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Artikel: The rôle of accretionary wedges in the growth of continents : asiatic examples from Argand to plate tectonics
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Anhang: Plates
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Plate 1

A simplified geological-tectonic map of the westernmost Kuen-Lun prepared on the basis of observations reported by Blanford (1878), De Terra (1932), Wyss (1940), Norin (1946) supplemented by the Geological Map of the Qinghai-Xizang Plateau (1980), the Geological Map of the Uygur Autonomous Region (1985) and Liu et al. (1988), plus the ERTS images E-2256-04472-6 and E-1457-04522-6. Because we used De Terra's (1932, pl. 1) map as the base map, the longitude and latitude readings do not exactly correspond with those in modern maps.
Some toponymy conforms to those given in the foldout map in the Colloque Kunlun-Karakorum 90 to enable the reader to compare our map with the information given in the abstracts of the Colloque.

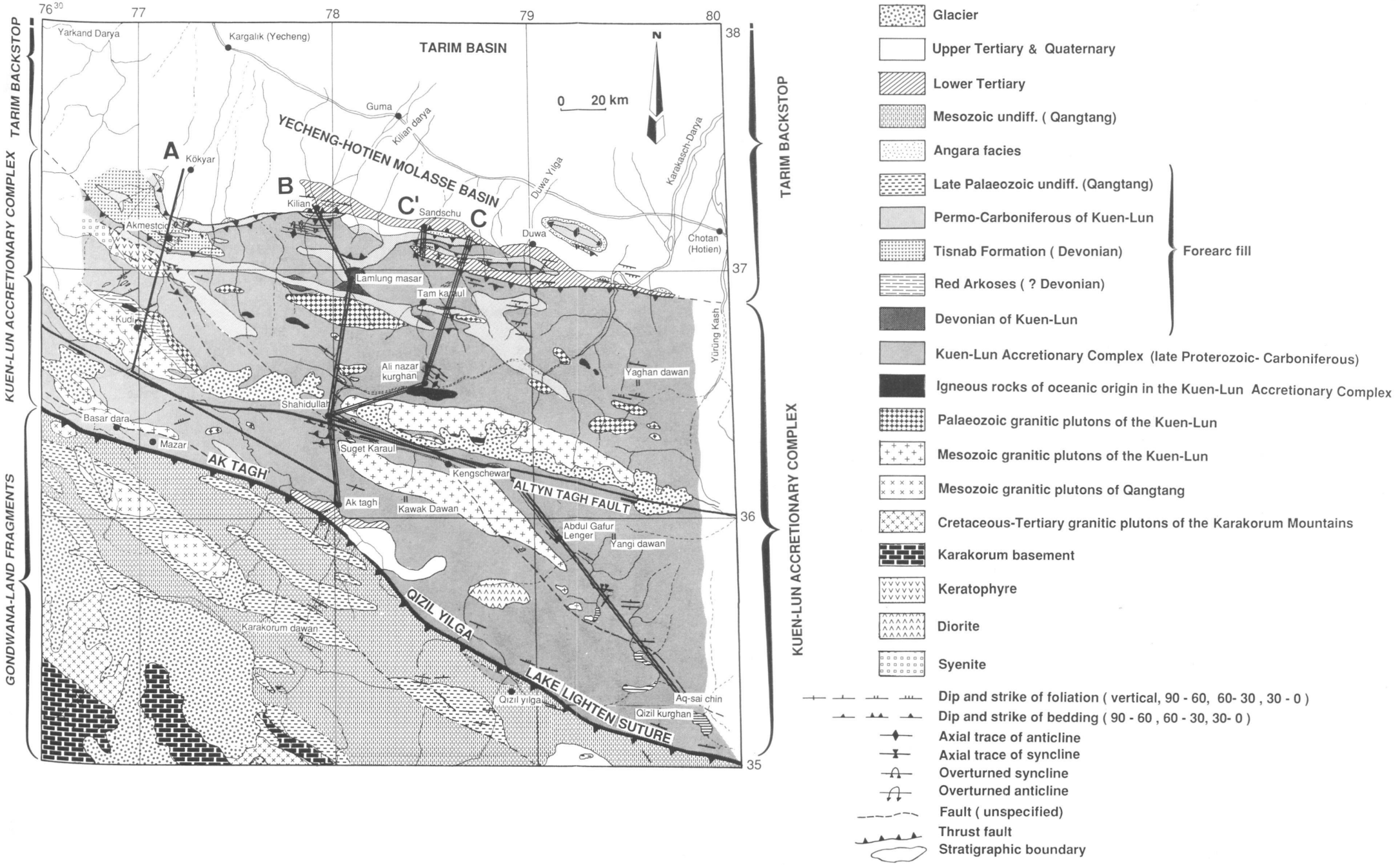

76 30
77
78
79
80
38
37
36
35
N
0 20 km
TARIM BASIN
Yarkand Darya
Kargalik (Yecheng)
Guma
Kilian darya
YECHENG-HOTIEN MOLASSE BASIN
Duwa Yilga
Karakasch-Darya
A
Kökyar
B
Kilian
C'
Sandschu
C
Duwa
Chotan (Hotien)
