BRINE EVOLUTION IN QAIDAM BASIN, NORTHERN TIBETAN PLATEAU, AND THE FORMATION OF PLAYAS AS MARS ANALOGUE SITE. W. G. Kong[1] M. P. Zheng[1] and F. J. Kong[1], [1] MLR Key Laboratory of Saline Lake Resources and Environments, Institute of Mineral Resources, CAGS, Beijing 100037, China. (Weigang.kong@gmail.com)

Introduction: Terrestrial analogue studies have served much critical information for understanding Mars [1]. Playa sediments in Qaidam Basin have a complete set of salt minerals, i.e. carbonates, sulfates, and chlorides，which have been identified on Mars [e.g. 2-4]. The geographical conditions and high elevation of these playas induces Mars-like environmental conditions, such as low precipitation, low relative humidity, low temperature, large seasonal and diurnal T variation, high UV radiation, etc. [5,6]. Thus the playas in the Qaidam Basin servers a good terrestrial reference for studying the depositional and secondary processes of martian salts.

From 2008, a set of analogue studies have been carried out on the playas in the Qaidam basin focusing on various aspects, including geology, mineralogy, astrobiology, and remote sensing [e.g. 5-9]. The general geological and environmental backgrounds of salt lakes on the Tibetan Plateau have been introduced in a previous abstract, and here, we will describe the brine evolution in the Qaidam basin and the formation of the playas (Dalangtan, Chaerhan, and Kunteyi) on the basis of previous literature to serve background information for current and future analogue studies [10].

Brine evolution and formation of Playas in the Qaidam Basin: The Qaidam Basin is bounded by the Qilian Mountains to the northeast, Altyn Tagh Mountains to the northwest and the Kunlun Mountains to the south (Fig. 1). The current bounding structures might have formed during the Indosinian tectonic stage at early Mesozoic, and Qaidam has become a continental basin since then. The landforms of the basin evolve ever since its birth. From the late Eocene, with the collision between the Eurasia and India plate, the Qaidam Basin entry the depression period, and a thick layer of sediments (normally 1400 to 2000 m) formed in the basin since Oligocene. Since then, the tectonic activities, especially the uplift of Tibetan Plateau and erosion, coupling the deposition processes, have driven the depositional center migrating inside the basin.

From Eocene, at the primary phase of Qaidam Basin, the depositional center sits at the southwest part. At this stage, the basin has fresh to low salinity water bodies, thus carbonated rich sediments deposited. From Oligocene, the deposition center migrated to the west part of the basin, i.e. the Dalangtan depression, and sulfate bearing sediments started to deposit. After that, the deposition center migrates to northeast, and the sulfate bearing sediments extents towards the north part of the basin (Kunteyi depression). The Pliocene is the first major salt forming period for Qaidam Basin, and the salt bearing sediments formed at the southwest part are dominated by sulfates, and those formed at the northwest part of basin are partially sulfates dominate and partially chlorides dominate. After Pliocene, the deposition center started to move towards southeast until reaching the east part of the basin at Pleistocene, reaching the second major salt forming stage, and the salt bearing sediments formed at this stage are mainly chlorides dominate. The distinct change in salt mineral assemblages among deposition centers indicates the migration and geochemical differentiation of brines inside the basin.

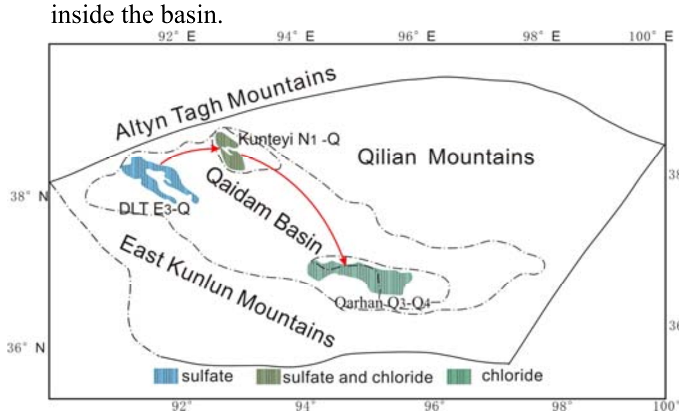

Fig.1 Schematic map of playas in the Qaidam basin with dominate salt types indicated. The red arrows show the brine migration trend, and the deposition periods are shown for each playa.

The Qaidam Paleolake occurred as the basin formed, and developed to be a large single water body until became many smaller lakes induced by the fast uplift of the Tibetan Plateau and dry climate at Miocene to Pliocene. In this long period (tens of millions years), a large quantity of salt forming irons has been dissolved by the paleolake due to water-rock interaction and has finally formed the salt rich sediments inside the basin. At late Pliocene, the brines in the west Qaidam basin mainly dried up induced by the fold uplift and dry climate, only some high salinity brines remained in local depressions, including the Dalangtan depression. And finally, the brines in these local depressions dried up in Quaternary, and formed a set of dry playas. Similar tectonic activities together with dry climates have made the brines in East Qaidam basin dry up and formed many dry playas, including the Kunteyi Playa and Qarhan Playa, at late Pleistocene.

