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SALINE LAKES AND SALT BASIN DEPOSITS IN CHINA

——SELECTED WORKS OF ZHENG MIANPING

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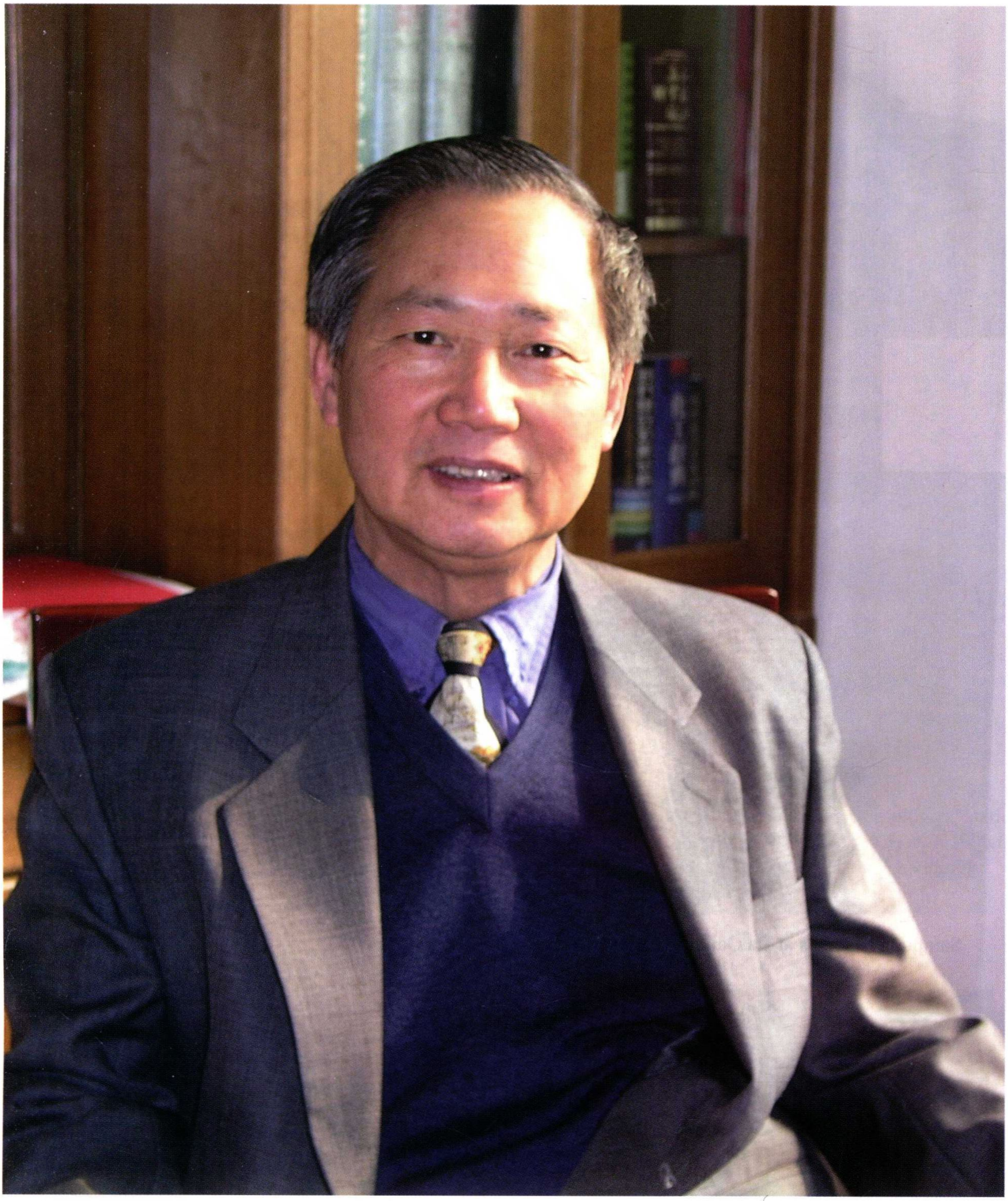
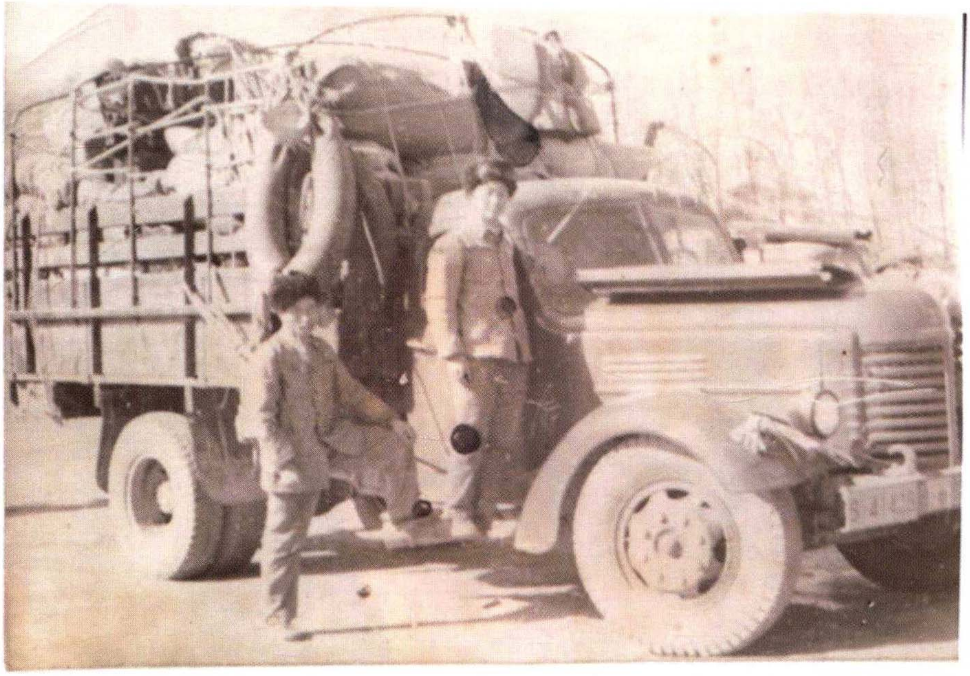
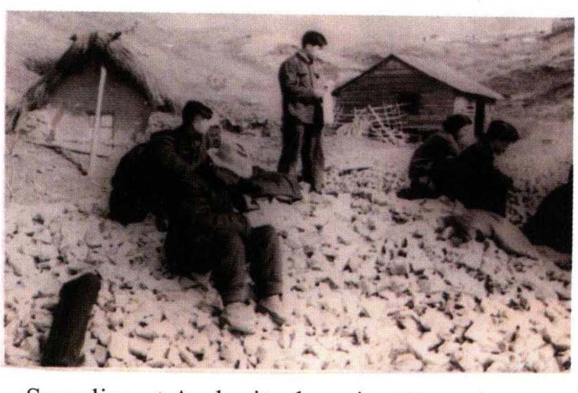


