INSTITUTE OF GEOLOGY CHINESE ACADEMY OF GEOLOGICAL SCIENCES

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Annual Report 2016

Institute of Geology
Chinese Academy of Geological Sciences
(CAGS)

Editorial Committee

Contents

Preface

The Institute of Geology, Chinese Academy of Geological Sciences (CAGS), is a national public scientific research institution and is mainly engaged in national fundamental, public, strategic and frontier geological survey and geoscientific research. Entering the new century, and in particular during the past 5 years, the Institute has made notable progress in scientific research, personnel training and international cooperation, with increasing cooperation and exchange activities, expanded fields of cooperation, abundant output of new research results, and an increased number of papers published in "Nature", "Science" and other high-impact international scientific journals. In the light of this new situation and in order to publicize, in a timely manner, annual progress and achievements of the Institute to enhance its international reputation, an English version of the Institute's Annual Report has been published since 2010.

Similar to previous reports, the Annual Report 2016 includes the following 7 parts: (1) Introduction to the Institute of Geology, CAGS; (2) Ongoing Research Projects; (3) Research Achievements and Important Progress; (4) International Cooperation and Academic Exchange; (5) Important Academic Activities in 2014; (6) Postgraduate Education; (7) Publications. In order to avoid confusion in the meaning of Chinese names, all Chinese family names in this Report are capitalized.

We express our sincere gratitude to colleagues of related research departments and centers of the Institute for their support and efforts in compiling this Report and providing related material – a written record of the hard work of the Institute's scientific research personnel for the year 2016.

Editorial Board of
The Annual Report (English Version) of the Institute of Geology,
Chinese Academy of Geological Sciences
27 May 2017

1. Brief Introduction to the Institute of Geology

The Institute of Geology, Chinese Academy of Geological Sciences (CAGS), was formally established in April 1956 but can be historically traced back to the former Central Geological Survey as early as the 1910s. As a national public scientific research institution, the Institute of Geology is an integral part of the national scientific and technological innovation system, providing technological support for national geoscientific research and investigations of geology and mineral resources. The Institute is mainly engaged in national, fundamental, public, and strategic geoscientific frontier research and basic geological survey. It is one of the important national research bases in the solid earth sciences, the application of earth science-related technologies, and the education of young geoscientists.

Since its establishment in 1956, the Institute has made considerable contributions to national economic growth by providing scientific and technological advice to major issues of social relevance such as resources, environmental protection, and large-scale construction projects. The Institute has also won recognition in theoretical advances in the geosciences by means of basic research in frontier disciplines. In the Institute, 17 geoscientists, such as HUANG Jiqing, XIE Jiarong, SUN Yunzhu, CHENG Yuqi, LI Chunyu, etc., were elected Academicians of the Chinese Academy of Sciences (CAS) and the Chinese Academy of Engineering (CAE). With its competitive research team and remarkable scientific achievements, the Institute strives to enhance its domestic and international status in the geoscientific community.

The Institute currently has 260 staff, including 5 Academicians, 57 Research Fellows, and 62 Associate Research Fellows. 170 staff memberss earned their doctoral degrees, and 35 earned their master degrees. Amongst the Senior Researchers there are 38 advisers of doctoral candidates and 41 advisers of master candidates.

By the end of 2016, the Institute had won 167 science and technology awards at national, provincial and ministerial levels, among which were 24 prizes of the National Science Conference Award, 11 prizes of the National Natural Science Award and the National Science and Technology Progress Award (2 first prizes, 5 second prizes, 3 third prizes and 1 fourth prize), 131 prizes of the Science and Technology Progress Award at the Provincial and Ministerial levels (17 first prizes, 44 second prizes, 56 third prizes and 14 fourth prizes). More than 3475 research papers and 126 monographs were published since 1981. Since 1991, 4 researchers of the Institute have won the Prize for Scientific and Technological Achievement or the Prize for Scientific and Technological Progress of the Ho Leung Ho Lee Foundation, 7 researchers have won the J. S. Lee Honorary Prize for Geosciences, and 5 researchers have won the National Natural Science Foundation of China for Distinguished Young Scholars.

Fig. 1. Main building of the Institute

Organizational framework

The structure of the Institute is as follows:

Administrative Departments

General Office

Science and Technology Department

Service and Security Department

Financial Department

Personnel and Education Department

Research Divisions

Division of Regional Geology and Mapping

Division of Tectonics

Division of Stratigraphy and Paleontology

Division of Metamorphic Rocks and Precambrian Geology

Division of Igneous Rocks

Laboratory of Continental Dynamics

Laboratory of Isotope Geology

Lithosphere Research Center

Beijing SHRIMP Center

Mineral and Energy Resources Center

Three-dimensional Geological Survey and Research Center

National Research Centres

Beijing SHRIMP Center

Key Laboratories

Key Laboratory of Continental Tectonics and Dynamics, Ministry of Land and Resources

Key Laboratory of Isotope Geology, Ministry of Land and Resources

Key Laboratory of Stratigraphy and Paleontology, Ministry of Land and Resources

Key Laboratory of Earthprobe and Geodynamics, Ministry of Land and Resources

Technological Support Organizations

Commission for the Geological Map of China (CGMC)

Center for Stratigraphy and Paleontology, China Geological Survey

Center for Three-dimensional Geological Survey and Research, China Geological Survey

Affiliated Academic Organizations

China Commission of International Continental Scientific Drilling

Commission of Regional Geology and Mineralization, Geological Society of China

Commission of Geological Mapping, Geological Society of China

Commission of Stratigraphy and Paleontology, Geological Society of China
Commission of Petrology, Geological Society of China
Commission of Isotope Geology, Geological Society of China
Commission of Metamorphism, Mineralogy and Geochemistry, Geological Society of China

Peer-reviewed Publication

Acta Petrologica et Mineralogica

Research Fields

Regional geology, mapping and related database construction
Regional and global tectonics
Origin and evolution of life, paleontological and stratigraphic correlation
Precambrian geology and early crustal evolution
Cenozoic geology and modern geological and ecological environments
Ultrahigh pressure metamorphism and metamorphic belts
Petrology, mineralogy, and earth materials science
Continental dynamics and mantle dynamics
Geological setting of mineralization and regional mineralization
Deep geophysical probing, lithospheric structure and geodynamics
Isotope geology theory, methods and applications
Quaternary geology and past global changes

2. Ongoing Research Projects

There were 156 ongoing research projects in 2016 as listed below.

2.1 Projects funded by the National Natural Science Foundation of China

Key Projects:

No.	Chief Investigator	Project	Duration	E-mail address
1	LI Haibing	Fault friction over time: Co-seismic weakening and post-seismic in-situ healing	2016-2020	lihaibing06@163.com
2	GAO Rui	The high resolution deep seismic probe and research for the lithospheric structure and deformation in the northeastern Tibetan Plateau	2016-2020	ruigao126@126.com
3	ZHU Xiangkun	A high-resolution study on Cryogenian interglacial oceanography: a record from the Yangtze basin	2015-2019	xiangkun@cags.ac.cn
4	LIU Fulai	The spatial extension, multiple metamorphism and magmatism, and tectonic evolution of the Jiao-Liao-Ji orogenic belt, North China Craton	2015-2019	lfl0225@sina.com
5	XU Zhiqin	Hot collisional orogenic dynamics: deformation, metamorphism and partial melting during exhumation process of the Great Himalaya complex (Central Nepal)	2015-2019	3077864156@qq
6	GAO Rui	Detailed structure of the lithosphere and deep processes of deformation in the transition from the northeastern Tibetan Plateau to the Alashan, Ordos and Sichuan Craton basins	2015-2019	gaorui@cags.ac.cn
7	WANG Tao	Spatial-temporal distribution of deep, old and juvenile continental crust and constraints on metallogenesis of northern Xinjiang and adjacent areas	2015-2018	taowang@cags.ac.cn
8	ZHANG Zeming	Metamorphism and tectonics of the eastern Himalayan orogen	2013-2017	zzm2111@sina.com
9	HOU Zengqian	Comparison of the main metallogenesis of the Himalayan-Zagros collisional orogenic system	2014-2018	houzengqian@126.com
10	LI Haibing	Fault friction over time: co-seismic weakening and post-seismic healing within the Wenchuan Fault	2014-2018	lihaibing06@163.com

General Projects:

No.	Chief Investigator	Project	Duration	E-mail Address
1	LV Junchang	The study of Cretaceous dinosaurian faunas from Henan Province	2013-2016	lujc2008@126.com
2	JIN Xiaochi	Establishment and correlation of Permian biostratigraphic sequences of the Tengchong Block, western Yunnan	2013-2016	jinxchi@cags.ac.cn
3	MENG Fancong	Genetic mineralogy of eclogite from the East Kunlun Mountains, western China	2013-2016	mengfancong@yeah.net
4	ZHANG Jianxin	Early Precambrian crustal evolution of the western Alxa block and constraints on the North China Craton	2013-2016	zjx66@yeah.net
5	QI Xuexiang	Identification of a Neoproterozoic magmatic belt in the Ailaoshan orogeny and its tectonic implications	2013-2016	qxuex2005@163.com
6	WANG Tao	The characteristics of rock assemblages and formation ages of a flysch mélange of the Bailongjiang Group in the western Qinling belt.	2013-2016	real-wt@sohu.com
7	Chevalier Marie-Luce	Towards final agreement on the total slip-rate and location of the entire Karakorum Fault, western Tibet	2013-2016	mlchevalier@hotmail.com
8	LI Jinyi	Provenance of Silurian-Permian clastic rocks on the northwestern margin of the Tarim basin and its constraints on the closure time of the Paleozoic ocean in the Tianshan Mountains	2013-2016	jyli2003@126.com
9	ZENG Lingsen	Construction of large leucogranite plutons along the Himalayan orogenic belt and thermal effects	2013-2016	zls1970@gmail.com
10	SONG Yucai	Study of the large Chaqupacha Pb-Zn deposit in the Fenghuo Shan-Nangqian fold-thrust belt, Tibet	2013-2016	songyucai@gmail.com
11	YANG Zhiming	Sources of metal and sulfur for post-collisional porphyry Cu deposits: A case study of the Qulong copper deposit, Tibet	2013-2016	zm.yang@hotmail.com
12	ZHU Xiangkun	Genesis of the Shilu Iron Ore Deposits, Hainan	2013-2016	xiangkun@cags.ac.cn
13	HE Rizheng	Structure of the front of the Asian mantle southward-subducted beneath North Tibet and effects on continental collision	2013-2016	herizheng@cags.ac.cn
14	LU Zhanwu	Research on the structural attribute of strong seismic reflections in the crust of the southern Qiangtang terrane in central Tibet	2013-2016	luzhanwu78@163.com
15	WANG Haiyan	Fine lithospheric structure and deep processes of the inland deformation of the Xuefeng mountain tectonic zone	2013-2016	hyanwhy@126.com
16	DONG Jin	Paleo-secular variations and environ- mental magnetic study on Holocene lake sediments from the monsoon marginal zone in eastern China	2014-2017	djin@cugb.edu.cn
17	GUO Lei	Spatial distribution, transition mechanism and timing of late Mesozoic crustal contraction and extension on the southeastern China-Mongolia border	2014-2017	guolei_cn@sina.com

18	GUO Xianpu	Study on Middle-Late Ordovician vertebrate fauna in Bachu County, South Xinjiang	2014-2017	guoxianpu@cags.ac.cn
19	JI Shu'an	Early Cretaceous vertebrate fauna from the Ordos Basin (Inner Mongolia) and related stratigraphic correlation	2014-2017	jishu_an@sina.com
20	LI Yibing	Petrological and geochronological studies on variable magmatic evolution during the early stages of the Izu-Bonin-Mariana Island-arc	2014-2017	tansei007@aliyun.com
21	LI Zhaoli	Determination of the Songduo suture zone in the Lahsa terrain and Indosinian orogeny of the Qinghai-Tibet Plateau	2014-2017	lizhaoli3@tom.com
22	LIU Chaohui	Tectonic features of the Zhaertai and Bayan Obo Groups at the northern margin of the North China Craton and their relationship with break-up of the Columbia supercontinent	2014-2017	denverliu82@gmail.com
23	LIU Fulai	Multiple metamorphic and partial melting events in the San Jiang complex belt, southeastern Tibetan Plateau	2014-2017	lfl0225@sina.com
24	LIU Yongqing	The Tuchengzi-Zhangjiakou Formations and basin evolution at the transition of the Jurassic-Cretaceous in the Yanshan Mts. and implications for the North China rift system	2014-2017	liuyongqing@cags.ac.cn
25	TONG Ying	Petrogenesis of Permian A-type granites in the middle segment of the border between Mongolia and China and tectonic implications	2014-2017	yingtong@cags.ac.cn
26	WANG Yanbin	Crust formation and evolution of the Archaean Block from the Rauer Group, Antarctica: constraints from geochemistry and zircon U-Pb, Hf-O isotopes	2014-2017	fengguangying198@163.com
27	XU Jiren	Analyses of seismic data recorded at different depths of the Donghai 5000 m borehole and study of the non-linear properties of seismic waves in different layers and the seismo-tectonics in and around the Tanlu fault	2014-2017	xujiren1125@aliyun.com
28	YAN Zhen	Sedimentary analysis of the wedge-top basin within the ophiolite mélange belt in the Lajishan Mountains	2014-2017	yanzhen@mail.igcas.ac.cn
29	YANG Tiannan	Dose the Longmu Co-Shuanghu suture connect with the Changning-Menglian suture?	2014-2017	yangtn@cags.ac.cn
30	YIN Chongyu	Study on the lower age of the Chang'an glaciation and the biostratigraphy of the Cryogenian Period in South China	2014-2017	chongyuyin@cags.net.cn
31	YU Changqing	The deep structure and physical properties of the Eastern Tarim basin	2014-2017	geoyucq@hotmail.com
32	ZHENG Hongwei	The crust and upper mantle 3-D seismic velocity structure and dynamics beneath the Tongbai Orogen and adjacent areas	2014-2017	zhenghongwei004@sina.com
33	ZHOU Xiwen	Metamorphic evolution and genesis of the Paleoproterozoic khondalite series in the Liaoning and Jilin regions	2014-2017	xwzhou@cags.ac.cn
34	CAI Zhihui	Study of the relationship between horizontal and vertical shear zones and kinematic implications of Diancang- shan, southeastern Tibet	2014-2016	cai-zhihui@hotmail.com

35	FENG Guangying	Geochronology and geochemistry of Permian-Triassic mafic dikes in the Songnen-Zhangguangcailing Range, Jilin Province	2014-2016	fengguangying198@163.com
36	GUO Xiaoyu	Lithospheric structure of the Liupan Shan thrust-nappe belt, northeastern Tibetan Plateau, and deep deformation	2014-2016	guomichele@gmail.com
37	HAN Liang	The fine structure for fault healing and its impact on the mechanical properties of the fault	2014-2016	hanliangla@163.com
38	LEI Min	Magmatic evolution and eruption dynamic process for the cone-forming stage of the Changbaishan Tianchi volcano: evidence from melt inclusions	2014-2016	leiminlm@126.com
39	LI Jin	Mo isotopes of Mesoproterozoic Fe and Mn sedimentary formations of North China and implications for the paleo-oceanic environment	2014-2016	lijin80119@hotmail.com
40	LI Zhonghai	Subduction-induced mantle flow and seismic anisotropy: numerical modeling	2014-2016	lzhhai@gmail.com
41	LIU Pinghua	Petrology and metamorphic evolution of the Daqingshan-Wulashan high pressure granulites, northwestern North China Craton	2014-2016	lph1213@126.com
42	LIU Shoujie	Zircon characteristics under ultrahigh-temperature conditions: a case study of ultrahigh-temperature metamorphic rocks from Inner Mongolia	2014-2016	sjliu@bjshrimp.cn
43	LIU Yong	Geochemistry of Mesozoic basic rocks and interface conversion of the asthenosphere in the Hunan-Jiangxi Province	2014-2016	liuyongfirst@163.com
44	NIU Xiaolu	Petrology and Os-Pb-Nd-Sr isotope geochemistry of Datong Triassic lamprophyres and their geological significance	2014-2016	niuxiaoludx@126.com
45	WANG Fang	The genesis and metamorphic evolution of blueschists in the southern segment of the Lancang River, south-western China	2014-2016	wangfang_mr@163.com
46	XIANG Hua	The genesis of early Paleozoic sapphirine-bearing mafic granulites in the Tongbai orogen	2014-2016	xianghua2710@gmail.com
47	YAN Bin	Fe, Mo isotope constraints on Neoproterozoic negative carbon isotope excursions	2014-2016	yanbin703@163.com
48	LI Ming	Graptolite stratigraphic sequence in Nanba, Yiyang of Hunan Province and re-subdivision of the Tremadocian Stage	2015-2017	liming@cags.ac.cn
49	MENG Meicen	Research on lycopsids from the Upper Devonian of the lower reaches of the Yangtze River	2015-2017	mengmeicen@gmail.com
50	WU Zhenjie	Cyclostratigraphic study of the Jiangshanian Stage at the Duibian section, Zhejiang	2015-2017	wuzhenjie_cags@163.com
51	KOU Caihua	Petrogenesis of mafic-ultramafic rocks in northern Guangxi and constraints on the tectonic evolution of the western Jiangnan Orogen	2015-2017	caihuakou@163.com
52	HUANG He	Mechanism of Nb-Ta enrichment and mineralization in the Boziguo'er alkali granite pluton in the South Tianshan, Xinjiang Province	2015-2017	huanghecugb@126.com

53	ZHANG Yinghui	Phase equilibria during partial melting of TTG gneisses and petrogenesis of potassic granites in the Hengshan Complex	2015-2017	yhzhang@sina.cn
54	ZHENG Ning	Study of features of early Paleozoic radiolarian siliceous rocks and sedimentary environment in Yongzhou-Pingxiang, Hunan and Jiangxi, South China	2015-2017	zhengninglaio@163.com
55	JIA Jianliang	Research on the conductive mechanism of lacustrine immature organic-rich shale, based on accumulation differences of organic matter and its interpretation model	2015-2017	jiajl0228@163.com
56	XIE Shiwen	Temporal and spatial distribution and zircon Hf-O isotopes of Paleoproterozoic magmatic rocks in the Jiaodong terrane	2015-2017	swxie210@163.com
57	LIU Jiang	Occurrence and weakening effect of amorphous carbon in the fault slip zone：A case study of the Wenchuan earthquake fault zone	2015-2017	liujiang689@163.com
58	LI Shan	Source, petrogenesis and tectonic implications of Triassic granitoids in the Linxi area of Inner Mongolia, southern Central Asian Orogenic Belt	2015-2017	lishan428@163.com
59	SUN Jian	Iron isotope investigation of hydrothermal sedimentary iron deposits: a case study of the Motuosala Iron deposit in Xinjiang Province	2015-2017	sunjiantc@163.com
60	CHEN Xijie	Petrogenesis and crust-mantle interaction related to early Permian extensional tectono-magmatic assemblages in the Harlik Mt., eastern Tianshan belt	2015-2017	chenxijie@cags.ac.cn
61	LIU Yingchao	Origin of F-rich fluids in carbonate- hosted Pb-Zn deposits in a thrust belt of a collisional orogen: A case study of the Mohailaheng deposit in Qinghai	2015-2017	lychappy@126.com
62	LI Jie	Development of Cenozoic reference material for Ar-Ar dating	2015-2017	huaer3312@sina.com
63	YANG Jing	$^{40}Ar/^{39}Ar$ geochronology of the oxidation zone of sulfide deposits (Liuhuangshan and Kangguer deposits) from the Tu-Ha basin recorded paleoclimatic significance	2015-2017	yangjing822822@gmail.com
64	ZHU Xiaosan	Study of the Precambrian collisional belt between the Yangtze and Cathaysia blocks, based on deep reflection seismic data	2015-2017	zhuxiaosan@yahoo.com
65	LI Wenhui	Research on joint inversion of deep seismic sounding and coincident deep seismic reflection data from the Qinling profile	2015-2017	dereklee1984@126.com
66	TIAN Shugang	Late Permian organic reefs and palaeogeographic conditions in the Linxi, area, Inner Mongolia - Jiutai, Jilin	2015-2018	sgtian@cags.ac.cn
67	YAO Jianxin	High-precision stratigraphic correlation between South China and Tibet during the major turning period of the Permian-Triassic biotic evolution	2015-2018	yaojianxin@cags.ac.cn
68	LIU Jianfeng	Petrogenesis and geological significance of early-middle Triassic mafic volcanic rocks from southeastern Inner Mongolia	2015-2018	wenjv@aliyun.com
69	ZHANG Zeming	Formation and evolution of the Precambrian crystalline basement of southeastern Tibet	2015-2018	zzm2111@sina.com

70	WU Cailai	Magmatic system dynamics in Shujiadian, Tongling	2015-2018	wucailai@126.com
71	Zhang Hongrui	Coupling between deformation and fluid flow in the Baiyangping ore-producing hydrothermal system, Sanjiang area	2015-2018	hongrui_1982@126.com
72	KUANG Hongwei	Formation mechanism and correlation of molar tooth carbonate—the sedimentary record in the Meso-Neoproterozoic	2015-2018	kuanghw@126.com
73	DONG Chunyan	Late Neoarchean to early Paleoprotero- zoic tectono-magmatic-thermal events in the Daqingshan area: Geology, geochemistry and zircon geochronology	2015-2018	dongchunyan@sina.com
74	XIE Hangqiang	Tectono-thermal events and tectonic setting during the late Neoarchean in western Shandong	2015-2018	rock@bjshrimp.cn
75	WAN Yusheng	Formation and evolution of the Archean basement in eastern Hebei: Geology, geochemistry and SHRIMP U-Pb zircon dating	2015-2018	wanyusheng@bjshrimp.cn
76	REN Liudong	Distribution of Pan-African orogenic belts in the East Antarctic Craton and geological features of the Prydz belt	2015-2018	ldren@cags.ac.cn
77	LU Haijian	Tectonic coupling between the Kumukuli basin and adjacent orogenic belts: evidence from paleomagnetism and low-temperature thermochronometry	2015-2018	haijianlu2007@126.com
78	CAO Hui	P-T-t-D path based on quantitative data of porphyroblast growth: a case study of Qilian Tuolemuchang	2015-2018	caohuicugb@hotmail.com
79	TANG Suohan	Precise determination of Ti isotope com-position in rock samples and geological application in mantle processes	2015-2018	tangsuohan@163.com
80	YANG Zhiming	Genesis of comb quartz layers: case studies from porphyry Cu deposits at Qulong, Tibet and Now Chun, Iran	2015-2018	zm.yang@hotmail.com
81	CHEN Wen	Isotope thermochronological research on orogenic and ore-forming processes in the eastern part of the western Tianshan orogenic belt	2015-2018	chenwenf@vip.sina.com
82	HOU Hesheng	Tectonophysics research and its significance for the Suihua-Hulin profile, northeast China	2015-2018	hesheng.hou@126.com
83	LI Suping	Pleistocene palynological sequence and paleoecology reconstruction of karst caves in Chongzuo, Guangxi	2016-2018	lisuping.ibcas@gmail.com
84	ZONG Pu	Study of Late Devonian Famennian brachiopod fauna from western Junggar, Xinjiang	2016-2018	zongpu0501@gmail.com
85	LI Ya	The studies of carpological remains of the aquatic angiosperms from the Miocene of northern Hebei Province, China	2016-2018	liya207@mails.gucas.ac.cn
86	YANG Ben	Systematic and biostratigraphic studies on the early Meishucunian small shelly fossils from the Daibu Member of the Yongshan area in Yunnan Province	2016-2018	benyang@cags.ac.cn
87	TIAN Zuolin	Phase equilibrium of the metamorphic PTt paths for granulites from Namche Barwa	2016-2018	zuolintian@163.com

88	XIONG Fahui	Origin of platinum group minerals in different types of chromitite from the Purang ophiolite, Tibet	2016-2018	xiongfahui@126.com
89	CAI Jia	Phase equilibria modeling constraints on the metamorphic-anatectic evolution of metasedimentary rocks within the Ji'an and Laoling groups, southern Jilin Province	2016-2018	caijia91052@126.com
90	DONG Hanwen	Tectonic evolution of the Medog shear zone and its constrains on the formation of the Namche Barwa Syntaxis	2016-2018	donghanwen123@126.com
91	MA XUxuan	Neoproterozoic magmatic events in the Central Tianshan block, NW China	2016-2018	xuxuan.ma@hotmail.com
92	ZHENG Rongguo	The geochronology, petrogenesis, and tectonic significance of the Gongpoquan group volcanic rocks in the Xiaohuangshan-Yueyashan region, Beishan, Inner Mongolia	2016-2018	rgzheng@163.com
93	HU Peiyuan	The tectonic significance of Cambrian volcano-sedimentary event of the Lhasa terrane, Tibetan plateau	2016-2018	azure_jlu@126.com
94	GAO Li'e	Himalayan orogenic belt in Caledonian times	2016-2018	liegao09@163.com
95	ZHANG Zhiyu	Genesis of pegmatoid shell: case studies from the super-large Dahutang tungsten deposit in Jiangxi Province	2016-2018	zhangzhiyu@cags.ac.cn
96	SUN Jingbo	Tectono-thermal evolution study of the Aqishan-yamansu area in the eastern Tianshan, NW China	2016-2018	jingbo95003@126.com
97	YU Shun	The tectono-thermal evolution and uplift/exhumation of thrust-fold zones in the Kuqa-South Tianshan area: constraints from low temperature thermochronometry	2016-2018	yushun0722@163.com
98	ZHAI Qingguo	Tectonics of the Tibetan plateau	2016-2018	zhaiqingguo@126.com
99	YANG Jingsui	A global study on the origin of UHP minerals in mantle peridotites and chromitites in ophiolites of different tectonic settings	2016-2020	yangjsui@cags.ac.cn
100	LIU Pengju	Ediacaran silicified microfossils from the Hunan and Guizhou Provinces and their biostratigraphic correlation	2016-2019	pengju@cags.ac.cn
101	TANG Feng	Macrofossil biotas in the late Ediacaran–Cambrian boundary interval of South China and biostratigraphic correlation	2016-2019	tangfeng@cags.ac.cn
102	ZHANG Cong	Tracing the ancient subcontinental lithospheric mantle----Example from garnet peridotite of the Lvliangshan terrane, North Qaidam UHP metamorphic belt	2016-2019	congzhang@pku.edu.cn
103	YU Shengyao	Anatexis, deformation and exhumation of UHP metamorphic rocks: a case study of the South Altun-North Qaidam UHP metamorphic belt	2016-2019	yushengyao1981@163.com
104	MENG En	Petrogenesis of the Paleoproterozoic metamorphic supracrustal sequence and meta-mafic intrusions in Liaoning and Jilin Provinces: constraints on the regional tectonic evolution	2016-2019	mengen0416@126.com

105	YANG Chonghui	Magmatic activity in the (2.4-2.3 Ga) global magmatic quiescence: A case study of the North China Craton	2016-2019	chhyang@139.com
106	ZHANG Jianxin	Metamorphic and deformational history of fossil subduction channels--examples from the North Qilian and North Altun	2016-2019	zjx66@yeah.net
107	ZHANG Jin	Study on the kinematics, stages and tectonic backgrounds of the main fault systems in and around the Alxa Block	2016-2019	zhangjinem@sina.com
108	SI Jialiang	Fluid-rock interaction during healing of the Longmenshan fault zone	2016-2019	gongrenbaqin@126.com
109	ZHAO Lei	Nature of the Daheishan mafic- ultramafic complex from the Yiwu area, East Junggar, and comparative study on ophiolites in the East and West Junggar	2016-2019	jleiz@163.com
110	YIN Jiyuan	Thermochronologic constraints on exhumation processes in the West Junggar metallogenic belt	2016-2019	yinjiyuan1983@163.com
111	ZHANG Yan	The study of Ar-Ar dating on ultrafine minerals	2016-2019	yzhang737@sina.com
112	HE Rizheng	Eastward tracing LongmuCo-Shuanghu suture zone and its tectonic significance	2016-2019	herizheng@cags.ac.cn
113	LU Zhanwu	Study of “bright spots” structures in deep seismic reflection profiles in central and western Tibet	2016-2019	luzhanwu78@163.com
114	LI Qiusheng	The deep process and geodynamics of Mesozoic tectonic transition in the intersection area of rhe Nanling Range-Wuyi Mountain, southeastern China -– applying a high dense array of broadband seismic observations	2016-2019	liqiusheng@cags.ac.cn
115	XIONG Xiaosong	Detailed structure of the lithosphere and numerical modeling of crustal growth in the middle region in the Great Xing'an Range	2016-2019	xsxung@126.com
116	WANG Haiyan	Lithosphere structure and development of the Qinling orogenic belt	2016-2019	hyanwhy@126.com

