APPLICATION OF AERIAL SIDE-LOOKING RADAR IMAGERY IN CHINA

Authors: Yang Pinghe, Wang Lianke
Institution: China Aviation Remote Sensing Corporation
Address: P.O.Box 9221, Beijing
Country: The People's Republic of China
Commission Number:

China made a relatively late start to employ microwave remote sensing technique and has by now only achieved preliminary results. The following is a presentation of the application of the side-looking radar imagery in China.

The Institute of Electronics of the Chinese Academy of Sciences and Shanghai Jiaotong University are the major institutions in China engaged in developing side-looking radar. In 1980, the Institute of Electronics of the Chinese Academy of Sciences conducted an imaging flight-test of its own-developed synthetic aperture side-looking radar (x-band), covering an area of 2,000 square kilometers, and obtained fairly clear terrain target imagery of the test area, with a scale factor being 1:150,000 and system resolution being 15m.

A real aperture side-looking radar system (Ka-band) developed by Shanghai Jiaotong University underwent a flight-test over Hangzhou Gulf in March 1987 and was used in the comprehensive remote sensing flights for flood prevention and disaster fighting over the Yongding River acrossing Beijing and Tianjin in July and August of the same year. During the several dozens of successful sorties, both the airborne display and the display of the ground reception system showed clear imagery and proved to be an effective means for real-time monitoring in struggle against flood in China.

The Ka-band multipolarized real aperture side-looking radar jointly developed by East China Institute of Chemical Technology, Sheng Mei Radio Factory and Dalian Surface Vessel Institute was employed in microwave remote sensing surveys of the distribution of water-clogging plants first in a region of Taiyuan, Shanxi in Jan. 1986 and then in Nansi Lake and the mid-reaches of the main stream of Huaihe River in Anhui in Aug. 1987. It was also used in a side-looking radar remote sensing survey over the multi-metallogenic provinces in Tongling, Anqing and Luzhong. Consequently, an area of 5,000 square kilometers was covered and HH polarized radar imagery of the above regions were obtained, with azimuth resolution being less than 20m and range resolution being less than 15m.

The 25th Institute of the Ministry of Astronautic Industry has developed a quasi-coherent SAR and RAR dual-modular imaging radar and carried out a number of successful flight-tests over Jinxi, Liaoning, in September, 1986.

China Aviation Remote Sensing Services Corporation introduduced, in 1984, an X-band earth resources side-looking

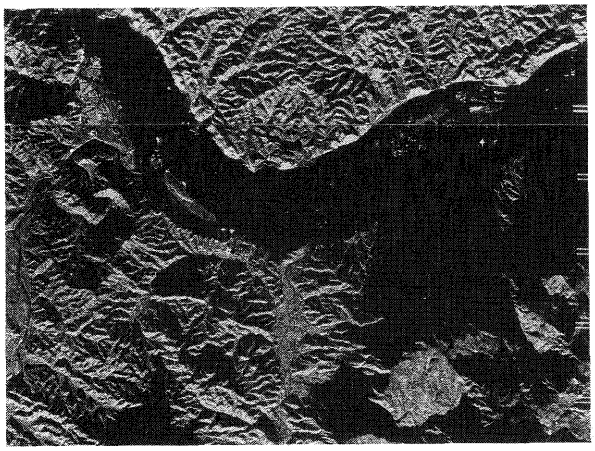
radar imaging system, thus enabling China's microwave remote sensing technique to enter a stage of practical employment. Since then, broad areas have been surveyed and mapped for the respective remote sensing or research institutions of Hunan Geologic Branch, the Ministry of Geology and Mineral Resources, the State Seismological Bureau, the Ministry of Water Resources and Electric Power, the Ministry of Forestry, the Ministry of Coal Industry, etc., and satisfatory results have been achieved.

