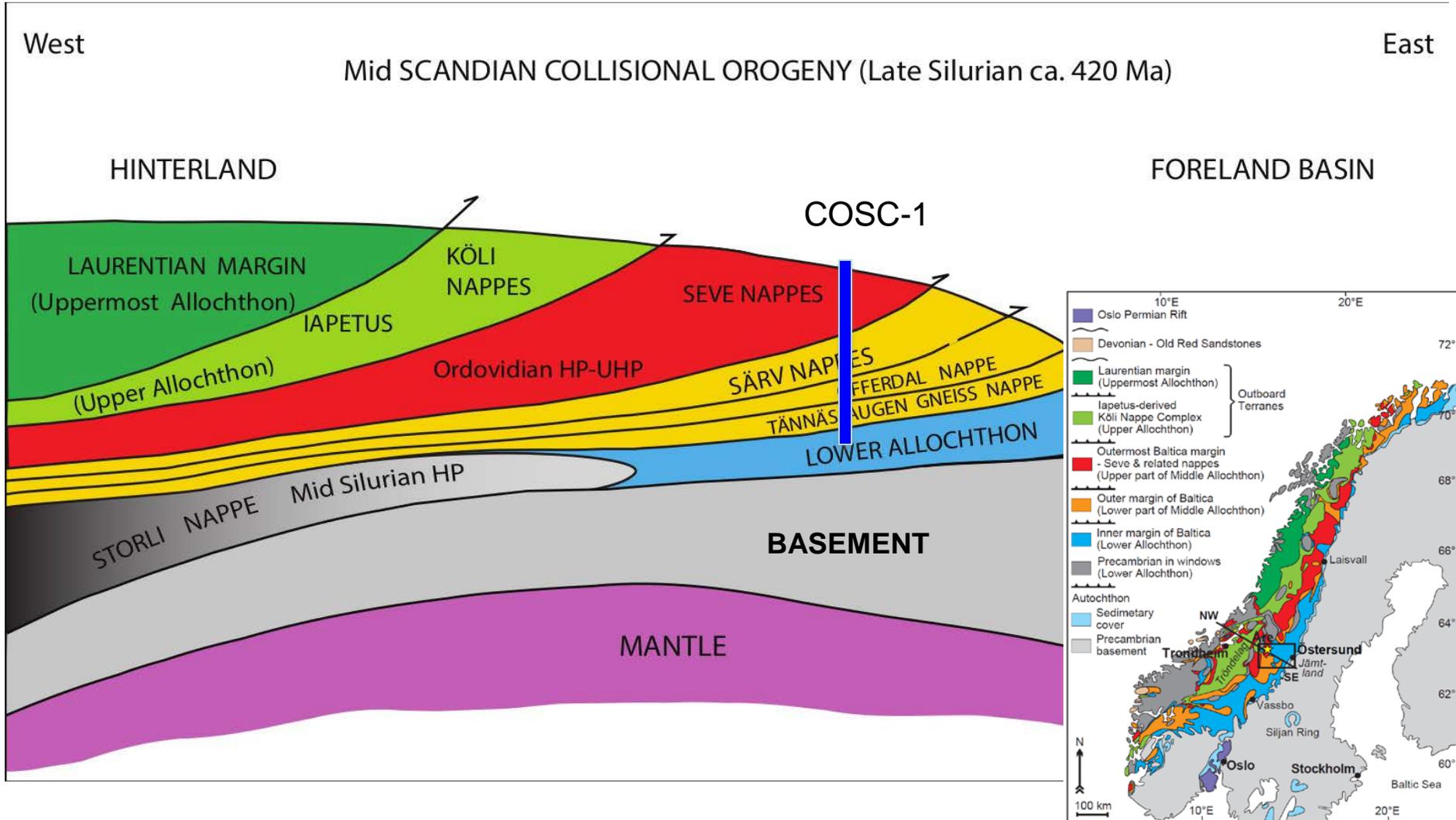




The COSC-1 deep borehole project in Sweden - Examples for subsurface characterization associated with the UFD deep borehole disposal project

