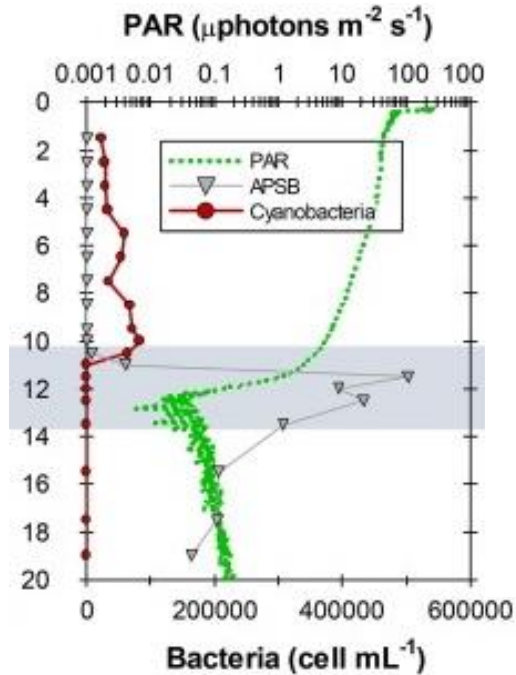


The chemocline separates the upper, oxygenated layer (above 13 m depth) and the lower, anoxic layer (below 13 m depth).

- Why do bottom waters become anoxic?
- What differences in water chemistry do you expect for these two layers?



Why do bottom waters become anoxic?

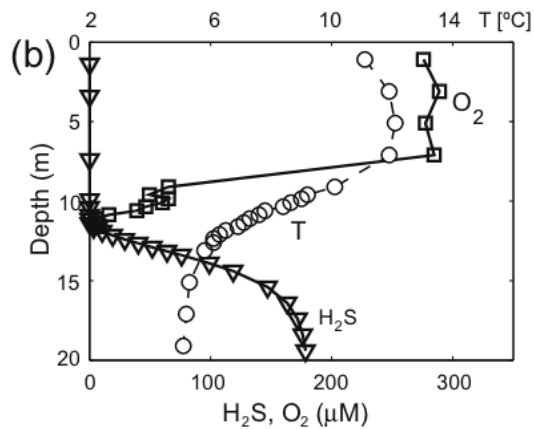
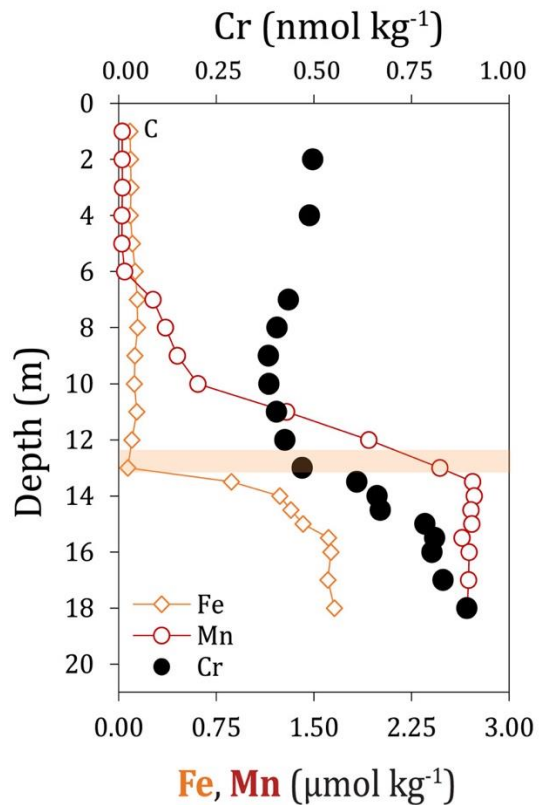
- High primary production in the surface layer (cyanobacteria)
- Formed organic matter sinks downward and is degraded in the chemocline and below
- Step-wise consumption of electron acceptors

PAR = photosynthetically active radiation
 APSB = anaerobic phototrophic sulfur bacteria

O ₂ present		O ₂ absent	
Oxic conditions		Weak anoxia	Strong anoxia
pε >> 0		pε ~ 0	
Oxidized solutes and solids:		Reduced solutes	
N	NO ₃ ⁻	NO ₂ ⁻	NH ₄ ⁺
S	SO ₄ ²⁻		S ⁰
C	CO _{2(aq)}		H ₂ S
Fe	Fe ^{III} ; e.g., FeOOH _(s)		Fe ²⁺
Mn	Mn ^{IV} ; e.g., MnO(OH) _{2(s)}	Mn ²⁺	CH ₄

What variations in water chemistry do you expect for these two layers?

