Isotope Biogeochemistry of Diagenesis caused by a Black Shale-fueled Deep Marine Biosphere (ODP Leg 207)

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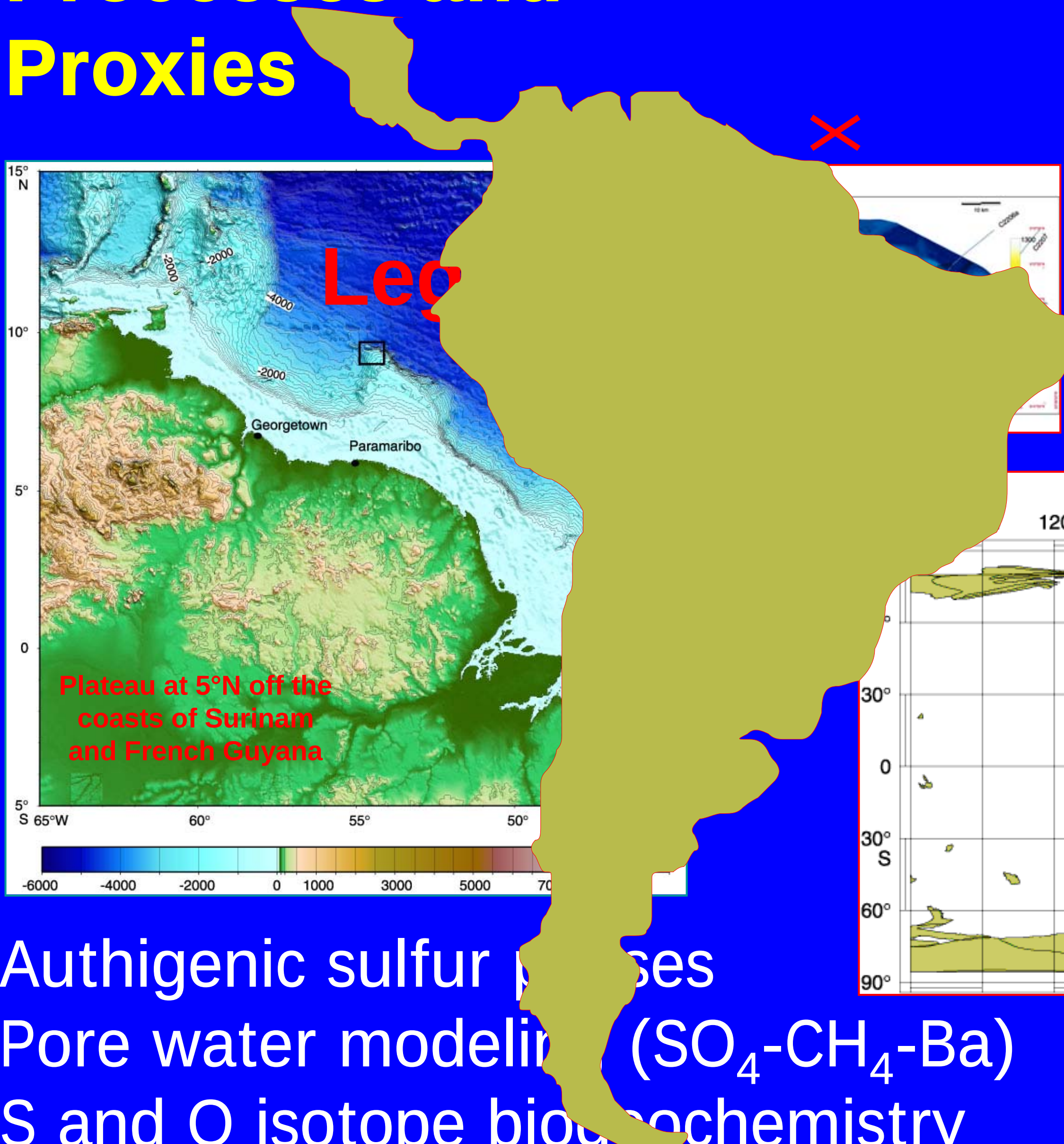
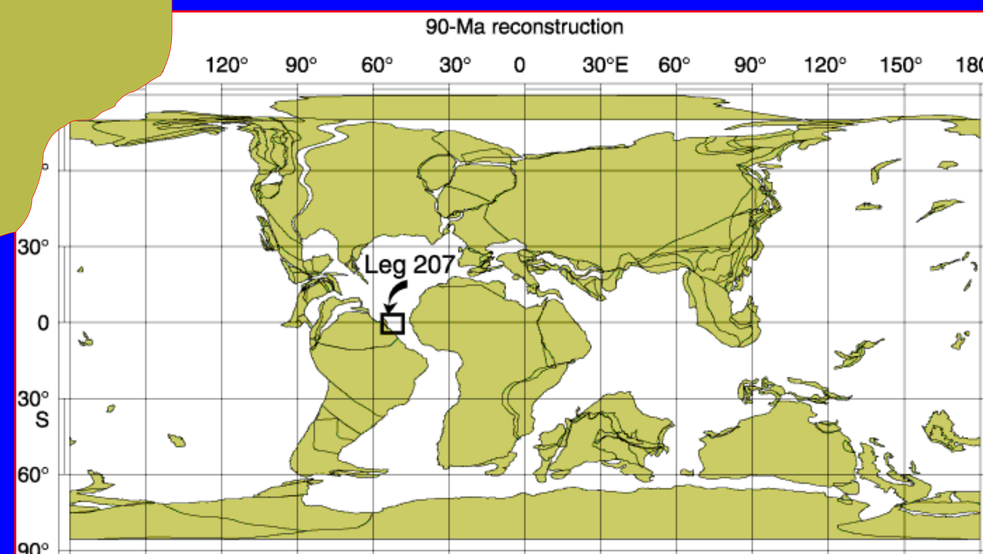
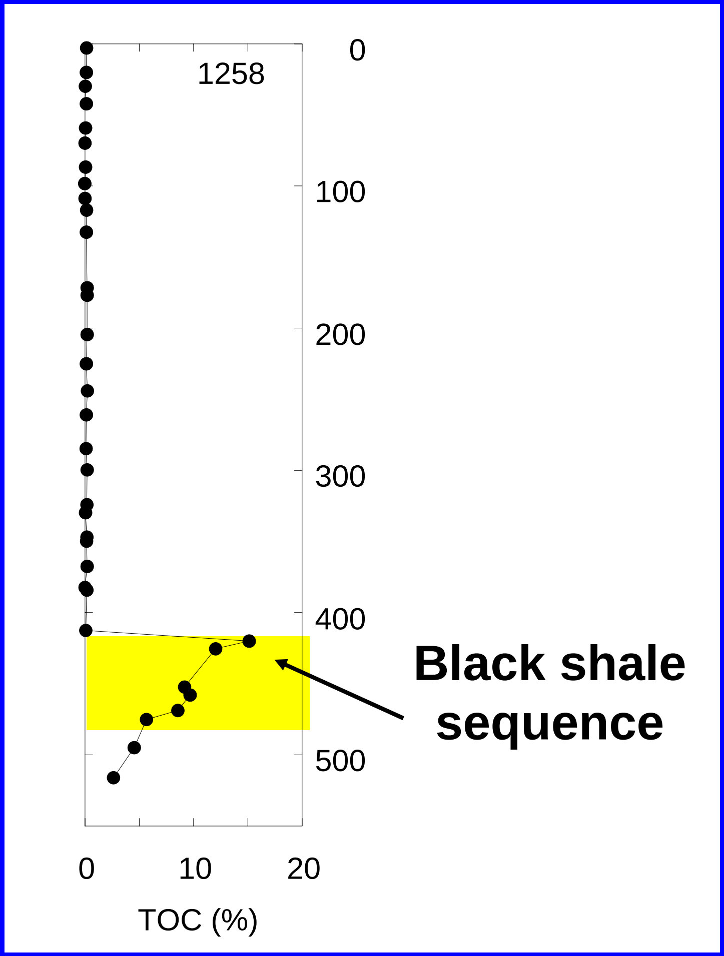
Black shales and Diagenesis: Processes and Proxies

