



# Mikrobielle Schwertmannit-Bildung

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TU Bergakademie Freiberg

Workshop 3 des Innovationsforums  
„Geobiotechnologie – mikrobiologische Verfahren in  
Bergbau und Umweltschutz“

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# **Gliederung**

**(1) Problem**

**(2) Genetische Untersuchungen zu Diversität und in einer Wasserreinigungsanlage**

**(3) Isolierungsversuche**

**(4) Schwertmannit-Bildung**

**(5) Mikrobielle Aktivität in Krusten**

**(6) Effekt von Phosphat**

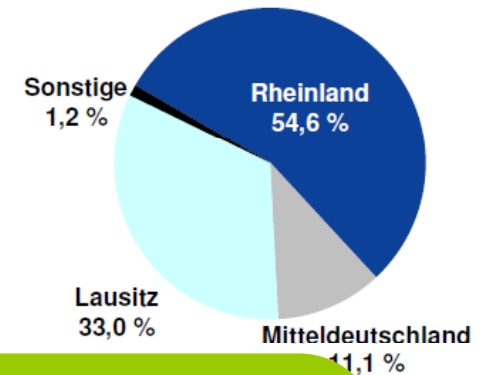




## Open Pit Lignite Mining



Förderung nach Revieren  
175,3 Mio. t

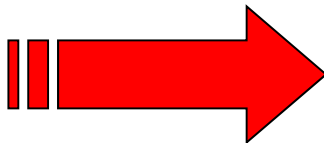
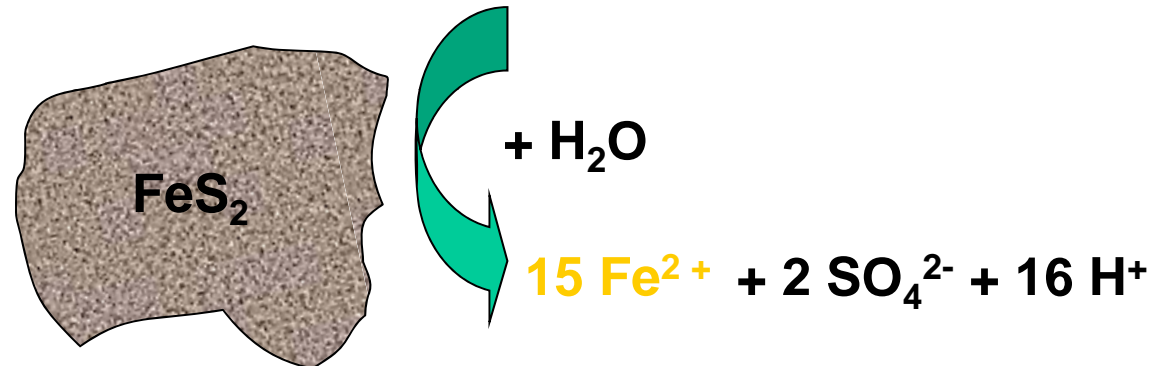
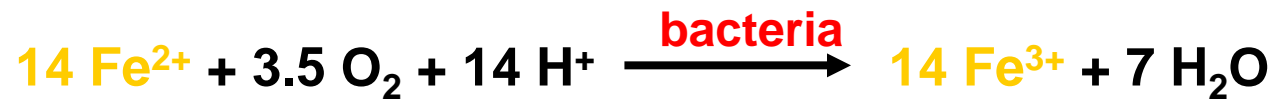


