42nd Annual Meeting of the Society for Organic Petrology

Geological Field Guide to the Datong Basin

7-10 September 2026 | Datong, China
China University of Mining and Technology (Beijing)
Taiyuan University of Technology

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(TSOP 2026)

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Safety instructions

Overview

Physical demands: low to medium — short walks over uneven ground and brief stops along mountain roadsides; no strenuous hiking is planned

Elevation range: approximately 900–1,800 m along the route

Weather: variable; approximately 9°C in the early morning, rising to 20–24°C around midday, rain remains possible.

Group equipment provided by the organisers

☑ Travel insurance.

☑ First-aid kit.

☑ Durable work gloves.

☑ Raincoat.

☑ Rock hammer (where permitted)

☑ Sample bags (where permitted)

Personal equipment checklist

Clothing and personal protection

☐ Hiking boots

☐ Extra clothing for cold weather.

☐ Hat.

☐ Sunscreen.

☐ Sunglasses.

☐ Insect repellent.

☐ Umbrella

Geological field equipment (optional)

☐ Hand lens

☐ GPS or smartphone with offline maps.

☐ Field notebook and pencils.

Emergency contact.

Name	Responsibilities	Phone	Email
Beilei Sun	General coordination	+86-13834547128	sunbeilei@tyut.edu.cn
Xiaofang He	General coordination	+86-13436391699	xiaofang.he@cumtb.edu.cn
Chao Liu	General coordination	+86-15536972780	tyutliuchao@163.com
Qunying Xu	Medical staff (doctor)	+86-13621336201	

Baggage storage

Beijing Nirvana Resort Beijing offers a baggage storage service. Unnecessary luggage can be deposited at the hotel on 7 September and pick up later.

Route and programme

Field excursion itinerary

Date	Itinerary	Overnight
7 Sep	Beijing–Datong; Datong Volcanoes National Geological Park	Hunyuan
8 Sep	Chuanchang abandoned open-pit coal mine	Datong
9 Sep	Jinhuagong National Mine Park; Yungang Grottoes	Datong
10 Sep	Direct Datong–Beijing coach return	—

Route anchors

(Google Earth kmz files: https://www.jianguoyun.com/p/Dci342sQofn7DRi71aYGIAA)

Day	Route	Distance
1	Nirvana Resort Beijing – Xuanhua Service Center – Haotian Hotel – Jinshan – Laohushan – Tongyue Hengjing Hotel	143.6 + 146.8 + 9.8 + 4.7 + 68.1 km **(total ≈ 373 km)**
2	Tongyue Hengjing Hotel – Chuanchang open-pit mine – Wufengshan Buddha – Weidu International Hotel	34.7 + 8.6 + 85.7 km **(total ≈ 132.3 km)**
3	Weidu International Hotel – Jinhuagong National Mine Park – Yungang Grottoes – Weidu International Hotel	18.5 + 5.7 + 17.8 km **(total ≈ 42.0 km)**
4	Weidu International Hotel – Nirvana Resort Beijing	323.0 km

Named stop coordinate index (Coordinates in decimal degrees using the WGS 84 datum.)

Stop No.	Stop name	Longitude (E)	Latitude (N)
1-1	Nirvana Resort Beijing	116.17476	40.08909
1-2	Xuanhua Service Center	115.02103	40.52442
1-3	Haotian Hotel, Datong — lunch stop	113.60328	40.03457
1-4	Jinshan volcanic site	113.62278	40.11150
1-5	Laohushan volcanic site	113.62203	40.08550
1-6	Tongyue Hengjing Hotel, Hunyuan	113.70249	39.70634
2-1	Chuanchang Village bus stop	113.90115	39.64791
2-2	Chuanchang open-pit coal-mine exposure	113.90996	39.64118
2-3	Chuanchang lunch/regrouping point	113.90713	39.64409
2-4	Dolomite and mine-exposure point	113.90527	39.64242
2-5	Wufengshan Qingshi Reclining Buddha	113.86655	39.70486
2-6	Weidu International Hotel, Datong	113.29508	40.07413
3-1	Jinhuagong National Mine Park	113.13198	40.10307
3-2	Jinhuagong mine canteen	113.13085	40.10371
3-3	Yungang Grottoes	113.12919	40.11048

Coach timetable

Monday 7 September 2026: Beijing → Datong volcanic field → Hunyuan	
07:30–07:45	Gather in the Nirvana Resort Beijing lobby and load luggage.
07:45–08:00	Welcome, safety reminder and morning head count.
08:00–10:10	Coach to Xuanhua Service Centre (143.6 km).
10:10–10:30	Comfort stop at Xuanhua Service Centre; head count before departure.
10:30–13:15	Continue by coach to Haotian Hotel, Datong (146.8 km).
13:15–14:30	Lunch at Haotian Hotel.
14:30–14:50	Coach to Jinshan volcanic site (9.8 km).
14:50–16:30	Field programme at Jinshan volcanic cone.
16:30–16:50	Short coach transfer to Laohushan (4.7 km).
16:50–17:20	Field stop at Laohushan volcanic cone.
17:20–18:30	Coach to Tongyue Hengjing Hotel, Hunyuan (68.1 km).
18:30–19:00	Hotel check-in and equipment check.
19:00–20:30	Dinner in Hunyuan.

Tuesday 8 September 2026: Hunyuan → Chuanchang → Wufengshan → Datong	
07:30–08:20	Gather in the hotel lobby; Coach to Chuanchang Village parking point (34.7 km).
08:20–08:40	Mine induction, access confirmation and PPE briefing.
08:40–11:10	Stop 2.1: Chuanchang coal-bearing section and mine exposure.
11:10–11:30	Walk/regroup at the organiser-marked lunch point.
11:30–12:20	Lunch and head count.
12:20–13:35	Stop 2.2: carbonate outcrop and structural-contact observations.
13:35–13:50	Return to the coach, remove/return PPE as directed, and head count.

Tuesday 8 September 2026: Hunyuan → Chuanchang → Wufengshan → Datong		
13:50–14:20	Coach to Wufengshan Qingshi Reclining Buddha (8.6 km).	
14:20–15:30	Stop 2.3: Wufengshan geological and heritage comparison.	
15:30–17:30	Coach to Weidu International Hotel, Datong (85.7 km).	
17:30–18:00	Hotel check-in.	
18:00–20:00	Dinner in Datong ancient city.	

Wednesday 9 September 2026: Jinhuagong National Mine Park → Yungang Grottoes		
07:45–08:00	Gather in the Weidu International Hotel lobby and complete the head count.	
08:00–08:40	Coach to Jinhuagong National Mine Park (18.5 km).	
08:40–09:00	Host briefing, access confirmation and mine-issued PPE.	
09:00–11:30	Jinhuagong National Mine Park programme and approved underground visit.	
11:30–12:15	Lunch at the Jinhuagong mine canteen.	
12:15–12:30	Coach to the Yungang Grottoes (5.7 km).	
12:30–16:30	Yungang Grottoes: sandstone, weathering and cultural-heritage programme.	
16:30–17:10	Coach return to Weidu International Hotel, Datong (17.8 km).	
18:00–19:00	Dinner in Datong.	

Thursday 10 September 2026: Datong → Beijing		
07:30–08:00	Hotel check-out, luggage loading and final Datong head count.	
08:00–10:15	Coach departs Weidu International Hotel and travels towards Beijing.	
10:15–10:35	Motorway service stop; exact location controlled by the driver.	
10:35–13:30	Arrive in Beijing	
13:30	Close of the excursion.	

* Participants should be in the lobby 15 minutes before coach departure.

Introduction to Datong

Shanxi — the name means "west of the mountains", after the Taihang range that forms its eastern rampart — occupies the eastern flank of the Loess Plateau in North China (Fig. 1), between the North China Plain and the Ordos Block. The province is a high, tilted tableland, framed by the Taihang Mountains to the east, the Lüliang Mountains to the west, the Heng Mountains and the Great Wall along its northern border with Inner Mongolia, and the Zhongtiao Mountains to the south; the Yellow River traces its western and southern boundary with Shaanxi. Roughly two-thirds of the province lies at elevations between about 1,000 and 1,800 m, cut by the north–south Fen River valley into a chain of basins that has shaped settlement in the region since antiquity. This excursion crosses the northern part of that plateau, from Beijing across the Taihang front into the Datong Basin at Shanxi's northern tip, then back again on the final day.

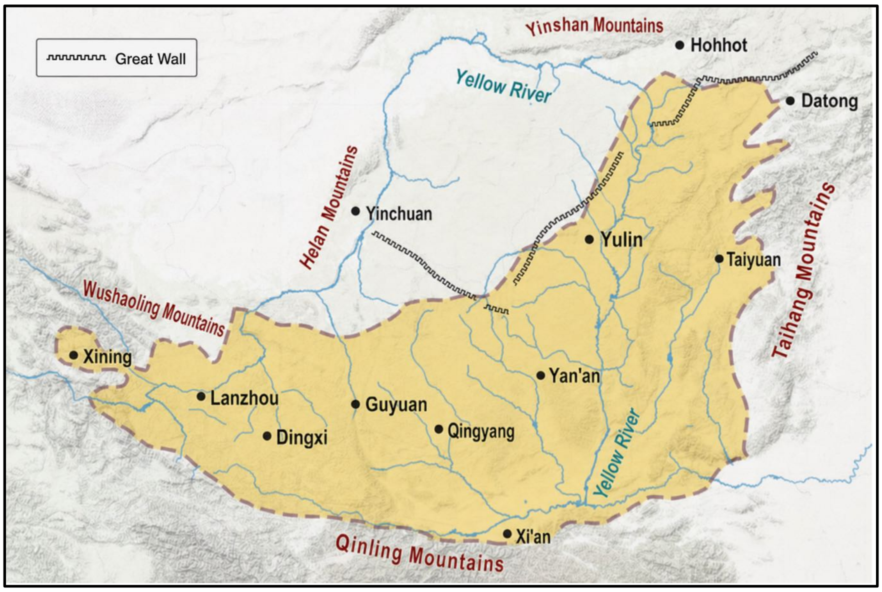

Fig. 1 Map showing the location of Datong and loess plateau.

