Archaeological GIS and Oasis Geography in the Tarim Basin

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The "pivot of Asia," as Lattimore called Chinese Turkestan (more prosaically the modern Xinjiang Uighur Autonomous Region), is an area where a great deal of ancient history, and especially prehistory, remains uncharted. At its center lies the Tarim Basin and the Taklamakan desert (Fig. 1), an immense and harsh landscape of sand dunes, pebble deserts, and salt flats. But along the foothills and at "terminal deltas" where rivers end in the desert, for millennia oasis settlements have flourished which were culturally and geographically tied at once to China, South Asia, western Central Asia, and the Eurasian steppe.

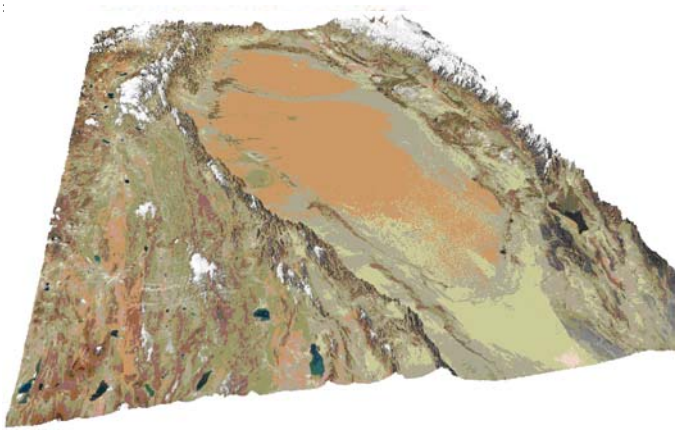

Fig. 1. A "fly-through" view of the Tarim basin, looking west (created from a true-color MODIS satellite image of the Tarim Basin [NASA, Visible Earth, http://visibleearth.nasa.gov/cgi-bin/viewrecord?23798], draped over a digital elevation model).

The exploration of the Tarim Basin at the beginning of the twentieth century was a time of spectacular discoveries, with unknown ancient languages and cultures coming to light from the inside of what had been a vast blank on the map, known almost solely from outside historical sources even when the idea of the Silk Road was first formulated. Within the last decade, research has once again begun to proceed apace, with numerous Chinese projects and joint projects with foreign researchers back on the ground in the field.[1] Here as in the other regions of Central Asia described in this section, GIS will undoubtedly play an important role in the future of establishing, interpreting, and synthesizing the archaeological record.[2] In the scope of evolving new techniques for understanding the historical geography of Central Asia, it is still only possible to sketch some directions for developing a regional archaeological GIS of this "poor sister" of the Central Asian culture areas. But at the scale of a single oasis, the Niya site, it also provides an application where the interpretive potential of GIS often alluded to has been of great utility.

Old maps in new bottles

Much of the work of early explorers of the Tarim basin remains substantive as archaeological data, but since many of those explorers were also working as the first scientific cartographers of the region, simply plotting the sites they discovered onto modern maps can be a difficult task. Geographical accuracy in their reports is often far from perfect, with vast areas still marked "unexplored," even on the beautiful set of American Army Maps published after a long lapse as the Sven Hedin *Central Asia Atlas* [Hedin 1966]. This set of maps is particularly valuable for collecting in one place the dated routes of early explorers across the entire region (Fig. 2). These routes and the locations of sites form a useful "base-map" for digitization, where in many cases specific areas can then be mapped in with greater accuracy from the original sources. For example, for Hedin's own

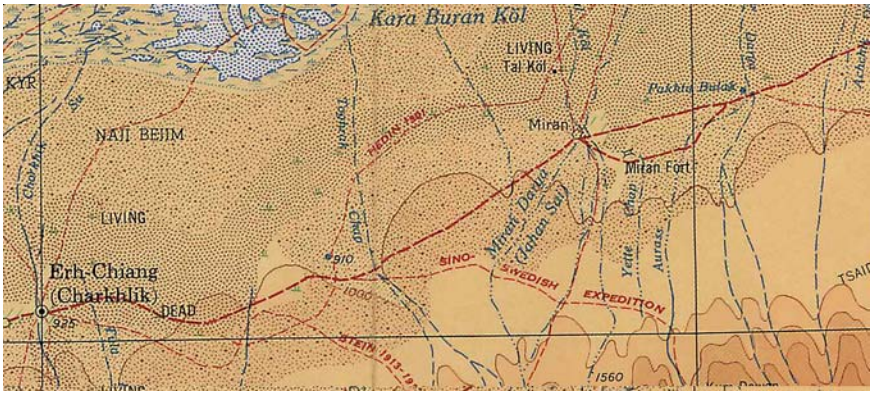

Fig. 2. A portion of a sheet from the Sven Hedin Central Asia Atlas in the area of Charkhlik, showing routes of early explorers. [After Hedin 1996].

observations, the maps published in earlier reports are often of a very large scale, being almost sketches of the landscape visible from his routes.

