MULTI-SOURCE REMOTE SENSING TECHNOLOGY USING IN THE SERVICE OF COAL RESOURCES EXPLORATION AND COAL INDUSTRY INFORMATIZATION CONSTRUCTION

Zhang Wenruo[a] Kang Gaofeng[b] Wang xiaopeng [b]

a Aerophotogrammtry & Remote Sensing of China Coal, Xi'an, China - zhangwenruo@arsc.com
b Remote sensing Application institute of Aerophotogrammtry & Remote Sensing of China Coal, Xi'an, China - kanggaofeng@mhyg.net, imagegis@163.com

Commission VII, WG VII/7

KEY WORDS: Satellite, Imagery, Geology, Exploration, Environment

ABSTRACT:

Remote sensing technology possesses high speed, real-time and other features of information acquisition and processing and can extensively be used in renewal of topographic maps, mapping of high precision remote sensing geology, mineral resources remote sensing survey, monitoring and governing of coal mine geologic calamity, coal mine engineering geologic evaluation, mine ecological environment monitoring and governing, mine field land use/cover change monitoring, mine field planning and other domains. By synthetically using multi source remote sensing technology, We can realize informational fast collection, processing and furnish the strong basic information and decision support for leader decision. It will surely bring the revolutionary advancement for coal industry to apply multi-source remote sensing technology to coal resource exploration and coal industry digitalization construction.

1. INTRODUCTIONS

Our earth is one planet with limited resource. Along with increase of earth population as well as humanity continuous pursuance for material civilization, pressure confronted by earth's resource and environment is continually intensified, resource is in exhaustion and environment is in deterioration. All these require people to know and understand our earth once again. How much resource can we still utilize to the end and how are on earth our surrounding environments？ Remote sensing technique is a kind of strong means of solving these problems. Remote sensing technique is a technology that carries out detection and discrimination for objective by perceiving the electromagnetic wave, visible light and infrared of target reflection or self-emitted radiation at long range. In the recent 20 years, the observation development and application of global space to ground has shown that aerospace remote sensing technology is a high-tech with comprehensive application and an importance scale of measuring science and technology development level of a country. Now no matter whether west developed countries or developing countries in Asia Pacific region attach full importance to develop the technology and hope that aerospace remote sensing technology will be able to furnish powerful impulse and reliable strategically decision gist for state economy constructional leap. Current remote sensing is no longer a simplex information acquisition and analytic technique means. Combined with geographic information system, global positioning system, a variety of surface observation technology, information analysis technology and so on, it is forming one brand-new earth information science. It is changing our conception, enhancing our ability and playing an active impulse role to promote new decision, management, and development model of humanity. The applied analysis of remote sensing information has been changed from single remote sensing data into mix and analyses of multi-time phase, multi-data source, from static analysis into dynamic monitoring, from qualitative survey for resource and environment into the computer aided ration autodraft, from surface description for a variety of phenomenon into software analysis and measure exploration.

Resolution of current remote sensing satellite image, in more than 30 years of satellite remote sensing appearance, has been enhanced rapidly, including spatial resolution, spectral resolution and time resolution. Spatial resolution refers to the least target dimension on ground seen from image, which can be expressed by the pixel size on ground. It has already been upgraded from 80 meters at the beginning of remote sensing to 30 meters, 10 meters, 5.8 meters, or even 1 meter, 0.61 meter, even 10 centimeters reachable in military purpose. Spectral resolution refers to imaging wave band scope. The more finely it is divided, the more the wave band, the higher the spectral resolution. Current technology can reach 5—6nm magnitude, with wave bands of more than 400. Subdividing spectra can enhance the ability for partitioning and identifying a target property and composition automatically time resolution refers to duration of re-access cycle. Presently earth-oriented satellite is the re-access cycle of 15 - 25 days in general. By launching the satellite constellation with reasonable distribution it can realize that earth is observed one time per 3—5 days. Thus it can be seen that remote sensing technique possesses high speed, real-time and other features of information acquisition and processing, at the same time it can be provided with high precision and quantification of application, etc. By synthetically using multi-source remote sensing technique it can realize informational fast collection and processing and furnish the strong basic information and decision support for leader decision. It will surely bring revolutionary advancement for coal industry to apply multi-source remote sensing technique to coal resource exploration and coal industry digitalization construction.