Shanxi's place in North China has always been defined by this position on the edge of the loess plateau, astride the routes linking the agricultural heartland to the steppe. Its short name, Jin, is inherited from the state of Jin, one of the major powers of the Spring and Autumn period in the first millennium BCE, and the province is counted among the early centres of Chinese civilisation, with settlement in the Fen valley reaching back to the Neolithic. Through the imperial period the region served as a military and cultural frontier — a corridor for the entry of Buddhism into China from Central Asia, and repeatedly a buffer and battleground between Han dynasties and the nomadic powers to the north. Datong, at the excursion's northern turning point, embodies this history directly: known in antiquity as Pingcheng, it was the capital of the Northern Wei dynasty from 398 to 494 CE, and it was under Northern Wei imperial patronage that the Yungang Grottoes, visited on Day 3, were carved into the sandstone cliffs west of the city. Datong later served as a secondary capital under the Liao and Jin dynasties and as a garrison town on the Ming and Qing frontier (Fig. 2), and its more recent history as one of China's principal coal-mining centres — continues that same identity as a place where resources, strategy and culture on the northern edge of China have long intersected.

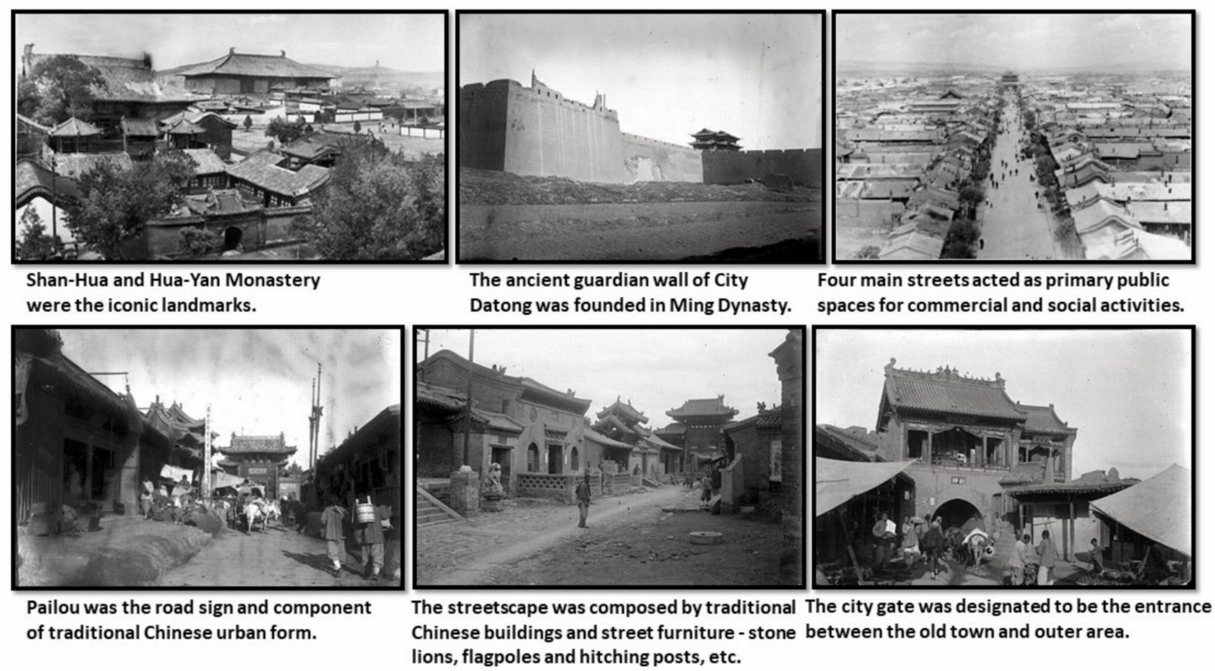

Fig. 2. The basic urban form of Datong was established during the Ming and Qing dynasties.[1]

Datong Ancient City and the Yungang Grottoes represent the city's historical and cultural heritage, while coal mines, railways, miners' settlements and large energy facilities form the other side of its modern industrial geography (Fig. 2). Abundant coal resources transformed Datong during the twentieth century into an industrial city centred on coal extraction, transportation and power generation. The distribution of coal mines influenced employment and population movement while also reshaping land use, transport networks and settlement patterns in western Datong and the surrounding counties.

While maintaining its coal-production and energy-supply capacity, Datong is promoting intelligent mining and environmentally responsible coal extraction, alongside the development of wind power, solar photovoltaics, and energy storage industries. Projects such as photovoltaic bases established in coal-mining subsidence areas have converted parts of the traditional mining landscape into sites of renewable-energy production. At the same time, Datong is strengthening the conservation and sustainable use of cultural resources while developing cultural tourism, equipment manufacturing and digital industries. Present-day Datong therefore retains the distinctive character of a coal-mining city while also undergoing a transition towards a diversified energy economy, cultural-heritage conservation and service-oriented urban development.

Geological Background of Datong Basin

Overview

The Datong Basin is a Cenozoic fault-controlled basin in northern Shanxi Province, centred on Datong City and drained by the Sanggan River. It is an elevated intermontane depression surrounded by the Hengshan and Guancen mountains, the Xiaowutai–Hengshan region, and uplands along the southern margin of the Inner Mongolian Plateau. The basin has a cool, semi-arid environment with grassland-dominated vegetation, widespread loess and alluvial deposits, and strong contrasts between loess-covered basin floors and dissected mountain fronts.[2–3] The Datong Basin is distinct from the Datong Coalfield, which refers primarily to older coal-bearing successions and associated mining districts, and from the neighbouring Hunyuan Basin, which is a separate fault depression within the northern Fenwei–Shanxi rift system (Fig. 3a).[2,4–5]

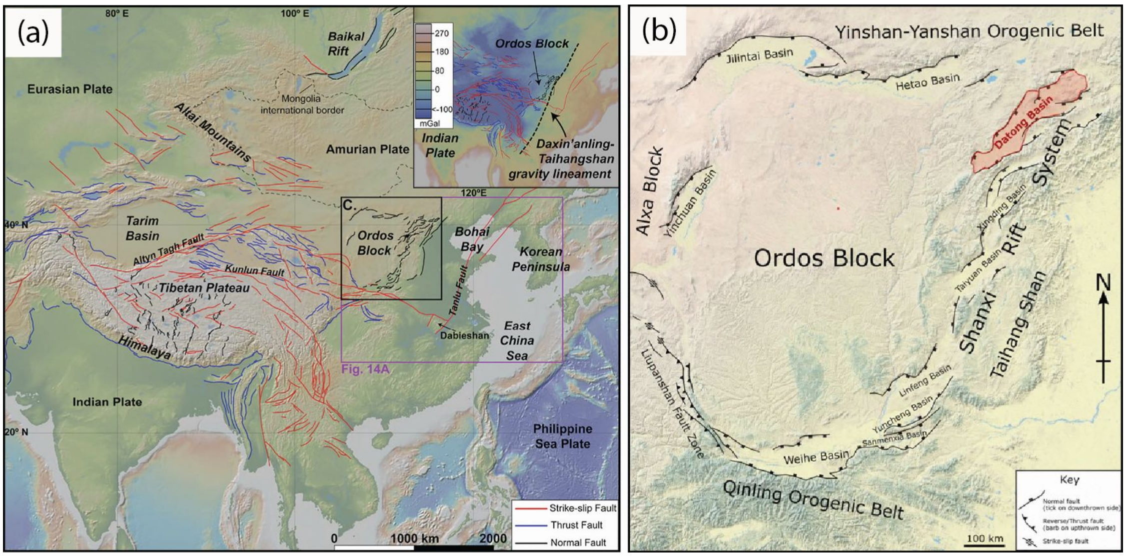

Fig. 3. (a) Regional fault map of central and eastern Asia, after Clinkscales et al.[6] Base map: Global Multi-Resolution Topography, available through GeoMapApp.[7] (b) Map of the Shanxi Rift System along the eastern margin of the Ordos Block (modified from Wikipedia).

Tectonic and structural framework

The Shanxi Rift is an intracontinental rift composed of linked Cenozoic basins (Fig. 3b). Regional thermochronology indicates that fault-related exhumation and subsidence began locally during the Paleogene, whereas basin-focused studies identify major late-Miocene reactivation and renewed subsidence at about 10–8 Ma. These interpretations can be reconciled by diachronous initiation, fault reactivation and the distinction between early flank deformation and development of the modern depocentre.[8–10] Extension has been attributed to far-field effects of both India–Asia collision and western Pacific subduction, although their relative contributions remain debated.[11]

The basin is an asymmetric graben to half-graben with a dominant northeast to north-northeast structural grain (Fig. 4a). The Kouquan Fault controls much of the western margin; the northern piedmont fault of the Hengshan Mountains is an important southern boundary (Fig. 4b); and the Yanggao–Tianzhen and Sanggan River fault systems affect the northern and eastern sectors. Huairen, Yingxian and Housuo form the principal depressions, separated by basement highs. Differential subsidence produced strong variations in facies and thickness, with as much as about 1,800 m of Cenozoic sediment in the Huairen depression. Intrabasinal faults also guided drainage, depocentre migration and the distribution of volcanic centres.[12–14]

