AfarinNameh

Essays on the Archaeology of Iran in Honour of Mehdi Rahbar

Edited by: YOUSEF MORADI

With the assistance of Susan Cantan, Edward J. Keall and Rasoul Boroujeni

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Anthrosol Detection in the Plain of Izeh

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Abstract: The inter montane plain of Izeh was a pivotal region of ancient Elam/Elymais, in between the Mesopotamian and the Iranian Plateau. The patterns of ancient settlement have been studied only to a very limited extent. The aim of this paper is to propose the possibility of investigating settlements on the basis of anthrosol detection, using multispectral satellite imagery.

Keywords: anthrosols, remote-sensing, multispectral analysis, settlement models, Elam, Elymais.

Introduction

The plain of Izeh was a pivotal region of ancient Elam/Elymais. The term 'Elam' and its Greek version 'Elymais' emerge in epigraphic records and historical sources of different periods as a state or confederation of states that interacted with other important political entities of the ancient Near East. Elam/Elymais benefited from the variety of its terrain and privileged position between the Mesopotamian alluvium and Iranian plateau. Contact with Mesopotamia seems to have been particularly frequent, as attested by written records and the material culture of Susiana.

In modern geographical terms, Elam/Elymais incorporates the present day province of Khuzestan and parts of the provinces of Fars, Kohgilouye va Boyerahmad, Kerman, Luristan and Kurdistan. Khuzestan can be considered as the heartland of this ancient political and cultural entity. The lowlands and highlands of Khuzestan are often seen in published literature in terms of dualism because of their different terrain (Amiet 1979). The lowlands, between Susiana and the Ram Hormuz region, are from a geological point of view an extension of the Mesopotamian alluvium. Proceeding from north to south they are characterized by dry, semi-arid and arid regions. The situation does not seem to have been very different in ancient times. However the lowlands, of alluvial origin, do benefit from the water of five main river courses, the Karkheh, Ab-e Dez, Karun, Marun and Zuhreh (or Hindian), that originate in the Bakthiari mountains. The highlands are a folded mountain chain, initially rising to about 800 m above sea level (asl) and then reaching about 1200 m, with peaks exceeding 3000 m. The chain is characterized by a series of parallel ridges and narrow gorges that lie in a north-west to south-east direction. The small valleys between the ridges are not suitable for settlement, but were extensively travelled in ancient times. These chains alternate with small valleys, sometimes of alluvial origin, like the plain of Izeh, which offer, on the contrary, good opportunities for human settlement despite the fact that their morphology differs from that of the lowlands. In these montane plains, settlement patterns are different from those identified in the lowlands, even though it must be acknowledged

* Introduction is by Jafar Mehr Kian, all the remaining parts by Vito Messina. If not otherwise indicated all images are elaborated by Vito Messina.

