

# International Geoscience Programme

## IGCP-724: 流体地球化学与地震预测

负责人：李 营  
项目秘书：胡 乐 田文君

单 位：中国地震局地震预测研究所



# 报告目录

- 1 项目简介
- 2 年度进展
- 3 年度部分成果介绍
- 4 下一步重点工作

# Accepted by International Geoscience Program Council, UNESCO

## Project 724 Fluid geochemistry and earthquake forecasting

Leader: Ying Li (China) with participating researchers from, Iran, Italy, Turkey and Greece

Fluid geochemistry anomalies can be an effective earthquake precursor. In this project, researchers plan to conduct comparative studies on the fluid geochemistry anomalies in high seismicity areas characterized by recent destructive earthquakes and challenge the use of the geochemistry of fluids in the earthquake forecasting.

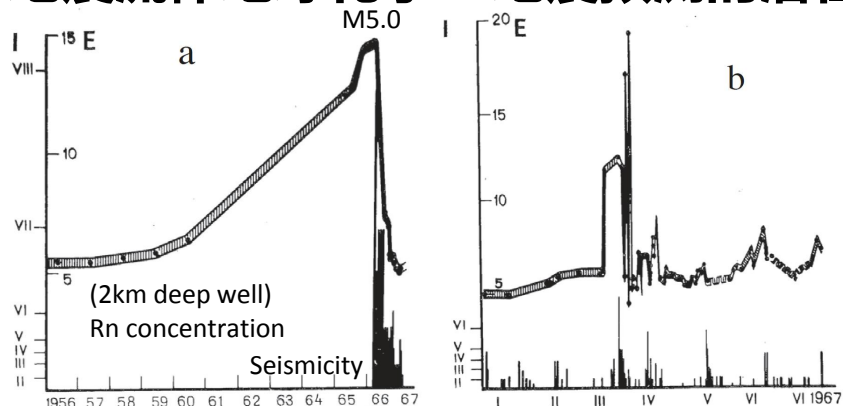


**1.2 IGCP Themes:** For the year 2021, only one special topic has been agreed on during the 6<sup>th</sup> council meeting held in March 2021. This topic is defined as follows: **“Enhancing Societal Acceptance of the Sustainable Development of Earth’s Geological Resources”**.

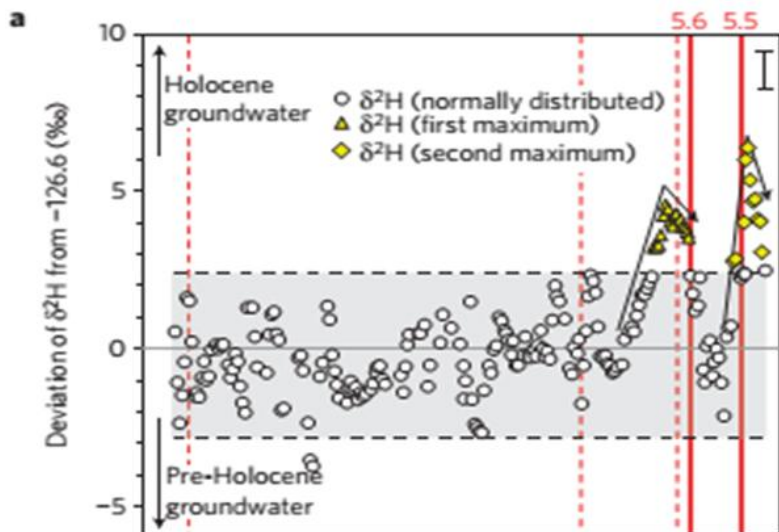
Please read carefully the definitions of the IGCP themes and the 2021 annually defined special topic (listed below) from IGCP 2021 project proposals call indicate the theme(s) which is/are relevant to your project.

- |  |   |                                     |
|--|---|-------------------------------------|
| 1.1 - Earth Resources  | → | <input type="checkbox"/>            |
| 1.2 - Global Change  | → | <input type="checkbox"/>            |
| 1.3 - Geohazards   | → | <input checked="" type="checkbox"/> |
| 1.4 - Hydrogeology   | → | <input type="checkbox"/>            |
| 1.5 - Geodynamic   | → | <input type="checkbox"/>            |
| .....1.6 - 2021 Annually defined special topic:<br><b>Enhancing Societal Acceptance of the Sustainable Development of Earth’s Geological Resources</b> | → | <input type="checkbox"/>            |

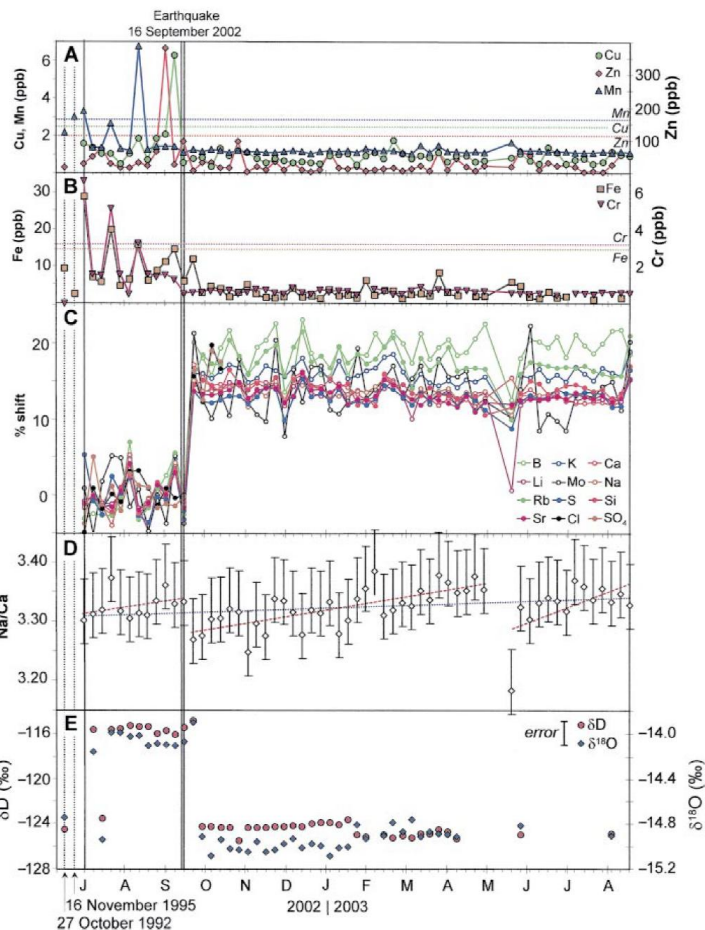
## 地震流体地球化学—地震预测的潜在手段



1966年乌兹别克斯坦塔什干M5.3地震及余震前水氡浓度变化 (Ulomov & Mavashev, 1971, Akad. Nauk SSR)



冰岛2014年5.6, 5.5地震前氢同位素异常 (Skelton et al. (2014))

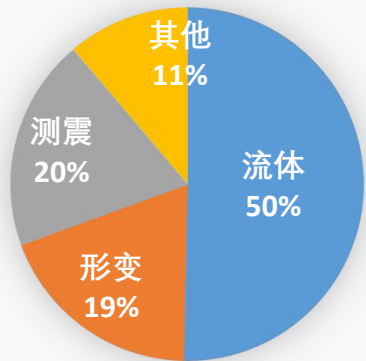


日本神户地震前地下水元素和同位素的同步变化 (Igarashi et al., 1995, Science; Tsunogai & Wakita, 1995, Science)

Claesson et al., 2004, Geology

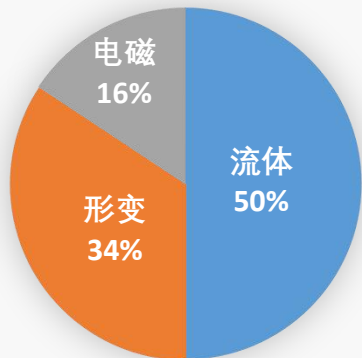
# 项目概要

流体地球化学异常作为地震前兆的主体，是短临预测的有效手段



1966-1999年

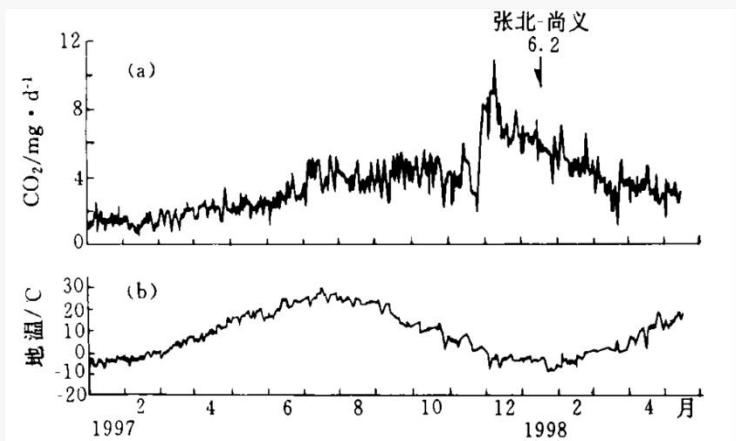
全国 $\geq 5.0$ 级地震异常统计  
(901个)



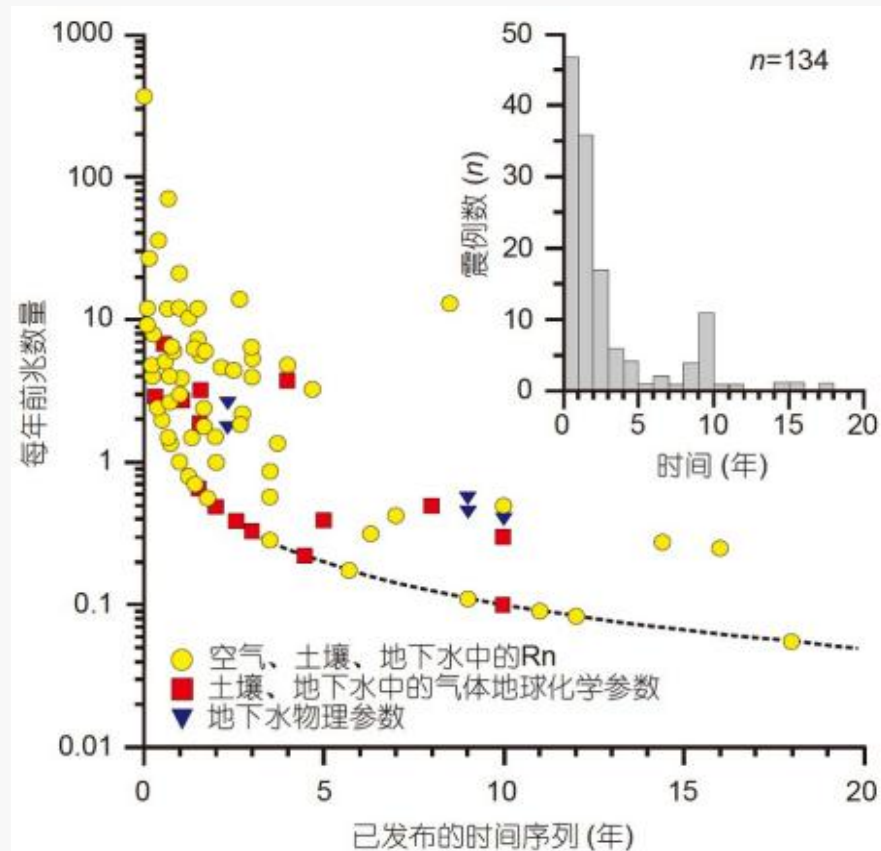
1976-1989年

首都圈 $\geq 5.5$ 级地震异常统计  
(210个)

(车用太, 2004, 北京: 气象出版社)



张北Ms6.2地震前断裂带 $CO_2$ 气体浓度和地温变化 (林元武等., 1998)



1967~2014年全球地震流体地球化学前兆统计图  
(Woith, 2015, *Eur Phys J-Spec Top*)





**项目目标：为受地震灾害影响国家的科研人员提供平台，分享他们在地震活动区地震流体地球化学的监测和研究工作。通过野外调查研究、观测数据（包括历史数据）和监测方法对比，总结地震地球化学异常成因机制，建立地震流体地球化学预测模型，推广运用先进的地震流体监测方法。**