Once digitized, this material can be overlaid on modern cartographic data, some of the best of which are the 1:200,000 and 1:100,000 maps produced by the Russian military.[3] The quality of these maps is better than the geodata so far released by their American counterparts, the National Imagery and Mapping Agency (NIMA), but the latter are already digitized, and can be easily manipulated in a GIS with other geodata. By overlaying these different data sources, information can be compared and verified, analyzed in relation to environmental data, and used for modeling. Overlaying archaeological data on remote sensing (satellite) images, for example, offers the potential of discovering paleochannels where new sites might be discovered. The ground-penetrating radar designed by NASA's Jet Propulsion Laboratory and flown on space shuttle missions over Niya[4] provides an excellent example of this potential, since it is particularly suited to penetrating sand, and has proved its archaeological utility in the discovery of paleochannels with Paleolithic remains in the Sahara, and the ancient "incense route" city of Ubar in Oman. But in order to make such data useful, it needs to be given an exact geographical reference in relation to archaeological sites which have already been documented on the ground.

Many of these sites were first documented by the "godfather" of the archaeology of the Tarim, Sir Aurel Stein, whose work [Stein 1907, 1921, and 1928] remains an essential source, with the locations of thousands of archaeological features in quite accurate spatial contextualization of surveyed and excavated archaeological material, given the practices common in his time. What is particularly striking is that in areas where Stein and his surveyors were sometimes working in true *terra incognita*, the error in the localization of sites (common especially in longitude) are only in the range of only a few kilometers, when compared with modern field observations made with a Geographic Positioning System (GPS). Fig. 3 shows some of these geodata georeferenced with a satellite image for the area between Khotan and Keriya.

As a basis for creating a GIS database of the sites recorded by Stein in the Tarim, high resolution digitizations of the set of maps published in *Innermost Asia* (which brings together data from all three of Stein's expeditions) have been georeferenced with current geodata.[5] A point set generated from these maps serves as a reference for attaching the identification, type of site, more detailed site-plans, and most importantly, database tables of the inventories which include the provenance of all the artifacts discovered by Stein. The particular importance of attaching these data tables to loci is the ability to query and manipulate

Fig. 3. Sites of the Khotan and Keriya drainages (excluding the newly discovered sites in the ancient northern Keriya delta [Debaine-Francfort and Idriss 2001]).

data as in any other database, within a spatial reference. While many of these databases need to be developed for specific regions, and from other sources, an enormous collection of these inventories are already available in the form of the International Dunhuang Project's online database (http://www.idp.bl.uk).

Beyond "dots on the map"

The utility of GIS as a tool for interpreting archaeological material is sometimes achieved in theory more than in practice, particularly at a regional scale, and in a region surveyed as inconsistently as much of Central Asia. It will in many cases first have a role of simply providing a spatial "catalog," while building models and explaining historical and geographical patterns depends on fine-grained analysis, and especially the ability to link spatial databases with large tables of archaeological information.

One of the sites in the Tarim where this kind of fine-grained analysis can be achieved is the Niya oasis, first discovered, mapped, and excavated by Stein, and the object of Sino-Japanese field project over the past decade [Sino-Japanese 1999]. This project used digital spatial technologies extensively, making the data available in a format readily converted into a GIS. The ancient oasis is spread over hundreds of hectares at the internal delta of a river ending in sand dunes, which are so conducive to archaeological preservation that there are scores of remains of dispersed hamlets of wattle and daub structures and other well preserved landscape features (fields, orchards, vineyards, canals, pools, bridges, etc.). While there is little of the vertical stratigraphy typical of Central Asia archaeological mounds, recent discoveries of remains of late Bronze Age material far out in the ancient delta attest to the important aspect of horizontal stratigraphy of the oasis, which is particularly suited to spatial analysis (Fig. 4).

