2017 EarthScope National Meeting

Outline of SinoProbe-I and Prospecting of SinoProbe-II

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Sinprobe Center and Nanjing University, China

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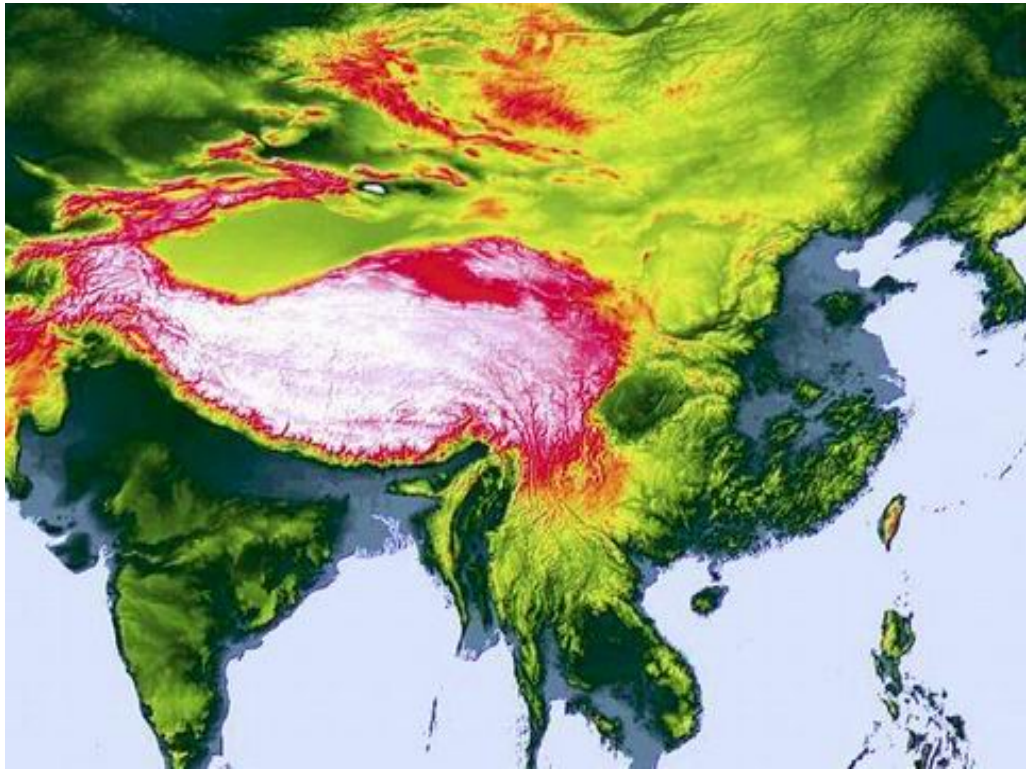
What is SinoProbe

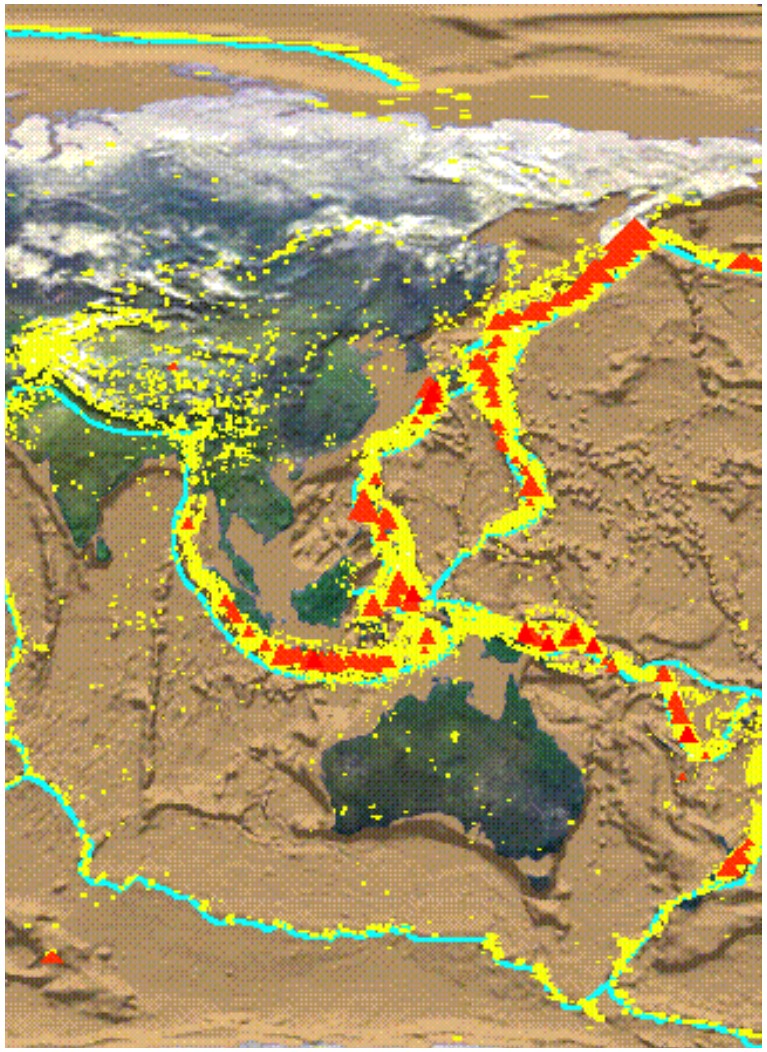
The SinoProbe – Deep Exploration in China, is a multidisciplinary earth science program in China, with the all aim to reveal the composition, structure and evolution of the continental lithosphere beneath Chinese continent, and promote capabilities of the scientific research and understanding of the Earth, exploration of natural resources, and early warning of geo-hazards. And to undersand several first-order problems in Earth Sciences in central and eastern Asia

SinoProbe- Ⅰ

The SinoProbe- Ⅰ started in 2008. The first 6 years from 2008-2014 is the initial phase of the SinoProbe, which is focused on the testing of the feasibility of deep exploration technologies in geophysics, geochemistry, and continental deep drilling in China. And procedure of data processing, and develop the deep exploration instruments.

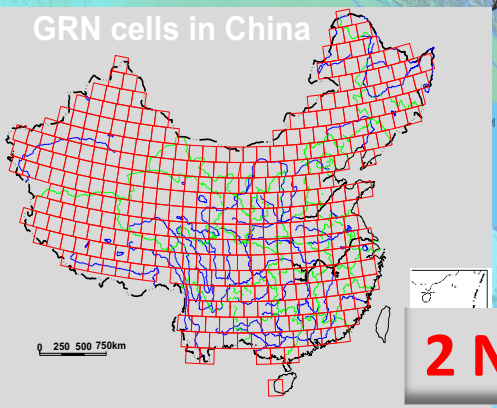
The total budget of the SinoProbe- Ⅰ is ca. $200M for 2008-2014.





China continent is controling under two geodynamics system, eg. plate collisin of Asia and India, and Pacific plate subdution.

Deployment Map of SinoProbe (2008-2014)



矿集区三维精细探测区
地应力与应变监测区
大陆科学钻探井位
电磁物理参数标准网

2 Network, 2 Key Area, 4 Belt, 7 Borehole Point

Affiliated Institutions and Researchers of SinoProbe

国土资源部 中国地质调查局 China Geological Survey

中国地质科学院 Chinese Academy of Geological Sciences

吉林大学

中国地质大学 China University of Geosciences

中国科学院地质与地球物理研究所 Institute of Geology and Geophysics, Chinese Academy of Sciences

中国地震局 地壳应力研究所 The Institute of Crustal Dynamics

中国科学院遥感应用研究所 IRSA Institute of Remote Sensing Applications Chinese Academy of Sciences

南京大学

同济大学 TONGJI UNIVERSITY

北京·中国地质大学 China University of Geosciences

118 Institute\Universities and 1500 scientists and engineers were involved; There are 10000 workers involving into the field exploration.

中国石油

中国科学技术大学 University of Science and Technology of China

中国石化 SINOPEC

中核集团核工业北京地质研究院 CNNC Beijing Research Institute of Uranium Geology

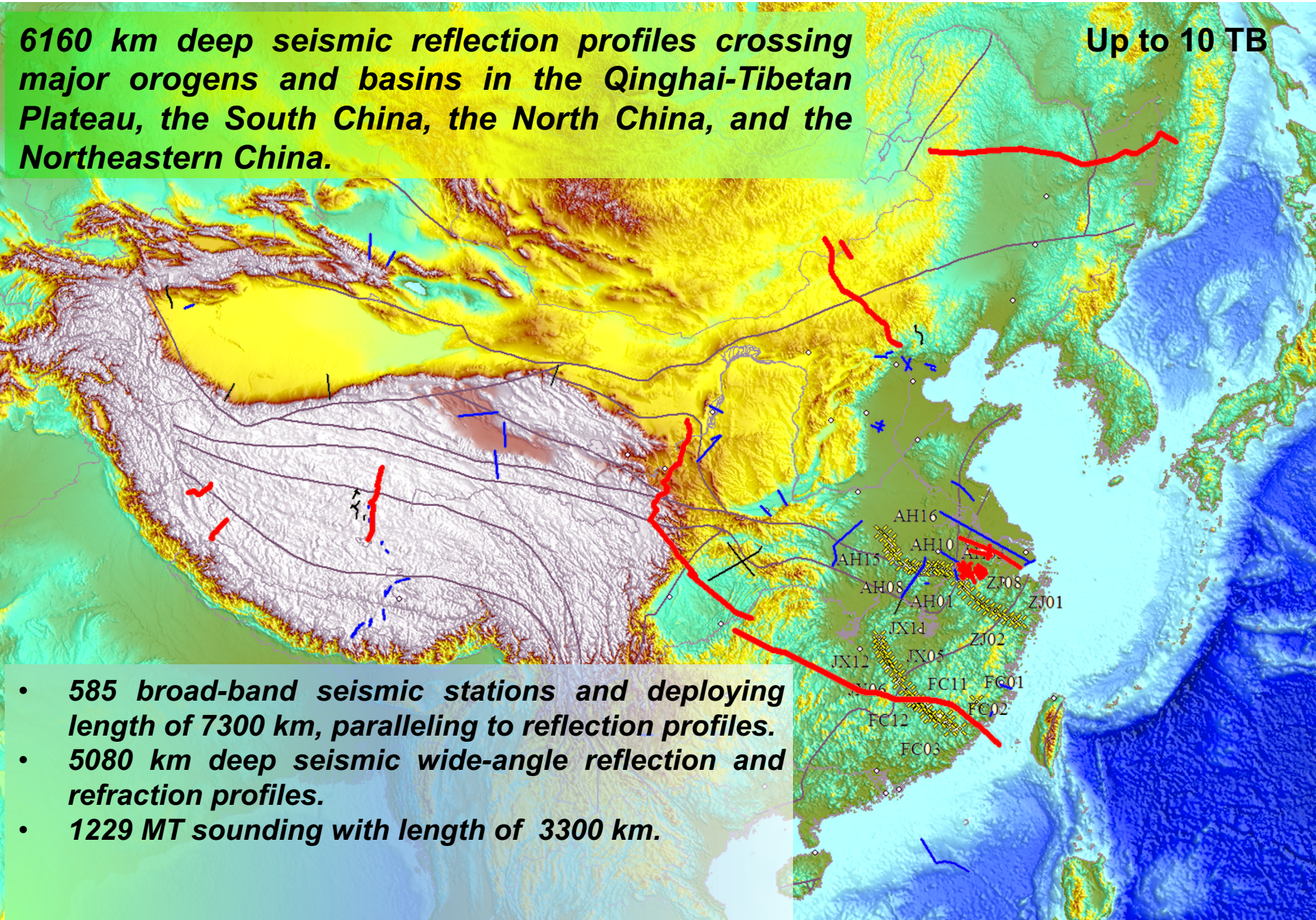
中国煤炭地质总局 China National Administration of Coal Geology

中南大学 Central South University

Big Data: Nation-Wide Geophysical Data

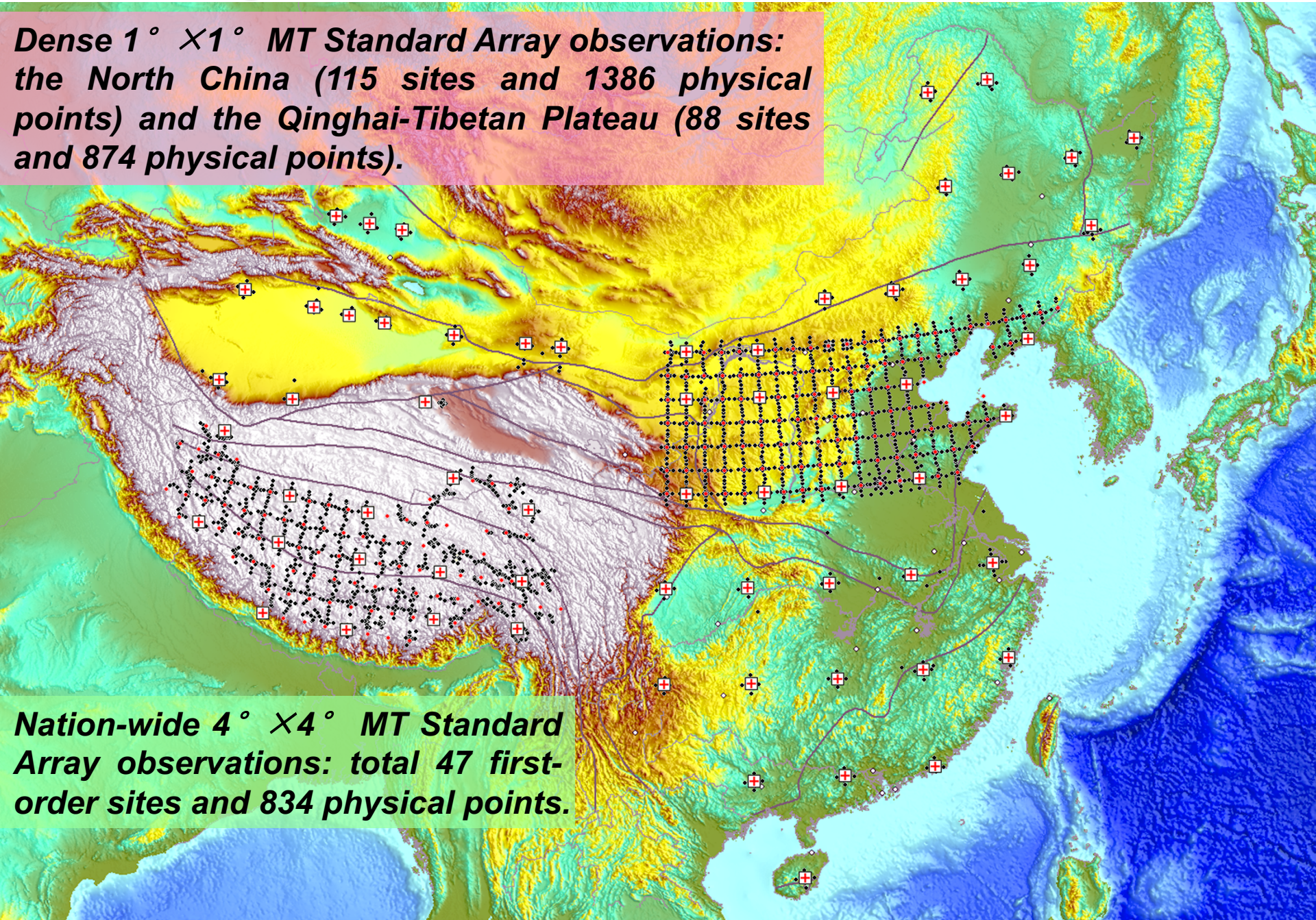
6160 km deep seismic reflection profiles crossing major orogens and basins in the Qinghai-Tibetan Plateau, the South China, the North China, and the Northeastern China.