## □ 项目概要

负责人 分别来自**中国、伊朗、意大利、土耳其、希腊、西班牙**



李 营  
中 国



Mohammad Mokhtari  
伊 朗



Antonio Caracausi  
意 大 利



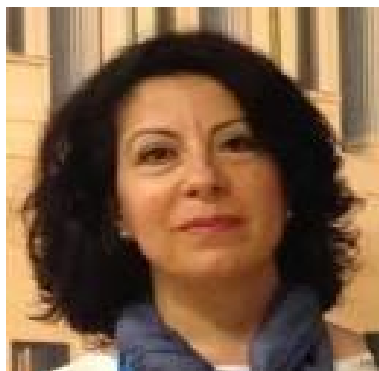
Galip Yuce  
土 耳 其



Paraskevi Nomikou  
希 腊



Giovanni Martinelli  
意 大 利



Nazan YALÇIN ERİK  
土 耳 其



Cristina Crespo Martín  
西 班 牙

# 报告目录

- 1 项目背景
- 2 年度进展
- 3 部分成果展示
- 4 下一步重点工作



## ● 组织召开“中美和全球破坏性地震”线上论坛


### China-US Forum on Recent Damaging Earthquakes of Western China, the USA and Globally

January 6, 2023 at 08:30 AM Beijing Time | January 5, 2023 at 16:30 PM West of US Time

Here is the Zoom meeting link:  
<https://zoom.us/j/96256742636?pwd=eWVlUkNlTlR2K280ZlJaeXZqOHVxQT09>  
 Zoom Meeting ID: 962 5674 2636 • Passcode: 746261

#### Schedule of Forum

Beijing time	West of US time	Topics	Speakers	Conveners
08:30-08:35	16:30-16:35	Welcoming speech of China side	Dr. Ying Li <i>IEF, CEA</i>	Dr. Guojie Meng <i>IEF, CEA</i>
08:35-08:40	16:35-16:40	Welcoming speech of US side	Dr. Walter D. Mooney <i>USGS</i>	
08:40-09:05	16:40-17:05	Shallow slip and surface rupture: critical factors of earthquake damage	Dr. Hongfeng Yang <i>CUHK</i>	Dr. Guojie Meng <i>IEF, CEA</i>
09:05-09:30	17:05-17:30	A Shallow Slip Event: The 2020 $M_{w}$ 5.1 Sparta North Carolina Earthquake	Dr. Fred F. Pollitz <i>USGS</i>	
09:30-09:55	17:30-17:55	How to define the types of earthquake-triggered landslides in Western China: Insight into several recent deadly cases	Dr. Yueren Xu <i>IEF, CEA</i>	Dr. Guojie Meng <i>IEF, CEA</i>
09:55-10:20	17:55-18:20	The 2019 $M_{w}$ 4 and $M_{w}$ 1 Ridgecrest, California Earthquake Sequence	Dr. Josie Nevitt <i>USGS</i>	
10:20-10:45	18:20-18:45	Hydrogeochemical short-term seismic precursor anomalies of hot springs before foreshock $M_{w}$ 5.8 earthquake along the Xianshuhe Fault Zone, southeastern Tibet Plateau	Dr. Xiaocheng Zhou <i>IEF, CEA</i>	Dr. Walter D. Mooney <i>USGS</i>
10:45-11:10	18:45-19:10	Crustal Stress and Earthquake Focal Mechanisms: New Insights	Dr. Jeanne Hardebeck <i>USGS</i>	
11:10-11:35	19:10-19:35	Fault source model and stress changes of the 2021 $M_{w}$ 7.4 Maduo earthquake, western China, constrained by InSAR and GPS measurements	Dr. Shunying Hong <i>IEF, CEA</i>	Dr. Guojie Meng <i>IEF, CEA</i>
11:35-12:00	19:35-20:00	The November 21, 2022 $M_{w}$ 5 Cianjur, Java, Indonesia Earthquake (336 Fatalities)	Dr. Walter D. Mooney <i>USGS</i>	
12:00-12:25	20:00-20:25	Pervasive low-velocity layer atop the mantle transition zone around China	Dr. Guohui Li <i>IEF, CEA</i>	

CEA: China Earthquake Administration  
 IEF: Institute of Earthquake Forecasting  
 USGS: United States Geological Survey  
 CUHK: The Chinese University of Hong Kong

Guidance: China Earthquake Administration, United States Geological Survey  
 Host in China: Institute of Earthquake Forecasting, China Earthquake Administration  
 Host in USA: United States Geological Survey.


### China-US Forum on Recent Damaging Earthquakes of Western China, the USA and Globally





**Dr. Hongfeng Yang, CUHK**  
 Dr. Yang is an associated professor in the Earth and Environmental Sciences Programme at The Chinese University of Hong Kong (CUHK). His research interests include earthquake source physics, subduction zone dynamics, fault zone structure and evolution, and induced earthquakes.



**Dr. Yueren Xu, IEF, CEA**  
 Dr. Xu is a geologist whose research focuses on the historical and current earthquake-triggered landslides and liquefaction using both Remote Sensing and fieldwork checking in West China and Loess Plateau.



**Dr. Xiaocheng Zhou, IEF, CEA**  
 Dr. Zhou is a geochemist. His research interests are short-term Earthquakes Prediction, spatial and temporal changes of fluid geochemistry in the Qinghai-Tibet Plateau by means of hydrogeochemistry, noble gas geochemistry and stable isotope geochemistry.



**Dr. Shunying Hong, IEF, CEA**  
 Dr. Hong is a geodesist whose research focuses on InSAR/GPS deformation measurement and geophysical inversion.



**Dr. Guohui Li, IEF, CEA**  
 Dr. Li is an associate professor in geophysics with special interests in deep Earth structure and dynamics.



**Dr. Fred Pollitz, USGS**  
 Dr. Fred Pollitz is a research geophysicist with the USGS Earthquake Science Center in Moffett Field, California. He analyzes seismic and geodetic data to study the earthquake source and the elastic properties of the crust.



**Dr. Josie Nevitt, USGS**  
 Dr. Josie Nevitt is a research geologist at the USGS Earthquake Science Center in Moffett Field, California. She analyzes evidence for surface ground deformation due to shallow crustal earthquakes and relates these to the earthquake source.



**Dr. Jeanne Hardebeck, USGS**  
 Dr. Jeanne Hardebeck is an earthquake seismologist with the USGS Earthquake Science Center in Moffett Field, California. She investigates earthquake source properties and crustal stress using seismic focal mechanisms and inversion techniques.

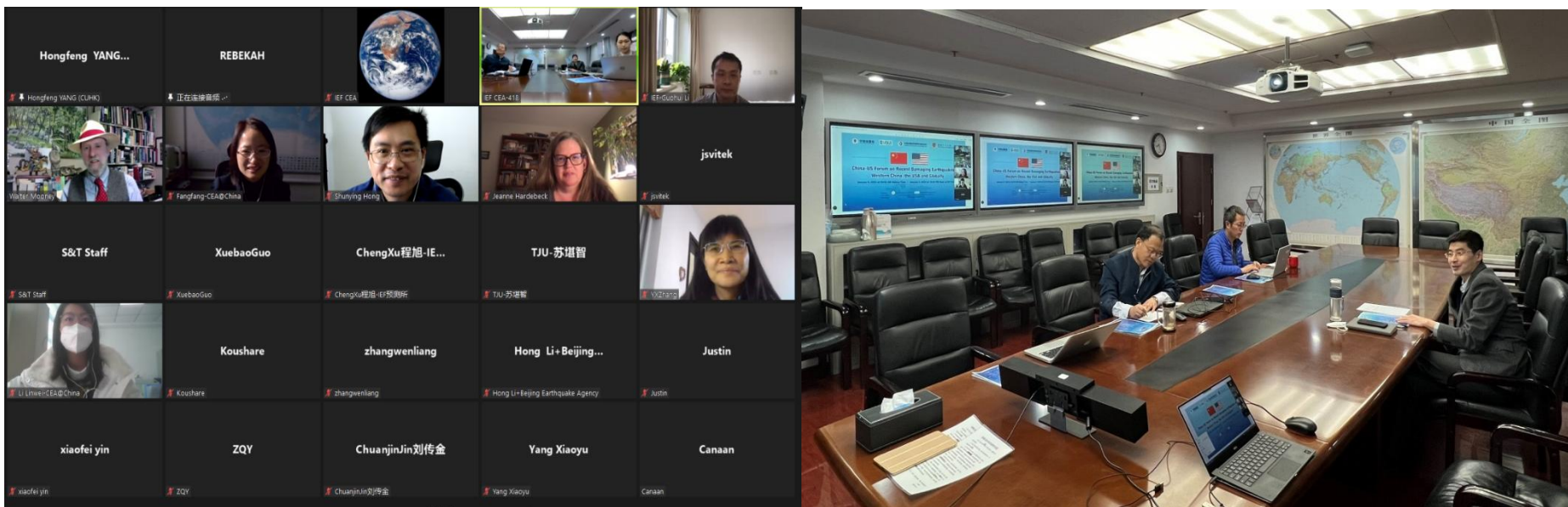


**Dr. Walter D. Mooney, USGS**  
 Dr. Walter D. Mooney is a research geophysicist and the USGS coordinator of the China-US Protocol for Earthquake and Volcano Studies. His office is located in Menlo Park, California. He studies the properties of the Earth's lithosphere, as well as earthquakes and tsunamis.

Zoom Meeting ID: **962 5674 2636**      Passcode: **745261**

论坛聚焦近期地震实例，双方9位专家学者进行报告交流，共3700多名科研人员线上参会

## ● 组织召开“中美和全球破坏性地震”线上论坛



学术活动促进了中美在地震科考、地震致灾机理、前兆成因等方面的研究合作，推动双方在地震科学、地震预测和防震减灾领域取得更丰富的研究成果。

## ● 举办土耳其“双震”震后研讨会

➤ 发震断层探讨

➤ 地震灾害初步评估

➤ 土耳其国际地震科考方案



### International Symposium on 6<sup>th</sup> February 2023 Turkiye earthquakes under the initiative of IGCP-724 project

2<sup>nd</sup> March 2023 at 14:00 PM Beijing Time | 2<sup>nd</sup> March 2023 at 09:00 AM Ankara Time | 2<sup>nd</sup> March 2023 at 07:00 AM European Time

Here is the ZOOM meeting room link:  
<https://zoom.us/j/98538876616?pwd=UTBJV1QxbHUwS0dLbDUwOUhVZlZz09>  
 Zoom Meeting ID: 985 3887 6616 · Passcode: 911959 · Venue: 418 Meeting Room, IEF, CEA

#### Schedule of Symposium

Beijing Time	Ankara Time	European Time	Topics	Speakers	Conveners
14:00-14:10	09:00-09:10	07:00-07:10	Opening Address	Division of Technology and International Cooperation, CEA	Prof. Dr. Ying Li IEF, CEA
14:10-14:35	09:10-09:35	07:10-07:35	The importance of monitoring gas and fluids geochemistry for East Anatolian Fault Zone and Hatay Province	Prof. Dr. Galip Yuce HU	
14:35-14:55	09:35-09:55	07:35-07:55	Neotectonics of Eastern Mediterranean	Prof. Dr. Bora Rojay METU	
14:55-15:15	09:55-10:15	07:55-08:15	Miocene-Quaternary Tectonic, Kinematic and Sedimentary Evolution of the Eastern Mediterranean Taurides and Offshore	Prof. Dr. Cenk Yaltirak ITU	Prof. Dr. Guojie Meng IEF, CEA
15:15-15:35	10:15-10:35	08:15-08:35	Field investigation and numerical analysis on damage to buildings and Antakya city in Turkey-Syria M7.8 Earthquake	Prof. Dr. Xuchuan Lin IEM, CEA	
15:35-15:55	10:35-10:55	08:35-08:55	Investigation of damage from remote sensing images in Turkey M7.8 Earthquake	Prof. Dr. AiXia Dou IEF, CEA	Prof. Dr. Guojie Meng IEF, CEA
15:55-16:15	10:55-11:15	08:55-09:15	Analysis of the impact of destructive earthquakes on infrastructure crossing faults in Türkiye	Prof. Dr. Aiwen Liu IGP, CEA	
16:15-16:35	11:15-11:35	09:15-09:35	Comparisons of the 2023 Turkey earthquake and recent large earthquakes in China	Dr. Jingxing Yu IG, CEA	
16:35-16:55	11:35-11:55	09:35-09:55	Introduction to A Guidebook to Earthquake Scientific Investigation	Dr. Tai Liu IEF, CEA	Prof. Dr. Galip Yuce HU
16:55-17:15	11:55-12:15	09:55-10:15	Combined geophysical, geochemical, and seismological observations along active strike-slip faults: the North-Anatolian and Dead Sea faults case studies	Prof. Dr. Luca Gasperini INRC	
17:15-17:35	12:15-12:35	10:15-10:35	Fluids geochemistry over seismic-prone areas	Prof. Dr. Francesco Italiano INGV	Prof. Dr. Ying Li IEF, CEA & Prof. Dr. Galip Yuce HU
17:35-18:00	12:35-13:00	10:35-11:00	Discussion, closing remarks and future plans		

**CEA:** China Earthquake Administration.  
**IEF:** Institute of Earthquake Forecasting.  
**IGP:** Institute of Geophysics.  
**IG:** Institute of Geology.  
**IEM:** Institute of Engineering Mechanics.  
**HU:** Hacettepe University (Ankara, Türkiye).

