Symposiums

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Environmental Changes and Human Activities in the Taklimakan Desert and Its Environs

Introduction to the Symposium

TAKAMURA Hiroki,* KADOMURA Hiroshi,*
SOHMA Hidehiro,** TASE Norio,***
and HAMADA Hiromi****

*Rissho University

**Nara Women's University

***University of Tsukuba

****Chiba University

In April 1983, the Association of Japanese Geographers established a research group on "Arid and Semi-Arid Regions" (headed by T. Takamura). After holding a symposium on "Desertification" in September 1986, the outcome of the group activities was synthesized in a special issue of the *Geographical Review of Japan* on "Desertification" which was published in February 1988. This served to stimulate research in Japan on arid lands worldwide, including those undergoing desertification and land degradation, and had a strong impact on the formation in 1990 of "The Japanese Association for Arid Land Studies" by those in the field.

Since its creation, the Japanese Association for Arid Land Studies has had a strong interest in the investigation of the Taklimakan Desert in China, which is one of the world's major deserts, and it organized a Japan-China international symposium on changes in the natural environment that serves as the foundation for life in the Taklimakan Desert. The symposium, which was held in June 1995, was entitled "Human Lifestyles and Environmental Changes in the Taklimakan Desert," and the February 1996 Issue of the Association's journal, the *Journal of Arid Land Studies*, was devoted to this topic.

Partially due to this background, research and academic exchange in Japan related to arid lands underwent tremendous diversification and internationalization, not only in the physical and social sciences, but also in the fields of

engineering and ecology. However, there was a lack of uniformity in regard to the terminology for arid lands and research methods, and little progress was made in the sharing of information. One result is that there are few compiled bibliographies of the literature on arid lands. In addition, the quality of the results from the research poorly reflected the amount of funds spent, and the initial goals were not achieved.

During the period 1998–2000, however, a new Japan-China international research project—"Land Degradation in the Oases on the South Side of the Taklimakan Desert," sponsored by a Grant-in-Aid for Scientific Research from the Ministry of Education, Culture, Sports, Science and Technology of Japan and headed by T. Takamura—has attempted to improve this situation and has reached the first stage of completion. Taking advantage of this occasion, as well as the general consensus that now is the time for promoting the exchange and cooperation among various organizations and researchers, we held the symposium summarized in these abstracts, with the goals of establishing again an "Arid and Semi-Arid Region Research Group," helping to clarify the current status and problems in arid lands studies, and promoting information exchange among researchers. The sixteen presentations at the symposium reflect work that was done not only by members of the Association of Japanese Geographers, but also by researchers from the Xinjiang University in China. We believe that each of the papers and discussions at the symposium will contribute to the advancement of research not only on the Taklimakan Desert but also on the world's arid lands in general by providing new findings, methodologies, and insights.

On the Daily Changes in Temperature of the Surface Sands in the Taklimakan Desert

SUZUKI Yuichi,* TAKAMURA Hiroki,*

OHTA Tsuyoshi,** and

INAMURA Akihiko***

*Rissho University

**University of Tokyo

***Geological Survey of Japan

The surface sand of the desert is extremely dry, so it is thought that its moisture content is almost zero, and it is expected that the range of the changes in surface soil temperature is large. The authors carried out field observations of soil temperature in the Taklimakan Desert in Xinjiang, China.

In order to obtain fundamental data on the heat and water content near the surface of the desert, field observations of soil temperature and water content of the surface sand were carried out 200 km north of Keriya, near the center of the desert.

In November 1998, the authors carried out the observations of soil temperature, and in August and September 1999, those for soil temperature and water content were taken. From these observations, the following results were obtained.

1) The amount of moisture content in the surface sand was measured using a simple soil moisture measuring instrument (ADR method). However, the moisture content was extremely low, so the authors could not obtain enough data.

2) The air temperature (dry bulb temperature) was the highest at 14:00 and the lowest at 6:00. Changes in wet bulb temperature showed the same tendency as those for dry bulb temperature.

3) The temperature of the surface soil, i.e. the soil temperature at 0 cm, was the highest at 14:00, when it rose to 65.1°C. The lowest was 14.9°C at 6:00.

4) The automatic recording sensors for soil temperature were set for depths at 5 cm, 15 cm, 30 cm, and 60 cm. The diurnal range of the soil temperature was the largest at 5 cm deep, being 19°C. The minimum was 25°C and the maximum was 45°C. The range of soil temperature at 15 cm is 4°C, at 30 cm 1.3°C, and at 60 cm almost zero.

5) The thermal diffusivity of surface sand was estimated to be 0.001 to 0.012 cm²/s.

Sediment Transport Processes along the Keriya River in the Southern Part of the Taklimakan Desert, Xinjiang, China

SHIMAZU Hiroshi

Rissho University

The Keriya River begins in the Kunlun Mountains and flows down into the Taklimakan Desert. The Yutian Oasis, which has one of the largest settlements along the southern rim of the desert, is situated on the toe of the Keriya River alluvial fan. This study aims to clarify the sediment transport processes along the Keriya River. The relationship between downstream change in channel slope and the diameter of the riverbed sediments is used for this discussion. Channel slopes were calculated from data taken in the field and morphometric analysis data from Chinese topographic maps.