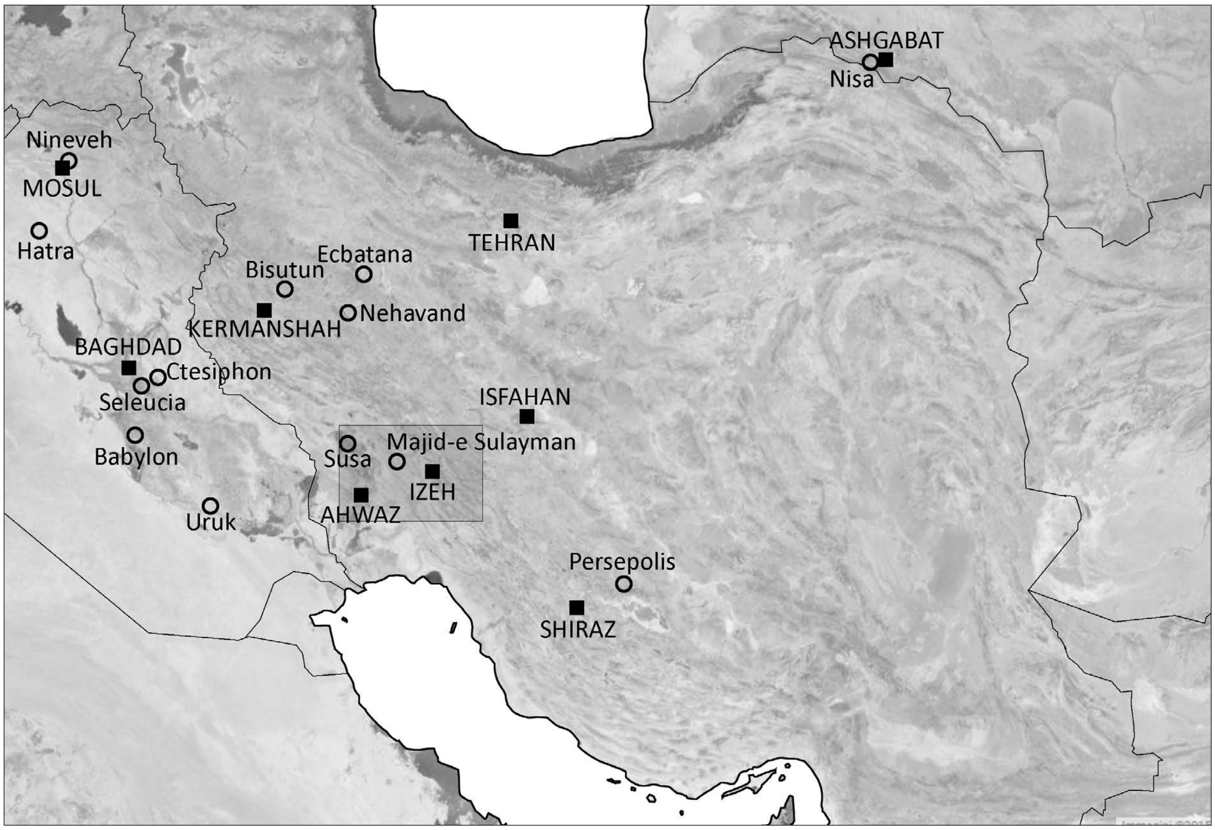

Fig. 1 Map of Iran. The inset shows Susiana and the plain of Izeh.

that the mountainous settlements have been studied only to a limited extent.

The aim of this paper, which is offered to Mehdi Rahbar, is to propose the possibility of investigating ancient settlements of the Izeh plain on the basis of the detection of anthropogenic soils—or anthrosols—through remote sensing observations using multispectral imagery.

Surveying the plain of Izeh

The plain of Izeh is located east of the lowlands of present-day Khuzestan—namely the alluvial plains of Susa, Ahwaz and Shushtar—at about 800 m asl (Fig. 1). Being easily reachable from the lowlands along natural land and water routes, it gives access to the Iranian plateau via the mountainous valleys and gorges that bisect the ridges of the Bakthiari mountains—an extension of the Zagros complex. These routes follow part of the river Karun.

According to maps produced by the Geological Survey of Iran and Iranian Ministry of Agriculture, the plain of Izeh can be defined as an alluvium composed mainly of salt marsh soils, delimited by Lower and Middle Cretaceous formations of Orbitolina limestone to the east, and Oligo-Miocene formations, including Asmari limestone formations, to the west. It differs from the lowlands (rich in clay deposits) for the type of soils and the hydrogeological setting. It benefited from the water of two seasonal lakes, the Miangharan and Bandoun—today two wetlands—and seasonal small watercourses originating from the lakes themselves or from the river Karun, which flows in meanders about 20 km to the east. These watercourses, of which only the exhausted beds remain, are not enough developed to form a network comparable to that in the lowlands. The consequent low connectivity does not seem to have been different in antiquity.[1]

In the highlands of Khuzestan, a survey was conducted in 1976 by the University of Michigan and the Iranian Center for Archaeological Research (ICAR) under the direction of Henry T. Wright: this covered the areas of the Dasht-e Gol and Iveh, but particularly the plain of Izeh (Shahideh 1979a: figs. 15-17; 1979b: figs. 21-24; Wright 1979a: figs. 26; Sajjidi 1979: fig. 36; Bayani 1979: figs. 39-40; Eqbal 1979: figs. 48-49; Wright 1979b: fig. 50).[2]

1. It must be said that the identification of paleo-riverbeds is very difficult.

2. The maps there published are not geo-referenced: the positioning of the sites identified on multi-temporal systems and GIS may be thus in-accurate.

Based on an extensive approach which was published almost immediately, this work is of basic importance for those who have studied ancient mountainous settlements in Elam/Elymais, but it did not promote further research. The reason is clear: the quantity and quality of data collected is not adequate for the creation of settlement models that can be compared with those created for the lowlands. This can be easily seen when looking at the maps published by Wright. These offer an overview of the plain's settlement history based on observation of the scarce surface material recovered there. It appears that settlement patterns of long-term occupation (from the Uruk to the Islamic periods) are much more dispersed than those identified in the plain of Susa. The Izeh plain, in which the leading site appears to have been Mal-e Mir (now overlapped by modern Izeh), seems characterized rather by the presence of a smaller number of sites. Traces of growth seem to be detectable only in the Sasanian period, with a peak after the Islamic conquest: a settlement pattern in which inhabited places seem quite isolated. Land use seems to have been less intense, and the propensity for dimensional and demographic growth less accentuated than in the lowlands. A smaller ground survey was also conducted in the area of the Hung-e Azhdar valley by the Iranian-Italian Joint Expedition in Khuzestan (Faraji *et al.* 2015: figs. 1-2).

Methods of anthrosol detection

In alluvial plains, the primary building and manufacturing material was clay. Clay was used for the mass production of pottery, figurines, objects and—in architecture—mud bricks. Because of their high propensity for decay, mud brick buildings were the subject of continuous maintenance. When abandoned, partially dismantled and flattened, new structures were built atop their remains and then flattened again, in a process that continued in some cases for millennia. For this reason, settlements in alluvial plains grew in height forming the characteristic mounds (known as 'tells' or 'tepes') that still feature today as distinctive archaeological landmarks.