2.2 Projects funded by the Ministry of Science and Technology and/or the Ministry of Finance

No.	Chief Investigator	Project	Duration	E-mail address
1	HOU Zengqian	Deep structure and ore-forming process of main mineralization systems in the Tibetan Orogen	2016-2020	houzengqian@126.com
2	LU Zhanwu	Fine structure of the lithosphere and deep processes in the main collision zone of the Tibetan Plateau	2016-2020	luzhanwu78@163.com
3	LI Qiusheng	Fine lithospheric structure and deep processes of the side colliding belt of Tibetan plateau	2016-2020	lqs1958@163.com
4	YANG Zhiming	Deep structure and ore-forming process of the main porphyry Cu-Mo-Au systems in the Tibetan Orogen	2016-2020	zm.yang@hotmail.com
5	ZHANG Zeming	Deep Earth processes and ore-forming events in the Tibetan Orogen	2016-2020	zzm2111@sina.com

6	KUANG Hongwei	Meso- to Neoproterozoic stratigraphic frame and depositional event correlation in China	2016-2020	kuanghw@126.com
7	XU Zhiqin	Tectonic regime and exploration prospecting of the central part of the main subduction-collision metallogenic belt, southern Tibet	2015-2017	3077864156@qq.com
8	TANG Suohan, LI Jie	Preparation of geochemical reference materials for Sm-Nd isotope measurement of silicate and (U-Th)/He dating of zircon	2015-2017	tangsuohan@163.com
9	ZHU Xiangkun	Mechanisms of Neoproterozoic mineralization of Mn, Fe and P in the Yangtze Basin	2014-2016	xiangkun@cags.ac.cn
10	PI Jinyun	Long-term deep borehole geophysical observation and comprehensive data analysis	2014-2016	jinyunpi@163.com
11	WANG Tao	Superposition of the Mongol–Okhotsk plate tectonic regime on the Paleo-Asian oceanic plate and its metallogenic systems	2013-2017	taowang@cags.ac.cn
12	LIU Dunyi	R & D of new models of TOF-SIMS for isotope geology	2011-2017	liudunyi@bjshrimp.cn
13	DING Xiaozhong	Geological records and maps of China and tectonic maps of Eurasia	2011-2016	xiaozhongding@sina.com

2.3 Projects funded by the China Geological Survey

No.	Chief Investigator	Project	Duration	E-mail address
1	ZHANG Jianxin	Geological survey project for Tethys-Tibet Plateau and tectonic setting of major metallogenic belts	2016	zjx66@yeah.net
2	YANG Jingsui	A comprehensive survey of chromite in the Yarlung-Zangbo and Bagong- Nujiang suture zones, Tibet	2016	yangjsui@163.com; yangjsui@cags.ac.cn
3	HOU Zengqian	Geological survey of the Gangdise-Sanjiang giant metallogenic belt and comparison of ore-forming processes with the Middle Tethyan metallogenic belt	2016	houzengqian@126.com
4	YU Changqing	Physical structure and deformation zone of the upper/middle/lower crust in the Tibetan Plateau	2016	geoyucq@qq.com
5	WANG Jun	Integrated mapping and comparison of the cross-border metallogenic belt in central East Asia	2016	wj257@126.com
6	JI Shu'an PENG Nan	The standards of regional strata and biota evolution in key areas and sedimentary rock geological pilot mapping	2016	jishu_an@sina.com pengnan19830120@126.com
7	LIU Fulai	Key geological issues of the North China Craton and its margin and metamorphic and pilot mapping	2016	lfl0225@sina.com
8	ZHANG Zeming	Key tectonic survey and pilot mapping of oro genic belts	2016	zzm2111@sina.com
9	XUE Huaimin	Study on major Phanerozoic magmatism evens in China and tentative mapping of igneous rocks	2016	huaiminx@sina.com.cn
10	GUAN Ye	Application and demonstration of 3D geoscience survey of southeastern areas in Inner Mongolia	2016	guanye@cags.ac.cn

11	LV Junchang	Database construction of index fossils in paleontology	2016	lujc2008@126.com
12	REN Jishun ZHAO Lei	Tectonic research and related map compilation for land and sea of China and adjacent area	2016	renjishun@cags.ac.cn jleiz@163.com
13	DING Xiaozhong	Geological tectonic division and comprehensive integration of regional geological survey of China	2016	xiaozhongding@sina.com
14	HOU Hesheng	Geological and geophysical survey of deep oil and gas in the Songliao Basin	2016	hesheng.hou@126.com
15	XIONG Xiaosong	The deep seismic probing of the crustal structure in the Qilian-Tianshan moutain belts and adjacent basin-range contact zone	2016	xsxung@126.com
16	LI Qiusheng	Deep geological survey along the Qinzhou-Hangzhou tectonic belts and adjacent areas	2016	lqs1958@163.com
17	YU Changqing	Basic geological survey of oil and gas in the southwest and southeast depressions of the Tarim Basin	2016	geoyucq@qq.com

3. Research achievements and important progress

3.1 Results of Natural Science Foundation projects completed in 2016

New technique for the study of orogenesis and porphyroblast formation mechanisms—Application of electron backscatter diffraction on foliation inflection/intersection axes (FIA) (chief researcher: CAO Hui)

This study shows that the Lanping basin experienced at least three phases of compressional deformation: (1) Late Middle Triassic compression was in an E-W direction, and Middle and Lower Triassic strata formed a tight overturned fold with penetrative axial cleavage; (2) Late Jurassic compression was in an E-W direction, and the Jurassic and pre-Jurassic strata formed open and superimposed folds; (3) Paleogene compression was in a NE-SW direction, and Oligocene and pre-Oligocene strata display open and superimposed folds. During the Paleocene to the early Eocene, compression was slow, and the basin was filled with lacustrine fine clastic rocks with evaporatites; during the late Eocene to Oligocene, compression was strong, accompanied by strike-slip and thrust structures, and the basin was filled with alluvial fan facies clastic rocks. Geological mapping classified the lithologies in the Jinding super large lead-zinc deposit into an allochthonous sequence, salt diapir-related rocks, and an autochthonous sequence. They are spatially distributed into upper, middle and lower parts. Among these lithologies, the salt diapir-related rocks comprise diapiric sand, various types of breccias, and gypsum. They are genetically linked to diapir-brecciation of the host rocks, followed by flow into a fluival system, caused by regional NE-SW thrusting. The orebody mainly appears in the lithologies related to salt diapirism. The hydrocarbon-rich fluid in the dome reacted with the gypsum through BSR±TSR and then formed H_2S. Subsequently, mineralization occurred bys mixing of H_2S and basin fluids transporting lead and zinc. The entire sediment-hosted ore-forming system includes: structurally-controlled vein copper, sediment-hosted stratiform copper (SSC), MVT Pb-Zn, Pb-Zn-Cu-Ag polymetallic vein systems. The structurally-controlled vein copper deposits formed during 60-49 Ma and 19 Ma. The Pb-Zn (-Cu-Ag) systems mainly formed during 35-29 Ma and later than 23-20 Ma; early stage thrusting led to ore-controlling structures, and late stage slip/extension led to fluid discharge and ore accumulation. Ore formation of MVT Pb-Zn deposits was related to lateral fluid migration driven by gravity through thrusting, followed by vertical fluid discharge through regional slip/extension. The Pb-Zn-transporting fluids were derived from down-infiltration basinal brines, and the metals were likely extracted from volcanic rocks and/or overlying sedimentary strata. The ore-controlling structures include lithological transitions, salt dome structures, karst/hydrothermal caves, faults and fractures. The ore-hosting rocks are salt diapir-related and Carboniferous-Triassic carbonate rocks. Reduction through fluid mixing or water-rock interaction led to metal precipitation.

Research on silicified acritarchs from the Ediacaran Doushantuo Formation at Shimen, Hunan, South China (chief researcher: CHEN Shouming)

In this study, fossiliferous chert and marine sediments of the Doushantuo Formation were studied at Zhongling, Shimen City, South China. Fossil horrizons in the Zhongling section were investigated, and biostratigraphy has been applied to establish a stratigraphic framework between Hunan and the Yangtze Gorges. In addition, various stratigraphic methods including bio-, chemical and chronostratigraphy have been used to find the marker of subdivision of the Ediacaran system, and to establish a paleoenvironmental evolutionary model on the basis of the Snowball Earth. Remarkable conclusions are as follows: Well-preserved acritarchs were found in the Zhongling section, including the Tianzhushania spinosa, which is a unique species in the lower assemblage in the Yangtze Gorges area, and it indicates that the acritarch assemblage can be correlated with the lower acritarch assemblage in the Yangtze Gorges area. The acritarch assemblage is a potential stratigraphic tool for regional correlation on

the Yangtze Platform. For the purpose of stratigraphic correlation and understanding the causal link between biotic evolution and paleo-environmental events, bio- and chemostratigraphy have been applied, multi-stratigraphic methods are beneficial for stratigraphic correlations, especially in the same basin. The geochemical record from the Doushantuo Formation suggests that the nutritive material sourced from weathering of continental material triggered the acritarchs evolution after the Snowball Earth.

Study of criteria for Pleistocene-Pliocene division in the Nihewan Basin, Hebei Province (chief researcher: CHI Zhenqing)

The well-preserved and exposed 'Nihewan beds' in the Nihewan Basin defina a Cenozoic non-marine strata. The lower part of the Taiergoudong section in this basin probably records continuous Neogene-Quaternary deposition, which may be an ideal candidate for the Q/N boundary standard stratotype section. On the basis of lithostratigraphic, biostratigraphic, and magnetostratigraphic characteristics of the Taiergoudong section and Haojiatai drill core, the Cenozoic sedimentary sequence of the Nihewan paleo-lake has been reasonably well defined in this project. The sedimentary environments of the Nihewan Basin and Paleolithic sites in this basin were systemically analyzed, and a paleogeographic framework ws also reconstructed. In addition, the location and markers of the Q/N boundary in the Nihewan Basin were summarized. The Haojiatai drill core with a length of 365.82 m is subdivided into six formations downward: The Upper Pleistocene Malan Formation with a thickness of 9.64 m, consists of eolian loess, and there is a depositional hiatus at the bottom and underlying strata; The Upper Pleistocene Haojiatai Formation with a thickness of 23.46 m was deposited in a shallow shore lacustrine environment; the Middle-Lower Pleistocene Xiaodukou Formation with a thickness of 32.2 m was deposited in a delta to lakeshore environment; the Lower Pleistocene Nihewan Formation with a thickness of 74.16 m was deposited in a shallow shore lacustrine environment; the Pliocene Daodi Formation with a thickness of 129.42 m consists of lake and marsh sediments; the Pliocene Huliuhe Formation with a thickness of 73.02 m consists of floodplain sediments. The Nihewan Formation in the Shanshazui, Majuangou, Heitugou, Xiaochangliang, and Shanshenmiaozui areas is dominated by fluvial sediments, and the sedimentary environment of Paleolithic sites in these areas are channels. Paleocurrent and anisotropy of magnetic susceptibility (AMS) results demonstrate that the northern part was higher than the southern area of the Nihewan basin during the Pliocene and Pleistocene, and intermediate to mafic volcanic rocks and metamorphic rocks were the major source of the basin during the early and late evolutionary stages, respectively. Detrital zircon U-Pb ages demonstrate that Cretaceous volcanic rocks were the common and important source rocks in the development of the basin, but abundant Proterozoic and pre-Proterozoic detritus was also transported into the basin since the Pleistocene. The location of the basal boundary of the Nihewan Formation from core analysis is 139.36 m, which is consistent with the M/G boundary. Compared with the Wucheng loess, both formations are characterized by voluminous calcareous slate. Their basal age is 2.6 Ma. Mammal fossils indicate that the strata of the East Taiergoudong section below 115.85 m should belong to the Upper Pliocence, but the upward part should be Lower Pleistonce. The M/G boundary on the East Taiergoudong section is located at around 114 m.

Magnesium isotope character and its constraints on the genesis of magnesite deposits in eastern Liaoning Province, China (chief researcher: DONG Aiguo)

In this study, we obtained the first Mg isotopic data from the world's largest strata-bound magnesite deposit belt (Huaziyu deposit), hosted by the ca. 2.1 Ga Dashiqiao Formation in northeastern China. The results indicate that the δ26Mg values of most magnesite ores range from -0.95 ‰ to -0.49 ‰ (-0.75 ± 0.26 ‰, 2SD) and are heavier than most dolostone and limestone, and also heavier than magnesite (-1.14 ± 0.15 ‰, 2SD) and marble (-1.22 ± 0.35 ‰, 2SD) from the Dashiqiao Formation. Moreover, the general increase in δ26Mg values of the magnesite ores are from -0.9 ‰ at the base to -0.6 ‰ at the top of the section. Based on Mg isotopes, Fe isotopes, carbon isotopes, oxygen isotopes, element concentrations, and field observations, we interpret the Huaziyu magnesite deposit to have been dominated by two processes: (1) abundant Mg-rich carbonate precipitation from seawater in a semi-

closed evaporative environment such as a lagoon; (2) magnesite formation during burial diagenesis, followed by transformation into giant magnesite ores during regional metamorphism. Giant strata-bound magnesite deposits are absent in modern and most Phanerozoic sedimentary environments and predominantly occur in Precambrian strata because Mg-rich seawater (from weathering of Mg-rich ultramafic rocks of Archean age) is a key requirement to generate Mg-rich precursor carbonate sediments that can later be transformed into giant magnesite ore deposits during burial diagenesis and regional metamorphism.

Early Mesozoic metamorphism and tectonic significance of the central and eastern Lhasa terranes (chief researcher: DONG Xin)

During 2013–2015, the project group has studied medium pressure (MP) metamorphic rocks and associated magmatic rocks from the Meldro Gongkar, Gongbogyamda, Nyingchi and Dongjiu areas in southeastern Tibet and achieved the following results: The Basongco metamorphic rocks underwent metamorphism in the Late Triassic–Early Jurassic during 204–185 Ma, and not in the Precambrian as previously considered. The metamorphic rocks including orthogneiss, paragneiss, schist, marble and amphibolite, experienced peak MP amphibolite-facies metamorphism under P–T conditions of 640–705 ºC and 6.0–8.0 kbar. Their protoliths were granodiorite, diorite and gabbro (Late Triassic–Early Jurassic at 201–198 Ma), clay and quartz sandstone (Carboniferous–Permian), and shaly-sandstone, calcareous-sandstone and limestone (Permian–Triassic). In combination with coeval MP metamorphic rocks from Yangbajain and HP metamorphic rocks from Sumdo, this study extends the early Mesozoic metamorphic belt in the mid-eastern Lhasa terrane up to 400 km. Moreover, the project also explored the genesis of early Mesozoic intrusive rocks from the Lhasa terrane, suggesting that these granitic rocks in different domains of the Lhasa terrane may have formed in different tectonic environments. This project has reported on Devonian and Cambrian magmatism in the southeastern Lhasa terrane and discussed its tectonic setting, supplying important constraints on the early-phase tectonic evolution of the Lhasa terrane. Furthermore, the project established a Mesoproterozoic–Neoproterozoic thermal-event record for the Lhasa terrane, showing that this terrane and the Indian continent had a similar Precambrian tectonic evolution, which was related to the amalgamation of supercontinents. Supported by this project, the team members published seven papers closely related in their research contents, of which three articles were published in international journals.

2.2~2.0 Ga geologic event in the Wutai and Zanhuang areas, central North China craton, and its tectonic features (chief researcher: DU Lilin)

Cratonization of North China is one of the key subjects in the early Precambrian evolution of China. The Paleoproterozoic evolution in North China is significant for unraveling its cratonization process. However, major debates still occur on the Paleoproterozoic geological processes in northern China. Our study of the 2.2～2.0 Ga geological events can provide better constraints on the evolutionary process of the North China craton. In this project we studied the 2.2～2.0 Ga sedimentary basins and coeval intrusives in the Wutai and Zanhuang areas, central North China Craton, and established the tectonic setting of the 2.2～2.0 Ga geological events in order to provide robust evidence for building an objective geological evolutionary model for the North China Craton. We collected 11 samples of clastic rocks from different subgroups of the Hutuo Group and completed zircon U-Pb and Hf isotopic studies. We also collected 2 granite pebbles and 2 quartz pebbles from the Sijizhuang Formation and completed zircon U-Pb and Hf isotopic analyses. Additionally, we obtained geochemical and Nd isotopic data for basalts of the Hutuo Group. We collected 10 sandstone samples from different sections of the Gantaohe Group and completed zircon U-Pb age and Hf isotopic analyses. We also identified dacite from the top of the Nansizhang Formation and obtained a zircon U-Pb age, and also presented the geochemical data for basalt in the Gantaohe Group. Additionally, we obtained geochemical data, zircon U-Pb ages and Hf isotopic results for 2.2～2.0 Ga granitic intrusives in the Wutai and Zanhuang areas. Based on our research, we defined the base of the Hutuo Group at 2.2 Ga and the depositional age for the Doucun and Dongye Subgroups between 2.2 Ga and 2.0 Ga, and the Guojiazhai Subgroup

after 1.9 Ga. We also established that the basic volcanic rocks of the Hutuo Group belong to the iron-rich tholeiitic series, emplaced is a within-plate setting. The youngest zircons from the base of the Gantaohe Group have a U-Pb age of ca. 2.1 Ga, and a dacite from the top of the Nansizhang Formation yielded a zircon U-Pb age of 2090±14 Ma, which suggests that the Gantaohe Group was deposited at ca. 2.1 Ga. Combined with 1.95～1.8 Ga metamorphism within the Trans-North China Orogen, we further confirmed a depositional age of 2.1 to 1.95 Ga for the Gantaohe Group. We also obtained geochemical data, zircon U-Pb ages and Hf-in-zircon isotopes and defined the Huangjinshan porphyry as an A-type granite. We also obtained zircon U-Pb ages of 2070～2090 Ma for different phases of the Xuting granite and found that potassic and sodic granites of the Xuting pluton belong to an A-type granite generation. Combining previous and our new research, we further suggested that the period 2.2～2.0 Ga represented an important tectono-thermal event in the North China Craton. 2.2～2.0 Ga magmatism and sedimentary basins in the Wutai and Zanhuang areas formed in a rift setting. Our research is significant for establishing Paleoproterozoic tectonic processes and reshaping the stabilization of the North China craton.

Zirconology of metamorphic oceanic crust, a case study from the Heilongjiang Complex in the Mudanjiang area (chief research: XIE Hangqiang)

Metamorphism of oceanic crust, in come instances, produces complex zircons, and it is necessary to work out a plausible interpretation of zircon ages based on integrated research methods. Many zircon age data have been produced for the Heilongjiang Complex in the Mudanjiang Area, but no identical interpretation has been reached. This project focused on the zirconology of this unit and to restrain the interpretation of zircon ages based on field geology, petrology, zircon O-isotopes, inclusion in zircon and Raman spectroscopy. etc. We have made following progress: 1) A garnet-biotite-quartz schist of relatively high metamorphic grade has been found in the Heilongjiang Complex in the Mudanjiang Area, and a metamorphic zircon age of 202±6 Ma has been obtained for the Heilongjiang Complex at the first time. 2) Most zircons in metagabbro or metabasalt with MORB or OIB geochemical signatures are inherited and do not record the formation age of magmatism. 3) The formation age of metasedimentary rocks, which are the dominant rock type of the Heilongjiang Complex in the Mudanjiang area, is younger than 260 Ma and suggests that the ocean was small. 4) The Huangsong Group in the Dongning area has a similar lithology to that of the Heilongjiang Complex in the Mudanjiang area, but the metamorphic age of 267±5 Ma is older than in the Heilongjiang Complex, so these two did not form in the same ocean. 5) The Heilongjiang Complex in the Yilan area is intruded by 250 Ma old granite, so its emplacement age is older than the Heilongjiang Complex in the Mudanjiang area, and probably formed in the different ocean. 6) Based on the zirconology and structural geology, we propose an Archipelago model for the tectonic interpretation in the Heilongjiang area during the Permian-Triassic period. This research solved, to a large extent, the age problem of the Heilongjiang Complex in the Mudanjiang and other area and can also be taken as an example to restrain the interpretation of zircon ages based on integrated research methods.

Detailed receiver function images of the fine crustal structure in the Tarim basin (chief researcher: QU Chen)

Using teleseismic records of a broadband seismic profile across the Tarim basin from north to south and an inversion of P-wave receiver functions, we obtained the Tarim Basin crystalline basement depth and sedimentary layer shear wave velocity structure. The results show the crystalline basement thickness between 1 and 14 km. The depth of crystalline basement and the Tarim Basin secondary unit division and aeromagnetic anomalies are basically the same, and the shallowest location is in the northern part of the Kuche depression to the South Tianshan Mountain, at about 0.8-2 km depth. The Bachu uplift, Tabei uplift is relatively shallow at a depth within 5.5 km, almost between 6 and 9 km. The Awati depression contains thick sediments, the deepest godown to 13 km. In the Yecheng depression to Mengaiti slope, the sedimentary layer becomes thin, from south to north it is reduced from 11.6 km to 7 km. Using the S receiver function we obtained the MOHO depth and thickness of the lithosphere in the Tarim Basin. The Moho depth varies between 45 and 55 km beneath the Yecheng depression, but below the Maigaiti Slope and Awati sag

and Tabei uplift, the depth is almost at 52-55 km and the Moho topography shows little ups and downs, in accord with craton crustal features. However, in the northern part of the Bachu uplift, the Moho shows a significantly uplift, and the shallowest section is only 42 km deep. Between the Calishaya and Tumuxiuke fracture, the Moho and the crystalline basement are the thinnest, and the southern and northern sides of the lithosphere structure is relatively stable. We speculate that the Precambrian North and South Tarim are two independent crustal blocks and were welded below the Tarim basin by the Permian mantle plume. The mantle material was weak due to eruption, forming flood basalt in the Bachu uplift.

A broadband seismic profile in northern North China to find traces of the upper mantle structure of the Paleo-Asian Ocean (chief researcher: LI Qiusheng)

We deployed 41 sets of broadband seismometers along the 'Sinoprobe' deep seismic reflection and wide angle reflection profile for a period of two years of observation. The collected data have been analyzed by several methods such as receiver function, and structural features at three depth levels, namely the Moho, continental lithosphere and mantle transition zone (MTZ) have been obtained. The crustal structure and distribution characteristics of Poisson's ratio obtained in this way suggest that the crust of the XingMeng orogenic belt has nearly reached isostatic equilibrium. The geometry of the lithosphere-asthenosphere boundary (LAB) obtained from S-wave receiver functions support a geodynamic model implying that ancient Paleo-Asian oceanic crust was subducted southwards beneath the northern margin of the North China Craton and the ocean was finally closed along Linxi fault zone. The lithosphere thickness data show that the northern margin of the North China Craton experienced lithospheric thinning, but there was little effect on the XingMeng orogenic belt. The 660 km discontinuity dropped about 25 km beneath the northern margin of North China Basin area and the MTZ thickens by 15 km compared to global models, implying that the MTZ may be affected by cold material.

Isotopic fractionation of Zn and Cu in plants (chief researcher: LI Shizhen)

The advent of high-precision, multi-collector–inductively coupled plasma–mass spectrometry (MC–ICP–MS) has made it possible to determine stable isotope abundances. Investigations of isotopic variations in transition metals such as Cu, Zn, Fe, Ca and Mg during the growth of plants represents a rapidly developing area of research. Preliminary results on fractionation processes and their mechanism in this project are in the following fields: 1) research on soil; 2) research on Cu isotopic fractionation during uptake and translocation of plants 3) research on the influence of soil conditions on Cu isotopic fractionation; 4) discussion on the mechanism of Cu isotopic fractionation during uptake and translocation of plants. The Cu isotope compositions of soil and Cu isotopic fractionation between plants and soil have also been obtained. 1) δ^{65}Cu and δ66Zn in soil are identical at 0.25 ‰ and -0.60 ‰, respectively, and no variation in isotope composition between parent and treatment soil after the experiment (-0.06 ‰<Δ^{65}Cu the treatment soil – parent soil <0.03 ‰; -0.08‰, Δ65Cu the treatment soil – parent soil <0.02 ‰); 2) fractionation of Cu and Zn between the phytoavailable component and total soil are different (Δ^{65}Cu phytoavailable component – total soil = 0.30 ‰; Δ^{66}Zn phytoavailable component – total soil = -0.02 ‰); 3) Cu and Zn isotopic fractionation occurs during the growth of a plant (-1.42‰ <Δ^{65}Cu plant –soil <-0.44 ‰; -0.31‰ <Δ^{66}Zn plant –soil <0.29 ‰). The key observations from these results are as follows. 1) The Cu and Zn isotope compositions of soils used for laboratory plant growth are uniform, and it is not necessary to consider the potential influence of variations in the Cu and Zn isotope compositions on the isotopic fractionation in these soil–plant systems; 2) Cu and Zn concentrations in plants depends on the free ions of phytoavailable components; 3) relative to total soil, there is enrichment in lighter Cu and Zn in the plant; 4) compared to Zn, the larger Cu isotopic fractionation occurs due to oxidation-reduction reactions; 5) variations in Cu and Zn isotope compositions exists in different tissues (i.e., phloem and xylem) and among bio-macromolecules; 6) Cu isotopic fractionation occurs during retranslocation, however, no isotopic fractionation occurs compared with the analytical error for Zn. In summary, in this study further Cu and Zn isotopic fractionation and mechanisms have been

recognized, and it is meaningful to use Cu and Zn isotope compositions to trace the uptake and translocation process in plants.

Paleomagnetic research on the spatial-temporal variations of Cenozoic block rotation between the northeastern margin of the Pamirs and the southern margin of the southwestern Tianshan (chief researcher: LIU Dongliang)

Paleomagnetic investigations has been performed on Miocene Wuqia Group strata in the east of Wuqian Town of the southwestern Tarim Basin, which belongs to the northeastern margin of the Pamir - Southwest Tianshan. Stepwise thermal demagnetization successfully isolated high unblocking temperature characteristic directions. Using principal component analysis to obtain high temperature characteristic remanence directions, we established a geomagnetic polarity timescale. Using the Geomagnetic Polarity Time Scale (Ogg, 2012), a high-resolution magnetostratigraphy of this section has been established. The sediments of this section were deposited from ~16.6 to ~9.9 Ma. The paleocurrent had a relatively stable East-West direction (parallel to the mountains), which indicates that the area had undergone stable uplift during this time. Therefore, the time of collision for the northeastern margin of the Pamir - Southwest Tianshan collision system was earlier than ~16.6 Ma. The statistics of the magnetic declination show that there have been no significant changes, indicating that collision system was mild. In addition, there existed a growth strata in the Xiyu Conglomerate Formation at the up of this profile. This growth strata indicates that abrupt collision and uplift occurred at the northeastern margin of the Pamir - Southwest Tianshan collisional system. According to the thickness of the sediment in this profile, this abrupt uplift and collision began at ~3 Ma.

