siltstones, marine limestone lens and thin layers interlayered and volcanic ash recorded by previous researchers (Zhong et al. 1995; Jia et al. 1999; Zhou et al. 2001; Zhang et al. 2007b). That indicates regionally marine–terrestrial transitional or marine–terrestrial interfingered environments with volcanic arc settings in Early Carboniferous to Early Permian. It gave way to a totally terrestrial environment in the NCC in late Early Permian.

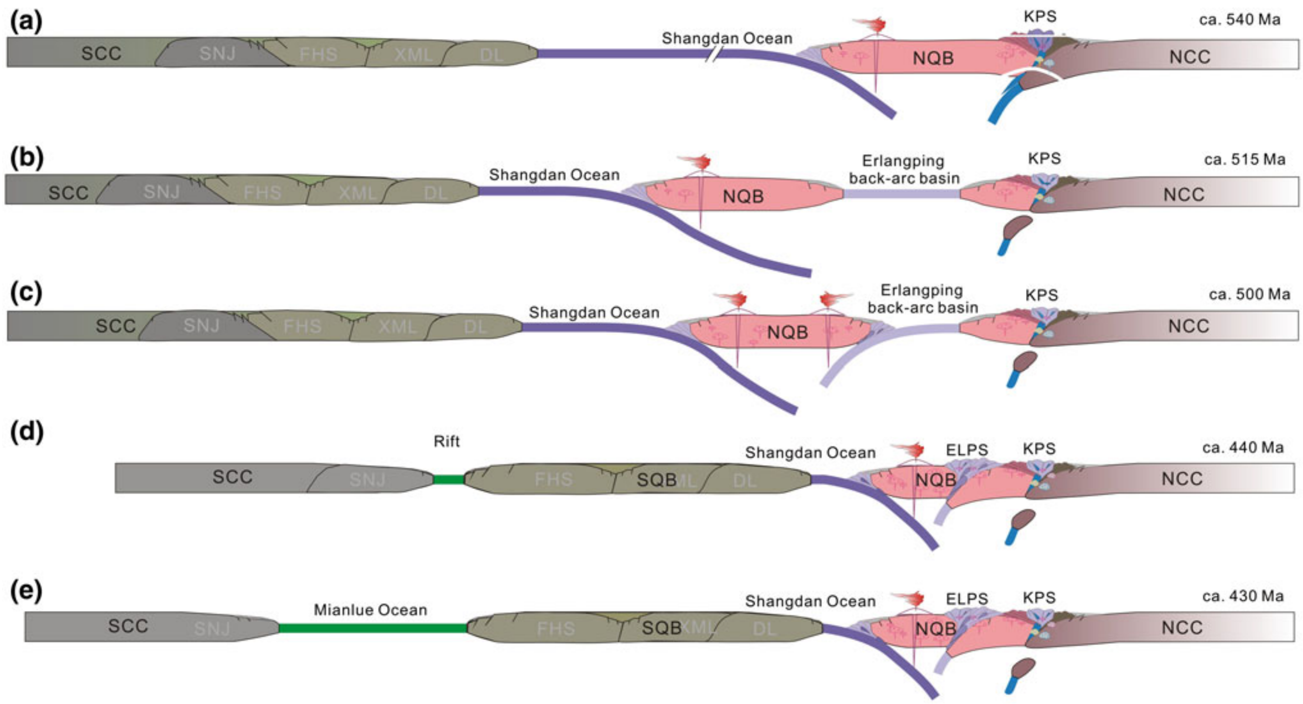


Fig. 18.4 Schematic cartoons showing evolution along the Shangdan suture and the Mianlue suture between the North Qinling Belt, South Qinling Belt and South China Craton, respectively during Early Paleozoic period (slightly modified after Dong and Santosh 2016). Not to scale. For explanation see text

18.3.2 Northern NCC and the Southern CAOB

Devonian is an important period for tectonic transition in the northern NCC and the southern CAOB. As talked above, the latest Silurian-Early Devonian Xibiehe Formation in the southern CAOB exhibits features of molasse or quasi-molasse and were considered as products of arc-continent collision (Zhao et al. 2010; Zhang et al. 2014a) or continent–continent collision and closure of the Paleo-Asian Ocean (Xu and Chen 1997; Xu et al. 2013). During this period, the northern NCC are characterized by emplacement of alkaline rocks (syenite, monzonite and alkaline granite) and minor mafic–ultramafic rocks (e.g. Luo et al. 2001; Jiang 2005; Zhang et al. 2007a, 2009a, 2010a; Shi et al. 2010; Wang et al. 2012). Some Devonian volcanic rocks consisting mainly of rhyolites have also been recognized from the Chifeng area in recent years (e.g., Liu et al. 2013; Ye et al. 2014a; Sun et al. 2015).

