Seismogenic destruction of the Kamenka medieval fortress, northern Issyk-Kul region, Tien Shan (Kyrgyzstan)

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Abstract

A paleoseismological study of the medieval Kamenka fortress in the northern part of the Issyk-Kul Lake depression, northern Tien Shan in Kyrgyzstan, revealed an oblique slip thrust fault scarp offsetting the fortification walls. This 700m long scarp is not related to the 1911 Kebin Earthquake (Ms 8.2) fault scarps which are widespread in the region, but as analysis of stratigraphy in a paleoseismic trench and archaeological evidence reveal, it can be assigned to a major 12th century AD earthquake which produced up to 4 m of oblique slip thrusting antithetic to that of the nearby dominant faults. The inferred surface rupturing earthquake apparently caused the fortress destruction and was likely the primary reason for its abandonment, not the Mongolian-Tatar invasions as previously thought.

Key words: archaeoseismology, fault-scarp, fortress, castle, surface fault, decline, Mongol-Tatar invasion, Issyk-Kul Lake, Tien Shan, Kyrgyzstan

Introduction

The destruction and decline of central Asian medieval cities in the 12th-14th centuries is usually attributed to Mongolian-Tatar invasions of Chingizkhan and Tamerlane (e.g., Toynbee, 1946; Saeki, 1951; The Mongol Mission, 1955; Needham, 1959). However, not all historians and archeologists follow that interpretation. For example, Gumilyov (2003) has noted that the comparatively small number of Mongolian soldiers and their lack of capacity for serious military operations has important historical implications. Recent archaeoseismological publications have

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shown the seismic character of destruction of some medieval cities in central Asia (e.g., Trifonov, 1978; Nikonov, 1996; Chediya et al., 1998; Korjenkov et al., 2003). Thus, the causes of destruction and of abandonment of some towns and regions in Central Asia during the XII-XIV centuries AD remain a matter of debate.

In this study, we focus on the Kamenka medieval fortress, which may help to shed some light on this debate. This fortress is located on the ancient Silk Route in the northern portion of the Issyk Kul basin; it was exposed to regional activity by Mongolian armies in the XII century, and lies within a major, active seismic belt of the northern Tien Shan (Fig. 1).

In 2004 we conducted an archaeoseismogical and paleoseismological study at the Kamenka medieval fortress to investigate the possibility of its seismogenic destruction. The results of this study and its implications for the history of the region in the XII century are presented below.

Historical and archeological background

What is known about the medieval history of the study area is summarized in Voropaeva et al., 2002. According to these authors, during X-XII centuries the present day Kyrgyzstan was a part of Karakhanides Kaghanate (State) with its capital in Balasogun-city (Fig. 1). During the first third of the XII century this territory was conquered by Kara-Kitays (Chinese) who established their Empire Si Lyao (Western Lyao).

The beginning of the 13th century was marked by the conquest of a major part of Central Asia by the Mongolian army of Chinghizkhan. After defeating the Nayman tribes in Siberia in 1208, routed Naymans settled in Si Lyao. In 1210, the Emirates of Khorezm and Maverannakhr united and shattered Kara-Kitays. The Kara-Kitays retreated eastwards to Lyao Empire's territory. Nayman tribes headed by prince Kuchluk stood on the side of the allied forces against Kara-Kitays. Kuchluk then seized the gurkhan (regent) of Kara-Kitays and their treasury.

After their victory in Siberia in 1208, the Mongolian army of Chinghizkhan advanced westwards towards the Tien Shan and the area dominated by Nayman prince Kuchluk after the 1210 battle (Voropaeva et al., 2002). Kuchluk had forced the Muslim population of eastern Turkestan and Semirechie (literally the "Seven Rivers" region; all territory north of the Tien Shan and Dzhugar Ranges), to accept either Buddhism or Christianity, and was not prepared to face the Mongolians.

In 1218, Chinghizkhan sent a detachment of 20,000 soldiers commanded by Dzhebe-Noyon against Kuchluk. Marching into the Semirechie, the Mongolian military leader claimed that everyone had the right to practice the religion of his or her fathers. In addition, the disciplined Mongolian army was ordered not to disturb non-resisting populations. The results of this successful political move by Dzhebe were noted immediately. Balasogun city (Fig. 1) voluntarily opened its gates to the Mongolians, and the population of Eastern Turkestan revolted against Kuchluk and killed his soldiers. In one of the Semirechie mountain gates, Kuchluk stood for the last battle with the Mongolians, but he was defeated and escaped. Soon after, the Mongolians caught him and he was beheaded.

These historical events imply that the population of medieval Kyrgyzstan cooperated with the conquering Mongolians for their own benefit and did not feel the horrors of Chinghizkhan's conquests. This also indicates that no sieges and subsequent destruction of towns occurred in the study area in the 13th century.

The Kamenka Fort

The Kamenka Fort complex was built on a major caravan route passing along the northern coast of Lake Issyk-Kul, one of the branches of the Great Silk Route (Fig. 1). The site is located north of Karool-Dyube village on the left side of Chon-Baysoorun River (Fig. 3). The fort complex consists of a fortress and of the associated civil buildings. The fortification system consists of two protective rectangular walls and of several towers (Figs. 4 and 5) built of non-burned clay bricks. The size of the internal rectangle is 180 x 180 m, while the external is 230 x 230 m. A citadel is located at the SW corner of the fortress.

The SW external wall of the fortress has been destroyed by lateral erosion of the River Chon-Baysoorun, while a tributary of the main channel has destroyed most of the NW wall (Fig. 5). The subsidiary buildings at the southern side of the fortress have been destroyed by land cultivation, while the central part of the fortress is occupied by the modern cemetery of Karaool-Dyube village. What survives at present from the fortifications is a gently sloping mass representing the degraded fortress wall, 4m high.

The ancient fortress was first identified in 1927 by P. P. Ivanov and was excavated by D. F. Vinnik in 1961. These excavations brought to light at 1.5 m depth an occupation layer with remnants of buildings and ceramics of the VIII-XII centuries (Ysyk-Kyol. Naryn. Encyclopedia, 1991). This provides some evidence that the fortress was abandoned in the XII century, and has only recently been reoccupied as a cemetery – in the XX century.

Geological background

The Tien Shan mountains are one of the most seismically active regions of the world, marked by frequent strong earthquakes (e.g., Kondorskaya and Shebalin, 1982; Molnar and Ghose, 2000; NEIC catalog: http://neic.usgs.gov/; ANSS catalog: http://quake.geo.berkeley.edu/anss; Fig. 1). Issyk-Kul Lake occupies one of largest depressions in these mountains, and corresponds to a tectonic depression bordered by antithetic convergent thrust faults (e.g., Chediya, 1993; Fig. 2).

The Kamenka fortress is located on the hanging wall of the border Aksu fault which separates the basement of the Kungey Range from Cenozoic deposits of the Issyk-Kul depression. The Aksu fault zone last broke during the Kebin 1911, M = 8.2, I_0 = X-XI earthquake (Bogdanovich et al., 1914, Delvaux et al., 2001, Arrowsmith, et al., 2005, see Fig. 3). Well-preserved fault scarps formed during this event can be observed along the southern outskirts of Karool- Dyube village where they cut transversely the Chon-Baysoorun river valley (Fig. 3).

