Using satellite imagery for mapping of the Chuya Steppe. Survey and inventory of archaeological sites in the valley of Yustid

Provisional report on the Belgian-Russian expedition in the Chuya-Steppe (July-August 2004)

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Introduction

Ghent University has an already long tradition of archaeological research in the Altai Republic. In 1995, it joined a Belgian-Russian team (together with the Royal Museums of Art and History of Brussels and the Free University of Brussels) in a project financed by the National Fund for Scientific Research (FWO-Vlaanderen). This project allowed us to finance excavations in Kizil (Tchungur area) (1995), Sebistey and Kalanegir (1996-1997). The last year was already more devoted to survey and inventory of archaeological sites, as excavations in this area became clearly at that moment a hot item⁵. A smaller project financed by the Flemish Ministry of Education allowed us to continue the survey and inventory of archaeological structures in the Ujmont Steppe (1999) and in the Maima area (2000)⁶.

Meanwhile, the Department of Archaeology of Ghent University started a new project on the use of satellite imagery for mapping and localisation of archaeological

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features. A result of this first research is a double university paper\textsuperscript{7}. A scientific paper about this research has been published in the international archaeological journal *Antiquity*\textsuperscript{8}.

Figure 1. Map of the Chuya region with an indication of the research areas in 2003 and 2004.

Based on the positive results of this case study, both the Department of Archaeology and the Department of Geography of the University of Ghent decided to apply for a grant to the Research Council of our University. This project has been granted for two years (2003 and 2004).

The first campaign took place from July 6\textsuperscript{th} to August 15\textsuperscript{th} in the western part of the Chuya Steppe (Altai) (Fig. 1). The actual fieldwork has been realised from July 9\textsuperscript{th} to August 6\textsuperscript{th}. Four parallel valleys to the South of the Steppe were chosen as research area: Sebystei, Ozék, Irbistu and Elangash.

The first 10 days of the fieldwork, the research was concentrated on topographical measurements with a GPS receiver, needed for the georeferencing of the CORONA satellite imagery and the making of a DEM. A total of 43 ground control points have

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been localised, spread over the whole area from Sebystei to Elangash (Fig. 2). During the expedition, the team used different devices for georeferencing:

- C-Nav (CC Technology): precision less than 1 meter, up to 20 cm;
- Garmin 12 XL hand GPS with external Motorola antenna: 1 meter;
- GPS receiver Motorola Oncore VP with external Motorola antenna: 1 meter;
- Garmin Vista hand GPS: 5 meters.

**Overview GPS measurements 2003 - South Chuya**

![Figure 2. Localisation of the geographical points (measured with the C-Nav differential receiver from C&C Technologies) in the Southeastern border of the Chuya steppe in 2003. Notice the unbalanced spread of the GCPs (red), caused by the limited accessibility of the research area (valleys).](image)

The results obtained by the different devices have been compared in order to decide which one is best suited for archaeological purposes and best for mapping (see below).

The processing of the topographical data and the satellite imagery in a digital photogrammetric platform⁹ provided us a good, trustable topographic map in a 1/20.000 scale (Fig. 3: orthophoto map). Together with this, a geomorphological map of the same area is made up.

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⁹ We use the Chinese software VirtuoZo 3.2.
In a next phase, the archaeological survey of the area yielded an inventory of 751 structures from 136 different sites. 152 structures have been localised by using GPS, 599 other structures by simple topographical sketching (azimuth and distance, starting from localised structures). Function, period and cultural attribution of the archaeological structures are based on morphologic elements and on comparisons with other sites and regions, and structures are found dating from the Bronze Age to the present.

This preliminary report is the result of the second campaign, from July 11th to August 10th in the eastern part of the Chuya Steppe (Altai) (Fig. 1). The actual fieldwork has been realised from July 17th to August 5th. This campaign was financed by the Belgian department of Science Policy.

