Above-Ground Silicification of Rooted Trees in a Hot-Spring Environment

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Silicification is the most important process of fossilization resulting in the preservation of internal tissues in plants, thereby providing essential information on the anatomy, life history, and evolution of land plants. However, fundamental knowledge of silica uptake, precipitation, and contribution to *in situ* plant fossilization is limited. To identify the cellular pathway of aqueous silica in upright standing trees, we investigated lodgepole pine (*Pinus contorta*) saplings in the hot-spring environment of Cistern Spring, Yellowstone National Park, USA. The trees were dead and decorticated (barkless).

Our multi-method analytical approach with X-ray diffraction, Raman spectroscopy, scanning electron microscopy, and electron probe microanalyses shows that surficially and internally co-precipitated amorphous silica, halite, and gypsum trace the flow of silica-rich fluid and document the pore fluid retention capability after temporary hot-spring water immersion and evaporation. The narrow latewood tracheids, pit chambers of the circular bordered pits, and horizontal rays are preferential sites of silica sphere precipitation. Element distribution maps reveal systematic differences between silica quantities deposited in early- and latewood, as well as between the lower and upper parts of the upright saplings. The even distribution of inorganic impurities in cell walls traces the anatomical structure of the wood, indicating rapid migration of chemically homogeneous fluid into the swollen organic substrate.

Our results show that the preferential pathway of silica-rich fluid into the above-ground wood of pine trees is through the decorticated periphery which took place during short-term flooding (days to weeks) of hot-spring fluid. In fact, the *in situ* silicification process is controlled by fluid retention in pore space during evaporative ion concentration. The shift in amorphous silica micromorphology (from dense layers to spheres) results from variable polymerization rates during evaporative ion concentration and availability of hydroxyl groups of lignin and holocellulose molecules of the cell wall. *In vivo* transport of silica-rich fluid by root pressure, capillary pressure, transpiration and/or evaporation pull plays an insignificant role in the silicification process of trees in growth position rooted in silica-rich substrates.