Professor Zheng Mianping

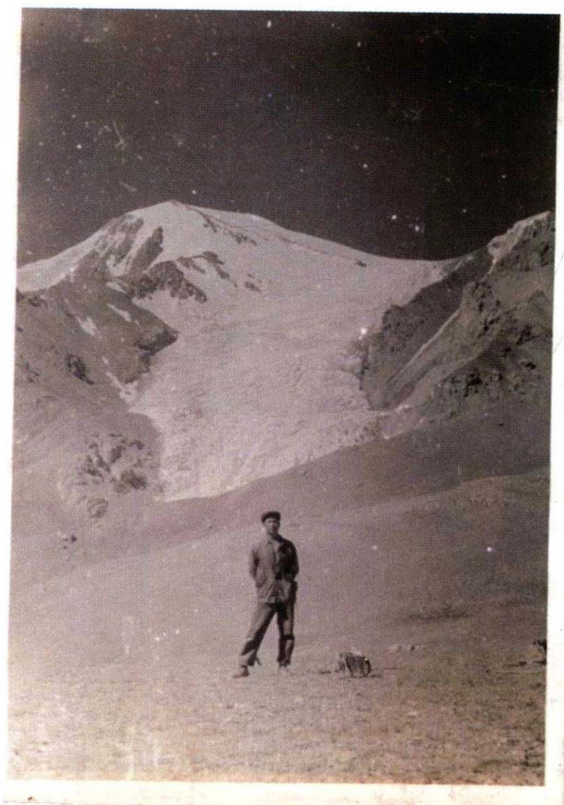


On the way to Qaidam basin for the first time in 1956 (right Zheng Mianping)

