

The Main Geological Events of the Chinese Archaean and Proterozoic Eons

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ABSTRACT

A systematic review and comparison of the time, sequence, nature, and characteristics of the major geological events of worldwide Archean and Chinese Precambrian and their interrelationships reveals that these events reveals the spatial-temporal pattern of the events and their significance in geological evolution. The study also touches upon relationship between Early Precambrian Era and plate tectonics. A comparison between the Precambrian major geological events and those elsewhere on the earth proves that the crustal evolution is characterized by striking irreversibility, gradualism, and synchronism. The geological events in China have their unique features, which show that China has a relatively complete record of formation and evolution of rocks, strata, structures, and organisms spanning 3800 Ma to 540 Ma. The Archean underwent multiple-stage complex metamorphism and deformation; metamorphism is on the higher end; komatiite is absent in the greenstone belts; cratonization occurred rather late and varied between the north and the south. The research results above provide main theoretical basis for deeply systematic researching the early dynamic evolution laws of the earth and the dynamic evolution characteristics of the tectonic plates.

Keywords: China; Archaean; Proterozoic; Precambrian; Geological Events

1. Introduction

The Precambrian Era, which spans roughly over eighty-five percent of the earth's recorded history out of its entire history, is a critical stage in the earth's evolution history, captivating geologists all over the world for its complex experience, rich mineral resources it produced, and its relevance to the research on the origin and evolution of the earth and life.

More than seventy percent of the land on the present-day earth is composed of Archean terrains and their metamorphosed equivalents. Therefore, that the evolution of the Archaean or Early Precambrian crust has in recent years become one of the biggest hotspots and challenges in geological research, which, in turn, has become an important source of inspiration for new research.

China is one of the countries which are bestowed with the most widespread Precambrian strata, facilitating research in this subject and nurturing a tradition of such research. The country has a relatively complete historical record (dating from 3800 Ma to 543 Ma) of formation and evolution of rocks, strata, structures, and organisms, which hosts a wide variety of minerals and displays an assortment of unique geological conditions.

This study synthesizes the author's own and other researchers' publications, systematically examines and compares the time, sequence, nature, and features of the Archean worldwide and Chinese Precambrian major geological events and their interrelationships, and identifies a spatial pattern of consistency, differentiation, and imbalance along with a temporal pattern of periodicity and cycles. These findings may provide a useful basis for the investigation of the evolution trend and for the division of the evolution stages of the earth in its early days, and offer significant clues to the relations between early-day structural framework and plate tectonics of the crust.

2. Main Geological Events of the Chinese Archaean Eon (Tables 1 and 2)

2.1. The Time Sequence and Features of Main Geological Events in Archaean Eon

Since 1980s four pieces of detrital zircon were separated from metamorphic quartz sandstone deposited about 2800 Ma at Mount Narryer in West Australia. The U-Pb age tested by ionic probe mass spectrum was 4200 Ma, and it represents the oldest known mineral age in the Earth [1,2]. Subsequently, the history of original crust could be pushed forward ca. 4300 Ma (see **Table 1**).

Ancient crustal rocks older than 3800 Ma globally are very rare. They have only been discovered in SW Greenland, NW Canada, and Enderby Land, South Pole [3,4]. The Isua Belt of Godthab district in SW Greenland was the earliest layered series which qualified as crustal rocks. They comprise mainly metamorphic volcanic rocks and sedimentary rocks >3000 m in thickness, and have a U-Pb age of ca. 3820 Ma based on detrital zircons. The granites that intrude the Isua Belt are some of the earliest known granites with a Rb-Sr age of 3780 Ma and have been transformed into the Amitsoq gneiss after metamorphism [5]. The gneiss which is exposed in large areas can be divided into three rock groups: tonalite, trondhjemite and granodiorite (TTG rock). These so-called “grey gneiss” became the primitive palaeo-continental nucleus. Between the continental nucleus and their margins, there are many greenstone belts which became hyperplasia body on the continental nucleus and the welded belts of continental nucleus.