Field data

Geomorphological and archeological observations

We noted the Kamenka fortress during our 2004 investigation of the surface faults of the 1911 Kebin earthquake. Field investigations of the fortress were inspired by the interpretation of detailed aerial photographs of the area of this earthquake. In these aerial photographs a lineament obliquely cutting the Kamenka fortress walls is clearly visible (Fig. 4).

The subsequent field study of this lineament revealed a scarp more than 700m long striking 138°, which is oblique to the major sub-latitudinal thrust bounding the Issyk-Kul Lake depression to the south of the fortress (Fig. 2, 5). The best manifestation of the fault scarp is in the surface of a Late-Pleistocene alluvial terrace to the north of the fortress (Figs. 4 and 5). At both ends the scarp disappears under cultivated land; at the NW, when reaching a Holocene alluvial terrace and to the SE just past the fortress walls (Fig. 5).

In addition to vertical offset, there is also a horizontal, left-lateral, component to the displacement along the fault scarp (Fig. 6a), which is well expressed in the NW internal wall of the fortification. There, the wall is shifted to the left 3.85 m and uplifted by up to 1.6 m (Fig. 6b). Maximum vertical displacement of 2.1 m along the rupture was observed in the NW external wall (Fig. 6c).

Our investigation was extended to the outskirts of the fortification. It revealed another NNW-striking fault zone parallel to the east slope of Chon-Baysoorun river valley (Fig. 5). Along this zone there were recent movements now expressed in a WSW-sloping alluvial fan by a series of fault scarps with the same trend. The 2 m tall fault scarp that cuts the fortress has an asymmetric fold-like morphology, with gentle back (SW) side rising upward into a broad flexure before breaking steeply on the frontal (NE) side. These characteristics imply a north-eastward vergence along a southwest-dipping fault plane (Fig. 7). From this observation we can conclude that the fault scarp is of co-seismic origin ("morphogenetic earthquake" sensu Caputo, 1993) and corresponds to an oblique thrust fault.

The following lines of regional geologic and geomorphic evidence indicate that the Kamenka scarp was formed by a thrust fault:

1. The tectonics of the region are characterized by thrust faulting.
2. The vergence of the fold is up-slope, making it difficult to explain its formation by gravitational forces.
3. The scarp has a fold-like form, characteristic for structures formed in contractional (reverse or thrust faulting) settings.
4. The linear nature of the scarp suggests a steeply dipping fault line as opposed to a shallowly dipping landslide.

The form of the "Kamenka" scarp is very similar to fault scarps that formed during the 1992 Suusamyr (M=7.3) earthquake in the northern Tien Shan (Bogachkin et al., 1997; Ghose et. al., 1997), this similarity in form provides additional support for the thrust hypothesis. In addition, the movements along the "Kamenka" fault have a strike slip component too as shown by the left-laterally offset fortress wall. Importantly, the scarp is sharp where it cuts the fortress walls. This morphology is most consistent with a single large offset event rather than multiple smaller events which would likely have produced a more subtle and degraded offset of the walls.

The degradation of the "fortress" scarp indicates that it is not a young feature and was likely not formed during the January 1911 Kebin earthquake. Bogdanovich et al., (1914) performed careful mapping of seismic deformation associated with the 1911 earthquake during the spring of 1911 and they show no indication of fault rupture in the area of the Kamenka fortress. Bogdanovich et al., (1914) show the main 1911 rupture terminating at the Chon-Baysoorun river valley, 12 kilometers down the valley, from the fortress area (Fig. 3).

Our work at the fortress caused significant interest among local inhabitants. Many of them told us that they found numerous human bones while digging graves in the modern cemetery of Karaool-Dyube village, inside the fortification. One of the local people – Arslan Dzhimberdiev, whose house is 200 m north of the fortress, stated that he had personally participated in several such excavations, and that he had found the skeleton of a man sitting next to a fireplace, and next to him the skeleton of a dog. In an adjacent grave the skeleton of a man lying on a plank bed was also found. This circumstantial evidence suggests that the medieval fortress inhabitants were victims of a sudden and unexpected event, and not normal burials (cf. Stiros, 1996; Stiros and Papageorgiou, 2000; Galadini et al., this vol.,). Along with the geologic indicators, this evidence indicates that the fortress occupants were victims of a sudden earthquake hitting the area. Unfortunately, we could not confirm the evidence for skeletal remains because archeologic excavations are not possible in this active Muslim cemetery.

Excavation across the fault scarp

In order to further test our earthquake hypothesis, we excavated a trench 16 m long, up to 4 m deep and 0.8-1.0 m wide across the fault scarp at a site where the scarp cuts almost perpendicularly across the creek that destroyed the northern wall of the fortress (Fig. 4).

The main characteristics of the sediments exposed in the trench are thick units of clay and loam (loess-like deposits), capped by a layer of undisturbed soil. We noted a buried soil in the eastern third of the exposure that likely represents a paleo-ground surface. The soil is also present on the hanging wall of the fault but is less well preserved. Associated with the paleosoil in the hanging wall is a horizon of crushed and broken bones. Above the paleosoil in the footwall there is a lens of well-sorted coarse sand. Pebble-sized clasts of Paleozoic-aged rocks are disseminated through the units and do not define any bedding. The recent soil covers the entire exposure.

In the NE part of the trench, the units described above are warped in a zone of distributed deformation (fractured and sheared sediments). We could not identify clear co-seismic rupture with confidence because of the homogeneous stratigraphy and distributed nature of the deformation. The western end of the buried soil in the eastern third of the exposure is strongly deformed where it enters the zone of distributed deformation. A lens of well-sorted coarse sand above the paleosoil does not cross the deformation zone and is likely colluvial material that has been shed from the scarp formed during the most recent earthquake. Preferential preservation of the paleosoil can be explained by stripping of the paleosoil horizon from the hanging wall of the fault and by colluvial sedimentation of coarse sand on top of the paleosoil in the footwall.

To summarize, we interpret the paleosoil as representing the pre-earthquake ground surface. This paleosoil has been warped and displaced by deformation in the most recent earthquake. The coarse sand/gruss that overlies the paleosoil was deposited immediately after the last activity along this fault as colluvium shed from the scarp. Only remnants of the paleosoil are discontinuously preserved in the hanging wall due to erosion and stripping of the scarp formed immediately after the most recent earthquake

Absolute age determination

In the trench walls, we found a horizon with abundant crushed and broken bones at a depth of 70-105 cm that corresponds with the remnants of the paleosoil in the hanging wall. All bones are large; they probably belonged to cattle or horses. The crushing was apparently done in order to extract marrow and the bones were disposed of by leaving them on the ground. We did not find bone fragments above this horizon. We collected samples from the top and bottom of the bone layer for determination of the absolute age using the ^{14}C method (Fig. 8). Dating was conducted at the Laboratory of Geology and Paleoclimatology of the Cenozoic at the Institute of Geology of Siberian Branch of the Russian Academy of Sciences in Novosibirsk. Determination of the radiocarbon age was done using the standard conventional method on the humic acid fraction.

