Research Interests – Jan Schönig

The horizontal movement of tectonic plates driven by the sinking of cold dense lithosphere into the mantle, known as subduction-related plate tectonics, is a unique feature of planet Earth in our solar system. The timing of the transition from a pre-subduction stagnant-lid behavior, which we observe on other rocky planets like Venus or Mars today, to subduction-related plate tectonics as well as the evolution of plate tectonics through Earth history are fundamental and widely debated questions in Earth sciences. Although most researchers agree that subduction-related plate tectonics initiated globally and persistently around 3 Ga ago, interpretations for the evolution of subduction tectonics to the modern-style regime and particularly the onset of modern-style plate tectonics are highly controversial. Characteristic features of modern-style plate tectonics are low geothermal gradients during subduction required to form high-pressure/low-temperature (HP/LT) rocks, and subduction depths exceeding 90 km necessary to form ultrahigh-pressure (UHP) rocks. Considering the crystalline rock record, it is implied that subduction tectonics evolved secularly from a hot and shallow regime to the modern-style cold and deep regime, with its onset interpreted to be as late as <1 Ga (Neoproterozoic) based on the virtual absence of HP/LT and UHP rocks. The operation and onset of cold and deep modern-style plate tectonics has high implications for the movement of elements between Earth surface and mantle, mantle convection processes, thermal regimes, the crustal growth rate, and any related interdisciplinary research.

My major research interest focuses on the investigation of geodynamic regimes through time, in particular regarding UHP metamorphism, by exploring the sedimentary archive. The main objective is to shed new light on the hypothesis that deep and cold subduction – and consequently modern-style plate tectonics – has operated prior to the Neoproterozoic. Up to now, solely the crystalline record has been considered. This approach, however, is prone to be biased by the decreasing preservation of crystalline rocks with increasing age, leading to global interpretations that are based on data collected from a tiny fraction of the rock volume formed at the given time interval. In contrast, by investigating detrital mineral grains, we make use of natural processes to sample rocks at the catchment scale, with each grain representing a sample on its own. Nevertheless, proving UHP metamorphism from a sedimentary perspective is challenging, because we face sand-sized single mineral grains that lost their paragenetic context, and thus the majority of techniques in the toolbox of metamorphic geology is not applicable. What remains, however, are mineral inclusions that are shielded from retrogression and processes of the sedimentary cycle by their stable host minerals in which they have been entrapped during metamorphic growth, whereby garnet is a prime candidate.

I started working on garnet single-grain provenance analysis during my B.Sc. studies with a focus on major-element chemistry acquired by electron-microprobe. In my M.Sc. studies, I began to combine detrital garnet chemistry with mineral inclusion assemblages identified by Raman spectroscopy. Besides the general value of previously unconsidered mineral inclusions as provenance indicators, the most remarkable finding are inclusions of monomineralic coesite in detrital garnet sourced from the Devonian UHP rocks of the Western Gneiss Region (Norway). This introduced the first approach to systematically and efficiently screen entire catchments on the presence of UHP rocks. During my ongoing PhD project, proof of concept has been demonstrated by findings of coesite- and diamond-bearing detrital garnet of the Carboniferous Saxonian Erzgebirge (Germany) as well as coesite-bearing garnet from the Neogene D'Entrecasteaux metamorphic complex (Papua New Guinea). In both regions, the detrital UHP garnets provide new insight regarding the geodynamic and lithological context. For the Erzgebirge, it was shown that UHP metamorphism affected a larger portion than previously expected and that the felsic country rocks were involved, leading to the interpretation of a largely coherent slab subducted to UHP conditions. In the D'Entrecasteaux complex, the youngest exhumed UHP terrane on Earth, evidence for UHP metamorphism was previously restricted to a single eclogite lens. The new results record a complete rock cycle from a sedimentary protolith, over subduction to UHP conditions and exhumation under increasing temperature, to erosion and final deposition of the garnet grains as beach placer.

As methodological aspects are set up now, my current research focuses on proving or falsifying the central hypothesis that modern-style plate tectonics operated prior to the Neoproterozoic. I focus on two Paleoproterozoic regions that are expected to have the highest potential to be affected by UHP metamorphism, the Nagssugtoqidian Orogen of Greenland, and the Trans-Hudson Orogen of Canada.