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News and Highlights

New Progress in Deep Earth Exploration and Application

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During October 24th–26th of 2018, the International Symposium on Deep Earth Exploration and Application was held in Beijing, China (Fig. 1). More than 300 experts from more than 20 countries and regions participated in the symposium. Well-known experts were invited to discuss important topics such as the evolution of the continents, the rheology of the lower crust, the deep carbon cycle, plate tectonics, deep seismic exploration, and achievements of systematic crustal exploration for seismic reflection, lithospheric structure and deep processes. Notable projects included Cretaceous Continental Scientific Drilling in the Songliao Basin, crustal and upper mantle structure of the Qinghai–Tibet Plateau, the International Lithosphere Project, the achievements and heritage of EarthScope, EON-ROSE in Canada, the analysis of exploration results in Western Australia, the contribution of Germany to Alp array, the achievements of deep structure research in Russia, the study of the lithosphere in the sub-Sahara using the African array, IRIS and earth exploration, rock probe, the exploration of deep seismic reflection profile on Mainland China, and two different mantle convection systems and reservoirs in the Western Pacific.

Focusing on the theme of the symposium, the participants discussed the deep structure and dynamics of the Himalayan–Tibetan orogenic belt and global collision zones, the transformation from continental rift to oceanic basin, the dynamics of intracontinental deformation, the relationship between surface processes and deep geodynamics, the deep cycle from the mantle to the crust, the monitoring of deep geological processes, the deep process of mineral resource formation, seismic activity, volcanism, deep geological processes and new technology of deep exploration. The main research contents and progress are as follows:

1 Deep structures and dynamics of Himalayan–Tibetan orogenic belt

Regarding the mantle crustal structure of the Qinghai–Tibet Plateau (QTP), a global collision zone, the experts mainly discussed the Moho surface in southern Tibet, the crust and upper mantle structure in eastern Tibet, the lithospheric three-dimensional resistivity structure in the northeastern QTP and the western part of the North China Block, the VP/VS image of the upper mantle in central Tibet, and the deep electrical structure in the middle part of the Sanjiang structural belt and its adjacent areas. With regard to the deep process of plateau uplifting, the eastern compression and northward expansion of the QTP, the shortening of the crustal scale in the eastern margin of the QTP, the rheological control of the lateral growth of the Tibet Plateau, the tectonic thermal simulation of Sikkim in the Himalayan region, the small-scale shear rate changes in the D layer of the Indian–Eurasian collision zone, the subsidence and subduction of the Tibetan lithosphere, and the continental subduction driving the Himalayan orogenic belt were discussed. Concerning the effect of the uplift of the Tibetan Plateau, the relationship between the growth of the Tibetan Plateau and the crust and Moho structures on the edge of the plateau, the fine lithospheric structure of the Sanjiang belt and the western margin of the Yangtze craton, the influence of the eastern evolution of the QTP on South China, the eastward expansion of the eastern Tibetan margin and the S-wave changes in the Western Himalaya–Tibet India-Ganges Plain were discussed.

2 Conversion from continental rift valley to ocean basin

The structure and evolution of the continents and their margins under the global system, the initial structure of continental rifts, the Alpha Array project for the structural imaging of the European lithosphere, the seismic profile imaging of the northern craton margin of Poland, the crustal model of the back-arc basin in southern Okhotsk, the focal earthquake of marine activity in the Japanese trench, the NGIMBN cross-conjugate graben in the East Java block, Indonesia, the deep velocity structure of the northwestern continental margin of the South China Sea, the extension of the South China Sea, the asymmetric simple shear extension in South China and the magnetotelluric evidence of lithospheric thinning were all discussed.