Both samples are bone fragments collected in the hanging wall of the thrust (fault scarp) within the paleosoil stratigraphic unit. Sample CHB-1 (COAH-5794) was collected in the lower part of the bone layer. Its age is 1715 ± 40 years BP (corresponding to a calibrated age 242-415 AD — 2σ; http://radiocarbon.pa.qub.ac.uk/calib/calib.html; ^{14}C half-life of 5570 years was used). Sample CHB-4 (COAH-5795) is stratigraphically higher than sample CHB-1 and is located near the top of the bone horizon, and its age is younger: 930 ± 60 year BP (corresponding to a calibrated age 999-1222 AD — 2σ). These two samples date stratigraphy deposited before the most recent earthquake because both samples were collected from fragments of paleosoil stratum which represent a paleo-ground surface that was at one time continuous, but has now been vertically offset by movement along the fault. Because we see no bones in the stratigraphy above the paleosoil, the uppermost bones may represent the last garbage of the Kamenka fortress occupants. The CHB-4 sample ^{14}C age also coincides with the date of the youngest ceramics collected in situ by the archaeologist D. F. Vinnik (XII century). Therefore, we conclude that the timing of the most recent earthquake on this fault coincides with the destruction and abandonment of the Kamenka fortress at the beginning of the XII century.

Discussion

The evidence presented here indicates that the fault scarp cutting the Kamenka fortress is related to a segment of an oblique-thrust fault. The possibility that this scarp is related to local ground instability of unconsolidated sediments should be excluded for the following reasons 1) the sense of displacement on the fault is up the slope, 2) the scarp is too linear to be the scar of short-transport landslides which are typically associated with shallowly dipping slip planes, 3) drag deformation in sediments observed in the paleoseismological trench suggest compressional motion.

Of interest with this earthquake is that it produced a short, 700m long scarp, but high amplitude of offset, up to 2 m thrusting and up to 4 m strike slip. This is not a surprise. Blind (or nearly blind) ruptures are typical in the intramontane depressions of the Tien Shan Mountains and elsewhere. For example, the rupture zone of the 1992 Suusamyr (Ms=7.3) earthquake, from aftershock data, extended for a distance of about 50 km along strike (Mellors et al., 1997), which is approximately equivalent to that expected from an event of this size (Kanamori and Anderson, 1975; Scholz, 1990) but its surface trace was only 4 km long. The lack of an extensive surface rupture from such a large event was explained by Ghose et al., (1997) as the result of a fault system where "blind" and "buried" rupture results in co-seismic folding of the layers above the fault (Yeats et al., 1981; Stein and King, 1984; Lin and Stein, 1989; Stein and Ekström, 1992).

A blind thrust interpretation would also be consistent with the Kamenka fortress fault where we did not see the rupture in the trench, while we observed a clear warping on the surface and trench stratigraphy. A similar interpretation was described for a fault scarp of Late Holocene age in the central sector of the Suusamyr valley, northern Kyrgyzstan (Korjenkov et al., 1999). A pronounced 3-m high fault scarp, which caused the recent drainage diversion of the Tokoylu River, was investigated with two paleoseismologic trenches. Also in that case, we did not observe any fault planes, however the drainage diversion and abandoned wind gaps across the scarp testify about its fast appearance in relief.

Thus, if earthquakes in the northern Tien Shan with similar lengths of surface faulting, such as the Suusamyr earthquake of 1992 (Ms = 7.3) (e.g., Bogachkin et al., 1997; Ghose et al., 1997; Korjenkov et al., 2004) are capable of seismic intensities of I_0 = IX-X (MM-31 Scale) due to significant co-seismic slip on the faults at depth, it is reasonable to assume a similar intensity for the earthquake that formed the Kamenka scarp. An earthquake of such energy would have completely destroyed all buildings associated with the fortress, especially given that the seismic rupture reached the surface exactly in the middle of the fortification. Although we cannot exclude the possibility that multiple earthquakes led to the destruction of the fortress, our interpretation is that a single, scarp-forming earthquake, is the most plausible explanation for the abandonment of the fortress.

We can only speculate about the indirect effect of the earthquake on the inhabitants of the fortress and its surroundings. The ground rupture through the fortress implies intensity of seismic shaking of IX-X (EMS). Such intensity should cause complete destruction of all clay and clay-brick buildings which would include structures within and adjacent to the fortress, leaving nothing to repair. If this fortress became a collective grave for many people, survivors would probably choose not to rebuild on the same site. For example, during the Suusamyr Ms=7.3 (I = X) 1992 earthquake in northern Tien Shan, a Road Repair Station (RRS) was destroyed. In one of the buildings, a mother with three children was killed. Workers from this RRS did not want to repair the previous construction because of their strong memory of the event.

Another result of our investigations is that the scarp offsetting the Kamenka fortress is not associated with the 1911 Kebin earthquake, and can be dated to approximately the beginning of the XII century. Hence, we assign the Kamenka scarp to a destructive earthquake of the medieval period. This interpretation is supported by reports of skeletons of people and house animals in positions that suggest unexpected entrapment. We interpret these remains as earthquake victims (Stiros, 1996; Stiros and Papageorgiou, 2001; etc). Based on archaeological excavations conducted at the fortress (Ysyk-Kyol. Naryn. Encyclopedia, 1991), these remains roughly correspond to the last period of occupation of the fortress in the XII century.

Historical implications

The available evidence indicates that a major, surface faulting earthquake destroyed the Kamenka fortress and killed many of its inhabitants in approximately the 12th c., and following this event, this very important fortification on the Silk Road was abandoned. The fortress may not have been rebuilt later because Chinghizkhan's armies were in the region and their presence may have caused a reassessment of the strategic value of the site. Interestingly, the abandonment of the destroyed fortress correlates with the period of Tatar invasions at the beginning of the 13th c. Hence, a deliberate destruction of the fortress and other cities and settlements in the region during the invasion, an explanation previously proposed by numerous investigators (Toynbee, 1946; Saeki, 1951; The Mongol Mission, 1955; Needham, 1959) should be rejected. This interpretation is consistent with more recent historical evidence, which indicates that the Mongol-Tatar occupation could not, and indeed did not, follow major military operations.
This result for the Kamenka fortress may have general implications for the history of the Central Asia. In the past, historians ignored the role of earthquakes and natural disasters and instead assigned most observed or inferred changes in the occupation history of sites and regions to invasions and wars. However, numerous cases indicate that natural effects, especially earthquakes, have played a catalyzing role in the history of sites and regions, or that destruction which were assumed to be evidence of hostile interventions were in fact caused by earthquake effects (Stiros, 1996 etc.).