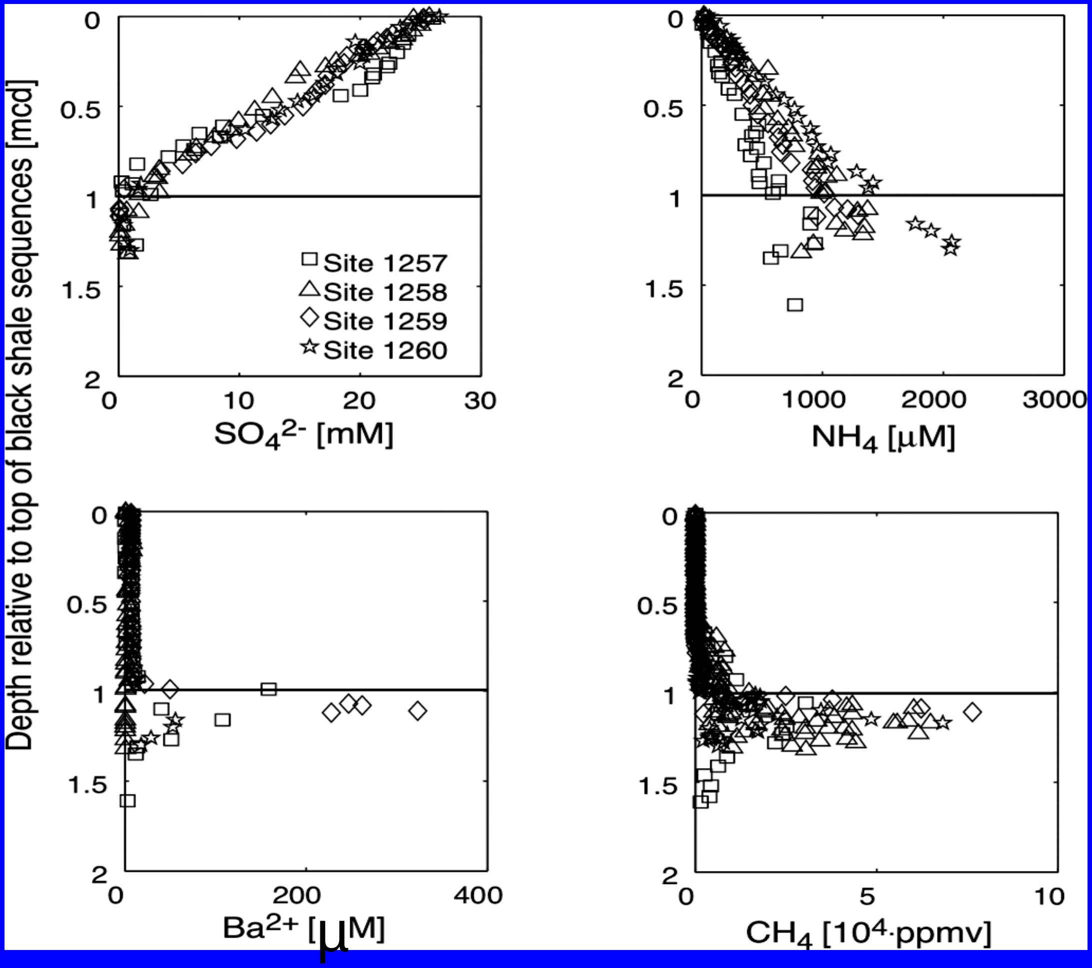




- Authigenic sulfur p ses
- Pore water modeli (SO$_4$-CH$_4$-Ba)
- S and O isotope biog ochemistry

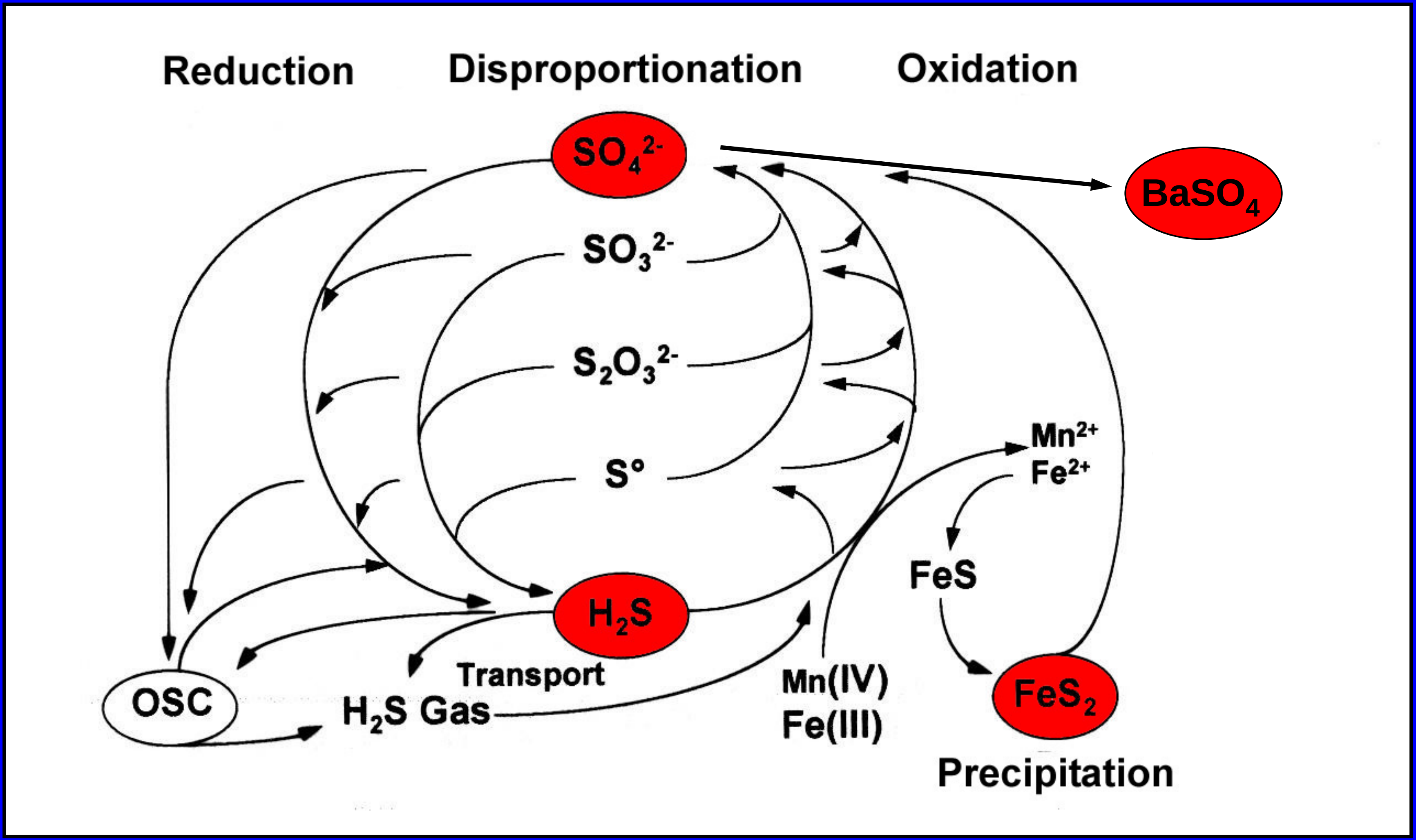
Black shales in Leg 207 sediments and pore water response