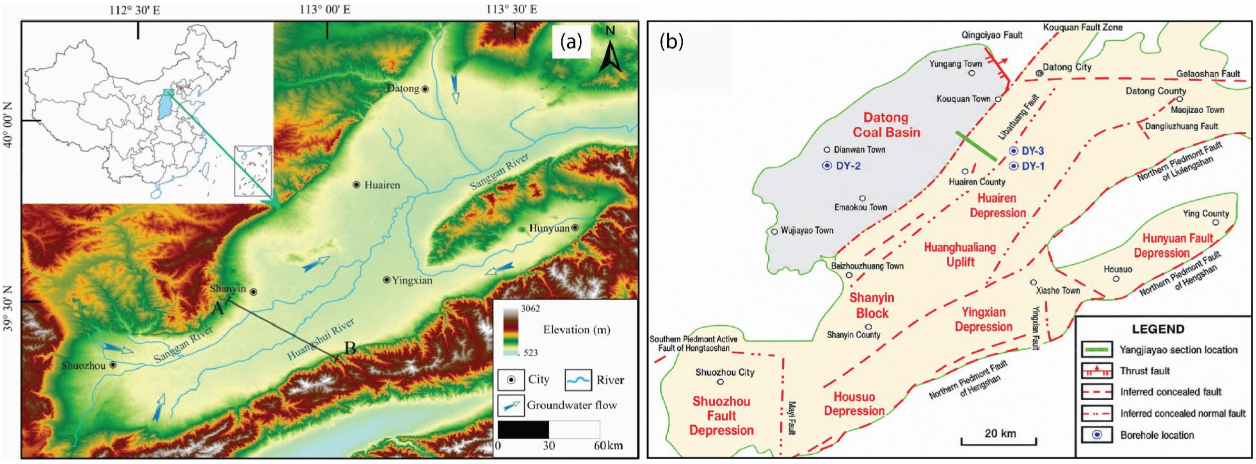

Fig. 4. (a) Location and elevation of the Datong Basin.[15] (b) Structural divisions of the Datong Basin and Datong Coalfield, showing the principal range-bounding faults.[16]

Stratigraphy and coalfield context

Archean–Paleoproterozoic gneiss, granulite and granitoid rocks form the crystalline basement. Cambrian–Ordovician shallow-marine carbonates overlie this foundation, followed by Carboniferous–Permian marine-to-continental strata in which the Taiyuan and Shanxi formations contain important coal measures. Triassic–Jurassic deposition was dominantly continental, with fluvial, floodplain, lacustrine and peat-forming environments. The Jurassic coalfield lies mainly west of the Kouquan Fault and belongs to the older, pre-Cenozoic framework rather than to the Cenozoic Datong Basin itself. Mesozoic shortening, fault reactivation, dike emplacement and later uplift further reorganized this inherited succession.[17–20] The principal formations of the Carboniferous–Permian succession in the Datong Basin include the Benxi, Taiyuan, Shanxi, Xiashihezi and Shangshihezi formations. A detailed stratigraphic description is provided under Day 2, Chuanchang abandoned open-pit mine section.

Day 1 — Datong volcanic field

Cenozoic volcanism in North China

Cenozoic volcanic rocks are widely distributed across the North China Craton and adjacent regions of eastern Asia. More than 590 volcanic edifices and over 50,000 km² of exposed basaltic lava constitute the northern part of the Cenozoic volcanic zone of eastern China (Fig. 5).[21] They are predominantly intraplate volcanic rocks, ranging from basanites and alkaline basalts to tholeiites and more evolved alkaline compositions. Their ocean-island-basalt-like trace-element patterns and mixed isotopic signatures indicate contributions from both depleted asthenospheric mantle and enriched mantle domains.[22–23]

The origin of this volcanism has been linked to several interacting processes, including lithospheric thinning, asthenospheric upwelling, intracontinental extension, and interaction between mantle-derived melts and the subcontinental lithospheric mantle. Pacific Plate subduction and the stagnation of Pacific slabs in the mantle transition zone may have contributed to mantle metasomatism, while the far-field effects of the India–Asia collision influenced regional deformation and faulting.[11,23–24] Because these processes operated at different times and depths, no single geodynamic model fully explains the spatial and chemical diversity of Cenozoic volcanism in North China.

It is well established that the Archean North China Craton (NCC) experienced widespread thermotectonic reactivation during the Late Mesozoic and Cenozoic, resulting in replacement of its old, cold, thick and depleted lithospheric mantle by younger, hotter, thinner and more fertile mantle.[25–27] More importantly, lithospheric thinning in the NCC may have proceeded diachronously. While the lithosphere was progressively thinned in the western NCC (east of the Daxinganling–Taihangshan gravity lineament; Fig. 1) during the Cenozoic, it thickened in the eastern NCC, probably owing to regional thermal decay following peak magmatism in the Late Cretaceous.[28] Datong Quaternary basalts were emplaced in the western NCC and are compositionally distinct from Oligocene and Miocene lavas elsewhere in the region.[28] Petrogenetic characterization of the Datong lavas is therefore important for understanding lithosphere–asthenosphere interaction during this major change in NCC lithospheric architecture.[25–27]

Datong volcanic field

The Datong volcanic field is located on the western side of the Taihangshan–Daxinganling gravity-gradient zone within the North China Craton. It occupies the northernmost basin of the Shanxi–Shaanxi Rift System and lies within the tectono-geomorphic framework of NNE-trending transtensional fault-bounded basins in eastern China. The volcanic field is bounded by the

Yanggao–Tianzhen Fault to the north, the Liulengshan piedmont fault to the south and the Kouquan Fault to the west.[29–30] The Quaternary basalts of Datong are exposed approximately between 39°55′22″ and 40°10′35″ N and between 113°34′17″ and 113°56′45″ E.

Previous studies have divided the Datong volcanic field into western and eastern sectors (Fig. 5b), with the Chenzhuang–Xubao line as the approximate boundary. In the western sector, basalts occur predominantly as explosive and effusive facies, forming more than 30 volcanic cones. Because these basalts were derived from greater depths, they are characterized by low silica and high alkali contents and are classified as alkaline basalts. Volcanism in the eastern sector was less explosive, and basaltic magmas commonly erupted along faults, particularly the Sanggan River and Liulengshan faults, producing extensive effusive basalt flows. Because the eastern-sector basalts were derived from shallower depths, they have relatively high silica and low alkali contents and are classified as tholeiitic basalts.[31–34]

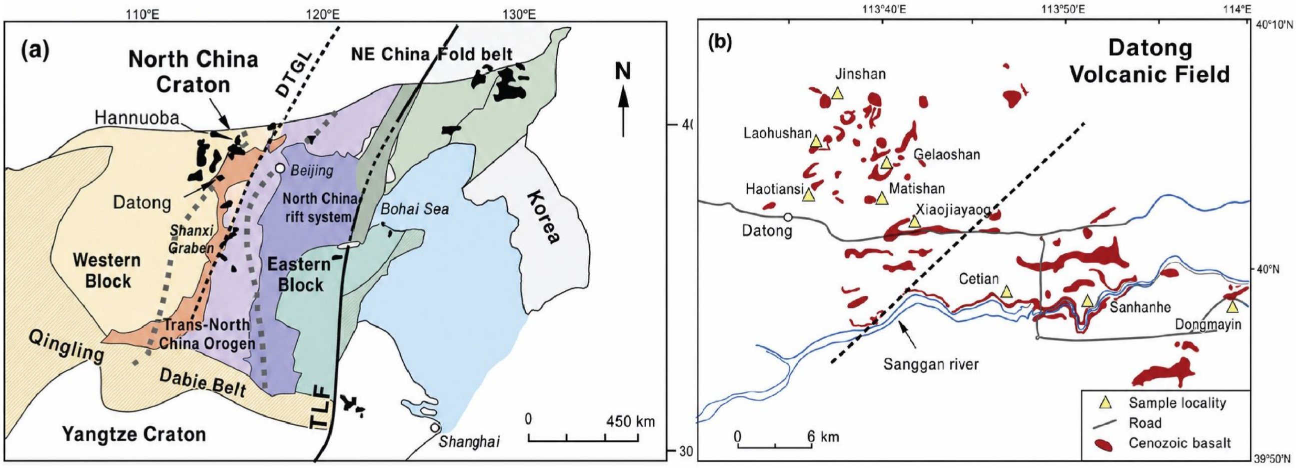

Fig. 5. (a) Simplified tectonic map of the North China Craton showing the distribution of Cenozoic basalts. (b) Quaternary basalts in the Datong volcanic field and sampling localities. The dashed line separates two morphologically and compositionally distinct parts of the field (modified after Xu et al.).[35]

The volcanic centres are commonly aligned along northeast-trending faults, particularly the Sanggan River fault system. This distribution indicates that inherited and active fractures played an important role in providing pathways for magma ascent. The field also displays a broad spatial contrast: western centres are generally cone-shaped and dominated by alkaline basalts, whereas eastern centres contain more extensive tholeiitic lava flows and fewer volcanic cones (Fig. 5).[36] The volcanic rocks also show distinctive petrological and geochemical features. This contrast makes the Datong volcanic field an important natural laboratory for studying the relationship between faulting, magma transport and mantle melting.

Spatial Variations and eruptive history of the Datong Volcanic Field

The Datong volcanic rocks include both alkaline and tholeiitic basalts. Their principal minerals are olivine, clinopyroxene, plagioclase, orthopyroxene and Fe–Ti oxides. Many samples display ocean-island-basalt-like or enriched-mid-ocean-ridge-basalt-like trace-element patterns, including enrichment in incompatible elements such as the light rare earth elements, Nb, Ta and Zr. It shows a northwest–southeast transition from alkali basalts to tholeiites, accompanied by a general eastward decrease in εNd values (Fig. 6). Why do alkaline basalts dominate the western field while tholeiitic basalts dominate the eastern field? Possible explanations include differences in melting degree, lithospheric thickness, source composition and magma–lithosphere interaction.