Up to 10 TB

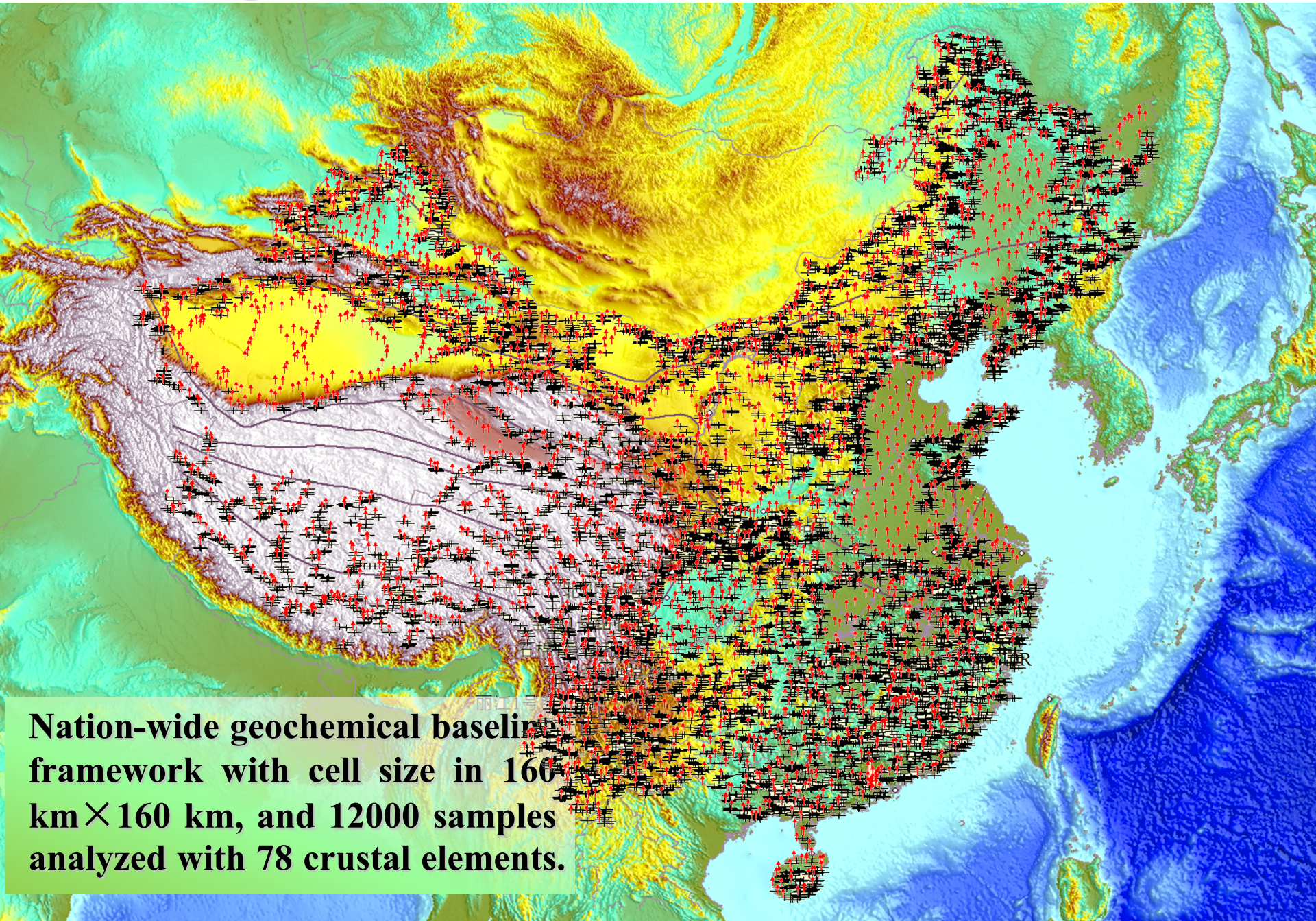


- ***585 broad-band seismic stations and deploying length of 7300 km, paralleling to reflection profiles.***
- ***5080 km deep seismic wide-angle reflection and refraction profiles.***
- ***1229 MT sounding with length of 3300 km.***

Big Data: Nation-Wide Geophysical Data

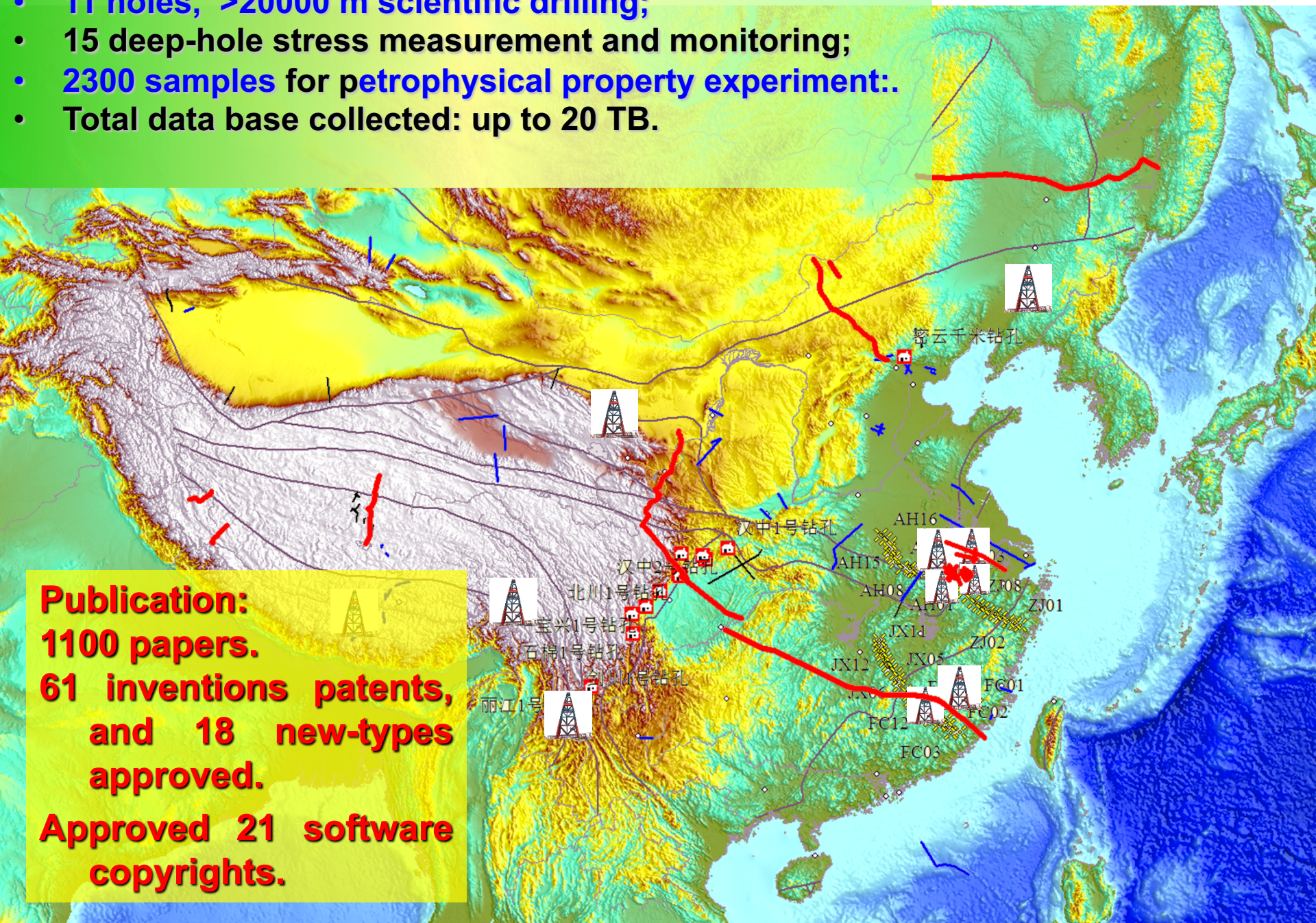


Big Data: Nation-Wide Geochemical Data



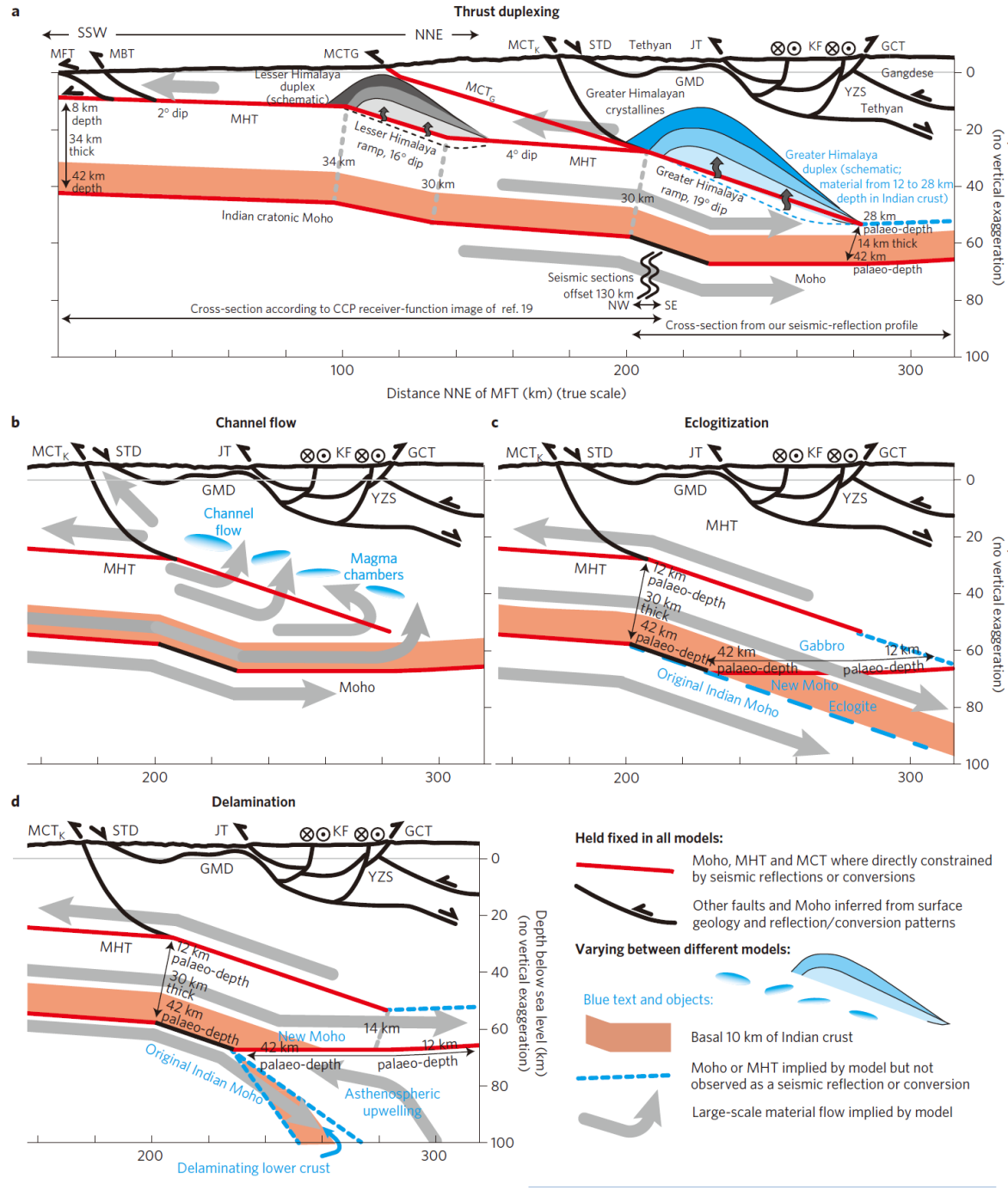
Nation-wide geochemical baseline framework with cell size in 160 km×160 km, and 12000 samples analyzed with 78 crustal elements.

- 11 holes, >20000 m scientific drilling;
- 15 deep-hole stress measurement and monitoring;
- 2300 samples for petrophysical property experiment:.
- Total data base collected: up to 20 TB.



Publication:
1100 papers.
61 inventions patents, and 18 new-types approved.
Approved 21 software copyrights.

Gao et al., 2016, Nature Geoscinces



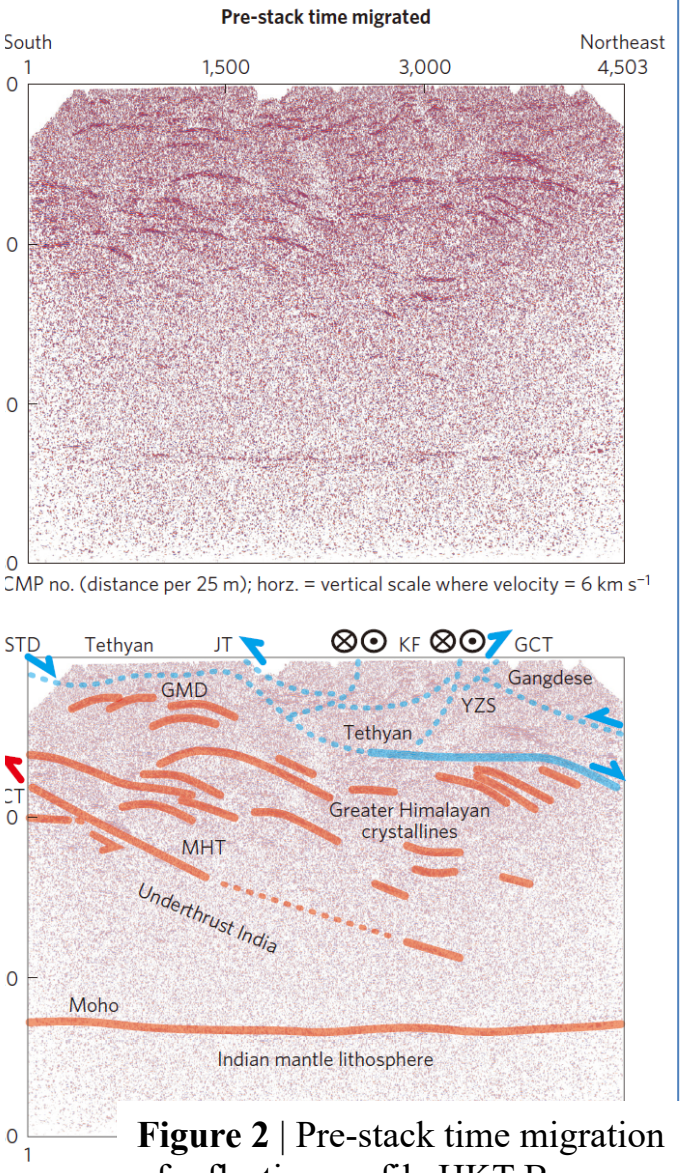
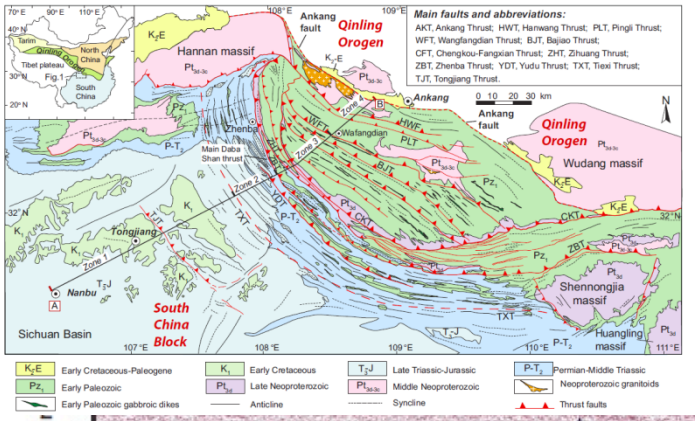


Figure 2 | Pre-stack time migration of reflection profile HKT-B

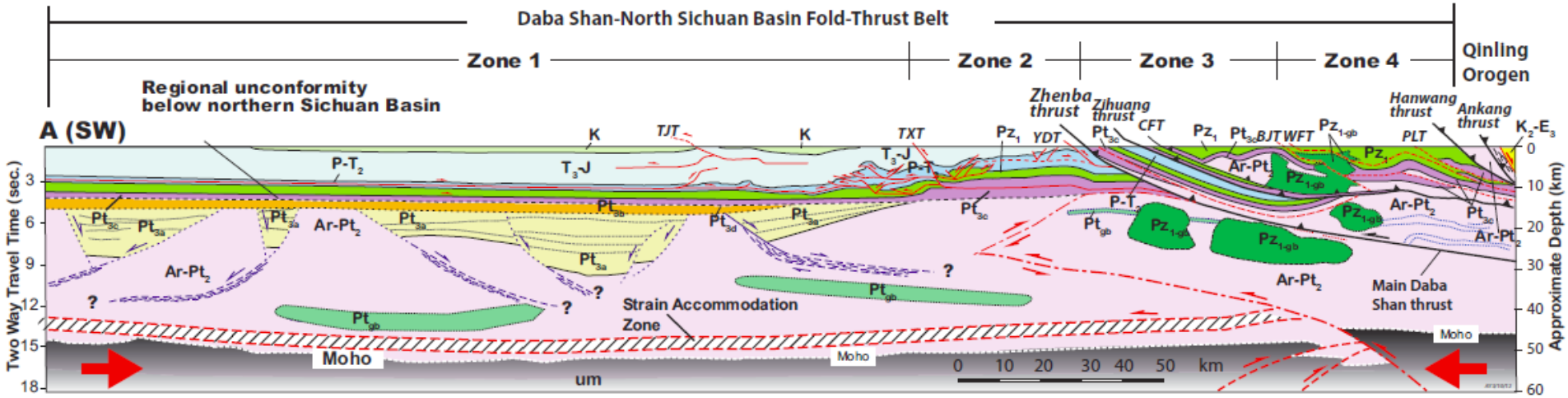
Cross section of Daba Shan thrust belt



(A) Tilted reflectors above the Main Daba Shan thrust. (B) Folded reflectors in zone 4. (C) Broadly folded reflectors truncated by the Main Daba Shan thrust.

