Tectonic evolution of the North Qilian Mountain:

From Paleozoic oceanic subduction to Cenozoic plateau expansion

A 8-days fieldtrip from Sunan to Dunhuang
Why the North Qilian Mountain?

• Early Paleozoic orogenic belt preceded with a cold oceanic subduction zone with a subduction history from 520 Ma to 440 Ma

• Reactivated as an intra-continental orogenic belt flanked on its northern side by a typical foreland fold-and-thrust belt due to the far-field effect of the India-Eurasia collision in the Cenozoic era

• Excellent outcrops and landscapes

• Convenient traffic conditions
Summary

• Day 0: arriving at Jiayuguan by air

• Days 1 – 3: early Paleozoic oceanic subduction and the subsequent orogeny *(Sunan County)*
  - Day 1: Oceanic subduction-related flysch (silurian), the overlying unconformity related to subsequent arc-continental collision *(northeast of Sunan)*
  - Day 2: Early Paleozoic ophiolite-like boninite-tholeiite sequence and felsic volcanic rocks *(along the road to Dachadaban)*
  - Day 3: Oceanic subduction-related metamorphic rocks, island arc granite and post-collisional deposits *(Jiugequanzi)*

• Days 4 – 7: The Cenozoic North Qilian Thrust Belt (NQTB) *(Yumen County)*
  - Day 4: The Jinfosi fold-and-thrust belt involving in a large granite pluton on the road to Yumen
  - Day 5: Cretaceous and Cenozoic sequences: initial timing *(Hongliuxia)*
  - Day 6: Long-distance nappes in the NQTB *(Kulong Shan)*
  - Day 7: Frontal thrusts of the NQTB *(Laojunniao)*

• Day 8: Early Paleozoic metamafic rocks south of the Dunhuang
Part 1

Days 1 – 3: early Paleozoic oceanic subduction and the subsequent orogeny (Sunan County)
Day 1

- Jiayuguan to Sunan (~3 hours driving)
- **Oceanic subduction and subsequent arc-continental collision**
  - *Stop 1.1*: Silurian flysch related to early Paleozoic oceanic subduction
  - *Stop 1.2*: the unconformity between the flysch and the overlying Carboniferous sequences related to subsequent arc-continental collision

Sunan for the night
The Silurian flysch north of Sunan

(a) Conglomerate interbedded with sandstone.

(b) Thin-layered fine-grain turbidite.

(c) Turbidite rhythm layers.

(d) Enlarge view of turbidite rhythm layers showing grain-sized change from siltstone to shale and the nonparallel wavy laminations.

(e) and (f) The Carboniferous limestone layers with wavy folds unconformably overlie on the deep-angled Silurian turbidite layers.
The **Silurian flysch** south of Sunan

*(left)* the Early – Middle Silurian **submarine fans**: green conglomerate and sandstone with upward-fining rhythm;

*(right)* the Late Silurian **turbidities**: grayish purple sandstones with wavemarks and crossbeddings.
Day 2

- Sunan to Dachadaban (Along the road to Qilian)

- **Early Paleozoic ophiolite-like boninite sequence**
  - **Stops 2.1 – 2.3**: Pillow lava, metallization, diabase dyke intrusions, massive dolerite and gabbro
  - **Stop 2.4**: Felsic volcanic rock

- Sunan for the night

Need to check the accurate positions of the stops with Prof. Shuguang Song.
Photographs showing the boninite sequence

(a) Sheeted dykes with single-chilled margins;

(b) – (d) Boninitic pillow lava, note that the pillows in panel (d) are overturned;

(e) – (g) Strong flattened and mylonitized pillows within thrusting fault belt;

(h) Boninitic intruded in boninitic pillow lava;

(i) Sheeted dyke swarm
Devonian molasse along the road to Dachadaban

(Left) the Devonian molasse deposited on the boninite complex;

(Right) Oligomictic conglomerate in the Devonian molasse
Day 3

- Sunan to Jiugequanzi
- Subduction-related metamorphic rocks and post-collisional deposits
  - **Stop 3.1**: Devonian Molasse
  - **Stops 3.2 and 3.3**: Low-grade blueschists with mineral assemblage of Lws-pmp-gln-ab
  - **Stop 3.4**: Peraluminous Granite and their enclaves
  - **Stop 3.5**: (optional) Cu-ore (if possible)
- Sunan for the night
Low-grade blueschists.

(a) Low-grade blueschist outcrop showing isoclinal folds.
(b) Micro-folds of glaucophane (Gln) and pumpellyite (Pmp) segregation bands.
(c) Pmp + Gln overprinting the primitive Cpx.
(d) Lws + Gln in the felsic blueschist;
(e) Lws + Gln + Pmp + Ab (+Chl) assemblage with intensive schistosity.
(f) Lws + Chl (+Ab) assemblage.
Devonian molasse

(Left) The Devonian molasse: grayish purple conglomerate
Days 4 – 7: The Cenozoic North Qilian Thrust Belt (NQTB) (Yumen County)
Simplified geological map

(Top) A geological section across the NQTB, the Jiuxi Basin and the Altyn Tagh fault system, showing the subsurface structure.
Day 4

- Sunan to Yumen (5.5-hours driving)
- Examine the front thrust of the North Qilian Thrust Belt (NQTB) along its east segment
  - Stop 4.1: The Jinfosi fold-and-thrust belt involving in a large granite pluton
- Yumen for the night
Jinfosi thrust belt

Blue: Silurian granite plutons

Yellow: Disconformity between the pluton and the Cenozoic Baiyanghe Fm (red sandstone).