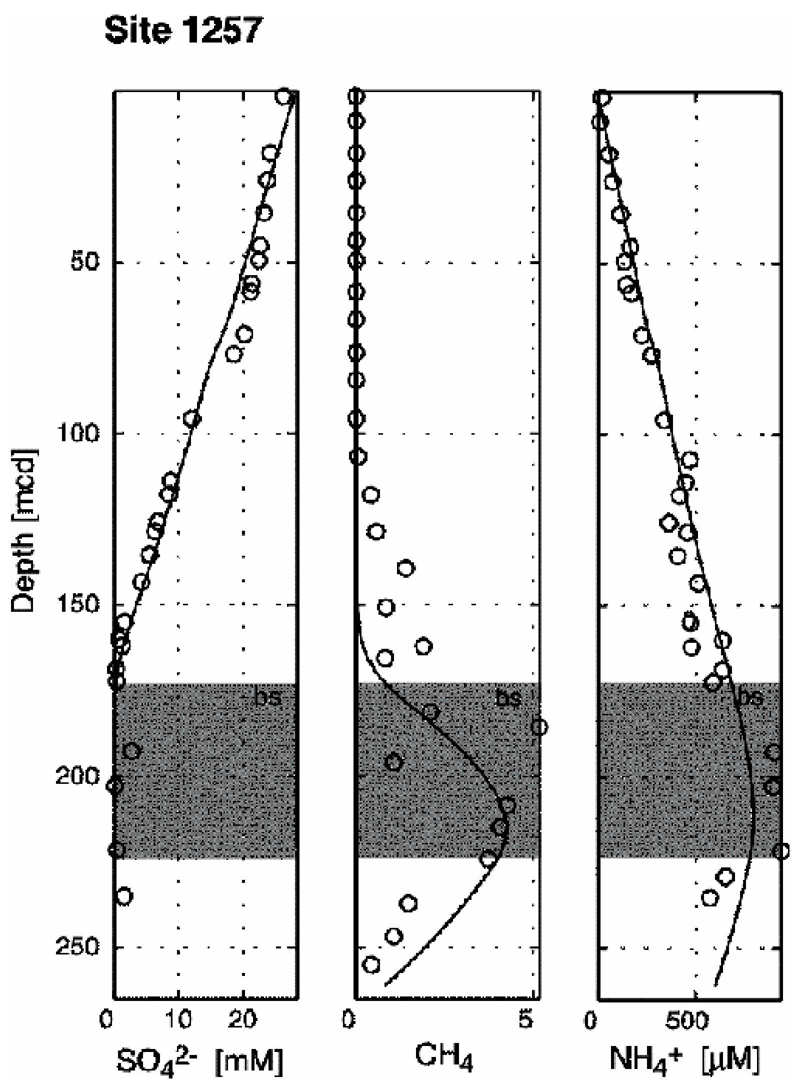


Pore water response
(normalized to top of black shales)

Sedimentary sulfur phases: Recorders for microbial activity, sulfur cycling and coupling to metals



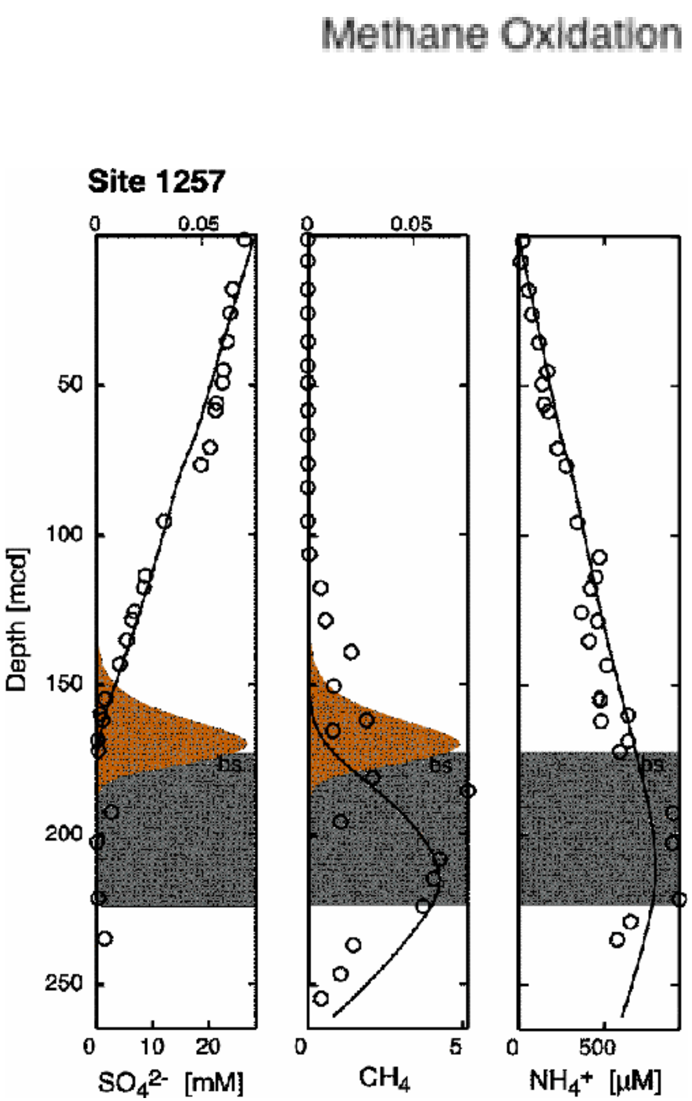
Pore waters as recorders of biogeochemical elements transformations



Pore water profiles indicate methanogenesis within the black shale sequence and microbial sulfate reduction above

Arndt et al. (submitted)