From latest Early Carboniferous period, the northern margin of NCC (including the accreted Bainaimiao arc belt) evolved as an Andean-style active continental margin due to southward subduction of the Paleo-Asian oceanic plate. As shown in Fig. 18.7, Carboniferous-Permian intrusive rocks are widely distributed in the northern NCC and constitute an east–west intrusive belt that is more than 1000 km long and up to 120 km wide. Moreover, many Late Carboniferous to Permian granitoid intrusions had been recognized from what were regarded previously as Archean to Paleoproterozoic lithological assemblages in the northern basement rocks of the NCC (e.g., Zhang et al. 2004, 2007c, 2009b, c; Wang et al. 2007). They consist mainly of diorite, quartz diorite, granodiorite and granite; other rocks are gabbro and tonalite and are calc-alkaline or high-K calc-alkaline, metaluminous or weak peraluminous, and were considered to reflect arc magmatism along an Andean-type continental margin (e.g. Wang and Liu 1986; Xiao et al. 2003, 2009; Li 2006; Wang et al. 2007; Zhang et al. 2007c, 2009b, c; Bai et al. 2013; Ma et al. 2013). Recent results on the Carboniferous-Permian volcanic rocks along two sides of the northern boundary fault of the NCC indicate their eruption during the Early Carboniferous to Late Permian from 347 ± 3 to 258 ± 1 Ma with a main rock association of basalt, basaltic andesite, andesite, dacite, rhyolite, tuff, tufaceous sandstone (Zhang et al. 2016). The Carboniferous-Permian volcanic rocks are not bimodal in composition and exhibit subduction-related geochemical features such as negative Nb and Ta anomalies of mafic to intermediate rocks on primitive mantle-normalized diagrams, indicating they were formed in an Andean-type continental arc.

The Solonker suture zone marks the final closure of the Paleo-Asian Ocean between the North China Block and the southern Mongolia composite terranes during the Late Permian to earliest Triassic (e.g. Wang and Liu 1986; Xiao et al. 2003, 2009; Li 2006; Windley et al. 2007; Wu et al. 2007;

