

National Report

Antarctic Earth Science Program of China

2015-2016

To the 34th SCAR SSG-Gs

Chinese Arctic and Antarctic Administration (CAA)

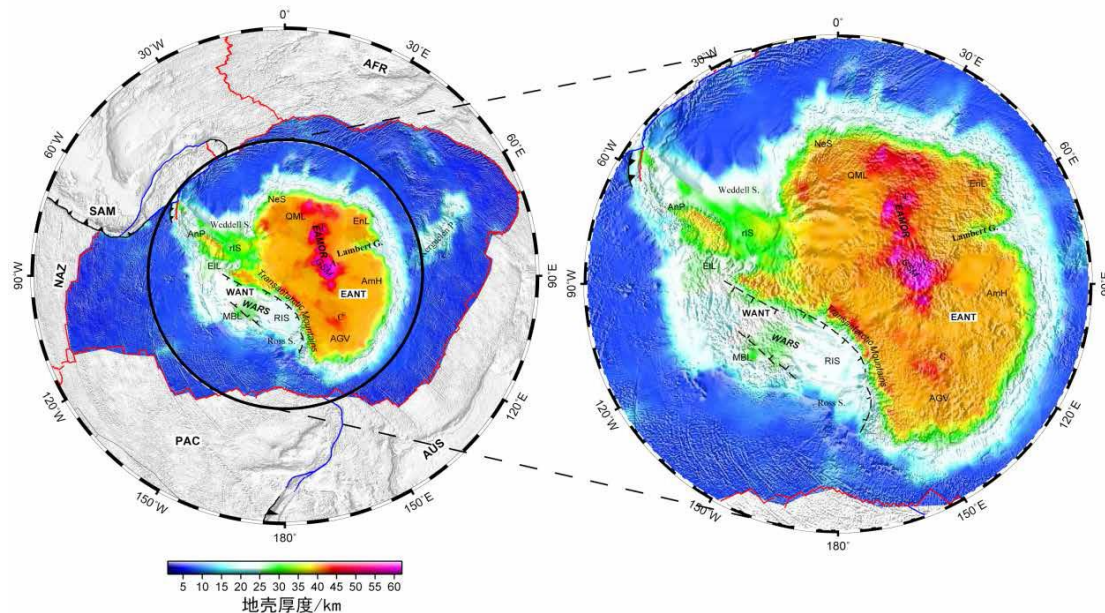
2016.8

Major Progress and Results of Scientific Research during 2015-16

(1) High-resolution 3-D crustal and lithospheric structure of the Antarctic plate

On the basis of the seismic observations obtained by USA, China and other countries, the first high resolution map on the crustal and lithospheric thicknesses covering the whole Antarctic plate was obtained. Some new information was retrieved from the new 3-D structure model. For example, the subglacial mountains of East Antarctica, with a crust as thick as 61 km, is collision suture of the Gondwana supercontinent amalgamation during the Pan-African orogeny; remnant of 20-Ma-ago subduction slab beneath the Antarctic Peninsula can be imaged; oceanic lithosphere thickening is dependent on the spreading rate of the oceanic ridge that formed the lithosphere.

This study was supported by the Polar Key Programmes and the NSFC, and the result was published in Journal of Geophysical Research: Solid Earth.

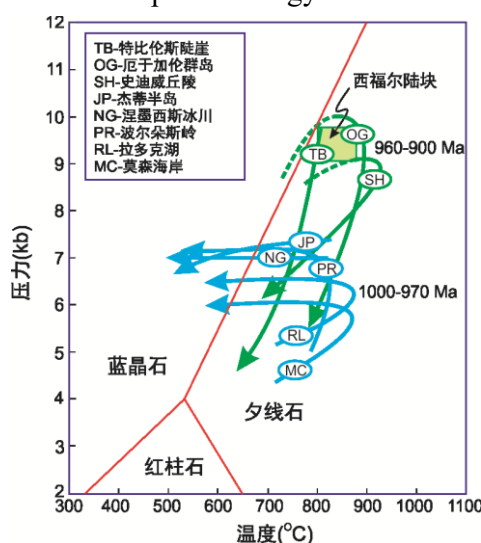


Crustal thickness of the Antarctic plate

(2) The recognition of the Grenvillian granulite facies metamorphism in the Vestfold Hills and its significance

Heterogeneous granulite facies metamorphism was recognized in mafic dykes from the southwestern Vestfold Block. This leads to an accurate determination of ages and P–T conditions of the Grenvillian metamorphism in the east of the Lambert Graben. It is suggested that the Vestfold Block may have involved the Rayner orogeny during the collision between the Indian craton and East Antarctica. It is important for the understanding of the Grenvillian tectonothermal events in the East Antarctic continent.

