In the Luo Chuan section, S5 is the best developed paleosol, and is laterally persistent and bright in color. It is composed of 2-3 stacked paleosols, ranging from 3-6 m thick. Its high maturity and great thickness indicate a period of stable warm paleoclimatic conditions. L9 and L15 loesses are silty, relatively coarser than the other loesses. It was interpreted as being formed during a period of strong winter trade winds. They are major groundwater reservoirs in the loess plateau region and are also important correlation markers.

Stop 4 (June 22) – Jin Suo Guan:
Characteristics of Upper Triassic oil shale, paleontology, and structural deformation
(Zhou et al., 2002, p. 125, Fig. 17c)

The section in this locality is the Upper Triassic Yanchang Formation, the same as in Stop 2. Here the deposits are deep-water lacustrine (i.e. profundal) facies (Fig. 4). Profundal lacustrine facies occur in Bed 8 to 3 of the formation, but are the most extensive in Bed 7, covering an area of 40,000 km^2.

Oil shale and turbidites are common in some deep-water lacustrine deposits. Oil shales contain a large amount (>25%) of thermally-altered organic matter, which is commonly of an algal origin. Oil shales indicate stratified and eutrophic lakes with minimal coarser siliciclastic influx. These type of lakes also are commonly brackish to saline. Turbidites are deposited by turbidity currents, a type of sediment gravity flow. Turbidity currents are density currents, generated when sediments are thoroughly mixed with water and, thus, become denser than the ambient water. It will flow down slope under the influence of gravity. Deposits of turbidity currents (i.e. turbidites) exhibit a particular succession of texture, lithology, and sedimentary structures, termed as the Bouma Sequence.

We will observe both oil shale and turbidite, as well as profundal fossil-rich shale in the locality. Fish fossils are unusually well preserved in the oil shales. Both the preservation of fossil fish and rich organic matter suggest an anoxic bottom water of the lake.

Stop 5 (June 23) – Zhao Lao Yu of Fu Pin:
Middle Ordovician shallow and deep-water carbonate deposits
(Zhou et al., 2002, p. 82-86, Fig. 18a)

The North China block had been repeated flooded during Early Cambrian to early Late Ordovician. The flooding came from the Qinling ocean from the west and south, forming vast epeiric seas on the block and shelf-margin seas at the southern margin of the block. Cambro-Ordovician carbonate rocks, intercalated with sandstone and shale, are thick and well exposed.

The rocks exposed in this stop are the Middle Ordovician Majiagou Formation and Middle-Upper Ordovician Zhaolaoyu Formation. The Majiagou Formation recorded three progressively larger shoreline transgression-regressions. It contains peritidal, open-marine, and evaporitic deposits. Marine transgression resumed at the beginning of Middle Ordovician and flooded only the southern and western parts of the Ordos Basin (Fig. 19). The flooded L-shaped trough was located in a fault zone, where syn-depositional faulting was active. These faults controlled the paleogeography of the narrow shelf. Basinward, subenvironments include shallow platform, high-energy shoals, deep-water slope, and trough. Carbonate turbidites were deposited on the slope. The paleogeography of the upper Middle Ordovician is similar to that of the Majiagou Formation, except that the western Ordos shelf deepened abruptly to the west. At the end of early Late Ordovician, seawater completely withdrew from the Ordos Basin.

In the Zhaolaoyu area, Middle Ordovician Majiagou Formation and Middle-Upper Ordovician Zhaolaoyu Formation are exposed. The Majiagou Formation consists of thick-bedded shallow-marine platform limestone. The Zhaolaoyu Formation has 4 members:

- Member 1: Dark gray, thin platy micrite, intercalated with black thin platy siliceous rocks that contains yellow and purplish red tuff. It is regionally persistent and is the regional stratigraphic markers. It is 95 m thick.

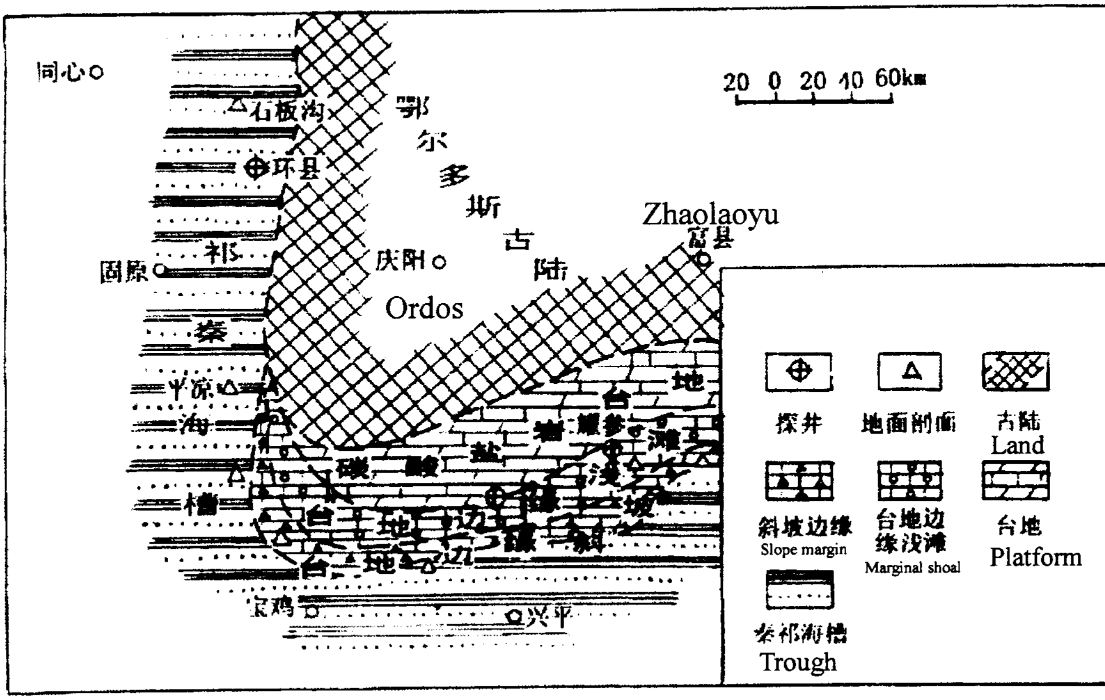

图 4-12 华北陆块西南部中奥陶世平凉期岩相古地理图

（冯增昭，1990）

Figure 19. Paleogeography of Middle-Ordovician Pingliang Formation, southwestern North China Block. From Zhou et al., 2002.

- Member 2: Dark gray, thin platy limestone and shaley limestone interbedded with limestone breccia, especially chaotic breccias. It is 225 m thick.
- Member 3: Dark gray, thin platy limestone and shaley limestone interbedded with limestone breccia. The amount of chaotic breccias is less than that in Member 2. However, it contains some grayish green, thick bedded tuffs. It is 155 m thick.
- Member 4: Dark gray thin platy limestone and shaley limestone interbeds. It is 300 m thick.

Members 1 and 2 are well exposed in Stop 5; they comprise a complete succession of deep-water carbonate gravity flow system.

The thin micrite in Zhaolaoyu Formation is centimeter or millimeter laminated, containing some trilobites and graptolites, and trace fossil *Nereites*, indicating a quiet deep-water environment. The carbonate mud may have been originated from storm-agitated counterparts on the shallow platform, and was trapped within the intermediate water and transported to the deep water. The mud was slowly settling down on the slope.

Micrite containing uniform-sized grains was deposited from the tail of turbidity currents. Thin-bedded and graded grainstones are commonly intercalated within thin micrites, and have planer, cross, and convolute beddings. The grainstones and grain-bearing micrite form the ABCE, AE, BCE, or CE combinations of the Bouma sequence. Breccia-bearing grainstones are well graded. Clasts are parallel to bedding planes, or imbricated. They occur as single beds or stacked successions. They are commonly adjacent to limestone breccias and together with grain-bearing micrite form the AE turbidite. Limestone breccia beds are 0.3-1 m thick. Clasts are mainly composed of thin-bedded deep-water limestone, with rare shallow-water clasts. The shallow-water clasts are dominantly rounded to subrounded sparry grainstones, and rarely, semi-consolidated micrite.