Red arrows point to fine-laminated reflectors below regional unconformity. Blue arrows point to strong mid-crustal reflectors. Interpreted fault.

Black arrows pointing to Moho, which is defined as the upper boundary of a 3-4 km thick zone of strong reflection.

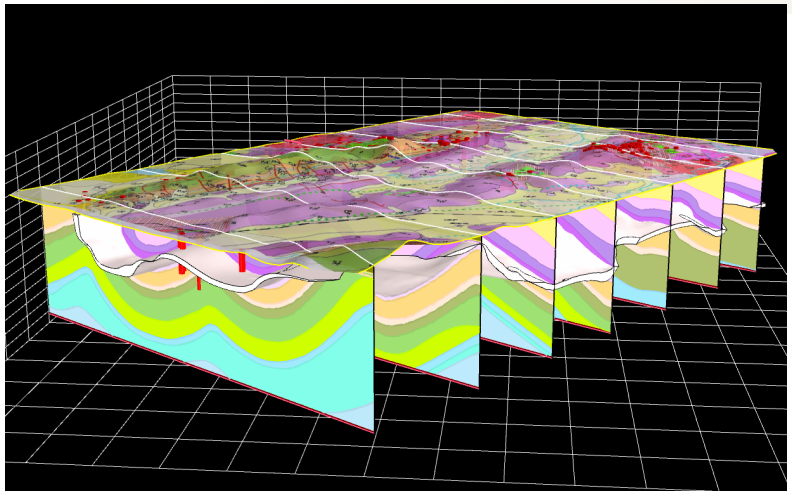


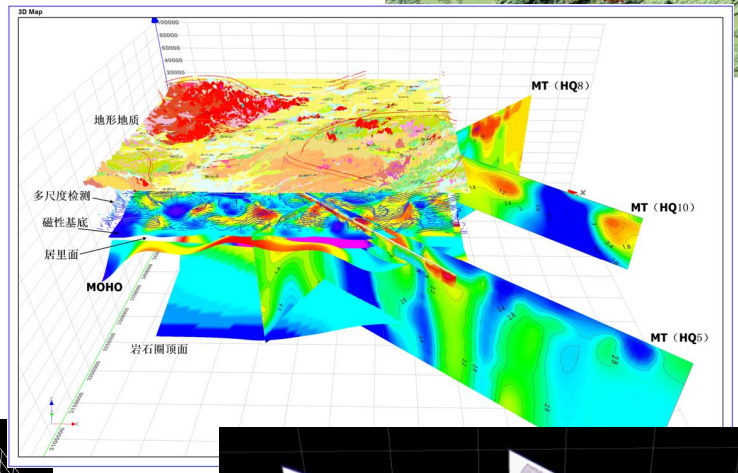
Nature of the contact subject to multiple interpretations. Nature of the contact well constrained by surface geology and seismic data.

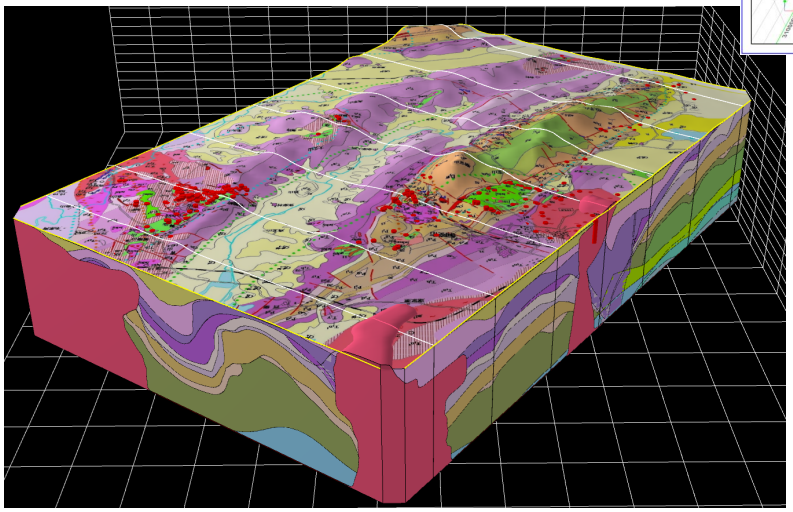
Dong et al.,2013, Geology

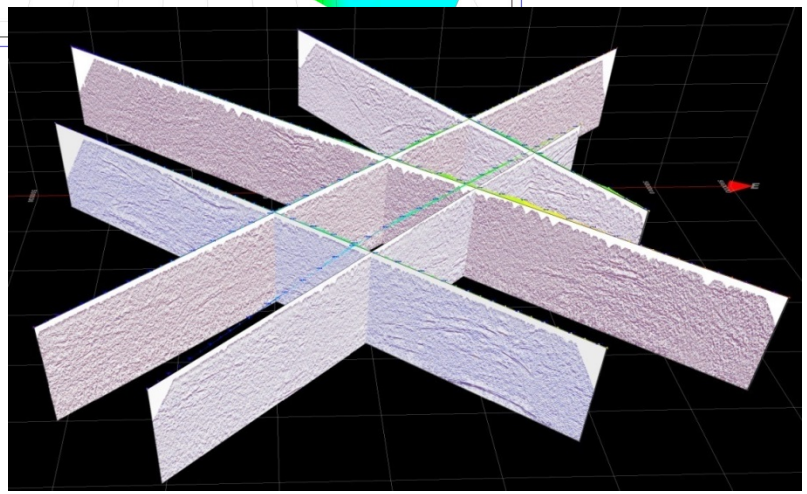
3D of mineral deposit in East China

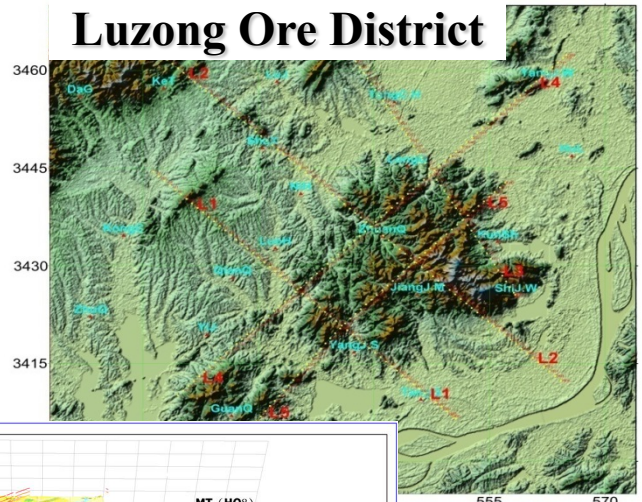
- **Bring up the technological process suited to 3D exploration and modeling of the ore concentration district**

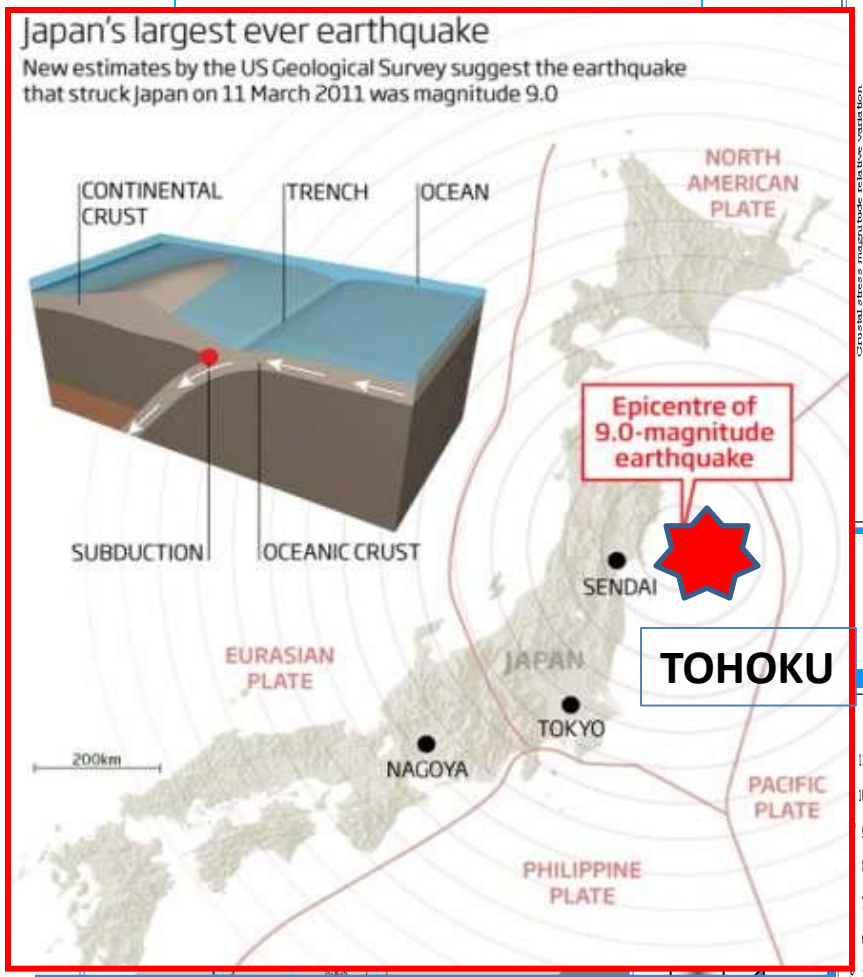


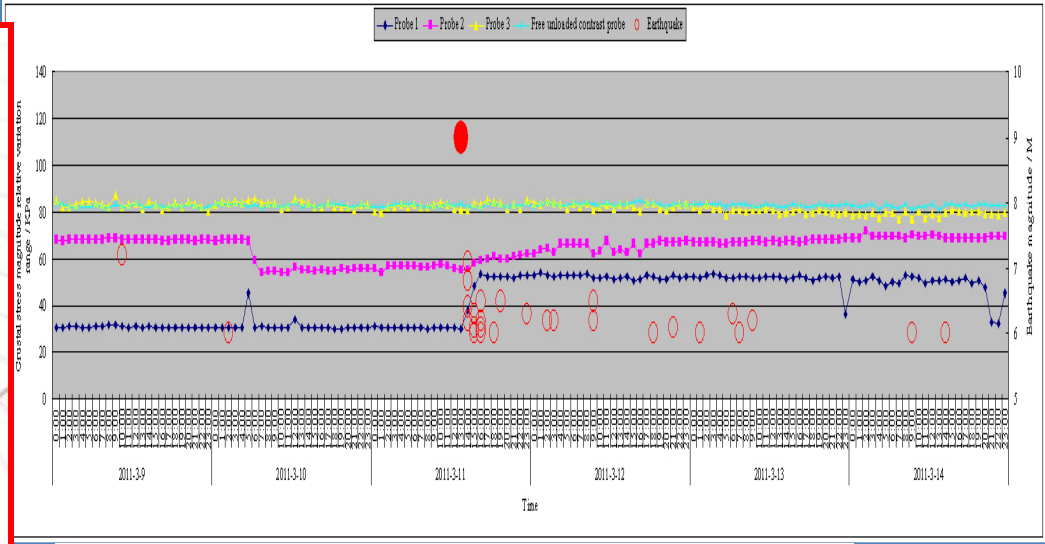




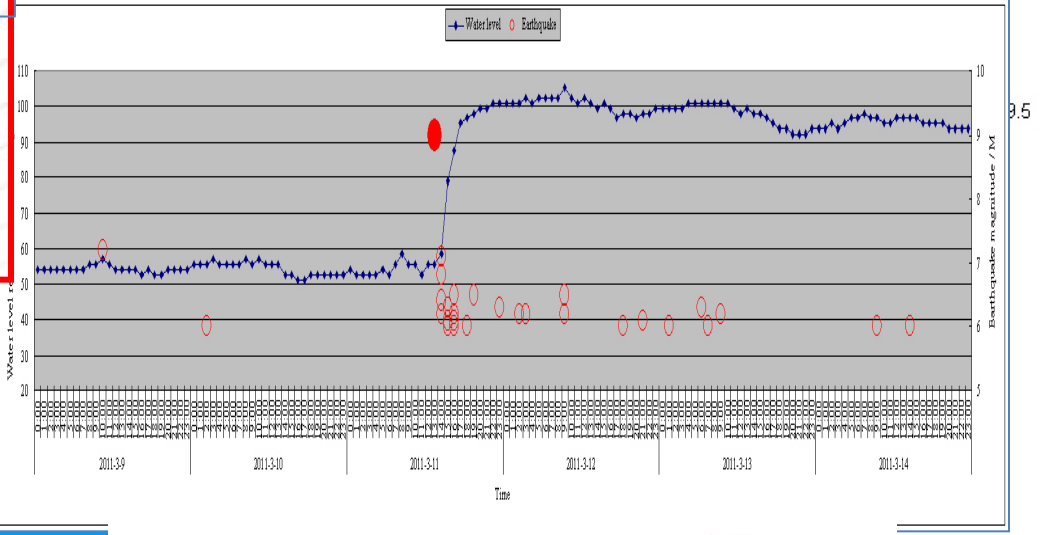




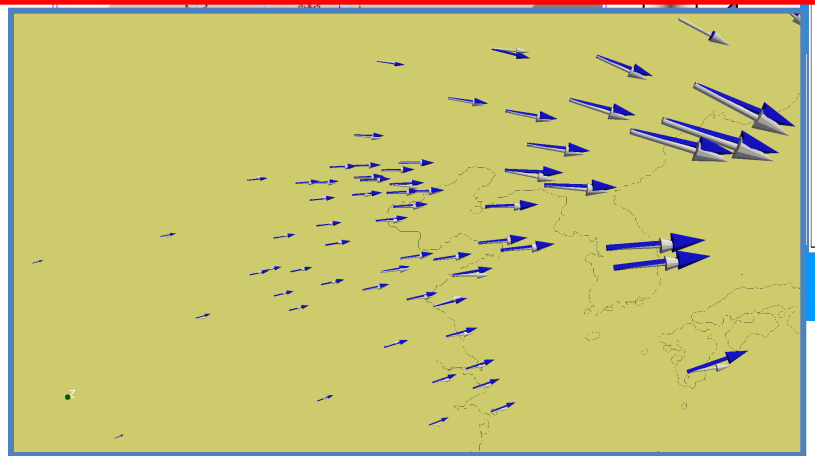




Stress change record of the Tohoku earthquake, 11 March, 2011 at Pinggu station, Beijing,（2011/3/9-2011/3/14）

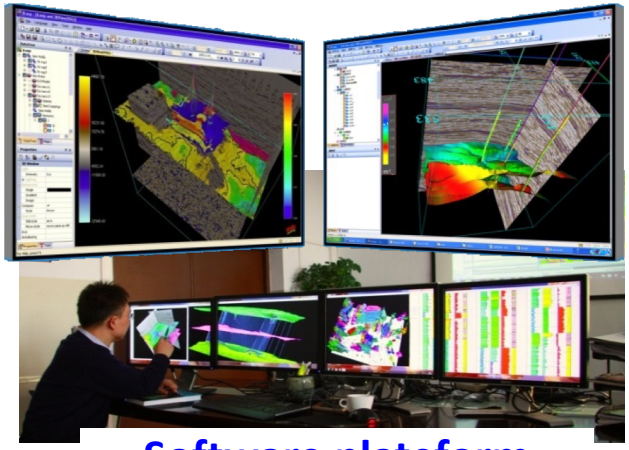


Water lever change record of Tohoku earthquake（2011/2/27-2011/3/14）



Instrumentation development

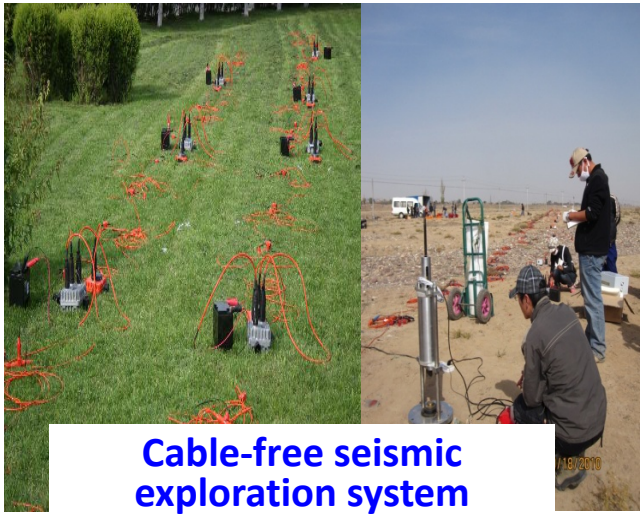
Developing Technological: ***Some instrumental platforms for deep exploration and data processing are developed by the SinoProbe.***



