Development and Utilization of Potassium Resources in Qinghai Salt Lakes

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CONTENTS

1 Brief introduction to QISL

1.1 Overview

Qinghai Institute of Salt Lakes (QISL)

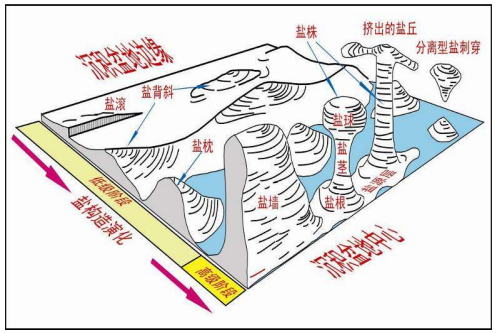
- Founded in 1965
- National institute affiliated to Chinese Academy of Sciences (CAS)
- Engages in exploration, development and utilization of salt lake resources
- China's only research institute for salt lakes
- Cradle of salt lake science and technology in China

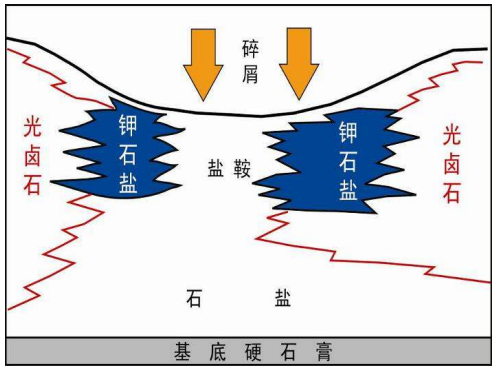
Currently, there are 235 employees in the institute, including 27 professors and 58 associate professors.