The breccia-bearing grainstone and well-oriented limestone breccia do not display the classic Bouma sequence. The well-developed graded beddings and the orientation of long axes of clasts parallel to paleocurrent suggest that they were transported by currents. These currents are probably high-density turbidity currents. On the other hand, the turbidites with well developed BCDE Bouma sequences were probably transported by low-density turbidity currents.

Chaotic limestone breccia has the greatest single-bed thickness, commonly larger than 1 m, with maximum 9-10 m thick. Beds are sheet-like and persistent. Clast composition is similar to those of oriented limestone breccias. The clasts, however, are mixed in size, show no preferred orientation, and are "floating" within fine-clast matrix. They are interpreted as subaqueous debris-flow deposits.

Silt and sand-sized grainstones are thinly-laminated, lenticular, or platy, and are intercalated within deep-water micrite. The grains are well sorted. Beds have a sharp base and top. They are not graded, contain abundant ripple marks. These features are characteristic of contourites deposited by hugging bottom currents.

In addition, the radiolarian siliceous rocks and volcanic tuffs are noticeable. Siliceous deposits are 50-70 cm thick, with a maximum of 2 m thickness. Single layers are 3-5 cm thick with mm-scale varves. Fossils are dominantly spiny, multi-cell, ball-shaped radiolarians, and rare ostracods and sponge spicules.

Individual tuffs are commonly 10-80 cm thick, with maximum of 2 m thickness. They have faint parallel laminations or planar beds, and rare graded beddings. Vitreous, crystalline, and lithic grains are dominant. Vitreous grains are mostly replaced by calcite or smectite, but still

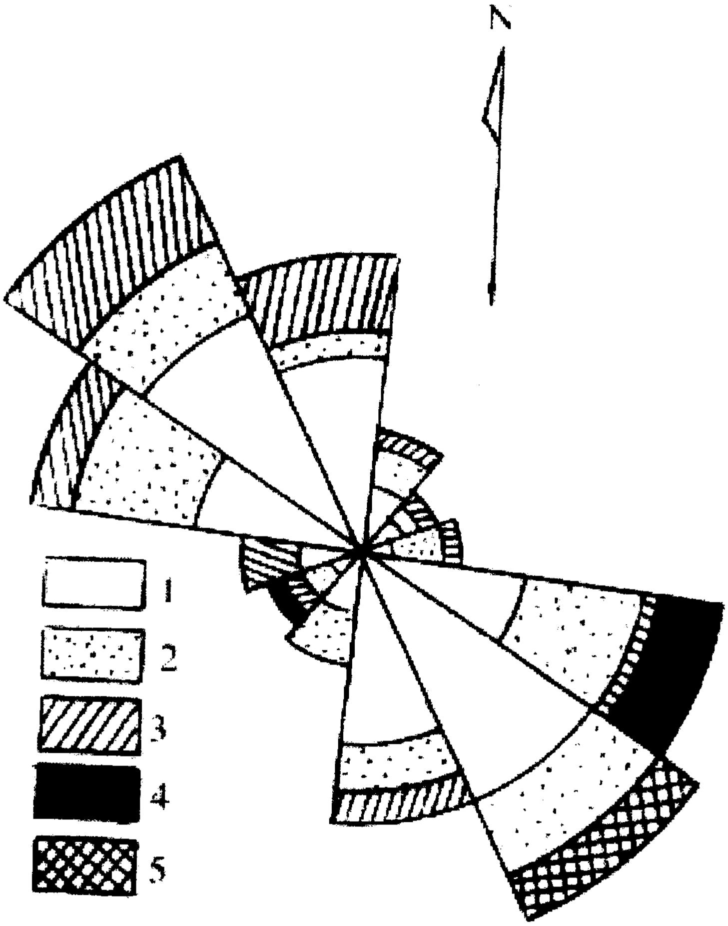

图 4-14　赵老峪组重力流古流向
1.粒序角砾石灰岩砾石长轴方向 75 个;2.杂乱角砾灰岩砾石长轴方向 32 个;3.粒序角砾灰岩砾石最大扁平面倾向 35 个;4.杂乱角砾灰岩顶层面波状起伏陡翼倾向 7 个;5.浊积岩交错纹层倾向 5 个

Figure 20. Paleocurrent directions of Zhaolaoyu Formation. 1. Long axis of clasts in breccia-bearing graded limestone conglomerate (75 samples). 2. Long axis of clasts in chaotic limestone conglomerate (32 samples). 3. Dip direction of flat pebbles in graded breccia-bearing limestone conglomerate (35 samples). 4. Dip direction of lee sides of ripple marks on top surfaces of chaotic breccia-bearing limestone (7 samples). 5. Cross beddings of turbidites (5 samples). From Zhou et al., 2002.

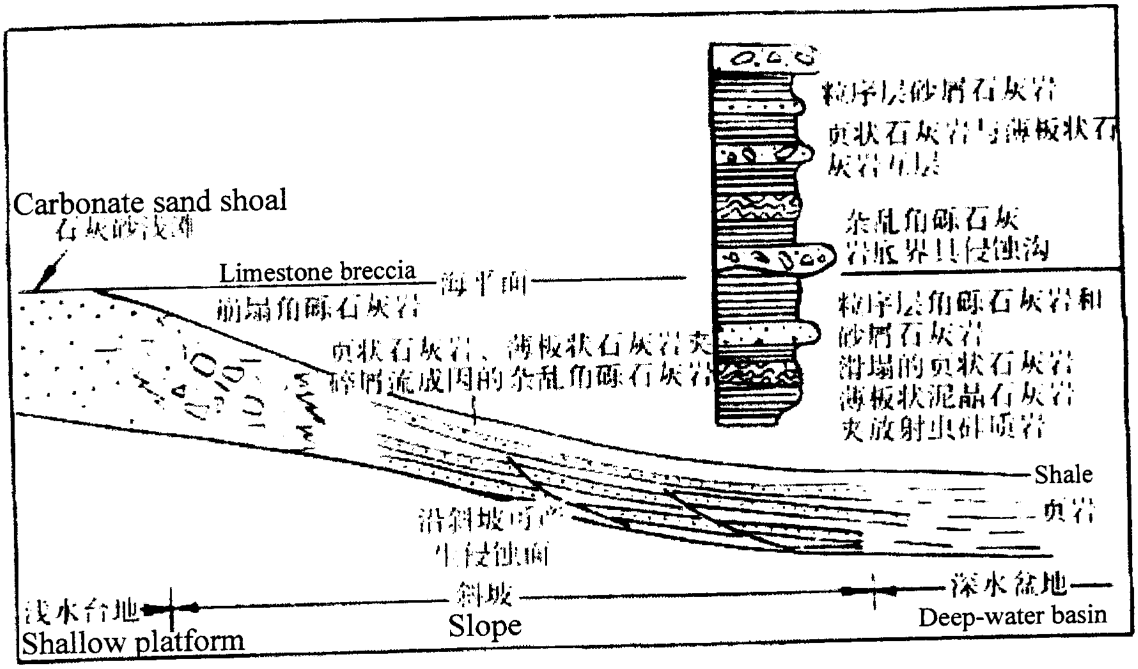

图 4-15 赵老峪组深水盆地边缘的沉积模式图

Figure 21. Depositional model of deep-water shelf margin of Zhaolaoyu Formation. From Zhou et al., 2002.

GEOLOGICAL TRAVERSE LEG-2 QINLING OROGEN
JUNE 25-29.

Stop 6 (June 25) – Luonan:
Neo-Archean metamorphic complex of Taihua Group in the minor Qinling and Huashan granitic intrusion, Meso-Proterozoic sedimentology of Gaoshanhe Group, Meso-Proterozoic sedimentology and structural geology of Fengjiawan Formation, Sedimentology of Neo-Proterozoic Sinian Luoquan Formation
(Zhou et al., 2002, p. 69-75)

1. Neo-Archean Taihua Group

The crystalline basement of the North China Plate consists of three rock complexes: Paleo-Archean (>3.1 billion years), Neo-Archean (2.5 billion years), and Paleo-Proterozoic (>1.8 billion years). Gneiss, amphibolite, quartzite, marble, granulitite, and many types of migmatite of complex metamorphic suites are present. Basement crystallization ended by the Luliang Orogeny at about 1.8 billion years.

