

## Research Advances

## The First Halite Age Revealed by MC-ICP-MS U-series Dating in Lop Nur, Northwestern China

LÜ Fenglin<sup>1,2,3</sup>, LIU Chenglin<sup>1,2,\*</sup>, JIAO Pengcheng<sup>1</sup>, ZHAO Jianxin<sup>3</sup> and ZHANG Hua<sup>1</sup>

<sup>1</sup> MLR Key Laboratory of Metallogeny and Mineral Assessment, Institute of Mineral Resources, Chinese Academy of Geological Sciences, Beijing 100037, China

<sup>2</sup> China University of Geosciences, Beijing 100083, China

<sup>3</sup> Radiogenic Isotope Facility, School of Earth Sciences, the University of Queensland, Brisbane 4072, QLD, Australia

### Objective

Quaternary saline lakes are significant for paleoclimatic reconstruction due to the high sensitivity of salt minerals to environmental changes. However, salts in these areas with great thickness such as halite or potash representing extreme environments have severely blocked the application of traditional chronological methods. This is typified by Lop Nur, since accurate age to constrain salt sequences is very limited hindering further exploration for climatic changes and genetic mechanism of potash resources. For the first time, this work used MC-ICP-MS U-series to date halite of Lop Nur. The obtained results combined with previous age data will provide new age constraints on salt sequences in this area and improve our understanding of phased evolution of saline lake and the formation of potash deposits on a time scale.

### Methods

Halite samples in this study were collected from the core ZKCL1 in the Luobei Sag, northern Lop Nur. Only halites with well-preserved cumulate and chevron crystals were selected to exclude recrystallization or dissolution. After hand-picking and washing with absolute alcohol, they were transferred to the ultra-clean Radiogenic Isotope Laboratory, the University of Queensland, to vet again under a light microscope in case of contamination by mixed dusts or muds during halite deposited. Approximately 0.005 ml of a <sup>229</sup>Th-<sup>233</sup>U mixed tracer (spike<sup>#1</sup>) was added to each pre-cleaned Teflon beaker, after which 0.3g of the sample material was weighed and added to the spiked beaker. Then it was dissolved with 25ml 1% HCl and co-precipitated with Fe(OH)<sub>2</sub>. At last U and Th was collected by using conventional ion-exchange

columns made of TRU resin following standard procedures. All samples were subsequently measured for U-Th isotopes using a Nu Plasma MC-ICP-MS. Following measurement, all U-Th ages were calculated with the Isoplot/Ex 3.00 program. U-Th data for each sample was plotted in <sup>230</sup>Th/<sup>238</sup>U versus <sup>234</sup>U/<sup>238</sup>U space and initial <sup>230</sup>Th contamination calculated was corrected using the bulk-Earth activity value of 0.82.

### Results

Measurements of U, Th isotopes and age data are shown in Appendix 1. High U/Th value (18.4–66.8) implies that uranium is richer than thorium in halite crystals which provides possibility for U-series dating. Certified Reference Material (CRM) YB-1 display the result around 30±0.1 ka and is in an average. Four samples with different stratigraphic depth yield corrective ages of 19.36 ka, 17.39 ka, 14.72 ka and 11.40 ka, respectively, with the relative errors range of 1.9%–5.4%. The calculated sedimentation rate during last 19.4 ka is 0.93 mm/a in this studied core, agreed with 1.2 mm/a and 0.98 mm/a of core ZK0800 and ZK1200B in Lop Nur (Fig. 1) revealed by other dating methods (Wang Mili and Liu Chenglin, 2001). In addition, our age range is plotted into the interglacial period during the last deglacial period (ca. 19–11 ka B.P.) characterized by global warming trend (Clark et al., 2011; Young-Suk BAK and Young-Up LEE, 2017). This is also supported by the occurrence of studied halite sediments. Therefore, the above evidences strongly suggest our age data is valid and representative.

Sedimentation rate of this studied core shows a decline from 0.80 mm/a to 0.18 mm/a during the interval. This could be the response to the warm and arid climate environment that a quick aridification lead to lowering or even ceasing of sedimentation rate due to upward shoaling or even desiccation of paleolake. In addition, our obtained