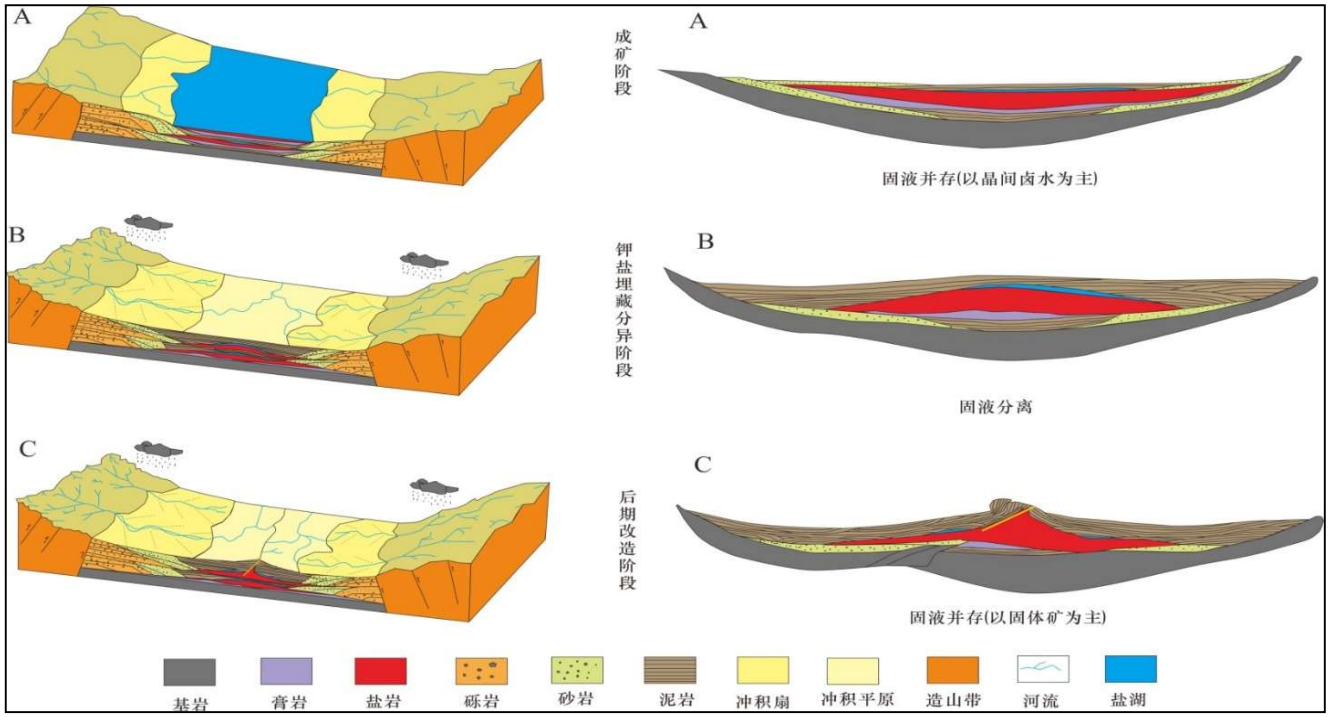


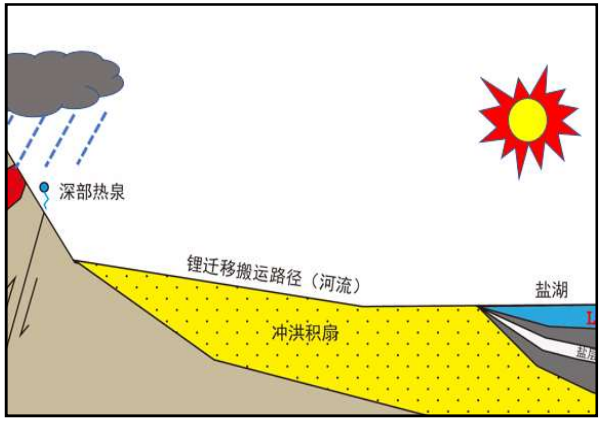
1.2 Research Divisions & Areas

(1) Salt Lake Geology and Environment Laboratory









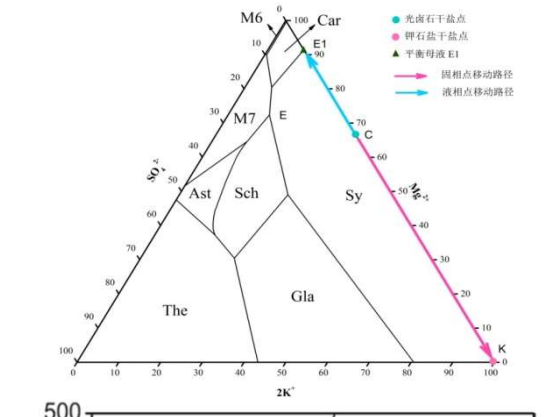
Salt Lake resource exploration and evaluation

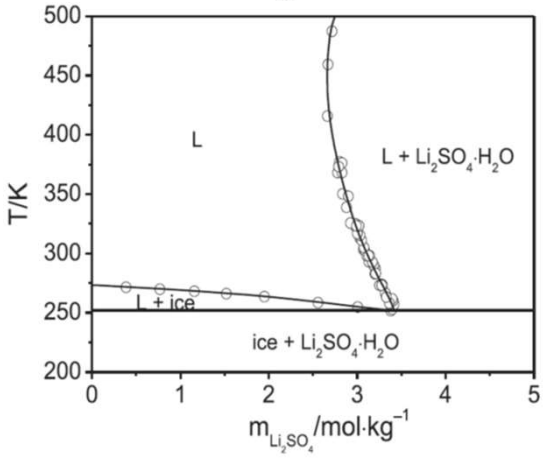
Salt lake formation and evolution

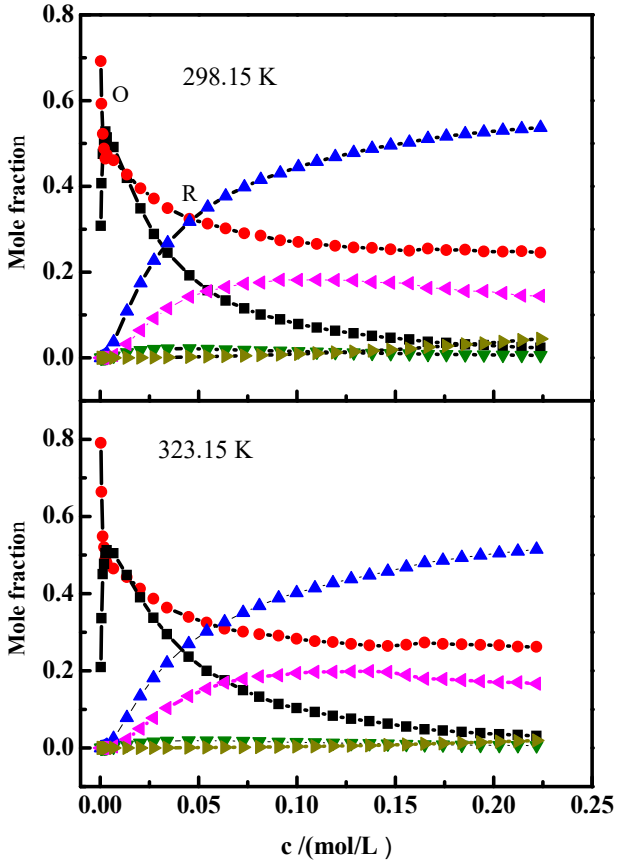
Salt lake sediments and salt minerals

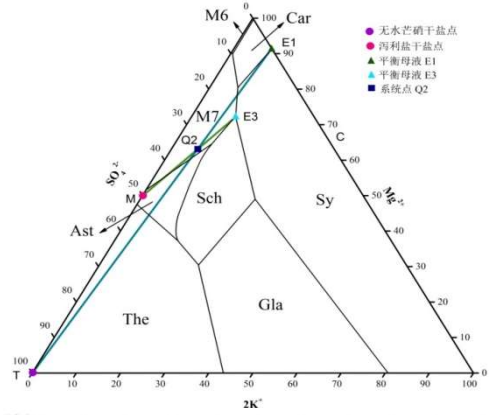
Isotopic geochemistry of salt lakes

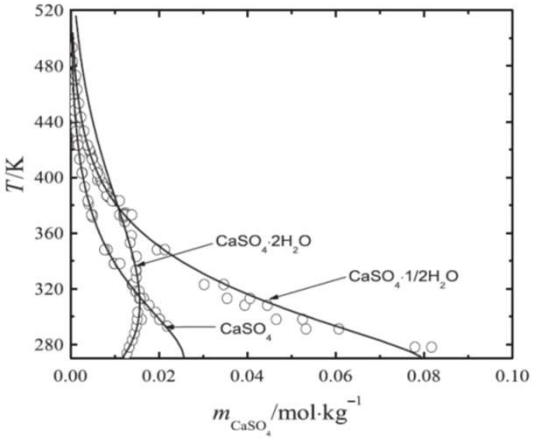
(2) Salt Lake Resources Chemistry Laboratory











