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Preliminary Study on the Isotopic Age of Metamorphism and Anatexis of the Fuping Group of the Environs of Xiaojue, Pingshan County, Hebei Province

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Part of the metamorphic rocks of the Early Precambrian Fuping Group of the study area have been subjected to differential anatexis shortly after the climax of regional metamorphism. Isotopic age studies of the zircons from both the metamorphic rocks and their anatectic derivatives by the single crystal U-Pb method have been carried out by the authors. The upper intercept age of the U-Pb concordia has been interpreted as the age of metamorphism or anatexis of the samples concerned. The results of the isotopic determination of zircons from the samples of three different rock types collected near Xiaojue and in the area further east (Fig. 1) give the age of regional metamorphism not younger than 2.55 ± 0.04 Ga, and those of the anatectic rock of granodioritic composition collected just east of Xiaojue, value of 2.47 ± 0.09 Ga for the age of anatexis. Thus both the metamorphism and anatexis are of the Neo-Archaean Fupingian movement. And the results for two samples from Xiakangiyayu, southeast of Xiaojue give an approximate age around 2.06~2.08 Ga for another episode of anatexis in the Paleo-Proterozoic time.

Key words: Fuping Group; isotopic age; age of regional metamorphism; age of anatexis

The Columnar Jointing in Cretaceous Clastic Rocks and the Rotation of Rift Shoulder in Sudan

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The Tertiary basaltic rocks are discontinuously distributed from the west to the northeast of Sudan, in the Sahara Desert, overlying the Cretaceous clastic rocks. The authors of this paper found a kind of columnar jointing in the Cretaceous clastic rocks in the Mellit area, western Sudan. The Cretaceous sedimentary rocks were baked by the basaltic lava flow erupted in the Early Miocene, contracting in volume owing to loss of water contained mainly in the clays of the clastic rocks, and thus forming the columnar jointing. According to the occurrences of jointing and the sedimentary strata the authors calculated the two different rotations of the Mellit block: the block

tilted toward 338° for 18° from Late Cretaceous to the beginning of Miocene, and tilted toward 138° for 18° since Miocene. By analyzing in detail the structural evolutionary history, from Mesozoic to Cenozoic, of different rift belts in western, northern, central and eastern Africa, the authors think that the Mellit area was on the northwestern shoulder of the South Sudan Rift. The rotation of the Mellit block toward northwest was the outward rotation of the northwestern shoulder of the South Sudan Rift during the rifting phase, and the rotation toward southeast was the inward rotation of the rift shoulder during the post-rift thermal sag episode. The authors also conclude that the South Sudan Rift entered the post-rift thermal sag phase because of the development and evolution of the East African Rift and Red Sea in the Cenozoic.

Key words: Sudan; Cretaceous; clastic rocks; columnar jointing; rift shoulder rotation

A New Sauropod Dinosaur from the Late Cretaceous of Tianzhen, Shanxi Province, China

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Two teeth and a relatively complete postcranial skeleton of a new sauropod dinosaur (*Huabeisaurus allocotus* gen. et sp. nov.) were discovered from the Upper Cretaceous Huiquanpu Formation, Tianzhen County, Shanxi Province. The new species is a large sauropod, about 20 m in length and 5 m in height.

Diagnosis: The teeth are peg-like; cervical vertebrae opisthocoelous, those in the middle region longer than others, neural spines bifurcated; dorsal vertebrae with deep pleurocoels, their neural spines high and unforked; a cervical vertebra in the middle part two to three times longer than a dorsal vertebra; five sacra with neural spines fused into a plate; caudal vertebrae clearly amphicoelous, their neural arches and spines situated on the front half of centrum; chevrons fork-shaped and unfurcated; elongated scapula with expanded proximal end and slightly expanded distal end; humerus similarly expanded at both ends; radius relatively straight, long and constricted in middle region, with expanded and twisted not proximal and distal ends on a horizontal plane; ilium very large and hemi-round, with a developed and forward pubic peduncle; ischiatic process of ilium poorly developed; pubis broad and blade-like, with an oval pubic foramen and triangular bony lamella between the axis of the shaft and the ischiatic border; ischium with a short shaft, yoke-like and rather expanded in proximal

end; femur stout and flattened anteroposteriorly, with a developed head situated just above the level of great trochanter; the fourth trochanter slightly swelled and located on the inner side medially above midlength of shaft; two condyles very well developed at distal end of femur; tibia and fibula rather compressed.

