Geomorphology and Archaeology: Landscape reconstruction in South-East Kazakhstan

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Project and Objectives
Our purpose is a landscape reconstruction outgoing from the late Bronze Age up to early Iron Age (2nd–1st millennium B.C.). The linking of the results from the method group should flow in a scenery model of historical "land of seven rivers", named Zhetisu.

Besides, the result of the investigation can deliver a new understanding of the concept "Space" at the moment of the Sakes culture. Moreover the collaboration with archaeologists is narrowly interlocked in a tandem project with archaeological scientist Anton Gass.

Our questions are how the Sakes culture use their landscape and are they agnopastoralists besides their nomadic life?

Geomorphology
The site is located in the vicinity of Turghen, between the northern Tien-Shan fault and the Ili Valley with River Ili.

"Land of seven rivers" contains 4 climatic zones after climatic system of Köppen. From northwest to southeast a desert climate, steppe climate, dry summer climate and humid cool winter climate are present.

For palaeoenvirontmental studies we interested in archives like river terraces, alluvial fans, loess sediments and organic remains.

Landcape can be divided in 4 geomorphological areas.
I.) Floodplaine-Area
II.) Alluvial-fan deposition
III.) Aeolian loess deposition
IV.) Tien-Shan Mountains

Processes
Geomorphological aspects in the land of seven rivers are glacial impacts: cirques, trough valleys and sharp mountain ridges. Deposits from mudflows are widespread located.

Through Sajliskij-Alatau with altitudes of more than 4500m a borderline from west to east retains humidity of western parts and arrange a pluvial system. Physical and chemical wheatering are intensive, so the material were bulked for erosion.

Reliefs from Peak Talgar (4.953m a.s.l.) through Ili-Valley (475m a.s.l.) achieved 4.478m a.s.l., with distance near 70km.

Connection between reliefs, bulked material and seismicity results in denudation processes.

Parallel Steps
To answer the interesting time period of 2nd to 1st millennium BC it is important to date material; organic and non-organic (14C and OSL-dating).

Discussion
Results of remote sensing, pollen and sediment analysis combined with Datings are followed by Interpretation can give knowledge of past processes and understand the landscape development by imprinting archaeological research (Fig.8) and conceptualize the landscape.

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The Sakian culture and its environment - Geoarchaeological investigations in Kazakhstan

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Introduction

Since summer 2008 the land of Seven Rivers, southeast Kazakhstan is in the focus of geoarchaeological investigations. Target are the graves - so-called kurgans - which can be found nearly all over the area. For the investigations a study site along the rivers issyk and Turghen, covering an area of c. 60 km² is selected. These kurgans are remains of the Sakian culture which inhabited the region in the early Iron Age. The Sakian are described as mounted warrior nomads and are a part of the “Scythian people” in the Eurasian steppes. We detected Kurgan-fields of the Sakian culture near the cities Issyk and Turghen. Their geomorphological setting and spatial distribution are investigated. This is supplemented by an intensive characterisation of present and past landscape, focussing characteristics of grave sites.

Objectives

The aim of this project is to answer questions such as:
- How did the Sakian inhabited and settled in this landscape?
- Did they cultivate plants?
- Were they agropastoralists beside their nomadic life?
- Is it possible to detect any evidences for an increase of morphodynamic activity for the time slice of the Sakian?

Methods

Following methods were applied:
(1) large scale geomorphological mapping,
(2) description, sampling and dating of sediment sections of valley-fills, alluvial plains and fluvial terraces within the loess-like sediment in the northern foreland of the Tien-Shan. Samples for dating are based on IRSL and radiocarbon (AMS) datings. AMS-datings were calibrate with CalPal (2007).
(3) grain-size distribution (laser-particle-analyser), mineralogy (XRD) and elemental composition (ICP-OES).
(4) Zonation of geomorphological units data from AsterDEM (Fig. 2) and ETM+ satellite images (Fig. 6).

Preliminary analysis of mapping results shows the kurgans of the Sakian are nearly all situated on alluvial fans.

Sediment analysis of profile 1 indicates in gully erosion (Fig. 5) in the geomorphological unit of “loess hills” and corresponds to a colluvial outcrop with most recent regressive erosion. Brown (2001) shows that landscape activities during wetter conditions result in gully erosion (Fig. 5).

IRSL-datings of the colluvial deposits give evidence for phases of Holocene slide activities. Dating are maximum ages and measured from polymineral fine grain (grain-size 4-11 μm) of sample. IRSL-ages are fading corrected. Stability of IRSL-measurements were encouraged by dose recovery & preheat plateau tests.