Thermodynamics and phase equilibrium of salt solution

Structural chemistry of salt solutions

Evaporation of salt lake brines and salt crystallization

Methods and techniques for salt lake resource separation

(3) Salt Lake Resources Comprehensive Utilization Engineering Center

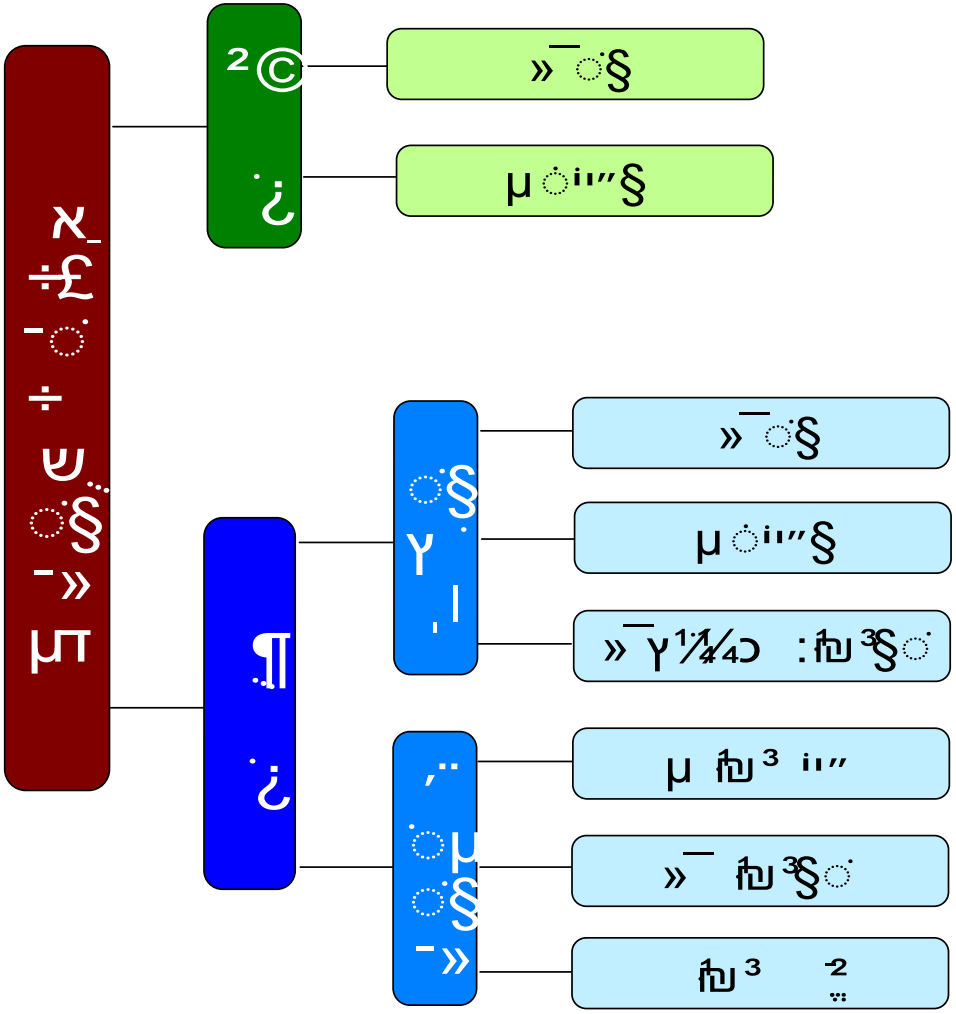
Salt lake potash production technology and engineering

Separation and extraction of lithium from salt lake brines

Specific and high value utilization of magnesium resources in salt lakes

Preparation of advanced materials based on salt lake resources

1.3 Education & Training



PhD degrees

Chemistry
Geology

Master degrees

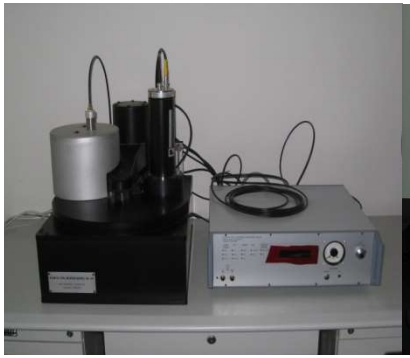
Chemistry
Geology
Chemical engineering and technology
Geological engineering
Chemical engineering
Materials engineering

We have postdoc openings in chemistry and geology all year round.

1.4 Support Departments

(1) Chemical Analysis and Testing Center of Salt Lakes

- Established in 1984
- Obtained national metrological certificate in 1994
- Analysis scope mainly including 13 categories and 25 items



(2) Salt Lake Resources and Environment Information Center

- ◆ Founded in 1965
- ◆ 100,000 books
- ◆ 11 subscribed electronic literature databases
- ◆ 80 electronic databases accessible though National Scientific Digital Library (NSDL) service platform
- ◆ Edited and published scientific and technological journal of salt lake research in Chinese

(3) Pilot Test Base

- Covering an area of 43 acres
- Having a comprehensive building
- Having a test workshop