**350 - 400 Mio. m<sup>3</sup>**  
mine water hoisted  
every year in Lusatia  
(Vattenfall, 2009)





## Environmental Problem: Pyrite Leaching

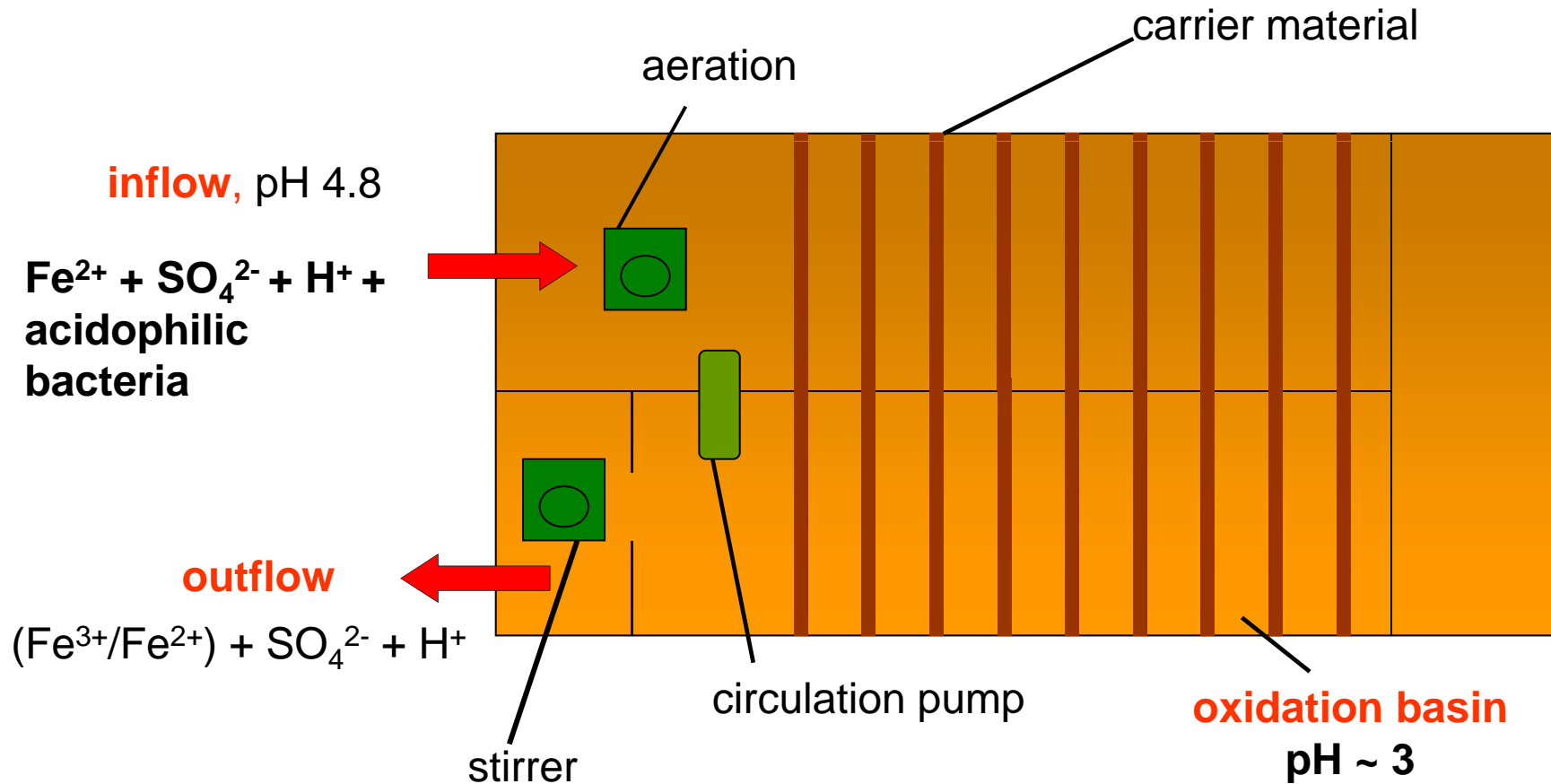


- low pH
- high loads of iron and sulfate
- heavy metal contamination





# The Solution: Biological Iron Oxidation





## Pilot Plants

First pilot plant



- Investigation period: 11 months
- Capacity 20 m<sup>3</sup>, shrinking with time
- constant characteristic of groundwater

Second pilot plant

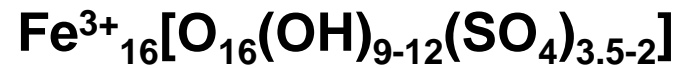


- Investigation period: 13 months
- Capacity 10 m<sup>3</sup>
- shifting characteristics of groundwater



# Formation of Iron Hydroxy Sulphates (IHS)

→ pH 2.5 - 4 formation of **schwertmannite**



Carrier material encrusted with schwertmannite



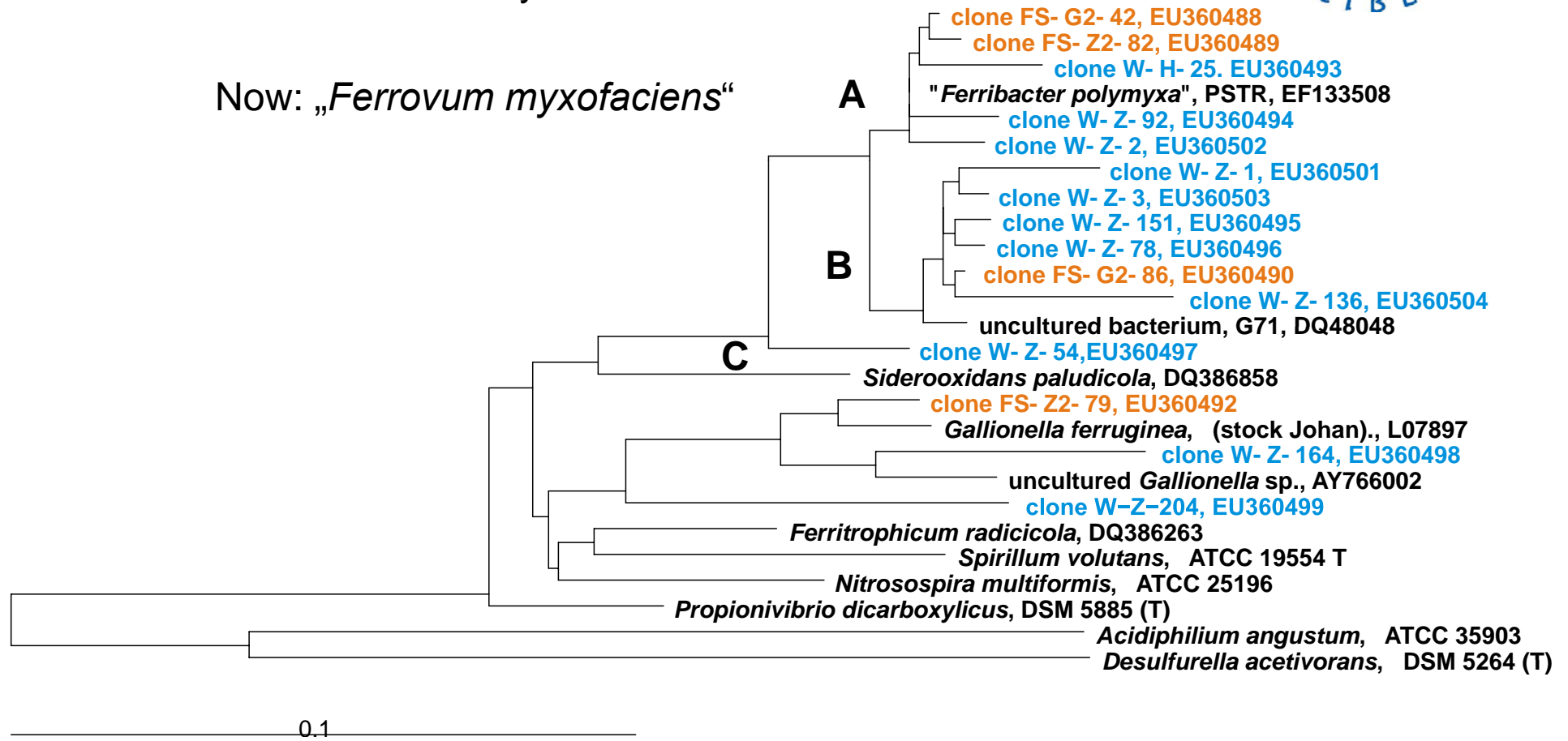
Scanning electron micrograph of schwertmannite crystals