Biostratigraphic division of acritarchs from the Ediacaran Doushantuo Formation in the Yangtze Gorges and their international correlation (chief researcher: LIU Pengjv)

Large acanthomorphic acritarchs are one of the most important biological types in the Ediacaran Period. Previous studies have shown that their potential for Ediacaran biostratigraphic subdivision and global correlation is becoming increasingly important. Ediacaran successions in the Yangtze Gorges area of South China, which are richly fossiliferous and have a long history of paleontological research, are one of the most important areas for the Global Standard Section and Point (GSSP) of the Ediacaran System. The systematic study of acanthomorphic acritarchs in the Yangtze Gorges area and their biostratigraphy will provide information for establishing global biostratigraphic successions (biozone) and chronostratigraphic subdivision. Based on thin section examination of chert samples collected from several typical sections, abundant large acanthomorphic acritarchs have been found in the Ediacaran Doushantuo Formation in the Yangtze Gorges area. A clear stratigraphic distribution of acritarchs has allowed two assemblages of acanthomorphic acritarchs to be established. They are a lower Tianzhushania spinosa assemblage and an upper Hocosphaeridium anozos–Hocosphaeridium scaberifacium–Tanarium conoideum assemblage. The lower T. spinosa assemblage is dominated by the taxon T. spinosa (more than 60 %), which occurs from the lowermost to the uppermost reaches of the assemblage. Apart from South China, T. spinosa has only been found in northern India (personal communication, Dr. Harshita), which shows that the lower T. spinosa assemblage may correlate with the acanthomorphic assemblage in northern India. By comparison with the lower assemblage, the upper Hocosphaeridium anozos–Hocosphaeridium scaberifacium–Tanarium conoideum assemblage preserves more acanthomorphic acritarchs, both in terms of number of individuals and in the diversity of the forms. The upper assemblage shares several species with the Ediacaran complex acritarchs palynoflora (ECAP) in Australia, and the species T. spinosa is not present in the ECAP of Australia. Hence, the upper assemblage of the Doushantuo Formation can be correlated with the ECAP of Australia, whereas the lower Tianzhushania spinosa assemblage appears to be missing in Australia. Similarly, many taxa from the upper acanthomorphic assemblage in the Yangtze Gorges area have been reported from Siberia and the East European Platform, which demonstrates that the upper assemblage is stratigraphically correlative with that of Siberia and the East European Platform. In addition, based on integrated

bio- and chemostratigraphic data (carbon isotopes), we propose that the Ediacaran can be subdivided into two series and five stages, and the Chenjiayuanzi section is the best section for establishment of a GSSP in the Ediacaran because of its well exposed and continuous outcrops and most complete distribution of acanthomorphs with excellent preservation.

Petrogenesis of the Changhai khondalite series in southeastern Liaoning Province, China and tectonic implications (chief researcher: MENG En)

The geological features and petrogenesis of Paleoproterozoic geological assemblages, widely exposed near Changhai town of southeastern Liaoning Province, could provide important constraints on the tectonic development and geological evolution of the Paleoproterozoic Jiao-liao-Ji Belt. In this project, detailed petrological, mineralogical, and geochemical studies on Paleoproterozoic supracrustal rocks of the Changhai and other areas of the Liao-Ji belt have been carried out, and the main conclusions are: 1) The Changhai metamorphic supracrustal rocks were deposited after 1.88 Ga and do not belong to the regional South Liaohe Group, and were given a new name: the Changhai Group; 2) sodium- and potassium-rich gneisses of the Changhai ancient basement were emplaced at ca. 2543 and 2518 Ma; 3) the magmatic precursor of meta-mafic rocks of the central Liaodong Peninsula was emplaced at ca. 2154 Ma, was metamorphosed at ca.1897 Ma, and formed in a back-arc basin; 4) the protoliths of the South Liaohe Group were deposited at some time after 2035 Ma, and peak metamorphism occurred at 1885 Ma; 5) there existed a ca. 2.08 Ga potassic-rich granite emplacement event in southeastern Jilin Province, which could have formed in a tectonic setting similar to a back-arc basin.

Partitioning of strike-slip and uplift during late Quaternary deformation along the Ashikule Fault, western segment of the Altyn Tagh Fault (chief researcher: PAN Jiawei)

The Altyn Tagh fault (ATF) is a large-scale sinistral strike-slip fault in Asia. As the northern boundary of the Tibetan Plateau, this fault plays an important role in accommodating the deformation resulting from the India/Eurasia collision. A study of the ATF is essential to evaluate continental deformation models of the Tibetan Plateau. On the basis of previous studies, this project focused on the key transition zone between the central and western segments of the ATF, which were poorly studied previously, to understand active tectonics of the Ashikule area. Besides, we carried out field investigation instantly after the 2014 Yutian M7.3 earthquake. Through three years of field investigation and integrated research, we determined that the late Quaternary slip rate on the Ashikule fault is 1.5-2.1 mm/yr, and we estimated that the total slip rate of the western ATF is relatively low (<10mm/yr). The large earthquake recurrence interval on the Ashikule fault was estimated to be about 500-700 years. We also determined the late Quaternary river incision rate in the Ashikule area, which is 0.2-0.35 mm/yr. This incision rate represents the average late Quaternary uplift rate of the northwestern Tibetan Plateau. The field investigations instantly conducted after the 2014 Yutian earthquake revealed that a ~29 km-long sinistral strike-slip co-seismic surface rupture zone was produced by this earthquake. The maximum horizontal displacement observed along the surface rupture zone is 1 m. This is the first instrument recorded M>7 sinistral strike-slip earthquake event along the ATF. Additionally, a study of the rupture process of the 2008 Wenchuan earthquake indicates that this earthquake consisted of two sub-events, and the late Quaternary slip rate on the Longmu Co-Gozha Co fault was estimated to have been <3mm/yr. An integrated geometry and kinematic analysis of faults around the Ashikule area indicates that the Ashikule fault, the Karakax fault, and the Longmu Co-Gozha Co fault all belong to the ATF system. These faults together controlled the tectonics and deformation of the northwestern Tibetan Plateau.

SHRIMP U-Pb dating of diagenetic xenotime in sedimentary rocks - a case study of the Changzhougou Formation (chief researcher: SHI Yuruo)

SHRIMP U-Pb dating of diagenetic xenotime from sedimentary rocks has provided robust minimum ages for sediment deposition. Xenotime (YPO4) may grow during early diagenesis and is typically present as a trace constituent in siliciclastic sedimentary rocks in the form of syntaxial outgrowths on detrital zircon grains. Diagenetic xenotime occurs in a wide variety of rock types, including conglomerate, sandstone, siltstone, shale, phosphorite and volcaniclastic rocks, that vary in age from the early Archean to the Mesozoic. Xenotime can be an isotopically robust U–Pb chronometer because it contains elevated levels of U (generally >1000 ppm) and very low concentrations of initial common Pb, and commonly yields concordant and precise ages. Authigenic-diagenic xenotime in Precambrian rocks from the Ming Tombs district are favorable for geochronological determination of the Precambrian strata of the North China Craton. There are abundant grains of authigenic-diagenic xenotime, forming irregular or pyramidal outgrowths on detrital zircon grains dispersed throughout siltstone close to the suture of the Changzhougou Formation. The xenotime is fine-grained, commonly occurring with a maximum dimension of <10 μm, and this makes it almost impossible to extract this mineral from these rock samples using traditional crushing and separation techniques. Therefore, the rock was crushed to a ~500 μm particle size, and this material was mounted on more than 20 epoxy discs, polished, photographed in reflected light, and the xenotime grains were identified using backscattered electron (BSE) imaging and Raman spectroscopy. Because of the small size of diagenetic xenotime crystals, an in-situ isotopic technique with a spatial resolution of <10 μm is required to date these minerals. Six analyses of xenotime that did not overlap zircon (no ZrO2+ counts were observed during analysis) yielded a weighted mean age of 1363 ± 25 Ma. Monazite and rutile grains were discovered by using energy spectrum analysis to study the silty mudstone which was collected from the lower part of the Chuanlinggou Formation in the Changping area, Beijing. The maximum particle size of monazite is up to 88 microns whereas the largest rutile is 20 microns. According to many back-scatter images, the monazite grains show jagged edges and irregular shapes, and appear as fishes, birds, flowers, worms and so on, whereas rutile is arranged as a string of beads. The overwhelming majority of the monazite and rutile grains occur in quartz or hematite veins. In places far away from these veins, however, monazite or rutile was only rarely found. These monazite grains with an age of ca. 152 Ma are were dated using a SHRIMP II instrument at the Beijing SHRIMP Center. According to the preliminary age data, we suggest that these monazite grains belong to a secondary monazite generation that is associated with a late hydrothermal event and did not form during diagenesis.

Petrogenesis of two periods of TTG gneiss formation in the Zanhuang area, Hebei Province (chief researcher: SONG Huixia)

Studies on the formation and evolution of the North China Craton (NCC) are currently hotspots for research in Precambrian geology. TTG gneisses mainly studied in this project are located in the Zanhuang area, Hebei Province, which belongs to the southern section of the Central Orogenic Belt in the NCC. Through research on the TTG gneisses in this area, more information can be provided on the formation and evolution process of the NCC. The gneisses in the research area can be divided into compositionally banded gneiss and homogeneous granodioritic gneiss. We dated the two types of gneiss and found that they were mainly generated during two periods. The age of the banded tonalitic gneiss is 2703 Ma, whereas the age of the banded dioritic gneiss is 2723 Ma. The age of the weakly banded dioritic gneiss is 2689 Ma, and the age of the homogeneous granodioritic gneiss is 2521 Ma. We also studied the geochemical characters of these two types of gneiss and found them to be similar to a certain degree. Both types are rich in Al, Si, Na and poor in K; the LREEs are enriched, and the HREEs are depleted, and fractionation between LREEs and HREEs is remarkable; an Eu anomaly is not obvious; the LILE are enriched, and the HFSE such as Nb, Ta, Ti, Yb and Y are depleted. In primitive mantle normalized spidergrams, Nb, Ta, Ti, P and Sm show negative anomalies. Both types of gneiss have similarities with Archaean high-Al TTG and adakite. Therefore we infer that both the 2703 Ma banded tonalitic gneiss and the 2521 Ma homogeneous granodioritic gneiss were derived from partial melting of juvenile crust. We also consider that they formed during two independent magmatic events. Through the geochemical study and field observations, no evolutionary relationship was found between them. After

formation of the protoliths of the 2.7 Ga TTGs, these rocks experienced anatectic processes and the gneiss with light and dark bands was formed. Combining the results of 2.7 Ga TTGs in the Luxi, Jiaodong Qixia, Wanbei Huoqiu, and Hebei Fuping areas, we suggest that magmatic events in the NCC had began on a large scale prior to 2.7 Ga, and this caused extensive crustal growth during this period. The widespread 2.5 Ga magmatic events in the NCC may offer support to the hypothesis of amalgamating microcontinents and that formed the basement of the NCC in the Paleoproterozoic.

Evolution and biostratigraphic significance of typical Ediacaran macroscopic fossil assemblages in southern China (chief researcher: TANG Feng)

New records on the unique eight-armed Ediacaran fossil Eoandro- meda octobrachiata, preserved in contrasting taphonomic windows from southern China and Australia, have been deduced to reflect an early comb jelly (ctenophore). The earliest animal macrofossils have not only bridged the international gaps in stratigraphy between the Sinian Doushantuo Formation and the relevant strata of Ediacara biota, but also extend back the first appearance of ctenophores back into Ediacaran biota by more than 30 Ma. Moreover, new discoveries would again crop the evolutionary tree of animals. The recent paleontological study is also more consistent with the molecular phylogenomic hypothesis, supporting to answer the puzzle of early animal evolution through new fossil evidence. This paper presents one of the well-preserved carbonaceous compressions from the Doushantuo Formation, Guizhou, South China – an abundant, presumed alga, Gesinella, with a complete rhizoid holdfast structure. The rhizoid base of this taxon is similar to Hiemalora, one of the most widely reported Ediacaran fossils, in shape and size. As the Ediacaran macroscopic carbonaceous compressions with the largest thallus, these new specimens of Doushantuo Gesinella offer insights into the benthic Ediacaran biota with casts and molds in the ascendant: the disc-shaped Hiemalora may be holdfast discs of multicellular algae rather than a medusoid organism or an attachment of other frond-like Ediacaran life. In recent years, newly described macrofossil algae, trace fossils and more complex possible Ediacaran-type fossils ("Jiangchuan Biota"), as well as numerous examples of the ribbon-like macrofossil Shaanxilithes have been found in strata underlying the base of the early Cambrian phosphatic layer. Relevant boundary sections from the Dengying Formation up to the base of phosphatic strata (Zhongyicun Member) suggest continuous deposition and contain diverse macrofossil assemblages (assemblage zones) which may be useful for defining the Dengyingxian Stage of the upper Ediacaran, followed by the Jinningian and Meishucunian Stages of the lowermost Cambrian. These sections are candidates for a potential Chinese standard stratotype section. An abundant and diversified assemblage of benthic fossils from the Ediacaran Doushantuo black shales in the Wenghui section, Guizhou Province, South China, contains two discoidal carbonaceous forms, Kullingia rotadiscopsis sp. nov. and Eoaequorea xingi gen. & sp. nov. The fossils have well-preserved concentric rings and radiating lines and resemble many circular casts and moulds in Ediacaran clastic and carbonate rocks worldwide. The Doushantuo carbonaceous macrofossils help us to enquire into the current functional identifications of circular disks as the holdfasts of unknown organism or scratch circles. We suggest that these carbonaceous compressions are prone to be the ancestor of pelagic jellyfish-like organisms with medusoid hydrozoan affinity.

Formation and evolution of an Archean granite-greenstone belt in western Shandong Province: geology, geochemistry and zircon dating (chief researcher: WAN Yusheng)

We carried out geological investigations, SHRIMP zircon dating, Hf-in-zircon isotope analysis and a whole-rock geochemical study of the Neoarchean granite-greenstone belt in western Shandong Province. We also worked on other areas of the North China Craton (NCC) for comparison. The main results are as follows. 1) The Archean basement in western Shandong can be divided into three belts. Belt A is a ate Neoarchean (2525-2490 Ma) crustally-derived granite belt in the northeast, Belt B is an early Neoarchean (2.75-2.60 Ga) rock belt in the center, and Belt C is a late Neoarchean (2550-2500 Ma) belt of juvenile rocks in the southwest. Ca. 2.7 Ga rocks have also been

discovered in Belts A and C, besides Belt B. This indicates that early Neoarchean rocks occur more widely in western Shandong than thought before. 2) Ten samples of different magmatic rock types, including hornblendite, gneissic tonalite, gneissic trondhjemite and gneissic granite, contain magmatic zircons with 207Pb/206Pb ages ranging from 2598 to 2667 Ma. They have εHf(t) values and Hf crustal model ages of 1.1 to +11.3 and 3.02–2.4 Ga, respectively. The middle Neoarchean rocks mainly occur together with early Neoarchean rocks in the northeastern portion of the central belt. Juvenile additions to continental crust and crustal recycling played important roles, and the entire Neoarchean tectonic evolution can be subdivided into middle to early Neoarchean (2.75–2.6 Ga) and late Neoarchean (2.6–2.5 Ga) events. 3) Different types of rocks (8 samples) in Belt B have metamorphic and anatectic zircons varying in age from 2.63 to 2.59 Ga, with an age peak at 2.61 Ga, suggesting that western Shandong experienced a regional tectono-thermal event at that time. Most zircons, whether magmatic or metamorphic, have δ18O values of 4.5–6.5 ‰ (V-SMOW). However, one sample has zircons showing low δ18O (V-SMOW) values, suggesting crustal extension and influx of meteoric water during the evolution of the rocks at least in local areas. 4) Western Shandong Province underwent a very strong tectono-thermal event at the end of the late Neoarchean. More than 20 samples from belts A, B and C contain metamorphic or anatectic zircons with ages of ~2.5 Ga. The protoliths of the rocks are 2.6-2.7 and 2.52-2.55 Ga in age. The late Neoarchean magmatism and metamorphism were closely associated in space and time, which was also identified in other areas of the NCC. 5) Late Neoarchean magma mingling has been identified in Belt C. The mingling belt extends for more than 10 km, and the rocks include syenogranite, monzogranite, granodiorite, quartz diorite and amphibolite with magmatic zircon ages of ~2.5 Ga. 6) We reviewed the spatial distribution, rock types, geochemical and Nd-Hf isotopic compositions of 2.7 Ga granitiods that are widely identified in the NCC. These granitoids are mainly tonalitic in composition. Our Nd-Hf isotope study indicates that the strong 2.7 Ga tectono-thermal event mainly involved juvenile additions to the continental crust.

Iron isotope fractionation during fluid exsolution of skarn-type deposits: a case study of a polymetallic deposit in the Middle-Lower Yangtze valley (chief researcher: WANG Yue)

Skarn-related mineralization is one of major types for high grade iron, copper, tungsten and tin ores and have important scientific and economic significance. Lots of studies on this aspect have been carried out in past decades, however, the source of metallic elements is still in hot controversial. With the development of method on high precision iron isotope messurement, a new tool to solve this problem provided. Fluid exsolution is a critical process during skarn-type mineralization and whether Fe isotope fractionate during this process is a key issue as this kind of information is crucial in tracing metal source using Fe isotope. Meanwhile, this kind of information also has important significance for developing the theory of isotopic geochemistry. Fe isotope investigation of intrusive rocks, altered rocks, ores and sedimental rocks from typical deposits in the Middle-Lower Yangtze valley under various of metallogenic geological settings and component systems has been carried out in this project to reveal Fe isotope behavior during fluid exsolution process, to illustrate regularity of variations in Fe isotope compositions, and to study whether the influence from distinguishing component systems on that regularity exist or not. Based on the above studies, a working model for directly tracing the metal source of skarn-type deposit by using Fe isotopic system is going to be built. In this project, a number of high-quality data has been acquired, which showing a tendency that endoskarn and magnetite are enriched in light iron isotopes relative to igneous rocks. Together with Fe isotopic compositions of wall-rocks of skarn deposit, this tendency can not be resulted by component mixing of wall-rock, which suggesting that Fe isotopes fractionated during fluid exsolution process and fluid exsoluted from igneous rocks is enriched in light iron isotopes. Comparations among Tongling, Edongnan and Ningwu districts, sulfide-dominated skarn deposits and Fe-dominated skarn deposits revealed a similar regulation of Fe isotope, indicating that igneous component and background of ore deposits may not change the regularity of Fe isotopes fractionation during fluid exsolution process. Based on above studies, we constraint metallic source of skarn deposit as magmatic source tracing by Fe isotopes. In this project, we also found the temporal and spatial zonation of Fe isotopes as fluid

evlution. Fe isotope compositions of ore-forming fluid will evolve with time as minerals precipitation progressed. This study provide a further comprehensive on metallic source and mineralisation processes directly tracing by metallic element, and the recognitions acquried in this project also provide a basic foundation on further studies on ore-deposit and exploration.

Detailed FIB and TEM studies of unusual mineral inclusions in chromite and mantle peridotite from the Kangjinla region of Tibet (chief researcher: XU Xiangzhen)

A series of unusual mantle minerals has been discovered from chromite and mantle peridotite in the Kangjinla region of the Yarlung Zangbo ophiolite zone. This project focuses on in-situ mineral inclusions together with petrological and mineralogical features of chromite and mantle peridotites. We collected data about the inner structure, spatial relationship, formation mechanism and stress environment of corundum, Fe-Ni alloys and in-situ inclusions, utilizing analytical methods such as focused ion beam (FIB), transmission electron microscope (TEM), cathodouminescence (CL) imaging, and Fourier transform infrared spectroscopy (FTIR), to determine the origin, formation depth, and physical/chemical settings of corundum and Fe-Ni alloys in ophiolite, and we carried out preliminary research on the genesis of the Luobusa chromite deposit. The project has achieved the following preliminary results after three years of detailed research. (1) Podiform chromitites and their host peridotites in the Kangjinla mining district of the Luobusa ophiolite contain similar associations of ultrahigh pressure (UHP), highly reduced and crustal-type minerals. Abundant diamonds have been recovered from both lithologies, and these are associated with a wide range of base metal alloys, native elements, carbides, oxides, silicates and others. The presence of UHP and highly reduced minerals in these rocks indicates that at least some of the chromite must have crystallized deep within the mantle as well as in a shallow mantle wedge in a supra-subduction zone (SSZ) environment. The unusual minerals were encapsulated in chromite grains and then carried upwards by mantle convection. The peridotite of Luobusa was trapped in the mantle wedge where it was modified by SSZ fluids and melts. Partial melting and mobilization of the chromite grains allowed them to be carried to shallow levels in melt channels and eventually deposited as chromitites near the crust-mantle boundary. The unusual minerals were preserved during this process because they were encapsulated in chromite grains, either during crystallization or during later fluid fluxing. (2) We identified two types of chromitite from the Luobusa ophiolite, eastern part of the Yarlung Zangbo suture zone, of which one is massive chromitite as harzburgite envelope and the other is disseminated chromitite as an envelope of a dunite shell. There is a large difference between the spinel chemical composition, PGE and Re-Os isotopic characteristics of the two types of chromitite, which suggests different evolutionary processes. (3) Mineral inclusions (TiN and Mg-Al-oxide) in corundum from the Kangjinla chromitite were investigated by TEM. Mg-Al-oxides indicate characteristics of ultra-high pressure with a Cmcm structure. (4) All diamonds contain nitrogen between 151 and 589 ppm and are, within error, type Ib by means of FTIR. They are different from most diamonds occurring in kimberlites and impact craters.

Continental dynamics and resource potential of the Qinghai-Tibet Plateau (chief researcher: XU Zhiqin)

Based on continental dynamics and according to the indentation record between India and Asian, this project investigates the evolution of the Neo-Tethyan Ocean and the mechanism transforming the India-Asia system from collision to strike-slip, as well as its effects on resource formation and environmental changes as a response to continental dynamics. Based on previously research, our research team has achieved considerable progress in understanding continental dynamics of the Tibetan Plateau, especially the evolution of Tethys and the growth of the Tibetan Plateau during the past decade. These achievements are as follows: (1) A hypothesis on formation of the Tibetan Plateau as a orogenic plateau was proposed; (2) reconstruction of the tectonic framework of the Tibetan-Tethys system; (3) discovery of in-situ diamonds and a deep mantle-derived mineral group in ophiolites distributed along the Neotethyan suture zone; (4) understanding of the subduction mechanism of the Neotethys oceanic basins; (5)

understanding the role of magmatism in the early phase of the Indo-Asian collision for exhumation of the Himalaya; (6) establishments of 3D models for the collisional orogeny and exhumation of the Himalaya; (7) new proposal for the extrusion of the SE Tibetan Plateau: 'crustal bending and decoupling'; (8) subduction- and collision-related continental gneiss domes in the Tibetan Plateau; (9) tectonic setting and the Wenchuan Earthquake mechanism at the eastern margin of the Tibetan Plateau; (10) Tibetan plateau collision mineralization model; (11) Numerical modeling of the Indo-Asian collisional process. This program aims to communicate with and stimulate interest amongst global geologists to better understand continental dynamics of the Tibetan Plateau.

Volcano-sedimentation and tectonic setting of mineralization of the Caotangou Group in the western section of the North Qinling Mountains (chief researcher: YAN Zhen)

The Caotangou Group is a suite of volcano-sedimentary rocks that experienced slight deformation and low-grade greenschist-facies metamorphism and is the important host strata of VMS-type deposits in the North Qinling Mountains. The volcano-sedimentary sequence of this unit has so far been overlooked, and its tectonic setting using geochemical data is hotly debated. On the basis of field mapping and typical section measuring, the rock-types and distribution, the ore-bearing lithology, and the volcanic sequence and genesis of the Caotangou Group were studied in detail in this project. The age, tectonic setting, mineralization, and relationship between the formation and the Proto-Tethyan Ocean were also studied by systematic investigations in paleontology, zircon geochronology, petrochemistry, Sr-Nd-Pb and Lu-Hf isotopic tracing, and fluid inclusions. These results do not only provide reliable evidence for the tectonic framework, mineral exploration and metallogenic prognosis in the North Qinling Mountains but also serve as an example for similar areas. Systematic studies on the facies and geochemistry demonstrate that the Caotangou Group represents a bimodal volcanic sequence formed in a backarc setting with massive sulfide horizons closely associated with a siliciclastic-felsic supracrustal sequence. Spatially, the proportion of felsic lavas decreases westwards but andesite increases. Mafic and felsic sequences mainly occur in the Laochang Mine, the dacite and dacitic sedimentary assemblage of which is the host lithology of the mineralization. SHRIMP and LA-ICP-MS zircon U-Pb ages for rhyolite and tuff of the Caotangou Group indicate that volcanism occurred during ca. 440-406 Ma, which is similar to dacite and andesitic basalt of the Xieyuguan Group. Precambrian xenocrystic zircon grains suggest that the subduction-related crustal source of these volcano-sedimentary rocks is closely related to the Qinling Group. In combination with previous results on the age of fossils, U-Pb ages of volcanic rocks, and the geochemistry of lavas and sulfides, we suggest that a southward-facing subduction-accretion system developed along the southern margin of the North China plate during 490-410 Ma, and subduction-related calc-alkaline magmatism did not end prior to ca. 400 Ma.

Geochronological and geochemical study of mafic-intermediate dikes in West Junggar, NW China (chief researcher: YIN Jiyuan)

The Carboniferous to Permian was a critical period for the tectonic evolution and ore-forming processes in the Central Asian Orogenic Belt (CAOB). However, as a key to understand the development of the CAOB, metallogenetic geodynamic settings are still hotly debated. We investigated late Paleozoic mafic-intermediate dikes and granitoids and carried out petrology, geochronology, elemental geochemistry and Sr-Nd-Hf isotope studies to investigate their ages, magma sources and petrogenesis and thus elucidate the geodynamic processes for the formation of the dikes and granitoids with implication for continental growth. Our results are summarized as follows: (1) We established the rocks association and formation ages of the mafic-intermediate dikes in the southern part of West Junggar, and we propose that events associated with ridge subduction likely played an important role in crustal growth in the CAOB; (2) we established the petrogenetic mechanism of two type sanukitoids in the West Junggar during the late Paleozoic; (3) we propose a new evolutionary model for the northern part of West Junggar in the early Carboniferous; (4) we established the formation ages and tectonic setting of late Paleozoic rocks in the West

Junggar; (5) we established the rocks association and formation ages for plutonic rocks during the transitional period from the early to late Paleozoic in the West Junggar, and we propose that a slab roll-back model can account for their petrogenesis and geodynamic processes. The above results have led to the publication of 10 peer-reviewed papers on international scientific journals such as Lithos, Tectonophysics and Gondwana Research.

Relationship between high-pressure granulite and adakitic rocks - a case study in the Dulan area, North Qaidam Mountains (chief researcher: YU Shengyao)

During the past three years (2014-2016), this project focused on high-pressure granulites and associated anatectic rocks from the early Paleozoic North Qaidam collisional orogen in northern Tibet. On the basis of fieldwork, petrology, mineralogy and geochronology, the following important results have been obtained: (1) On the basis of large-scale mapping, a high-pressure granulite unit has been recognized in the Dulan area of the North Qaidam UHP metamorphic terrane. The high-pressure granulite probably formed in a thickened lower crust, and penecontemporaneous metamorphic ages but different geothermal gradients between HP granulites and related UHP eclogite define a possible paired metamorphic belt generated in a subduction–collision setting. (2) An adakite-like leucosome has been recognized in high-pressure granulites of the Dulan area. The petrography, geochronology and geochemistry suggest that high-pressure granulite formation and anatexis occurred in a thickened lower crust, which provides a natural laboratory for observing the formation and emplacement mechanism of adakite. (3) An integrated study of the petrology, geochronology and geochemistry demonstrates that partial melting of the UHP metamorphic rocks in the NQD UHP terrane mainly occurred during the initial phase of retrogression, and anatectic melts probably crystallized under granulite-facies conditions. (4) Metapelite and metamafic rocks commonly experienced granulite-facies metamorphism, accompanied by anatexis and granitoid magmatism. Geochronological data indicate that granulite-facies metamorphism, anatexis and magmatism occurred simultaneously but later than the peak of UHP metamorphism.

