Remote Sensing Roman and Byzantine Eastern Frontier Zone in Landscape: Case Studies from Syria and Turkey

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Abstract The Euphrates and the Tigris valleys in greater Mesopotamia provide a treasure trove for archaeologists studying the Roman and Byzantine eras. There existed some parts of the eastern frontier zone of the Roman and Byzantine empires, remains of which are in modern Syria and Turkey. This was also the stage where some of the first steps in archaeological remote sensing were taken in aerial archaeology in the Near East in the beginning of the twentieth century. It also became an arena in which the Finnish project SYGIS and the Finnish-Swedish Archaeological Project in Mesopotamia (FSAPM) applied satellite imagery, cartographic data, historical sources and Geographic Information Systems (GIS) in archaeological prospecting, surveying and mapping. Declassified CORONA satellite photographs from the 1960s were used in prospecting and environmental studies. Landsat-7 ETM, QuickBird and GeoEye images were also purchased. The spatial resolution of the images provided means to trace Roman sites and roads. SPOT images were acquired as well, and they revealed settlements and agricultural fields in the neighbourhood of the Euphrates valley. Landscape models were produced fusing satellite imagery with DEM (digital elevation model) data, either from the SRTM mission or ASTER imagery to visualize and study the contexts in different types of environments and landscapes. Contrasts appeared between dry mountainous areas and flat irrigated agricultural areas in the river valley of Syria to hilly agricultural areas in mainly rain-fed eastern Turkey. In a multiperiod survey in Syria concentrating on nomadic and settled cultures, it was realized that the area comprised plenty of Roman and Byzantine remains that we integrated into the survey and studied in the context of the region. This Roman Limes area provided sites that reflected the network and military strategy. Visibility and viewshed analyses were able to be carried out with DEM data from X-SAR shuttle mission and ASTER-DEM data. They provided

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military aspects for defending the eastern frontier zone. In Turkey the landscape modelling provided means to understand the hilly and fertile landscape and positions of fortified Roman/Byzantine towns on hills in the Parthian/Persian frontier.

Keywords Archaeology · Roman · Byzantine · Remote sensing · Aerial photographs · Satellite imagery · Prospecting · Surveying · CORONA · X-SAR mission · SRTM · Landsat · SPOT · QuickBird · GeoEye · ASTER-DEM

Introduction

The Near East was a stage where some of the first steps in aerial archaeology were taken, especially in the area of the Roman eastern frontier zone. The Euphrates and the Tigris valleys proved to be treasure troves for archaeologists studying Roman and Byzantine remains in the Near East. There in modern Syria and Turkey, in ancient greater Mesopotamia, once existed parts of the eastern frontier zone of the Roman and Byzantine empires. Here in this article we do not deal with other parts of the frontier zone that continued from Syria to modern Israel and Jordan as far as Arabia but concentrate on areas that have been studied by Finnish and Finnish-Swedish projects in central Syria and eastern Turkey.

The natural frontiers between the west and east, including the twin rivers, mountains, agricultural areas and deserts, became cultural boundaries between the classical and oriental worlds. Beside the enemies in Parthia/Persia, natural features in environment and nomads living in the area clearly had been driving forces in creating the boundaries and frontiers. According to one theory, the pressure of nomads to the Roman Empire was one of the reasons for fortifying the frontier area, especially the so-called Outer Limes that protected the empire from desert forces. But more major enemies lurked in the mountainous areas of Parthia/Persia in the east. The Silk Road formed a vein connecting these worlds to each other. Also various other roads were laid in the desert for military reasons and trade purposes. The roads such as the *Via Nova Traiana* and the *Strata Diocletiana* became expressions of Roman border politics connecting military installations (Lönnqvist et al. 2011).

This article concentrates on two projects the Finnish project SYGIS (the Syrian GIS) for surveying and mapping Jebel Bishri in Central Syria and the Finnish-Swedish Archaeological Project in Mesopotamia (FSAPM) in modern Turkey. The present authors have carried out these projects applying satellite photographs/imagery, cartographic data and historical sources as well as field surveying including ground-penetrating radar (GPR) in tracing, recording and documenting sites in the Eastern Frontier of the Roman and Byzantine empires. The project in Syria took place in the mountainous region of Jebel Bishri in the Palmyrides (Fig. 1), located between the Euphrates river and the Syrian Desert, in 1999/2000–2010. Although the primary goal of the SYGIS project was to study the relationship of pastoral nomads and village people in the area from the survey data through the ages, the regional approach of the survey took into account all the periods and revealed the

Fig. 1 The project areas in the mountainous regions of Jebel Bishri and Tūr Abdin in Mesopotamia

unexpected amounts of Roman sites (see Lönnqvist et al. 2006). The second project was started in 2014 in the mountainous area of Tūr Abdin in the Tigris valley in eastern Turkey (Fig. 1). Both areas in Syria and Turkey belong to the greater area of Mesopotamia in the valleys of the Euphrates and the Tigris.

The preliminary reports of the Finnish project SYGIS have appeared in the journal *KASKAL* (Vol. 3, 2006, and Vol. 6, 2009), and the first volume of the final publication *Jebel Bishri in Context: Introduction to the Archaeological Studies and the Neighbourhood of Jebel Bishri in Central Syria* (Lönnqvist 2008) came out following several other publications after 2010. The larger last volume of the final publication of SYGIS is *Jebel Bishri in Focus: Remote sensing, archaeological surveying, mapping and GIS studies of Jebel Bishri in central Syria by the Finnish project SYGIS* appeared in 2011 (Lönnqvist et al. 2011). A preliminary report of the Finnish-Swedish FSAPM project in Turkey is concentrating on remote sensing and documentation by photographing and was published in *ISPRS Annals* (Silver et al. 2017).

What is important is to note that the area where the Finnish project SYGIS in Syria worked became the central scene of the administration of ISIS/ISIL, Raqqa beneath Jebel Bishri as its capital in 2013–2017, and heavy looting of archaeological sites including those of the Finnish project was to follow. Already in the first year of the Syrian civil war, the Syrian General Directory of Antiquities and Museums reported damage to the Roman/Byzantine fort of Tabūs that the Finns had earlier documented. Satellite imagery, such as UNOSAT, has been the source of data to follow the destruction and looting of sites without access during the occupation of ISIS.

In Turkey the areas where the Finnish-Swedish project FSAPM worked the threats for archaeological remains were different. The Tigris dam projects, agricultural works and heavy building endeavours endanger sites and their future. Therefore documentation of sites was urgent. In both cases, in Syria and Turkey, the coordinate information has been essential to locate and map sites, also for their further monitoring and visits. UTM coordinates have been used in both cases either based on satellite imagery, maps or capturing GPS points on the ground. The coordinate information is essential for identification of archaeological sites and protecting them.

First Steps in Remote Sensing: From Air to Space in the Near East

Such pioneers as L.W.B. Rees (1929), Antoine Poidebard (1934) and Sir Aurel Stein (Gregory and Kennedy 1985) started aerial studies in Syria (Fig. 2), Iraq and Jordan after the First World War. In the use of historical photograph archives, also German aerial photographs from the First World War have proved to be useful in archaeological remote sensing studies in the Near East later on (Bewley and Kennedy 2013). Poidebard and Aurel Stein concentrated in their studies on the Roman Eastern Frontier zone, or the so- called Eastern Limes, tracing fortresses, forts, military posts and roads. They mapped sites but did not check and verify in all the cases the nature of sites and roads on the ground.

