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SHRIMP U-Pb Dating of Zircons of a Dark-coloured Eclogite and a Garnet-bearing Gneissic-granitic Rock from Bixiling, Eastern Dabie Area—Isotope Chronological Evidence of Neoproterozoic HP-UHP Metamorphism

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The paper reports SHRIMP U-Pb zircon data of a dark-coloured eclogite and a post-eclogite garnet-bearing gneissic-granitic rock from the Bixiling area, Yuexi County, Anhui Province, in the eastern Dabie Mountains. The eclogite, which is metamorphosed basic tuff, contains very scarce zircons in omphacite or garnet, but more in quartz. They usually exhibit a double-layered texture clearly shown in cathodoluminescence images. Their main inner parts give a $^{206}\text{Pb}/^{238}\text{U}$ age of 757 ± 7 Ma, representing the approximate age of the HP-UHP metamorphic event, during which the eclogite was formed. The outer peripheral parts of the zircons, which have been modified by late-stage fluids, give an age of 223 ± 3 Ma. The granitic rock contains more zircons of anatectic origin found mostly in feldspar and quartz and usually also showing a similar composite texture. The main inner parts of the anatectic zircons with rhythmic zoning give a $^{206}\text{Pb}/^{238}\text{U}$ age of 727 ± 15 Ma for the approximate age of the emplacement of the granitic rock, and their outer parts, an age of 219 ± 3 Ma for a similar or even the same fluid transformation event. It is thus suggested that the HP-UHP metamorphism of the Bixiling eclogite facies rocks took place during the Neoproterozoic Jinningian, and the Indosinian age values may only represent a late event in the nature of fluid transformation.

Key words: Bixiling, Dabie Mountains, dark-coloured eclogite, gneissic-granitic rock, Neoproterozoic Jinningian, SHRIMP dating

Petrological Structure and Thermal Structure of the Dabie Orogenic Belt and Its Geological Implications

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Both petrological structure and thermal structure indicate that the Dabie collisional orogenic belt was formed by superposition of two different petrostructural blocks, representing two different deep crustal continental sections. From an analysis of the physical property (density) of the high-pressure (HP)-ultrahigh-pressure (UHP) metamorphic rocks, the authors suggest that the felsic crust can be subducted to the mantle depth if it has a special petrological structure. Both low temperature and rapid exhumation are believed to be the major reason for lack of both syncollisional and postcollisional granites. The float-sink effect is the mechanical mechanism for the formation and exhumation of UHP rocks.

Key words: petrological structure, thermal structure, UHP rock, orogenic/deep processes, Dabie orogenic belt

Chronological Framework of the Early Precambrian Important Events in the Lüliang Area, Shanxi Province

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Based on the chronological data and relevant geological evidence, the chronological framework of the early Precambrian important geological events in the Lüliang area has been established in this paper. There are two types of zircon in the biotite leptynite of the Jiehekou Group. One is detrital zircon with a rounded-ovoid shape and an upper intercept age of 2803 ± 108 Ma, which is interpreted as the formation time of the source rock of the biotite leptynite. The other is metamorphic zircon with a short-prismatic shape and an upper intercept age of 2028 ± 45 Ma, which represents a later tectono-thermal event. After synthesizing the relationships between various geological events and the results of Sm-Nd isotopic study, the authors put the sedimentary event of the Jiehekou Group in the time span of 2600–2400 Ma. The metabasic volcanics of the Jinzhouyu Formation of the Lüliang Group have a Sm-Nd isochron age of 2351 ± 56 Ma. The magmatic zircons from meta-tuff of the same

formation yields a concordia age of 2360 ± 95 Ma. Therefore, the volcanic eruption of the Jinzhouyu Formation of the Lüliang Group occurred in the time span of 2360–2350 Ma. The 2124 ± 38 Ma age of zircons from the meta-tuff of the Bailongshan Formation of the Yejishan Group represents the formation time of the volcanic rocks. The hornblende-plagioclase gneiss and biotite-plagioclase gneiss from the Chijianling complex yield zircon U-Pb concordia ages of 2151 ± 12 Ma and 2152 ± 35 Ma respectively, which means that the complex formed at 2150 Ma. The monzonitic granite in the Jiaoloushen area intruded at 2031 ± 47 Ma, and finally charnockite intrusion in the Luyashan area took place around 1800 ± 7 Ma.