Sampling of brines at Da Qaidam salt lake



Sampling at Ascharite deposit at Fengcheng, Liaoning, in Nov. 1957 (second from left, professor Shchukin, former chief engineer of Ministry of Chemical Industry of USSR, third from left, Zheng Mianping)



Working at Xiagangjiang glacier, Ngari, 1960 at elevation of 5400m

1-1

1-2

Discovery of new type of Cesium-Bearing Gerserite at Tagejia, Tibet, in 1984

2-1 Observation of dunaliella salina at the Tufa island of the North Zabuye lake (from left, Zheng Yuan, Zheng Mianping, Xiang Jun)

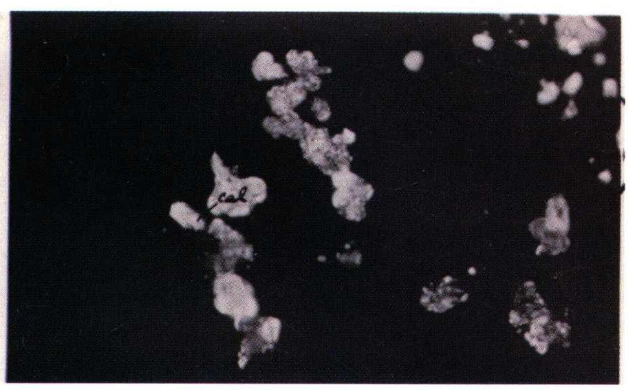
2-2 The establishment of meteorological station in the middle part of Zabuye salt lake in 1990 (left Qi Wen, middle Zheng Mianping)

2-3 The research group lead by Zheng Mianping at Zabuye lake in 1995

2-4 Working at the salt pan to build the research base for Li production (from left, Zheng Mianping, Yang Huipeng, Wang Gaoshang)

Chinese-America collaboration (expeditions of experts from both USA and China at Zabuye lake in 1988, 7th from left is Zheng Mianping, the leader of Chinese group, 9th from left is H. Holland, the leader of American group

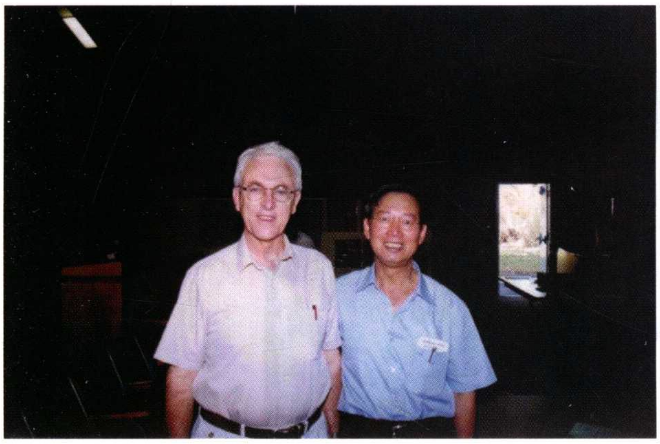
3-1 On the way to Daerduo depression of Lop Nor, along Kongque river in Oct. 1989



3-3 First discovery of carnalite at Lop Nor

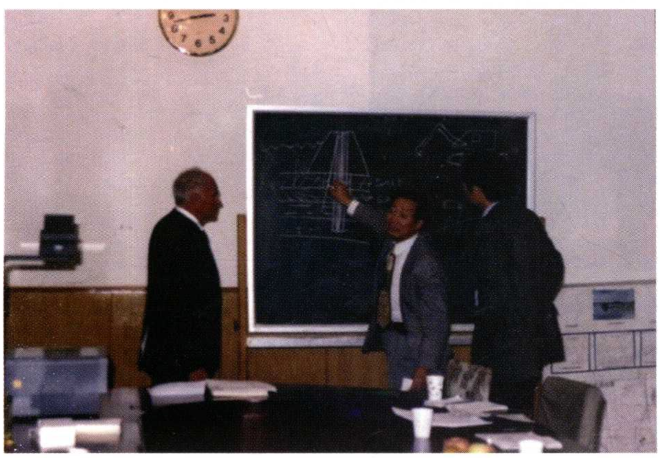
3-2 Building the drilling rig on the salt crust of Lop Nor

