Application for membership of UNESCO Global Geopark

Annex 2: B-Geological Heritage

Name of Applicant: Funiushan Geopark

Province: Henan

Country: P. R. China

Submission Date:
B-Geological Heritage

Geological overview:
Funiushan is formed by the convergence, subduction, collision, suture and uplift of North China paleoplate and Yangtze paleoplate, and located in the east section of Qinling orogenic belt. Through geological evolution history over 2.5 billion years, the geopark mainly reserves paleontology relics such as the typical rock stratum stratigraphic section, tectonic relics, the Cretaceous dinosaur fossil group, and granite landscape, karst landscape as well as the pond/pool waterscapes. In addition, because of locating in the climate transitional zone of China’s south to north, Funiushan area has abundant animal and plant resources, and thick historical and cultural heritages.

1 General geological description of the proposed Geopark

1.1 Stratum
Funiushan Geopark locates in the east section of Qinling Orogenic Belt and the exposed strata across North China and South China two large regions. The strata of the Neoarchean, Paleoproterozoic, Mesoproterozoic, Neoproterozoic, Paleozoic, Mesozoic, and Cainozoic have all been exposed (table 1-1). Affected by the orogenetic movement and nappe tectonic belt, the stratigraphic units appear in the forms of tectonic slice, rock mass, folded mountain and synclinal basin, the main strata exposed are as follows: (1) Palaeoproterozoic Qinling Gr. (Pt1Q), Mesoproterozoic and neoproterozoic Xiahe Gr. (Pt2,X.) and Kuanping Gr. (Pt2,K.), lower palaeozoic Erlangping Gr (Pz1,E), Xiaozhai Formation (Pz1x), Baoshuping Formation (Pz1b) and upper palaeozoic Shishuyuan Formation (Pz2š) in Qin-Qi-Kun stratigraphic region of North China stratigraphic superregion; (2) Neoarchean erathem Taihua Gr. (Ar1T), Mesoproterozoic erathem Xionger Group (Pt2,X), Gaoshanhe Formation (Pt2,g) and Guandaokou Group (Pt2,G), Neoproterozoic erathem Luanchuan Group (Pt2,L), Sinian system Sanchakou Group (Zs) and Taowan Formation(Zt), Mesozoic erathem upper cretaceous Qiupa Formation(K2q), Cenozoic erathem paleocene series Gaoyugou Formation (E1g), Eocene Series Tantou Formation (E2t) and Oligocene series Shitaijie Formation (E3š) in Yu-Shan stratum subregion, Jin-Ji-Lu-Yu stratigraphic region of North China stratigraphic superregion; (3) Neoproterozoic erathem Guishan Gr. (Pt3g), lower palaeozoic erathem Zhoujingou Gr. (Pz2zh.), Devonian system Nanwan Formation (Dn), Mesozoic erathem Upper cretaceous Gaogou Formation (K1g), Xiaguang Formation (K1x), Majiacun Formation(K1m) and Shigou Formation (K1š) in South Qingling-Dabieshan stratigraphic region of South China stratigraphic superregion;

1.2 Structure
Funiushan Geopark locates in the core part of east section of Qinling Orogenic Belt, and acrosses most areas of 3 secondary structural units including hinterland thrusting fault fold belt of Qinling orogenic belt, imbricate thrusting and napping tectonic belt of North Qingling, thrusting and napping tectonic belt in north of South Qingling, with clear structural feature. Through Jinning movement, the Caledonian movement, the Indosinian movement, the Yanshan movement and himalayan movement, a series of compound fold which are in NW-SN direction and fault basin have been developed, large fault such as Shangnan-Danfeng Fracture Belt (plate suture), Luanchuan Fracture Belt, Zhuyangguan-Xiaoguan Fracture Belt, Waxuezi-Qiaoduan Fracture Belt, Muijiaya-Neixiang Fracture Belt and Machaoing Fracture Belt have traversed the region, forming the boundary of geotectonic unit, and controlling the deposition after mesoproterozoic.
Figure 2-2 The Regional Geological Map of Funiushan Geopark

Legend
- Quaternary System
- Neogene System
- Cretaceous System
- Triassic System
- Jurassic System
- Silurian
- Ordovician
- Cambrian
- Devonian
- Triassic Gr
- Eccaing Gr
- Sigun System
- Ophiobdaeous System
- Palaeocene Gr
- Neogene Gr
- Miocene Gr
- Peral Gr
- Duolting Gr
- Quing Gr
- Zubbis Gr
- basic rock
- intermediate rock
- acid rock
- volcanic rock
- sedimentary rock
- Geopark boundary
<table>
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<tr>
<th>Stratigraphic division</th>
<th>Stratigraphic age</th>
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<th>Lithology</th>
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<td>Oligocene</td>
<td>Shitoujie Formation</td>
<td>Compound glutenite</td>
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<td>Eocene</td>
<td>Tantou Formation</td>
<td>Argillite and marlstone, limestone and sandstone, glutenite, conglomerate interbed, oil shale</td>
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<td>Paleocene</td>
<td>Gaoyugou Formation</td>
<td>Argillite, sandy mudstone and sandstone, containing mammal fossil and other paleontological fossils</td>
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<td>Mesozoic</td>
<td>Cretaceous</td>
<td>Qiupa Formation</td>
<td>Conglomerate, pebbly sandstone and clay rock, containing dinosaur fossil and other paleontological fossils</td>
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<td>Neoproterozoic</td>
<td>Sinian</td>
<td>Taowan Formation</td>
<td>Carbonaceous phyllite and gritiotte</td>
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<td>Sanchakou Formation</td>
<td>Carbonaceous sericite schist, calcareous conglomerate</td>
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<td>Luanchuan Group</td>
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<td>Guandaokou Group</td>
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<td>Changchengian</td>
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<td>upper palaeozoic</td>
<td>Shishuyuan Formation</td>
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<td>Lower Paleozoic</td>
<td>Baoshuping Formation</td>
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<td>Xiaozhai Formation</td>
<td>Andalusite mica quartz schist formation</td>
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<td>Erlangping Group</td>
<td>Shallow metamorphic intermediate-basic volcanic rock with clasolite and carbonate series</td>
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<td>Xiah Group</td>
<td>Felsic schist -- calc silicate rock</td>
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<td>Majiacun Formation</td>
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<td>Xiaguan Formation</td>
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<td>Gaogou Formation</td>
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<td>Nanwan Formation</td>
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<td>Zoujiangou Formation</td>
<td>Mica quartzose schist – plagioclase hornblende schist -- marble</td>
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<td>Guishan Formation</td>
<td>Garnet two mica quartz schist – marble -- plagioclase amphibolites</td>
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</table>
1.3 Magmatic activity

The magmatic activity develops in Funiushan area, and it is the product of specific stages and environmental condition in the orogenic process and evolution history of the Qinling orogenic belt. During the long geological evolution, magmatic activity is frequent and intense with the characteristics of obvious multi-period and multi-cycle. Therefore, magmatic rock whether intrusive rock or extrusive rock, exposes a lot with extensive distribution and various types, ranging from ultrabasic rock, basic rock, intermediate rock, acidic rock to alkali rock. The distribution of magmatic rock is generally in line with the regional tectonic line, showing approximately EW or NE direction, most of them can be appeared in forms of stock, dike, vein, etc, while some in forms of batholiths and laccolith. According to the results of rock mass geology and isotope chronology, the period of magmatic rocks in the region can be divided into Lvliang period, Jinning period, Caledonian period, Variscan period, Yanshan period, etc; The rocks in Funiushan area are mainly intermediate-acid rock, basic and ultrabasic rocks have a small distribution. In the north of Shangnan-Danfeng Fracture Belt and south of Zhuyangguan-Xiaoguan Fracture Belt, collisional granite major orogenic period is dominated, combining with subducting granite. In the north of Zhuyangguan-Xiaoguan Fracture Belt, subducting granite in major orogenic period and intra-plate granite in intra-plate orogenic period are dominated.

1.4 Evolution of the regional geology

Funiushan Geopark lies in the core part of east section of Qinling Orogenic Belt of China Central Orogenic System. It is an important region where the compound continental orogenic belt occurred subduction and collision, convergence and joint, uplift orogenic, and it is also a region where the geoheritage have been systematically and well preserved, and the region has a long history of geological evolution. According to regional geological evolution history, tectonic evolution in the continental margin of North China plate and intra-plate orogenesis have laid the foundation for geomorphic pattern and rudiment of geomorphologic landscape. The range of Funiushan is formed by the convergence, subduction, collision, suture and uplift of North China paleoplate and Yangtze Paleoplate in major orogenic epoch. Before, on the crystalline basement
of Neoarchean and Paleoproterozoic, Mesoproterozoic continental rift and Neoproterozoic-early Paleozoic backarc small oceanic basin evolutionary process have been gone through. In the postorogenic extension stage of late cretaceous period, the Funiushan area is mainly intense intracontinental magma intrusion activities and the formation of intermountain basins, such as some “red-bed basin” (Xixia basin, Xiaguan basin, Tantou basin, etc) distributing between the fault-block mountain in the forms of strip, and remarkable cretaceous dinosaur-egg fossil group are reserved in this place. Since the Himalayan movement and the new tectonic movement, the mountainous region has been in strong upwarding process, the earth’s crust was intermittently raised and fracture, with multiple denudation, leveling and accumulation, forming the present obvious terrace features of Funiushan area and developing 5 levels of erosion basis. I-level erosion basis, located above the altitude of 2000m, is the commanding height of the region, for example, Laojunshan (2197m), Jijiaojian (2212.5m), Yuhuangding (2211.6m), etc. These granite peaks expand in NW-SE direction, forming the main ridge of the Funiushan; II-level erosion basis, located above the altitude of 1500m, is mainly granite peak cluster landscape, and there are hanging valley, waterfalls, hydraulic drop, pothole and pond among the peak cluster; III-level erosion basis, located above the altitude of 800m, is middle-low mountain terrain, there are landforms including laccolithic mountain, narrow gorge, hydraulic drop, karst cave and riverine lake; IV-level erosion basis is located above the altitude of 500m, the geomorphic type is dominated by fold and block mountains, and there is fault valley, klippe, karst cave and waterfalls, etc; V-level erosion basis, located above the altitude of 200m, is mainly low mountain hilly terrain, and heritages like cretaceous dinosaur-egg fossil group are mainly reserved in the red-bed basin.