Key words: early Precambrian, isotopic chronology, geological event, Lüliang area, Shanxi Province

Retrogressive Microstructures in High-Pressure and Ultra-high-Pressure Metamorphic Rocks in the Dabie Mountains: Enlightenment to the Exhumation Process

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A number of retrogressive microstructures have been found in the ultrahigh-pressure (UHP) metamorphic rocks in the Dabie Mountains. There are four major types: (1) oriented mineral inclusions resulting from exsolution; (2) pseudomorphic replacements resulting from polymorphic transformation; (3) solid-solid reaction resulting in corona texture; (4) coronas and symplectites formed by retrogressive reaction involving fluids. On the basis of the microstructural relationships, retrometamorphic evolution stages of UHP metamorphic rocks can be distinguished and a related retrometamorphic *P-T* path can be constructed. A two-stage uplift and exhumation history subsequent to the peak UHP metamorphism and collisional orogeny can be recognized: the early stage witnessed the isothermal decompressive retrometamorphism induced by “extrusion”, and the late stage witnessed retrometamorphism, break-off of subducting slabs, upwelling of the asthenosphere, induced partial melting of the mid-lower crust, and crustal-scale extension and further uplift and exhumation of the UHP metamorphic rocks caused by the decrease in density of the lower-middle crust in the crustal extension regime. Finally, a three-stage model of post-collision uplift and exhumation is presented.

Key words: ultrahigh-pressure metamorphic rocks, decompressive retrometamorphism, microstructure, uplift and exhumation processes, Dabie Mountains

Late Yanshanian Granites in the Jiuzihe-Tiantangzhai Area and Uplift of the Core of the Dabie Orogenic Belt

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Late Yanshanian granites, which are widespread in the Jiuzihe-Tiantangzhai area at the core of the Dabie orogenic belt, forming the main part of the famous Tiantangzhai granitic complex, can be grouped into 5 rock types (units), i.e. the Jiuzihe gneissose granite, Wujiaoshan granodiorite, Tiantangzhai porphyritic granite, Bodaofeng fine-grained granite and Bijiaoshan leucogranite. Their country rocks are the Neo-Archaean Dabie complex which has experienced regional metamorphism of amphibolite-granulite facies and migmatization. According to their relationship with the main structure of the study area—the NE-trending dextral strike-slip ductile shear zone, the granites can be classified into the following three tectonic types: syn-tectonic, late-tectonic and post-tectonic. From the viewpoint of petrogenesis, the last two belong to typical magmatic granites, while the syntectonic Jiuzihe gneissose granite belongs to the shear-anatexis granite. The basic cause for the extensive shear-anatexis is the introduction of fluids resulting from strike-slip ductile shearing, which caused lowering of the rocks' melting point. The information obtained from the late Yanshanian granites in this area indicates that the uplift of the core of the Dabie orogenic belt occurred in the Early Cretaceous, with an elevation rate (14 mm/a) much greater than the denudation rate of modern mountains. This rapid uplifting is the result of interaction between the Pacific plate and the Asian continent, rather than the result of the collision between the North China and Yangtze blocks.

Key words: Tiantangzhai granitic complex, shear-anatexis, marginal-Pacific tectonic system, Dabie orogenic belt, late Yanshanian

Petrographical Study of Zircons and SHRIMP Dating of the Caledonian Xiongdi Eclogite, Northwestern Dabie Mountains

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The Xiongdi eclogite at Luoshan County, Henan Province, occurs in the Sujiahe tectonic mélange in the western Dabie Mountains. Zircons from the rock occur in garnet and other metamorphic minerals with clear sharp boundaries and exhibit textures growing under metamorphic conditions. They are multifaceted under the scanning electron microscope, thus indicating their growth in a solid medium.

