Ravenglass: Roman port, a miniature railway, and a geological testbed

Professor Richard Worden: the University of Liverpool

The Ravenglass Estuary in west Cumbria covers an area of about 6 square kilometers and has a mighty tidal range of nearly 8 meters. Sediment in the Ravenglass Estuary is sand-rich but has areas of distinct mud enrichment and localized pebble beds. The estuary is fed by three tidal rivers, the Esk, Mite, and Irt, all meeting in a central estuarine basin directly to the west of the village of Ravenglass. The estuary is connected to the Irish Sea through a single, 500 meter-wide tidal inlet that flows between two dune-topped barrier systems. The estuary empties slightly more slowly than it fills due to its overall shape and the presence of two enclosing coastal spits. The high tidal range has allowed Ravenglass to be used a port since the Roman occupation of northern England about 2000 years ago. The estuary was used for transporting ore materials from the central Lake District via a narrow-gauge railway, that has now become a major tourist attraction taking people from Ravenglass to Boot village in upper Eskdale.

About 20 years ago, my team at Liverpool started experimenting with animal-sediment interactions, testing the effects of burrowing animals on sediment mineralogy and texture. We showed that the common lugworm results in changes in the fabric of previously discretely layered sand and mud, by creating clay-coated sand-grains via bio-glue. We decided to investigate this further by working in modern sedimentary systems because clay coats on sand grain can lead to anomalously high porosity deep in sedimentary basins, but only if the clay coat is chlorite-rich. After interesting research excursions to western Iceland, NW Spain and Mauritius, we decided to focus on Ravenglass as the three arms of the estuary drain different types of bedrock (testing the possible role of provenance), accessibility does not present a problem, the river basin is largely not developed by housing or other buildings, and the high tidal range leaves 90% of the sediment exposed at low tide.

Sampling has included nearly 500 surface sediment samples, about 30 one-meter cores, and 20 cores of up to 15 m drilled by a geotechnical subcontractor. Analysis has included laser particle grain size analysis, mineralogy (by XRD), sediment composition (by XRF), petrography (by light optics, a range of SEM techniques, amd micro X-ray CT scanning), water analysis (by stable isotopes and geochemistry), organic geochemistry of sediment, radiometric dating, and. Recently, the application of machine learning approaches. This research area at Liverpool has led to 11 PhD students, and more than 27 publications (with lots more to come). It is has also spawned research initiatives at Durham and Newcastle Universities in the UK, the University of Paris in France, Delft University in the Netherlands and Bergen University in Norway.

The work has shown that clay minerals in general, and clay coats on sand grains in particular, are localised within specific depositional environments. At least some of the grain coats are caused by the action of microbiota (specifically diatoms) living in the sediment and leaving a sticky biofilm on host sand grains. The work has also shown that specific clay minerals are heterogeneously distributed within the estuary. This modern (post-Holocene) has allowed us to create models to predict clay mineral and clay coat distribution in ancient and deeply buried rocks to be used for geo-energy purposes. The latest possible application of this work is for carbon capture and storage purposes because Fe- and Mg-rich chlorite is one of the few common sedimentary minerals that can cause solid sequestration of the injected CO_2.

In this talk, you will be told about the various sampling campaigns and the efforts required to drill geotechnical cores in estuaries and nearby farmers' fields. You will see lots of images of different parts of estuaries, with a variety of sedimentary structures. You will also see images of what sediment in estuaries looks like down a high-powered microscope. Finally, you will hear about the applications of this sustained research initiative and where it is going next.