Software plateform

3D electromagnetic exploration system

10km continental scientific drilling equipment

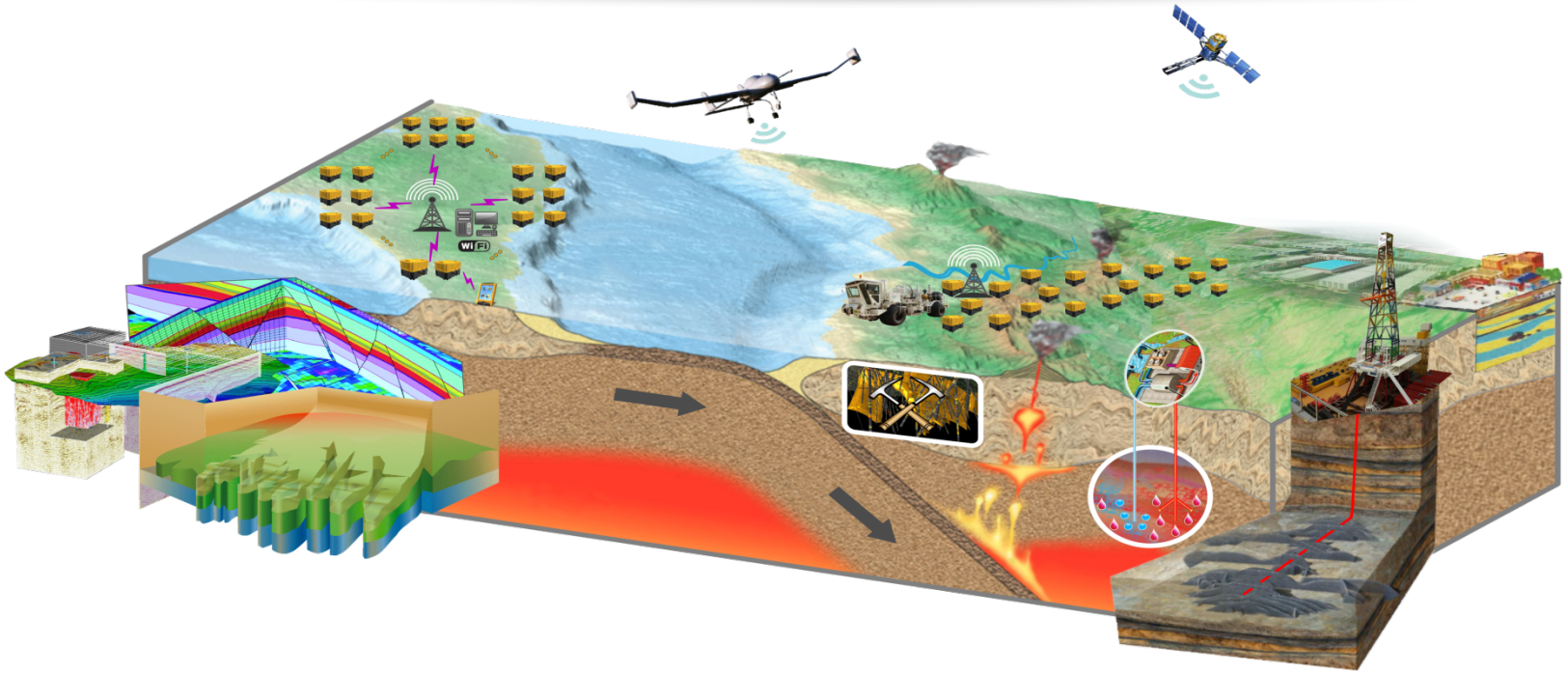


Cable-free seismic exploration system

Unmanned aerial vehicle aeromagnetic system

SinoProbe-Ⅱ(2018-2030?)

China has already fully employed the national strategy of big scientific research on "Deep Space, Deep Earth and Deep Ocean" for 2030. Recently, to probe into the Deep Earth has been planed as a priority in the national strategy following the SinProbe-Ⅰ.



SinoProbe-2 objectives and tasks

To development of exploring system of technology and equipment

To focus on deep energy \ mineral resources \geo-harzads and urban undergroud space

To reveal structures of deep earth and to understanding the deep process

Roadmap

4 deep levels to probe and exploration

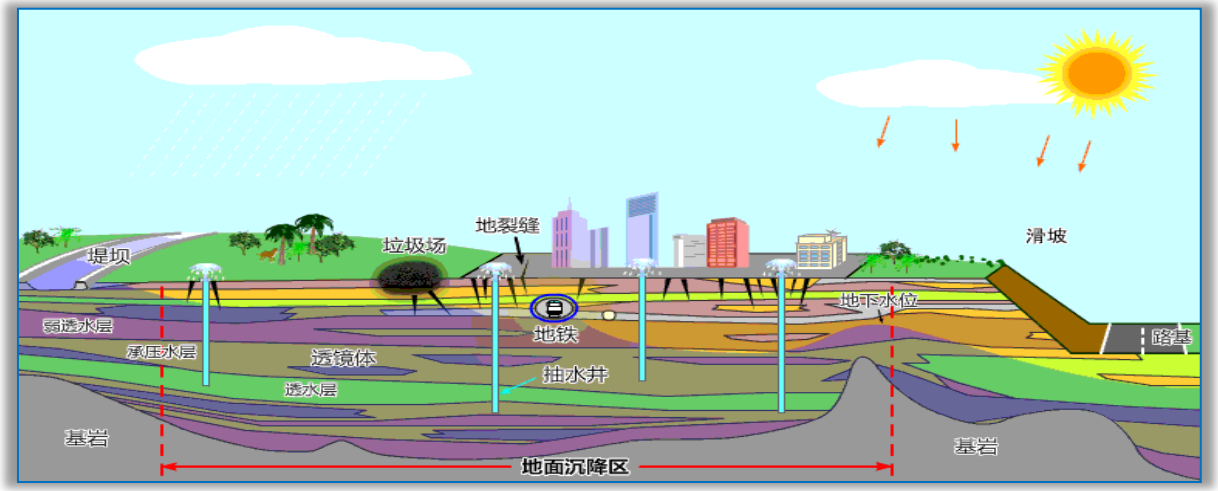
Depth	Target	Resolution	Technical / Requirement
0.5km	Underground Space Using	m	Fine Technology in Shallow Layers
1km	Aquifer Exploration	m	Aviation & Ground
3 km	Metal Mineral	m~10m	Multi parameter Precision Positioning technology
4 km	Unconventional oil and gas	~m	Seismic and multi parameter combination
4-6km	Geothermal resources development	10m	Terrestrial Heat Flow Electromagnetism, Seismic and drilling
10 km	Deep oil and gas exploration	~10m	Seismic and multi parameter combination
40 km	Perspective Earth, Earthquake, Volcano	100m-level	Deep seismic reflection, Magnetotelluric
1000 km	Deep structure, Dynamics	10km-level	Natural seismic network, High temperature and high pressure experiment, Numerical simulation

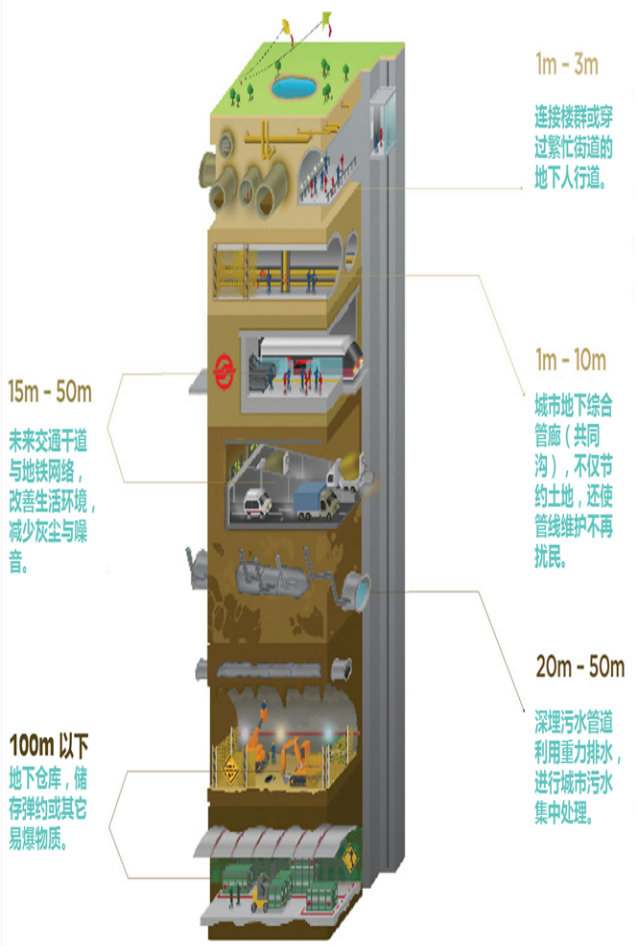
Figure 2: Relation Between Four Levels of Exploration Depth and Technical Equipments

Projects will be Designed

Project 1: Underground Space Survey and Safe Utilization

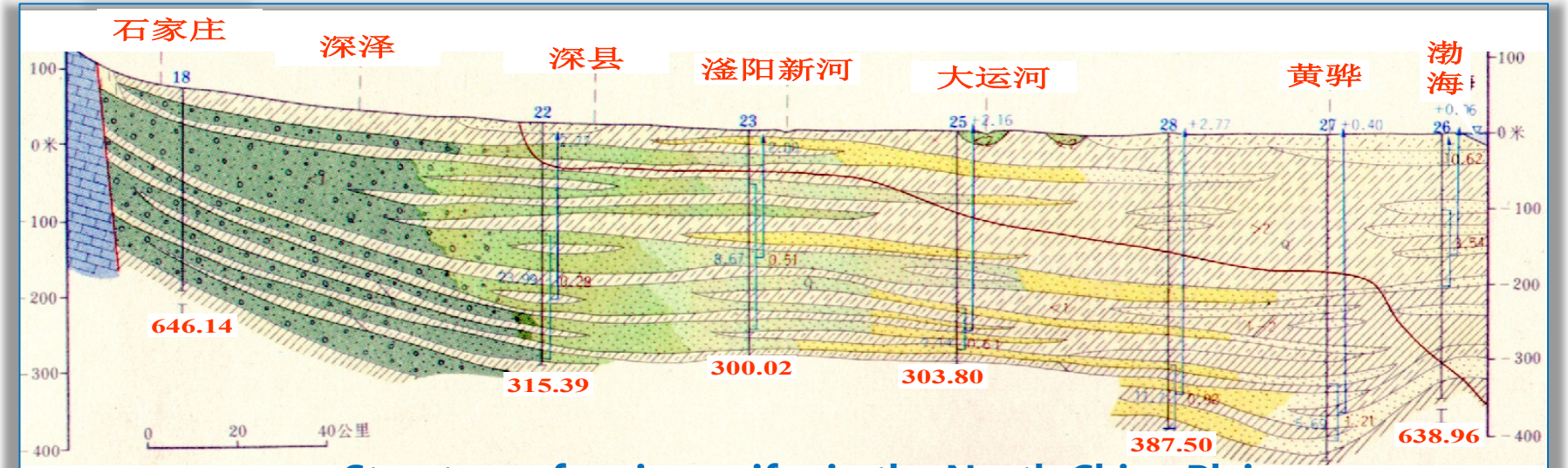
Conduct urban underground space resources, establish 3D geological models at depth of 200m, and evaluate the volume of urban underground space resources to ensure overall urban safety and safe utilization of underground space resources.





Project 2: Deep Aquifer Structural Survey

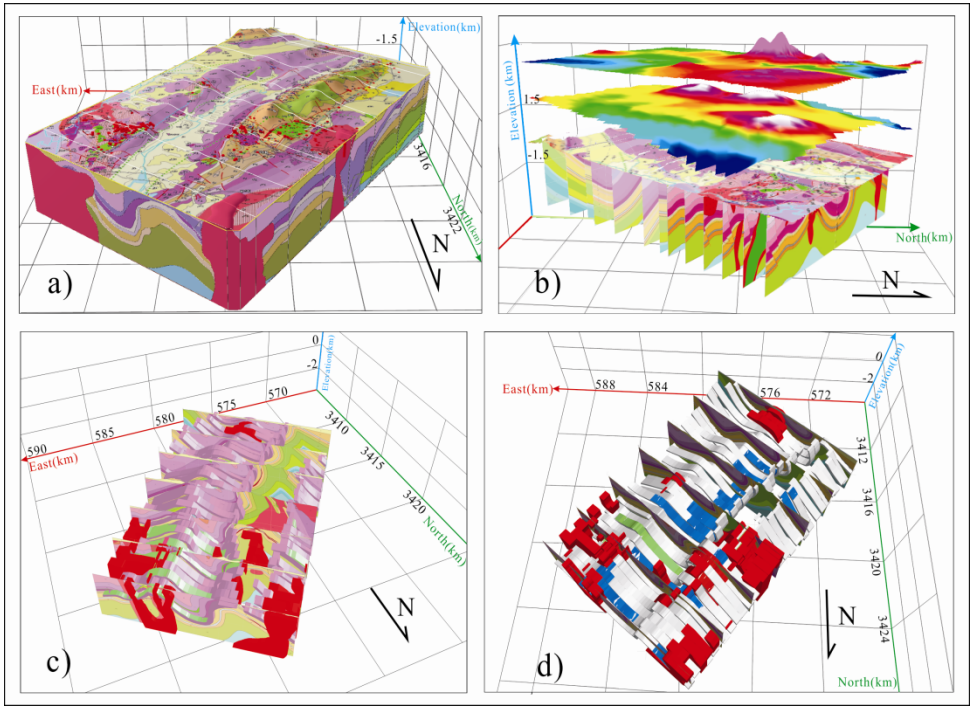
Focus on major aquifer structural exploration at the depths of 500-2,000m, explore new room for emergency water supply; increase supply capacity in regions with dense population and fast economic development.