# Novel Lineages of $\beta$ -Proteobacteria

- 800 clones analysed

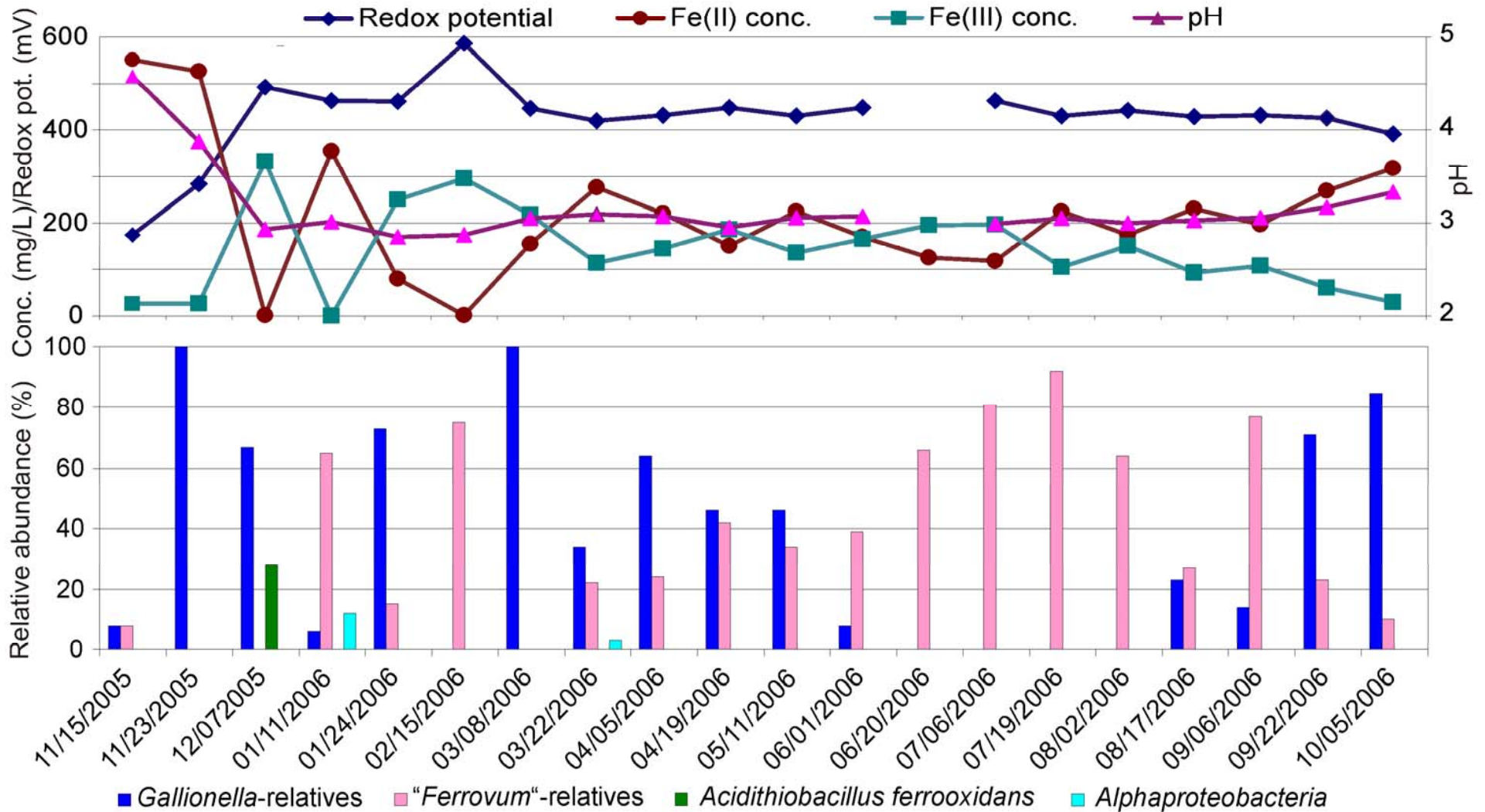
Now: „*Ferrovum myxofaciens*“





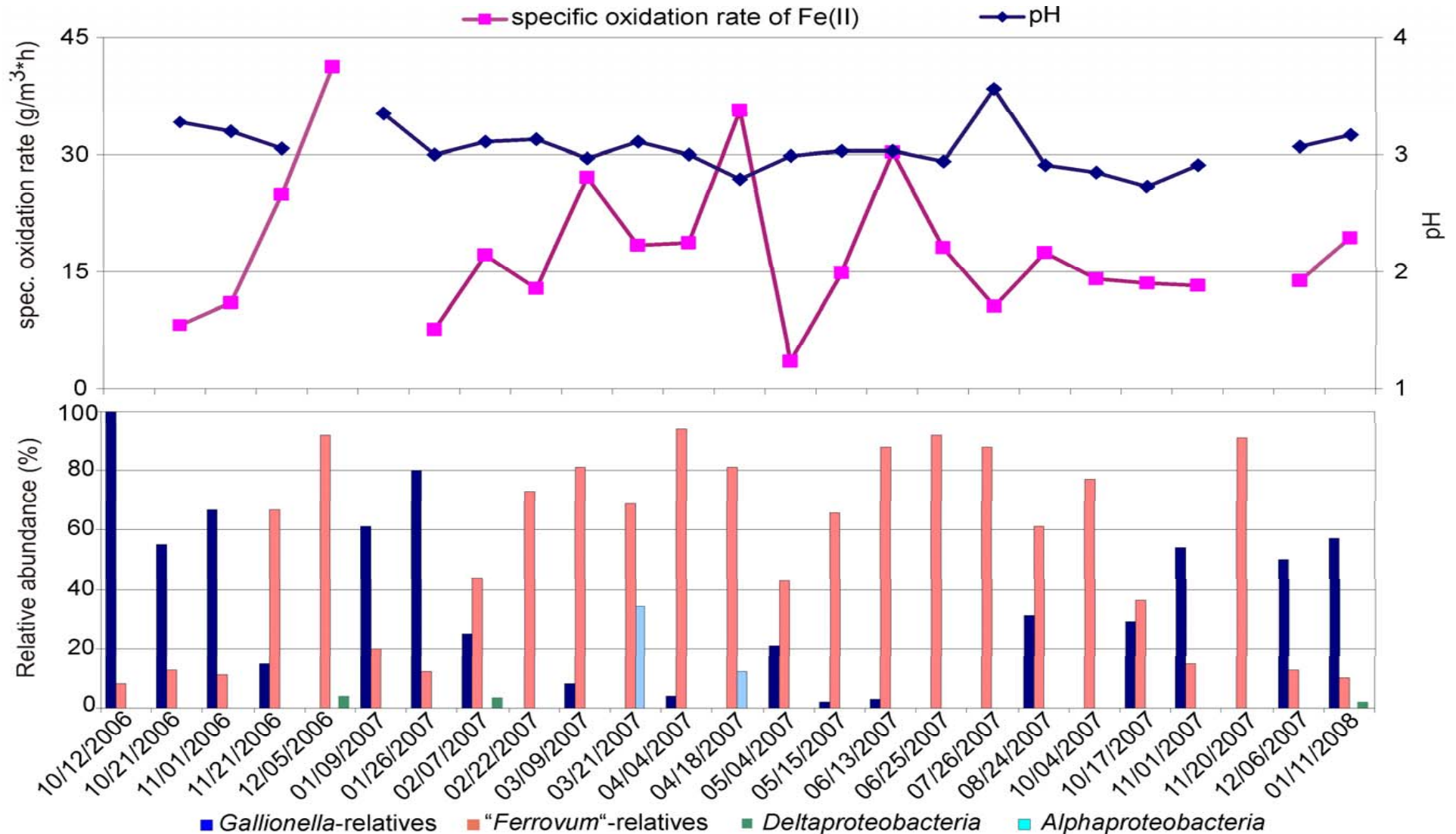


## Population dynamics in the first pilot plant detected by T-RFLP over 11 months



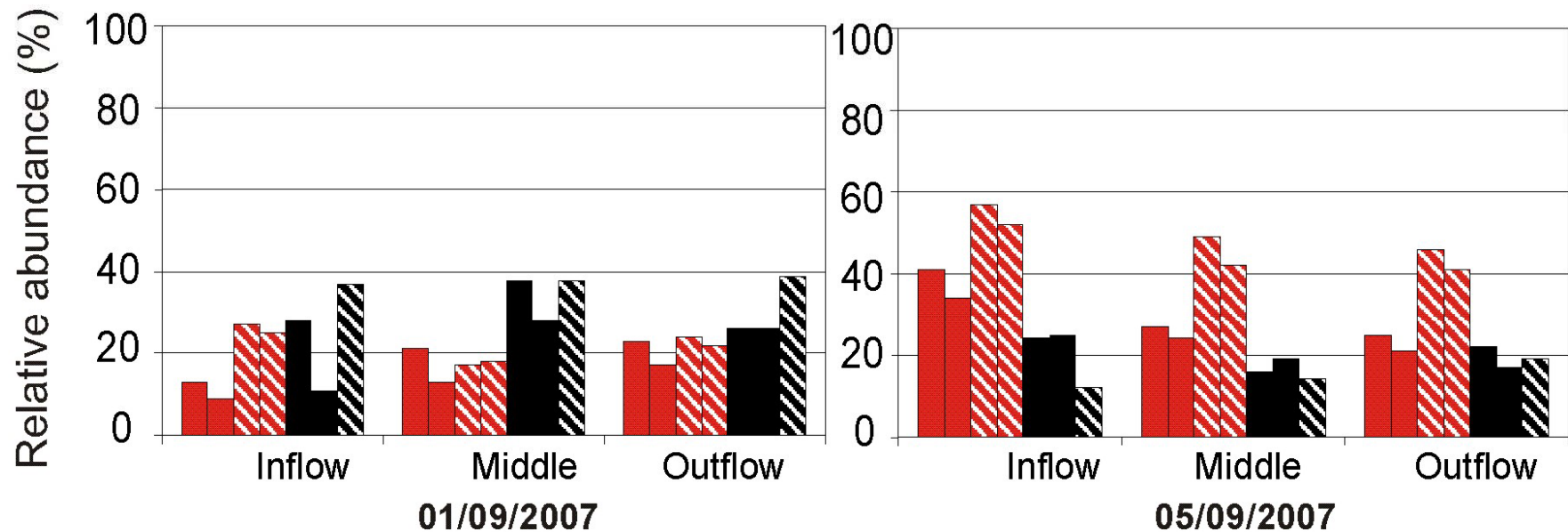


## Population dynamics in the second pilot plant detected by T-RFLP over 13 months