Red: Frontal thrust
(Top) The Hongshancun anticline. The Silurian granite is exposed in the core and overlain disconformably by the red sandstone of the Cenozoic Baiyanghe Fm. Note that the anticline has a steeper northern limb. *North is on the right.*
**Disconformity** between the Silurian granite pluton (left) and the Baiyanghe Fm (right).

*Note* the numerous small caves in the massive sandstone of the Baiyanghe Fm.
Day 5

• Yumen to Hongliuxia

• **Cretaceous and Cenozoic sequences in the front of the NQTB: initial timing**
  
  – *Stop 5.1*: Cretaceous mudstone and sandstone
  
  – *Stop 5.2*: K₁ volcanos and dikes
  
  – *Stop 5.3*: Huoshaogou Fm. (40 – 34 Ma)
  
  – *Stop 5.4*: Baiyanghe Fm. (34 – 16 Ma)
  
  – *Stop 5.5*: Top of the Baiyanghe Fm. and the overall deformation on high
  
  – Stop 5.6: Shulehe Fm. (16 – 4.5 Ma)
  
  – Stop 5.7: Yumen Conglomerate (< 4.5 Ma)

• **Yumen for the night**
Cretaceous volcano and sedimentary rocks

(Top) Cretaceous volcano (highland in the background) and sedimentary rocks (sandstone and mudstone in the foreground)
Huoshaoogou Fm. (40 – 34 Ma)

(Top) Conglomerate and sandstone in the Huoshaoogou Fm.
Baiyanghe Fm. (34 – 16 Ma)

(Top) Tough cross-beddings;
(Left) Stone pillars consisting of massive pebbly sandstone.
Upper part of the Shulehe Fm. (16 - 4.5 Ma): sandstone interbeded with conglomerate
Yumen Fm. (< 4.5 Ma)

Clast-supported massive conglomerate
Day 6

Need to check the specific stops in the field in advance

- Yumen to Kulongshan
- **Long-distance nappes in the NQTB**
  - *Stops 6.1*: tectonic windows
  - *Stop 6.2*: thrust in the front of the North Qilian Mountain
  - *Stop 6.3*: deformed Yumen conglomerate
- Yumen for the night
Anmenkou nappes in the NQTB

(Upper) an overview of the Anmenkou tectonic window; North is on the right;

(Right) northern part of the tectonic window; North is on the right.
Day 7

- Yumen to Laojunmiao
- **Frontal thrust of the NQTB**
  - *Stop 7.1*: A whole view of the Laojunmiao anticline, the Shiyou river and related terrace
  - *Stops 7.2, 7.3 and 7.5*: upward coarsening rhythm of the Cenozoic sequences
  - *Stop 7.4*: the northeastward-inclined Laojunmiao anticline
  - *Stop 7.6*: history of the first oilfield in China
- Yumen for the night
Laojunmiao anticline and the terraces related to Shiyou River (Stop 7.1)
Kink-band in the northern limb of the Laojunmiao anticline
Stop 7.2: fine-grained sandstone and mudstone in the lower part of the Shulehe Fm. (prodelta)
Stop 7.3: Massive sandstone in the middle - upper part of the Shulehe Fm. (delta front)

Note the lens-shaped sand bodies
Stop 7.5: Conglomerate in the lower part of the Yumen Fm. (fluvial - alluvial fan)
Stop 7.6: first oil well in China (1939.3, 115.5m)
Day 8: Early Paleozoic metamafic rocks south of the Dunhuang

Part 3

Singing Sands dunes (Mingsha Shan)
Crescent Spring (Yueya Quan)
Mogao Grottoes
Sanwei Shan
Day 8

- Yumen to Dunhuang
- **Bedrock south of Dunhuang** (along the road to Sanweishan)
  - *Stop 8.1*: metamafic rocks, including garnet–clinopyroxene amphibolites (410 ± 11 Ma), garnet-free amphibolites (403 ± 8 Ma), and garnet–mica amphibolites (441 ± 3, 408 ± 12, 370 ± 2 Ma)
- Dunhuang for the night

Zhao, et al., 2016, GR, 30, 207-223
Photos of the metamorphic rocks in the Sanweishan near Dunhuang

(a) garnet–clinopyroxene amphibolite in granitic gneiss as lens;

(b) a garnet–clinopyroxene amphibolite from Sanweishan area;

(c) a garnet-free amphibolite in quartz–schist as layer;

(d) a garnet–mica amphibollite in granitic pegmatite as lens.

Zhao, et al., 2016, GR, 30, 207-223
Further reading

Part 1 (Days 1 – 3)


Part 2 (Days 4 – 7)


Part 3 (Day 8)