Balloons and kites were mounted with cameras in the nineteenth century before the invention of aeroplanes, and also Aurel Stein already used balloons for aerial photographing of archaeological sites in the beginning of the twentieth century. The benefits of the bird's eye view were gradually recognized in detecting ancient remains. The capture of the sight from the air opened a new approach for reconnais-

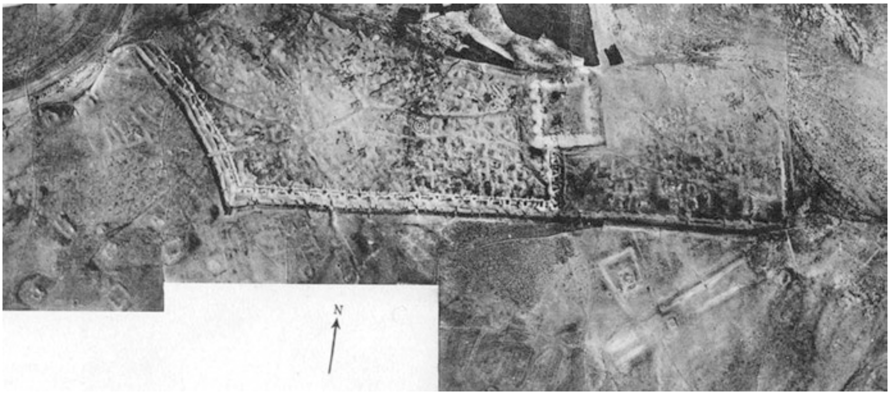

Fig. 2 The Roman site of Sura on the Euphrates in Syria photographed by A. Poidebard (1934) from air

sance. The optimal conditions revealed features that were not visible on the ground level, especially using certain light conditions of a day and changes in vegetation cover during various seasons. The so-called crop marks also have become indicators of ancient sites and monuments that can be identified from the air and space. The scale of the approach also provided a new view to the environmental and landscape contexts. Landscapes and signs of human traces were detected from various heights and angles. After R. Mouterde's and A. Poidebard's (1945) work in Syria, aerial photographs were especially used by archaeologists in Jordan, and David Kennedy (see, e.g. Kennedy 1982; Kennedy and Bewley 2004) became a major promulgator of their use in archaeology in his studies of the Roman frontier zone in Jordan.

After aerial photographing, new technologies to find archaeological sites using remote sensing from space and under the ground have revolutionized the archaeological prospection in recent decades. Aerial photographs were followed by satellite imagery, and space archaeology became a field of double meanings: either meaning remote sensing archaeological sites from various platforms from space or studying space junk that has landed on earth. Remote sensing by aerial photography and satellite imagery has benefited from ideal cloudless conditions to which the Near East with desert and steppe regions and length of sunny seasons has been useful for visibility.

Satellite imagery had been used in archaeological prospecting already in the 1970s (see Lönnqvist and Stefanakis 2009, 1230). But the satellite imagery and radar data for archaeological prospecting in the Near East were especially applied by NASA's Jet Pupolsion Laboratories in California in the 1980s. It resulted in such claimed discoveries as Ubar, a lost city in Oman in Southern Arabia mentioned in the tales of the Arabian Nights, the Bible and the Koran. The site had been covered by desert sands through time. The city was on the caravan trail for transporting frankincenses made of aromatic resins but had remained unrecovered for centuries (Evans et al. 1994; Space Today Online 2006).

Global positioning system (GPS), total stations and Geographic Information Systems (GIS) had brought additional ways to capture site data combining location information from satellites to the ground and spatially analysing the information (Lönnqvist and Stefanakis 2009). Like capturing radar data SAR (synthetic aperture radar) has provided means to have digital elevation model (DEM) data in tiles. Laser scanners like LiDAR (light detection and ranging) have brought even more ways to trace sites that are covered by vegetation. Digitalization revolutionized the field. The digital image has offered new ways to analyse and model information (see Harrower and Comer 2013).

The Data Sources of SYGIS, the Finnish Project in Syria and the Finnish-Swedish FSAPM Project in Turkey

The Finnish archaeological surveying and mapping project SYGIS was established to study Jebel Bishri in central Syria in 1999/2000. The project applied satellite imagery and Geographic Information Systems (GIS) in prospecting and mapping archaeological sites. In 1999 the project was accepted to NASA's world monitoring program through the German Aerospace Center. Due to this program, the project was able to get the X-band DEM of NASA's Shuttle Radar Shuttle Topography Mission which was to serve as a basis for the future landscape modelling of Jebel Bishri and the Euphrates valley (Lönnqvist et al. 2011).

SYGIS first acquired both Landsat-7 ETM satellite image data and black and white declassified CORONA satellite photographs to be used as data sources for prospecting, surveying and mapping archaeological sites in the Jebel Bishri region (Lönnqvist and Törmä 2003). Landsat images were especially useful in studying environment and landscapes in colour making a spatial contrast between the river valley, oases and the desert-steppe environment. Cluster analysis, for example, revealed various environmental features invisible with a naked eye from the tesselated images before clustering. Also Landsat images from various years, taken in various seasons, provided means for environmental analysis over years and in specific seasonal circumstances. The orthorectified panchromatic channel of Landsat-7 with 15 m resolution was used for field mapping with MapSheets Express software. Ground survey took equally place in 15 m interval field walking (Lönnqvist et al. 2011) (Fig. 3).

David Kennedy (1998) had used CORONA declassified satellite photographs to study archaeological sites in Turkey in the 1990s. These CIA photographs on film dated back to the 1960s, and the spatial resolution of them reached up to 1.8 metre that was better than other satellite imagery that had been available in civil markets

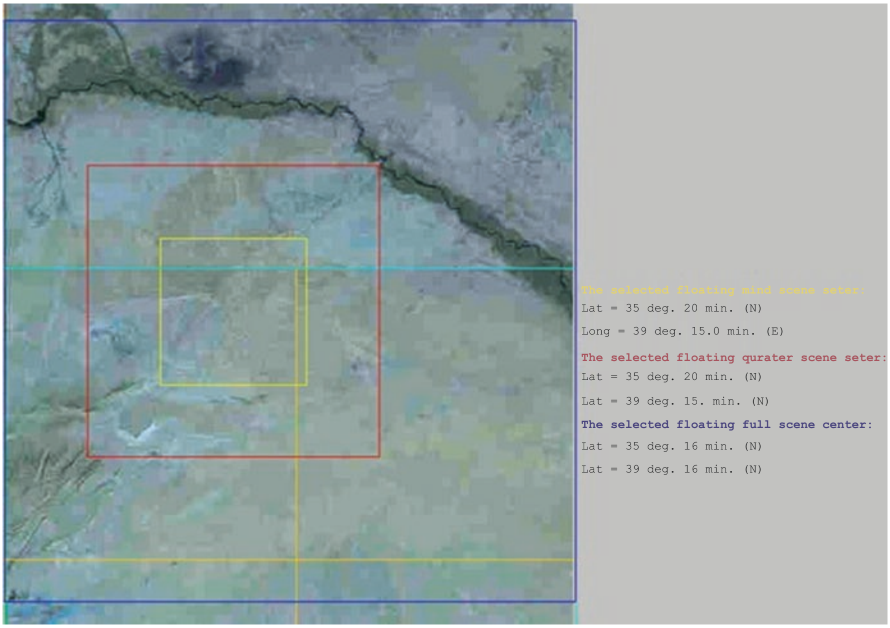

Fig. 3 Landsat-7 satellite image zooming in over Jebel Bishri

before. The benefits have been in their low price, the high spatial resolution and date in detecting sites and features in the landscape before some constructions and changes in the environment had taken place. The use of CORONA photographs opened a new view to study the evolution of landscapes and sites through decades beginning from the 1960s. The application of CORONA by Jason Ur (2003) in Turkey was published in the same year as the first reports of the Finnish project using the respective photographs in Syria came out (Lönnqvist and Törmä 2003).