The process of mounding was also accompanied by the formation of anthrosols that likewise originated by human occupation. Anthrosols are formed from organic components, mostly derived from waste and the decay of mud bricks. For this reason their texture, hydrological, and reflective properties differ significantly from pedogenetic soils, making them well visible in ground surveys and aerial or satellite imagery (Menze & Ur 2012: 778-781). Being aware that the spectral signatures of decayed structures and anthrosols can change considerably during the year, an observer should be able to identify the presence of archaeological sites following a multi-temporal approach, even if it must be stressed that multispectral signatures can be difficult to read because of the relatively low spatial resolution of many images.

While mounds can be clearly detected in the visible range, because of their contour and height—especially in images captured prior to disturbance by modern agricultural activities—the archaeological matrix of anthrosols is above all detectable in the invisible range, particularly in the infrared or near-infrared spectrum (IR+NIR), thanks to the capturing of images by multispectral sensors.

Anthrosol detection in the plain of Izeh

In mountainous lands the collection of surface material and detection of anthrosols is much more difficult to achieve than in the lowlands, even in the case of mountainous valleys of alluvial origin, like the plain of Izeh. In the highlands the building material is more normally represented by roughly cut, undressed stones that are continuously re-used and do not result in the same mounding process attested in the lowlands. Because of the fact that the bedrock is much closer to the surface, it is usually covered by lithosols, and the ground slope facilitates erosion. As a result, the presence of anthrosols is less easy to recognize. This makes intermontane sites less visible than the sites in alluvial lowlands.

The low visibility of ancient mountainous sites makes data acquisition hard to accomplish. Settlements or traces of human activity are difficult to identify, either in ground surveys or using remote sensing techniques. On the other hand the analysis of multispectral satellite imagery allows an analyst rather to see that there is some incoherence when comparing ground surveys with anomalies observed on aerial images. What is observed on images coincides with what is observed on the ground only in part; furthermore, it is not always easy to distinguish anthrosols from pedogenetic soils. However, the cross-analysis of both kinds of data does allow an observer at least to define a more complete picture. For this reason a geo-referenced map of the Izeh plain, including information derived from the maps published by Wright, data collected by the survey of

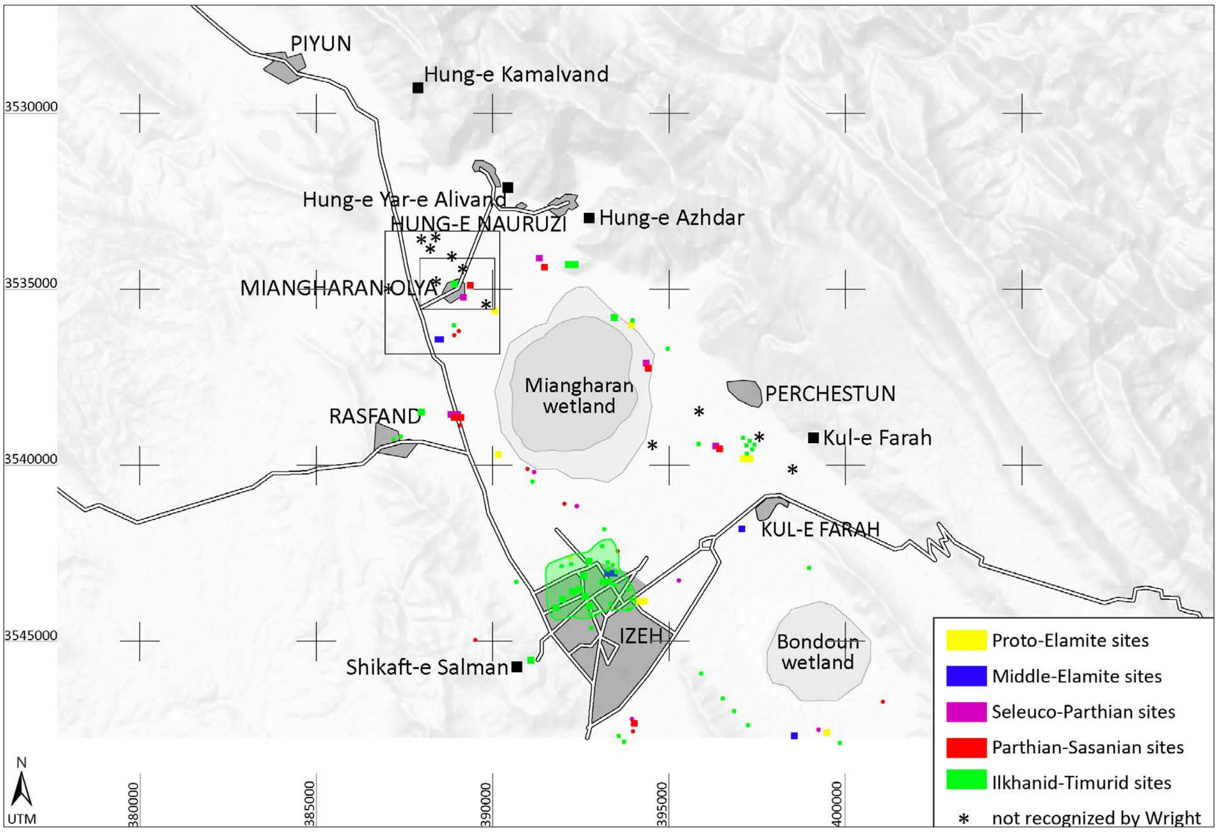

Fig. 2 Map of the plain of Izeh showing the sites recognized by Wright and those identified by remote sensing observations. The insets show ROI 1 and the area of Miangharan Olya and Choga Haji Najaat (detail of ROI 1).