The Neo-Archean Taihua Group is exposed along the roadcut from Luo Fu to Hua Yang Chuan (Fig. 18b). It is composed mainly of biotite-plagioclase gneiss, biotite-hornblende-plagioclase gneiss, banded migmatite, intercalated with plagioclase-hornblende schist, granulite, hornblende schist, feldspathic quartzite, marble, graphite schist, graphite-bearing banded marble, magnetite quartzite, magnetite amphibolite. Migmatization is common and magmatism is intense. The radiometric age of Taihua Group ranges from 2.58-2.31 billion years. Metamorphism reached a grade of amphibolite facies and locally granulite facies. The parent rocks (protoliths) are marine sedimentary and volcanic rocks.

2. Meso-Proterozoic Gaoshanhe and Luonan groups

Siliciclastic and carbonate sedimentary rocks were deposited on the crystalline basement during Meso- and Neo-Proterozoic eras, including the Xiong-Er, Gaoshanhe, Luonan, and

Luanchuan groups. The Gaoshanhe Group is a thick succession of terrigenous siliciclastic deposits overlying the Xiong-Er Group with a parallel unconformable to conformable contact. It contains an overall fining-upward progradational succession (Fig. 22). Some sandstones and slates in the lower and upper parts of the group show characteristics of delta front deposits, and were interpreted as deltaic and estuary deposits.

The Luonan Group, in turn, overlies the Gaoshanhe Group conformably, and is characterized by thick carbonate deposits. The Fengjiawan Formation is the uppermost of the Luonan Group. The carbonate successions are composed of peritidal carbonate cycles of several types (Figs. 23, 24, 25). Sedimentary structures include mud cracks, autoclastic breccias, mm-cm scale varves and laminations, lenticular and flaser beddings, wave and tide-related structures, algal laminations, and stromatolites. These deposits suggest a Meso-Proterozoic stable marginal sea environment in the southern margin of the North China block.

The Meso- and Neo-Proterozoic sedimentary rocks are weakly deformed and slightly metamorphosed or un-metamorphosed. The sections along the road cuts are designated as Meso- and Neo-Proterozoic stratotypes and are protected.

3. Sinian (Ediacaran) Luoquan Formation:

Upper Sinian Luoquan Formation overlies Fengjiawan Formation with a parallel unconformable contact (Fig. 26). It consists of two lithologically contrasting members. The upper member is composed of siliciclastic rocks. Sedimentary structures include lenticular, wavy, and flaser beddings, tidal bundles, herring-bone cross bedding, imbrications of flat mudstone pebbles, and various ripple marks, indicating a tidal flat environment. The lower member is composed of coarse siliciclastic deposits, containing well laminated clast-bearing dolomite to

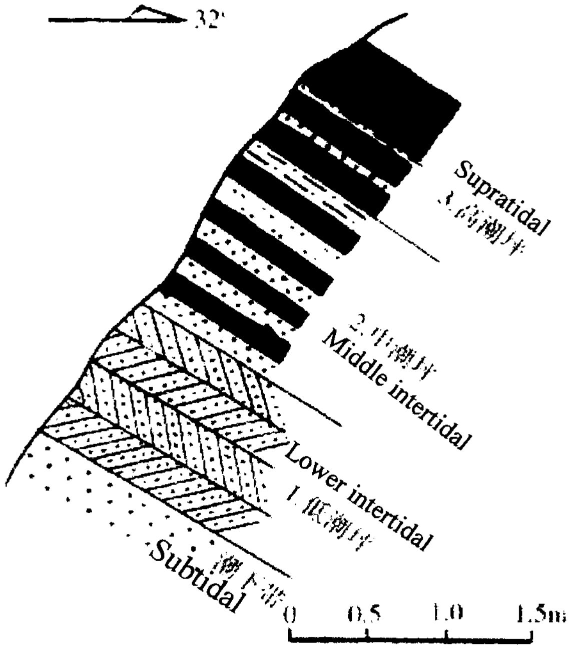

图 4-2 高山河群潮坪沉积剖面图
Figure 22. Field sketch of peritidal deposits of Gaoshanhe Group. From Zhou et al., 2002.

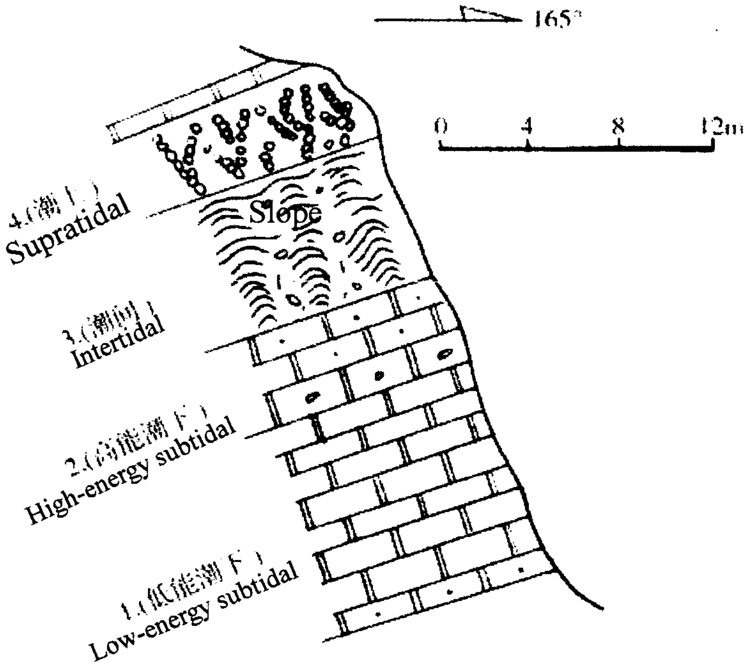

图 4-3 洛南群龙家园组叠层序列剖面图
Figure 23. Field sketch of stromatolite successions of Longjiayuan Formation of Luo-nan Group. From Zhou et al., 2002.

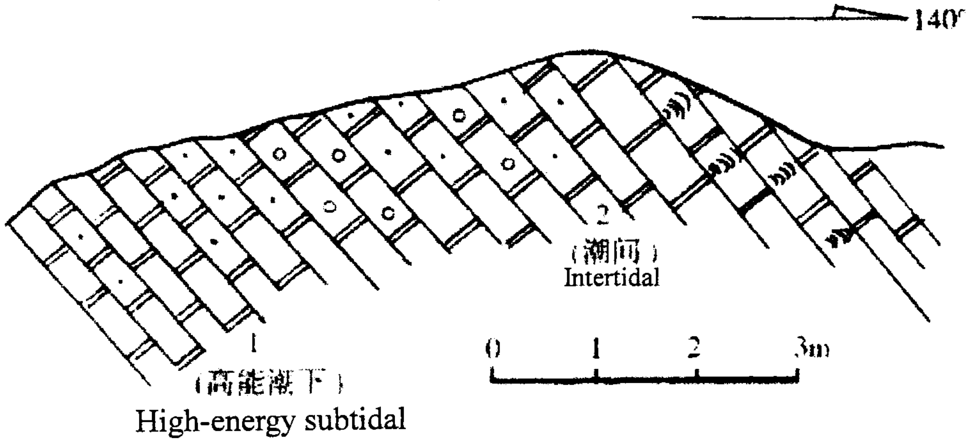

图 4-4 洛南群杜关组粒状序列剖面图

Figure 24. Field sketch of graded successions of Duguan Formation, Luo-nan Group. From Zhou et al., 2002.