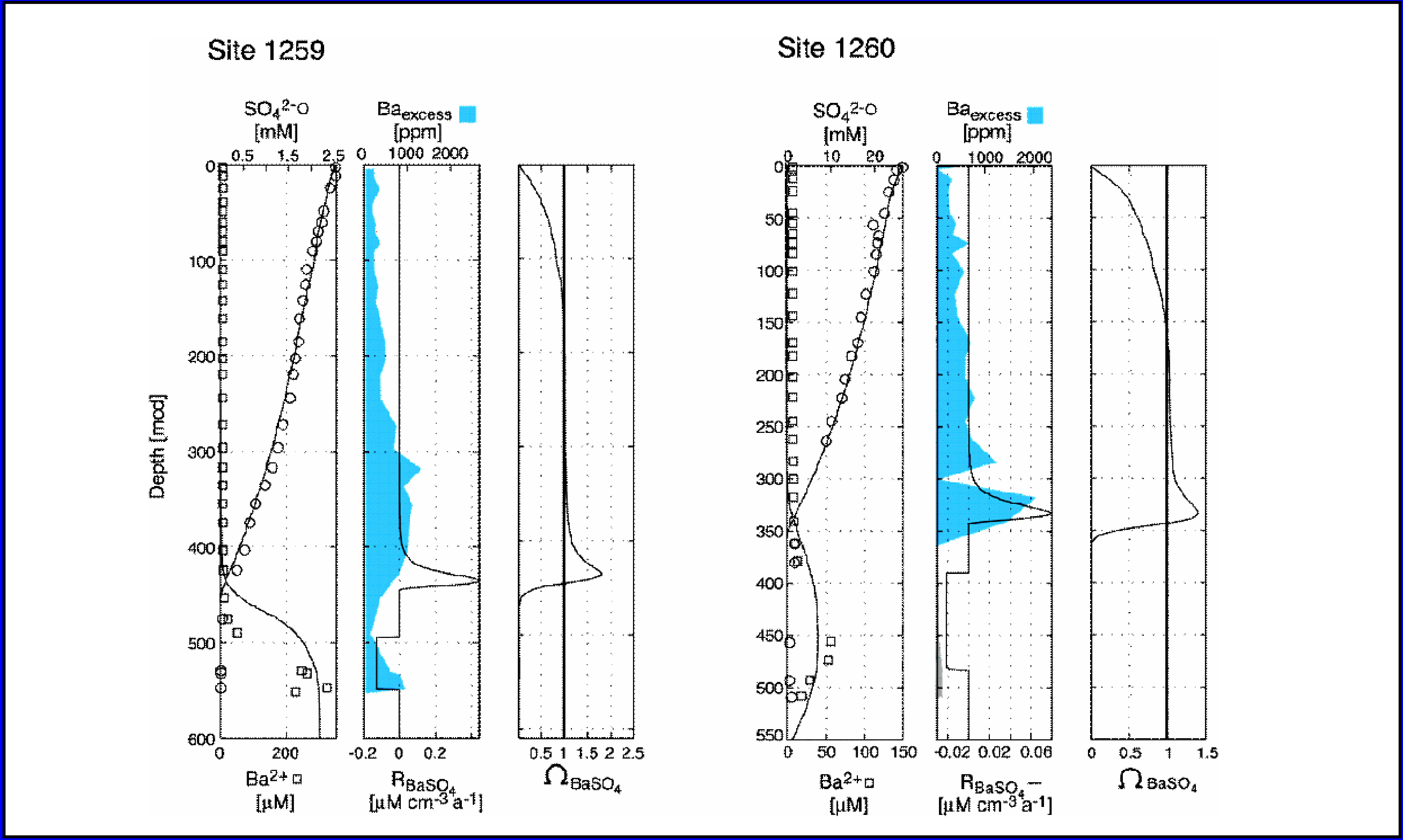
Anaerobic Oxidation of Methane



Modeling of pore water profiles indicate anaerobic oxidation of methane at the sulfate-methane transition associated with sulfate reduction

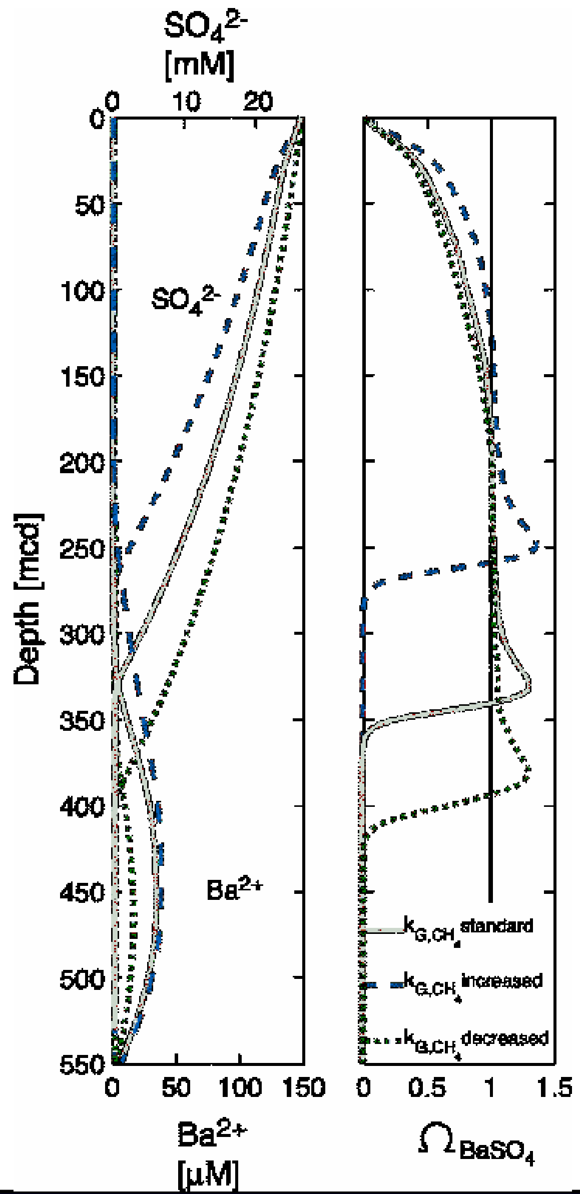
Arndt et al. (submitted)

Dissolution and Precipitation of Barite: Measured Ba excess and rate modeling



Arndt et al. (submitted)

Methanogenesis & Pore Water Gradients

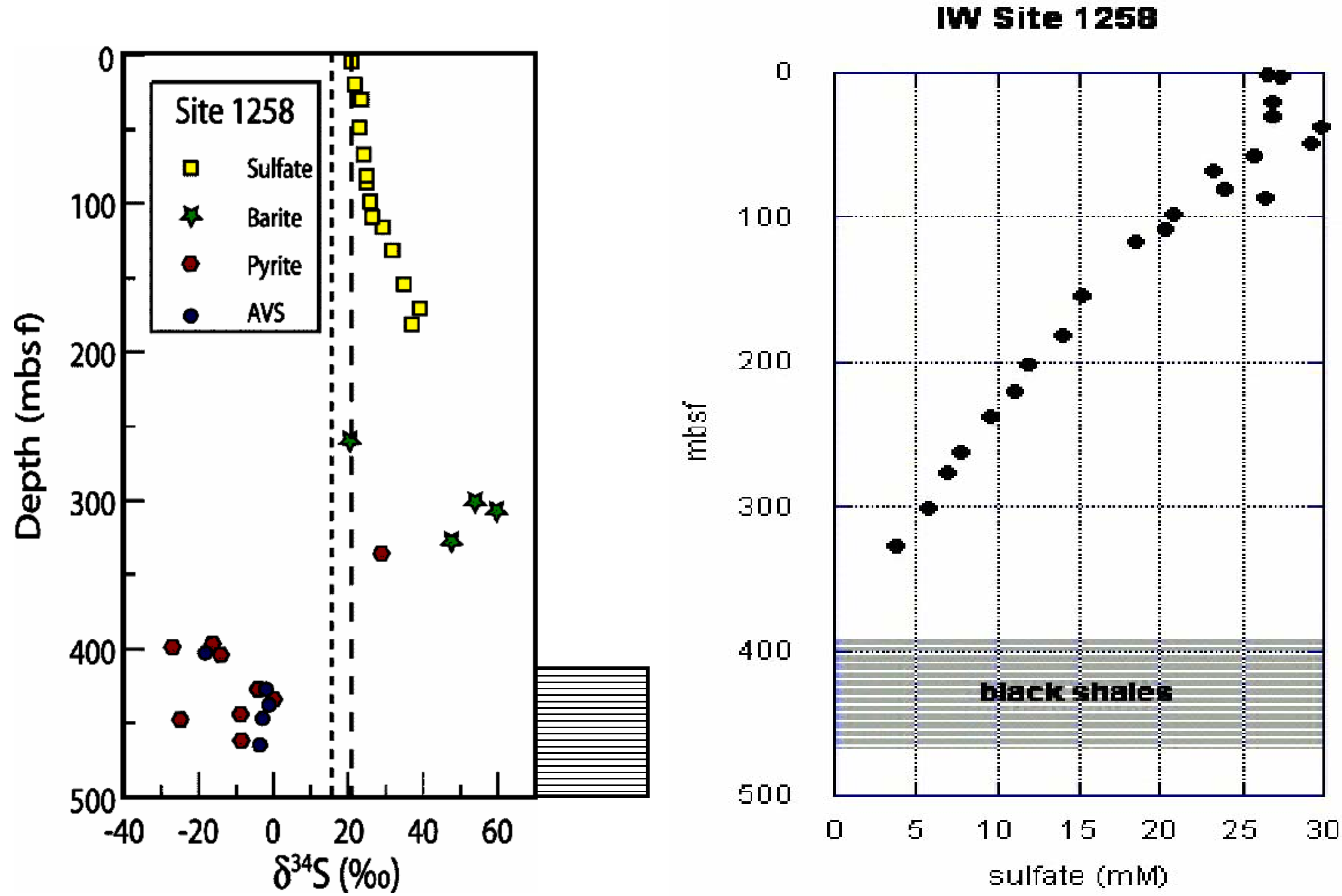


Sulfate-barium-gradients are controlled by methanogenesis rate in the black shales:

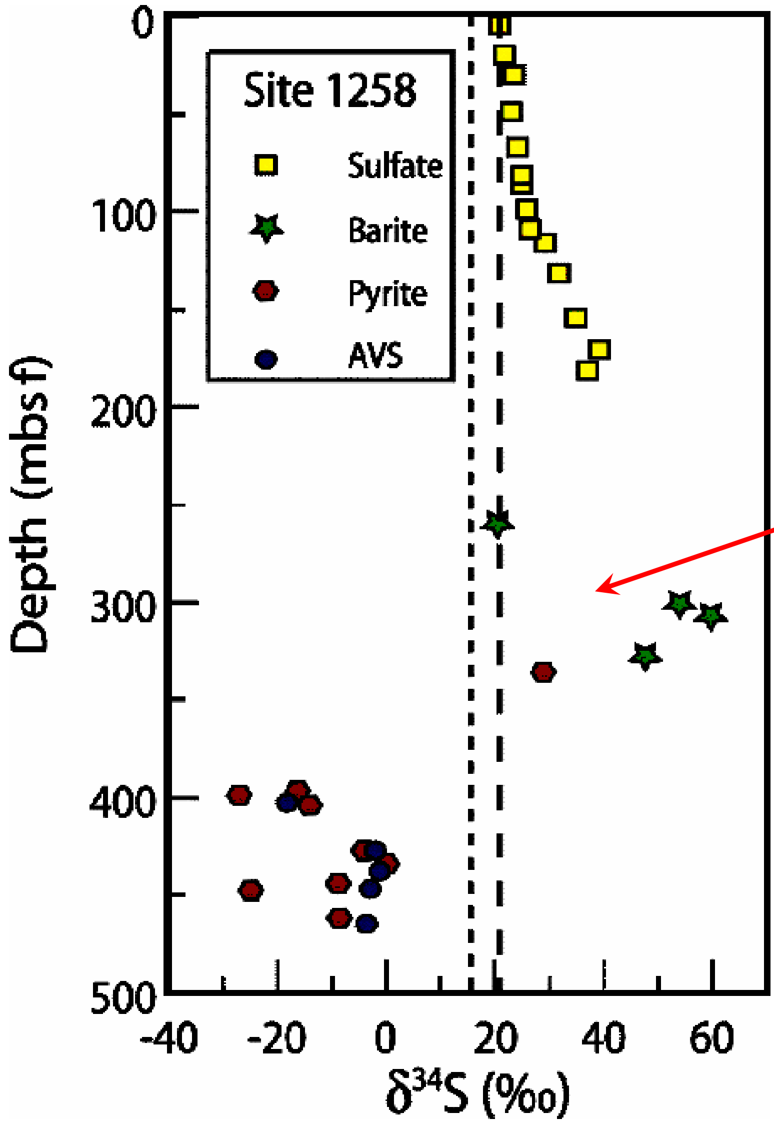
Implications for characteristic S and O isotope enrichments in authigenic sulfur phases

Arndt et al. (submitted)

Sulfur isotope biogeochemistry

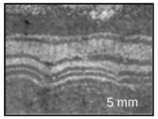


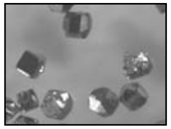
Sulfur isotope biogeochemistry



Isotopic composition of dissolved sulfate as indicator for ongoing microbial sulfate reduction