2 Listing and description of geosites within the proposed Geopark

2.1 List of representative geosites

<table>
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<tr>
<th>SN</th>
<th>Geosites</th>
<th>Significance</th>
<th>Use</th>
<th>The types of geoheritage</th>
<th>Total</th>
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### 2.2 Description of geosites

#### G01 Nanyangosaurus zhugeii Fossil Locality

In the upper cretaceous Xiaguan Formation, Angou village, Neixiang County, an incomplete dinosaur skeleton with the length of 4.5m was discovered, including partial dorsal vertebra and ischium, complete sacral vertebra, most of caudal vertebra and relatively complete anterior hind limbs, the dinosaur was named as “Nanyangosaurus zhugeii” by Xuxing, Zhao Xijin, etc (2000).

#### G02 Baotianmansaurus henanensis Fossil Locality

In the middle-lower part of upper cretaceous Xiaguan Formation, Wugangcun, Neixiang County, dinosaur fossils were discovered including 1 incomplete anterior vertebral body (the third notocentrum), 1 mid-posterior vertebral body, 5 dorsal ribs, 1 sacral vertebra body, 1 incomplete anterior vertebral body and shoulder blade, the dinosaur was named as “Baotianmansaurus henanensis” by Zhang Xingliao, Lv Junchang, etc (2009).
**G03 Zhoujiagou Dinosaur Fossil Locality**

In the middle-lower part of upper cretaceous Majiacun Formation, Zhoujiagou village, Xixia County, the dinosaur skeleton fossils including dorsal vertebra, partial girdle and posterior limb were discovered, and the dinosaur was named as “Xixianykus zhangi” by Xu Xing, Wang Deyou, etc (2010); and some skeletons of the hadrosaur dinosaur were named as “Zhanghenglong yangchengensis” by Xing Hai, Wang Deyou, etc (2014); In addition, fossils including tooth of Carnosauria, maxillary teeth of hadrosaurids were also discovered.

**G04 Xixiasaurus henanensis Fossil Locality**

In the stratum of upper cretaceous Gaogou Formation, Zhaoying Village, Xixia County, an upper jaw bone was discovered, and it was named as Xixiasaurus henanensis by Lv Junchang, Xu Li (2010), it was the first troodontids fossil discovered in China.

**G05 Beibeilong sinensis Fossil Locality**

In the stratum of upper cretaceous Gaogou Formation, Zhaoying village, Xixia County, a dinosaur embryonic skeleton fossil symbiosised with 4 longiteresoolithus xixiaensis which were bilayer distribution were discovered, the lengths of each dinosaur egg and skeletal fossil are 43cm and 118cm respectively, the tail was missed, and it was named “Baby louie” (1996), it was the first time that embryos fossil was discovered in longiteresoolithus. It was discovered by local villagers in 1993, and then lost to the United States. Finally, it was shipped back to China until December 19, 2013 and donated to the Henan Geological Museum.

**G06 Sanlimiao Dinosaur-egg Fossil Locality**

In the middle and top part of upper cretaceous Majiacun Formation, Sanlimiao village, Xixia County, a large number of dinosaur egg fossils were discovered, including Dentroolithus sanlimiaensis, Dentroolithus dendriticus, Paraspheeroolithus sp., Paraspheeroolithus irenensis and so on. The Dinosaur-egg Site Museum has already been built.

**G07 Yangcheng Dinosaur-egg Fossil Locality**

In the middle-top part of upper cretaceous, Gaogou Formation, Fanying, Liuying, Zhaoying, Zhangtang villages, Xixia County, the world’s rarest dinosaur-egg fossils were reserved including Longiteresoolithus xixiaensis, Prismatoolithus gebiensis and etc; There were abundant dinosaur-egg fossils in the strata of upper cretaceous, Majiacun Formation, Yangcheng town, including Paraspheeroolithus, Paraspheeroolithus irenensis, Faveoloolithus and Dendroolithus.

**G08 Miaoshan Dinosaur-egg Fossil Locality**

In the stratum of upper cretaceous Gaogou Formation around Miaoshanshui village, Xixia County, the world rarest dinosaur eggs fossil such as Longiteresoolithus xixiaensis and other types were discovered, accompanied by more dinosaur bone fossils.

**G09 Hetaoshu Dinosaur-egg Fossil Locality**

Dinosaur egg fossils in Hetaoshu village, Xixia County were mainly heterochthonous burial types, dinosaur egg fossils discovered in the lower part of upper cretaceous Gaogou Formation were Faveoloolithus and Dentroolithus, Youngoolithus.

**G10 Xiaguan Dinosaur-egg Fossil Locality**

In the prunosus and brownish red sandy mudstone of upper cretaceous Xiaguan Formation, Houzhuang village, Neixiang County, dinosaur-egg fossils such as Youngoolithus xiaguanensis were discovered, and a rare dinosaur footprint was found in fossil with a nest of 16 dinosaur eggs.

**G11 Shijiawan Dinosaur footprint Fossil Locality**

In the stratum of upper cretaceous Xiaguan Formation around Shijiawan village, Neixiang County, a kind of sauropods fossil was found, later it was identified as *Eubrontes* (undefined species).

**G12 Neixiangoolithus yani Fang Fossil Locality**

In the stratum of upper cretaceous Xiaguan Formation (it was called Sangping Formation by original author) around Qiliping village, Neixiang County, a nest of alligator egg fossils with more than 30 small round eggs were discovered, each egg was 5.5×5cm, it was named as Neixiangoolithus yani by Fang Xiaosi and other professors (2007).

**G13 Protornithoolithus tumendongensis Fossil Localit**

In the stratum of upper cretaceous Majiacun Formation (it was called Zhaoying Formation by original author), north of Tumendong village, Xixia County, the bird-egg fossil was discovered, with the shape of small half-long egg, and the length was 4cm, it was named as Protornithoolithus tumendongensis by Fang Xiaosi and other professors (2007).

**G14 Sanlimiao Relics Fossil Locality**

The vestigiofossils in the river and lake deposit of upper cretaceous Majiacun Formation,
Sanlimiao village, Xixia County, were more developed, professors from Henan Polytechnic University has surveyed that there were 7 families, 13 genera fossils including *Beaconites coronus*, *Beaconites antarcticus*, *Palaeophycus tubularis*, etc (2004, 2007).

**G15 Tianbao Palaeoinvertebrates Fossil Locality**
In the griotte of palaeoproterozoic Yanlinggou Formation, Tianbao village, Xixia County, Henan Regional Geological Survey Team (1973) has collected some fossils including *Scolecodonta* and *Chitinozoa* with some microfossil plants. It is the only place that discovering this type of fossils in Qinling groups.

**G16 Tuanyuan Palaeoinvertebrates Fossil Locality**
In the griotte of palaeoproterozoic Yanlinggou Formation, Tianbao village, Xixia County, Lao Ziqiang and other professors collected radiolarian (7 families, 14 species) and phytoplankton fossils; the Fourth Team of Henan Institute of Geological Survey collected metacrinus stem fossil in 1987; Wang Naiwen collected conodonts and tabulata fossils in 1989.

**G17 Fanying Palaeoinvertebrates Fossil Locality**
In the milldle-lower stratum of upper cretaceous Gaogou Formation, Fanying village, Xixia County, invertebrate fossils including bivalves (8 families), ostracodas (6 families) and gastropods (4 families) were discovered by Henan Academy of Land and Resources Sciences and the Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences (Wang Deyou, etc, 2006; Pan Huazhang, etc, 2007; Chen Jinhua, etc, 2007; Cao Meizhen, etc, 2011).

**G18 Ligou Palaeoinvertebrates Fossil Locality**
In the milldle stratum of upper cretaceous Majiacun Formation, Ligou village, Xixia County, invertebrate fossils including bivalves (4 families), ostracodas (12 families, 20 species) and gastropods (1 species) were discovered by Henan Academy of Land and Resources Sciences and the Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences (Wang Deyou, etc, 2006; Pan Huazhang, etc, 2007; Chen Jinhua, etc, 2007; Cao Meizhen, etc, 2011) and China Geological Museum (Fang Xiaosi, etc, 2007; Pang Xiaqing, etc, 2008).