Vice Premier Zhou Jiahua with experts from China and overseas

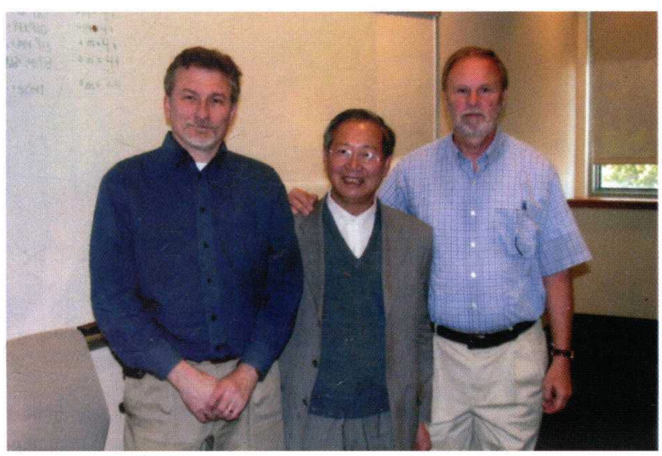


Professor W.D.Willams and Professor Mianping Zheng during the seventh International Conference on Salt Lake Research in 1998

Some representatives during seventh International Conference on Salt Lake Research in 1998

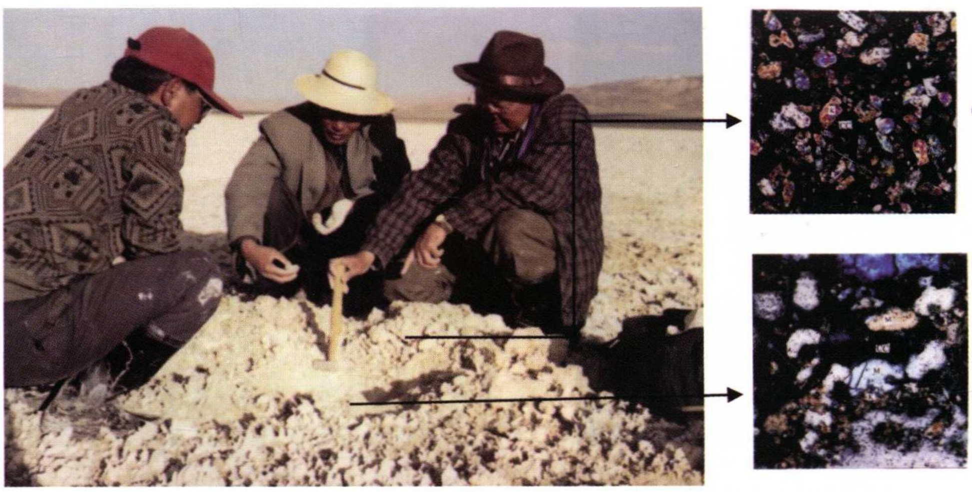


Discussing with David S. Butts, an American experts on salt pans, in 2000



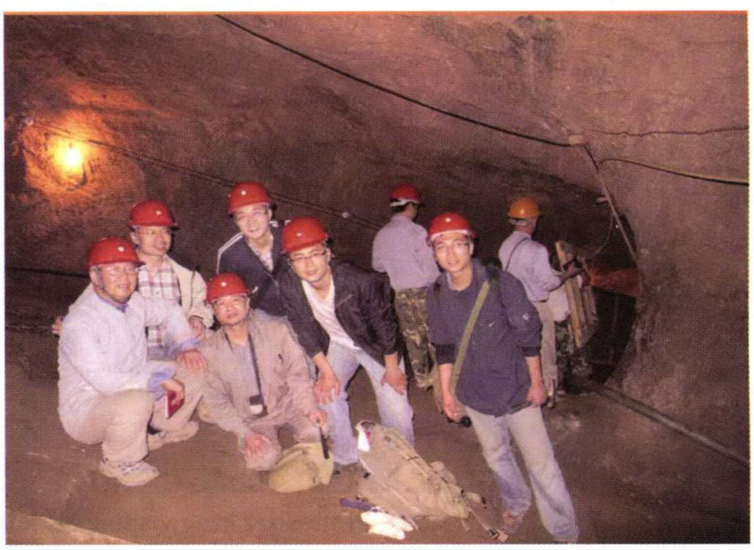
Professor Zheng visiting the Washington University for joint research on Mars salts in 2009(From left, Wiens Douglas; Zheng Mianping; Arvidson Raymond)