## Confirmation of TRFLP Data by Real Time PCR



Result of T-RFLP:

■ *Ferrovum*-relatives  
(digestion with 2 different enzymes)

■ *Gallionella*-relatives  
(digestion with 1 enzyme)

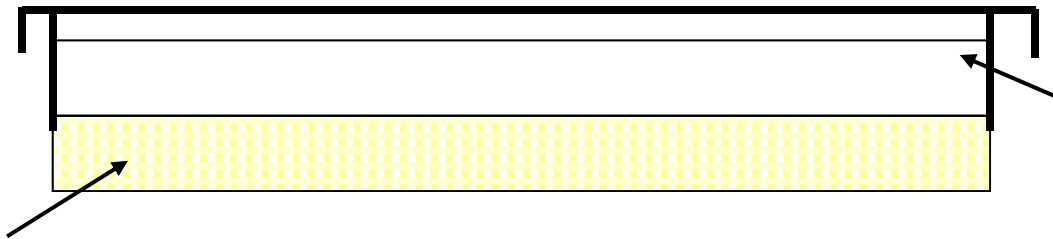
Result of Real-time PCR:

■ *Ferrovum*-relatives  
■ *Gallionella*-relatives



## Cultivation of “*Ferrovum myxofaciens*”

Overlay plate technique [Johnson, 1995]



