DIAGENESIS OF SILICEOUS SINTER DEPOSITS IN THE U.S.A. AND NEW ZEALAND.

Bridget Y. Lynne

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Department of Geology,
University of Auckland, New Zealand

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ABSTRACT

Siliceous sinters are hot-spring deposits that initially form as silica deposits from discharging alkali chloride thermal fluids. The biotic and abiotic components present in the path of the hot-spring discharge channels are subject to rapid mineralization by the precipitating silica. Hydrothermal systems have been implicated as possible sites for the origin and evolution of early life. Therefore, sinters may serve as analogs for recording environmental conditions akin to those that prevailed on Earth millions of years ago. However, with time, sinters also undergo a series of silica phase transformations and other post-depositional overprints. These changes must be recognized if paleoenvironmental information is to be successfully extracted from the sinter archive. In this study, four sinter deposits were examined with different plate tectonic settings and climatic histories. They have a range of ^{14}C AMS ages: (1) the ~6300 years BP sinter from Steamboat Springs, Nevada, U.S.A., (2) the ~1920 years BP sinter from Opal Mound, Roosevelt Hot Springs, Utah, U.S.A., (3) the ~450 years BP deposit from Sinter Island, Taupo Volcanic Zone, New Zealand, and (4) a 2 year old Wairakei drain sinter placed within a fumarole at Orakei Korako, Taupo Volcanic Zone, New Zealand. The sinter transplanted into the fumarole yielded only opal-A and quartz mineralogies after the field experiment; whereas, the other three sinters have captured the entire diagenetic continuum of siliceous mineral phases, namely opal-A, opal-A/CT, opal-CT, opal-C, quartz ± moganite. Collectively, these sinter deposits enabled mineralogic, morphologic, and crystallographic diagenetic pathways to be mapped at the sub-micron scale using a variety of analytical techniques. Regardless of location, mineralogical transformations were almost identical. The accompanying morphological changes consist of a repeating pattern of nano-micro-nano-sized silica particle changes, and follow the Ostwald step rule. Each silica phase exhibits a particular morphology, namely opal-A spheres, opal-A/CT nanospheres, opal-CT bladed lepispheres, opal-C nanostructures, and quartz micro-crystals. The length of time required for each sinter to reach mineralogical maturity (i.e., become quartzose) varies among deposits, and can be attributed to differences in both environmental and diagenetic

post-depositional events. Diagenesis is controlled by shifts in micro-scale physico-chemical conditions that are not time dependant. In all sinters, mineralogic transformations precede morphologic modifications, and both are driven by crystallographic (i.e., internal mineral structure) changes. During diagenetic transformations, the crystal axes of opal-CT, opal-C and incipient quartz develop incrementally. The arrangement of nano- and micron-scale morphological features in the sinter matrix for each silica phase is not random but represents emerging orientations of future quartz crystal faces. Post-depositional events also are recorded within sinters (e.g., tephra deposition, faulting, lowering of the local water table, further pulses of thermal fluids), but are site-specific, and can occur at any temporal stage during a sinter's history. Such overprinting (e.g., by acid steam condensate infiltration, mineral dissolution) may accelerate or retard diagenesis or obliterate primary textures. Furthermore, brecciation and recementation may create a deposit with a range of silica phase minerals and ages. Nonetheless, primary textures can persist in the geologic record despite up to five silica phase transformations and potentially multiple post-depositional events. Thus, sinter deposits require a complete analysis of its post-depositional components and their interaction with diagenetic processes in order to reconstruct the spatial and temporal setting of the original hot-spring environment.

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