Morphologically the new genus is different from the Late Jurassic *Euhelopus*, *Omeisaurus*, *Mamenchisaurus*, *Brachiosaurus*, *Camarasaurus* and *Diplodocus* in China and the world. It is also different from the Late Jurassic—Early Cretaceous *Phuwiangosaurus* in Thailand and the Upper Cretaceous *Nemegtosaurus*, *Opisthocoelicaudia* in Mongolia as well as *Titanosaurus* in India. So far as we know, sauropod dinosaurs of the Late Cretaceous, especially complete specimens, are rarely discovered. Therefore, the new discovery has significantly enriched the sauropod dinosaur record in China, and has an important bearing on the study of the taxonomy, evolution, migration, extinction and paleobiogeography of the Late Cretaceous sauropod dinosaurs.

Key words: sauropod dinosaur; *Huabeisaurus allocotus* (gen. et sp. nov.); Late Cretaceous; Tianzhen; Shanxi

Geochemistry of the Shizishan Copper Deposits, Yimen, Yunnan

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Copper deposits of the Yimen type are stratiform copper deposits that occur in the Yinmin, Luoxue and Lüzhijiang formations of the Proterozoic Kunyang Group. The Shizishan copper deposit is one of the typical deposits of the Yimen type. The Kunyang Group is distributed in the narrow and long belt constrained by the Lüzhijiang lithospheric fault and the Xichang-Yimen crustal fault, probably deposited under continental rift condition. Based on their mineralization feature, ore-bearing strata and mineral assemblages, the Shizishan copper deposits may be divided into three subtypes.

(1) Exhalative hydrothermal sedimentation-reformed copper deposit, which is the main type and occurs in the siliceous dolomite and argillaceous dolomite of the Luoxue Formation and the siliceous slate at the bottom of the Etouchang Formation. The orebodies are stratiform and stratoid deposits, with the primary minerals, such as chalcopyrite (minor pyrite), dolomite, albite and microcrystal quartz, are distributed along the beddings, forming the laminated structure.

(2) Reformed sedimentary sandstone copper deposit.

(3) Copper-bearing magnetite related to spilite.

The ore-bearing Yinmin, Luoxue and Etouchang formation are characterized by an assemblage of terrigenous clastic rocks, carbonate and carbonaceous mudstone with alkali basic volcanic rocks and hydrothermal sedimentary rocks. Among the banded siliceous dolomite and dolomitic silicalite on the top of

the Luoxue Formation and at the bottom of the Etouchang Formation, the silicalite occurs in a striped and laminated structure, often associated with albite and chalcopyrite, as a result of hydrothermal sedimentation.

Generally the chemical composition of the hydrothermal sedimentary rocks in the region is characterized by rather low SiO_2 , and high CaO , MgO , Na_2O and K_2O content, similar to the typical hydrothermal sedimentary rocks of China and other countries. The trace elements have the features of enriched copper and high contents of Zn, Pb, Ag, Bi, Mo and As. The trace element association of the hydrothermal sedimentary rocks has an inherited and consistent feature with that of the basic volcanic rocks of the region.

In pyrite and chalcopyrite of the ores, the contents of Ni, Co, Zn and Se are comparatively high, and Co/Ni is from 2.12 to 92.88. With the strengthening of the exhalation, ΣREE and LREE of the strata and the sulfides become lower. The REE distribution curves are generally paralleled with each other, and have an obvious Eu depletion and a small Ce negative anomaly. The $\delta^{34}\text{S}$ values range from -4.37‰ to 14.7‰, the maximum disparity is 19.07‰, average value at 6.18‰; $\delta^{18}\text{O}$ values range from 14.07‰ to 19.25‰, averaging 17.07‰; $\delta^{13}\text{C}$ values range from -10.51‰ to 0.39‰, averaging values -4.12‰.