Sterile underlayer inoculated with the heterotrophic *Acidiphilium cryptum* SJH

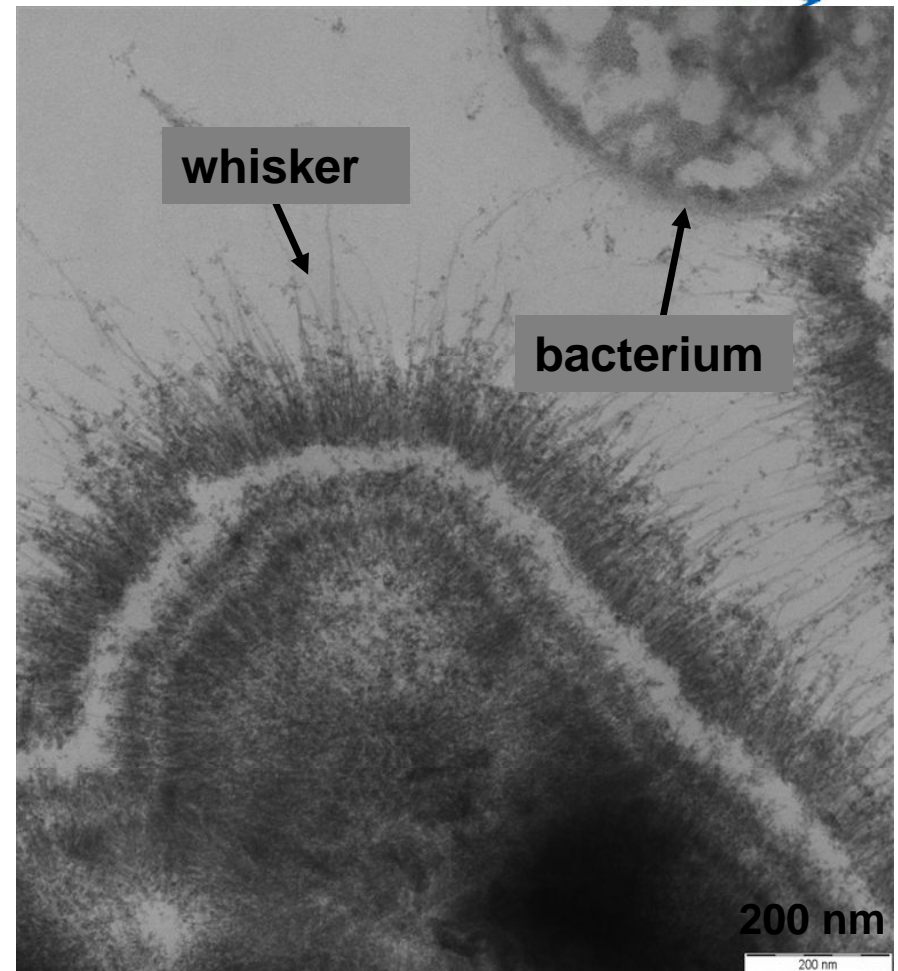
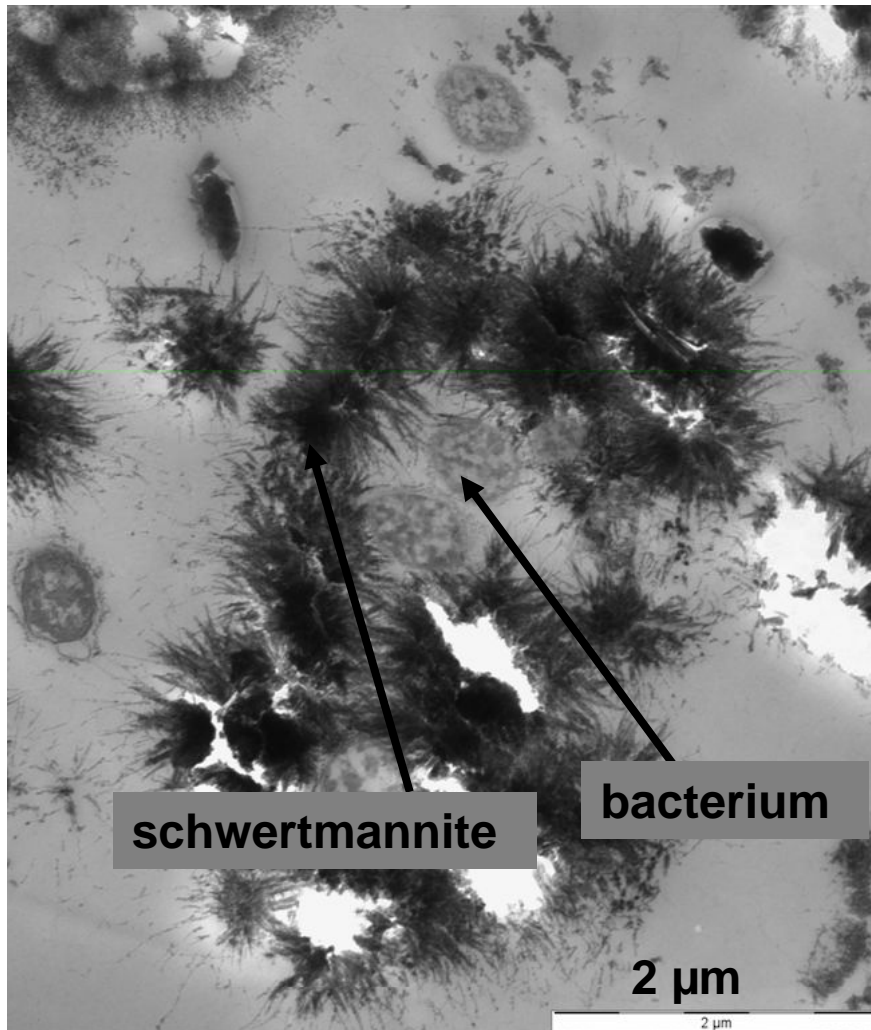
Sterile top layer of agarose



Highest BLAST similarity [%]	Medium (pH)	Bacteria class
„ <i>Ferribacter polymyxa</i> “ strain PSTR [ 97% ]	iFeo <sub>2</sub> (2.5 –3.5)	$\beta$ -Proteobacteria
<i>Thiomonas</i> sp. PK44 [ 97% ]	FeThio <sub>2</sub> (6.5)	$\beta$ -Proteobacteria
Acid streamer bacterium PK51 [ 96% ]	FeThio <sub>2</sub> (6.5)	$\gamma$ -Proteobacteria
<i>Halothiobacillus</i> sp. WJ18 [ 96% ]	FeThio <sub>2</sub> (6.5)	$\gamma$ -Proteobacteria
Uncultured bacterium clone placa1_b9 [ 98% ]	iFeo <sub>2</sub> (2.5)	<i>Nitrospirae</i>



