J.-M. Le Tensorer, R. Jagher & M. Otte (eds.). *The Lower and Middle Palaeolithic in the Middle East and Neighbouring Regions.*
Basel Symposium (May 8-10 2008).
Liège, ERAUL 126, 2011, p. 143-150.

DEVELOPMENT OF A GEOSPATIAL DATABASE WITH WEBGIS FUNCTIONS FOR THE PALEOLITHIC OF THE IRANIAN PLATEAU

Saman HEYDARI-GURAN[1], Elham GHASIDIAN[2], Michael MÄRKER[3] & Nicholas J. CONARD[4]
[1] Institut für Naturwissenchaftlische Archäologie (INA) Rümelinstraße 19-23, D-72070 Tübingen, saman.heydari@ifu.uni-tuebingen.de
[2] elham.ghasidian@uni-tuebingen.de
[3] Heidelberger Akademie der Wissenschaften,University of Tübingen, Germany, michael.maerker@geographie.uni-tuebingen.de
[4] Institut für Ur-und Frühgeschichte und Archäologie des Mittelalters; Abteilung Ältere Urgeschichte und Quartärökologie Schloss Hohentübingen, University Tübingen, Germany, nicholas.conard@uni-tuebingen.de

Introduction

In this paper we present a concept for the storage, exchange, presentation and analysis of geospatial, environmental and archaeological data to study and assess Paleolithic settlement systems and subsistence strategies of the Iranian Plateau carried out in the Tübingen Iranian Stone Age Research Project (TISARP). We use Geographic Information Systems (GIS), database solutions and web based technologies to handle and process archaeological and physiographic information. The Project deals with a variety of variables and formats such as geology, geomorphology, landforms, and Paleolithic archaeology in vector and raster as well as table and text formats. The study presents a unique set of archaeological information sampled on the Iranian plateau and its physiographic settings. The structure of the system is aimed at exchanging information and to provide a platform to add information and discuss results and research on the Paleolithic of the Iranian Plateau. Hence, the system is designed to be an international central data focus of all kind of archaeological and related physiographic information to investigate and model with holistic approaches the early human settlement dynamics, subsistent and land use on the Iranian Plateau.

In the past few decades, environmental studies have shown an increasing importance for the interpretation of archaeological processes. In early studies it was already pointed out that the understanding of culture and behavior of ancient populations is related to the natural environment (Smyntyna 2003). Meanwhile for three decades, geoinformatic technologies such as Geographic Information System (GIS hereafter) image processing, remote sensing as well as database systems have been used to complement and enhance archaeological research (e.g. Kvamme 1999; Galiatsatos 2004). The geographical information systems have moved from the domain of computer specialist into the wider archaeological community, providing it with a powerful tool for research and data management (Conolly & Lake 2006). Modern archaeological science depends on large collections of diverse, mundane objects (such as potsherds, stone tools and debris, and animal and plant remains), rather than small collections of treasures (Snow *et al.* 2006). Researchers have used archaeological data sets, and diverse methods, to interpret prehistoric hunter-gatherer behavior in ecological context (Banks *et al.* 2006, 2008).

Modern Iran covers an area of 1.648.000 square kilometers in the Middle East including various environments and land forms, water and raw material resources and heterogeneous topography. Up till now numerous professional Paleolithic archaeological investigations were carried out in the main regions of the Zagros and the Alborz Mountains of Iran (see references cited in Smith 1986; Biglari 2001; Roustaei *et al.* 2004). However, we can point out only a few studies for the Central Plateau (Conard *et al.* 2006; Heydari-Guran & Ghasidian 2011; Biglari 2004). But, compared to the Levant, there is no clear picture of the Paleolithic periods in this part of the world. Most of the investigations were spatially very scattered and they often lacked a clear research design. Due to its pivotal geographic position, most probably, the Iranian Plateau was a major transit route of early humans moving from west to east. This transit route along the Iranian Plateau is bordered by the Persian Gulf and the Caspian Sea from the southern and northern sides (Heydari-Guran 2011) (fig. 1).

The aim of this project is to provide a platform to gather all types of geoinformation specifically, concerning the early human settlement dynamics, subsistence and land use for the Iranian Plateau.