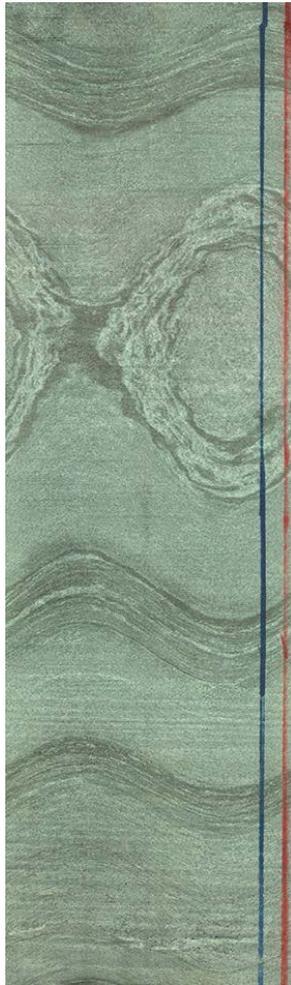
Pat Dobson
UFD Meeting
June 8, 2016

COSC-1 – Study of Seve Nappe



Core Drilling – 2.5 km hole

100 % core recovery
HQ to 1616 m
NQ to 2496 m

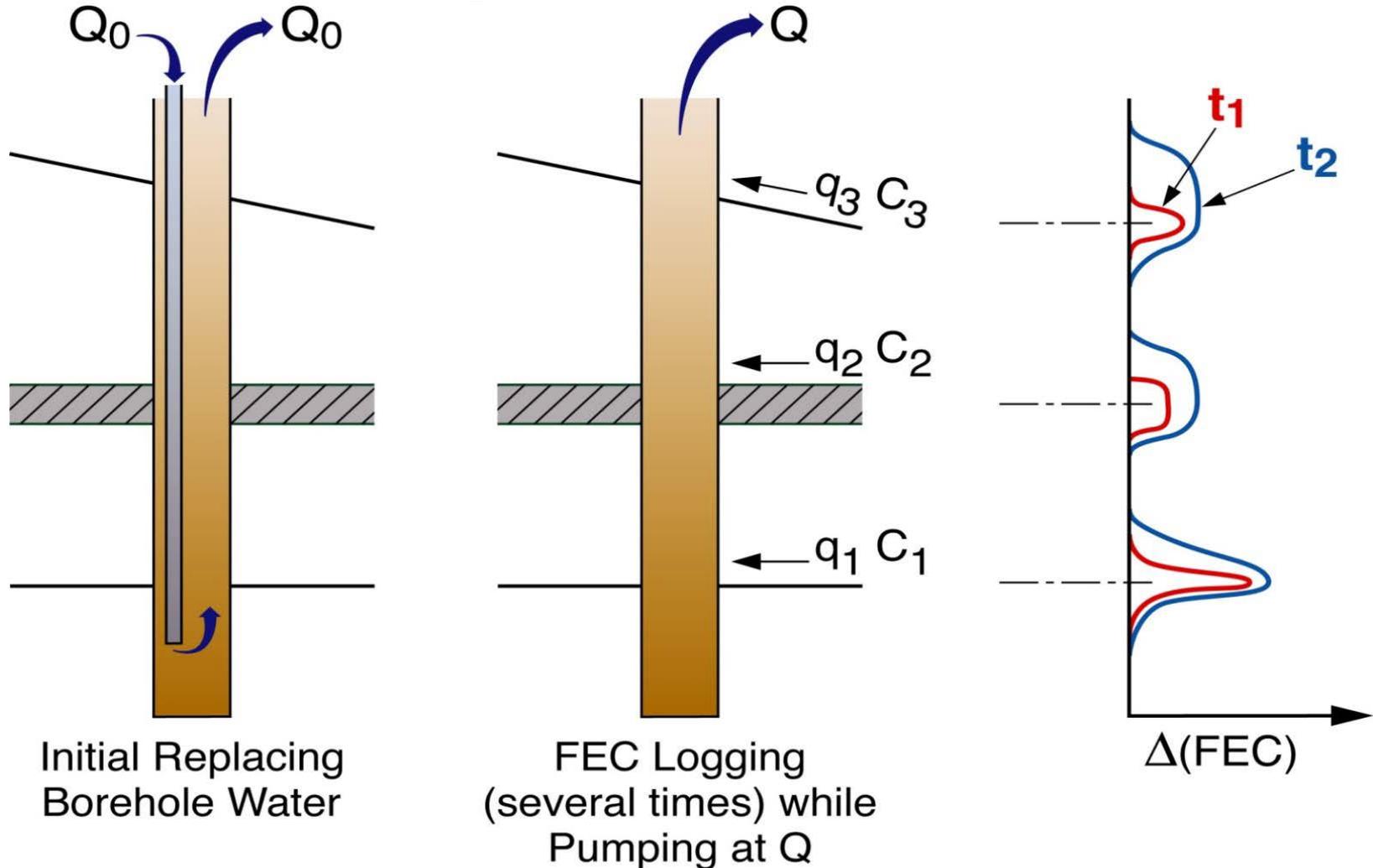


Detailed logging of core for lithology and rock properties
Core photographs and scans
Density, p-wave velocity, magnetic susceptibility
Primary lithologies – gneiss and amphibolite