**METU:** Middle East Technical University (Ankara, Türkiye).  
**ITU:** Istanbul Technical University (Istanbul, Türkiye).  
**INRC:** Italian National Research Council, Italy.  
**INGV:** National Institute of Geophysics and Volcanology, Italy.

**Organizers:**  
 Institute of Earthquake Forecasting (IEF), China Earthquake Administration (CEA)  
 Hacettepe University (Ankara, Turkey)



# 会议

## ● 举办土耳其“双震”震后研讨会



研讨会得到了中国地震局科技与国际合作司的大力支持，来自中国、土耳其、意大利、伊朗、西班牙及我国台湾地区2200余名研究人员线上或线下参会。



## ● 项目组参加中国地震局土耳其“双震”震后科学考察



➤ 沿破裂带砂土液化观测

➤ 温泉水样16件

➤ 温泉气样4件

➤ 土壤气体测量37处





## ● 召开项目年度启动会

### The First plenary of IGCP-724 in 2023 was held

Date: July 19, 2023 | [ ▲ ▲ ▲ ] [Print] [Close]

The first plenary of IGCP-724 project "Fluid geochemistry and earthquake forecasting" in 2023 was held online on June 14, 2023.

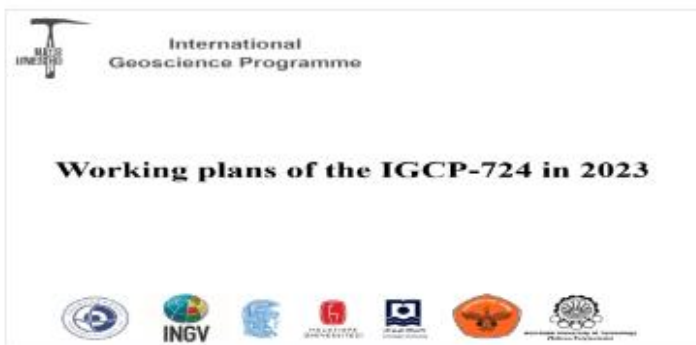
All leaders discussed the current progress of the project, the problems project encountered in the past and corresponding solutions, and work plans for the project this year. After discussion, leaders and participants all agree to make every effort to ensure the implementation of the project and meet the requirements the Committee.

To enhance the connections among the research teams, all leaders decided to hold a meeting once a month by the end of this year, an expert will be invited to make an academic presentation on each meeting.

➤ 总结已有成果

➤ 明确年度计划

➤ 完善项目整体实施方案



## ● 举办第二届培训班课程—暨中国地质调查局“发展中国家地质调查信息化技术培训班”

The screenshot displays a Zoom meeting interface. The main window shows a presentation slide titled "Seismic fluid geochemistry of active fault zone and fluid model building" by Li Ying, dated November 16, 2023. The slide includes logos for IGCP-724 and the Institute of Earthquake Forecasting, China Earthquake Administration. A sidebar on the left lists participants from various countries, including Uganda, China, Zimbabwe, and Laos. Below the main window, a smaller window shows a photograph of a laboratory with the caption "Inert gas isotope" and "INGV, Italy".

**IGCP-724 project and training course**

Ying Li; Antonio Caracausi; Mohammad Mokhtari; Galip Yuce; Paraskevi Nomikou; Giovanni Martinelli

**Seismic fluid geochemistry of active fault zone and fluid model building**

Li Ying  
Institute of Earthquake Forecasting, China Earthquake Administration  
November 16, 2023

**Inert gas isotope**

INGV, Italy

**Object of study**

- Geothermal water
- Hot spring gas
- Soil gas

**Foreword | Method | Monitoring | Mechanism | Application | Prospect**

- Element composition
- Isotopic composition
- Fluid flux and emission
- Temperature of geothermal reservoir
- Circulation depth
- Water-rock reaction
- Migration process
- ...

**Spatial-temporal revolution features of fluid**

- Source and supply channel of fluid
- Relationship between fluid and seismicity
- Influence of fluid on environment
- Relationship between fluid and tectonic settings
- Geochemistry, geophysics, petrology, tectonic geology ...

Du Jianguo et al., 2018

培训课程持续约3小时，80余名国外学者参与了此次培训课程。

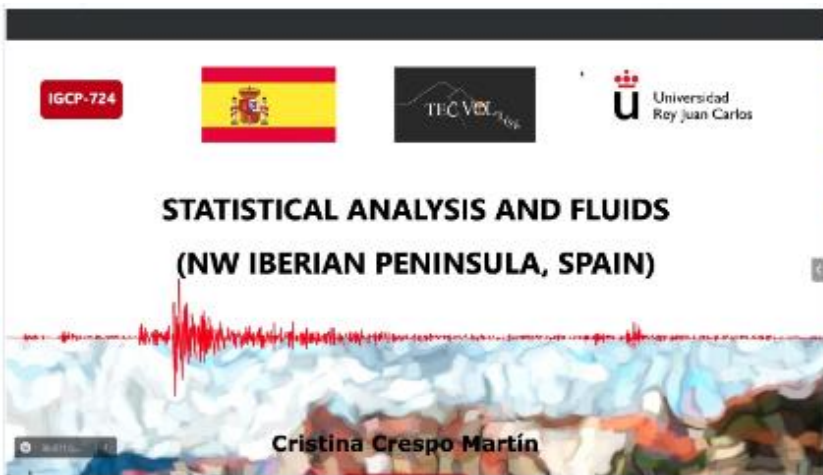
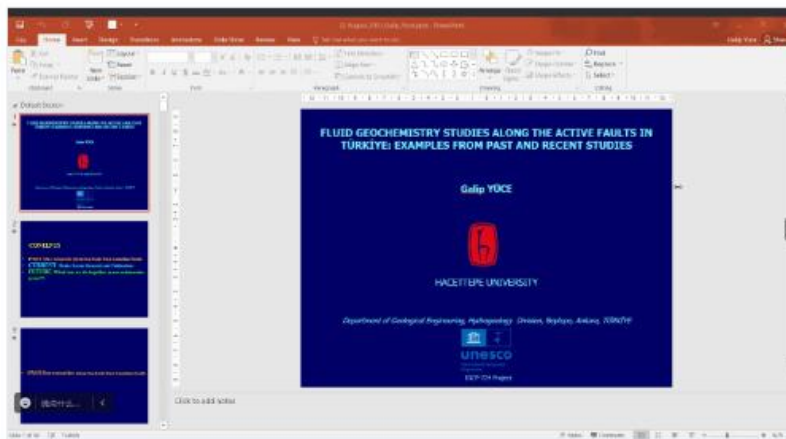
## ● 项目组月度例会

### Monthly presentations by Galip Yüce and Cristina Crespo

Date: October 16, 2023 | [A A A] [Print] [Close]

In order to keep up on the progress of each group of the IGCP-724, and find new ways of cooperations, monthly sharing meeting was suggested to be held by all leaders.

- 分享最新成果
- 掌握项目进度
- 寻求深入合作切入点



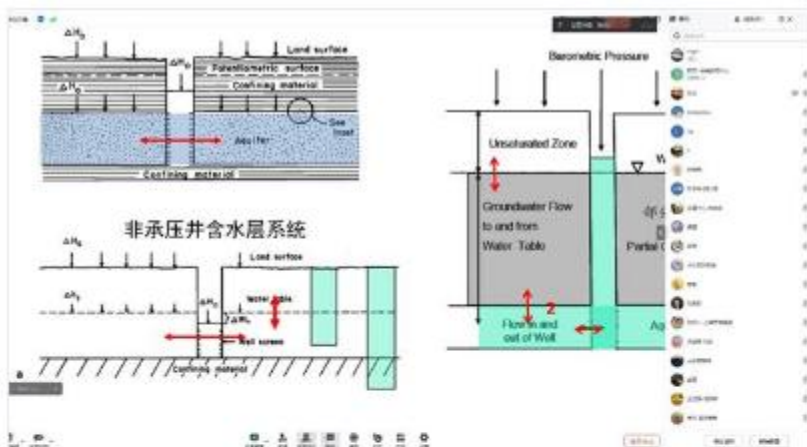


## ● 地震科普讲堂



Home About Leaders Participants Meetings Publications Links Contact

Science popularization was held within the frame of IGCP-724

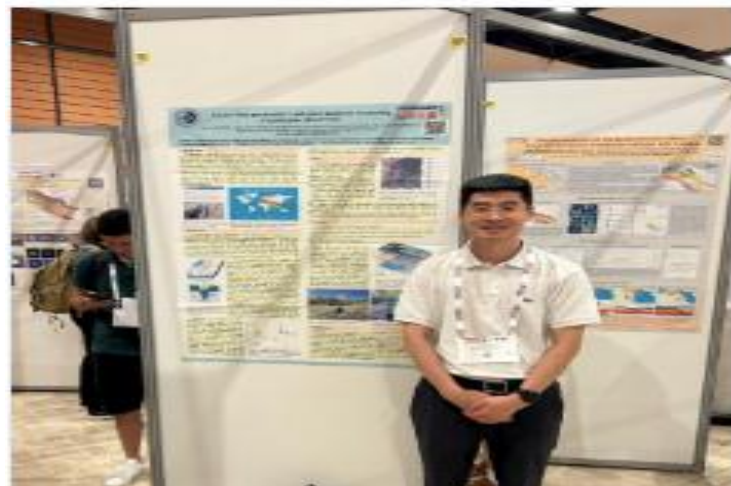
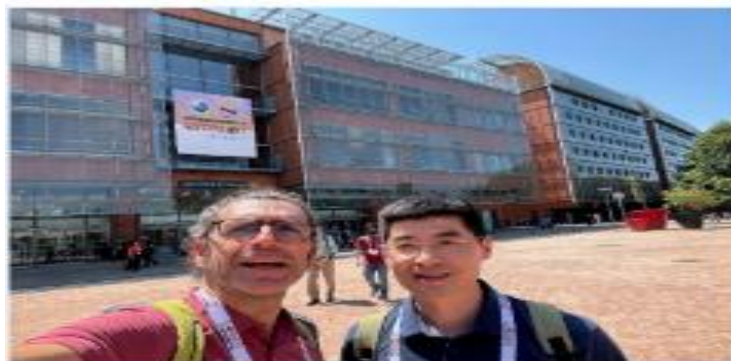


## ● 国际学术交流会议



Home About Leaders Participants Meetings Publications Links Contact

Project leaders Ying Li and Antonio Caracausi attended the Goldschmidt Conference 2023



# 网站运行

- 及时更新项目最新信息  
保障网站正常运行

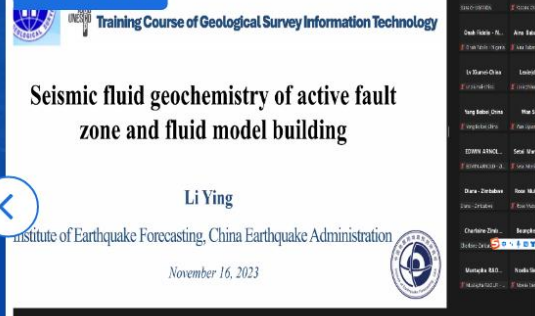
<https://www.ief.ac.cn/IGCP724/>



[Home](#) [About](#) [Leaders](#) [Participants](#) [Meetings](#) [Publications](#) [Links](#) [Contact](#) 

## NEWS

Nov 17, 2023



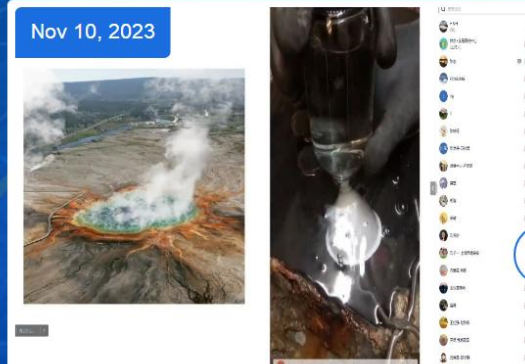
The second training course under the IGCP-724 project frame was held On November 6, 2023.