**G19 Shijiawan Palaeoinvertebrates Fossil Locality**
In the stratum of upper cretaceous, Xiaguan Formation, Shijiawan village, Neixiang County, invertebrate fossils including bivalves (4 families), ostracodas (12 species) and gastropods (1 species) were discovered by Henan Academy of Land and Resources Sciences (Wang Deyou, etc, 2011).

**G20 Caogou Ostracoda and Charophyta Fossil Locality**
In the top stratum of upper cretaceous Shigou Formation, Caogou village, Xixia County, 6 species of Ostracoda fossils such as *Talicypridea* sp., square-type *Talicypridea* (conformis), etc and 4 species of Charophytas such as *Mesochara voluta* Grambast and *Aclistochara jilinensis*, etc were discovered by Henan Academy of Land and Resources Sciences and the Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences (Wang Deyou, etc, 2006).

**G21 Ligou Paleobotany Fossil Locality**
In the milldle stratum of upper cretaceous Majiacun Formation, Ligou village, Xixia County, 9 species of paleobotany fossils such as *Otozamites* sp., *Ginkgoites*, sp., *Pseudofrenelopsis* sp. etc were discovered by Henan Academy of Land and Resources Sciences and the Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences (Wang Deyou, etc, 2006).

**G22 Shijiawan Paleobotany and Charophyta Fossil Locality**
In the stratum of upper cretaceous Xiaguan Formation, Shijiawan, Xixia County, 6 species of paleobotany fossils such as *Pseudofrenelopsis papillosa*, *Pseudofrenelopsis* sp., etc and 6 species of charophyta such as *Aclistochara*, *Aclistochara*, A. *mundula* Peck, etc were discovered by Henan Academy of Land and Resources Sciences (Wang Deyou, etc, 2006).

**G23 Fanying Charophyta Fossil Locality**
In the lower stratum of upper cretaceous Gaogou Formation, Fanying village, Xixia County, 6 species of Charophyta such as *Mesochara voluta* Grambast, *Aclistochara* sp., *Aclistochara jilinensis*, etc were discovered by Henan Academy of Land and Resources Sciences and the Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences (Wang Deyou, etc, 2006).

**G24 Yakou Charophyta Fossil Locality**
In the top stratum of upper cretaceous Majiacun Formation, Qiyu village, Xixia County, 3 species of Charophyta such as *Mesochara voluta* Grambast, *Aclistochara* sp., *Aclistochara mundula* Peck, etc were discovered by Henan Academy of Land and Resources Sciences and the Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences (Wang Deyou, etc, 2006).

**G25 Guozhuang Formation Holostratotype Section**
Located in the south of Guozhuang Village, Neixiang County, Guozhuang Formation Holostratotype Section was surveyed by the Henan Regional Geological Survey Team in 1981, and it is also name foundation place of Guozhuang Formation; the main lithologic characters are migmatization garnet biotite plagioclase gneiss, plagioclase hornblende gneiss, gneiss with diopside plagioclase hornblende and dolomitic marble; It was in conformable contact with upper Yanlinggou Formation and the bottom wasn’t be seen; It is the component of the crystalline diamictite basement of Qinling Orogenic Belt, belonging to early proterozoic.

G26 Yanlinggou Formation Lectostratotype Section
Located in Luotuogou, Xixia County and Huangjin, Neixiang County, Yanlinggou Formation Lectostratotype Section was surveyed by the Fourth Team of Henan Institute of Geological Survey in 1987; the main lithologic characters are thick-layer graphite marble, marble, strip with quartz or block mass and carbonaceous marble; The base of Yanlinggou Formation Lectostratotype Section is in conformable contact with Guozhuangyan Formation, and its top has a faulted contact with Xiaozhai Formation; it is the component of the crystalline diamictite basement of Qinling Orogenic Belt, belonging to early proterozoic.

G27 Yanlinggou Formation Hypostratotype Section
Located in Maizishan, Neixiang County, Yanlinggou Formation Hypostratotype Section was surveyed by Beijing Geological College in 1960; the main lithologic characters are thick-layer graphite marble, marble, strip with quartz or block mass and carbonaceous marble; the base of Yanlinggou Formation Hypostratotype Section is in conformable contact with Guozhuangyan Formation, and its top has a faulted contact with Guishanyan Formation; it is the component of the crystalline diamictite basement of Qinling Orogenic Belt, belonging to early Proterozoic.

G28 Shicaogou Formation Holostratotype Section
Located in the east of Shicaogou, Shuanglong Town, Xixia County, Shicaogou Formation Holostratotype Section was surveyed by the Fourth Team of Henan Institute of Geological Survey in 1987; and it is also name foundation place of Shicaogou Formation; the exposed thickness of section is 1214.11m, the main lithologic characters are garnet sillimanite biotite plagioclase gneiss, garnet sillimanite biotite two-feldspar gneiss, sillimanite gneiss, diopside granulite and marble; it cannot be seen on the top, and the base of Shicaogou Formation Holostratotype Section is in conformable contact with Yanlinggou Formation; it is the component of the crystalline diamictite basement of Qinling Orogenic Belt, belonging to early proterozoic.

G29 Zhaigen Formation Holostratotype Section
Zhaigen Formation Holostratotype Section is located in Zhaigen village, Xixia County, which is also name foundation place of Zhaigen Formation, and it was named by Professor Lao Ziqing in 1989 and was re-surveyed by Henan Regional Geological Survey Team in 1993; the main lithologic characters are garnet two mica quartz schist, biotite quartz schist, hornblende schist with a few thin layer marble and quartzite; It is in fault contact with the underlying Qinling Gr., and is in disconformable coverage with the overlying Jiepai Formation, and it belongs to meso-proterozoic .

G30 Jiepai Formation Lectostratotype Section
Jiepai Formation Lectostratotype Section is located in Jiepai village, Xixia County, which is also name foundation place of Jiepai Formation, and it was named by Professor Yan Lianquan in 1959 and was re-surveyed by Henan Regional Geological Survey Team in 1993; the main lithologic characters are white banded marble, biotite calcareous quartz schist, hornblende schist and cordierite tuberculate schist, mica calcareous quartz schist, the base of Jiepai Formation Lectostratotype Section is in conformable contact with Zhaigen Formation; it belongs to Meso-proterozoic era.

G31 Meiyaogou Formation Holostratotype Section
Meiyaogou Formation Holostratotype Section is located in Meiyaogou, east of Luanchuan County, which is also name foundation place of Jiepai Formation, and it was surveyed by the Third Geology Team of Henan Province in 1978; the main lithologic characters are quartzite, two-mica schist, dolomite marble, Marble containing stromatolites with magnetite mica schist and stone-cike coal; the base of it is in conformable contact with Nannihu Formation and its top is conformable covered by Dahongkou Formation; it belongs to Jixianian Period.

G32 Damiao Formation Holostratotype Section
Damiao Formation Holostratotype Section is located in Damiao village, Xixia County, which is also name foundation place of Damiao Formation, and it was named by Professor Jin Shouwen
in 1973 and was surveyed by the Measurement Team of Henan Province in 1973; the main lithologic characters are marble, biotite silicious slate, quartz keratophyre, feldspar quartz sandstone, spilite, tuffaceous sandstone, glutenite, etc; the top of it is in conformable contact with Huoshenmiao Formation and the bottom cannot be seen; it belongs to early palaeozoic.

**G33 Huoshenmiao Formation Holostratotype Section**
Huoshenmiao Formation Holostratotype Section is located Huoshenmiao village, Xixia County, which is also name foundation place of Huoshenmiao Formation, and it was named by Professor Jin Shouwen in 1973 and was surveyed by the Measurement Team of Henan Province in 1973; the main lithologic characters are a set of thick layers of spilite, spilitic porphyrite with tuff; The base of it is in conformable contact with Damiao Formation and its top is conformable covered by Xiaozhai Formation; it belongs to early Palaeozoic.

**G34 Zhoujingou Formation Holostratotype Section**
Zhoujingou Formation Holostratotype Section is located in Zhoujingou, Xixia County, which is also name foundation place of Zhoujingou Formation, and it was surveyed by the Measurement Team of Henan Province in 1973; the main lithologic characters are two mica (white mica) quartz schist, calcareous two mica quartz schist, two mica muscovite schist with quartzite, leptite, silty metamorphic, etc; it is all in faulted contact with the south of Douling Gr., the east of Nanwan Formation and upper cretaceous; it belongs to early palaeozoic.

**G35 Shishuyuan Formation Holostratotype Section**
Shishuyuan Formation Holostratotype Section is located in Zhoujingou, Xixia County, which is also name foundation place of Zhoujingou Formation, and it was surveyed by the Measurement Team of Henan Province in 1986; the main lithologic characters are sericite quartz schist, metamorphic quartz sandstone and porphyritic biotite quartz schist, carbonaceous sericite quartz schist; it is all in faulted contact with the south of Huoshenmiao Formation, the north of Kuanping Gr.; it belongs to late palaeozoic devonian.