2. LANDFORM MAP RENEWAL USING REMOTE SENSING IMAGE

Because most of landform map of our country were plotted before the 1980s. Road, habitation and other elements have very large changes. Additionally because of adjustment of administrative division of villages and towns, administrative division of County and under County has also very large changes, which are not reflected in the original map. As a foundation map of field investigation exploration and coal geology mapping working, the existing landform map already had no means of meeting real work demand, thus renewal is urgent.

Data of satellite remote sensing image is strong in real-time feature and wide in covering surface, already becoming an important approach of obtaining and renewing information needed by heterogeneous, difference scale databases of state basic scale topographic map and state fundamental geography information system. Thus it is required to adopt remote sensing image of different resolution to carry out renewing processing for existing landform maps and collect a great deal of relevant data and documents for correction.

Scanning and rectification are performed for existing map data and numeralization are performed according to job specification. Then according to scale, high resolution SPOT, IKONOS, Quickbird and other images are adopted to carry out rectification and mix processing of geographical coordinates. After mosaic, cut is performed to generate images map coordinates. After understanding local basic status in remote sensing image and map, sampling of field investigation and keystone region are ascertained to carry out survey and plotting in the field to obtain identification characteristic of image and collect data from local related departments at the same time. According to the collected document and field investigation experience, remote sensing image is utilized to carry out renewal for digital map and carry out inspection for renewing results. Finally according to principle of map design, map layer design, symbolization map decoration and other workings are performed to obtain the aesthetic and precise map data.

3. HIGH PRECISION REMOTE SENSING GEOLOGY MAPPING

Because current 1: 250000 area mapping working and original 1: 200000 geologic map of our country had no means of meeting the working precision of survey and exploration of regional coal resource, as a basis of coal resources exploration, it is also urgent to unfold 1: 50000 or bigger scale geologic mapping working of keystone region.

As a kind of basic technique means, remote sensing technique has been extensively used by geologic survey work. Along with unceasing elevation of aerospace remote sensing technology in spectra and spatial resolution aspects, it furnishes new development chances for geology application of remote sensing again. For example, airborne hyper-spectra, multi-spectral technique can obtain the remote sensing image and data from space at the same time, thereby furnish narrow band, hyper-spectra, high resolution reflecting data and gray scale value for surface geology spectrum quantitative analysis and also furnish strong document support for the geology personnel to use the computer technical classification directly to generate the required enhancing information image of rock and mineral.

By means of remote sensing technique, taking the regional geological mapping as objective, it applies the image unit method, image rock unit method and unit profile method rationale to carry out explanation for regional strata, rock mass, structure and other factors.

3.1 Sedimentary Strata aspect

1. Quaternary sediment explanation can use the remote sensing image to ascertain manifold genetic types of quaternary system, whose certainty of geological boundary and modal plotting surpass ground reconnaissance geology survey.

2. It can identify the boundary of mapping unit of formal lithostratigraphic unit, whose accuracy ratio can reach 80－100 % except individual segments. It can trace and ascertain informal stratum unit extension and pinch out, more portable and accurate than ground trover.

3. Combined with high resolution satellite image or aero photographic image, it can carry out identification for contact relation among strata, such as unconformity, parallel unconformity, more effective especially for tectonic contact relation.

4. It can carry out a trover for lithofacies variance of identical stratum, especially lava variance situation in lava strata, whose effect surpasses ground investigation.

5. According to predominance of remote sensing image which is wide in visual field and strong in transverse contrast, it can correct locations where predecessor has processing errors and can set up stratigraphic framework of surveyed area remote sensing to direct fieldwork demonstration working.

6. It is self-explanatory that remote sensing image has predominance for unfrequented regional strata mapping.

3.2 Magmatic rock area

1. Remote sensing image can almost reach 100% for identifying rock mass borderline and the plotted rock mass boundary surpass ground observation in accuracy rating.

2. The recognition rate is greater than 60% for complex interior unit boundary.

3. It can only identify main class currently for lithology discrimination, with concrete detail needing a fieldwork.

4. In the section where interpretation effect of middling resolution image explanation is better, combined with high resolution satellite image or aero photographic image, it can differentiate vein rock, the order interpenetration relation, distribution regularity, coping residual body, wall rock xenolith and wall-rock alteration phenomena in rock mass. It can also identify partial schistosity, contact relation and other structure phenomena and furnish macro information for perching mechanism of rock mass.

5. By utilizing remote sensing predominance, it can carry out re-merger and disinterring for magmatic rock unit and sequence for which predecessor partition and merger is comparatively turbid.

3.3 Metamorphic rock area

1. In middle to deep metamorphic rock area, it can commendably identify out image information of marble and quartz rock. According to the image marker strata, in epimetamorphism rocky area it can commendably carry out identification and mapping for stratum unit.

