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**General Institute of Water
Resources and Hydropower
Planning and Design, MWR**

Zoning management for geothermal energy regulation in China

Yan Yang

Hohai University

**General Institute of Water Resources and Hydropower Planning
and Design, MWR**

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Outlines

Part 1 | Geothermal energy in China

Part 2 | Framework of prohibited and restricted area zoning

What is Geothermal energy?

Geothermal energy is the heat within the earth.





What is Geothermal energy?



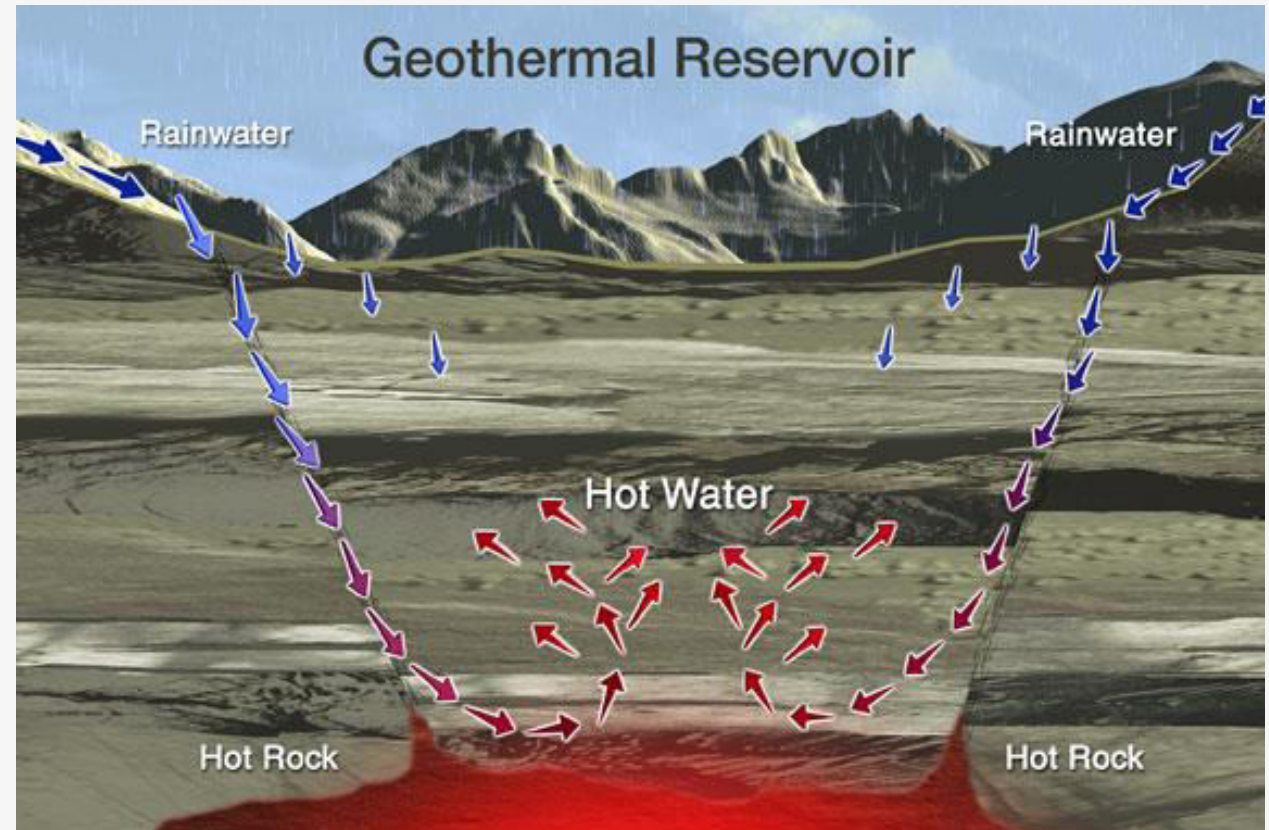
What is Geothermal energy?

The forms of geothermal energy could be:

- heat
- hot water
- dry hot rock




- Energy (form)
- Resources (utilization)



What is Geothermal energy?

The purposes of geothermal energy use:

- Direct use
 - Geothermal power generation
- 
- Hot spring bath
 - Geothermal space heating
 - Geothermal heat pump
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 - Enhanced Geothermal Systems