The study was supported by the Polar Key Programmes and the NSFC, and the result was published in Journal of Metamorphic Geology.



P–T conditions of granulite facies metamorphism of mafic dykes from the southwestern Vestfold Block and P–T paths of the Grenvillian metamorphism estimated for different localities in the Rayner orogeny

(3) P-T history of high-grade metamorphic rocks in the Larsemann Hills, East Antarctica and its tectonic implications

Pelitic granulites in the high-grade metamorphic rocks of the Larsemann Hills, East Antarctica, preserve important messages for an early (~1000 Ma) (M1) and late (~530 Ma) (M2-M3) high-grade metamorphic events; however, their complete P–T history has not yet been set up. Through detailed petrography and thermodynamic phase diagram modeling, a complete P–T evolutionary process was presented in this study, suggesting that the early (M1) metamorphic event has contrasting P–T evolutionary history, which is genetically associated with the northern Prince Charles Mountains and the Rayner Complex; whereas the late (M2-M3) metamorphic events have decompression P–T history, which should actually reflect an extensive intra-continental orogenic event. The result was published in Lithos.

(4) Meteorite collection in the Grove Mountains, inland of the EAIS.

More than 12000 meteorites have been collected in the Grove Mountains since 1998. 635 meteorites were newly collected during 32th CHINARE 2015-2016. The indoor research relative are on carry out in several academic institutions and universities.

(5) Modern sedimentary process of NO₃⁻ in surface snow of the traverse from the Zhongshan Station to Dome A

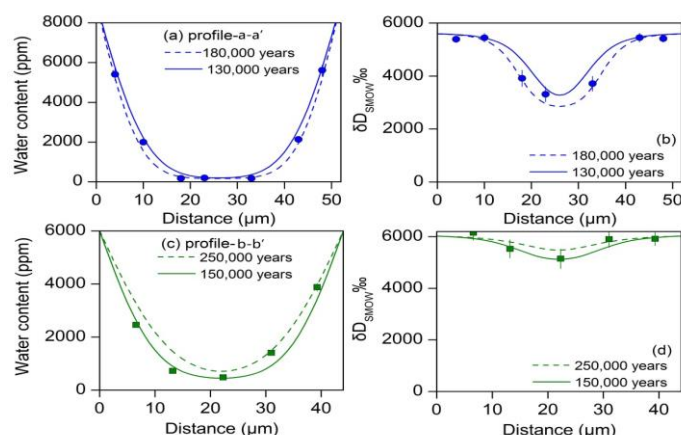
Analysis was conducted about NO₃⁻ isotopic composition in snow samples collected from seven snowpits to preliminarily investigate the post-depositional processing of nitrate in snow, along the traverse route from the Zhongshan Station to Dome A, east Antarctica. Accumulation rates were found to be the major influence factors on post-depositional processing of nitrate in snow. At sites of the continental interior (low accumulation), NO₃⁻ isotopic fractional distillation in near-surface snow (i.e., top 20 cm) was consistent with a Rayleigh-type process. In the snowpits closer to the coast, apparent seasonal variations of NO₃⁻ concentration and NO₃⁻ isotopic composition were observed. Very low concentration of ¹⁵N NO₃⁻ in austral summer was extremely likely derived from the inland transportation of NO_x/HNO₃, and the O₃ oxidization played a leading role in the formation process of NO₃⁻ in austral winter. Presently, preliminary study demonstrated that NO₃⁻/NO_x conversion was very active in snow - air interface.

The result was published in *Atmospheric Chemistry & Physics Discussions*.