Nov 15, 2023



Project Leader Galip Yüce was interviewed by a Famous Media/Newspaper in Turkiye

Nov 10, 2023



Science popularization was held within the frame of IGCP-724



# 项目申请

- 获批国家重点研发计划课题—“巴颜喀拉活动地块强震高危险区短临预测研究”，总经费448.66万元。

课题编号：2023YFC3012005

密 级：公开

## 国家重点研发计划 课题任务书

课题名称： 巴颜喀拉活动地块强震高危险区短临预测研究

所属项目： 巴颜喀拉活动地块强震从集机制与高危险区预测

所属专项： 重大自然灾害防控与公共安全

项目牵头承担单位： 中国地震局地质研究所

课题承担单位： 中国地震局地震预测研究所

课题负责人： 李营

执行期限： 2023年11月至2025年10月



中华人民共和国科学技术部制

2023年11月23日



项目牵头承担单位（甲方）： 法定代表人签字（签章）： 	 2023年12月5日
项目负责人签字（签章）： 	2023年12月5日
课题承担单位（乙方）： 法定代表人签字（签章）： 	 2023年11月30日
课题负责人签字（签章）： 	2023年11月30日

## □ 发表文章

---

1. *Martinelli G, Pierotti L, Facca G, and Gherardi F. (2023). Geofluids as a possible unconventional tool for seismic hazard assessment. Front. Earth Sci. 2023, 11:1286817. [https://doi: 10.3389/feart.2023.1286817](https://doi.org/10.3389/feart.2023.1286817)*
2. *Martín-González F, Crespo-Martín C, Cesca S, González-Muños S. (2023). Understanding seismicity and seismotectonics in a stable continental region (NW Iberian Peninsula): Implications for the nature of intraplate seismicity. Glob Planet Change. 227: 104177. <https://doi.org/10.1016/j.gloplacha.2023.104177>*
3. *Yasin, D., Yüce, G. (2023) "Isotope and hydrochemical characteristics of thermal waters along the active fault zone (Erzin-Hatay/Turkey) and their geothermal potential," Turkish Journal of Earth Sciences, 2023, 32 (6): 2. <https://doi.org/10.55730/1300-0985.1871>.*
4. *Caracausi A, Camarda M, Chiaraluce L, De Gregorio S, Favara R, Pisciotta F A. (2023). A novel infrastructure for the continuous monitoring of soil CO<sub>2</sub> emissions: A case study at the Alto Tiberina Near Fault Observatory in Italy. Front. Earth Sci. 2023, [https://doi: 10.3389/feart.2023.1172643](https://doi.org/10.3389/feart.2023.1172643).*
5. *Li Y, Chen Z, Sun AH, Liu ZF, Caracausi A, Martinelli Giovanni, Lu C. (2023). Geochemical features and seismic imaging of the tectonic zone between the Tibetan Plateau and Ordos Block, central northern China. **Chemical Geology**, 622, 121386. <https://doi.org/10.1016/j.chemgeo.2023.121386>*
6. *Tian J, Stefánsson A, Li Y, Li L, Xing L, Li Z, Li Y, Zhou X. (2023). Geochemistry of thermal fluids and the genesis of granite-hosted Huangshadong geothermal system, Southeast China. *Geothermics*, 2023, 109: 102647.*
7. *Liu J, Zhou X\*, Li Y\*, He M, Li J, Dong J, Tian J, Yan Y, Ouyang S and Liu F. (2023). Relationship between hydrogeochemical characteristics of hot springs and seismic activity in the Jinshajiang fault zone, Southeast Tibetan Plateau. *Front. Earth Sci.* 2023, 10:1015134. [https://doi: 10.3389/feart.2022.1015134](https://doi.org/10.3389/feart.2022.1015134).*
8. *Ding Z, Zhou X\*, Wang C\*, Li J, He M, Tian J, Saimaiernaji K, Zhu C, Yan W, Ma R, Li X, Li N, Liang H, Zhang T, Dong J. (2023). Hydrogeochemical characterization and precursor anomalies of hot springs in the North Tianshan orogen. **Applied Geochemistry**, 158:105813.*

## □ 发表文章

9. He P, Zhang H, Li S, Zhou X, Zhou X\*, He M, Tian J, Zhang Y, Wu Z, Chen T, Liu Y, Aldahan A, Huang Y\*. *Geological and hydrochemical controls on water chemistry and stable isotopes of hot springs in the Three Parallel Rivers Region, southeast Tibetan Plateau: The genesis of geothermal waters. **Science of The Total Environment**, 2024, 906:167648.*
10. Bai Y, Shi Z\*, Zhou X\*, Wu C, Wang G, He M, Li J, Dong J, Tian J, Yan Y, Liu F, Ouyang S, Yao B, Wang Y, Zeng Z, Kong X. (2023). *Gas geochemical evidence for the India-Asia lithospheric transition boundary near the Karakorum fault in western Tibet. **Chemical Geology**, 639:121728.*
11. Zhang F, Li Y\*, Zhou X\*, Huang T, Tian J, Cheng Y, Zhao Y. (2023). *Geochemical behaviors of rare earth elements in granite-hosted geothermal systems in SE China. **Geothermics**, 115:102826.*
12. Liang J, Yu Y, Shi Z\*, Li Z, Huang Y, Song H, Xu J, Wang X, Zhou X, Huang L, Luo Z, Tong J, Zhai W. (2023). *Geothermal Springs with High  $\delta^{13}\text{C}_{\text{CO}_2}$ -DIC along the Xianshuihe Fault, Western Sichuan, China: A Geochemical Signature of Enhanced Deep Tectonic Activity, **Journal of Hydrology**, 623: 129760. <https://doi.org/10.1016/j.jhydrol.2023.129760>.*
13. Luo Z B, Zhou X C, He M, Liang J L, Li J C, Dong J Y, Tian J, Yan Y C, Li Y, Liu F L, Ouyang S P, Liu K Y, Yao B Y, Wang Y W, Zeng Z J. (2023). *Earthquakes evoked by lower crustal flow: Evidence from hot spring geochemistry in Lijiang-Xiaojinhe fault. **Journal of Hydrology**, 619, 129334. <https://doi.org/10.1016/j.jhydrol.2023.129334>.*
14. Tian J, Zhou X C, Yan Y C, He M, Li J C, Dong J Y, Liu F L, Ouyang S P, Li Y, Tian L, Wang Y C, Huang T M, Pang Z H. (2023). *Earthquake-induced impulsive release of water in the fractured aquifer system: Insights from the long-term hydrochemical monitoring of hot springs in the Southeast Tibetan Plateau. **Applied Geochemistry**, 148, 105553. <https://doi.org/10.1016/j.apgeochem.2022.105553>.*
15. Tang J, Zhou X C, Zhang Y X, Tian J, He M, Li J C, Dong J Y, Yan Y C, Liu F L, Ouyang S P, Liu K Y. (2023). *Hydrogeochemistry of Fault-Related Hot Springs in the Qaidam Basin, China. **Applied Sciences**, 13(3), 1415. <https://doi.org/10.3390/app13031415>.*

## □ 发表文章

16. Liu F L, Zhou X C, Dong J Y, Yan Y C, Tian J, Li J C, Ouyang S P, H M, Liu K Y, Yao B Y, Wang Y W, Zeng Z J, Li Y. (2023). Soil gas CO<sub>2</sub> emissions from active faults: A case study from the Anninghe-Zemuhe Fault, Southeastern Tibetan Plateau, China. *Frontiers in Earth Science*, 1117862.
17. Sun Y T, Zhou X C, H M, Yan Y C, Tian J, Li J C, Dong J Y, Zhang Y. (2023). Geochemical characteristics and water quality assessment of trace elements in geothermal springs in the Gulu-Yadong rift, Tibetan Plateau. *Geothermics*, 111, 102720. <https://doi.org/10.1016/j.geothermics.2023.102720>
18. Wang Y C, Zhou X C, Tian J, Zhou J L, H M, Li J C, Dong J Y, Yan Y C, Liu F L, Yao B Y, Wang Y W, Zeng Z J, Liu K Y, Li L W, Li Z P, Xing L T. (2023). Volatile characteristics and fluxes of He-CO<sub>2</sub> systematics in the southeastern Tibetan Plateau: Constraints on regional seismic activities. *Journal of Hydrology*, 617, 129042. <https://doi.org/10.1016/j.jhydrol.2022.129042>
19. Zhao D Y, Zhou X C, Zhang Y X, H M, Tian J, Shen J F, Li Y, Qiu G L, Du F, Zhang X M, Yang Y, Zeng J, Rui X L, Liao F, Guan Z J. (2023). Hydrogeochemical Study of Hot Springs along the Tingri-Nyima Rift: Relationshi between Fluids and Earthquakes. *Water*, 15(8), 1634. <https://doi.org/10.3390/w15081634>
20. Liu Z, Chen Z, Li Y, Du P, Zhao Y, Lei L, Lu C, Huangfu R. (2023). Degassing of soil gas radon and its implication to fault activity in the western margin of the Ordos Block, China. *Terra Nova*, 1–10. <https://doi.org/10.1111/ter.12695>.
21. Lu C, Zhou X, Chen Z, Liu Z F, Li Y et al. (2023). Earthquake geochemical scientific expedition and research. *Earthquake Research Advances*, 3, 100239. <https://doi.org/10.1016/j.eqrea.2023.100239>. Constraints on geological structures and dynamics along the Tian
22. Wang s, Zhou X, Tian J, He M et al. (2023). Shan-Pamir orogenic belt with helium isotopes in hot springs. *Applied Geochemistry*, 160, 105859.

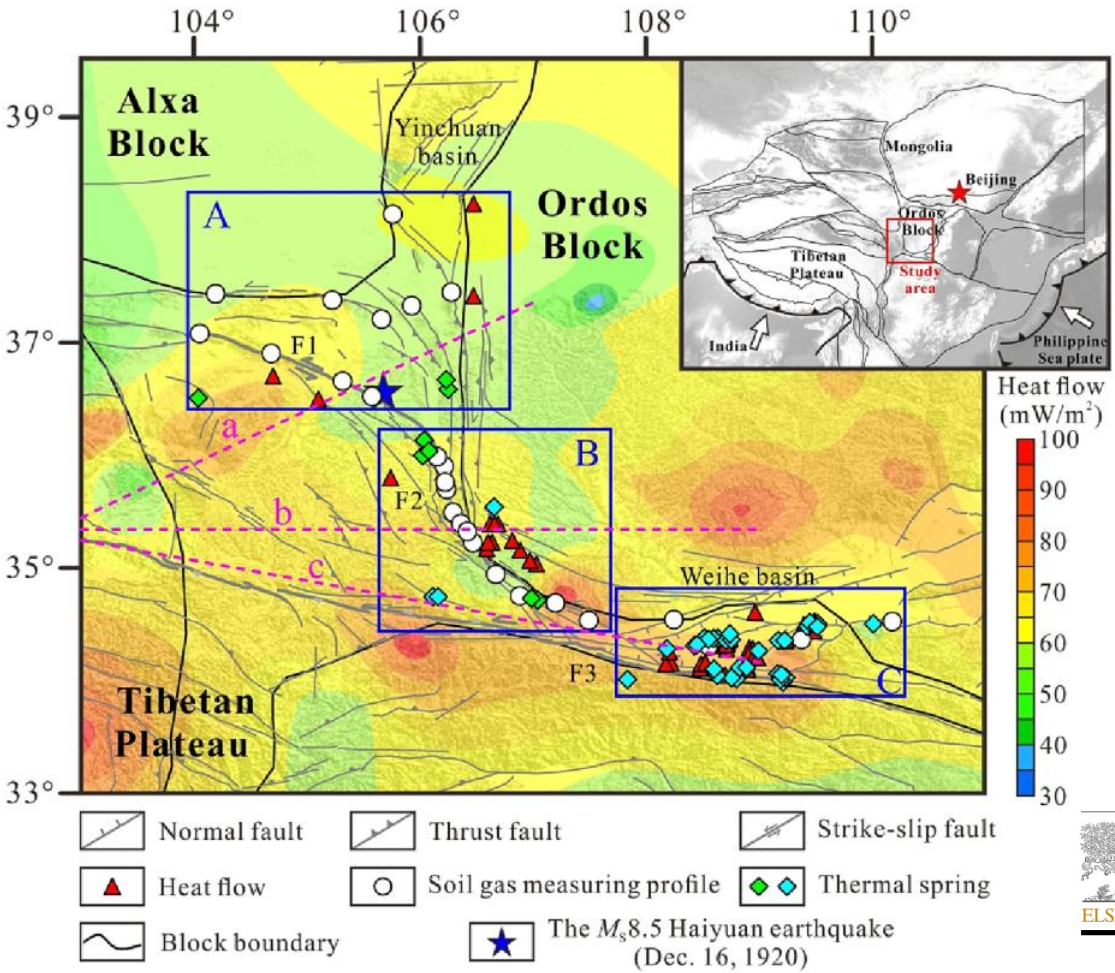
本年度，共发表论文SCI 21 篇，在《地震地质》期刊组织专辑一部

# 报告目录

- 1 项目概要
- 2 年度进展
- 3 部分成果展示
- 4 下一步重点工作



# 一、青藏高原与鄂尔多斯地块构造接触带地震及地球化学特征





26个剖面  
 CO<sub>2</sub>的浓度测点508个  
 通量测点92个  
 温泉气体样品8件

Contents lists available at [ScienceDirect](http://ScienceDirect)