## Transmission Electron Microscopy (TEM)

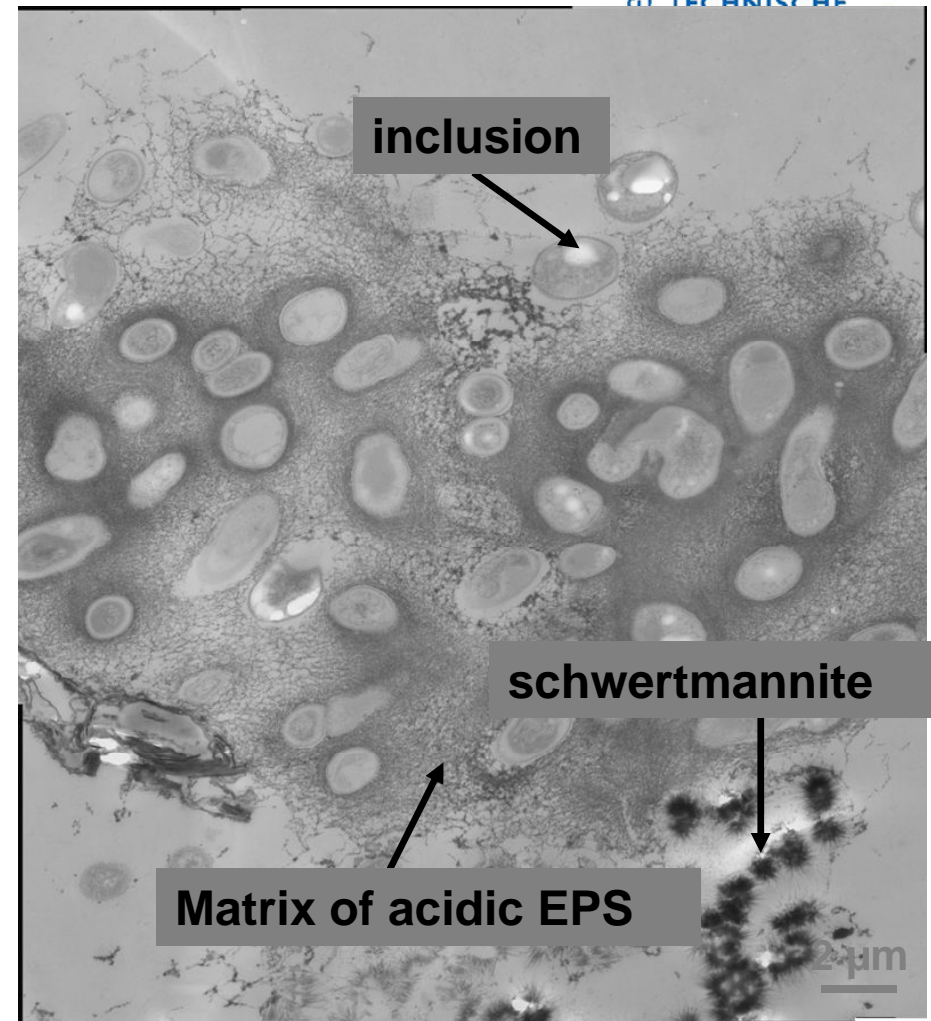
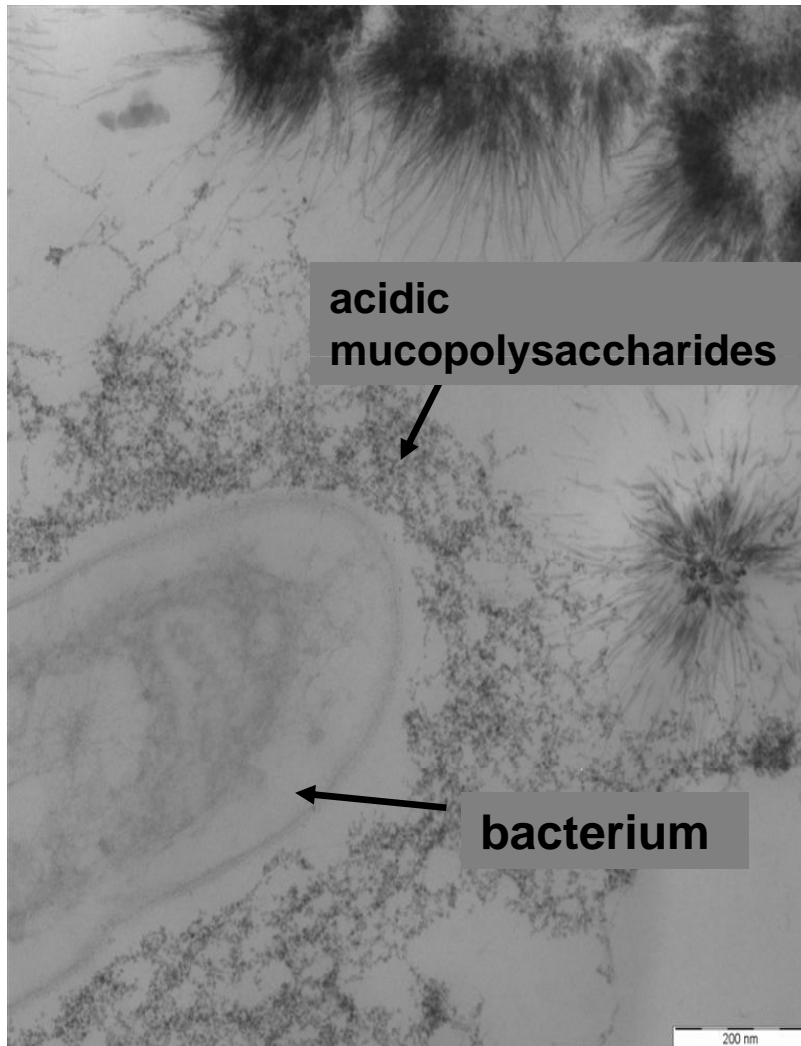