(6) Underground water of Mars suggested by hydrogen isotope of Martian meteorite from Antarctica

GRV 020090 is one of the two specimen of Martian meteorite recovered by CHINARE from Antarctica, and crystallized from magma chamber of Mars around 200 Ma ago. The water contents and hydrogen isotope of magmatic inclusions and apatite of this sample acquired by SIMS reveals the following facts: ① Both water contents and hydrogen isotope of magmatic inclusion are zoned, indicating that the Martian ground water was added into the magmatic inclusion via diffusing, which proves that the volcanic activity of Mars can melt the subsurface glacier to form liquid water; ② The duration of the liquid water can reach up to 0.25 Ma based on the diffusion calculation and is in favor of the existence of life; ③ The hydrogen isotope composition by accurate detection shows that the D/H ratio of Martian underground water is 6 times higher than that of Earth, suggesting that more water was escaped from Mars and the paleo-ocean was larger and deeper than previous thought; ④ The positive correlation between the water contents and the hydrogen isotope of apatite suggests the residual water of the parent magma is gradually enriched during crystallization and contaminated by Martian crustal materials when ascending. The water contents of the parent magma and Martian mantle based on the first crystallized apatite are 380-450 ppm and 38-45 ppm respectively, significantly drier than Earth mantle.

This study was supported by the NSFC, and the result was published in *Geochimica Et Cosmochimica Acta*.

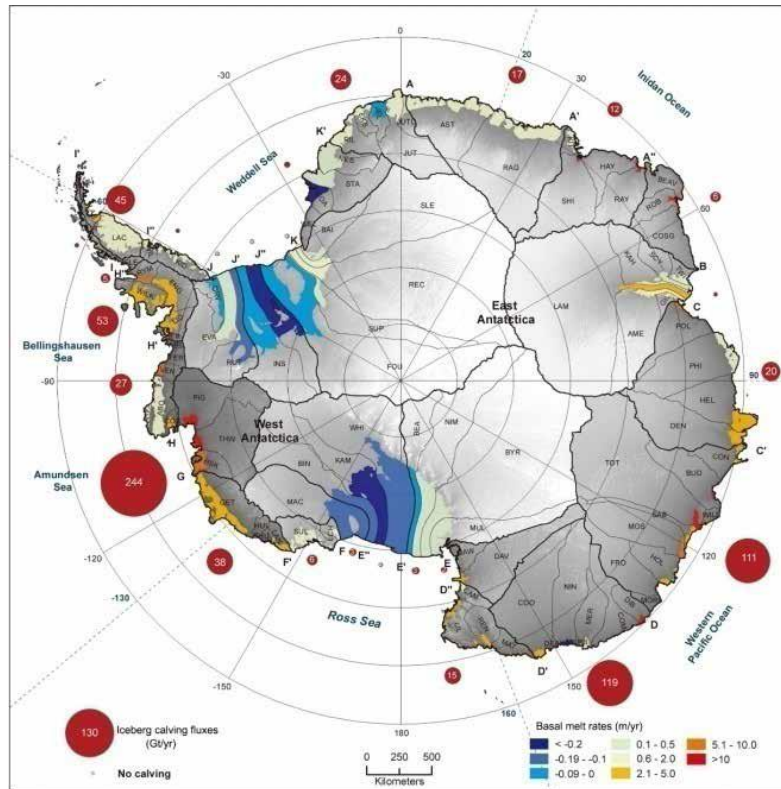


Water content and hydrogen isotope profiles of magmatic inclusions of GRV 020090 Martian meteorite

(7) Iceberg calving and retreat of Antarctic ice shelves enhanced by ocean driven thinning

Antarctic ice shelves play a significant role in stabilizing inland ice flow, which decides the contribution to the rise of the global sea level. For the first time, iceberg calving events larger than 1 km² were measured around the Antarctica coast using satellite images, based on which the ‘health status’ of all ice shelves were assessed. According to the directly-observed data, the Antarctic mass loss due to iceberg calving and basal melting was estimated. It is found that between 2005 and 2011, the total mass loss due to iceberg calving of 755 ± 24 gigatonnes per year (Gt/y) is only half the total loss due to basal melting of 1516 ± 106 Gt/y. The result also shows that some large ice shelves are expanding; meanwhile more small ones are diminishing. The ice shelves, whose shrinkage in spatial extent resulting from high calving rate, are also experiencing thinning in thickness due to basal melting, suggesting that they are more sensitive to ocean forcing than previous expectation.

This study was supported by the NSFC, the 973 Program, the Polar Key Programmes, and the result was published in Proceedings of the National Academy of Sciences.