**G36 Yangqigou Ultrabasite**
Located in Yangqigou, Xixia County, Yangqigou Ultrabasite emplaced meso-neoproterozoic erathem Xiahe Gr. in the east of Shangnan-Danfeng fracture Belt. Affected by the tectonism, the rock is deformed strongly, forming different scale mylonite belt, schistositized zone and cataclasite; The rock mass is composed of dunite, harzburgite, bixtagit and garnet plagioclase hornblende schist, and is the ocean floor piece of ancient Qinling ocean, it represents that east Qinling have existed Meso-Neoproterozoic finite extension small ocean basin, and gone through convergence and joint of Ocean-land interaction in Jinning period, which is a very precious geological relic.

**G37 Dehe Gneissic Monzonitic Granite**
Located in Dehe, Xixia County, Dehe Gneissic Monzonitic Granite emplaced meso-neoproterozoic erathem Xiahge Gr., paleoproterozoic Qinling Gr. in the east of Shangnan-Danfeng fracture Belt. Affected by the tectonism, the rocks are all deformed strongly with gneissosity develop; the main lithologic characters are gneissic porphyaceous biotite monzonitic granite, which has the mineralogical characteristics of typical S-type granite. It represents the product of the early intense convergence main collision orogenic stage. It is of great significance to study the tectonic evolution of Qinling orogenic belt.

**G38 Xizhuanghe Plagiogranite**
M-type granite which named as Xizhuanghe plagiogranite was founded in Xizhuanghe, Xixia County in 1984, and it is EW direction with long strip, which is consistent with the development of the regional tectonic line. It emplaced early palaeozoic Erlangping group marine facies basic volcanic rocks in Caledonian period; the main lithologic characters are fine medium plagiogranite, plagiogranite close symbiosis with basic volcanic rock of Erlangping group ophiolite. It is the component (light color composition) of Erlang ping Group backarc small oceanic basin ophiolite. The formation of the rock mass was in the middle and late period of early palaeozoic (Ordovician-Silurian), and was magmatic activity product of volcanic arc or nascent ocean, and it is the only M-type plagiogranite of Qinling orogenic belt.

**G39 Wuduoshan Monzonitic Granite**
The rock is one of the large scale complex plutonites (444~480Ma), the lithologic characters are mainly monzonitic granite, distributing mostly in Baotianman region, the north of Neixiang County; it emplaced paleoproterozoic Qinling Gr., early palaeozoic Erlangping group in Caledonian period; According to the structure, mineral composition and contacting relation of
rocks. Wuduoshan Monzonitic Granite can be divided into fine medium biotite monzonitic granite unit and medium spotted fine medium biotite monzonitic granite unit.

**G40 Toudaohe Monzonitic Granite**

Located in northwest of Doudaohe, Neixiang County, the granite expands along Zhuyangguan-Xiaguan fracture belt in NW-SE direction with banded shape, it emplaced early palaeozoic Baoshuping group in Caledonian period; the lithologic characters are medium fine granular monzonitic granite, affected by the tectonism, strong partial mylonitize forms granitic mylonite.

**G41 Laojunshan Monzonitic Granite**

Laojunshan Monzonitic Granite emplaced lower palaeozoic erathem Erlangping group or meso-neoproterozoic erathem Kuanping Gr. along the south and north of main ridge line of Funiushan, belonging to Laojunshan rock mass in late Yanshanian, the lithologic characters are medium spotted medium granular monzonitic granite, forming in early cretaceous.

**G42 Huanghuaman Monzonitic Granite**

Located in the north off Zhuyangguan-Xiaguan fracture belt, Huanghuaman Monzonitic Granite emplaced lower palaeozoic erathem Xiaozhai Formation in the shape of roundness and oval. It is composed of two groups of rock, the main lithologic characters are monzonitic granite; of which, the external rock is medium spotted fine medium granular biotite monzonitic granite, while the internal rock is fine medium granular biotite monzonitic granite; the forming age was early cretaceous.

**G43 The tectonic relics of Shangnan-Danfeng Fracture Belt**

Shangnan-Danfeng Fracture Belt is structural suture zone of North China plate and Yangtze plate and boundary fracture dividing the south and north of ancient China; About 290 million years ago, the Yangtze plate subducted and welded to the North China plate, thus forming the Shangnan-Danfeng fracture belt; In the geopark, it is exposed along Xiguan village and Shilongyan of Xixia County, Fuziya and Mashankou of Neixiang County, and is composed of many ductile and fragile tectonic belts formed in different stages, with the width ranging from 1 to 10 km, the strata involved are paleoproterozoic erathem Qinling Gr., meso-neoproterozoic erathem Xiahe Gr., neoproterozoic erathem Guishan Gr., Devonian system Nanwan Formation, cretaceous system, etc. It is an important fracture belt for studying the tectonic evolution of North China plate and Qinling orogenic belt.

**G44 The tectonic relics of Luanchuan Fracture Belt**

Luanchuan Fracture Belt is an important geological boundary in the tectonic framework of China, and it links to Luoran Fracture Belt in Shaanxi province and connects to Feizhong Fracture Belt in Anhui province, the total length is 1200 km; It exposes along Heigou – Luanchuan – Queshan -- Gushi in Henan province, with the length of 540km; The fracture belt was formed in paleo- mesoproterozoic era, it was composed of a series of fractures that were parallel, diagonal, interwoven and bifurcated, which were nearly EW banding distribution, and the width are tens to hundreds of meters; the fracture belt characterized by multi-stage activities can be divided into mylonite belt, lenticular-foliated tectonic belt and cataclastic tectonic belt, it is an important fracture belt to study the tectonic evolution of North China plate and Qinling orogenic belt, with high scientific value.

**G45 The tectonic relics of Zhuyangguan-Xiaguan Fracture Belt**

Zhuyangguan-Xiaguan Fracture Belt starts from the boundary between Henan and Shaanxi province in the west, through Zhuyangguan in Lushi County, Junmahe in Xixia County, Xiaguan in Neixiang County to the east of Liuquanpu in Zhenping County, then immerse into Nanyang Basin; it consists of multiple fractured assemblages that are paralleled and branch compounded with the belt. The width is 2~3km, and is the boundary fracture between the Erlangping Gr and Qinling Gr. of Qinling orogenic belt; Ductile shear belt is characterized by large scale, long term activity and multi-stage structure superposition, and it is the most powerful ductile shear belt in the orogenic belt. In the geopark the development is mainly in the mountainous area, the stratum on the north and south sides of the fracture rise steeply, within the fracture belt there develop squeezing lenticle, tectonic crumple, mylonite, etc.

**G46 The tectonic relics of Mujiaya-Neixiang Fracture Belt**

Mujiaya-Neixiang Fracture Belt shows NWW direction in Henan province, and distributes along Mujiaya (Xixia) – Neixiang – Tongbai – Shangcheng, hundreds of meters wide broken belt, mylonite, kataclasite, schistosity, secondary fracture are comparatively developed. Near the bat
cave, the passed part of fracture belt formed shaping deformation belt and sheath folds and other tectonic relics.

**G47 The tectonic relics of Waxuezi-Qiaoduan Fracture Belt**

Waxuezi-Qiaoduan Fracture Belt was formed in the Neoproterozoic -- early Paleozoic, it starts from Shaanxi province, through Waxuezi in Lushi County, and Qiaoduan in Nanzhao County to Minggang in Xinyang City, the total length is over 300 km, it is the fracture belt composed by multiple paralleled fractured assemblages, of which the exposed width of mylonite belt and lenticular -- schistositized belt reach more than 400 meters, with the characteristic of thrusting from the north to south. Waxuezi-Qiaoduan fracture belt is the boundary fracture between the Kuanping Gr. (mes-neoproterozoic erathem) and Erlangping Gr (lower palaeozoic erathem), the geological structure relics is rich and typical, which plays an important role in the study of the tectonic evolution of the qinling orogenic belt, which is of great scientific value.

**G48 The Watershed Syncline Structure**

The Watershed Syncline Structure is located beside the G311 national highway in Tianbao Village, Xixia County, and this syncline is wide and gentle with EW distribution, the attitude of rock formation which the two edges incline to slot part is gentle, the slot part is composed of huge thick marble with garnet sillimanite biotite two-feldspar gneiss which belonging to Yanlinggou Formation, Qinling Gr. of palaeoproterozoic erathem.

**G49 Qinkou Inverted Anticlinal Structure**

Qinkou Inverted Anticlinal Structure is located beside the G311 national highway in the north of Qinkou, Xixia County, and it is steep inverted anticline with same inclination, of which the axis is in EW direction and axial surface is north tending to south inverted, its core part is composed of huge thick marble with thin quartzite which belonging to Yanlinggou Formation, Qinling Gr. of palaeoproterozoic erathem.

**G50 Laojieling Granite Landform**

Located in taiping town, Xixia County, the parent rock of Laojieling was Laojunshan rock mass in Yanshan period, the granite rock mass is extruded by the nappe tectons fracture in late orogenic belt to form steep and slow two sets of cross joint systems, then in the process of Funiushan rapidly uplift, through long-term tectonic denudation, unique serrated or arrowed peak cluster were formed, which was typical granite landform of Qinling orogenic belt. In addition, there were also some granite peak pillars (such as Qingren Peak, Jiangjun Peak, etc.), pictographic stones landscape (such as Funiushan God, “go on a pilgrimage for the Buddhist Scriptures”, etc.).

