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Silicon stable isotope systematics of the >3.4 Ga Apex and Strelley Pool Cherts: new constraints on silica sources and the δ^{30}Si composition of Paleoarchean seawater

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Silicon (Si) isotopes in Archean cherts offer important insights into the environmental conditions and biogeochemical processes of the early Earth. This study presents the first δ^{30}Si data for the 3.46 Ga Apex Chert from the Pilbara Craton (Western Australia), which contains microstructures that have generated significant debate regarding their potential biogenic origin [1][2]. Additionally, we provide new δ^{30}Si data for the 3.43 Ga Strelley Pool Chert, an important Paleoarchean microbialite locality. Both cherts exhibit similar δ^{30}Si values, with most values ranging between +0.5 and +1‰, suggesting that the silica in both units was likely derived from a common source, which we interpret to represent Paleoarchean seawater. Building on previous field, laboratory, and rock record insights into drivers of Si isotope fractionation, we explore several processes that explain these isotope compositions, including kinetic fractionation, equilibrium fractionation, and later re-equilibration. We further develop an isotope mass balance model to better understand Paleoarchean Si cycling in light of these new results. Our results have important implications for the controversial microfossils reported from the Apex chert. First, the similarities in δ^{30}Si values between the Apex Chert and Strelley Pool Chert suggest that both cherts likely sourced their silica from a common source, likely Paleoarchean seawater. Our results do not exclude the possibility that the depositional conditions of the Apex Chert were compatible with life. Rather, the observed δ^{30}Si signatures imply that the Apex Chert formed in a marine-hydrothermal context that could have supported early biogeochemical processes, and the organic matter preserved there may have ultimately derived from surface processes, such as implicated by the hydrothermal pump model of Duda et al.[3].

[1] Schopf (1993), *Science*, 260(5108), 640–646.

[2] Brasier et al. (2005), *Precambrian Research*, 140(1–2), 55–102.

[3] Duda et al. (2018), *Biogeosciences*, 15(5), 1535–1548.