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Figure captions for a paper by

A. M. Korjenkov, R. Arrowsmith, C. Crosby, E. Mamyrov, L. A. Orlova, I. E. Povolotskaya, K. Tabaldiev " Direct seismogenic destruction of the Kamenka medieval fortress, northern Issyk-Kul region, Tien Shan"

Fig. 1. Topography and seismicity of the Tien Shan Mountains and adjacent areas. Blue circles represent earthquakes from NEIC catalog (historical – 1963 http://neic.usgs.gov/), red circles - from ANSS (1963 – present http://quake.geo.berkeley.edu/anss). Dashed lines depict some Silk Route Pathways. The white arrow shows the location of study area. Semirechie ("Seven Rivers" region) includes all territory north of the Tien Shan and Dzhugar range.

Fig. 2. Structural setting of the Issyk-Kul Lake and the basin. In the north, the Issyk-Kul depression in bounded by the Kungey Ala-Too range and by a set of en-echelon border thrust faults, i.e., the west Toguz-Bulak, the Kultor, the northern Aksu and Taldy-Bulak faults (ticks indicate thrusted limb of the fault and dip direction of the fault plane). The Terskey Ala-Too range bounds the depression in the south along with the southern pre-Terskey fault zone. The white arrow shows location of studied area.

Fig. 3. Location of study site on the north shore of Issyk Kul Lake. Locations of figures 4 and 5 are also indicated. 1: Seismic ruptures formed during the 1911 Kebin earthquake and 2: Rock slides and landslides occurred during the earthquake. Modified after Bogdanovich et al., 1914

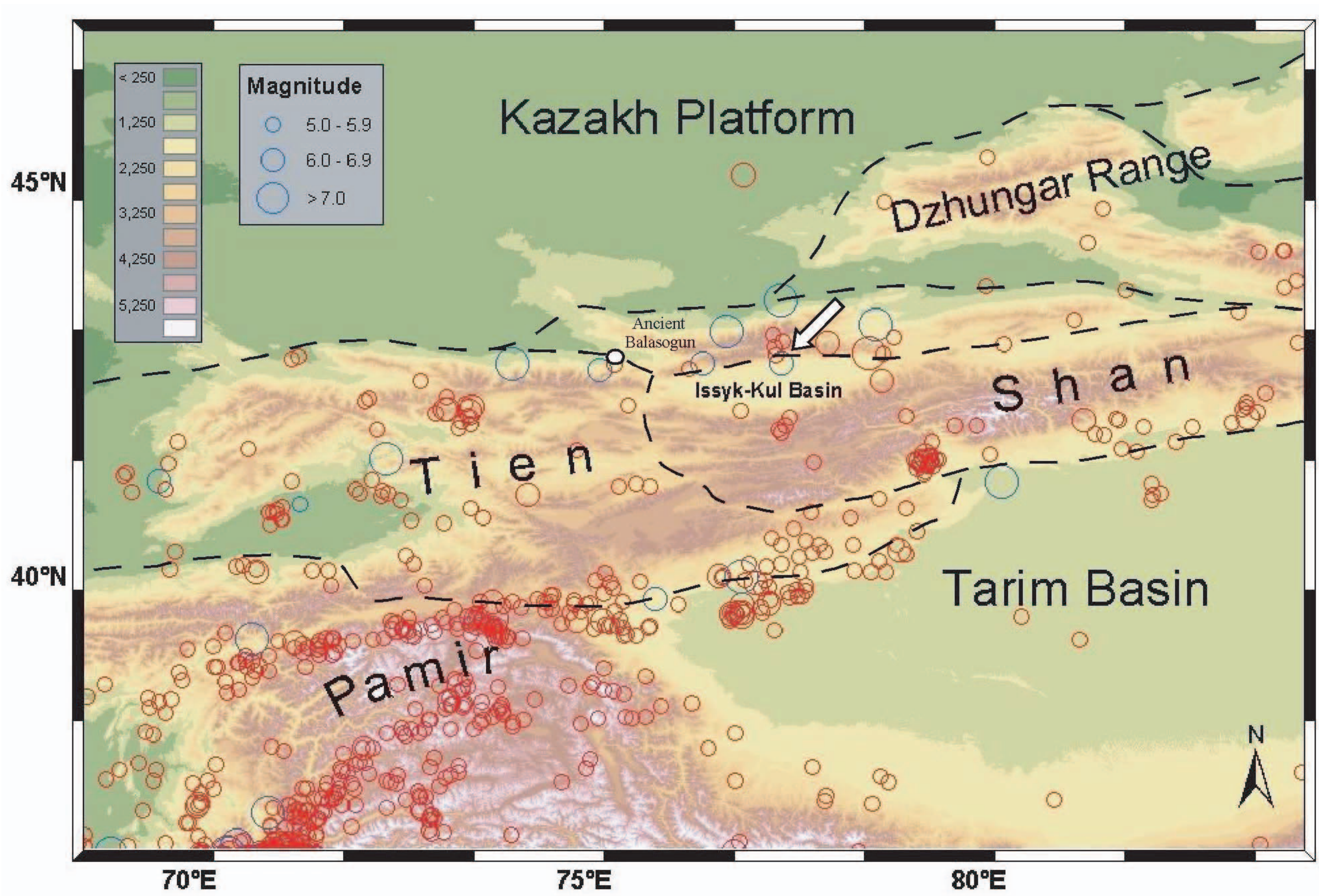
Fig. 4. Aerial photograph (scale 1:47,000) showing the Kamenka fortress and the fault scarp (shown by arrows).

Fig. 5. Schematic map of the Kamenka medieval fortress location and fault rupture. Note that SW external wall of the fortress was completely washed out by the Chon-Baysoorun river. Its NW wall was partly washed out and significantly deformed by a tributary of Chon-Baysoorun River. 1 - fault scarps (ticks indicate thrusted limb of the fault and dip direction of the fault plane), 2 - fortress walls, 3 - rivers and artificial channels, 4 - contour lines drawn at 50 m, 5 - absolute marks of the area in meters.