2. It can better identify out old granite body of metamorphic rock region.

3. According to structural feature of marker bed, it can analyses deformation process for metamorphic rock area and is also fully effective for identification of the deeper deformation band of alinement and reticulation.

4. REMOTE SENSING SURVEYS FOR MINERAL RESOURCES

Our country is rich in mineral resources and remote sensing technique is fully broad in application prospects. Remote sensing technique has already been comparatively mature in regional geological mapping and procured nice effects. There are also more discoveries in geologic structure and mineral study, with cycle largely shortened and expense economized at the same time.

In survey aspect of geology mineral resources, remote sensing technique has developed from indirect detection to direct detection phase in our country, for instance, in Zhun Ge Er region of Xinjiang it directly detects out alteration zone of rock gold mine by using the subdividing infrared and multispectral scanning technology and achieves an important headway of remote sensing technique by which to directly search a gold mine. Our country also carries out the direct detection test of remote sensing of oil and natural gas resources by using short wave infrared imaging spectrum scanner in Xinjiang. Via information enhancement and extraction by using the remote sensing image data, it captures the hydrocarbon abnormity caused by microseepage leak on surface by oil gas accumulation, further achieves the purpose of direct detection. The project obtains confirmations in many production tests in Xinjiang Tarim Basin. Successful application of these technologies exerts an active action for expediting western development in our country.

Aiming at coal industry taking manifold satellite remote sensing image as information source, it farthest extracts regarding rock (sedimentary rock, magmatic rock and metamorphic rock), strata (especially coal bearing strata), structure, coal geology abnormity and other information within survey areas, combined with predecessor's data, analyze geologic structure characteristic and coal geology basic feature of region of interest, unfolds the demonstration working of field investigation, understands the upgrowth characteristic and deposit state of coal bearing strata, studies coal accumulation regularity and delineates coal bearing prospect area.

Taking visual interpretation as predominating and computer information extraction image as supplement, image explanation mainly explains regional control basin, coal controlling fault, stratal distribution, lithology, lithofacies and thickness changes orderliness, dislocation, plicated property, scale and upgrowth characteristic, finally establishes interpretation symbols of remote sensing of strata and structure and frames out the demonstration plan of field investigation. To extrude the characteristic of coal-bearing strata and non-coal-bearing strata, it enriches image information of dislocation, fold and other structures, enhances explanation effect, feasibility and foreseeability of survey working. It can also carry out digital enhancement processing for image by manifold methods.
Remote sensing geology explanation and field investigation demonstration can ascertain the epoch, distribution range, depositional feature of coalbearing strata and change of coalbearing features. By analyzing space distributive orderliness, on the basis of survey comparison for correlative layers, it can delineates various coalbearing strata in survey area.

Via information extraction of geognosy of remote sensing image, it can explain and verify main fault structure within area. According to every geology block characteristic and boundary fault property, starting from coal series gather and deposit background, structural unit can be partitioned to analyze control action of rupture and all levels of structural unit for coal series.

Via analyses and research for age-old geography of gather coal acting, ancestral structure evolution, gather coal action, gather coal basin genesis of various periods, it can ascertain type of gathering coal basin in area.

Tectonic framework of remote sensing geology of work area is established to analyze the control action of coal structure for coal basin and coal series, to study coal basin genesis, to ascertain distribution range of coal basin and coalbearing strata, to understand upgrowth and deposit characteristic of coalbearing strata, to study ancestral structure, age-old geography and depositional environment of coalforming period, to analyze reconstruction action of anaphase structure for coal basin, coal seam and coal quality, to summarize coal accumulation regularity, under precondition of mastering coal accumulation regularity fully and to delineate prospect area of containing coal.

Applying remote sensing technique to carry out coal resource survey possesses accuracy, high efficiency, economy and a good many of other predominance, especially on occasions in which work area is bad in natural conditions, inconvenient in traffic, coal geology study is low in degree, it can exert fully remote sensing technique’s predominance and procure new outcomes.

5. MINE FIELD GEOLOGIC HAZARD MONITORING AND GOVERNING

Coal district geologic hazard is mainly surface collapse, fracture, mine water invasion caused by underground mining and coast and fracture generated by open pit mining. In underground production area surface collapse and fracture ordinarily exist in coalfield district, especially in exploitation of major scale coal industry base, it is more striking. The surface of working section is in the instability in long term, harmful to tilth, bourg, road facility and mine safe production in mining section, already becoming an important factor to restrict area economic development. Along with increase of mining depth and complexity of exploitation conditions, especially exploitation in minefield of complex hydrogeologic condition, mine water invasion will also be increasingly striking. In addition, coal gangues pile up in various coal districts and occupy more than 9000 mou, in which to occupy farm area of about 3000 mou. Main harms of coal gangue are spontaneous combustion, dust nuisance and explosion, pollution of minefield environment and harm of human health.