**Satellite imagery and mapping**

Corona satellite images are old (‘60ies en 70ies) American photographs and can now freely be afforded on Internet ([http://earthexplorer.usgs.gov](http://earthexplorer.usgs.gov)). For the Altai region, images from series KH4, KH4A en KH4B are available. The main difference between these three series is the resolution of the images (KH4: 25 feet; KH4A: 9 feet; KH4B 6 feet). Especially KH4A and KH4B are useful for mapping as well as for archaeological purposes.
We use the images as the basis for detailed topographic mapping of the research area, as adequate civil maps are not available. The used methodology can be found in the report of the campaign of 2003 (see attachment) and in some of our publications\textsuperscript{10}.

In order to make georeferenced maps, it is necessary to localise as precisely as possible a series of points in the landscape (Ground Control Points). For this, the use of Global Positioning Systems (GPS) is necessary. During the expedition of 2003, the team used 4 different GPS receivers (see above). The analysis afterwards showed clearly the high accuracy (in this example: standard deviation report of 0.58 m supplied by the receiver, after 30 minutes of initializing) and stability (standard deviation of 0.03 m over the measurement period) of the C-Nav's results. We took the C-Nav's mean position as a benchmark for the Motorola Oncore VP and the Garmin 12XL: the multi-station differential post-processing results of the Motorola Oncore VP and the Garmin 12XL are similar, with the Motorola Oncore VP (standard deviation of 1.74 m and 0.59 m mismatch, as compared to the C-Nav mean) performing slightly better than the Garmin 12XL (standard deviation of 2.19 m and 0.74 m mismatch, as compared to the C-Nav mean) (Table A).

<table>
<thead>
<tr>
<th>C&amp;C C-Nav vs. Motorola Oncore VP</th>
<th>0.59 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>C&amp;C C-Nav vs. Garmin 12XL</td>
<td>0.74 m</td>
</tr>
<tr>
<td>Motorola Oncore VP vs. Garmin 12XL</td>
<td>1.18 m</td>
</tr>
</tbody>
</table>

Table A. Mismatch between the mean positions obtained using each of the three system setups for point 10070302.

It seems clear that the proposed techniques involving the Motorola Oncore VP and the Garmin 12XL are useful when the stand-alone GPS accuracy of 5-10 m is insufficient: both systems yield planimetric accuracies of 1-2 m. Altimetric accuracy is generally 2 till 3 times worse (3-5 m). Their main disadvantage is that the results are not available in real-time and need post-processing. It is self-evident that when the highest possible accuracy needs to be attained, much more costly equipment such as the C&C C-Nav system remains indispensable and can yield accuracies of decimeter level in real-time without the need of the traditional differential technique including the use of a second GPS-receiver-unit as reference station.

In 2004, we could not use the C-Nav system again (in 2003, Dredging International provided us costless with the equipment), and there was no budget to buy the equipment ourselves, so we had to search another solution\textsuperscript{11}. Taking into account the results of our analysis, we were confident to use one of the other evaluated systems that showed to have an accuracy of 1-2m.

A total of 385 points have been localised with the Garmin 12 XL (attached to a laptop, which recorded the received signals with the software GRINGO). This was a huge work and a full-time job for the geographer in the team. All individual

\textsuperscript{10} See note 8

\textsuperscript{11} We decided to apply for additional funding, that has been approved by FWO-Vlaanderen to prof. dr. ir. Alain De Wulf. He will buy a C-Nav receiver in 2005, that than will be used a.o. in the next Altai campaigns (beginning with the summer campaigns of 2005-2006).
archaeological sites were localised (338 measurements on 291 sites), some of which can serve as a GCP for the topographical mapping as they are clearly visible on the satellite imagery. Additionally, 47 topographical GCPs were measured, spread over the whole area of the Yustid Valley (Fig. 4 and Fig. 5).