Geospatial information and Paleolithic archaeology

Much, of the data that archaeologists recover is spatial in nature, or has an important spatial component (Wheatley & Gillings 2002). Many Prehistorians concerned with site distributions have noted that a geographical approach is fundamental to spatial analysis (Clark 1977). However, geographical theories of spatial organization have influenced some prehistoric applications, primarily through the concept that the environment presents economic challenges to which that the society must respond with rational planning. To address the objectives of this study highlighted above, a spatial database was created. Thereafter, we carried out geospatial analysis to examine the distri-

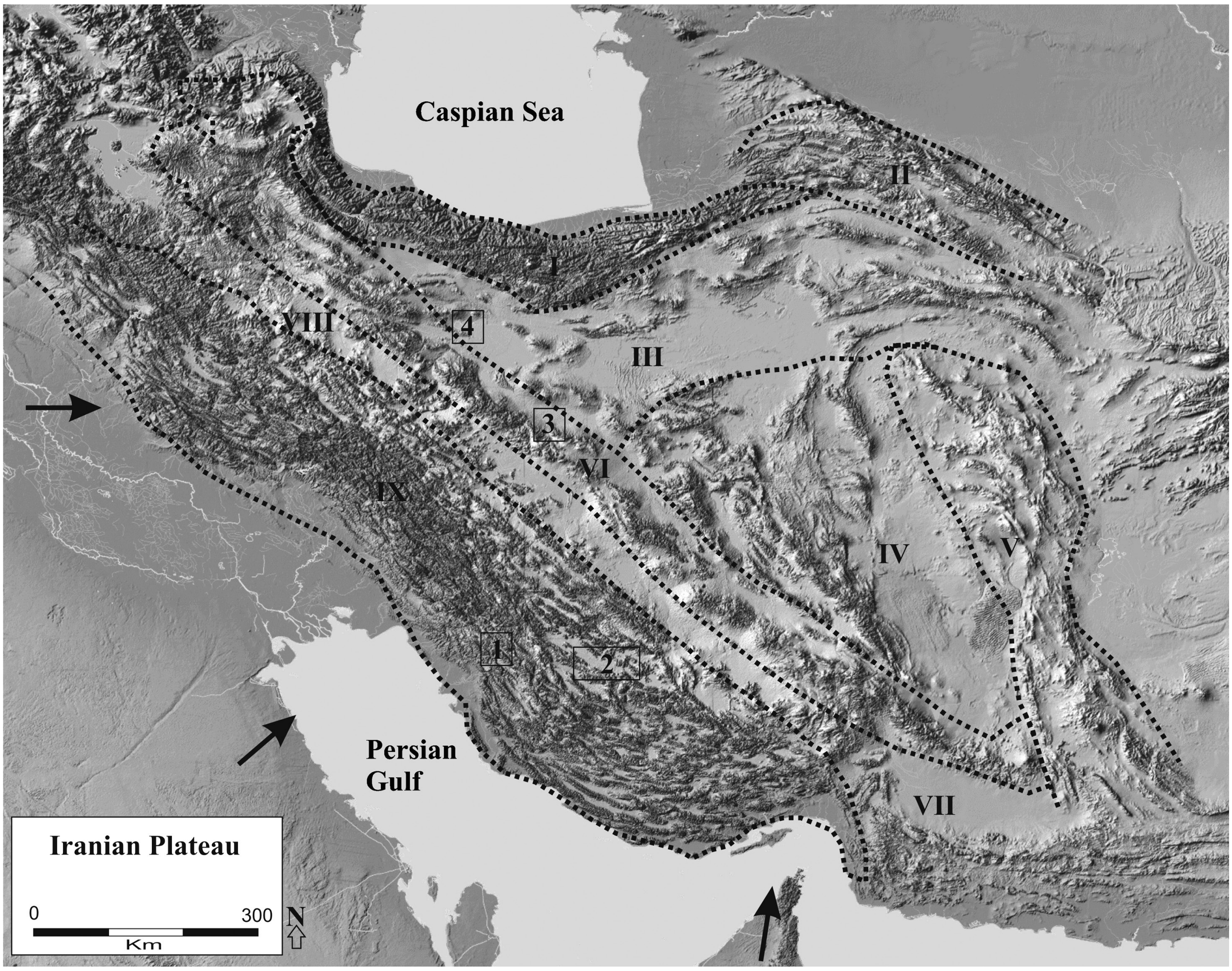


Figure 1 - Landscape structural division of the Iranian Plateau and the regions mentioned in the text. 1: Dasht-e Rostam, Gachsaran Region; 2: Marvdasht and Arsanjan Regions; 3: Arisman Region; 4: Zavyeh Region. I: Alborz Mountains; II: Kopeh Dagh Mountains; III: Central Plateau; IV: Lut desert; V: Eastern Iran; VI: Urumieh – Dokhtar volcanic belt: VII; Makran Mountains; VIII: Sanandaj – Sirjan metamorphic belt; IX: Zagros Mountains. The arrows indicate the most probably migration route of early human to the Iranian Plateau.

bution of Paleolithic sites and settlements across space and through time in relation to the environment. In table 1 some examples of this relationship lists.