Carbonate rich sediments: Like other sedimentary basins, carbonate rich sediments distributes all over the basin. Thick carbonate rich sediments deposited when the Qaidam Paleolake had fresh or low salinity waters at early Cenozoic. After Oligocene, carbonate rich sediments began to deposit in salt bearing strata.

Sulfate rich sediments and Dalangtan Playa

As discussed above, sulfate rich sediments dominate in the first salt forming period at Pliocene, and distributes widely in the west Qaidam Basin. During this period, the sulfate rich sediments first deposited at areas centered at Dalangtan secondary basin, then extends to the northwest Qaidam basin. At late Pliocene, only little amount of high salinity sulfate brine was left in local depressions including the Dalangtan depression. And the residual sulfate brine in the Dalangtan depression finally dried up at Holocene forming the Dalangtan Playa.

Dalangtan (DLT) Playa locates in the centered depression of the DLT secondary depression (38°0′–38°40′N, 91°10′–92°10′E), west margin of Qaidam basin. The mineralogy of DLT Playa was described by several studies including the recent one by us [11]. The common occurrence of halite in samples collected from vertical sections from shallow subsurface strata at various locations of the playa support that the sulfate brine residual from the first salt forming Pliocene are highly concentrated to the stage of halite saturation. The dominate sulfate phase in the strata at edge of playa is mirabilite, a hydrated sodium sulfate, and that in the strata at the center of the playa is hexahydrite, a hydrated magnesium sulfate. This deposition trend from Na to Mg sulfate follows the normal geochemical evolutions trend of sulfate brines.

Chloride rich sediments and Qarhan Playa: In the second salt forming period of Qaidam Basin at Pleistocene, chloride rich sediments deposited at regions centered at the Qarhan lake area. The chlorite brine, which comes from the migration from the west Qaidam Basin, in the Qarhan depression finally dried up and formed the Qarhan Playa at the Holocene.

Qarhan Playa is the dry areas in the Qarhan lake region (36°37′–37°12′N, 93°42′–96°14′E), center of the Qaidam Basin. Chloride rich minerals, mainly halite, occur in the strata since Pleistocene, and carnallite, sylvite, and bischofite starts to occur in Holocene strata, representing a late stage of chloride brine.

Kunteyi Playa: During Pliocene, the deposition center of Qaidam basin moves to northeast, and the sulfate brine extended to the Kunteyi salt lake area(38°24′–39°20′N, 92°45′–93°25′E). As migration went on, the brine chemistry evolves to an intermediate stage and started the transformation to chloride brines. These brines partially dried up, and formed Kunteyi Playa and Kunteyi Salt Lake today.

The Kunteyi Playa has salt bearing strata of up to hundreds of meters thick. In this region, sulfates such as gypsum, mirabilite, and glauberite occur in the lower part of the strata, while hydrated chlorides, e.g. bischofite and antarcticite occur in the upper part of the strata or surface of outcrops.

Table 1. Salt minerals at playas in Qaidam Basin [10-12].

DLT	Kunteyi	Qarhan
gypsum bassanite anhydrite mirabilite D'Ansite blodite thenardite glauberite halite glaserite hexahydrite sylvite pentahydrite leonite glaserite langbeinite starkeyite kieserite loeweite polyhalite picromerite carnallite	gypsum bassanite mirabilite thenardite glauberite blodite loeweite exahydrite starkeyite polyhalite sylvite bischofite halite antarcticite	gypsum anhydrite carnallite sylvite halite bischofite

Discussion: The Qaidam Basin is a continental basin with long standing water bodies, which has dissolved a large quantity of salt forming irons from water-rock interaction. These water bodies dried up and a set of Mars related salt minerals deposited. Although the brine evolution in the Qaidam basin does not help much on explaining the origin of martian salts so far, the migration and geochemical differentiations of brines in Qaidam basin can serve a reference, since our knowledge of martian salts is far too limited referring to their importance for Mars science.

The Playas in Qaidam Basin have a full set of salt minerals, i.e. carbonates, sulfates and chlorides. Especially, the occurrence of Mars related salt minerals (gypsum, hexahydrite, bichofite, blodite, antarcticite, etc., Table 1) under Mars-like environments provides an opportunity to carry out analogue studies for better understanding the secondary processes of martian salts. Besides, these playas can also be a good analogue for fundamental spectroscopic and remote sensing studies for helping the Mars explorations.

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