Overview GPS measurements 2004 - Yustid Valley

We are convinced these measurements will provide us with a good map after post processing, as there were several advantages compared to the campaign of last year:

- the GCP’s have a very good X and Y spreading, covering the whole of the satellite image, as the valley of Yustid and surroundings proved to be relatively accessible (Fig. 4) (last year, we had to limit the topographical survey to the narrow valleys, resulting in an unbalanced spread, see Fig. 2).
- the GCP’s have a better spreading in Z, as we took measurements at an altitude of ca. 1800m asl to 2200m asl.
- in 2004, we worked with the KH4B images, that have a better resolution (KH4B 2004: 6ft - KH4A 2003: 9ft). This means it was easier to locate reliable GCP’s on the satellite images, and it was possible to locate them more precisely than last year (see Fig. 5).

Figure 4. Ground Control Points (red) and localized sites (green) in the Valley of Yustid and surroundings, measured during the 2004 campaign (Garmin 12 XL – GRINGO).
Archaeological Survey and Inventory

The archaeological fieldwork in the Yustid Valley started on July 17th and lasted till August 4th.

Our first intention was to survey the whole area of the Yustid Valley (and maybe the surroundings), but this appeared to be an impossible mission. The amount of archaeological structures, especially in the middle part of the Yustid Valley, was tremendously high. Therefore we decided to focus this campaign only on the right bank of the middle part of the river, including the alluvial plain (see Fig. 6). Although the surveyed area was quite limited (some 8x3 km or 24 km²), more than 2300 different structures were recorded. During the 2003 survey campaign in the east of the Chuya, we recorded 751 archaeological structures in 4 valleys (covering some 300 km²). We estimate that at least one and very probably two more survey campaigns would be necessary to survey exhaustively the whole Yustid Valley area.

The survey consisted first of the localisation of all archaeological sites with GPS (see above). Secondly, all archaeological structures have been recorded using azimuth and distance, in a way to produce site plans. Thirdly, the structures were described, measured and photographed. A tentatively date of each structure is based on morphology, literature and comparisons with other sites and regions. Only excavations could confirm or change this attribution.

We are convinced that within the surveyed area no archaeological feature has been missed, except maybe for some smaller structures like the rectangular “parterre” stone settings. As opposed to last year’s survey, all structures were found within the different terraces of the right bank and the alluvial part of the river.
Although we discovered and registered some rock carvings on archaeological structures (steles, for example site KA-422, see Fig. 7 A), we only found one single petroglyph site (KA-377, see Fig. 7 B).
In total, 291 “sites” were located (Fig. 8). This term is no more than a useful way to record “places of archaeological interest” and does certainly not mean that we consider it as an archaeological unit. Some sites are for one single structure (as e.g. one Turkish kurgan), but in many cases, one site concerns many structures (for instance a Bronze Age kereksur, followed by a Scythian burial place of, say, twelve kurgans, an amount of stone circles in the west of it, and some steles in the east, followed by Hunno-Sarmatian cemetery, some Turkish ogradki and ethnographic burials).

The precise definition of what could be considered as one archaeological site was hampered by the high density in the area (Fig. 9). We tried to set up a system, based on distance buffering (e.g. all structures that clustered within 30m of the main monument belong to that site) but the typology of the sites appeared to be so diverse it was almost not possible to stick to that oversimplified system. When the database is completely finished (maps, photographs, data...) we will have to reconsider the divisions we made in the field.