The surveyed river course can be divided into four sections, being the upper section, the fan surface section, the fan toe section, and the desert section. The upper section is between Pulu (2,500 m a.s.l.) and the fan apex (1,900 m a.s.l.), and it has a channel slope between 4% and 1%. This section is a dissected valley in the hills along the northern foot of the Kunlun Mountains. In the valley there are several levels of terraces, and the riverbed has huge boulders larger than 100 cm. The boulders were transported by mudflows, not by gravelly type debris flows which occur in the steep slope rivers in Japan. The mudflows include much fine sand and silt and are caused by meltwater floods in spring. The fan surface section extends to the Yutian Oasis (1,420 m a.s.l.). In this section the many artificial channels used for irrigation are widely distributed on the fan, however the original channel of the Keriya River is not clear. The slope of the fan surface decreases downstream from 1.4% to 0.7%. Sorting takes place and gravels accumulate on the fan, their sizes decreasing downstream. In the fan toe section the channel dissects the fan surface at 10 to 20 m in depth. The channel slope in this section decreases from 0.5% to 0.2%. Weathered fan deposits are washed out and are crushed into finer sediments. In this

section the sorting process is very strong. At the end of the fan toe section (1,370 m a.s.l.), the channel slope decreases abruptly to 0.1%. Because all the gravels are deposited on the fan and in the fan toe section, only sandy and silty sediments are transported into the desert.

The Present State and Problems of Soil Degradation in the Oases on the Southern Margin of the Taklimakan Desert

ZAYDUN Payzulla and
TAKAMURA Hiroki
Rissho University

China currently has a crisis in feeding 1.3 billion people. Western China is an arid and semi-arid area that occupies 55% of the total land area of China and where efforts in mitigating soil degradation are required in order to help solve this problem. Since the southern margin of the Taklimakan Desert is an extremely arid region, soil degradation has become the most serious problem in this area.

The total area of desertified land in each oasis and its peripheral area of the Hotan district has reached 16,700 ha since 1955, and it occupies 4.6% of the oasis area. Of that area, 5,900 ha has become desertified from cultivated land. Since the prevailing wind directions are north-westerly and westerly, in the Qira oasis most of the soil which is being desertified is concentrated in the west and northwest of the oasis where the groundwater level is deep.

Soil salinization is a serious problem in this region. At present, the area under secondary salinization in the Hotan district has reached 17,400 ha, which includes 7.8% of the cultivated land. Since the topography is comparatively low in the eastern and northeastern section of the Qira oasis, and the groundwater level is high (within 2 m), saline deposits have accumulated there at the soil surface. Its water is saline, although the soil texture is sandy.

From a field study on land devastation in the Qira oasis, it is estimated that a total of 4,913 ha became desertified from 1949 to 2000, and that the area of salinization is 4,581 ha. It is well recognized that desertification has progressed rapidly with the increase in groundwater depth. It is estimated that the depth of the groundwater level of the non-desertified area is higher

than 3.7 m, and that it is lower than 7.5 m in the extremely desertified area. The problem of salinity in the irrigation water, which produces secondary salinization and can be blamed on poor irrigation technology, cannot be solved by water management and soil management alone. Solutions to the problems of energy shortages and poverty have not been forthcoming, hence these problems continue to linger in this region.

Discharge Change Estimated by the Downstream Variation in Water Chemistry: A Case Study of the Keriya River, Xinjiang, China

OHTA Tsuyoshi,* TAKAMURA Hiroki,**
SUZUKI Yuichi, ** INAMURA Akihiko,***
YASUHARA Masaya,*** TIYIP Tashpolat,****
and YIMIT Hamid****

*University of Tokyo

**Rissho University

***Geological Survey of Japan

****Xinjiang University

Among the environmental problems in arid areas, water problems such as shortages and high salinity can be very serious. In order to secure a proper quantity and quality of water, it is important to foster a better understanding of hydrological environments in arid areas, based on such hydrological data as precipitation, river discharge, and evapotranspiration. However, because water is scarce and unevenly distributed in arid areas, the amount of hydrological data that can be observed in an arid area is very limited.

The objective of this study was to apply the best method to make use of limited hydrological data in an arid area. The regional variations in the water chemistry of the Keriya River basin, Xinjiang, China, are demonstrated, and the rate of decrease in river discharge has been calculated from the downstream changes in the water chemistry.

According to its water chemistry, the Keriya River can be divided into four reaches, as explained here.

1) In the upper reach, the longitudinal changes in the chemical composition of the river water are caused by the confluence of tributary streams. An isotopic altitude effect is detected.