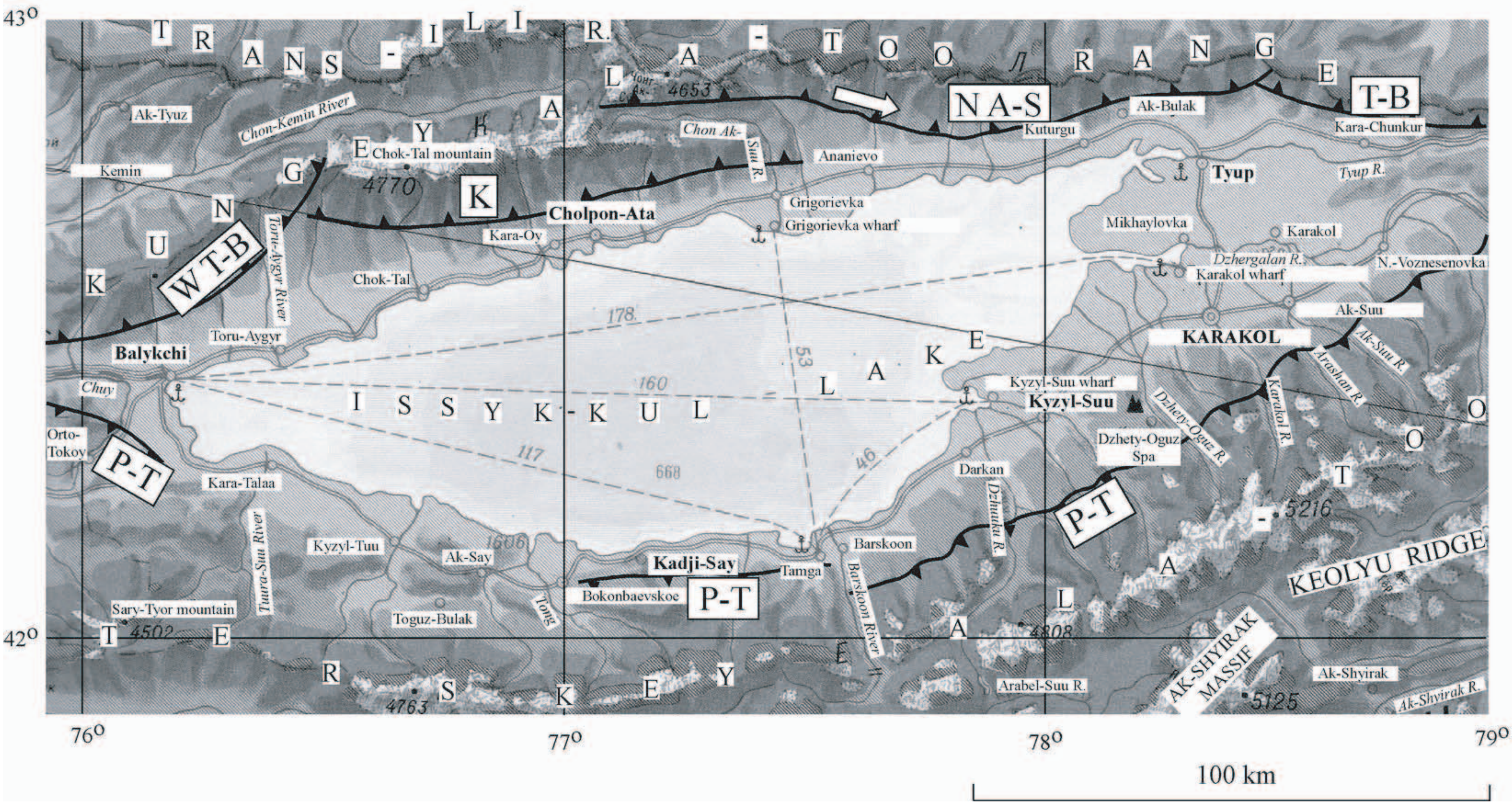
Fig. 6. Rupture in fortress walls. a) Scheme (map view) of rupture in NW wall; the wall is not only shifted laterally (left-lateral strike-slip), but also vertically (western wall marked by + is thrust upward). b) Horizontal displacement of NW internal wall on 3.85 m. c) Vertical displacement of NW external wall on 2.1 m. A man stands for scale.

Fig. 7. Schematic section of the Kamenka fault scarp. We propose thrust movements along the fault plane because the motion on the fault is up the slope, and the scarp itself has a fold-like form typical for compression conditions.

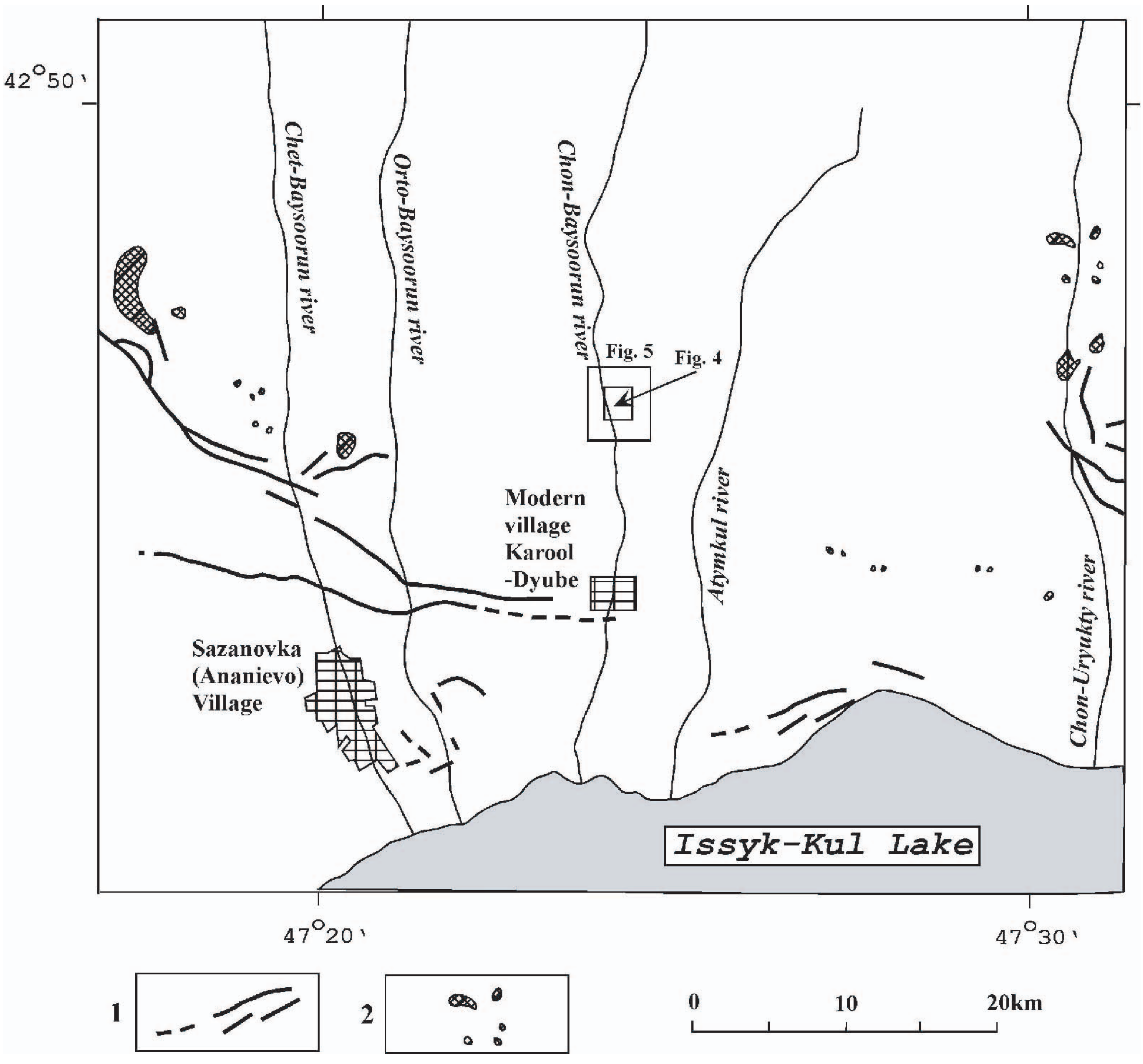
Fig. 8. A log of southern wall of the paleoseismic trench excavated across the fault scarp. 1 - soil layers, 2 - clay, 3 - loam, 4 – coarse sand, 5 - cobbles, 6 - places of sample collection.

