

An Idea for Ruins Research through Cooperation with Interpretation of the High-resolution Satellite Images, Archeology, Historical Documents and Geography

Hidehiro SOHMA^{*1)}, Ran TIAN¹⁾, Jien WEI²⁾, Kazuki MORIYA³⁾, Shinobu IGURO⁴⁾, Toshio ITO⁵⁾, Noboru OGATA⁶⁾ and Zhiyong YU⁷⁾

Abstract: High-resolution satellite images can easily compare the details of the ruins nearly the same periods based on the archeological information. Moreover, the cooperation through joint field surveys with field scientists of geography, archeology and geo-archeology, in addition to historian and specialist on interpretation of satellite images is preferable. Discussions at fields with various realms of specialists are very fruitful not only for understanding in details of the ruins but for natural environments and terrestrial conditions both of the present and past. Research style on the ruins through cooperation with high-resolution satellite images, archeology, historical documents and geography was named SAHiG being effective in the arid and semi-arid environments. Results of SAHiG for ruins of the Han Dynasty and the Xixia- Yuan periods at Ejina area, in the lower reaches of the Heihe River, Inner Mongolia, China, are reported.

Key Words: Archeology, China, Geography, High-resolution satellite images, Historical documents

1. Introduction

Introduction of high-resolution satellite images, such as IKONOS, QuickBird and ALOS has opened new roads on the research for the historical geography and archeology, especially for ruins in the arid and semi-arid environments. Today, we can easily get satellite images from the small scale of about 10² kms to larger one of about 10² ms with seamless through the web site of "Google Earth". Satellite Images are very effective for observation of earth surfaces and ruins, such as casts of irrigation canals, agricultural fields and wall-surrounded cities. Moreover, they are useful for research on environments and terrestrial conditions around ruins from the sky not only in the larger scale but also in smaller one.

High-resolution satellite images can easily compare the details of the ruins nearly the same periods based on the archeological information. Moreover, cooperation through the joint field survey with fields scientist of geography, archeology and geo-archeology, in addition to historians and specialists on interpretation of satellite images. Discussions at the field with various realms of specialists are very fruitful not only understanding in details of the ruins but natural environments and terrestrial conditions both of the present and past. Research style on the ruins through cooperation

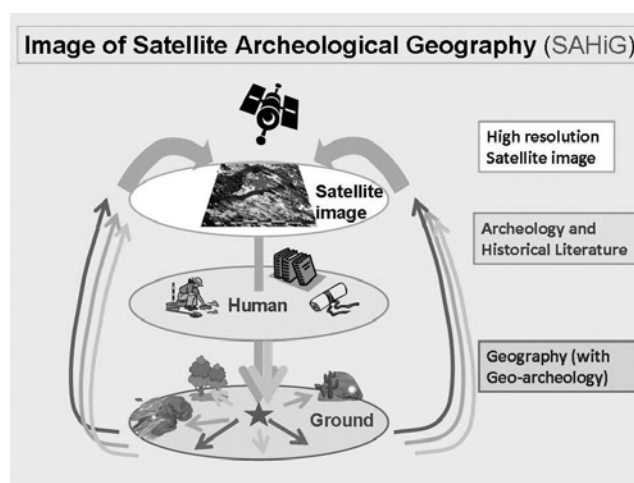


Fig. 1. Image of SAHiG.

with high-resolution satellite images, archeology, historical documents and geography was named SAHiG (Fig. 1), being effective in arid and semi-arid environments.

The purpose of this paper is to introduce results of SAHiG for ruins of Han Dynasty and Xixia/Yuan periods in the arid region of China. The study area is mainly lower reaches of the Heihe River, western part of Inner Mongolia, China (Fig. 2), and the annual precipitation is about 40mm and the mean air-temperature is 8.2°C (Editorial board of regional book on Ejina Qi, 1998).