Since 1990s, the trondhjemite found in the Anshan Mountain of China and dated ca. 3800 Ma could be divided into two types: Baijiafen trondhjemite (also known as ortho-gneiss) and Dongshan trondhjemite migmatite. In addition, Liu D. Y, Nutman A. P., Compston W. obtained a U-Pb age between 3500 Ma - 3850 Ma from a single-grain zircon found in Huang Boyu, eastern Hebei Province [6]. It was the earliest dated rock in China. Caozhuang Rock represents the earliest super crustal Rocks. These rocks show the evolution of an early continental nucleus (craton) in China.

The greenstones (early greenstone) of the Palaeo-

Middle Archean Era are represented globally by the Swaziland greenstone of Barberton, South Africa in African shield [7], and Warawoona greenstone of Yilgarn shield, West Australia [8]. The amphibolites of Xiaolaihe greenstone belt in Liaoning, NE China which have a 3000 Ma Sm-Nd isochron age belong to this early greenstones event [9], and comprise komatiites, mafic rock and offshore marine sedimentary deposits as the main characteristics. Combined they form a complete volcanic-sedimentary cycle. The appearance of advanced metamorphic zone of late Palaeo-Middle Archean Era (granulite facies) was part of the global granulite-facies metamorphic event that happened in the earliest phase of lithosphere formation. It is marked worldwide by strong tectogenesis (tectono-thermal event) and regional metamorphism, and represents the first collision of ancient continental nucleus and land masses, and which made the original lithosphere sink and was shaped into granulite facies after deep melting and into charnockite after remelting. This “Movement” (event) can be recognized in North America, Europe, West Australia, and Africa. In Africa, it was called the Dahomey Movement. In China, many scientists agreed to name this movement the Qianxi Movement. According to the tectogenesis and intensity of magma activities and universality of regional metamorphism, the time period of 2900 - 3000 Ma can be regarded as the demarcation age between the Palaeo-Middle Archean Era and the Neo-Archean Era. The trondhjemite event of early Neo-Archean Era is recorded in Southwest Finland, Norway, and West Greenland. Along with the grey gneiss, it has formed the bulk of

Table 1. The time sequence of main geological events in Archean Eon.

Geologic Chronology	Event Sequence	Main Geologic Events	Crustal Movement	Isotopic Age	Main Districts
Archean Eon	8	Kali granite Intrusive and large-scale regional metamorphism	~Ken Nore Movement~	2500 Ma 2600 - 2500 Ma	Canada, West Australia, China, Finland
Neo-Archeozoic Eon	7	Late Archean Greenstone Terrane (Late Greenstone)	~~~~	2800 - 2700 Ma	North America, South Africa, West Australia, Russian
	6	Trondhjemite Event	~ Dahomey Movement ~	2800 - 2900 Ma	West Finland, Greenland, China
	5	Early Archean Granulite Event (Global Regional Metamorphism)		3000 - 2900 Ma	Covering globally
	4	Ancient Archean Granite-Greenstone Terrance (Early Greenstone) (Some districts suffered high-grade regional metamorphism)	~~~~	3400 - 3100 Ma	South Africa, West Australia India, and China
Paleo-Middle Archeozoic Eon and Pre-Archean Eon	3	The earliest granite intrusion and metamorphic event (Amitsoq Granite)	~~~~	3800 - 3700 Ma	Greenland, Canada, China
	2	The earliest layered rock system (Greenland Isuah Group)		3820 Ma	Southwest Greenland
	1	The earliest geological record (zircon age)		4200 Ma	West Australia

Archean rocks or intruded into ancient greenstone belts.

In Qian'an of eastern Hebei Province, Qingyuan of northern Liaoning Province, Anshan of Southern Liaoning Province, and Taishan of western of Shandong Province, there is a lot of charnockite exposed (see **Table 2**). For example, in Qian'an of eastern Hebei Province ancient charnockite was found intruded in the grey gneiss of Qianxi granulite facies. Cored with its rock mass, Qingyuan charnockite featured within migmatite belt and granulite (grey gneiss) to the outer zone [10]. Reference [10] shows that charnockite was formed by remelting, crystal fractionation and metasomatism. Its intrusion is dated as the same as that of granulite formation, ca. 2800 - 2900 Ma.

