Remote Sensing Research for Arid Ecology–Geography Environment of Mountain Area in North–West of China

——for Qilian Ranges Heihe River Valley as an Example

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Abstract

This paper illustrates two–seasonal experiments on the reflection spectrum's characteristics of typical ground objects of various kinds of eco–geographic environment in Heihe River reaches of Qilian Mountains. The arid eco–geographic environment has been anaylized using colour images of landsat TM 4,5,3, (Zhang–ye sheet, Aug.,15,1987). The image's interpretation signs and the spectrum reflection features of typical ground objects in four seasons and different environment are introduced in detail, and the basic conditions are provided for the application of remote sensing technology in ecological research.

Ecology is a science concerning about the relationships between the markind, living beings and the environment on which they depend[1]. Thus, the analysis of ecology–geography environment gives the basis for the ecology ressearch, and is also one of the key problems. Ecology–geography environment represents itself as a substance existing in various spatial patterns in physical world, though it is influenced by some factors such as climate, geomorphy, hydrologic properties and soil. All of this makes it possible to introduce remote sensing technology to the research of ecology. As we know, the remote sensingimages are record of ground truth, so it is undoubted that the various types of ecology–geography environment could be reflected on the remote sensing images. Under the guide of this thought, we interpreted the TM colour composite images scaled at 1:200,000 which were photographed on Aug. 15th, 1987 and covered Northwestern China's Zhangye district which includes the ecology–geography environment of Heihe River Valley of Qilian Ranges. Combining with field work, we made experiments on the characteristics of the reflectance spectra of typical ground objects. This paper tries to establish the interpretation marks of remote sensing images of arid ecology–geography environment (landscape) of Northwestern China's mountain areas by focusing on the properties of ecology–geography environment of Heihe river valley of Qilian Ranges and analysing the reflectance spectra curves of typical ground objects, and thus, the paper provided the basic data for the application ways of remote sensing technology in ecology research.

1. The general physical geography situation of the tested area.

The tested area is located in the Northwestern China's Qilian Ranges area.

The Heihe River springs from Qilian Ranges, confluencing Babao River, Tuolai River, liyuanhe River and Bailang River, passing along across the plain of Hexi Corridor, and is buried in oblivion of the northern part of Badanjiling Desert, and is also the largest river in Hexi Corridor. The tested area shows its geomorphic characteristic as the huge and cold mountains in the south and broad valley plain in the middle and the vast expanse of desert in the north, and respectively, the heights above the sea level ranging from 5,000 m to 3,000 m and 1,000 m, and therefore, the area is typical of vertical zone of climate, the annual precipitation varies from 700 mm — 600 mm in the mountains to 200 mm — 100 mm on the plain, and the average temperature from ＜2.0℃ in the mountains to the 5—7℃ on the plain. So, obviously the test area's climate belong to arid one, and its ecological environment is quite vulnerable, such as grassland's degradation, soil salinization, land desertification etc. Thus, it is of great significance to reasonably utilize the ecologic law to guide the production practice by studying the arid ecology system's progressive law of Heihe valley in northwestern China's arid mountains.

2. The interpretation tenets of remote sensing inmages of ecology–geography environment and its classification principle.

The spatial patterns of ecology–geography environment are the results of the comprehensive interaction of climate, geology and geomorphy, hydrology and soil. The essential foundation of utilizing remote sensing images to study ecology–geography environment lies on the interrelationship and condition of those factorg, i.e. under a certain geomorphic and climatic condition, the corresponding soil and plant have been developed, and whatever change that one of them takes would cause the changes or coordination of the others. The living beings would be capable of existing if they adapte themselves to their surroundings; and if not, the death await them. By using these relationships and according to the color density ratio and stripe of remote sensing images, we can directly deduce certain ecology-geography environment, this is the very principle of interpretation of remate sensing images of ecology-geography environment. Heihe River valley belong to high mountain ecology system of land ecology system, as stated above, Qilian Ranges' ecology-geography environment is typical of obviously vertical varification, this is because of its geomorphic features which determines different temperatures from top of the mountains to its foot, different precipitation, air humidity, cloud amount, wind velocity, sun shine etc.