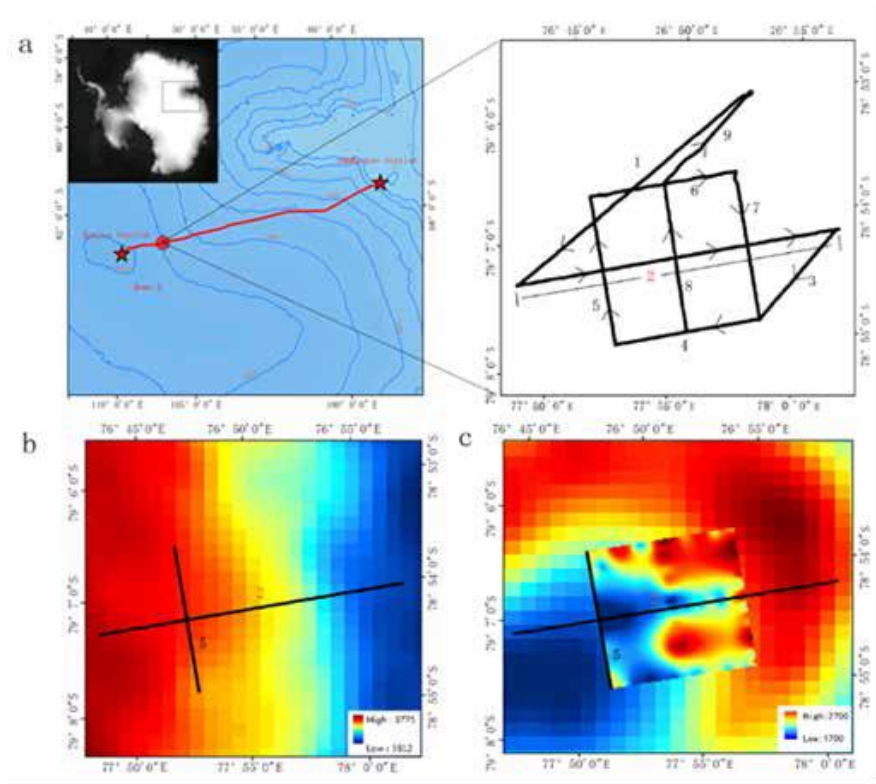


Distribution of iceberg calving and melting of Antarctic shelves

(8) Freeze-on ice zone in East Antarctica detected by ground-based ice-penetrating radar

The 29th CHINARE at the inland traverse from the Zhongshan station to the Kunlun station on the East Antarctic ice sheet provided an opportunity to reveal englacial freeze-on ice using ice-penetrating radar. A radar dataset along the profile was collected using a new ground-based radar system with a high-frequency of 150 MHz. A typical example of a freeze-on ice structure was revealed in the radar images, similar to that found in the Dome A region. The subglacial stratigraphy showed a new freeze-on ice zone with a length of 10 km near the ice-bedrock interface along the traverse, located 1044–1056 km from the coast.

This result was published in *Science Bulletin*.



Map of the traverse from the Zhongshan station to the Kunlun station on the East Antarctic ice sheet. (a) Surface elevation contours derived from RADARSAT; (b) Surface elevation data from Bedmap2; (c) Bed elevation

(9) ^{17}O -excess study in surface snow from the Zhongshan Station to Dome A

The investigation of ^{17}O -excess is a new frontier of water stable isotopes. Based on ^{17}O -excess measurements of surface snow along the traverse from the Zhongshan Station to Dome A, East Antarctic, it is found for the first time a significant decreasing trend of ^{17}O -excess from the coast to the central Antarctica, which is expected by the isotopic model. Additionally, the isotopic data from the traverse were used to optimize the parameters of the Mixed Cloud Isotopic Model (MCIM) and the sensitivities of stable isotopes to climatic factors were calculated. The analysis of the sensitivity laid a theoretical basis for quantitative reconstruction of paleoclimate from the isotopic records from deep ice cores at Dome A.

This study was supported by the NSFC and the Polar Key Programmes, and the result was published in *Earth and Planetary Science Letters*.

(10) Spatial and temporal variations of mercury in snow and ice of Eastern Antarctica and the influencing factors

The spatial and temporal variations of mercury in snow and ice along the transect from the Zhongshan Station to Dome A in Eastern Antarctica and the influencing factors were studied.