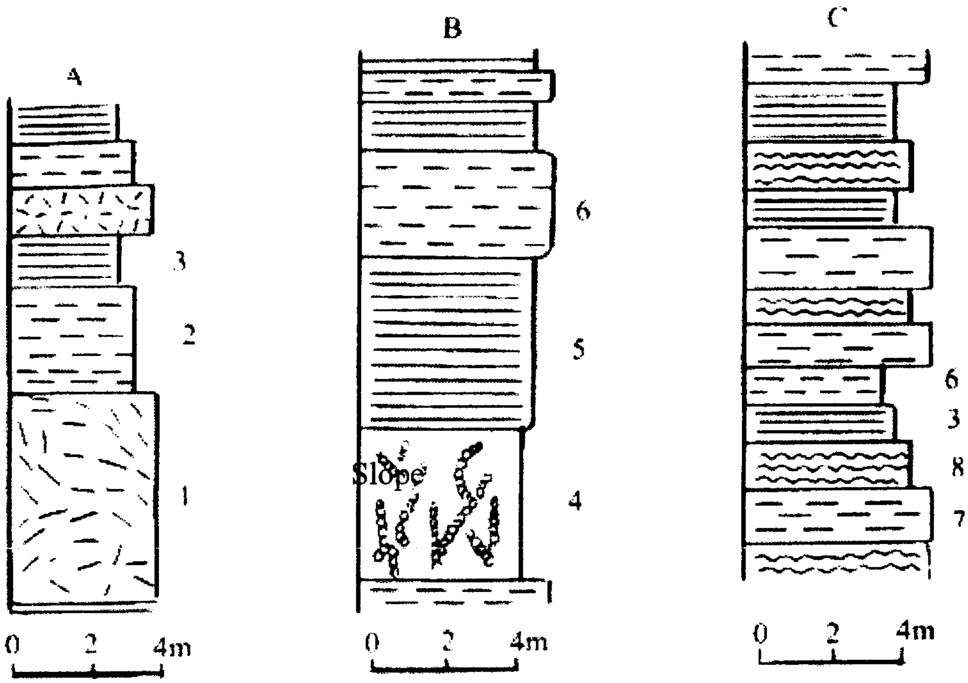

图 4-5 洛南群沉积韵律类型

A. A 型韵律；B. B 型韵律；C. C 型韵律

1. 含燧石砾石细晶白云岩；2. 粉晶白云岩；3. 纹层状泥晶白云岩；4. 假棵枝叠层石白云岩；5. 纹层状燧石白云岩；6. 泥晶白云岩；7. 含宽燧石条带粉晶白云岩；8. 含燧石条带细晶白云岩

Figure 25. Types of rhythmic successions of Luo-nan Group. 1. Cherty dolomicrite, 2. silty dolomite, 3. laminated dolomicrite, 4. pseudo-branching stromatolitic dolomite, 5. laminated cherty dolomite, 6. dolomicrite, 7. silty dolomite with banded chert lentils, 8. chert lentil-bearing dolomicrite. From Zhou et al., 2002.

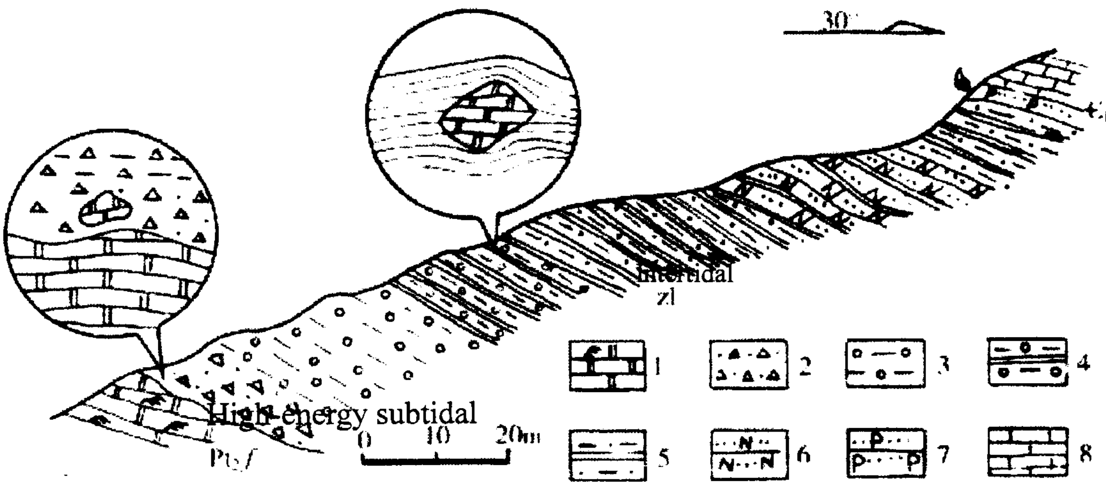

图 4-10 洛南上张湾上震旦统罗圈组实测剖面图
1.叠层石白云岩;2.块状白云质角砾岩;3.纹层状砾石质白云岩;4.纹层状含砾砂屑白云岩;
5.砂质黏土板岩;6.长石石英砂岩;7.磷质砂岩;8.灰岩

Figure 26. Measured section of Luoquan Formation, Upper Sinian in Luo-nan. 1. Stromatolitic dolomite, 2. massive dolomitic breccia, 3. laminated brecciated dolomite, 4. laminated clast-bearing sandy dolomite, 5. sandy clay slate, 6. feldspathic quartz sandstone, 7. phosphatic sandstone, 8. limestone. From Zhou et al., 2002.

dolomitic breccia, massive dolomitic breccia, and well-laminated clast-bearing sandy coarse dolomite. Their origin is controversial. Many researchers think they are glacial deposits (diamictite). Below is a summary of sedimentary features:

Varved brecciated dolomite and dolomitic breccia have a variety of carbonate grains with mixed grain sizes and angular to subangular grain shapes. The accumulation is thin, shows no apparent hiatus with overlying deposits, but is commonly missing laterally. Clasts are not abundant and are small, angular, and uniform in composition. Varves suggest a quiet-water environment. The clasts were probably derived by glacial carving of underlying carbonate bedrocks, were transported over a short distance with minimum lithologic mixing by a small glacier, and were deposited in shallow peri-glacial waters.

The massive dolomitic conglomerates do not have glacial slickensides and slip planes, and no features characteristic of glacial diamictite. It is probably a subaqueous mud flow deposit. Rocks overlying this facies contain abundant dropstones, suggesting the sediments of this facies may be originated from glacial deposits, which were modified through mass wasting processes and transported and deposited subaqueously.

Varved clast-bearing sandy dolomite contains clasts cutting/disrupting subjacent varves, suggesting a dropstone origin for the clasts. The amount and size of clasts decreases upward. In comparison to carbonate grains, quartz sand increases upward, suggesting a gradual climate warming and glacial retreat.

Although the above features suggest a glacial origin of Luoquan deposits, some geologists think they are non-glacial coarse clastic deposits in a rift zone.

The Luoquan Formation at this stop is ~100 m thick, and thickens to 279 m to the east (Fig. 27).