2) The middle reach runs through the

Keriya (Yutian) Oasis, which is located on the toe of an alluvial fan. In this reach, the downstream change in the water chemistry of the river water is very complex. The regional variation in the chemical and isotopic composition of the groundwater is great. These facts suggest that the interchange between the river water and groundwater plays an important role in the water chemistry in this reach. However, other factors such as the conjunction with a large tributary and the use of irrigation water around the Keriya Oasis remain to be examined.

3) In the lower reach, evaporation has a great influence on the chemical and isotopic compositions. The river water is more concentrated chemically and isotopically heavier in the lower reaches. Electric conductivity, Na^+ , Cl^- , SiO_2 , δD , and $\delta^{18}\text{O}$ increase at a constant rate. The rate of decrease in river discharge can be calculated using these downstream changes, and the evaporation loss in this reach is estimated at 40% at most.

4) In the lowermost reach, where the Keriya River breaks up into a few channels, the downstream change in the water chemistry of the river is complex, and the groundwater chemistry shows a great regional variety. It is possible that the interchange between the river water and groundwater causes these variations.

The Chemical Composition of River Water and Groundwater on the Southern Margin of the Taklimakan Desert of China

TAKAMURA Hiroki,* KONO Tadashi,**

OHTA Tsuyoshi,*** SUZUKI Yuichi,*

YASUHARA Masaya,****

INAMURA Akihiko,****

KISHIMOTO Junpei,*****

YIMIT Hamid,***** TIYIP Tashpolat,*****

and XIONG Heigang*****

*Rissho University

**Nippon Bunri University

***Tokyo University

****Geological Survey of Japan

*****Nissoku Co.

*****Xinjiang University

The purpose of this study was to investigate temporal and spatial changes of stable isotopes and the chemical composition of the river water and groundwater in the Keriya, Niya, and

Qarqan watersheds, and to elucidate the hydrological environment on the southern margin of the Taklimakan Desert in China. The three watersheds, located in arid and semiarid regions, were divided into areas based on hydrological conditions, and the water quality of each area was examined.

The source of the three rivers is a glacier straddling the 6,500 m high Kunlun Mountains, their middle parts flow through piedmont alluvial fans, and their downstream parts disappear in the middle of the Taklimakan Desert. The river basins invariably become arid because they have less than 250 mm annual precipitation.

Water quality was determined by analyzing twelve samples of river water and ten samples of groundwater in the Keriya River basin, one sample of river water and four samples of groundwater in the Niya River basin, and 14 samples of groundwater (well water) in the Qarqan River basin. The results of analysis of the Niya River in May showed a Ca-SO_4 type geologic eluviation with little change from the upper area to the lower area. This finding suggests a relatively active crosscurrent of river water and groundwater. On the other hand, the groundwater quality on the flanks of the Qarqan River basin showed a Ca-Mg-SO_4 type upstream, with a progressively greater concentration downstream, and characteristics of a Na-Cl type evaporation effect were also found. The water quality showed high concentrations because there were few settlements downstream. Also water samples could not be taken in the middle part of the basin because of contamination by irrigation water used in the vicinity of Qarqan City. The water quality of the Keriya River basin was of the Na-HCO_3 and $\text{Ca}^{2+}\text{-HCO}_3$ types upstream, while the middle and farthest downstream areas were of the Na-Cl type throughout the year. Although stable isotopes of river water in the Keriya River basin presented a rather complex longitudinal change in conjunction with the confluence of crosscurrents, there was a high degree of distribution in the basin and comparative study revealed its effectiveness. The influence of evaporation increased in accordance with the distance downstream, chemical composition be-

came concentrated, and the water became noticeably heavy with isotopes.

In general, the river basins of this region can be classified into five hydrological zones: the snow and ice accumulation zone at the headwaters in the Kunlun Mountains, the evaporation and permeation zone of the alluvial fan and the floodplain in the upper and middle parts of the basin (the effluent stream zone), the river water/groundwater crosscurrent zone in the middle of the basin (the influent stream zone, or groundwater intake river water zone and stony desert), the intermittent river water zone of the lower area (influents and evaporation zone on the sand dune area), and the non-stream zone of the lowest basin (ancient oasis settlement distribution area in the desert zone of severe evaporation).

Groundwater Level Variation and Its Environmental Effects in the Southern Part of the Tarim Basin (The Case of the Qira Oasis)

YIMIT Hamid,* TIYIP Tashpolat,*
and TAKAMURA Hiroki**

*Xinjiang University

**Rissho University

The Qira Oasis lies in the southern part of the Tarim Basin and along the northern foot of the Kunlun Mountains. Its ecological environment has been influenced by human activities in the last 50 years, and it has become an area where water has been sought and utilized.

The level of the surface water in the oasis is about 10 to 100 m higher than the groundwater level, so a great deal of surface water seeps down to replenish the groundwater but turns into a subsurface stream. Whatever remaining surface water that does not evaporate is directed toward irrigated places, but most of it seeps down to form underground water. Some small rivers disappear in this area, but the Nur and Qira Rivers flow into the plain of the oasis.