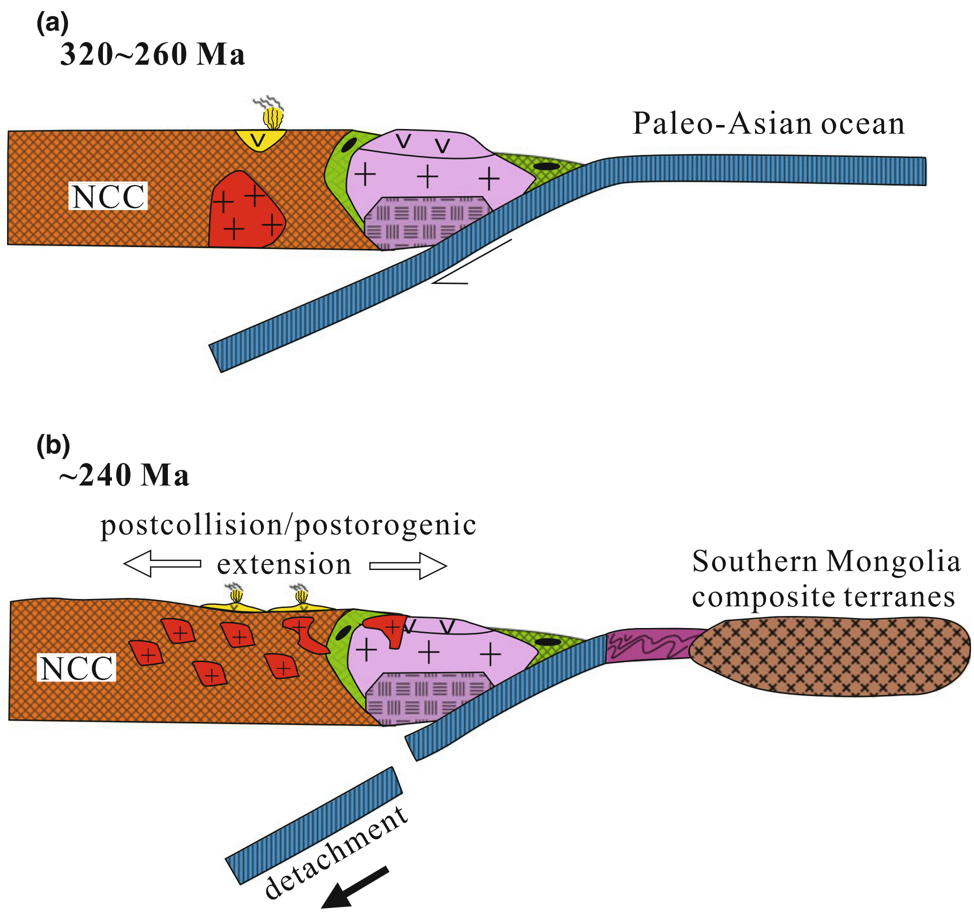


Fig. 18.5 Schematic cartoons showing evolution of the northern margin of the NCC during Late Paleozoic to Early Mesozoic period

Zhang et al. 2007c, 2009b, c; Miao et al. 2008; Li et al. 2009; Chen et al. 2009; Eizenhöfer et al. 2014). However, the decease of the Paleo-Asian oceanic subduction beneath the northern North China Block in its middle-western parts is a little earlier than that in its eastern part, as indicated by a slight decrease of the upper limits of the volcanic sequences from west to east (Zhang et al. 2016).

18.3.3 Southern NCC and QOB

The continuous deposition from Middle Devonian to Lower Triassic successions in the SQB doubted the consideration of the NQB exhumed in Late Paleozoic based on the deformational features, together with the metamorphic and cooling ages, and suggest the lack of full collision between the NQB and SQB after the closure of the Shangdan Ocean (Dong and Santosh 2016).

The birth of the Mianlue Ocean is indicated by the bimodal volcanic rocks around earliest Silurian (Fig. 18.8, Dong and Santosh 2016). The Late Devonian to Carboniferous radiolarian fauna in the interlayered cherts from the volcanics (Wang et al. 1999), as well as the Carboniferous radiolarian fauna from the cherts interlayered within the ophiolite in the Mianlue segment (Feng et al. 1996), indicates that the Mianlue Ocean existed during Devonian to Carboniferous (Fig. 18.8; Dong and Santosh 2016). The subduction of the Mianlue Ocean is indicated by the arc-related volcanic rocks in the ophiolite exposed in the SQB (Lai and Yang 1997; Liu et al. 2015; Dong and Santosh 2016) and lasted to the end of Paleozoic (Fig. 18.8; Dong and Santosh 2016).

18.4 Early Mesozoic Tectonics

18.4.1 Southern NCC and QOB

In Triassic, the significant tectonic event was collision between the NCC and SCC along QOB and formation of HP–UHP rocks in the Hong'an-Dabie-Sulu terranes. That resulted from the gradual consumption of the Mianlue oceanic crust during ca. 220–210 Ma between the SQB and SCC (Fig. 18.8 c), finally forming a major suture along which the NCC and SCC which amalgamated during Late Triassic (Dong and Santosh 2016). In the Hong'an-Dabie-Sulu terranes, the prograde quartz eclogite facies metamorphism and the UHP metamorphism occurred respectively,

