APPLICATION OF THE IMAGE INTERPRETATION FROM AIRPHOTOS TAKEN IN THE DIFFERENT PERIODS FOR THE DEBRIS FLOW RESEARCH

(Northwest University, China , Zhang RENLIN)

ABSTRACT

The natural hazard in mountainous regions where debris flow is most developed and active has been put a focal task of research and control in the Jiangjia Ravine. The previous efforts are mainly devoted to the analyses of both findings in the field investigation and data from the monitor stations following the traditional way , that is , to spread over a whole area from one point. In order to inquire furinto the causes at the beginning and the consequences at the end of debris flow it will be able to provide much more comprehensive information of disastrous activity to combine correctly the image interpretation of airphotos taken in the different periods with the on-the-spot investigation on the major districts of the study area. The information content which can be extracted from airphoto analysis to a great extent depends upon how about the professional knowledge of interpreters and the technical instruments used by them. There is a presentation of some preliminary results and suggestions for improvement in the artical.

KEY WORDS : Image interpretation. Debris flow. Natural hazard.

1. INTRODUCTION

Collapse, landslide, debris and so on are all the natural hazards which take place easily in most of mountainous regions. Like other disasters such as volcano, earthquake , drought, storm and hurricane etc. they can wreak havoc with the economic construction of those regions and the lives and property of local residents. China is a country which abounds with mountains. The majestic mountains and hills cover its vast area where the natural conditions, both climatic and geologic , are extremely complicated. With economic exploitation of mountain area a threat of mountainous hazards is increasing severely. Consequently, it is of a great immediate significance and economic benefit to adopt a variety of the new technological means for research and control of mountainous disasters.

In the southwest China there are many mountainous regions with lofty summits and deep ravines. The precipitous terrain makes passage quite inconvenient; besides, the changeable weather brings about a great deal of difficulties to the detailed survey over a large scope of ground. Therefore, it will be able to obtain the most sufficient information of the disastrous activities in the study area to combine correctly the image interpretation of the remotely sensed data with the field investigation. In particular, the aerial photographs are all the systematic material with certain longitudinal and lateral overlaps, thus one can recognize the dangerous canyon by stereoscopic viewing, make clear various fundamental elements which have interrelation between each other in the natural environment, and compile thematic maps on the basis of the various geographic information from identification and classification so as to provide the radical technical data about excavation and filling of earth and stone in quantities during road construction engineering, hydraulic structure project, mining and defence building.

In airphotos one has recorded the spectral radiation characteristics of terrestrial surface objects within the wavelengths of visible light and near infrared during the exposure moment of camera. However, the mountainous hazards, particularly the most typical debris flow, are all the dynamic development process from the outbreak to the resulted changes of landform. Consequently it is preferable to make good use of the analysis and comparison of the airphotos taken from different periods for the purpose of a study into the condition of those disasters. Generally speaking, the changes of the earth's surface shape due to weathering and erosion go on more slowly than the ones of crop growth, thus it is most desirable to use the airphotos separated by many years from each other during the contrast between them.

The occurence of mountain disaster is attributed to a result from the interaction between natural environment and human activity over a long period of time. Debris flow of the Jiangjia Ravine in Dongchuan, Yunnan is a more typical case. There are frequent activities of collapse and landslide, severe loss of water and erosion of soil, widespread and diversified debris flows so well developed and active in this area where the situation is rarely matched either at home or abroad. Here the author would bring in a brief account of how things are in the processes of airphoto interpretation and field survey on the region, show the obtained results and existing problems for a further research.

2. PROCEDURE OF AIRPHOTO INTERPRETATION

The Jiangjia Ravine is located in the northeast part of Yunnan Province. It is one of the rivulets on the east bank of Xiaojiang River that flows from south to north and empties into the Jinsha River. Its geographical scope covers about the north latitude 26°13' — 26°17' and the east longitude 103°6' — 103°13'. The whole drainage area amounts to 48.6 square kilometers. It is situated at the west periphery of the Wumeng Mountain area where the terrain inclines from east to west. The altitude of most parts is between 1500 and 2900 metres. The source place of this typical debris flow is developed along the well-known Great Xiaojiang Fault of the seismic belt from south to north, an area which is characterised by an old intricate tectonic system, intense neotectonic activity and frequent seismic activity.