Study of eclogite and garnet peridotite in western North Qaidam and their constraints on the evolution of a subduction zone (chief researcher: ZHANG Cong)

Eclogite and garnet peridotite with different protoliths and ages of formation are preserved in the North Qaidam ultrahigh pressure metamorphic (UHPM) belt, providing us with a good opportunity to study geodynamic process on a plate boundary and rock associations, mineral structures and element mobility, etc. during subduction and exhumation in an orogenic belt. This project focuses on petrological, mineralogical, phase equilibrium and geochronological work on eclogites and associated rocks in the North Qaidam UHPM belt and the Sumdo area, eastern Tibet, in order to constrain the metamorphic processes of eclogite and garnet peridotite formation with different geochemical characteristics and different geological settings. We further speculate on the geodynamic setting and the interaction of oceanic and continental material in different types of subduction and collision. The results show that there are two types of eclogite with different mineral assemblages and geochemical features in the Xitieshan terrane, North Qaidam UHPM belt. Similar PTt characters show that these rocks formed during the same orogeny. Compared with typical oceanic eclogite in the Sumdo area, it shows that the eclogite from different tectonic settings attained strikingly different mineral assemblages and P-T paths during retrogression, providing the basis for studies on chemical element mobility. In a comparative study on garnet peridotite from both North Qaidam and the Scandinavian Caledonides, we developed a simplified conceptual model to classify orogenic garnet peridotite with their P-T conditions during formation and the time lag of the formation and subduction and future constrain the evolutionary of orogenic garnet peridotite.

Provenance and deformation of early Paleozoic sediments along the southern and eastern margins of the Alax Block and their tectonic implications (chief

researcher: ZHANG Jin)

Detrital zircon ages of the early Paleozoic Xiangshan Group and the Dahuangshan Formation in the southeastern Alxa Block show that both sequences are late Cambrian in age, but the top parts of both successions may be Early Ordovician in age. The detrital zircon age spectra and paleocurrents analysis also show that the provenance of both sequences were in the eastern Ghats–Rayner orogenic belt and the Wilkes–Albany–Fraser orogenic belt in eastern Gondwana. The North China Block and the North Qilian orogenic belts are not the source regions for the Dahuangshan Formation and the Xiangshan Group. Similar paleontology, paleomagnetic data and detrital zircon age spectra indicate that the Alxa Block was located to the north of the eastern Gondwanan continent (present coordinates). A weighted mean age of 277.2±2.8 Ma for the diabase emplaced into the Xiangshan Group was obtained, indicating that the diabase is early-middle Permian in age. The diabase was a product of an intraplate extension event. The data suggest that the study region was once in a back-arc extensional setting in the early-middle Permian caused by northward subduction of the Yangtze Block beneath the North China Block. Emplacement of the late Paleozoic diabase in the study region argues against the idea that the so-called "Helan aulacogen" did not develop during the early Paleozoic and a "collision-induced rift" also did not develop during the late Paleozoic. There may have been a back-arc extension environment in the study region during the early-middle Permian during convergence between the NCP and the Yangtze Plate. Detrital zircon LA-ICP-MS U-Pb ages and paleocurrent analysis of the Paleozoic strata in the southeastern Alxa Block and structural analysis along the eastern Alxa Block show that amalgamation of the Alxa and North China Blocks occurred between the Late Devonian and early Carboniferous. An important north-south trending deformation belt of Late Devonian age was found along the eastern Alxa Block, which indicates nearly east-west compression during the late Paleozoic. In addition to the above east-west compression, a Triassic ductile left-lateral strike-slip fault, a Late Jurassic top-to-the southeast thrusting event, an Early Cretaceous extension event, an early Cenozoic top-to-the northwest thrusting event, a middle Cenozoic left-lateral strike-slipping event and a late Cenozoic extension event were documented in the eastern Alxa Block. All these deformation events were related to multi-phase intraplate tectonics occurring in China since the Triassic. The boundary of the Triassic Ordos Basin was not extensional but is a large strike-slip fault. The discovery of a large Cenozoic left-lateral strike-slip fault along the eastern Alxa Block may indicate that the Altyn Tage fault may already have been connected with the eastern Alxa Block during the early Cenozoic.

Ages, characteristics and tectonic implications of ophiolites from the southern Xiemisitai Mountain in West Junggar, Xinjiang (chief researcher: ZHAO Lei)

This project investigates the components, rock assemblages and field occurrence of ophiolites in the southern Xiemisitai Mountain and obtained geochronological and geochemical data for the ophiolite. The results enable us to discuss a comparison and connection of ophiolites in West Junggar and eastern Kazakhstan, and the distribution of paleo-oceanic and paleo-continental domains in Central Asia. The southern Xiemisitai Mountain contain ophiolite fragments consisting of serpentinized peridotite, gabbro, basalt, spilite, chert blocks and homologous pyroclastic rocks. LA-ICP-MS zircon U–Pb ages for gabbro in the Chagantaolegai ophiolite are 517 ± 3 and 519 ± 3 Ma. Serpentinized peridotites in the ophiolite show low rare earth element (REE) abundances (0.61–0.94 μg/g) and a slight loss of middle REEs. Chagantaolegai metagabbro samples have flat to slightly light REE depleted patterns with a narrow range of REE abundances. The Chagantaolegai spilites and metagabbros display similar flat patterns and show a geochemical signature similar to mid-ocean ridge basalt (MORB) between Yb and Zr, and diverge from MORB towards the most incompatible elements in MORB-normalized multi-element variation diagrams. The Th/Yb vs. Nb/Yb diagram for the spilite samples also suggests a mid-ocean ridge (MOR) setting. All geochemical characteristics of the Chagantaolegai ophiolite point to a MOR origin. Positive εNd(t) values (0.78 to +9.85) suggest that the gabbros and spilites were derived from a chemically inhomogeneous depleted mantle source. The Chagantaolegai ophiolite spatial-temporal characteristics correlate well with the Kujibai and Hongguleleng ophiolites in the northern West Junggar, and the Zhaur and Balkybek ophiolites in eastern Kazakhstan. These data

show that early Palaeozoic oceanic crust began to develop in the early to middle Cambrian in the northern West Junggar. The Darbut ophiolite in the Sartohay region is covered unconformably by sedimentary-volcanic series of the Tailegula Formation. LA-ICP-MS U-Pb dating of zircons from a dacite yielded a 206Pb/238U weighted mean age of 349 ±2 Ma. The dacites show linear REE patterns with LREE enrichment and negative Eu anomalies. The average Sr, Sr/Y, and La/Yb of dacites in the Tailegula Formation are 195×10-6, 5.2 and 4.6, respectively, much less than those of classic arc dacites and adakites. Combined with low-grade deformation and metamorphism, the dacites in the Tailegula Formation are suggested to have erupted in a rift environment. Based on regional geological data, nine representative column maps were prepared for tectonic subdivision, and the South Saur Fault is suggested to be the northern boundary of the Chingiz–Tarbagatai early Palaeozoic orogen in the West Junggar, whereas an inferred buried fault in the Heshituoluogai depression separates the Chingiz–Tarbagatai early Palaeozoic orogen from the West Junggar- East Kazakhstan residual ocean in the south.

3.2 Results of completed National Key Basic Research and Development Projects

Comparative study of the orogenic mechanisms for main orogenic belts in China (Project Leader: CAO Hui)

The project mainly focused on studying the composition, structure, dynamic evolution and deep driving mechanism for the main orogenic belts in China (Tianshan orogenic belt, Songpan Ganzi-Qinling Dabie orogenic belt, Qiangtang-Sanjiang orogenic belt, Himalayan orogenic belt and southern China orogenic belt), based on the theory of "continental dynamics". The main innovations of this project are as follows:

(1) We proposed a 3D tectonic model for the Greater Himalayan Complex

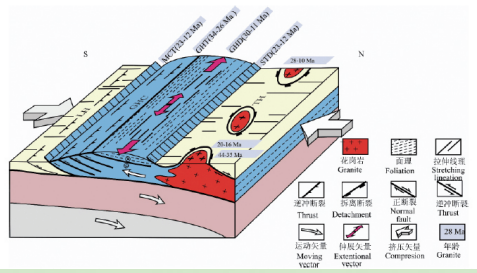


Fig. 3.2.1 3D tectonic model of the Greater Himalayan Complex

(2) We poposed a three-dimensional drawer-tectonics escape model for the southeastern Tibetan plateau

(3) We summarized the evolution of the Paleo-Tethys system and accretionary orogenesis in the Tibet Plateau and the mechanism of the Indosinian orogenic system

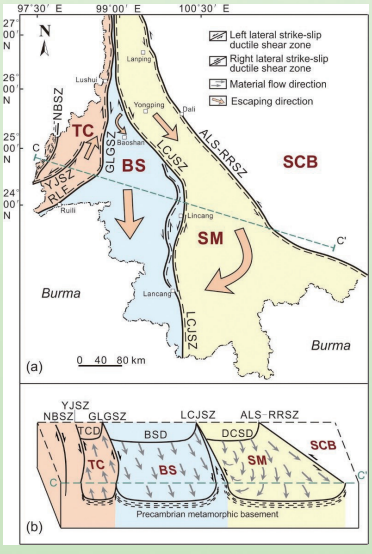


Fig. 3.2.2 Drawer-tectonics escape model for the SE Tibetan plateau

(4) We proposed two possible models for the Indian/Asian subduction collision system.

(5) We discussed the late Paleozoic accretionary orogenesis in the middle East Tianshan Mountains

(6) We confirmed the nature of the early Paleozoic continental orogenic belt in South China.

Deep seismic reflection experiments and the study of crustal structures (Project Leader: GAO Rui)

After four years of hard work (2013-2016), the project group has overfulfilled all proposed objectives of the project, and great achievements were obtained. According to the objectives of this project and the corresponding

implementing plans, we have carried out supplementary experiments in certain critical areas, and the seismic reflection data obtained were systematically processed. In the end, based on a structural interpretation of the dominant data from a long and deep seismic reflection profile, together with other geological and geophysical data sets, we conducted an integrated analysis and the following results were achieved:

(1) We completed data collection of a 403 km-long deep seismic reflection profile; we integrated processing of a 3294.6 km-long deep seismic reflection profile; cross section data were acquired along a 1010 km long wide-angle reflection/refraction profile; a 2150 km-long crustal velocity structure profile was obtained; data acquisition and processing was carried out in a 1830 km-long magnetotelluric (MT) sounding profile; we carried out grid drawing of a fence diagram for a 2500 km-long deep seismic reflection profile; geological mapping of a 220 km-long profile in the western Himalayas was carried out; we conducted multiscale waveform inversion experiments; we obtained a 400 km-long crust-mantle velocity structure profile across the Great Xing'an Range; we carried out an integrated 3D analysis of the long deep seismic reflection profile, the gravity anomaly, the magnetic anomaly and the geological data for an area of ca. 192000 km2.

(2) We have tested and developed several advanced techniques regarding imaging of the structural geometry of the lower crust and the Moho by near-vertical single shots, as well as techniques to conduct integrated exploration between deep seismic reflection and refraction.

(3) We have tested and developed a series of special processing techniques for geophysical profiles and techniques for joint-constraint processing and interpretation.

(4) The fine crustal structure and deep deformation in the research area have been well documented. In order to address the key geological problems under the complicated geological conditions of China, fine processing and supplementary exploration have been conducted to explore the deep crustal structure of typical regions. Interaction between the crust and mantle has been illustrated. Consequently, based on data acquisition and convincing evidence, together with surface structural investigations, the relationship between the crustal structure and deep deformation has been reconstructed after systematic analysis. The following results were obtained: 1) A reflective Moho has become evident for the first time beneath the Yarluang-Zangbo suture zone in the western Himalayas, and a nearly flat Moho does not support the hypothesis of a 10-20 km offset of the Moho beneath this suture zone. In addition, seismic reflection exploration indicates a crustal-scale duplex structure on both sides of the Yarlung-Zangbo suture zone, a process that thickened the crust. The leading edge of the subducting Indian continental crust becomes thinner from south to north and is thinned to less than 12 km beneath the Yarlung-Zangbo suture zone; 2) The Yangtze crystalline basement extends beyond the Longmen Shan fault zone to the west into areas adjacent to the Longriba fault zone. This indicates that the Longriba fault zone, rather than the Longmen Shan fault zone, marks the westernmost edge of the Yangtze block (Fig. 3.2.3); 3) A fossil subduction zone was identified beneath the western Sichuan basin, indicating that structural differentiation exists in the lower-middle crust between the western and eastern segments of the Sichuan crystalline basement. Thus, the Yangtze craton was composed of two sub-continents in the Proterozoic and these two sub-continents merged to become one craton during the Neoproterozoic (1000-850 Ma) (Fig. 3.2.4); 4) Different crustal-scale structural features were identified on both sides of the Minjiang fault zone and the Huya fault zone. In addition, the Huya fault zone cuts through the Moho and is recognized as a new active block boundary in the eastern Tibetan Plateau. This significant finding provides strong support for revealing the mechanism regarding growth and lateral escape of the Tibetan Plateau; 5) Decoupled crustal

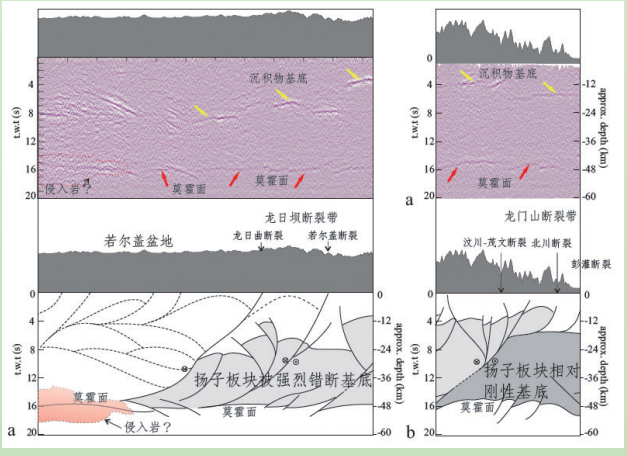


Fig.3.2.3 Part of the deep seismic reflection profile crossing the northeastern segment of the Longmen Shan fault zone

deformation with respect to lateral escape of the northeastern Tibetan Plateau was identified. This model not only accounts for the interaction and accommodation among large-scale intrablock strike-slip faults but throws new light on the eastward extent of large-scale strike-slip faults and their relationship to northward growth of the plateau (Fig. 3.2.5).

A total of 55 peer-reviewed papers were published with support of this project. Among these are 36 papers listed in the SCI index (27 papers in foreign journals and 9 in Chinese journals). Three published papers belong to the International EI index. Additionally, there are 46 conference abstracts and 7 of these were for international conferences. This project has supported 5 postdoctoral researchers and 8 PhD students. Three project members were promoted to Associate Researcher and two were promoted to Full Professor.

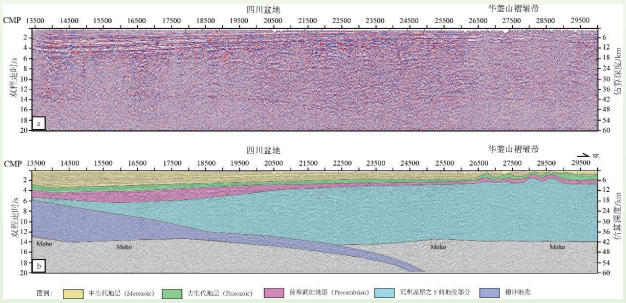


Fig.3.2.4 Deep seismic reflection profile across the Sichuan basin

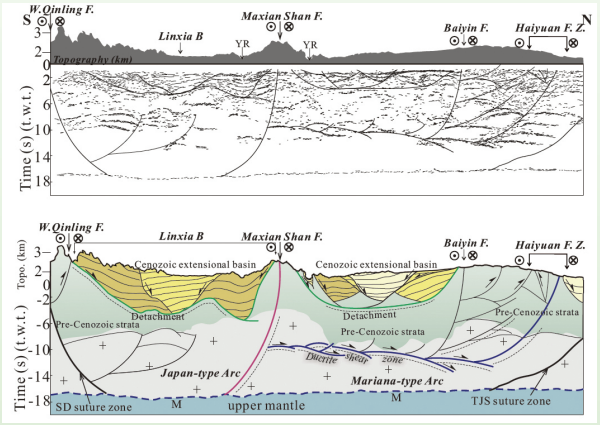


Fig. 3.2.5 Simplified composite line drawings and structural interpretation of deep seismic reflection profile in the northeastern Tibetan Plateau

Test of multi-scale imaging technology and study of crust and upper mantle velocity and density imaging in Central Asia/East Asia (Project Leader: HE Rizheng)

This is the 5th task "Multiscale Imaging Technology Test and Study on Crust & Upper Mantle Velocity & Density Imaging in Central Asia/East Asia" (SinoProbe-02-05), established in SinoProbe-02 of the Crust Exploration Plan. As the only regional research task in SinoProbe-02, its objective was to experimentally investigate the imaging technology of multiscale seismic velocity and gravity density according to the deep physical properties of the crust and upper mantle of the Asian continent and integrate a set of high-tech imaging technologies. This project has studied the crust-mantle velocity structure and density structure in the research area by passive seismic observation data in Central and East Asia and the global gravity field data, which have provided a basis for deepening the understanding and interpretation of plate tectonic movements and continent dynamics.

Through five years of research and calculations from 2008 to 2012, all participating organizations completed the designed tasks, reached the expected objectives and obtained the anticipated achievements. The main results are as follows:

(1) We collected and sorted out seismic wave event records and seismic phase reports. We collected, sorted out and formulated a sedimentary formation density and thickness chart for Central Asia/East Asia and surrounding regions, a bouguer gravity anomaly chart, an isostasy gravity anomaly chart and an upper mantle density distribution chart.

(2) New methods were developed such as a full-wave finite-frequency tomography method with topographic relief, a spherical-coordinate double-difference travel time tomography method based on eikonal equation and teleseismic P-wave anisotropic tomography method, and we have verified their reliability and validity through examples; we also developed a sequential inversion method for seismic-gravity joint inversion, based on the ART technology, and we

have documented a quick solving method for a full-mantle convection model under large Lateral Viscosity Variation (LVV).

(3) We studied the Moho depth and crustal average Vp/Vs specific values beneath the China Mainland and obtained a P-wave velocity model and Sv-wave velocity model by using a time travel tomography method. We obtained the 1-D velocity structure of part of the stations by applying the finite-frequency full-wave inversion method and the convection image of the shallow part of the mantle and the convection stress field at the bottom of the lithosphere.

(4) At the conclusion of this project, 41 papers were published, of which 23 are listed in the SCI/EI (11 papers from the first funding of the project, 4 papers from the secondary funding and 8 papers from other fundings) and 18 of these are listed in GCJC. We attended domestic and overseas conferences for more than 50 person-times and promoted 11 doctoral and 11 masters theses.

Observation and experiment of broadband seismic and crust-mantle velocity research (Project Leader: LI Qiusheng)

This is part of the Sinoprobe Project, led by the Chinese Academy of Geological Sciences and co-led by Nanjing University, Institute of Geology and Geophysics of the Chinese Academy of Sciences, the Institute of Geophysics of the China Earthquake Administration, the Institute of Tibetan Plateau of the Chinese Academy of Sciences and the Institute of Mineral Resources of the Chinese Academy of Geological Sciences, in the period 2008 – 2014.

The Digital Acquisition System (DAS) comes from several world-class providers of seismological instrumentation, such as REFTEK (US), Kinematics (US) and Nanometrics Inc. (CA); and the Sensor is mostly from Guralp (CMG-3T or 3ESP) and a few Trillium 120 and STS-2. Nearly 600 broadband seismographs were deployed in the Qinghai Tibet Plateau and adjacent areas, in southern China and northeast China (Fig. 3.2.6)

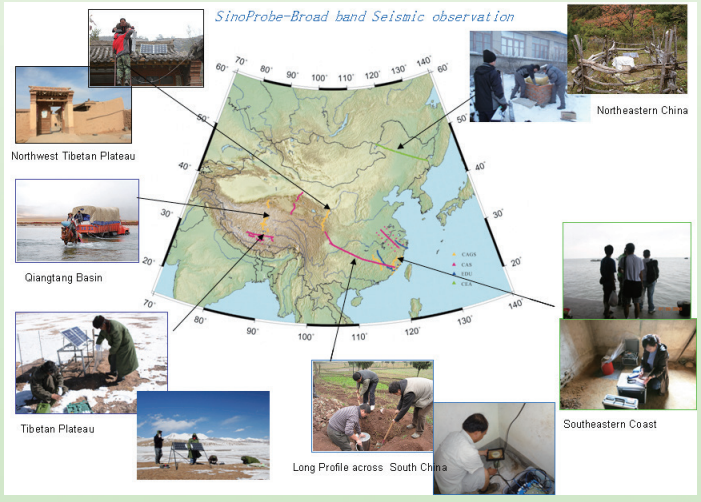


Fig.3.2.6 Deployment of Sinoprobe broadband seismic observations

We focused on the following scientific issues:

(1) Deep structural features and boundary positions of the main blocks in southern China.

(2) The deep and widespread distribution of magmatic rocks in southern China and the response of the southeastern continental margin to subduction of the Philippines plate.

(3) The leading edge of the subducted lithospheric mantle of the Indian continent and convergence of the lithospheric mantle in India and the deep state of the North-South rift.

(4) The deep structure of the Songliao Basin and the dynamics of western Pacific subduction.

We examined linear patterns to understand the fundamental characteristics and relationships of tectonic blocks in the seismic profiles. The temporary station spread was 10 to 25 km and earthquake events were recorded continuously at a sample rate of 50 sps for one and a half years. There is a total of 5 TB of raw data in the Sinoprobe database for analysis.

Current seismological methods, such as receiver function, body wave and surface wave tomography and anisotropy analysis (shear wave split) were used together or individually, and the highlight are as follows:

(1) The North China Craton lithospheric mantle was underthrust beneath the entire Qilian orogenic belt (LI Qiusheng Group).

As only dense observation profiles of receiver functions were available through the Qinling-Qilian-Alxa region at that longitude, our result is adding new evidence for southward Asian subduction. It is clearly demonstrated in a receiver function CCP profile that the North China Craton lithospheric mantle was underthrust beneath the entire Qilian orogen. Accordingly, there developed thick-skinned crustal accretionary wedges above a mid-lower crustal decollement at the northeastern margin of the Tibetan Plateau.

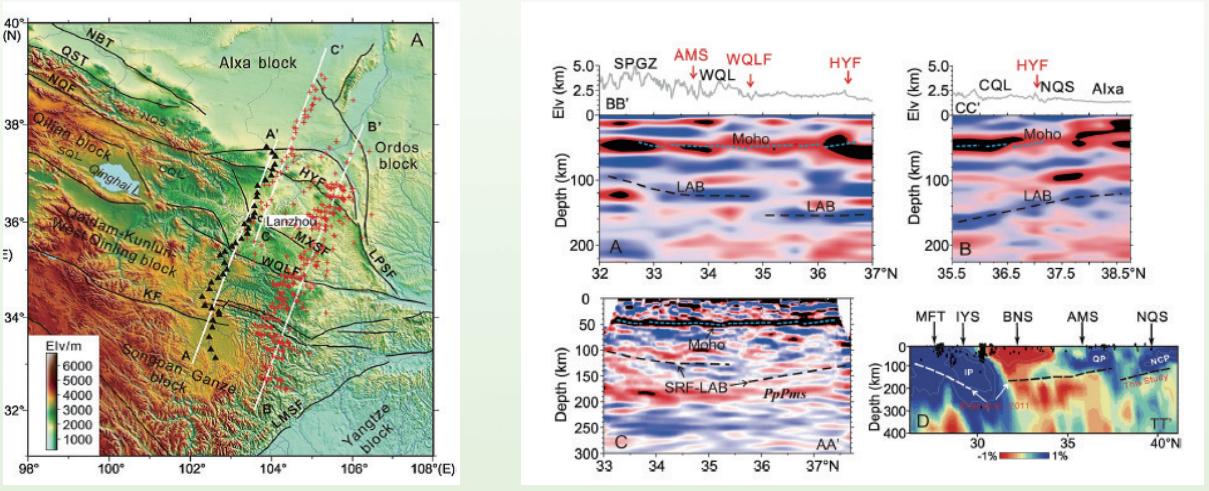


Fig.3.2.7 Broadband seismic observation and receiver function results through the northeastern margin of the Tibetan Plateau

We also added evidence to observations of Moho complications such as doubling below major surface faults in the north, similar to comparable observations in south-central Tibet.

The results of shear wave splitting analysis indicates that crustal decoupling occurred primarily in the Qilian orogen and vertically coherent deformation is dominant within the Tibetan Plateau.

Overall, our results provide critical observational evidence for a dynamic model of the Asian lithopheric mantle wedging southwards into the Tibetan Plateau and growth and outward expansion of its northeastern margin.

(2) Development of a tearing model of the Indian lithospheric slab beneath the southern Lhasa block (ZHANG Zhongjie Group)

We observed that shear wave (SKS) splitting delay-times systematically increased from 0.2 seconds (East) to 1 seconds (West) along the profile of broadband seismic data the in Gangdise-Southern Lhasa block; the distribution characteristics of SKS delay-time can be explained by slab tearing or breaking due to angular changes as the Indian plate subduct northwards (Fig. 3.2.8).

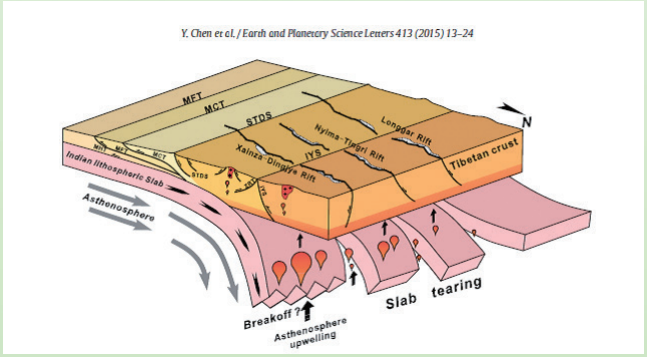


Fig.3.2.8 Tearing model of the Indian lithospheric slab beneath southern Lhasa block

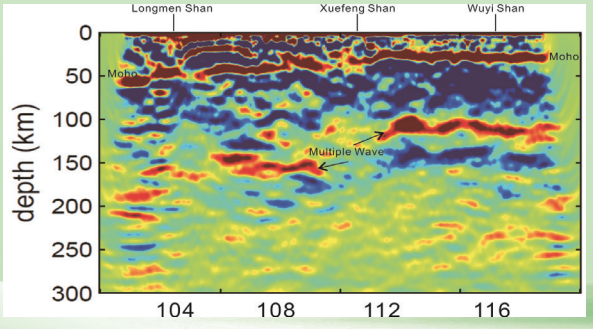


Fig.3.2.9 Migrated image of receiver function along the South China Profile

(3) The boundary of the Cathays block and the Yangtze craton has been clearly defined (CHEN Ling Group)

The crustal and upper mantle structure through the whole of southern China was imaged by teleseismic receiver function and shows that the crustal thickness and Moho sharpness of the Yangtze Craton is distinctly different from that of the Cathays Block. The boundary belt was clearly defined along the Xuefeng fault.