The concept that we develop and the related structure for geodata handling, manipulation and presentation will be utilized to answer questions concerning the influence of environmental characteristics such as geology, landform (Heydari-Guran 2004, 2007; Heydari-Guran *et al.* 2009) and hydrology on settlement, dynamics and land use in different landscapes of the Iranian Plateau during Middle and Upper Paleolithic. Subsequently this knowledge we use to develop a predictive model using recorded topographical and geomorphological data to estimate the potential archaeological areas of uninvestigated regions. In this regard we will be able to increase our knowledge of the physical geography of the Iranian Plateau associated with Paleolithic occupations and work toward our goal of developing reliable predictive models.

Methods

In order to create the Paleolithic geoarchaeological database, we set up a spatial relational database realized with the software PostgreSQL (www.postgresql.org). Spatial data was preprocessed with open source software SAGA, R, and ESRI ARCGIS commercial packages. Preprocessing includes plausibility test, geocoding or transformation of data. To guarantee open access, we utilized the PostgrSQL Database with PostGIS support for spatial data objects (http://postgis.refractions.net) in combination with the UMN Mapserser (http://www.umn-mapserver.de). Thus, the data are available for a vast audience via internet. To address the aims of this study, large amounts of spatial data were collected, preprocessed, stored and analyzed. For this purpose all the available data from the previous Paleolithic excavations and surveys of Iran, were transferred to the web based GIS-database system. The latter one can be subdivided in four functional units after Wheatley & Gilling (2002:11):

① The Data Entry subsystem handles all of the tasks involved in the translation of raw data into an input stream of known and carefully controlled characteristics.

② The Spatial Database subsystem for storing spatial, topological and attribute information.

③ The Manipulation and Analysis subsystem takes care of all data transformations and carries out spatial analysis and modeling function.

④ The visualization and reporting subsystem returns the result

Spatial archaeological phenomenon	Geoecological explanation
Distribution of caves and rockshelter sites along the Zagros Mountains	Karstic formations and active tectonic structure
Seasonal hunter-gatherer camp sites within a heterogeneous landscape	Availability of resources
Reconstructing mobility strategies among Paleolithic societies in southern Zagros Mountains	Multi-seasonal or single seasonal occupation
Suggested "Nuclear Zone" for the late Paleolithic periods in the Zagros Mountains	Tendency of early humans to adapt to a specific natural environment
Distribution of open air Paleolithic sites in the Central Plateau of Iran	Existence of sand dunes, travertines and lacustrines deposits with a good archaeological preservation

Table 1 - Examples of relationship of Palaeolithic sites and their environment.

of queries and analyses to the user in the form of maps and other graphics as well as text.

The data entry is providing scanned, digitized, and measured data by Global Positioning Systems (GPS) or field survey. Therefore different data formats such as shapes for vector data, images for raster data and table formats for point data are offered. Data manipulation and analysis is guaranteed by interfaces to the open source statistical software packages as well as open source GIS software like SAGA. The system is implemented on a UNIX based platform (FreeBDS) as well as on windows based desktop computer systems running ESRI ArcMap 9 software, SAGA and R.

The database GIS environment contains two main components. The primary component is the ability graphically to display information that has at least two dimensional spatial attributes (e.g. both a northing and an easting coordinate). Any data that has a spatial component in terms of coordinates is georeferenced (Mickelson 2002). The second component is the geo-relational database. A geo-relational database contains georeferenced spatial data.

Materials and Paleolithic archaeological data acquisition strategy

The first analysis that we conducted to assess the spatial distribution of Paleolithic human settlements rely on Digital Elevation Model (DEM). The DEMs utilized in this first phase of the study are based on SRTM data that was pre-processed with ARCGIS to eliminate artifacts, sinks and no data areas. Then it was passed to SAGA where the terrain analysis was performed. The information yielded was fed into the database WEBGIS System.

This study requires a large detailed database of Paleolithic archaeological attributes of the study region. The database was constructed by acquiring all reasonably available and reliable information on the Paleolithic period. To include this information into the GIS database system a minimum constrain was the presence of spatial attributes or a local site identification code. The database that covers the study areas contains an inventory record on more than 800 Paleolithic archaeological sites and localities. Originally, these data were reported in journal articles, institutional reports and monographs by different authors. This Paleolithic information was coded in GIS (ArcMap 9) utilizing the native dBASE format.