1. Application in Geologic Survey

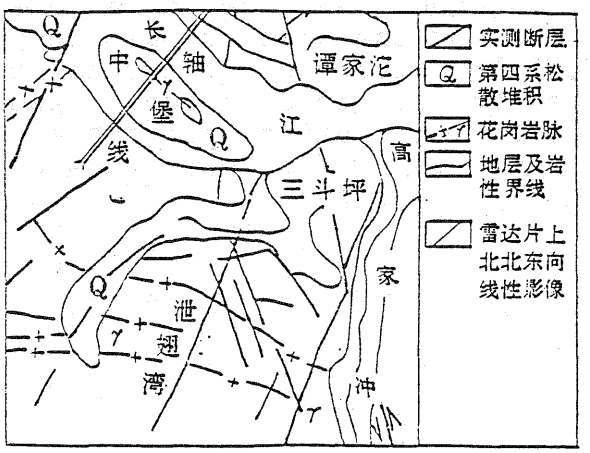
A. Distinct Structure Interpretation Result

To meet the construction needs of The Three Gorges Project, the Remote Sensing Centre of the Ministry of Geology and Mineral Resources acquired, in Jan. 1985, from China Aviation Remote Sensing Services Corporation, side-looking airborne radar imagery covering 20,000 square kilometers from Wanxian County to Yichang City with a scale factor of 1:100,000. The said imagery, with clear images and abundant information, turned out to be of excellent quality, particularly in respect of linear structures. Many new discoveries were made through comparing the information recorded in original documents with the results obtained from the interpretation of linear structures, rock avalanche, landslip and mud-rock flow and the estimation of flooded areas and economic losses.

Side-Looking Radar Imagery of San Dou Ping



A Graph Based on Geologic Interpretation of Side-Looking Radar Imagery of San Dou Ping



Surveyed fault

Q 4th-series loose accumulation

Granite range

Stratum and lithologic boundary

Linear image on radar film in NNE direction

There are 46 faults of more than 20km each in length interpreted from the imagery, of which only 13 existed on old geologic maps and the other 33 are newly discovered. This result sufficiently demonstrates the significant practical value of microwave remote sensing technique to geologic researches.

The newly discovered faults have drawn considerable attention of the specialists and authoritative departments concerned as they provide sounder scientific basis for the biggest hydraulic engineering site selection and dam foundation stability evaluation.

After performing geologic interpretation of the x-band aerial side-looking radar imagery of Bashang grassland North of the Great Wall, we have come to know that side-looking radar imagery, due to its directional effect, is sensitive to minor terrene flunctuations and capable of giving prominence to fine terrene features. Furthermore, thanks to its continuous coverage of large areas, the radar imagery may accumulate the fine terrain differences over a long distance, thereby enhancing linear appearance. This macroscopic and comprehensive display, in conjunction with side-looking technique, enhances the appearances of the geologic features that can not be easily seen on visible light photographs and helps interpret linear structures. The systematic remote sensing interpretation results exhibit that the linear structure density shown on the structure maps acquired from side-looking radar imagery is obviously higher than that on satellite and aerial photographs.

B. Feasible, Whereas Difficult Lithological Interpretation

The variation of imagery colour tones is the indicating feature for distinguishing rocks. As far as visible light photography band is concerned, the variations of the colour tones (or colours) on the photographs record mainly the difference in spectral reflectance of ground objects, reflect the chemical properties of geologic bodies and can help distinguish the rocks of different chemical properties and rock alteration. Whereas the variations of colour tones on side-looking radar imagery primarily reflect the differences in such physical features as ground location and roughness of geologic bodies. The differences are often influenced by soils, vegetations, humanity and other factors, thus causing some difficulties to lithological interpretation by using side-looking radar imagery. Therefore, it is hard to evaluate the geologic sense of the colour tone differences found on side-looking radar imagery. Nevertheless, some rocks can still be distinguished with the help of the characteristic that the side-looking radae imagery gives prominence to fine terrene features. We have distinguished metamorphic rocks and volcanic rock in the Bashang grassland by referring to the clear metamorphic lineations in N-W direction and the obvious fine lamination patterns.