(4) New observations on lithospheric structure along the southeastern margin of the Eurasia plate (LI Qiusheng Group, WANG Liangshu Group and SHI Danian Group)

Crustal thinning towards the coast

The southeastern margin of the Chinese Mainland, eastwards towards the western Pacific, is the most active continental margin in the world.

The results of teleseismic receiver function analysis show that the crust tends to thin from inland to the coastal area at a rate of 2 km per 100 km (33~29 km), and the average is 31.3 km, the present characteristics of the transition from continental to oceanic crust.

Min River fault

The Min River fault extends deep to the Moho and has a obvious controlling effect on the internal activities of the crust such as the earthquakes, geothermal patterns, etc..

Thin lithosphere

A negative phase was found at 7 seconds of the P wave receiver function, which also appears in the data of a regional permanent station. Although the negative phase arrived earlier than the global model (IASP91) and very close to the Moho, we are sure it is not a side lobe of the Moho phase, because it does not change and move up and down with varying filter parameters. It also does not have antisymmetric features against the main lobe of the Moho phase (positive). We propose that the phase is the converted wave from the lithosphere/asthenosphere interface (LAB). The negative seismic phase is clearer in CCP profile. Although the propagation velocity of S waves is obviously different from that of P waves, the negative phase is imaged at the same average depth of 60-80 km as the migration image of P and S wave receiver function. This observation indicates that not only the crust but also the lithosphere of southeastern China is thinning towards the east.

Dynamics of the southeastern margin of the Eurasian plate

We have not seen clear uplifts or downdips of the 410 km and 660 km discontinuities in depth migration images of P wave receiver functions (along the long section across the whole of southern China or the coastal sections), although the absolute depth of the two discontinuities is slightly greater than the values of the IASP91 model. The thickness of the transition zone (depth 660 to depth 410) is normal and shows no indications of plume or plate subduction beneath the upper mantle of southern China.

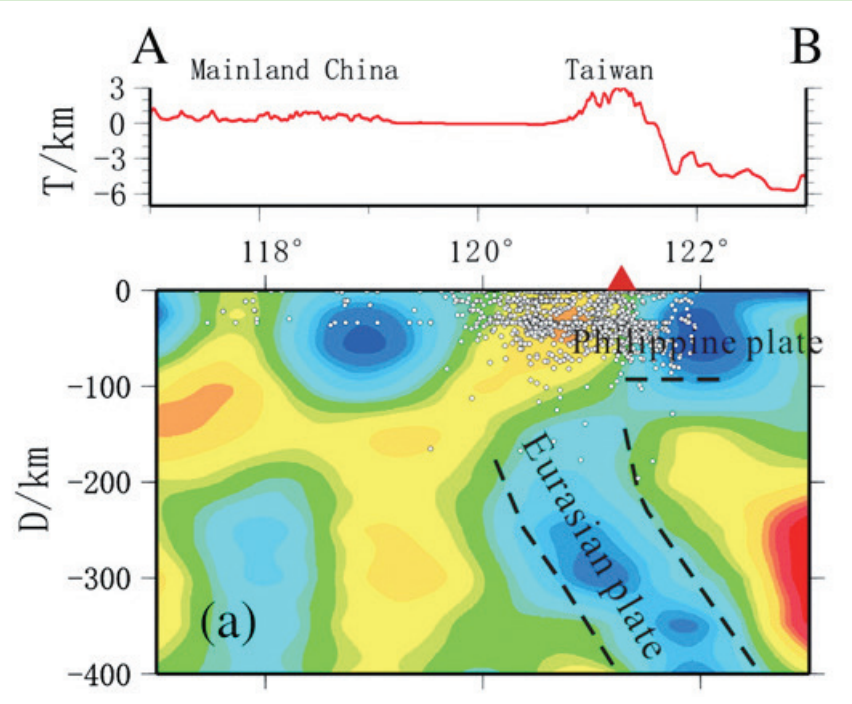


Fig. 3.2.10 Cross section of P-wave tomography across the Taiwan Strait

The driving forces may come from the upper mantle. Tomography research shows that the upper mantle in the southeastern coastal region of China and the Taiwan Strait is well developed with low velocity anomalies from 150 km to 400 km, but this is not obvious in inland areas. It is suggested that the formation of high temperature and thin lithosphere in southeastern of China is caused by deeper mantle dynamics.

Body wave tomography data show that the Eurasian plate with a high velocity appears at a depth of 60 to 100 km and is underthrust gently beneath the western edge of Taiwan Island. Affected by steep angle subduction of the opposite Philippine plate, the Eurasia plate slab breaks off beneath the Taiwan Strait and hot material from the deep mantle is upwelling along the gap and leads to high heat flow on both sides of the Taiwan Strait.

(5) Observation on deep structure of the Songliao Basin and the influence of western Pacific subduction (WU Qingju Group)

60 broadband seismic instruments have been deployed in a long profile across the Greater Xing'an Range and the Songliao Basin, and Pn wave imaging, body wave traveltime tomography, receiver function analysis, shear wave splitting and so on have been undertaken.

The regional average of Pn is 7.95 km/s, lower than the average 8.0 km/s of the Chinese continent. The southern Songliao Basin, the Liaohe Basin and the Bohai Basin are characterized by low velocity anomalies (7.6-7.8 km/s) and they are surrounded by areas of relative high velocity (7.95-8.2 km/s) as shown in Fig. 3.2.11.

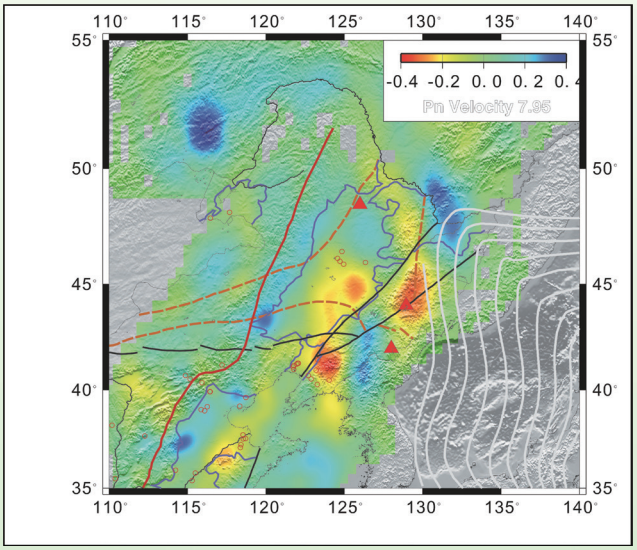


Fig. 3.2.11 Tomographic view of Pn waves in northeastern China

Body wave travel-time tomography

Beneath the volcanic areas of Changbai, Arxan and Wudalianchi velocity anomalies extend to the mantle transition zone, but the low velocity anomaly beneath the Wudalianchi volcano only extends down only about 100 km; the low velocity anomaly maybe a cooling magma body; the low velocity anomalies beneath the Songliao Basin is connected below 400 km with low velocity anomalies beneath Changbai and Arxan and extends to the lower mantle as a channel for the upwelling of hot material of the lower mantle to the upper mantle.

P and S wave receiver function

The results of P wave and S wave receiver function form H-K stack and CCP are in good agreement (Fig. 3.2.12). In the west of the Greater Xing'an Range, the Moho depth is about 40 km. In the transition zone of the Songliao basin to the small Xing'an Ridge, the Moho becomes shallow to about 29~33 km; the Moho deepens and dips eastwards east of the Small Xing'an Range and is deepest at F2 and forms an overlapping structure with the crust.

The Moho interface of S wave receiver function is consistent with the P waves. The lateral variation of lithosphere and crustal thickness is also consistent. This indicates considerable rigidity of the lithosphere of northeastern China. The LAB in the west of the Greater Xing'an Range is buried at about 140-160 km in the east and becomes gradually shallower towards the Songliao Basin where it appears at about 100 km. The LAB interface is weak in the east of the Small Xing'an Range. Compared with the surrounding orogenic belts, the thickness of the lithosphere and crust of the Songliao basin are obviously reduced, but the lithosphere thickness is thinned more significantly.

The shear wave polarization direction of fast waves in northeastern China is NNW, the velocity of wave delay is 0.8~1.4s. The stable and fast polarization direction in the Greater Khingan Range area, Songliao Basin is less, the fast direction of the Songliao basin is consistent with the Greater Khingan Range. East of the Tanlu fault it is difficult to distinguish the fast polarization direction.

The fast direction in the Greater Khingan Range Songliao Basin is mainly affected by the anisotropy of the lithosphere. The complex anisotropy to the east of the Tanlu fault may be caused by the influence of the subducting plate, the overlying plate and mantle flow.

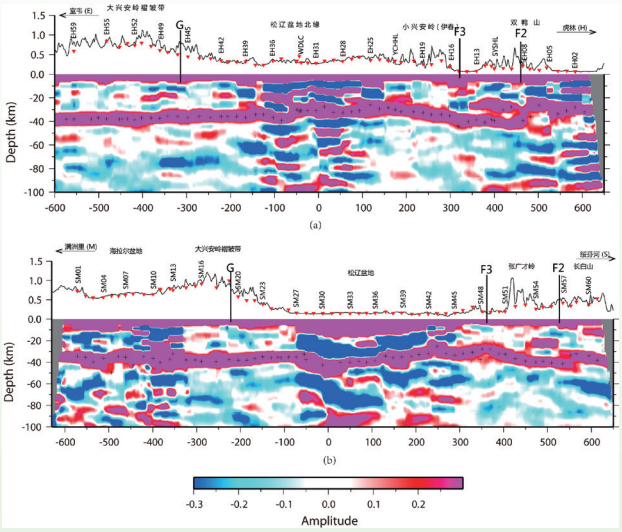


Fig.3.2.12 Coherence of CCP stack and H-k grid search P and S wave receiver function

Integration of deep probing technology and tests of integrated technology of geophysical cross-sections (Project Leader: LU Zhanwu)

The study of geological cross-sections along a deep seismic reflection profile and experimental research on the integrated interpretation and fusion technique using regional and sectional data were carried out in this project. The project integrated the combined reflection and refraction techniques, established a technical guide for deep exploration, produced a popular science video regarding deep exploration technology and achievements, and obtained the following results:

(1) An experiment combining the reflection and refraction exploration techniques was done successfully and provides new technical support for deep exploration. The experiment achieved multiple aims including diminishing the costs of field data acquisition, increasing the folds of refraction, improving the resolution and the quality of observations, obtaining a single-fold reflection profile of the Moho discontinuity and improving the processing accuracy by means of constrained refraction and reflection processing.

(2) A corridor geological map and a 0-50 km section geological map were compiled along the deep seismic reflection profile. The regional and sectional data were integrated and an interpretation was researched. Research on field data from five study areas located, respectively, in the central region of the Qinghai-Tibet Plateau, the eastern margin of the Qinghai Tibet Plateau, the northern margin of North China, South China, the Songliao Basin was completed. Comprehensive research on non-seismic data from the northeastern margin of the Qinghai Tibet Plateau, on broad-band seismic data from Longmenshan and on a seismic reflection profile and geological data from northeastern China (Songliao Basin) provides surface geological data and regional geophysical field data for an integrated interpretation of the seismic profile.

(3) Based on the integration of experimental research of other research groups on detecting technology and processing and interpretation technology, this project established a deep exploration technical guide (proposed draft), which consists of 4 parts, namely a guide for deep seismic reflection profile acquisition and processing technology, a guide for artificial source deep seismic exploration technology, and a guide for broad-band seismic observation technology and magnetotelluric sounding method technology. The guide constitutes the technical preparation for further deep exploration experiments.

(4) A popular science video concerning deep exploration technology and achievements was made in this project. The content of the video includes earth structural characteristics, gravity deep exploration technology, magnetic force

deep exploration technology, magnetotelluric sounding deep exploration technology and seismic deep exploration technology. The purpose of this video is to introduce deep geophysical exploration and its results to the public.

Metallogenic systematics and exploration model for Cu-Mo polymetallic systems in the Anji-Dexing ore belt (Project Leader: PAN Xiaofei)

The Anji-Dexing metallogenetic belt is about 500 km long and is located in the northeastern part of the well-known NE-trending QinHang suture. In order to complete the ore-exploration task in the unknown and deep area, four aspects on the reginal metallogenetic systematics, typical ore deposit genetic models and exploration methods have been studied during the past 5 years.

It is confirmed that most of the known large deposits are of magmatic-hydrothermal types and are located at the intersection of NE-, NW-, and nearly W-E-striking faults under control of the Wan-Zhe-Gan deep fault in the Anji-Dexing metallogenetic belt. All typical deposits have no specific wall rock except that skarn-type deposits are related to carbonate or carbonate-bearing formations. The ore-forming time can be divided into four phases from old to young (183~170 Ma, 162~141 Ma, 141~134 Ma, 125~117 Ma). All intrusions correlated with magmatic-hydrothermal types of deposits are high-K calcium alkaline felsic rocks including granite, granitic porphyry, dioritic porphyry and orthoclase granite porphyry, and some of these show features of adakitic rocks, and the Sr, Nd and Pb isotopes indicate that they are derived from both crust and mantle. Material from the mantle is more voluminous when the deposits contain large volumes of copper and gold.

The study of the metallogenic mechanism for the Dexing porphyry Cu (Mo, Au) deposit, the Zhuxi skarn W-Cu deposit, the Tianjingshan gold deposit and the Anji Mo, Pb, Zn, and Ag deposit on alteration, mineralization, ore-forming fluid and H-O-S-Pb isotopes has been completed, and four metallogenetic models for these deposits have been developed. Combined with the reginal setting and deep magma evolution, models for porphyry, subvolcanic and hydrothermal Cu (Mo, Au) metallogenetic series related to I-type magmas have been developed and show that the mineralization originated from juvenile crust. In contrast, skarn and hydrothermal W (Cu), Au (Pb, Zn) deposits related to S-type magmas resulted from crustal melting. Porphyry and W-Mo (Pb, Zn) mineralization related to I-S transition or A-type magmas evolved from variable degreed of crustal-mantle interaction.

Previous research on gravity profile measurement, high-precision magnetic measurement, geochemical data of stream sediments and soil have been combined with our research results of different exploring methods including remote sensing, gravity profile measurement high-precision magnetic measurement and comprehensive logging measurement. These were carried out by our project team in the Zhuxi, Tianjingshan and Anji typical ore fields during the past five years, to predict areas for metallogenic prospecting. Geological, geophysical and geochemical prospecting indicators and remote sensing information were summarized to develop prospecting models. Some exploration drilling was carried out to verify the above research results. More than 200 million tons of WO3 resources have been identified.

Model for deep prospecting, integration of exploration technology, and genesis of porphyry Cu-Mo-Au deposits in the Shanyang-Zhashui ore concentration area, Shanxi Province (Project Leader: YAN Zhen)

With accretion, superposition of collision orogeny and its metallogenic theory and metallogenic tectonic specifics as theoretical guidance, employing aeromagnetic interpretation, large-scale geological mapping and laboratory analysis, we studied the combination and distribution of ore-bearing porphyry rocks. By the comprehensive research on emplacement sequences, geochronology and geochemistry, we illuminated the petrogenesis and tectonic environment of ore-bearing intrusive rocks and further analyzed the coupling relationship between structure and magmatism.

Through detailed field investigation, we systematically studied the ore-controlling structures of the Cu-Mo-Au deposits and the tectonic style of the ore-concentration area. Based on exact U-Pb and Ar-Ar ages, we identified a two phase structural evolution in the Shanyang-Zhashui area. In addition, through detailed research on petrology, geochronology, geochemistry, D-O-S-Pb and He-Ar isotopes, we confirmed the metallogenic epoch, evolution of ore-forming fluids and the source for the ore-forming material in typical Cu Mo Au deposits. In combining our results, we discussed the metallogenic environment and coupling relationship between magma, structure, fluid and mineralization. Furthermore, by collection and summarizing the existing geological material, we selected favorable areas for gravity, aeromagnetic interpretation mapping and structural mapping, and summarized the metallogenic regularity and analysis of the main ore-controlling factors. Comparing alteration mapping, geophysical anomaly features, geochemical indicator elements and remote sensing alteration information, we assessed the geology, remote sensing, as well as geophysical and geochemical prospecting and established a prospecting model. Through geological, geophysical, geochemical, alteration mineral mapping and rock composition, we established a fast positioning technology for concealed rocks and ore bodies, and developed a mineral deposit exploration model. Using new technology we analyzed the original data, and selected abnormal areas for prospecting. Based on deep drilling in the abnormal area, we further optimized the combination of prospecting methods and improved our exploration model. On this basis we proposed the best combined method for the deep prospecting of porphyry Cu-Mo deposits in composite orogenic belts.

3.3 Results of China Geological Survey Projects completed in 2016

Research on isotopic dating methods required for exploration of metallic mineral deposits (Project Leader: CHEN Wen)

The research period for the geological mineral survey & evaluation project "Research on Isotopic Dating Method Needed for Exploration of Metallic Ore Deposits" was 2013-2015. The main aim was to specify isotopic dating methods needed for the survey of metallic ore deposits, to undertake instrument debugging, hardware configuration and exploration and optimization of experimental processes, to establish the zircon (U-Th)/He isotopic dating method and the experimental process for superfine mineral Ar-Ar isotopic dating, to perfect sulfide Re-Os isotopic analysis in magmatic metallic mineral deposits and to select typical metallic mineral deposits and tectonic zones for method validation so as to provide technical support for research on formation of mineral deposit, their uplift and denudation. The main results are as follows:

(1) China's first single-grain zircon (U-Th)/He dating laboratory was established. 1) We completed the construction of a (U-Th)/He dating laboratory and successfully installed a helium isotope quadrupole mass spectrometer (QMS), the analytical precision of which for 4He (helium-4) in zircon samples is above 5‰; 2) We established the experimental process for single-grain zircon (U-Th)/He dating and dated standard samples of the FCT and Sri Lanka zircons. Our (U-Th)/He age for the FCT zircon (recommended age is 28.3±2.6 Ma) is between 25.81 Ma and 30.72 Ma and the weighted average age is 28.18 ± 0.51 Ma; our (U-Th)/He age for the Sri Lanka zircon (recommended age is 470±11 Ma) is between 445.5 Ma and 489.5 Ma and the weighted average value after eliminating outliers is 479.0±8.0 Ma. The analytical errors for zircon (U-Th)/He dating of the above samples are between 2.7 and 4.6 %, which are below 5 %. The ages for two international standard samples tested are both consistent with the reference values, indicating that our laboratory process for zircon (U-Th)/He dating is precise and reliable.

(2) Remarkable progress was achieved in superfine mineral Ar-Ar dating. 1) We successfully installed and debugged a noble gas mass spectrometer (Helix MC), the key index of which meets the requirements of precise measurement of the content of Ar isotope and the precision of measuring the 40Ar peak is better than 0.5 ‰ (the best value may reach 0.05 ‰). The long-term monitoring results for the 40Ar/36Ar value of atmospheric argon

are mostly between 293 and 297, the average value is 295.69, which is consistent with the Neil value (295.5), indicating that the instrument and experimental process are of reliable precision; 2) We successfully developed an experimental processes of superfine-grain sample making and fractionation for metal ores and rock samples, and mineral separation and check for superfine Neogene potassium-bearing minerals; 3) Using a step-heating Ar experiment to study the Ar release characteristic in superfine minerals, we established the experimental process for Ar extraction from superfine minerals; 4) Using Ar-Ar dating of standard samples from conventional to superfine size, we provisionally determined the lower limit of the size of mineral samples where the nuclear recoil effect obviously influences the dating result. The experimental results indicate that we can still obtain reliable Ar-Ar ages from samples as fine as 300 mesh, which considerably enlarges the fractional range for Ar-Ar dating.

(3) Progress was also achieved in metal sulfide Re-Os dating. 1) By reducing the total procedural blank and increasing Os recovery, the ionization rate and ion current density, we further optimized the chemical preparation process of Re-Os isotope samples and obtained precise analysis of ~10 pg-grade sulfide (such as pyrrhotite), the precision of which may reach 5 ‰; 2) We obtained a Re-Os isochron for a sulfide mineral combination such as pyrite in the Huangshandong Cu-Ni deposit in Xinjiang, the age of which is consistent with a zircon U-Pb age within error, verifying the stability and reliability of this Re-Os dating process. Based on this, we believe that Re-Os isotope dating by selecting minerals formed during the same geological event, with the same cause of formation, and with one or more sulfides symbiotic on a microscale and with homogeneous isotopes within a small range can help use to obtain an isochron age of geological significance. This further expands the objects for Re-Os isotopic dating.

(4) Research on the hydatogen sediment optical stimulated luminescence (OSL) dating technology. 1) We systematically established the OSL signal strength and equivalent distribution of different types of modern hydatogen sediments in northern China and analyzed the influence of the signal zero returning degree on age precision. The results show that the equivalents of modern sediment residuals with different causes of formation and with different sizes in the northern region, northern China plains and northern China region vary considerably, and the measured data are of great significance to hydatogen sediment OSL dating in northern China; 2) We improved the pre-treatment and testing process of hydatogen sediments and developed a basis and method suitable for the treatment and selection of OSL age data of hydatogen sediments, by which we reduced the dating error to within 5 % and expanded the OSL dating range of hydatogen sediments, making it possible to obtain the age of sediments more than 200,000 years old.

(5) Research progress in method validation and application demonstration. By zircon and apatite (U-Th)/He dating, as well as superfine mineral and normal size mineral Ar-Ar dating, we defined the upper limit of the age of the hydrothermal processed at the Katebaasu Gold Deposit located in the western Tianshan. We also established the uplift and erosion history of the deposit, revealed the thermal evolution history in the middle range of the South Tianshan since the Paleozoic and the uplift and erosion history since the Early Jurassic, determined the metallogenetic epoch and analyzed the genesis for the Wangfeng gold deposit in the South Tianshan.

Tectonic attributes and evolution of the Paleoproterozoic Jiao–Liao–Ji Belt, eastern North China Craton (Project Leader: MENG En)

Extensive research over a two-year period has yielded the following results:

(1) The Paleoproterozoic metamorphic volcanic rocks in the southern and northern zones of the Liao–Ji Belt are calc-alkaline in composition, and were erupted at an active continental margin and a back-arc basin, respectively, at ~2.19 Ga, and were metamorphosed at 1.90 and 1.85 Ga.

(2) The protoliths of the Paleoproterozoic metamorphic sedimentary rocks in the southern and northern zones were deposited in the same tectonic environment after 2.02 Ga and were metamorphosed at the same time as the metavolcanic rocks.

(3) TTG gneisses formed at ~2.50 Ga in the southeastern Jilin Province.

(4) Paleoproterozoic granitic magmatism occurred in three pulses at 2.17–2.11 Ga, and 2.09–2.08 Ga granites were emplaced in a back-arc environment, whereas 1.90–1.85 Ga granites are syn-collisional.

(5) The metagabbro/diabase of the central Liaodong Peninsula formed in a back-arc basin at 2.15 Ga and was metamorphosed at 1.90 Ga.

Tectonic evolution and metallogenetic potential of important ophiolite belts in China (Project Leader: XIAO Xuchang)

Ophiolite is a remnant of oceanic crust and plays a key role in the identification of paleoplate sutures and reconstructing the evolution of ancient ocean basins. A complete ophiolite suite is composed of peridotite, cumulate gabbro, mafic sheets or dikes, pillow lava, and deep sea sediments. We investigated important ophiolite belts in China, and their features are summarized as follows.

(1) The Shimian ophiolite in the western Yangtze Block is a tectonic complex which mainly consists of serpentinite, gabbro, basalt, and rodingite. Zircon U–Pb dating using a sensitive high-resolution ion microprobe (SHRIMP) on a gabbro sample yielded an age of 1066 ± 11 Ma, representing the formation age of the Shimian ophiolite. All basalt and gabbro samples are tholeiitic in composition and have normal mid-ocean ridge basalt (N-MORB)-like trace element patterns with negative Nb and Ti anomalies. The low zircon δ18O (4.6 to 5.6 ‰) and high positive zircon εHf(t) (+10.8 to +18.3) values indicate that these rocks were derived from a depleted mantle source. These features are comparable with those of basaltic rocks in SSZ-type ophiolites.

(2) The NE Jiangxi ophiolite in the eastern Jiangnan Orogen is a tectonic mélange that mainly consists of individual tectonic blocks comprising pyroxenite, gabbro, basalt, diorite, granite and chert in a matrix of serpentinite or tuffaceous graywacke. The basalts display markedly negative Nb–Ta anomalies and show a geochemical affinity to island-arc basalt (IAB), indicating a slightly enriched MORB-type mantle source that was significantly influenced by subduction-derived fluids and/or melts. SIMS zircon U–Pb dating of gabbros gave ages of 995 ± 22 Ma and 993 ± 12 Ma, which are interpreted as the formation age of the NE Jiangxi ophiolite. Positive zircon εHf(t) (+8.8 to +13.8) values for the gabbros and whole-rock εNd(t) (+5.5 to +6.6) values for the basalts indicate that the NE Jiangxi ophiolite originated from an isotopically homogeneous depleted mantle source. The diversity of MORB- to IAB-like basalts and the presence of Fe–Ti basalts favor formation of the NE Jiangxi ophiolite during the initial rifting phase of an intra-oceanic back-arc basin between an oceanic arc (Huaiyu Terrane) and the continental margin of the Yangtze Block (Jiuling Terrane) at ca. 990 Ma.

(3) The Nyainqentanglha Group is one of the most important Precambrian rock sequences in the Tibetan Plateau and is composed of a suite of tectonic slices with different sizes and ages, including metasedimentary, metavolcanic and meta-basic-felsic intrusive rocks. We reported new zircon U-Pb ages and Hf isotopes as well as whole-rock major and trace element compositions for metagabbro from the Nyainqentanglha Group in the Ren Co area, north-central Lhasa terrane, Tibet. LA-ICP-MS and SIMS U-Pb zircon dating yielded weighted mean 206Pb/238U ages of 930.9±7.3 and 925.2±6.2 Ma, respectively. Zircons of the metagabbro exhibit pudding, fan-shaped or slight zoned textures and high Th/U ratios (0.73–31.6), indicating that they are of magmatic origin, and the above ages represent the tome of crystallization of the metagabbro protolith. The metagabbros contain low SiO_2 concentrations (47.83–49.32wt. %) and show sub-alkaline chemical features. Chondrite-normalized rare earth element (REE) and primitive-mantle-normalized trace element multi-element patterns indicate that these rocks can be divided into two groups. The REE and trace element patterns of both groups are similar to those of N-type mid-ocean ridge basalt (N-MORB), but Group A samples have relatively higher REE and high field strength element (HFSE) contents than Group B samples. The high field strength element ratios (Ce/Zr, Th/Yb, Th/La, La/Yb, La/Sm, La/Nb, Zr/Nb, Hf/Nb, and Y/Nb) of both groups are comparable to those of N-MORB. In addition, the metagabbros also display some chemical features of island arc tholeiite (IAT), whereas Group B samples show some subduction affinity in geochemical discrimination diagrams. Furthermore, zircons of the metagabbros have strongly positive εHf(t) values (8.26–13.7) and young zircon Hf model ages (tDM = 933–1205 Ma), suggesting that the protoliths are derived from a long-term depleted mantle source. These features indicate that the metagabbros are probably remnants of early Neoproterozoic oceanic crust.