When the seeped groundwater is flowing to the upper part of the oasis in the east of the plain, which has fine soil on the edge of a diluvial fan, the lower topography and the weakening ability of the water to infiltrate further underground causes the water level to rise, and some of the subsurface streams formed by infiltration reach the ground in the form of a

spring. This has resulted in six spring rivulets in the Damko and Gulahma irrigation area where discharge reaches $0.9 \times 10^8 \text{ m}^3$. Not counting the water which is pumped in the county, $1.21 \times 10^8 \text{ m}^3$ of the groundwater becomes runoff from these springs, accounting for 20.7% of total runoff.

The characteristics of the yearly variation of groundwater depth are:

1) Groundwater level and depth increase gradually from north to south in the Qira Oasis. In the southwestern part of the oasis the groundwater level declined 15 to 20 m from 1982 to 1997, lower amounts being to the north and the least variations being on the edge of the desert.

2) The southwestern part of the oasis experiences declines more quickly than does the northeast, which increases in relative proportions.

3) In the eastern part of the oasis, the groundwater level rises. In the middle of the Gulahma Oasis, the groundwater's depth is 2 to 5 m, which is 3 to 6 m higher than it was in the 1950s. However, it changes little in Damko, varying only between 2 and 3 m.

In regard to the relationship between groundwater and soil salinity, the results of this research show that soil salinity is associated with groundwater depth. The deeper the groundwater, the less the soil salinity, and vice versa. When the groundwater is near the surface, the soil salinity has a close connection with it, but as the groundwater level declines, it has less influence on soil salinity. When the groundwater depth is less than 2 m, soil salinity varies strongly with the groundwater level variation, but this influence declines when the groundwater level is between 2 and 3 m and is negligible when it is more than 3 m deep.

Historical Paleoclimatic Changes since about 4.0 kaB.P. Recorded in the Niya Section, Southern Xinjiang

ZHONG Wei,* XIONG Heigang,*
TIYIP Tashpolat,* TAKAMURA Hiroki,**
and SHU Qiang*

*Xinjiang University

**Rissho University

One of the seven key plans of the IGBP pro-

ject is the PAGES, of which the mutual relationship between mankind and natural environmental changes during historical times has attracted great attention all over the world. Due to the difficult natural conditions, study of these issues has not progressed far in southern Xinjiang. Hence, to study the interrelationship between human activities and paleoenvironmental evolution during the historical period in this area is of great theoretical and practical significance to throw light on the formation and development of the extremely dry climate, to explain the processes of the historical evolution of man-land relationships in an arid area, and to promote regional sustainable development.

For an understanding of the relationship between the processes of paleoenvironmental and climatic evolution and the human activities in southern Xinjiang during the historic period, we obtained a high resolution deposit section from Minfeng County in October 1999. For this article, we extracted some information about paleoenvironmental changes based on this section.

Through a comprehensive study of the high resolution multi-geological proxies of the Niya section, a paleoenvironmental history around 4.0 kaB.P. in this area has been reconstructed. During the last 4,000 years, the area of the southern Tarim Basin has experienced alternations of relatively cold-moist and relatively warm-dry periods. Three evident cold-moist periods (4.0–3.45 kaB.P., 2.50–1.90 kaB.P., about 1.40–1.00 kaB.P.) and three warm-dry periods (3.45–2.50 kaB.P., 1.90–1.40 kaB.P., 1.00 kaB.P.–present) have been identified, and they coincide with historical temperature fluctuation records in eastern China. The present study also shows that the paleoclimatic changes that occurred in the Niya section in the past 4,000 years presented a clear Westerlies style model, according to which relative humidity increases during cold periods, but a dry regime characterizes warm periods. Our studies also demonstrated that human activities were closely related to the evolution of the paleoclimate in southern Xinjiang. The paleoclimate played a very important role in influencing the evolution of agriculture and other human activities since 4.0

kaB.P.

Research on Plant Community Diversity and Its Spatial Distribution Structure in an Oasis-Desert Ecotone in the Southern Taklimakan

ABDUSALIH Nurbay,* XIONG Heigang,*

TIYIP Tashpolat,* ZHONG Wei,*

TAKAMURA Hiroki,** and

HUANG Peipou*

*Xinjiang University

**Rissho University

Because environmental conditions and the adaptation of vegetation types naturally vary in different regions, particular plant communities are combined to form a regular combination in a particular natural environment. Research in plant community diversity examines the differences in constitution, structure, function, and dynamic aspects of a plant community, so researching plant community diversity and its spatial distribution is important for studying landscape ecology.

This paper analyses the relationships between the species diversity index of different vegetation types, the evenness of vegetation types, and succession phases based on field research and data about the oasis-desert ecotone in Keriya and Qira from 1996 to 2000. The changes in the diversity index of vegetation types and their evenness in this area reflect different habitats and a fragile ecological environment. An increase in community diversity corresponded to community succession, but the community diversity in this area is not as high as it theoretically might be.

Species diversity corresponds with altitude and sand components. There are distinctive degrees of landscape change from south to north (oasis to desert) in the ecotone around 150 m. Species diversity and landscape contribute to the evolving characteristic of vegetation in the ecotone. The diversity index and evenness index both reflect the same result, but the Shannon-Wiener index is more sensitive to changes in the ecotone.