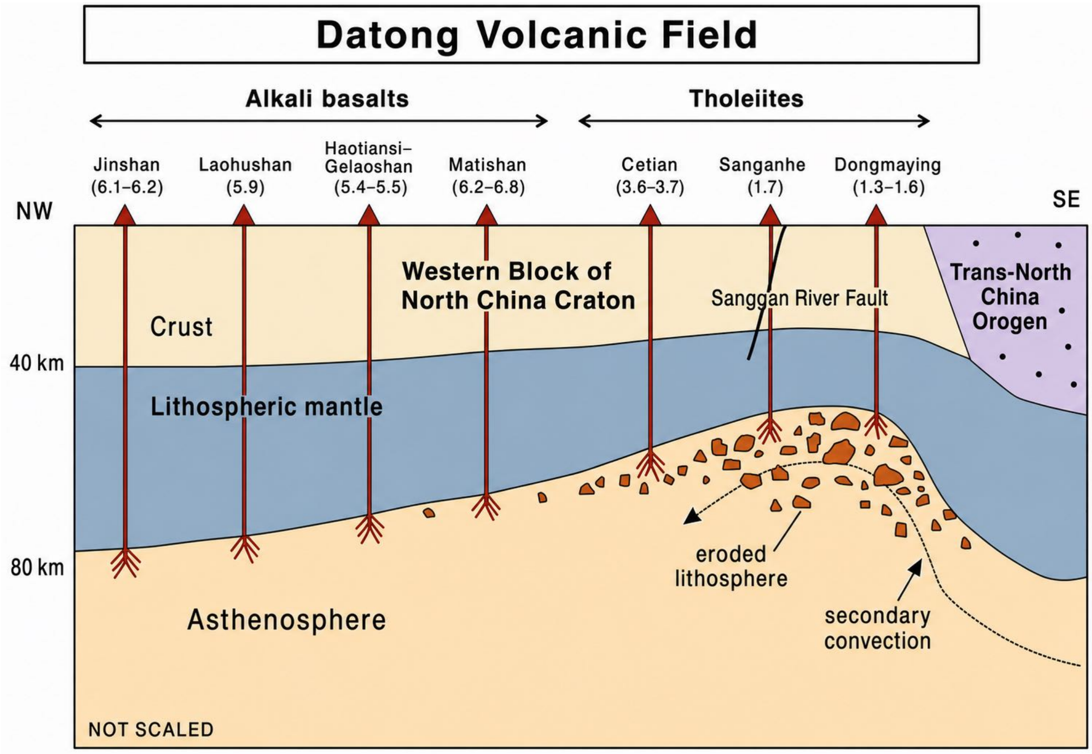

Fig. 6. Cartoon illustrating a model for the spatial distribution of Quaternary basalts in the Datong volcanic field. The numbers in parentheses below the locality names are the εNd ranges reported by Xu et al.; they suggest distinct mantle characteristics from west to east.[35]

Volcanism occurred episodically during the Quaternary. The eruptive history of the Datong basalts can generally be divided into three stages. (1) Effusive basalts at Cetian Reservoir in the eastern sector erupted at approximately 0.74–0.54 Ma (lower Haotianshan and Langwoshan). (2) Explosive-facies basalts in the western sector and effusive-facies basalts in the eastern sector erupted extensively at approximately 0.4–0.3 Ma (Gushan and Cetianshan). (3) Large-scale eruptions at approximately 0.2 Ma are represented by effusive basalts along the piedmont fault near Qiulin Village, forming Jinshan, Heishan and the upper part of Haotianshan.[37–38] However, radiocarbon dating of loess incorporated into products of the Dongpingshan scoria cone yielded an age of approximately 7,300 calibrated years BP, providing evidence for Holocene volcanism [36]. These differing results show that the chronology of the field remains unresolved, but they support describing Datong as dormant rather than definitively extinct.

Key volcanic cones in the Datong Volcanic Field (Fig. 7)

- **Stop 1-4: Jinshan (Gold Mountain):** A remarkably intact, symmetrical cone shaped like a glowing horseshoe.
- **Stop 1-5: Laohushan (Tiger Mountain):** elevation 1206 m, the best location to have an overview of the whole volcanic cluster.
- **Heishan:** the highest cone in the area
- **Langwoshan (Wolf Mountain):** Features the largest and deepest crater in the cluster, allowing visitors to walk inside.
- **Haotian Mountain:** topped by the historic Haotian Temple built right on the crater.
- **Gelao Mountain:** Noted for its peach-heart shape and radial erosion grooves that offer sweeping panoramic views.

Fig. 7. Key volcanic cones from Datong Volcanic Cluster (photos from internet)

Stop by stop introduction

Stop 1.1 Nirvana Resort Beijing

Stop 1.2 Xuanhua Service Center

Stop 1.3 Haotian Hotel for lunch

Stop 1.4: Jinshan cone

The cone is horseshoe-shaped and consists of interbedded basaltic scoria and pyroclastic deposits. Molten volcanic material overflowed from the crater and flowed outward, breaching the cone and producing its horseshoe-shaped form. The opening of the cone faces NNE (Fig. 8).

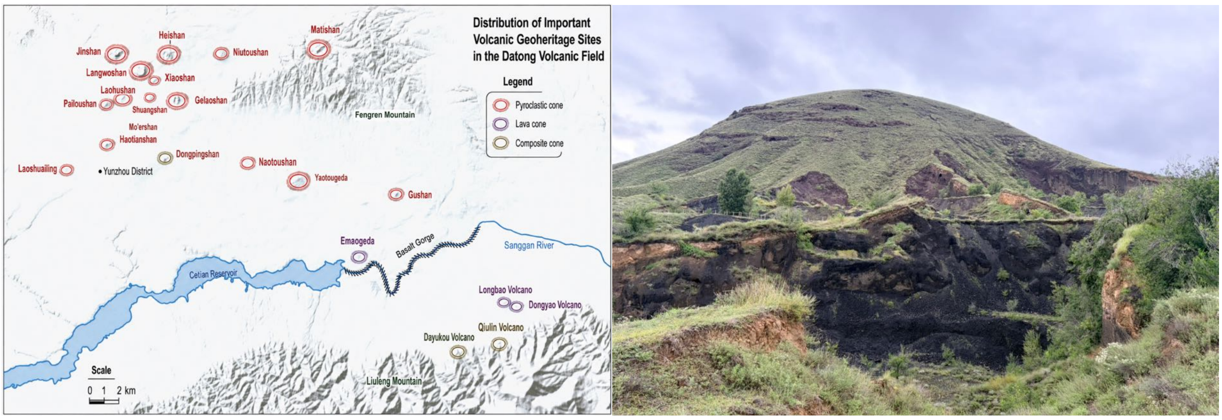

Fig. 8. Datong Volcanic Cluster and Overview of Jinshan Cone

Fig. 9. Volcanic ash layers in Jinshan volcano

Viewed from a distance, Jinshan comprises three thick layers of differently coloured scoria and pyroclastic material: the lower layer is black, the middle layer is greyish black and the upper layer is reddish brown (Fig. 9). These layers indicate that Jinshan was formed by the accumulation of volcanic ejecta during three successive eruptions separated by relatively short intervals (Fig. 10).

Fig. 10. (a) Large-scale volcanic bombs in volcanic ash layers; (b) Lava flow structure

Stop 1.5 Laohushan Cone

The principal basis for classifying it as a scoria cone is that the Datong volcanoes are generally small and were commonly formed during a single eruptive episode. They consist predominantly of pyroclastic material, with only minor lava flows. In particular, most of the volcanic bombs are scoriaceous or twisted in form, while the texture of the lapilli closely resembles that of the scoriaceous bombs (Fig. 11).

Most of the lapilli, however, are loose and unconsolidated. This distinguishes the Datong volcanoes from typical scoria cones, in which the lapilli are commonly heat-altered and welded together through agglutination caused by reheating.

Fig. 11 Overview of Laohushan volcano

Day 2 — Chuanchang closed open-pit coal mine

The main focus is the stratigraphy, coal seams and structural framework of the closed Chuanchang open-pit coal mine area in the southeastern part of the Hunyuan coal-producing district, Southwestern Datong. Particular attention will be given to the coal-bearing Upper Carboniferous Taiyuan Formation and to the normal faults that control the distribution and preservation of the coal measures (Fig. 12).

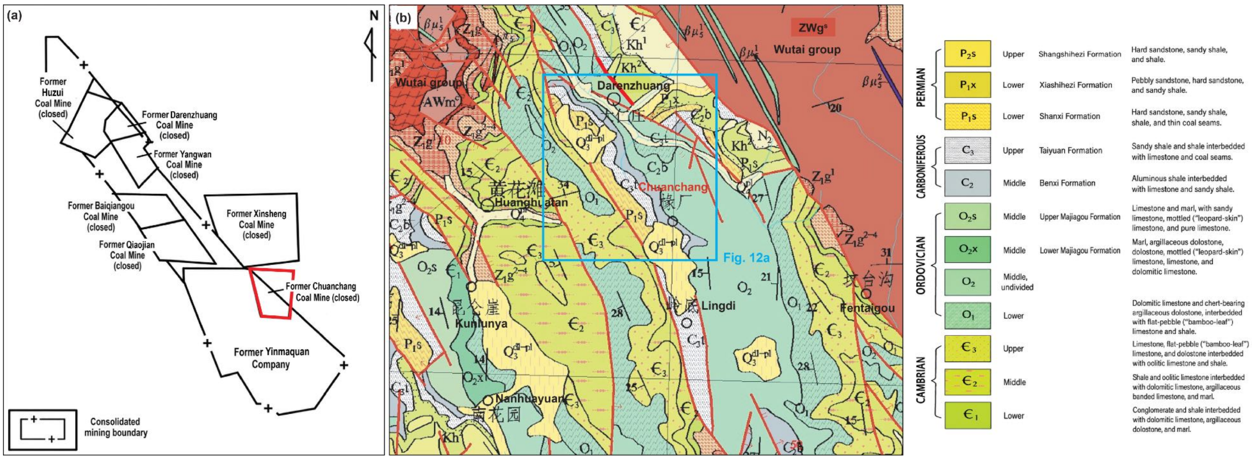

Fig. 12. (a) Historic distribution of mines within and around the integrated Dongbang minefield; the Chuanchang coal mine is labelled in the southeastern sector. (b) Geological map of the study area[39]

Regional Late Palaeozoic stratigraphic framework

The province-wide coal-bearing sequence rests unconformably on a Cambrian–Ordovician carbonate platform, following a regional hiatus that spans most of the Late Ordovician through Early Carboniferous (Fig. 13). The Benxi Formation marks the base of the transgressive clastic sequence deposited onto this eroded carbonate surface. The overlying Taiyuan Formation consists of interbedded coal, siltstone, mudstone and limestone, generally interpreted as lagoonal and carbonate-platform to lower-delta-plain deposits under marine-influenced conditions.[40–41] The Shanxi Formation sits conformably above, recording the upward transition to upper-delta-plain and fluvial conditions as marine influence waned across North China. Coal petrographic and geochemical studies indicate that Taiyuan Formation coals, formed under more reducing and marine-influenced conditions, differ systematically from the overlying Shanxi Formation coals—typically showing higher vitrinite content, lower ash yield and higher sulfur, compared with more oxidizing terrestrial signatures upward in the Shanxi Formation.[42] This vertical facies change—from marine-influenced lagoon/platform coal to fluvial/deltaic coal—is one of the more reliable field criteria for distinguishing the two formations where contacts are poorly exposed.