**Chemical Geology**

journal homepage: [www.elsevier.com/locate/chemgeo](http://www.elsevier.com/locate/chemgeo)

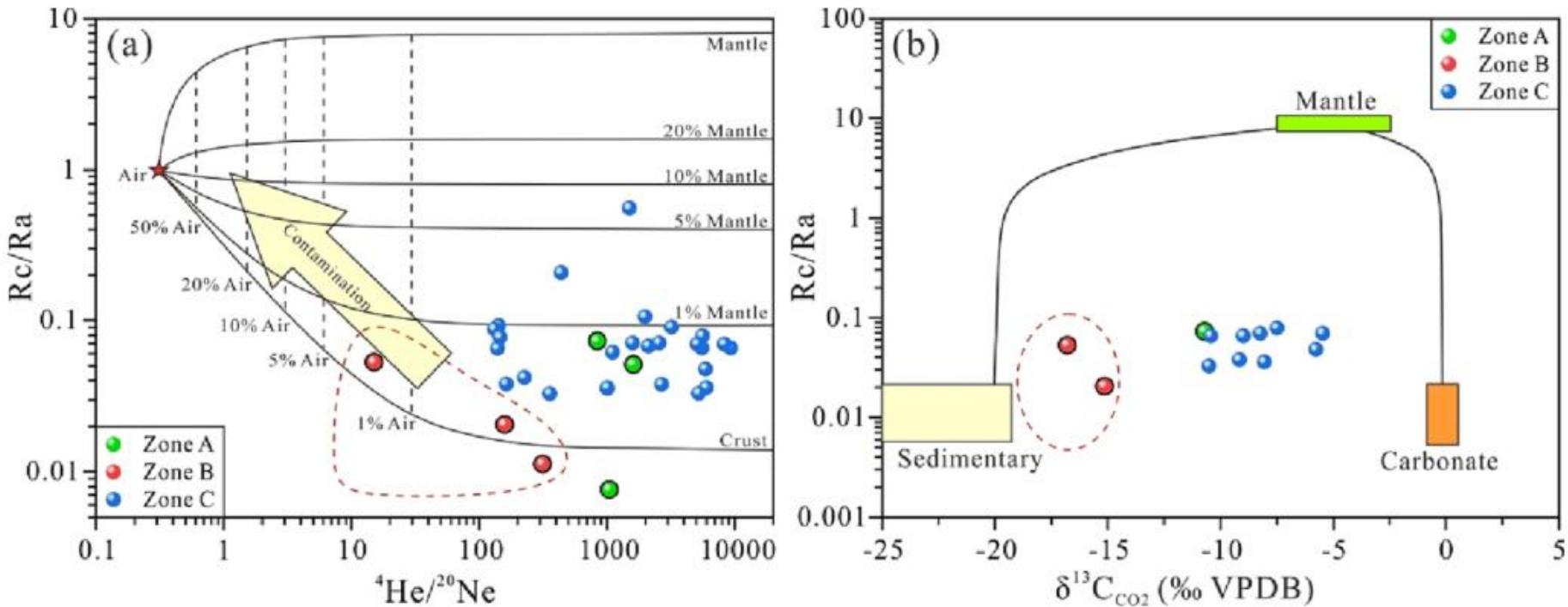
Geochemical features and seismic imaging of the tectonic zone between the Tibetan Plateau and Ordos Block, central northern China

Ying Li<sup>a</sup>, Zhi Chen<sup>a,\*</sup>, Anhui Sun<sup>a</sup>, Zhaofei Liu<sup>b</sup>, Antonio Caracausi<sup>c</sup>, Giovanni Martinelli<sup>c</sup>, Chang Lu<sup>a</sup>

<sup>a</sup> Key Laboratory of Earthquake Prediction (Institute of Earthquake Forecasting, China Earthquake Administration), Beijing 100036, China  
<sup>b</sup> School of the Earth and Resources, China University of Geosciences, Beijing 100083, China  
<sup>c</sup> INGV-National Institute of Geophysics and Volcanology Dept. of Palermo, Palermo 90146, Italy



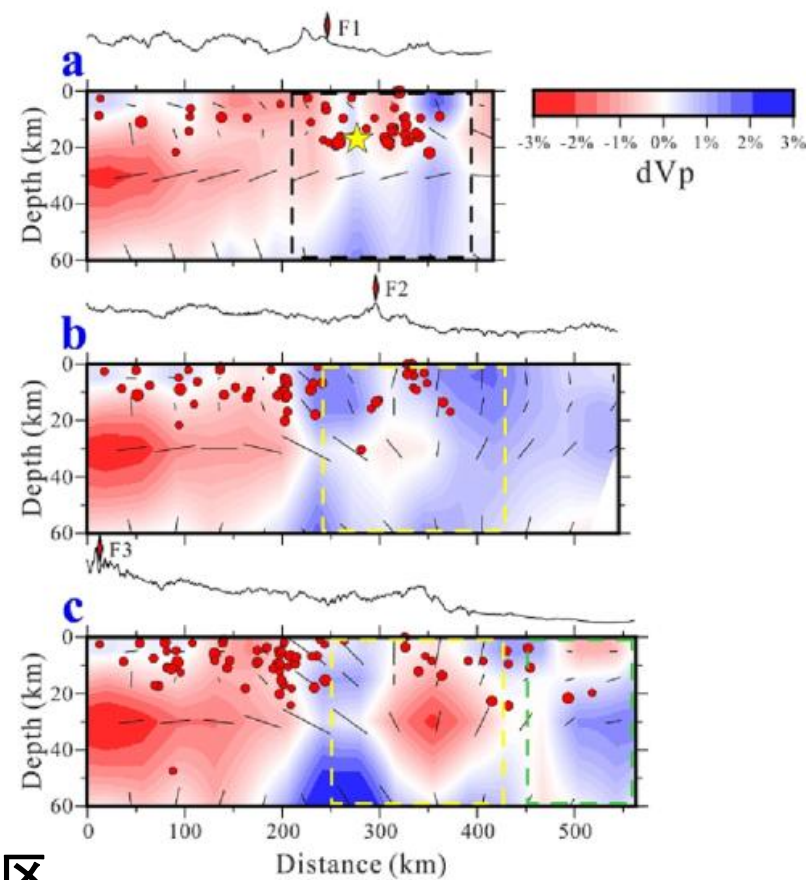
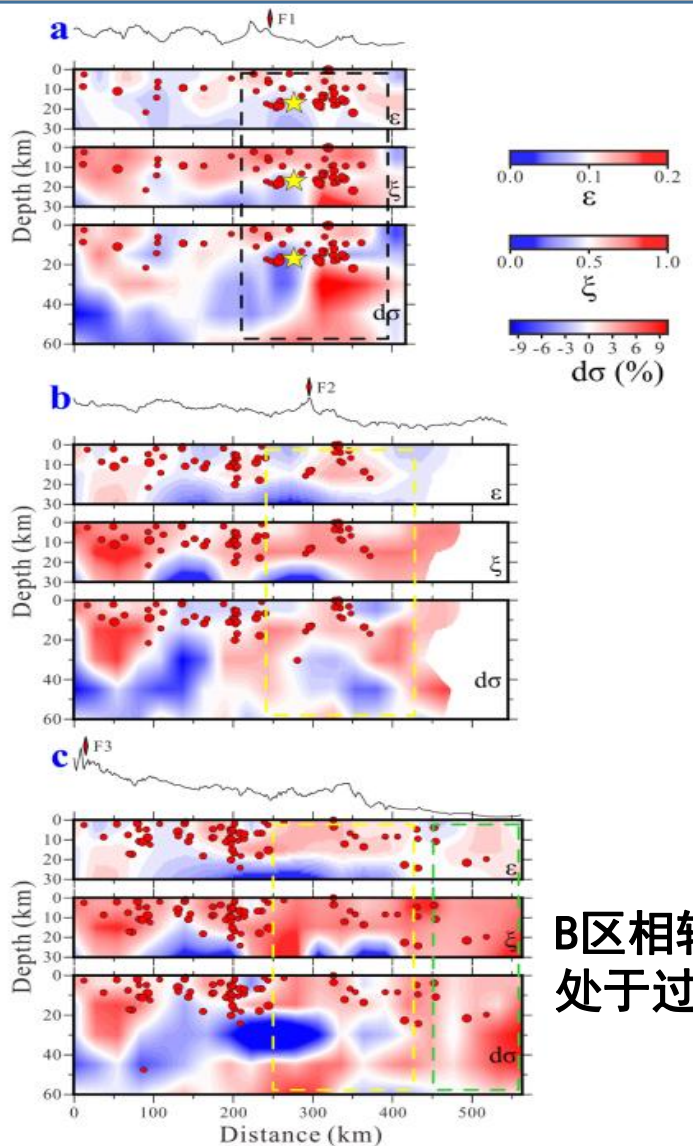
# 一、青藏高原与鄂尔多斯地块构造接触带地震及地球化学特征



研究区温泉气体同位素关系图，a:  ${}^3He/{}^4He$  (Rc/Ra) 与  ${}^4He/{}^{20}Ne$ ; b:  ${}^3He/{}^4He$  (Rc/Ra) 与  $\delta^{13}C_{CO_2}$