Hot spring



Greenhouse heating

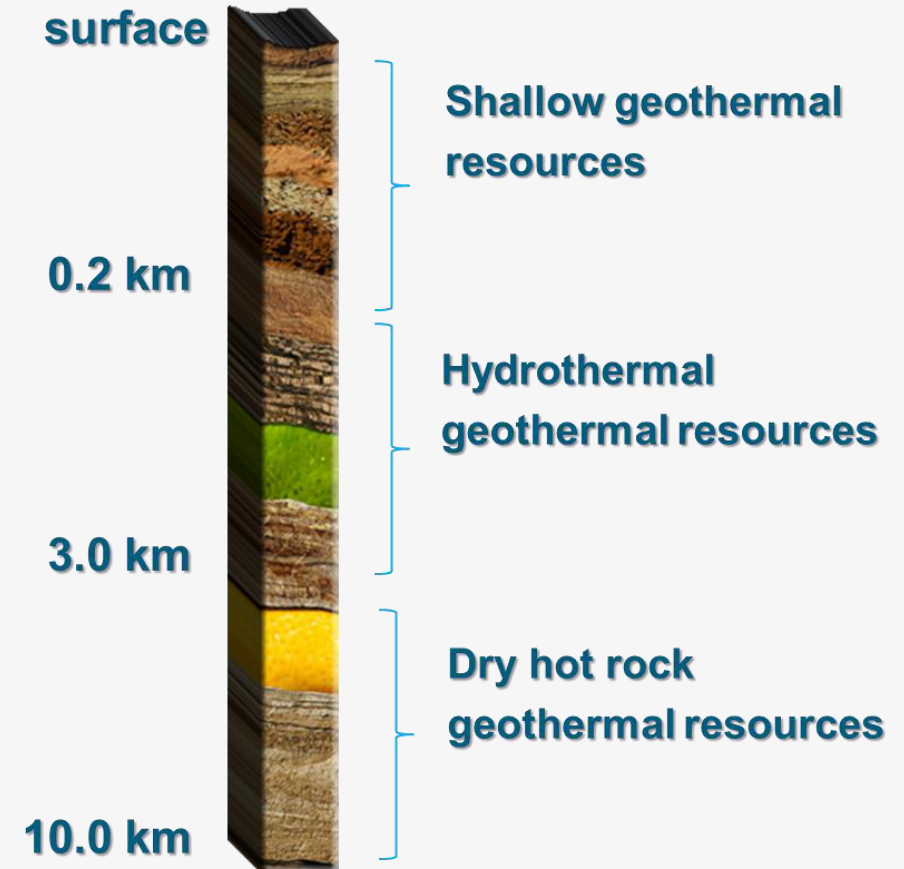


Geothermal power generation

What is Geothermal energy?

How to use?

Resource type			Reservoir depth	Groundwater utilization mode
Shallow geothermal resources			< 200 m	ground-source heat pump technology for heating or cooling, including buried pipe heat pump, underground water source heat pump, etc
Hydrothermal resources	Low-medium temperature	Sedimentary basin	< 4km	The ground water is withdrawn through wells, and then the cooled geothermal water is injected into the ground through reinjection wells
		Uplift mountain		
High temperature				
Hot dry rock resources			2-3km	Without water withdrawal, it is mined by artificially building heat storage and constructing fluid circulation



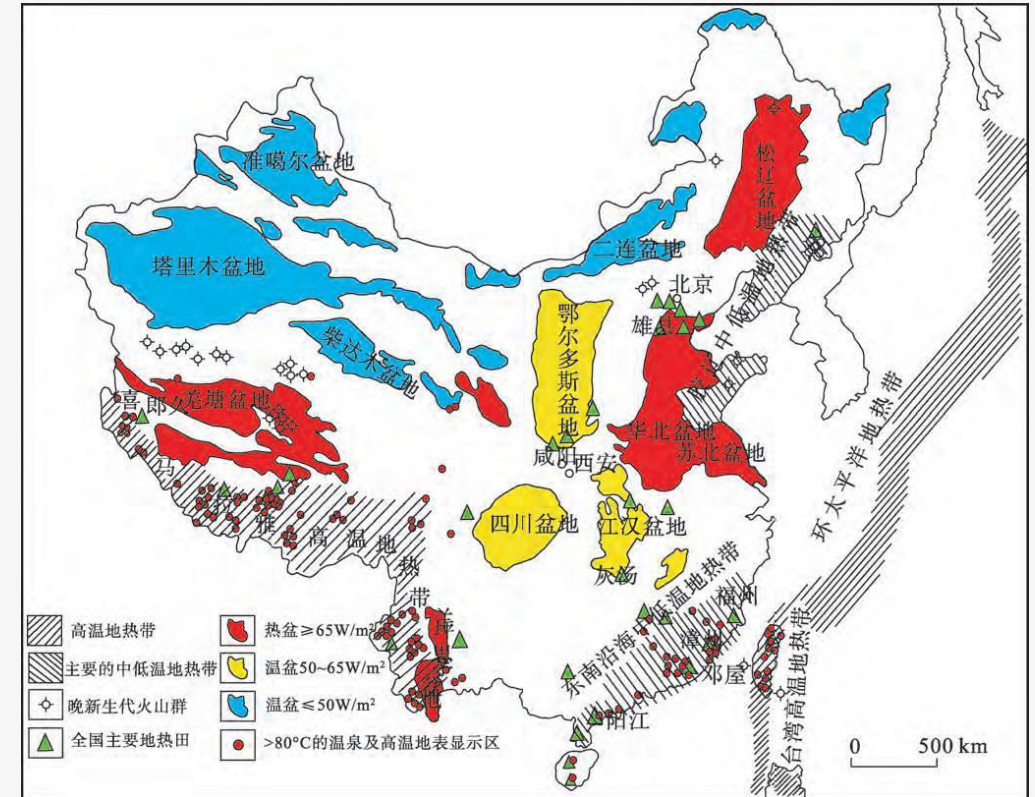
Part 1 Geothermal energy in China

- **Geothermal resources and exploitation in China**
- **Main issues and challenges**
- **Geothermal energy management in China**