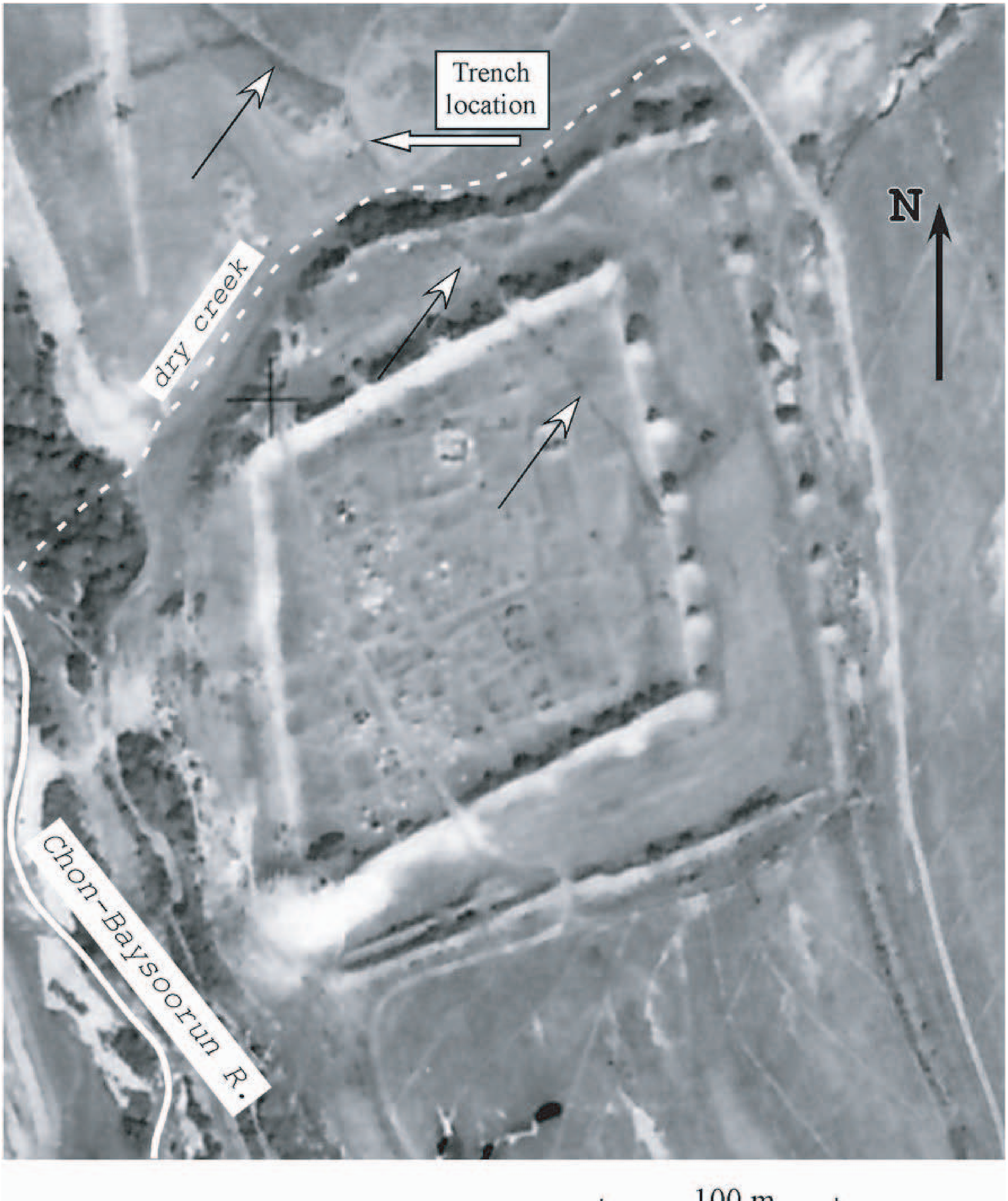


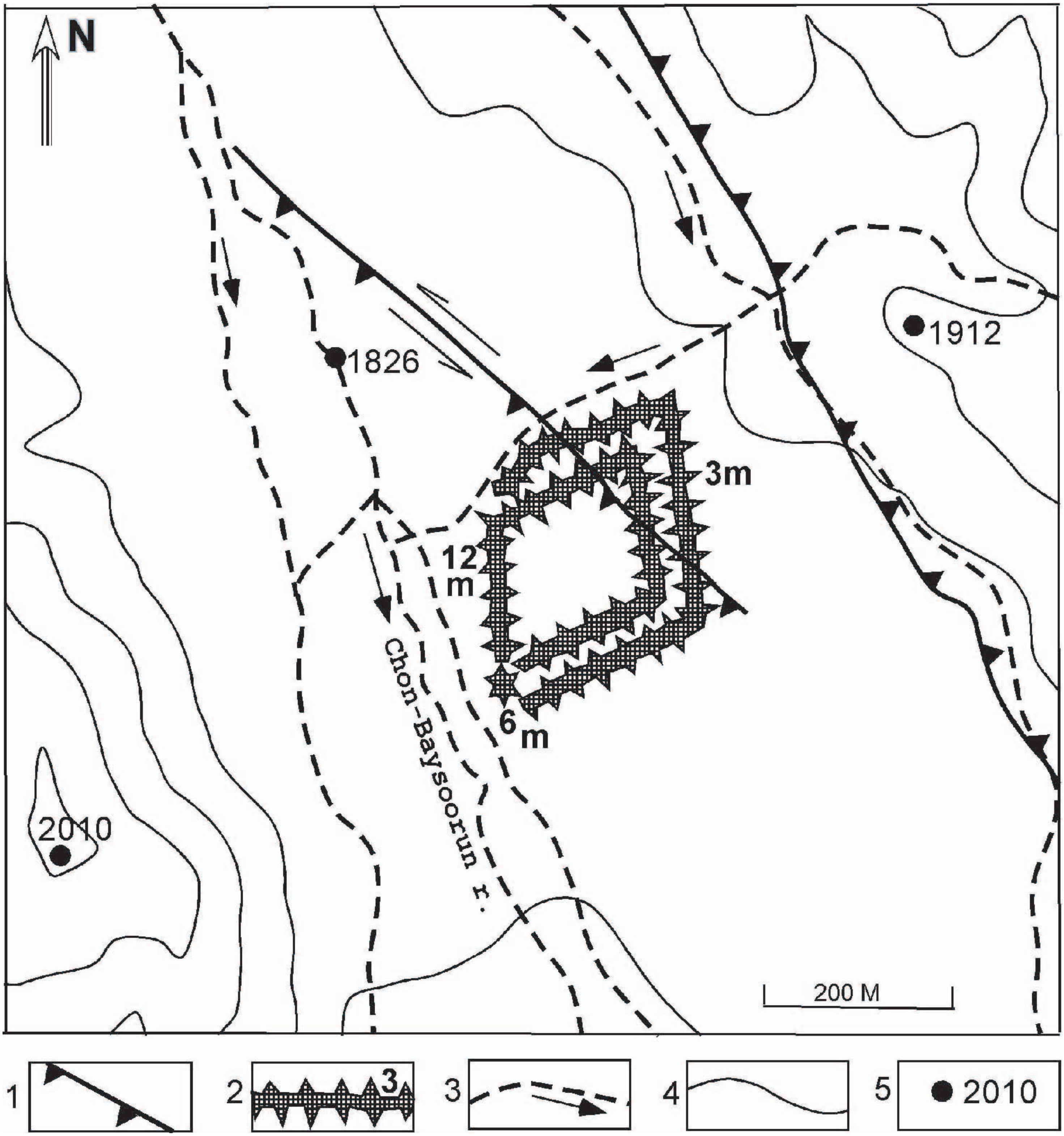
< 250
1,250
2,250
3,250
4,250
5,250
Magnitude
5.0 - 5.9
6.0 - 6.9
>7.0
Kazakh Platform
Dzhungar Range
Ancient Balasogun
Issyk-Kul Basin
T i e n
S h a n
Pamir
Tarim Basin
N
45°N
40°N
70°E
75°E
80°E