References


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IRSL - Dating of loessic sediments in the Land of Seven Rivers, Kazakhstan

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Introduction
Since summer 2008 the land of Seven Rivers (Kazakhstan) is in the focus of geoarchaeological investigations and has been studied in order to understand the relationship between the activity of the Saka nomads who are a part of the “Scythian people” in the Eurasian steppe and the change in the landscape.

Targets of our investigations are the Saka graves – so-called kurgans - which are found nearly all over the area along the rivers Issyk and Turkhen (Fig. 1). These kurgans are remains of the Saka culture inhabited in the region during the early Iron Age. Two outcrops of the Loess hills (MB842 and 926), which are close to the concentrated distribution of kurgans, and a profile MB924 located on an alluvial fan of river Issyk (Fig. 2), were investigated.

Nine samples for infrared stimulated luminescence (IRSL) dating were collected to estimate the ages of the loess and colluvial sediments.

Objectives
The aim of this project is to answer questions such as:
- Did landscape changed during activity of Sakaian culture?
- Is it possible to determine evidences for an increase of morphodynamic activity around the 1st mill. BC?

Protocol for IRSL measurements
Laboratory IRSL experiments with single aliquot regenerative-dose protocol (SAR) were carried out from facies with non-polymineral fine grains (4-11 μm) of aeolian and colluvial sediments.

For D$_0$ measurements we used a modified elevated temperature post-IR IRSL protocol after Buylaërt et al. (2009):

$$D_0 = \frac{\sum_{i=1}^{n} T_i}{n}$$

Where $D_0$ is the mean signal and $T_i$ is the response to the related test dose.

Results
The fading-corrected IRSL and post-IR IRSL ages agreed for 6 samples but the post-IR IRSL ages overestimated the IRSL ages for the 3 samples (MB926):

<table>
<thead>
<tr>
<th>Sample</th>
<th>Difference in ka</th>
<th>Depositional environment</th>
<th>Bleach character</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB926</td>
<td>0.4</td>
<td>Loess hill (sod)</td>
<td>well bleached</td>
</tr>
<tr>
<td></td>
<td>1.8</td>
<td>Loess hills (colluvial)</td>
<td>insufficient bleached</td>
</tr>
<tr>
<td></td>
<td>2.6</td>
<td>Alluvial fan (aeolian &amp; fluvial)</td>
<td>well bleached</td>
</tr>
<tr>
<td></td>
<td>9.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.2</td>
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</table>

Both IRSL and post-IR IRSL ages from MB926 showed inverse relationship with the depth, suggesting the sediments were not sufficiently bleached before deposition.

Discussion
The preheat and the post-IR IRSL measurement temperatures were selected according to the results of the preheat plateau test and the dose recovery test (Fig. 4a). Small recuperation (< 5%) and recycling ratio (< 1.0) support the suitability of the protocol for $D_0$ measurements (Fig. 4b).

Spatial analysis of the profile MB926 indicates that the site is located on the loess hills (Fig. 5). The sediments are interpreted as a colluvium due to the most recent regressive erosion. We interpret the age reversal and the difference between the IRSL and post-IR IRSL ages due to insufficient bleaching during transport and sedimentation. The overestimation of the post-IR IRSL age suggests this signal is less sensitive to light exposure than the IRSL signal.

Suitability: Sample LUM2128 (MB926)
(a) Preheat plateau test
(Plateau at 250°C; 15 Aliquots)

(b) Recuperation rate and Recycling ratio
(8 Aliquots)

Fig. 4: (a) Preheat plateau test and Dose recovery test, (b) Recuperation rate and Recycling ratio of LUM2128 (sample of MB926).

On the other hand, the IRSL and post-IR IRSL ages from the aeolian outcrops (MB842 and MB924) in loess hills show comparable ages, which suggest the grains were sufficiently bleached. The youngest IRSL age (4.6 ka, IR50) was obtained from 0.4 m from the top from MB924, which is slightly older than the age of Kurgan (Early Iron age, ~2.6 ka).

Thus the difference between IRSL and post-IR IRSL ages can be used as an indicator of the degree of bleaching prior to deposition.

Conclusion
As a result of IRSL and post-IR IRSL dating, the ages are in agreement for the 6 samples from the loess profile and in disagreement for the 3 samples from the colluvial profile.

We interpret the difference between the IRSL and post-IR IRSL ages is due to different residual doses before deposition. This age difference will be a useful indicator to judge if the sediments are well bleached or not for polymineral fine grains, i.e. if the ages are reliable.