3 Dynamics of intracontinental deformation

With regard to continental mantle structure, the experts introduced and discussed the density of the upper mantle in Europe and the North Atlantic, the thermochemical anomalies of the continental lithospheric mantle in Siberia –North America and southern Africa, the Neoproterozoic lithospheric mantle structure in western Saudi Arabia, the

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continental shelf in the Barents Sea, the asthenosphere distribution characteristics in the eastern part of the Central Asian orogenic belt, the lithospheric structure of the North China Craton, and high-resolution lithospheric velocity structure of Mainland China. As for the dynamics of continental evolution, the convergence and rupture mechanisms of the Rodinia supercontinental core, the uplift mechanism of the Tibetan continent on the plateau continent, the crustal shear wave velocity structure and geodynamics of the Tan–Lu fault system, tectonic movement evolution of the Ordos Basin, brittle and ductile deformation and obliquity under the extensional tectonic background of the Central Asian orogenic belt, and the structural evolution of a triclinic-type transpressional high strain zone were discussed. On special rock types revealing continental characteristics, the Paleo-Archaean (3.7 Ga) Tarim craton plate tectonics revealed by TTG gneiss, the conductivity of minerals and rocks in the crust-upper mantle transition zone and subduction zone, the role of enrichment of regenerated sediments at deep mantle source, the experimental study of deformation and dehydration fracture of ophiolite in subduction zones, the shear catalysis and fabric transformation of mantle water in the lower lithosphere of the Siberian Craton were discussed.

4 Relationship between surface processes and deep geodynamics

In this aspect, the symposium participants mainly discussed the relationship between paleo-surface characteristics caused by mantle plume and deep crustal processes, slope processes caused by earthquakes, seismic deformation in central and southern Tibet, surface micro-deformation caused by deep dynamics, geological hazards in the Ailaoshan area of Yunnan Province, China, the role of fault geometry in large thrust sliding between simultaneous earthquakes and earthquakes in general, the inversion of sliding source parameters of the Xishan village landslide in Sichuan Province, geochemical mapping of surface weathered soils for major blocks in Australia, geochemical mapping of tectonic assemblages in Northern Ireland, a genetic model of thermo-dry rock resources along the southeastern coast of China, a high-resolution three-dimensional displacement field and its relationship with seismic, volcanic and underground nuclear tests.

5 Deep cycle from mantle to crust

Discovery of $CaIrO_3$-type Al_2O_3 in corundum from the Luobusa ophiolite in Tibet revealing the recycling of crust and mantle, the study of IODP Exp 366 in the Mariana subduction system, the evidence of deep mantle recycling recorded in global ophiolite, the stability of carbonate melt in the mantle, the protolith nature of diamondiferous metamorphic rocks in the Kokchetav Massif of Kazakhstan, the carbon isotope of diamond formation, the Pn travel time tomography used to study upper mantle structure, the velocity and density characteristics of subducting oceanic crust and the causes of seismic heterogeneity of the lower mantle in the Lhasa–Zhihezi region were discussed.

6 Monitoring deep geological processes

This topic mainly discussed the monitoring of deep earth processes based on distributed optical fiber sensing, the combination of ground P and S waves in microseismic monitoring, the drilling system of introduced electromagnetic measurement into relay stations, the study of output performance models of slim hole turbocharger, the new method of labeling low-abundance prokaryotic cells, ultra-deep scientific drilling-lessons learned from the development of modern drilling technology, microseisms before the *M*s 4.2 offshore earthquake in Istanbul, the control of seismic activity in the deep geothermal process at a depth of 1.6 km in Finland, the efficient plugging agent of intelligent gel in deep wells, the new perspective of exploring deep life, the design of adaptive bionic PDC bits in soft and hard interbedded strata, the exploration of the deepest boundaries of the earth biosphere, borehole stability in deep strata, borehole long-range acoustic imaging, and the time-lapse gravity method, a general method for monitoring dynamic process, simultaneous imaging of conductor and medium scatterers, comprehensive exploration of the deep-sea biosphere in the Illinois Basin, USA, and the application of ultra-high temperature water-based drilling fluids in the study of GR1 high temperature dry water wells.