In view of influence factors of ecology-geography environment, geomorphy is a decisive factor which determines topography and foundmental patterns of physical environment, further more, the plant and soil are not only the indicators of water and heat quantity, but also the main components of ecology-geography environment. There four, in the classification of ecology-geography environment, and in regard to the geomorphic types such as super-high mountain, high mountain, medium-high mountain, low mountain, river valley and plain, we devided them as the 1st classification unit and the dividing of the 2nd classification mainly depends on the varifications of plant and soil, thus, every geomorphic unit is a ecology systems, in which the corresponding living beings live.

There are various geomorphy types as well as its ecology-geography environment which have been moulded by some factors such as glacier, cold and forzen weathering, wind and rain ravage, and dry corroding.

3. The basic characteristics of ecology-geography environment of test area and their reflection on the remote sensing images.

1) Super-high mountain district.

The ecology-geography environment distributed in super-high mountain district include two types: glacier and constant existing snow belt, and cold desert belt. The former one is located 4,200— 4,500 m above sea level its annual average temperature is between -6℃ — -8℃ with abundant annual precipitation of 600—700 mm, half of which is in solid state. Its glacier and constant existing snow belt are well developed and the tops of the mountains are covered with white snow throughout the year. The ice and snow melting water is the main source of ground water. The latter are scattered 3,900 —4,200 m above sea level with cold climate and strong cold and frozen weathering process. Its zenith plants mainly consists of scattered blocks of bryophyte, lichen and other cuslio-like plants; its ground matter consists of moraine and rocky waste, it soil belong to cold-desert one. The frozen earth layers are popluelar here and stable owing to high ith elevation, cold climate, hard ecological conditions and little human influence.

The glacier and constant existing snow belt and cold desert belt are quite clear on TM images, especially the snow cover which is in white block form and has a bit of real object feelings, so it is easy to tell it among the white blocks of clouds. The glacier is in strip or tongue-like shape; if the surface of glacier is melting, then it is in pale blue and in the mean while it gives out a little of stereoscopic feeding.

The cold-desert strips nepresent themselves on remote sensing images as bluegrey color, and are distributed in the form of circular around the glacier-snow belt, the boundary between them is pretty obvious owing to their constituent matter such as ice moraine and rocky waste. Because of rare plants existing there, it is almost impossible to lock for any red strip or print on the remote sensing images.

2) High mountain district

The ecology-geography environment of the district mainly connsists of high mountain grassy marshland. Located at elevation of 3,600—3,900 m on gentle slope, the plants of the district primarily consists of wormwood, combined with a little bryophte, and densely growes with its covering rate of 80—90% or more; on some part of the ground with considerable hummidity growes marsh grass, and here is used mainly as summer grazing land. Its soil layer is comparatively thin and is composed of ice-water fluid deposites; soil belong to high mountain meadow soil. The district belong to multiyear frozen soil of island-like, and the lower line of the soil is 3,500 m beneath the ground surface. Bacause this kind of ecologic environment is quite vuluerable, any physical factor(e.x. the transition of climate from cold to warm one) and humman interferences(e.x. over loading cattle on pasture) could cause to some extent the changes of ecology environment, because both of the two factors could probably induce the degradation process of frozen soil and thus deepen the depth of the seasonal melting layer, permeating downwards of ground water, as a result, there is not enough water for plant's root, and finally, a series of ecological conditions go from bad to worse, such as degradation of pasture land, desertification of land etc. It is quite slow for island-like frozen soil to recover its original state from its damaged state because the cold climate and low temperature stand as a big obstacle of natural progressive process of vegetation. Therefore, much attention should be paid for the scientific utilization of it and the protection for environment.

In contrasted with super high mountain district, this district's vegetation covering rate is considerably larger.

High mountain meadow and marsh meadow show themselves in bright red color on remote sensing images, and owing to the large covering rate of plants, the red blocks of it on the images feels smooth and fine just like red carpet, and thus its boundary with the above district is quite clear, and is the upper limit line of high mountain meadow.

