Amorphous silica plays an important role in the retention of radionuclides and metals in aquifer, tailings, and soils (e.g., Allard et al. 1999; Schindler et al. 2009a; Schindler and Hochella 2015) and can play an important role in the retention of radionuclides in the surroundings of a potential nuclear waste repository (Lichtner and Eikenberg 1994; Smellie and Karlsson 1999; Techer et al. 2006; Shao et al. 2013). For example, opal has been identified as one of the predominant secondary phases that forms during the alteration of volcanic tuff, a formerly pro-posed host rock for the repository of high-level nuclear waste at Yucca Mountain, Nevada, U.S.A. (Ewing and von Hippel 2009; Long and Ewing 2004; MacFarlane and Ewing 2006). Field studies at the latter location and experimental studies on volcanic tuff have shown that amorphous silica (opal) and calcite are the dominant secondary minerals that form within fractures during evaporation of meteoric water (e.g., Szabo, and Kyser 1990; Paces et al. 2001; Whelan et al. 2002) and through circulation of water in tuff under low-\(T\) conditions (<100 °C), respectively (Dobson et al. 2003. Amorphous silica could also occur at the interface between altered cementitious material and siliceous host rocks of a multi-barrier repository system at a potential nuclear-waste disposal site. Alteration of cementitious material in a repository would result in hyper-alkaline solutions with pH values above 10.5, which could persist over an extended time frame within the repository (10^5–10^6 years; Braney et al. 1993; Schwyn et al. 2012; Smith et al. 2015). Propagation of the hyper-alkaline solutions into the siliceous host rocks would result in the dissolution of silicate minerals, the neutralization of the solutions toward lower pH-values (pH < 9), and precipitation of Ca-silica-bearing phases, including (amorphous) silica along their flow path (Lichtner and Eikenberg 1994; Smellie and Karlsson 1999; Techer et al. 2006; Shao et al. 2013).

Geochronological studies of U-bearing opals at Yucca Mountain and Spor Mountain, Utah, U.S.A., show that amorphous silica can retain U over millions of years (Zielinski et al. 1977; Ludwig et al. 1980; Paces et al. 2001, 2004) and indicate the significance of amorphous silica precipitates on long-term retention of U. However, despite many field and experimental studies on the speciation, adsorption, and incorporation of U into opal, agate, chaledony, and amorphous silica (Dugger et