General exploration or boron deposits at chagcam caka, Tibet, 2002 (A new type of boron deposits was discovered by Zheng Mianping in 1961), left panel: primary euhedral kurnakovite and euhedral pinnoite surrounded by mirabilite, subsumption structure 4×10(+)



6.3×6.3(+)

Observation of magnesium borates bearing sections by Zheng Mianping (right) and colleagues at the primary terraces of Nie'er Co, Tibet, in 2000



Field work at Mengyejing potassium deposit (left Zheng Mianping)

Introduction

Academician Zheng Mianping has been working on salt lakes and ancient salt deposits for more than half century, and this book is a selection of his works covering almost all the aspects in salt science. The 12th international conference, convened by Academician Zheng, will be held in China this year, and this book is written in English to serve reference for foreign colleagues who study salt lakes and salt bearing deposits.

Most of the materials in this book have been published with some minorerrors corrected, and some new materials are added as supplements. Five chapters are organized based on disciplines of selected works. The first chapter gives the concept of salinology and saline systems, which is a high level systematic summary of salt sciences. Chapter 2 introduces the Saline Lakes and their resources in China. Chapter 3 includes some studies on palaeoclimate through detailed investigation of salt lake sediments. Chapter 4 focuses on the geoecology aspect of salt lakes, and introduces the concept of "Salt lake agriculture" proposed by Academician Zheng. Chapter 5 introduces salt basins and the new progresses in potassium exploration in China.

The publishing of this book was greatly supported by Science Press, and was greatly helped by the editors Zhang Jingfei and Bu Xin. Special thanks to Professor Fei Zhenbi for translating most parts of this book. During the organization of this book, Kong Weigang, Hu Yun, Chang Huilin, Wang Hailei, Zhang Xuefei, Wang Yunsheng, Zhang Zhen, Yan Lijuan and many other colleagues have helped on editing and translation. All these support and help make this book get published on time.

All maps in this book are sketch maps, and they may have historical limitations.

"Selected Works of Zheng MianPing" editorial group
June 2014

Contents

Chapter 1 Thoughts on Salinology and Saline Systems Research

1.1 On Salinology*

1.1.1 Introduction

Saline lakes are an important type of lake, *viz.* one where water-bodies contain a relatively high concentration of dissolved salts. According to recent advances in the study of saline lake geology, biology and other fields, I suggest that the lower limit of salinity for saline lakes *sensu stricto* be defined as >3.5%, while that for saline lakes *sensu lato*≥0.30% or in excess of 3 $g \cdot l^{-1}$ (Williams, 1996). Saline lakes can contain important raw materials for industry, agriculture, and medicine, e.g. halite, mirabilite, lithium, magnesium, boron, gypsum calcium chloride, tungsten, cesium, rubidium, strontium, hydromagnesite and zeolite. Considerable amounts of biological resources, such as halophilic algae, *Artemia*, *Spirulina*, of economic and scientific value, occur in saline lakes. Moreover, saline lakes are important for tourism. The heat-storing features of lake brine solar evaporation ponds have also been used in electricity. Finally, saline lakes are sensitive indicators of the past and important for reconstructing paleoclimatic, paleoenvironmental and tectonic events.

