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THE PROGRESSION AND FUTURE OF POLAR MAPPING IN CHINA

PANG X.(1), LIU H.(2), JIANG S.(3)

(1) Wuhan University, School of Resource and Environmental Science, Wuhan University, Chinese Antarctic Center of Surveying and Mapping, WUHAN, CHINA ; (2) Wuhan University, School of Resource and Environmental Science, WUHAN, CHINA ; (3) Wuhan University, Chinese Antarctic Center of Surveying and Mapping, WUHAN, CHINA

1. BACKGROUND AND OBJECTIVES

Chinese polar expedition has achieved a batch of high-level results of scientific research in the fields of polar glaciology, oceanography, ecology, surveying and mapping, bio-ecology, atmospheric science and solar-terrestrial physics in the past twenty-six years. The transition from traditional surveying to digital surveying, then to informationization polar surveying and mapping is available gradually, and the system of Chinese informationizaion surveying and mapping technology has been established fundamentally, including establishment of polar mapping datum, acquisition and mapping technology of spatial data of polar special environment, construction of digital polar basic geographical information frame and polar mapping making. Until now, China has successfully mapped all kinds of geographical maps including the first map of the South Antarctic Great Wall Station, the first map of the Antarctic Zhongshan Station and the first ice topographic map of the Antarctic Kunlun Station, which cover an area of around two hundred thousand square kilometers. Moreover, it has worked out the small-scale maps covering all regions and large-scale topographical maps covering key areas of Chinese scientific exploration in the Arctic and Antarctica , and mapped and published all kinds of scales of more than 200 Antarctic maps covering different areas. The kinds of maps include general maps, thematic maps, image maps, electronic maps and anchorage maps, etc. In addition, it has named more than 300 Antarctic geographical names by Chinese standard. Atlas of The Arctic and Antarctica, published in December of 2009, is the first atlas reflecting natural geographical environment of the Arctic and Antarctica and achievements of Chinese polar surveying and mapping scientific exploration. The atlas was edited by the key laboratory for Polar Surveying and Mapping Science of Wuhan University, and published by China Cartographic Publishing House.

2. APPROACHES & METHODS

2.1 Designing and Mapping of Scale Maps of the Arctic and Antarctica Series

By making use of 2D & 3D graphic and imaging techniques and dynamic visualization, the basic geographical features of the two-pole regions were expressed in details, multi-aspect, multi-dimension and high degree of accuracy, and the small-scale maps and mid & small-scale regional maps series were drawn up in the form of the traditional simulating maps and multimedia electronic maps.

2.1.1 Antarctic Map and View of the Arctic Region, made of paper in version, with the scales of 1:5500000 and 1:5000000 respectively, two full-size sheets, large format, large amount of information and strong visualization, have the single-picture and multitasking function. Antarctic Map is a image map of Antarctica with the most overall visualization and largest amount of information in the current domestic and foreign Antarctic exploration countries. View of the Arctic Region is the first independently-developed Arctic map at home. As for two series of map products by the Arctic and Antarctica as map-lands, the coordination of series of products is considered fully in content, page and artistic designs, but also given consideration to requirements of map design and expression for geographical features of different regions in the Arctic and Antarctica. So, it is the organic unity in contrast and coordination. The electronic editions of the Multimedia Electronic Map of the Antarctica and the Multimedia Electronic Map of the Arctic Regions can function as comprehensive expression of 2D map, 3D dynamic map, satellite images, and inquiry of relevant the general situation, landform, scientific exploration, resources, climate, environment protection and photographs of Antarctica in the form of texts, charts, pictures, voice, animation, videos, etc. Both maps have detailed contents with strong visualization.

All kinds of the finished maps of the Arctic and Antarctica cover the extensive coverage with rich contents and various scales. A series consists of two double full-size maps with scales 1:5000000 and 1:5500000 covering the whole areas of the Arctic and Antarctica, which all types of natural elements, social economical factors and elements of scientific survey of two poles' regions could be expressed by means of remote sensing images and layer colors by contour line. For local key areas, such as areas of two stations and Fildes Peninsula, their maps were drawn by the large scales（1:500, 1:1000, etc）, three-dimensional

terrains and symbols which were employed to denote the geographical features of the stations. They were applied matching with corresponding line maps, so as to provide station management, planning and construction. As for other scientific exploration activity and research areas, maps with different scales of 1:5000，1:10000, 1:20000, 1:100000 and 1:200000 had been mapped so as to meet requirements of the Antarctic exploration and research.