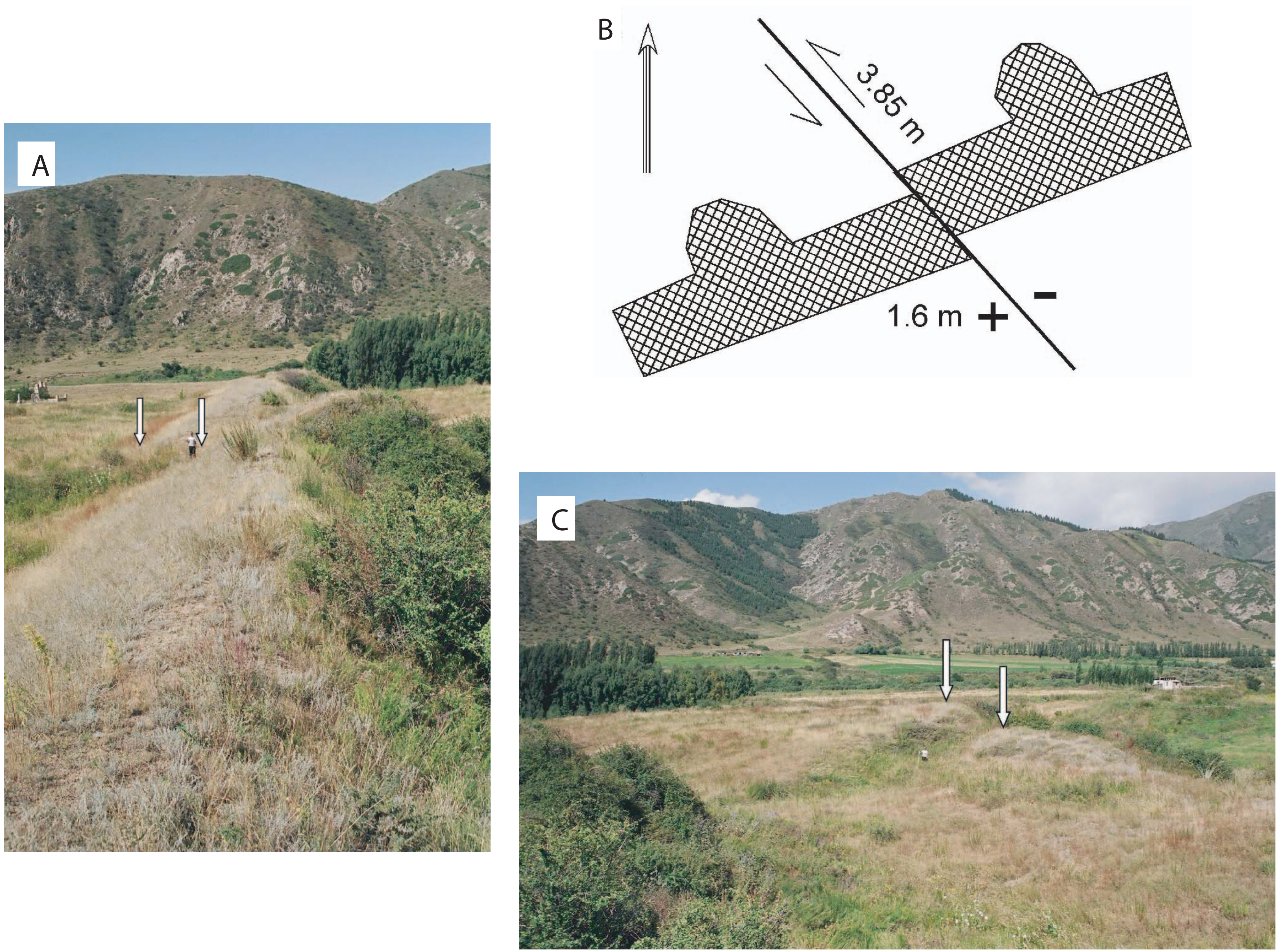
TRANS-ILI-ALA-TOO RANGE
KUNGEY-ALA-TOO
TERSKEY-ALA-TOO
ISSYK-KUL LAKE
KEOLYU RIDGE
AK-SHYIRAK MASSIF
WT-B
K
NA-S
T-B
P-T
P-T
P-T
Balykchi
Cholpon-Ata
Kadji-Say
Kyzyl-Suu
KARAKOL
Tyup
Kemin
Ak-Tyuz
Chon-Kemin River
Chok-Tal mountain
Chok-Tal
Toru-Aygyr
Toru-Aygyr River
Kara-Oy
Grigorievka
Grigorievka wharf
Ananievo
Chon Ak-Suu R.
Kuturgu
Ak-Bulak
Kara-Chunkur
Tyup R.
Mikhaylovka
Karakol
Dzhergalan R.
Karakol wharf
N.-Voznesenovka
Ak-Suu
Ak-Suu R.
Arashan R.
Karakol R.
Dzhety-Oguz R.
Dzhety-Oguz Spa
Kyzyl-Suu wharf
Darkan
Dzhuuku R.
Barskoon
Barskoon River
Tamga
Bokonbaevskoe
Tong
Ak-Say
Kyzyl-Tuu
Toguz-Bulak
Kara-Talaa
Tuura-Suu River
Sary-Tyor mountain
Orto-Tokoy
Chuy
Arabel-Suu R.
Ak-Shyirak
Ak-Shyirak R.
4770
4653
4502
4763
4808
5216
5125
1606
178.
160
117
668
53
46
43°
42°
76°
77°
78°
79°
100 km