In the Chinese Archean Craton, there was a trend that

the granite evolved from the early tonalite and trondhjemite, to the late kaligranite. From its components, we also can conclude that it accords with the model of continental growth; in the early stage abundant in sodium, later in calcium. Zhou *et al.* separated an apatite sample from the 3.8 Ga (zircon SHRIMP U-Th-Pb age) meta-quartz-diorite sample in Anshan area and using SHRIMP II. 32 analyses yielded a 207Pb/206Pb weighted mean age of 3007 ± 22 Ma. This is interpreted as the age of recrystallization of the apatite during the very intense thermo-tectonic events at ~ 3.0 Ga in the Anshan area.

In the late Archean Era, greenstones (late greenstone) are widespread and exposed in many shield regions of the world (see **Table 2**). They comprise mainly mafic rock, acid-intermediate volcanic rock, and clastic sedimentary

Table 2. Isotopic age of main geological events in Archean Eon.

Main Events	Region	Name of Sample	Isotopic Age (Ma)
Kali granite	Labrador, Canada	Structured Kali granite	2600 ± 100
	West Greenland	Structured Kali granite	2550
	Wutaishan Mountain, China	E-Kou Granite	2514 U-Pb
	Yilgarn, Australia	Structured Kali granite	2600
	Shanhaiguan, China	Structured Kali granite	2600 - 2400 U-Pb
	Kutsu Granite, Finland	Structured Kali granite	2650 Zircon U-Pb
Neoarchean Era Late Greenstone	Ural District, Russian	Gneiss in Greenstone	2700 U-Pb
	Superior, Canada	Greenstone Belt	2650 - 2800
	Kambalda, Yilgarn, Australia	Greenstone Belt	2790 ± 30 Sm-Nd
	Brazil Massif	Schist in Greenstone	2700 - 2900
	Zimbabwe, Africa	Greenstone Belt	2600 - 2700
	Wutaishan Mountain, China	Wutai Greenstone Belt	2800 2900 U-Pb
	Qingyuan, China	Qingyuan Greenstone Belt	2844 ± 47 Sm-Nd Isochrone
Trondhjemite	Intrusive Greenstone Belt, Southwest of Finland	Trondhjemite	2800 - 2900 Zircon U-Pb
	Intrusive Greenstone Belt, West Finland	Trondhjemite	2800 - 2900 Zircon U-Pb
	Intrusive Nuuk Gneiss, West Greenland	Trondhjemite	3040 ± 50 Rb-Sr Whole-Rock Isochrone
	Intrusive Qianxi Rock, Qian'an, Jidong, China	Trondhjemite	2860 - 3010 Pb-Pb Whole-Rock Model Age
	Xiaolaihe Intrusive Granulite, Qingyuan, Liaobei region, China	Trondhjemite	2800 - 2900
Ancient Mesozoarchean Era Granulite Event	Limpopo Belt, South Africa	Granulite	3150
	Labrador, Canada	Granulite	2800 ± 200
	Aldan Massif, Russian	Granulite (Charnockite Deteroprate)	2900 - 3010 U-Pb
	Antarctic Suonisi mountain	Granulite	≥2948 ± 31 U-Pb
	West Greenland	Granulite	2800 - 2950 Rb-Sr
	Brazil Massif	Granulite	3000 ± 100
	Qingyuan, China	Jingjiagou Granulite	2924 ± 325 Rb-Sr Isochrone
Ancient Mesozoarchean Era Early Greenstone	Dharwar Massif, South India	Dharwar Complex Greenstone	3358 Rb-Sr Whole-Rock Isochrone
	Pilbara Massif, Australia	Pilbara Complex Greenstone	3450 Sm-Nd
	Qingyuan, China	Xiaolaihe Greenstone Belt	3018 ± 20 Sm-Nd Isochrone
	Anshan, China	Plagioclase Amphibolites	
		Banded Magnet Quartzite	3140 U-Pb
	Yilgarn massif, Australia	Quartz plagioclase gneiss	3348 ± 30 Rb-Sr
Barberton, South Africa	Swaziland Complex Fulgurite	3450 ± 30 Sm-Nd Isochrone	