The cartographic data that the SYGIS project utilized consisted of UK aerial military maps and Russian topographic maps. The Syrian officials refused to provide local military maps of detailed information and offered only tourist maps to be used. A. Poidebard's and R. Mouterde's aerial photographs and maps as well as Alois Musil's (1927, 1928) itineraries were valuable sources of information. Ancient cartographic data and site names from the Roman and Byzantine times, such as available in Ptolemy's Geography, *Notitia Dignitatum* and *Tabula Peutingeriana* were needed as the source of reference and identification for ancient sites. Interviews with local Bedouins were valuable source of information of sites as well. The Bedouins were used as informants prior and during the field campaigns.

The Syrians published *Space Image Atlas: Syria* and *Syria, Archaeology from Space* just in the turn of the new millennium and before the first publications by the Finnish project SYGIS came out in 2003. The atlases were published by the General Organisation of Remote Sensing (GORS) in Damascus which in 2004 also organized a conference on remote sensing and development in which SYGIS was invited to give a presentation on archaeology, remote sensing and cultural heritage. Beside various subjects in the field of developing studies, some colleagues from Britain and Iraq also dealt with archaeology.

Furthermore in 2003 the Finnish project purchased QuickBird satellite imagery with high spatial resolution of 0.60 m, and later SPOT images were acquired. No Google Earth was available yet at that time. Google created the program in 2005, and it soon became common as an open source for prospecting archaeological sites. However, still in the mid of the first decade of the twenty-first century, its coverage and spatial resolution were not sufficient for the Finnish project. On the other hand, it needs to be mentioned that the applicability of Google Earth for various analyses is limited, and therefore it does not allow all the photogrammetric and analytical benefits needed in GIS, compared to the use of tessellated satellite imagery. After the end of the Finnish project in 2010, the Google Earth 3D became already available (Lönnqvist et al. 2012).

The Finnish-Swedish project in eastern Turkey in Mesopotamia has used comparable data sources to those of SYGIS. The leaders of the project in Turkey were largely the same as in SYGIS. Now the Google Earth was applied for preliminary studies, and CORONA photographs were acquired for environmental studies and landscape prospection. Local administrators helped to locate some Roman sites that were known but that still lacked proper documentation and study. The sites that we documented in Turkey laid outside Poidebard's maps of the eastern frontier zone, and no reconnaissance had been published of them and their location before. As availability of QuickBird had ceased, we ordered GeoEye-1 satellite image with even higher spatial resolution of 0.46 m covering an area that we had visited and chosen for closer studies (Silver et al. 2017).

Landscapes as Contexts: Spatial Boundaries and River Channel Changes

To understand cultures and their development, one needs to study their environmental and landscape contexts. Jebel Bishri belongs not only to the desert-steppe areas but also to the mountain chain of the Palmyrides in Syria. That part of the Palmyrides is geologically named as the “Bishri block”. Brew et al. (2003) have produced a map providing a digital elevation model that visualizes the geological nature of the block, the Euphrates trough and the Jezira plains reaching the Mardin highs of Tūr Abdin in eastern Turkey.

The Finnish project SYGIS utilized satellite imagery in studying the spatial differences in the nature between the desert, the mountain and the sown between the Syrian Desert and the Euphrates. Landsat images clearly provided the visual data of the contrast between the brown desert and desert-steppe compared to the irrigated and agricultural green river valley and desert oases (Lönnqvist and Törmä 2004). Water is the source of human activities, cultures and civilizations, and in desert areas especially oases have attracted people from early times. Indeed the El Kowm oasis on the western piedmont of Jebel Bishri is providing evidence of long-term human impact (Lönnqvist et al. 2011). But also the Euphrates with its fans has provided an early stage for agriculture (Moore et al. 2000).

We were able to study the changes in the Euphrates valley landscape, especially extracting visible information of the old channels with CORONA satellite photographs and also analysing the changes in Landsat images (Fig. 4). The river channels had changed their courses by time. More recent changes were able to be studied and analysed with Landsat images. It was clear that some of the ancient sites had become buried in silt along the channel changes through millennia, and some that had been at the river bank as harbours had become remote in their location to the river (Lönnqvist et al. 2007).

It was also the interest of the Finnish-Swedish project FSAPM to understand Roman and Byzantine sites in the undulating landscape of the Tigris valley. The annual precipitation in the higher altitudes of Tūr Abdin area in the Tigris valley is considerably higher than in the Euphrates valley in Syria. Vine is flourishing in the neighbourhood, and Ömerli is still famous for its vines and grape production (Silver et al. 2017). Landscape models were produced fusing GeoEye satellite imagery with Aster-DEM data. These provided views for using natural hills as bases for fortified sites (Silver et al. 2017).

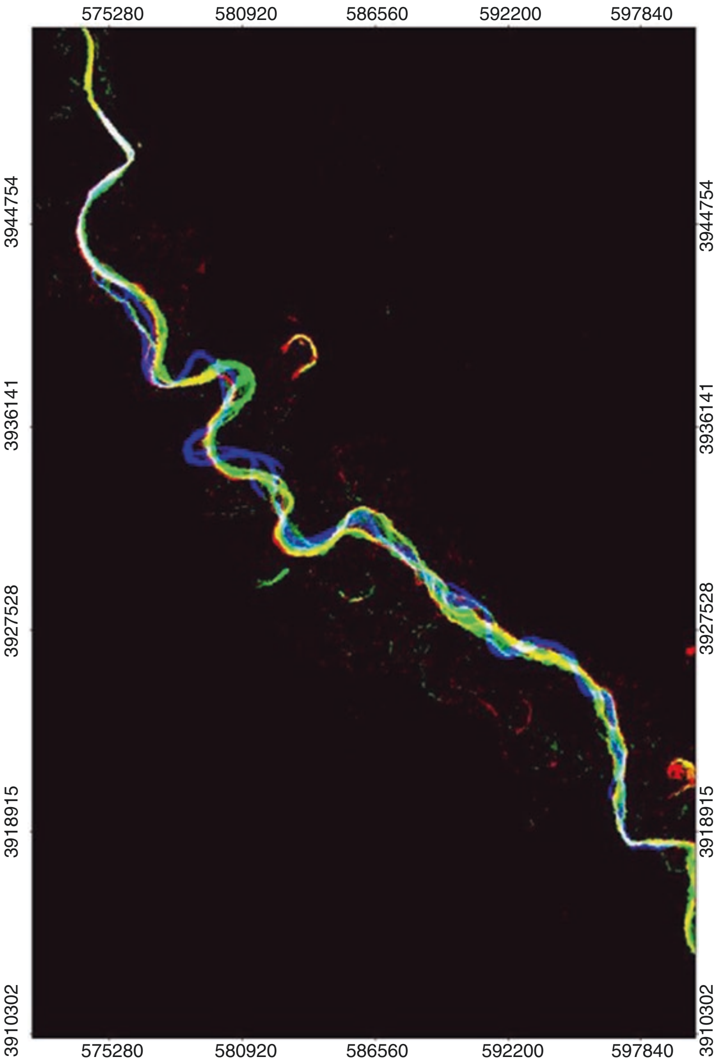

Fig. 4 The analyses of the Euphrates river channel changes over decades CORONA and Landsat images