Structure of main aquifer in the North China Plain

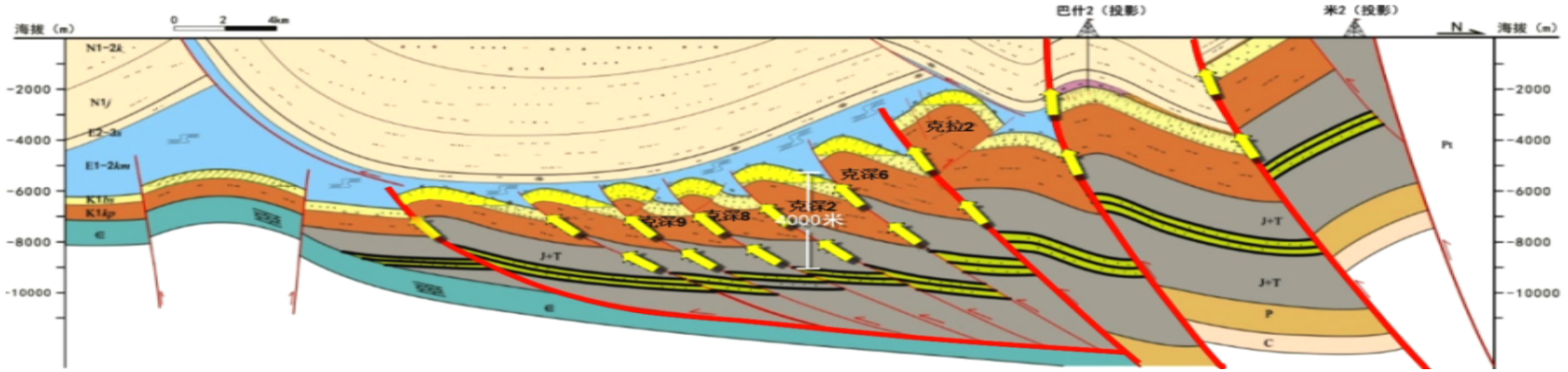
Project 3: Exploration and Evaluation of Deep Mineral Resources (less than 3,000m in depth)

- **Understand deep controlling and space distribution of minerals, innovate deep metallogenisis theories and develop deep exploration technologies, and form effective 3-D exploration technology capabilities at the depth of 3,000m**



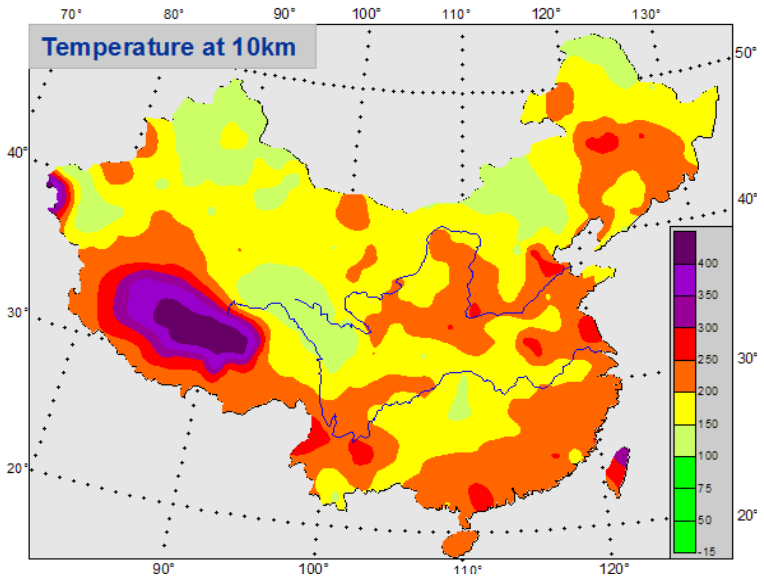
Project 4: Deep Oil and Gas Exploration and Mining

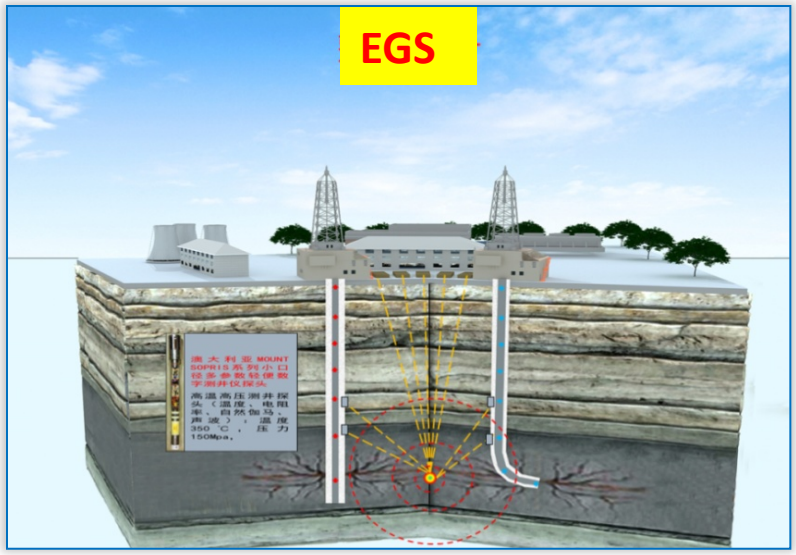
- **Focus on super-deep oil and gas (6000-10000m), deep shale oil (>3500m), shale gas (>4000m), as well as organic and inorganic composite hydrocarbon; Identify hydrocarbon accumulation mechanisms to evaluate resources potential**



Project 5: Geothermal Resources Exploration and Geothermal Utilization

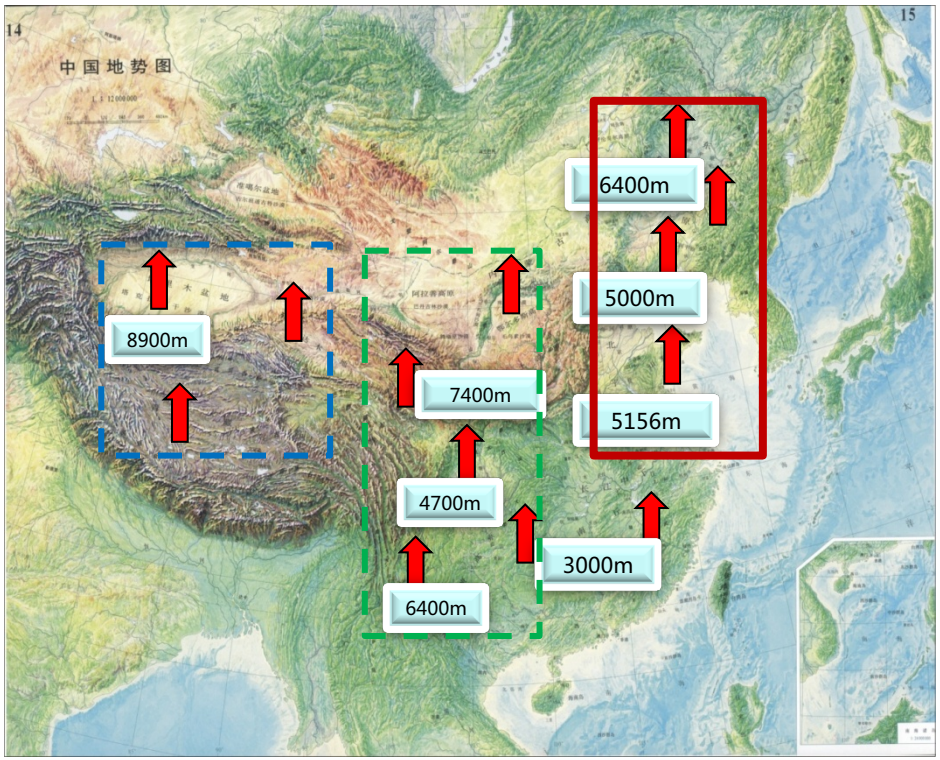
Carry out deep geothermal resources exploration; Reveal accumulation mechanism of deep geothermal resouces; Form geothermal resources exploration and development technologies; Evaluate geothermal resources potential; Build geothermal scientific development and utilization platforms; Propose scientific development and utilization of regional geothermal resources;





Project 6: Deep Underground Monitoring and Crustal Activity Monitoring

Build well group (4000-7000m) observation systems along Tan-lu Fault Zone in east and Longmenshan Active Fault in west of China; Realize the combination of surface seismic stations, surface and underground (less than 1000m) stress.



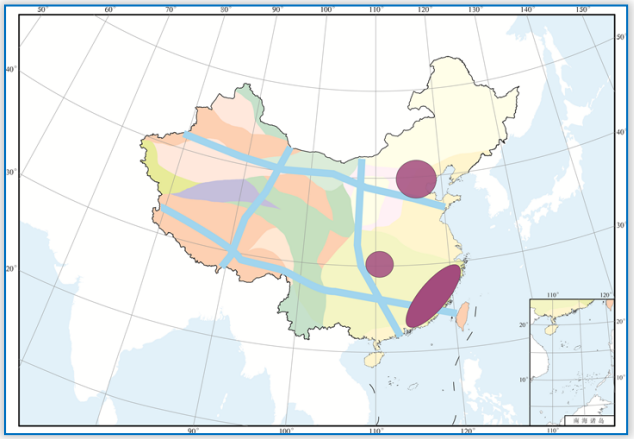
Topic : National Stress Monitoring Network

Establish stress monitoring networks of China’ s major tectonic units and active belts and observation stations of major active faults so as to increase the level of crustal activity monitoring.

(1)National stress monitoring network;

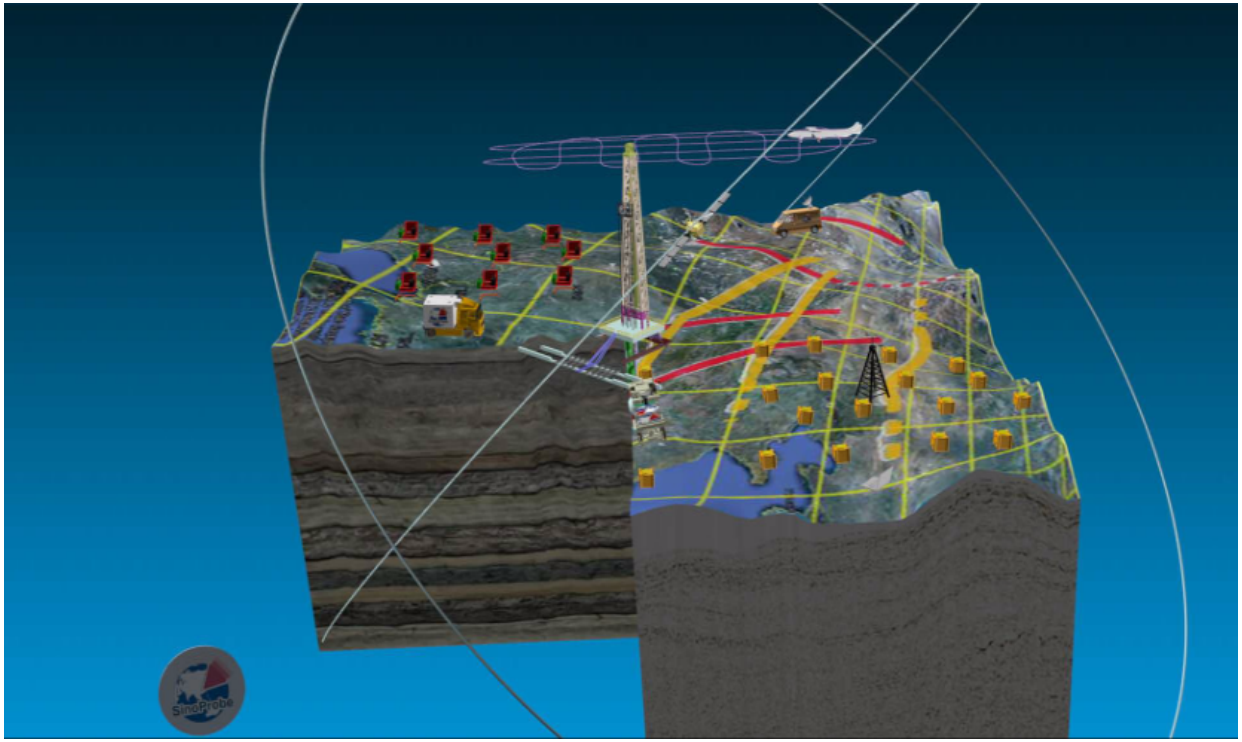
(2)stress observation station group of major active faults。

Deploy 100 drilling holes to carry out deep hole monitoring measurement along the 4 national stress measurement profiles.



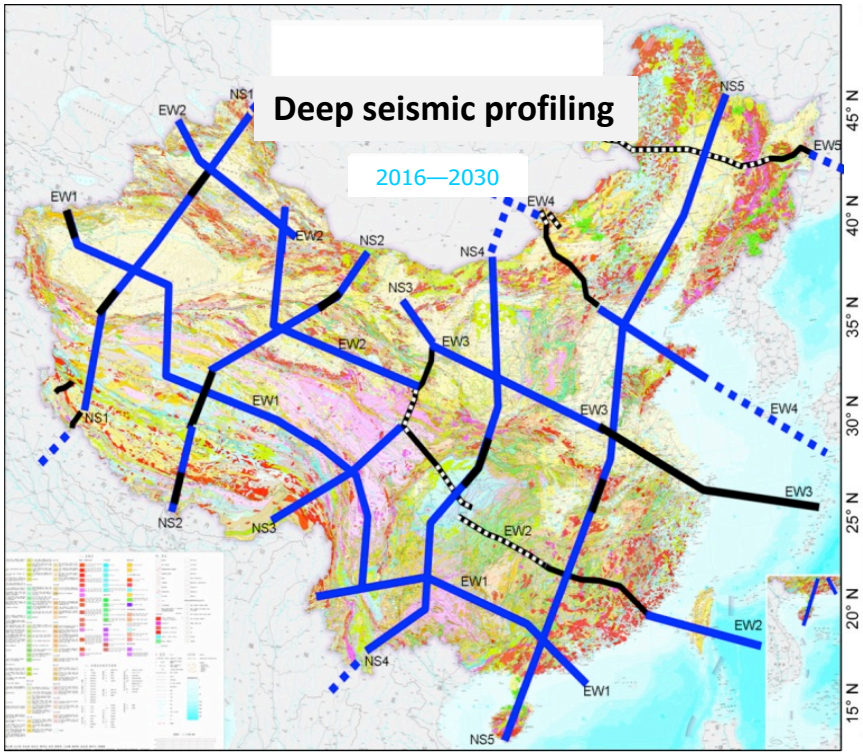
Project 7: Development Technology and Equipment of Deep Exploration

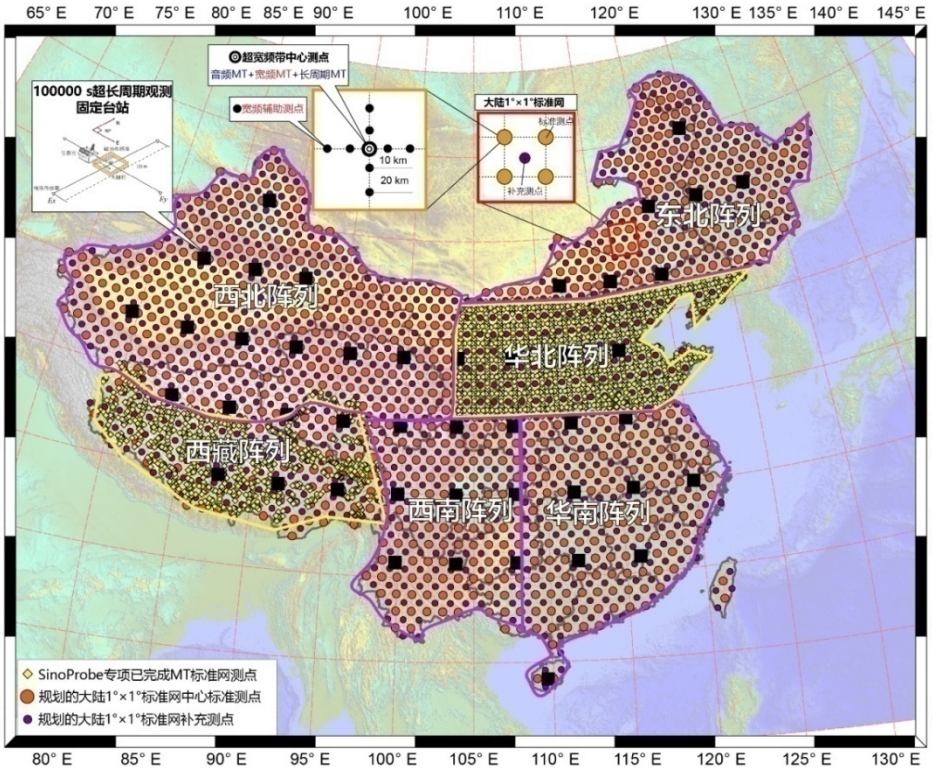
Development in key deep exploration instruments and equipment;such as super deep scientific drilling equipment(15000m).