**B区气体来源有明显差异**

# 一、青藏高原与鄂尔多斯地块构造接触带地震及地球化学特征



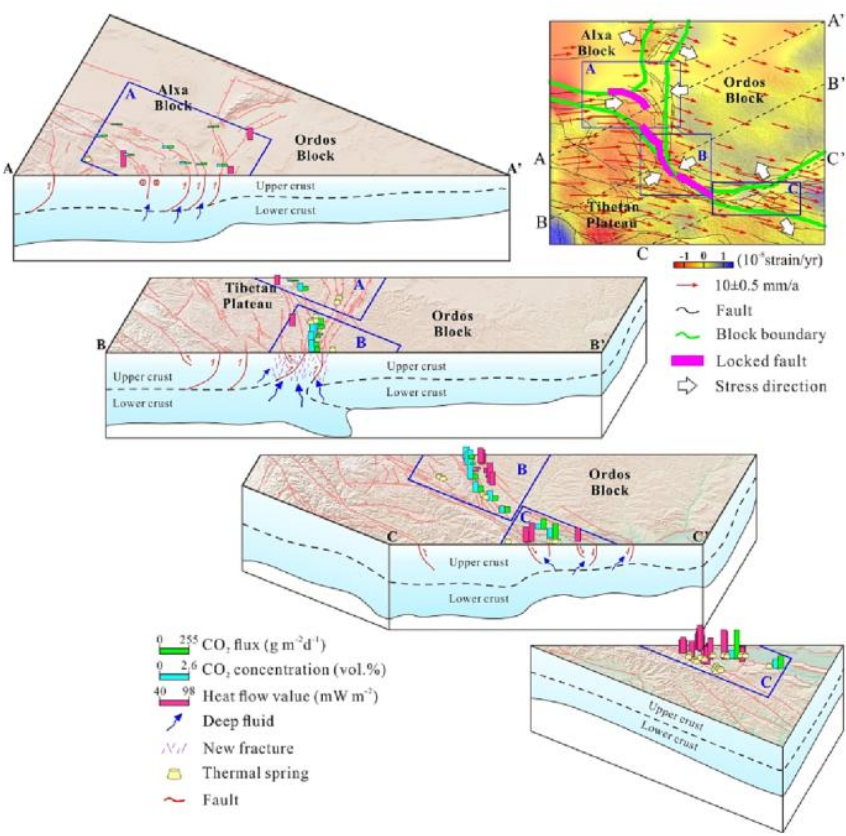
**B区相较于A, C区  
处于过渡状态**

研究区三条剖面纵波速度变化  
( $dV_p$ ) 的各向异性截面图

研究区三条剖面的裂缝密度( $\epsilon$ )、饱和度( $\xi$ )和泊松比( $\sigma$ )的横断面地震波呈像图



# 一、青藏高原与鄂尔多斯地块构造接触带地震及地球化学特征

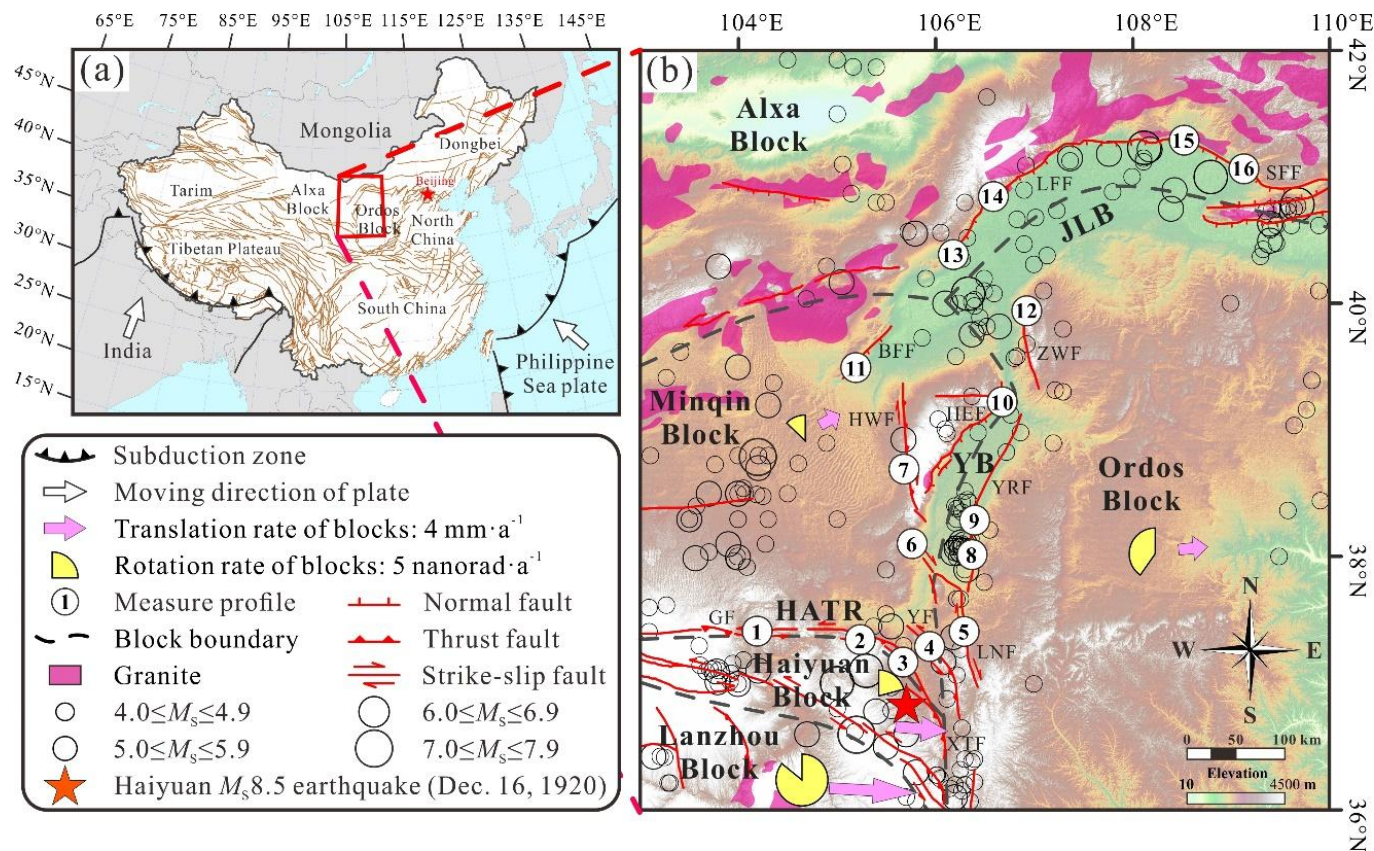


- A, B, C区, 流体地球化学特征、大地热流、地球物理成像均存在明显的空间异质性。
- C区以伸展构造为主, 地壳均质性高 $\epsilon$ 、高 $\xi$ 和相对高 $\sigma$ , 热流、CO<sub>2</sub>浓度和通量高, 以地壳源性气体为主。A区以逆冲和走滑断层为主, 局部断裂带闭锁, 中下地壳 $\epsilon$ 、 $\xi$ 和 $\sigma$ 较低, 气体排放弱, 热流小。
- B区同样以逆冲断层和走滑断层为主, 大部分断层曾经处于强烈的闭锁状态, 与A区相比, B区上地壳CO<sub>2</sub>通量和热流较大,  $\epsilon$ 、 $\xi$ 和 $\sigma$ 较大, 且CO<sub>2</sub>浓度高于C区, 但B区浅层组分贡献较大

青藏高原-鄂尔多斯地块接触带构造特征的概念模型

- B区为青藏高原与鄂尔多斯地块的收敛边界。

## 二、鄂尔多斯西缘土壤气Rn排放特征及其对断裂活动的指示意义

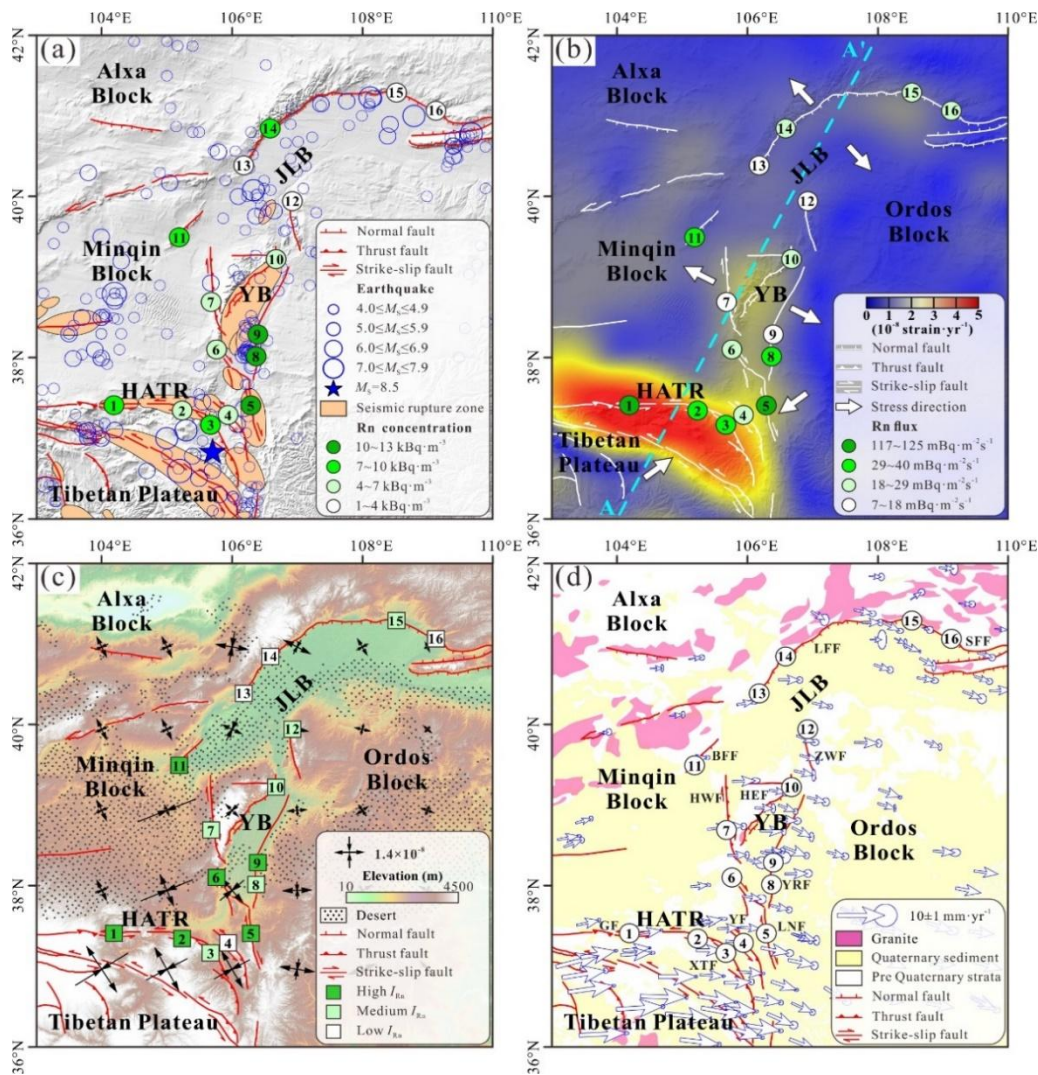


鄂尔多斯西缘的构造图及块体的运动状态

印度板块和欧亚板块的碰撞导致了青藏高原和华北克拉通在鄂尔多斯块体的西南部发生了汇聚。这种碰撞导致了研究区域内块体之间的不同运动模式，并导致了11个主要活动断层的形成。



## 二、鄂尔多斯西缘土壤气Rn排放特征及其对断裂活动的指示意义



地震、构造与断层活动是影响Rn排放主要因素。排放高值集中在海原弧形构造区和银川盆地，呈现南高北低的趋势。结合剪切应变率、地壳水平应变率和GPS水平速度场，认为青藏高原的北东向的挤压和鄂尔多斯块体的阻挡，导致了研究区南部的高渗透性。

(a) 氡浓度、地震破裂带和地震分布图。(b) 氡通量和剪切应变率的分布。(c)  $I_{Rn}$ 和地壳水平应变率的分布，以及沙漠的地理位置。(d) 花岗岩分布及鄂尔多斯地块周围GPS水平速度场。

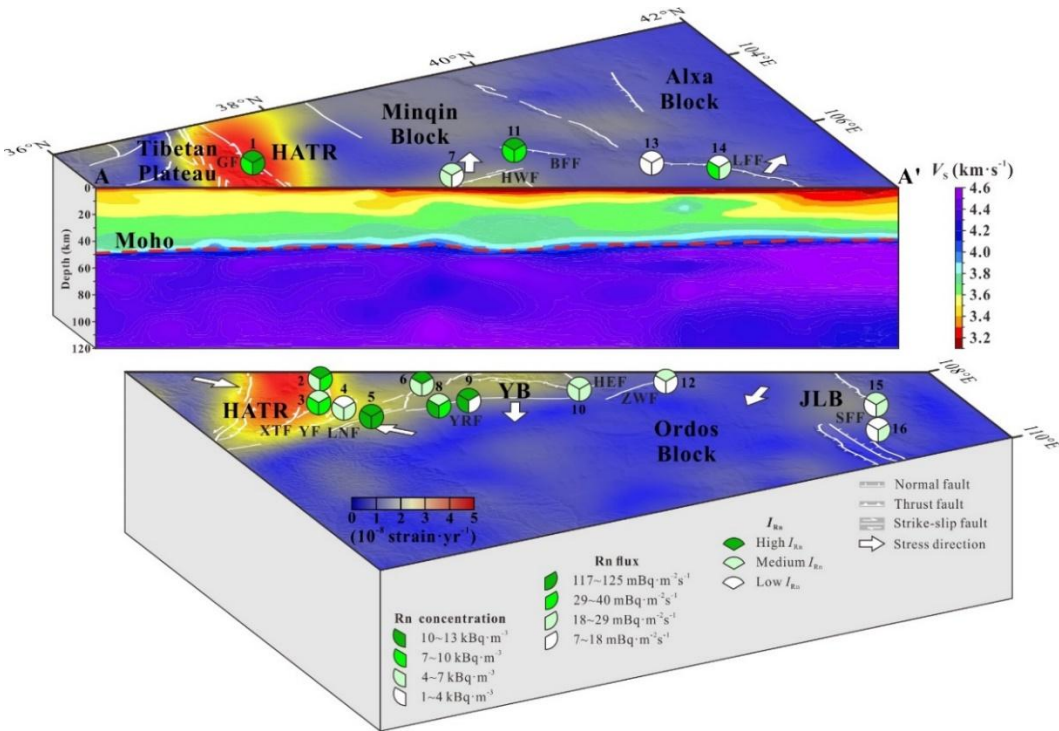
# 二、鄂尔多斯西缘土壤气Rn排放特征及其对断裂活动的指示意义

$I_{Rn}$  指数评估断层活动

海原弧形构造区 高活动性 ( $I_{Rn} > 1.9$ )

银川盆地 中活动性 ( $1.9 > I_{Rn} > 1.5$ )

吉兰泰-临河盆地 低活动性 ( $I_{Rn} < 1.5$ )