**G51 Baotianman Granite Landform**

Located in Xiaguan town, Neixiang County, the parent rock of Baotianman Granite Landform was Wuduoshan rock mass in caledonian period, approximately horizontal and steep primary joint development. In the process of Funiushan rapidly uplift, besides some granite peak cluster were formed, due to cracking and the gravity collapse along both sides of vertical joint, a peak wall with the fall reaching tens or even hundreds of meters was also formed, liking a camel look back.

**G52 Qixingtan Granite “pile-up stones”**

Located in Qiliping, Neixiang County, the parent rock was Wuduoshan rock mass in caledonian period, primary vertical joint and horizontal joint developed. In the process of Funiushan rapidly uplift, with the rock body reducing loads and releasing pressure, through adjusting for equilibrium, the rock expanded elastic playback, forming approximately horizontal sheet cracking structure. A peculiar “pile-up stones” were formed through weathering and denudation, which is unique granite landform of Qinling orogenic belt.

**G53 Huanghuaman Granite Waterfall**

Exposed in the area of Erlangping, Xixia County, Yanshan period Huanghuaman rock intruded into extensional stage of the post-orogenic period 90 million years ago, the rock showed sheet joint development, through the weathering and denudation, a smooth and steep palisades was formed. Natural precipitation and humic acid water in the soil layer of plant roots have eroded several grooves on the granite palisades, and it extended from the top to the foot of the mountain, liking great waterfall falling from the sky.

**G54 Laojunshan Granite Landform**

Located in the south of Luanchuan County, the parent rock was Laojunshan rock mass in Yanshan period, through the nappe tectonics of Qinling orogenic belt, the rock mass was pushed from north to south, forming a tension-shear fracture system perpendicular to the principle stress plane, granite body
that located in the front of nappe occur gravity sliding, through long-term weathering and denudation, it formed granite peak cluster, peak forest landforms on Laojunshan, and local people call Laojunshan as “stone forest”, which is unique granite landform of Qinling orogenic belt.

**G55 Longyuwan Granite Landform**
Located in Longyuwan, Luanchuan County, the parent rock was Laojunshan rock mass in Yanshan period, various primary and secondary joints developed. In the process of Funiushan rapidly uplift, through long-term weathering and denudation, granite peak cluster including Jijiaojian (the highest peak of Funiushan, altitude 2212.5m) were formed, lining up along the main ridge line of Funiushan, and it was called “nine planets into a straight line peak”, forming the watershed of the Yangtze river and the Yellow River in the central plain area. Meanwhile, a high-drop, high-angle fault cliff was also formed, which was extremely spectacular.

**G56 Baiyunshan Granite Landform**
Located in Baihe town, Song County, the parent rock of Baiyunshan was Laojunshan rock mass in Yanshan period, various primary and secondary joints developed. Through the nappe tectonics of Qinling orogenic belt, the rock mass was pushed from north to south, in the process of Funiushan rapidly uplift, through long-term weathering and denudation, granite peak cluster including Yuhuangding (the main peak, altitude 2211.6m) were formed in Longyuwan, meanwhile, a high-drop, high-angle fault cliff was also formed.

**G57 Muzhaling Granite Landform**
Located in Checun town, Song County, the parent rock of Muzhaling Granite Landform was Funiushan rock mass in Yanshan period, various primary and secondary joints developed. The spheroidal weathering and the sheet fracturing were obvious, through long-term weathering and denudation, pictographic mountains or image stone such as Guanmao Peak, Sanjiangjun Peak, Zhonghuashima Peak, Shiji Peak were formed in Muzhaling, meanwhile, a high-drop, high-angle fault cliff was also formed.

**G58 Zhenwuding Granite Landform**
Located in Checun town, Song County, the parent rock of Zhenwuding Granite Landform was Funiushan rock mass in Yanshan period, various primary and secondary joints developed. In the process of Funiushan rapidly uplift, through long-term weathering and denudation, geomorphologic landscape group such as Giant Column, Peak Forest and Peak cluster were formed in Zhenwuding.

**G59 Yunloushan Granite Landform**
Located in Mashankou, Neixiang County, the parent rock of Yunloushan Granite Landform was Wuduoshan rock mass in Caledonian period, various primary and secondary joints developed. In the process of Funiushan rapidly uplift, through long-term weathering and denudation, block mountains such as Baotashan and Guangtushan and granite peak cluster landforms were formed in this area.

**G60 Tianxin Cave Karst Landform**
Located in Qiliping, Neixiang County, the parent rock of Tianxin Cave was griotte with graphite formed in early palaeozoic. Affected by the tectonism of Zhuyangguan-Xiaguan Fracture Belt and underground water corrosion, besides stalactite landscape such as stalagmite, columns, cave shield, curtain and waterfall, various structural traces and textures formed a number of various patterns of rock paintings on the cave wall, which was unique karst landform of Qinling orogenic belt.

**G61 Yunhua (Bat) Cave Karst landform**
Located in Wuliqiao, Xixia County, the parent rock of Yunhua (Bat) Cave was composed by depositional clastic rocks, carbonatite, etc (Zhoujingou Formation) of littoral-shallow sea. Affected by the tectonism of Mujiaya-Neixiang Fracture Belt and underground water corrosion, except for stalactite in different shapes, various structural traces and textures also formed a number of various patterns of rock paintings on the cave wall, which was unique karst landform of Qinling orogenic belt.

**G62 Jiguan Cave Karst Landform**
Located in Jiguanshan, 3km west of Luanchuan County, Jiguan Cave was formed nappe carbonate tectonic slice in lower Paleozoic, affected by the tectonism of Luanchuan Fracture Belt and Yihe valley underground water corrosion, step karst cave with the length of 5600m and fall of 138m and stalactite landscapes such as stalagmite, cave flag, curtain and waterfall, cave shield were formed. The temperature in the cave is 18°C all the year round, “Non-gravity water” such as water vapor, pellicular water and capillary water which is rich in calcium ion, forms crystal
needle and cave flower and other landscapes, it was honoured as “the first cave in north China”.

**G63 Lotus Cave Karst Landform**

Located in Dufuling, Xixia County, the parent rock of Lotus Cave was composed by paleoproterozoic griotte and etc. Affected by the tectonism of Zhuyangguan-Xiaguan Fracture Belt and underground water corrosion, karst cave with the height of 7m and an area of 3500m² was formed, and the stalactites developed in the cave are in different shapes, the cave is so named because one of giant stalactite resembles the lotus in bud.

**G64 Funiu underground river Karst Landform**

Located in Xiaoshui village, Xixia County, the parent rock was composed by paleoproterozoic griotte and etc. Affected by the tectonism of Zhuyangguan-Xiaguan Fracture Belt and underground water corrosion, underground river with the length of over 500 was formed, stalactites in different shapes were developed on both sides of the river.

**G65 Laojun Cave Karst Landform**

Located in Damiao village, Xixia County, the parent rock was composed by early Paleozoic griotte and etc. The groundwater has occurred long-term corrosion along the tectonic fissures, forming the Laojun Cave. Various stalactites were developed in the cave.

**G66 Erlangping pillow-shaped Volcanic Lava Landform**

Located in Wantan village, Xixia County, Erlangping pillow-shaped Volcanic Lava Landform was composed by basic volcanic lava and volcanic sedimentary rock in Lower Paleozoic Huoshenmiao Formation, Erlangping Group. The lava presented a pillow-shaped ellipsoid and stacked on top of each other.

**G67 Shimen Lake Reversed Fold Mountain Landform**

Located in both sides of Shimen Lake, Wuliqiao town, Reversed Fold Mountain was double inverted anticlinal structure that Paleoproterozoic Qinling Gr. Yanlinggou Formation griotte occurred thrust-nappe in late major orogenic period of Qinling orogenic belt, which was the typical example of Reversed Fold Mountain Landform in Qinling orogenic belt.

**G68 Longtangou Fluvial Landform, Pools and Waterfalls**

Located in Longtangou, Xixia County, influenced by the crust periodic uplift for 65 million years, Xizhuanghe River, branch of Sheweihe River conducted long-term fluvial erosion on riverbed constituted by Huahuaman rock mass in Yanshan period along the mountain, forming 72 pools and 19 waterfalls landforms.

**G69 Wudaozhuang Fluvial Landform, Pools and Waterfalls**

Located in Wuzhuanggou, Xixia County, influenced by the crust periodic uplift for 65 million years, Wuzhuanggou water, branch of Sheweihe River, conducted long-term fluvial erosion on riverbed constituted by Huahuaman rock mass in Yanshan period along the mountain, forming 22 pools and 5 waterfalls landforms.

**G68 Qixingtan Fluvial Landform, Pools and Waterfalls**

Located in Qixingtan, Neixiang County, influenced by the crust periodic uplift for 65 million years, the upstream rivers of Qita River conducted long-term fluvial erosion on riverbed constituted by Wuduoshan rock mass in Caledonian period along the mountain, forming pothole (like Hehuan waterfall, Feilong waterfall, Feixian waterfall, Yulian waterfall, Huanying pool, Yulong pool, etc.)