1.5 Main Works

(1) Analysis methods of brines and solid salts

Chemical analysis

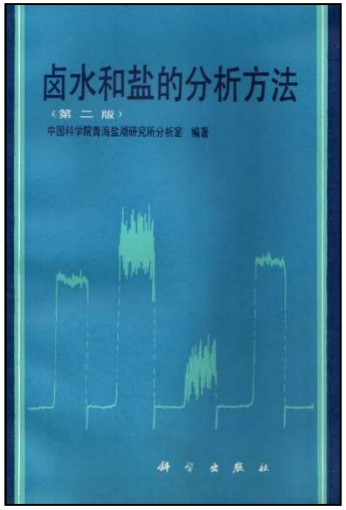
Differential thermometric titration

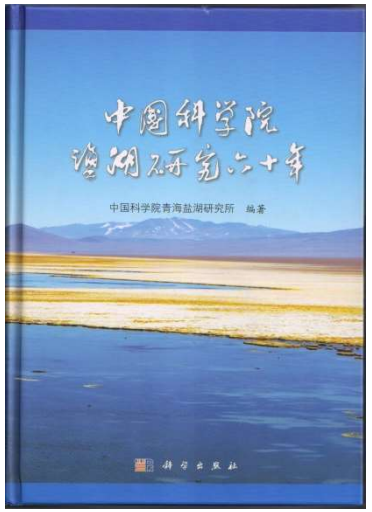
Atomic spectrum analysis

Ion selective electrode analysis method

Isotopic mass spectrometry

Atomic mass determination of elements





(2) Investigation and evaluation of salt lake resources

◆ Carried out a systematic and in-depth investigation of main salt lakes in China

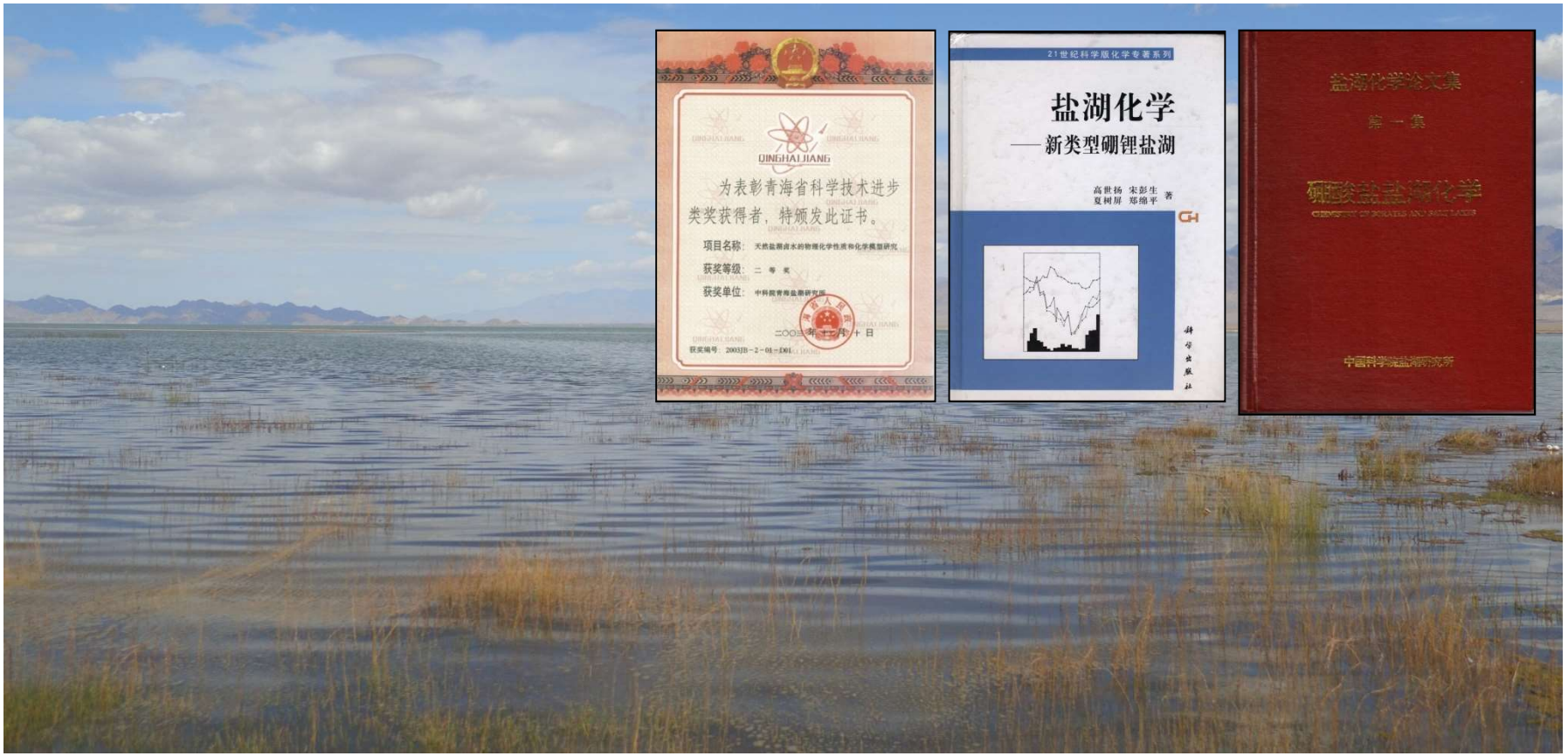
◆ Published several monographs

Tibet Salt Lakes
Xinjiang Salt Lakes
Inner Mongolia Salt Lakes
Salt Lakes in the Qaidam Basin
Clay Minerals in Salt Lakes in China
Origin of ancient anomalous potassium evaporites
China Salt Lake Resources and Their Development and Utilization

(3) Salt solution chemistry and phase equilibrium

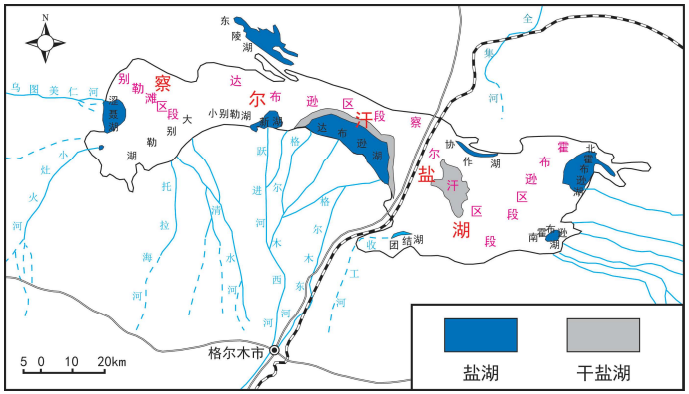
◆ Carried out according to the characteristics of salt lake brines in China