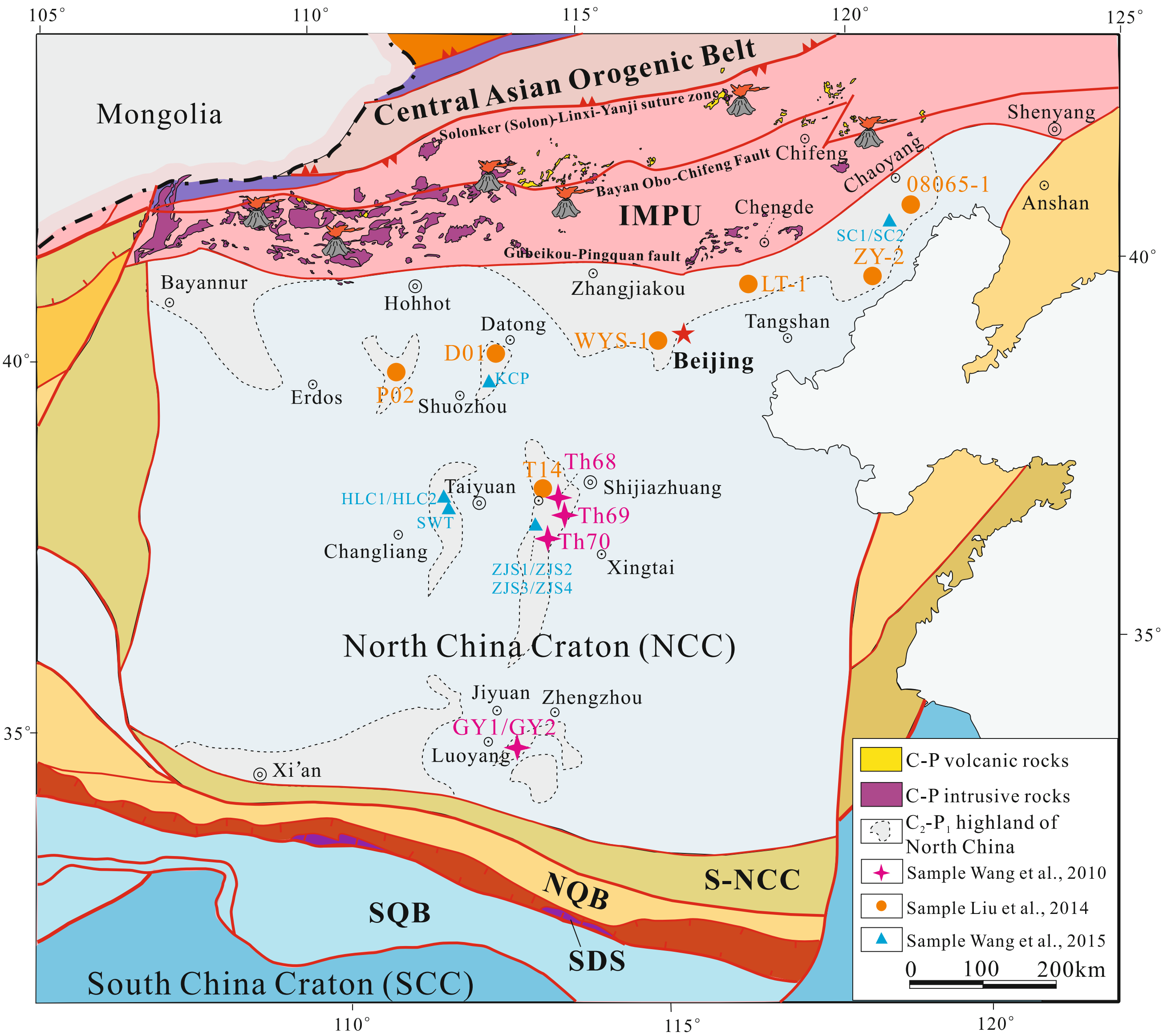


Fig. 18.6 Late Paleozoic paleogeographical map of the NCC. For explanation, see text