2.2 Study on Key Technology of Polar Remote Sensing Mapping

On the basis of optical remote sensing, synthetic aperture radar, laser-measured height, aerial photograph and multisource data mix technology, some technical problems had been solved such as non-ground control point mapping in polar region, and automatic interpretation of ice and snow features. At the same time, a complete set of polar-regional landform graphs, high-resolution plane satellite images and digital mapping technology of digital elevation models had been established. This provides important basic data for multi-disciplinary polar scientific researches. A great many pictures and data were provided for the design of investigation paths, motorcade navigation, safety of team members and facilities and map plotting of multidisciplinary achievements of the Antarctic scientific exploration. In addition, the important three-dimensional information was supplied for researches of surveying & mapping and other disciplines.

2.2.1 Study on Key Technology of High-resolution Remote Sensing Mapping for Antarctica

By taking advantage of more than 1000 multichannel satellite images photographed in different seasons by the US land satellite from 1999 to 2002, a great quantity of satellite image data were restored to restore real states successfully through applications of such key techniques as DN-value saturation overflow adjustment, radiation correction and transmission of surficial reflectivity. The 15-meter high-resolution fusion image bank and land coverage mapping were established. Meanwhile, the monitoring techniques for polar changes were developed making use of domestic satellite data. At the same time of surficial coverage interpretation for a great many data, the collection for the large-range on-site spectra were performed by using the advanced field radiation survey meters, so as to verify the accuracy of “landscape map” of terrestrial Antarctica.

At present, four times of the whole Antarctic mapping were performed all by the US. The resolution for the whole Antarctic mapping at the fourth time was 30 meters. We had completed the 15-meter high-resolution Antarctic image database and drawn up land coverage map of the regions in Antarctica, specially, accurate change monitoring was conducted for fast-changing surficial types of coverage in the margin regions of the Antarctic Continent. So, China can understand further the regions of Antarctica, and promote studies on relevant changes, and upgrade the future influential in the affairs of Antarctica.

2.2.2 Regional Aerophotogrammetry and Polar Digital Mapping by Multisource Remote Sensing Data

Our key investigation regions include Great Wall Station (Fildes Peninsula), Zhongshan Station (Larsemann Hills Region), Kunlun Station (Dome A Area), Grove Mountains Regions and Panda Section (Zhongshan Station—Dome A), etc..

With Hasselblad H1D digital camera attached on Heli-9 helicopter manufactured by Harbin Aircraft Industry (Group), the aerophotogrammetry was performed for the Zhongshan Station’s anchorage rock-exposed areas (including rock-exposed islands), Zhongshan Station Area and Larsemann Hills Region. The aero-surveying task with an area of 340 square meters had been done, namely, Concord Peninsula with 20 square kilometers at flight height of 500 meters, Larsemann Hills, Crocodile Island and the rock-exposed area west of Crocodile Island with 320 square kilometers at the flight height of 1000 meters. 50 corresponding surface marks and nine new GPS points were set. The air routes were set according to conventional methods. The aerosurveying was conducted flying by the east-west direction. The image map series of Larsemann Hill were worked out by taking advantage of aerosurveying photographs. Because there were no ground actual measuring control points and the control points in images were not easy to distinguish, the satellite ephemeris (position and velocity of satellite) and attitude parameters (omeqa, phi, kappa) carried by the satellite images were employed to solve orientation elements of image pairs. In consideration of GLAS height-measurement data which had sound vertical accuracy and positioning accuracy, these data were input into model to improve the success rate of image matching in the process of DEM fetch and reduce wrong matching points.

The synthetic aperture radar interferometry (InSAR) technique and GPS were combined to generate the digital elevation model (DEM) of core area of Grove Mountains. By comparison to DEM generated by InSAR and actual-measurement data, the standard deviation 5.4 meters could be gained in a stable area. This meets requirement of mapping of Antarctica, so it can further prove that InSAR is feasible to apply for the whole Grove Mountains and more range of map making in Antarctica. The research result that

InSAR is used for making map of Grove Mountains will save a great deal of manpower, material resources and financial capacity, and gives forceful support for Chinese research on Antarctica. If there are more time series data, the changing process of appearance of ice will be probed by mapping.

The two bands 3N and 3B data of stereograms about Grove Mountains mapped by ASTERL1A satellite over Antarctica were applied to generate relative DEM of Grove Mountains. The time gaining image data was 27 December, 2001, and ground resolution was 15 meters.

The 1:200000 orthophotomap of Zhongshan Station to Dome-A region was manufactured by using Landsat ETM satellite image data. Because ASTER optical image had a high spatial resolution (15m) and ICESat/GLAS height-measurement data had higher height accuracy (13.8cm) in the study, ASTER three-dimensional data were fused with ICESat/GLAS height-measurement data to pick up the high-accuracy digital height model in the surveying route. In analysis, the result had showed that the DEM accuracy was improved greatly. The relative DEM vertical accuracy was prior to 15 meters in some areas, which was up to 1:50000 mapping standard.

In addition, the 1:50000 and 1:100000 satellite image maps were drawn by using the SPOT-5 and IKONOS image.