* Corresponding author: hsohma@cc.nara-wu.ac.jp

(Received July 18th, 2011; Accepted October 4th 2011)

Kitauoya-nishimachi, Nara, Nara, 630-8506, Japan, Tel&Fax: +81-742-20-3324

1) Nara Women's University

3) Osaka Shoin Women's University

5) Osaka Kyoiku University

7) Kyoto University

2) Renmin University of China

4) Waseda Institute for Advanced Study

6) Xinjiang Institute of cultural relics and Archaeology

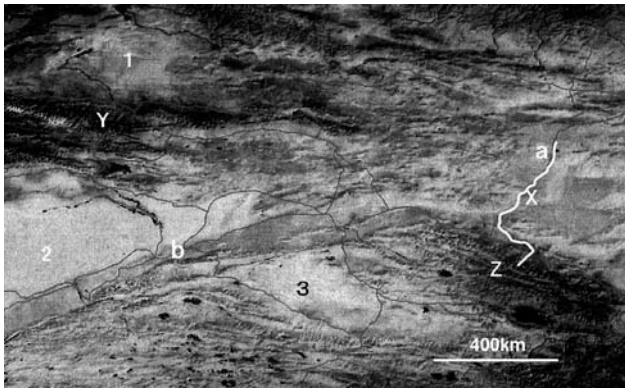


Fig. 2. Study area. a: Ejina b. Miran X. Heihe River Y. Tian Shan Mt Z. Qeilin Mt. 1. Jungal Basin 2. Tarim Basin 3. Zaidum Basin (modified from Research Center for silkroad, 1995)

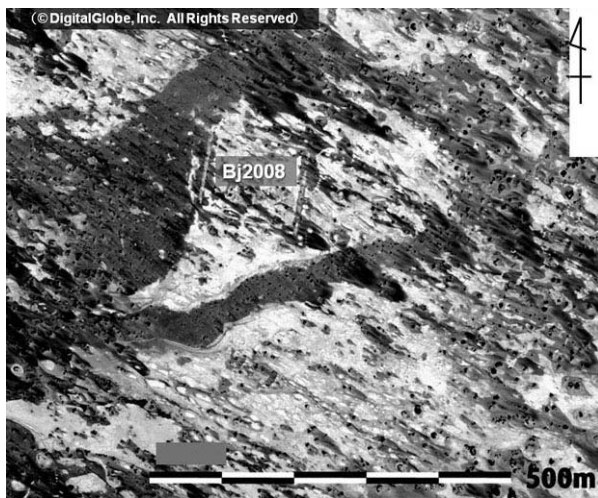


Fig. 3. QuickBird image of Bj2008 ruins

In the Han Dynasty, Juyan colonial soldier-settlement was built in this area (Sommarström, 1956, 1958; Institute of archaeology, Chinese Academy of Social Sciences, 1980; Cultural relic research team of Gansu, 1984).

2. Bj2008 ruins

Based on interpretation of the QuickBird Image, un-reported wall-surrounded ruins, named Bj2008, were observed (Fig. 3, Sohma *et al.*, 2009), with nearly the square shape in the plane with length from 120m to 140m. These features are nearly same both in the size and the plane shape of the largest ones of the Han Dynasty in the study area (Sohma *et al.*, 2010). A channel cast covered by aeolian sand deposits with dark colored (Fig. 3) reminds at the southern part of the Bj2008 ruins, in the slightly meandering pattern.

Locations of main wall-surrounded ruins and three platoons of the Han Dynasty (Cultural relic research team of Gansu, 1984) are illustrated in the Figure 4. Figure 4 shows following special relationships of ruins and terrestrial conditions of the area, a) the Bj2008 ruins are situated just on

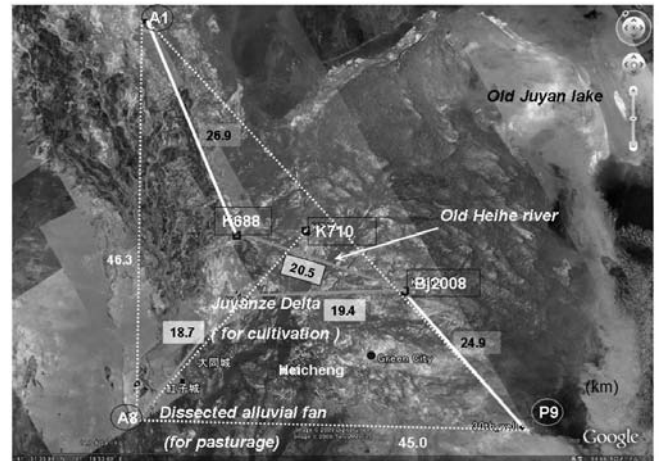


Fig. 4. Locations of main wall-surrounded ruins and three Platoons. (Each numbers show distance in km. Touched in the GoogleEarth Image)

the line connecting platoons of the P9 and the A1, b) distance between the Bj2008 and P9 is nearly same between the K688 and A1, c) the connected line between A8 and P9 roughly separates areas for cultivation and for pasturage, and the A8 platoon is the pivot of cultivation area.