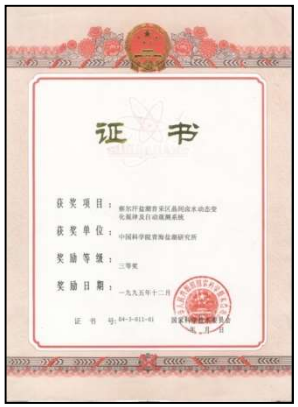
◆ Provided theoretical guidance for the development and utilization of salt lake resources, and especially for the salt lake industry in China



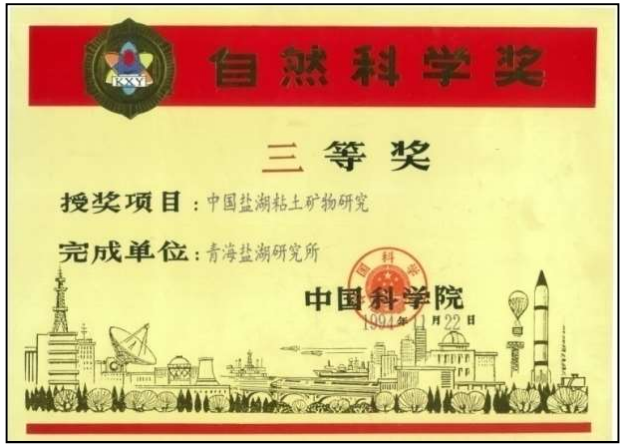
(4) Having made a systematic and comprehensive contributions to potash fertilizer industry in China

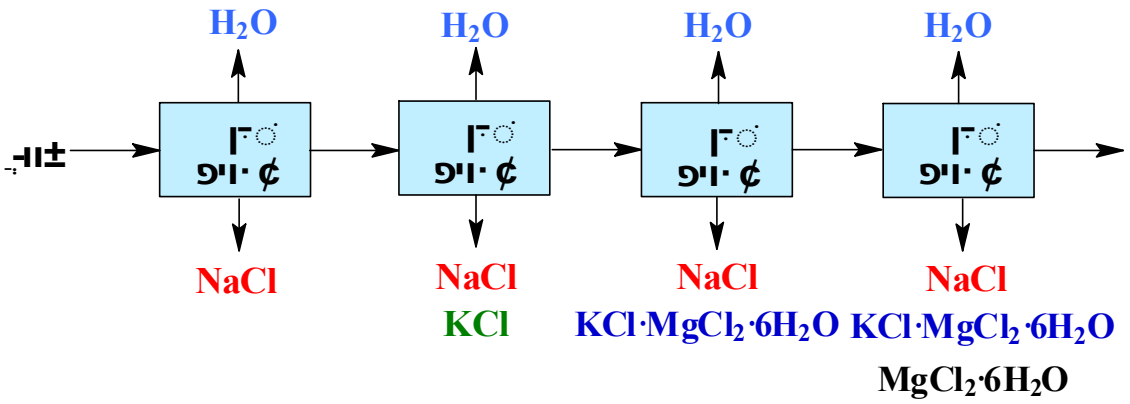
① Brine mining, hydrochemistry, water dynamics and automatic observation



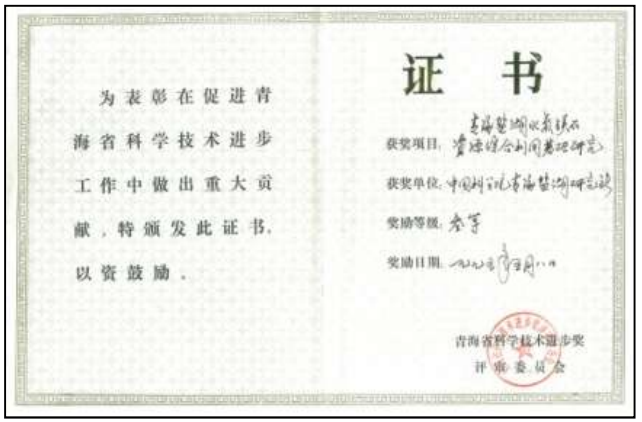


② Salt field processing using solar pond techniques





③ Separation techniques



④ Development of potash production technology and engineering cooperated with companies

(5) Extraction and recovery of lithium from brines with a high Mg/Li ratio

A series of lithium extraction methods have been studied in QISL

- Precipitation method
- Calcination method
- Salting out method
- Adsorption method
- Membrane method
- Solvent Extraction method

Membrane and solvent extraction methods are more suitable for the recovery of lithium from brines with a high Mg/Li ratio.