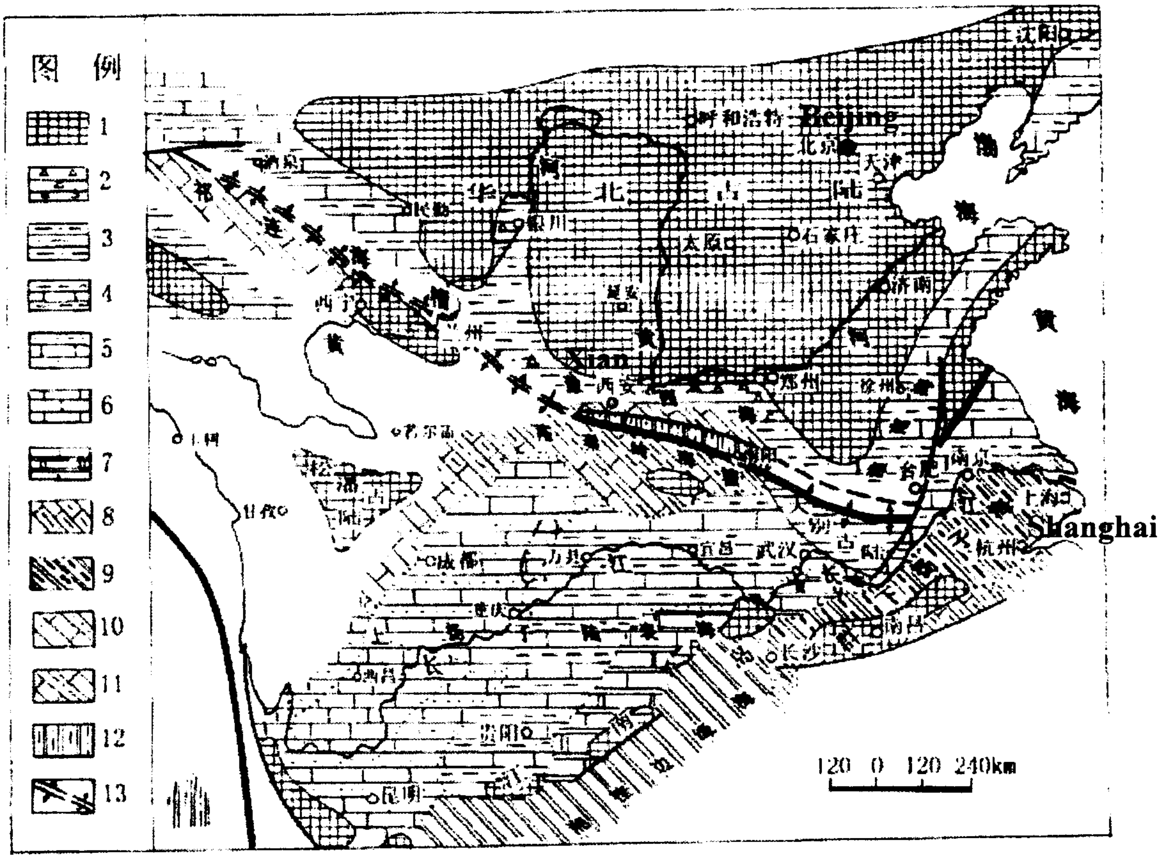

图 4-9 中国中东部晚震旦世古地理图

（王鸿祯等修改，1985）

1.古陆；2.冰碛；3.滨浅海碎屑及泥质组合；4.浅海泥质及碳酸盐组合；5.滨浅海碎屑及碳酸盐组合；6.滨浅海碳酸盐组合；7.浅海碳酸盐及硅质组合；8.边缘海碎屑硅质及碳酸盐组合；9.边缘海泥质及硅质组合；10.边缘海碎屑及硅质组合；11.边缘海泥质及碳酸盐组合；12.半深海碎屑复理石组合；13.扩张带

Figure 27 Late Sinian paleogeography, east-central China. 1. Land, 2., tillite, 3. littoral siliciclastics, 4. shallow marine mud and carbonate, 5. littoral clastic and carbonate, 6. littoral to shallow marine carbonate, 7. shallow marine carbonate and siliceous deposits, 8. marginal sea siliceous and carbonate, 9. marginal sea mud and siliceous deposits, 10. marginal sea siliciclastic and siliceous deposits. 11. marginal sea mud and carbonate, 12. slope clastic flysh, 13. extensional zone. From Zhou et al., 2002.

Stop 7 (June 26) – Luonan:
Sedimentology of Permian Luonanyaogou Formation, Neo-Proterozoic Taowan Group

This stop is located in the Northern Qinling Structural Belt. Here the Sinian-Upper Paleozoic contains two types of rocks: metamorphosed sedimentary-volcanic rocks and metamorphosed sedimentary rocks. The former is dominant but regionally discontinuous.

1. Neo-Proterozoic Taowan Group (Zhou et al., 2002, p. 94-96)

The Taowan Group at this stop is representative of the metamorphosed sedimentary rocks in northern part of the Northern Qinling Structural Belt, and exposed discontinuously from west to east. It is composed mainly of phyllite, meta-siltstone, meta-sandstone, meta-quartz sandstone, marble, thin platy marble, schistose micrite, dolomitic conglomerate intercalated with dolomite, and micrite and dolomite lenses. The rocks are marine sedimentary rocks that had experienced multiple severe deformations, reaching the schistose metamorphic grade. Its age is Sinian to Early Paleozoic.

The terrigenous clastic and carbonate rocks of the Taowan Group contain a variety of mass wasting structures. They are overall fining upward, and were interpreted as a retrogradational succession deposited from shallow to deep water in a margin sea. It is time equivalent to the Luoquan Formation to the north, together forming a continental interior-marginal sea sedimentary mosaic.

Three episodes of tectonic deformation can be interpreted from the Taowan Group (Zhou et al., 2002, p. 204):

- The first episode is north-to-south overthrusting under a regional compressive background. Ductile shear zones and folds formed. The associated structures are penetrative new cleavages and rootless folds within the cleavages. Metamorphism reached the greenstone metamorphic facies, suggesting a medium-shallow burial depth. The metamorphic age is 410 Ma.

- The second episode is characterized by re-folding of previous cleavages and brittle-ductile reverse faulting. The structures also indicate a south-verging reverse faulting at a shallow burial depth. The metamorphic age is 284 Ma. The above two episodes can be well observed near the city of Lunan (Fig. 28), where Permian rocks overlie the Taowan Group with an angular unconformity.
- The third episode is characterized by broad gentle folding of the overlying Permian strata and the previous cleavages within the Taowan. Some brittle faulting also occurred. Where deformation is severe, intense folding and ductile-brittle reserve faulting occurred with associated folding cleavages. The third episode is apparently of a Late Paleozoic-Mesozoic age.

The sedimentary and structural evidence suggests that the Northern Qinling Structural Belt had experienced a cycle of seafloor spreading to subduction during Early Paleozoic.

2. Permian (Zhou et al., 2002, p. 114, 202-203)

Continental and marginal-marine coarse siliciclastic sedimentary rocks were deposited in intermontane rift basins in the Northern Qinling Structural Belt during Late Carboniferous to Mesozoic. These deposits are distributed from west to east and were altered by younger tectonic activities.