As a kind of specific bad geology phenomena, No matter whether landslides, collapse, mudflow and other disasters or disaster colony formed by them, the shape, hue, image texture structure and so on they assume on remote sensing image have definite difference with circumjacent background. Thus it is directly identified and delineated from remote sensing image for scale, morphological characteristics and gestation feature of collapse, slide, mud and other geologic hazards, by which it can carry out systemic and comprehensive survey for generant geologic hazard points and hidden danger points of geologic hazard in target area via remote sensing explanation of geology disasters to ascertain their distribution, scale, formation cause, upgrowth feature, development trend, harmfulness and influencing factor, on the basis of which to carry out geologic hazard zoning, to partition easy occurring geologic hazard, to appraise easy occurring degree and to furnish base data for preventing the geologic hazard hidden danger and establishing the geologic hazard monitoring network.

On the basis of using high resolution satellite image or aero photographic image to carry out remote sensing explanation, geologic hazard distribution graph can be compiled via explanation and survey for coast, dilapidation, mudflow and so on. It can express a variety of geologic hazard position, boundary, element and other time and space features and plane scale in detail and become one of important base data and basic gist of planning and design even geologic hazard evaluation, in addition, it can also carry out disaster genetic analysis and trend anticipation from macroscopy.

Governing for geologic hazard shall first master extent of damage and development trend of geologic hazard, which includes casualty of personnel and livestock casualty, loss of village, mine, highway, bridge, hydraulic architecture and other property as well as demolition of soil, forest, water area and other natural resources. Using remote sensing technique to carry out geologic hazard survey, except that casualty of personnel and livestock is difficult to be statistic, can carry out real-time or quasi real time survey and evaluation for demolition situation of engineering facilities and natural resources and furnish the exact gist for disaster salvage.

Remote sensing technique is one rising hi-tech means. Not only it is necessary, but also feasible that using remote sensing technique unfolds the geologic hazard survey. Remote sensing technique can be transpierced to overall process of survey, monitoring, pre-warning and evaluation of geologic hazard. Along with gradual perfection of remote sensing technique theory and gradual elevation of spatial resolution spatial resolution, time resolution and spectrogram resolution of remote sensing image, remote sensing technique will certainly become one of indispensable means of macro-survey of geologic hazard and environment of pregnant disaster as well as evaluation of disaster body dynamic monitoring and the situation of disaster loss.

6. GEOLOGIC EVALUATION OF MINE FIELD ENGINEERING

Surrounding mine field infrastructure construction, it carries out engineering geologic investigation and appraisal of remote sensing of road, the site of factory and other engineering types and fully exert intuitionistic, fast, exact, high efficient predominance of remote sensing technique. On the basis of analyzing the existing area geology and bad geology, taking satellite image as basic information source, It unfolds the engineering geology remote sensing explanation, entirely extracts relative topography and relief, stratum lighology, geologic structure, hydrogeologic condition, engineering geologic condition, bad geology, vegetation and other information and carries out field investigation validation. Via aggregate analysis study, it initially ascertains engineering geology actuality, bad geology phenomenological type, distribution state, upgrowth feature, development trend and vegetational type, coverage and height, appraises engineering geologic condition and stability zone by zone to carry out sub area by engineering geology complexity for entire project area and presents the corresponding updated scheme and next step survey working proposal.

6.1 Engineering geology remote sensing analyses

1. Geomorphy type remote sensing analyses
According to relief genetic type and morphological characteristics, different relief genetic type possesses different image texture, drainage type and other image features, by remote sensing explanation, it can carry out a partition for zonal relief.

2. Rock soil mass type remote sensing analyses
On the basis of full explanation of stratum lithology, based on rock type, structure fabrication, formation rule, physical mechanical property and so on, it can carry out engineering geology rock formation partition for rock soil mass in area.

6.2 Geologic structure remote sensing analyses

By explanation of fault structure property, scale, space distribution feature, it ascertains relative time sequence and explains the active structure and focuses to analyze the possible generant impact for engineering.