Studying Roman and Byzantine Sites with Satellite Imagery

Before the Finnish project Jebel Bishri had largely remained an empty spot in the maps and atlases of the Roman empire. CORONA photographs and Landsat images appeared to be valuable data sources in general prospection and mapping. Sites were explored at the edges of the mountain and inner regions. In the eastern piedmont, Poidebard's aerial photographs and maps led to study the surrounding oases on the ground in 2000. They were visited, and Roman activities were confirmed at Shukhna and Taibe (Lönnqvist et al. 2011).

Not far from Taibe the surroundings of the Umayyad castle known as Qasr al-Hayr ash-Sharqi were studied. It appeared that the site had been already occupied during the Roman times and offered quarries as well as tombs in the neighbourhood dating from the Late Roman and Byzantine times. The tombs were documented and associated pottery recorded for the dating purposes. The existence of Bedouin tent camps in the eastern piedmont appeared in Poidebard's aerial photographs from the 1920s and 1930s, and CORONA photographs revealed the earlier environmental conditions of the neighbourhood with orchards. At Darakhlia, in the central areas of the mountain, a large Roman water harvesting site with a barrage or a dam and a stepped pool associated with a watchtower was traced with the local informants and documented in 2000–2004 (Lönnqvist et al. 2011).

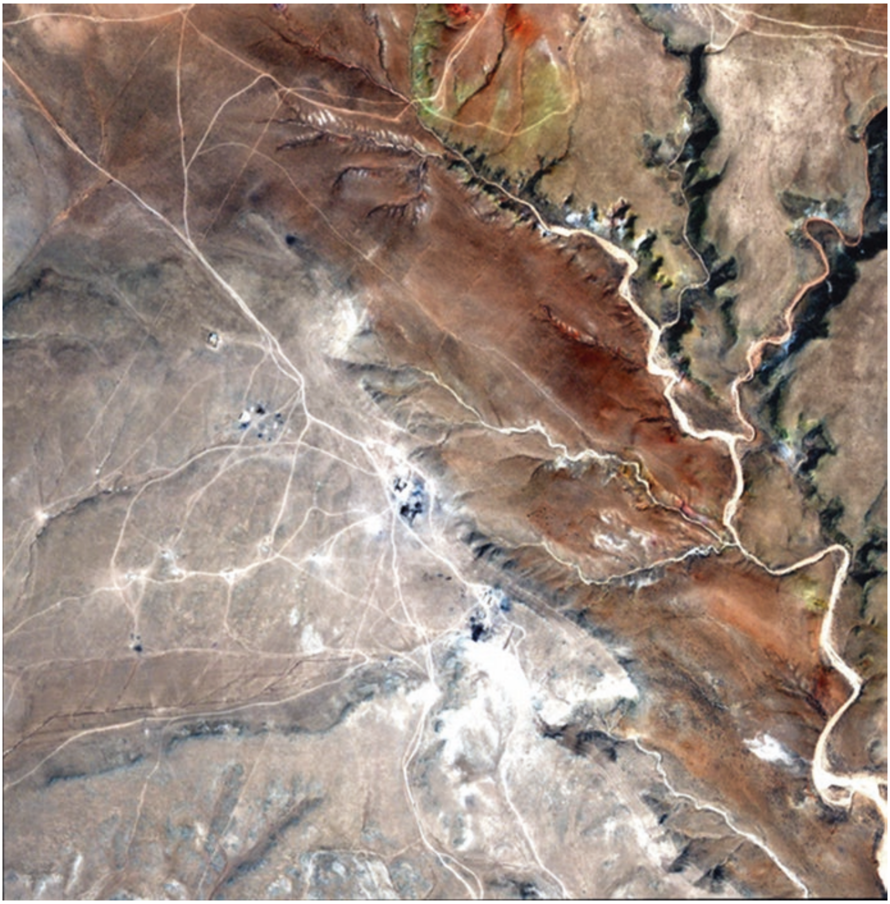

Fig. 5 A Roman military camp on Jebel Bishri identified on a QuickBird image

Fig. 6 A Roman camp originally identified on a QuickBird image and studied on the ground on Jebel Bishri. Note the Via principalis running through it. (Photo: Kenneth Lönnqvist 2005)

Beside informants consisting of local Bedouins, the purchase of QuickBird imagery in 2003 covering parts of the central areas of the mountain proper of Jebel Bishri provided 0.6 m spatial resolution in panchromatic channel. The resolution was able to reveal very interesting sites that had not been able to be seen on the ground before. In the images, we found a temporary Roman military camp of a play card shape (Figs. 5 and 6), near the barrage that led to concentrated searches in the area in question. Furthermore a Roman military posts and dwelling sites in the central areas of the mountain were visited on the ground and mapped with Landsat imagery. It became clear that there had been a special corridor for military supply for the Roman troops, possible including Palmyrenes, through Jebel Bishri towards the Euphrates. We have called this "Bishri corridor" that fills some gap on cartographic sources and in our knowledge of Roman presence between Palmyra and the Euphrates. The Euphrates forms a border area, called the Euphrates Limes that had been also temporarily under Palmyra while it was a client kingdom under Rome (Lönnqvist et al. 2011).

There on the Euphrates border, CORONA photographs and Landsat images appeared to be useful in mapping forts and fortresses (Figs. 7 and 11). A military post with Roman houses was mapped in Qseybe in central northeastern parts of Jebel Bishri. It needs to be emphasized that besides remote sensing, experimental studies on the ground are essential in identifying sites and their nature. Misinterpretation can take