Akmestcic
Lamlung masar
Tam kaoul
Kudi
Yürüng Kash
Ali nazar kurghan
Yaghan dawan
Shahidullar
Basar dara
Mazar
AK TAGH
Suget Karaul
Kengschewar
ALTYN TAGH FAULT
Ak tagh
Kawak Dawan
Abdul Gafur Lenger
Yangi dawan
Karakorum dawan
QIZIL YILGA
LAKE LIGHTEN SUTURE
Qizil yilga
Aq-sai chin
Qizil kurghan
TARIM BACKSTOP
KUEN-LUN ACCRETIONARY COMPLEX
GONDWANA-LAND FRAGMENTS
TARIM BACKSTOP
KUEN-LUN ACCRETIONARY COMPLEX
Glacier
Upper Tertiary & Quaternary
Lower Tertiary
Mesozoic undiff. (Qangtang)
Angara facies
Late Palaeozoic undiff. (Qangtang)
Permo-Carboniferous of Kuen-Lun
Tisnab Formation (Devonian)
Red Arkoses (? Devonian)
Devonian of Kuen-Lun
Forearc fill
Kuen-Lun Accretionary Complex (late Proterozoic- Carboniferous)
Igneous rocks of oceanic origin in the Kuen-Lun Accretionary Complex
Palaeozoic granitic plutons of the Kuen-Lun
Mesozoic granitic plutons of the Kuen-Lun
Mesozoic granitic plutons of Qangtang
Cretaceous-Tertiary granitic plutons of the Karakorum Mountains
Karakorum basement
Keratophyre
Diorite
Syenite
Dip and strike of foliation (vertical, 90 - 60, 60- 30 , 30 - 0)
Dip and strike of bedding (90 - 60 , 60 - 30, 30- 0)
Axial trace of anticline
Axial trace of syncline
Overturned syncline
Overturned anticline
Fault (unspecified)
Thrust fault
Stratigraphic boundary