2.3 Large-scale GPS Mapping in the Core Area

During the 15th and 25th Chinese Antarctic surveys, the real-time dynamic difference GPS (RTK) technique was applied to perform mapping of topographic maps in the key areas. In survey, two sets of GPS receivers were used at main substation and mobile substation. It could conduct synchro-jointly measurement with tracking substation of Zhongshan Station to gain high-accuracy datum. On the ice rock hill, 14000 GPS terrain points were measured accurately so that the first 1:25000 topographic map of Grove Mountains was available surveyed by manual work on the highland ice cap in the history of expeditions. In addition, the topographic maps of DomeA area and the station area of Zhongshan Station were measured in the field.

2.4 Design and Mapping of the Atlas of the Arctic and Antarctica

The Atlas of the Arctic and Antarctica is the first one reflecting the natural geographical environment of the Arctic and Antarctica and results of Chinese surveying and mapping scientific expedition in two Poles. The Atlas deals with systematic, standard and scientific summary and classification for all kinds of mapping results of surveying and mapping of the Arctic and Antarctica. It contains results of the multidisciplinary polar expedition and research and relative information at home and abroad, and reflects comprehensively history and research achievement of Chinese surveying and mapping of two poles in the past 25 years.

The Atlas is made up of seven parts, i.e. Introductory Maps, Overview of Arctic and Antarctica, Regional Geographical Maps of Antarctica, Regional Geographic Maps of Arctic, Chinese Antarctic Research Areas, the Arctic Research Areas and Appendix. It gathers systematically 70 general geographical maps, thematic maps and image maps totally, and 150 pictures with explanation of 22000 words. The Atlas adopts full numerical map mapping technology based on color map desktop-publishing system (DTP).

3. RESULTS

In the more than 20 years, all kinds of Antarctic maps mapped by China are abundant in content and scale with extensive map sheet coverage. A series that covers the whole regions of the Arctic and Antarctica is made up of two 1:5000000 and 1:5500000 double full-size maps. Such ways as the remote sensing images and layer colors matching with contour lines are applied for expression of all kinds of natural elements, social economic factors and scientific investigation factors in the two pole regions. For local crucial areas, such as areas of two stations and Fildes peninsula, their maps were mapped by the large scales, three-dimensional terrains and symbols which were employed to denote the geographical features of the stations. They were applied matching with corresponding line maps, so as to provide station management, planning and construction. As for other scientific exploration activity and research areas, different scales of maps with different scales 1:5000，1:10000, 1:20000, 1:100000 and 1:200000 had been mapped so as to meet requirements of the Antarctic exploration and research. In the aspect of kinds of maps, various image maps have been mapped making use of aerial photograph and multisource remote sensing data aiming at difficult and particularity of surveying and mapping in Antarctica.

4. CONCLUSION AND FUTURE PLANS

According to the mid and long-term plans and the 12th Five-Year Plan of the Chinese Polar Scientific Expedition, the medium-term plan for the polar mapping is as follows:

4.1 Realize full coverage of small-scale (1:250000) topographic maps, and perform surveying and mapping of 1:10000—1:50000 topographic maps for key exploration areas, and of 1:500 topographic maps of areas of the Expedition Stations (upgrade).

4.2 Map and issue the satellite images of the whole Antarctica by our independent satellite image data with supplementary foreign satellite image data, as well as jointly data from optical satellite, SAR satellite and height-measurement satellite. Build up the Chinese independent satellite image database of the whole Antarctic Continent, so as to provide the important basic data for study on Antarctica and global changes.

4.3 Perform surveying and mapping of 1:10000-1:50000 topographic maps for the key rock-exposed areas in Antarctica. Apply the domestic cartographic satellite image stereo-model data to perform surveying & mapping and DEM & DOM manufacturing for 1:50000 topographic map of regions such as investigation areas from Zhongshan to Kunlun, Antarctic peninsula, Amery Ice Shelf, Charles Prince Mountain, Victoria area, etc.

4.4 Perform under-ice and underwater topography mapping of Antarctica, and measure depth by using the Airborne Radar and Ground Penetrate Radar. Conduct GPS measurement simultaneously, and realize mapping of under-ice topographic map in the measuring area by fusion of data of the airborne radar, round radar and the existing depth-measurement data.

Based on GPS RTK, D-GPS and PPP techniques and sonar technology, measure the Great Gulf of Fildes Peninsula, underwater topography of sea area of the Prydz Bay, and make multi-scale underwater topographic maps.

4.5 Based on remote sensing data, DEM data and field survey data, draw up the 1:1000000 digital landform distribution maps of the Antarctogea, and provide background data for the Antarctic scientific expedition and global climate changes.

4.6 Compile the comprehensive atlas of resources and environment for the Arctic and Antarctica on the basis of the investigation on the comprehensive environment of two Poles.