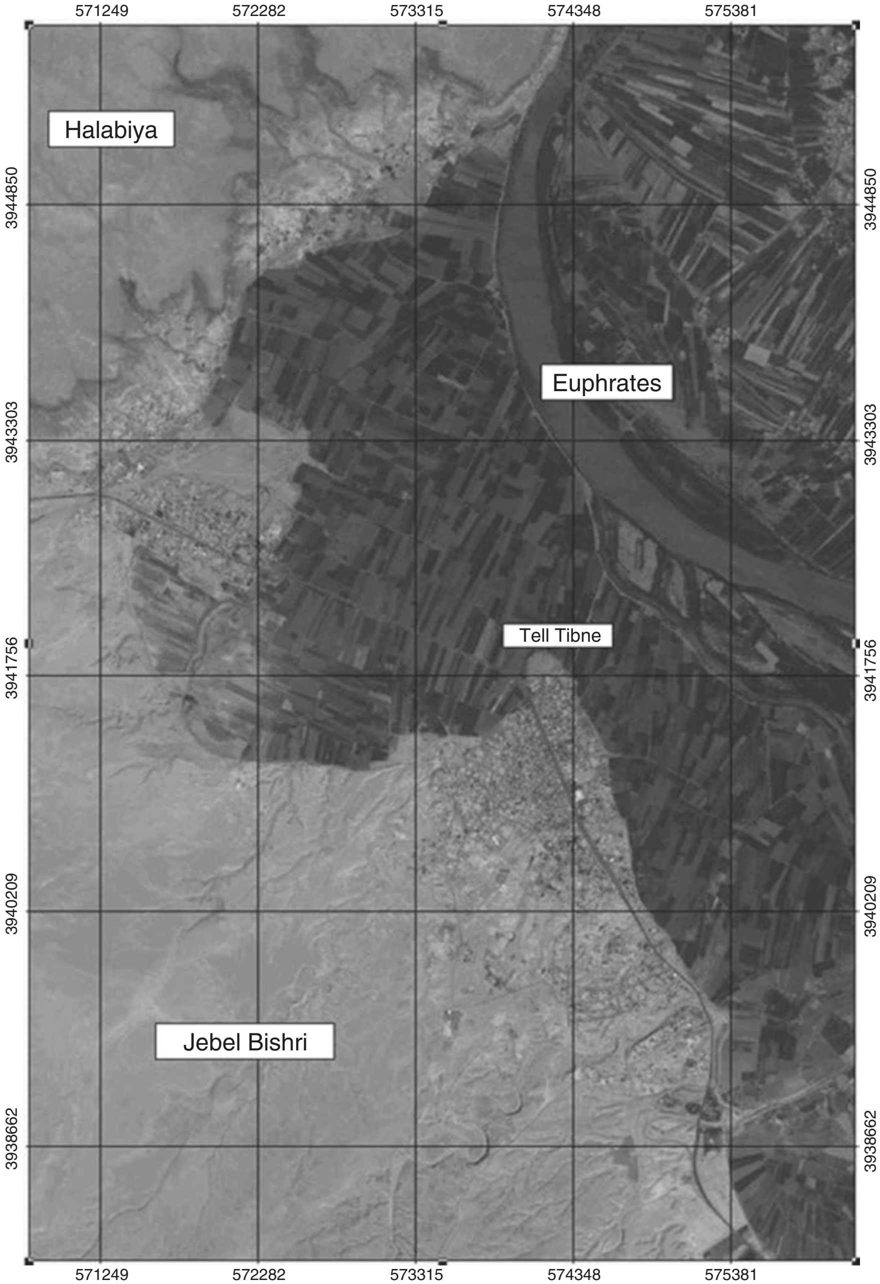

Fig. 7 Tell Tibne, possible Roman site of Mambri, visible at the edge of the Euphrates valley and mapped on Landsat-7 image with ERDAS MapSheets Express software. (Mapping Minna Lönnqvist)

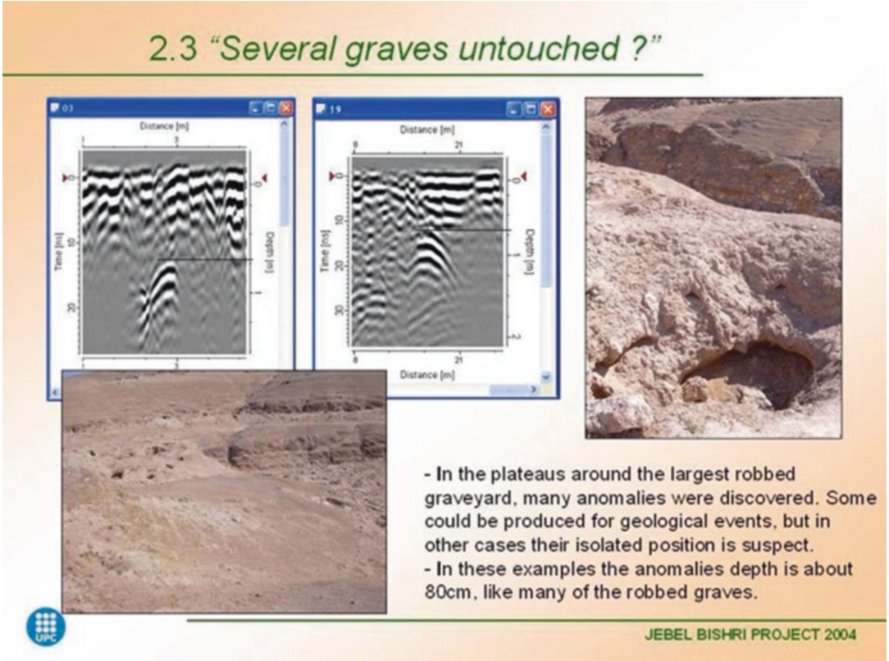

Fig. 8 Prospecting eventual graveyards near the Roman fort of Tabūs with ground-penetrating radar (GPR). (Prospection by Josep Pedrez Rodes)

place without studies on the ground and collection of surface finds. In all the cases of the forts and fortresses, military posts and camps, we collected Roman pottery and glass for the site identification and reference for the dating (Lönnqvist et al. 2011).

The Late Roman/Byzantine fort of Tell Tabūs that had been earlier studied by Friedrich Sarre and Ernst Herzfeld (1911, 1920) was documented by SYGIS with satellite mapping and on the ground by tacheometry in 2004. The nearby cemetery was also documented by drawing and remote sensing by using ground-penetrating radar (GPR) (Fig. 8). It appeared that there were still unidentified underground tombs with galleries. A number of tombs had been looted resulting in a moon-like landscape. Tell Tibne (Fig. 7) near Halabiya and the fortress of Zenobia that dates from the Byzantine era was also mapped with satellite imagery and documented with a tacheometry. The DEM model of the site was created from tacheometry measurements on the ground, and a special map showing the visible structures on the surface was produced. The stamped pottery indicated Parthian influence as well as Late Roman and Byzantine occupation of the site. It is possible that the site can be identified as Mambri, the fortress site built by Diocletian (Lönnqvist et al. 2011).

Also ground-penetrating radar (GPR) was used as a remote sensing device during the Finnish project on the Euphrates side in 2004. Important remote sensing studies with geophysical methods on the ground had earlier been carried out by Andreas Schmidt-Colinet in the Palmyra district. These studies led to the discovery

Fig. 9 Visualizing the Roman/Byzantine site of Keferde in Turkey with a GeoEye satellite image. (Mapping Minna Silver 2017)

of the subsurface ruins of Hellenistic Palmyra (see Schmidt-Colinet et al. 2016). The studies were indicated in the new archaeological atlas published by GORS. While the Finnish project was working in the desert, German team with Syrians also used geophysical means to study a Roman fortress of Qreiye in the village of Ayyash, near Deir ez-Zor on the Euphrates (Gschwind and Hasan 2008).