研究区模型图以及地壳水平应变率及横波速度 ( $V_s$ ) 垂直剖面图

Received: 12 June 2023 | Revised: 25 September 2023 | Accepted: 23 October 2023

DOI: 10.1111/ter.12695

RESEARCH ARTICLE

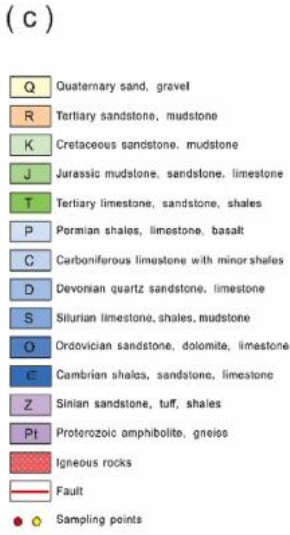
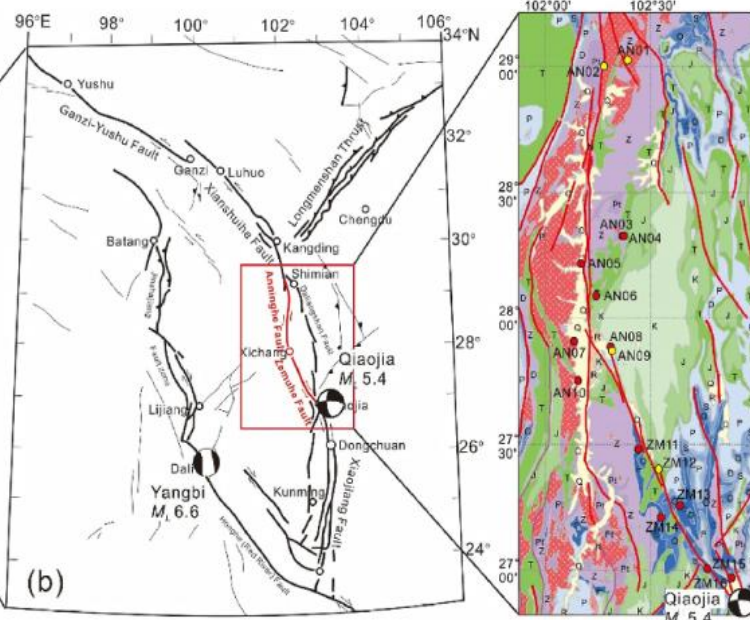
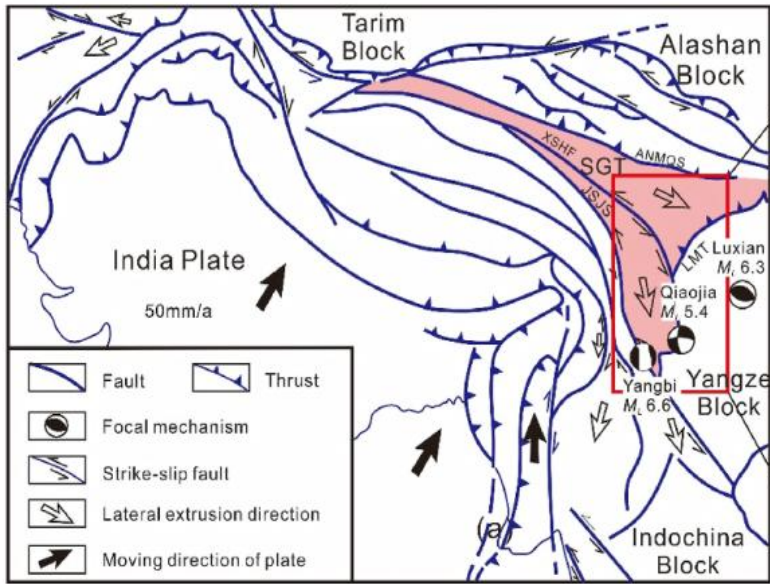
Terra Nova WILEY

Degassing of soil gas radon and its implication to fault activity in the western margin of the Ordos Block, China

Zhaofei Liu<sup>1,2</sup> | Zhi Chen<sup>1</sup> | Ying Li<sup>1</sup> | Peng Du<sup>3</sup> | Yuanxin Zhao<sup>4</sup> | Lei Lei<sup>5</sup> | Chang Lu<sup>1</sup> | Ruilin Huangfu<sup>2,6</sup>



# 三、地震引起的裂隙含水层系统中的水脉冲释放



对安宁河-则木河断裂沿线的16个温泉进行了时空维度的水化学变化研究：

- (1) 研究断裂带沿线温泉的成因机制；
- (2) 分析震中与温泉分布的关系；
- (3) 揭示温泉对地震的水化学响应机制。

Applied Geochemistry 148 (2023) 105553

Contents lists available at ScienceDirect

**Applied Geochemistry**

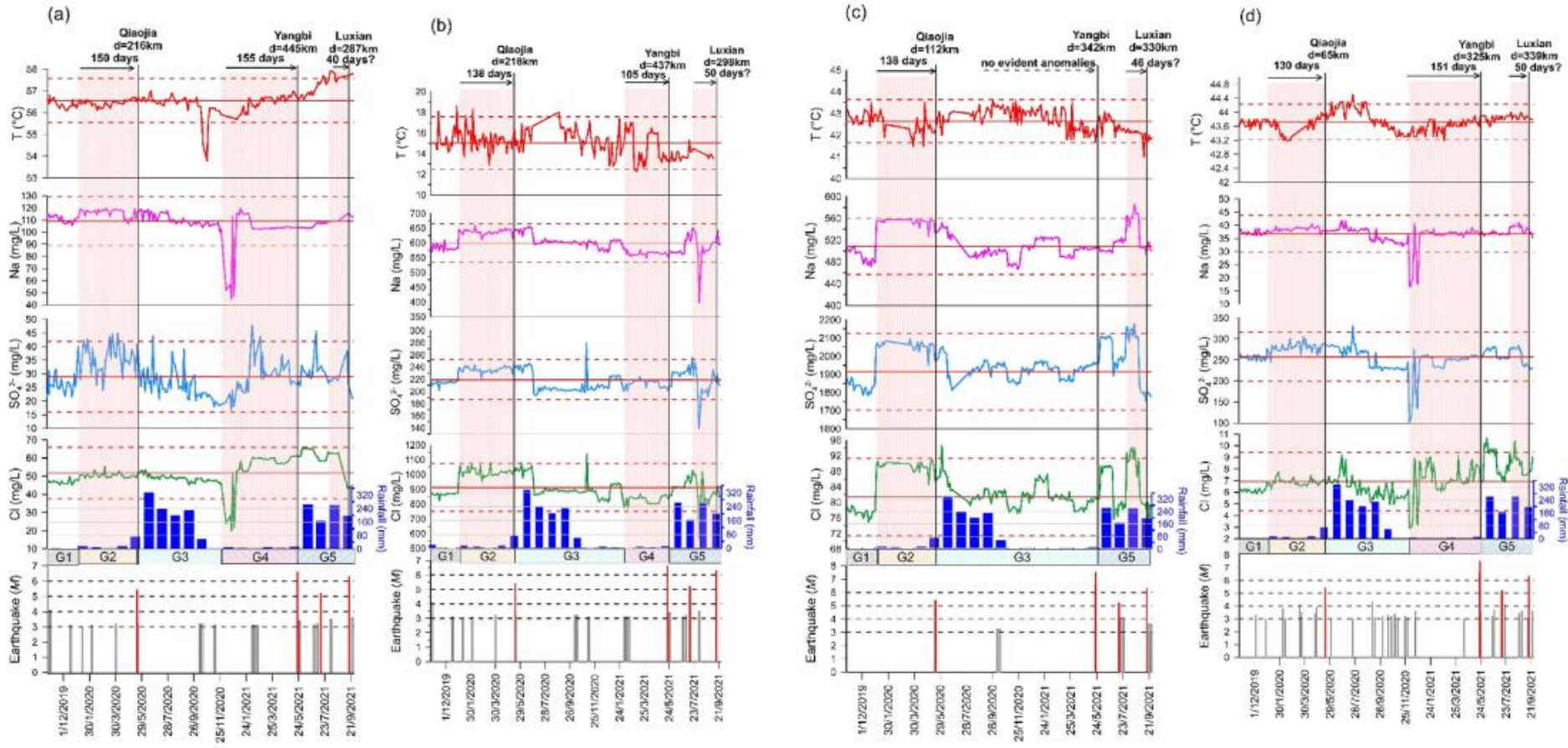
journal homepage: [www.elsevier.com/locate/apgeochem](http://www.elsevier.com/locate/apgeochem)

Earthquake-induced impulsive release of water in the fractured aquifer system: Insights from the long-term hydrochemical monitoring of hot springs in the Southeast Tibetan Plateau

Jiao Tian<sup>a</sup>, Xiaocheng Zhou<sup>a,\*</sup>, Yucong Yan<sup>a</sup>, Miao He<sup>a</sup>, Jingchao Li<sup>a</sup>, Jinyuan Dong<sup>a</sup>, Fengli Liu<sup>a</sup>, Shupeí Ouyang<sup>a</sup>, Ying Li<sup>a</sup>, Lei Tian<sup>b</sup>, Yingchun Wang<sup>c</sup>, Tianming Huang<sup>d</sup>, Zhonghe Pang<sup>d</sup>



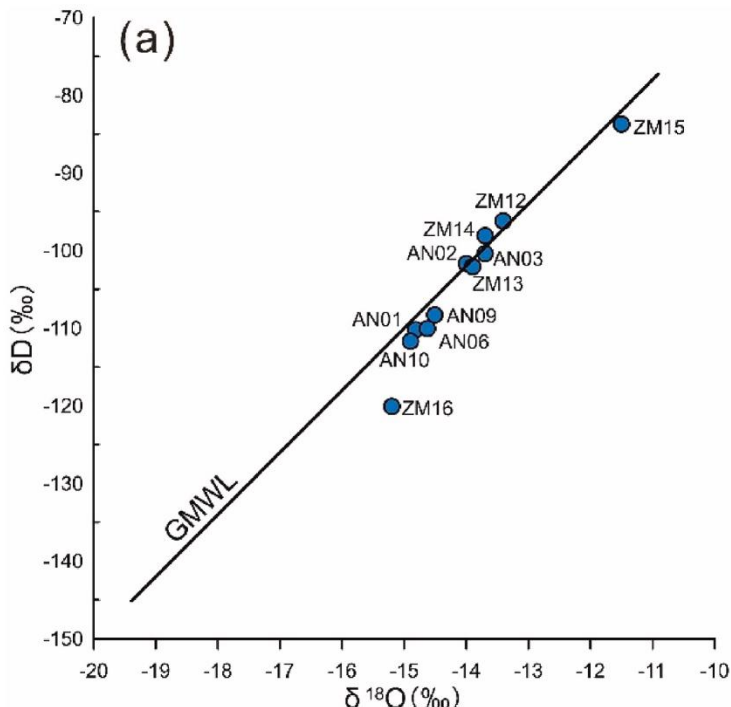
# 三、地震引起的裂隙含水层系统中的水脉冲释放



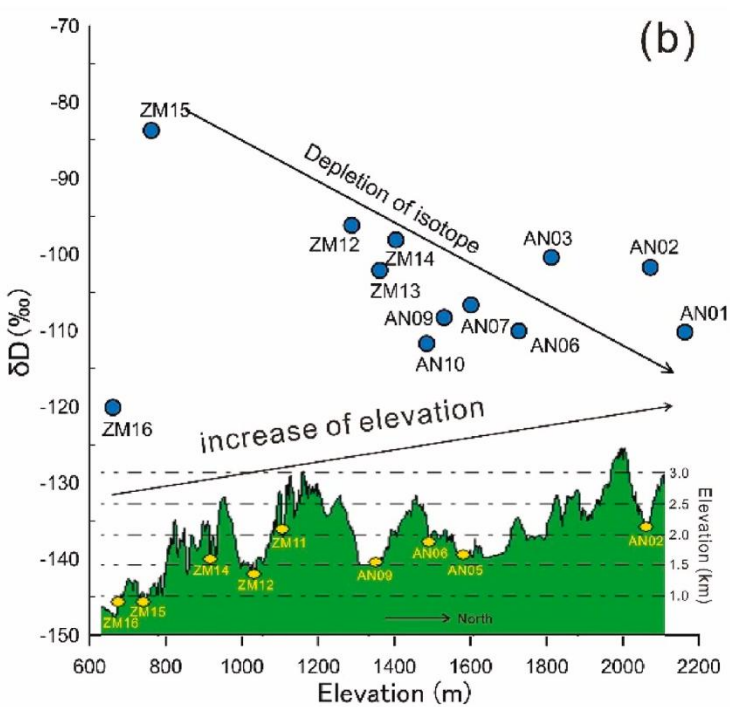
四个长期监测的温泉 (a) AN01、(b) AN02、(c) AN09和 (d) ZM12的温度 (T)、Na<sup>+</sup>、Cl<sup>-</sup>和SO<sub>4</sub><sup>2-</sup>浓度变化与地震的对应关系



