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3-Phase Modeling for the Origin of Chinese Lithium-Rich Brines

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There are significantly different origins and mineralizations among various lithium-rich brines of the world. As for Clayton Valley, Nevada, the data and interpretations recently presented suggest that the model previously proposed (Price, et al., 2000; Munk and Chamberlain, 2011) is basically correct. It is the only producer in the United States and, in 2008, accounted for about 6% of global production (Goonan, 2012). Li brines are pumped from six different aquifers in the subsurface. Prior to development, a salt flat and brine pool existed in the northern part of the basin. Hectorite ($Na_{0.3}(Mg,Li)_3Si_4O_{10}(OH)_2$) in modern and ancient playa sediments contains up to 1,000 ppm Li. However, initially there probably was much more lithium in the rhyolite tuff than previously realized(A. H. Hofstra et al. ,2013). Hofstra et al. argued such lithium-enriched rhyolites generally have small volumes (1–10 km) and can release a large amount of lithium into a restricted area (Fig 1, Fig 2).

A. H. Hofstra et al. (2013) envisioned a simple model (Fig. 1) in which highly fractionated, lithophile element-enriched, A- or S-type granitic magmas erupt and deposit ash into closed drainage basins. The drop in pressure during a volcanic eruption results in fluid saturation, vesiculation of melt, and fragmentation of glass. Lithium in glass diffuses to shard surfaces, whereas lithium in magmatic fluid may condense onto dust particles or shard surfaces. The resulting lithium-enriched brine may react with basin sediments to form Li clay deposits and/or descend into permeable aquifers where it can reside for millions of years. Successive eruptions of ash into the same drainage basin increase resource potential. However, A. H. Hofstra et al. (2013) only emphsized two processes: (1) Lithium Diffusion in Plutonic and Volcanic Environments; (2) Lithium Partitioning between Rhyolite Melt and Exsolved Fluid. In fact, they are both taken place in very early process. Further, Hofstra’s model merely argued the volcanic source and origin of lithium predominantly in America rather than the deep plutonic source representative in China.

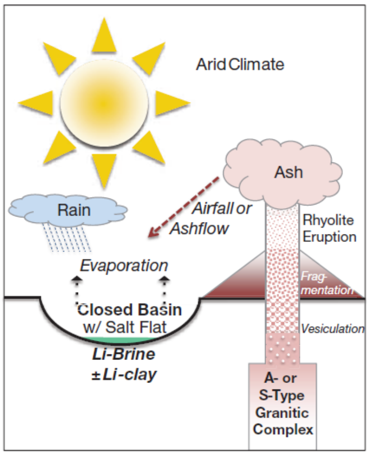

Fig. 1. Schematic model for Li brine and clay deposits. See text for further description. From A. H. Hofstra et al. (2013).

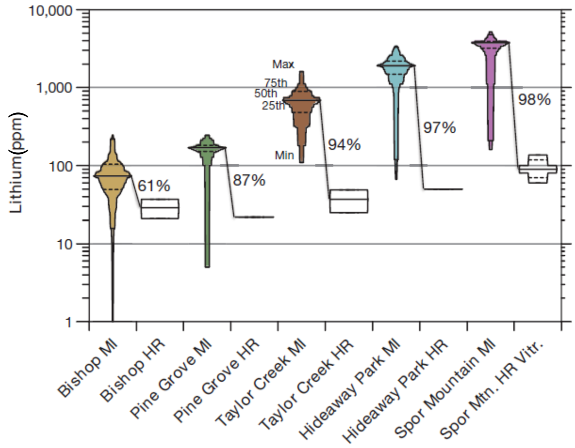

Fig. 2. Paired proportional box plot of lithium abundance in melt inclusions (MI) and host rock (HR) in the Bishop, Pine Grove, Taylor Creek, Hideaway Park, and Spor Mountain rhyolites. Median abundances were used to calculate the percent lithium depletions shown.. From A. H. Hofstra et al. (2013).

We herein propose a three-phase model for the origin and mineralization for various lithium-rich brines and then apply it to Chinese lithium-rich brines. In phase 1, during the volcanic or plutonic environment, the Lithium-enriched ash-flow tuffs and rhyolite flows, supply the

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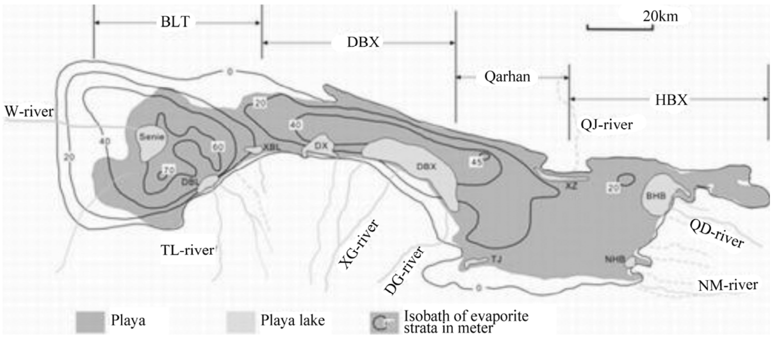

Fig. 3. Lithium salt lakes and rivers in the Qaidam Basin (2014).

original source for the Li brine deposit. In phase 2, during the weathering and erosion of the lithium-enclosed rock, lithium element were collected and transported from the rock into the fluid carrier mainly downward into the lake. Meteoric water both hydrolyzes glass and leaches lithium from ash deposits and transports it into the lower part of basin where it accumulates in a playa or salar. In phase 3, arid climatic conditions concentrate the lithium present in meteoric water by evaporation to form salt flats. Frequently, the formation of alternating lacustrine deposits, salt beds, and lithium-rich brines has been attributed to multiple wetting and drying periods during the Pleistocene (Munk and Chamberlain, 2011).

In China, the second phase could be clearly described in detail. For instance, rich reserves of lithium salt lakes in the Qaidam Basin, accounting for about 80 percent of China's total lithium brine resources (Fig.3). Very recently, the Qinghai Salt Lake Institute, Chinese Academy of Sciences, has made important progress for the material source of lithium, enrichment mineralization processes in a new round of research of Geology and Environmental Laboratory led by Yu Junqing. Task Force found that lithium comes from Kunlun fault fracture zone intersection perennial supplying 1.5 km long stretches of hot springs with more than 150 fountains, and through the Hongshui River and Grenoble River system enter four salt lakes, namely Le Beach, East and West Terrains, Yiliping. Currently, the Grenoble River contains lithium up to 748.8 tons per year.

Therefore, we should noticed the source material for lithium brine usually are associated with alteration and weathering of volcanic eruptions on rocks in South America Andes salar of Uyuni distribution of a large area of the surrounding volcanic eruption rocks, while lithium-rich salt lakes in the Qaidam Basin and surrounding mountains sinks or pooling basins are rarely distributed volcanic eruption rocks. In our 3-phase model, American brines are mainly attributed to the phase one, while Chinese brines are caused during phase two, with the similar evaporation role of phase three.

Key words: 3-phase modeling, lithium brine origin, Qaidam Basin

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