the Italian-Iranian joint expedition, and observations of multispectral satellite imagery, is proposed here (Fig. 2). This reproduces—with some scepticism—the same sites' chronology proposed by Wright, and is the product of a multi-temporal approach: a military map in scale 1:50,000 made in 1999, used as the basis for UTM co-ordinates, and ortho-ready satellite images acquired by multispectral sensors from 2013 to 2018 are also merged on the same GIS software.[3] The inset shows a region of interest, called ROI 1, that surrounds the village of Miangharan Olya and is the object of the present study.

Satellite images were observed in different channels (particularly IR+NIR), using filters, calibration, convolutions and equalization so as to emphasize, as far as possible, the spectral signature of anomalies that can be interpreted as traces of ancient settlements (Figs. 3-4), in particular anthrosols. They were combined to produce the multi-temporal map of ROI 1 (Fig. 6). Multispectral analysis revealed anomalies and buried structures that do not seem to have been identified during the preceding ground surveys. For instance, the use of different filters allows an observer to see the presence of a buried structure, though it is not possible to deduce more precise indications of function and date: this is located north-east of the village of Miangharan Olya, in an area known as Choga Haji Najaat (Figs. 4-5). Here, an ancient building of large dimensions can be seen. This is barely perceptible, especially when the area is cultivated, for it does not emerge as a mound above ground—even as a very low one. It is clearly distinguishable however when observed on multispectral satellite images. Its remains must be buried immediately beneath the surface, given that their imprint is quite clear in images captured from above. A squared building, measuring at least 110 m in length and width, is clearly visible between two modern pats. The building has four symmetrical wings, each measuring about 30 m in width, arranged perhaps around a central squared court or unbuilt area, roughly measuring 50×50 m. Its corners are perfectly oriented to the cardinal points of the compass (Fig. 5) (Faraji *et al.* 2015: 78-79, fig. 22). On the surface, a few fragments of baked bricks can be found together with a few potsherds of common ware. This is the most evident anomaly that can be detected