GeoEye satellite imagery appeared to be very useful for identifying Roman and Byzantine structures of a town of the so-called oppidum type and named Keferde in the Tūr Abdin mountains of eastern Turkey. The upper and lower towns were identified, and structures were photographed including a large polygonical tower (see Fig. 9). Pottery from the Late Roman and especially Byzantine era was identified on the surface for dating purposes. A possible wine pressing area and cultic caves with tombs were observed. Further to the northeast, a larger fortified town was found at Besikkaya and tentatively identified as Beioubaitha. The fortification systems at both sites, especially in the last one, were imposing. At Besikkaya a massive tower governed the site, and curtain walls ran along the slopes. Inside the walls, there were houses that belonged to a present-day village. Remains of a church of a basilica type were encountered as a reused barn. There fine *sigillata* pottery dating from the Roman era was found (Silver et al. 2017).

Fig. 10 Measuring and mapping the Roman/Byzantine fort of Tabūs on Jebel Bishri with a tacheometre and a prism. (Photo: Eivind Seland 2004)

Networks of Ancient Roads in Syria

Already Poidebard (1934) had documented Roman roads from the air in the Syrian Desert. We were also able to delineate such with satellite photographs and imagery associated with ground identification. Photogrammetric and spatial studies have been earlier carried out by Finns in studying ancient roads from the Roman period in Petra in Jordan (Haggrén et al. 2002, 2005), and others at the same time in various areas in the Near East (Gates 2006) (Figs. 11 and 12).

The location of the Roman/Byzantine fort of Tabūs on Jebel Bishri above the Euphrates in association of an ancient road was detected. The road was clearly aligned so that it could have been observed from the tower of the fort (Fig. 10). The Roman origin of this paved road was observed not only in its alignment but also in its structure and based on associated pottery. Quarrying for pavement stones was convenient beside the mountain. Also the local officials were on the opinion that the road that could be observed from the tower of the fort of Tabūs was of Roman origin, at least in its alignment. That road was also documented with a tacheometre, GPS waypoints and hand drawing, and its structure was studied by remote sensing methods with a ground-penetrating radar (GPR). The GPS waypoints were also laid on a Landsat-7 image to create a map (Fig. 11). Another ancient road cut through the mountain slope beneath Tabūs was also detected on the ground and on a Landsat-7 image (Lönnqvist et al. 2005b, 2011; Silver et al. 2015b).

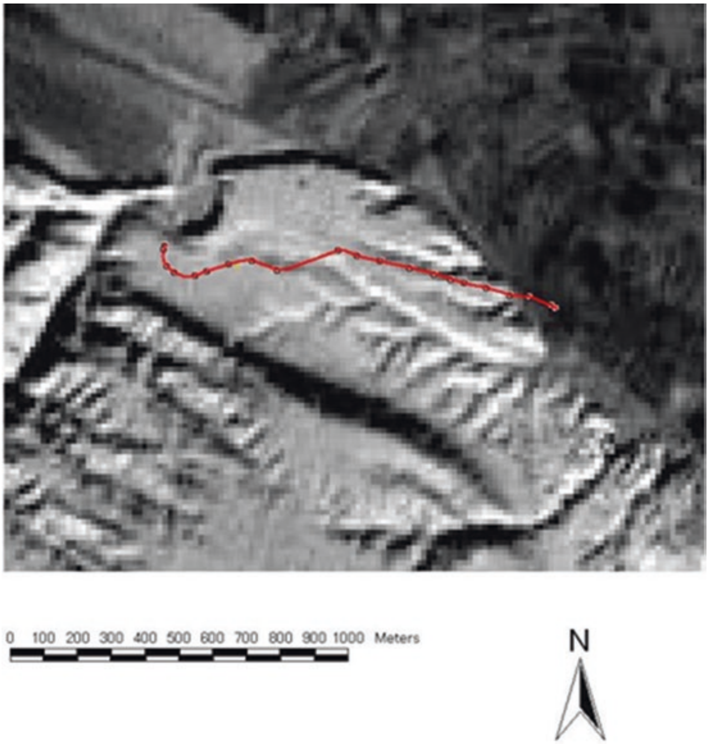

Fig. 11 Ancient road mapped with GPR waypoints on Landsat-7 satellite image. (Mapping by Jari Okkonen 2004)

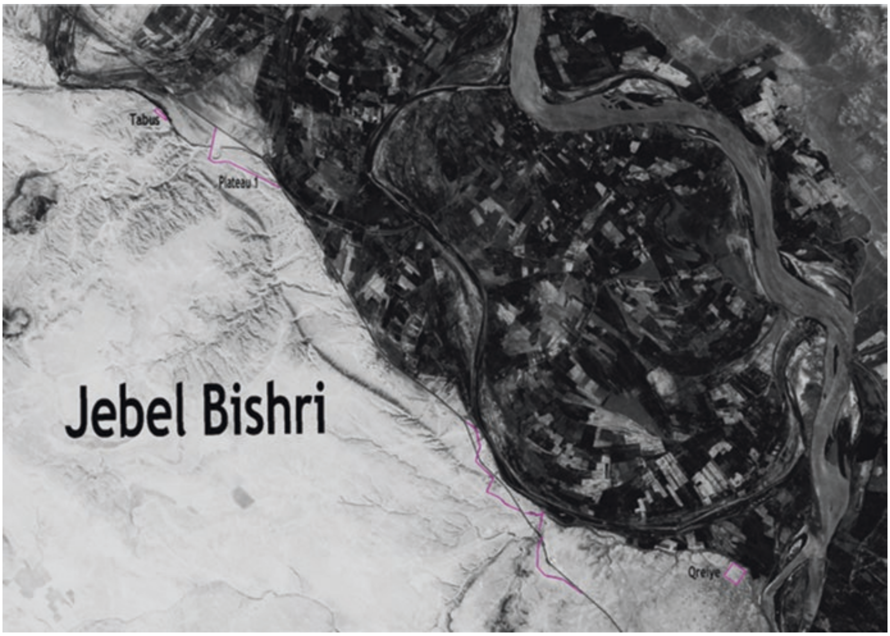

Fig. 12 Finding the continuation of the Roman road alignments on CORONA satellite photograph between the Roman sites of Tabus and Qreiye at the edge of Jebel Bishri on the Euphrates in 2005

The continuation of the road from Tabūs along the Euphrates to the fort of Qreiye was detected near the area of the village of Ayyash with the help CORONA satellite photographs (Fig. 12), and the studies to verify the road alignment were continued on the ground in 2005. It was clear that the CORONA photographs from the 1960s were able to reveal the road that had since been affected by agriculture, traffic and new road constructions (Lönnqvist et al. 2011; Silver et al. 2015b). Hollow ways had been earlier studied by Jason Ur (2003) with CORONA. In our case it was clear that the sound stony terrace that belonged to the piedmont of Jebel Bishri had been used for a road in the area that was vulnerable for flooding. The stretches of this paved road connected Roman sites in the Euphrates frontier, and there also were ancient and more recent bridge points. The vital way to verify the findings was to study the remains of the detected stretches on the ground (Lönnqvist et al. 2011).

Roman dirt roads were further identified on the mountain, especially one crossing a camp like a straight *via principalis* visible on our QuickBird satellite imagery and studied on the ground (Lönnqvist et al. 2009, 2011; Silver et al. 2015b).