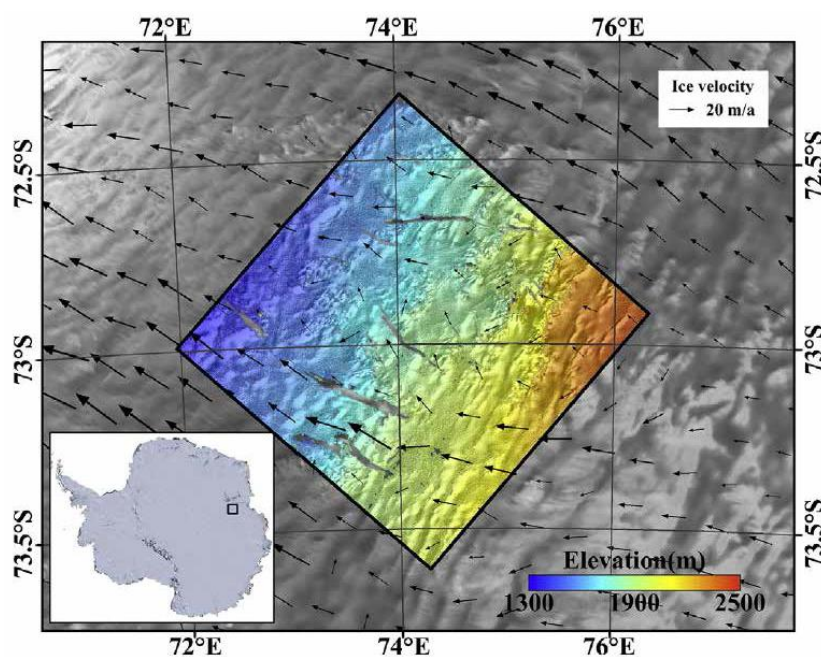
Spatially, the distribution of total mercury in coastal region (less than 600km in distance) shows a decreasing trend with the increase of distance, indicating the important contribution from the nearby ocean regions. For the inland region, the total mercury concentration increases with the increase of distance, indicating the potential transport of the mercury from mid-low-latitudes via the stratospheric airflow. Besides, the special precipitation style in the inland region maybe another influencing factor. The preliminary estimate of the total mercury deposited in inland area and the whole Antarctic continent were also been made in the research.

This study was supported by the Polar Key Programmes and the NSFC, and the result was published in *Tellus B*.

(11) Improvement of InSAR elevation models of Antarctica using baseline-combination method and laser altimetry

A method was proposed for generating high-accuracy and high-resolution DEMs using interferometric synthetic aperture radar (InSAR) and Ice, Cloud and land Elevation Satellite (ICESat) laser altimetry to reduce the influence of ice motion, satellite orbital errors and topographically correlated atmospheric delays. A case study in the Grove Mountains area shows that the InSAR DEM precision is better than that of the RAMP DEM and the Bamber DEM. The new DEM and long-baseline interferogram are used to calculate ice velocity over the Grove Mountains area where GPS measurements have been collected for comparison. Compared to the NASA MEaSUREs Antarctica Ice Velocity Map, ice velocity estimates from long-baseline interferogram and the new DEM have a smaller RMS error. This suggests that with the new DEM, baseline length is no longer a limiting factor for the accuracy of InSAR-based ice velocity mapping.

This study was supported by the 863 Program and the NSFC, and the result was published in *Remote Sensing of the Environment*.



Envisat InSAR DEM of the Grove Mountains area, Eastern Antarctica

(12) Assessment of Sea Ice Simulations in the CMIP5 Models

The simulations of Arctic and Antarctic sea ice concentration, sea ice extent, sea ice thickness, sea ice volume and their long-term trends from all the coupled models of CMIP5 (Coupled Model Intercomparison Project Phase 5) were evaluated in this study. It is the first time that the sea ice simulations from all the CMIP5 models are evaluated, and the results are important for the predication of sea ice in the 21th century and the improvement of coupled models.

This study was supported by the Polar Key Programmes, and the result was published in *The Cryosphere*.

(13) Transport of atmospheric chemical elements to polar region depends on large-scale atmospheric circulation: spatial distribution and source analysis

Precipitation (rain and snow) samples were collected over the Western Pacific – Indian Ocean - Eastern Antarctica atmosphere during the CHINARE from Shanghai to Antarctica. The contents of chemical elements in the samples were analyzed and the influence of atmospheric circulation was discussed related on largescale transport of chemical elements. The results showed that chemical constituents in the atmosphere presented significant spatial variation and was distributed with an obvious latitude gradient. Higher concentration features appeared close to the areas with human activities with lower concentration in the southern Indian Ocean area. Spatial analysis indicated that the Western Indian Ocean Intertropical Convergence Zone (ITCZ) had significantly affected the transport of chemical elements in hemisphere scale. Chemical elements in northern hemisphere influenced by the upflow of Hadley circulation were hard to transport to the southern hemisphere, leading to the result that chemical elements in the Antarctic snow were more likely to reflect the influence of the Southern Hemisphere input.