3. Images © Digital Globe 15 October 2009, 11 August 2013, 29 November 2016, 23 January 2017.

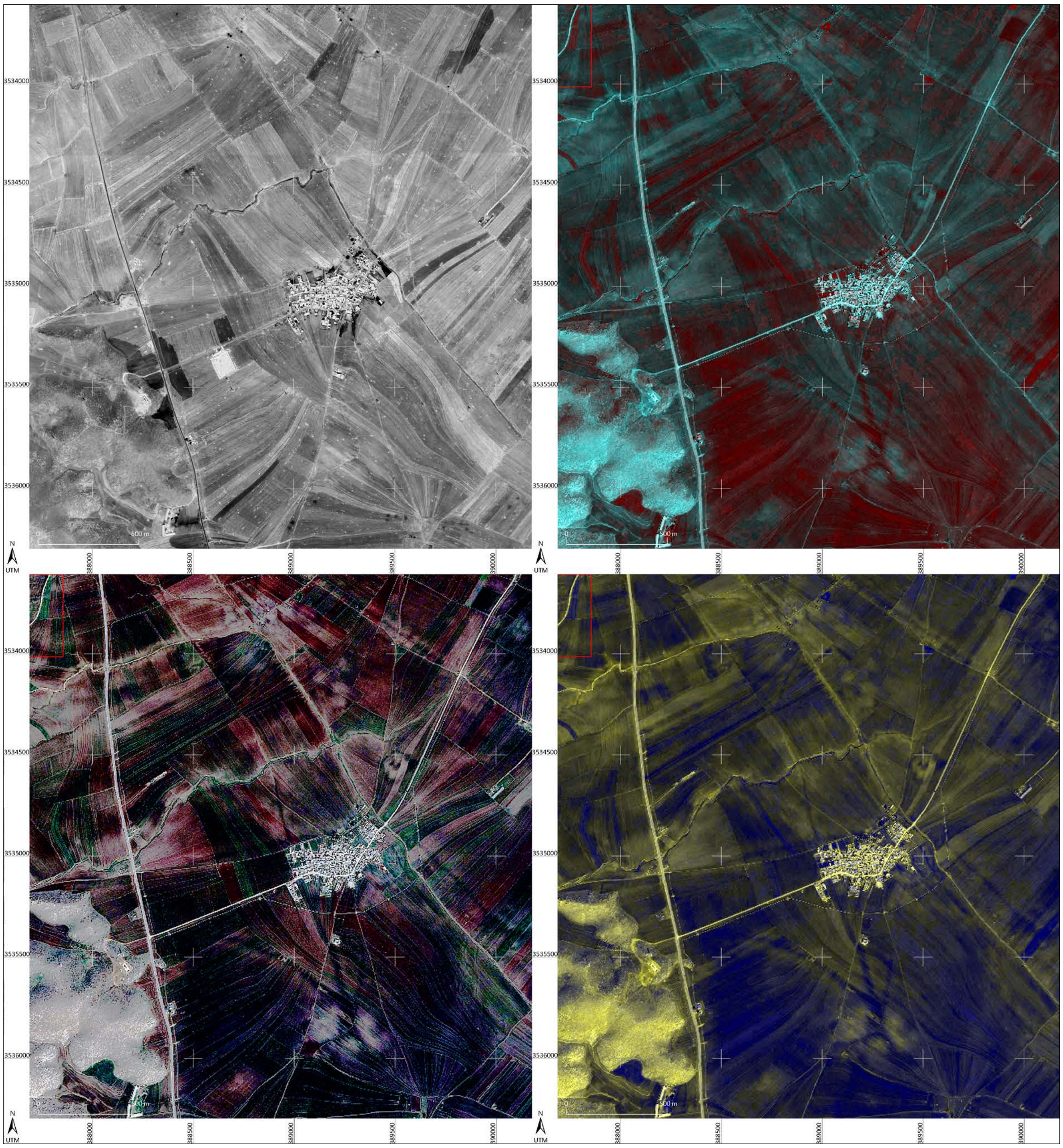

Fig. 3 Multispectral analysis of ROI 1. Top left, panchromatic satellite image (23 January 2017); top right, IR+NIR channels; down left, equalization after Gaussian convolution; down right, filter veg suppression after equalization.

due to the observation of multispectral imagery; it is not the only one, however. Spectral signatures that could be related to the traces of a human presence can be also seen in ROI 1, and interpreted as anthrosols: they have characteristic reflective properties, namely brightness and colour, that make them different from the surrounding terrain, which is of pedogenetic origin. At least thirteen anomalies can be seen in an area of about 10 km^2 (Fig. 6), which can be listed and briefly described as follows:

1. ca. 320×370 m, inner court ca. 290×300 m, wings (or massive walls) measuring ca. 30 m in width, ca. 76,500 m^2. At the south-west corner, a huge building or bastion of ca. 70×70 m. It is delimited to the North by the bed of an exhausted stream that flows to the south and also separates it from site no. 2, located to the east. A further streambed, flowing from east to west separates it from site no. 3, located immediately to the south.

2. ca. 200×120 m, quadrangular in shape, 23,800 m^2.