rock (turbidites). In the Canadian greenstone belt, andesite accounts for 30% of rocks, but in the greenstone belt of Southern Africa and Australia, andesite only accounts for small-scale [11]. Their isotopic age was recorded about 2600 - 2900 Ma. The greenstone belts in Jiapigou of Jilin, Qingyuan of Liaoning, western Shandong Province region, Jiaodong region, and Jinbei region came into being during this period. For example, Sm-Nd isochron age of plagioclase amphibolites in Qingyuan greenstone belt was 2844 Ma [12] (Shen *et al.*, 1993).

2.2. The Archean-Proterozoic Boundary and Cratonization

Throughout the course of crustal evolution, the most remarkable change or the most important tectono-thermal event is the formation of the Archean-Proterozoic boundary and cratonization, that represent the most profound changes in earth evolution history, the finish of proliferation of early continental crust and the beginning of plate mechanism, have Epoch-making significance. Cratonization served to stabilize the continents and showed earth-wide diachronism. The earliest rigid craton occurred 3.0 Ga ago, one example being the Kaapvaal Craton in South Africa, where were developed cover sediments dating back to 3.0 Ga. Both Mesoproterozoic and Neoproterozoic Eons proved critical to cratonization. Cratonization in North America, Greenland, Baltic, Australia and South Africa occurred at 2.7 to 2.8 Ga, whereas that in north India, north China and Brazil started at 2.45 Ga (Wang 1999) [2]. The formation and penetrating of abundant TTG rocks and their subsequent gneiss facies metamorphic differentiation are key factors in cratonization, and collision and collage of small continental crusts is a significant indicator for large-scale cratonization. Study of the non-deformed and non-metamorphosed mafic diabase dyke swarms centering around 2.6 to 2.7 Ga in age concluded that continental crust at the time was already rather stable and apparently rigid [13]. These dyke swarms, extending up to thousands of kilometers, developed in cratons in North America, Australia, and north India, and melted within the crust at ca 2.5 to 2.6 Ga on an earth-wide scale to form potassium-rich granite, which is nicknamed post-collision granite, for the simple reason that it was formed toward the end of cratonization set off by collision and coalition of numerous island arcs and microcontinents [14]. Potassium-rich granite formed by the intra-crust melting process symbolizes the maturity of cratons and may serve as a signpost for the Archean-Proterozoic boundary [15].

Most of the regions in China were affected by this movement, e.g. Taihangshan Mountain [16], Wutai Mountain [17], and Anshan region. It is the first large-scale continental-building period in the Precambrian of China,

and by this movement the north of China formed the united, large-scale, rigid and stable North-China land mass [15].

2.3. Research on the Evolution of Early Precambrian Crust and Plate Tectonics

The formation and accretion of Archean crust remains a controversial topic in modern geological sciences, one of the debates being whether the Phanerozoic plate tectonics mechanism can be applied to the study of the Archean Eon in general and Mesoproterozoic and Early Archean in particular [18]. There is evidence that the plate tectonics theory, in a general sense, can be unquestionably applied to Neoproterozoic. Orogenic belts of inter-continental scale are found in both Neoproterozoic and Early Proterozoic; crustal structures resembling Phanerozoic orogenic belts are found in Early Proterozoic, where also identified are ophiolites typical of Early Proterozoic, such as Purtuniqu ophiolite (1.988 Ga) in Canada, Jormua ophiolite (1.996 Ga) in Finland, and Payson Ophiolite (1.73 Ga) in the US [19]. All these evidence strongly favors the application of the plate tectonic theory to Early Proterozoic, although evidence favoring Neoproterozoic plate tectonics is disputable. As pointed out by Hamilton (1985) [20], the Archean terrains do not have reliable equivalents to ophiolites, magmatic arcs, growth cones, and fore arc basins, all of which are associated with underthrusts and collisions in Phanerozoic plate tectonics.