UFD funded activities – COSC-1

- Flowing fluid electric conductivity (FFEC) logging of well to detect flowing fractures – [Chin-Fu Tsang](#)
- Modeling of FFEC logging results – [Chris Doughty](#)
- Sampling and analysis of microbial communities associated with fracture zones – [Yvette Piceno](#), [Lauren Tom](#) & [Gary Andersen](#)
- Characterization of water compositions – [Pat Dobson](#), [Lasse Ahonen](#) & [Riikka Kietäväinen](#)
- Laboratory studies of fractured core samples – [Tim Kneafsey](#) & [Sharon Borglin](#)
- Workshop with COSC-1 science team – [Chris Juhlin](#) & team

FFEC – Transmissivity and Hydraulic Head



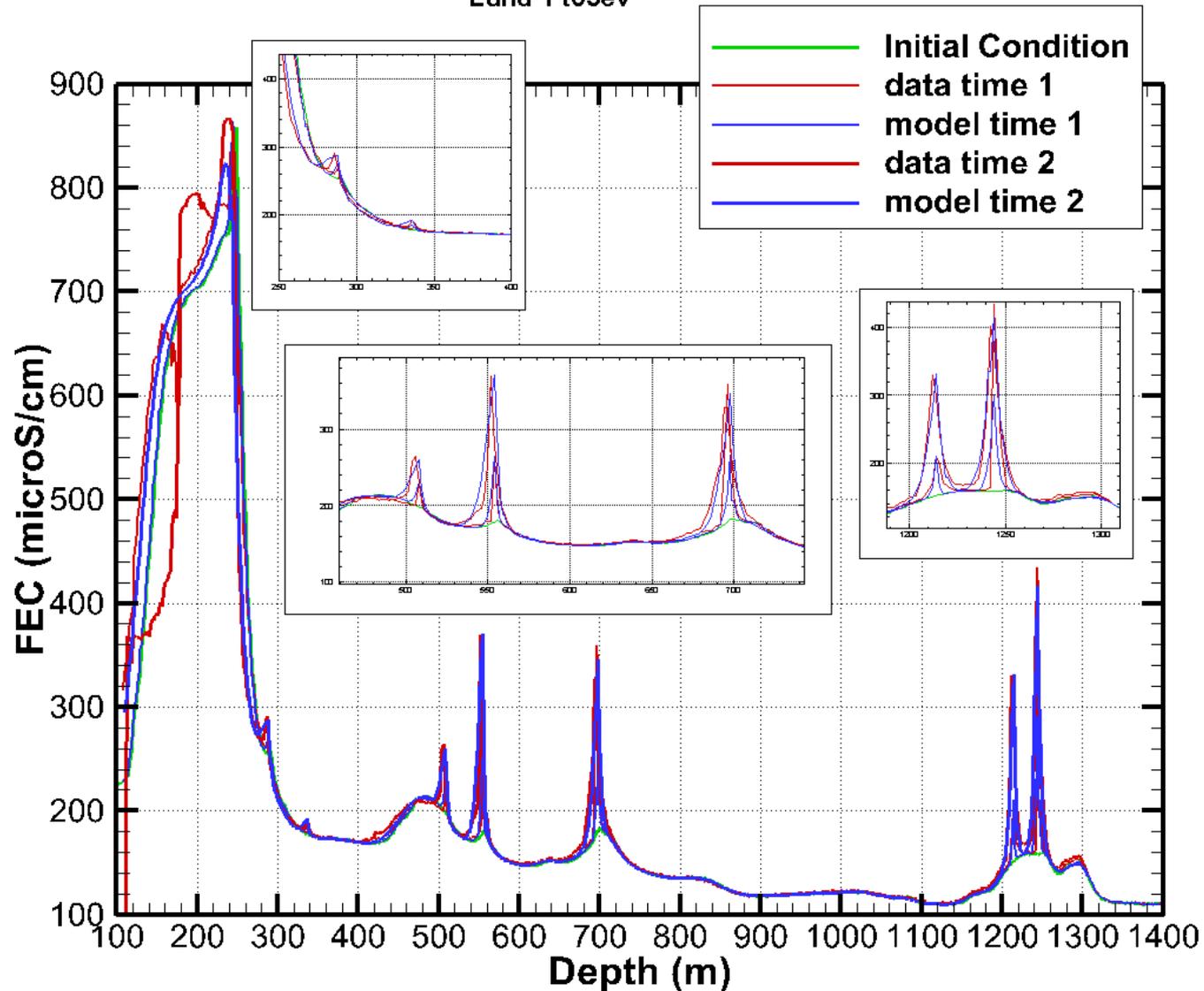
ESD06-001

FFEC Logging Runs

	10 July 2014	11 October 2014	15 October 2014
	Lund-1	<i>ICDP -- identified 2 deepest inflows</i>	Lund-2
Duration of test	1 day	About 8 hours	1 day
Log interval	100-1610 m	1600-2500 m	100-2000 m
Approximate drawdown during pumping	About -70 m	About 33 m	About -50 m
Time of pumping to P1	2 hours	2 hours	3 hours
Time of pumping to P2	10 hours	---	11 hours

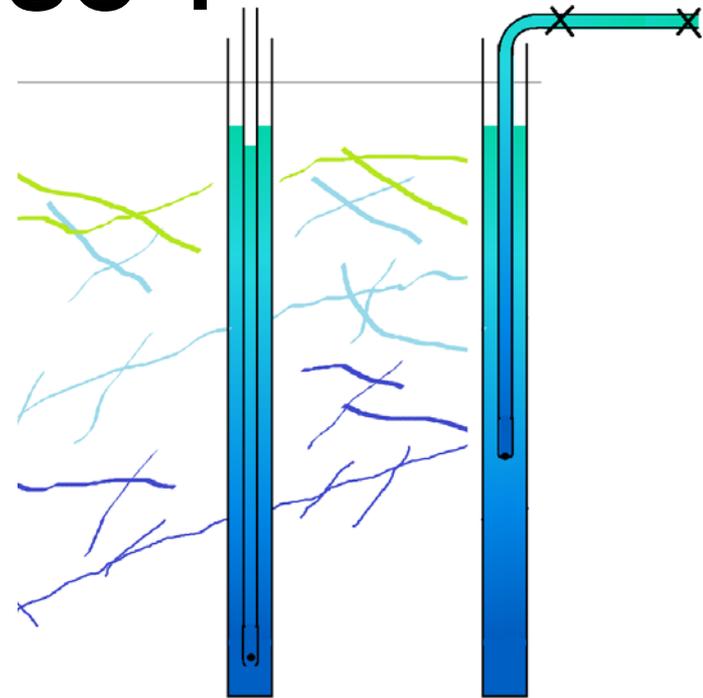
Logging Results & Simulations (DP = 70 m)