SHRIMP analyses give $^{206}\text{Pb}/^{238}\text{U}$ ages ranging from 335–424 Ma for the zircons, showing a certain degree of radiogenic lead loss; so the age of 424 ± 5 Ma reflects the minimum age of the metamorphic zircons. From the above data combined with the previous Sm–Nd, ^{40}Ar – ^{39}Ar , U–Pb and $^{207}\text{Pb}/^{206}\text{Pb}$ data, it is suggested that the peak metamorphism of the Xiongdiian eclogite is between 424–480 Ma. The present study confirms that there do exist a Caledonian HP–UHP metamorphic event in the western part of the Dabie orogenic belt.

Key words: Dabie Mountains, Caledonian, eclogite, SHRIMP study

On the Recognition of the Permian-Triassic Luhuo Palaeorift in Western Sichuan and Its Geological Evolution

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The Luhuo palaeorift lies in the Garzê–Songpan massif. Its boundary faults, the Dingqu–Jiajinong–Quesuo fault and the Ximaliduo–Sertar fault, were reflected as faults cutting the lithosphere during the late Variscan and Indosinian periods. They dip NE and SW respectively, forming the graben-type sea basin. The stratified cumulus basic-ultrabasic intrusive bodies in the rift are the result of deep-seated tectonic intrusion. The Permian and Triassic volcanic rocks outcropping in the region are characteristic of seafloor (or mid-oceanic ridge) tholeiite as viewed from their occurrence, lithology and chemical composition. The Permian basalts and basic-ultrabasic rocks at the bottom of the Permian strata may be the constituents of ophiolite, which may be the primary oceanic crust formed by the spreading of the back-arc marginal sea. The chemical composition of basic-ultrabasic rocks associated with Triassic basalts reveals the tectonic evolution from continental rifting to oceanic rifting. The development of turbidite, volcanic rocks, olistostrome and deep-sea cherts with a considerable thickness is different from that of the adjacent region. The materials for deposition were mainly from the northeastern and southwestern directions, which supports the existence of the rift. The Luhuo belt is also the boundary between subregions of regional magnetic fields, in which linear magnetic anomalies are shown. It can be determined from the above that the Luhuo palaeorift is a Permian-Triassic seafloor rift developed on the Yangtze-type basement. It experienced the primary rifting stage (in the Late Permian), depositional depression stage (in the Early to Late Triassic), intense rifting stage (in the middle Late Triassic), and withering stage (in the late Late Triassic). After the closing of the rift, due to the interaction among the Indian plate, Pacific plate and Sino-Korean plate, the Songpan–Garzê massif including the Luhuo rift was in a depression environment, in which Yanshanian intermediate-acid intrusive rocks (chiefly the I-type) occurred. It can be known from analyses of the pa-

laeostress that the stress field in the Luhuo rift changed from the nearly WSW–ENE compression in the early Yanshanian period through the nearly NNE–SSW compression in the late Yanshanian period to the nearly NE–SW compression in the Himalayan period.

Key words: rift, geological evolution, western Sichuan

The Late Ordovician Radiolarian Assemblage of the North Qinling Back-arc Basin, China