The vegetation succession in an oasis-desert ecotone is different from that on sand hills because the water and the nutritional conditions of the soil are better in the ecotone. Therefore, biological classes, quantity, and biological light-

ness are much better than on sand hills, which has led to an interest in economic development in the Keriya-Qira ecotone. Because of this, people should protect the environment by modifying their use of fuel and working towards sustainable development in their regional economy.

The ecological environment is fragile in the ecotone, especially during the period of recovery after wood has been cut down. In one area there is a well-used path where the species diversity index is very low, even though it is at a high elevation between sand hills. Human intervention is therefore very important for ecological recovery in desert regions.

Irrigation Agriculture in the Minfeng Oasis, Niya Prefecture, Xinjiang Uighur Autonomous Region, China

SAWADA Hiroyuki
Rissho University

The object of this paper is to report on changes in the irrigated agriculture practiced in the Minfeng Oasis, one of the oases being developed along the southern rim of the Taklimakan Desert, as well as the irrigation system itself and the problems the system involves.

The irrigated agriculture carried on in the Minfeng Oasis has been changed remarkably by the spread of year-round irrigation owing to the construction of a large irrigation canal, the digging of wells for irrigation, and the introduction of cotton as a cash crop.

Under the irrigation system in which irrigated work can be conducted simultaneously in each farmland division, all the farmers till their fields within the same season. The irrigation system, furthermore, is useful for maintaining economic equality among the farmers, so it has prevented a remarkable development of agricultural productivity through ingenuity and competitions among the farmers.

Agricultural Life in the Niya Oasis

UMEMURA Hiroshi and
SUZUKI Kentaro
Chuo University

The farmers of the Niya (Minfeng) Oasis in the southern part of the Taklimakan Desert in Xinjiang, China, live in traditional farmland but

are facing economic change. Just before the Chinese governmental plan to develop the western regions was to be implemented in this area, we conducted a field study of their conditions in September 2000.

98% of the population of over 33,000 in Niya prefecture are Uyghurs, and 95% are farmers. 65% of them are purely crop farmers, and the rest also breed cattle. The main crops are corn and summer wheat, and cotton is widely cultivated. The cultivated land of the village of Niya is 4,875 ha, about 70% of which was developed after the construction of the Bayiba (8-18) Canal in 1971. The population of the Chimliq-Ostan *kent* belonging to this village, where we conducted interviews, is 229 houses comprising 1,161 individuals, almost all of whom are Uyghurs and 75% of whom are natives of this *kent*.

Because of the shortage of water for irrigation, the cultivated land is limited. The village government has to allot 14 a equally to each male between 18 and 50 years old and each female between 20 and 45. According to what we learned from the interviews, there had not been many opportunities to develop new industries that would create anything but small jobs outside the agricultural sector in the last 20 years.

This area has a traditional Islamic culture, as do other places in southern Xinjiang, but it is stifled by the government because of a fear of influence from Islamic countries west of Xinjiang. The governmental policy of birth control, incidentally, seems to be well established among the villagers.

Based on published data, the Niya Oasis seems to have started cultivating cash crops and breeding cattle to complement millet cultivation. Farmers expect to earn money from fruit which will be consumed by users of the newly constructed highway that crosses the Taklimakan Desert.

The problems facing this area are 1) since the scarcity of water limits the rapid development of agriculture, new industry or a new irrigation canal will be needed for economic development, despite the population being small; and 2) if sudden industrial change is created from outside, the traditional Muslim farmers will suffer

from socioeconomic confusion.

The Hydrological Environment and Movement of Ancient Oases in the Southern Part of the Taklimakan Desert, China

OMAR Gulmira and
TAKAMURA Hiroki

Rissho University

Over the past 2,000 years, oases in the southern part of the Taklimakan Desert have shifted upstream on every river to their present locations. Because the exact reason for this was not known, this study aimed to elucidate the cause from a hydrological perspective. Climatic change and the location of ancient oases in the southern part of the Taklimakan Desert indicate that these oases flourished during warm periods. Evidence shows that the volume of river discharge increased considerably during warm periods in ancient times. The river discharge during each period when the ancient oases were present was calculated by using a correlation formula for the discharge yield and the length of the permanent stream in the rivers at present (water loss = $0.435 \text{ m}^3/\text{s}/\text{km}$). The discharge of the Keriya River increased sixfold during the time of the Han Dynasty (206 B.C.–A.D. 220), and that of the Niya River increased tenfold. Additionally, the variation in river discharge was influenced by human activities when the amount of water taken from the rivers for irrigation and the necessities of living led to a decrease in discharge.