These facts suggest the systematical construction ideas for control systems of the Juyan colonial soldier- settlement area in the Former Han Dynasty.

3. Paleo-agricultural fields in the lower reaches of the Heihe River

Though Jimg (2006) has discussed the paleo- agricultural fields in the lower reaches of the Heihe River, details are not yet clear. Sohma *et al.* (2009) reported the relative heights of Tamarix cones developed on the irrigation canals of the Han Dynasty and the Xixia/Yuen periods are clearly different.

Figure 5 shows the surface conditions around the Bj2008 ruins. The scaly patterns at the eastern marginal part of the Figure 5 show areas of active sand dunes. And there are many parts showing the parallel lines pattern in the NW - SE direction, especially they are clear at the eastern and southern parts of the Bj2008 ruins. These parallel lines pattern are correspond to the yardang topography formed by the severe wind erosion from NW to SE direction. White or bright parts in mosaic pattern are the mud deserts which roughly correspond to the paleo- agricultural fields. Very dark parts are mainly sand deposited parts except the meandering pattern parts which show the paleo-channel casts (Fig. 5).

Figure 6 shows irrigation canal casts of the different periods. Upper one is situated just at the northwestern part of the Bj2008 ruins and belongs to the area of parallel lines pattern. The higher part is an irrigation canal cast and height

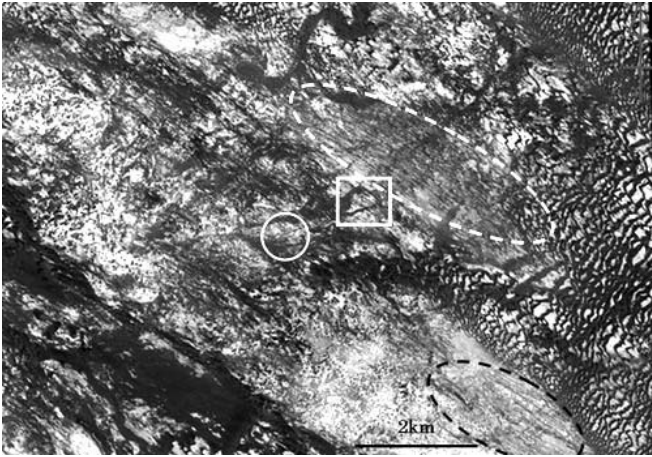


Fig. 5. QuickBird image around Bj2008 ruins. : Bj2008 : agricultural fields of the Xixia and Yuen dynasties, elliptic broken line: area of parallel lines pattern



Fig. 6. Irrigation canal cast near the Nj2008 ruins. Upper: irrigation canal cast of the Former Han dynasty, area of the parallel lines pattern in Figure 5. Lower: irrigation canal cast of the Xixia and Yuen dynasty, “ in Figure 5

differences from the mud desert of the both side are about three meters to four meters (Fig. 6). And the latter parts are considered to the paleo-cultivated fields severely eroded by the strong winds.

Lower one (Fig. 6) is an irrigation canal cast remained at about 700 meters from the Bj2008 ruins to the southwest. There are many fragments of earthen material of the Xixia/Yuen periods near the irrigation canal cast. Height differences between the canal cast and the mud desert of the both side are less than one meter and these values are nearly same those of the irrigation canal casts at eastern part of the

Green City ruins situated about 8 km to the southwest (Sohma *et al.*, 2010). Therefore, the irrigation canal cast of the lower one in the Figure 6 is considered to the cast of the Xixia/Yuen periods.

Based on the above mentioned, upper one in the Figure 6 is considered to the cast of the Former Han Dynasty. In addition, the land surface pattern of long parallel lines around the Bj2008 ruins suggests the possibility that this corresponds to the cast of agricultural fields carried out the “Dai tian cultivate method (Ohshima, 1956)” described in the Former Han Dynasty documents. The method, standing for severe dry and strong wind blown conditions, is composed with long and narrow of alternative ridges and gutters surface pattern, and positions of rows and ridges being changed every year. This method was widely practiced in the arid and semi-arid regions at the Former Han Dynasty. Under the severe wind condition, it is natural to consider that cultivated fields have been easily eroded, and only the main irrigation canals changed to the yardang partly remained after abandonment of the cultivation.