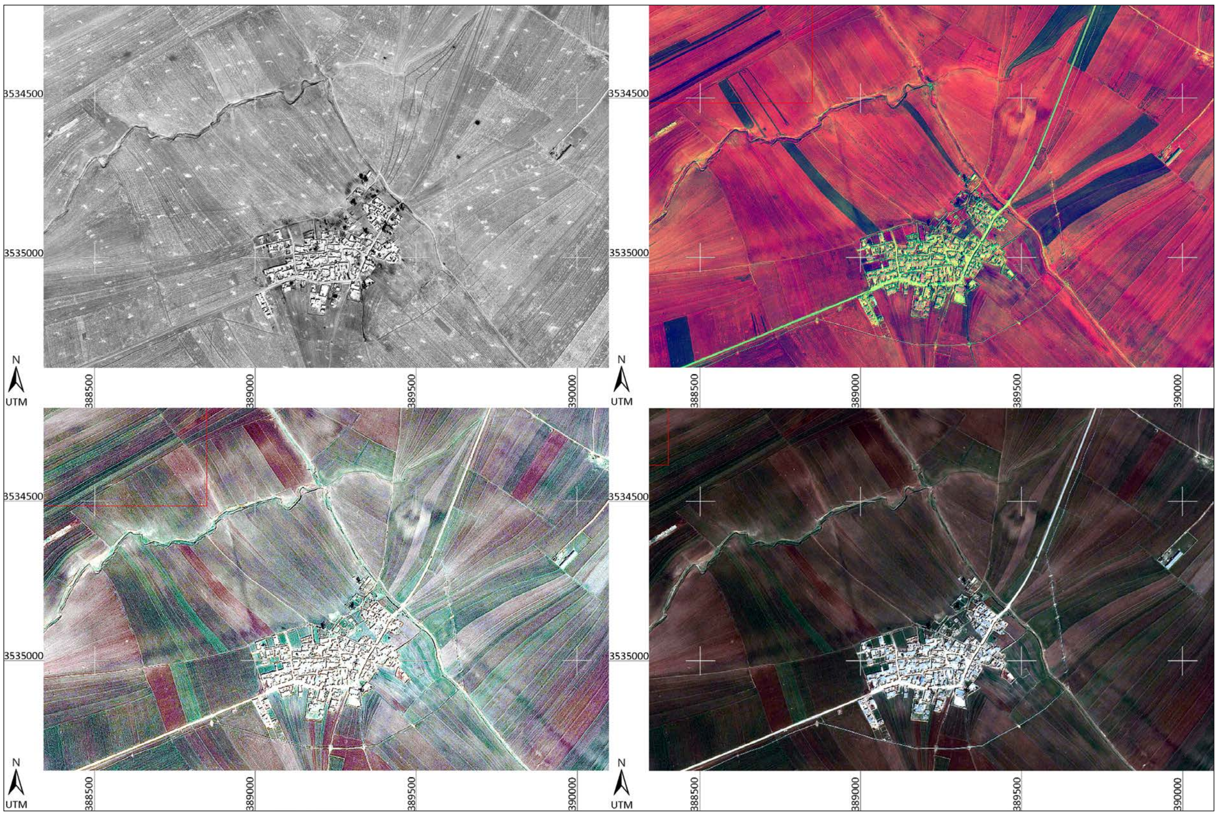

Fig. 4 Multispectral analysis of the area of Miangharan Olya and Choga Haji Najaat (detail of ROI 1). Top left, panchromatic satellite image (11 August 2013); top right, IR channel; down left, equalization after Gaussian convolution; down right, RX anomaly detection after Laplacian convolution.

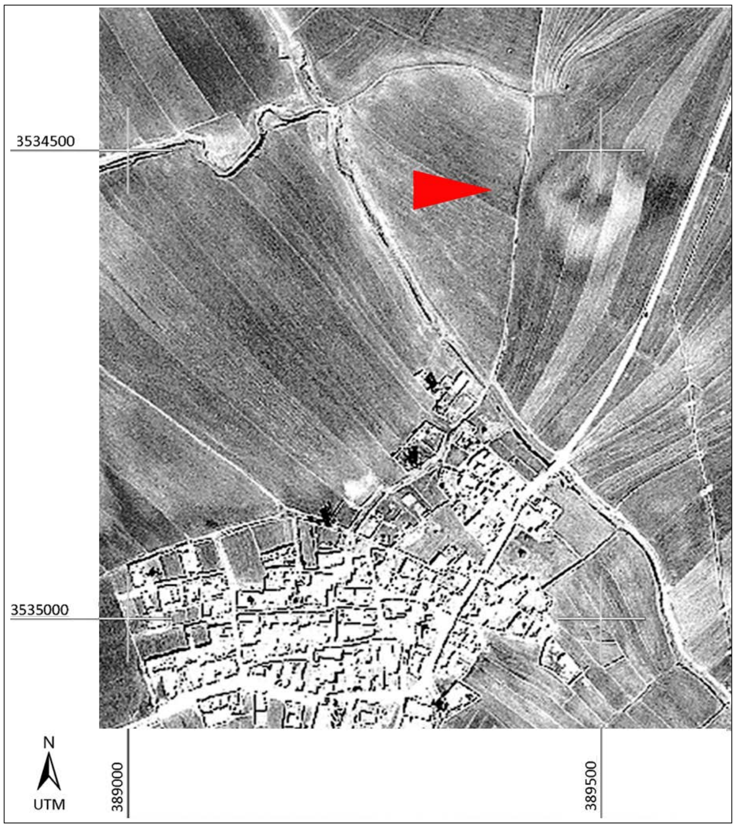

Fig. 5 Grey-scale detail of the area of Choga Haji Najaat, North of Miangharan Olya, from the previous image. The recognized buried structure (site no. 7) is indicated by a red pointer.