Many geological records associated with collision and underthrust are found in both late Archean and early Proterozoic. North China Retained a wealth of late Archean collision orogeny records. The Neoproterozoic ductile shear zones and high-pressure granulite facies belts in northwest Hebei, China, are supposed to have resulted from collisions of terrains [21]. Petro-chemistry, trace element (including REE) and isotope data of Archean volcanic rocks indicate that such rocks from North China continental platform formed in a paleo-tectonic environment similar to modern island arcs and that they are primarily tholeiitic and, to a lesser degree, komatiitic [22]. Most of the North America craton resulted from collisions and welding of seven microcontinents and numerous island arcs at ca 1.8 to 2.0 Ga to form a united craton [23]. Numerous U-Pb Zircon datings and field observations led to a collisional-orogenic model for the Early Proterozoic orogenic belt in west Greenland, assuming that the initial arc rock assemblages of Early Proterozoic thrust and overlaid the gneiss of Archean, and that Archean gneiss and Early Proterozoic upper crustal rocks alternated and superposed. In the north Australia craton, crustal accretion throughout Neoproterozoic and Early Proterozoic was controlled by underthrusts and lateral accretion.

To sum up, the plate tectonics mechanism set to work definitely in Early Proterozoic and, with less certainty, also in Neoproterozoic—at least in processes related to plate tectonics, such as collisions. The commencement of processes related to plate tectonics and the workings of plate tectonics had a tremendous impact on the rapid crustal accretion. Throughout geological times, crustal accretion was uneven. Most of the present-day continental crust was formed in the Archean and the Proterozoic Eons.

3. Main Geological Events of the Chinese Precambrian Eon

Following the publication of Zhang Qinwen, Xu Daoyi, Mao Xueying (1984) many research papers appeared on the geological events in the Proterozoic Eon [24], e.g. from Lutai, North China [16], Zhongtiaoshan Mountain [25], Wutaishan Mountain [26], Luliangshan Mountain [27], and Taihangshan Mountain [6]. By analyzing the characteristic of the Bengbu Orogeny in Neoproterozoic, Longchuan Orogeny, Dikou Orogeny in the Paleoproterozoic, late-Mesoproterozoic Fengyang Orogeny, Shengong Orogeny in the end of Neoproterozoic, we think that the Fengyang and Shengong Orogenics result in the jointing of the North China, Yangtze and the Cathaysia paleo-plates. With these researches, the chronotectonic framework about main geological events in Lutai of North China and each featured districts in Precambrian Period were preliminarily established.

From the comparison between the sequence of main geological events in the Chinese Archean (see **Table 3**) and the main geological events of the Archean Eon elsewhere (see **Tables 1-4**), it is evident that most of these events were global, and all of these events have representatives in China. It also testifies to the irreversibility and periodicities of the development and evolution of the crust globally, and China as one of the most ancient continental crust regions developed in step with other most ancient continental cratons.

In addition, this comparison of events highlights the particularity and complexity of geological events of the Chinese Precambrian. For example, the middle-early-stage greenstone of the Archean Eon lacked the true presence of komatiite, the mineral deposits in greenstone belts were also less profound than those of greenstone belts outside China; moreover, in the Proterozoic Eon the uranium conglomerate and tillites in China contain scarce gold and the plagioclase rocks of the Mesoproterozoic Era are rare. However in the Middle-Neoproterozoic Era there were some great biologic events recorded (see **Table 3**). And it also distinguished from other places worldwide, even the time period when it occurred would advance from several hundred million to ten million years. We should also indicate that in the Paleoproterozoic

zoic Era it was very rare to find magmatic activity in continents world-wide during the period from 2400 - 2200 Ma, but in the north of China there are many such events accurately recorded (see **Table 3**). All of these events have spoken volumes for the particularity and complexity of geological events of the Chinese Precambrian.