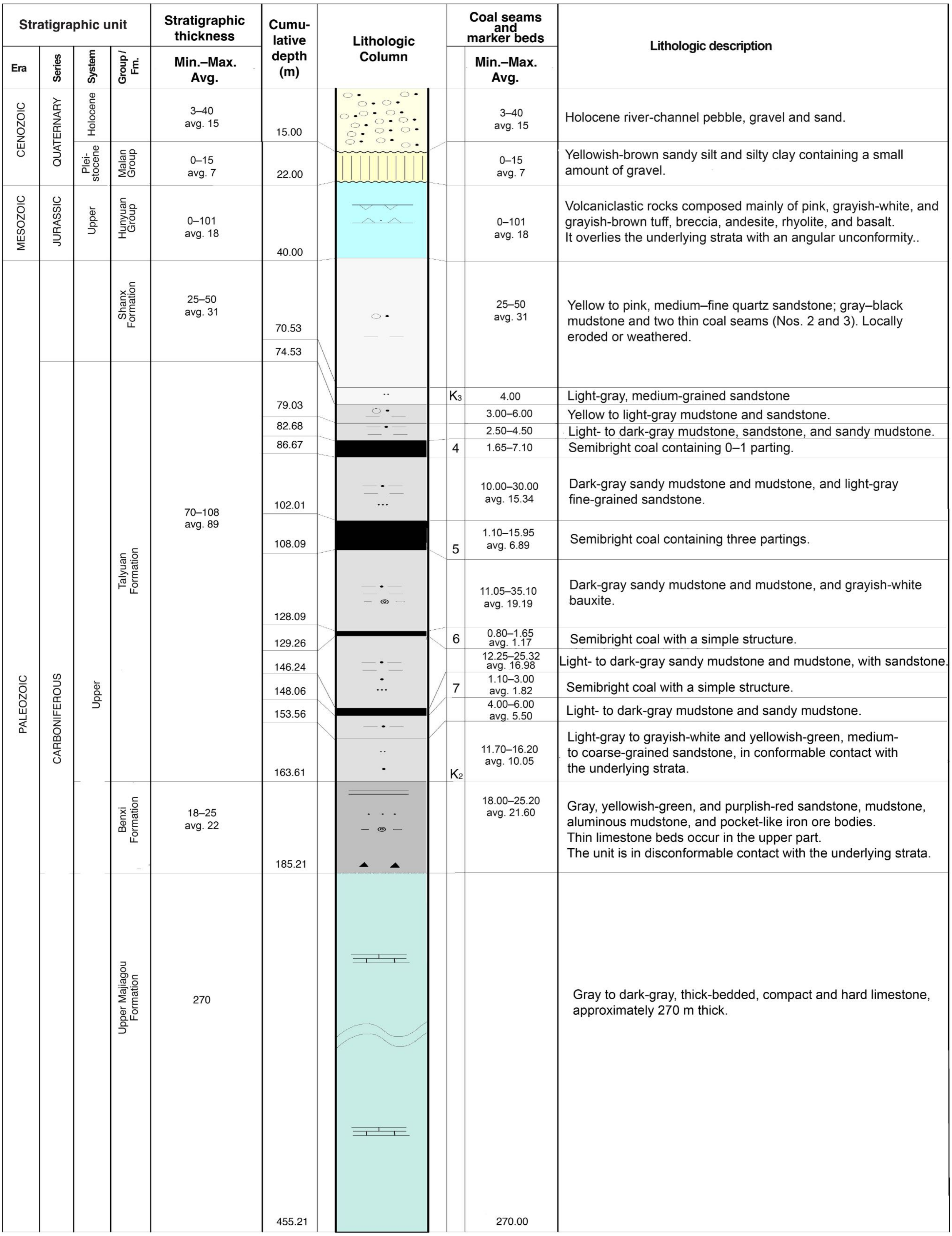

Fig. 13. Coal-bearing part of the composite stratigraphic column, emphasizing the Benxi, Taiyuan and Shanxi formations and seams 4–7. Source: 2011 Dongbang reserve-verification report.[39]

Stratigraphy of the Hunyuan Coal Mine Area

Cambrian (Є)

The Cambrian succession consists mainly of grey, purple-red and yellow thin-bedded limestone, flat-pebble ("bamboo-leaf") limestone and oolitic limestone, with thin shale interbeds. It is approximately 510 m thick and is exposed in the western part of the mine area.

Ordovician (O)

The Ordovician succession is dominated by grey, thick- to very thick-bedded limestone, dolomitic limestone, flat-pebble limestone and mottled ("leopard-skin") limestone. It is approximately 270 m thick and crops out locally in both the western and eastern parts of the mine area.

Carboniferous (C)

Middle Carboniferous Benxi Formation (C_2b)

The upper part of the Benxi Formation consists of hard, grey, cryptocrystalline limestone. Fractures are relatively well developed and commonly filled by calcite veins. The lower part comprises grey mudstone, bauxite and brown Shanxi-type ironstone. The formation is 18.0–25.2 m thick, averaging 21.6 m, and rests disconformably on the underlying strata.

Upper Carboniferous Taiyuan Formation (C_3t)

The Taiyuan Formation is the principal coal-bearing unit in the mine area. It consists of grey to yellow, medium- to fine-grained quartz sandstone; grey, dark-grey and greyish-black sandy mudstone and mudstone; and coal. The mudstone and sandy mudstone contain abundant fossil plant fragments.

Four mineable seams—Nos. 4, 5, 6 and 7—occur in the southern part of the mine area. In the northern part, only seams Nos. 4, 5 and 6 are present. The formation is 70–108 m thick, averaging 82.07 m, and crops out locally in the eastern part of the mine area.

The Taiyuan Formation succession, described from base to top, is as follows:

Permian (P)

Lower Permian Shanxi Formation (P_1s)

The Shanxi Formation consists mainly of yellow, yellowish-white and pink, medium- to fine-grained quartz sandstone, together with grey to black mudstone and coal. It contains Coal Seams Nos. 2 and 3. Because the strata occur at shallow depths, these seams have commonly been removed by erosion or affected by weathering and oxidation.

The formation is 25–50 m thick, averaging 30.53 m, and is conformable with the underlying Taiyuan Formation.

Jurassic System (J)

Upper Jurassic Hunyuan Group (J_3h)

The upper part of the Hunyuan Group comprises soft, yellowish-white tuff. The lower part consists of hard rock whose weathered fracture surfaces are stained rusty brown. The Hunyuan Group rests unconformably on the underlying strata. It is locally preserved, with a thickness of 0–101 m and an average thickness of approximately 18 m. it is mostly exposed in Jinhuagong Mine Park on Day 3.

Quaternary System (Q)

Upper Pleistocene Malan Formation (Q_3m)

Most of the Dongbang mine area is covered by Quaternary loess. The Malan Formation consists predominantly of young loess, with local red clay. The loess is homogeneous and massive, without visible bedding, and is silty, calcareous and porous. A gravel bed occurs locally at its base. The formation is 0–15 m thick, averaging approximately 7 m.

Holocene deposits

Modern channel deposits occur along the Nanhewan riverbed. They consist mainly of pebbles, gravel and sand and are 3–40 m thick, averaging approximately 15 m.

Structural geology

The Dongbang mine area occupies the southeastern part of the Hunyuan coal-producing district. Its coal-bearing succession is controlled principally by the NNW-trending Lingdi normal fault. The mine area is elongated north–south and relatively narrow east–west, with the coal measures preserved within a NW–SE-trending synclinal depression. In the northern part of the mine area, the strata form a west-dipping monocline. In the south, they form a broad, gentle syncline. The synclinal axis trends NNW, while its hinge plunges SSE at approximately 3–5°. West of the synclinal axis, the strata dip northeastward at 5–15°.

Lingdi Normal Fault (F_1): The Lingdi Fault forms the western boundary of the mine area. It extends from Douzui Mountain through Xiliang, southward to the western slope near Lingdi Village in Lingqiu County and northward to the area west of Qiaojian Village. The fault strikes N25–30°W. Its plane dips N60–65°E at approximately 80°. The estimated displacement is 200–300 m, with uplift of the western block. Cambrian and Ordovician limestones are exposed in the uplifted block, producing a natural geological boundary to the mine area.

Yinmaquan Normal Fault (F_2): The Yinmaquan Fault crosses the river flats in the southern part of the mine area. It terminates westward against the Lingdi Fault and extends approximately 1.5 km eastward towards Chuanchang Village. The fault strikes approximately N88°E and dips at about 87°. Its displacement decreases eastward from approximately 8–10 m to 3–5 m.

Stop by stop introduction

Stop 2.1: Bus stop

Fig. 14. Google Earth satellite image showing the field-trip route and Stops 2.1–2.5 around the Chuanchang open-pit coal mine. Blue lines indicate the access route. Imagery © 2026 CNES/Airbus via Google Earth.