The Conditions of the Miran Ruins and the Present Miran Oasis in the Southeastern Part of the Tarim Basin, China, Based on an Interpretation of Declassified Intelligence Satellite Photographs

SOHMA Hidehiro

Nara Women's University

Since antiquity the Tarim Basin has been an important area along the so-called Silk Road. Many remains from the Han through the Tang dynasties are found here, and it is well known that there are ruins such as those of Niya, Karadong, and Dandanoilik located 100 to 300 km downstream from present-day oases at the foot of the mountains and along the same north-flowing rivers. These ruins are found on the

southern margin and near the center of the basin and are limited to the areas downstream from the current oases from Qira to Qarqan. Because there had been little research into the reasons for this, this study examined the Miran Ruins which are located along the former road that went along the southeastern part of the Tarim Basin, and which have similarities with the ruins mentioned above. The research was undertaken by using Corona Satellite photographs to examine the local environment and the geographical relationship of the Miran Ruins with the present oasis of Miran at the base of the mountains. One result was to compile basic data for a uniform understanding of the geographical relationship between ruins in the entire Tarim Basin and present-day oases at the foot of the mountains.

Corona Satellite photographs with a maximum terrestrial resolution of about 2 m were made available to the public in 1995. These photographs can be viewed stereoscopically and are easily digitized from the film. In surveys of archeological ruins in regions for which it is difficult to obtain aerial photographs, those from satellites are extremely useful.

The Miran River runs from the southern Altun mountain range into the Tarim Basin, and the Miran Oasis was developed for agriculture at the edge of the alluvial fan at the foot of the mountains. Later, the river merged several kilometers downstream with the Qarqan River, which runs east-northeast nearly parallel to the base of the mountains. The Miran Ruins are a possible site of the Lolan Kingdom, which may have moved in 77 B.C., and from these ruins have been unearthed "winged angel figures" thought to be from temple ruins. On the other hand, the current old castle of Miran was the main castle of the Tufan people of Tibet sometime around the 8th and 9th centuries A.D. These types of ruins therefore date to at least two different periods.

Both the Miran Oasis and the Miran Ruins are located at the end of the complex alluvial fan formed by the Miran River. It is presumed that the ruins are irrigation canals and a road network, and two sets of land division patterns are observed. One exhibits a cross-type pattern of approximate rectangles lying in essentially

north-south and east-west directions, which are quite different from those of the castle walls of the old Miran Castle. The other pattern is close to a slightly deformed rhombus that has been pressed in from the north and south, and it is centered on the old Miran Castle. The intervals between its main roads leading to the ruins are larger than those on the first pattern. These ruins are located on a newer alluvial plain which had formed above that with the older ruins, and they are located slightly further downstream than the older ruins. The relative height of both geomorphic surfaces is less than 5 m.

From the fact that the current Miran Oasis and the Miran Ruins are on different geomorphic surfaces, and that the geomorphic surface on which the ruins of irrigation canals and the like were located is thought to have been mostly low-lying ground at the time it was used, it seems highly possible that new geomorphic surfaces were added after these structures became ruins. This kind of positional relationship between the Miran Oasis and the Miran Ruins is thought to reflect that, apart from the changes in flow volume, the volume of flow in the Miran River was fundamentally smaller than that of the Niya River, and also that oases could not be formed at a long distance downstream because of the merging of the Miran with the main stream, the Qarqan River, not far downstream from the Miran Oasis.

Topography and Environmental Changes in the Taklimakan Desert

ENDO Kunihiko and
KANEMAKI Motoko
Nihon University

Based on the results of field surveys and analytical studies, environmental changes in the Quaternary, processes of landform evolution in the Taklimakan Desert, especially in regard to the formation of its draa ridges, and environmental changes in the last 20,000 years were discussed.

A 100 m-long core which was taken from the center of Lop Nur covers all of the Quaternary. The results from pollen analysis made it clear that the aridity of the Taklimakan Desert has increased since the early Pleistocene, when for-

est and steppe environments alternated periodically. In the middle and late Pleistocene, however, steppe and desert environments alternated periodically. These changes may correspond to glacial/interglacial cycles.

In the Tarim Basin, inflowing rivers form alluvial fans at the margin of the basin and alluvial terraces (A to F) along the rivers in the inner Taklimakan Desert. The old terraces are covered with eolian sand in such formations as vegetation cones, barchan dunes, and draa ridges. Many factors are related to the local landform evolution, one being tectonic movement along the southern margin of the basin.

An important factor is the transport of surface materials by the prevailing northeasterly wind. Fluvial activities from the Kunlun Mountains cause floods and transport a great amount of sediment into the desert areas. The northeasterly wind carries sand and silt sediments back to the center and southern part of the desert.

The most striking characteristic of the Taklimakan Desert is its draa ridges, massive longitudinal sand dunes with heights from 40 to 150 m and lengths of a few tens to more than 100 km. The draa can be divided into two groups according to the directions of their ridges. One group has a NE-SW axis, which was formed by the northeasterly wind and occupies almost all of the area in the eastern half of the desert. The other has a NW-SE axis formed by the northwesterly wind and is distributed only in the western and southern parts of the desert.