To observe the performance of geological events of each region worldwide there are some obvious discrepancies and imbalance, such as the degree and timing of sequences of some geological events in southern hemisphere compared to the northern hemisphere. For instance in Early Archean greenstone events, the time of first appearance was much earlier and the metamorphic degree much lower in the southern hemisphere, while the time is much later and the metamorphic degree much higher in the northern hemisphere. To observe these geological events in a long-term direction, there is some obvious cyclicity and periodicity of Earth's rhythm [28]. For example, complete volcano-sedimentary cycles can be divided, which experienced the intrusion of sodium granites in the early Archean Era and intrusion of potassic granites in the late Archean Era. The Palaeoproterozoic Era basically could be regarded as a complete sedimentary cycle (it was a volcano-sedimentary cycle in China) which also was intruded by the potassic granites. The Chinese Middle-Neoproterozoic Era also formed a complete sedimentary-cycle, but the occurrence of main geological events in this period was mainly affected by the stability of the Earth's crust and increase of oxygen content (marked by the appearance of red beds and early animals).

4. Conclusions

As a result of the systematic analysis, we can conclude that:

1) A systematic review and comparison of the major geological events of worldwide Archean and Chinese Precambrian and their interrelationships reveals that these events show a spatial pattern of consistency, differentiation, and imbalance along with a temporal pattern of periodicity and cycles. The research conclusions above have important theory and application value to deeply systematic know the early dynamic evolution characteristics and the geological environment evolution law and geological mineral resources formed enrichment law of the earth.

2) The comparison between the Chinese Precambrian major geological events and the Archean worldwide ones indicates that major geological events tended to unfold on a global scale and that crustal evolution showed considerable irreversibility, gradualism, and synchronism. Specifically, the stages of the Archean crustal evolution

Table 3. The sequence of great Chinese Precambrian geological events.

Geological Period		Event Sequence	Great Geological Event	Geological Movement	Isotopic Age Ma	Geological Evolvement Features	Main Regions and Performance	
Phanerozoic Eon	Paleozoic Era							
Proterozoic Eon	Neoproterozoic Era	26	The Geological Event between Sinian System and Cambrian System		600 - 545	From now on Southern Sedimentary Cover Germinating	Yunnan, Sichuan, between Sinian system and Cambrian System (the iridium anomaly of black claypan could be the case of aerolite fall.	
		25	Ediacaran Fauna Event		670 - 545		Liaoning, Jiangsu and Anhui, Sichuan and Yunnan, Hubei, Xinjiang, Hunan, Shanxi, the late Sinian period, the trace fossil and metazoa dominated, algae plants were much more diversified.	
		24	Tectogenesis Event between Pre-Sinian Period and Sinian Period		850 - 800		In the end of South and Northwest China Sinian system, the movement shaped the wide-spread basement fold regional metamorphism and magma, Chinese platform has shaped basically.	
					850 - 750	~Jinning Movement~		In North China, Liaonan district, Jiangsu and Anhui, Qingbaikou system Jing'eryu series and Sinian system, metazoan and macro algae appeared.
		23	Pre-Ediacaran Fauna Event (Huainan Fauna)		900 - 850		Because of the Fourth Large-Scale Shield-Building Movement Yangzi Platform and	From the late of macro benthic algal of North China Qingbaikou system Changlongshan series to the biota of early Sinian period (Longfengshan Biota to Huainan Biota) the macro algae and metazoa dominated.
		22	Pre-Ediacaran Fauna Event (Longfengshan Biota)		900 - 600		North-China and Tarim Platform Formed into United Chinese Platform	Some districts of North China, Yangzi, South China, Xinjiang Sinian System Archaic-city period, Nantuo period, Luoquan period ice age
		21	Neo-Paleozoic Glacier Activity Event					
		20	~Granville Movement~ Late Mesoproterozoic Era Reversed-polarity Event (Global Event)			1000		Jixian Hongshuizhuang period and Tieling period magnetic-pole reversed (reversed polarity) Jixian system Yangzhuang series red beds (Yangzhuang period red beds) (1715 Ma - 1767 Ma)
		19	Late Mesoproterozoic Era (Third Stage) Red Beds Event			1100 - 1050		Chengde Great Temple plagioclase, Miyun ring-spot granite (1715 Ma - 1767 Ma)
		18	Global Plagioclase Ring-spot					The shuttle shape, boat shape, and flake eukaryote were found in the bottom of Great-Wall system of Yanshan district (Luo Qiling), the macro algae fossil were found in the bottom of Tuanshan group.
	17	Granite Intrusion Event Earliest Eukaryote		~Sibao Movement~ (Qinyu Rising)	1400 - 1300		Northwest Hebei Xuanlong Iron ore in the bottom of Changzhougou Formation of Jixian (Chuanlinggou red beds)	
	16	Appearance Event Mesoproterozoic Early Red-Reds Event			1800 - 1400		Cosmic dust in the quartzite of Changzhougou Formation of North China Great Wall system (Ye Lianjun)	
	15	Mesoproterozoic Era North-China Fall Event			1850 - 1700			
					1850 - 1750			