Plate 2

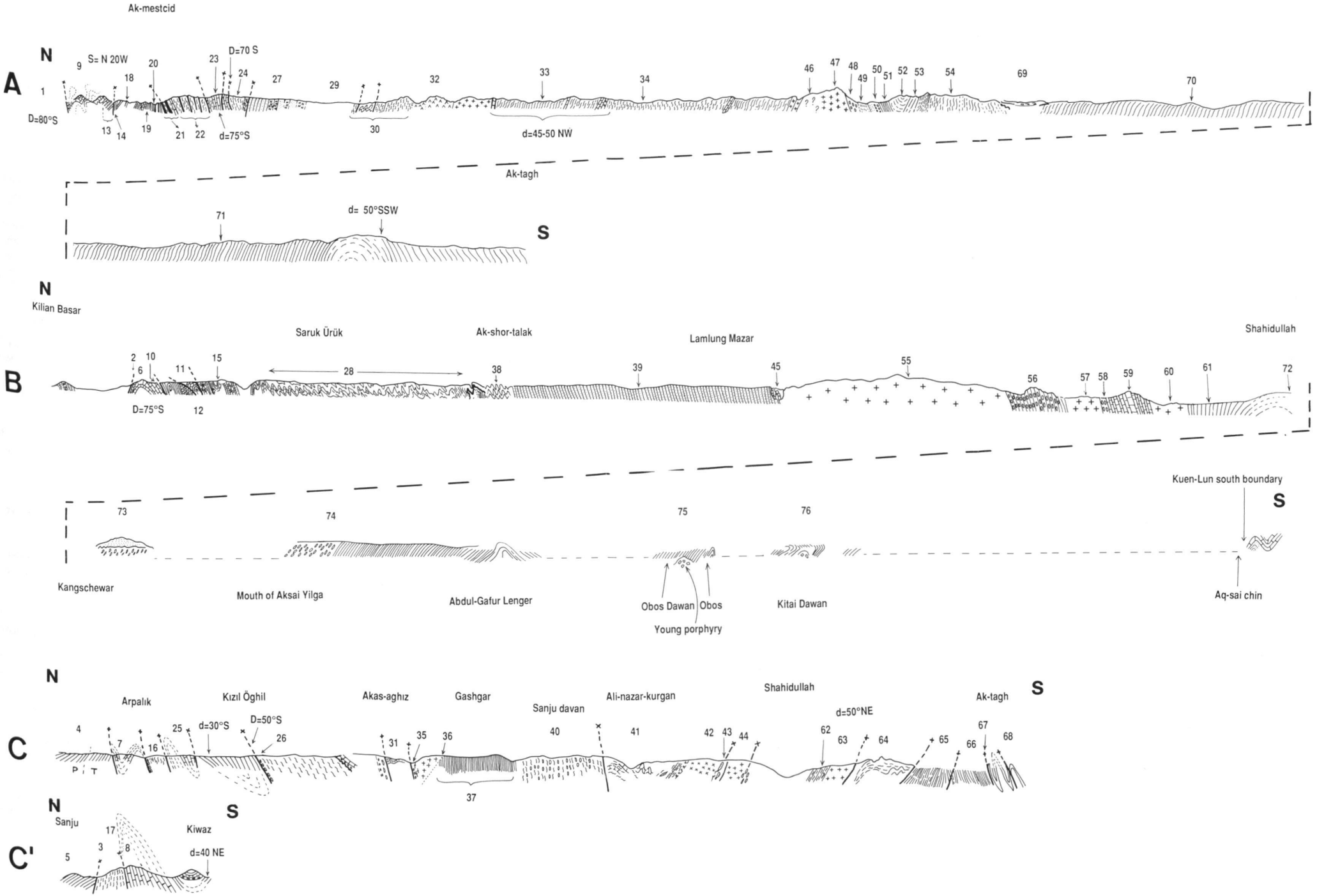
A. Geological cross-section from about Kök-yar to Ak-tagh.

B. Geological cross-section from about Kilian Basar to Aq-sai Chin.

C. Geological cross-section from about Arpalik to Ak-tagh.

C′. Geological cross-section from Sanju to Kiwaz.

For sources and the description of the numbered localities see the text and the Appendix. In these sections, notice the persistent steepness of the foliation! For locations of the cross-sections, see Plate 1.


A
Ak-mestcid
N
S= N 20W
D=70 S
D=80°S
d=75°S
d=45-50 NW
Ak-tagh
d= 50°SSW
S
B
N
Kilian Basar
Saruk Ürük
Ak-shor-talak
Lamlung Mazar
Shahidullah
D=75°S
Kuen-Lun south boundary
S
Kangschewar
Mouth of Aksai Yilga
Abdul-Gafur Lenger
Obos Dawan
Obos
Young porphyry
Kitai Dawan
Aq-sai chin
C
N
Arpalık
Kızıl Öghil
Akas-aghız
Gashgar
Sanju davan
Ali-nazar-kurgan
Shahidullah
Ak-tagh
S
d=30°S
D=50°S
d=50°NE
P I T
C'
N
Sanju
Kiwaz
S
d=40 NE

APPENDIX

Notes on Plate 2, Sections A–C′

In the following descriptions – means a *conformable* contact; ~ means an *unconformable* contact.

For localities 1–3 see the text.

C 4: P – Pleistocene conglomerates and gravel, stratified sand deposits and laminated silt.
T – Tertiary formations of the Tarim Basin (Norin 1946). For T see C′ 5 below.

C′ 5: Bottom to top: Red sandstones – Coarse, grey calcareous sandstones and chloritic marls with *Gryphaea:* Middle Eocene (Norin 1946, p. 20; for the uncertainty on the species see Blanford 1878, p. 22, and footnote 2).

C 6: Light grey dolomitic limestone with strong, steeply N-Dipping foliation – Reddish grey limestones with no fossils (De Terra 1932). Perhaps Partly equivalent to the Upper Carboniferous Tagarqi Group consisting of 308 m of carbonates. Lower part contains *Protritices* and ostracodes; upper part *Pseudoschwagerina,* indicating the presence of Asselian and possibly also Sakmarian (Bureau of Geology and Mineral resources of Xinjiang Uygur Autonomous Region 1985).

C 7: Grey, semi-crystalline limestones: Carboniferous-Permian (Norin 1946).

