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# Multinuclear NMR study of Cs-bearing geyserites of the Targejia hot spring cesium deposit in Tibet

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## Abstract

The large scale Targejia hot spring type Cs deposit in Tibet is unique and still active today with the distribution of hot springs being controlled by tectonic movements of the Tibetan Plateau. The ore bodies of the Targejia Cs deposit are mainly composed of geyserite, a Cs-containing opal. In this study, a combination of X-ray diffraction, infrared spectroscopy, and $^{29}$Si, $^{1}$H, $^{133}$Cs magic angle spinning nuclear magnetic resonance (MAS NMR) were used to study the location and mobilization of Cs in geyserites. $^{29}$Si NMR spectra indicate that the relative amounts of $Q^2$, $Q^3$, and $Q^4$ species vary in geyserite samples of different mineralization stages. Based on the $^{133}$Cs chemical shift as well as the change in $^{29}$Si chemical shift ranges (especially for $Q^2$), cesium is inferred to associate with $Q^3$ and $Q^2$ silanol groups, where it is coordinated by $O^{2-}$, $OH^-$, and $H_2O$ as a network modifying cation. As Cs-bearing geyserite ages and dehydrates, $Q^2$ and $Q^3$ polymerize giving an increase in $Q^4$. This is accompanied with a decrease in Cs content indicating that Cs may be leached out from the opals as it loses its original coordination environment in the silicate framework.

**Keywords:** Cs-bearing geyserite deposits, Tibet, $^{29}$Si, $^{133}$Cs, $^{1}$H MAS NMR, IR, silanol groups, mineralization