SCIENCES & BIOENGINEERING SCIENCES

The Research Group

Analytical, Environmental and Geo- Chemistry

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

Sebastiaan VAN DE VELDE

to obtain the degree of Doctor of Sciences

Joint PhD with Universiteit Antwerpen

Title of the PhD thesis:

Electron shuttling and elemental cycling in the seafloor

Promotors:

Prof. dr. ir. Filip Meysman
Prof. dr. Yue Gao

The defence will take place on

Friday June 8 2018 at 14.00h

in the U-Residence, Green room at the Campus Humanities, Sciences and Engineering of the Vrije Universiteit Brussel, Pleinlaan 2 - 1050 Elsene, and will be followed by a reception.

Members of the jury:
Prof. dr. Martine Leermakers (chairman)
Prof. dr. Stijn Temmerman (secretary, UA)
Prof. Bo Thamdrup
(Syddansk Universitet, Denemarken)
Dr. Sandra Arndt (ULB)
Dr. Tim Ferdelman
(Mac Planck Inst. of Marine Microbiology)

Curriculum vitae

Sebastiaan van de Velde (°1990) graduated as Master of Science in Chemistry at the VUB in 2013. Afterwards, he started his PhD research on sediment geochemistry as an FWO Aspirant fellow.
During his PhD he stayed 3 months at the university of Leeds (UK) and had several shorter research stays at other institutes. He also participated in 2 research cruises to the Baltic Sea.
His research has resulted in 7 international peer-reviewed publications, of which 4 as first author. He presented his work at several international conferences, during one of which he was awarded a presentation prize. During his PhD, he also acted as an ambassador for marine research conducted on board of the RV Simon Stevin, and he was regional representative of the youth-section of the Royal Flemish Chemistry Society.

Abstract of the PhD research

The seafloor (or marine sediment) is an invaluable part for the cycle of chemical elements (carbon, nitrogen, sulphur) through planet earth. The sediment is an efficient reactor that recycles 90 % of the sulphur and carbon it receives, back to the water column. The settling of organic carbon, which is a reduced compound (i.e. rich in negatively charged electrons), starts a complex series of redox-reactions (oxidation of organic carbon coupled to the reduction of, e.g., oxygen). The transformations that occur when chemical species pass through the upper 10 – 100 cm of the seafloor (also called 'early diagenesis'), determines which elements and what fractions are either stored in the deep mantle or are recycled back to the ocean and atmosphere.

Redox transformations are strongly affected by the presence or absence of micro-, as well as macro-organisms. In this PhD project I investigated the impact two type of ecosystem engineers have on the biogeochemical cycling of carbon, iron, sulphur and associated trace elements in the seafloor: Long filamentous micro-organisms (cable bacteria) and large macro-fauna (inducing bioturbation). Both ecosystem engineers stimulate the recycling of carbon, sulphur and iron. Cable bacteria do this by acidifying the top few centimetres of the sediment, and bioturbation, by enhancing the transport of solid particles and dissolved substances in the sediment.

A field study in the coastal North Sea showed that the acidic environment generated by cable bacteria in the upper 5 cm of the sediment promotes the dissolution of acid sensitive minerals like FeS and $CaCO_3$. The dissolution of these minerals releases iron and related trace metals (manganese, cobalt, arsenic) in the pore water. A fraction of these elements re-precipitates at the oxygen-rich sediment-water interface. However, under fluctuating oxygen concentrations (from fully oxygenated to oxygen depleted), cable bacteria actually amplify the seasonal cycle of arsenic release from the sediment, as revealed by a study in Lake Grevelingen.

Animals that inhabit the seafloor stimulate the transport of solid particles by their burrowing activity (bio-mixing), as well as the exchange of dissolved species in the pore water of the sediment with the overlying water column by the flushing of their burrows (bio-irrigation). A field study in the Blakeney salt marsh (Norwich, UK) showed how bioturbation actually limits the burial of organic carbon and reduced iron-sulphide and diagenetic modelling reveals that the geochemical effects are already noticeable at very low bioturbation activity. Implementing these results in a long-term model, showed that the evolution of burrowing could have induced a low-oxygen atmosphere in the past and might have triggered global warming by increasing atmospheric CO_2 during the Cambrian explosion (when multicellular life developed in the ocean, ~500 million years ago). Finally, field data following a human-induced sediment mixing event (which is essentially equivalent to human bioturbation) from the Belgian Coastal Zone suggests that bottom trawl fishing and dredging also limits organic carbon burial, and provides a clear illustration of how human activity can inadvertently change the coastal carbon cycle.