C′ 8: Grey, semi-crystalline limestone containing *Spirifer (striatus?)* and *Fenestellae* (Blanford 1878). Wyss (1940) collected here an Uralian (uppermost Carboniferous) fauna.

A 9: Fusulinid-bearing, dark grey, hard limestones, cut by numerous faults and slickensides. In the stream bed, *Schwagerina*-bearing whitish grey limestone – Greyish red well-bedded crinoid limestone. General strike N 25 W, dip 40 E (De Terra 1932).

B 10: North to south between two thrust faults: Strongly flattened, nodular, foliated limestone-Sandstone alternating with siliceous calcareous schists – Green-grey quartzite schists.

B 11: Dark, thinly-bedded limestone.

B 12: Grey-green sandstones (?Lower Carboniferous) =? Heshilapu Formation.

A 13: Grey-green clastics: Lower Carboniferous (probably Heshilapu Formation equivalent: Bureau of Geology and Mineral resources of Xinjiang Uygur Autonomous Region 1985).

A 14: Greenschists: 360 m thick (visible structural thickness), strongly schistose green tuffite (De Terra 1932).

B 15: Phyllites and "quartzite schist" (De Terra 1932).

C 16: Strongly brecciated fault contact: quartzose biotite-chlorite and chlorit-sericite schists (identical in character to the contact seen at loc. 26: see below) (De Terra 1932).

C′ 17: Chlorite schists (Blanford 1878).

A 18: Reddish violet and green-grey Tisnab Beds. Farther south red, quartzitic sandstones and red conglomerates. Clasts consist of red hornstein, porphyry, greenschist or tuffite and quartzite. Southward, the conglomerate becomes coarser. All this is underlain by tuff schists of Devonian age (De Terra 1932).

A 19: South of a steep fault are reddish-grey, poorly-bedded limestones (?Devonian), underlain by red slates with 60° dip to the NE (De Terra 1932).

A 20: South of a steep fault follow sandstones, tuffs and diabase interlayers. To the S, the diabases become foliated (De Terra 1932).

A 21: Marbles and limestones are interlayered with diabases tectonically, farther south follow:

A 22: Strongly foliated, steeply south-dipping diabases and tuffs (De Terra 1932).

A 23: From north to south between two faults: reddish crystalline limestone, foliated and strongly dislocated exhibiting numerous slickensides. Then across a schist band, 75°S-dipping dark grey limestones and reddish marbles alternate (De Terra 1932).

A 24: Green tuff-schists (De Terra 1932) containing chlorite (Blanford 1878, p. 42). Followed southward by foliated marble (De Terra 1932).

C 25: Grey, semi-crystalline limestone with moderate to steep southerly dip (Norin 1946).

C 26: Fault breccia, containing angular and subangular fragments and blocks of Carboniferous grey limestone. The thrust mass consists of chlorite-albite schists, green-gray calcareous, epidote-chlorite-albite schist, quartzose chlorite-biotite, chlorite-muscovite schists that are fine-grained and titanite-rich. Grade of metamorphism increases southward (Norin 1946).

In the parallel Sanju Valley to the west, the same section contains, in the north, a very thick, monotonous series of coarse, grey-green phyllitic greywackes with rounded conglomerate clasts. This is followed southwards by a large thickness of monomict limestone conglomerate, which is then succeeded by an alternation of phyllitic slates and beds of white limestone and marble (Norin 1948).

This section is unconformably overlain by a sequence, consisting at the base of a very coarse conglomerate of crystalline schists, quartz clasts and limestones (clast size generally 10–20 cm with some 50-cm clasts), overlain by a black, massive siltstone with solitary milky quartz fragments and finally a bluish black carbonaceous limestone with fossil fragments and one coral.

A 27: Foliated greywacke and quartzite according to De Terra (1932). In the same section, along ± 77°20′E (Achiq Yilga), Norin (1948) describes keratophyre, porphyry and pyroclastics with undefined Palaeozoic limestone.

B 28: Schists and quartzitic sandstones (De Terra 1932).

A 29: Loess.

A 30: Phyllites and "green, foliated, siliceous rocks" (De Terra 1932).

C 31: Dark, violet-grey, very fine-grained quartzitic arkoses and conglomerates (Blanford 1878; Norin 1946).

A 32: Chloritic schists (Blanford 1878).

A 34: Quartzite and hornblende-schists. Cut in all directions by quartz veins with black tourmaline (Blanford 1878).

C 35: Strongly brecciated granite.

C 36: One possible unconformity here? (see Blanford 1878, p. 21).