Lund 1 t03ev

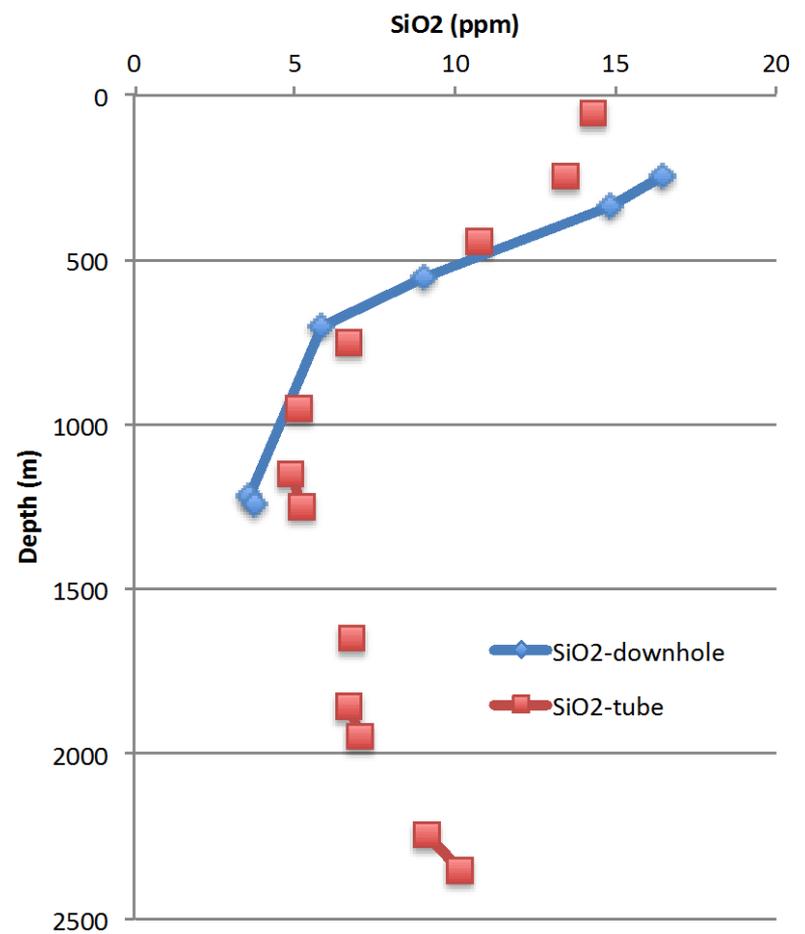
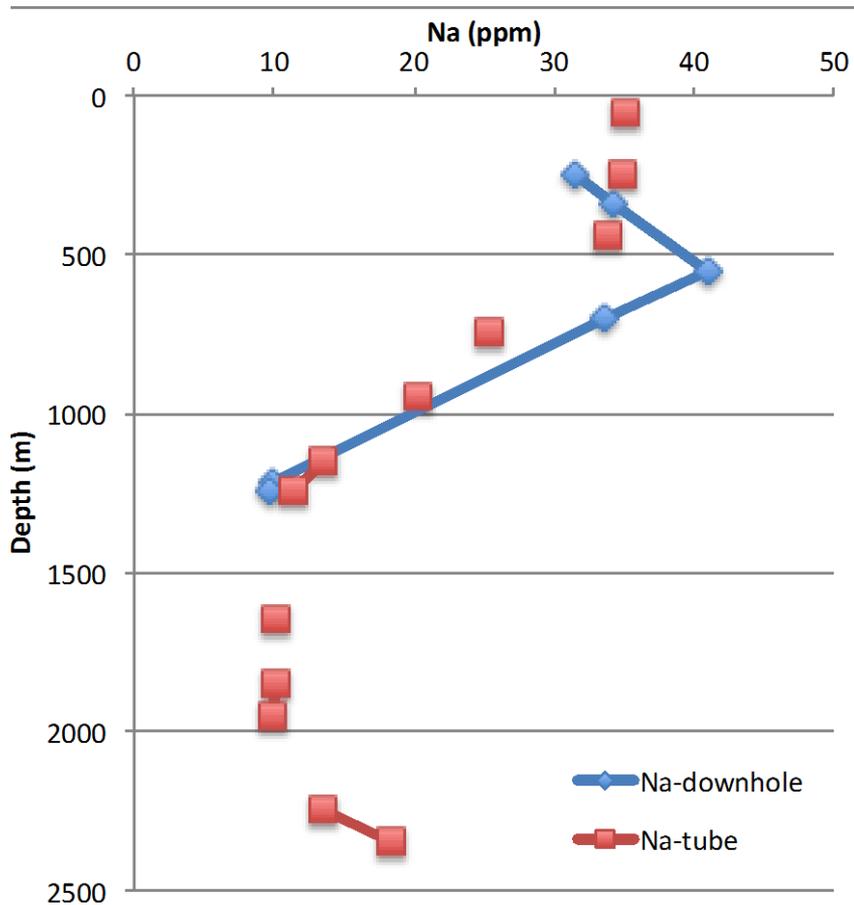