① Membrane method

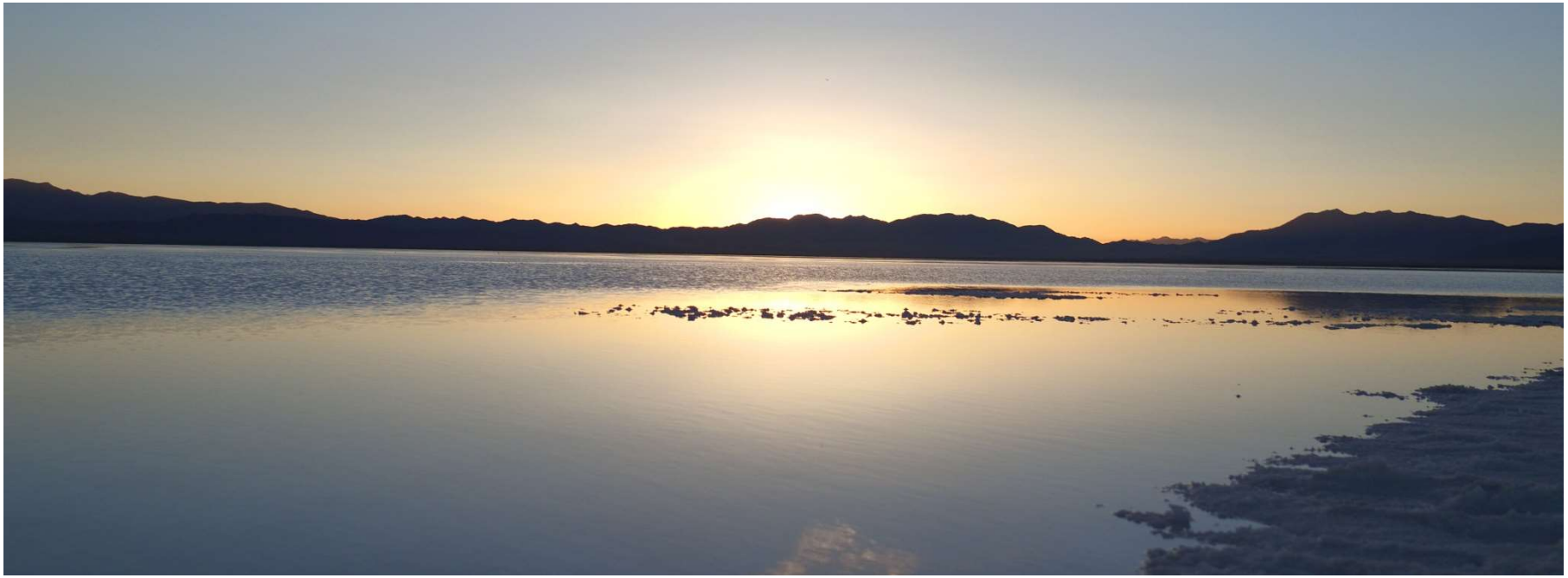
- Mainly physical process
- Relatively low cost
- Environmentally friendly
- Battery grade Li_2CO_3

Based on this method, two production lines have been built in China, with each production line having a capacity of 10,000 t/a. The production process is stable and continuous.

② Solvent extraction method

- ◆ High efficiency
- ◆ High recovery
- ◆ Short process without solar pond evaporation in some cases

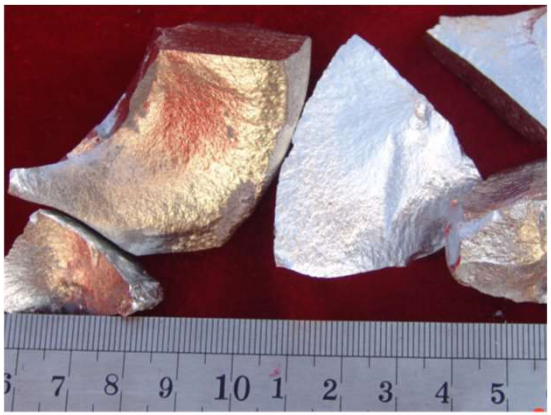
- ◆ Developed over ten efficient extraction systems
- ◆ Carried out whole process experiments using salt lake brines with different compositions and Mg/Li ratios
- ◆ Completed pilot tests using typical salt lake brines in China and abroad

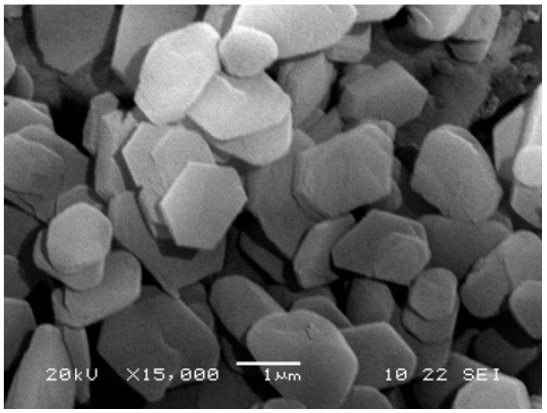


(6) Material preparation based on salt lake resources

Specific magnesium building materials
$Mg(OH)_2$ fire retardants
Lithium metal and aluminum-lithium intermediate alloys
Magnesium intermediate alloys
Mixed salts for energy storage

Pilot engineering tests have been completed





2 Research on exploration, exploitation and utilization of Qinghai salt lake resources

(1) Investigation and evaluation of salt lake resources

Prof. Liu Dagang (1904-1991), Academician of CAS, pioneer of salt lake science and technology in China, the first director of QISL, CAS

- In 1955, Institute of Chemistry, CAS established a physicochemical analysis group led by Prof. Liu Dagang.
- In 1956, physical and chemical studies on Chaka Salt Lake in Qinghai Province were carried out by this group.
- In 1957, the salt lake scientific investigation team of CAS was formed with Prof. Liu Dagang as the team leader.