Part 1 Geothermal energy in China

□ Geothermal resources of China

- China's shallow geothermal energy resources: equivalent to **9.5 billion** tons of standard coal.
 - Annual availability: equivalent to **350 million** tons of standard coal.
- (Ministry of Land Resources, China)*



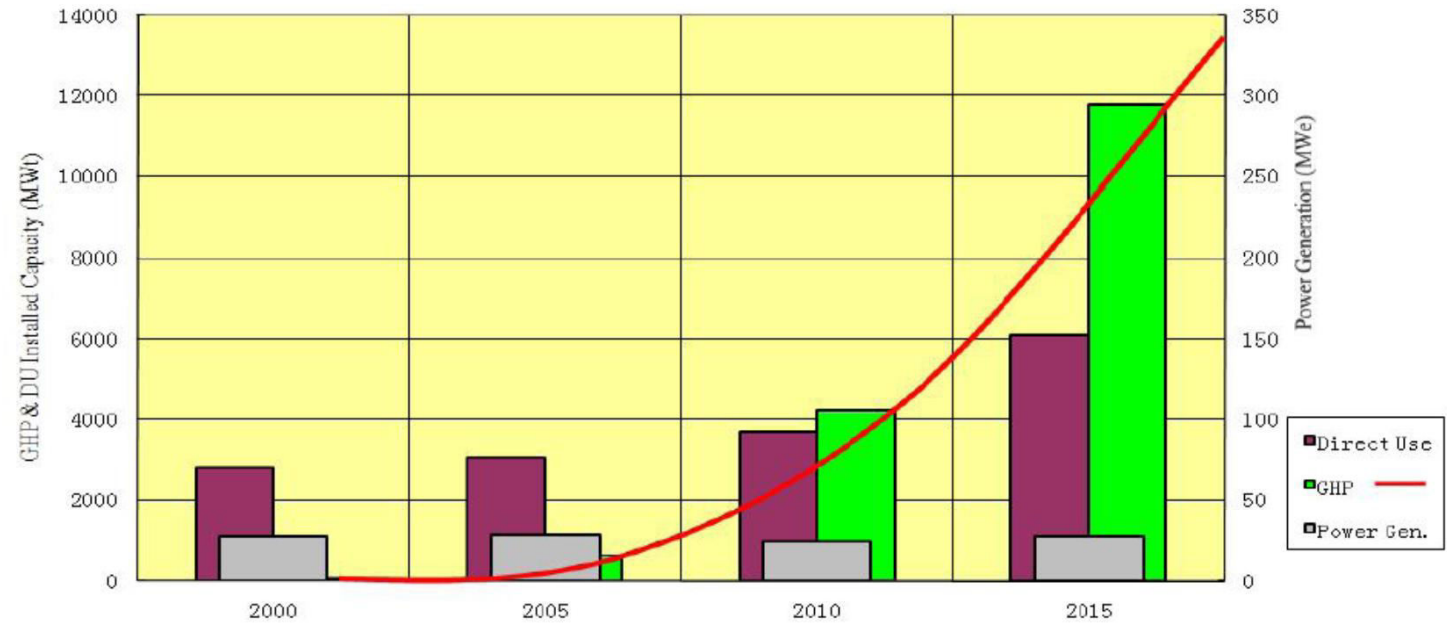
Distribution of geothermal energy resources in China (source : China Renewable Energy Development Report 2019)

Part 1 Geothermal energy in China

□ Exploitation of geothermal energy in China

- Chinese geothermal annual energy use for direct use occupies the first place in the world since 2000.
- 2010-2014, the installed capacity of geothermal direct use: 6,089 MWt, annual energy use 74,041 TJ/yr.
- When together with geothermal heat pump the installed capacity and annual energy use are 17,870 MWt and 174,352 TJ/yr respectively.

(Zheng et al. 2019)



Geothermal energy utilization growth in China (2000-2015)

Part 1 Geothermal energy in China

□ Main issues and challenges

- **Water resource issues**

Cooling, heating and injection process require large amount of water, which may lead to waste and pollution of water.