Stop 2.2: Taiyuan Formation

The Chuanchang open-pit mine is approximately square in shape (Fig. 14), with a minefield area of about 0.43 km². Mining began in ~1989 and ceased before 2000 (Fig. 15). The coal-bearing strata are controlled by the NNE-trending Lingdi normal fault (F1; Fig. 12), and the mine is bounded to the south by the Yinmaquan normal fault (F2; Fig. 12b). The minefield is elongated north–south and narrow east–west, with the coal measures preserved within a NW–SE-trending synclinal trough. In the northern part of the minefield, the strata form a west-dipping monocline, whereas the southern part is characterized by a broad, gentle syncline (Fig. 12). The synclinal axis trends NNW, and its hinge plunges SSE at 3–5°. Relative to the synclinal axis, strata on the western limb dip northeast at 5–15°.[39]

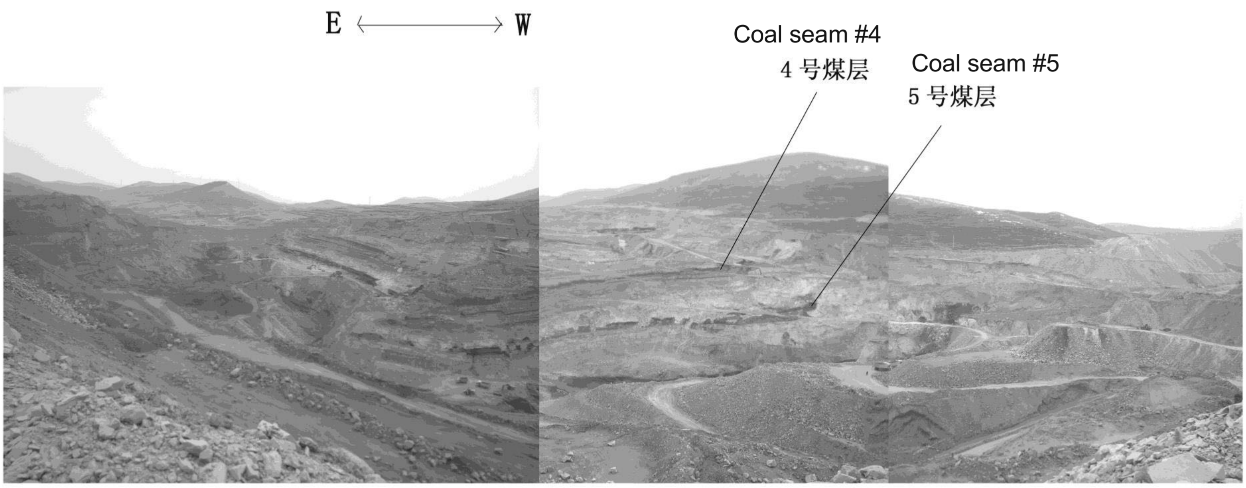

Fig. 15. Old panoramic view of the Chuanchang open-pit coal mine showing the exposed positions of coal seams 4 and 5. East is to the left and west to the right.

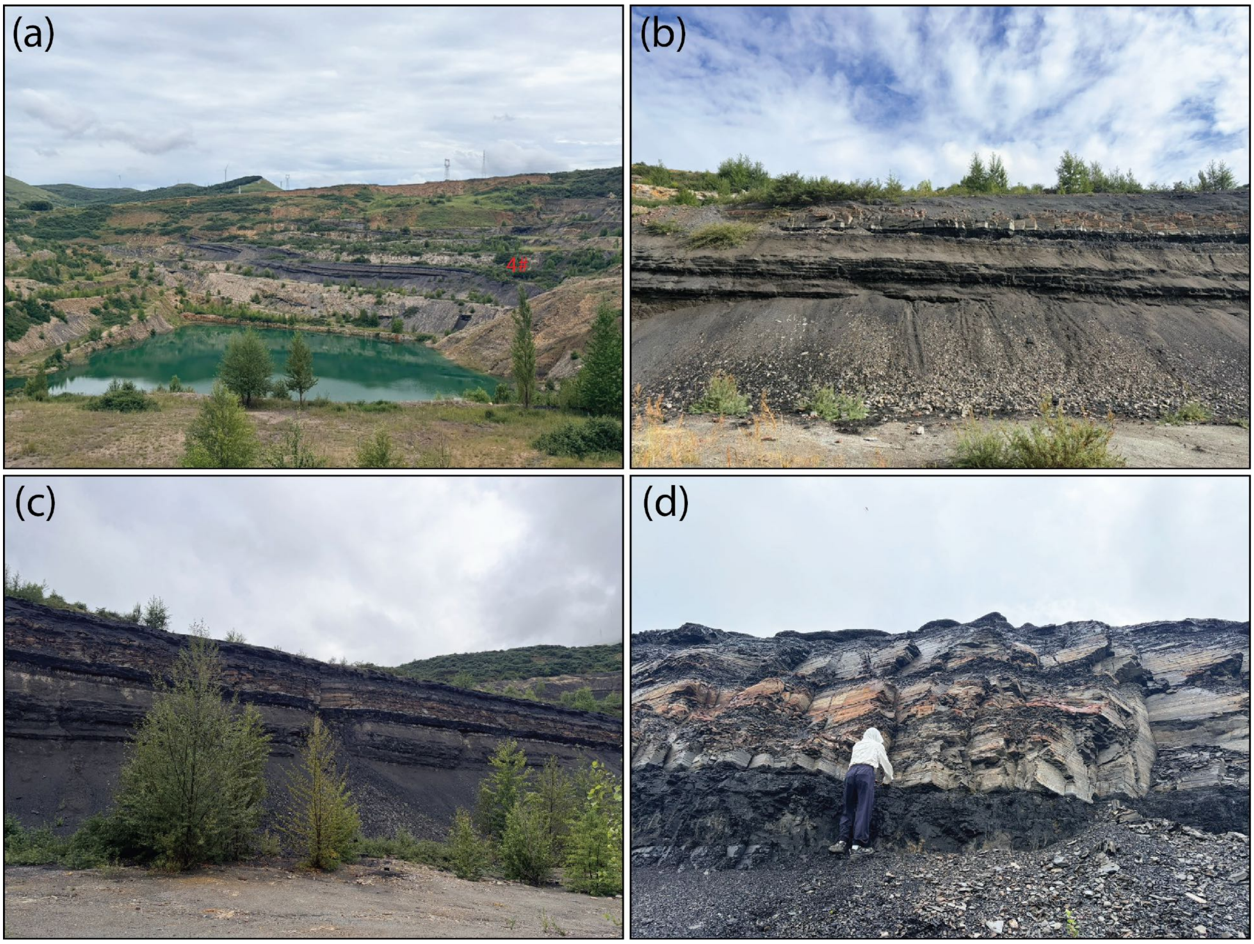

Fig 16. Field characteristics of the coal-bearing succession at the Chuanchang open-pit coal mine. (a) Overview of the open pit and exposed coal-bearing strata; the position of Coal Seam 4 is marked in red. (b) Field exposure of the interpreted boundary between the Upper Carboniferous Taiyuan Formation and the Lower Permian Shanxi Formation. (c) Representative interbedded coal and clastic strata used for coal-quality and macroscopic petrological observations. (d) Local structural deformation of the coal-bearing strata; person for scale.

The Lower Permian Shanxi Formation contains two to three non-mineable seams (Fig. 16), whereas the Upper Carboniferous Taiyuan Formation (70–108 m thick) hosts mineable seams 4–7, with a combined mean coal thickness of 13.87 m (Table 1). Seam 5 is the thickest and most laterally persistent; it splits northward into seams 5-1 and 5-2 and was the principal seam worked at the Chuanchang Mine. Seam 7 is mainly confined to the central-southern part of the minefield.

Table 1 Characteristics of Mineable Coal Seams in the Taiyuan Formation

Coal seam	Thickness range (m)	Mean thickness (m)	Mean spacing (m)	Structure	Stability	Mineability	Roof lithology	Floor lithology
4	1.65–7.10	3.99	15.34	Complex	Stable	Mostly mineable	Medium-/fine-grained sandstone	Mudstone
5	1.10–15.95	6.89	19.19	Complex	Stable	Fully mineable	Fine-grained sandstone	Mudstone
6	0.80–1.65	1.17	16.98	Simple	Stable	Mostly mineable	Fine-grained sandstone	Mudstone
7	0–3.00	1.82	—	Simple	Relatively stable	Locally mineable	Carbonaceous mudstone	Mudstone

In terms of coal quality (Table 2), the seams are classified as long-flame or non-caking coal. Historical air-dried ash, total sulfur and gross calorific values are as follows: Seam 4, long-flame coal, 11.82% ash, 0.52% total sulfur and 27.64 MJ kg^{-1}; Seam 5, non-caking coal, 18.76% ash, 2.09% total sulfur and 25.17 MJ kg^{-1}; Seam 6, long-flame coal, 11.25% ash, 2.10% total sulfur and 28.22 MJ kg^{-1}; and Seam 7, non-caking coal, 20.44% ash, 1.28% total sulfur and 22.33 MJ kg^{-1}.[39] These figures are useful for framing field and sampling questions, but they pre-date the excursion and may use a different analytical basis (raw, air-dried, dry or washed product) from material collected in 2026; the datasets should therefore not be combined directly.

Table 2 Key coal-quality parameters of Chuanchang closed open-pit mine

Seam	Coal classification	Ash (%)	Volatile matter (%)	Fixed carbon (%)	Total sulfur (%)	Gross calorific value (MJ/kg)	Apparent density (t/m³)	Overall quality
4	Long-flame coal (CY)	11.82 / 8.31	43.30 / 37.39	50.00 / 62.91	0.52 / 0.49	27.64	1.32	Low ash, low sulfur, high calorific value
5	Non-caking coal (BN)	18.76 / 8.251	45.08 / 35.47	44.61 / 19.26*	2.09 / 1.87	25.17	1.27	Medium ash, medium-high sulfur, medium calorific value
6	Long-flame coal (CY)	11.25 / 6.48	39.52 / 42.34	53.67 / 53.92	2.10 / 2.16	28.22	1.31	Low ash, medium-high sulfur, high calorific value
7	Non-caking coal (BN)	20.44 / —	34.26 / —	37.99 / —	1.28 / —	22.33	1.31	Medium ash, medium sulfur, low calorific value

Stop 2.3: Lunch place

Stop 2.4：Ordovician dolomite outcrop

The outcrop consists mainly of pale-grey to buff, medium- to thick-bedded dolomite that is locally weathered and cut by fractures and joints (Fig. 17). Some surfaces contain abundant tubular and locally branching trace fossils, forming a dense ichnofabric that records extensive bioturbation of the original carbonate sediment.