TEM thin sections from IHS material of the pilot plant





## Transmission Electron Microscopy (TEM)



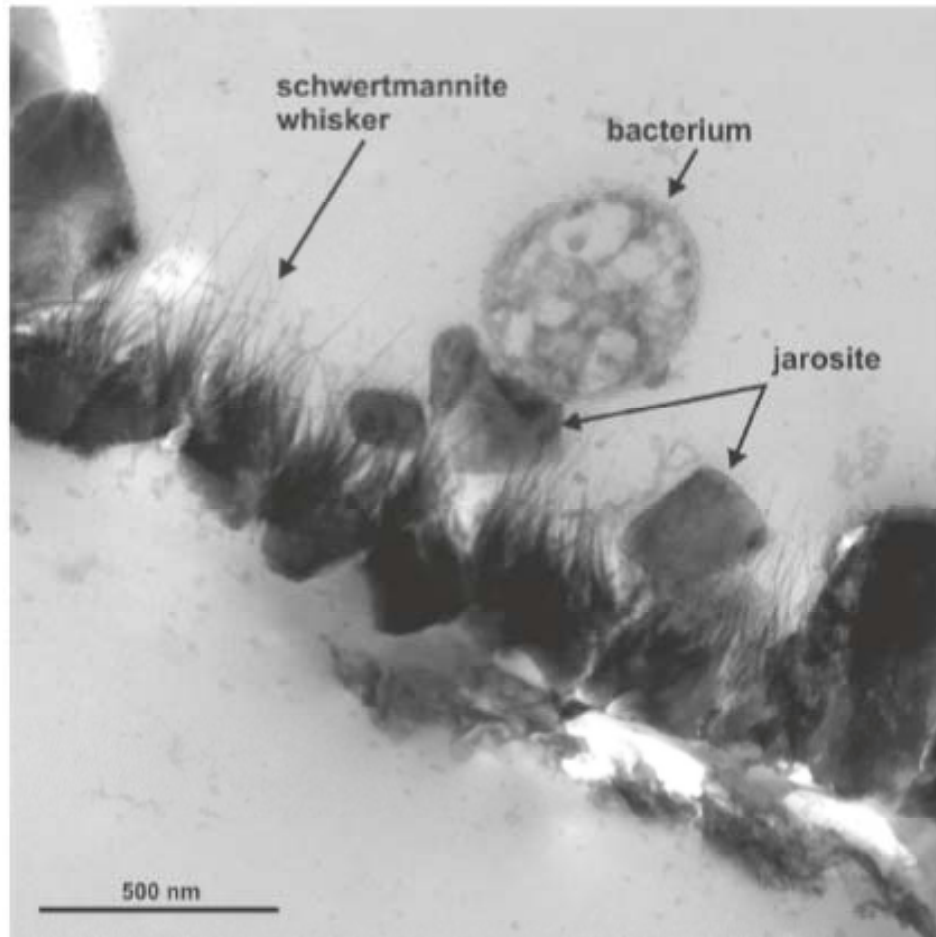
TEM images of minerals formed by strain EHS 6 in shake flasks, pH 2.2

Hedrich et al. Environ. Sci. Technol. 45, 7685-7692, 2011





## Transmission Electron Microscopy (TEM)



ThO<sub>2</sub> staining

Beginning of stationary phase

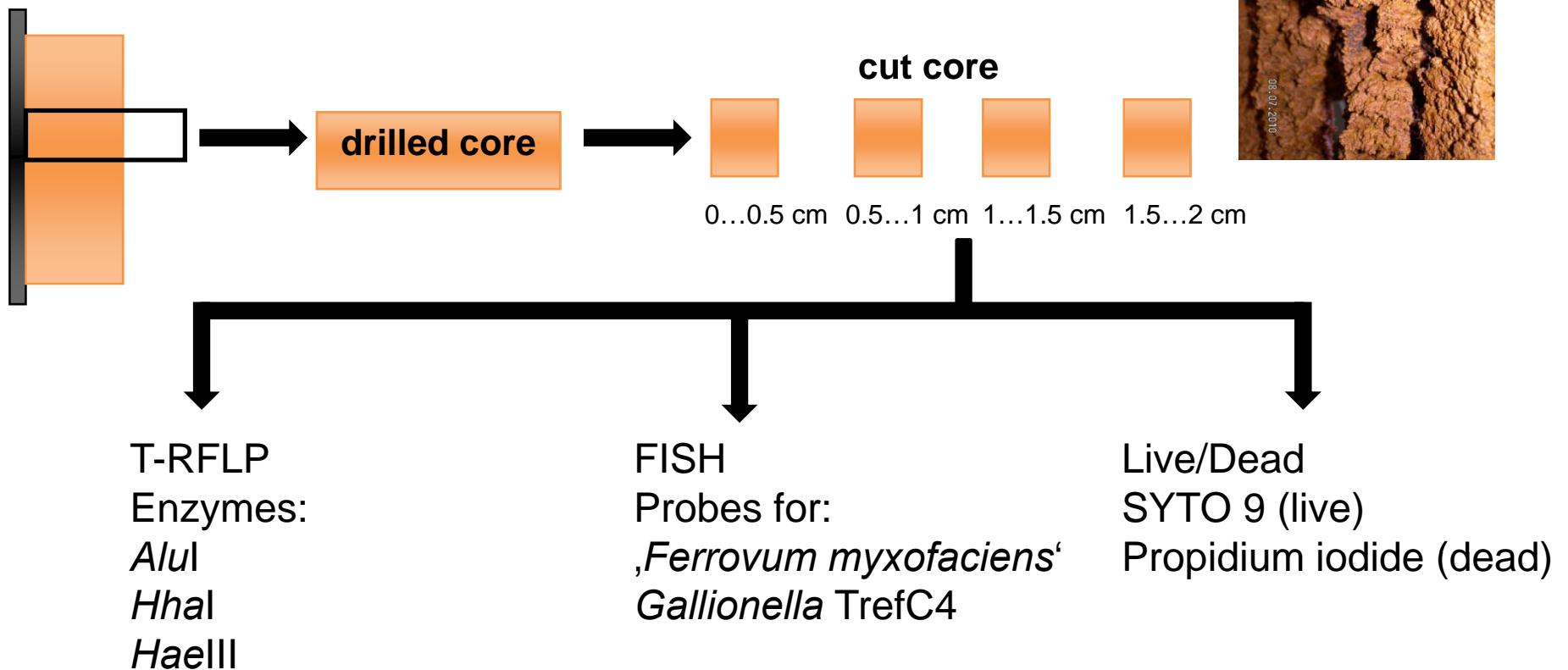
TEM image of minerals formed by strain EHS 6 in shake flasks