Radiocarbon and TL datings clarified the age of the terrace deposits and sand dunes, including the draa ridges. Terrace F and the draa ridges covering it date to around 17,000 y.B.P., while Terrace E and its draa ridges date to about 13,000 y.B.P. From 10,000 to 8,000 y.B.P., the draa topography was partly modified, and since then the formation of draa has not continued, so only barchan dunes are migrating on the surface.

These processes suggest that rapid melting of mountain glaciers caused large scale floods in the desert areas during the last stage of the Last Glacial. Thin flood sediments, a sheet of sand and silt, widely covered the dried-up desert surface and were easily transported by northeast-

erly and northwesterly winds to make draa ridges in the desert and loess beyond it.

Population Problems and Some Countermeasures in Yutian County

XIONG Heigang,* ZHONG Wei,*
TIYIP Tashpolat,* YIMIT Hamid,*
ABDUSALIH Nurbay,* MA Xiaoyu,*
TAKAMURA Hiroki,** and
SUZUKI Yuichi**

*Xinjiang University

**Rissho University

By analyzing the population in Yutian county, we can find that it is experiencing fast growth, which negatively affects the already backward economy and fragile ecology in the region. To a certain degree, it can be concluded that the fast growth of the population is the main factor that causes poverty and a shortage of local natural resources. We have analyzed the population change in Yutian county in order to forecast further changes, solve the population problem, and provide a scientific basis for eliminating poverty and making the county prosperous.

"Western Development" needs a good relationship between the population, resources, and environment for sustainable development. The most important factor in sustainable development is population, so we must regard population as the main factor in the relationship. To study the population well, we need to know what causes changes in it, something that is especially important in this underdeveloped, desert region inhabited by a minority people. We must control population growth to strike a balance between it and economic development, to enhance the quality of the people so that they will be a valuable human resource, to create a stable social environment for "Western Development," to have the optimum population for sustainable development, and to turn poverty into prosperity.

Yutian is an agriculture-oriented region where the effects of history, nature, geography, and economy have caused a serious problem of overpopulation. The population structure is not rational. As can be seen from the first, second, third, and fourth censuses, more than 90% of the population in Yutian is agricultural.

However, farmland is limited, and the contradiction between increasing population growth and limited farmland is obvious. To improve the population structure, we first need to solve the problem of overpopulation in the agricultural sector.

We can solve this problem by doing the following:

- 1) Increase job opportunities and encourage farmers to leave the countryside for the towns.
- 2) Develop town and township enterprises to encourage the agricultural population to enter the industrial and service sectors, which themselves require developing. This not only creates jobs to absorb the excess population, but also satisfies the physical and mental needs of the people.

- 3) Export labor so that people can work as farmers when necessary and as nonagricultural workers or businessmen in the agricultural off-season. This could contribute to the development of agriculture and the high technology industry. The structure of the urban and suburban populations, the industrial and agricultural populations, and the sex ratios ought to be rational.

The population problem in Yutian reflects the problem of other poor regions in Xinjiang as well. If we study the population problem carefully in Yutian, we can contribute to solving the overall population problem in Xinjiang and help to solve the problem of poverty as well.

Study on Dynamic Change in an Oasis-Desert Ecotone Using Fractal Theory

TIYIP Tashpolat,* DING Jianli,*
ZHAN Jianqiang,* and
TAKAMURA Hiroki**

*Xinjiang University

**Rissho University

This study was based on detailed information obtained in the study area, used multi-time satellite remote sensing data for its main sources of information, and analyzed and quantified the desertification of Qira county and changes in its oasis-desert ecotone. The function of fractal theory in the quantitative analysis of the oasis-desert ecotone is discussed and proved to be valid. The model set up in this study could be

useful for making decisions about regional development and construction.

An oasis is a special, fragile ecosystem, so it is important to develop oases rationally and harmoniously. Studying the process and features of conversion from an oasis to a desert has great significance for understanding the progress of evolution, ecological features, and their formation in a such a special zone.

Based on the remotely sensed data, this particular paper discusses the feasibility of fractal theory in regard to how an oasis evolves into a desert and draws the following conclusions:

- 1) Fractal theory is viable when used to study evolutionary trends in an oasis that is converting to desert land. The calculated values for fractal dimensions corresponded with the concurrent distribution of oasis, oasis-desert, and desert ecotones.

- 2) Results of fractal dimensions over time reflect the evolutionary trend in the study area. The fractal dimension values for the oasis and oasis-desert ecotones especially tend to increase.

- 3) The fractal dimensions range from 1.40 to 1.70. In this range, the development and evolution of each ecosystem element, as well as the interaction among elements, will be in a dynamically balanced state.

- 4) Alongside indices of the development of society and the increasing destruction of the environment by humans, that for the fractal dimension of the oasis-desert ecotone will remain the most important because the other two will vary according to the present situation.

- 5) Quantitatively, it was determined that if any fractal dimension value is higher than 1.70, the balance in an oasis and desert ecotone system will be broken. When this happens, the local government should pay attention so that the ecological system is not destroyed.