Regionally, Ordovician carbonate rocks form the substrate beneath the younger Benxi, Taiyuan and Shanxi formations. The unconformable contact at the base of the Benxi Formation represents a major depositional break before the accumulation of the later coal-bearing succession, although this contact is not necessarily exposed at Stop 2.4. The site therefore provides useful regional context for the nearby Chuanchang coal-mine section by contrasting the older marine carbonate succession with the overlying clastic and coal-bearing strata. A formal formation-level assignment should remain provisional unless supported by a detailed geological map or measured stratigraphic section.

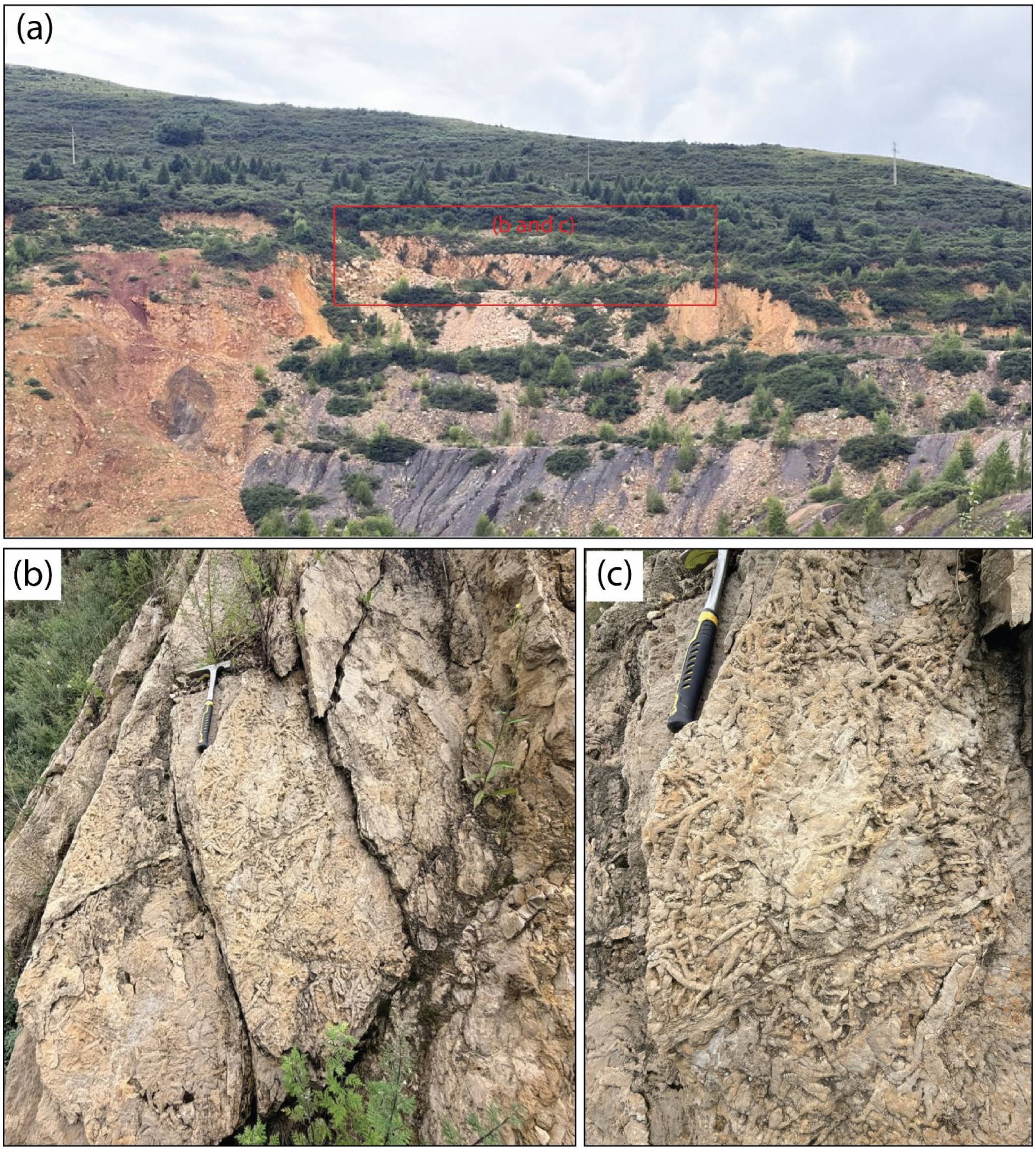

Fig. 17. Dolomite exposure at Stop 2.4 near the Chuanchang open-pit coal mine. (a) Overview of the outcrop; the red box indicates the location of panels (b) and (c). (b) Weathered dolomite surface containing abundant tubular trace fossils; hammer for scale. (c) Close-up of the densely distributed burrow structures and associated bioturbation.

Stop 2.5: Wufeng Mountain reclining Buddha

Wufeng Mountain lies approximately 12 km southeast of Hunyuan County and forms part of the Hengshan mountain range. It is about a 1.5-hour drive from central Datong. The mountain takes its name from its five prominent peaks, whose outline resembles the five fingers of a human hand. At the foot of the mountain is a broad, level area enclosed by wooded hills.

A notable cultural feature is a reclining Buddha carved from bluestone and reportedly weighing about 300 tonnes (Fig. 18). Beside the statue stands a traditional performance stage. Temple fairs are held here during Buddhist festivals, and an annual blessing ceremony known locally as the Baixian Assembly takes place on 15 May. Visitors from surrounding communities gather for religious observances and folk performances, including portrayals of the four pilgrims from Journey to the West. The event is one of the most important annual festivals for nearby villages.

This heritage site sets within a carbonate-bearing landscape. The regional comparison rests on the contrast between this carbonate bedrock and the clastic, coal-bearing successions seen at Chuanchang.

Fig. 18. Cultural features at Stop 2.5, Wufeng Mountain. (a) The bluestone reclining Buddha sheltered beneath a natural rock overhang, with the ceremonial courtyard and pavilions in the foreground. (b) The wooded access path leading to the religious site at the foot of the mountain.

Stop 2.6: Weidu International Hotel, Datong

Day 3 — Jinhuagong National Mine Park and the Yungang Grottoes

Stop 3.1 Jinhuagong National Mine Park

Jinhuagong National Mine Park is located west of Datong, directly across the river from the UNESCO World Heritage Site of the Yungang Grottoes. Its setting brings together two very different aspects of Datong's regional identity: the long history of coal mining and the internationally renowned Buddhist heritage represented by the grottoes. Developed from the former Jinhuagong coal-mining complex, the park preserves a working-mining landscape while interpreting the geological origin, extraction, utilisation and cultural significance of coal. It therefore provides an important link between the natural history of the Datong Coalfield and the industrial and social development of the city.

Fig. 19. Industrial heritage area of Jinhuagong National Mine Park. (a) Panoramic winter view showing preserved coal-handling machinery, conveyor structures and associated mining facilities. (b) Entrance landscape featuring a monumental coal sculpture and a stylised mine headframe, symbolising the site's coal-mining history and industrial heritage.

According to the park introduction, Jinhuagong is one of China's earliest and most extensive coal-mine tourism destinations based on an authentic underground mining environment. It is designated as a National AAAA Tourist Attraction and has also served as a national demonstration site for industrial tourism, science education, ecological development and study tours. The park incorporates the Datong Coal Museum, an underground mine-exploration route, a coal-mining industrial heritage area (Fig. 19) and a former miners' residential area. Together, these sites illustrate the relationship between the coal resource, the mine, its workforce and the surrounding landscape.[43]

Underground Mine Exploration Tour

Located 156 m underground, the Underground Mine Exploration Tour is described by the park as the world's largest attraction of its kind and the first in China where visitors can explore an authentic underground mine environment (Fig. 20). Covering 17,500 m², including 9,500 m² open to visitors, the mine exposes Jurassic coal-bearing strata approximately 140 million years old (Fig. 21).[43]

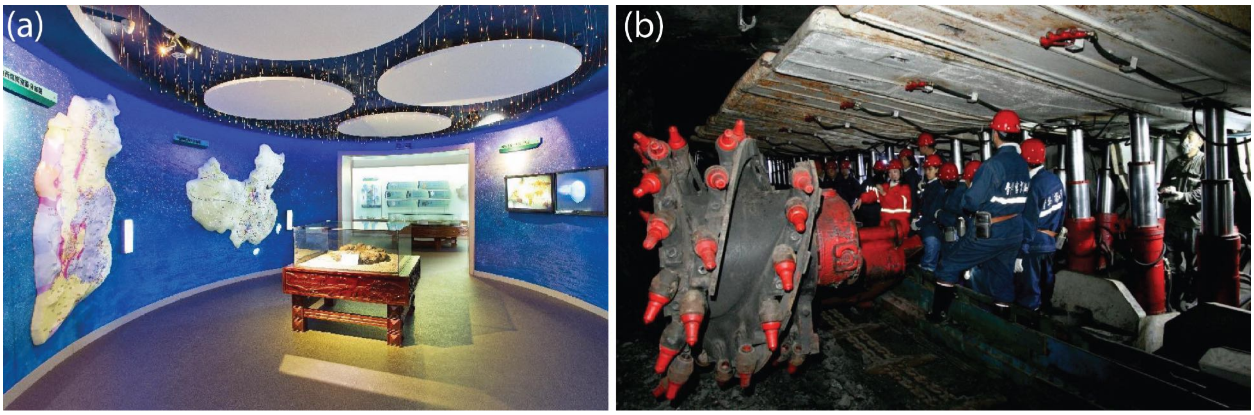

Fig. 20. Underground mine exploration tour

Visitors can experience the everyday life of a miner by riding a mine train, wearing miners' clothing and a headlamp, and enjoying a traditional miners' meal. They can also operate a coal drill and mining machinery and even try extracting coal themselves. This immersive experience offers a vivid appreciation of the miners' spirit of dedication and pursuit of excellence, as well as their sincerity, resilience, and warm-hearted character.