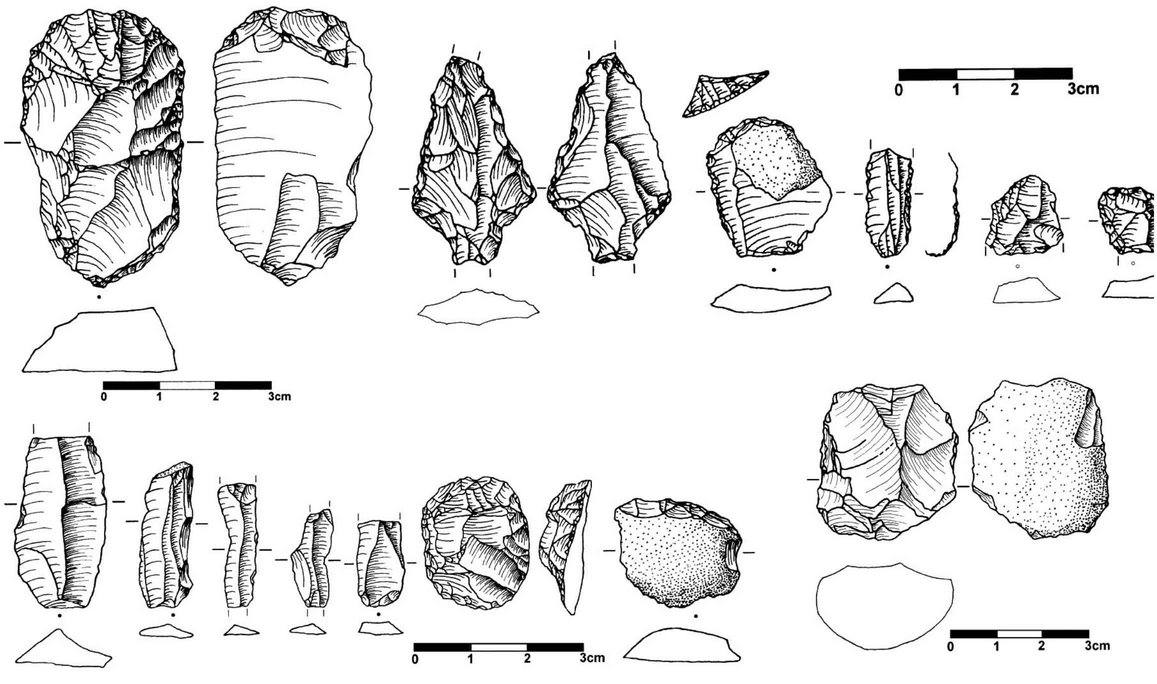
Acquisition and development of environmental data layers

There are three approaches that may be taken to obtain environmental data for GIS projects: acquire existing data layers, collect environmental data directly from the field and construct new data layers from existing maps. Most of the data we collected was in analogue format such as topographical, geological and geomorphological maps. The primary data sources employed in this project are SRTM Digital Elevation Models (DEM) obtained by CIGIAR (http://srtm.csi.cgiar.org). A DEM is a cell-based or raster data layer. Each cell is assigned one elevation value. The DEMS used in this first phase of the study have a 90 m cell size. For a small area where exactly DEMS were generated from digitized topographic map contours with 90m resolution. By terrain analysis other environmental layers can be created from the DEM. Slope, aspect, hydrography (stream network), insolation (solar radiation), and ecological relevant indices like wetness index, transport capacity or stream power (Wilson & Gallant 2000). Moreover, data layers were entirely or partially generated from field work such as GPS points or way points.

Field work

The Tübingen Iranian Stone Age Research Project (TISARP) was established in 2004. From then, TISARP team conducted several field seasons during 2004-2007 in different parts of the country including Tehran, Esfahan, Fars and Kohgiluyeh-Boyerahmad provinces. The team first study area was the sand dunes of Qaleh Gusheh and the travertine localities that lay several kilometers north of Arisman in Esfahan province. Qaleh Gusheh is one small region within the Rig Boland, a belt of mobile sand dunes stretching over 200 km and lying northeast of the Karkas Mountains and southwest of the Latif Mountains. The vast majority of the Rig Boland has not been studied, and TISARP work in the Qaleh Gusheh region represents the first attempt to collect systematic data on the Stone Age sites in this area. Followed by the Paleolithic research done by S. Heydari-Guran, (Heydari-Guran & Ghasidian 2011) in 2004 which resulted to document 18 localities, the TISARP team has confirmed the

A.



B.

Figure 2 - A: Typical landscape of the Zagros Mountains. View to south overlooking the Baba Guri valley and Paleolithic rockshelter of Zard-Narenjo (Photo: S. Heydari-Guran); B: Examples of lithic artifacts from Dasht-e Rostam-Gachsaran, Southwestern Zagros Mountains of Iran.

high potential of the region during the Paleolithic time and added 8 more localities (fig. 2).