- **Geological environmental problems**

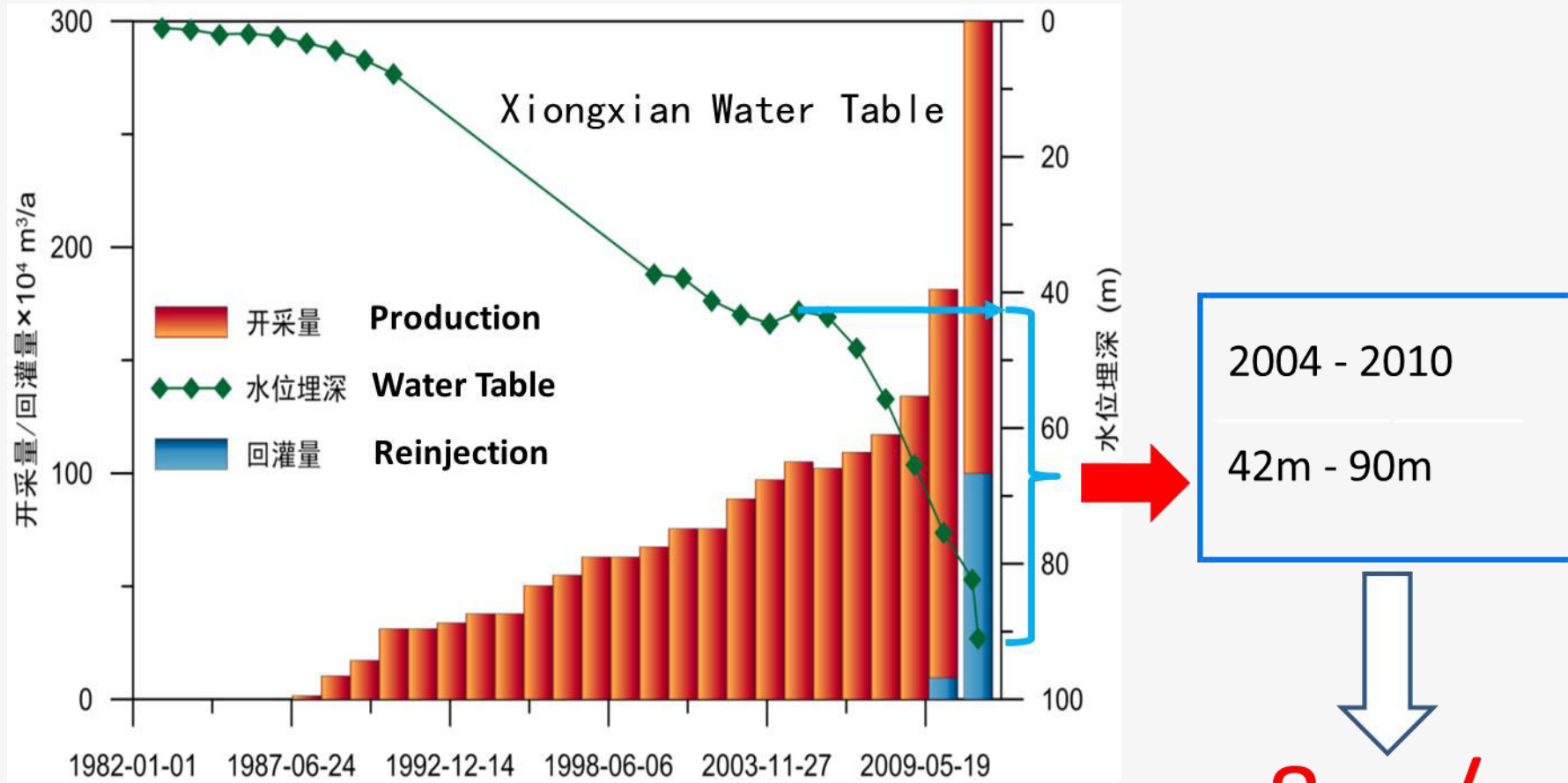
underground drilling and water injection may cause some damage and disturbance to the underground system, and may lead to changes in the geological environment and the destruction of the ecosystem, such as the land subsidence, cracks or collapse....

- **Earthquakes**

Geothermal energy extraction requires the use of large-scale drilling equipment, which generates noise and vibration waves, such as seismic waves, that adversely affect the residents of neighboring communities and may even cause problems such as soil loosening and cracks.

Part 1 Geothermal energy in China

□ Main issues and challenges



Drawdown of groundwater table from 1982-2009 in Xiong'an New Area

(Kong et al, 2021)

8 m/a

Part 1 Geothermal energy in China

□ Geothermal energy management in China

- **Legislation:**

- Water Resources Law
- Renewable Energy Act
- Mineral Resources Law
- Local legislation: 7 provinces



- Water Resources
- Renewable Energy
- Mineral Resources

- **Administration:**

- a mining permit
- a water extraction permit
- Permit revoked if 100% recharge cannot be guaranteed

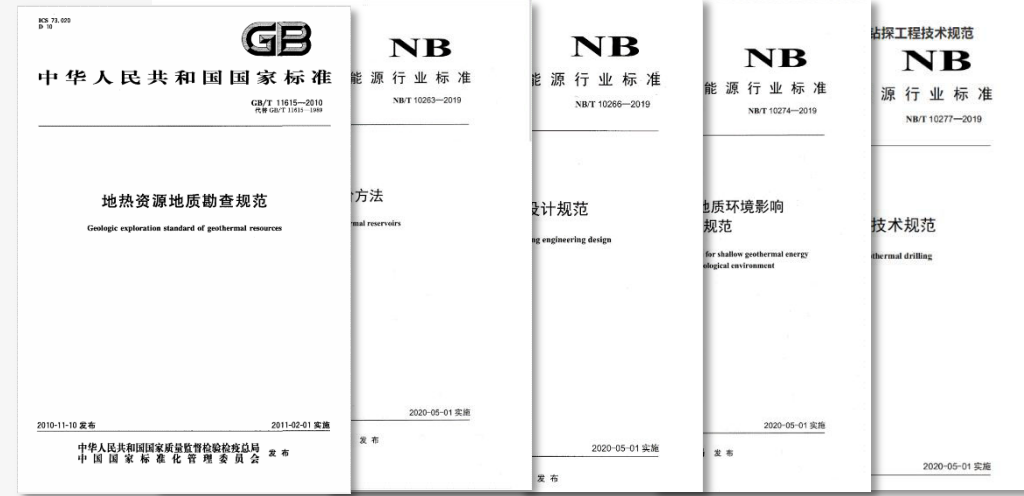
- **Main concern:**

- Causing geological or environmental problem
- Reducing groundwater reserve, especially deep confined groundwater
- Pollution
-