6.3 Hydrogeologic condition analyses

Deposit and distribution of underground water are mainly subjected to be controlled by geologic structure, relief, lithology, climate and ancient landform conditions. According to explanation for water-bearing rock within area, combined with deposit condition and waterpower feature, it can carry out appraisal for underground water type and water abundance.

6.4 geological hazard remote sensing analyses and easy occurring degree forecast

With essential information source of satellite image, via remote sensing explanation, field investigation validation and available information analyses, it can ascertain coast, dilapidation, mudflow, instability incline and other bad geology phenomena. On the basis of explanation of bad geology points in detail, based on principle of whether to have effect for engineering; principle of mean upgrowth density of bad geology phenomena; principle of topographic relief, engineering geology rock formation, geologic structure and inducing factor similarity; principle of regional engineering geology condition integrality, it adopt a fuzzy mathematics syntheses judge method to carry out analyses of forecast and partition for easy occurring degree of bad geology.

6.5 Engineering geology complexity partition

On the basis of region stability, it can be measured mainly from topographical relief, stratum lighology, fault structure, rock soil mass property, bad geology phenomena, hydrogeologic condition, recent tectonics movement, Earthquake and other aspects. It also considers the productive state of rock and human activities of destructing geology environment and other factors, adopts qualitative evaluation method and carries out partition for complexity degree of engineering geologic condition of the project area.

6.6 Engineering geologic evaluation and scheme selection

On the basis of appraisal partition and engineering geology division for the relief, structure, hydrological geology, bad geology, engineering geologic condition and others, it carries out analysis appraisal for engineering geology characteristic and main engineering geological problems of the project area and carries out selection for the drafted scheme.

7. MINE ECOLOGICAL ENVIRONMENT MONITORING AND GOVERNING

Ecological environment has already become one of focal points of government and public attention, especially a frail ecology cold and dry area like our country's west, it is fully important to carry out monitoring for ecology environment. Mine ecological environment problems mainly include open exploitation delay, goaf, ore tailing, wastewater, groundwater overdraft and others.

Because it is remarkably clear and striking that various ecology elements are represented on remote sensing map, furthermore it is very easy to distinguish out their size, shape, area and other elements, it can use remote sensing image to carry out identification and plotting for main ecology factors. All mine ecological environment problems have the direct or oblique reflection on remote sensing image, thus it can also find up their distribution scope, area and others by remote sensing explanation combined with field investigation mode.

On the basis of remote sensing investigation of regional ecological environment and mine field ecological environment problem, the suggestion for ecological environment governing is presented. The governing for mine ecological environment mainly includes re-cultivation, re-green, tailings disposal and use, waste water treatment and use, groundwater overdraft monitoring and control, development and use of mine disuse terra and disuse engineering facilities.

Using remote sensing multi-time phase feature can not only make out a judge for ecology actuality, but also monitor its change trend and governing result.

8. MINE FIELD LAND USE/LAND COVER CHANGE MONITORING

Using multi-source remote sensing data can carry out a geometry correction, calibration, mix together, mosaic, enhancing processing to enhance spectral recognition ability for ground objects; Then, it carries out direct calculation of point-to-point for mine field different time-phase remote sensing image and adopts computer and manual work methods to find change information for land utilization type. Via fieldwork verification, it can ascertain mutative position, scope, type and area to realize fast monitoring for mine field land use and overcast change and furnish a gist for mine field planning and development.

9. MINE FIELD PLANNING

Via remote sensing geology mapping and mineral resources survey appraisal, it realizes exploration for mine field coal resource and analysis of existing circumstance of development and use. Via ecological environment survey it realizes analysis of existing circumstance for mine ecological environment. By monitoring mine field land use / overcast change, it realizes analysis of existing circumstance for mine field land use; Combined with supply and demand situation analyses and forecast of mineral resources, it ascertains the program objective mission. By engineering geologic investigation of remote sensing, it ascertains the planning scheme; thereby realizes integral planning for entire mine.

10. EPILOGUES

Satellite remote sensing can cover every corner of earth. For any country and region it does not exist any blank area of information acquisition caused by nature or social factors. satellite remote sensing document can timely furnish spatial information of identical time phase, identical wave band, identical scale, identical precision for spacious regions and manifold remote sensing information source of heterogeneous and different scale, such as multispectral ETM＋, SPOT, CBERS, IKONOS, Quickbird and others, high spectral MODIS, Hyperion, aviation imaging spectrograph OMIS and others, synthetic aperture radar image such as RADARSAT, ERS, JERS and others. It furnishes numerous selection for coal resources exploration and relevant information acquisition and possesses extensive application prospects.

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