1.1.2 Trends of scientific and technological development

If we consider that research on saline lakes started from an analysis of the brines of the Karabugaz Lagoon in the mid-nineteenth century, saline lake research has experienced three stages. The first stage lasted from the middle of the nineteenth to the beginning of the twentieth century (the Van't-Hoff school and N.S. Kurnakov school). Research during this period was dominated by physical-chemical analysis. The second stage, from the early-twentieth century to the 1960s, can be referred to as the stage of traditional geological, biological and chemical disciplinary research. Since the 1970s, research on saline lakes has developed into a stage with multidisciplinary research (Matter and Tucker, 1978; Kushner, 1978; Eugster and Hardie, 1978; Smith, 1979; Brock, 1979; Dietor, 1979; Gwynn, 1980; Nissenbaum, 1980; Borowitzka et al., 1981; Hammer, 1981; Williams, 1981; Yuan, 1982; Javor, 1989; Hurlbert, 1993; Zheng, 1995, 1996; Oren, 1999).

1. *Development and expansion of the scope of research on saline lakes*

Saline lakes are valuable natural resources. With continued reconnaissance, exploration and development of their resources, research on them has deepened and its scope expanded, with progress in experimental studies of their values and uses. The concept of saline lakes as mainly solid mineral resources has been outdated. Large amounts of important raw materials for the chemical industry, agriculture, metallurgical industry and medicine are now obtained from saline lakes. In some brines, biological resources are present in large amounts. In addition, the heat-storing features of saline lake brines have been used in "solar energy salt pond" electricity and playas have been used to build highways, railways and even airfields.

2. *Value and use of saline lake brines*

Mineral resources of saline lakes and their applications are shown in Table 1.1.1. In saline lakes, there are

* Zheng Mianping. 2001. On salinology. Hydrobiologia, 466: 339-347.

usually complex ores with solid and liquid states. Significant advances in the investigation, valuation and uses have been made with considerable economic benefits. For example, in Great Salt Lake, long-term fundamental and applied research has focused on mineral and biological resources, hydrochemistry, and engineering and includes meteorological and hydrological observations over 140 years (Gwynn, 1980). The annual gross value of the potash, magnesium, sodium sulfate and halite reaches about one billion dollars. Another example is the Atacama Salt Lake in Chile, where the Cyprus-Foot Company and SQM Company invested 60 million dollars for feasibility studies of development of lithium production and then established a lithium plant that is now the largest in size and produces lowest cost lithium. Simultaneous production of lithium salt, potash salt, borate and sodium sulfate occur with an annual gross product of more than one billion dollars. Since 1997, SQM has greatly reduced the cost of Li_2CO_3 and eliminated many hard rock lithium ventures (McCracken and Mike, 1998).

Table 1.1.1 Summary of types, magnitudes and uses of saline lake resources

Type				Magnitude and ccurrence	Uses
Classic material			Clay, sand, gravel, volcanic ash	Large quantities available; economic-geographic conditions appropriate; exploitable	Used in building and road paving, and especially clay used in brick-making; volcanic ash used as absorbents for automobiles, ship docks and factories
Solid-state minerals	Dominant evaporites	Carbonates	1. Calcite, aragonite, dolomite, magnesite	Commonly dispersed; low purity; but calcite occurs as large accumulations	Calcite can be used as lime
			Hydromagnesite	A few thousand tons discovered in Tibet, China	Can be used for refractory magnesium bricks
			2. Trona, soda and other alkali-bearing materials	Vary in magnitude from several hundreds tons and several hundred million tons (in U.S.A., Russia, Inner Mongolia of China, Kenya)	Widely applied in glass, textile, paper-making, dye, rubber, synthetic rubber, medicine, battery, detergent and chemical industries
			3. Li-bearing magnesite, Zabuyaite (Li_2CO_3)	Commonly contain a few per mil to a few hundred ppm Li_2CO_3 (Zubuye Lake and Bangkog Lake, Tibet)	Mainly used in special glass, ceramic, aluminium smelting, chemical products, synthetic rubber, medicine, batteries, lubricant, air purifier
		Sulfates	1. Gypsum and anhydrite	Mostly dispersed and locally occur as a few million tons of gypsum accumulations	Used in light building materials, agriculture, gypsum products and other daily life products
			2. Thenardite and mirabilite	Mirabilite deposits and part of thenardite deposits have large magnitude and high purity, larger ones attain a few hundred million to a few billion tons (e.g. in Karabujiaz Gulf, Russia)	Used in glass, paper-making, detergent, dynamite, medicine and metallurgical industries
			3. Epsomite and kieserite	Range from a few hundred to a few hundred thousand tons	Medicine and chemical Industries
			4. Bloedite	Generally dispersed, and in some areas reserves attain few tens of million tons (e.g. in Russia)	Used in manufacturing magnesium glass for laboratory use yielding good effects
			5. Aphthitalite, picromerite, kainite, polyhalite, syngenite, and hanksite	Dispersed and locally picromerite occurs as potash layers (Dalang P. and Da Qaidam L., China); can be mined for multi-purpose uses	Mainly used in agriculture and chemical industry
		Halides	1. Halite	Ranges from a few hundreds of thousands of tons to a few hundreds of billions of tons (e.g. Qarhan P., China); widely distributed in world	Mainly used in edible salt and basic chemical industry; those used for edible salt and fodder make up to 65%–70%
			2. Potash	Commonly dispersed; in places reserves up from $n\times10^4$ to $n\times10^7$ tons (Potash Lake of Qaidam and Potash Valley of Red Sea)	About 90% used in agriculture, and the rest in the chemical and military industries