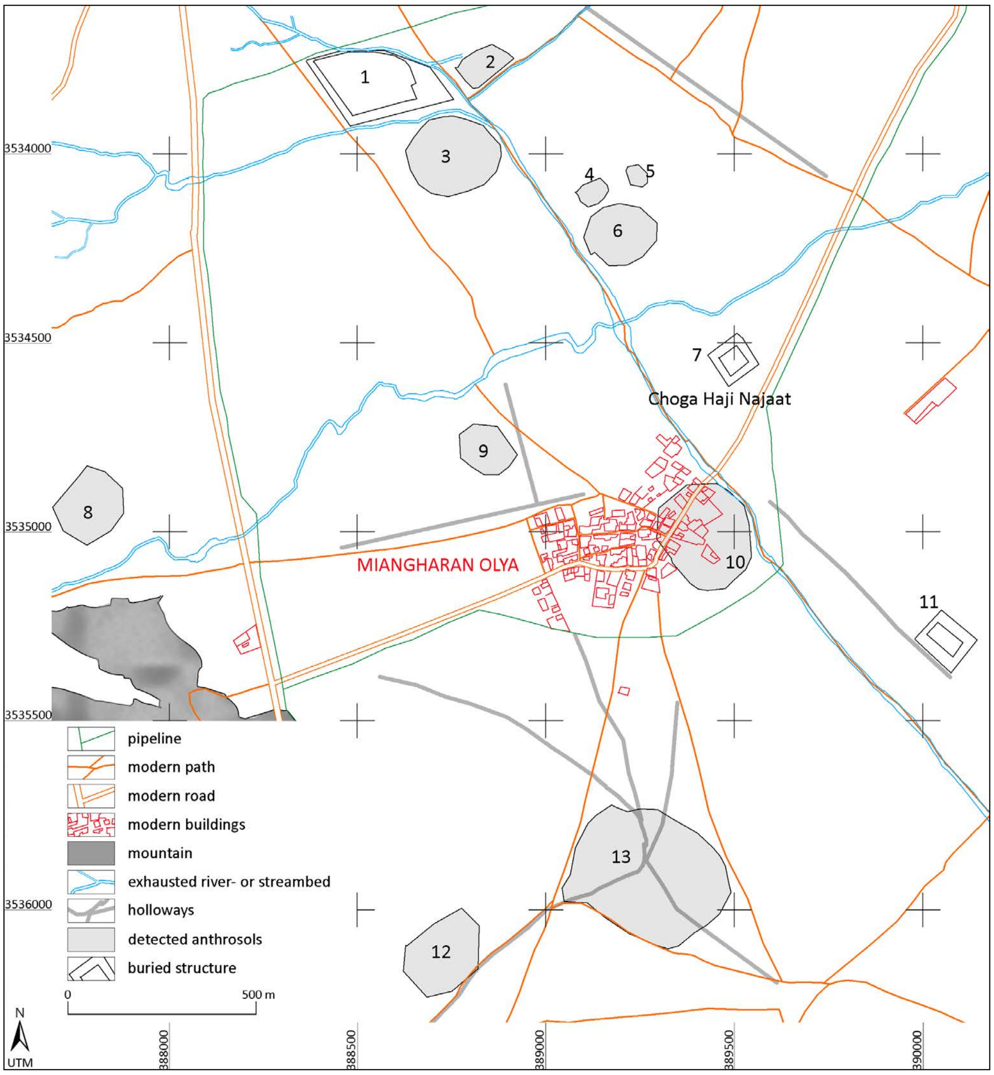

Fig. 6 Multi-temporal map of ROI 1.

3. ca. 70,200 m².

4. ca. 6,600 m².

5. ca. 3,900 m².

6. ca. 26,000 m². Possibly part of a complex also including sites nos. 4 and 5 and delimited to the west by the same streambed flowing close to sites nos. 1-3.

7. Known as Choga Haji Najaat. ca. 110×110 m, inner court ca. 50×50 m, four wings, each measuring ca. 30 m in width, ca. 14,000 m². This is described above (Fig. 5).

8. ca. 38,000 m².

9. ca. 17,000 m².

10. ca. 76,000 m². Partially overlapped by Miangharan Olya; the presence of pottery assemblages at the outskirts of the modern village also seems to corroborate the hypothesis that it partially overlaps an ancient site; this could be one of the sites already recognized by Wright and dated from the Seleucid to the Sasanian periods (Eqbal 1979: figs. 48-49).

11. ca. 130×90 m, inner court ca. 50×30 m, four wings, each measuring ca. 30 m in width, ca. 15,000 m². When observed, this seems quite similar to site no. 7 for its layout and dimensions.

12. ca. 32,000 m²; this could be one of the sites already recognized by Wright and dated the Middle-Elamite period (Bayani 1979: figs. 39-40).

13. ca. 93,000 m². By far the largest site identified in ROI 1; this can be one of the sites already recognized by Wright and dated from the Parthian to the Ilkhanid-Timurid periods (Eqbal 1979: figs. 48-49; Wright 1979b: fig. 50).

It is very interesting to see that the great majority of the sites identified by remote sensing observations do not appear on the maps published by Wright,

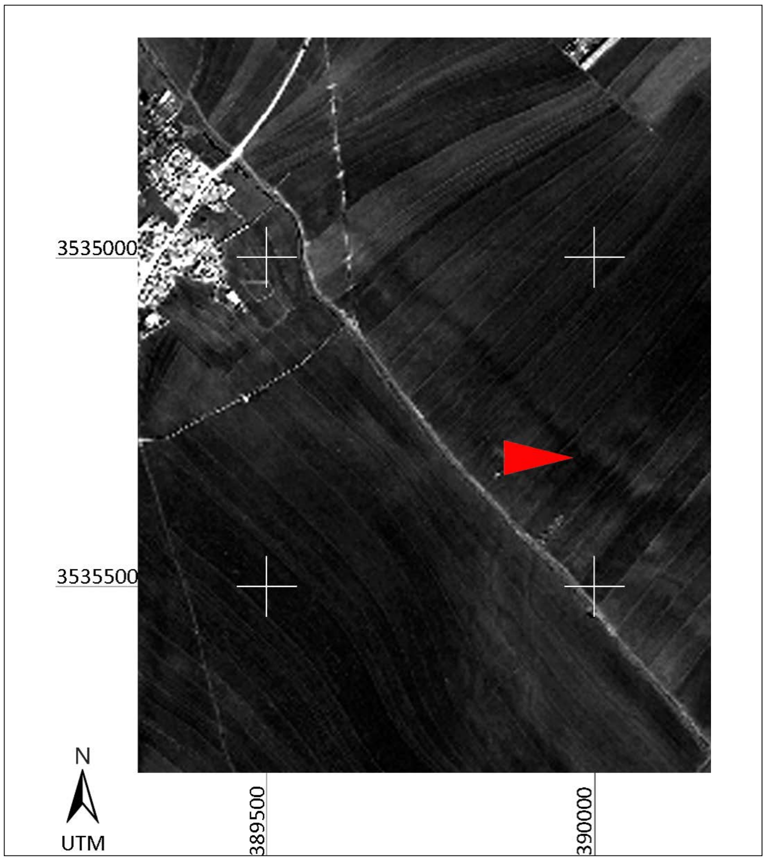

Fig. 7 Grey-scale detail of the area South of Miangharan Olya from image in Fig. 3. A buried structure (site no. 11) and holloway are indicated by a red pointer.