Vegetation Patterns in Relation to Edaphic Conditions and Land Degradation in the Southern Part of the Taklimakan Desert

KADOMURA Hiroshi
Rissho University

In the southern part of the Taklimakan Desert, because of harsh environmental conditions characterized by extreme aridity and high sa-

linity in the soil (widespread saline soils, solonchaks, and salinized soils) and groundwater, the flora is dominated by salt-tolerant xerophytic and halohytic plants and is poor in species diversity, particularly in tree species. As exemplified by the area of the Keriya and Niya Rivers, and with the exception of the sand dune fields, the land surface can be classified into the following major geomorphological units from the foot of the Kunlun Mountains in the south to the interior of the desert in the north: piedmont alluvial fans of stony to gravelly deposits dating to the Pleistocene, Holocene to recent alluvial plains of sandy to silty deposits, recent deltaic plains of fine sandy to muddy deposits (particularly from the Keriya River), and lacustrine plains that originated from former lakes in the inter-dune depressions. These macro-landform series arranged by river courses, as well as their relationship to groundwater depth, have a strong effect on the macro-scale vegetation pattern.

At a more detailed scale, site-specific habitat conditions, particularly soil moisture and salinity that are determined by micro-topographic factors, have decisive effects on vegetation patterns. Among others, the distribution pattern and growth forms of *Phragmites communis*, *Glycyrrhiza inflata*, and *Sophora alopecuroides* found in the deltaic terrain at Daryabuyi on the Keriya River, and the habitat preference and growth forms of *Phragmites communis*, *Lycium ruthenicum*, and other salt-tolerant dwarf shrubby species observed on salt-affected terrain in the eastern periphery of the Minfeng Oasis have provided interesting examples.

Sophora alopecuroides is a primary invader of a degraded, unstable habitat and can be used as an indicator of land degradation. However, this is a useful plant that can be utilized for agrochemicals, medicines, green manure, and sand dune fixation. It is well known that *Glycyrrhiza* spp. (licorice) and *Lycium* spp. (boxthorn) are valuable medical plants. In light of this, the on-site conservation and sustainable utilization strategies for these dryland plant species should be elaborated on the basis of detailed phytogeographical studies. These strategies should be planned and implemented with the participation of local populations, as well as be

integrated into rural development programs that are consistent with the China National

Action Program to Combat Desertification within the framework of the UNCCD.

Maps and Museums in the Age of Information Technologies (IT)

The Aim of the Symposium

HOSOI Shosuke,* UCHIDA Kazuko,**

ASANO Toshihisa*** and

YAMAMOTO Kayoko****

*Soka University

**Okayama University

***Hiroshima University

****Lake Biwa Research Institute

This symposium was organized by the Committee for Promotion of the Establishment of the National Museum for Map & GIS of the Association of Japanese Geographers. We, members of the Committee, organized this symposium in collaboration of all members of the Committee who belong to or have relations with various organizations to form and invite the panellers group.

On the establishment of the National Museum for Map & GIS (provisional name), a recommendation was presented by the Science Council of Japan to the Prime Minister in 1988. To realize this recommendation, this Committee was set up in the Association of Japanese Geographers and various promotion activities have been done. As a result, a part of the recommendation, the part of GIS research, was realized as the Center for Spatial Information Science (CSIS) at University of Tokyo in 1998.

However, the part of map museum has remained unrealized. So the Committee has continued to act to fulfill the recommendation. It has held symposia on the necessity of the National Museum for Map & GIS, and on the existing new map museums such as the Map & Survey Museum of the Geographical Survey Institute, the World Distribution Map Center of the Gifu Prefecture Library, etc. and inspecting meetings in existing various museums, besides business meetings.

Recently, the progress and diffusion of information technologies are remarkable, and new

information technologies are applied to map production, preservation and distribution, and also to museum and library activities like the examples of "digital museum" or "electronic library" with internet in the Tokyo University Digital Museum or in the National Diet Library.

Therefore, we organized this symposium to recognize the current situation and future trends in these fields, listening to and discussing reports about recent activities and future trends in mapping organizations such as the Geographical Survey Institute, the Hydrographic and Oceanographic Office and Heibonsha Cartographic Publishing Co. and in research institutes such as the Center for Spatial Information Science (CSIS) and the Lake Biwa Research Institute, about recent activities in the National Museum of Japanese History and the National Diet Library; and about the necessity of preservation of maps and plans prepared for public organizations and the internet homepages of various museums. We also considered a short report by FUCHIMOTO Masataka (Asia Air Survey Co., Ltd.) on the technological trends in the survey industry in Japan, the keywords of which were urban control point survey, large scale mapping, GPS, laser profiler, survey with total station (electronic distancemeter and transit combined), image sensing, remote sensing and GIS, with comments by NOGAMI Michio (Nihon University) and by NISHIKAWA Osamu (University of Tokyo), and to contribute to design the future National Museum for Map & GIS.

Geographic Information from the Geographical Survey Institute

TANIOKA Seiichi

Geographical Survey Institute

The Geographical Survey Institute (GSI), the national mapping agency of Japan, has pro-