Note: Observations by Norin and Stoliczka (Blanford 1878) differ considerably regarding localities 31, 35 and 36 possibly because of the intimate tectonic intermixing of granite, veined gneiss, and schists. De Terra agrees more closely with Norin whom we followed in our depiction of the section.

C 37: Steep dips of schistosity according to Blanford (1878).

B 38: Foliated conglomerates consisting of reddish quartz and alternating with quartzites (De Terra 1932). The Geological Map of Xinjiang Uygur Autonomous Region (1985) shows these as belonging to the "Upper Devonian Tiznab Formation". The Bureau of Geology and Mineral resources of Xinjiang Uygur Autonomous Region (1985, p. 20) describes the rocks as mottled clastic rocks of continental origin with the plant fossils of *Trachytriletes subminor* and *Lepidozonotriletes normalis.*

B 39: Very coarse-grained greywackes and quartz schists with conglomeratic schists. Clasts are quartz and black siliceous schists. The whole is very strongly folded (Norin 1946).

C 40: Locally abundant garnet-bearing micaschists, cut in places by veins of jade (Blanford 1878).

C 41: A highly deformed sequence consisting of garnet-muscovite schists, massive quartzites, quartz schists, dolerites and mafic alkalic rocks (Norin 1946). Intruded by

C 42: Plagioclase amphibolite (metagabbro) (Norin 1946).

C 43: Micro-folded calc-schists and granitic cataclasite marking the location of a south-vergent thrust fault (Norin 1946).

C 44: Fine-grained granodiorite.

C 45: Grey-white and grey-blue, foliated marble folded with the greywackes and quartz schists. Contact with the granite is intrusive with many schist xenoliths according to De Terra (1932); faulted according to Norin (1946).

A 46: Arkoses?

A 47: Granite

A 48: Gneiss

A 49: Shales

A 50: Conglomerates and sandstones

A 51: Shales

A 52: Conglomerates as in locality 31 according to Blanford (1878). Norin (1946) here describes violet, fine-grained arkoses (?Angara beds of Mesozoic age).

Note: Observations by Norin (1946) and Stoliczka (Blanford 1878) contradict each other here exactly as in the case of localities 31, 35 and 36 and probably for a similar reason. That is why the relations between the successive rock types in localities 46 through 52 are not indicated.

A 53: Black slates (Blanford 1878).

A 54: Quartz greywackes (Blanford 1878).

B 55: Hornblende-rich biotite granite with many mafic xenoliths. Granite is visibly foliated and locally porphyritic. The foliated structure is especially emphasized by feldspars (De Terra 1932). The Geological Map of the

Xinjiang Uygur Autonomous Region (1985) indicates that this is an "early Variscan" granodiorite, while the Geological Map of the Qinghai-Xizang (Tibet) Plateau (1980) maps it as "middle Variscan". Liu et al. (1988) have it as partly Indosinian (Triassic) and partly early Yenshanian (Jurassic). We follow Liu et al. (1988) in the light of the recent synthesis of the Kuen-Lun granitic rocks by Zhang & Xie (1990).

B56: Injection gneisses and hornblende gneisses, likely a highly foliated marginal facies of the granodiorite (De Terra 1932).

B57: Porphyry granite stock intruding and partially melting the hornblende gneisses of locality 56, which is invaded by numerous aplitic dykes emanating from the granite (De Terra 1932). If the hornblende gneisses are indeed a marginal facies of the granodiorite in locality 55, then the porphyry granite here must be younger. Liu et al. (1988) indeed show it as younger (Yenshanian) than the granodiorite (Indosinian).

B58: Strongly folded migmatitic gneisses and hornblende schists (De Terra 1932).

B59: Blue-grey, banded and foliated marbles (De Terra 1932).

B60: Granite

B61: Quartz-schists, grading southwards into hornblende and chlorite schists. From here southward, the dominant vergence of the schistosity is southward (De Terra 1932).

C62: Graphitic phyllites and quartzite schists, passing southward into hornblende and chlorite schists. The contact with the granite (locality 63) is intrusive as indicated by the xenoliths of the schists in the granite and aplite veins in the schists (De Terra 1932).

C63: Granite

C64: The granite is thrust southward onto a sequence of quartz schists, coralline marbles and calc-phyllites showing more than one phase of folding (De Terra 1932).

C65: Dark slates and quartz-greywackes. Near the fault contact with the rocks of locality 64 are graphite phyllites. Southward, the dark slates disappear and the sequence is represented only by green-grayish "quartzite schists".