Altogether two sets of airphoto material are offered for interpretation. Those are all the black-and-white prints which have not been rectified. The flight missions of taking photographs were carried out in 1957 and 1979 respectively. The frame size of early airphotos is 18 x 18 cm and the photo scale is 1:60000. The flight stripe was arranged in the west - east direction. The later airphotos have the frame size of 23 x 23 cm and the scale of 1:30000. Those were taken in the south - north direction. All airphotos in two stages were taken by the cameras with the short focal length and super wide angle of view. Since most of the relative elevation differences between ridge and valley are over 500 metres the image error due to the central projection on photos becomes extremely great, and the deformation of feature outline is quite clear as well.

Airphotos contain much information on the earth's surface including the general characteristics of geomorphology, geology, hydrology, pedology, botany and human activities which can be passed on largely to the interpreters by so-called direct signals, that is, shape, size, tone, texture, pattern and shadow of the various features in the study area. However, a lot of the essential information by that one can reveal those things which account for the disastrous activities such as mud-rock flow is also necessary for their recognition through the indirect signals. The indirect signals never show the physical attributes of terrain feature. Thus they are not able to ensure a validity of the topographical identification by themselves. Nevertheless they can suggest an existence of those objects which are impossible to define from the direct signals or have not come out in the formation of image on photos. Using properly the indirect signals is of assistance to get rid of the various explanation of the conclusion made of analysing solely the direct signals, and able to learn about some additional features of the target. Indirect signal means an inference from the relative position and mutual relation of different surface features as well as the outcomes of the economic activities of mankind. Seeking the indirect signals of features on airphotos is to find out the bases on that one can make a conjecture and judgement on them. It is more complicated than identifying the direct signals because the indirect ones are not acceptable to the naked eyes. Interpreters should have a good grasp of more comprehensive knowledge and perform an attentive analysis. Only through an unceasing practice can much experience be acquired eventually.

Owing to the poor technical condition the airphoto analysis is still conducted by the traditional way of visual interpretation in which the procedure is gradually thoroughgoing from general survey to essential search. At the initial stage we carry out a rough examination on the single aerial photographs taken at two different dates to recognize the varied topographic elements and land-covers, draw a clear distinction between ridge and valley, look for a sector of the area eroded by wind and rain from the density and pattern of linear images. In order to ascertain the changes of soil erosion during an interval of 22 years it is necessary to observe simultaneously those two sets of airphoto in the same region and with a different taken time. For reduction in disturbance due to a great difference of scales between two sheets of airphotos as far as possible we have adopted such a visual method of viewing the airphotos at scale 1:30000 directly and the ones at 1:60000 with the aid of a magnifier. All places where there are variations of image characteristics have to be recorded one by one for further verification of them. For the sake of a reliable verification of the quantitative nature on the denudation and erosion of the earth's surface as well as the disastrous evolution at last it is indispensable to carry out the stereoscopic viewing of all the image pairs under a mirror stereoscope with an accent on the places which have been put into records. Some difficulties may occur due to a large variation of the parallaxes, both horizontal and vertical, in observing the spatial models. To solve the problem one should set the eye base to be parallel to the photographic image base provided the basal orientation of stereopair is accomplished correctly, shift one of photos or both of them to the left or right slowly so that the corresponding images can be amalgamated into one for the normal survey. For convenience' sake in the practice it is preferable to find out at first the conjugate image points which are clearly definable on both photos and point out them respectively with two forefingers, then move slowly the photos under the stereoscope up to a certain interval so that both visual images of forefinger's tip coincide with each other, which leads the corresponding images of the identical feature in a stereopair to be merged more or less. Next, one may rotates photos slowly around their image centres clockwise or counter-clockwise. If the homologous images merged previously separate again at that time one can shift any one of photos to a little left or right. When both photograph bases of stereopair are located at the same straight line it is bound to see a three-dimensional model similar to the ground truth under a stereoscope.