Project 8: Deep Process and Geodynamics

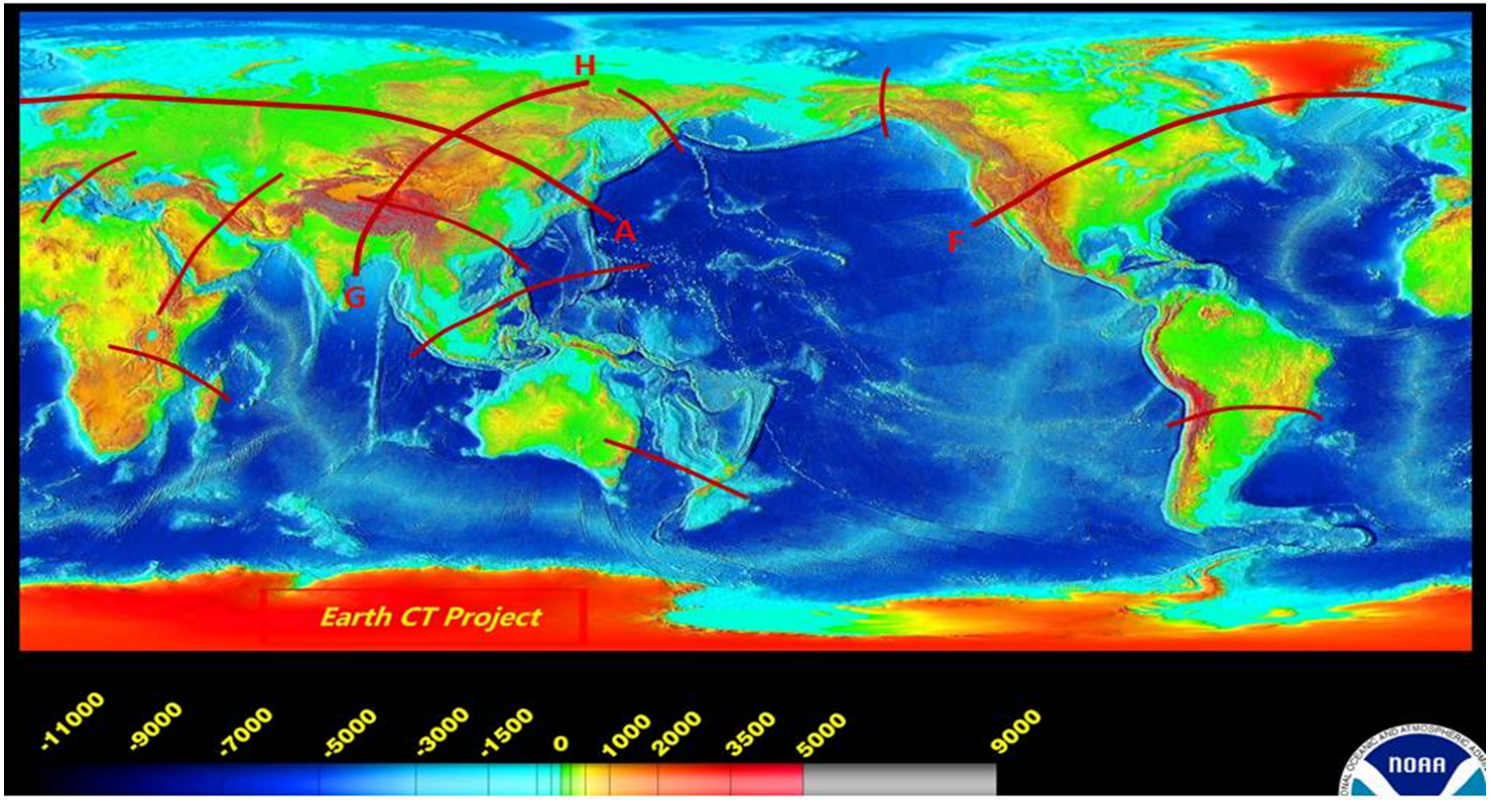
- **Strengthen exploration of the lithosphere and composition of Eastern Central Asia and reveal the deep process and relevant influence on surface environment\resources\geoharzads.**





“The Earth CT”: an international cooperation

- To integrate the profilings to make a global transection
- Leading by deep seismic reflection technology and adopting multi-disciplinary approaches, transcontinental, continental-oceanic, super-long and high-resolution will focus on comprehensive research on geoscience transect.



1、 Lithosphere transect and geoscience corridor in global “Big Cross”

(1) Eurasian continent-Atlantic-North American continent transect and corridor (A-F transect, about 20,200km).

(2) **India-Tibetan Plateau-Baikal-Siberia geoscience transect** (Chart 1, G-H transect, about 8,000km).

2、 Lithosphere transect and geoscience corridor in Critical Zones

Mineral Deposits Map

Scale 1 : 2 500 000

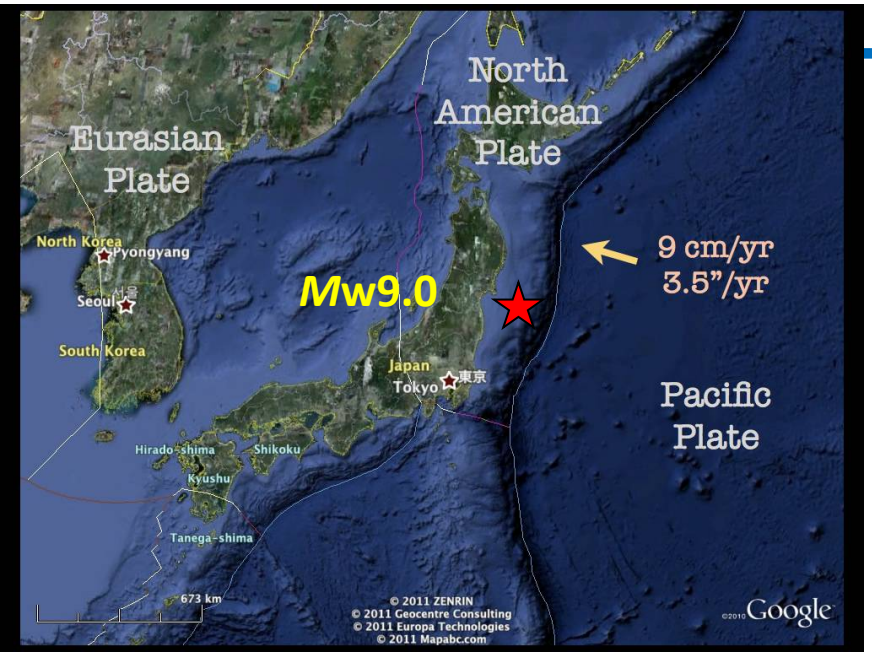
China
Kazakhstan
Kyrghyzstan
Mongolia
North Korea
Republic of Korea
Russia
Turkmenistan
Uzbekistan
Tadjikistan

Deposits size:

Large
Medium
Smal

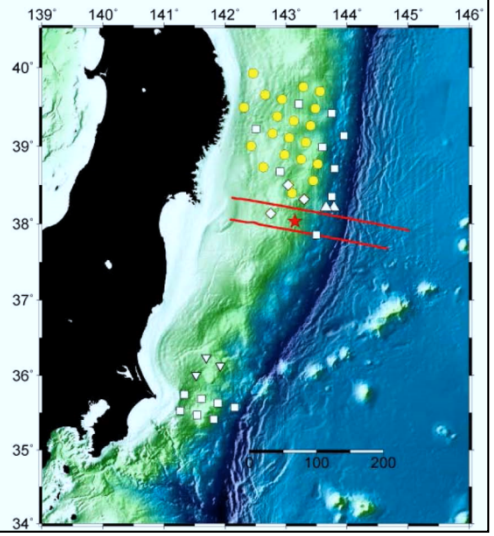
Tohoku Earthquake(Mw9.0)

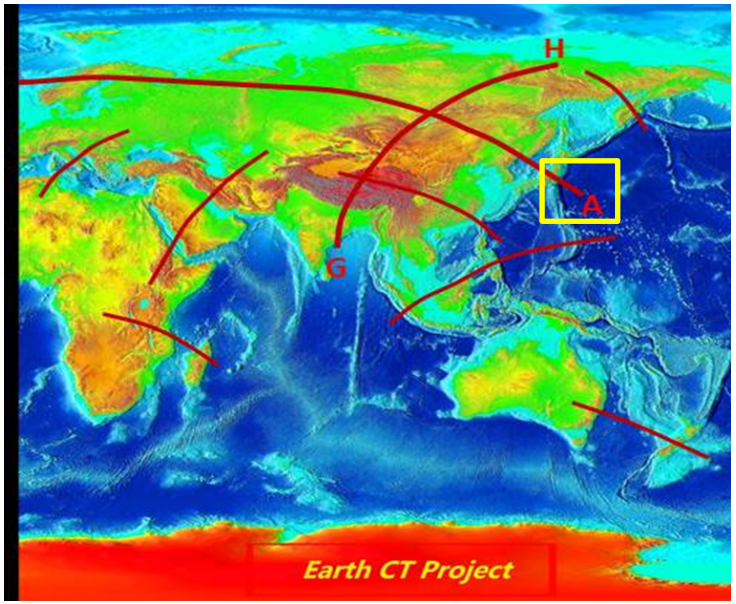
日本宫城大地震



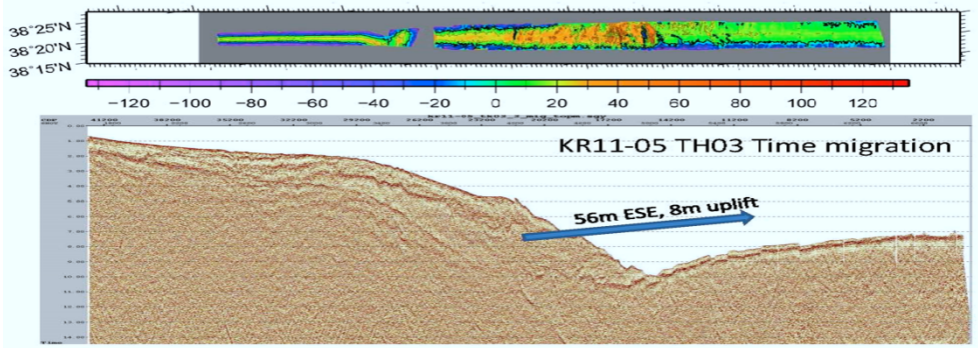
Rapid response geophysical cruise

- 2011/3/14～3/31（18days）、
- R/V KAIRE
- OBS deployment and recovery: JAMSTEC, ERI, Tohoku Univ. OBS and OBP
- Seismic reflection survey
- Seabeam

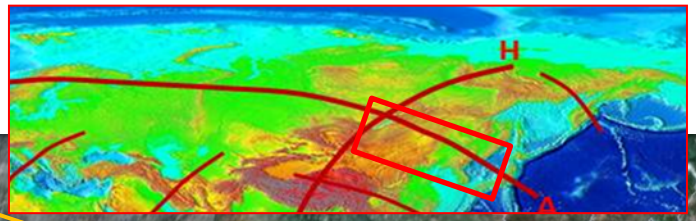


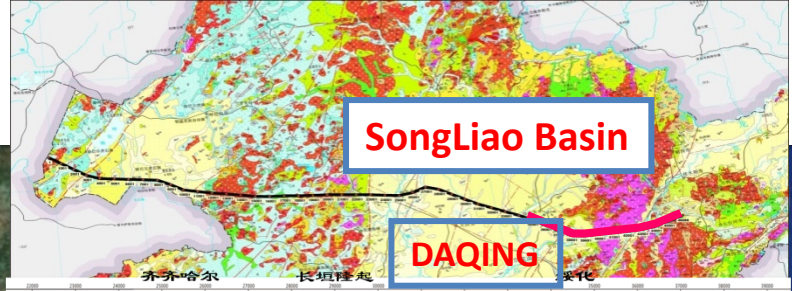


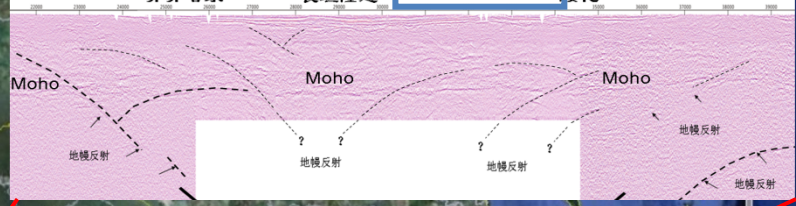
Bathymetry: before and after the earthquake [KR11-05 TH03] — [KR99-08 MY102]

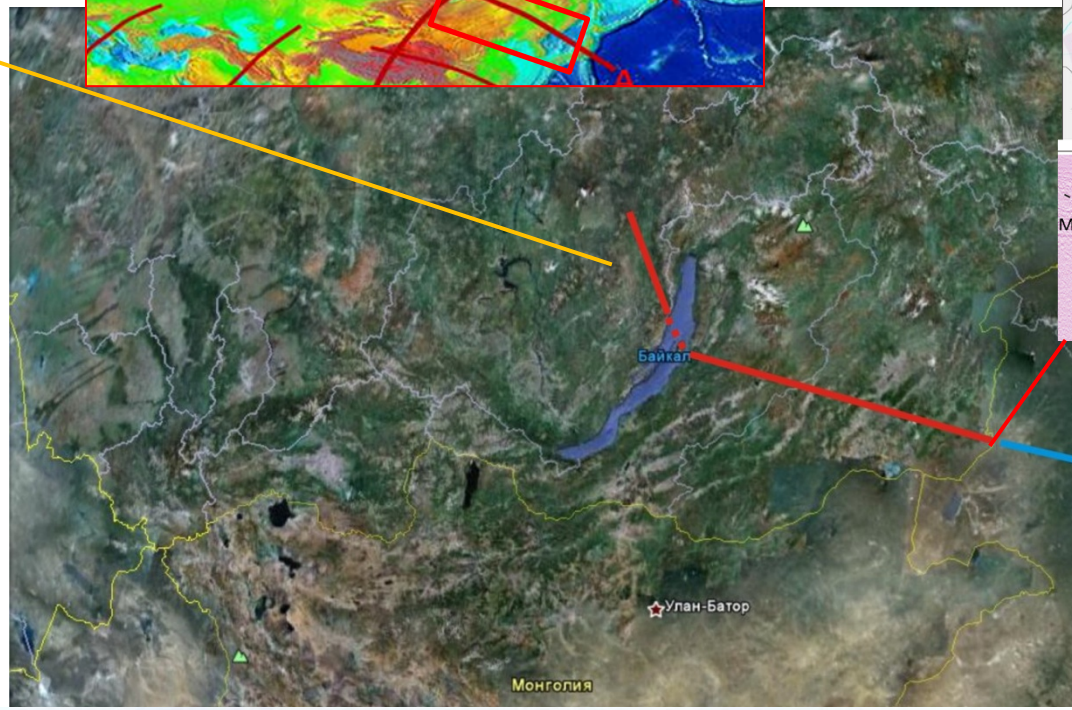


Overriding block may move about 56 m ESE-ward and about 8 m uplift, but need more processing