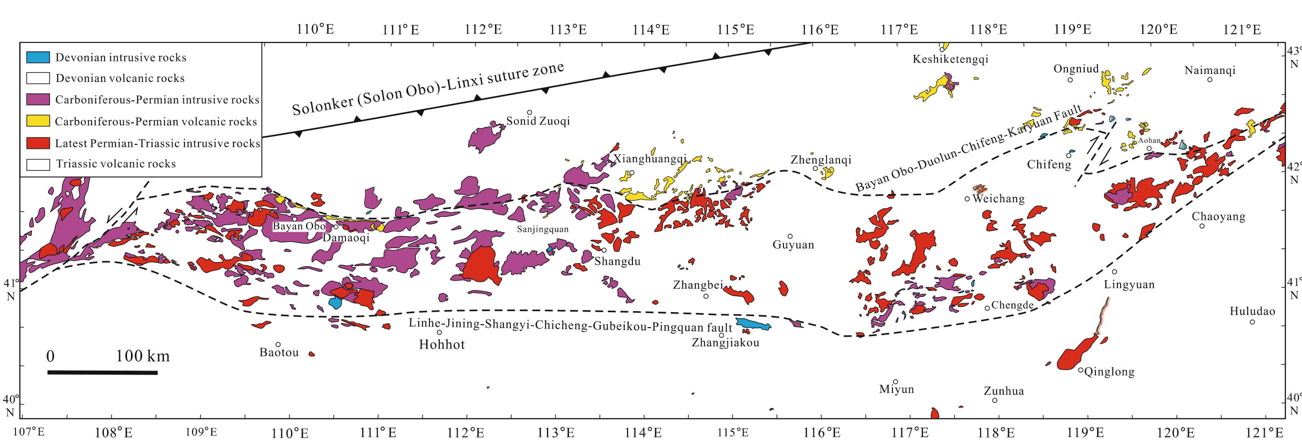


Fig. 18.7 Sketch map showing distribution of the Late Paleozoic magmatic rocks in the northern NCC (modified after Zhang et al. 2016)

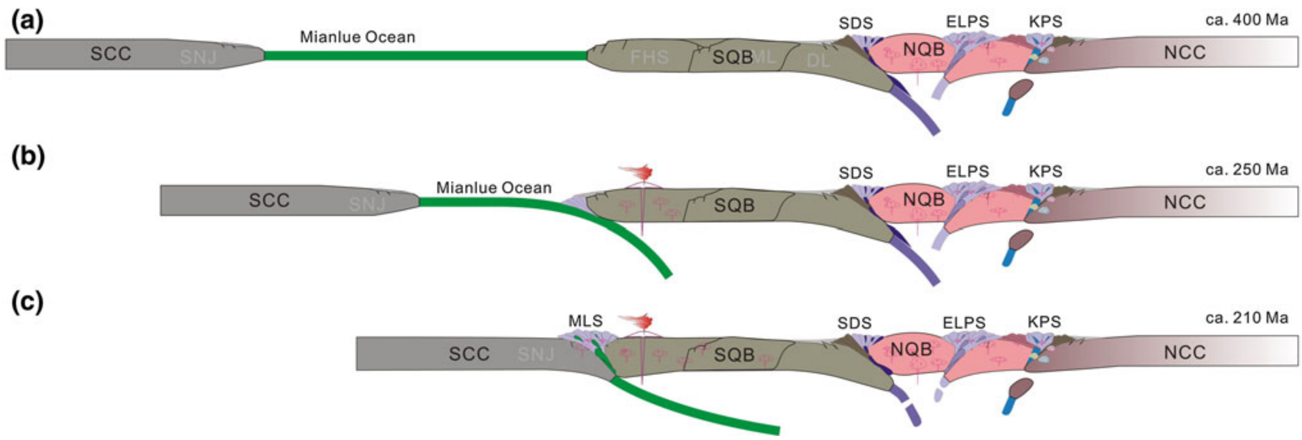


Fig. 18.8 Schematic cartoons showing evolution along the Mianlue suture between the South Qinling Belt and South China Craton, respectively during Late Paleozoic period (slightly modified after Dong and Santosh 2016). Not to scale. For explanation, see text

successively at 246 ± 7 and at 234 ± 4 Ma (Liu et al. 2006, 2015). While syn-UHP and syn-HP southeast-vergent thrusting formed a series of stacked structural slices at 241–231 and at 225–215 Ma (Li et al. 2010). This was followed by southeast-vergent folding under amphibolite facies conditions at 215–205 Ma; then a third generation of flexural folding occurred at shallow levels at 200–184 Ma. These two extrusion episodes correlate with the two stages of Triassic exhumation of the Dabie HP–UHP rocks, respectively, during continental collision (Li et al. 2010). This collision resulted in continental crust thickening and partial melting to generate the large volumes of granitoids in the SQB ranging of ca. 220–210 Ma. At ca. 200 Ma, the thickened crust and orogen rapidly collapsed resulting in the emplacement of post-collisional rapakivi-texture granitoids during ca. 210–200 Ma and exhumation of the quasi-high pressure granulite at ca. 199–192 Ma (Dong and Santosh 2016).

