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Integrated RS, GIS and GPS approaches to archaeological prospecting in the Hexi Corridor, NW China: a case study of the royal road to ancient Dunhuang

Lei Luo [a, b, c], Xinyuan Wang [a, c, *], Chuansheng Liu [a, c], Huadong Guo [a, c], Xiaocui Du [a, c]

[a] Key Laboratory of Digital Earth Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, 100094 Beijing, China
[b] University of Chinese Academy of Sciences, 100049 Beijing, China
[c] International Centre on Space Technologies for Natural and Cultural Heritage, 100094 Beijing, China

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ABSTRACT

According to historic records, the wasteland northeast of modern Dunhuang oasis contains remarkable, undiscovered monuments of medieval courier stations. In this study, statistical analysis of historic records and census data, image processing and interpretation of satellite remote sensing images, GIS analysis, and field surveys were carried out to contribute to the discovery of courier stations and the reconstruction of the medieval royal road system from Guazhou to Shazhou. Firstly, in order to obtain the existence regions of courier stations, historic records and census data were abstracted and digitized, for generating preliminary regions of interest by using GIS tools. Secondly, dried river channels and traces of the Great Wall were extracted from the remote sensing images, and GIS buffer and overlay analyses were applied to the creation of prospective sub-areas. Thirdly, prospective sub-areas were mapped from very high resolution WorldView-2 images, and suspected sites were found based on the human-computer interactive interpretation. Fourthly, suspected sites were investigated on the GPS-based archaeological survey, and were confirmed as two courier stations based on the remains of Han-Tang period observed at sites' surface. Lastly, the royal road to ancient Dunhuang, one of the most important sections of the royal road system in the Hexi Corridor, was discussed and reconstructed with the combined application of remote sensing imagery and ground-truthing.

1. Introduction

With the rapid development of science and technology, especially combined applications in the natural sciences and the humanities and social sciences, archaeology has developed into several new subfields, such as environmental archaeology, historical archaeology, remote sensing archaeology, and other multidisciplinary approaches. Both the horizontal scale and vertical depth have been extending in archaeological prospection with the rise of Earth observation technology and computer science since the 1950s. Earth observation technology mainly based on remote sensing (RS), GIS, and global positioning system (GPS), collectively called 3S (Deng et al., 2010; Nie and Yang, 2009; Luo et al., 2012), has become an important tool helping archaeologists to prospect and understand archaeological sites, to discover hidden sites, and to resolve real archaeological problems.

Remote sensing as a non-destructive tool to uncover remains of ancient human occupation and past landscapes has been used for archaeological applications since the 1970s when it started to be available for civil purposes (Noviello, 2013). Archaeologists have used a variety of ever-more sophisticated techniques to identify, extract, delineate and analyze archaeological sites and their surroundings (Clark et al., 1998; Brivio et al., 2000; Ur, 2003; De Laet et al., 2007; Masini and Lasaponara, 2007; Beck et al., 2007; Wisemann and Baz, 2007; Lasaponara and Masini, 2007, 2011, 2012, 2014; Parcak, 2007, 2009; Alexakis et al., 2011; Morehart, 2012; D'Orazio et al., 2012).

GIS has over the last 10 years become an important tool in archaeology. The three main applications of GIS in archaeology are visualization, spatial analysis and modeling (Church et al., 2000; Brandt et al., 1992; Van Dalen, 1999; Woodman, 2000), and Conolly and Lake (2006: 33–50) note that four typical applications

* Corresponding author. Key Laboratory of Digital Earth Science, Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences, 100094 Beijing, China.
E-mail addresses: xywang@ceode.ac.cn, wangxy@radi.ac.cn (X. Wang).

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of GIS in archaeology are management of archaeological resources, excavation, landscape archaeology (or field-working) and the spatial modeling of past human behavior. GIS-based archaeology is now paid more and more attention all over the world and there have been many successful cases which are mostly engaged in cultural resource management and academic research (Espa et al., 2006; Evans et al., 2007; Siart et al., 2008; Alexakis et al., 2011; Sadr and Rodier, 2012).

GPS is a satellite navigation system used to provide precise locations to receivers on the Earth surface. GPS units can record site, feature, and survey information with accuracy within a few centimeters. Archaeological surveying and field work have been enriched and become more effective through the use of GPS, such as the use of GPS units to plot survey transects and archaeological sites and features (Maktav et al., 2009; Chapman and Noort, 2001; Luo et al., 2012). At present, hand-held GPS units are widely employed to identify specific points by archaeologist.

Archaeological predictive modeling (APM) is one of the most common methodologies in quantitative archaeology (Wheatley and Gillings, 2002: 79). There have been some inductive GIS-based APM methods proposed (Warren, 1990; Brandt et al., 1992; Vaughn and Crawford, 2009; Konstantinos and Athanasios, 2011; Carrer, 2013; Stirn, 2014), but none have been very successful in discovering the new sites. Because of most of them are built to mapping archaeological potential based on the specific characteristics of the known sites, including topographical, hydrological and humanistic characteristics. In this study, derived from historic records, APM that integrate RS and GIS techniques can expedite and realize the process of site discovery by identifying prospective subareas of high archaeological potential for subsequent GPS-based field investigation.