Part 1 Geothermal energy in China

Geothermal energy management in China

- Several technical standards at national and sector levels:
- Geothermal resources investigation/ evaluation/ designing/ construction
- Policy documents issued by different sectors:
 - Medium- and long-term development plan for renewable energy
 - Twelfth Five-Year Plan for Renewable Energy Development
 -



Part 1 Geothermal energy in China

□ Summary

Majority of regulations and practices are limited as follows:

- focus on encouraging the exploitation of geothermal energy and concern **very limited from the perspective of regulating geothermal energy development and reducing environmental risks.**
- the management and governance of geothermal energy and technical research are limited at the project scale
- can only work after hazards occur and have limited methods to alleviate, but penalty.....

Part 1 Geothermal energy in China

□ Geothermal energy management in China

- **Groundwater Management Regulation**

(Enacted October 29, 2021, effective December 1, 2021)

Article 51

- The local government is responsible for **delineating the prohibited and restricted zones (PRZs), for geothermal energy utilization projects requiring water withdrawal (GUPs)** in accordance with the hydrogeological conditions and the requirements for groundwater protection.
- **It is prohibited to construct GUPs in centralized groundwater drinking water sources.**
- **It is prohibited to extract groundwater that is difficult to be renewed for GUPs construction.**
- The construction of a GUPs shall measure the water withdrawal and recharge, **implement 100% recharge in the same aquifer, and shall not cause pollution to groundwater.**

Part 2 Framework of PRZs zoning

- **Objective and motivation**
- **Frame and path**
- **Zoning standard and method**



Part 2 Framework of PRZs zoning

□ Objective and motivation

- A zoning approach as a preventive management approach
 - to avoid wasteful development of geothermal heat
 - to avoid ecological and environmental problems more efficiently.
- An evaluation framework at regional scale:
 - evaluate the possible adverse impacts under different conditions on the groundwater system from the perspectives of environmental risks, recharge conditions and resource utilization

- Output: several type of zones (prohibited zone, restricted zone, utilization zone) with no blanks
- Framework: A series of index, standards and steps.



Part 2 Framework of PRZs zoning

□ Target and boundary conditions

Target:

- Geothermal energy development and utilization project that needs to withdraw water.