Owing to the vertical exaggeration in stereoviewing a mountain slope looks more precipitous in an optical model under stereoscope than its actual appearance. Sometimes it is visible that a bigger outcrop of bedrock appears at the bright hillside. With the broken rock stratum and sparse vegetation in this mountain area erosion is aggravated so heavily as to form a lot of convex slopes. There are many steep slopes in both sides of a mountain ridge. One can discover the substance piled up by force of gravity at the foot of a mountain due to collapse and landslide. Those broken and strained rifts newly revealed during a survey of the later airphotos are probably the outcomes in the initial stage of debris flow occurrence. After a careful analysis it is possible to identify the developing trend of landslide activities in the confluence of debris flow with the lapse of time.

Some misidentification in viewing a single photograph may be eliminated through stereoscopic examination, especially for the airphotos of early age those linea-ments caused by the scratched or wiped traces of film itself during the photographic process might be excluded from gullies and crevasses.

3. IMAGE ANALYSIS AND FIELD SURVEY

Having finished the observation and contrast of two sets of airphotos with different years and checked the relevant place names on the map one finds out over 30 positions where there appear more distinct variations. (See Fig.1. The locations indexed by letters are consistent with the following alphabetic description.) It is possible to classify them as follows.

A.) The old gullies are widened and stretched upwards. Near by them have a few new cutting gullies emerged. The positions showing most clear include the Menqian Ravine and its source branches such as the Dadi, Mashangwa and Shanjiacun Ravines as well as the Zhangjiadi Ravine that is one of branches of the Duozhao Ravine. In viewing single photographs the linear images present a tendency to increase and extend on the basis of comparison of the later with the early. Besides the width of lineament is enlarged in varying degrees. Under a stereoscope one can see those linear images, both original and newly emerged, are the cutting down gullies or crevasses. The concave places of jagged periphery in the convex top of mountain are mostly the gully sources eroding upwards.

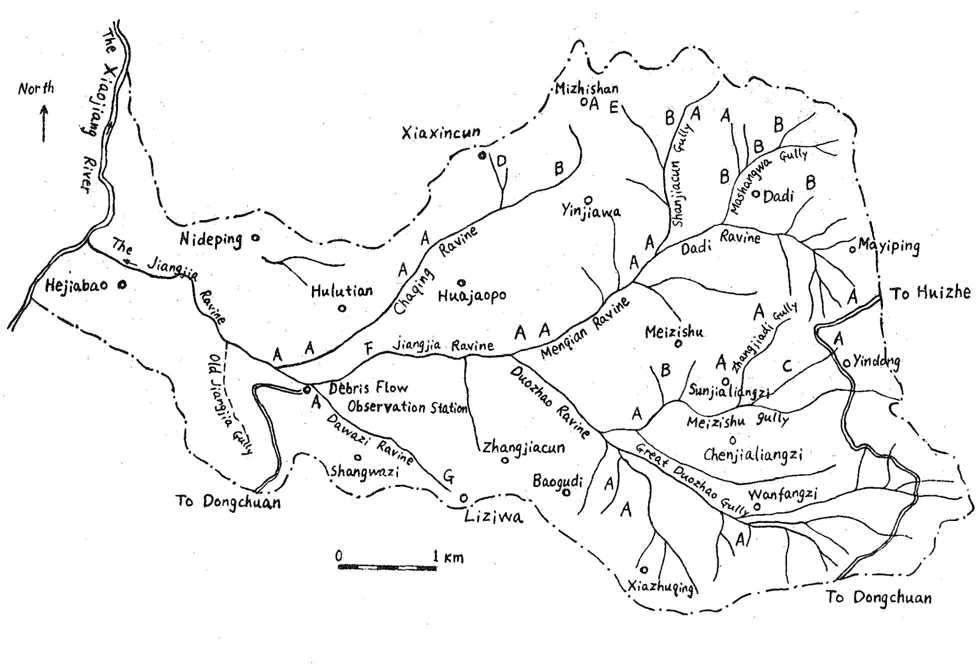

Fig.1 The Synoptic map of airphoto analyses in the Jiangjia Ravine drainage area.