- Oxic layer: oxidized solutes and solids
- Anoxic layer: elevated concentrations of reduced Mn, Fe, H₂S



Do concentration profiles follow the expected redox sequence?

E_H -pH stability diagram to the rescue!

Which parameters do you need? (These are given in the paper referenced below)

- Temperature: 5.5 °C
- Pressure: 1 bar
- Total iron concentration: 1 $\mu\text{mol/L}$
- Bicarbonate: 1 mmol/L
- Calcium: 1 mmol/L
- Sulfate: 3 mmol/L
- Phosphate: 3 $\mu\text{mol/L}$

E_H -pH stability diagram: Solution

Basis	Command	Results	Plot
diagram species			
Fe++	\updownarrow	1.0e-06	activity
on axes			
H+	\updownarrow	on x axis	
	pH	from 0.0	to 14.0 increment 2.0
e-	\updownarrow	O2(aq)	on y axis
	Eh	from -0.75	to 1.25 increment 0.5
in the presence of			
H2O		1.0	activity solvent
Ca++	\updownarrow	0.001	activity
HCO3-	\updownarrow	0.001	activity
HPO4--	\updownarrow	3.0e-06	activity
SO4--	\updownarrow	0.003	activity
temperature		5.5	C
pressure		1.0	bars
<input type="button" value="add"/> <input type="button" value="delete"/>			

E_H -pH stability diagram: Solution

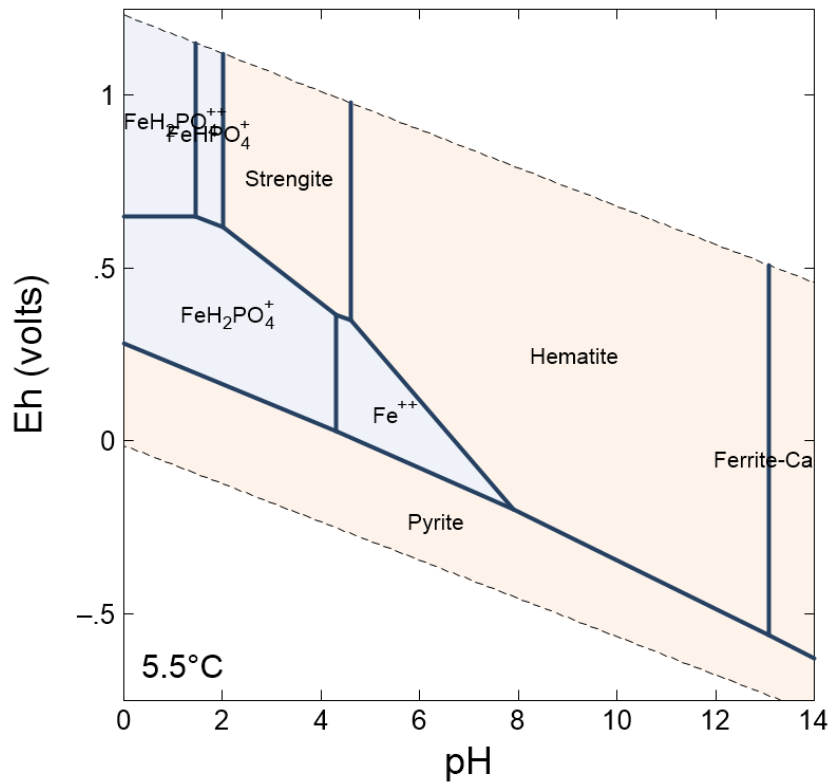
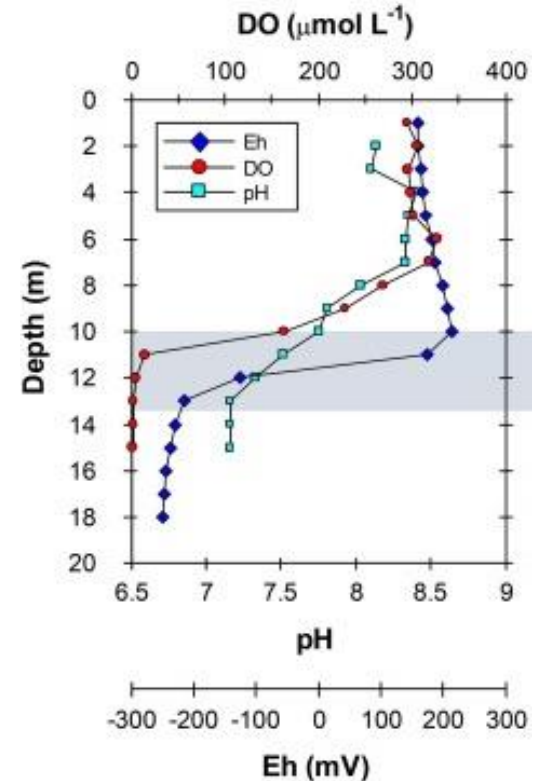