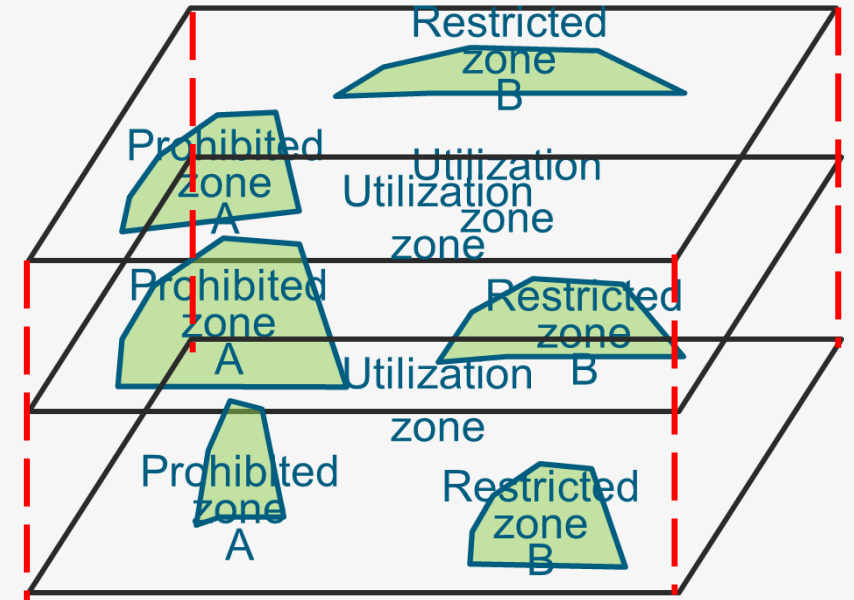
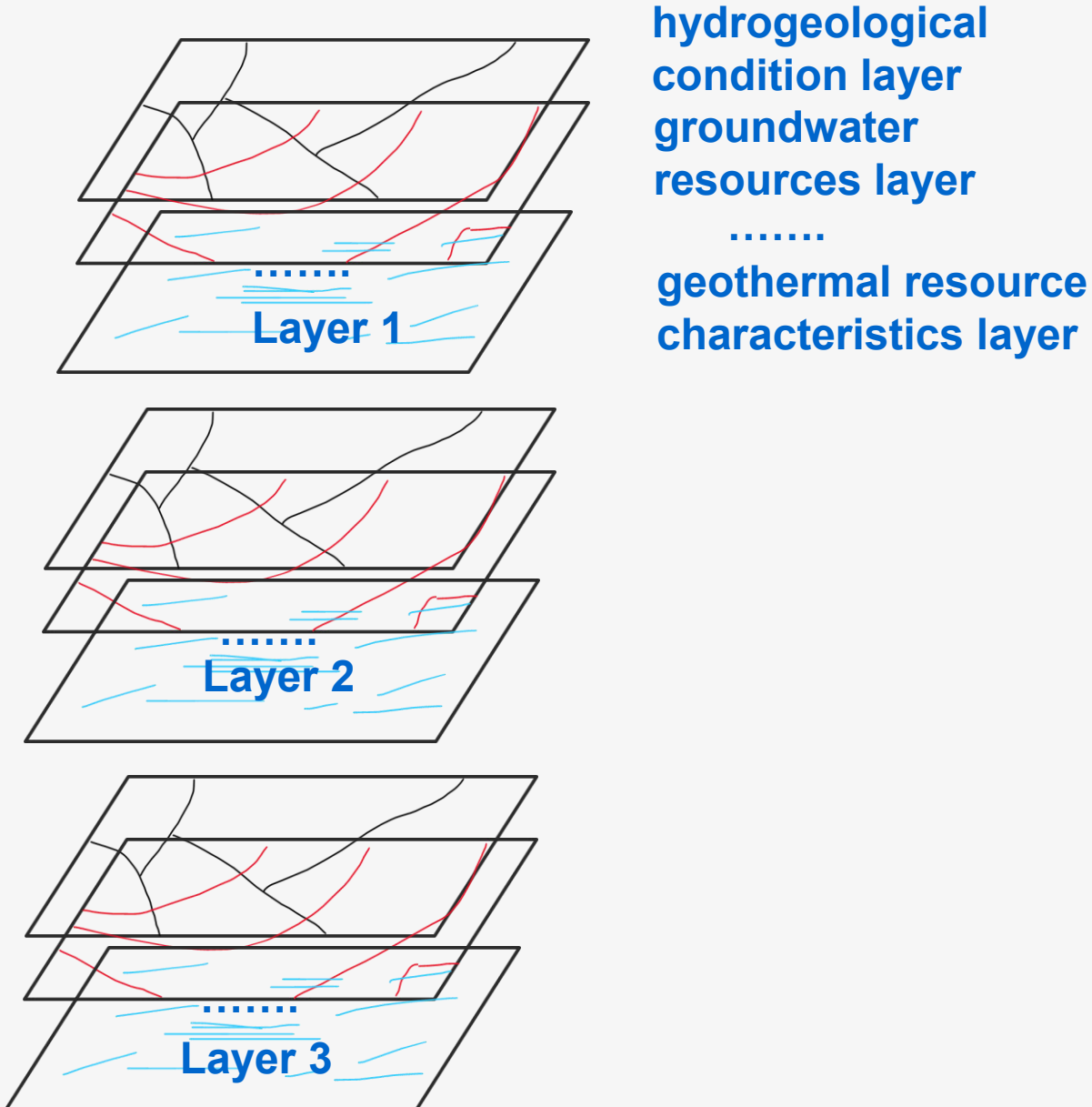
Pre-conditions posed by Groundwater Management Regulation:

- The prohibited zone should at least include centralized drinking water source and groundwater aquifers that are difficult to renew.
- As long as water withdraw, it must meet at least 1:1 reinjection of the same aquifer, and must not cause pollution.



Part 2 Framework of PRZs zoning

□ Frame and path for Prohibited Zone



Different layers form quasi-3 dimension "zone"

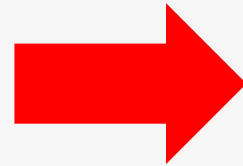
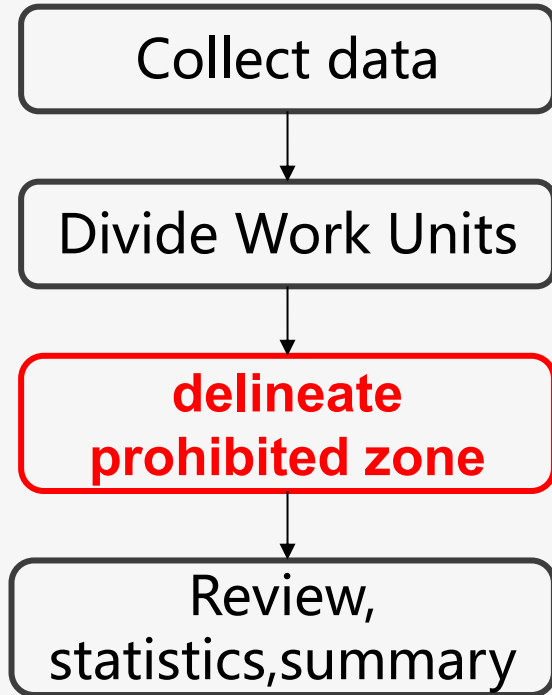