Hunan Remote Sensing Centre has made a step forward in employing side-looking radar imagery to revise and compile geologic maps. They have established geologic lithological interpretation signs in Chenzhou Region by means of X-band side-looking radar imagery.

The Aerosurveying Remote Sensing Corporation of the Ministry of Coal Industry employs side-looking radar imagery of the east slope of the Luliang Mountain Range in lithological interpretation and has made the following summary: The important question of lithological interpretation is to investigate the surface roughness of rocks of different types. By comparing land survey result with imagery to determine the relative elevation of the surface roughness of various rocks and their grey level on imagery, as well as referring to the macro-geomorphic features, hydrographic features, pattern structure, lamination, etc., of various rocks, many kinds of geologic bodies can be interpreted. For example, they have, in the above-mentioned area, distinguished 9 kinds of geologic bodies, namely, granite of the Archean Era, alkaline complex of the Mesozoic Era, dyke rocks, metamorphic rocks, C-P coal-series stratum, detrital rock series of marine-continental facies, P_2-T continental facies red fragmental rocks, Q3 loess and Q4 loose accumulation.

C. Application in Mineral Deposit Research

The Aerosurveying Remote Sensing Corporation of the Ministry of Coal Industry has conducted exploratory application research using side-looking radar imagery (covering approx. 2,000 square kilometers) of Taiyuan West Mountain Coal Field. The interpretation and analysis of the radar imagery has made detailed research conclusions available now for optimum pitch angle selection, survey direction selection, geologic interpretation signs, fault structure interpretation result, coal distribution images, etc. They have read out from the radar imagery of the West Mountain region more than 100 linear structures, the majority of which correspond to the fault structures already known. With the fault structures of different grades clearly shown on imagery in a broad sense, the law of distribution of such mineral deposits as coal field can be clearly observed. At present, MSS visible light photographs and thermal infrared imagery can not do so well as the radar imagery. The big fault at Xishe, about 80km in length, is Class 1 structure controlling the west boundary of the coal field. On the imagery, it is shown as a banded image of 1km in width. After interpreting the fault structures, we have come to the conclusion that the radar imagery containing broad information and having high resolution is more suitable for regional structure research such as coal fields.

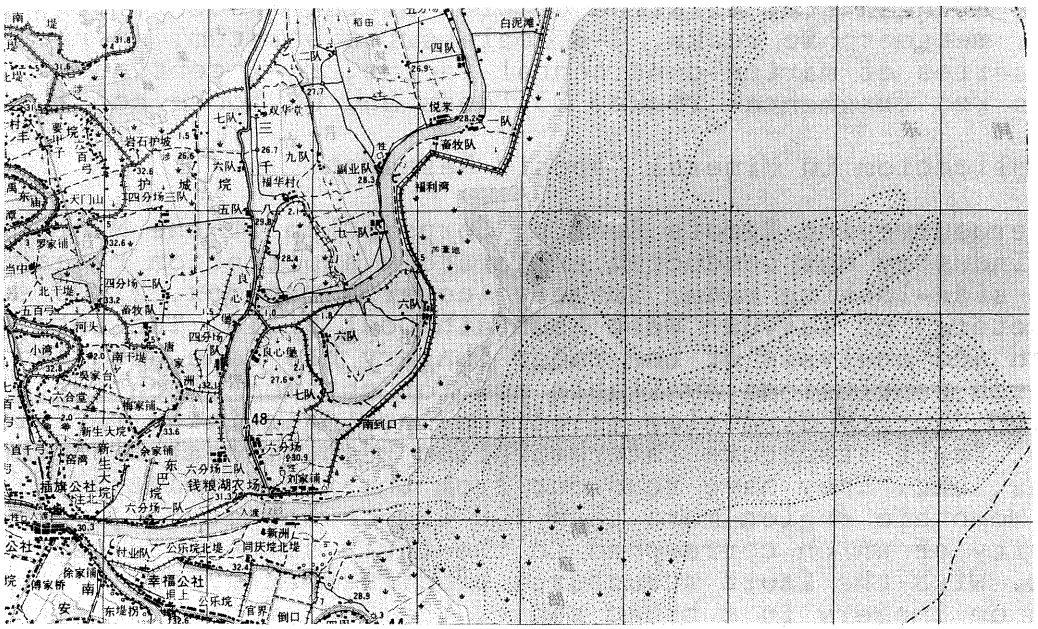
Hunan Remote Sensing Centre has gained much in utilizing side-looking radar imagery of Chenzhou area for prospecting and set contours of four long-term minerogenetic provinces. After performing geologic interpretation of side-looking radar imagery and satellite imagery, they have, based on the remote sensing imagery and the geologic and exploration results, made comprehensive analysis and worked out the contours of the four long-term minerogenetic provinces in Chenzhou-Guilin region, namely, Huangzujiang, Yazhixian, Changchengling and Litian.