18.4.2 The Northern NCC

The final closure of the Paleo-Asian Ocean and amalgamation of the northern North China Block with composite terranes of southern Mongolia during the Late Permian to earliest Triassic was followed by post-collisional/post-orogenic extension, large-volume magmatism and significant continental growth (Zhang et al. 2009b, 2012). There is a tectonic transition from post-collisional/post-orogenic extension to intraplate extension during Early Mesozoic time (Yang et al. 2012; Ye et al. 2014b). In contrast to typical continental orogenic belts such as, the European Alps and Asian Himalaya, amalgamation between the Mongolian arc terranes and the North China Block was a 'soft' or 'weak' collision between a large continental block and composite arcs with associated subduction-accretion complexes, characterized by the absence of syn-collisional S-type granitoids and high-pressure metamorphism in the northern NCC (e.g., Zhang et al. 2009b). Moreover, there were significant changes in magmatic rock associations from the latest Permian to Middle-Late Triassic time, and in deformation patterns from Early-Middle Triassic to Late Triassic-Early Jurassic in the northern NCC (Zhang et al. 2014b, and reference therein). Early Triassic magmatic rocks are mainly composed of monzogranite, syenogranite, monzonite, rhyolitic welded tuff, rhyolite and tuffaceous sandstone, with minor mafic-ultramafic rocks and granodiorite. Middle-Late Triassic magmatic rocks consist mainly diorite, granodiorite, monzogranite, syenogranite, monzonite, syenite and intermediate volcanic rocks such as andesite, trachyandesite, and autoclastic trachyandesite breccia (Zhang et al. 2009a, 2012; Yang et al. 2012; Chen et al. 2013; Ye et al. 2014b). Geochemical and isotopic results show that asthenospheric melts were strongly involved in petrogenesis of the Middle-Late Triassic mafic-ultramafic and alkaline rocks, which may mark the start of carton destruction and lithospheric thinning of the northern NCC (Zhang et al. 2009a, 2012; Ye et al. 2014b).

The Panshan region is located in the eastern Yanshan fold-thrust belt of the northern NCC. The region, west of the Malanyu anticlinorium is characteristic of folds surrounding the Panshan pluton. The Zhuangguoyu and Fujunshan synclines were truncated in south by the Jixian thrust, which was intruded by the Panshan pluton. Along the Jixian thrust it can be observed that the Changcheng and Jixian systems were thrusted upon the Jixian and Qingbaikou systems. North of the Panshan pluton the Hongshikan anticline was