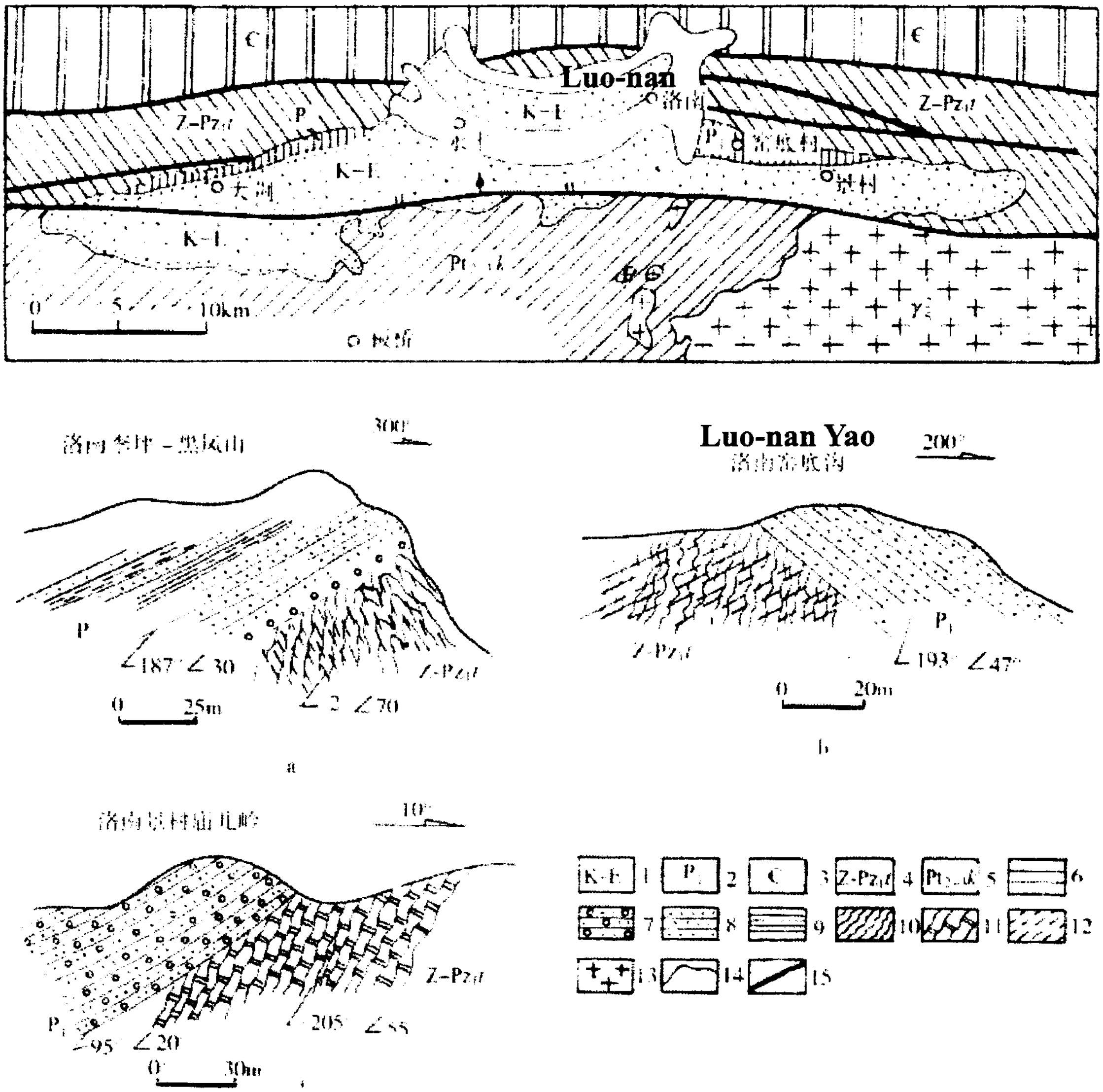

图 6-17 洛南地区的二叠系地质略图和构造剖面图

1.白垩系－第三系;2.二叠系;3.寒武系;4.震旦系－下古生界陶湾群;5.中、新元古界宽坪群;6.砾岩;7.含砾砂岩;8.砂岩;9.砂页岩;10.绢云绿泥石英千枚岩、钙质千枚岩、片理化大理岩;11.片理化石英大理岩;12.劈理;13.花岗岩;14.地质界线;15.断层

Figure 28. Simplified geologic map and structural cross sections of Permian, Luo-nan area. 1. Cretaceous-Tertiary, 2. Permian, 3. Cambrian, 4. Sinian-Lower Paleozoic Taowan Group, 5. Meso-Neo-Proterozoic Guanping Group, 6. conglomerate, 7. conglomeratic sandstone, 8. sandstone, 9. sandy shale, 10. mica-chlorite-quartz phyllite, calcitic phyllite, schistose marble, 11. schistose quartzose marble, 12. cleavages, 13, granite, 14, geological contacts, 15, faults. From Zhou et al., 2002.

In this stop, the Permian rocks are composed of grayish white sandstone and conglomerate and variegated, light yellow, and grayish black sandy mudrock intercalated with coals in the lower part, and reddish brown medium-coarse quartzose feldspathic sandstone and grayish purple fine sandstone and mudrock, interpreted as fluvial-lacustrine deposits.

The Permian strata were weakly deformed in this area (Fig. 28). The relict strata strike east-west, and dip to the south at 30-40°. They are unconformably overlain by Tertiary rocks. The angular unconformity between overlying Permian and underlying Neo-Proterozoic Taowan Group is spectacular. The structural styles across the unconformity are strikingly different. Permian strata are weakly deformed and unmetamorphosed, whereas the Taowan Group is characterized by multiple intense deformations and metamorphism. The relict Permian strata are the limb of a vertical broad fold with well developed bedding-parallel joints associated with the folding.

Stop 8 (June 27) – Sha Gou Jie: Tertiary Weihe Graben (Plate IIIb), Metamorphic complexes of the Paleo-Proterozoic Qinling Group

1. Weihe Graben (Zhou et al., 2002, p. 180-185):

A tectonic sequence includes all stratigraphic systems that formed during one tectonic cycle. A tectonic cycle spans an early stage of basin formation and a late stage of basin closing and mountain building and associated basin formation (such as foreland basins). A tectonic sequence is bounded by regional unconformities at base and top. A tectonic sequence can be subdivided into sub-sequences. It is characterized by its unique stratigraphy, sedimentary environments, structural deformation, metamorphism, and magmatism. It represents a period of uni-directional lithospheric evolution that is not reversible. Comparison and correlation of different tectonic units of a tectonic sequence, including its stratigraphy, deformation, metamorphism, and magmatism, will unravel the regional tectonic evolution.

Methods differ between tectonic studies of cratonic versus orogenic regions. In orogenic belts, stratigraphy has two general types: metamorphosed sedimentary-volcanic systems and metamorphic complex systems. The former system can be studied by reconstructing original parent rocks and their sedimentary environments and, thus, identifying regional unconformities that demarcate tectonic sequences. For metamorphic complex systems, a comprehensive analysis of deformation, metamorphism, magmatism, geochemistry, and radiometric age dating has to be carried out to ascertain the age of parent rocks and original tectonic settings, ages of deformation and metamorphism and their tectonic dynamics.

The end-Mesozoic-to-Cenozoic tectonic sequence in central and eastern China is characterized by a series of basins formed by extensional rift and transform pull-apart (Fig. 29a).

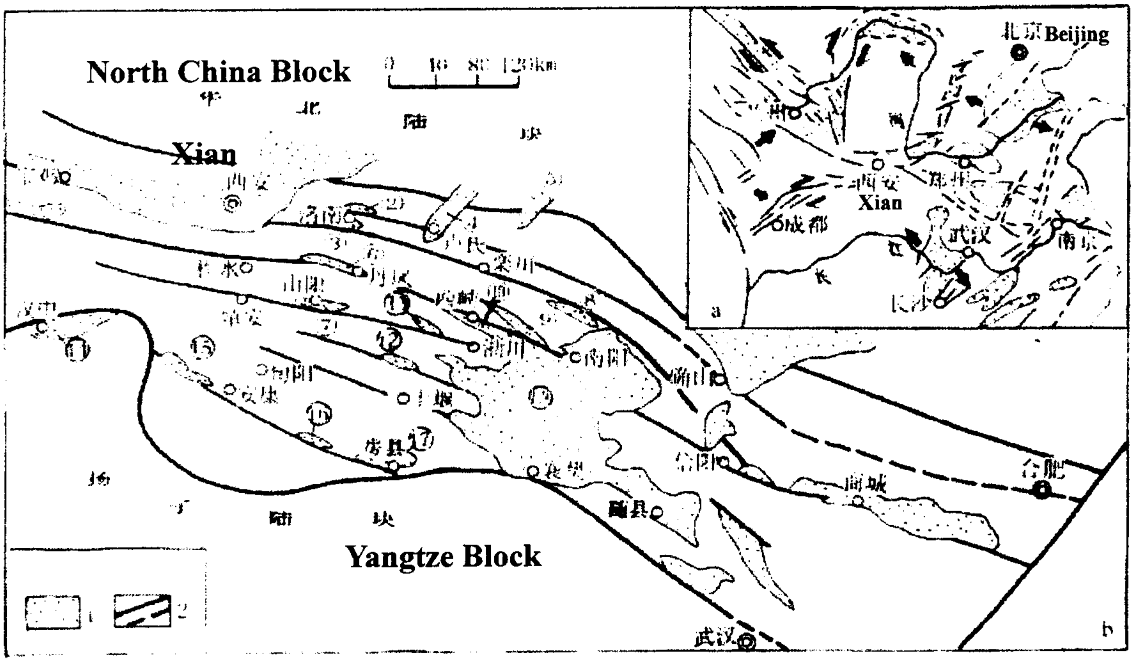

图 6-2　东秦岭－大别造山带及邻区中新生代盆地分布略图

a. 秦岭－大别造山带及邻区早第三纪盆地分布及构造应力场(马杏垣等,1989);b. 东秦岭－大别构造山带中新生代盆地分布图　1. 中新生代盆地:①渭河盆地;②石门盆地;③洛南盆地;④卢氏盆地;⑤潭头盆地;⑥商－丹盆地;⑦山阳盆地;⑧马市坪盆地;⑨夏馆盆地;⑩西峡盆地;⑪李官桥盆地;⑫郧西盆地;⑬南襄盆地;⑭汉中盆地;⑮汉阴盆地;⑯宝丰盆地;⑰房县盆地　2. 主要断层

Figure 29. Mesozoic-Cenozoic basins in eastern Qinling-Dabie orogenic belt. a. Paleogene basins and stress field; b. Mesozoic-Cenozoic basins in eastern Qinling-Dabie orogenic belt. 1. Mesozoic-Cenozoic basins: 1) Weihe basin, 2)Shimen basin, 3) Luo-nan basin, 4) Lushi basin, 5) Tantou basin, 6) Shang-Dan basin, 7), Shanyang basin, 9) Mashiping basin, 10) Xixia basin, 11) Liguanqiao basin, 12) Yunxi basin, 13) Nanxiang basin, 14) Hanzhong basin, 15) Hanying basin, 16) Baofeng basin, 17) Fangxian basin. 2. Major faults. From Zhou et al., 2002.