In Fars Province, the TISARP team focused on different regions of Sabz Mountain near the confluence of the Kur and

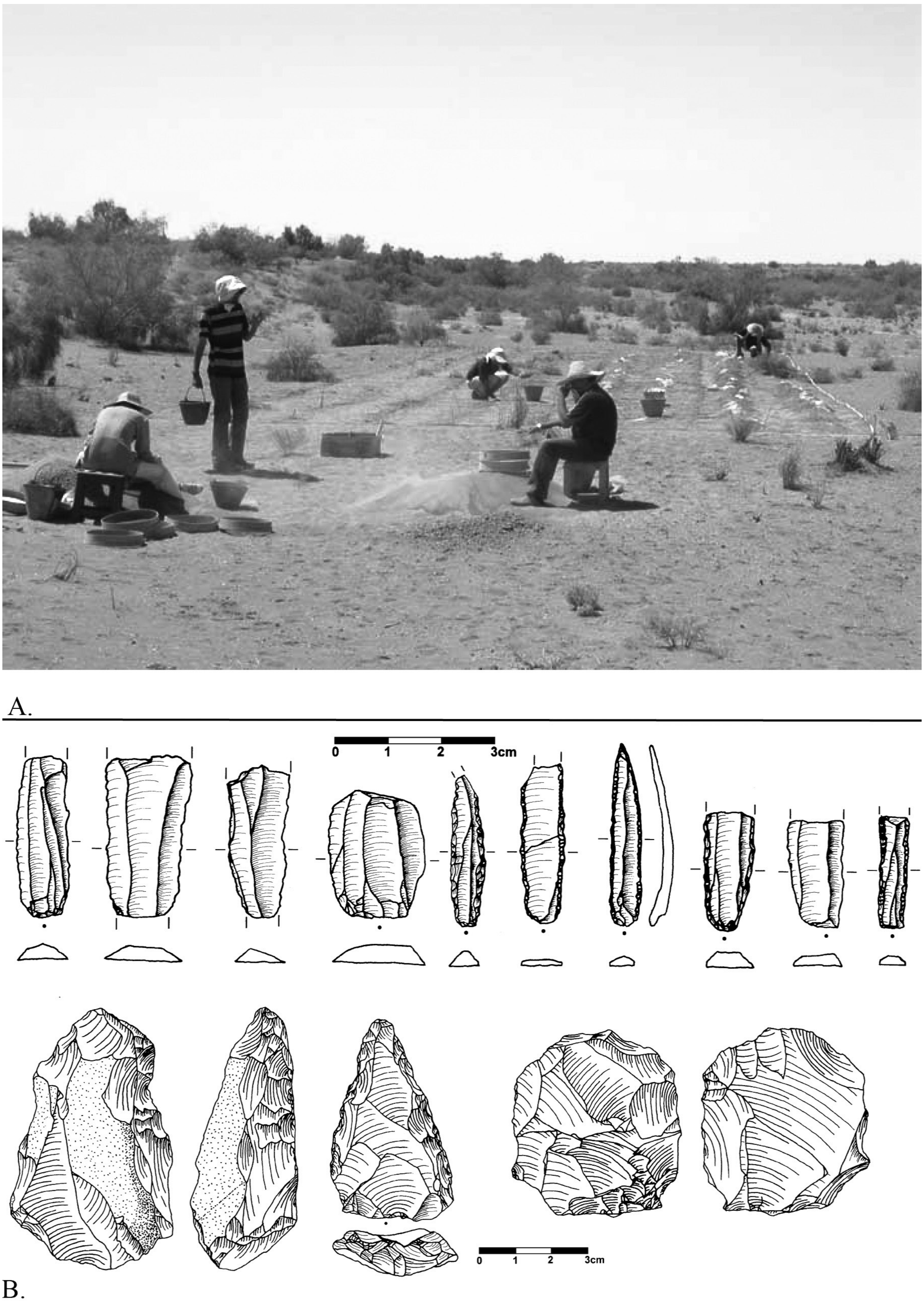


Figure 3 - A: View to east overlooking the Qaleh Gusheh 1; a Paleolithic open air site; Arisman sand dunes. (Photo: N. J. Conard); B: Examples of lithic artifacts from Qaleh Gusheh open air sites, the Central Plateau of Iran.

Sivand rivers, the Tang-e Bolaghi Valley west of the town of Pasargad, Nourabad and Dasht-e Rostam Regions which provided a wealth of new information. The Dasht-e Rostam Region consists of two Plains of Dasht-e Rostam I and II which are connected with the Yagheh Sangar Pass. Here, the numerous strategic sites overlooking the pass between Dasht-e Rostam I and II were attractive spots throughout much of the prehistoric and historic periods (Conard *et al.* 2006). The main focus of