Heavy barite and pyrite above black shales as recorders for AOM



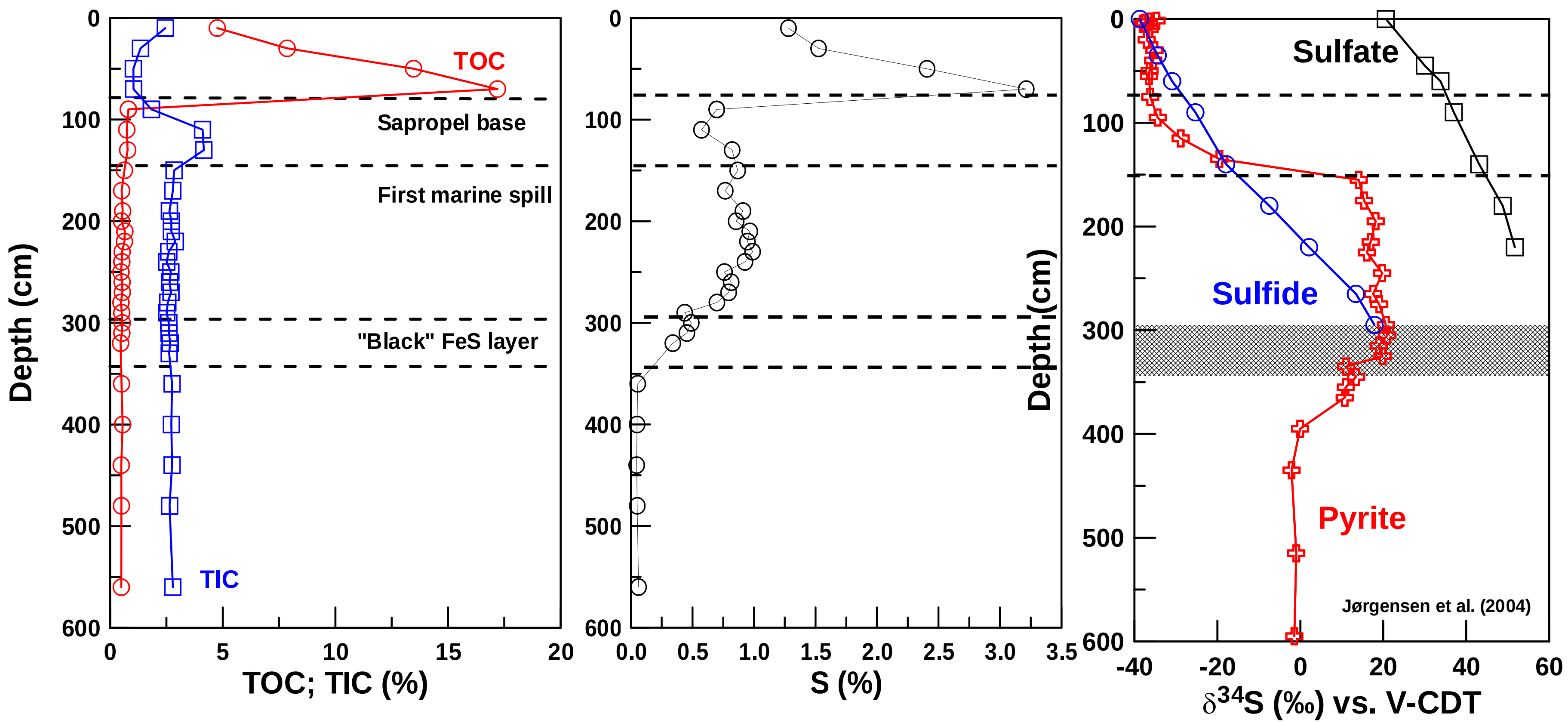


Authigenic pyrite concretion and euhedral crystals

Pyrite and AVS in black shales reflect early reactions in the sulfur cycle

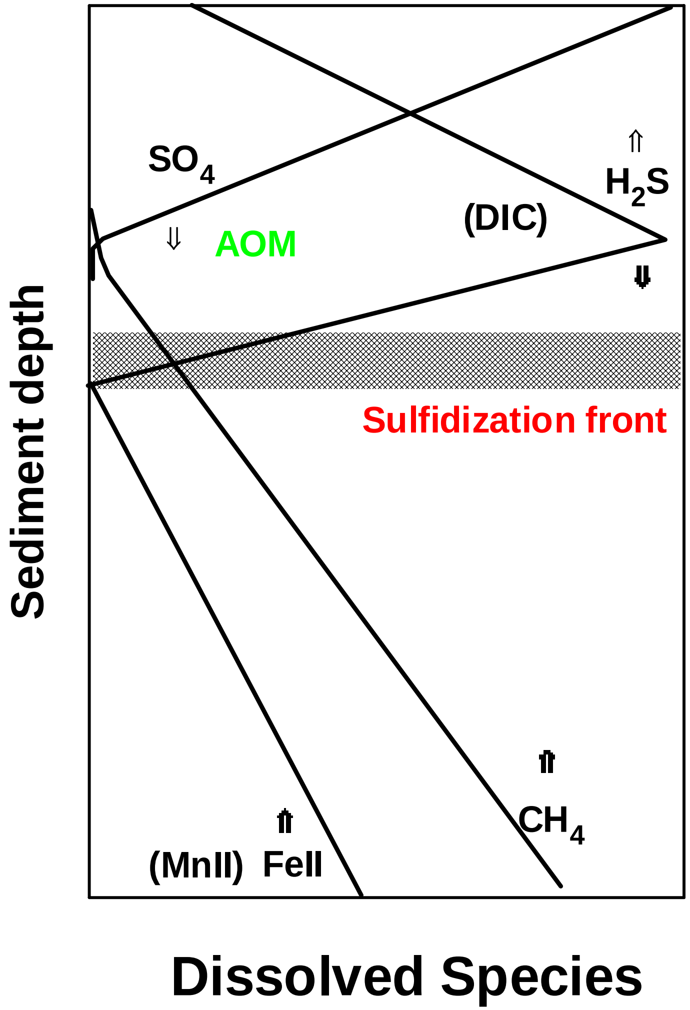
Similar results at all sites

Black Sea sediments as a Model System



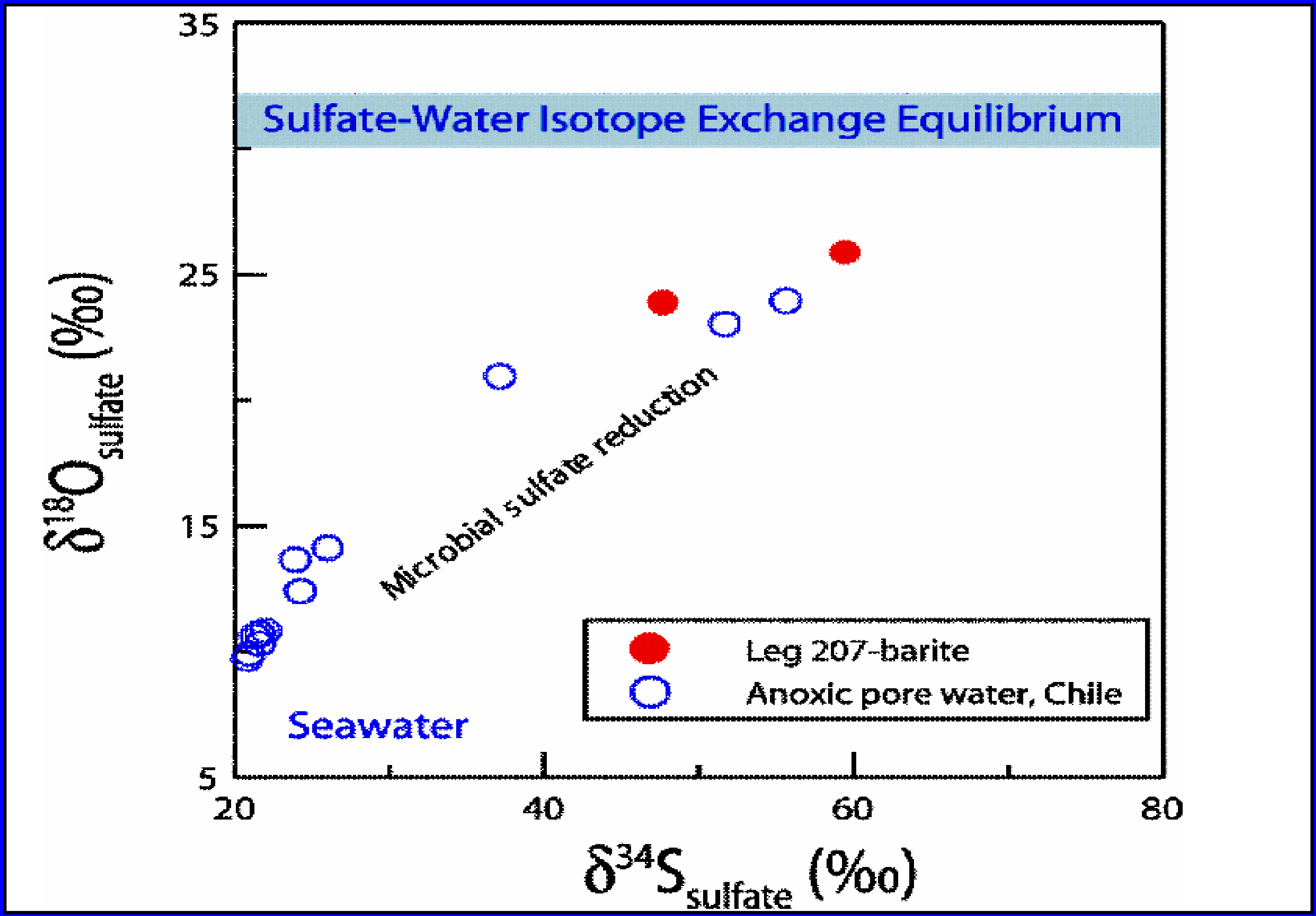
Diagenetic Sulfidization as a Process leading to Decoupling of C and S and heavy Sedimentary Sulfides

Black Sea sediments as a Model System



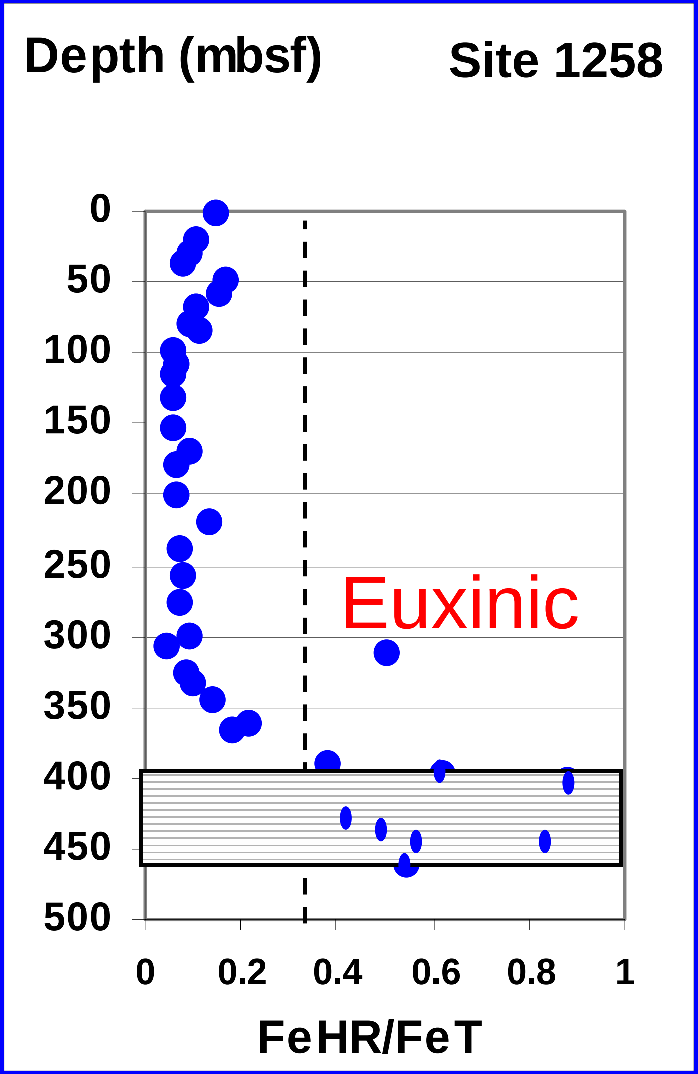
Anaerobic Methane Oxidation as the Driving Force