Continued

Paleoproterozoic Era	14	~Hudsonian Movement~ Granite Intrusion Event	~Lvliang Movement~ (Main Stage)	1800 1900 - 1800	From now on North Sedimentary Cover Germinating	Lvliang rock body (rifting period granite), Liaonan granite, Shanxi Fenghuangshan Lotus rock body In the middle and north of China and Sichuan and Yunnan district (rifting) there were a lot of basic and ultrabasic magma activities. The early Lvliang activities made the early Proterozoic stratum of Jidong district suffered greenschist facies regional metamorphism. Zhongdoucun Subpopulation Slate of Hutuo Group, Songshan Group red beds (Hutuo period red beds) the deep-seated fault of Archean Eon Craton, such as Huairou of Beijing, Zhongtiaoshan, Taihangshan mountain, Wutaishan Mountain. The formation of Hutuo group, Shuangzishan Group, Qinglonghe Group, Zhongtiaogroup, Lanhe group, Liaohe group, Fenzishan group.
	13	Late Basic-Magma Event (Global Intrusion Event)		2000 - 1900		
	12	Region Metamorphism Event	~Qinglonghe Movement~	2100 - 2000	The Second Large-Scale Shield-Building Movement Made North-China Massif and Tarim Massif United.	
	11	Earliest First-Stage Red-Beds Event		2400 - 2200		
	10	Early Basic-Magma Intrusion Event		2400 - 1900	Non-opogenic Movement Basic Rock Event	
	9	Bulk Carbonate, Stromatolite and Ferrosilicon Sedimentation Event				
	8	~Ken Nore Movement~		2600 - 2500		
	7	Kali granite Intrusion and Metamorphic Event Neo-Archeozoic North-China		2600 - 2500 2800 - 2700	The first time large-scale shield-building movement formed the united North-China massif (or continental massif)	
Neoproterozoic Era	6	Aerolite-Fall Event Late (Secondary) Greenstone Body Formation	~Wutai Movement~	3000 - 2900 2970 - 2829		
	5	Earliest Natrium Granite Intrusion and Metamorphose (Granulite) Event	~Qianxi Movement~	3000	Shape II volcanic sediment cycle around the land mass sediment.	
	4	Early (Origin) Greenstone Formation	Qianxi Group Complex	>3000	Important structure-heat event in Archean Eon	
Archean Eon	3	Earliest Layered Rock in North China: (Qianxi Rock) Qianqing Rock and other basement rock	~~~~?	3500 Ling-zhi Operation	Shaping the original massif (Early Continent) by jointing the continental nuclear and greenstone belt	
	2	Earliest Meta-Crustose (Acid Basic Rock Intrusion)	Caozhuang Rock (Complex)	3800 - 3850	Shaping I volcanic sediment cycle around the continental sediment.	
	1	Earliest Rock Record	Original Insialic Crust		Qianxi complex depositing on Caozhuang Formation.	
					First tectonic-thermal event (acidic rock intrusion, basic rock intrusion) (Original continental formation). Caozhuang formation depositing on original crust Original sal-crust formation stage.	

Table 4. Stages of China and the World Precambrian Evolution and the formation and breakup of pan-continental.

