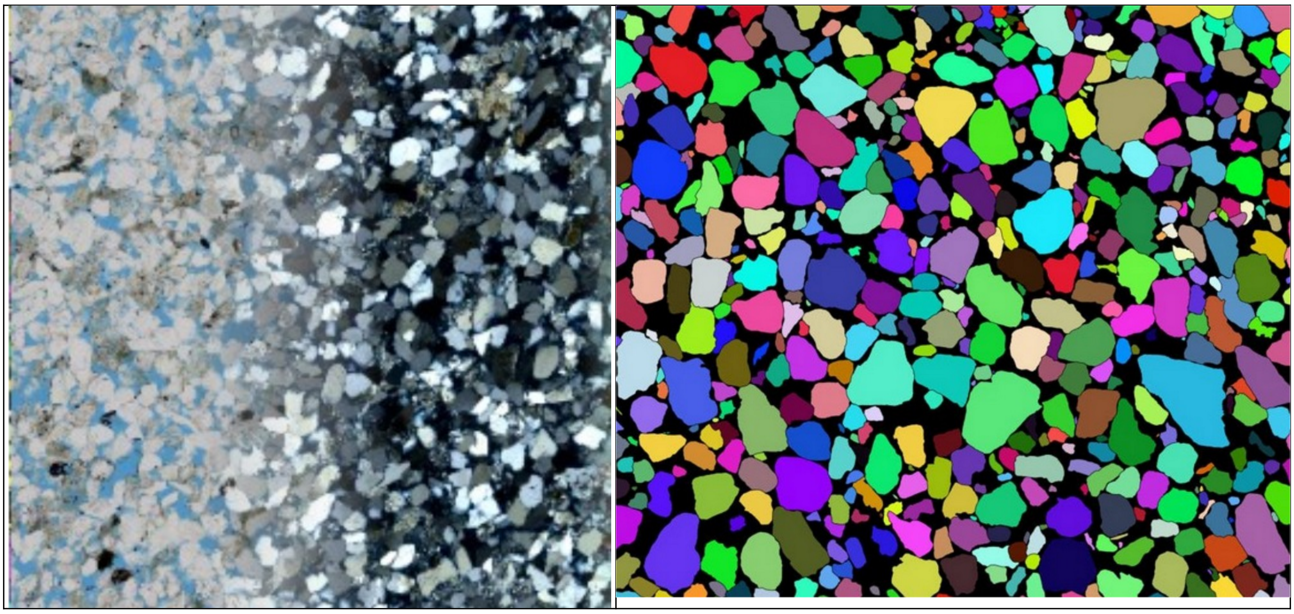
Sub-pixel co-registration of polarized microscope thin-section images



The ongoing gas depletion from the Groningen gas field led to pressure loss within the sandstones, which resulted in reservoir compaction, an associated surface subsidence and an increasing seismicity. In order to quantify the subsidence rate, and estimate local seismic event probabilities, a detailed rock property model of Groningen's reservoir is needed. For inferring the rock properties, multi-spectral scans of core-sample rock thin sections are available to the *Geo-Energy group* at UG's *Energy and Sustainability* research institute. The thin sections include tiny mineral grains (like sand grains) and filament material (akin to hard cement) between the grains. Some grains are separate from the filament via a surrounding thin-film coating. The type, shape and size of the grain, the presence-/absence of a coating film, and the filament area contribute to the target rock properties.

Computationally, transforming the thin-section photograph to quantified rock properties entangles (a) a sub-pixel accurate segmentation of grains, coating and filaments, (b) the grain labeling of different type- and size categories, (c) the sub-pixel accurate registration of the spectral image stack (and a re-alignment of the segment boundaries), and (d) the vectorized description of non-stationary, image-derived statistical properties for mineral objects. Here, we focus on the **co-registration of the spectral image stack**.

The thin-section images are already provided with a coarse alignment. Yet, due to the tiny feature size, a sub-pixel accurate registration of the spectral stack is required for deriving grain feature descriptors. Furthermore, due to the variable grain response to the spectral polarization, the grains appearance, or even their absence in certain spectra, is a challenge to the image co-registration. The aim of this projects is to (a) extract pixel correspondences and (b) rigid-body transformation matrices between polarized layers. Various methods (e.g. feature extraction, optical flow, deep-learning methods, or a combinations their) can be used. Coarse object segmentation is provided aside the spectral stack to support the registration task.

The project goals can be summarized as follows:

- Design and develop a sub-pixel accurate co-registration of polarized thin-section images
- Survey, pre-select and experiment with different types of image registration algorithms
- Assess the feasibility and accuracy of the tested registration procedures
- Design and develop a comparative visualization of the registration accuracy for the full-spectrum image stack