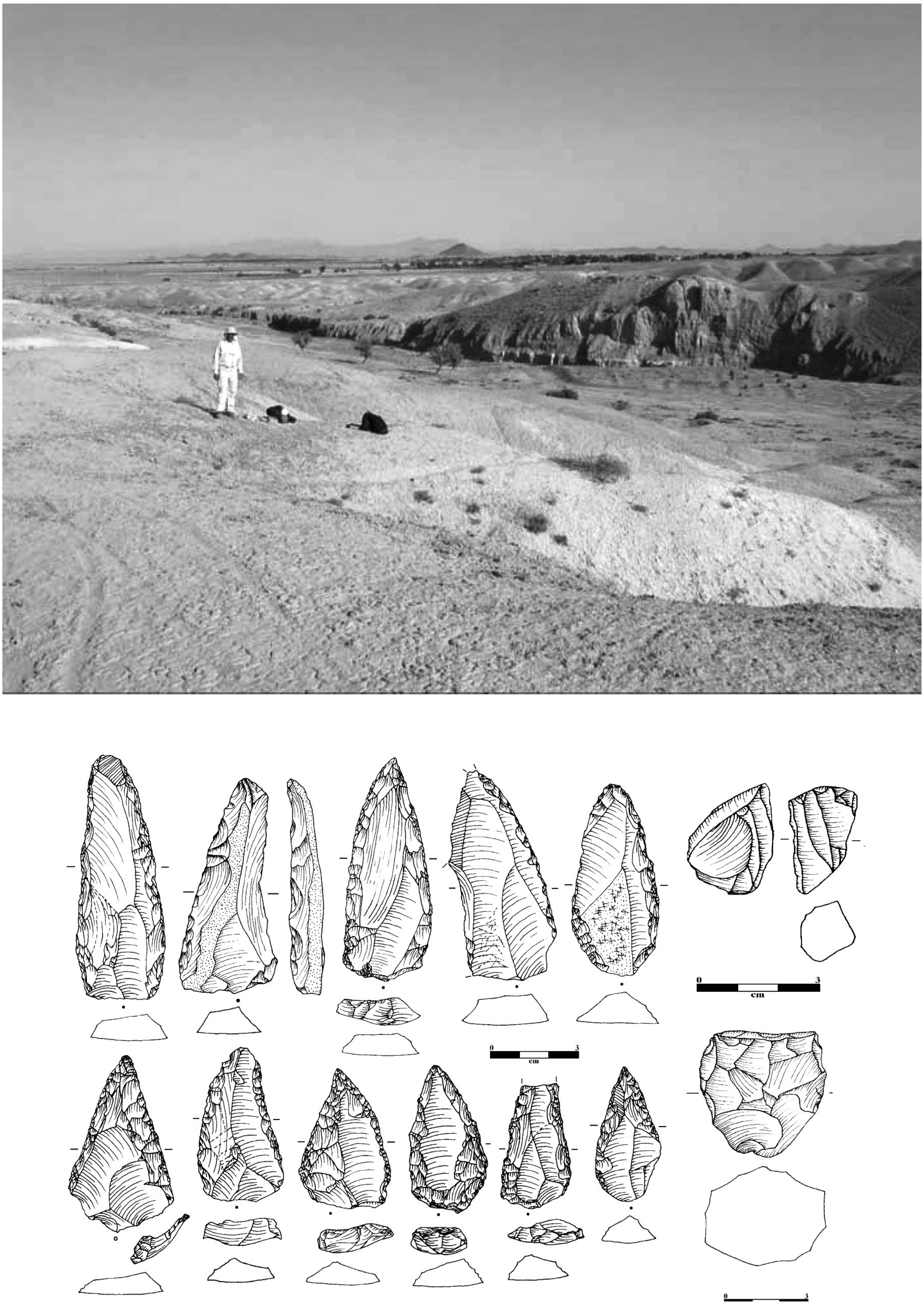


Figure 4 - A: View to south overlooking the Zavyeh 8; a Paleolithic open air locality; Paleo-lacustrine environment. (Photo: N. J. Conard); B: Examples of lithic artifacts from Zavyeh localities, North Central Plateau of Iran.

the TISARP team was the Dasht-e Rostam Region where totally we identified 121 Paleolithic localities. The research design emphasized the collection of artifacts and ecological data for establishing the natural and cultural history of the Dasht-e Rostam (Conard *et al.* in press). Excavating at one of the cave sites at Dasht-e Rostam called Ghar-e Boof during two seasons of 2006 and 2007 was significant for establishing an improved cultural stratigraphic framework for the Paleolithic of the southwestern Zagros and reconstructing Stone Age patterns of land use in this region (Conard *et al.* in press) (fig. 3).

In Kohgiluyeh-Boyerahmad Province, the TISARP team visited several sites to the east of Gachsaran and south of Basht Region including the Khanahmad and Sukhteh areas which were originally identified by A. Azadi of the ICAR in Gachsaran. The team added significantly to the previous lithic collections from these sites and confirmed the prevalence of Late Paleolithic material at both sites (Conard *et al.* 2006).