B.) The denudation area of slope becomes large and the material accumulated along both banks of a brooklet increases as well . The situation is visible almost everywhere on both slopes of the main channel in the Jiangjia Ravine. With an enlargement of denuded surface the slope exposed to the sun reflects more strongly so that the areal images of greyish white have increased in the later photographs. Stereoviewing helps us identify the material piled up. In consideration of the carrying action by mountain torrents those fan-shaped heaps do not show the actual quantity of matter slided downwards.

C.) There appear some bigger outcrops of bedrock in which each image looks like a bright spot accompanied by a dark stain that implies its shadow. Most of them distribute in the middle slope from the highway section near by the south Yindong down to Sunjialiangzi in the west direction. What caused bedrock to come up out of the ground is in consequence of that the surface soil has been washed away. It often becomes one of the important sources to supply debris flow.

D.) The deeply cutting gullies in both sides of a flat-topped ridge are jointed at a saddle. As a result there is a possibility of that one gully captures running water from another one. For example, near the Xiaxincun Village water may be led into a gully of the south slope from the north one, then gathered up by the Chaqing Ravine. From stereoviewing one is in a position to discover the fact of that the gullies of two sides are connected in a saddle. When one carefully observes the stereomodel of later airphotos it is visible that the channel traversed the saddle of a mountain ridge inclines slightly to the south, which demonstrates a severe erosion at the south slope.

E.) A huge bulk of landslide located in the east farmland of the Mizhishan Village continues to move slowly downwards. The shadow of steep wall changes from narrow to broad in the direction down slope. Under a stereoscope one can make out the steep wall with a continuous changing height is just the split position where the bulky landslide starts to drop out of the mountain body.

F.) The current channel in the shoal of the main Jiangjia Ravine is close to the north bank. There is the collapsed matter in a heap near by the south one. Water channel appears in a dark lineament on photographs. Piles of earth and stone are found out mainly through stereoviewing and not easy on a single photo since they are most near by the dark slope.

G.) The branches of the Dawazi Ravine at the source place carry on cutting down toward the top of Liziwa highland and the jigsaw-like edge of rock on the top periphery has been elongated obviously. In comparison of two different airphotos with each other one may recognize a trend of that the branch gullies are increasing and stretching upwards.

Among seven aforesaid cases (A) and (B) are the most widespread ones and the great majority of them occur in the east and northeast districts of this mountain region as the primary sources of debris flow.

On the map the Wumeng mountain Range as a border between Yunnan and Guizhou runs from northeast to southwest and the Jiangjia Ravine is situated in the west part facing the wind of the Indian Ocean airflow in summer. As a result it becomes a rainy area against the wind. The mountain rainstorm in summer can supply debris flow plenty of water.

In July 1990 the author took part in the field investigation of this drainage area . The survey routes covered almost the districts where the changes of ground were indicated by airphoto interpretation . The field inspection of the later airphotos gave us a deeper understanding of the development of debris flow in every valley and gully.