3) Medium-high mountain district

The ecology-geography environment of this district is much complicated. Influened by particular topography such as slope and its orientation, and its main land-scapes including meadow bushes, meadow grassland, mountainous grasslang, meadow bushes are mainly scattered at 3,400— 3,700 m above sea level on sunbackward slope of mountain. The sunbackward slope poccess ideal water supply and hummidity condition, this results in luxmg growth of bushes, high mountain willow and bush cinquefoil. Its soil belong to bushes meadow soil. The sunwards mountain slope has good beam radiation, and is comparably dry, its vegetation mainly conrists of bryophyte, weilincai, their covering rate is up to 60—80%; the soil belong to mountain tshernosem, and is typical of meadow grassland, on remote sensing images, sunbackwards slope is in dark red blocks; sunwards slope is in bright red. Abont 2,400—3,400 m below it is forest—bush and mountain pasture landscape, with the former one distributed on sunbackwards slope and the latter one on sunwards slope as well as on gentle hill ground. The forest mainly develops along Qilian mountain and Longshou mountain which is in the northern part of the test area; because of its moderate precipitation, about 300— 500 mm, the forest mainly consists of arbor, and the main kind is Qinghai dragon spruce and Qilian one, both of them belong to ever—green—needle—leaf woods. Beneath the woods, bushes are luxury on the taupe cinnamon soil. This kind of landscape could be observed along the Binggou of Qilian county as well as in Longshou hill of Dongda mountain. The sunwards slope show the mountain grassland scene developed mainly at 2,400—2,600 m above sea level, with precipitation ranging between 100— 200 mm and dry climate and under—developed plants which primarily consists of arid—perssistant plants such as stipa, prairie and sheatgrass and their covering rate is about 50%; the soil is mountains castanozem.

On remote sensing images woods and bushes are in dark—red strips or blocks, but the mountain pasture is in light red and of less density owing to its poor covering rate.

In the process of interpreting the land scapes of ecologic environment in medium—high mountains; much more attention worth being paid to the possible confusion of images of meadow bushes and woods—bushes owing to the colour similarity between them. However, this problem could be solved if we analyse their verical zonality of plants as well as their elevation and slope orientation Nevertheless, the best method is to make contrastive analysis on multi—temporal remote sensing images and therefore acquire satisfactory results. Bacause the evergreen woods is popular in the test area, they are also in red colour on remote sensing images photographed in winter, but in this season the meadow bushes turn yellow and them show themselves in pale or grey blue color rather than in red, therefore in this way can the meadow bushes be distinguished from among the woods—bushes.

In this distirct, husbandry is the main style of production; but due to the comparatively more humman activities here, such as over loading the grassland and denudating forest, the protection for ecologic environment becomes one of the most urgent problems.

4) Hills district

The hilly land work its elevation of no more than 2,4000 is occupied by landscape of desert grass land. It is typical of strong dry—denudation, sparse plants covering which include various arid—perssistant plants such as desert—oriented stipa, shart flower stipa, gem, synclphalon; Their covering rate is about 10—20%. The ground matter is coarse, and the soils belong to mountain sierozem, Much of this kind of landscape is in grey—yellow colour, and some others are in red—yellow colour.

The ecological environment of hills belongs to desert pasture one, and its productivity is quite poor owing to arid land and low temperature throughout the year, so apart from a little of it could be used as grazing land, much of it has barely been changed by humman beings.

5) Plain beside mountain foot

This kind of plain was formed by movement of runoff or snow and ice melting water current which brought large amount of rocky waste to be deposited at the foot of the mountain. This district is broad and vast, and the layers of the depositions are quite regular considering their constituent matter, e.x. downwards from foot of the mountain the particulator matter turned from coarse to fine particle, and formed a series of arid, semi—arid desert ecology system such as rock matter, sand matter and earth matter. Here the vegetation are rare except the arid—persistent plants such as harmel, syncephalon.