Tectonic settings and main mineral deposits in the Tethyan metallogenic domain in southwestern Asia (Project Leader: ZHANG Hongrui)

Located in southwestern Asia, the Zagros orogen is an important segment of the Tethyan metallogenic domain (TMD). It contains numerous large or giant ore deposits, such as Mehdi Abad, Sar Cheshmeh, and Sungun. The main achievements of this project are as follows:

(1) The tectono-magmatic and metallogenic evolution of the Zagros orogen is reviewed. Four major tectonic units are recognized, they are the Zagros fold-and-thrust belt (ZFTB), the Sanandaj–Sirjan zone (SSZ), the Urumieh–Dokhtar magmatic assemblage (UDMA), and the central Iran block (CI). The Zagros was generated during Paleozoic-Mesozoic Tethyan accretionary and Cenozoic continental collisional orogenesis. The Neo-Tethyan oceanic slab was subducted beneath the SSZ during Jurassic and Cretaceous and left a back arc basin in the north of the SSZ where volcanogenic massive sulphide deposits and the Mehdi Abad Pb–Zn deposit formed. A mafic to ultramafic complex hosting Cr mineralization formed in the south of the SSZ. This podiform chromite was emplaced 40 Ma later during obduction of the oceanic crust. At the end of the Eocene to Oligocene, collision between the Arabian and Eurasian continents occurred which caused the northern margin of the Arabian plate to become deformed (ZFTB), and abundant magmatic activity occurred between the SSZ and CI (UDMA). Some adakitic granites hosting Cu mineralization intruded during the early Miocene. The collision also led to Pb-Zn mineralization in the SSZ. The Zagros orogen has been in a post-collisional stage since the middle Miocene.

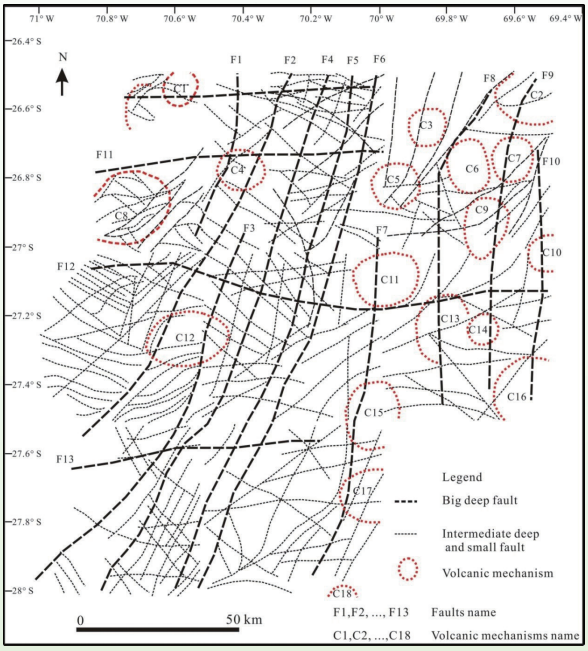
(2) The main and significant metallogenic belts in the Zagros include the Zagros podiform chromite, the Arasbaran–Kerman porphyry Cu–Mo–Au, and the Takab-Yazd Pb–Zn deposits. Among these, the Takab-Yazd belt is composed of two types of deposits, e.g., MVT-like deposits and volcanogenic massive sulfide (VMS) deposits.

(3) Synthesizing the architecture and tectonic evolution of collisional orogens within the TMD and comparisons with these collisional orogenic systems led to identification of four basic collision types: orthogonal and asymmetric (e.g., the Tibetan collision), orthogonal and symmetric (Pyrenees), oblique and symmetric (Alpine), and oblique and asymmetric (Zagros). The tectonic evolution of collisional orogens typically includes three major processes: (a) syn-collisional continental convergence, (b) late-collisional transform faulring, and (c) post-collisional crustal extension, each forming distinct types of ore deposits in specific settings.

Division of the Andean metallogenic domain in South America and regional metallogenic structures in northern Chile (Project Leader: ZHU Xiaosan)

The Andean metallogenic belt is the most famous belt worldwide for copper, gold and multi-metal mineralization. There are a several large to giant copper, gold and polymetallic deposits in the Andean belt. We divided the Andean metallogenic domain into three metallogenic provinces, and they are the North, Middle and South Andean metallogenic provinces, based on the basement composition, tectono-magmatic evolution, plate subduction, difference of mineralization and major metallogenic types of the Andes. We also subdivided the 3 metallogenic provinces into 14 metallogenic belts and briefly elaborate on their geological background and metallogenic characteristics.

The Atacama and Domeyko faults systems in northern Chile control tectono-magmatic activities migrating eastward and the types of mineral resources. We processed and interpreted aeromagnetic data from northern Chile with reducing to pole, upward field continuation, the second derivative calculation in a vertical direction, inclination angle calculation and analytical signal amplitude analysis. We discovered the locations and planar distribution characteristics of regional deep faults along the NNE and N-S directions. We also found the main reasons for formation of the tectono-magmatic belts and that there are nearly parallel deep faults distributed from west to east and multiple magmatic activities along these faults. We ascertained the locations of volcanic mechanisms and the relationships between these and with the regional deep faults. We deduced the spatial distribution of mafic-intermediate igneous rocks, felsic igneous rocks, intrusive rocks and sedimentary sequences. We revealed linear



positive magnetic anomalies and magnetic anomaly gradient zones based on the slowly varying background negative magnetic anomaly field, which indicates that strong magmatic activity occurred along these regional deep faults, and our survey revealed favorable areas for copper and polymetallic mineralization.

The detailed division of the Andean metallogenic belt provided basic information on further sub-division and summarized regional metallogenic regularities. This study also provided some basic information for further research in geology, structural characteristics and mineral resource prospecting in northern Chile.

Fig.3.3.1 Cartoon showing interpreted faults and volcanic mechanisms based on the aeromagnetic data in northern Chile. The faults are shown as F1, F2,..., F6 and F13. The volcanic mechanisms are shown as C1, C2, ..., C16 and C18

3.4 Important Scientific Awards

Two projects won the first grade award of the Ministry of Land and Resources, China:

1:5 Million International Geological Map of Asia (REN Jishun, NIU Baogui, WANG Jun, JIN Xiaochi, HE Zhengjun, QIU Yang et al.)

The International Geological Map of Asia at a scale of 1:5 000 000 (IGMA5000) was compiled by the CGMW Subcommission for South and East Asia in collaboration with the Subcommissions for Northern Eurasia, the Middle East and Seafloor Maps and is a major cooperative project under the aegis of CGMW with the support of UNESCO and IUGS. Launched in 2005 and completed in 2012, the enterprise involved more than 100 geologists from 20 Asian and European countries. It was also supported by substantial efforts of the China Geological Survey. The IGMA5000 was published by Geological Publishing House in 2013.

The IGMA5000 is the first-of-its-kind digitally-created international geological map of Asia depicting the geology of both the continent and offshore areas. The map spans the entirety of Asia and its peripheral regions from the Alps in the west to the Mariana Trench in the east and from the Arctic Ocean in the north to the Java Trench in the south. It will provide an essential foundation for users to explore the geology of Asia from a global perspective and help with the understanding of the tectonic relationship between the Asian continent and its neighboring continents and oceans.

Using the ArcGIS platform with a spatial database, the IGMA5000 was compiled in accordance with international standards. The stratigraphic classification on the map follows the International Chronostratigraphic Chart, revised by the International Commission on Stratigraphy in 2012. Igneous rocks are classified according to category diagrams recommended by the IUGS Subcommission on the Systematics of Igneous Rocks. The classification of metamorphic facies is based on temperature and pressure. Structural features, such as faults, are expressed by commonly used structural symbols.

In the course of compiling the present map, eight thematic research projects have been set-up in order to solve

some key problems encountered in the study of Asian geology, and major advances are manifested in the following understandings: (1) The most significant Neoarchean tectono-thermal event in the Sino-Korean craton and the Indian craton occurred at 2.5 Ga rather than at 2.7 Ga. (2) The basal boundary of the Meso-Neoproterozoic Jixian section in China is not dated at 1.8 Ga as defined previously, but less than 1.68 Ga. (3) The basement of the Yangtze craton finally stabilized at 0.75–0.8 Ga, which is 0.2–0.3 Ga later than the Greenville orogenic cycle. (4) Large volumes of Mesozoic volcanic rocks occurring in the eastern Asian coastal area are mainly Cretaceous and not Upper Jurassic–Lower Cretaceous in age. (5) Most Carboniferous–Permian volcanic rocks in Central Asia do not seem to be the result of arc volcanism but the product of an extensional phase. (6) The patterns of temporal-spacial distribution of granitoids and ophiolites in Asia have been systematically investigated through a great amount of data, and some important geological aspects of Asia can be viewed on IGMA5000.

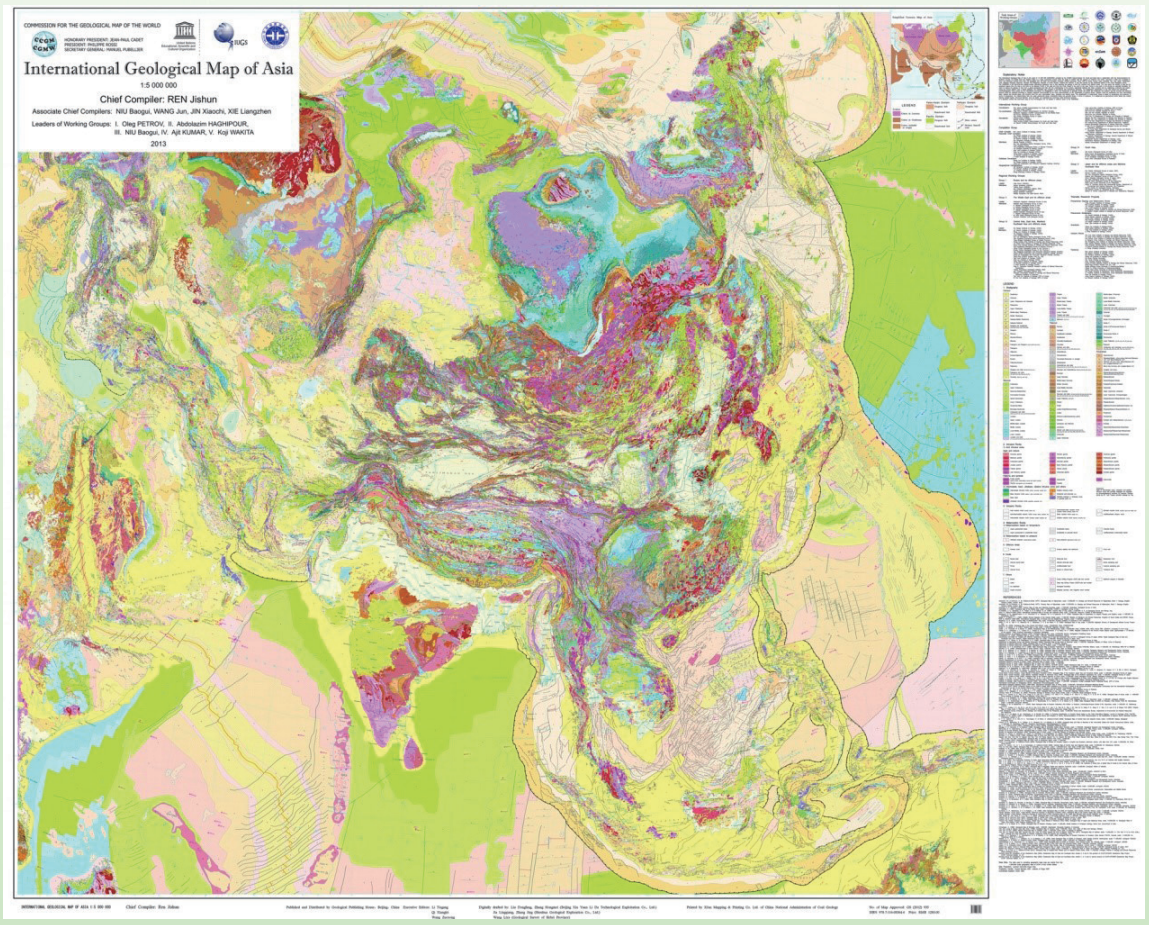


Fig 3.4.1. 1:5M International Geological Map of Asia

Theoretical innovation in metallogenesis and its application to ore prospecting for sediment-hosted Zn-Pb polymetallic deposits in the Sanjiang orogen (HOU Zengqian, PAN Tong, SONG Yucai, LI Shijing, YANG Tiannan, SUN Zekun et al.)

The Sanjiang belt is the best potential strategic base for metal resources. Ore exploration in the South Sanjiang belt has achieved a breakthrough in the last 30 years but remained stagnant in the North Sanjiang belt. Since 2006, our team has undertaken a several projects in the North Sanjiang belt under the leadership of national ministries and local governments. Ten years of work has resulted in important breakthroughs as follows.

(1) A new model for the tectonic evolution of the Sanjiang orogenic belt has been developed. We suggest that the Sanjiang orogenic belt has undergone two phases Paleo Tethyan subduction and three phases of Mesozoic to Cenozoic collision. The felsic rock series formed in a continental marginal arc and carbonate deposition occurred in posterior-arc foreland basin. This and the subduction orogenic period have contributed key elements for large-scale mineralization whereas a fold-and-thrust belt of the collision orogenic period has provided an important tectonic environment.

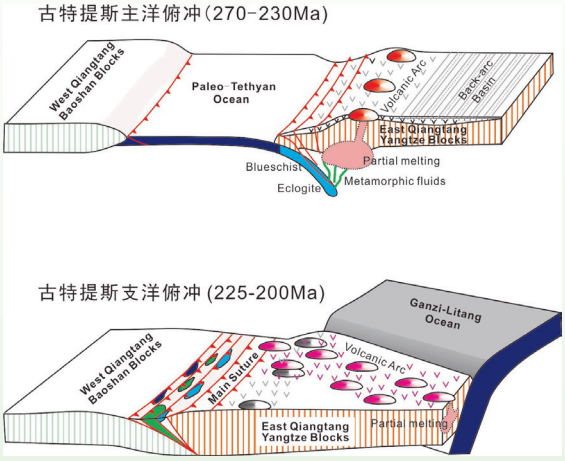


Fig 3.4.2. Tectonic evolution of the Paleo-Tethys in the Sanjiang belt.

(2) A new Pb-Zn metallogenic theory for continental collision has been developed. The new theory indicates that (1) large-scale Pb-Zn mineralization occurred during the Cenozoic collisional orogenesis and was unloaded in the thrust-fold belt of the Sanjiang orogen; (2) the thrust nappe resulting from collision produced decoupled detachment structures at depth and produced structural traps in the front belt; oxidizing metal-rich basinal brines migrated to the structural traps via the decoupled detachments, driven by regional thrusting and compressive forces; (3) when the regional stress field changed from compression to extension, multiple fluid pathways were reactivated by extension and strike-slip faulting, and sulfide precipitation occurred in the fracture systems by mixing of the oxidizing metal-rich brines and the reduced basinal brines. This theory is different from the classical MVT Pb-Zn theory, it explains the regional metallogeny of the Sanjiang orogen, correctly forecast a 1500 m-long Pb-Zn metallogenic belt, and provided important information for regional prospection.

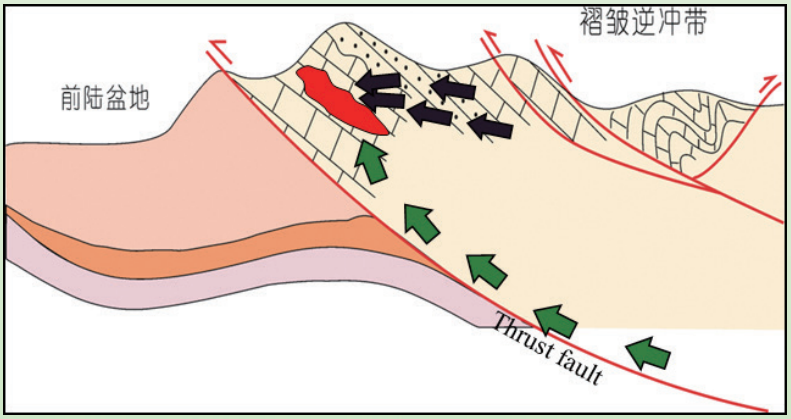


Fig 3.4.3. New Pb-Zn metallogenic theory for continental collision

(3) A Pb-Zn metallogenic model and an exploration model have been developed. Our team recognized four different Pb-Zn deposit types including the Jinding type, the Hexi-Sanshan type, the Dongmozhazhua type and the Duocaima type, found out the ore-controlling factors, developed deposit exploration models and the most effectively combined exploration methods, respectively, and achieved breakthroughs in the search for new ore in different deposits.

(4) A major breakthrough has been obtained in theoretical guidance for prospecting. In the Tuotuohe District, an innovative model for the best prospecting method of "ore being controlled by the thrust nappe system + audio magnetotelluric sounding positioning" and exploration deployment scenery has been developed. Through systematic prospecting, great breakthrough has been achieved in the Duocaima mining area with 6200000 tons of new lead and zinc resources, and an ultra-large type lead-zinc mine was established. In the Yushu District, large-scale tectonic lithofacies mapping was conducted and thrust fault system and ore controlling recoil structure were delineated. We also explored the spatial distribution of ore-bearing formations by using the intermediate gradient and geoelectrochemical extraction measures, controlling the ore body position through systematic drilling. A new breakthrough in prospecting has been achieved in the Mohailaheng and Dongmozhazhua mining areas with 1500000 and 1080000 tons of new lead and zinc resources respectively, both of these are large-scale deposits. The total volume of newly discovered resources discovered by this project are Pb+Zn: 11000000 tons, Ag: 1000 tons, Cu: 1000000

tons, demonstrating the largest breakthrough in Qinghai lead-zinc prospecting for the past 30 years.

This project has obtained one invention patent and one intellectual property right. It has published 46 articles, has been awarded a second prize for scientific progress of Qinghai Province and two first prizes and one second prize for geological prospecting results of Qinghai Province. This project has raised the international academic status and the level of mineral exploration in China. It has increased the reserves of lead and zinc of our country, and the potential economic value is 1553.4 billion yuan, and it stimulated commercial exploration funds are 7.1 billion yuan, market financing is nearly 3.1 billion yuan.

4. International Cooperation and Academic Exchange

4.1 Attendance at International Conferences

45 geologists of the Institute attended the 35th International Geological Congress (Cape Town, South Africa)

Invited by Dr. G.A. Botha, Secretary-General of the 35th International Geological Congress (IGC), and headed by Dr. WANG Tao, Deputy Director of the Institute, 45 geologists of the Institute attended the 35th IGC that took place in Cape Town, South Africa from 21 August to 4 September 2016. 39 members of the team delivered 41 presentations. The team convened three sessions and co-convened four other sessions.

Fig. 4.1.1. WANG Tao giving an oral presentation at the 35th IGC

Fig.4.1.2. Academician XU Zhiqin (third from left) and her team members at the 35th IGC

Fig. 4.1.3. ZHANG Zeming giving an oral presentation

Fig.4.1.4. WANG Yanbin giving an oral presentation

Fig. 4.1.5-6 Group photos taken during two post-conference field trips

LI Yibing attended the IODP Expedition 352 (IBM Fore Arc) science meeting (Cyprus)

Invited by Prof. Katerina PETRONOTIS, Expedition 352 Project Manager and Staff Scientist of the International Ocean Discovery Program (IODP), Dr. LI Yibing attended the IODP Expedition 352 (IBM Fore Arc) science meeting held in Cyprus on 8-15 May 2016. He delivered a presentation with the title "Zircon and rutile analyses on Exp. 352 samples: Results, and implications for the understanding of subduction initiation".

LI Haibing and colleagues attended the HKT 2016 (Aussois, France)

Invited by Dr. Natalie VÖGELI, General Chair of the HKT 2016 (an international conference on Himalayan-Karakoram-Tibetan Geology), Drs. LI Haibing, Marie-Luce Chevalier and PAN Jiawei attended the conference held in Aussois, France, from 9 to 12 May, 2016. They delivered oral presentations as follows: "The 2014 Mw 6.9 Yutian earthquake: first surface rupture along the western Altyn Tagh fault system"(LI Haibing), "Tectonic geomorphology of the Litang fault system, SE Tibetan Plateau, and implication for regional seismic hazard" (Marie-Luce Chevalier), and "Discovery of the 17th Century Paleo-earthquake in Shuanghu Graben, central Tibet" (PAN Jiawei).

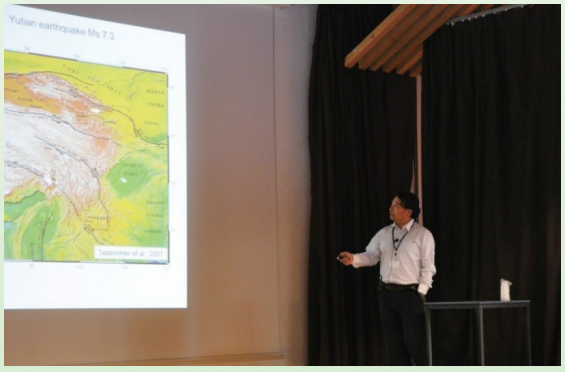


Fig.4.1.7. LI Haibing giving a presentation at the conference

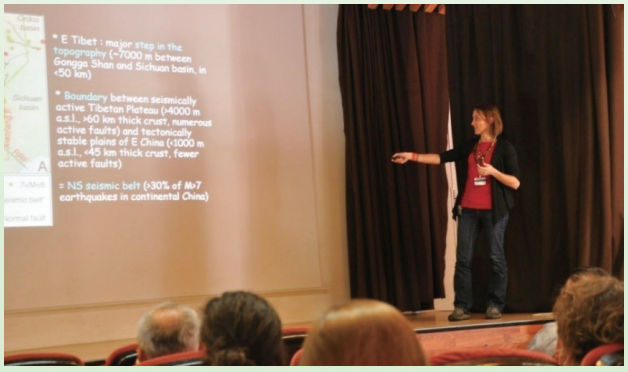


Fig.4.1.8. Marie-Luce Chevalier giving a presentation at the conference

YANG Jingsui and colleagues attended the second workshop of IGCP-649 (Diamonds and Mantle Recycling) (Agros, Cyprus)

Invited by Professor Dr. Yildrim DILEK of the Department of Geology and Environmental Earth Sciences of Miami University, and Vice President of the International Union of Geological Sciences (IUGS), Drs. YANG Jingsui, ZHU Xiangkun, CHEN Songyong, ZHANG Cong, LIU Fei, Xiongfahui, ZHAI Qingguo and SUN Jian attended the second workshop of IGCP-649 (Diamonds and Mantle Recycling) held in Agros, Cyprus (including both pre- and post-conference field trips to the classical Troodos ophiolite), during the week of 14-20 May 2016.

Fig.4.1.9. YANG Jingsui giving a presentation at the workshop

Fig.4.1.10. Group photo taken during the field trip to the Troodos ophiolite

ZHU Xiangkun and colleagues attended the Goldschmidt Conference 2016 (Yokohama, Japan)

Invited by Dr. Harue MASUDA, Chair of the Local Organizing Committee of the Goldschmidt Conference 2016, Drs. ZHU Xiangkun, LI Zhihong, SUN Jian and LIU Yan attended the conference, held from 26 June to 1 July 2016 in Yokohama, Japan. They delivered the following presentations at the meeting: Redox state evolution of the late Cryogenian Ocean: A case study from the Nanhua Basin (ZHU Xiangkun); Fe isotope and trace element variations in the Shilu Fe-ore deposit, Hainan Province, China (SUN Jian); Alteration and mineralization of carbonatite-syenite complexes in the Mianning-Dechang REE Belt, Sichuan Province, southwest China (LIU Yan); and "Fe isotope composition of Paleoproterozoic Superior-type iron formation from the North China Craton" (LI Zhihong).

Fig.4.1.11. ZHU Xiangkun (middle), LI Zhihong (left) and SUN Jian (right) at the conference.

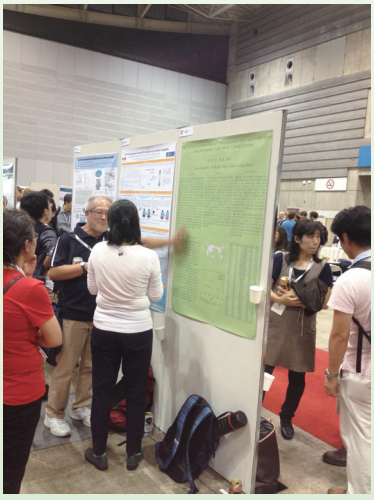


Fig.4.1.12. LI Zhihong (middle) giving a poster presentation.

LI Tingdong and colleagues attended the 14th workshop of the joint project "Deep processes and metallogeny of northern-central-eastern Asia and adjacent areas" (Vladivostok, Russia)

Invited by Dr. Oleg PETROV, Director-General of VSEGEI, Academician LI Tingdong and Drs. LIU Yanxue, REN Liudong, YOU Guoqing and ZHANG Heng attended the 14th workshop of the joint project "Deep processes and metallogeny of northern-central-eastern Asia and adjacent areas" held on 3-6 October, 2016 in Vladivostok at the Far East Geological Institute of the Russian Academy of Sciences, and a post-conference field trip.

Fig.4.1.13. Academician LI Tingdong (third from right) on behalf of the Chinese team signing the documents

Fig. 4.1.14. Exchanging ideas during the workshop

Fig. 4.1.15. Group photo of the Chinese team during the field trip

Fig. 4.1.16. Another photo of the field trip

LI Haibing attended the 5th International Geohazard Research Symposium in memory of Prof. Tsanyao Frank YANG (IGRS 2016) (Taipei, Taiwan)

Invited by Prof. Sheng-Rong SONG (Convener) on behalf of the Organizing Committee of the 5th International Geohazard Research Symposium - in memory of Prof. Tsanyao Frank YANG (IGRS 2016), Dr. LI Haibing attended the symposium held in Taipei, Taiwan, from 17 to 20 October 2016. He delivered an invited talk entitled "Correlation between faulting processes, fault zone structures and geohazards triggered by the 2008 Wenchuan earthquake, western China".

JIN Xiaochi and HUANG Hao attended the the 5th International Conference of the IGCP Project 589 (Yangon, Myanmar)

The 5th International Conference of IGCP Project 589 was held from 25 October to 2 November 2016 in Yangon, Myanmar. As the IGCP-589 Project leader, Dr. JIN Xiaochi, hosted the opening and closing ceremony and the workshop and delivered an keynote address entitled "Development of the Asian Tethyan realm: Progress and problems" and another presentation entitled "Transitional carbonate facies between cool and warm settings: A Permian case from the Baoshan Block in western Yunnan, China". Dr. HUANG Hao gave an oral presentation entitled "Permian carbonate ooids in the Baoshan Block, western Yunnan (China): implications for Cimmerian paleogeography". The two visitors also participated in pre- and post-conference field excursions.

Fig. 4.1.17. JIN Xiaochi delivering a keynote address

Fig.4.1.18. JIN Xiaochi and HUANG Hao during the field excursion

LI Haibing and colleagues attended the 2016 Fall Meeting of the American Geophysical Union (AGU) in San Francisco, USA

The 2016 Fall Meeting of the American Geophysical Union (AGU) was held on 12-16 December 2016 in San Francisco, USA. Drs. LI Haibing, Marie-Luce CHEVALIER, SI Jialiang, LIU Dongliang, PAN Jiawei, WANG

Huan and ZHENG Yong attended the meeting. As the convener, Dr. Marie-Luce CHEVALIER hosted the Session on "Asian Tectonics: From continental collision to subduction"; Dr. LI Haibing delivered an invited presentation entiltled "Late Quarternary characteristic slip and slip-rate along the Karakax fault (Western Altyn Tagh fault), Tibet"; other members of the team deliverd poster presentations with the titles of "New paleomagnetic results constrain the Cenozoic episodic uplift and evolution kinematics between the Pamirs and southwestern Tien Shan" (LIU Dongliang), "Holocene slip-rate of the western Altyn Tagh fault (Kuyake basin)" (PAN Jiawei), "Physical and chemical properties of the creeping fault ruptured in the 2008 Mw 7.9 Wenchuan earthquake from the WFSD-3P cores, eastern Tibet" (WANG Huan) and "New geochronology constraints on timing and depth of ancient earthquakes along the Longmen Shan fault belt, eastern Tibet" (ZHENG Yong).