# 三、地震引起的裂隙含水层系统中的水脉冲释放



地热水样品的  $\delta^{18}\text{O}$  和  $\delta^2\text{H}$  值

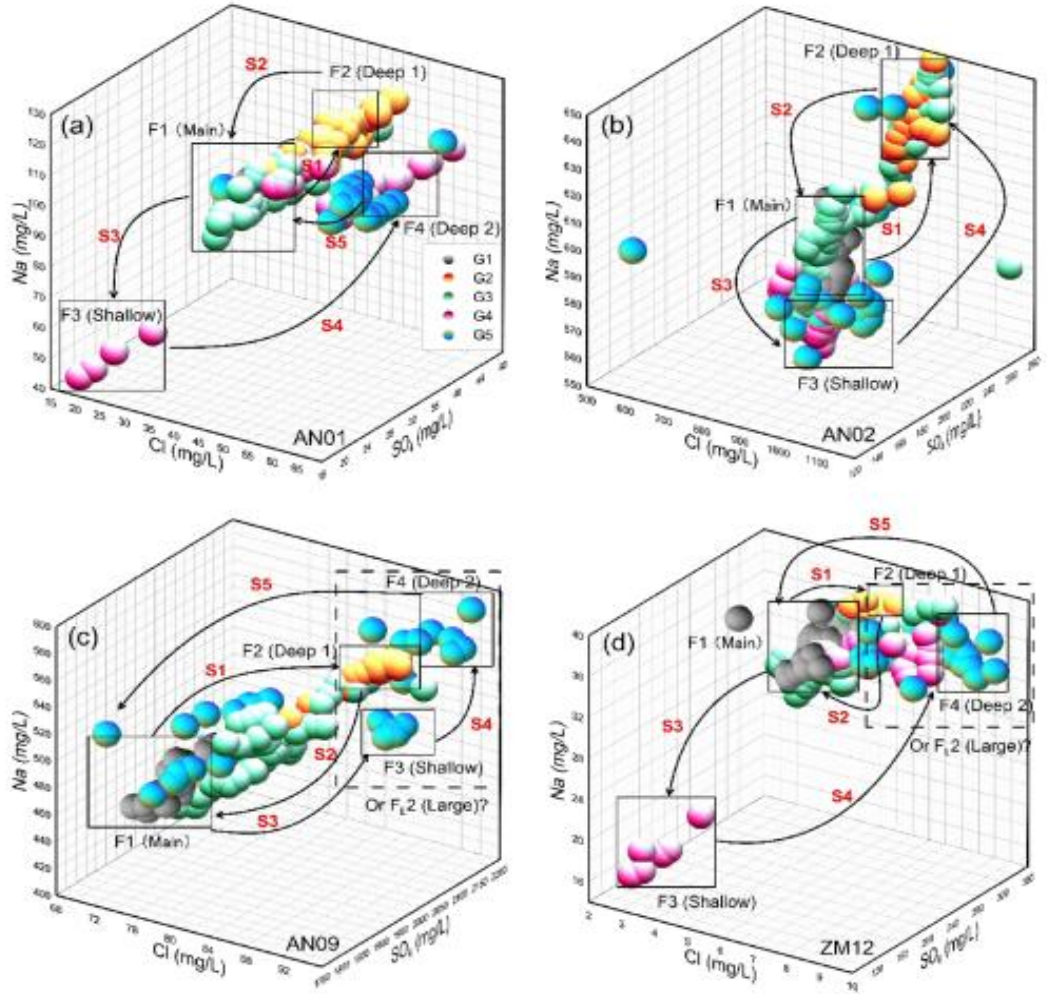


$\delta^2\text{H}$  值和 高程 以及 温泉 沿线 的高程 剖面

所有样本都沿着全球气象水线（GMWL）分布，表明渗透降水是地热水的来源（图a）。图b显示了海拔高度对同位素分馏的影响，同位素组成在大多数温泉水中表现出显著的海拔效应，而不是 $\delta^{18}\text{O}$ 偏移的现象表明，表明在地下循环过程中，温泉水没有受到强烈/长期的水岩相互作用影响。因此，不同含水单元混合作用可能是控制温泉水化变化的控制因素。

# 二、温泉地球化学揭示丽江-红河断裂带受下地壳流控制的地震

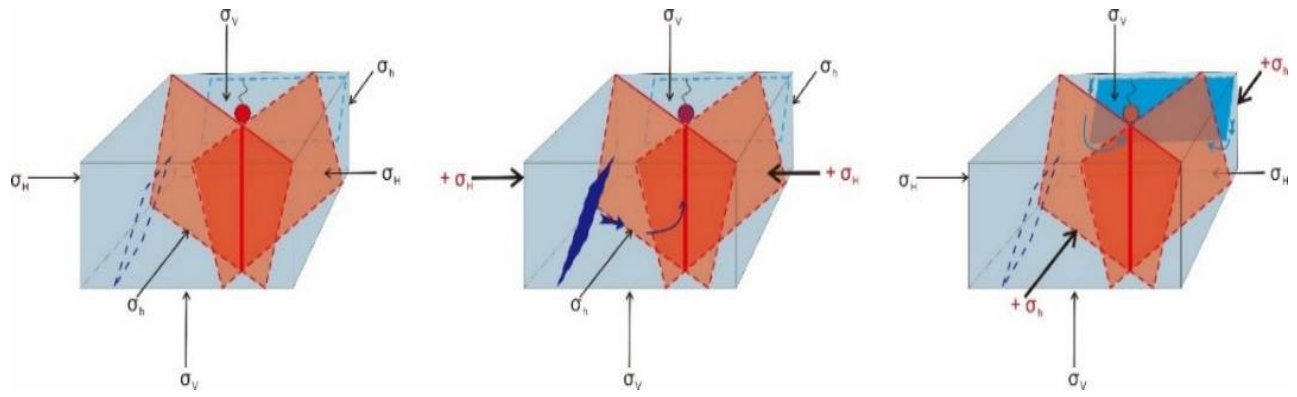
地震诱发的裂隙含水系统的弹性释水过程：次级裂隙中可能贮存有与主裂隙化学性质不同的水体，在地应力加载和释放的过程中，次级裂隙水被脉冲式注入主裂隙中，导致温泉水的化学组分浓度出现异常。



四个长期监测的温泉 (a) AN01、(b) AN02、(c) AN09和 (d) ZM12温泉水化学的3D变化机制

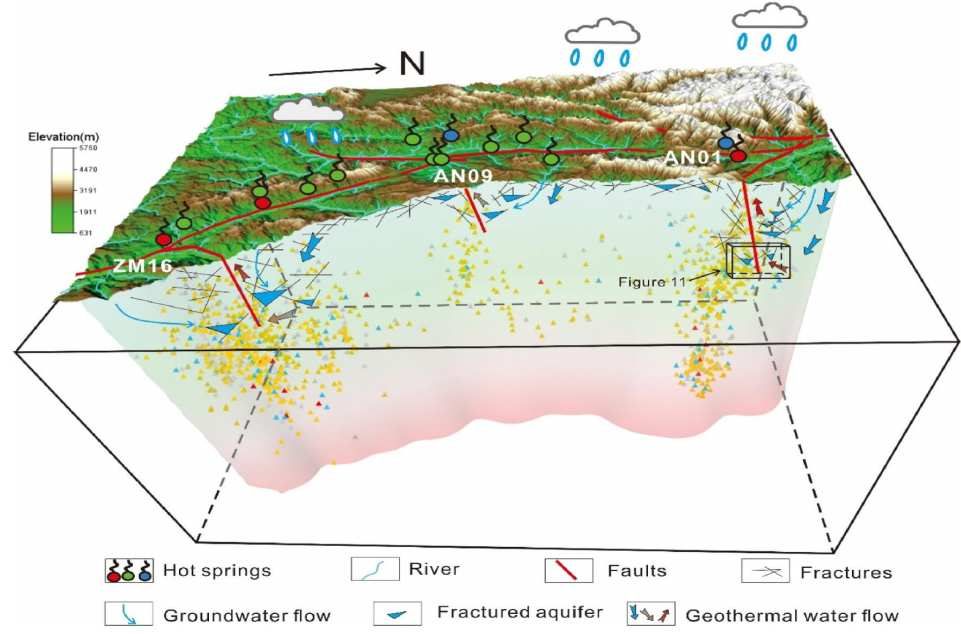


# 三、地震引起的裂隙含水层系统中的水脉冲释放



地震应力加卸载方向的改变导致不同次级裂隙水混入的示意图

地震诱发的裂隙含水层弹性释水过程导致温泉水化学呈现时间维度变化的机理

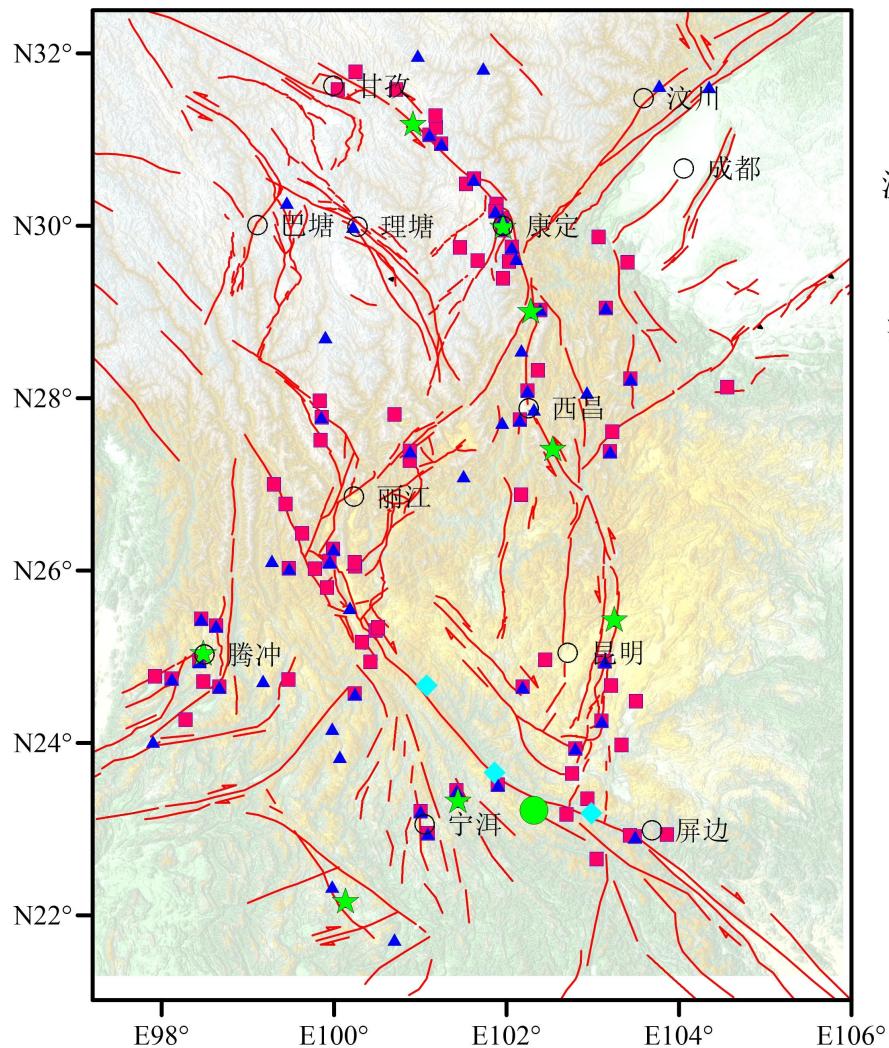


安宁河-则木河断裂温泉流体循环模式

# 报告目录

- 1 项目概要
- 2 年度进展
- 3 部分成果展示
- 4 下一步重点工作

# 下一步重点工作



- ▲ 温泉水化监测点 (70)
- 温泉气体监测站 (80)
- ◆ 断层气监测站 (3)
- 深井气体监测站 (1)
- ★ 已建温泉气体监测站 (8)



## 未来川滇流体地球化学观测网 162个测点

- 进一步推进中国地震科学实验场区流体地球化学连续观测站点建设
- 加强合作交流，参加2024年国际气体地球化学学会
- 国际合作项目联合申请

# 致 谢

**衷心感谢中国国际地球科学计划全国委员会对本项目的  
大力支持！**

**敬请批评指正！**