The Weihe Basin is a graben system (Fig. 29b). It developed on the transition zone between the stable Ordos block and Qinling Orogen, and is characterized by great subsidence.

The Weihe Basin developed in Paleogene, but initial rifting probably started as early as Late Cretaceous. It is bounded by the northern and southern bounding faults that cut across the Qinling Orogen, extends east to west, and are controlled by a series of normal faults (Fig. 30). The basement can be divided into two parts by the central Weihe Fault. The northern basement is composed of Meso- and Neo-Proterozoic, Lower Paleozoic and Upper Paleozoic, and Mesozoic sedimentary rocks, whereas the southern basement is composed of Neo-Archean and Paleo-Proterozoic metamorphic rocks and Meso- and Neo-Proterozoic sedimentary rocks, and Caledonian (Silurian-Devonian) and Yanshanian (Cretaceous-Tertiary) granites.

The structural grain and Cenozoic sedimentation of Weihe Basin are manly controlled by the east-west major faults, forming a southward-deepening, asymmetrical rift basin, 300-400 m deep in the north and 7500 m deep in the south. Cenozoic subsidence is at least 10 km.

The main faults are dominantly normal with a strike-slip component, and are currently active. The Kouzeng Fault is well exposed (Plate IIIb), dipping 40-50°, as a left-lateral normal fault. Active faulting is also reflected by the ground fractures and seismic activities (Fig. 31). Ground fractures are the most severe geologic hazard in the Xian area.

2. Paleo-Proterozoic Qinling Group in Weiziling (Zhou et al., 2002, p. 207-209)

This stop is located in the Northern Qinling Structural Belt. The Qinling Group is exposed as large lenticular blocks throughout the entire belt (Figs.32, 33). It is composed of biotite-plagioclase gneiss, amphibolite, and plagioclase hornblende schist, garnet-bearing biotite plagioclase gneiss, garnet biotite gneiss, and graphite marble, as a suite of medium to deeply

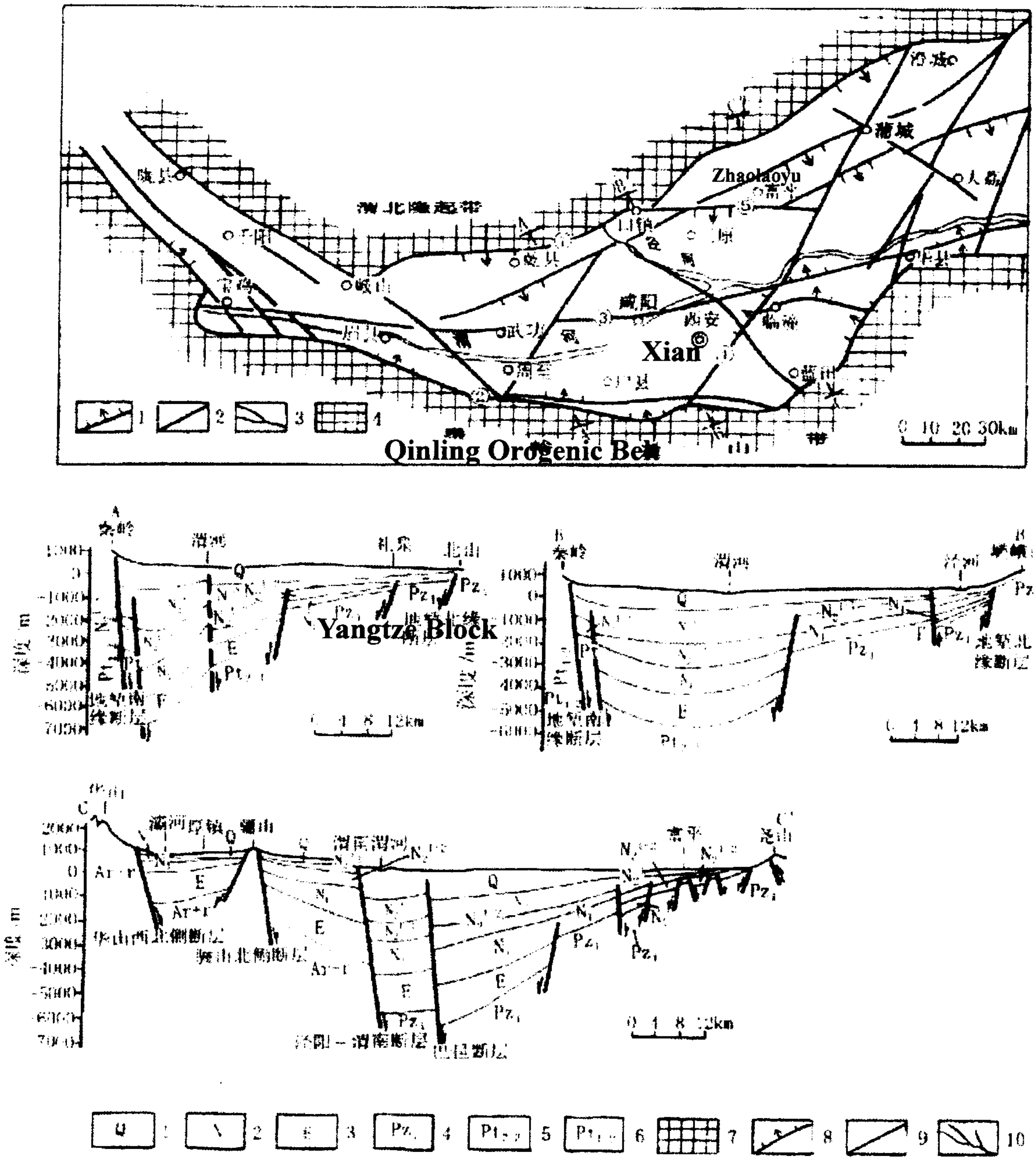

图 6-3 渭河盆地构造略图和地质剖面图

1. 第四系；2. 新第三系；3. 老第三系；4. 下古生界；5. 中、新元古界；6. 古、中元古界；7. 山地；8. 正断层；9. 断层；10. 河流。A－A′、B－B′、C－C′为剖面位置。①. 渭河盆地北缘断裂；②渭河盆地南缘断裂；③渭河断裂；④长安－临潼断裂；⑤口镇－阎良－关山断裂

Figure 30. Simplified structural map and cross section, Weihe Basin. 1. Quaternary, 2. Neogene, 3. Paleogene, 4. Lower Paleozoic, 5. Meso-Neo-Proterozoic, 7. mountains, 8. normal faults, 9, faults, 10. rivers. 1) Northern bounding fault of Weihe Basin, 2) southern bounding fault of Weihe Basin, 3), Weihe Fault, 4) Chang-An-Lingtong Fault, 5) Kouzheng-Yanliang-Guanshan Fault. From Zhou et al., 2002.

