Morphology, Distribution, and Estimated Eruption Volumes for Intracaldera Felsic Tuff Deposits in the Archean Sturgeon Lake Subaqueous Caldera Complex, Northwestern Ontario

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The Archean (c. 2735 Ma) Sturgeon Lake Caldera Complex (SLCC) of northwestern Ontario comprises a north-facing, homoclinal, bimodal sequence of caldera-associated, greenschist-facies metamorphosed volcanic, intrusive, and sedimentary strata with a composite thickness of nearly 3000 m and a strike length of at least 25 km. The steeply dipping nature of the strata provides a cross-sectional view of a caldera complex that is typically not available in ancient or modern volcanic sequences. Detailed facies mapping indicates that the pre-caldera strata composed an extensive shield volcano complex that was formed in a dominantly subaerial environment and, locally, within shallow subaqueous conditions. The onset of explosive felsic volcanism brought about the formation of a subaqueous, piecemeal ash flow caldera. Based on stratigraphic displacement associated with synvolcanic faults, the floor of the caldera appears to have initially collapsed to approximately 1 km water depth.

Five episodes of intracaldera subaqueous explosive felsic volcanism are represented by rhyodacitic to rhyolitic recrystallized vitric ash tuff lapilli tuff units: a) the High Level Lake tuffs; b) the Mattabi tuffs; c) the Lower L tuffs; d) the Middle L tuffs; and e) the Upper L tuffs. Coarse heterolithic mesobreccia and megabreccia deposits are interstratified with the High Level Lake deposits, suggesting that this eruption was associated with a caldera-forming event. Each of the tuffs hosts massive to semi-massive sulfide deposits, indicating the subaqueous environment of their deposition.

The High Level Lake and Mattabi tuffs have estimated volumes of 16 km3 and 27km3, respectively. These events are similar in scale to caldera-associated eruptions at Krakatau (10 km3, 1883) and Santorini (25-30 km3, 3.6 ka). Each unit is characterized by two distinct depositional facies: 1) lower, quartz-phyric, poorly sorted, non-graded, massive ash tuffs and pumice lapilli tuffs that vary from 80-155 meters in thickness; and 2) upper, overlying well-sorted, laminated to

medium-bedded, massive to normally graded ash tuff deposits that range from 1-13 meters in thickness. The Lower L, Middle L, and Upper L tuffs have estimated volumes of 2 km3, 6.5 km3, and 3 km3. Each unit is also characterized by two depositional facies:
1) lower, quartz-phyric or quartz-feldspar-phyric, poorly sorted to well-sorted, typically normally graded, massive to very thickly bedded ash tuffs and pumice lapilli tuffs that vary from 3-30 meters thick; and 2) upper, overlying, well-sorted, laminated to very thickly bedded, normally graded ash tuffs which range from <1-45 meters in thickness. Although evidence of the original glassy character of these rocks is locally present (e.g. spherulites), textures unambiguously indicating hot emplacement of the tuffs (e.g. welding, gas escape pipes) have not been observed.

We interpret all five intracaldera tuff units in the SLCC to represent deposits from subaqueous eruption-fed density currents (e.g. White, 2000). The voluminous High Level Lake and Mattabi tuffs were deposited from high particle concentration (gas-supported?) flows, along with dilute aqueous density currents which transported pyroclasts away from the flow margin, and water-settled ash. The less voluminous Lower L, Middle L, and Upper L eruptions were insufficient to drive subaqueous gas-supported flows, and the associated deposits formed primarily from eruption-fed aqueous density currents and associated water-settled ash.