Continued

Type				Magnitude and occurrence	Uses
Solid-state minerals	Dominant evaporites	Halides	3. Carnallite	$n \times 10^4$ to $n \times 10^7$ tons KCl, and $n \times 10^4$ to 10^7 tons MgCl; low grade; generally difficult to mine as an independent mineral (e.g. Qarhan P., Qaidam, China)	(1) Use of KCl same as above; (2) magnesium salt used in producing metal magnesium and its alloy and medicine
			4. Bischofite	Locally forms separate accumulations, up to a few million tons (Dalangtan P., China)	Same as above
		Borates	Borax	B_2O_3 ranges from a few tens to a few millions tons; high-grade boron ores (e.g. W. U.S.A., plateau of S. America, Tibet of China)	Widely applied in more than 100 industries, such as glass, glass fiber, porcelain glaze, detergent and steel smelting
			Mg borate	B_2O_3 ranges from $n \times 10^4$ to $n \times 10^6$ tons; acid-soluble boron ore (e.g. Zacang Caka and Da Qaidam L. of China, Argentina)	Same as above
			Ulexite	B_2O_3, a few tens to a few tens of thousand tons; can be partly decomposed in hot water (e.g. N. Chile and W. U.S.A.)	Same as above
			Colemanite	B_2O_3, a few tens to a few tens of thou- sand tons; acid-soluble boron ores	Same as above
		Nitrates	Soda niter	About a few tens to a few millions tons (e.g. desert area in N. Chile)	Used in dynamite, chemical industry, agriculture
			Niter	Smaller in magnitude than soda niter (e.g. N. Chile and Uzong Bulak of Xinjiang, China	Used in chemical industry, dynamite and fire-words
		Iodates	Lautarite, Brueggenite	Dispersed in niter ore; can be mined as a by-product (e.g. N. Chile)	Mainly used in medical industry, chemical industry, agriculture and environmental hygiene
		Uranates	Pitchblende, Ursilite, Carnotite, Autunite	Can form accumulations of commercial value (e.g. W. Australia, W. U.S.A.)	Used in nuclear power station and military aspects
		Calcium chloride	Antarcticite and other $CaCl_2$ minerals	Can form commercial mineral deposits; known ones dispersed (e.g. N. Antarctic and Qaidam); can form commercial ore beds (e.g. Bristol Lake, W. U.S.A.)	Used in driers, chemical Reagents
		Silicates Others, Iron minerals	Hydroglass, Magadiite, Goethite, limonite, pyrite, marcasite	Mostly dispersed; locally occur as thin beds (Magadi Lake) Occur in a few acid saline lakes; goethite and limonite can make up modern deposits with over a few millions tons (e.g. Tyrrell L., Australia); high grade	Not yet used Possible use in iron smelting
	Sedimentary minerals	Silicates	Zeolite	Can form industrial ore beds (e.g. salt lakes in W. U.S.A.)	Environmental protection, metal recovery and agriculture
			Bedded chert, opal	Bedded cherts may have larger magnitude (e.g. Magadi Lake, Kenya)	Not yet used
		Organic ooze		Locally contains large amount of organic ooze and may form large bedded accumulations	Liquid fuel can be extracted Through heat treatment