Based on the above mentioned, it is clear the “Dai tian cultivate method” was performed near the Bj2008 ruins at least in the Former Han Dynasty.

4. Estimation of the paleo-irrigation methods

4.1. In case of the lower reaches of the Heihe River

Patches of the cultivated fields of the rectangular in plane shape are clearly distinguished near the habitation site of the Xixia /Yuan periods (Fig. 7). This site is about 3.5 km from the Green City ruins to the southeast and belongs to the delta area of the ancient Heihe River. The dark slightly curved line crossing from northwest to southeast (Fig. 7), is the irrigation canal cast of the Xixia /Yuan periods. Each patch, surrounded by the ridges partly remained with tiny trees, is very flat surface and bordered on the irrigation canal cast. Patches of the cultivated fields of the rectangular in plane shape, bordered by the casts of irrigation canals or channels, are widely remained surrounding area of the Figure 7.

Based on the above mentioned, it is considered the irrigation of the bowl method was applied surrounding area of the Figure 7.

4.2. In case of the Miran ruins

The Miran ruins remains at the lower part of alluvial fan formed by the Miran River running from the Aljin Mt, and at least used in 3th to 4th centuries and 8th to 9th centuries (Stein, 1921). Figure 8 is the QuickBird image of the Miran ruins area. On the Figure 8, the radial pattern of the casts of main irrigation channels and many branched irrigation canal are very clear. In detail, each patch surrounded by ridges is open at the

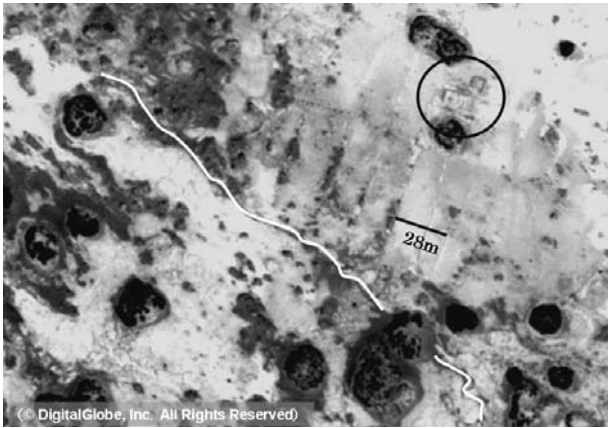


Fig. 7 Habitation site of the Xixia Dynasty/Yuan Dynasty () and cultivated (food production) field casts of rectangular in plane shape. Upper: QuickBird Image, lower: field picture. White curved line: irrigation canal casts.

lower part and suggests application of the border and/or splash irrigation methods during the past cultivation periods. At the fields, signs of salinization were slightly observed. It is considered that the terrestrial condition of the alluvial fan where surface water is easy to seepage to the ground was the important factor for choosing the irrigation methods.

Namely, it is clear the difference between the irrigation methods at the lower reaches the delta area of the Heihe River and the alluvial fan area of the Miran ruins conducted through the interpretation of the QickBird image and field works. And it is considered the difference in the terrestrial conditions of the both area was one of the decisive factors for selecting the irrigation method.

5. Concluding remark

1. Existence of the Bj2008 ruins and distribution of the main installations suggest that control systems of the Juyan colonial soldier-settlement has been practiced based on the ideas for systematical construction.
2. The casts of agricultural fields considered to be carried out the *Dai tian cultivate* method of the Former Han dynasty,

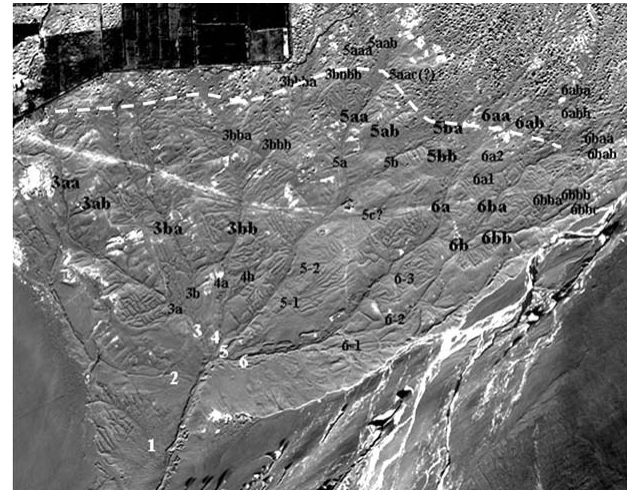


Fig. 8 Distributaries pattern of irrigation canal casts in the Miran ruins area. Dotted line roughly corresponds with the upper limit of the tamarix cone area

were introduced.