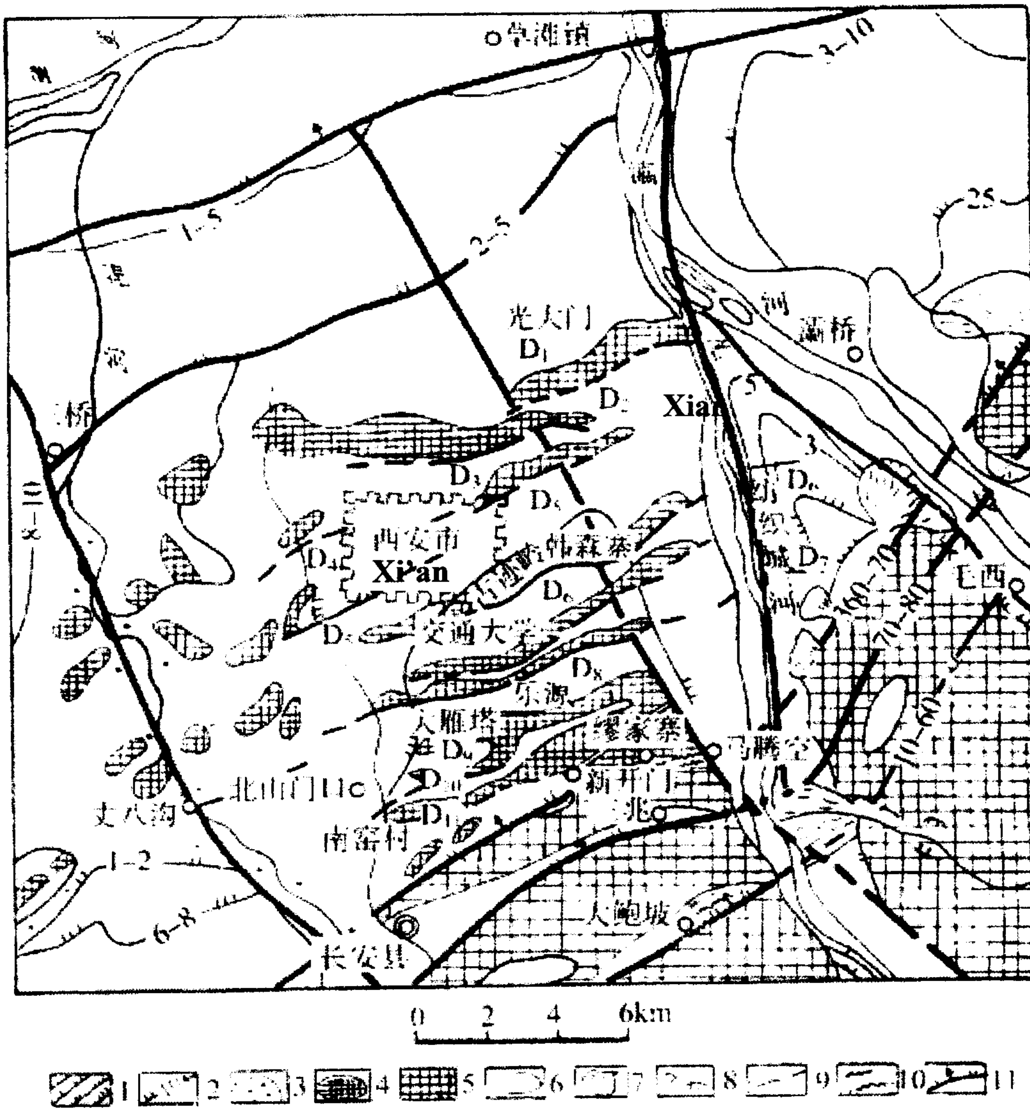

图 6-4 西安地裂缝分布及构造地貌图

（据陕一水，转引自彭建兵等，1992）

1. 河流阶地，Ⅰ－Ⅳ级，数字代表阶地高差(m)；2. 黄土陡坎及高差(m)；3. 冲积层；4. 黄土梁；5. 黄土台原；6. 梁或原间洼地；7. 洪积层；8. 滑坡；9. 现今活动地裂缝带及其编号；10. 历史地裂缝；11. 活动正断层 D_1. 井上村地裂缝带；D_2. 辛家庙地裂缝带；D_3. 八府庄地裂缝带；D_4. 劳动公园地裂缝带；D_5. 西北大学地裂缝带；D_6. 和平门地裂缝带；D_7. 艺术学院－秦川机械厂地裂缝带；D_8. 小寨地裂缝带；D_9. 大雁塔地裂缝带；D_{10}. 陕西师范大学地裂缝带；D_{11}. 新开门地裂缝带

Figure 31. Ground fractures and structural landscape of the city of Xi'an. 1. River terraces, numbers represent elevation difference in meter. 2. Loess terraces and elevation differences. 3. Alluvial deposits. 4. Loess ridges. 5. Loess mesas. 6. Depressions. 7. Flood deposits. 8. Landslides. 9. Active fracture zones. 10. Historical fractures. 11. Active normal faults (D5- Northwestern University Fracture); D6 - Big Pagoda Fracture. From Zhou et al., 2002.

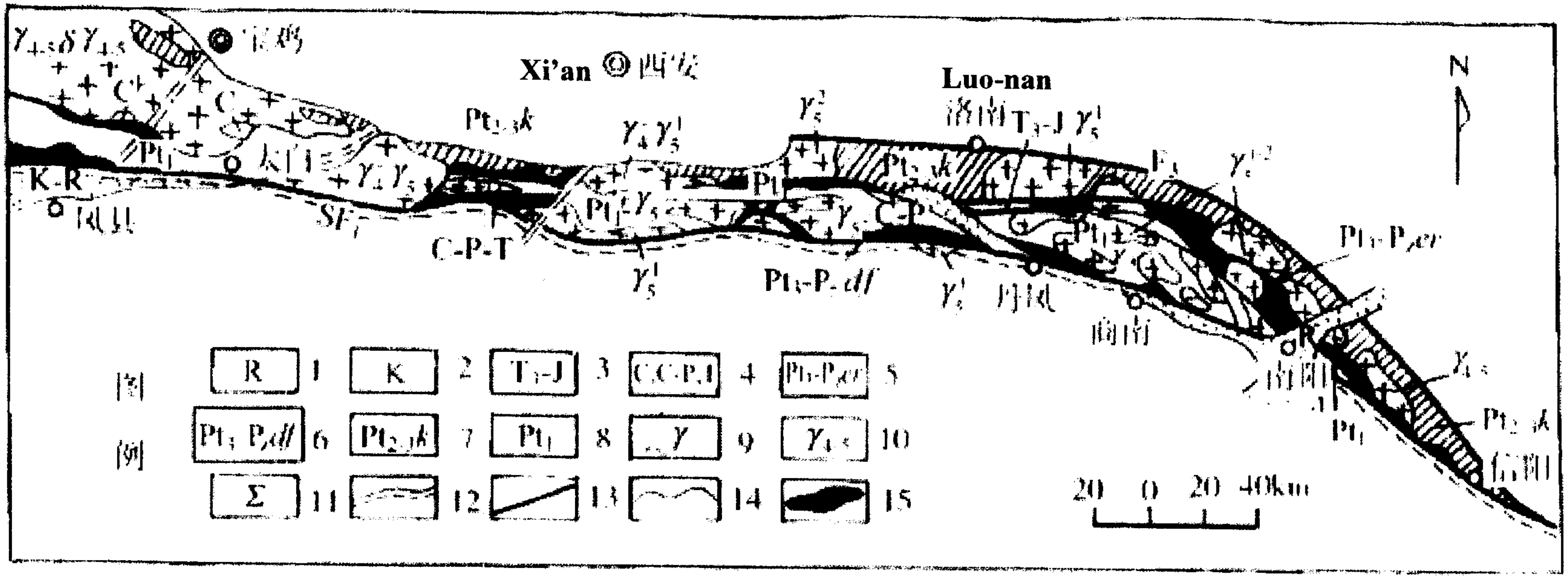

图 4-6 北秦岭构造带地质略图

（张国伟等，2001）

1.第三系；2.白垩系；3.上三叠统-侏罗系；4.石炭系-二叠系-三叠系；5.新元古界-下古生界二郎坪群；6.新元古界-下古生界丹凤群；7.中、新元古界宽坪群；8.古元古界秦岭群；9.花岗岩；10.印支-燕山期花岗岩；11.超基性岩；12.韧性、脆性断层带；13.脆性断层；14.地质界线；15.变沉积-火山岩带

Figure 32. Simplified geologic map of Northern Qinling Belt. 1. Tertiary, 2. Cretaceous, 3. Upper Triassic-Jurassic, 4. Carboniferous-Permian-Triassic, 5. Neo-Proterozoic-Lower Paleozoic Erlangping Group, 6. Neo-Proterozic-Lower Paleozoic Danfeng Group, 7. Meso-Neo-Proterozoic Qinling Group, 8. Paleo-Proterozoic Qinling Group, 9. Granite, 10. Indosinian-Yanshanian granite, 11. ultra-mafic rocks, 12. ductile-brittle fault zone, 13. brittle fault zone, 14. geologic contact, 15. meta-sedimentary-volcanic rocks. From Zhou et al., 2002.