At present it is difficult to say if the morphodynamic activity was increased or not by Sakaian culture. Further chronological data close to the top of the sections are necessary combined with a geomorphological mapping and the reconstruction of palaeoprecipitations from climate model.

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Sediment based proxies and downscaled paleoclimatological approach – a qualitative approach to reconstruct late Holocene landscapes

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Introduction

A landscape reconstruction of the late Holocene (~4 ka) is the major objective in the Land of Seven Rivers, southeast of Kazakhstan. Information on late Holocene landscape conditions and potential changes is scarce and needs to be clarified.

Therefore, a qualitative approach with sediment based proxies [weathering index, Luminescence (IRSL) and AMS dating, carbon content (TIC)] and a downscaled ECHO-G paleo-precipitation model [time series for 6.0 ka to 0.1 ka] was applied to investigate the paleoenvironmental conditions.

Nomadic Scythians (Sakian) people inhabited the Land of Seven Rivers during the first Mill. BC [WAGNER, 2006] – remnants are the kurgan fields [Fig.1]. The multi-proxy study shows how paleoenvironmental conditions for the late Holocene landscape may be approximated.

Objectives

1. Reconstructing the regional late Holocene landscape!
2. Are there changes in paleoprecipitation during the late Holocene (~4 ka)? Is there evidence for more humid conditions in this steppe region?
3. Are there any evidences for late Holocene morphodynamic activity?

Methods

Sediment based proxies:
- Depositional environment
- Weathering index [ICP-OES]
- Weathering index [LCI-MSI]
- Luminescence dating
- AMS dating

Paleoprecipitation model:
Statistically downscaled precipitation time series for the climate station Almaty (mountains) and Balhash (steppes) from 6 ka until present day derived from a general circulation model simulation with ECHO-G [WAGNER et al., 2007].

References
SCHÜTT, B. et al. (2010): Late Quaternary transition from lacustrine to a fluvio-lacustrine environment in the northwestern Tian Shan Mountains to the pan. In comparison with TIC a correlation is observed. In varied depths of 50 cm, 100 cm and 150 cm [0.13·x] from mountains to pan.

Results and Discussion

Ardeian, alluvial and colluvial outcrops were studied near cities Issyk and Turghen, 55 km east of Almaty. The depositional environments for studied outcrops [Fig.2] differ between the landscape units and passing three climatic zones after KOEPPEN [1936].

Sediment proxy of TIC ranges between 0.04% and 2.27%. In varied depths of 50 cm, 100 cm and 150 cm the catenarian TIC of all outcrops increases in 100 cm [p.11±] and 150 cm [0.07±] from mountains to pan. Grain sizes [Fig.3] show silt and sand fraction dominated sediments.

The modified weathering index [mCIA after NESBITT and YOUNG, 1982] with mean values of

- mCIA = 0.07·x
- mCIA = 1.61·x

range from 0.87 to 69. In summary, a negative gradient in 100 cm [1.61±] and in 150 cm depth [2.87±] explains a decreasing weathering index from northern Tian Shan Mountains to the pan. In comparison with TIC a correlation of r = 0.78 was identified, suggesting calcium dominated carbonates explain primarily the weathering processes.

The geochronological frame of IRSL [1.7±0.2 ka to 18.8±2.5 ka] and AMS ages [1.81±0.05 cal ka BP to 18.8±2.5 ka] indicate pre- to late Holocene sediment deposits.

Conclusions

To reconstruct late Holocene landscapes sediment based proxies and modeled paleoprecipitation are presented. Reconstruction of paleoenvironmental conditions due to weathering changes and depositional environment [SCHÜTT et al., 2010] was applied. Based on a modified weathering index [mCIA] and a statistically downscaled paleoprecipitation model the late Holocene landscape has been approximated.

Evidences for paleoprecipitation changes to more humid conditions during the late Holocene (~4 ka) cannot be determined [Fig.4a].

Further, the landscape units show different late Holocene sediment dynamics from the Tian Shan Mountains to the northwared Pan. Dynamic areas are Loose hills and the Pan. The alluvial mega fan show adynamic sediment deposits in late Holocene, suggesting a stable landscape unit during the last 4 ka.

Fig. 1: Sakian Kurgan-field (Issyk) on alluvial fan near Almaty.

Fig. 2: Locations of studied outcrops

Fig. 3: Sediment based proxies of all outcrops

Fig. 4: a) Downscaled paleoprecipitation model for steppe (Balhash) and mountain climate station (Almaty) b) 50yr-averange of climatic model data in Fig.4a.