Tube sampling in COSC-1

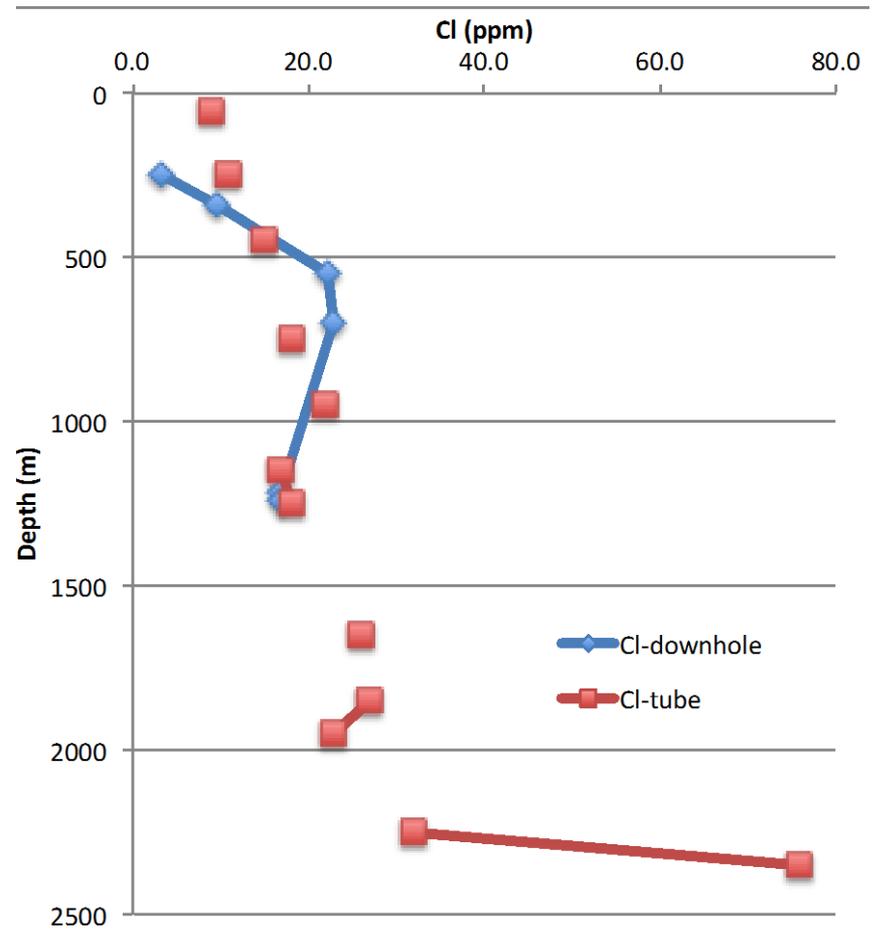
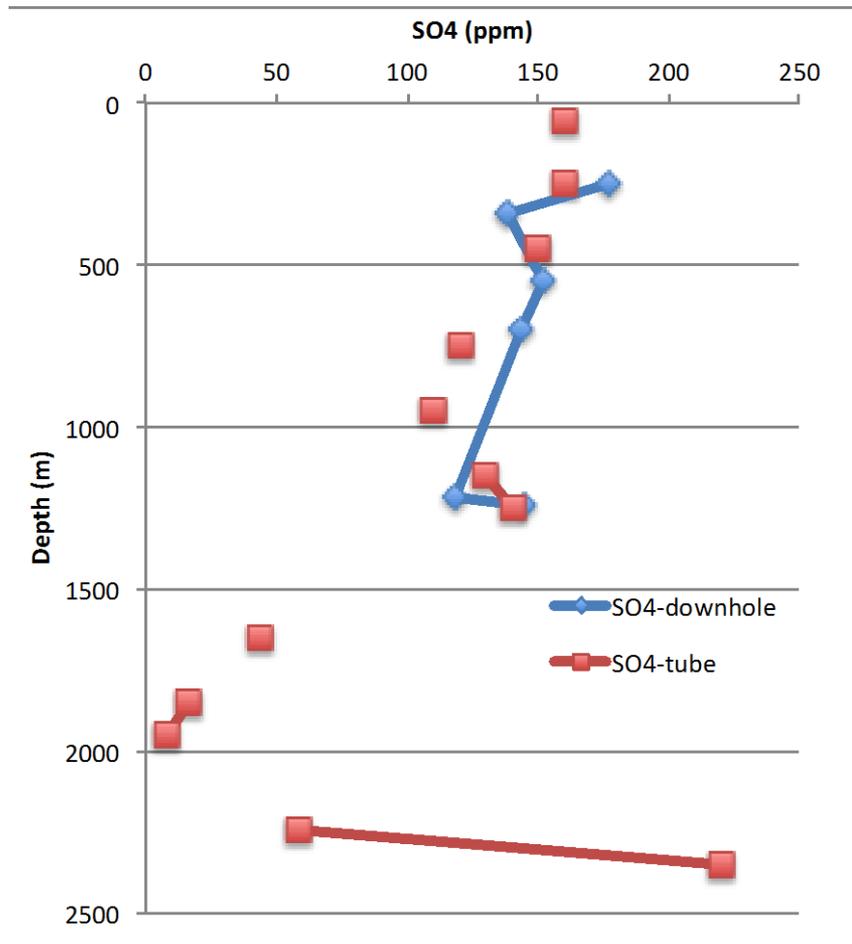
- Day 1: tube was lowered down the borehole, lower end to 2450 m
- Days 2-3: sample retrieval
 - In sections of 100 m (shut off by clamps)
 - 8 subsections, 6 m each were isolated from different depths for microbial studies.
 - Gas samples were extracted to evacuated gas vials by a needle through the tube
 - Water samples for chemical and isotopic determinations were drained to sampling bottles
 - Electrical conductivity and pH measured on site



Water Chemistry Variations



Water Chemistry Variations



Bacterial Community Profiling

Sample Information

Tubing samples

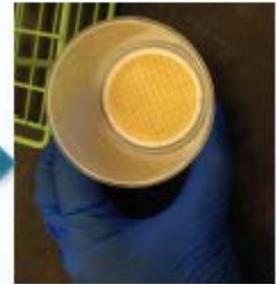
Collected
16 – 17
September

Arrived
23 Sept.