The result of this study was published in *Global Biogeochemical Cycles*.

(14) Thematic cartograph of Antarctic and Arctic environment maps and release of standard base maps

Cartograph models and methods for Antarctic and Arctic environment maps under various scales were studied, and parts of maps for the Resource Environment Atlas of the Antarctic and Arctic were completed. According to the requirement of various disciplines in polar on-site investigation and outcome expression and adhering to thematic cartograph standards and Antarctic surveying and mapping technical standards, over 130 standard geographic base maps with various scales at the form of line graph, photomap and hill-shading were plotted. The base maps were released online for users to design and download. The Atlas for Placenames of the Antarctic was also compiled and published. This study was supported by the Polar Key Programmes, Chinese Placename Research Project and Surveying and Mapping Project for Public Good.

The Standard Base Map Release System for the Polar Environment Comprehensive

Investigation & Assessment Programmes can be visited via <http://219.233.250.175:81/>.



Interface of the base map release system



Topographic map of Rathman hills



Resource Environment Atlas of the Antarctic and Arctic

Major field Projects of Scientific Research during 2016-17

No.	Project	Organization	Task source	Principal
1.	Investigation into Fildes Peninsula and its surrounding area	Institute of Geomechanics, Chinese Academy of Geological Sciences	Chinese Polar Environment Comprehensive Investigation & Assessment Programmes	Yue ZHAO
2.	Remote sensing investigation into water Color and temperature by at the sea around the Antarctic	National Satellite Ocean Application Service	Chinese Polar Environment Comprehensive Investigation & Assessment Programmes	Jianqiang LIU and Huiping XU
3.	Observations of Earth magnetic field and ionospheric scintillation (yearly)	Institute of Geology and Geophysics, Chinese Academy of Sciences	Other	Baiqi NING
4.	Geophysical observations (yearly)	Institute of Geodesy and Geophysics, Chinese Academy of Sciences	Other	Xinghua Hao
5.	Observation of the perennial GPS/bd tracking station and the tide observation (yearly)	Wuhan University	Other	Zemin Wang
6.	Deep ice core drilling	Polar Research Institute of China	Chinese Polar Environment Comprehensive Investigation & Assessment Programmes	Yuansheng LI
7.	Glaciological investigation into Ice sheet sections	Polar Research Institute of China	Chinese Polar Environment Comprehensive Investigation & Assessment Programmes	Yuansheng LI, Bo Sun and Cunde XIAO
8.	Astronomical observation in Dome A Purple Mountain Observatory	Chinese Academy of Sciences	Chinese Polar Environment Comprehensive Investigation & Assessment Programmes	Lifan WANG
9.	Observations of surface structure and morphology for ice sheets from Zhongshan	Polar Research Institute of China	Chinese Polar Environment Comprehensive Investigation & Assessment Programmes	Bo SUN

	to Kunlun Station			
10.	Surveying and Mapping in Antarctic Inland	Wuhan University Heilongjiang Administration of Surveying, Mapping and Geo-information	Chinese Polar Environment Comprehensive Investigation & Assessment Programmes	Zemin WANG and Wenhui WU
11.	Subglacial topography detection with Ice radar	Institute of Tibetan Plateau Research, Chinese Academy of Sciences	Chinese Polar Environment Comprehensive Investigation & Assessment Programmes	Xiaohan LIU and Yawei LI
12.	Natural Earth quick Observations	Institute of Tibetan Plateau Research, Chinese Academy of Sciences.	Chinese Polar Environment Comprehensive Investigation & Assessment Programmes	Junmeng ZHAO, Hongbing LIU and Gong DENG
13.	Field geological survey	Guangzhou Institute of Geochemistry, Chinese Academy of Sciences	National Natural Science Fund (NSFC)	Laixi TONG
14.	Investigation by Geochemistry	Institute of Mineral Resources Research, China Metallurgical Geology Bureau	Chinese Polar Environment Comprehensive Investigation & Assessment Programmes	Feixin HUANG and Yan LI
15.	Cenozoic history of the EAIS and palaeo environment research	Institute of Tibetan Plateau Research, Chinese Academy of Sciences	Chinese Polar Environment Comprehensive Investigation & Assessment Programmes	Xiaohan LIU and Aimin FANG
16.	Meteorite collection	Guilin University of Technology	Other	Bingkui MIAO and Hongyi CHEN