All sites were recorded with a YU prefix (YU-001, YU-002, etc.) (all sites in the Yustid Valley) and with a KA prefix (all sites within the Kosh-Agach administrative area). These codes are unique codes for registration in the Altari database, developed by Ghent University.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Number</th>
<th>Date and remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kereksur</td>
<td>103</td>
<td>Bronze Age</td>
</tr>
<tr>
<td>Kurgan</td>
<td>206</td>
<td>Turkish, Scythian</td>
</tr>
<tr>
<td>Ogradka</td>
<td>94</td>
<td>Turkish</td>
</tr>
<tr>
<td>Stone concentration</td>
<td>340</td>
<td>All periods</td>
</tr>
<tr>
<td>Stone circle</td>
<td>1227</td>
<td>Scythian, Bronze Age</td>
</tr>
<tr>
<td>Rectangular (parterre)</td>
<td>96</td>
<td>Unknown</td>
</tr>
<tr>
<td>Stele</td>
<td>271</td>
<td>All periods</td>
</tr>
<tr>
<td>Alignment</td>
<td>16</td>
<td>Unknown</td>
</tr>
<tr>
<td>Ethnographic grave</td>
<td>9</td>
<td>Ethnographic period</td>
</tr>
<tr>
<td>Petroglyph site</td>
<td>1</td>
<td>All periods</td>
</tr>
<tr>
<td>Zone of interest</td>
<td></td>
<td>These zones are located with multiple GPS measurements, and indicate concentrations of alignments, stone settings, etc. that were too complicated to record in detail within the limited campaign of 2004.</td>
</tr>
</tbody>
</table>
Figure 9. This example clearly shows the density of the archaeological structures in the Yustid Valley, which makes it very hard to define individual sites. This small part of the research area, located on the first river terrace, shows more than 200 structures, which we divided into some 20 'preliminary sites'.

The oldest recorded structures go back to the **Bronze Age** (3$^{rd}$-2$^{nd}$ mill. BCE). 1014 structures were attributed to this period: 98 kereksurs (ritual monuments), 4 kurgans (burial mounds), 25 steles, 841 stone circles and 30 concentrations of stones, presumably of ritual nature.

The kereksurs are characterised by a quite large and high mound of smaller stones; mostly the mound is flattened on top. In some cases, one can recognise a dual construction, with a smaller heap over a larger heap of stones (like a reversed soup dish, see Fig. 10). The diameter of these mounds varies from some meters up to 25 or 30 meters, the height from 0.3 to 2 meters. A large part of these structures is enclosed by a circular (see Fig. 11) or quadrangular bank. Mound and bank can be linked by several spokes. The banks have diameters from 10 to 95 meter. They are surrounded by small stone circles: in some cases it concerns only one or two circles; in other cases we located more than 60 of these circles.
These monuments are generally considered to be ritual structures. The stone circles seem to confirm this interpretation, as they are considered to be small fire and/or offering places. It is worth mentioning, however, that on the left bank of the River Yustid, the Russian archaeologist Kubarev\textsuperscript{12} excavated two of these monuments and discovered some burials.

The kereksurs are located along the border of the first river terrace and are remarkably concentrated in the eastern part of our research area, where the terrace becomes considerably narrower (Fig. 12). The largest exception is the enormous kereksur (YU-001), which is situated on the second terrace, far from the alluvial zone, in the lower part of the valley (Fig 13).

A second type of monument is the large stele. At least 4 steles can be related to the Bronze Age. Except for one, all are connected to several stone circles; in the case of site YU-141, we registered more than 100 circles and 18 smaller steles (see Fig. 14).
Scythian cemeteries are maybe the easiest sites to discover and record. Their North-South orientation, the possible presence of steles in the East and stone circles in the West is well known. We recorded more than 90 Scythian kurgans (burial mounds) in the research area (Fig. 15). They have a diameter varying from 5 to 15 meter and are characterised by the presence of a central depression, due to the collapse of the burial chamber and/or robbing. 73 of these mounds can be attributed to six Scythian burial places (YU-034/057/069/076/089/216), were the kurgans are orientated in a North-South axis. These burial places count 4 to 13 kurgans. One very large cemetery, YU-076, consisted of 28 mounds. In almost all cases, these cemeteries are surrounded by steles in the East and stone circles or small stone concentrations in the West (a total of 46 steles, 148 stone circles and 203 ritual stone concentrations was recorded). For the more isolated mounds, the dating is based on the presence of the central depression. Again, only excavations can confirm this chronology.

