SCIENCES & BIOENGINEERING SCIENCES

The Research Group

Analytical, Environmental and Geo-Chemistry

has the honor to invite you to the public defense of the PhD thesis of

Chunyang Zhou

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

Understanding biogeochemical processes of trace elements in marine sediments at various spatial scales

Promotor:
Prof. dr. Yue Gao
Co-promotor:
Prof. dr. Willy Baeyens

The defense will take place on

Tuesday, February 16, 2021 at 14h00

The defense can be followed through a live stream. Contact Chunyang.Zhou@vub.be for more information

Members of the jury

Prof. dr. Steven Goderis (VUB, chair)
Prof. dr. Martine Leermakers (VUB, secretary)
Prof. dr. Hao Zhang (Lancaster University, UK)
Dr. Ludovic Lesven (Lille University, France)

Curriculum vitae

Chunyang Zhou obtained his master degree of environmental science in Nanjing University, China in 2016. He then started his PhD under the supervision of Prof. Yue Gao and Prof. Willy Baeyens at the research group of AMGC in VUB. His PhD research is devoted to improving our understanding of biogeochemical processes of trace elements in sediments by investigating at various spatial scales and two dimensions. His work has led to the publication of three scientific articles as first author in peer-reviewed journals. He also presented his work in many international conferences and helped in teaching and supervising bachelor and master projects.

Abstract of the PhD research

Marine sediment is a key component involved in the biogeochemical cycling of trace elements, acting both as a sink and a source. The chemical transformations occurring at the surface sediment, also known as early diagenesis, determine how trace elements are eventually buried in the deep sediment or how they are recycled back to the water column.
The chemical transformations are commonly induced by the deposition and degradation of reactive organic matter at the sediment surface and are accompanied by the consumption of a series of available oxidants (e.g. oxygen, nitrate, Fe and Mn oxides, sulfate). Those redox reactions may occur at discrete, small-scale locations (microniches) at various depths within the surface sediment and promote a high degree of variability in the cycling of terminal electron acceptors and associated trace elements. Although the concern on investigating relevant mobilization/immobilization processes within microniches is growing, our understanding of the small-scale sediment processes of trace elements is still limited. In this PhD project, we investigated trace element mobilization in surface sediments from normal scale (cm), over sub-scale (sub-cm) to ultra-fine scale (sub-mm) at two contrasting marine ecosystems, Belgian coastal zone (BCZ) and Gotland basin (GB) in the center of the Baltic Sea, characterized by oxic and anoxic bottom waters respectively. Routine sediment treatment methods including porewater extraction and solid phase sequential extraction, combined with a novel, performant passive sampling technique, Diffusive Gradients in Thin films (DGT) were used, allowing us to better understand mobilization mechanisms of trace elements in differing marine sediments. Before the field application, the DGT method was optimized to comply with high resolution imaging of trace metals by using an improved binding agent (ground Chelex-100 resin), which overcomes the problems other agents were facing.
In the BCZ sediments, we discovered two mobilization mechanisms respectively for trace metal cations and oxyanions. The mobilization of trace metal cations (Co, Pb, Ni, Cu) is controlled by the dissolution of FeS induced by porewater acidification, while that of oxyanions (P, V, As) is controlled by the reductive dissolution of Fe oxides. In the GB sediments, we discovered that the mobilization/immobilization of P is closely linked with Mn and two mechanisms were revealed. DGT induced fluxes in sediments (DIFS) model was applied to characterize the release kinetics of P and Mn from sediment solid phase. Most trace elements were removed from porewater by (co)precipitating as sulfides or with FeS. Apart from those findings discovered at fine scale (sub-cm), by coupling DGT with laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) we also obtained two dimensional and high resolution (2D-HR, sub-mm) images of trace elements in both BCZ and GB sediments. With 2D-HR images, we are able to characterize the shape, size, and location of microniches and identify the mobilization mechanisms of trace elements within microniches. Furthermore, the unraveled horizontal distribution of trace elements shows that sediment processes are much more complicated than what we observed from 1D profiles.