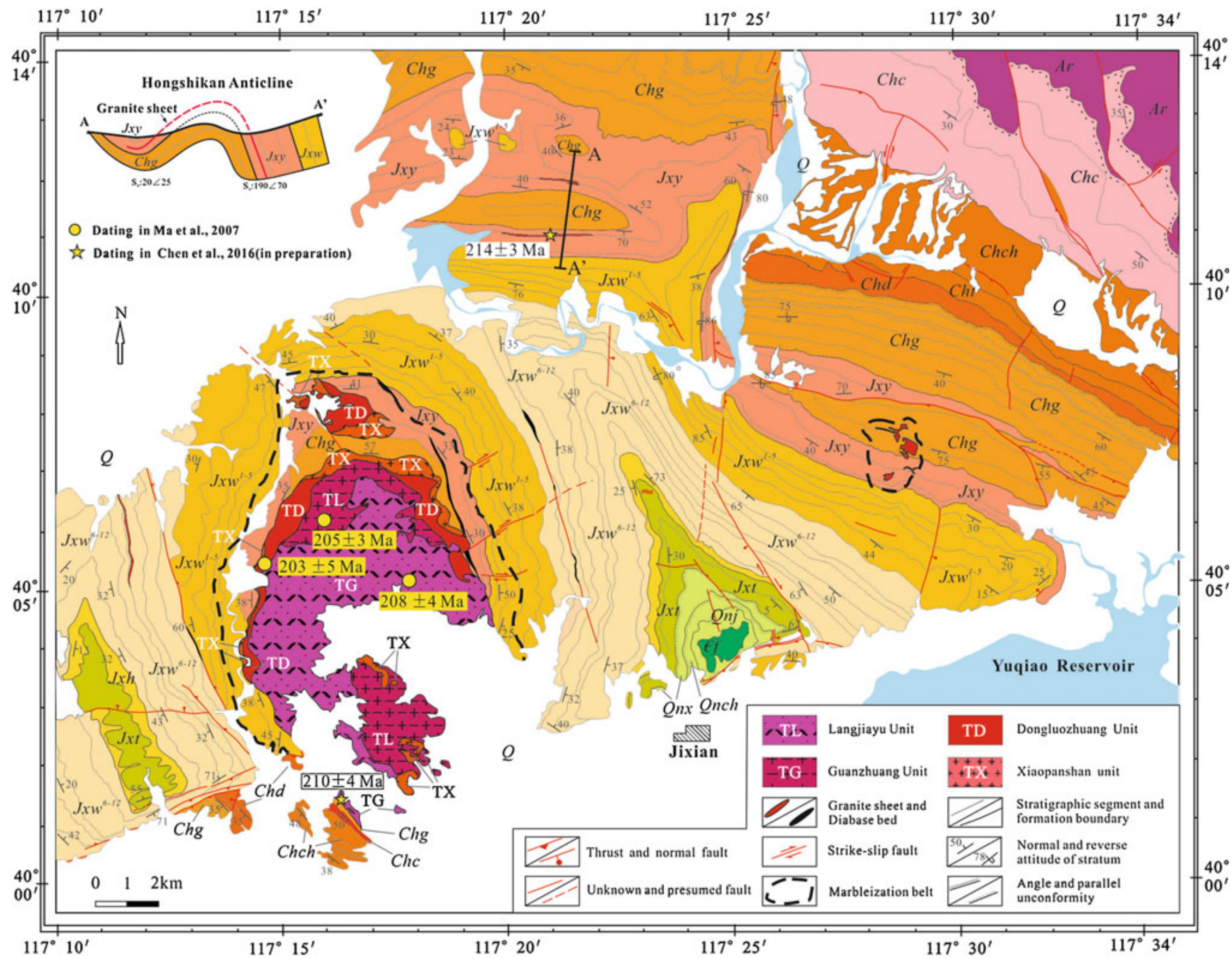


Fig. 18.9 Geological map of the Panshan region, the northern NCC showing Late Triassic deformation and plutons. For explanation, see text

intruded by granitic sheets at its wings in the same stratum of the Yangzhuang Formation (Fig. 18.9). Zircon U–Pb dating of the sample from the southern wing yielded an intrusive age 214 ± 3 Ma (Zhao et al. 2010), which can constrain folding and thrusting postdated 214 Ma. The dating of the samples from the Guanzhuang unit gave the zircon U–Pb ages at 210 ± 4 and 208 ± 4 Ma. The observation and evidence above show that folding, thrusting and magmatism in the Panshan pluton occurred at around 210 Ma in Late Triassic time. Combined with our data on tectonic deformation in Late Triassic to Early Jurassic obtained from the Niuyingzi region, western Liaoning (Hu et al. 2010), the Xiabancheng region, northern Hebei (Liu et al. 2012b), the Dushan region and the northeastern Hebei (Ye et al. 2014c) the conclusion can be reached that the northern NCC witnessed regional intense deformation at around 210 Ma and initial decratonization of the NCC.

18.5 Summary

The NCC, Bainaimiao arc belt and the northward subduction of the Shangdan Ocean started their evolution from around 520 Ma when Gondwana assembled in its peak tectonism. The Middle Ordovician marine regression and regional uplift of the NCC occurred after deposition of the Majiagou Formation, which led to the paleogeographic change of the NCC, especially in the eastern Ordos basin and potash formation. That coincided with diamondiferous kimberlite magmatism in the eastern and northeast NCC at ca. 463–470 Ma. The hidden magmatic event in deep of NCC was simultaneous with the global tectonic event around 430 Ma, which suggested global tectonic settings for the regional tectonic events of the NCC in Early Paleozoic.

The Late Carboniferous to Early Permian 'G' layer of bauxites overlain disconformably upon the Middle Ordovician limestone were derived mainly from ashes produced by volcanism mainly in IMPU when the northern margin of the NCC evolved as an Andean-style active continental margin. The Late Carboniferous to Early Permian clastic coal-bearing sequence interlayered with marine limestone and volcanic ash formed in terrestrial–marine transitional or terrestrial environment with volcanic-arc settings.

The final collision between the SCO and SQB along the Mianlue suture resulted in intense deformation of QOB and HP/UHP metamorphism in Hong'an-Dabie-Sulu terranes in Late Triassic. In the northern NCC, intense tectonic deformation and significant changes in and magmatism occurred in Late Triassic, around 210 Ma. This suggests that the NCC was not a craton in Late Triassic.

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