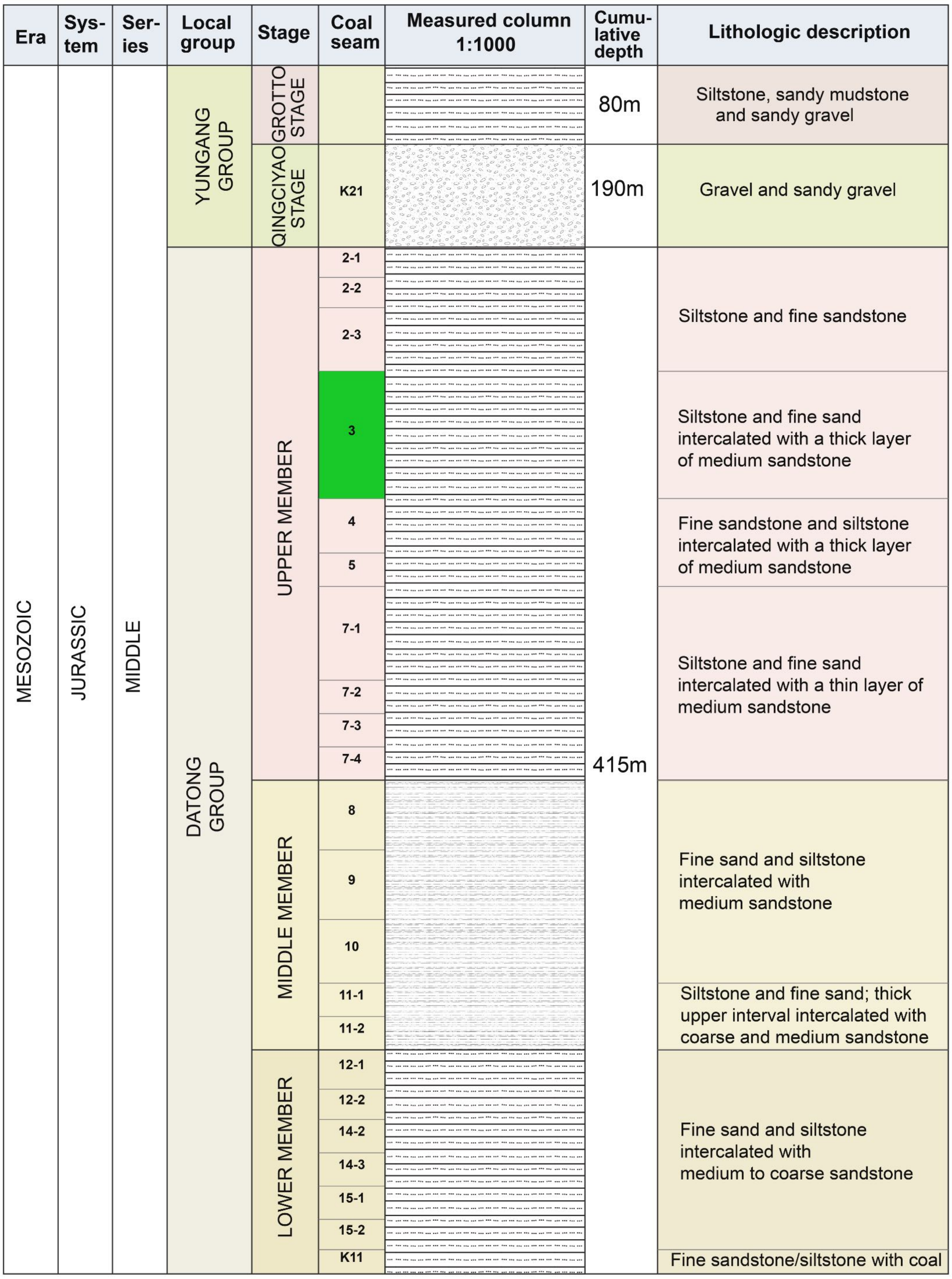

Fig. 21. Middle Jurassic Yungang–Datong stratigraphic column

For field-trip participants, the underground route offers an opportunity to consider how geological information is translated into mining practice. Particular attention may be given to coal-seam thickness and continuity, the character of the roof and floor rocks, the occurrence of partings, fractures and joints, and the engineering measures used to maintain underground stability. Mining excavations also demonstrate how geological structures influence roadway orientation, working-face design, ventilation, drainage and coal recovery. Features produced by excavation or ground pressure should be distinguished from primary bedding, natural joints and tectonic structures.

Industrial heritage and mining communities

The park preserves a substantial collection of industrial structures associated with the former mine. These include the inclined-shaft crane platform, the winding-engine house, a century-old winding engine, boiler and compressor buildings, hot-air furnace facilities, a surface electrical substation and parts of the coal-transport system. The surviving buildings and machinery record the infrastructure required to move workers, equipment and coal between the surface and underground workings. They also demonstrate that a coal mine is not simply an excavation but a highly integrated industrial system involving power, ventilation, transport, water management, communications and coal preparation.

The former miners' residential area adds an important social dimension to the visit. Covering approximately 45,000 m², it is one of the most complete surviving relocation sites associated with the Jinhuagong mine. Its stone-built outer walls and clearly preserved layout retain elements of the original mining-community architecture. The area records the living environment of earlier generations of miners and their families, allowing the history of coal production to be understood through the people and communities that supported it.

Landscape restoration and regional context

Jinhuagong National Mine Park also illustrates the reuse and ecological rehabilitation of former mining land. Jinyang Lake covers approximately 32,000 m² and represents an attempt to combine mine-water treatment, water recycling and low-carbon landscape design. Its shoreline, planted wetlands, embankments and wooden walkways have transformed a previously industrial setting into a recreational ecological space. Guiling Pool and the adjoining viewing platform were similarly developed on rehabilitated waste-rock ground. These areas demonstrate how mine waste and disturbed land can be stabilized, replanted and incorporated into a new post-mining landscape.[43]

The Datong coalfield is a dual-period coalfield, carrying both Jurassic and Carboniferous–Permian coal-bearing successions; the Jurassic continental strata have historically been central to the Datong mining district, while the deeper Late Palaeozoic coal measures — the same Benxi–Taiyuan–Shanxi succession seen at Chuanchang — also occur regionally. The host briefing on the day must identify the formation, seam and mine level actually encountered on the visitor route, since seam numbers should never be carried across from one mine to another without an independent correlation. The official mine-park description includes a genuine underground tourism route; the 2026 access level, electronic-device rules and PPE requirements are set by the host on the day and override anything stated here.

Within the mine-park setting, coal lithotype and banding record maceral and mineral heterogeneity and the original peat-forming conditions, read from brightness, band thickness, cleat and mineral matter; the roof and floor record the depositional environment and the ground-control behaviour of the working, read from lithology, bedding and any fossils or plant debris; a parting or split records a change in peat accumulation, clastic influx or channel influence, read from its thickness, lateral continuity and contact geometry; a fault or old working records post-depositional structure or mining legacy, read from orientation, displacement, support response and access restriction; and a museum specimen is selected teaching material rather than an in-situ exposure, and should be read for its stated provenance, seam, collection point and preparation rather than treated as equivalent to the working face. No independent movement, sampling, open flame, smoking or unapproved electronic device is permitted underground, and the group remains between assigned guides, stopping work immediately if visibility, ventilation, footing or personal comfort becomes unsafe.

Coal is best read together with its immediate roof, floor and any intervening partings, since a coal band, mudstone parting or sandstone roof each records a local change in peat accumulation, clastic influx or channel proximity, and cleats and joints record later fracture development; the mine opening makes these relations visible in three dimensions, though support and excavation can obscure their original lateral continuity. The site also illustrates the distinction between geological exposure and industrial interpretation: a reconstructed gallery, an equipment display or a selected specimen communicates mining history well, but its geological meaning depends on a stated provenance, and the comparison with Chuanchang remains conceptual — both sites belong to the wider Datong coalfield, but the formation, mine level and seam at Jinhuagong must be independently identified before a seam number or stratigraphic label is carried across from one to the other.

Stop 3.2 Lunch at the Mine Park

Stop 3.3 Datong Yungang Grottoes

The Yungang Grottoes represent one of the most important surviving monuments of early Buddhist cave art in China. Excavated mainly between the mid-fifth and early sixth centuries during the Northern Wei Dynasty, the complex records the introduction and transformation of Buddhist artistic traditions in northern China. UNESCO documents 252 caves and niches, approximately 51,000 statues and around 18,000 m² of carved surfaces. In recognition of its exceptional historical and artistic significance, the site was inscribed on the UNESCO World Heritage List in 2001.[44]

Fig. 22. Buddhist sculpture carved into the sandstone cliff at the Yungang Grottoes

The location and preservation of the grottoes are closely linked to their geological setting. The sculptures and chambers were carved into the Middle Jurassic Yungang Formation, which consists predominantly of medium- to coarse-grained feldspathic sandstone interbedded with mudstone and sandy mudstone. The sandstone was sufficiently workable for large-scale excavation and detailed carving, but its heterogeneous composition has also produced marked differences in long-term durability （Fig. 22）. Grain size, mineral composition, cement type, bedding, clay-rich interbeds, joints and pore connectivity all influence the mechanical behaviour of the cliff and its response to weathering.

Day 4 · Thursday 10 September — Datong to Beijing

On the final day, the group will return directly to Beijing by motorway. The coach will leave the Weidu International Hotel in Datong in the morning and travel approximately 323 km to Nirvana Resort Beijing. One service-area stop is planned, with the location chosen by the driver according to traffic conditions and required rest breaks.

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