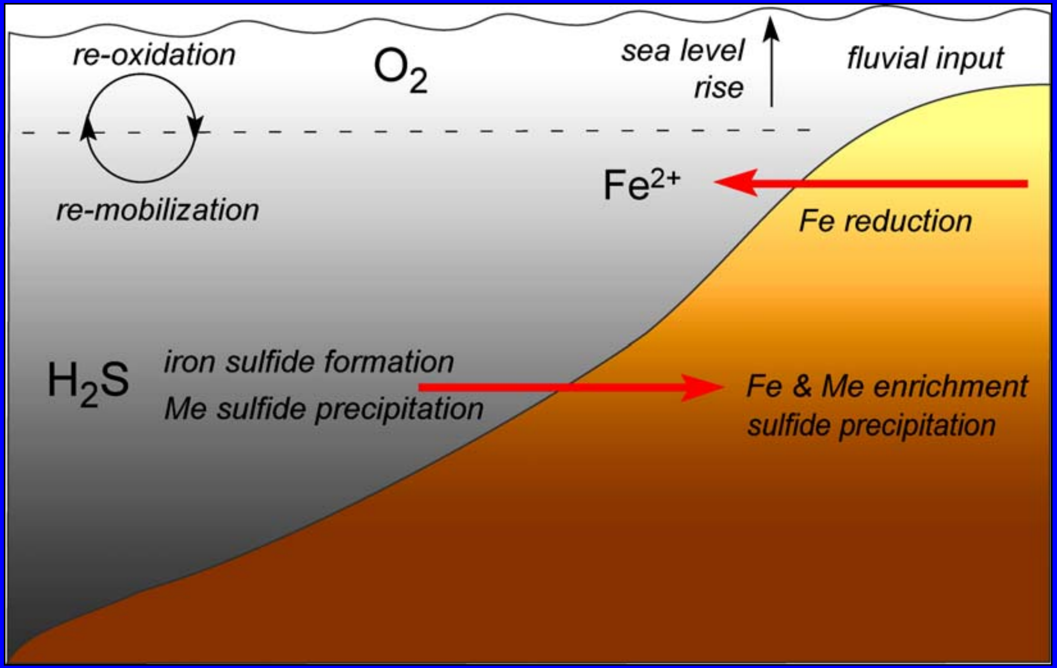
S and O isotope co-variations in authigenic barite: Recorders of pore water composition and enzymatic intracellular activity



Chile data: Böttcher et al. (2001)

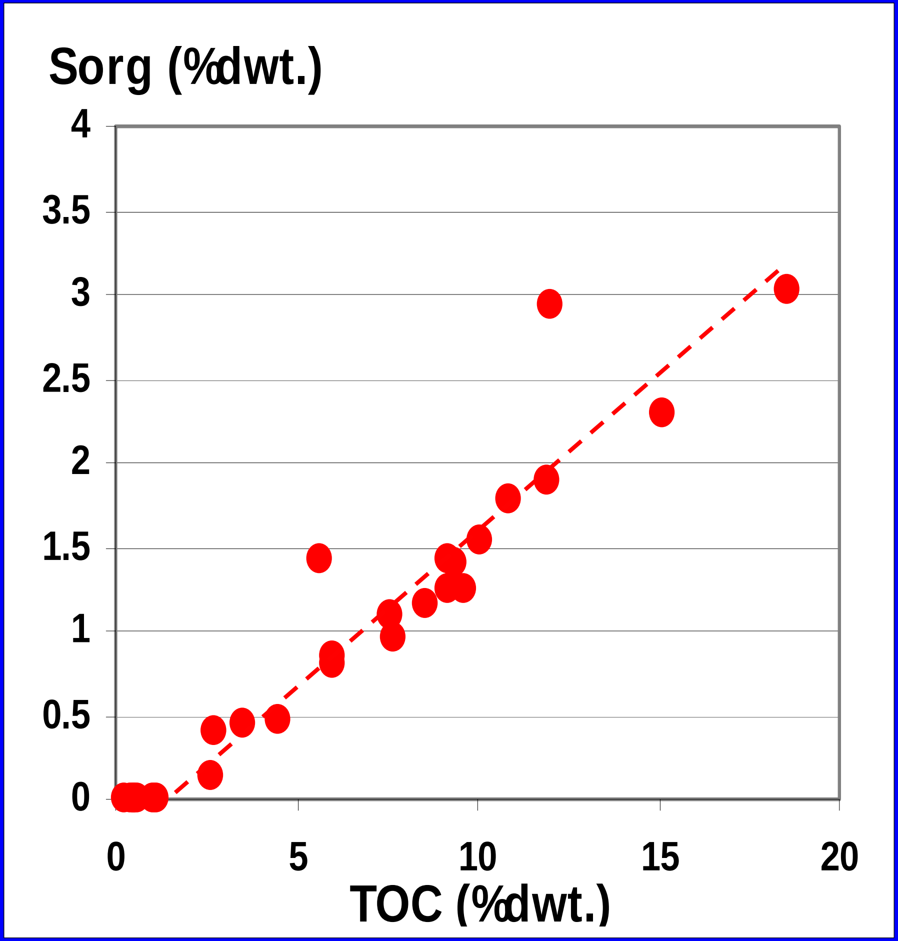
Euxinic conditions during black shale formation