because they were not recognizable on the ground: only the location of three sites out of thirteen (here nos. 10, 12 and 13) appear to correspond to the spots indicated on those maps. This clearly demonstrates the low visibility of sites in the highlands. In mountainous lands that are exclusively characterized by lithosols, such as the areas around the plain of Izeh, the visibility of ancient sites is even lower. As a consequence, the interpretation of settlement patterns through models is less easy than in alluvial lowlands, or even misleading: for instance, ancient sites examined through excavation, with the remains of monumental stone architecture built-up on bedrock, like the great terraced sanctuaries of Majid-e Sulayman, Bard-e Neshandeh[4] and Kal-e Chendar (in the valley of Shami),[5] do not reveal clear traces of settlement. However it is very difficult to imagine that they were built in the middle of nowhere or were not connected to ancient road systems.

This said, it must be stressed that, even in a context of low connectivity, sites in ROI 1 are as a rule located very close to streambeds. This is particularly evident when looking at sites nos. 1-7, 10-11, which all flank the two banks of the same watercourse—a stream running from south to north that originated in Lake Miangharan. We do not have any information on the sites' chronology because of the almost complete lack of surface materials, but it is clear that the watercourses are the main reason for their placement.

Holloways can also be observed. These are the result of sites being connected, as seems well demonstrated by the traces of ancient paths linking site no. 13 to nos. 10 and 12. These are the three sites also shown in the maps published by Wright, and it is very interesting to note that while sites 10 and 13 share the same occupation phases—dated to the Parthian-Sasanian periods—site no. 12 is dated to the Middle-Elamite age: the fact that it is connected to site no. 13 must be thus explained in some way, a

4. These are the famous terraced sanctuaries brought to light by Roman Ghirshman (Ghirshman 1976).

5. This is a terraced sanctuary and cemetery dated to the Hellenistic and Parthian periods, recently excavated by the Iranian-Italian Joint Expedition in Khuzestan, co-directed by the present authors. Up to now, no settlement was identified on the ground. Preliminary reports are published on the Journal Parthica, but see also Messina & Mehr Kian 2014; Messina 2015.

phase of re-occupation perhaps, for which no surface materials have survived.

Another incoherence is represented by site no. 13 itself. This covers the same area in the maps published by Wright and includes three sites of smaller dimensions: however, when observed through aerial imagery it can be seen that one big site is crossed by a network of paths leading in almost all directions.

Conclusion

The extension of the area under investigation covers about 10 km^2. Remote sensing observations reveal the presence of thirteen sites, namely about one site per 1.3 km^2 (or 0.7 sites per km^2). Settlements are higher in number than those identified by Wright, and so is their density. This said, it must be also noted that, if the chronology proposed by Wright is considered correct, almost half of the identified sites were dated to the Islamic period on the basis of a small amount of surface materials (Wright 1979b: 124-126). However, it must be taken into consideration that conceivably the lack of correspondence between the areas identified as anthrosols and the visible traces of an ancient settlement may be due to soil movement or human activity like agriculture. The fact that the areas here identified as anthrosols could not correspond to the real extension of an ancient settlement precisely, because anthropogenic soils could have exceeded the limit of a site due to flotation or subsequent human activities like agriculture, must be taken into consideration.

In any case, the density per km^2 is not so different from that recorded for the alluvial lowlands. If one considers the map published by Wenke (Wenke 1981: figs. 2-5), which is more detailed than those published by Adams (Adams 1962: figs. 3-6), it is possible to see the presence of over eighty sites between the rivers Karkheh and Ab-e Dez (about 300 km^2), namely about one site every 3.7 km^2 (or 0.26 sites per km^2), and over one hundred sites east of the river Ab-e Dez (over 300 km^2), namely about one site every 3 km^2 (0.33 sites per km^2).

The picture developed for ROI 1 seems to show that patterns of settlement can be described effectively by models only to a limited extent, because the quality and quantity of data collected by ground surveys or remote sensing observations is not always adequate. The use of settlement models in mountainous terrain is even less indicative than the reconstructions proposed for alluvial lowlands, for in the latter case the traces left by human activities and the resulting archaeological mounds are more visible. Validation in mountainous contexts can be performed only by stratigraphic excavations, because ground surveys alone (extensive and/or intensive) do not offer sufficient reliability, due to the low visibility of the sites and low occurrence of surface materials (which are often only residual). The same can be said for remote sensing observations. Settlement models created on the basis of data acquired through systematic excavations at different sites can describe the reality of settlement patterns of an area much more effectively, or at least in a less uncertain way.

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آفرین نامه

مقاله‌های باستان‌شناسی در نکوداشت استاد مهدی رهبر

به‌کوشش: یوسف مرادی

با همکاری سوزان کنتن، ادوارد جان کیل و رسول بروجنی