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The Weibei area is located on the north side of the Weihe River near the Qinling Mountains. During the early Palaeozoic it belonged to the North China carbonate platform, but at the beginning of the Late Ordovician, it subsided and developed into a deep-water basin merging into the North Qinling back-arc basin, where it received carbonate slope deposits of a total thickness of about 800 m, including thin-bedded limestones, cherts, tuff and brecciform limestone as well as slumped limestones. This set of strata, named the Zhaolaoyu Formation by Mei Zhichao et al., yields radiolarians, graptolites and conodonts in its lower part. Graptolites and conodonts collected from the thin-bedded limestones indicate a Caradocian age. The well-preserved radiolarian *Inanibigutta* aff. *inconstans*–*Syntagentactinia biocculosa* assemblage produced in it is characterized by a high diversity with 7 families, 14 genera and 23 species, the dominance of Inaniguttidae, Halpentactiniidae and Polyentactiniinae, and especially *Inanigutta*, *Inanibigutta*, and *Polyentactinia*, inadequacy of Entactiniinae and Palaeosce-nidiidae existing dominantly in the Ordovician of Europe, America and Australia, in particular, and absence of the important element, *Kalimnaspheera*, of Australia and America. Therefore, the general feature of this assemblage is very similar to that of the Landeilo–Caradocian assemblage of Kazakhstan. As is known at present, Asia is the place rich in the most highly diverse Ordovician radiolarian fossils. These facts indicate that the ancient Qinling Ocean can have been related to the Palaeasia Ocean.

Key words: Ordovician, radiolaria, palaeogeography

^{14}C Dating of Holocene Volcanic Rocks of the Jingpohu Region, Heilongjiang Province, and Characteristics of Their Source Regions

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Holocene volcanoes of the Jingpohu region, Heilongjiang

Province, are situated in the "Crater Forest" and "Frog Pool" areas to the northwest of the Jingpo Lake. Three gagatite samples from the strata of the first and second sub-cycles of Nos.

I and V (Daganpao) craters of the "Crater Forest" and the first sub-cycle of No. XII crater of the "Frog Pool" respectively were used for ^{14}C dating. The dating results are 3430 ± 60 , 2470 ± 120 , 2470 ± 110 and 3490 ± 140 years respectively (the gagatite sample collected from No. V crater was measured twice). Based on the existence of three volcanic sub-cycles in the study area, as well as the geological characteristics and the oldest age of the trees in the study area, it is inferred that the last volcanic eruption happened about 2000 years to 1000 years ago. The interval of two eruptions is about 1000 years. It shows that the Jingpohu volcano is one of the most dangerous volcanoes in Northeast China. Great differences in petrological and geochemical characteristics of the basaltic rocks and mantle inclusions between the "Crater Forest" and the "Frog Pool" show the extreme heterogeneity of the mantle source beneath the Jingpohu region 3490 years ago. It was probably related to the third-class activity of the mantle plume beneath the area.

Key words: ^{14}C dating, Holocene volcano, characteristics of source region, Jingpohu region, Heilongjiang Province

First Discovery of Angiospermous Pollen from the Yixian Formation in Western Liaoning

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This paper reports fossil pollen collected recently from the Upper Jurassic Yixian Formation of western Liaoning Province, and first demonstrates the oldest known angiospermous pollen

in the world. These earliest angiospermous pollen consists of inaperturate-pollen type, protomonocolpate-pollen type and prototricolpate-pollen type. The findings show that angiosperms occurred during the Late Jurassic and are characterized by many types of pollen grains, and propose that there might exist an original centre of angiosperms in East Asia.

Key words: angiospermous pollen, Late Jurassic, Yixian Formation, Liaoning

Relationship between the Carbon Isotope Composition of Single Alkanes in Plants and Their Growing Environment

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The carbon isotope composition of single alkanes ($\delta^{13}\text{C}$ -ia) in two plants (*Leontopodium leontopodioides* and *Taraxacum mongolicum*) growing in the northeastern Qinghai-Tibet plateau was analyzed by means of GC-IMS in order to know its relationship with altitude, and furthermore, to gain new data for the research on climatic changes. The results show that the $\delta^{13}\text{C}$ -ia values in n-alkanes with odd carbon atoms are relatively small and increase with the altitude, whereas those of n-alkanes with even carbon atoms are discrete and change irregularly. These values may be good indicators for changes in temperature and P_{CO_2} of the growing conditions of plants.

Key words: alkane, carbon isotope, altitude, climate, plant