One of the burial places, site YU-216, is located on a hill slope. The five other large cemeteries are placed on the border of the river terrace. If we consider also the smaller burial place YU-046, a pattern in the distribution seems to appear, with intervals of 650-700 meter.

The situation of the Hunno-Sarmatian monuments is more problematic. During our prospection last year we discovered a lot of relatively small stone heaps (2x1m, 3x2m etc.); in a first chronological attribution we estimated that these sites were possibly of Hunno-Sarmatian date. It is however clear now that this attribution is not correct: small stone heaps seem to appear in a lot of cases together with stone circles related to burial monuments, especially Scythian. They can be considered as ritual structures, as the stone circles are (see above). As a result of this new interpretation, Hunno-Sarmatian monuments are very rare in the Yustid Valley, except for one possible funeral (?) monument.
The **Turkish period** is very well represented in the area. Especially ogradki seem to be very common (Fig. 16). We recorded more than 90 of these ritual monuments. In some cases, they seem to be isolated, whilst in other cases, they appear in clusters of 3 to 5 of them. Some of them have annex structures to the East, as balbals (small steles; 189 in total) or stone circles (135 in total). Sometimes, these balbals have petroglyphs or are even sculptured. Some 40 kurgans are attributed to the Turkish period, although no excavation has been executed. They are isolated and especially spread over the alluvial zone of the Yustid River. For the ogradki as well as for the kurgans, we have no clear view yet of their spatial organisation nor their relation to other monuments. It is clear however that we do not have the same spatial organisation as in the Western border of the Chuya Steppe (as was mentioned in previous reports).

Randomly, some **ethnographic structures** were recorded, but this is certainly not systematically. In many cases, it is quite difficult to assess a date for perturbations of older structures, as kurgans for example.

It is worth mentioning that not all monuments we discovered could be recorded in detail. During the work of inventory, we found 4 zones with a very high density of small structures as uncommon circular and rectangular stone settings, alignments of buried stones, etc (Fig. 17). Some of these structures were very hard to identify, and mostly the chronology is unknown. As these structures were not easily describable without identifying and drawing all individual stones (hundreds!) on a very detailed plan – a process that would take several days per concentration – we had to limit the
recording of these zones to a generalised description. We located all zones by multiple GPS measurements and made dozens of photographs for illustration.

Figure 16. Turkish ogradka with 4 balbals to the East (YU-129 / KA-286).

Figure 17. An example of an archaeological zone with a very high density of small structures: here an alignment of buried stones and a rectangular stone setting.

Finally, some structures could not be attributed to one or another period, because of their isolated position, because of their “special” form. Amongst them, we would like to mention site Irbistu 9, with a rectangular setting of buried stones and a series of radial stone rows. No good comparison for this site is known.
**Future programme**

It is our intention to continue the survey and inventory of the Chuya steppe, following the methodology assessed during the two past campaigns. The more western part, up to Beltir and further, is one of the possible goals for a next campaign. As we have at our disposal excellent KH-4B images of the archaeologically very important area to the south of the Chuya Steppe, the Ukok high plateau, our research could also concentrate on that area. In this context it is worth mentioning that local authorities are working out a program to protect this area and are planning to install a cultural and natural reserve. For this purpose, they want an inventory of the archaeological heritage in the area, for reasons of protection and possible enclosure to the public (cultural tourism). The team of Ghent University was asked to make up this inventory in the coming years.

We are working out collaboration with different UNESCO sectors (Culture, Science) to make it possible to continue the work in the area. The main objective here is the protection of the frozen tombs in the area (many of them can be found on the same Ukok plateau) and the monitoring of permafrost. With the support of the authorities of Russia, Kazakhstan, China and Mongolia, it may be possible to inscribe these valuable monuments on the World Heritage List.

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