**G70 Tianhe Gorge Fluvial Erosion Landform**

Located in Dajingou to Sandaohe area of the Tuanhe upstream, Neixiang County, due to the fall more than 200 meters, the river eroded in vertical and lateral at the same time, forming gorge and incised meander (S-model river turns) landscape respectively, it is an ideal place to carry out water rafting.

**G71 Jiulonghe Fluvial Landform, Pools and Waterfalls**

Jiulonghe River originated from Baiyunshan, Song County, the north of Funiushan, and was a tributary of Yangtze River basin and Han River system into the Central Plain-- one of the source waters of Baihe River. The river conducted long-term fluvial erosion on riverbed constituted by Laojunshan rock mass in Yanshan period along the mountain, forming pothole (like
Huanglongjing), pools and waterfalls (such as Zhenzhu pool, Heilong pool, Jiulong waterfall, Bailong waterfall, etc.), of which, the total fall of Jiulong waterfall, which is constituted by three-level water fall, reaches 103m.

**G74 Jiuzhuanggou Fluvial Landform, Pools and Waterfalls**
Jiuzhuanggou originated from Muzhaling, Song County, the north of Funiushan, and was a tributary of Huaihe River and one of the source waters of Shahe River. The river conducted long-term fluvial erosion on riverbed constituted by Funiushan rock mass in Yanshan period along the mountain, forming pothole (like Longjing), pools and waterfalls (such as Yuhua pool, Long pool, Jiulong waterfall, Bailong waterfall, etc.), of which, Bailong waterfall pour down along Bailongzhuang bluff, with the fall of 113m.

**G75 Baichitan Fluvial Landform, Pools and Waterfalls**
Jiulonggou, located in Cuizhuang village, Nanzhao County, was a tributary of Yangtze River basin and Han River system into the Central Plain—one of the source water of Baihe River. The river conducted long-term fluvial erosion on riverbed constituted by granite mass along the mountain, forming 6 groups of pools and waterfalls such as Baichitan waterfall, Yangjiaotan waterfall, Niumotan waterfall, Shibantan waterfall, etc, of which, the area of Baichitan is about 30m², and its deep reaches hundred feet.

**G76 Zhaigou Fluvial Landform, Pools and Waterfalls**
Zhaigou was located in 6km southeast of Luanchuan County, the branch of Yihe river conducted long-term fluvial erosion on riverbed constituted by Laojunshan rock mass in Yanshan period along the mountain, forming landforms such as pools with clear water and pouring waterfall.

**G77 Yangzigou Fluvial Landform, Pools and Waterfalls**
Yang Zigou, located in 5km west of Luanchuan County, got its name because Fan Lihua, heroine in Tang Dynasty, settled down and raised children here. Pools and waterfalls linked together were formed by the erosion of the branch of Yihe River.

**G78 Tongtianxia Fluvial Landform, Pools and Waterfalls**
Tong Tianxia, located in Miaozi town, Luanchuan County, got its name because of sheer cliffs and steep mountains and pouring waterfall in the gorge.

**G79 Shimen Lake**
Located above the gorge of Funiushan, 10km north of Xixia County, Shimen Lake was a high gorge and flat lake landscape formed on Guanhe River at the end of the last century, which was the production of Shimen water conservancy project. It is one of the important water sources of China’s south-to-north water diversion project, with the length of 15km, the width of 100~12000m, the water area of over 10000mu, and is known as “small three gorges in north China”.

**G80 Baiyun Lake**
Located in Baiyunshan, Song County, with the altitude of 1500m, Baiyun Lake was formed man-made dams impounding many small tributaries which developed in the upstream of Baihe River. The lake is clear with ripples, reflecting with leisurely white clouds and forming picturesque scenery.

**G81 Guanhe Rafting**
Guanhe River is a tributary of Danjiang River, which is 109.4 km long. Guanhe Rafting refers to a snake curve shaped watercourse in Shuahaiaguan channel segment of Guanhe River upstream, Xixia County. The river banks are filled with densely forest, the valley is deep and narrow, and the current is turbulent with large fall, so it is called “the first rafting place in the central plains”.

**G82 Debris-flow Relics at Gutangou**
Located in Gutangou, Baotianman, Debris-flow Relics at Gutangou, namely pteroceltis tatarinowii forest with stone ripraps were moved here by massive debris flow, and they grew together here afterward.

3 Details on the interest of these sites in terms of their international, national, regional or local value

3.1 The important value of geoheritage

3.1.1 Earth scientific value

Geoheritages reserved in the park are not only in various types but also rich in earth science culture connotation, especially the typical stratigraphic section, tectonic relics and geomorphologic landscape in Qinling orogenic belt and the cretaceous dinosaur egg fossil and so
on, they all have higher scientific value. It is an ideal place to study the evolution of the qinling orogenic belt, Chinese mainland and even the dinosaur extinction event.

The following aspects are the main reflection:

(1) Qinling orogenic belt, as an important part of the central orogenic system, is the natural boundary between the north and south of China in geology, geography, biology and climate, owning a prominent position in the process of Chinese mainland formation and evolution. Located in the important part of Qinling orogenic belt, Funiushan crosses three second-class tectonic units, through 2.5 billion years geological evolution, different stages of orogenic movements and geological tectonics, some typical rock stratigraphic section and structural features formed are exposed both inside and around the geopark, their continental dynamics messages are the important evidences for studying the formation, development, evolution of plates and the subduction collision orogenic process. In the study of Qinling orogenic belt or the contrast with other orogenic belts, it has typical significance in geosciences.

Figure 2-3 Recumbent fold in Paleoproterozoic Qinling Rock Group (left) and Pillow Lava in Lower Palaeozoic Erlangping Rock Group (right)

Figure 2-4 The tectonic relics of Shangan-Danfeng Fracture Belt

Figure 2-5 The tectonic relics of Zhuyangguan-Xiaguan Fracture Belt

(2) Xixia Basin, Xiaguan Basin and the Cretaceous red layer of the Tantou Basin formed in postorogenic extension stage of Qinling Orogenic Belt have reserved rich paleontological fossils such as dinosaur eggs, dinosaur, palaeoinvertebrates, paleobotany and etc., of which the dinosaur egg fossils are matchless in the world, in terms of the range of distribution, amount, variety and degree of preservation, and the Longiateresoolithus xixiaensis and Prismatoolithus gebiensis, the peculiar types in the world, are the world's rarest paleontological wonders and the treasure of natural history;
Together with the newly discovered dinosaur fossils in recent years, this area has become an important part of the world’s cretaceous dinosaur fauna, and the fossils have high scientific value and it has international significance especially in the study of paleobiology, such as the evolution of cretaceous dinosaurs and extinction, and global geological problems such as the earth cataclysm.

Figure 2-6 A staggering number of cretaceous dinosaur egg fossils in their original burying state

Figure 2-7 Longiteresoolithus xixiaensis (Left) and Prismatoolithus gebiensis (Right), the peculiar types of dinosaur egg fossils in the world

Figure 2-8 The dinosaur embryo skeletal fossils “Beibei long sinensis” first discovered in the Longiteresoolithus xixiaensis.

Figure 2-9 Superimposed reservoir of various eggs (Longiteresoolithus xixiaensis, square) Parapherooolithus, and Faveoololithus

Figure 2-10 The dinosaur footprints on dinosaur Youngoolithus Xiaguanensis (within the
Figure 2-11 The reconstruction of the skeleton of *Nanyangosaurus zhugeii* (left) and the dinosaur tooth fossils of Baryonychine discovered firstly in Asia (right)

Figure 2-12 The skeleton restorations of the *Zhanghenglong yangchengensis* (left) and the *Xixianykus zhangi* (right 1 and right 2)

Figure 2-13 The skeleton of the *Baotianmansaurus henanensis* (left) and the skeleton of *Xixiasaurus henanensis* and its restorations (right 1 and right 2)

(3) There are different genetic types of granite body with different periods and various granite landforms formed by long-term tectonic denudation and weathering, tectonic karst cave and various stalactites and tectonic rock painting formed in the hole, and waterscapes such as fluvial erosion landform, pools and waterfalls formed in the process of mountain rapid uplifting in Funiushan area. They all reflect the background of the continental orogenic belt, not only having typical geomorphology research significance, but also having higher scientific value in the study of landscape forming causes and its relationship with regional tectonic evolution process.
Figure 2-14 Funiushan granite landforms (peak cluster, waterfall, peak wall and pile-up stone, etc.)

Figure 2-15 The stalactite and tectonic rock paintings in the Funiushan karst cave

Figure 2-16 Funiushan fluvial landforms, ponds and waterfalls landscapes
3.1.2 Aesthetic values

Through long-time geological evolution and tectonic movements in different periods, Funiushan area has formed a unique geomorphic landscape especially in the park, for example, granite peak cluster/peak forest represented by Jijiaojian, Laojieling, Laojunshan, Baiyunshan, Baotianman and etc, stand on the main ridge line of the Funiushan, with majestic, rugged and steep mountain peak, weirdly shaped rock, towering cliff; Karst geomorphologic landscapes represented by Jiguan cave, Tianxin cave and Yunhua cave are known for their colorful and various shaped stalactites, the tectonic rock paintings presented on the wall of the cave are unique and beautiful; Fluvial erosion landforms and waterscapes represented by Longtangou, Qixingtan, Qiulin River and valley, Jiulong waterfall are very beautiful liking pictures, the waterfalls and green trees and mountains reflect each others; With high vegetation coverage, the beautiful natural ecological environment and a variety of biological communities are also an important part of the park’s landscapes. It is a kind of natural landscape not only having magnificent and rough northern scenery but also having the elegant and exquisite landscapes of Jiangnan, forming the unique natural landscape in the south-north climate transition zone, which has high aesthetic value.