The climate in the drainage area of the Jiangjia Ravine belongs to the subtropical one with sharp distinction between the dry and wet seasons. The precipitation is on the increase as the altitude rises. The field survey was conducted in the period of rainfall peaks. There were often showers in the mountain over 2000 metres; it was cloudy and cool; road became muddy and mist floated everywhere. The spot observation had to be carried out under the shelter of umbrella sometimes. However, it was just at that time that we had an opportunity to see the scene of debris flow outbreak and the tremendous destructive power when debris flow rushed down out of mountain valley. Besides, we could observe the situation of eroded slope after rain and the derivatives such as collapse, subsidence and deep cutting etc. due to the action of water and gravity. The surface earth coverage in this area is mostly the laterite soil. In highland there is only very thin layer of soil and outcrops of limestone are visible everywhere. The layer of soil in middle slopes is thicker because there is an accumulation owing to landslide and alluviation. With reclamation in rotation and plantation on steep slopes the soil is impoverished and degraded severely. There is not a stretch of woodland and scatter merely odd pieces of younger trees in whole area. Potato, oats, buckwheat, corn and so on are in the majority of crops. The higher the place is, the poorer the growth of them. The auther had seen that the bulky collapses took place in several sections of the main highway from Dongchuan to Huizhe passing through the Yindong district of this area. It caused the traffic in danger, and one vehicle could not give another the right of way. In the worst situation the total transportation was broken off at all. Between Mayiping and Yinjiawa there had been a simply-built highway in the past for the purpose of transporting ore. Nowadays most sections of the way were damaged. There are water puddles and shale fragments everywhere on the way. Trucks can only go to the north side of the Mayiping Village which is at the position less than two kilometers from the intersect through that the highway between Dongchuan and Huizhe passes. As to the country roads connecting the villages in slope they are frequently forced to alter the previous routes and sometimes have to be abandoned entirely.

A ditch constructed for irrigation along hillside from the place in the neighbourhood of the upstream confluence of the Chaqing Ravine to the Nideping terrace repeatedly suffers the attack from rainstorms in summer. Whenever the mountain torrent has finished farmers must rebuild those dangerous bank segments partly bursted by flood waters and dredge the channel blocked up by silt.

The upper reaches of the Menqian Ravine and its branches in the northeast of the study area are also the mining districts run by the local people. Vegetation on slopes has been removed completely. The broken shale by weathering scatters everywhere. Even without exploding for mining one can hear the rustle of crushed stones slipping downwards on slope and see a cloud of dust rising in the air from a distance whenever wind blows in canyon. No doubt, this is an important source of debris flow, as a consequence the inferences drawn from airphoto analysis have been verified at the end.

4. A FURTHER DISCUSSION

The observation and research of debris flows among which the Jiangjia Ravine is taken as a typical one have attracted attention of many experts in the mountainous hazards at home and abroad. The debris flow observation and research station constructed by the Academia Sinica has collected a vast amount of observation data and investigation reports from the beginning in 1961 and especially since 1980, achieved several progresses on the theoretical study, application practice and research method etc. and created favourable conditions for the disciplinary development of the science of debris flow as well as the disaster control planning. The past efforts are mainly devoted to the analyses of both findings in the field survey and data recorded from the monitor stations in order to explore the the principles and laws governing the formation and development of debris flows, and then set up the dynamic models of debris flows. This is a traditional approach to geographic study, namely to spread over a whole area from one point. It can only reach a limited degree of depth and breadth of research work in the rugged mountain area where passage is rather difficult because the detailed field investigation needs to cost a great quantity of manpower and finances, moreover the special preparation in advance is necessary and some dangerous districts have to be given up for the sake of safety in practical activities. The emergence and development of remote sensing technology make the comprehensive geographic survey be able to begin with the integral analyses over a large scope. Recently the application of airphoto interpretation to the investigation of mountainous hazards is becoming increasingly common. Airphoto is not only a general miniature of geographic landscape but also a real reflection of ground scene at the moment of exposure. Interpretation process is to examine photographic images for the purpose of identifying features and judging their significance, describing their relationship with the surroundings, determining their relative locations and extents, revealing their evolution laws from the physical characteristics and distribution patterns of themselves. As a rule one makes a decision concerning what photographic scale is suitable according to the aim of research , extent of desired details and physical condition of terrain. The larger the scale is, the more details are contained in images, thus the more information about the geomorphologic elements of debris flow and the phenomena associated with them may be presented. Using the airphotos of scale 1:7000, for instance, one may even discover the gigantic boulders on shoal of debris flow under a stereoscope. However, the number of airphotos and their expense must quickly increase with enlargement of photo scale. Therefore a choice of scale should be made in accordance with a balance of the various advantages and disadvantages. It is important to realize clearly that airphoto interpretation is impossible of replacing field investigation entirely. For study of a special subject the information extracted from airphotos is merely a part of the desirable as usual. For example, in debris flow research it is unlikely to get the information of determining nature of rocks and thickness of accumulation, assessing hydrogeological conditions and so forth immediately from stereoviewing of aerial photographs. Identifying objects on the basis of their image characteristics is a complicated process. The result of identification may show the exact features to be studied or not find out them or make misunderstanding. No other outcomes can take place in this process. Success in photo interpretation will vary with the training and experience of the interpreter, the nature of objects being interpreted, and the quality of the photographs being used. Cognizance and incognizance of features that appear on airphotos are usually a random event with more or less uncertainty. The reason why mistakes and omissions are caused during interpretation should be considered as the intricate interrelations between the natural objects plus insufficient study of them, and a certain lack of the reliable signals for identification. In order to make the information from airphoto interpretation perfect and substantial it is indispensable to supplement the field investigation of some key districts.

