Predicting the In Situ Distribution of AVS from Sediment Profile Images

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Introduction

Photo: Kay Vopel

Figure 1. The SPI-Scan instrument used to obtain high-resolution in situ sediment profile images.

Organic enrichment of coastal sediments is a major concern worldwide. In estuaries, up to 90% of the deposited organic carbon is mineralised by bacterial sulfate reduction (Jørgensen 1982). Hydrogen sulfide (H_2S), produced during sulfate reduction, reacts with dissolved iron or reactive iron minerals to form acid-extractable iron sulfides (termed acid volatile sulfide, AVS) that contribute to the distinct black colouration of organic-rich sediment.

AVS measurements have not been used in routine monitoring because they are time consuming; the sediment is treated in a laboratory with deoxygenated acid to extract H_2S, which is then quantified photometrically or electrochemically. Bull and Williamson (2001) tested a new approach to predict the sediment AVS concentration, hereafter [AVS], from sediment images. The authors used film photography in a laboratory and found a weak linear correlation ($R^2 = 0.67$) between sediment colour intensity and [AVS] as measured by a microdiffusion technique.

With the help of new technology, our goal was to further develop the above approach into a rapid technique for monitoring the in situ distribution of AVS.

Methods

Sediment sampling

- 7 subtidal sediment cores collected at 15 m water depth off the coast of Waiheke Island, New Zealand

Image acquisition

- In situ deployment of sediment profile imaging device (SPI-Scan, Benthic Science Ltd.) (**Fig. 1**)

Image and AVS analysis

- Each core sectioned in 5 mm increments and each slice homogenised
- 1 g of each slice extracted in deoxygenated 1 M HCl. [AVS], in the form of H_2S under acidic conditions, measured directly with an amperometric H_2S microelectrode
- Image of the remaining slice obtained using a flatbed scanner
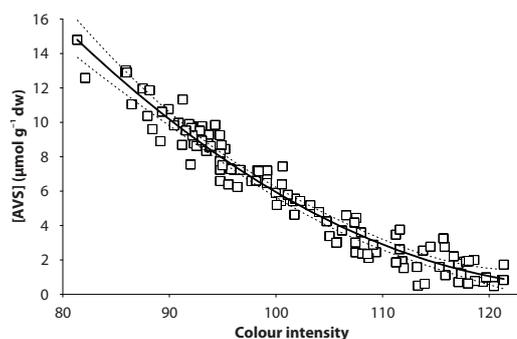- Colour intensity of each slice correlated to the measured [AVS] (**Fig. 2**)

Figure 2. Correlation between sediment colour intensity and [AVS]. Solid and dashed lines denote the quadratic fit ($R^2 = 0.95$) and the 95% confidence interval. Each data point is from a 5 mm section of a sediment core.

Findings

We established a strong correlation (**Fig. 2**) between sediment colour intensity and [AVS] allowing for the accurate prediction of the in situ distribution of AVS from a sediment profile image.

Two types of AVS predictions can be made: (1) the colour intensities of horizontally aligned pixels are averaged to obtain a vertical [AVS] profile (**Fig. 3A**), or (2) individual pixel colour intensities are mapped to create a two dimensional distribution plot of [AVS] (**Fig. 3B**).
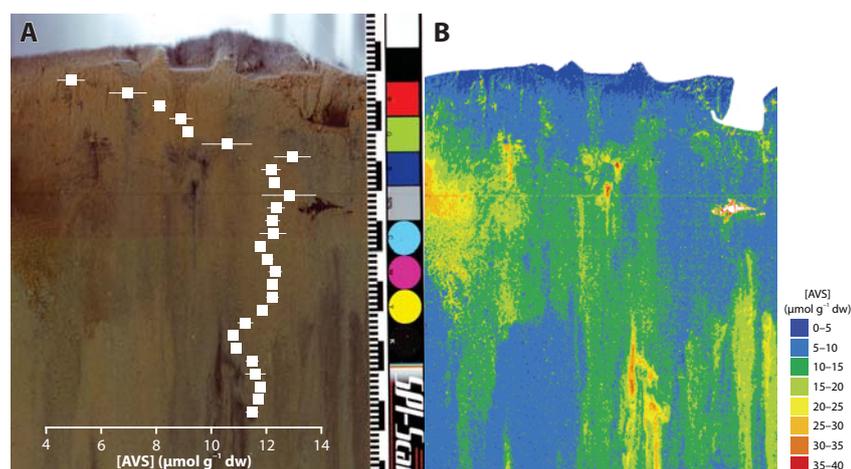

Figure 3. (A) Example of an in situ sediment profile image. Small black and white bars on the scale to the right of the picture are 1 mm each, the larger bars are 10 mm. The image is overlaid with the predicted [AVS] profile. **(B)** A two dimensional AVS distribution plot derived from the image in (A).

Conclusion

Using *in situ* sediment profile imagery and amperometric H_2S microelectrodes, we have vastly improved the predictive power of the Bull and Williamson (2001) approach. Our new technique makes AVS an accessible parameter for rapid assessment of the effects of organic enrichment in marine sedimentary environments.

References

Bull DC, Williamson RB (2001) Prediction of principal metal-binding solid phases in estuarine sediments from color image analysis. Environmental Science and Technology 35:1658-1662

Jørgensen BB (1982) Mineralization of organic matter in the sea bed—the role of sulphate reduction. Nature 296:643-645