3. Based on the height difference between the irrigation canal casts and abandoned cultivated fields around the Bj2008 ruins, it will be possible to separate the used agricultural fields between the Former Han dynasty and the Xixia/Yuan Dynasty.
4. Estimated paleo-irrigation methods between the delta area of the lower reaches of the Heihe River and the lower part of the alluvial fan area of the Miran ruins is different, mainly reflecting the differences in the terrestrial condition.
5. Based on the above mentioned, it is confirmed SAHiG is very effective for research of ruins in the arid environment.

Acknowledgement

This work was supported by the Grant-in-Aid for Scientific Research (A) of JSPS, No. 19251009.

Appendix

Followings are corresponding index of Chinese characters and English letters.

Juyan colonial soldier-settlemen: 居延屯田

platoons: 候官

platoons of the P9: 卅井候官

platoons of the A1: 殄北候官

Dai tian cultivate method: 代田法

References

- Cultural relic research team of Gansu (1984): Research reports on the Beacon towers of Han Dynasty in the lower reaches of Gansu Province. In Cultural relic research team of Gansu and Gansu Museum eds, *Research Anthology of the Wooden Slips of the Han Dynasty*. Gansu People's Publishing Agency, 62-84. (In Chinese)

- Editorial board of regional book on Ejina Qi (1998): *Regional book on Ejina Qi*. Regional book publication house, Ejina, 844p. (In Chinese)
- Institute of archaeology, Chinese Academy of Social Sciences (1980): *Juyan Wooden Slips of the Han Dynasty*". Zhonghua publication house, Beijing. (In Chinese)
- Jing A. (2006): *Vicissitudes of Juyan - Seek for disappeared oasis*. Zhonghua publication house, Beijing. (In Chinese)
- Ohshima R. (1955): *Colonial soldier-settlement and Dai tian cultivation. The Journal of Oriental researches*, **14**(1/2): 1-22. (In Japanese)
- Sohma H. (2004): Ruins of "SILK Road" in the Northwestern China, viewed from Corona Satellite Photographs; in cases of Lou-lan, Miran and Turpan. *Proceedings of the Nara Symposium for Digital Silk Roads*, National Institute of Informatics, 299-308.
- Sohma H., Mu G., Qi W., Hori K., Endo K., Kato Y., Moriya K. (2007): Ruins and environmental changes remained on/around them. *Project Report on the Oasis-region*. **6**(2): 107-121. (In Japanese)
- Sohma H., Tian R., Wei J., Moriya K., Iguro S., Ito T., Ogata N. (2009): Contribution of the high-resolution satellite images to the research on historical science and archaeology; in a case the arid region of China. *Ancient Studies*, **1**: 45-54. (In Japanese)
- Sohma H., Tian R., Wei J., Moriya K., Iguro S., Ito, T. (2010): Unreported wall-surrounded ruins and their significance, in the case of the lower reaches of the Heihe River, Inner Mongolia, China. *Proceedings of the 14th International Conference of HISTORICAL GEOGRAPHY*, Kyoto University Press, Kyoto, 257-258.
- Sommarström B. (1956): Archaeological Researches in the Edsen-Gol region Inner Mongolia, part 1. *Reports from the Scientific Expedition to the North-Western province China under the leadership of Dr Sven Hedin - The Sino-Swedish Expedition-*, 39, Statens Etnografiska Museum, Stockholm: 1-188.
- Sommarström B. (1958): Archaeological Researches in the Edsen-Gol region Inner Mongolia, part 2. *Reports from the Scientific Expedition to the North-Western province China under the leadership of Dr Sven Hedin - The Sino-Swedish Expedition-*, 41, Statens Etnografiska Museum, Stockholm: 188-386.
- Stein A. (1921): *SERINDIA*. V.1-V.5, Oxford, London.
- Zhu Z., Liu Y., Gao Q., Hu Z., Yang Y. (1983): The Environmental Changes and Desertification processes in Historical Period in the Areas of Ancient Juyan-Heicheng Region, in Western Inner Mongolia. *Journal of desert research*, **3**(2): 1-8. (In Chinese)