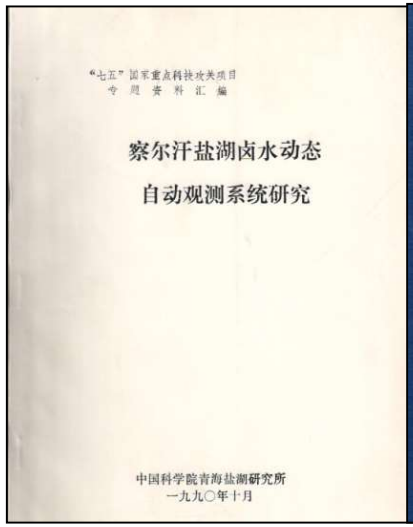
♦ From 1957 to 1964, this team and other relevant units conducted in-depth research on salt lakes in the Qaidam Basin, especially Qarhan Salt Lake and Dachaidan Salt Lake.

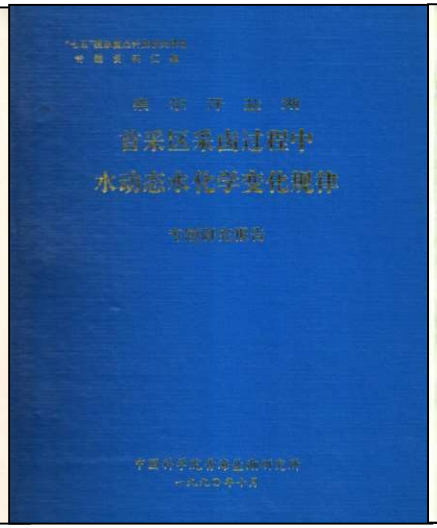
♦ The first hydrochemistry map of salt lakes in the Qaidam Basin was compiled.

(2) Brine mining, hydrochemistry, water dynamics and automatic observation

In the 1980s and 1990s, QISL undertook the national "seventh five-year" and "eighth five-year" scientific and technological research projects, conducted studies on brine mining, hydrochemistry and water dynamics of the Qarhan Salt Lake, and revealed the change processes and laws of brines in the process of brine extraction.

- **Chemical characteristics of lake surface brines**
- **Characteristics of salt systems and intercrystalline brine chemistry**
- **Chemical dynamic changes of intercrystalline brines**
- **Dynamic changes of intercrystalline brine level**





(3) Salt field processing using solar pond techniques

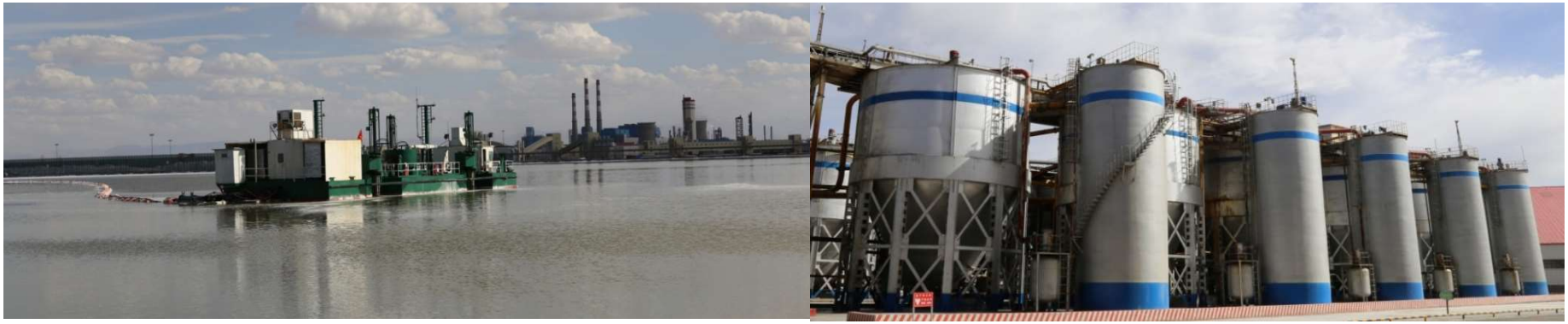
Brine in Qarhan Salt Lake is a typical chloride type brine. Material balance calculation and salt pan process design can be carried out according to the equilibrium phase diagram of Na^+, K^+, Mg^{2+}//Cl-H_2O quaternary system. Researchers of QISL finished the tests of isothermal evaporation, natural evaporation, etc. The experimental results provided an important basis for salt pan process tests.

(4) Separation techniques

From 1977 to 1990, researchers of QISL carried out bench-scale experiments or pilot tests for the cold decomposition-flotation, cold decomposition-hot dissolution crystallization, and reverse flotation-cold crystallization techniques.

(5) Development of potash production technology and engineering cooperated with companies

In the early years after the founding of our institute, more than 100 scientists conducted field tests in the region of Qarhan Salt lake, and obtained a complete set of technologies and technological processes, which were provided to Qinghai Potash Fertilizer Plant.



QISL cooperated with Qinghai Salt Lake Industry Co., Ltd. and its predecessor companies, through hard work and selfless dedication, has made a significant contribution to the potash fertilizer industry in China.