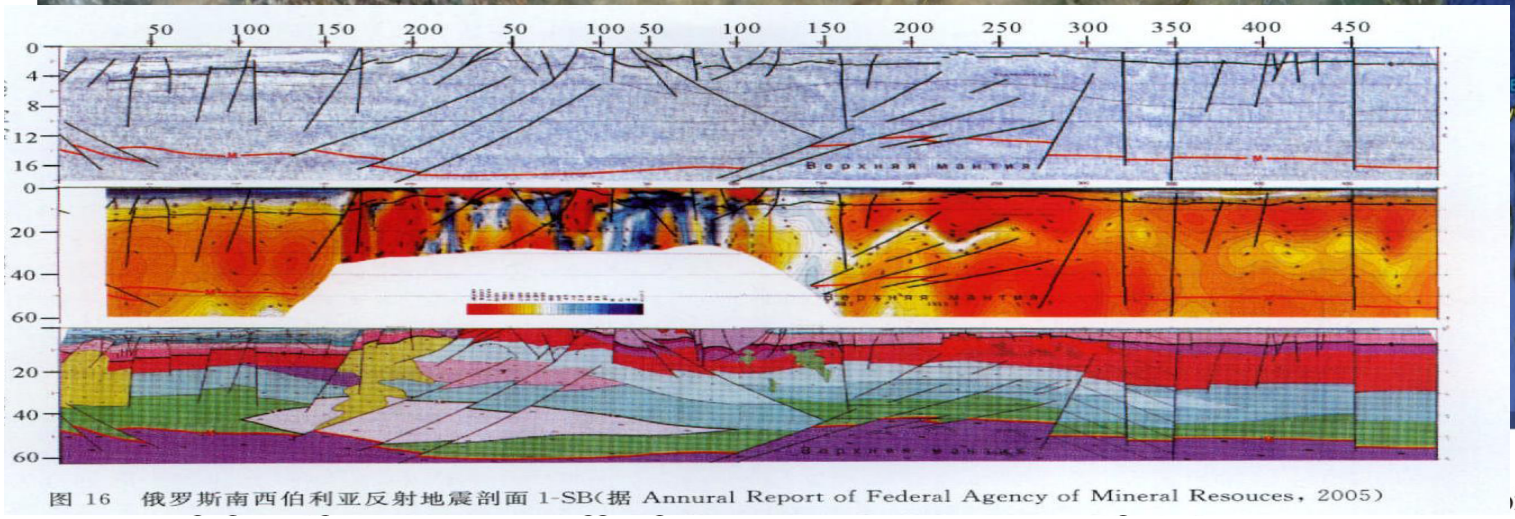
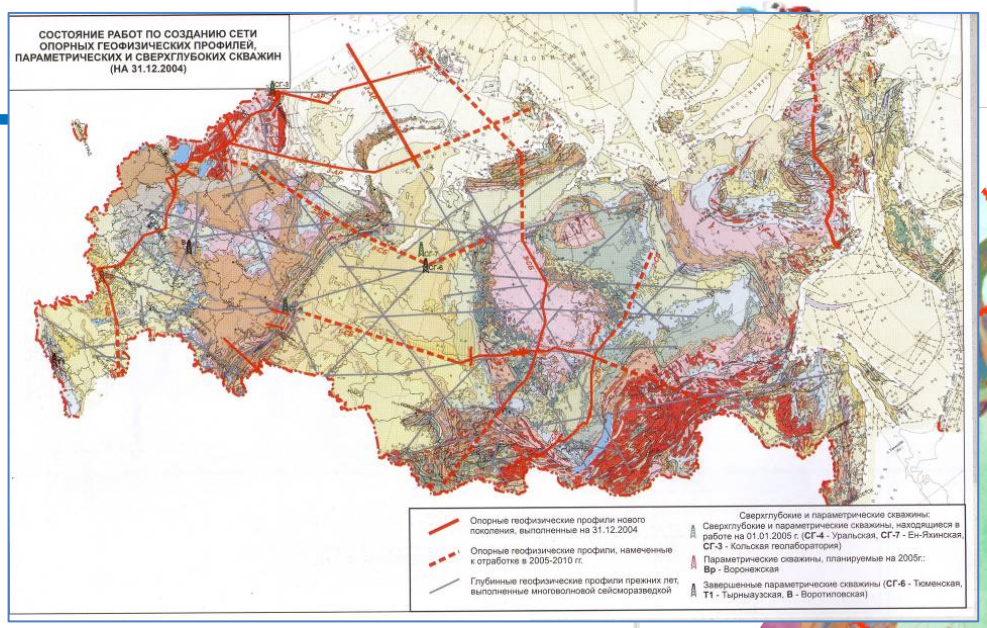
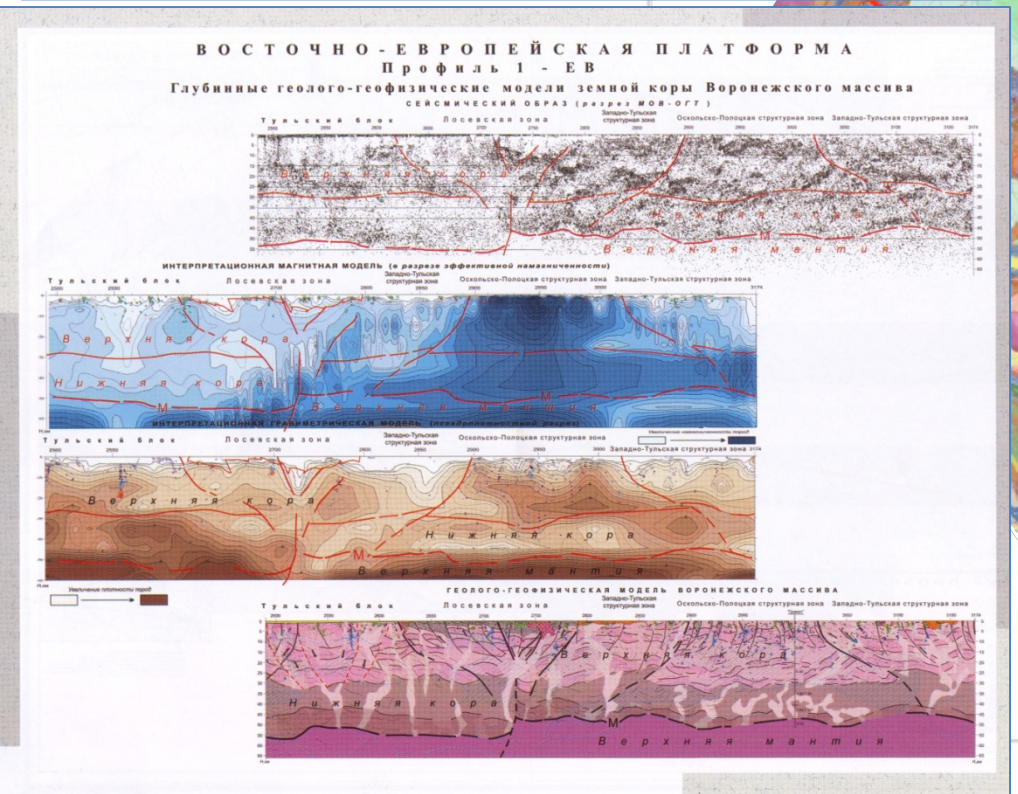


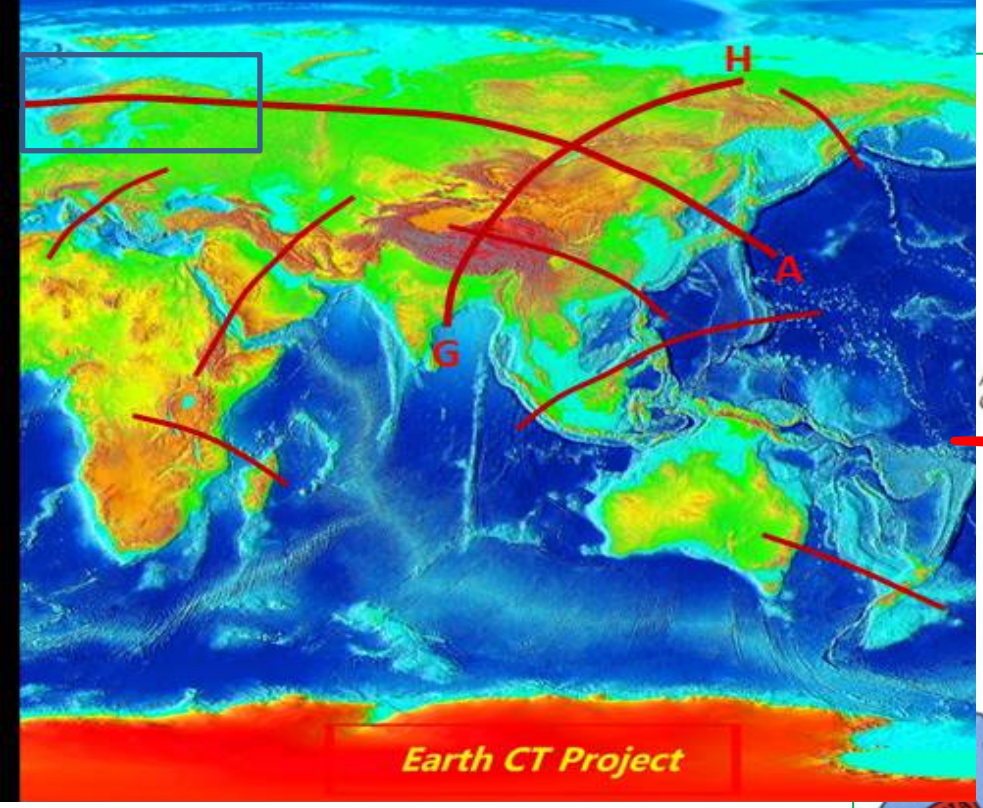
图 16 俄罗斯南西伯利亚反射地震剖面 1-SB(据 Annural Report of Federal Agency of Mineral Resouces, 2005)

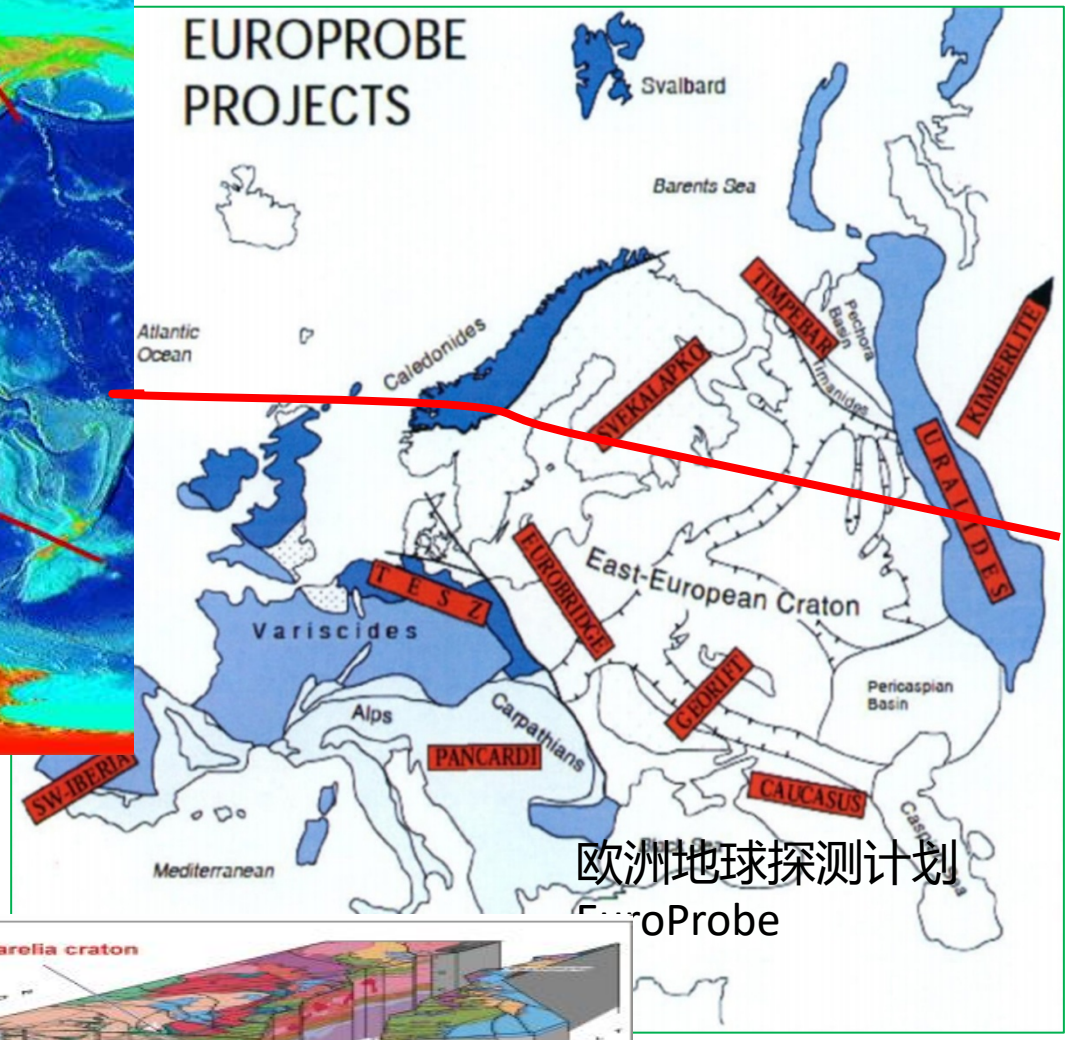
ой Народной Республики


СОСТОЯНИЕ РАБОТ ПО СОЗДАНИЮ СЕТИ ОПОРНЫХ ГЕОФИЗИЧЕСКИХ ПРОФИЛЕЙ, ПАРАМЕТРИЧЕСКИХ И СВЕРХГЛУБОКИХ СКВАЖИН (НА 31.12.2004)
Опорные геофизические профили нового поколения, выполненные на 31.12.2004
Опорные геофизические профили, намеченные к отработке в 2005-2010 гг.
Глубинные геофизические профили прежних лет, выполненные многоволновой сейсморазведкой
Сверхглубокие и параметрические скважины:
Сверхглубокие и параметрические скважины, находящиеся в работе на 01.01.2005 г. (СГ-4 - Уральская, СГ-7 - Ен-Яхинская, СГ-3 - Кольская геолаборатория)
Параметрические скважины, планируемые на 2005г.: Вр - Воронежская
Завершенные параметрические скважины (СГ-6 - Тюменская, Т1 - Тырныаузская, В - Воротиловская)


ВОСТОЧНО-ЕВРОПЕЙСКАЯ ПЛАТФОРМА
Профиль 1 - ЕВ
Глубинные геолого-геофизические модели земной коры Воронежского массива
СЕЙСМИЧЕСКИЙ ОБРАЗ (разрез МОВ-ОГТ)
ИНТЕРПРЕТАЦИОННАЯ МАГНИТНАЯ МОДЕЛЬ (в разрезе эффективной намагниченности)
ИНТЕРПРЕТАЦИОННАЯ ГРАВИМЕТРИЧЕСКАЯ МОДЕЛЬ (псевдоплотностной разрез)
ГЕОЛОГО-ГЕОФИЗИЧЕСКАЯ МОДЕЛЬ ВОРОНЕЖСКОГО МАССИВА
Тульский блок
Лосевская зона
Западно-Тульская структурная зона
Оскольско-Полоцкая структурная зона
Верхняя кора
Нижняя кора
Верхняя мантия
M