Maybe a real 3 dimension "zone" in the future



Part 2 Framework of PRZs zoning

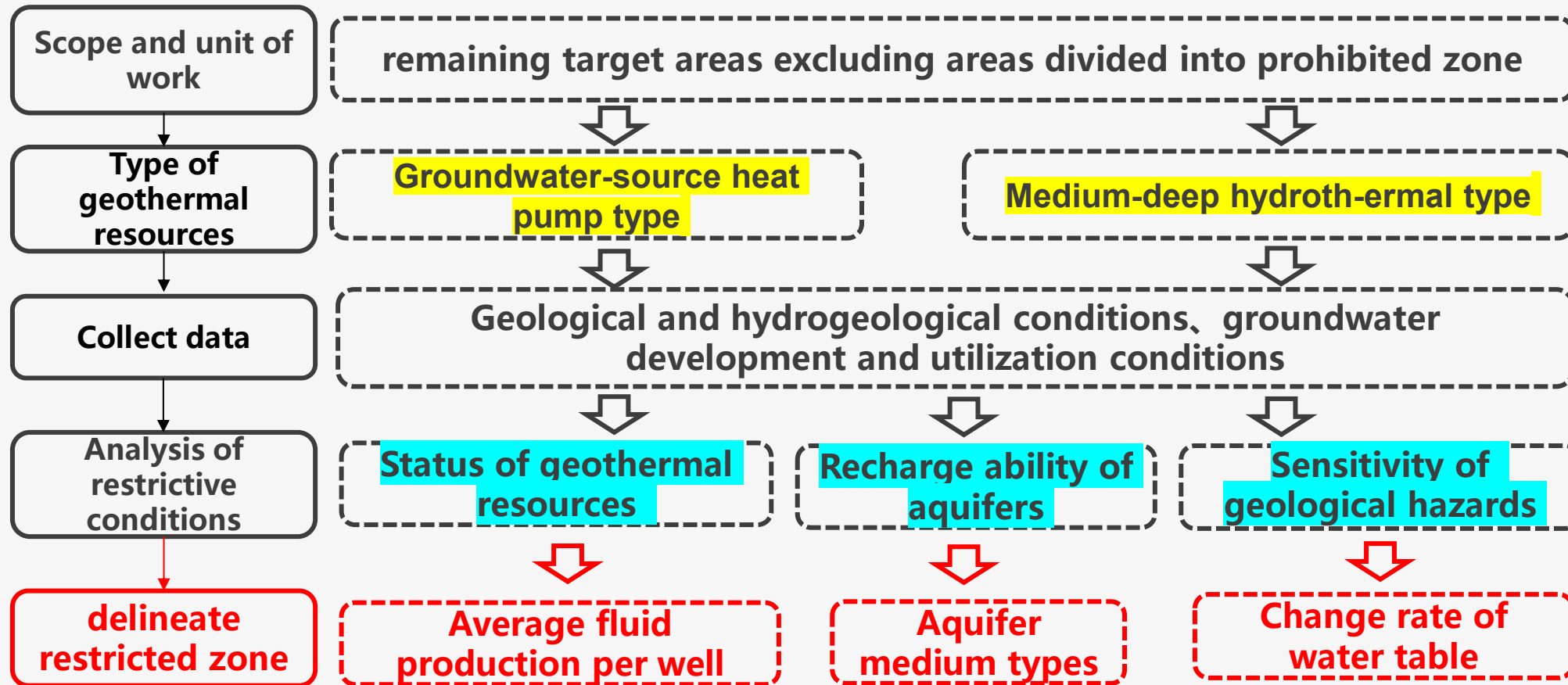
□ Frame and path for Prohibited Zone



Program Type	Prohibited zone
Groundwater-source heat pump	Areas where groundwater is difficult to renew
	Prohibited area of groundwater
	Overextraction area of groundwater
	Centralized drinking water source
	Key cultural relics reserve
	Key traffic engineering protected areas
	Areas with environmental geological problems such as land subsidence and seawater intrusion
Medium-deep hydrothermal energy utilization	Areas where groundwater is difficult to renew
	Centralized drinking water source
	The non-centralized drinking water source whose water quality is better than Class II
	Key cultural relics reserve
	Key traffic engineering protected areas
Areas with environmental geological problems such as land subsidence and seawater intrusion	

Part 2 Framework of PRZs zoning

□ Frame and path for Restricted Zone



**Key
index**



Part 2 Framework of PRZs zoning

□ Zoning standard and index for Restricted Zone identifying

□ Status of geothermal resources

Stratigraphic configuration, aquifer medium type, Aquifer thickness and water abundance feature determine the quantity and sustainability of geothermal resources.