The rocky matter and sand matter based desert covers mainly on fluvial splays and broad dried river bed, and the most of them show typical rocky matter based desert which can be remarkably reflected in form of blue—grey splays on remote sensing images, and the more rocky matter the more density of blue color it has.

Sand matter based or earth matter based desert are mainly distributed in the middle and lower reaches of modern rivers or in the middle and the lower part of broad flood splays.

The ground surface is dry, and some of its lower land which is within the reach of subground water show the landscape of salty desert. The earth—sand matter based desert is in white—light yellow—yellow colour on remote sensing images, and further more, the finer the earth is, the more salt it contains and become drier and more pale color; althouth salty desert is also in white colour, it is easy to be telled from the former one because it has salt halo and irregular dyeing patterns.

The water shortage and poor productiviry are the two characteristicses of vulnerable desert ecosystem. Because of drought and wind in addition to sand matter deposition which is deep and porous, all of them constituted the poten—tial factors of inducing the trend of desertification; and the over farming and over grazing of land and the uncontrolled felling trees accelerated the speed of desertification. However, if the adequate sunshine days and heat resources were utilized, provided with irregation and fertilizer, desert could become potential area of considerable productivity[2]. That is to say, by means of positive humman activities such as constructing irrigation system and forestating the bare land to prevent it from invading of desert, that desert ecosystem could be changed into artificial oasis of ecosystem[3].

6) Desert and oasis district

The northern part of the test area is neighboured with Badanjiling desert, and there are floating sand and semifixed sand developed. Most of the floating sand drift belong to new-moon-like sand drift or sand drift chains. Plants growing on it mainly consists of suo-suo, rose willow nitrhria, all of them are components of desert ecosystem.

The remote ensing images of desert is quite easy to be distinguished from others because it is in shape of wave and its remarkable yellow-yellowish white colour. The spots of brown-red colour could remind us whether a certain sand drife is a fixed one or semifixed one.

The artificially irrigated oases are mainly scattered along Zhangye, Gaotai and Lingze, and they are the main commoditive grain production bases of Hexi Corridor, and the especially famous one is Zhangye which merits the name of "Gold Zhangye" as a green pearl on the Silk Road. The main crops of the oases are rice, wheat, corn and soybean. Poplar, narrow-leaved oleaster woods were planted at field ridge to prevent wind and sand.

Oases which is in red colour of different density on remote sensing image distributed around village, and the large blocks of farm land could be seen its geometric patterns. The windproof and sand-fixing woods is often in brown-red strips.

Oaris is a agricultural ecosystem which is strictly managed by humman beings. So, the key problem of supporting agricultural ecology environment is to promote humman being's knowlege about physical environmental conditions of farm production.

As stated above, there are not only rich types of ecology-geography environments but also vertical zonality law in the test area, and every ecosystem corresponds to its special image on TM remote sensing photos. In other words, the ecology-geography envrionment (i.e. ecological landscape) could be fully displayed on remote sensing images. The application of remote sensing image in the analysis of ecology-geography environment shows a new approach for ecology research, this is because that all the living beings living in a certain ecosystem constantly exchange matter and energy with their environment, in the mean while, the ecology environment is changing after the elapsing of time, changing of space and other factors (including humman beings and physical elements). So, the ecology-geography environment is in constant changing process. The introduation of remote sensing technology provides an advantageous condition for monitoring ecological environment, grasping its changing law, forecasting the changing trend of ecological environment as well as protecting efficiently the ecological environment.

4. Analysis of spectral properties of typical ground objects of various ecology-geography environment belts.

Why the remote sensing images are capable of showing the varieties of ecology-geography environment? The essential reason is that the various ground objects such as the varieties of plants, their covering rate, quality of matter and water supply, all of those comprehensively affectes the reflectance properties of spectral variations, therefore different ground object corresponds different colour hue and colour variety, and therefore the very basis for analysing various kinds of ecology-geography environment is layed. Thus, spectral property of ground object is also the theoretic basis of interpretation of remote sensing image of ecology-geography environment.