6 m sections



~ 0.5 L



Bottle samples

Collected
02 – 03
October

Arrived
08 Oct.



~ 1 L



Profiling Methods

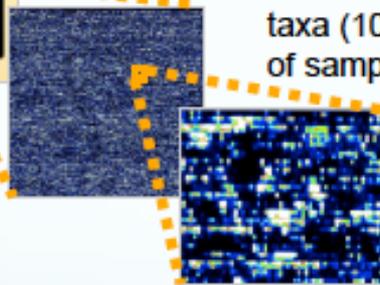
PhyloChip G3

16S rRNA

25-mer probes



- 1 M nucleotide probes
- Detect low abundance taxa (10^{-4} abundance of sample)

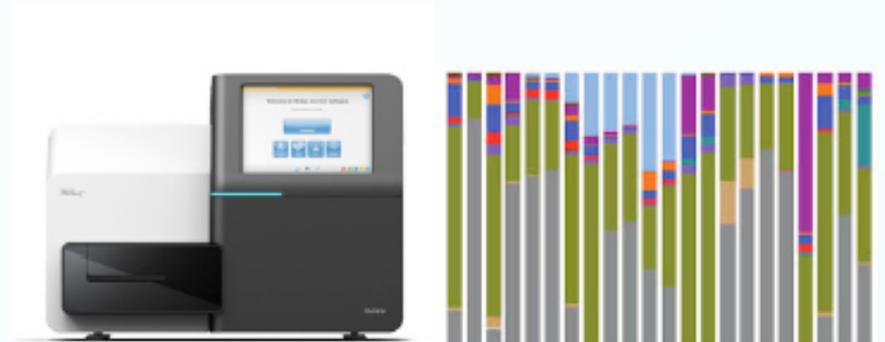


Sensitive to small differences in community structure (β -diversity)

iTag Sequencing

16S rRNA

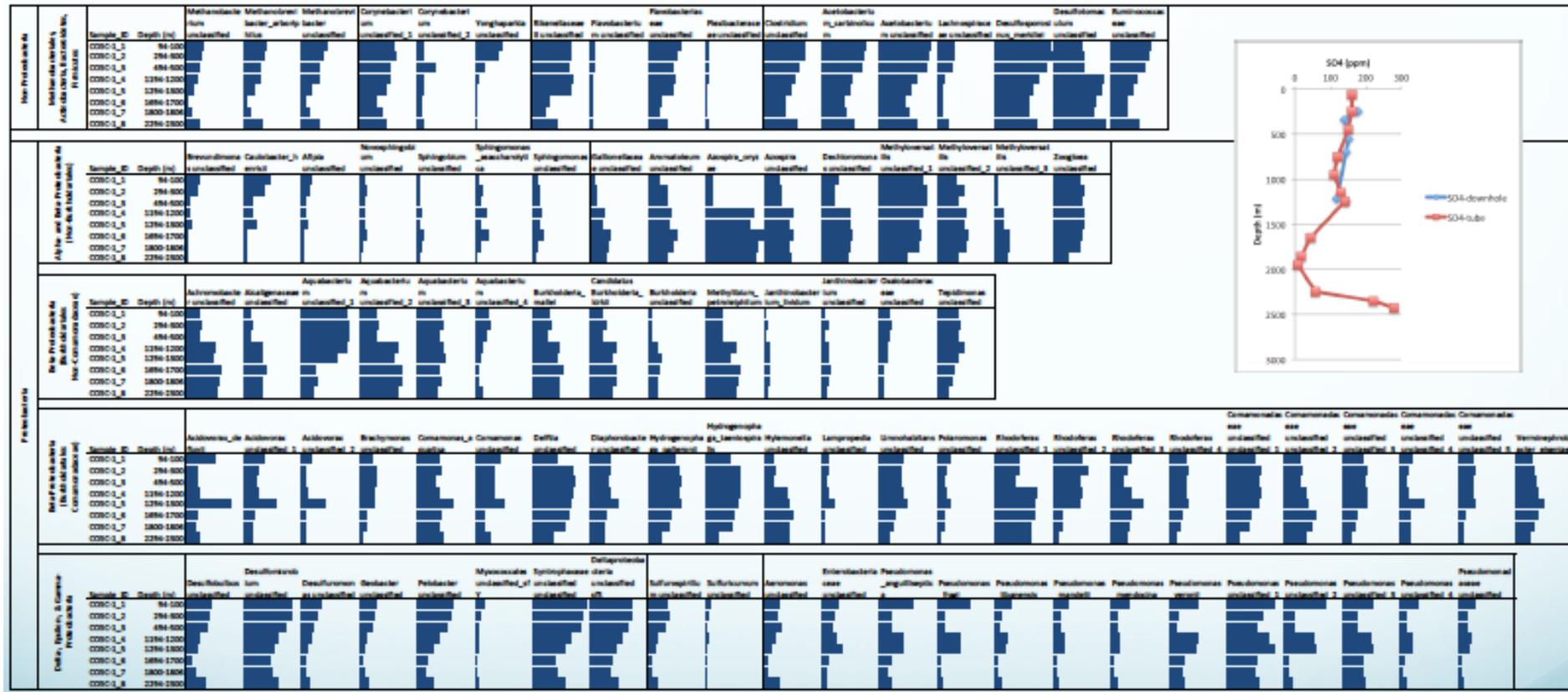
V4 region (~300bp read length)