Building on earlier work by the members of the Tübingen Iranian Stone Age Research Project (TISARP) and other colleagues (Djamali *et al.* 2005; Conard *et al.* 2006; Heydari-Guran *et al.* 2009; Ghasidian *et al.* 2009), the 2006 field season documented the geological setting and cultural affiliation of Paleolithic sites in the Zavyeh Pleistocene lake basin in the Central Plain of Iran located at Tehran Province (fig. 4). This topic is relevant in the context of suggestions that central Iran has a limited settlement history and only a modest Paleolithic record (Smith 1986; Conard *et al.* 2007). The TISARP team plans to continue research in the above mentioned areas especially the Dasht-e Rostam Region and plans to extend the area of study in the framework of the present paper.

Towards a land geoecological classification and terrain analysis

In a large scale study, the Iranian Plateau has been divided into four main physiographic formations and structures as the settings of Paleolithic occupations such as: fluvial, desert, coastal and mountain (volcanic and sedimentary) terrains.

Among the different environmental characteristics, eight fundamental parameters are selected as a part of geoecological analysis which have played important role in the early human settlement systems and dynamics and subsistence strategies. These parameters which have been drawn from DEMs are:
① Elevation above sea level,
② Slope (gradient),
③ Aspect (direction of slope),
④ Curvatures,
⑤ Horizontal and vertical distances to river network,
⑥ Topographic wetness index,
⑦ Erosion deposition zones and
⑧ Stream power index.

As our work continues, these indices will allow us to separate different terrain units with specific process dominance. Other geoecological variables included: geological structure, raw material, climatic zone, geomorphology, maximum relief, soil texture and drainage and the density of marsh, swamp, spring and cliff.

Concluding remarks

The organization of this project was motivated by the important discoveries of Paleolithic caves, rockshelters and open air sites in Zagros Mountains and the Central Plateau of Iran during the field seasons of 2004-2007. The great amount of archaeological information of the Paleolithic sites in different geological contexts including karst topography, sand dunes, travertine and lacustrine formations (Heydari 2007) necessitate the organizing and processing in a data bank associating with the environmental parameters.

The database-web GIS platform is available on the internet under the following address www.roceeh.uni-tuebingen.de/TISARP.html. On the website we provide general information on fieldwork and a link to the web based database with GIS functions. On request we provide public access to the system where you can visualize the spatial data on the Paleolithic of the Iranian plateau.

Web-based geoinformatic tools are powerful exchange platforms and also provide strong analytical tools. Emerging geospatial database for the Iranian Plateau collaborates geoecological information with archaeological data in order to collating archival datasets, providing tools to help, locating, access and contribute data resources and producing regional maps for Paleolithic sites and their surroundings.

The application of geospatial database for Paleolithic sites will help to detect settlements patterns, and landuse in the entire region of the Iranian Plateau. GIS and its tools for geospatial analyses have not been used before for this region, and we look forward to testing relationships of Paleolithic sites and geoecological settings.

Acknowledgements

We wish to thank Professor Jean-Marie Le Tensorer the organizer of the Basel Symposium for Paleolithic Research for inviting us which this paper based on our presentation. We are very grateful to Andrew W. Kandel, for his valuable suggestions on the primary manuscript of this paper. We especially thank Dorota Wojtczak and Daniel Schuhmann for facilitating this publication and their supports. Many thanks go to the anonymous reviewers.

References

Banks W.E., d'Errico F., Dibble H.L., Krishtalka L., West D., Olszewski D.I., Peterson A.T., Anderson D.G., Gillam J.C., Montet-White A., Crucifix M., Marean C.W., Sanchez-Goni M.-F., Wolfarth B., Vanhaeran M. (2006) - Eco-cultural niche modeling: new tools for reconstructing the geography and ecology of past human populations. *PaleoAnthropology* 4:68-83.

Banks W.E., d'Errico F., Peterson A.T., Vanhaeren M., Kageyama M., Sepulchre P., Ramstein G., Jost A., Lunt D. (2008) - Human ecological niches and ranges during the LGM in Europe derived from an application of eco-cultural niche modeling. *Journal of Archaeological Science* 35:481-491.

Biglari F. (2001) - Recent Finds of Paleolithic Period from Bisotun, Central Western Zagros Mountains. *Iranian Journal of Archaeology and History* 28:50-60.

Biglari F. (2004) - The Preliminary Survey of Paleolithic Sites in the Kashan region. In: S.M. Shahmirzadi (ed.), *The Silversmiths of Sialk (Sialk Reconsideration Project), Report No. 2.* Tehran, Archaeological Research Center, Iranian Cultural Heritage Organization, p. 151-168.

Clark J.G.D. (1977) - *Spatial Archaeology*. New York, Academic Press.