The aim of this study is to present a case study to demonstrate how RS, GIS and GPS technologies have been able to contribute to the discovery, interpretation and documentation of medieval courier stations on the royal road system in Dunhuang.

2. Study area

The Silk Road was opened up for communication between ancient China and the Western world in the 2nd century B.C. This is of great significance for archeological prospection, with a huge number of archaeological monuments distributed along Silk Road routes, especially in the Hexi Corridor. Hexi Corridor, part of the ancient Silk Road running northwest from the Yellow River (Fig. 1a, b), was the most important route from East China to the Tarim Basin and Central Asia for traders and soldiers.

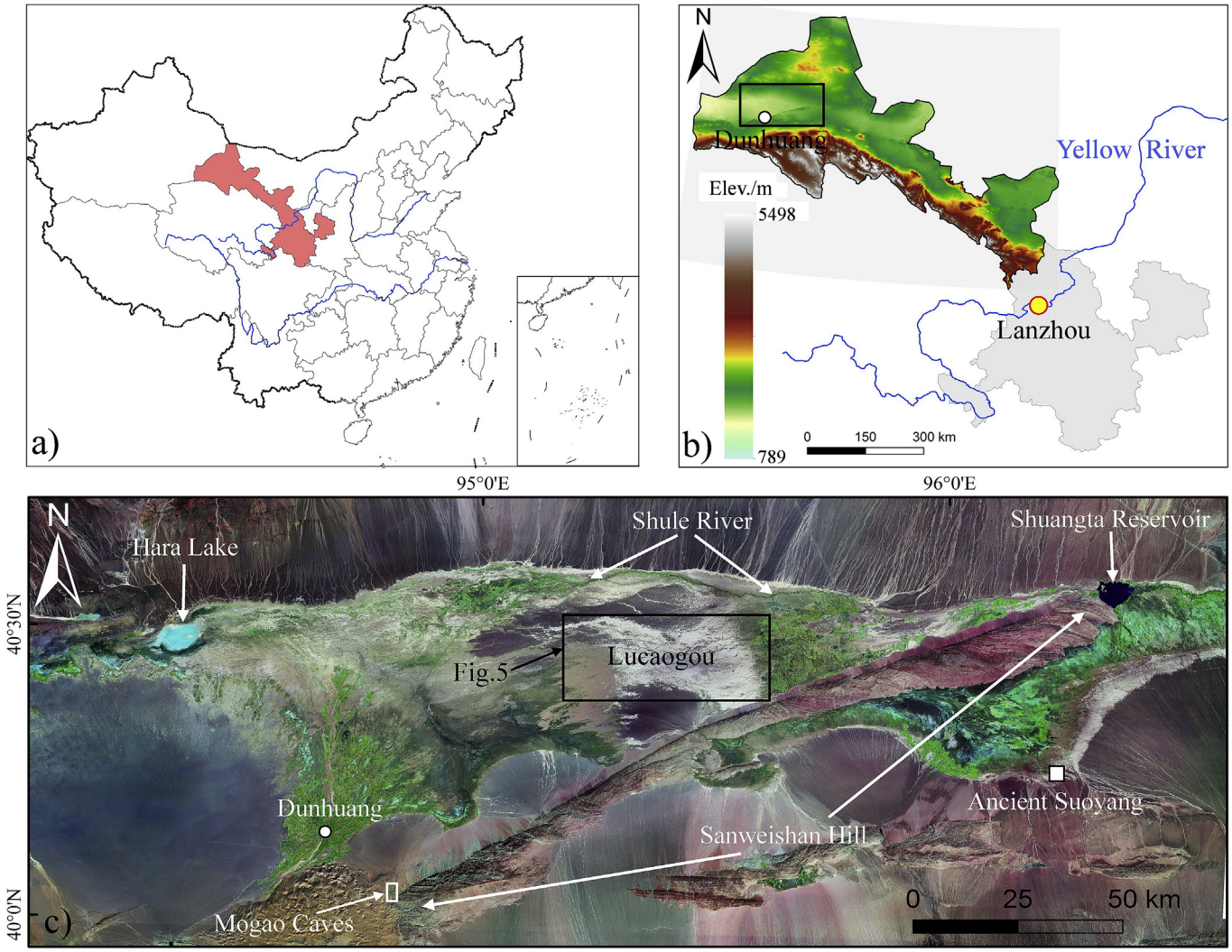

Fig. 1. Location of the study area. a) Hexi Corridor in NW China; b) DEM map of the Hexi Corridor; c) Landsat ETM + data (R (7) G (4) B (1) compositions) from the box in (b).