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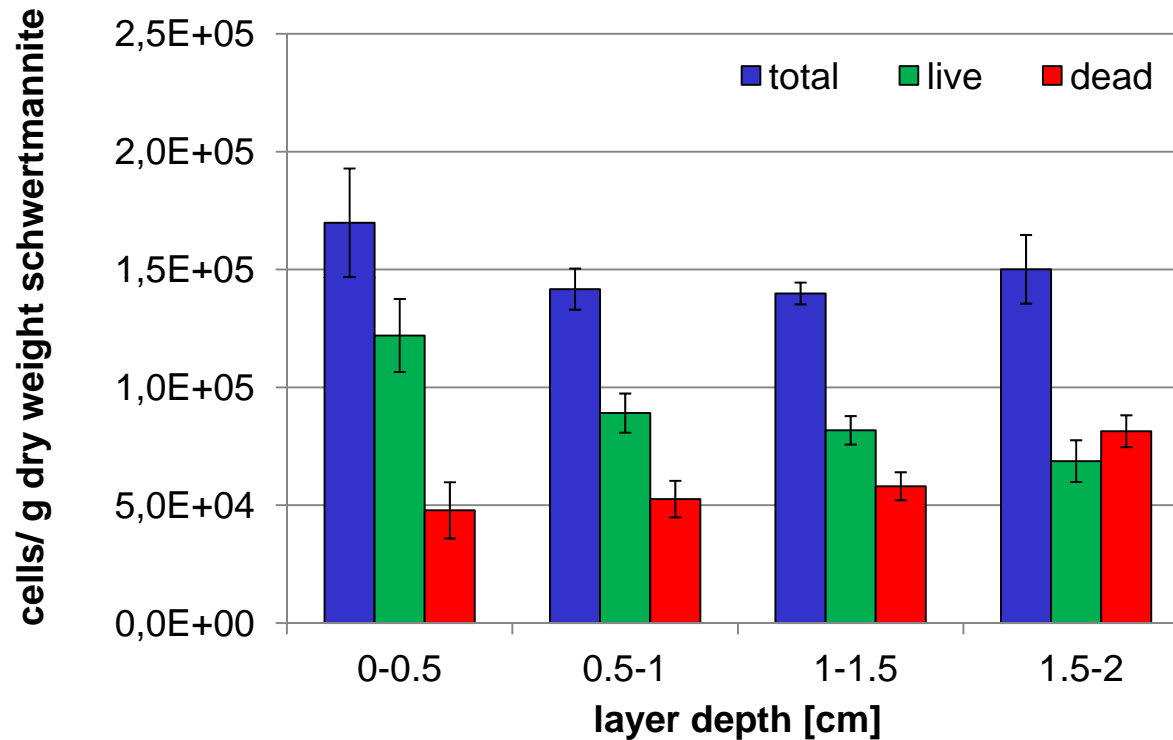


## Microbial Activity in Schwertmannite?





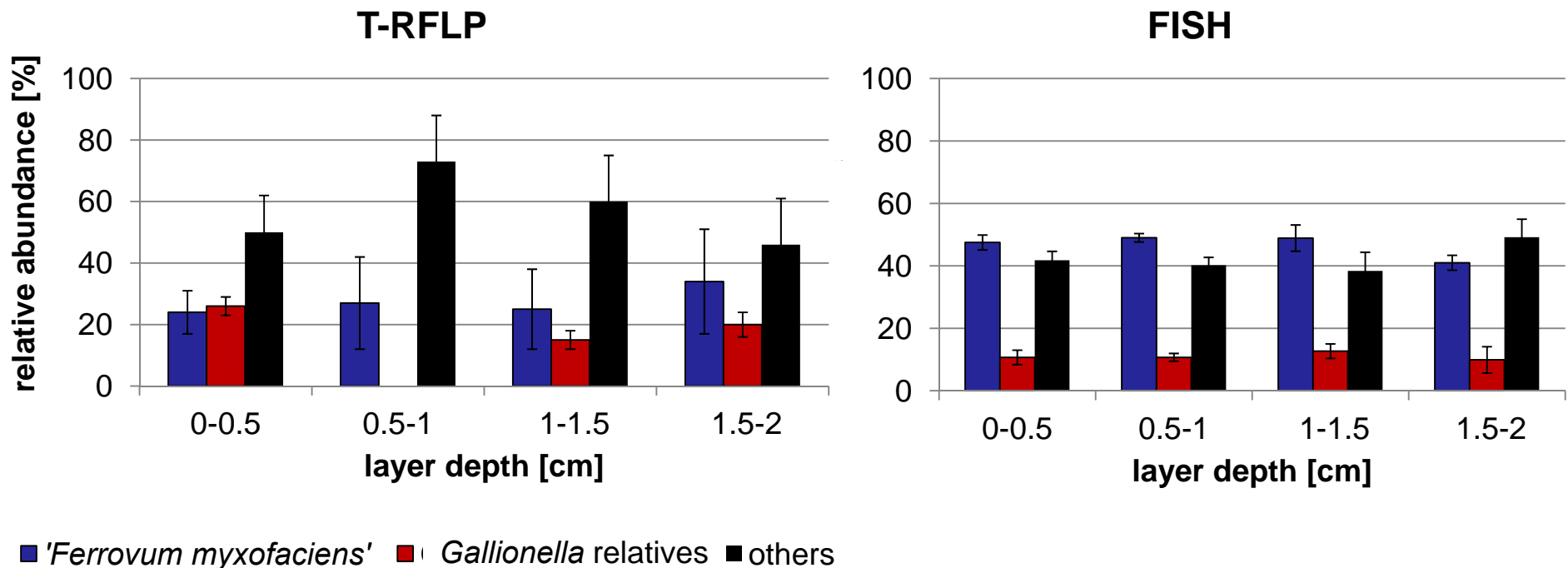
## Cell Number in Schwertmannite Layer



- Slight decrease of the total cell number with increasing depth
- Significant decrease of living cells with increasing mineral depth



## Microbial Community in Schwertmannite Layer



Microbial community of each schwertmannite layer dominated by '*Ferrovum myxofaciens*' and *Gallionella* relatives





## Dank an

- Kolleginnen im Labor

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Kooperationspartner

- **Sie**  
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Federal Ministry for Education and Research