\* Corresponding author. E-mail: fenglinlyu0103@hotmail.com

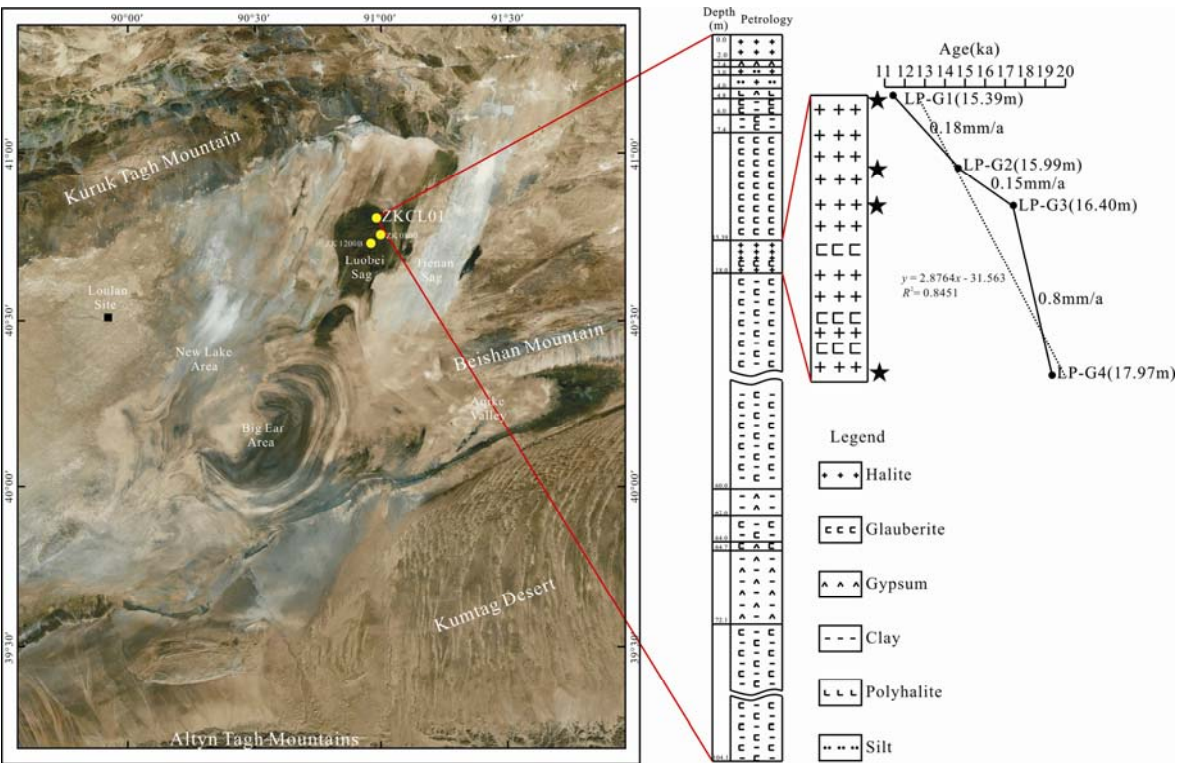


Fig. 1. Locality and petrology of the studied core.

ages of halite are much older than previously reported  $^{14}\text{C}$  age ( $\sim 8.6$  ka B.P.) of potassium-enriched brine, displaying an asynchronous between halite and brine

### Conclusion

In this contribution, MC-ICP-MS U-series dating for the first time is applied to dating halite in Lop Nur. The obtained data provide bridge on a time scale between evaporite area and non-evaporite area, salt sediments and brine. Our age data of halite and the occurrence of halite sediments indicate warm and dry climate condition dominates Lop Nur during last 19–11 ka. Combined with the age of brine, we tentatively infer that climate condition could be characterized by constant dry and warm since halites deposited, which is likely to be one of key driving forces for the formation of potassium-enriched brine in such a short interval.

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### Appendix 1 U-series dating results of halite crystals from the core ZKCL1

| Sample | Depth (m) | Type       | U (ppb) | Th (ppb) | $^{234}\text{U}/^{238}\text{U}$ | $^{230}\text{Th}/^{232}\text{Th}$ | $^{230}\text{Th}/^{238}\text{U}$ | Age (ka) (uncorrected) | Age(ka) (corrected) |
|--------|-----------|------------|---------|----------|---------------------------------|-----------------------------------|----------------------------------|------------------------|---------------------|
| LP-G1  | 15.39     | Halite     | 99.6    | 1.49     | $1.015\pm 0.001$                | $21.20\pm 0.11$                   | $0.104\pm 0.000$                 | $11.839\pm 0.05$       | $11.402\pm 0.22$    |
| LP-G2  | 15.99     | Halite     | 51.6    | 2.8      | $1.03\pm 0.001$                 | $8.00\pm 0.05$                    | $0.143\pm 0.001$                 | $16.289\pm 0.10$       | $14.718\pm 0.79$    |
| LP-G3  | 16.40     | Halite     | 40.3    | 2.07     | $1.014\pm 0.001$                | $9.55\pm 0.08$                    | $0.161\pm 0.001$                 | $18.899\pm 0.17$       | $17.390\pm 0.78$    |
| LP-G4  | 17.97     | Halite     | 23.3    | 1.07     | $1.006\pm 0.002$                | $11.46\pm 0.1$                    | $0.174\pm 0.002$                 | $20.731\pm 0.20$       | $19.363\pm 0.72$    |
| YB-1   |           | stalagmite | 129     | 0.46     | $1.742\pm 0.02$                 | $362\pm 1.87$                     | $0.427\pm 0.002$                 | $30.052\pm 0.14$       | $29.994\pm 0.14$    |