3.1.3 The educational and scientific research values

Located in an important part of Qinling orogenic belt, Funiushan Geopark have reserved various geological relics formed by unique geotectonic background, with rich scientific significance. Therefore this geopark is a scientific research, student teaching and education base for Qinling orogenic belt and the cretaceous dinosaurs. It is of great significance for the public to explore the earth's mysteries and understand the harmonious coexistence relationship between human beings and earth environment.

Since joining the Global Geopark Network in 2006, the abundant geological relics, animal and plant resources of Funiushan Geopark have attracted universities and research institutions including China University of Geosciences (Wuhan), The institute of geology, Chinese Academy of Geological Sciences, Zhengzhou University, Henan University, Henan Polytechnic University, Henan Academy of Land and Resources Sciences, Nanyang Institute of Technology and Nanyang Normal University to establish scientific research/teaching base. With the gradually revealed of the science popularization value of the natural resources liking geological relics, Funiushan Geopark has been approved successively as “Henan Land and Resources Science Education Base” (2008), “First Batch of National Land and Resources Science Popularization Base” (2009), “National Science Education Base” (2010), and Xixia Dinosaur-egg Fossil Museum has been named as “Xixia branch, the Geological Museum of China” (2007). In addition, relying on the resource advantages of the Cretaceous dinosaur-egg fossil group and Qinling orogenic belt, two bases including Henan Xixia Dinosaur-egg Fossil Group Scientific Field Observation and Research Base and the Henan...
Luanchuan Mo-W-Pb-Zn-Ag Polymetallic Ore Scientific Field Observation and Research Base were approved to the establishment by the Ministry of Land and Resources in 2011.

All in all, with the science popularization and research and teaching activities implementing, the scientific value and function of Funiushan typical geological relics and other natural resources are gradually reflected, it is of great significance to improve the scientific and cultural level of people and promote the progress of social civilization.

3.1.4 Tourism development value

In Funiushan region, The rare geological relics, exotic landscape and abundant flora and fauna resources constitute a three-dimensional and multi-level tourism environment together; what’s more, Funiushan region has a long history and strong culture with many places of interest and historical sites, here is also the climate transitional zone between northern subtropical zone and warm temperate zone and the watershed of the Yangtze river, Yellow River and huaihe river, and combined with convenient transportation and pleasant climate, it is an ideal location to conduct geological tourism activities. Since joining the Global Geopark Network in 2006, the tourism development in the Funiushan area has become the new growth pole of natural eco-tourism industry in Henan province and the important pillar of regional economic development, thus creating necessary conditions for developing and utilizing natural resources, cultural landscape and ecological environment with high level and quality; Meanwhile, with the construction of geopark improving better, the development of tourist industry based on geological tourism will certainly have a positive role in promoting regional economic development, and it is of great significance for some poor people in Funiushan area out of poverty as soon as possible.

3.2 The comparison of important geoheritages

3.2.1 The comparison of Cretaceous dinosaur-egg fossil groups

Dinosaur-egg fossil is a very precious paleontological fossil, and it was first discovered at Cretaceous strata in Provence, southern France in 1869, then some dinosaur-egg fossis were discovered in Mongolia and China’s Inner Mongolia, Shandong, Henan, Guangdong, Jiangxi, Hubei, Shaanxi, Zhejiang and other places. Compared with the above dinosaur-egg fossil places, the Cretaceous dinosaur-egg fossil group in Funiushan geopark have the following characteristics:

（1）Wide distribution. The dinosaur-egg fossil are all discovered in the upper Cretaceous Gaogou group, Majiacun group and Shigou group, with the scope exceeding 400km2 and burial concentration, presenting a stripped and layered distribution, there are about 20 egg layers.

（2）Various species and large quantity. The dinosaur-egg fossils already discovered here have 8 families, 13 genera, 24 species, 6 comparative species and 10 indeterminate species, which incldled most of China dinosaur-egg species (8 families, 18 genera, 57 species, 7 comparative species and 10 indeterminate species), of which Longiteresoolithus xixiaensis and Prismatooolithus geiensis are rare types of dinosaur eggs in the world; Funiushan geopark is known to have the largest number of dinosaur egg fossils that already discovered, and just in Xixia basin, there are more than 5000 dinosaur-egg fossils discovered and over 10-thousand dinosaur eggs buried in the ground. It is a rare dinosaur-egg fossil relic areas in China and all over the world by far.

（3）the original preserved state is good with many kinds of fossils coexisting. Dinosaur-egg fossils are mostly reserved in autochthonous and hypautochthonous burial state, which can better reflect the paleogeography and natural environment of that time; Dinosaur-egg Fossils have been found to be symbiotic with dinosaur skeleton, dinosaur footprints, palaeoinvertebrates fossils and sporopollen, and some new discoveries have been made.
In short, dinosaur-egg fossils reserved in the Cretaceous red layer, south of Funiushan geopark are the remains of the earth and biology evolution during the Mesozoic era, and they are the world rarest paleontological wonders and the treasure of natural history. Together with the newly discovered dinosaur fossils in the Cretaceous red layer, north of Funiushan geopark, they constitute an important part of the global dinosaur fauna in the cretaceous period, having high international comparative significance. It is of great significance for studying lifestyle, reproduction habit and extinction of cretaceous dinosaurs, and global geological problems such as the relevant earth cataclysms.

3.2.2 Comparison of Qinling orogenic belt relics

The Central Orogenic belt which Qinling orogenic belt belonging to is a typical compound continental orogenic belt around the world, playing an important role in the formation of China mainland and global crustal evolution, and together with Cordillera orogenic belt, Appalachian orogen, Alpine-Himalayan orogenic belt, they are all giant orogenic belt in the world. Compared with other orogenic belts, Qinling orogenic belt has both the common basic characteristics and its own unique characteristics: it is mainly a collision belt of ancient North China and Yangtze Plates, differing from subduction collision orogenic belt pattern of typical oceanic plates and also the other orogenic belt patterns, meanwhile, the long subduction collision of the main orogenic period and the complex superposition of the orogenic system in different azimuth during the same period made the formation and evolution more complicated. In current Global Geopark, Qinling Zhongnanshan geopark is also located in Qinling orogenic belt, and compared with the former, Funiushan Geopark has the following differences:

(1) Zhongnanshan and Funiushan are located respectively in central and eastern part of Qinling, and as for the tectonic unit division of Qinling orogenic belt, Zhongnanshan Geopark is relatively single, while Funiushan Geopark crosses 3 secondary structural units of Qinling orogenic belt.

(2) Besides the geological relics such as plates suture line, ophiolite suite in Zhongnanshan geopark, the Qinling Orogenic belt relics reserved in Funiushan geopark are much more rich, it not only has stratum in each era and volcanic rocks, intrusive rocks recording geological history for about 2.5 billion years, but also various structural feature reflecting tectonic evolution history of Qinling orogenic belt.

All in all, various relics in Funiushan Geopark are an important part of Qinling orogenic belt, containing a large amount of information about orogenic process, and it has a very high scientific value for studying tectonic evolution process of Qinling orogenic belt and its comparison with other orogenic belt.

3.2.3 Comparison of Granite Landform

Compared with some Global Geoparks (for example Huangshan, Sanqingshan, Hexigten, Taishan and etc.), which the granite landforms as the main geological heritages, the granite landforms in Funiushan Geopark have the following characteristics:

(1) They have obvious characteristics of orogenic belt. The granite landforms in Funiushan area are formed by not only the collision and subduction of palaeoslab in main orogenic period, but also regional extension in post orogenic period; Due to the tectonic process, the granite secondary joint develop, and uplifts to the surface with the collisional orogenesis, then occurs tectonic denudation, forming different types of granite landforms, its formation process is obversely different from granite landforms in non-orogenic areas at home and abroad.
Therefore, it has extremely high scientific significance for studying the relationship between Granite and orogenesis in Qinling orogenic belt.

(2) Granite landforms are various. Wuduoshan rock mass in Caledonian period and Laojunshan and Huanghuaman rock mass in Yanshan period, which exposed along the main ridge line of Funiushan and its south and north, are the carriers of granite geomorphologic landforms. Its lithology is mainly biotite monzonitic granite with various primary and secondary joint developments, and through the tectonic erosion and weathering, various types of granite landforms are formed such as peak cluster, peak forest, peak column, peak wall, pile-up stones and waterfalls and pictographic stones, constituting unique granite landform series in Funiushan area.