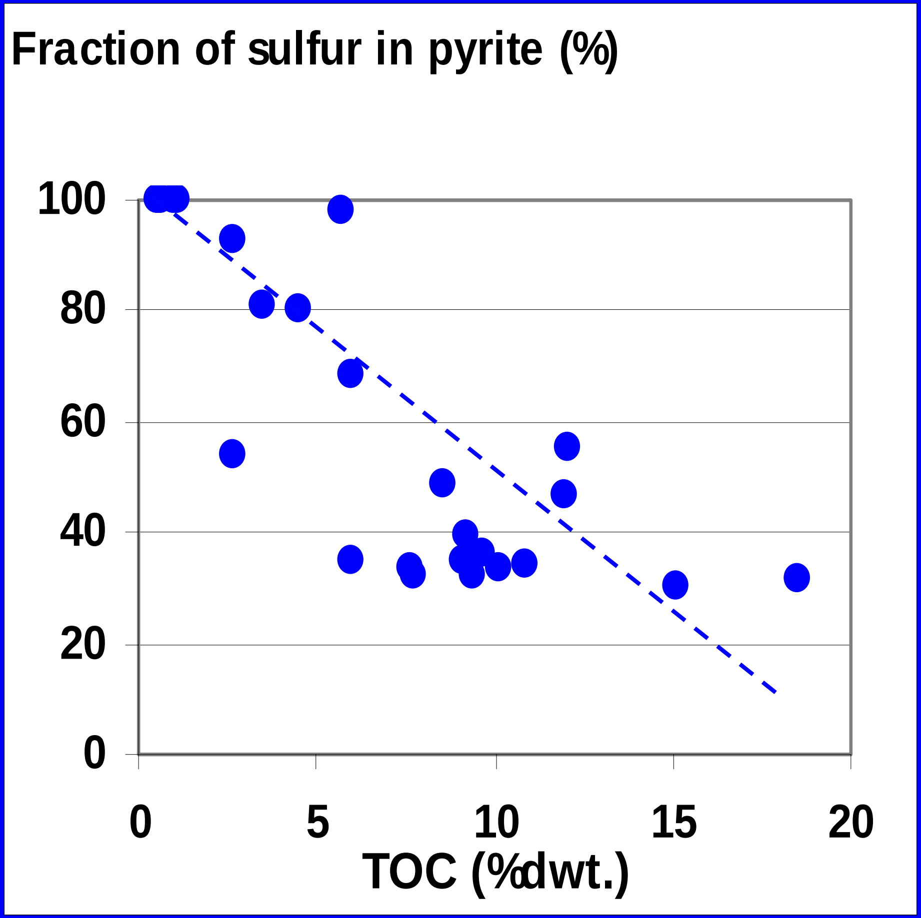




Pyrite formation in the water column

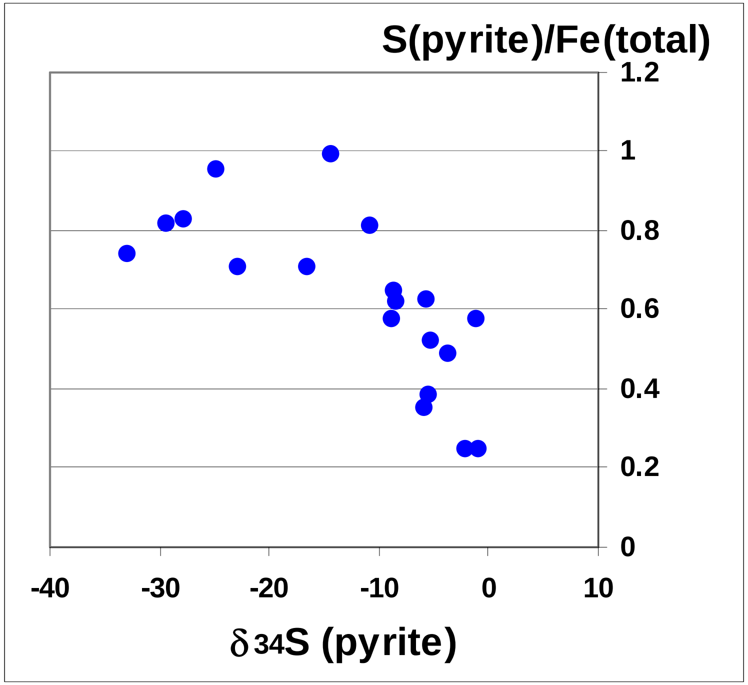
Sulf(id)urization of iron and organic matter in black shales





- The relative importance of sulfurization of organic matter increases with its content

Sulfur isotope partitioning into pyrite of black shales

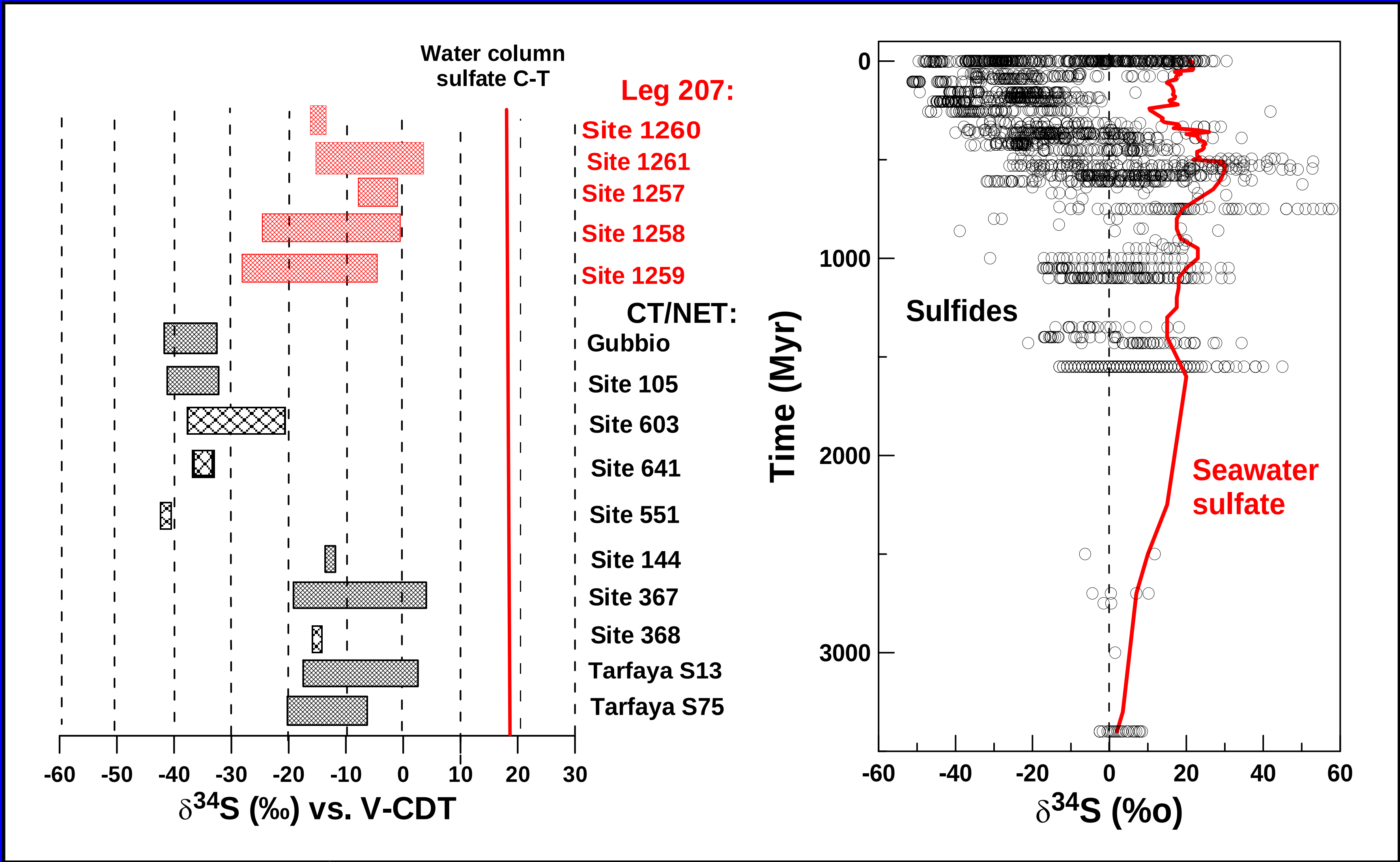


Iron and S isotope geochemistry

Similar trend for TOC

Enhanced S redox cycling at higher TOC

Heavy sulfur isotopes in pyrite: Recorders for AOM vs. closed system



CT/NET data: Böttcher & Kuypers (unpublished)

Data: Canfield, Strauss, Böttcher

Conclusions

- Pore waters in sediments at Demerara Rise reflect biogeochemical processes dominated by sulfate reduction associated with anaerobic methane oxidation
- The depth of the sulfate-methane transition zone, as well as the availibility of sulfate at depth are exclusively controlled by the production of methane in the black shale sequences
- Activity of deep biosphere microbial activity is reflected in the sulfur isotopic composition of the different sulfur-containing phases
- Reactive iron contents indicate water column derived pyrite in black shales. Also mirrored by S isotope data.
- The relative importance of sulfurization of organic matter depends on the availability of organic matter
- Isotopically heavy sulfate and pyrite mineral phases are suggested to be indicators for anaerobic methane oxidation