Fig. 4.1.19. Group photo of the team at the meeting

Fig. 4.1.20. LI Haibing delivering the invited presentation

Fig. 4.1.21. Marie-Luce CHEVALIER (third from right) hosting the session

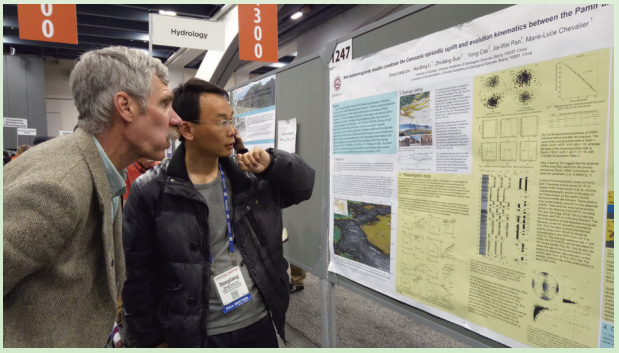


Fig. 4.1.22. LIU Dongliang (right) and his poster at the meeting

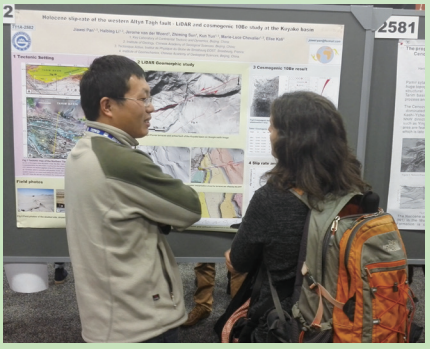


Fig. 4.1.23. PAN Jiawei (left) and his poster at the meeting

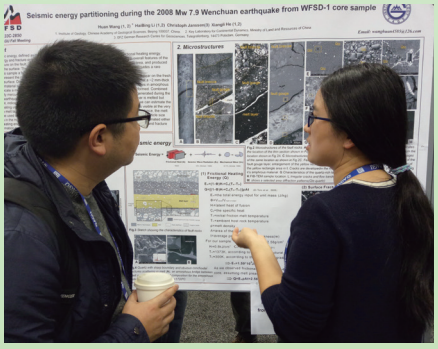


Fig. 4.1.24. WANG Huan (right) and her poster at the meeting

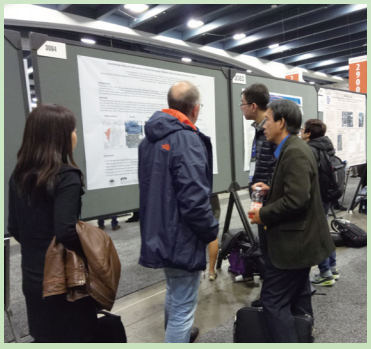


Fig. 4.1.25. ZHENG Yong (third from left) and his poster at the meeting

4.2 Foreign visits and visits to Taiwan (China) by members of the Institute

LI Shan conducted cooperative research at the National Taiwan University (Taiwan, China)

Invited by Prof. Sun-Lin CHUNG of the Department of Geosciences, College of Science of the National Taiwan University, Dr. LI Shan visited this university and conducted cooperative research from 12 September, 2015 to 22 August, 2016.

SUN Jian conducted cooperative research at the University of Oxford (Oxford, UK)

Invited by Ms. Emma SMITH, HR Officer in the Department of Earth Sciences at the University of Oxford, Dr. SUN Jian visited this University as an Academic Visitor to share knowledge and experience and hold informal discussions with Prof. Gideon HENDERSON from 10 November 2015 to 7 May 2016.

Fig.4.2.1. Chemical purification of the samples by the apparatus "Prepfast"

SONG Yucai visited the Colorado School of Mines (Illinois, USA)

Invited by Prof. David LEACH of the Colorado School of Mines (CSM), USA, Dr. SONG Yucai visited the Department of Geology and Geological Engineering at CSM to conduct collaborative research as a visiting scientist from 1 March to 30 September 2016.

XU Zhiqin and colleagues conducted cooperative research at Tribhuvan University (Kathmandu, Nepal)

Invited by Assoc. Prof. Madan Ratna MANANDHAR, Head of Department of Geology, Tri-Chandra Campus, Tribhuvan University, Nepal, Academician XU Zhiqin and Drs. CAO Hui, LI Huaqi and DONG Hanwen visited this Department and conducted field work around Kathmandu, Hetauda, Trishuli and Dhunche in central Nepal in connection with the research project "Hot collisional orogenic kynematics: Deformation, metamorphism and partial melting for exhumation processes of the Great Himalaya Complex (central Nepal)" from 27 April to 11 May 2016.

Fig.4.2.2. Academician XU Zhiqin (second from right) exchanging ideas with Prof. Madan Ratna Manander (first from left)

Fig.4.2.3. Group photo of participants of the two sides to the field trip

LI Qiusheng and ZHANG Hongshuang conducted cooperative research at the National Central University (Taiwan,China)

Invited by Assistant Prof. KUO Chenhao of the Department of Earth Sciences, National Central University (NCU), Drs. LI Qiusheng and ZHANG Hongshuang visited this Department and conducted academic exchanges from 23 to 31 May, 2016.

Fig.4.2.4. Group photo of the two sides during academic exchanges.

GUO Lei and ZHANG Lei participated in a joint field trip in Mongolia

Invited by Dr. Kh. TSOGTBAATAR, Director of the Institute of Paleontology and Geology, Mongolian Academy of Sciences, Drs. GUO Lei and ZHANG Lei visited this Institute and attended international fieldwork in the Project "Geology, tectonics and metallogenesis of Central Asian orogenic belt" during 26 May to 18 June 2016.

Fig. 4.2.5. Group photo of participants of the two sides to the field trip (at Zamyn-Uud train station)

LIU Fulai and colleagues were awarded Visiting Fellowships at the University of Tokyo (Tokyo, Japan)

Invited by Dr. Tsuyoshi IIZUKA of the Department of Earth and Planetary Science, University of Tokyo, Drs. LIU Fulai, WANG Fang and CAI Jia were awarded Visiting Fellowships at this University to conduct research and undertake collaborative work with Dr. Tsuyoshi IIZUKA and other members of the academic staff in this Department from 23 June to 22 July 2016. They conducted U-Th-Pb dating, REE and Lu-Hf isotopic analyses on zircon, monazite, apatite, and xenotime separated from various metamorphic and granitic rocks collected in the Archean basement and Paleoproterozoic orogenic belts of the North China Craton as well as an orogenic belt in the Yunnan area.

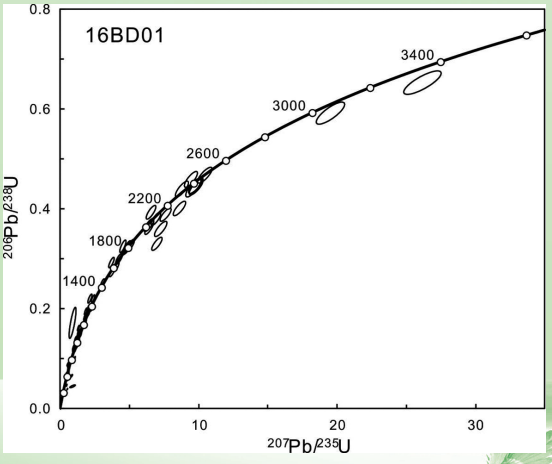


Fig.4.2.6. U-Pb analyses of zircons from sample 16BD01

WANG Tao visited the A.P. Karpinsky Russian Geological Research Institute (FGUP "VSEGEI") and the Main Department of Geology of the Government of Tajikistan (Russia and Tajikistan)

Invited by the A.P. Karpinsky Russian Geological Research Institute (FGUP "VSEGEI") and the Main Department of Geology of the Government of Tajikistan, Dr. WANG Tao, as a member of the CGS delegation led by Deputy Director WANG Yan, visited the above institutes of the two country during 13 to 20 July 2016.

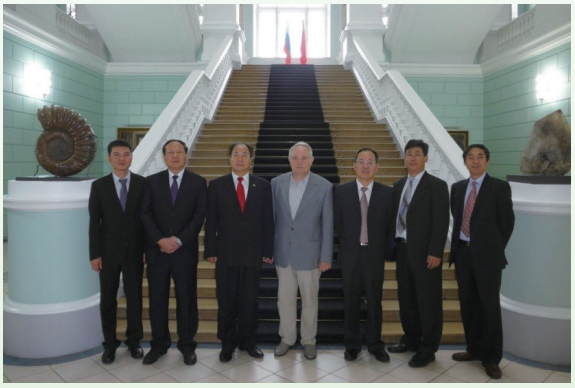


Fig.4.2.7. The delegation (WANG Tao, first from right) visiting the A.P. Karpinsky Russian Geological Research Institute

LIU Dunyi and colleagues carried out research collaboration at the University of Queensland (Brisbane, Australia)

Invited by Prof. Jian-xin ZHAO, Head of the Radiogenic Isotope Facility at the School of Earth Sciences, University of Queensland, Prof. LIU Dunyi and his team visited Australia from 16 to 27 July 2016 to carry out research collaboration on techniques and application of carbonate U-series and U-Pb isochron dating methods for Quaternary palaeo-environmental and palaeo-hazard research; illite Rb-Sr isochron dating for hydrocarbon and palaeo-earthquake research; etc., discussing the possibility for establishing a joint Sino-Australia geochronology and geochemistry Shared Research Platform, and ways for implementing an internet-based remote-control system for two-way access to each other's facilities.

Fig. 4.2.8. After his report, Prof. LIU Dunyi (first from left) discussing future cooperation with Prof. ZHAO Jian-xin (second from right)

Fig.4.2.9. Visiting the Centre for Microscopy and Microanalysis of the University of Queensland

GUAN Ye and LU Zhanwu visited the University of California, Los Angeles (UCLA), and Stanford University for academic exchanges (California, USA)

Invited by Prof. An YIN of the University of California, Los Angeles (UCLA), and Prof. Simon KLEMPERER of Stanford University, Drs. GUAN Ye and LU Zhanwu visited these two universities to discuss their joint project on unraveling the nature and tectonic implications of seismically imaged bright spots in Tibet and to discuss and jointly work on seismic data processing and interpretation of data from the Sinoprobe profiles along Zanda-Gar separately from 21 July to 1 August 2016.

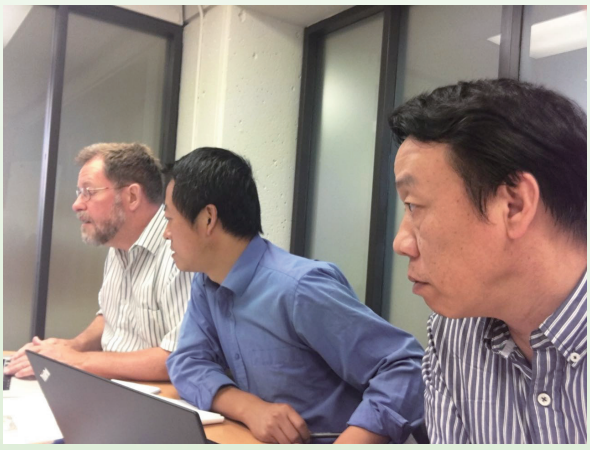


Fig. 4.2.10. Working with Prof. Simon Klemperer (first from left) at Stanford University

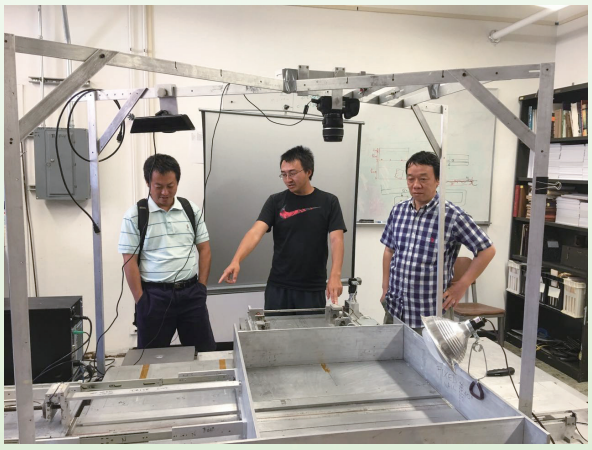


Fig. 4.2.11. Visiting the Sandbox Modeling Laboratory of UCLA

GUO Lei and colleagues undertook further geosciences cooperation under the terms of the MOU between CGS and SGS at the Saskatchewan Geological Survey (Saskatchewan, Canada)

Under the terms of the Memorandum of Understanding (MOU), signed between the Saskatchewan Geological Survey (SGS), Saskatchewan Ministry of the Economy, Canada, and the China Geological Survey (CGS) in May 2013, and invited by Dr. Gary DELANEY, Chief Geologist of SGS, Drs. GUO Lei, ZHU Xiaosan and ZHANG Yinghui visited Saskatchewan, Canada, from 10 July to 3 August 2016 to undertake further geoscience cooperation under the terms of the MOU and as detailed in the subsequently agreed Project Annex to the MOU.

Fig.4.2.12. Group photo of participants of the two sides to the field trip

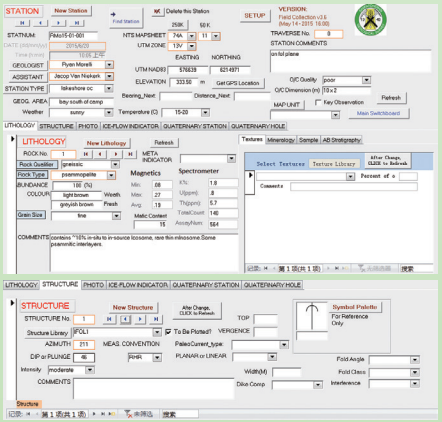


Fig.4.2.13. Showing the "Microsoft Access" (SGS geological survey database)

WANG Huan conducted cooperative research at the National Taiwan University (Taiwan, China)

Invited by Prof. SONG Sheng-rong of the Department of Geosciences, College of Science of the National Taiwan University, Dr. WANG Huan visited this university and conducted cooperative research from 8 August to 30 November, 2016. During her stay she delivered a lecture entitled “Fault weakening and strengthening during the 2008 Wenchuan earthquake”.

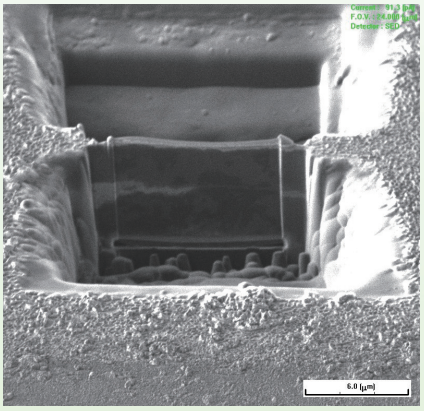


Fig. 4.2.14. In situ-sampling by focused ion beam

Fig. 4.2.15. Color 3D laser scanning microscope

QIU Tian and WU Weiwei visited the Polytechnic University of Tirana, Albania, for collaborative research and field studies (Tirana, Albania)

Assoc. Prof. Dr. Ylber MUCEKU, Head of Department, Institute of Geosciences, Energy, Water and Environment of the Polytechnic University of Tirana, Albania, invited Drs. QIU Tian and WU Weiwei for a visit in Albania for collaborative research and field work in the framework of IGCP - 649 projects “Diamonds and Recycling Mantle” from 1 to 29 September, 2016.

Fig.4.2.16. Prof. Nezir Mekshiqi (first from right) introducing geological phenomena at the field trip

LIU Fulai and colleagues undertook exchange field work with the Chonbuk National University (Jeonju, Republic of Korea)

Invited by LEE NamHo, President of Chonbuk National University, Republic of Korea, Drs. LIU Fulai, LIU Pinghua, LIU Chaohui and TIAN Zhonghua visited this university to do exchange field work which aims to compare the geology of Korea with China for a better understanding of the tectonics of northeastern Asia, from 20 September to 1 October 2016.

Fig.4.2.17. Group photo of participants of the two sides to the field trip

LIU Dunyi and colleagues accepted the visiting status as Campus Visitors at the Australian National University (Canberra, Australia)

Invited by Prof. Stephen EGGINS, Director of the Research School of Earth Sciences, School Administration, Australian National University, Prof. LIU Dunyi and his team visited Australia from 23 to 29 October 2016 to accept visiting status as Campus Visitors at this university and conduct collaborative research.

YANG Tiannan and colleagues conducted geological investigations on Iranian porphyry copper, gold and MVT type deposits (Tehran, Iran)

Invited by Dr. Mehraj AGHAZADEH of the Department of Geology, Payam Noor University, Drs. YANG Tiannan, YANG Zhiming, SONG Yucai, ZHANG Hongrui and LIU Yingchao visited this university for geological investigations of Iranian porphyry copper, gold and MVT type deposits during 10 to 28 November, 2016.

WANG Haiyan and colleagues visited the University of California at Los Angeles (UCLA), for academic exchanges (California,USA)

Invited byProf. An YIN of the University of California, Los Angeles (UCLA) and Prof. Simon KLEMPERER of Stanford University, Drs. WANG Haiyan, XIONG Xiaosong and LI Hongqiang visited these universities to continue their collaborative work on interpreting the seismic reflection data from the Qinling orogenic belt and south China and to participate in the first international symposium on “The Birth and Evolution of the Pacific Basin and their Impacts on the Tectonic History of East Asia and the North America Cordillera”, from 3 to 16 December 2016.

Fig.4.2.18. Working with Prof. An Yin (in the middle) at UCLA (1)

Fig.4.2.19. Working with Prof. An Yin (in the middle) at UCLA (2)

GAO Rui and YE Zhuo visited the University of California, Los Angeles (UCLA) and the University of Illinois at Urbana-Champaign for academic exchanges (California and Illinois, USA)

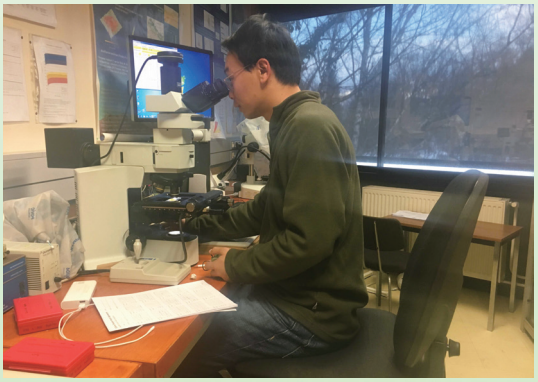
Invited by Prof. An YIN of the University of California, Los Angeles (UCLA) and Prof. Xiaodong SONG of the University of Illinois at Urbana-Champaign, Academician GAO Rui and Dr. YE Zhuo visited these two universities to continue their collaborative work on interpreting seismic reflection data from the Qinling orogenic belt and southern China and participated in the first field workshop on “The Birth and Evolution of the Pacific Basin and their Impacts on the Tectonic History of East Asia and the North America Cordillera”; and to collaborate on studies on

the Tibetan Plateau with the goal to collaborate on seismic tomography and anisotropy of the Tibetan Plateau using broadband data as well as plans for future collaboration seperately in November and December of 2016.

Fig.4.2.20. Academician GAO Rui at the AGU meeting

Fig.4.2.21. YE Zhuo (front) during the field trip

LIU Dongliang visited the ISTerre thermochronology laboratory for collaborative research (Grenoble, France)



Invited by Dr. Matthias BERNET, Director of the Fission-Track Laboratory at the Université Grenoble Alpes in France, Dr. LIU Dongliang visited the ISTerre thermochronology laboratory of this university to work on the new apatite fission-track samples of the Western Kunlun Mountains exhumation study during the period of 20 December 2016 to 24 January 2017.

Fig.4.2.22 LIU Dongliang working on samples at the ISTerre thermochronology laboratory

4.3 Academic Visitors to the Institute

Visit of TSERENDASH Narantsetseg of Institute of Paleontology and Geology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia

Invited by Dr. GUO Lei, Research Fellow TSERENDASH Narantsetseg of the Institute of Paleontology and Geology, Mongolian Academy of Sciences, Mongolia visited the Institute of Geology for collaborative research during 7 January to 5 Februry 2016.

Visit of Mihai DUCEA and Adriana STOICA from the University of Arizona, USA

Invited by Dr. ZENG Lingsen, Prof. Mihai DUCEA and Dr. Adriana STOICA from the University of Arizona, USA, visited the Institute of Geology for collaborative research and visited China University of Geosciences (Wuhan) of Hubei Province during 7-13 March, 2016.

Visit of Enkh-Orshikh ORSOO of Institute of Paleontology and Geology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia

Invited by Dr. GUO Lei, Research Fellow Enkh-Orshikh ORSOO of the Institute of Paleontology and Geology, Mongolian Academy of Sciences, Mongolia visited the Institute of Geology for collaborative research during 5 March to 3 April 2016.

Visit of Alfred KRÖNER and Yamirka ROJAS-AGRAMONTE from the University of Mainz, Germany

World-famous geologist and Honorary Professor of the Beijing SHRIMP Center of the Institute of Geology, Prof. Alfred KRÖNER, visited the Beijing SHRIMP Center for collaborative research during March and April as well as September to November of 2016, respectively. Post-doctoral researcher Yamirka ROJAS-AGRAMONTE also visited the Beijing SHRIMP Center in September to November 2016. During their visits, Prof. Kröner and Dr. Rojas-Agramonte also helped with the organization of the International Precambrian Research Centre of China (IPRCC) annual academic events.

Visit of Steve CLEMENT from Ion Optical Consulting, Canada

Invited by Prof. LIU Dunyi, Dr. Steve CLEMENT, internationally well-known Canadian specialist on mass spectrometry and ion optical design, visited the Beijing SHRIMP Centre twice in March and November 2016, respectively. The main purpose of his visits was to complete the annual work plan of the Specially-Funded Programme on National Key Scientific Instruments and Equipment Development – "New models of TOF-SIMS for Isotope Geology".

Visit of John HYDER from Australian Scientific Instruments (ASI), Australia

Invited by Prof. LIU Dunyi, Chief Engineer John HYDER from Australian Scientific Instruments visited the Beijing SHRIMP Center of the Institute of Geology during 4-8 April 2016. The purpose of visit was to replace the Sample Stage and upgrade the hardware of the SHRIMP IIe-MC in order to obtain much better stability of the SHRIMP performance.

Fig.4.3.1. John HYDER (first from right) replacing the Sample Stage

Visit of Ian WILLIAMS from the Australian National University and Bruce GODFREY from ASI, Canberra, Australia

Invited by Prof. LIU Dunyi, SHRIMP specialist Prof. Ian WILLIAMS of the Research School of Earth Sciences, Australian National University, and Dr. Bruce GODFREY, CEO of ASI Australia, visited the Beijing SHRIMP Center for the "Seminar on SHRIMP Instruments and SHRIMP IV Promotion" held on 7 April 2016.

Fig.4.3.2. Prof. Ian WILLIAMS giving a presention

Fig.4.3.3. Dr. Bruce GODFREY introducing SHRIMP IV

Visit of Jian-xin ZHAO from the University of Queensland, Australia

Approved by the China Geological Survey (CGS) and the Chinese Academy of Geological Sciences (CAGS), Prof. Jian-xin ZHAO was appointed as Senior Overseas Visiting Scholar in early 2015. Prof. ZHAO will work in the Beijing SHRIMP Center for at least 3 months every year. His work is to help the Center to establish an Open Innovation Platform based on non-traditional isotope ultra-clean laboratory, and techniques such as U-Th series dating, other young sediment dating as well as isotopic tracing.

During his stay in Beijing for carrying out research in 2016, Prof. ZHAO participated in a field trip to Guangxi Province of China in April and gave an academic presentation entitled “High-precision U/Th dating of coral mortality: Evidence for shifted ecological baselines on the nearshore Great Barrier Reef” in the Institute of Geology on 12 May. He participated in a second field trip to Guangxi Province in September, and visited Hangzhou for an academic conference in September.

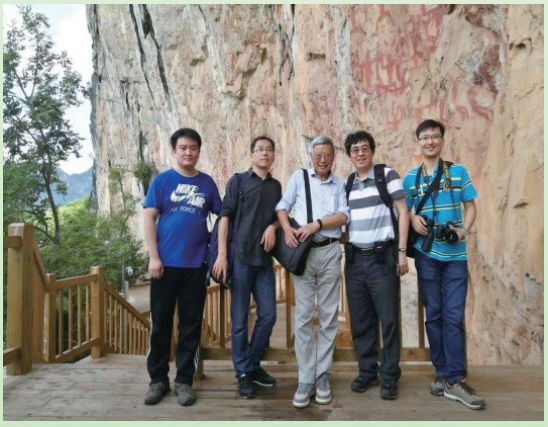


Fig.4.3.4. Prof. Jian-xin ZHAO (second from right) at the field trip

Fig.4.3.5. Prof. Jian-xin ZHAO giving a presentation

Visit of Yildirim DILEK from the University of Miami, USA

Invited by Dr. YANG Jingsui, Prof. Yildirim DILEK of the University of Miami, USA, visited the Key Laboratory of Continental Tectonics and Dynamics of the Institute of Geology during 1-31 May 2016, for academic exchanges.

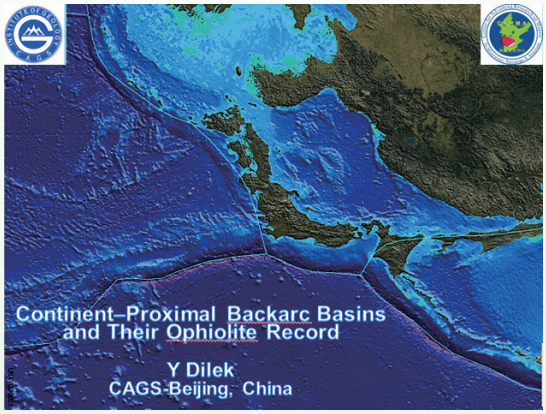


Fig.4.3.6. Prof. Yildirim DILEK giving a presentation

Visit of SONG Sheng-rong, HSU Shao-chen and LIN Jia-chih from the National Taiwan University, Taiwan

Invited by Dr. LI Haibing, Prof. SONG Sheng-rong and his two master degree candidates HSU Shao-chen and LIN Jia-chih from the National Taiwan University, Taiwan, visited the Scientific Drilling Center in Pi County, Chengdu, Sichuan Province of China for collaborative research and participated in field work in related areas (along the Longmenshan fault) of Sichuan Province during 21 June to 1 July 2016.

Fig.4.3.7. Prof. SONG Sheng-rong (first from left) giving a lecture

Fig.4.3.8. Prof. SONG Sheng-rong and Dr. LI Haibing's team at the drill core store of the Scientific Drilling Center

Visit of Martin KUNDRÁT from Comenius University, Bratislava, Slovak Republic

Invited by Dr. LV Junchang, Associate Prof. Martin KUNDRÁT of the Archosaur Evo-Devo Research Group, Comenius University in Bratislva, Slovak Republic, visited the Institute of Geology for collaborative research and participated in field work in related areas of Liaoning Province, Henan Province and Jiangxi Province of China during 1 to 22 July 2016.

Fig.4.3.9. Prof. Martin KUNDRÁT working with Dr. LV Junchang (1)

Fig.4.3.10. Prof. Martin KUNDRÁT working with Dr. LV Junchang (2)

Visit of Bor-ming JAHN from National Taiwan University

World-famous geochemist, Knight of the French Ministry of National Education, and Honorary Professor of the Beijing SHRIMP Centre and the Institute of Geology, Prof. Bor-ming JAHN visited the Beijing SHRIMP Centre for collaborative research during 15 July to 15 August 2016. During his stay, Prof. JAHN also gave two lectures on "Writing papers in Earth sciences in English" to the young geologists of the Institute of Geology and another academic report entitled "Crustal and tectonic evolution of accretionary orogens in NE Asia".