7 Deep-seated process of mineral resources formation

Traditional geophysical methods are mainly adopted for mineral resources exploration, such as audio-frequency magnetotelluric sounding in the Tongling mining area of China, electrical structural characteristics and metallogenic prospects of the Shangrao section in Xinjiang Basin, velocity of lower crust-upper mantle in South China, anisotropic structure and its deep metallogenic significance, seismic imaging of lithospheric structure and upper mantle deformation in eastern China and its tectonic implication, magnetotelluric data used to study the electrical structure of the lower Yangtze depression (middle section), the crustal electrical structure of magnetotelluric and its constraints on mineralization, the structure of continental mantle and geophysical study, the collision zone between the Siberian plate and the North China Craton and deep magnetotelluric structure. In addition, it is also indispensable to investigate the geological background of any mining area, for example, lithospheric imaging was used to study the concealed terrain and rock system in the southern Lhasa block, the contribution of bismuth (tellurium) melt to gold mineralization, the identification and determination of the boundary between the Cathaysian and Yangtze blocks, preliminary understanding of gravity and magnetic field, genesis of a porphyry copper metallogenic belt after giant collision in southern Tibet, geological enlightenment from surface to deep earth, upper mantle structure in southeastern Ireland by teleseismic travel time tomography.

8 Seismic activity, volcanism and deep geological processes

Earthquake research mainly focused on the following: analysis of results of the Iraq–Iran boundary earthquakes,

Fig. 1. The International Symposium on Deep Earth Exploration and Application was held in Beijing, China.

the seismicity of the Himalayan orogenic belt, the determination of the co-seismic frictional characteristics of the strong thrust in the 2012 Nicosia earthquake with magnitude 7.6, the estimation of the site effect on Jordan's Gerash archaeological city, Asian seismicity, earthquake disaster and economic growth, and seismic risk assessment, the China earthquake test site: scientific challenges, inland earthquakes, complex spatial and temporal patterns and their impacts on disasters. On volcanism, this symposium mainly discussed seismic evidence of volcanic activity and velocity changes in Changbaishan Mountain, northeast China, and the seismic structure of volcanoes in the Changbai Plate from the joint inversion of environmental noise and reception function. On deep geological processes, geophysical observation of the lithosphere-asthenosphere system in the QTP and adjacent areas, deep tectonic and geodynamic significance under the Cenozoic volcanic rocks in northeast China, evidence of volcanic lithospheric deformation of Nuomihe volcano in northeast China, and structural and chronological characteristics of the crystalline basement on the northern Caucasus front were discussed.

9 New technology of deep exploration

The main methods of deep exploration technology are deep seismic reflection, full wave inversion application in long offset source data, full wave inversion application in the establishment of crustal scale velocity models in complex subduction zones, active source geophone application in passive source imaging, high resolution passive imaging of dense geophone array, crustal structure imaging of multiple seismic measurements. Magnetotelluric methods, such as magnetotelluric research in the geothermal area of Zhangzhou basin in southeastern China, direction evaluation of magnetotelluric survey, high-resolution crustal structure recorded by super-density array, work on the Ordos block, etc., include seismic data denoising based on shear wave transformation and a data-driven framework, synchronous measurement of crustal anisotropy and Moho surface geometry, the shear velocity structure of the eastern crust and upper mantle, application of the constrained probability method to the 3D gravity inversion crustal scale model on the continental margin of the Rift Valley off Newfoundland, eastern Canada, numerical simulation and evaluation of electromagnetic telemetry of horizontal wells in parts of the Tarim Basin, and achievements of the EarthScope array in North America. Ultra-deep drilling technologies include force distribution and cutting behavior analysis of a single wearing tool, single-tooth PDC cutting rock-breaking mechanism research, tribological characteristics under high temperature aging FKM O annular abrasive conditions, prospective research on the management of ultra-deep complex well pressure drilling technology, and high resolution imaging of bits while drilling under geological steering systems. Remote sensing technologies include SQUID gradient data compensation in an aeronautical magnetic tensor gradient measurement system, stone-based technology, development of airborne gravity gradiometer for the British flexible accelerometer and the noise suppression method for superconducting full -tensor aeromagnetic gradient measurement data.

The symposium organizers have published a collection of abstracts. Detailed content is available on the official website of ACTA GEOLOGICA SINICA (English edition) at http://www.geojournals.cn/dzxbcn/ch/index.aspx; https: //onlinelibrary.wiley.com/journal/17556724.

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