Identify the most abundant organisms within a sample (α -diversity), as well as see large differences across samples (β -diversity)

PhyloChip – Tubing Samples

Microbial differences as a function of depth & geochemistry

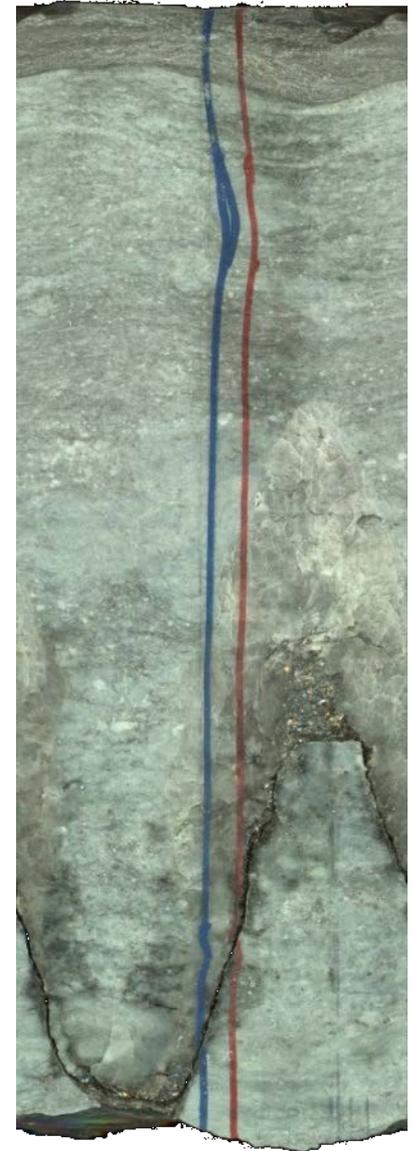


Key Observations – PhyloChip Data

- Microbial communities differ along depth profile:
 - Three distinct zones: <1000 m, 1200-1300 m, >1600 m (2300 m sometimes different)
 - Acidovorax, Pseudomonas, Comamonas, Diaphrobacter: strong peak at 1300 m
 - • Azospira, Desulfotomaculum, Achromobacter: increase with depth
- Many organisms (esp. sulfur-cycling bacteria) show a similar trend in relative abundance as TDS, SO₄, and Na

COSC Core Study

- Seven core samples correlated with fracture flow to be analyzed for fracture permeability in the lab
- Lab measurements of crossflow through fractures pending completion of confining system



COSC Workshop (Dec. 2015)

- Chris Juhlin – Overview of the COSC-1 Project
- Pat Dobson – Role of COSC-1 studies in DOE Deep Borehole Program
- Chin-Fu Tsang – FFEC logging and water sampling at COSC-1
- Christine Doughty – Initial modeling analysis of FFEC results
- Christophe Pascal – COSC-1 geothermal research, present status
- Wenning Quinn – Borehole stress measurements and fractures in COSC-1
- Sharon Borglin – Fracture flow in permeable cores – experimental design and testing
- Bjarne Almqvist – Structural geology of the COSC-1 setting
- Pat Dobson – Variations in water chemistry from COSC-1
- Yvette Piceno – Bacterial community profiling of COSC-1 water samples: A preliminary assessment
- María García Juanatey – MT studies on COSC-1
- Doug Schmitt – The Hunt well