Fig.4.3.11. Prof. Bor-ming JAHN giving a presentation

Fig.4.3.12. Attendees asking questions after the report

Visit of Igor POSPELOV from the A.P. Karpinsky Russian Geological Research Institute (FGUP "VSEGEI")

Invited by Academician LI Tingdong and Dr. WANG Jun, Dr. Igor POSPELOV of the A.P. Karpinsky Russian Geological Research Institute (FGUP "VSEGEI") visited the Institute of Geology for mapping collaboration on 1-22 August 2016.

Visit of Cees Roelof VAN STAAL from the Geological Survey of Canada

Invited by Dr. HE Zhenyu, Prof. Cees Roelof VAN STAAL of the Geological Survey of Canada visited the Institute of Geology for collaborative research and participated in fieldwork in related areas of Gansu Province, China, during 1 August to 31 October, 2016.

Fig.4.3.13. Prof. Cees R. VAN STAAL (first from left) and Dr. HE Zhenyu (in the middle) discussing academic issues during the field trip

Fig.4.3.14. Prof. Cees R. VAN STAAL giving a presentation

Visit of Philippe Hervé LEPOUP of the Université de Lyon and Anne REPLUMAZ-PRADELLE of Université Joseph Fourie, France

Invited by Dr. Marie-Luce CHEVALIER, Prof. Philippe Hervé LEPOUP from the Université de Lyon and Prof. Anne REPLUMAZ-PRADELLE from the Université Joseph Fourie, France, visited the Key Laboratory of Continental Tectonics and Dynamics of the Institute of Geology and participated in fieldwork in related areas of Yunnan and Sichuan Provinces, China, during 30 September to 5 November, 2016.

Fig.4.3.15. Profs. Philippe Hervé LEPOUP and Anne REPLUMAZ-PRADELLE, and Dr. Marie-Luce CHEALIER during the field trip

Fig.4.3.16 Prof. Philippe Hervé LEPOUP (second from right) discussing cooperation issues with members of the Institute

Visit of Jonathan AITCHISON from the University of Queensland and Soloman BUCKMAN from the University of Wollongong, Australia

Invited by Dr. YAN Zhen, Prof. Jonathan AITCHISON of the School of Geography Planning and Environmental Management, University of Queensland, and Dr. Soloman BUCKMAN from the University of Wollongong, Australia, visited the Institute of Geology for collaborative research and delivered oral presentations during 5-24 October, 2016.

Fig.4.3.17. Prof. Jonathan AITCHISON giving a presentation

Fig.4.3.18. Prof. Solomon BUCKMAN giving a presentation

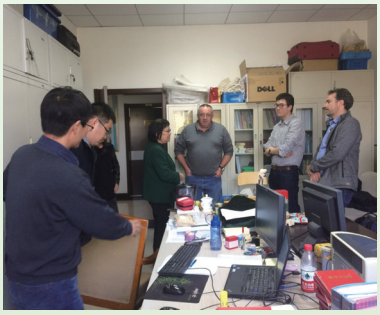


Fig.4.3.19. Academician XU Zhiqin (fourth from right) discussing academic issues with the two professors

Fig.4.3.20. Dr. YANG Jingsui discussing cooperation issues with the two professors

Visit of James WHITE and Marco BRENNA from the University of Otago, New Zealand

Invited by Dr. XIANG Zhongjin, Prof. James WHITE and Dr. Marco BRENNA of the Geology Department, University of Otago, New Zealand, conducted cooperative research during joint fieldwork in related areas of Sichuan and Yunnan Provinces of China from 17 to 28 October, 2016.

Fig.4.3.21. Prof. James WHITE at the field trip

Fig.4.3.22. Dr. Marco BRENNA at the field trip

Visit of Michael BROWN from the University of Maryland and Walter MOONEY from the U.S. Geological Survey, Menlo Park, USA

Invited by Prof. LIU Dunyi of the Beijing SHRIMP Center, two key members of the International Precambrian Research Centre of China (IPRCC), Prof. Michael BROWN from the University of Maryland, and Dr. Walter MOONEY from the U.S. Geological Survey visited the Center from 19 to 27 October 2016. Both professors lectured at the IPRCC Short Course 2016 "Global geodynamic processes" and participated in an international field excursion in eastern Hebei Province, during their visits.

Visit of Julian PEARCE from Cardiff University, UK

Invited by Dr. YANG Jingsui, Prof. Julian PEARCE of Cardiff University, UK, conducted cooperative research in the Key Laboratory of Continental Tectonics and Dynamics of the Institute of Geology from 1 October to 31 December, 2016.

Fig.4.3.23. Prof. PEARCE giving a presentation

Fig.4.3.24. Prof. PEARCE visiting the LA -ICP-MS Lab of the National Research Center for Geoanalysis, CAGS

Visit of UDORATINA Oxana from the Institute of Geology, Komi Science Center, Uralian Division of the Russian Academy of Sciences, Russia

Invited by Dr. MENG Fancong, Research Fellow UDORATINA Oxana of the Institute of Geology, Komi Science Center of the Uralian Division of the Russian Academy of Sciences, Russia, visited the Key Laboratory of Continental Tectonics and Dynamics of the Institute of Geology during 1-10 November 2016, for academic exchanges.

Fig.4.3.25. UDORATINA Oxana (second from left) working at the Isotope Lab of Tianjin Center, CGS

Fig.4.3.26. Members of the Institute attending UDORATINA Oxana's presentation

Visit of Nicholas Stanley BELSHAW from Oxford University, UK

Invited by Dr. ZHU Xiangkun, Prof. Nicholas Stanley BELSHAW from the Department of Earth Sciences, Oxford University, UK, conducted cooperative research in the Key Laboratory of Isotope Geology of the Institute of Geology during 3-30 November, 2016.

Visit of Lidya TARHAN and Noah PLANAVSKY from Yale University, USA

Invited by Dr. TANG Feng, Drs. Lidya TARHAN and Noah PLANAVSKY from the Department of Geology and Geophysics, Yale University, USA, conducted cooperative research in the Institute of Geology during 14-28 November 2016.

Fig.4.3.27. Dr. TARHAN giving a presentation

Fig.4.3.28. Drs. Noah PLANAVSKY, Lidya TARHAN and TANG Feng (front three) during the field trip

Visit of Michael STEINER from the Free University of Berlin, Germany

Invited by Dr. YANG Ben, Dr. Michael STEINER from the Free University Berlin, Germany, visited the Institute of Geology for collaborative research and participated in fieldwork in related areas of Sichuan and Yunnan Provinces of China during 12 November to 8 December 2016.

Visit of David LEACH from the U.S. Geological Survey

Invited by Dr. SONG Yucai, Dr. David LEACH, former researcher of the U.S. Geological Survey, who is an Honorary Professor of the Institute of Geology, visited the Institute of Geology and conducted collaborative research during 5 December 2016 to 3 Januaray 2017.

Visit of Chimidtseren ANAAD and Ariuntsetseg GANBAT from the Mongolian University of Science and Technology, Ulaanbaatar, Mongolia

Invited by Dr. YANG Ben, Dr. Chimidtseren ANAAD and Ms. Ariuntsetseg GANBAT from the Mongolian University of Science and Technology, Ulaanbaatar, Mongolia, visited the Institute of Geology for collaborative research and participated in fieldwork in related areas of Tianjin and Shanxi Province of China during 25 December 2016 to 9 January 2017.

5. Important Academic Activities in 2016

5.1 International conferences and field excursions organized and held by the Institute

The 2nd IGCP-649 Workshop on "Probing the Oceanic Mantle: Troodos Ophiolite as a case study"

The 2nd IGCP-649 (Diamonds and Mantle Recycling) Workshop on "Probing the Oceanic Mantle: Troodos Ophiolite as a case study", sponsored by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Union of Geological Sciences (IUGS), and jointly organized by the IGCP-649 Project of the Institute of Geology and the Geological Survey Department of Cyprus, was successfully held in Agros, Cyprus, during the week of 14-20 May 2016. The Workshop (with both pre- and post-conference field trips to the classical Troodos ophiolite) brought together a large group of international scientists with a wide range of expertise ranging from mineralogy, petrology, geochemistry, to geophysics, structural geology and geodynamic modeling, with applications to the petrogenetic and tectonic development of ophiolites and related chromitite deposits.

Prof. YANG Jingsui, the first leader of the IGCP-649 Project, introduced the progress made in the year and the plan for the 3rd Workshop of 2017. Prof. Julian PEARCE of Cardiff University guided the participants on the field trips. Over 50 delegates from more than 10 countries such as USA, UK, Russia, Czech Republic, Morocco, Cuba, Egypt and Turkey, etc. attended the workshop and participated in the field excursions to the classical Troodos ophiolite.

Fig 5.1.1. Workshop successfuly held in Agros, Cyprus

Fig 5.1.2. Group photo taken during the field trip

Fig 5.1.3. Prof. Julian PEARCE guiding the field trip

Fig 5.1.4. Group photo of the project leaders and key members of the Geological Survey Department of Cyprus

2016 Short Course of the International Precambrian Research Centre of China (IPRCC) on "Global Geodynamic Processes"

The IPRCC Short Course 2016 "Global Geodynamic Processes" was held at CAGS in Beijing on 21-23 October 2016. Two world-famous specialists, Professor Paul Felix HOFFMAN of the University of Victoria, Canada, and Professor Martin Julian VAN KRANENDONK of the University of New South Wales, Australia, were invited as lecturers for the course. Several other core members of IPRCC such as Professor Michael BROWN from the University of Maryland and Walter MOONEY from U.S. Geological Survey, Menlo Park, USA, and so on, also delivered excellent reports durig the course. More than 150 postgraduate students and young geologists from all over China participated in the course.

In order to help young Chinese geologists to have a better understanding of the most important and cutting-edge developments in recent geological research, and to promote international cooperation between Chinese and foreign geologists, the IPRCC has so far organized 7 short training courses on different topics since 2010. Several world-famous specialists are invited to Beijing as lecturers for the course every year. This series of courses has already become one of the most representative academic activities organized by IPRCC and is very popular among university students and young geologists.

Fig 5.1.5. Group photo of key members of the IPRCC and lecturers of the 2016 Short Course

Fig 5.1.6. Prof. Paul Felix HOFFMAN giving a lecture

Fig 5.1.7 Prof. Martin Julian VAN KRANENDONK giving a lecture

IPRCC 2016 Field Workshop

The IPRCC 2016 Field Workshop was held in eastern Hebei Province from 24 to 27 October 2016. More than 10 geologists and postgraduate students from Canada, Germany, the UK and the SHRIMP Center participated in the workshop. The field workshop involved the early Precambrian plutonic and supracrustal rocks in eastern Hebei Province, including the Qinghuangdao Granites, the Jielingkou-Anziling Complex, the Dantazi-Zhuzangzi supracrustal rocks, the Caozhuang Complex in Huangbaiyu, Qian'an, the Santunying grey gneisses, and mafic-ultramafic rocks near Caojiapu, Zunhua.

Drs. WAN Yusheng and XIE Hangqiang and colleagues from the SHRIMP Center prepared a field guidebook that introduced the geology of the excursion as well as some important research results obtained in this area. In the field, the lecturers and students also had a lively discussion on the early Precambrian geological evolution of eastern Hebei.

Fig 5.1.8. International Field Excursion in eastern Hebei Province (1)

Fig 5.1.9. International Field Excursion in eastern Hebei Province (2)

5.2 Other Academic Activities

The 2016 Academic Workshop of the Institute of Geology was held on 18 January 2017

In order to exchange and discuss the scientific and technological results obtained in 2016, the Institute of Geology held the 2016 Academic Workshop on 18 January 2017. Eleven young experts recommended by different divisions (centers) of the Institute — Drs. YAN Zhen, SHI Yuruo, LI Yuan, Marie-Luce CHEVALIER, LIU Chaohui, YANG Ben, LI Wenhui, LIU Yong, SUN Jian, LI Shan and HUANG He, gave academic presentations. About 70 researchers and postgraduate students, including leaders of the Institute, attended the workshop.

Subsequently, some divisions (centers) organized special sessions for further discussion. The Annual Workshop was a great success and facilitated exchange and discussion of ideas and promoted the research capabilities of the Institute.

Fig 5.2.1. Dr. LI Wenhui giving a presentation

Fig 5.2.2. Dr. YAN Zhen answering questions after his report

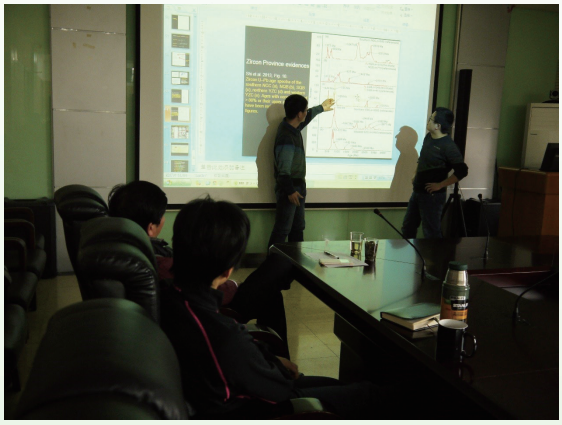


Fig 5.2.3. Discussion after Dr. YANG Ben's presentation

Fig 5.2.4. Researchers and students attending the Workshop

The 47th Earth Day: activities to popularize scientific geological knowledge

(1) Dr. LV Junchang delivered a lecture on dinosaurs

In order to mark the 47th Earth Day, arouse public awareness of protecting the environment and resources, and help the young generation to get a better understanding of the Earth, Dr. LV Junchang delivered a lecture entitled "The Lord of Sky at the Age of Dinosaurs" for the pupils of Beijing Dongsijiutiao Primary School on 18 April 2016. With the example of extinction of the Pterosaurs, Dr. LV enlightened the pupils to protect the environment and care for the Earth in their daily lives. After his lecture, Dr. LV patiently answered questions, evoking heated discussion.

Fig 5.2.5. Dr. LV Junchang delivering the lecture

Fig 5.2.6. The pupils listening attentively

(2) The Key Laboratory of Stratigraphy and Paleontology, Ministry of Land and Resources, opened to the public

The Key Laboratory of Stratigraphy and Paleontology, Ministry of Land and Resources, welcomed over 40 visitors from the Xiazhuang Primary School of Miyun County of Beijing. With the help of the Corridor Screen popularizing the knowledge of the evolution of life, Dr. TANG Feng gave a vivid interpretation of the history of life on Earth. The pupils also examined the paleontological fossils with the microscope of the laboratory and watched the operation of the Scanning Electron Microscope.

Dr. LV Junchang delivered a second lecture on dinosaurs to the pupils to arouse their awareness of protecting the environment and resources. The volunteer instructor of the lab spent time away from busy work to introduce the popular knowledge of Paleontology, the Earth and the environment to guide the students to understand geological phenomena. They also led them to recognize fossils, microscopes, etc., encouraging them to become geologists in the future.

Fig. 5.2.7. Dr. LI Ming introducing progress made in the research on paleontology of the lab

Fig. 5.2.9. Dr. LIU Pengju demonstrating how to use a microscope

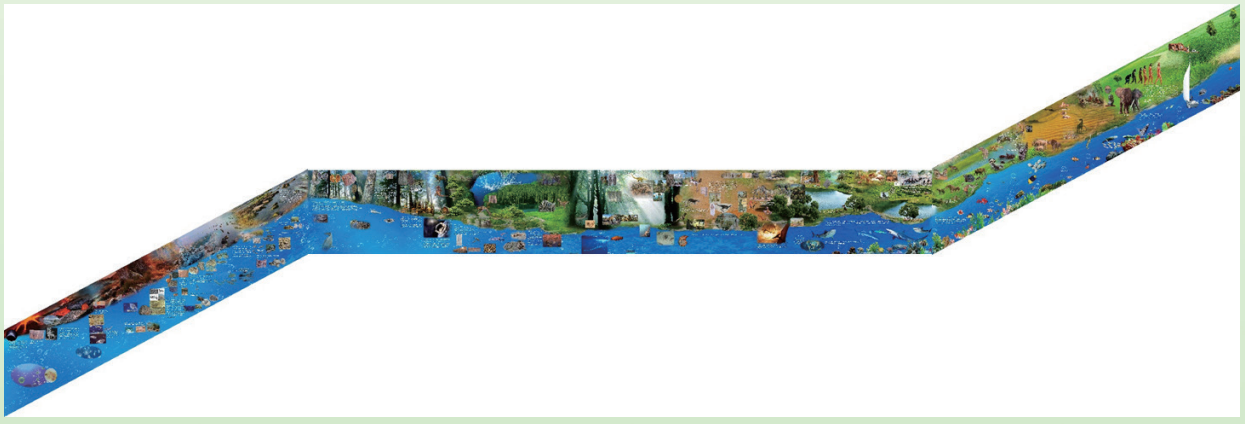


Fig. 5.2.8. The Corridor Screen popularizing knowledge about the evolution of life

Fig. 5.2.10. Dr. TANG Feng introducing the Comparison Table of Geological Time and Life Evolution

Fig.5.2.11. Dr. JI Zhansheng introducing the predecessors dedicated to Earth Sciences of the Institute

6. Postgraduate Education

6.1 Postgraduate advisors

There were 107 postgraduate students in the Institute in 2016, including 54 doctoral and 53 master degree candidates. The Institute had 19 new candidates for the doctoral degree and 18 for the master degree. Detailed information on the 40 professorial advisors of doctoral students and 41 advisors of master students is listed below.

Advisors of doctoral students			
No.	**Name**	**Speciality**	**E-mail address**
1	SHEN Qihan	Early Precambrian geology and metamorphic methodology	huixiasong@cags.ac.cn
2	XIAO Xuchang	Tectonic geology, ophiolites, and HP metamorphic belts	xxchng@public.bta.net.cn
3	XU Zhiqin*	Micro- and macrotectonics, geodynamics	xzq@ccsd.cn
4	REN Jishun	Geotonics and global tectonics	renjishun@cags.ac.cn
5	YANG Wencai*	Geophysics	yangwencai@ccsd.org.cn
6	LI Tingdong	Regional geology	litdong@163.com
7	GAO Rui	Deep geophysical probing, lithospheric structure, and geodynamics	gaorui@cags.ac.cn
8	HOU Zengqian	Regional metallogeny	houzengqian@126.com
9	LIU Dunyi	Geochronology and isotope geochemistry	liudunyi@bjshrimp.cn
10	YANG Jingsui	Petrology	yangjingsui@yahoo.com.cn
11	YAO Jianxin	Conodont fauna, stratigraphy	yaojianxin@gmail.com
12	WANG Tao[1]	Tectonics and magmatic geology	taowang@cags.net.cn
13	LI Jinyi	Tectonics	jyli2003@126.com
14	CHEN Wen	Geochronology	chenwenf@vip.sina.com
15	ZHU Xiangkun	Geochronology	xkzhu0824@gmail.com
16	WU Cailai	Regional igneous petrology, agrogeology	wucailai@126.com
17	WAN Yusheng	SHRIMP geochronology, isotope geochemistry, and early Precambrian geology	wanyusheng@bjshrimp.cn
18	JIN Xiaochi	Biostratigraphy, sedimentology and paleogeography	jinxchi@cags.ac.cn
19	LIU Fulai	UHP metamorphic belts, geochronology	lfl0225@sina.com
20	ZHANG Jianxin	Metamorphsm and orogenic deformation	zjx66@yeah.net
21	ZHANG Zeming	Paleontology and metamorphic geology	zzm2111@sina.com
22	LI Haibing	Active tectonics and tectonic geomophology	lihaibing06@yahoo.com.cn
23	ZENG Lingsen	Petrology, geochemistry and tectonics	changting1970@yahoo.com
24	YAN Zhen	Structural geology	yanzhen@mail.iggcas.ac.cn
25	LIU Pengju	Paleontology and stratigraphy	pengju@cags.ac.cn
26	YANG Tiannan	Tectonics	yangtn@cags.ac.cn
27	MENG Fancong	Igneous petrology	mengfancong@yeah.net
28	LV Junchang	Mesozoic reptiles (dinosaurs, pterosaurs) and biostratigraphy	Lujc2008@126.com
29	LI Qiusheng	Geodetection and information technology	liqiusheng@cags.ac.cn
30	QI Xuexiang	Geotectonics	qxuex2005@163.com
31	XUE Huaimin	Mineralogy, petrology, and metallogeny	huaiminx@sina.com
32	DING Xiaozhong	Geotectonics	xiaozhongding@sina.com
33	REN Liudong	Mineralogy, petrology, and metallogeny	ldren@cags.ac.cn
34	WANG Yanbin	Geochemistry	wangyanbin@bjshrimp.cn
35	SHI Yuruo	Geochemistry	shiyuruo@bjshrimp.cn
36	ZHANG Jin	Geotectonics	zhangjinem@sina.com
37	LIU Yongqing	Sedimentology	liuyongqing@cags.ac.cn
38	ZHAI Qingguo	Tectonics	zhaiqingguo@126.com
39	HE Bizhu	Mineral resources investigation and exploration	hebizhu@vip.sina.com
40	YANG Zhiming	Petrology	zm.yang@hotmail.com

*Visiting professor of the Institute.

Advisors of Master students			
No.	**Name**	**Speciality**	**E-mail address**
1	CAO Hui	Tectonics	caohuicugb@hotmail.com
2	DONG Chunyan	Geochronology	dongchunyan@sina.com
3	HE Rizheng	Geophysics	herizheng@cags.ac.cn
4	HE Zhenyu	Petrology	ahhzy@163.com
5	JI Shu'an	Mesozoic reptiles (including birds) and biostratigraphy	jishu_an@sina.com
6	JI Zhansheng	Paleontology and stratigraphy	jizhansheng@vip.sina.com
7	KUANG Hongwei	Paleontology and stratigraphy	kuanghw@126.com
8	LIU Chaohui	Mineralogy, petrology, and metallogeny	denverliu82@gmail.com
9	LIU Dongliang	Tectonics	pillar131@163.com
10	LIU Jianfeng	Geochronology	wenjv@aliyun.com
11	LIU Jianhui	Tectonics	liujianhui1999@163.com
12	LIU Pinghua	Mineralogy, petrology, and metallogeny	lph1213@126.com
13	LIU Yan[1]	Petrology	yanliu0315@yahoo.com.cn
14	LIU Yan[2]	Petrology	ly@cugb.edu.cn
15	LU Zhanwu	Geophysics	luzhanwu78@163.com
16	Marie-Luce CHEVALIER	Tectonics	mlchevalier@hotmail.com
17	MENG En	Petrology	mengen0416@126.com
18	QIU Xiaoping	Petrology	qiuxping@cags.ac.cn
19	QU Junfeng	Mineralogy, petrology, and metallogeny	qujf@cags.ac.cn
20	SONG Biao	SHRIMP geochronology	songbiao@cags.ac.cn
21	SONG Yucai	Mineralogy, petrology, and metallogeny	song_yucai@aliyun.com
22	TANG Feng	Paleontology and stratigraphy	tangfeng@cags.ac.cn
23	TONG Ying	Petrology	yingtong@pku.org.cn
24	WANG Yong	Quaternary geology	wangyong@cags.ac.cn
25	XIE Hangqiang	Zircon geochronology	rock@bjshrimp.cn
26	YANG Chonghui	Metamorphic geology	chhyang@cags.ac.cn
27	YIN Jiyuan	Geochemistry	yinjiyuan1983@163.com
28	YOU Guoqing	Petrology	youchina@126.com
29	YU Changqing	Geophysical prospecting and information technology	yucq@tom.com
30	ZHANG Cong	Petrology	congzhang@pku.edu.cn
31	ZHAO Lei	Geotectonics	jleiz@163.com
32	ZHOU Xiwen	Metamorphic geology	xwzhou@cags.ac.cn
33	DU Lilin	Mineralogy, petrology, and metallogeny	dulilin7310@cags.ac.cn
34	WANG Haiyan	Solid-earth geophysics	hyanwhy@126.com
35	XU Xiangzhen	Mineralogy, petrology, and metallogeny	xuxiangzhensjl@aliyun.com
36	XU Qinqin	Geotectonics	qinqin2002dz1@163.com
37	ZHANG Hongrui	Geotectonics	hongrui_1982@126.com
38	DONG Jin	Quaternary geology	djin@cugb.edu.cn
39	LIU Yingchao	Mineralogy, petrology, and metallogeny	lychappy@126.com
40	WANG Tao[2]	Geotectonics	real_wt@126.com
41	HOU Hesheng	Earth exploration and information technology	hesheng.hou@126.com

6.2 Educational Activities and News

Eighteen graduate students were awarded diplomas at the 2016 Graduation Ceremony

Eleven doctoral and fifteen postgraduate students completed their studies and obtained their degrees in 2016. YE Zhuo won the CHENG Yuqi Excellent Graduate Award; XU Huan and CHEN Yanhong received the CHENG Yuqi Excellent Thesis Award; TIAN Yazhou, WANG Nengsheng were awarded the academic "Outstanding Graduate" honor of the Chinese Academy of Geological Sciences (CAGS), and fourteen additional graduate students received the academic "excellent student" honorary title of CAGS. MENG Yuanku and SHI Fuqiang were awarded "excellent graduate students" by the Beijing Education Department.

In 2016, LIU Yongqing, ZHAI Qingguo, HE Bizhu and YANG Zhiming were promoted to advisers of doctoral candidate students; DU Lilin, WANG Haiyan, XU Xiangzhen, XU Qinqin, ZHANG Hongrui, DONG Jin, LIU Yingchao, WANG Tao and HOU Hesheng were approved to be advisors of Master students by the Degree Assessing Committee of CAGS.

Fig. 6.2.1 CAGS Graduation Ceremony of the 2016 postgraduate students

Fig. 6.2.2 Group photo of the 2016 postgraduate students of the Institute

7. Publications

7.1 English language publications:

Alexeiev, D.V., Kröner, A., Hegner, E., Rojas-Agramonte, Y., Biske, Yu.S., Wong, J., Geng, H.Y., Ivleva, E.A., Mühlberg, M., Mikolaichuk, A.V., Liu, D., 2016. Late Ordovician arc system revealed in the Kyrgyz Middle Tianshan: From arc-continent collision to subsequent evolution of a Palaeozoic continental margin. Gondwana Research, 39, 261-291.

Chai Peng, Sun Jinggui, Hou Zengqian, Xing Shuwen, Wang Zhongyu, 2016. Geological, fluid inclusion, H–O–S–Pb isotope, and Ar–Ar geochronology constraints on the genesis of the Nancha gold deposit, southern Jilin Province, northeast China. Ore Geology Reviews, 72: 1053-1071.

Chen Songyong, Yang Jingsui, Wu Yong, Wu Weiwei, Zhang Cai, 2016. The characteristics of Yongzhu–Guomang Lake ophiolitic melange in Bangong-Nujiang Suture, Xizang(Tibet), China. Acta Geologica Sinica (English Edition), 90 (supp. 1): 209.

Ding Huixia, Hou Qingye, Zhang Zeming, 2016. Petrogenesis and tectonic significance of the Eocene adakite-like rocks in western Yunnan, southeastern Tibetan Plateau. Lithos, 245: 161-173.

Ding Huixia, Zhang Zeming, Dong Xin, Tian Zuolin, Xiang Hua, Mu Hongchen, Gou Zhengbin, Shui Xinfang, Li Wangchao, Mao Lingjuan, 2016. Early Eocene (c. 50Ma) collision of the Indian and Asian continents: constraints from the North Himalayan metamorphic rocks, southeastern Tibet. Earth and Planetary Science Letters, 435:64-73.

Ding Huixia, Zhang Zeming, Hu Kaiming, Dong Xin, Xiang Hua, Mu Hongchen, 2016. P–T–t–D paths of the North Himalayan metamorphic rocks: implications for the Himalayan orogeny. Tectonophysics, 683: 393-404.

Ding Huixia, Zhang Zeming, 2016. Neoproterozoic granitoids in the eastern Himalayan orogen and their tectonic implications. Precambrian Research, 285: 1-9.

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