3 Establishment and development of potash industry in Qarhan Salt Lake, Qinghai Province

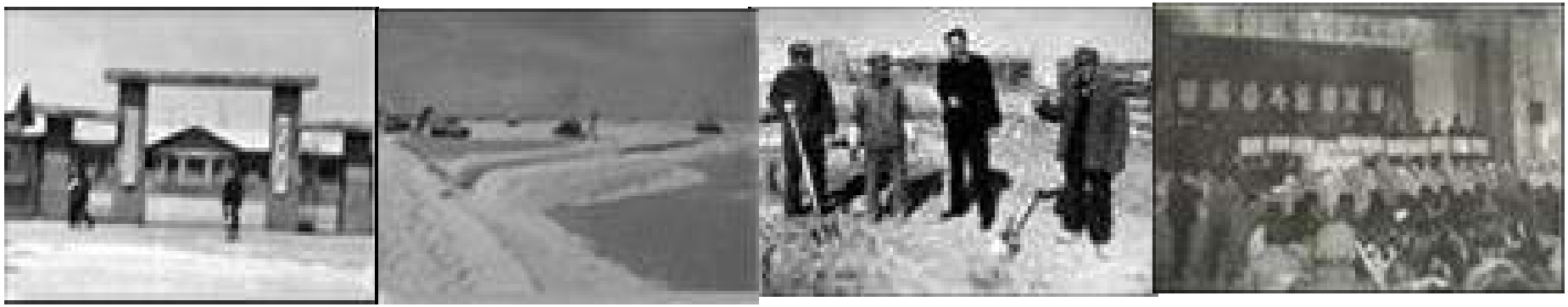
Qarhan Salt Lake in Qinghai Province has an area of 5856 km^2. As the second largest salt lake in the world by area, it was the first choice for potash production in China. Based on the resources of Qarhan Salt Lake, the construction and development of salt lake potash industry can be divided into six stages.

(1) First stage (First startup, 1958-1986)

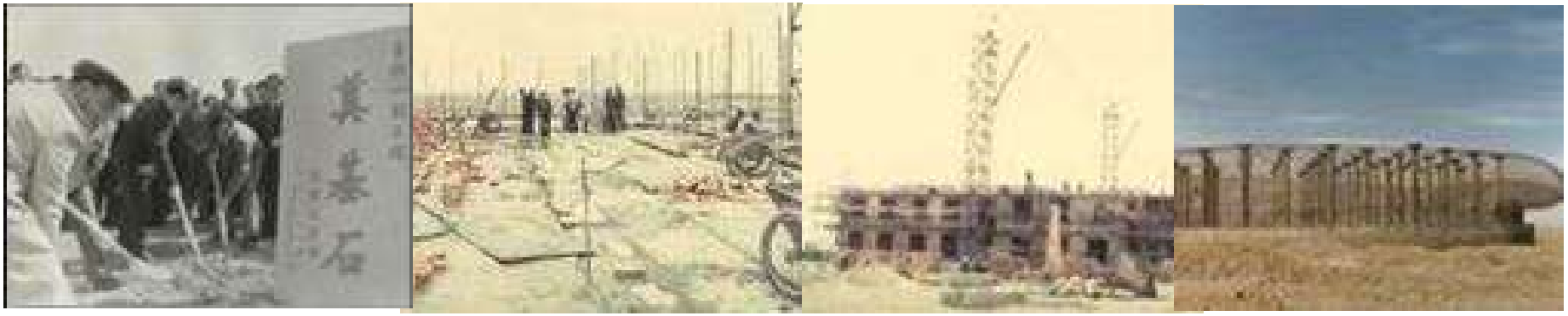
◆ In 1958, Qinghai Qarhan Potash Fertilizer Plant was built and put into operation. Cold decomposition method was used to produce KCl fertilizer.

◆ In 1969, a production line with an annual KCl output of 10,000 tons was built. Cold decomposition-flotation technique was used.

◆ In 1983, the production capacity was expanded to 40,000 tons per year.



(2) Second stage (Second startup, 1987-1989)



◆ In 1987, a special railway line for the transportation of potash fertilizer was built.

◆ In 1988, the first unit of the power plant was built to generate electricity.

◆ In 1989, a new production line of 30,000 tons potassium chloride was put into operation, thus expanding the annual output of the whole plant to 70,000 tons.

(3) The third stage (Pilot production period, 1990-1992)

◆ In 1990, the daily output of the secondary line has reached the design capacity.

◆ In 1992, the first-stage project of Qinghai Potash Plant formally passed the national acceptance.

(4) The fourth stage (Production and operation period, 1993-1998)

◆ In 1996, KCl production broke through 240,000 tons and Qinghai Salt Lake Industry Group Co., Ltd. was established.

(5) The fifth stage (Period of rapid development, 1999-2014)

- In 2000, the reverse flotation-cold crystallization process was successfully applied in production.
- In 2005 and 2007, the annual output of potassium chloride reached 1.43 and 1.96 million tons, respectively.
- In 2008, one of the first Ten Landmark Projects of China's Western Development - Qinghai Million tons Potash Fertilizer Project was completed successfully.
- In 2010, the annual output of potassium chloride reached 2.39 million tons and the product quality was upgraded.
- In 2013, a new million-ton potash fertilizer production line was completed successfully.

(6) The sixth stage (Period for comprehensive utilization of salt lake resources, 2015-)

- Now, Qinghai Salt Lake Industry Co., Ltd. has an annual KCl production capacity of over five million tons.
- The company also produces lithium and magnesium products, etc.

4 Summary

- China has become one of the world's important potash production bases.
- Main potash production techniques, including cold decomposition-flotation, cold decomposition-hot dissolution crystallization, reverse flotation-cold crystallization，etc. have been successfully practiced in Qinghai salt lakes.
- China's potash self-sufficiency rate has reached over 50%.
- China has basically set up a system of education, scientific research and commercial utilization for the production of potash fertilizers based on salt lake resources.
- However, as the largest developing country, as on of the largest agricultural countries in the world, China has a very long way to go to ensure the sustainable development of national potash industry, to produce and apply potassium-containing compound fertilizers to increase fertilizer efficiency, to establish a modern national fertilizer system to support the rapid development of China's agriculture, and finally to provide a strong support to make China an agricultural power in the world.

Thanks for listening !