Niya is exceptional not only for a degree of preservation of an ancient landscape, but for the discovery of hundreds of 3rd-4th c. CE wooden administrative tablets dispersed at settlements as far as 20 kilometers apart across the oasis. These texts (letters, legal documents, contracts, tax lists, etc.), written in the Gandhari language native to what is today Pakistan and Afghanistan, contain a great deal of information on the everyday economic and social organization of the oasis.[6] Many different types of data in these documents are suited to discrete "coding" in a textual database, and GIS enables the attribute tables of these data to be linked directly to their archaeological contexts. This allows for a wide range of spatial querying, and the confrontation of textual data with models derived from the spatial analysis of archaeological material alone.

As part of the author's dissertation research, this database of textual information from the documents is being used within a GIS as a basis for the reconstruction of the organization and use of space in the ancient oasis, and to study aspects of daily life. This has made it possible to reconstruct the spatial structure of the ancient landscape in detail. For example, by analyzing texts for certain prosopographic criteria, it is possible to discover, settlement by settlement, a set of locations in the space of the oasis that can be associated with individuals in the documents. From these associations, it is possible to map the location and extent of toponyms and administrative units that cut across the textual and archaeological record, providing clues for the spatial organization of territorial kinship groups, the organization and mechanisms of agricultural production and redistribution, and so on.

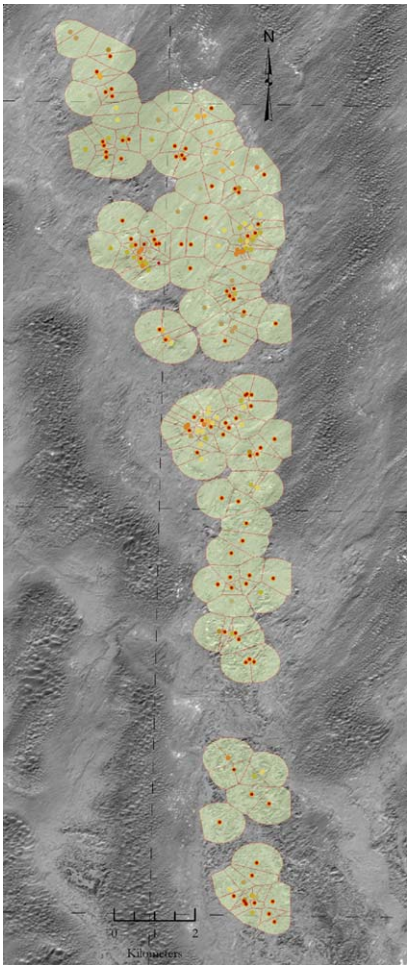

Fig. 4. GIS of the Niya oasis, incorporating digital data from the Sino-Japanese expedition, the material of Stein, and other spatial data. The "buffers" around archaeological features are used as part of one method of reconstructing the organization of space.

In a wider geographical and archaeological perspective, one goal of this research is to develop models of the organization of daily life in the early Inner Asian oasis, particularly at an economic level, which can be applied to oases across the so-called Silk Road. One direction for the application of GIS for modeling is to confront the reconstructions of the spatial organization from Niya with the

archaeological data of a similar nature from other oases of the southern Tarim, in order to understand their ecological evolution, inter-oasis relations, and similar themes. Another direction is to incorporate other textual and historical data which can be linked to the GIS — for example, economic data from later Khotanese, Bactrian, and other corpora, or the detailed demographic information provided by the "census" of the Tarim Basin oasis-states in the *Han-shu* (Hulsewé and Loewe 1979) across the last centuries BCE and first few centuries CE.

Geographically, the characterization of the region as a "pivot" throughout history has been and undoubtedly will continue to be borne out by new discoveries and interpretations of relatively local phenomena having far-reaching consequences. At the same time, because parts of the Tarim basin exemplify, in an extreme form, many of the common features of central Asian oases, it forms an excellent laboratory for building models of the evolution of settlement history with a wider importance. By uniting these sources, one can hope that GIS will provide a new means for working out some of the key geographical characteristics of the evolution of the Inner Asian oasis across time.

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Notes

1. See especially the well-illustrated volume of Debaine-Francfort and Idriss 2001, and Mei 2000.

2. From another direction, projects such as the China Historical GIS (http://www.people.fas.harvard.edu/~chgis/) could also become valuable in this respect.

3. Some excellent modern Chinese maps are also available for certain regions. Of particular interest for archaeologists are the examples included in the volume containing Debaine-Francfort 2001.

4. http://visibleearth.nasa.gov/cgi-bin/viewrecord?1337.

5. The digitized maps from *Innermost Asia* were generously provided by Susan Whitfield of the International Dunhuang Project (http://www.idp.bl.uk).

6. For a general survey of their contents, see Atwood 1991.