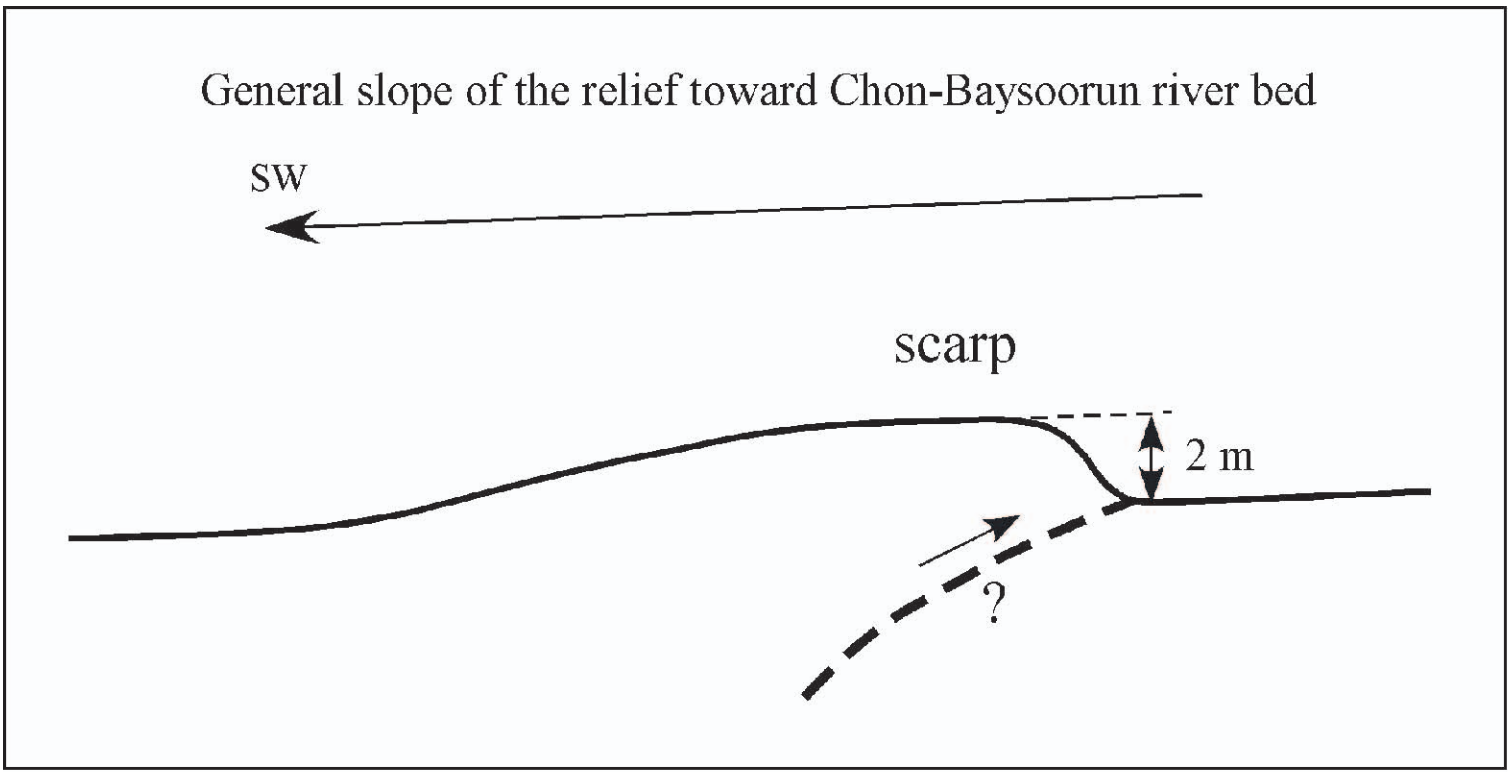

42°50'
Chet-Baysoorun river
Orto-Baysoorun river
Chon-Baysoorun river
Fig. 5
Fig. 4
Atymkul river
Chon-Uryukty river
Modern
village
Karool
-Dyube
Sazanovka
(Ananievo)
Village
Issyk-Kul Lake
47°20'
47°30'
1
2
0
10
20km

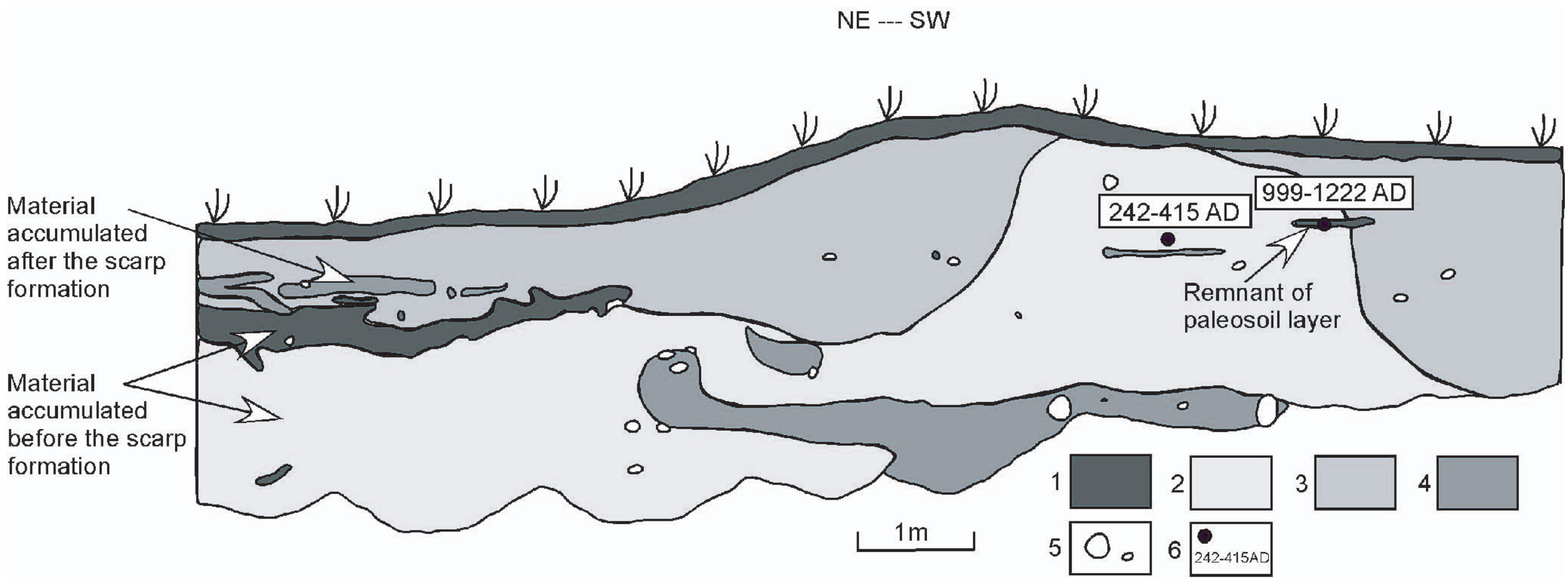

Trench
location
N
dry creek
Chon-Baysoorun R.
100 m



N
1826
1912
3m
12
m
6
m
Chon-Baysoorun r.
2010
200 M
1
2
3
3
4
5
2010


A
B
3.85 m
1.6 m
+
-
C


General slope of the relief toward Chon-Baysoorun river bed
SW
scarp
2 m
?


NE --- SW
Material accumulated after the scarp formation
Material accumulated before the scarp formation
242-415 AD
999-1222 AD
Remnant of paleosoil layer
1m
1
2
3
4
5
6
242-415AD