# Stumm and Schindler: Mineral-water interface chemistry, a retrospective

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The early work of Werner Stumm and Paul Schindler in the 1960's laid the foundational conceptual models and developed the early empirical experimental basis for most of the work to follow from their students and collaborators. They shared a common view of the importance of the role the mineral/solution interface plays in regulating/mediating reactions in natural aquatic systems. The early development of conceptual models identifying individual sites (site-binding) at metal oxide surfaces as the reaction sites (weak acids) provided the framework to link two-dimensional surface reactions to the solution chemistry of the overlying aqueous solutions, thus employing the full range of solution chemical models and tools. The academic and professional tree extending from these two insightful pioneers links several generations of researchers, including those today using the most modern spectroscopic tools allowing verification of the early concepts and extending the surface science in many new directions.

# Conditions for craton formation and longevity

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Archean cratons are unique owing to their thickness and composition. Whereas post-Archean lithosphere is less than 120 km thick and in many Phanerozoic regions even thinner than old oceanic lithosphere (<100 km), Archean cratons reach 200 km or more. Cratonic mantle is composed primarily of very magnesian peridotites that represent residues of up to 4% melt extraction. Such depleted residues are rare in post-Archean continental lithospheres, and in the case of oceanic lithospheres, maximum depletions of 20-30 % are only found in the top of the melting column. Archean cratons have also remained relatively undisturbed since their formation, but post-Archean continental lithospheres are more easily re-worked and convectively eroded. Although cratonic peridotite xenoliths derive from pressures as high as 7 GPa (~200 km), their protoliths formed by high-degree melting at pressures less than 3 GPa. Finally, 'eclogitic' xenoliths from cratons suggest the presence of altered oceanic crust and sub-arc cumulate protoliths within cratonic mantle. Thus, Archean continents may have originated by the stacking or underthrusting of oceanic/arc lithosphere.

Formation by accretion, however, is difficult because cold, oceanic lithospheres is too strong to be deformed and thickened. One solution to this problem is that serpentinized oceanic slabs facilitate the underthrusting required to make thick cratons, while serpentine dehydration during underthrusting causes fault-healing, culminating in cratonization. The extent of underthrusting depends on the thickness of the initial serpentinite layer, itself limited by the average oceanic geotherm. Our modeling suggests that the thermal conditions necessary for craton formation may have been optimal in the mid to late Archean. Today, thick cratons do not form because slab serpentinization is too extensive to achieve full fault-healing, allowing oceanic plates to efficiently subduct rather than laterally accrete as required for cratonization.

The fate of continents may be related to their initial thickness. Magmatic refertilization destabilizes the base of continents by increasing density and decreasing viscosity. The amount of magmas available for refertilization is limited by "head-space" for decompression melting. Thin lithosphere is thus more vulnerable to chemically destabilization, whereas cratons are too thick from the outset to permit extensive decompression melting from below.