Landscape Modelling, Visibility and Viewshed Analyses

Landscape studies using satellite imagery have increased in the past decade (see Comer and Harrower 2013). As previously mentioned, the Finnish project SYGIS had started applying satellite imagery also for landscape studies from the beginning of the project first using Landsat images and CORONA photographs. As previously mentioned, the X- SAR 2000 mission (Rabus et al. 2003) provided DEM data from the region of Jebel Bishri enabling the construction of landscape models fusing the radar data with Landsat-7 imagery in 2003 (Fig. 13). A fly-over animation was used so that one can approach the Euphrates and Jebel Bishri from various directions, both from the southeast and the Jezira (see www.helsinki.fi/hum/arla/sygis). The satellite data also allowed to capture a 3D scene mosaic over the peninsula of Halabiya with a Landsat-4 MSS (Lönnqvist et al. 2011, 55).

GIS has provided means to study visibilities in landscape (see Wheatley and Gillings 2000). On the southwestern edge of Jebel Bishri, prehistoric and Bronze Age sites were met in numbers, and visibilities toward the eastern oases were studied with landscape models that were constructed by using Russian topographic maps and Landsat-7 image data using Image drape software (Lönnqvist et al. 2011) (Fig. 14). Landscape models of desert-steppe areas to study the environmental contexts were also created fusing QuickBird imagery with ASTER-DEM data (Fig. 15). That fusion produced natural kind of models because of the high spatial resolution of QuickBird imagery. (Lönnqvist et al. 2012).

The same visibility obviously served the Romans and Palmyrenes in inspecting the areas (the plains and the *wadis*) (Silver et al. 2017, 2018). Special attention was paid to the visibilities between various forts and fortresses on the Euphrates. A viewshed analysis (see Wheatley 1995) was carried out between three forts, namely, Tabūs, Qreiye and Mambri on the Euphrates using SRTM data (Fig. 16). Attention was especially paid on intervisibility. The location of the Tabūs fort in the middle of

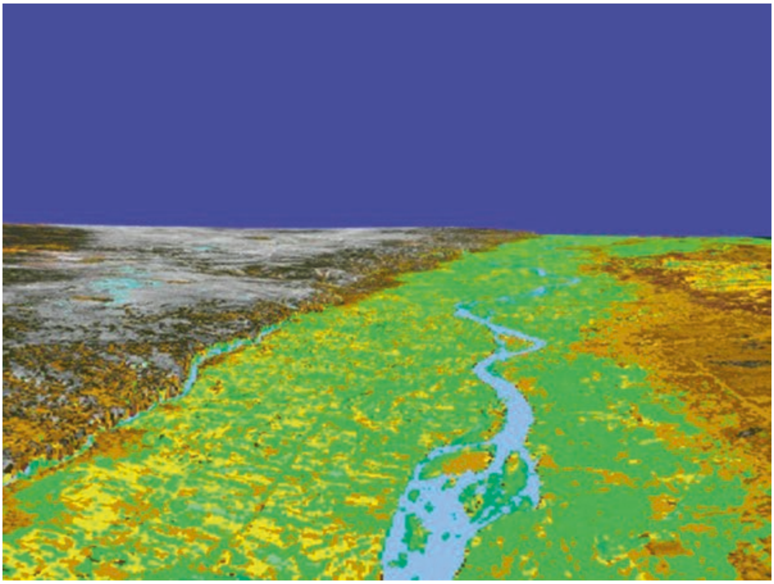

Fig. 13 A 3D landscape model displaying Jebel Bishri and the Euphrates valley from east to west constructed fusing Landsat-7 image with X-SAR-mission data. (Constructed by Markus Törmä 2003)

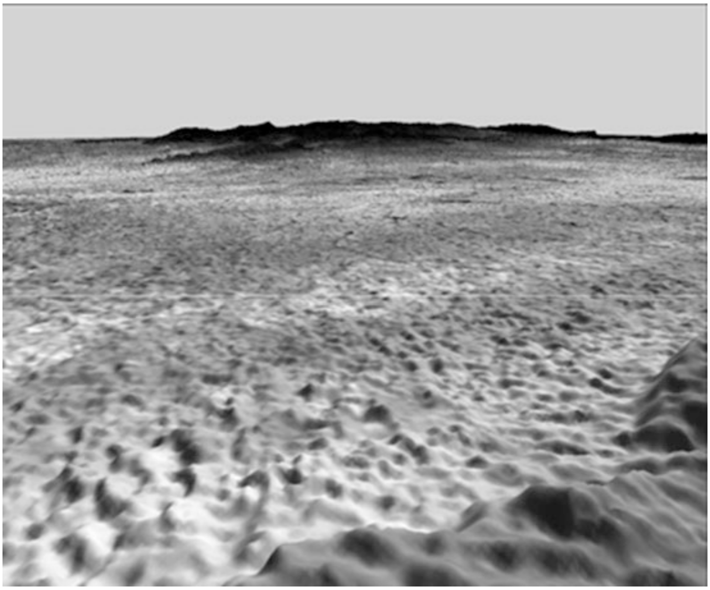

Fig. 14 Visibility analyses from the western edge of Jebel Bishri fusing Landsat images with topographic data. (3D modeling by Markus Törmä 2010)

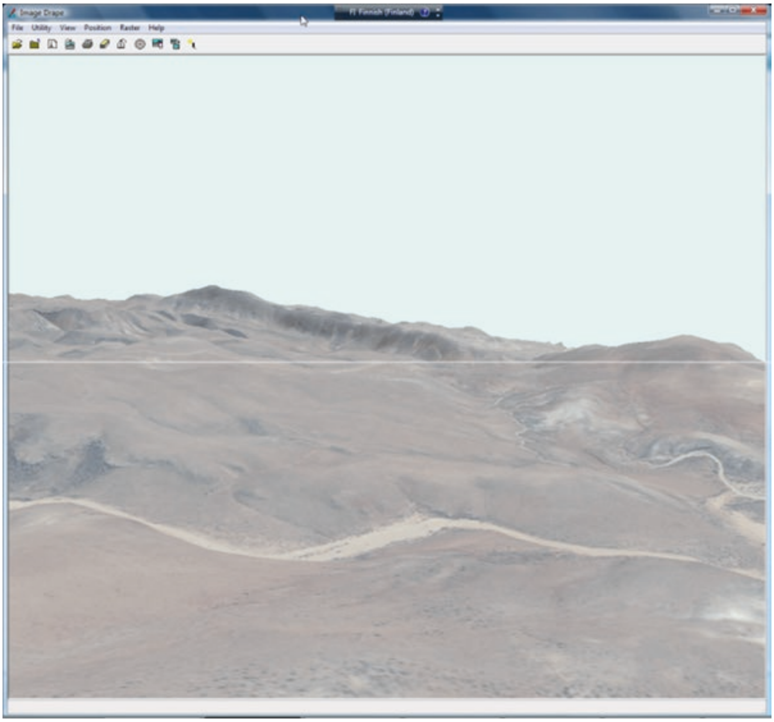

Fig. 15 Modelling the steppic landscape in 3D on Jebel Bishri fusing QuickBird imagery with ASTER-DEM data. (Constructed by Markus Törmä 2012)

the three forts and on higher elevation compared to the sites lower in the river valley made it a kind of a relay station (Lönnqvist et al. 2005a).