2. Application in Map Revision and Compilation

The Surveying and Mapping Team of Hunan Geologic and Mineral Branch, by using 1:100,000 side-looking radar imagery, has

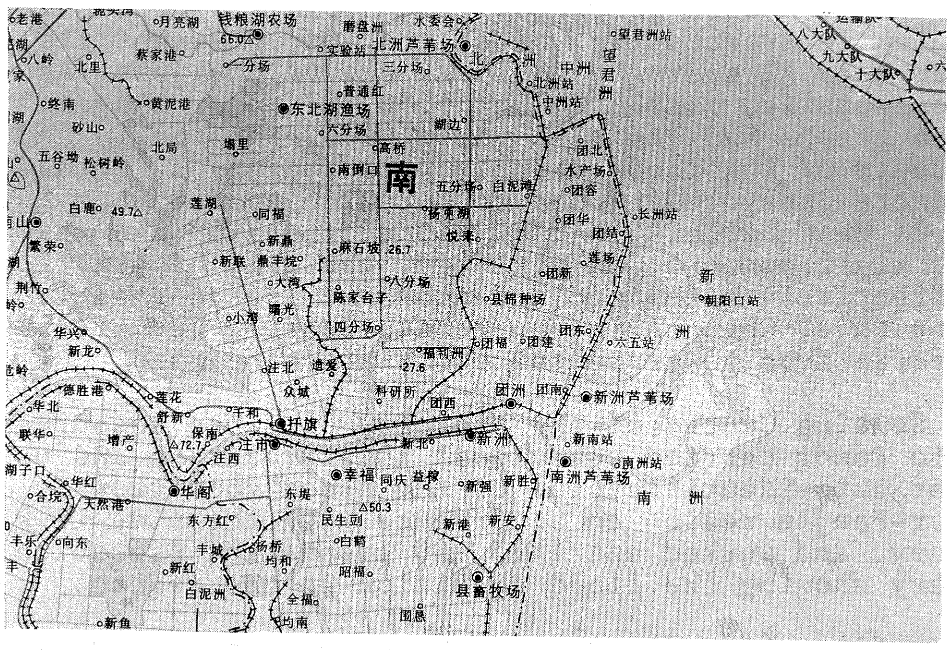
updated the existing 1:200,000 topographical map and hydrographic map and compiled "Map of Dongting Lake" displaying the present water area of the lake, current names of places and transportation network. On the basis of this map, they have added hydraulic engineering key elements and compiled "Hydraulic Engineering Map of Dongting Lake" which serves as the basic map for comprehensive tackling of the lake, flood prevention, dyke building, cropland arrangement, land utilization, course control and hydraulic engineering planning, and plays an important role for the hydraulic construction and land management in Hunan Province.