Geological age	Isotopic age millions of years (Ma)	Tectono-thermal event orogeny			Crustal evolution and the formation of China (craton)	World Precambrian the formation of pan-continental and orogeny
		China	Europe, Africa	North America		
Neoproterozoic	800	Jinning movement			The fourth large-scale orogenic movement sutured together the Yangtze, North China, and Tarim landmasses, forging the primitive united China continental platform.	Disintegration of Pangaea;
	1000	Sibao movement (Qinyu ascension)	Gothic movement	Greeneville movement	The third large-scale orogenic movement sutured together the Yangtze landmass and China landmass, forging the Yangtze platform.	The Grenville orogeny sutured together the late Mesoproterozoic and early Neoproterozoic orogenic belts to form the Rodinia global supercontinent. In recent years, pangaea problems become a hot issue (Lu 2003; Wang <i>et al.</i> 2002).
Paleoproterozoic	1800 - 1850	Luliang movement	Carey Lane movement	Hudson movement	The second large-scale orogenic movement sutured together the North China landmass and Tarim landmass.	Hudsonian Orogeny (Kenora) generated orogenic belts; Accretion, collision and welding of orogenic belts on the edges of the North Atlantic craton (which in North America, Greenland, Baltic), formed still greater cratonic terrains.
	2600 - 2500	Fuping movement	Samith movement	Ken Nuocer movement	The first large-scale orogenic movement generated the rigid primitive united North China continental platform (or block), (Cratonization).	Though suturing and lateral accretion, Ken Nuocer orogeny brought together the landmasses and orogenic belts in the African, Brazilian, Greenland, Canadian, Australian, Baltic, Aldan, and North China Shields to form an extensive cratonic landmass.
Archean	3000 - 2850				Continental core welded with greenstone belts to form the primitive landmass (or block).	Continental core welded with greenstone belts to form the primitive landmass;
	3500 - 3700	Qianxi movement	Africa Dahomey movement			
Middle-Paleoarchean	4000 - 3800				Formation of early continental core (earliest supracrustal rock).	Formation of early continental core (earliest supracrustal rock).
					The formation of primitive Si-Al crust.	The formation of primitive Si-Al crust.

across the earth roughly coincided with each other (see **Table 4**); all old landmasses (cratons) are composed of granite-greenstone belts and high-grade gneiss (granulite) terrains, featuring universal multiple-stage metamorphism of various degrees, structure characterized by flat “gneiss domes” and oval structures and ductile shear zones, universal violent magmatism, dominated by acid in-

trusion at both the early and the late stages, and roughly synchronized major orogenic movements.

3) The major geological events exhibit striking differentiation and imbalance across the ancient lands. For example, both the time when the Archean cratonization occurred and the degree of the resulted metamorphism vary widely from land to land. Cratonization in South

Africa, Australia, Antarctica, and North America was earlier or the earliest and resulted in a lower degree of metamorphism; whereas cratonization in North China, Russia and India occurred at a later time and led to a higher degree of metamorphism. The differentiation of the degree of metamorphism in early global different areas decided the great differentiation of enrichment and distribution of the metamorphic dynamic mineral in different regions.

4) The time when the geological events occurred shows a remarkable cyclical pattern periodicity or geological rhythm. For example, the formation of the Archean Pangea or Supercontinent appears to be cyclical, with supposedly 250 Ma to 350 Ma as a cycle; magmatism is also cyclical, characterized by intrusion of primarily sodic granite at the early stage and by primarily potassic granite at the late stage, the same cyclical pattern is also found in the Proterozoic Era. Both Paleoproterozoic and Neoproterozoic host a complete volcanic-sedimentary cycle (sequence recovery of greenstone belts). Likewise, both Paleoproterozoic and Meso-Neoproterozoic host two complete volcanic-sedimentary cycles.

5) The Precambrian major geological events in China are comparable to those in elsewhere on the earth but also have their unique features. China has a relatively complete record of formation and evolution of rocks, strata, structures, and organisms spanning 3800 Ma to 540 Ma, 1400 Ma ago Macro-biological appeared [29], 800 Ma to 900 Ma ago, Macroscopic multi-cellular complex biological appeared (Longfengshan Biota) [30]. The Archean underwent multiple-stage complex metamorphism and deformation; metamorphism is on the higher end; komatite is absent in the greenstone belts; cratonization occurred rather late and varied between the north and the south.

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