C66: Across a south-vergent fault contact are steeply south-dipping (note change of vergence!) titanite schists and quartz-phyllites.

Note: The pelites in localities 65 and 66 form the Bazar Dara Slates of Gaetani et al. (1990). The ages of these may even reach into the Triassic!

C67: A steeply south-dipping fault forms the boundary between the steep pelite belt of the Kuen-Lun and the north-vergent, tightly folded and thrust western Qang-Tang stratigraphy constituting the "Surukwat Thrust Sheets" of Gaetani et al. (1990) and the "Tethysfaltenland" of De Terra (1932). This fault here represents the fundamental architectural divide in the Tethysides (see Fig. 10) and corresponds with the main Palaeo-Tethyan suture here cf. Şengör (1984).

C68: The Surukwat Thrust Sheets. The stratigraphy here consists, from base to top, of 1) grey to bluish calcareous slate and yellowish grey calcareous sandstone – 2) black, somewhat silicified coralline limestone – 3) black to yellowish grey calcareous sandstone with crinoids – 4) red crinoidal limestone with brachiopods – 5) schistose, whitish-yellow crinoidal limestone – 6) reddish-white diplopora-bearing limestone, 1–2 are Carboniferous, 3–4 are Permian and 5–6 are Triassic in age (De Terra 1932). For more extensive description with rich fossil lists see also Dainelli (1933, 1934).

A69: Mesozoic continental formations of the "Angara facies" (Blanford 1878).

A70: Grey and pink schists with local graphitic layers (Blanford 1878).

A71: Grey or brownish, silky micarchist (Blanford 1878).

A72: Between Shahidullah and to the east-southeast of Kangschewar:

In Suget Karaul: Migmatitic gneiss with interlayers of ophicalcite and hornblende schists.

About 10 km up the Karakash Valley 7 miles to the east-southeast of Balakchi: "Jade" mines. (Blanford 1878). These are mainly nephrite mines (see De Terra 1932, p. 44). Nephrite occurs in veins in mica or hornblende schists and the veins contain much dolomite (Blanford 1878). The dips of schists are either vertical or inclined very steeply to the south. 2–3 m thick lenses of white-yellow or white-green ophicalcite occur in finely platy chlorite or hornblende schists, locally with gneissic texture. In these are veins of epidote-albite, pure serpentinite, and nephrite. There are also orthogneisses, amphibolite schists, and calc-silicate hornfels. Most of these rocks seem to have developed by the contact effects of the biotite-granites in the area (Blanford 1878; De Terra 1932; Wyss 1940). Towards Kangschewar again nephrite and jadeite mines. Here too they occur in association with ophicalcite in hornblende schists and gneisses (De Terra 1932).

At Kangschewar a diorite yielded a Zr age of about 470 Ma. To the southwest, at the Sanshiliyingfang military base a 192 Ma Zr age was obtained on a granite. Farther east, at the Qiyi bridge, there is a Rb-Sr biotite age of 215 Ma on a granite (all the ages according to pers. comm. from Dr. Wang Yi, 1991).

B 73: Gneiss underlying red arkoses.

B 74: Migmatites and garnet gneisses near the granite contact passing southeastward into aplite-infested schists. These then give way to garnetiferous micaschists with numerous pegmatites and quartz veins that become fewer as one moves away from the major intrusion (see Fig. 11). Finally the pelites become dark phyllites and quartz schists. Near Abdul Gâfur Lenger the schistosity is folded by an upright, open, slightly north-vergent fold.

B 75: Greywackes, quartz schists, phyllites with upright to somewhat south-vergent close folds.

B 76: Greywackes, quartz schists and phyllites continue, but here with at least one major recumbent fold (De Terra 1932, p. 40; Norin 1946, p. 32).

Strongly folded phyllites and quartz-schists, greywackes continue south-southeastwards all the way to Aq-sai Chin, where Hedin (1909, p. 95) found "blood-red conglomerate, which lay upon green schists". The conglomerate was later found to be Tertiary in age covering deformed Cretaceous rocks that in turn rest unconformably on the older phyllites, quartz-schists and greywackes (cf. De Terra 1932; Norin 1946, 1974, 1979).

Note: 75 and 76 are equivalents of the Bazar Dara slates of Gaetani et al. (1990) and the monotonous pelites of Matte et al. (1991) whose age may reach into the Triassic. Dainelli (1934, map) included these in his *"scisti cristallini di età indeterminata prevalentemente pre-siluriana"*, hinting that not all crystalline schists in the Kuen-Lun were pre-Silurian.