Topographical Map Before Revision



Side-Looking Radar Imagery

A Map Revised According to Radar Imagery



The above examples have proved that it is greatly advantageous to use side-looking radar imagery to revise and compile maps for cloud-prevailent plains and lakes. However, is it possible to employ side-looking radar imagery for revising and compiling maps of hilly land and mountain areas? A few remote sensing surveying and mapping institutions in China have the following point of view: Such features as upside down configuration, overlapping and shadowing of side-looking radar imagery impose certain difficulties upon overhead imaging. Therefore, at present, side-looking radar imagery must be employed in conjunction with other means (e.g. visible light photographs). For revising and compiling maps of gently undulated land, topographic information acquired lately and the newly obtained ground objects' information can be used. However, it is now still difficult to use side-looking radar imagery to revise and compile maps of mountain areas and more efforts ought to be made to seek for the possibility of using computer to process the digitized radar imagery converted from images to digital data so as to increase the geometric precision of imagery required by map compilation.

3. Application in Flood Control and Disaster Relief

Aerial microwave remote sensing made positive contributions in flood control and disaster relief work in Liaoning, China.

In August, 1985, flood occurred in Liaoning Province, the Liaohe River overflowed its banks and its dykes were breached in many places. Panjin City, Shuguang oil field and many other important factories in that region were threatened by the flood. In order to know the condition of the disaster at the lower reaches of the river, the National Flood Control Headquarters issued an instruction of conducting microwave surveying and mapping over the area. Upon receiving the order on August 28, China Aviation Remote Sensing Services Corp. started to image

the flooded area of 110,000 square kilometers using side-looking airborne radar, and then performed ground imagery processing, mosaics, quick interpretation and estimation of essentials, etc. It took them only 22 hours to complete all of the jobs. As a result, they supplied 1:100,000 and 1:50,000 radar images, flooded area graphs and other valuable data. The timely and accurate supply of the flood distribution imagery by China Aviation Remote Sensing Services Corporation enabled the National Flood Control Headquarters to take flood diversion and rescuing measures at right moment. Consequently, the raid of 4th flood peak was effectively withstood and economic losses greatly reduced. For this, China Aviation Remote Sensing Services Corp. won high praise from governmental officials concerned.

The Remote Sensing Centre of the Ministry of Water Resources and Electric Power carried out visual interpretation and used computer for auto-identification of the flood condition in Liaohe River-Panjin region in accordance with the side-looking radar imagery, and worked out 1:25,000 graphs and pseudo colour radar imagery showing the flood condition in the region.

This was the first time for the side-looking airborne radar to be used in China to investigate flood condition and to direct flood control and disaster relief work. The results have shown the following evident characteristics:

(1). The radar is highly mobile and can quickly produce microwave imagery and timely provide flooding information.