3.2.4 Comparison of karst geomorphologic landscape

Compared with some Global Geoparks (for example Leye-Fengshan, Zhijin Cave, Xingwen, Shilin and etc.), which karst landforms as the main geological heritages, the Karst landforms in Funiushan Geopark have the following characteristics: the karst landforms in Funiushan area are dominated by karst caves, and these karst caves are all related to the nappe tectonic and faulted structure in main orogenic period, they are developed from mylonitic marble in the fault zone, or carbonic acid rock blocks under the surface of nappe tectonic. There are not only general stalagmites, column, curtain, waterfall, cave flower and other calcareous sinter, but also plastic rheological texture presented on the cave wall in the form of tectonic rock paintings which caused by strong dynamic metamorphic deformation, rock shear tensile and fold crumpled. They are comprehensive reflection of rock, strata, geological structure and geological function of internal and external forces, and they illustrate continental orogeny characteristics of Funiushan karst landforms, and also show the heterogeneity of karst landforms in south of China, forming the unique karst landform types in China.

4 Listing and description of other sites of natural, cultural and intangible heritage interest and how they are related to the geological sites and how they are integrated into the proposed Geopark

4.1 Listing and description of other sites of natural, cultural and intangible interest

Located in the climate transitional zone between northern subtropical zone and warm temperate zone, Funiushan area not only has diversified natural ecological resources, but also has rich cultural landscape and intangible cultural heritages (See table 2-3).

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<td>ET</td>
<td>Intangible Cultural Heritage</td>
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<td>I03</td>
<td>Xiping Folk Music</td>
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Notes:  E: Earth-science popularization  T: Tourism, S: Scientific research

N01 Baotianman World Biosphere Reserve
Located in the hinterland of Funiushan, Baotianman was approved as National Nature Reserve in 1998, and then was approved as Baotianman World Biosphere Reserve by UNESCO in 2001. With unique ecological environment and rich animal and plant resources, it is the most complete transitional zone integrated forest ecosystem in central China. There are 2911 species of higher plants, 14 species of amphibians, 213 species of reptiles, 62 species of animals, 67 species of fishes and 936 species of insects, winning the reputation of “animal kingdom” and “species gene pool”. A total of 12387 specimens have been collected, which are extremely important for biodiversity research.

N02 Funiushan National Nature Reserve
Covering three counties of Nanyang city including Xixia, Neixiang and Nanzhao and two counties of Luoyang city including Luanchuan and Songxian, Funiushan National Nature Reserve was approved to be established by the State Council in 1997, belonging to the forest ecological nature reserve, and the main protection objects are transitional zone integrated forest ecosystem and rare and endangered species, precious trees and their living environment. There are abundant animal and plant resources in the protected area, of which there are 31 species of national protection plants and 48 species of national protection animals.

N03 Longyuwan National Forest Park
Located in Luanchuan County, Henan Province and approved to be established in 1994, Longyuwan National Forest Park has abundant animal and plant resources, with as high as 98.6% forest coverage rate, acres of larch sheltering sky and lotus covering everywhere. Negative ions per cubic centimeter air reach as many as 85000, having unique health care effect, it is known as the “natural oxygen bar”.

N04 Baiyunshan National Forest Park
Located in Song County, Henan province and approved to be established in 1992, its forest coverage rate is as high as 98.5%, and the vegetation show a various vertical band distribution, from the bottom to top, there are deciduous broad-leaved forest, subalpine coniferous forest, theropecedrymion and sub-alpine shrub meadow, forming forest oxygen bar, peony garden, rhododendron forest, ginkgo forest and other ecological recreational area. Here is the kingdom of animals and plants with 235 species of wild animals, 1889 species of vascular plants, known as the “Natural Museum”.

N05 Sishan National Forest Park
Located in the west of Xixia county, Henan province and approved to be established in 1992, the park is dominated by pinus massoniana forest with shrubs such as forsythia, winter jasmine, rhododendron and spirea, forming the evergreen forest landscape.

N06 Xixia Provincial Nature Reserve of Giant Salamander
Located in Funiushan area of Xixia County and approved to be established in 1992, its main protection objects are the giant salamanders and their living environment. There are many streams with rapid flow in the protected area, and it is a good place for breeding amphibians such as giant salamander and cold water fishes, which is a typical representative of the stream aquatic ecosystem.

Figure 2-18 Forest ecological landscape (Larix kaempferi, daylilies, rhododendron, lichen and etc.)
Figure 2-19 Rare animals and plants (Hericium erinaceus, Fraxinus mandshurica, Panthera pardus, giant Salamander, Luehdorfia chinensis, Aquila chrysaetos and etc.)

Figure 2-20 Meteorological landscape

C01 Neixiang Local Magistrate’s Office
Located in Neixiang, Henan Province, Neixiang Local Magistrate’s Office was built in the Yuan dynasty (AD 1304) and rebuilt in the Qing dynasty, covering an area of more than 2 thousand square meters, with more than 280 houses. It was the best-preserved magistrate’s office in China feudal society, and it was listed as one of national key cultural preservation units in 1996.

C02 Great Wall Ruin Site of Chu State
It is distributed in Nanzhao, Neixiang County, Henan Province. According to historical materials, it was built by Chu State, in Chunqiu period, as the earliest Great Wall in China, and it was named as “father of the Great Wall”, providing important materials for studying the history of the Great Wall in China. It was listed as one of the sixth batch of regional key cultural preservation units in 2013.

C03 Fan Li Memorial Site
Located in Neixiang, Henan province, it was memorial site for the historical celebrity Fan Li in Chunqiu period, as the ancestor of businessmen, and he was called “Shangsheng”. There are memorial buildings such as Licheng and temple for him. It has become a memorial place for Fan Li, which integrates history, worship, pilgrimage and historical and cultural together.

C04 Laojunshan Taoist cultural buildings
Located in Laojunshan, Henan province, Taoist cultural buildings include Cultural center of Lao-tzu, Bronze statue of Lao-tzu, Laojun temple and other buildings, with Lao-tzu culture as the soul, these buildings show the profound Taoist culture, among them the giant bronze statue of Lao-tzu is 59m high with 360 tons of copper, which is the largest bronze statue of Lao-tzu in China.

C05 Yi Yin Temple
Manzitou, in the west of Luanchuan County, Henan province, is the birthplace of Yi Yin who was the famous prime minister in Shang dynasty. It has been found that there is stone tablet “ploughing land” of Ming dynasty and cultural relics such as the stone axes, stone arrowheads and red pottery fragments belonging to the Neolithic Age. Along Yihe river, there are Yi Yin temple, Yi Yin statue and Yi Yin cultural square.

C06 Zhang Liang Temple
Zhang Liang Temple is located beside the Baiyun Lake of Baiyunshan, Henan Province, and once it was a secluded place for Zhang Liang, who was the Liuhou of Western Han Dynasty, the current temple was rebuilt on its original site with 1100 m² housing area, and the total area is 5.3 hectares.

C07 Yuhuang pavilion at Baiyunshan
Located in Yuhuangding of Baiyunshan, Henan Province, Yuhuang pavilion is the highest Taoist temple in Henan province, covering an area of 246 m². Landing in the pavilion, the sights of surrounding areas and the vertical distribution of plants can be seen clearly.

Figure 2-21 Neixiang Local Magistrate’s Office of Yuan dynasty (left) and Great Wall Ruin Site of Chu State (right)

Figure 2-22 Fan Li hometown—Shangsheng estates (left) and Yi Yin temple for famous prime minister in Shang dynasty (right)

Figure 2-23 Laojunshan Taoist cultural buildings (left) and Yunyan temple and the pagoda (right)

Figure 2-24 Zhang Liang Temple (left) and Yuhuang pavilion (right) at Baiyunshan
N01 Wanbang (traditional Chinese opera)
Wanbang is one of the rare local operas in Henan Province, mainly sung in Nanyang city and its surrounding area but gradually declined. Wan bang was listed as the first batch of national intangible cultural heritage by the State Council in 2006.

N02 Zhenping Jade Carving
Jade carving is traditional jade carving handicraft in Zhenping, Henan Province, famous for its exquisite carving and innovative design. It began in Han dynasty, and the raw materials used were mainly Nanyang dushan jade. It was listed as the second batch of national intangible cultural heritage by the State Council in 2008.

N03 Xiping Folk Music
It is the folk music of Han nationality in Xiping, Henan Province, with rich content and unique personality, and there are many forms such as solo, two people sing, many people sing, unison and so on. It is a very precious cultural heritage in the existing folk music of Han nationality. It was listed as the second batch of national intangible cultural heritage by the State Council in 2008.

Figure 2-25 Wangbang--National intangible cultural heritage

4.2 Integration between Non-geologic site and the proposed Geopark
Geological heritages and non-geological heritages resources including natural ecology and human landscape and intangible cultural heritage in Funiushan area have intertwined closely together, and they are all brought into unified planning and management of the Geopark, on the one hand, through the establishment of the corresponding list, appropriate protective measures are taken, on the other hand, through the perfect traffic network, resources are linked together to constitute geopark tourism network; Meanwhile, through the establishment of Geopark’s identification system (explanation board, guide board), museum exhibition, publicity at vistor center and distributing centre, the introduction on the geopark website and related science publicity materials (guidebook, brochure, tourist map), non-geologic site and the proposed Geopark integrated together.