

Pre-Hallandian metamorphism in the Sveconorwegian Province – its implication on the tectonic evolution of the Baltic Shield.

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It has long been debate whether the Sveconorwegian Province in SW Sweden has suffered pre-Sveconorwegian (>1.1 Ga) metamorphic imprints. However, today it is agreed upon that the pre-Sveconorwegian Hallandian (~1.45 Ga) event has influenced this province. Any older metamorphic events have not been revealed by using U-Pb geochronology on minerals hitherto.

In this study we have taken use of intrusive relations to find suitable samples in order to constrain metamorphic events. Ion-probe dating of zircon and titanite was carried out from different rock types of the Sveconorwegian Province in SW Sweden, both west and east of a N-S trending, Sveconorwegian shear zone, the Mylonite Zone. Intrusion and metamorphic ages were dated for both veined and gneissic rocks as well as for corresponding crosscutting younger rocks. In this way the formation of veins was constrained on both sides of the Mylonite Zone.

To the east in the easternmost part of the Eastern Segment formation of early veins were formed between 1.66 Ga - 1.53 Ga, and anatectic, granitoid magmas related to basic intrusions were formed at 1.53 ±0.03 Ga. To the west (Western Segment), the formation of early veins and folding is constrained between 1.61 Ga and 1.52 Ga, and formation of pegmatite related to basic intrusions to 1.54 ±0.02 Ga. Here also zircon growth indicates a Sveconorwegian thermal event in contrast to what was found in our samples from the easternmost Eastern Segment.

The findings of Pre-Hallandian (>1.45 Ga) metamorphism and magmatism across the Mylonite Zone, separating the Western and Eastern Segments of the Sveconorwegian Province in Sweden suggest that these parts of the Baltic Shield were united at least at ~1.54 Ga. Thus, it is suggested that the Mylonite Zone is a Sveconorwegian terrane boundary rather than a Sveconorwegian suture.

Modeling inverse adsorption isotope effects for CO₂ and CH₄ from experimental and field data

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Transport of CO₂ and CH₄ through porous media is affected by diffusion, gas-liquid partitioning, advection and adsorption processes. Adsorption, diffusion, and gas-liquid partitioning processes are affected by isotope substitution. Although considerable effort has been placed on understanding stable isotope effects associated with diffusion and gas-liquid partitioning, significantly fewer results have been measured for adsorption carbon isotope effects of CO₂ and CH₄ on geologically relevant substrates, temperatures and pressures. Early work by Bruner *et al.* (1966), Van Hook (1967) and Corcia and Liberty (1969) explored hydrogen isotope adsorption isotope effects for methane on dry and wet glass columns with limited carbon isotope results. Here we report experimentally measured carbon isotope fractionations for CO₂ on illite and quartz substrates at 298K using a 1-D column apparatus as well as preliminary field results of methane carbon isotope values from the caprock of a natural gas reservoir. Observed adsorption isotope effects are compared to diffusion effects conducted in unpacked 1-D columns. Results are modeled using an analytical solution to a coupled advection-diffusion-adsorption transport model. Measured diffusivities from diffusion experiments are in excellent agreement with binary diffusion constants calculated for ¹³CO₂-Helium and ¹²CO₂-Helium using the Fuller Equation whereby the ratio of diffusivities between ¹³CO₂ and ¹²CO₂ is 0.99909. In contrast to diffusion where ¹²CO₂ preferentially populates the front of the chromatographic peak, adsorption of CO₂ and CH₄ has the opposite effect whereby preferential adsorption of ¹²CO₂ is observed, resulting in the 'front' of the chromatographic peak becoming enriched in ¹³CO₂. Similar observations are made for methane in a shale adsorption-dominated system whereby methane furthest from the reservoir is approx. 15 permil heavier than the reservoir gas. This inverse chromatographic effect for CO₂ and CH₄ is modeled well using the Rayleigh Equation ($\alpha=1.0086$) and the transport equation (retardation factor=0.999). These results demonstrate the importance of understanding adsorption isotopic effects and potentially offers a tool to quantify surface area and/or transport distance in geological reservoirs.