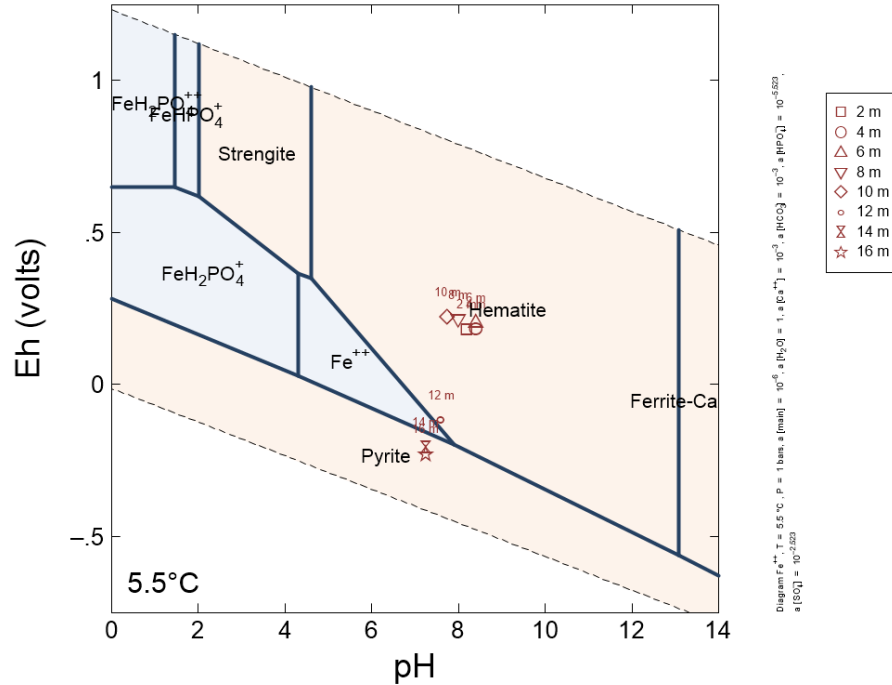
Diagram Fe^{++} , $T = 5.5^\circ C$, $P = 1 \text{ bar}$, $a(\text{main}) = 10^{-6}$, $[H_2O] = 1$, $[Ca^{++}] = 10^{-3}$, $a(\text{CO}_2) = 10^{-3}$, $a(\text{HCO}_3^-) = 10^{-3}$, $a(\text{HPO}_4^{2-}) = 10^{-6.523}$, $a(\text{SO}_4^{2-}) = 10^{-2.523}$

E_H -pH stability diagram: Solution

- Now add the data from the figure on the right into your E_H -pH diagram.
- To do so, create a GSS file, add the data, and then drag and drop it into your E_H -pH diagram.



E_h -pH stability diagram: Solution



FeS is expected to precipitate in the anoxic zone and likely causes the increase in particulate concentrations we observed.