In our more recent study, after the SYGIS project ended in 2010 and the Syrian civil war started in 2011, we studied visibility from ancient tower tombs. The most famous ones are situated in Palmyra, but the structures are met in the Syro-Mesopotamian region in general. We wished to find out whether tombs had also been used as watch towers. The locations of the tombs and viewshed analyses indicated double function for these and their staircase towers: both as watchtowers and as tombs. There were more evidences to reinstate the hypothesis of defensive purpose in Palmyra and Hatra where tombs were also integrated in the walls surrounding the cities (Silver et al. 2015a, 2018).

In eastern Turkey in the area of Tūr Abdin, landscape models (Fig. 17) were produced fusing GeoEye-1 imagery with EU-DEM (European Digital Elevation Model data using SRTM and ASTER-DEM) with ERDAS ER Mapper 2016. They provided a way to visualize the potentials for visibility from the fortified sites of Keferde to Beioubaita. The traffic could have moved in valleys that provided natural contours to walk. Visibility and means for movement were useful or even essential in the border zones in the Roman and Byzantine times, when the threat of Parthians

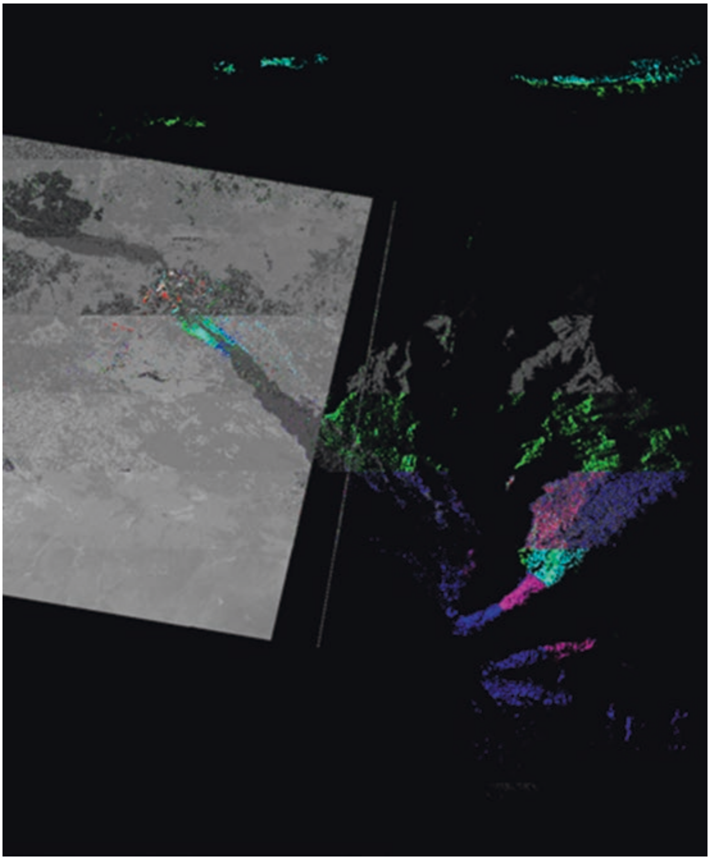

Fig. 16 A viewshed analysis between Roman forts on Jebel Bishri and along the Euphrates applying Landsat satellite imagery and SRTM data. (Analysis by Markus Törmä 2005)

or Persians was imminent (Silver et al. 2017). The landscape of sites in Tūr Abdin in the respective models is visibly fertile and agricultural compared to the models of the steppic and desert areas of Jebel Bishri (Fig. 15) that is and has been the realm of pastoral nomads.

Final Remarks

It needs to be mentioned that the areas that the Finnish project SYGIS and the Finnish-Swedish project FSAPM in greater Mesopotamia have studied are located in the areas where heritage has been at risk. Sites on Jebel Bishri in Syria have suffered from the military interference, destruction and heavy looting since the civil

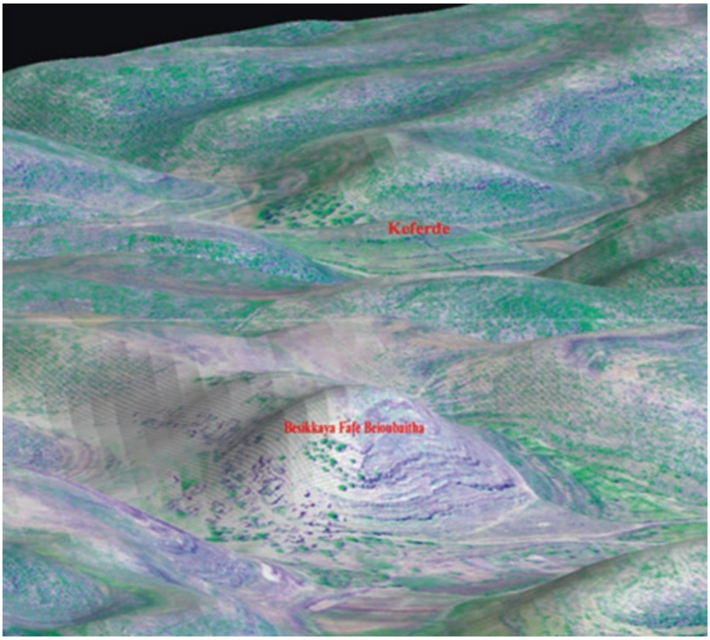

Fig. 17 A 3D landscape model displaying Roman/Byzantine sites in Tūr Abdin constructed by fusing GeoEye imagery with EU-DEM data from SRTM and ASTER- DEM. (Constructed by Markus Törmä 2017)

war started in 2011. Tūr Abdin is in the region of Turkey that is affected by large Tigris dam projects and agricultural development and building. Therefore, the swift documentation of sites and monuments has been of utmost value. New sites and monuments were detected by prospecting with satellite imagery and combining the results with experimental field work by surveying on the ground, also using GPS and GPR in Syria.

Unclassified CORONA satellite photographs have been widely used in archaeological prospecting in the Near East during the past decades. The benefits have been in their low price, high spatial resolution for detecting sites and features in the landscape before some constructions and changes in the environment had taken place. Landsat images have been valuable data sources for environmental studies, also enabling to see changes through the years and carrying out various analyses to extract environmental information. They have also been used in mapping archaeological sites and carrying out landscape modelling by fusing the data with DEM tiles from SRTM and ASTER-DEM or with topographical map information. Landscape models have also provided means for visibility studies and viewshed analyses.

Google Earth and other higher spatial resolution images such as QuickBird and GeoEye have revealed Roman sites such as military camps, roads and forts in detail. Because of their higher spatial resolution, the images have also provided more natural type of landscape models when fusing them with radar data. The environmental differences between the Syrian and Turkish sites are clear; those in Syria were in the steppic landscape, while those in Turkey were in areas of rain-fed agriculture.

The manifold advantages of remote sensing have become evident in archaeology in recent decades. Now when the Near East has been in turmoil, the remote sensing is in some cases the only way to carry out studies and monitoring sites. That we have location information, like UTM coordinates, is of utmost importance in saving the location information and eventually the sites with heritage value. For research new mappings of the Roman frontier, modellings and analyses have opened wider views for understanding of military strategies and social, economic and cultural lives in the region.

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