Key words: Shizishan copper deposit; Exhalative hydrothermal—sedimentary mineralizing

Magnetostratigraphy and Palaeolatitudes of Hole K1 in Lop Nur, Xinjiang

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From satellite images, it may be found that hole K1 is located on the northern margin of the Lop Nur “helix” structure, at 90.5°E and 40.3°N, with an elevation of 780 m above sea level. It is the only hole that has been studied systematically in the Lop Nur region at present. The magnetostratigraphic study indicates that by choosing the hole depth of 61–62 m as the boundary, the interval above the depth belongs to the Brunhes normal polarity zone (Br), the interval below the depth belongs to the Matuyama reversed polarity zone (Ma), and the normal polarity migration at depths of 97–100 m on the hole bottom should belong to the Cobb Mountains polarity event. According to the Cande & Kent geomagnetic polarity time scale, the age of the strata on the hole bottom is 1.20 Ma, assigned to the middle part of the early Pleistocene. The middle Pleistocene, late Pleistocene and Holocene strata are >50 m, about 10 m and <5 m thick, respectively. Calculation of palaeomagnetic data shows that the palaeolatitude of hole K1 of Lop Nur is 34.1°N. And, according to the calculation of palaeomagnetic data from the Kuche and Qaqa sections, their palaeolatitudes are 26.7°N

and 20.0°N respectively. In comparison with the present latitude, their positions have all migrated northwards. This feature is closely related to the compressional collision of the Indian and Eurasian plates and the sinistral strike-slip movement of the Altun fault on the southern margin of the Tarim basin.

Key words: Lop Nur; Tarim basin; magnetostratigraphy; palaeolatitude; neotectonic movement

The Formation of Yanshanian Granitic Magma in Dabie Mountains: Dehydration or Aquifer Melting—with Tiantangzhai and Jiuzihe Granites as Examples

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There are large areas of late Yanshanian granites in the Dabie orogenic belt, but the formation mode of the relevant granitic magma is still under discussion. Taking the typical Yanshanian granites in the North Dabie block—the Tiantangzhai and Jiuzihe granites as examples, the writers endeavour to discuss certain aspects of the formation mode of the granitic magma by studying the characteristics of the chemical compositions of biotite and hornblende of the granites and petrological features of enclaves in the intrusions, in the light of recent results of experimental petrology on dehydration melting and aquifer melting. It is suggested that: ① Some biotites in the Tiantangzhai and Jiuzihe granites and their enclaves were residual minerals. ② Some of the hornblends could be new-born minerals, and others, residual ones. ③ The banded bodies in granites were residuals of anatexis. ④ The Tiantangzhai and Jiuzihe granites were formed by aquifer melting, and the South Dabie block could be the important source region of water.

Key words: petrogenesis of granite; dehydration melting; aquifer melting; mineral characteristics; enclave characteristics; aquifer fluid; Dabie orogenic belt

A Discussion on Petroleum Migration in the Lunnan Oil-field of Xinjiang Based on Nitrogen Compounds

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Non-hydrocarbon technique has attracted more and more attention in petroleum exploration and exploitation. It has been proved that pyrrolic nitrogen compounds, a kind of non-hydrocarbon fraction, could be used as effective “tracers” in oil migration and as parameters in evaluating the quantity of migrated oil. These compounds are generally of polarity, and so

will take part in the interaction of the oil-water-rock system, which is the reason why the compounds have an obvious migration fractionation effect. There are abundant pyrrolic nitrogen compounds in oils of the Lunnan area, and there are obvious differences in the absolute abundance and relative distribution of the compounds among oils of the same formation or different formations, showing significant oil-migration fractionation effects. The results indicate that: (1) Tertiary and Jurassic oils have possibly migrated for a longer distance than Ordovician and Carboniferous oils. This is shown by the following facts: a) The average abundance of pyrrolic nitrogen compound fractionation of Ordovician oil is 37.65×10^{-6} , generally higher than that of Tertiary and Jurassic oils (average value 13.6×10^{-6}) and Carboniferous oils (average value 10.21×10^{-6}); b) Tertiary and Jurassic oils are rich in highly alkyl-substituted carbazoles and benzocarbazoles relative to Ordovician and Carboniferous oils; c) Tertiary and Jurassic oils are rich in isomers in which nitrogen atoms are marked relative to Ordovician and Carboniferous oils. (2) According to the fractionation of pyrrolic compounds, the position of the main changing point of Ordovician and Carboniferous oils is dominant in the southwest of the Lunnan and Sandamo faults, and the direction of oil migration is from west to east. Therefore, the source rock is inferred to be the lower indigenous strata in the Manjaer sag. (3) Similarly, it is suggested that the main charging point of Tertiary and Jurassic oils be at the higher location of the Lunnan fault. Oils accumulated in Tertiary and Jurassic formations have probably been regulated by tectonization lately. The oils are likely to migrate from northwest to southeast during the redistribution. (4) The results also show that part of the Carboniferous oil may be generated by the Carboniferous source rocks of the same horizon or nearby.