Conard N.J., Ghasidian E., Heydari S., Zeidee M. (2006) - Report on the 2005 survey of the Tübingen-Iranian Stone Age Research Project in the provinces of Esfahan, Fars and Kohgiluyeh-Boyerahmad. *Archaeological Reports* 5:9-34.

Conard N.J., Ghasidian E., Heydari S., Naderi R., Zaidee M. (2007) - The 2006 Season of the Tübingen-Iranian Stone Age Research Project in the Provinces of Fars and Markazi. In: H. Fazeli (ed.), *9th Annual report of Archaeological Organisation*, Tehran, ICAR, p. 43-67.

Conard N.J., Ghasidian E., Heydari S., Zeidi M. (in press) - The 2007 Season of the Tübingen Iranian Stone Age Research Project in Dasht-e Rostam, Fars Province.

Conolly J. & Lake M. (2006) - *Geographical Information System in Archaeology*. Cambridge, Cambridge University Press.

Djamali M., Esu D., Gliozzi E., Okhravi R., Soulié-Marsche I., (2005) - Palaeoenvironment of a lacustrine-palustrine carbonate complex: Zarand Basin, Saveh, Central Iran. *Palaeogeography Palaeoclimatology Palaeoecology* 237:315-334.

Galiatsatos N. (2004) - *Assessment of the CORONA series of satellite imagery for landscape archaeology. A case study from the Orontes valley, Syria*. PhD thesis, University of Durham. Department of Geography.

Ghasidian E., Azadi A., Heydari S., Conard N. J. (2009) - Late Palaeolithic Blade Production in the Basht Region of the Southwestern Zagros; Iran. 15th UISPP Congress Lisbon.

Heydari S. (2004) - Rohmaterialvorkommen für Stein in Iran Einige Fallstudien. In: T. Stöllner, R. Slotta, A. Vatandoust (eds.), *Persiens antike Pracht*. Bochum, p. 124-129.

Heydari S. (2007) - The impact of geology and geomorphology on cave and rockshelter archaeological site formation, preservation and distribution in the Zagros Mountain of Iran. *Geoarchaeology: An international Journal* 22(6):653-669.

Heydari-Guran S. & Ghasidian E. (2011) - Paleolithic su:rvey in the Arisman region, western Central Iranian Plateau. In: A. Vatanduost, H. Parzinger, & B. Helwing (eds.), *Early Mining and Metallurgy on the Western Central Iranian Plateau*. Verlag Phlipp Von Zabrern, Mainz, Archäologie in Iran und Turan Band 9:484-498.

Heydari-Guran S., Ghasidian E. & Conard N.J. (2009) - Paleolithic Sites on Travertine and Tufa Formations in Iran. In: M. Otte, F. Biglari & J. Jaubert (eds), *Iran Palaeolithic*. Proceedings of the XV World Congress UISPP, Lisbonne, Vol. 28, BAR International Series 1968:109-124.

Huggett R.J. (1995) - *Geoecology, An Evolutionary Approach*. London and New York, Routledge.

Kvamme K.L. (1999) - Recent Directions and Developments in Geographic Information Systems. J*ournal of Archaeological Research* 7(2):153-201.

Kvamme K.L. (2006) - There and Back Again: Revisiting Archaeological Location Modeling. In: M.W. Mehrer & K.L. Wescott (eds.), *GIS and Archaeological Site Location Modeling*. Boca Raton, CRC-Taylor & Francis, p. 3-38.

Mickelson A.M. (2002) - *Changes in prehistoric settlement patterns as a result of shifts in subsistence practices in eastern Kentucky*. PhD dissertation, Ohio State University.

Peterman L.G. (1992) - Geographical Information Systems: Archaeology's Latest Tool. *The Biblical Archaeologist* 55(3):162-167.

Roustaei K., Vahdati Nasab H., Biglari F., Heydari S., Clark G.A., Lindly J.M. (2004) - Recent Paleolithic surveys in Lurestan. *Current Anthropology* 45:692-707.

Smith P.E.L. (1986) - *Paleolithic archaeology in Iran. The American Institute of Iranian Studies Monograph 1*. Philadelphia, The University Museum, University of Pennsylvania.

Smyntyna O.V. (2003)- The Environmental approach to Prehistoric studies. Concepts and theories. *History and Theory* 42(4):44-59.

Snow D.R., Gahegan M., Lee Giles C., Hirth K.G., Milner G.R., Mitra P., Wang J.Z. (2006) - Cybertools and Archaeology. *Science* 311:958-959.

Wheatley D. & Gillings M. (2002) - *Spatial Technology and Archaeology; The Archaeological Applications of GIS*. London and New York, Taylor& Francis.

Wilson J.P. & Gallant J.C. (2000) - *Terrain Analysis: Principles and Applications*. New York. John Wiley and Sons.