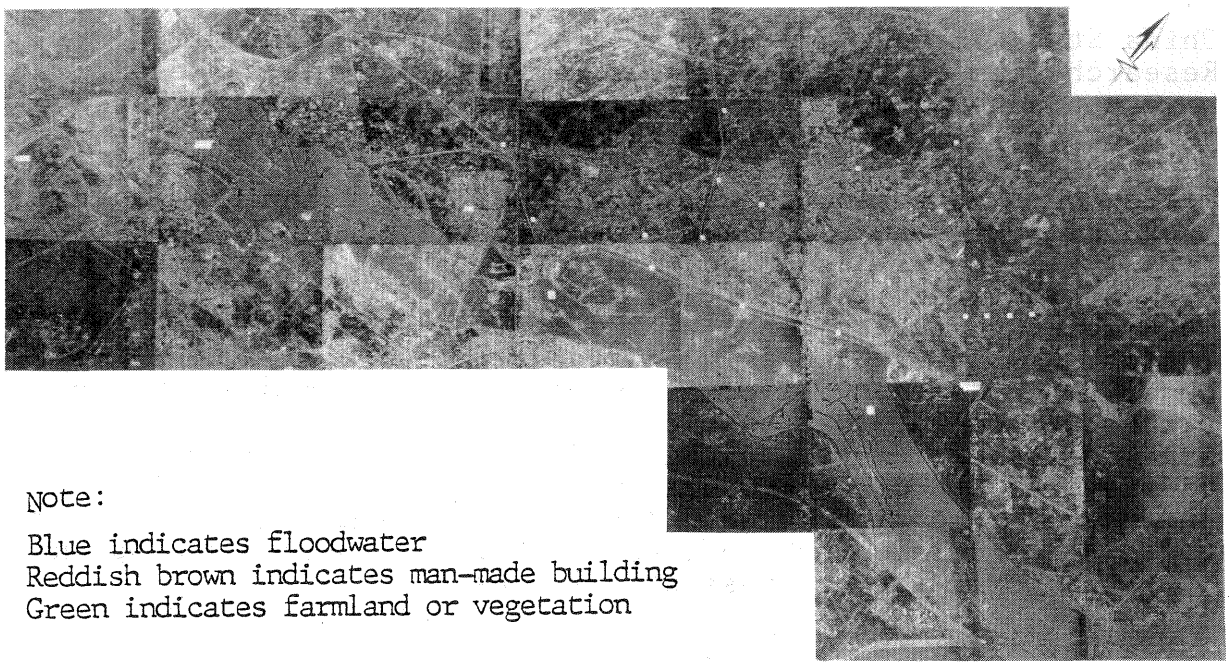
(2). Radar imagery has higher resolution, contains more information and can supply the details required in struggle against various disasters.

(3). Microwave imagery clearly indicates water-land boundaries and is conducive to investigating the scope of flooded area.

(4). Side-looking radar imagery of plain areas has very small geometric distortion and needs not be geometrically calibrated when in use, thus saving a lot of time for flood condition investigation and reducing workload.

The following is a piece of side-looking radar imagery of the flood condition in Panjin area processed by computer.

Side-Looking Radar Imagery of the Flood Condition in Panjin Area Processed by Computer



Note:

Blue indicates floodwater
Reddish brown indicates man-made building
Green indicates farmland or vegetation

4. Application in Forestry Investigation and Other Fields

In the year of 1985, the Institute of Forestry Investigation and Planning of the Ministry of Forestry conducted research work in Shaxian County, Fujian Province, on the response of soils and forests to microwave imagery using X-band side-looking radar imagery. The detection interpretation and land survey offered the following results:

It is possible to perform visual interpretation of soil types on 1:50,000 radar imagery and there exist potentialities in distinction of forest types and investigation of forest resources. The following are a few pieces of information gathered from practical research:

(1). The accuracy of soil interpretation can reach 90% and above;

(2). The accuracy of Grade 3 forest interpretation can reach 85% and above;

(3). It is not difficult to locate and draw the contours of forest boundaries and compartment network;

(4). It is fruitful to locate contours of small compartments on radar imagery.

China has large areas of virgin forests and there is a good prospect of employing microwave remote sensing technique to investigate forest resources.

The Research Institute of Chinese National Seismological Bureau has made seismological and resources development researches on Hainan Island and Leizhou Peninsula using side-looking radar imagery.

China State Surveys and Mapping Branch and the Hydraulic Research Team of the Ministry of Geology and Mineral Resources have conducted studies on map measurement and water location respectively using side-looking radar imagery.

Microwave remote sensing is an informational technique having broad prospects and has manifested its incomparable strength firstly in geology and flood monitoring. Should it be used in conjunction with visible light remote sensing and infrared remote sensing, achievements will definitely be made in many more fields. Remote sensing is a new technique which is under comprehensive development all over the world. Only through further strengthening international cooperation and research, can the superiority of remote sensing in quick supply, macroscopic display and abundant accumulation of information be exhibited and enhanced . We wish to join hands with friends the world over to work for developing the remote sensing technique and advancing the worldwide progress of sciences.

(The End)