In order to grasp the spectral properties of reflectance of ground objects, and to establish interpretation markes of remote sensing image of ecology-geography environment, on September 1st to 15th of 1987, and on April 9th to 22nd of 1988, the spectral reflectance properties of typical ground objects in various ecologic environment belts were tested by using the Field Spectrum Radiometer of SRM-1200 type made in Japan. By doing so, the seasonal spectrum reflectance law could be learned and therefore provided theoritical basis for analysing multiseasonal remote sensing images. After analysing the test data of spectral reflectance of ground objects of typical ecology-geography environment, the following could be concluded:

1) According to the test results made in September of 1987, there are also vertical zonality law over the spectral reflectance properties of plants. As illustrated in Fig.1, the reflectance rate of near-infrared band of sedge has a decline trend following the accumulation of its elevation. It is not hard to see that the sedge of different elevation has different habitats, i.e. different water supply and different temperature; therefore the growing periods of plants were delayed as their elevations raise. During the test period, in which plants began to turn yellow so they were very sensible to the temperature changes. For instance the sedge which grew on the upper part of mountain turned comparably earlier into yellow state because of the declining content of chlorophec of it, so this made its reflectance rate of near-infrared band lower; meanwhile, on lower part of mountain the sedge were growing pretty good owing to its more content of chlorophyll.

2) As illustrated in fig.2, the spectral reflectance curve (the result of test in April of 1988) of sedge of different elevation shows that it likes neither the plant's spectral reflectance curve which appears abrupt turns at near infrared spectrum nor that of soil, but somewhat transitional characteristitcs between soil and plant. After being analysed, it is believed that the trend reflected, it is believed that the trend reflected not only the sprouting state of plants in April, but also the influence and soil on spectral reflectance properties. The spectral

reflectance curve of sedge growing in April show obscue vertical zonality in the period. Fig.2 also illustrates that the difference existing between spectral reflectance curve of sedge and that of Qilian Pine which still show its typical plant characteristics owing to it ever green property, which lays the theoritical foundation to identify evergreen woods from deciduous tree and grass.

3) The soil surface under natural state apparently showed a strengthening reflectant capability from coarse soil to fine soil. As illustrated in Fig.3 and Fig.4, the rocky desert has the poorest spectral reflectance rate, and from rock–sand soil to sand soil and earth soil, their respective spectral reflectance rate is gradually high. Therefore, on remote sensing images, the rocky desert appeares heavy blue; sand desert shows the grey white or hight yellow, and earth desert represents itself in yellow–white or white color. Of course this law is often interfered by other factors such as its content of water. As shown in fig. 4, the spectral reflectance rate of wet salt soil is lower than that of dry salt soil.

4) Unlike sedge, the spectral reflectance curve of Qilian Pine and bushes growing in September (shown in Fig.5) had an obvious absorbing peak near 750 nm spectrum band. This spectrum band is worth noting, because this characteristics provides some information for distingnishing arbor and bushes from grass

5) Fig.6 illustrates spectral reflectance curves of the main crops growing in september in oasis ecological environment. The three crops' reflectance curves at blue band and near infrared band are similar and the curves cross with each other, so they are not easy to be identified from the others. However, after passing the near infrared spectrum band, their reflectance differences begin to increase, and it tells us that this band is the best one to be used to distinguish corn, rice and wheat.

6) Accordng to the spectral reflectance test on Heihe River and longshouqu water body, in April, their reflectance rate lies between 550 nm and 950 nm, and the rate is generally higher than that in september, whose peak appears near 650 nm (as illustrated in Fig.7). Based on analysing, Heihe River and its tributaries mainly receives snow melting water of Qilian Mountains; and April is the very period in which the snow is melting, and the melting water with large quantity of mud and sand, running down into Heihe River and its tributaines and cause the abrupt increase of spectral reflectance rate at 550–950 nm band which is quite sensitive to mud and sand contents of water body.

In conclusion, the above analysis on spectral reflectance characteristicses of various typical ecology–geography environment provides theoritical basis for interpretantion of multi–spectral and multi–temperal images of remote sensing.

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Note: In this paper, the Fig.s. are omitted.