Key words: Lunnan area; pyrrolic nitrogen compounds; oil migration

Geochemistry of the Anzishan Ophiolitic Complex in the Mian-Lüe Belt of Qinling Orogen—Evidence and Implication of the Palaeo-ocean Crust

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The Anzishan ophiolitic complex is located in the eastern section of the Mian-Lüe ophiolitic and tectonic melange belt, Qinling orogen, center China. It consists of serpentinized peridotites and metamorphosed MORB-type mafic igneous rocks. The serpentinized peridotites (harzburgites and a few dunites) represent the upmost part of the palaeo-ocean mantle. Whereas the metamorphosed mafic igneous rocks, which are characterized by depleted LREE and very high Nd isotopic ratios similar to MORB, are remainders of the palaeo-ocean crust. These

facts suggest that this complex is another typical ophiolite within the Mian-Lüe ophiolitic and tectonic melange belt. The geochemical characters of the meta-mafic rocks reveal that this ophiolitic complex was most probably formed in a small ocean basin or back-arc basin. However, the Pb, Nd isotopic systems of the Anzishan ophiolitic complex from the eastern section are distinct from those of the ophiolites from the western section. The palaeo-ocean crust in Anzishan is probably older than the ophiolites in the western section of the Mian-Lüe belt. Thus, the meta-mafic rocks of the Anzishan ophiolitic complex were derived from an isotopic mantle reservoir different from the those in the western section. This infers that the Mian-Lüe ophiolitic and tectonic melange belt has a more complex evolution history than hitherto considered.

Key words: ophiolite; lead and neodymium isotopes; amphibolite; Mian-Lüe belt; Qinling

Carbon Content and Isotope Composition of Granites from Southeastern China

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Both the content and isotope composition of bulk carbon in apatite and the granites of different ages from southeastern China have been determined by using the EA-MS online techniques. The results show that the carbon content ranges from

0.04% to 0.79%, and $\delta^{13}\text{C}$ from -7.51‰ to -37.03‰ for the granites. A positive correlation in $\delta^{13}\text{C}$ between apatite and the granite indicates that the granitic magma was not affected by crust contamination or hydrothermal alteration during its uplift and crystallization, so that the isotope composition of bulk carbon reflects the isotopic feature of its source. Some of the granites were re-analyzed after the HCl dissolution, and the results show that there are different forms of carbon in granites (carbonate carbon and noncarbonate carbon). The content and isotope composition of bulk carbon show a log-normal distribution and a two-peak normal distribution, respectively, pointing to mixing processes between different carbon reservoirs. Along with the Nd and Sr isotope data, a non-simple two end-member mixing model is suggested with respect to the carbon isotope composition and carbon content of the granites as well as Nd and Sr isotopes. The two end-members have the isotopic features of the mantle and the crust, respectively. The mantle end-member has a single $\delta^{13}\text{C}$ value of -7‰, whereas the crustal end-member has variable $\delta^{13}\text{C}$ values from -35‰ to -20‰ and also corresponds to large variations in the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios (0.715 to 0.735) but a unified ϵ_{Nd} value of -18. Some of the I-type granites with the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios less than 0.710 also have the lower $\delta^{13}\text{C}$ values of -30‰ to -20‰, probably implying that their igneous protoliths have been to surface and been suffered contamination of the organic carbon.

Key words: carbonate; organic carbon; carbon isotope; geochemistry; mixing; granite