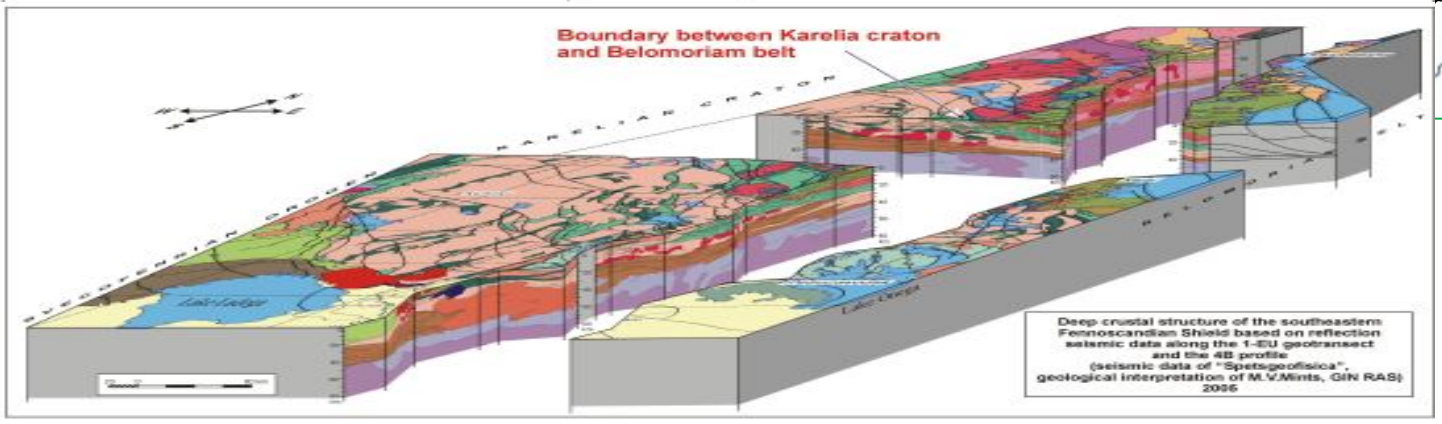

TECTONIC MAP OF NORTHERN-CENTRAL-EASTERN ASIA AND ADJACENT AREAS

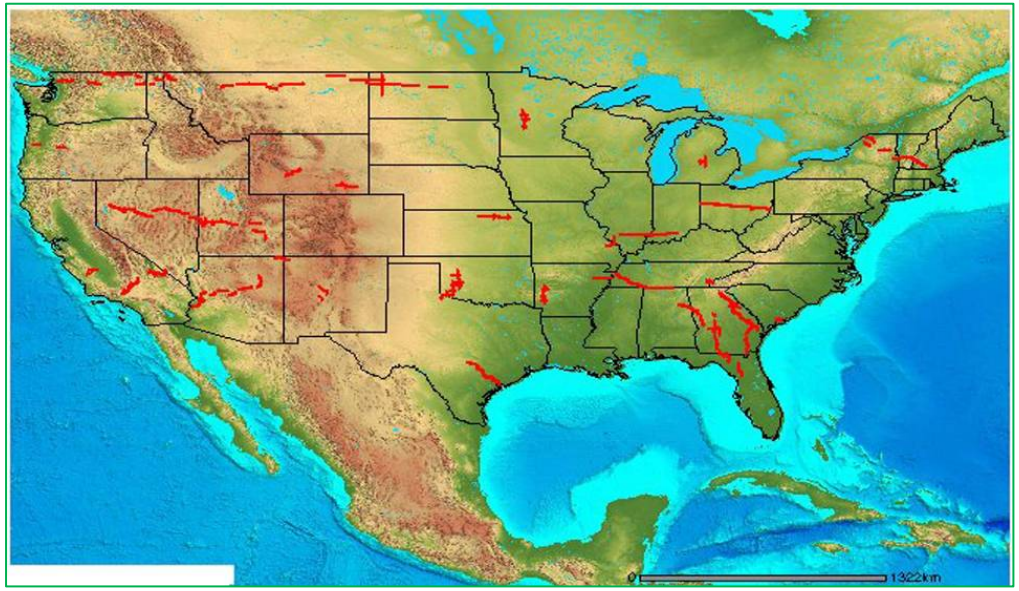


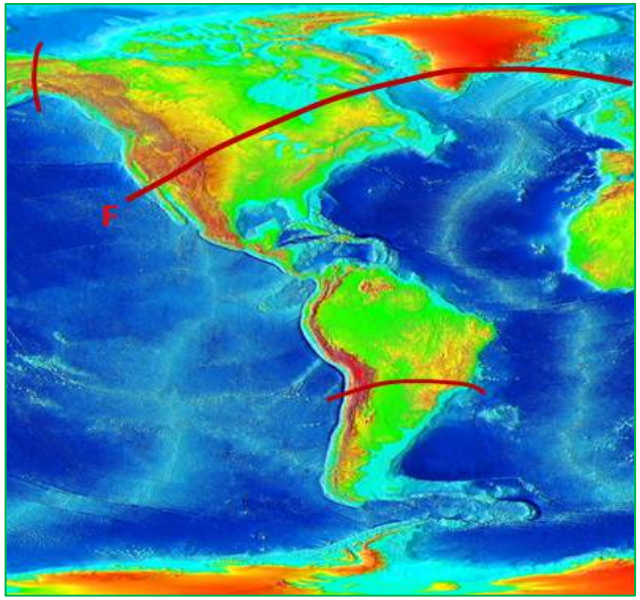


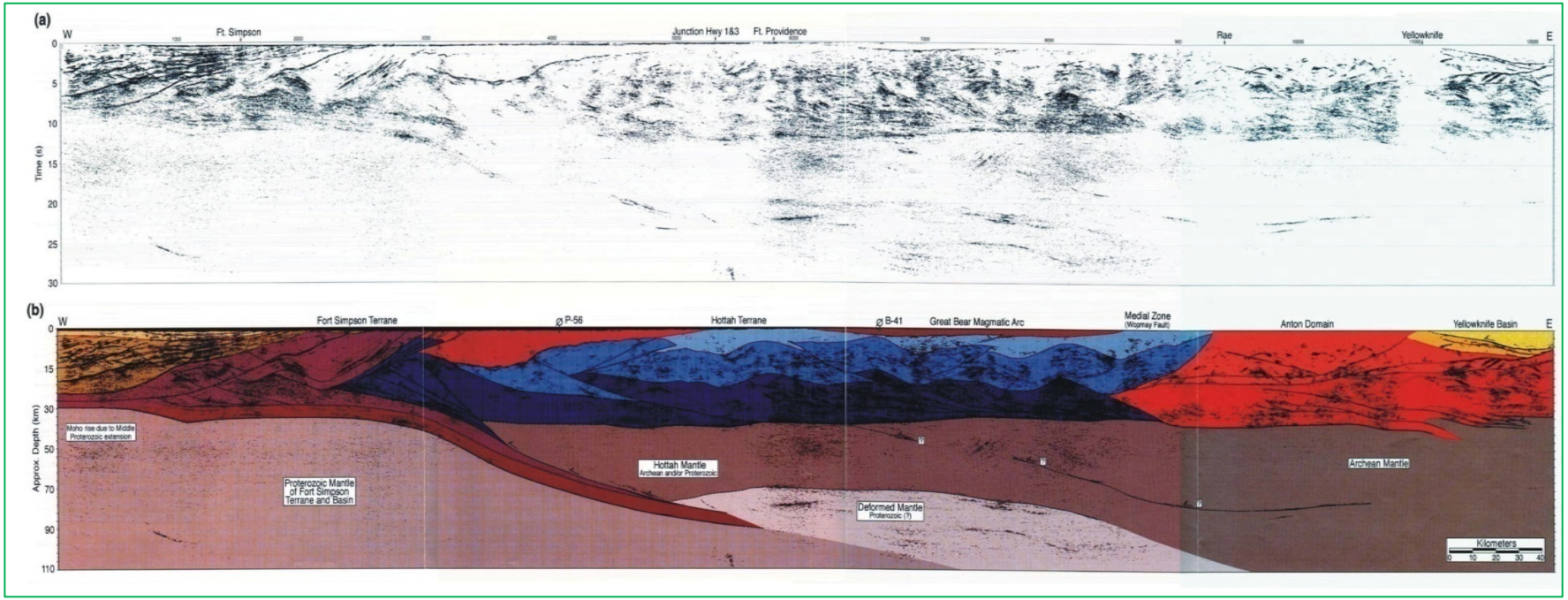
欧洲地球探测计划

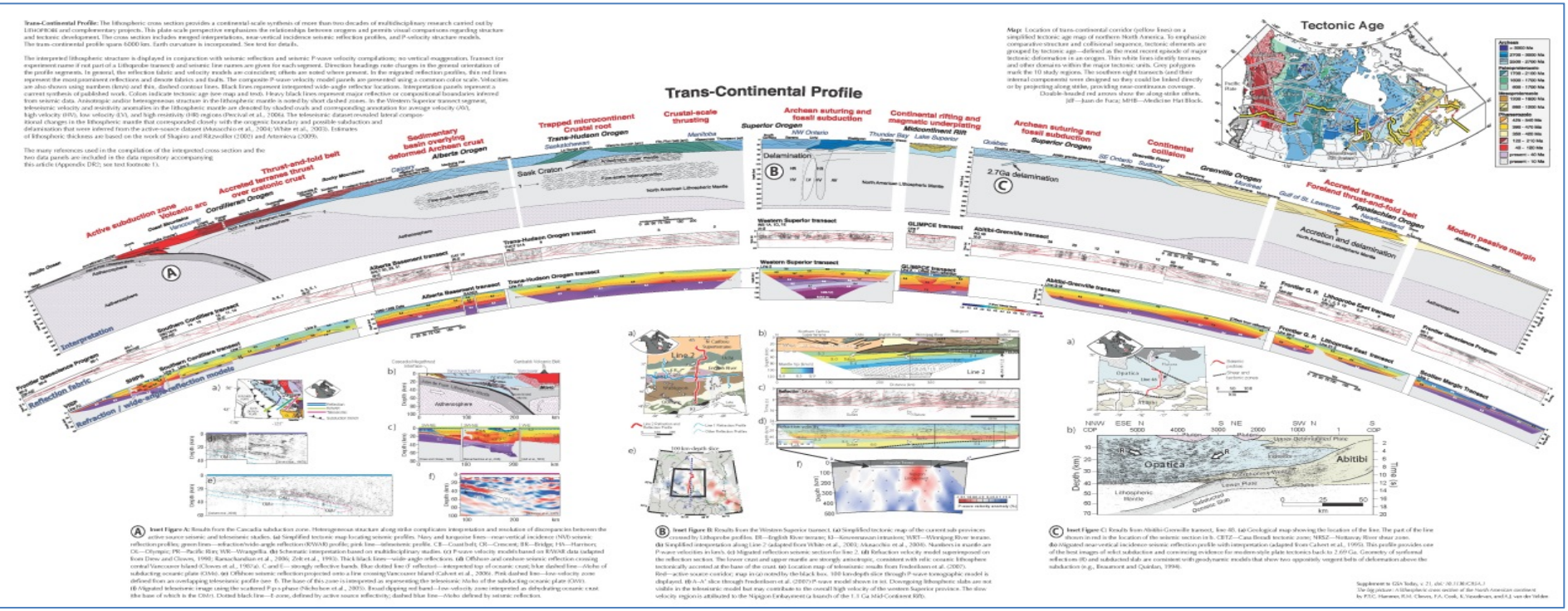
EuroProbe




1322km


F


(a)
W
Ft. Simpson
Junction Hwy 1&3
Ft. Providence
Rae
Yellowknife
E
Time (s)
0
5
10
15
20
25
30
(b)
W
Fort Simpson Terrane
Ø P-56
Hottah Terrane
Ø B-41
Great Bear Magmatic Arc
Medial Zone
(Wopmay Fault)
Anton Domain
Yellowknife Basin
E
Approx. Depth (km)
0
15
30
50
70
90
110
Moho rise due to Middle Proterozoic extension
Proterozoic Mantle of Fort Simpson Terrane and Basin
Hottah Mantle
Archean and/or Proterozoic
Deformed Mantle
Proterozoic (?)
Archean Mantle
Kilometers
0
10
20
30
40



Inset Figure A: Results from the Cascadia subduction zone. Heterogeneous structure along strike complicates interpretation and resolution of discrepancies between the active source seismic and teleseismic studies. **(a)** Simplified tectonic map locating seismic profiles. Navy and turquoise lines—near-vertical incidence (NVI) seismic reflection profiles; green lines—refraction/wide-angle reflection (RWAR) profile; pink line—teleseismic profile. CB—Coast belt; CR—Crescent; HR—Bridge; HA—Harrison; OL—Olympic; PR—Pacific Rim; WR—Wrangellia. **(b)** Schematic interpretation based on multidisciplinary studies. **(c)** P-wave velocity models based on RWAR data (adapted from Drew and Clowes, 1990; Ramachandran et al., 2006; Zelt et al., 1993). Thick black lines—wide-angle reflectors. **(d)** Offshore and onshore seismic reflection crossing central Vancouver Island (Clowes et al., 1987a). C and E—strongly reflective bands. Blue dotted line (F reflector)—interpreted top of oceanic crust; blue dashed line—Moho of subducting oceanic plate (GMt). **(e)** Offshore seismic reflection projected onto a line crossing Vancouver Island (Calvert et al., 2006). Pink dashed line—low-velocity zone defined from an overlapping teleseismic profile (see fi. The base of this zone is interpreted as representing the teleseismic Mohs of the subducting oceanic plate (GWt). **(f)** Migrated teleseismic image using the scattered P-to-s phase (Nicholson et al., 2005). Broad dipping red band—low-velocity zone interpreted as dehydrating oceanic crust (the base of which is the GMt). Dotted black line—E zone, defined by active source reflectivity; dashed blue line—Moho defined by seismic reflection.

Inset Figure B: Results from the Western Superior transect. **(a)** Simplified tectonic map of the current sub provinces crossed by Lithoprobe profiles. ER—English River terrane; KI—Kenoran-ean intrusives; WRT—Winnipeg River terranes. **(b)** Simplified interpretation along Line 2 (adapted from White et al., 2003; Musacchio et al., 2004). Numbers in mantle are P-wave velocities in km/s. **(c)** Migrated reflection seismic section for line 2. **(d)** Refraction velocity model superimposed on the reflection section. The lower crust and upper mantle are strongly anisotropic, consistent with relic oceanic lithosphere tectonically accreted at the base of the crust. **(e)** Location map of teleseismic results from Frederiksen et al. (2007). Red—active source corridor; map in (e) noted by the black box. 100 km-depth slice through P-wave tomographic model is displayed. **(f)** A–A′ slice through Frederiksen et al. (2007) P-wave model shown in (e). Downgoing lithospheric slabs are not visible in the teleseismic model but may contribute to the overall high velocity of the western Superior province. The slow velocity region is attributed to the Nipigon Embayment (a branch of the 1.1 Ga Mid-Continent Rift).

Inset Figure C: Results from Abitibi-Grenville transect, line 88. **(a)** Geological map showing the location of the line. The part of the line shown in red is the location of the seismic section in b. CBTZ—Cana Brouill tectonic zone; NBSZ—Nottaway River shear zone. **(b)** Migrated near-vertical incidence seismic reflection profile with interpretation (adapted from Calvert et al., 1995). This profile provides one of the best images of relict subduction and convincing evidence for modern-style plate tectonics back to 2.69 Ga. Geometry of synformal reflectors (R) and subducted slab are consistent with geodynamic models that show two oppositely vergent belts of deformation above the subduction (e.g., Beaumont and Quinlan, 1994).

Supplement to GSA Today, v. 21, doi: 10.1130/GSAT-1
The Big picture: A lithospheric cross section of the North American continent
by P.T.C. Hammer, R.M. Clowes, F.A. Cook, K. Vasudevan, and E.J. van der Velden

Imaging of lithosphere across the trancontinent

International Cooperation Organizations

Sino-US Cooperation Forum o
Deep Exploration
深部探测中美合作论坛

主办单位：深部探测技术与实验研究专项管理办公室
时　　间：2011年4月28日9:00-12:00
地　　点：中国地质科学院深部探测研究中心（地科院院内西侧）
主 讲 人：董树文 研究员
Leonard E. Johnson 教授
David Simpson 博士
Francis Wu 教授
参加研讨人员： Prof. Walter Mooney（USGS），Dr. Emily Ashworth（NSF），
深部探测技术与实验研究专项（SinoProbe）相关项目负责人、在研人员，欢迎有兴趣的专家、学生参加。

中国深部探测进展
Prof. Dong Shu wen, PI.of SinProbe,Vice President of CAGS
（深部探测技术与实验研究专项负责人，中国地质科学院副院长）

国际地学计划（IGCP）科学执行局委员（2004-至今），IGCP中国全委会秘书长（1999—至今），国际岩石圈中国全委会副秘书长，联合国教科文组织（UNESCO）国际岩溶研究中心理事（2008-），美国地震科学探测联合体（IRIS）外籍委员。长期从事构造地质、深部地质探测研究，在长江中下游、大别山碰撞造山带、东秦岭造山带、大巴山造山带等开展构造变形、深部探测与研究，近年负责开展中国东亚洲东部大地构造演化、燕山运动多向陆内造山机制，亚洲中部及邻区地质图系、亚洲三维地质结构与矿产资源等研究，先后主持20余项国家、省、部级科研项目。

美国国家自然科学基金会大陆动力学计划概况
Prof. Leonard E. Johnson, Program Director, Directorate for Geosciences, Divisionof Earth Sciences, NSF
（美国科学基金会地球学部部大陆动力学项目主任）

美国科学基金会地球学部主要负责大陆、造陆运动块起源、结构、组成、动力学演化等相关学科的综合性研究项目的资助、设立、评估和监督工作，特别侧重于那些集多学科、多方法研究于一体的、多部门联合参与的、中长期规划的大型地学项目的设立和资助工作。其中陆动力学部设立的项目主要有Earth Scope（美国地学透镜计划）、地球物理、岩石与地球化学、构造地质学、地球生物学验设备与设施建设等。

美国地学透镜计划
Dr. David Simpson, President of RS Consortium
（美国地震学研究联合会主席）

从1991年起担任美国地震学研究联合会主席。IRIS的美国境外设立了100多个分支机构，其主要职责是协调、统下，IRIS还负责全美地震学研究实验设备的开发与维护。行的全球地震台网（GSN）、大陆岩石圈地震台阵研究计划（PASSCAL）、NSF的北美地壳结构与演化地球物理精细观测，数据管理系统以及相关教验设施和实验基地，用以资助大学和政府进行地震、地球结构、大陆动力

综合地球动力学研究项目——台湾新造山运动
Prof. Francis Wu，Washington University
（美国华盛顿大学教授）

地震学与构造地球物理学教授，先后参加或主持的研上地幔结构与构造、新西兰及周边地区地壳与上地幔结构地幔结构，曾担任过西太平洋地球物理会议副主席、台湾物理中心（ICTP）讲师等职。

SinoProbe　NSF

NSF & IRIS visitors in Beijing, Apr 26-27, 2011

International symposium of deep exploration into lithosphere-2011.Nov. Beijing

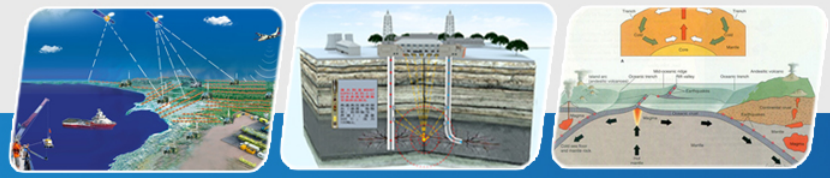
have displayed on platform of AGU, EGU, JGG, SGF and China from 2009-2013

Press conference :
SinoProbe: An Unprecedented View Insight Earth's Largest Continent
AGU Fall Meeting, San Francisco, 2013.12.9.

Jeffery F. Director EarthScope National Office
Tim Ahern, Director of Data Services, IRIS
Hans Thybo, President EGU and ILP
Irina Artemieva, EGU Chair of Geodynamics;
Uli Harms, head of ICDP;
Thomas Secrete-general,ICDP;
Randy Keller ， Oklahoma University.
Frances T. Wu, University of Southern California.
Liu Mian ,Misouli University
Carl Tape, EarthScope; and others

Introduction of Sinoprobe-2

AGU Meeting, 2016.12.15



Thank you for your attention

swdong@nju.edu.cn
swdong@sinoprobe.org