The two sets of aerial photographs in the drainage area of the Jiangjia Ravine are all the materials purchased from other agencies. Originally they were specified for the purpose of making the topographic maps. According to the requirement for acquiring detailed knowledge of the disastrous situation of debris flows in a given region they do not necessarily meet a demand for the optimal scale. Fortunately their better image sharpness is in favor of establishing an impression as if the interpreter is personally in that mountain scene. A lot of apparent variations on the ground in the course of two different photographic times can be identified by means of stereoviewing. But for a quantitative comparison of the terrain changes reflected through examining photographic images of two different times it is preferable to construct the digital terrain models with an identical scale. Without the modern computer-aided photogrammetric instruments it is not easy to realize the comprehensive and accurate analyses.

Lastly, because of the complexity of mountainous terrain it is impossible of understanding all mysteries hidden in the image of various features even for the most capable photo interpreters. In order to convenient to unify the interpretation of image signals it is necessary to collect and prepare the typical photo-interpretation keys for the thematic research. With respect to debris flow study these typical keys are composed of ones including the varied basic elements forming natural debris flows, the source, riverbed and alluvial fan etc. for visual interpretation. Photo keys are very useful for the training, broadening scope of cognition and infering what on earth the unknown features are from known ones. Though the time when taking photographs, the area being interpreted and its natural conditions are not likely same, those keys provide guidance about the correct identification of features or conditions on the photographic images and hence reduce a lot of uncertain factors. An airphoto interpretation key can help the interpreter conceive and evaluate the information presented by images in an organized and consistent manner, consequently the effectiveness of analysing aerial photographs will be improved. Furthermore the utilization of airphoto interpretation keys will facilitate realization of the automatic recognition and analysis of images in computers, and at the same time a priori knowledge stored by keys may also constitute an important part of the knowledge base of a regional geographic information system.

REFERENCES

1. Wu Jishan, Kang Zicheng, Tian Lianquan, Zhang Shucheng. 1990.
Debris Flow Observation and Research on the Jiangjia Ravine of Yunnan Province.
Scientific Press, Beijing, China.

2. Fleishman. S. M. 1986.
Debris Flow. (Chinese Copy Translated by Yao Deji.)
Scientific Press, Beijing, China.

3. Du Ronghuan, Kang Zicheng, Chen Xunqian, Zhu Pingyi et al. 1987.
Debris Flow Research on the Xiaojiang River Basin of Yunnan Province -- Its review and perspective.
The Branch Publishing House of Scientific Document Press. Chongqing, China.

4. Jin Yuang & Chen Hanyuan. 1985.
Photo Interpretation.
Published by Wuhan Institute of Surveying and Mapping, Wuhan, China.