□ Recharge ability of aquifers

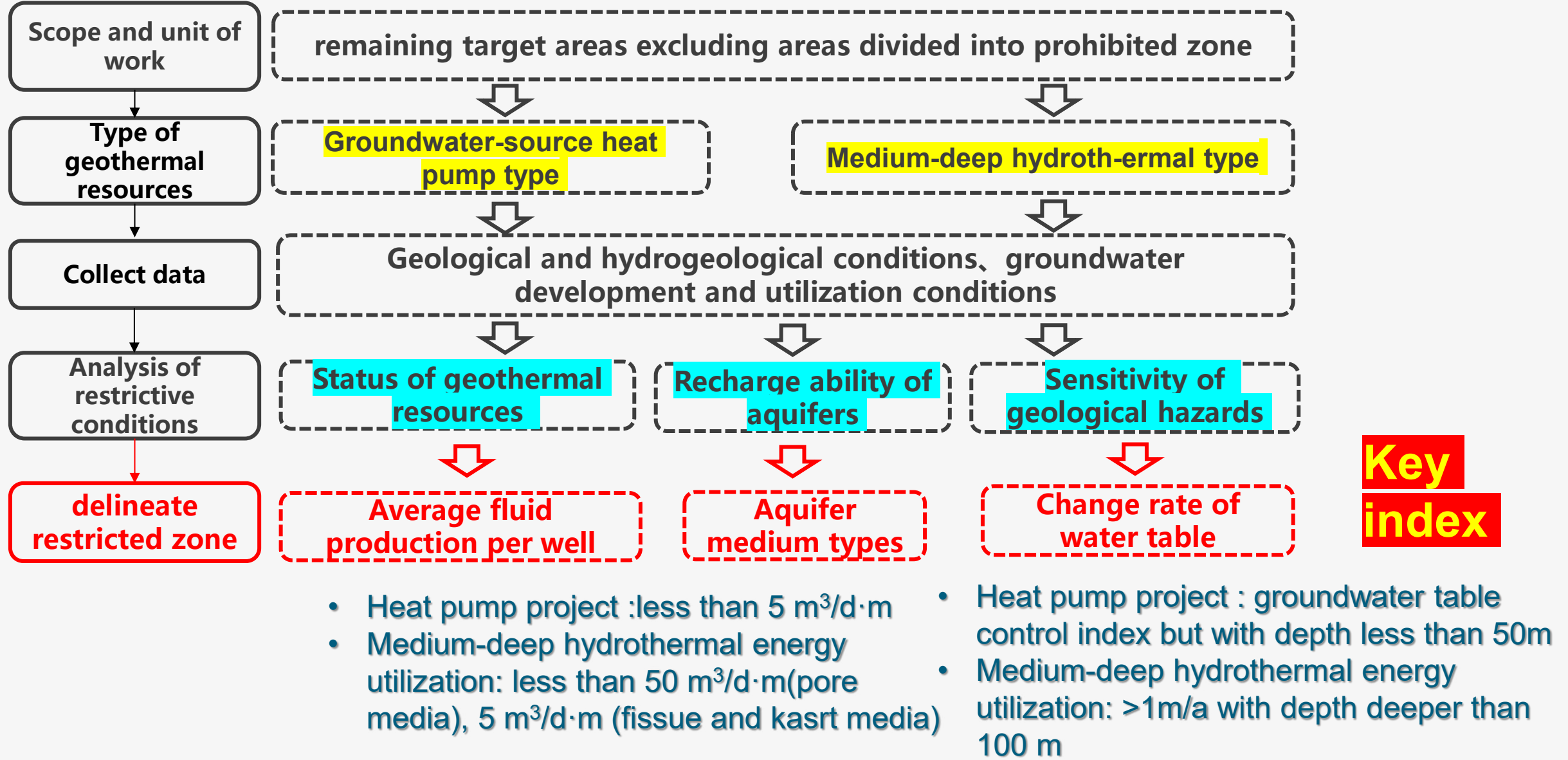
Lithology, structure and hydrogeological condition of aquifers determine the reinjection ability of aquifers, reinjection ability affects the suitability of geothermal exploitation.

□ Sensitivity of environmental geological hazards

Environmental geological condition influences the possibility and scale of geological disasters, determining the engineering safety of geothermal exploitation.

Part 2 Framework of PRZs zoning

□ Zoning standard and index for Restricted Zone identifying



THANKS!



Part 2 Framework of PRZs zoning

□ Zoning method and steps for Restricted Zone identifying

Project of groundwater-source heat pump

1. Firstly, determine the scope and unit of work, which are the remaining target areas excluding the areas divided into prohibited zone;
2. Then, determine the key hydrogeological parameters on the basis of analyzing and mastering the relevant data of regional hydrology and geology;
3. The results of the delineation of restricted zone determined based on the following methods:
 - Restricted area of groundwater;
 - The non-centralized drinking water source whose water quality is better than Class II;
 - The area where average fluid unit production of geothermal Wells is less than $5 \text{ m}^3/\text{d}\cdot\text{m}$;
 - The area where the pore aquifer with the water table deeper than 50 m is located



Part 2 Framework of PRZs zoning

□ Zoning method and steps for Restricted Zone identifying

Project of Medium-deep hydrothermal energy utilization

1. Firstly, determine the scope and unit of work, which are the remaining target areas excluding the areas divided into prohibited zone;
2. Then, determine the key hydrogeological parameters on the basis of analyzing and mastering the relevant data of regional hydrology and geology;
3. Delineate the restricted zone according to key hydrogeological parameters:
 - The depth of water table in the working unit is greater than **100m**, and the average water table decline rate of the aquifer taken in the past five years is greater than or equal to **1 m/a**;
 - For pore water, the average geothermal fluid production per well in the working unit is less than **50 m³/d·m**; For fissure and karst water, it is less than **5 m³/d·m**.

Part 3 Case study



Part 3 Case study

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