SHELF SEA BIOGEOCHEMISTRY
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NERC SCIENCE OF THE ENVIRONMENT

Department for Environment Food & Rural Affairs

Enhanced iron supply from the continental slope by intermediate nepheloid layers

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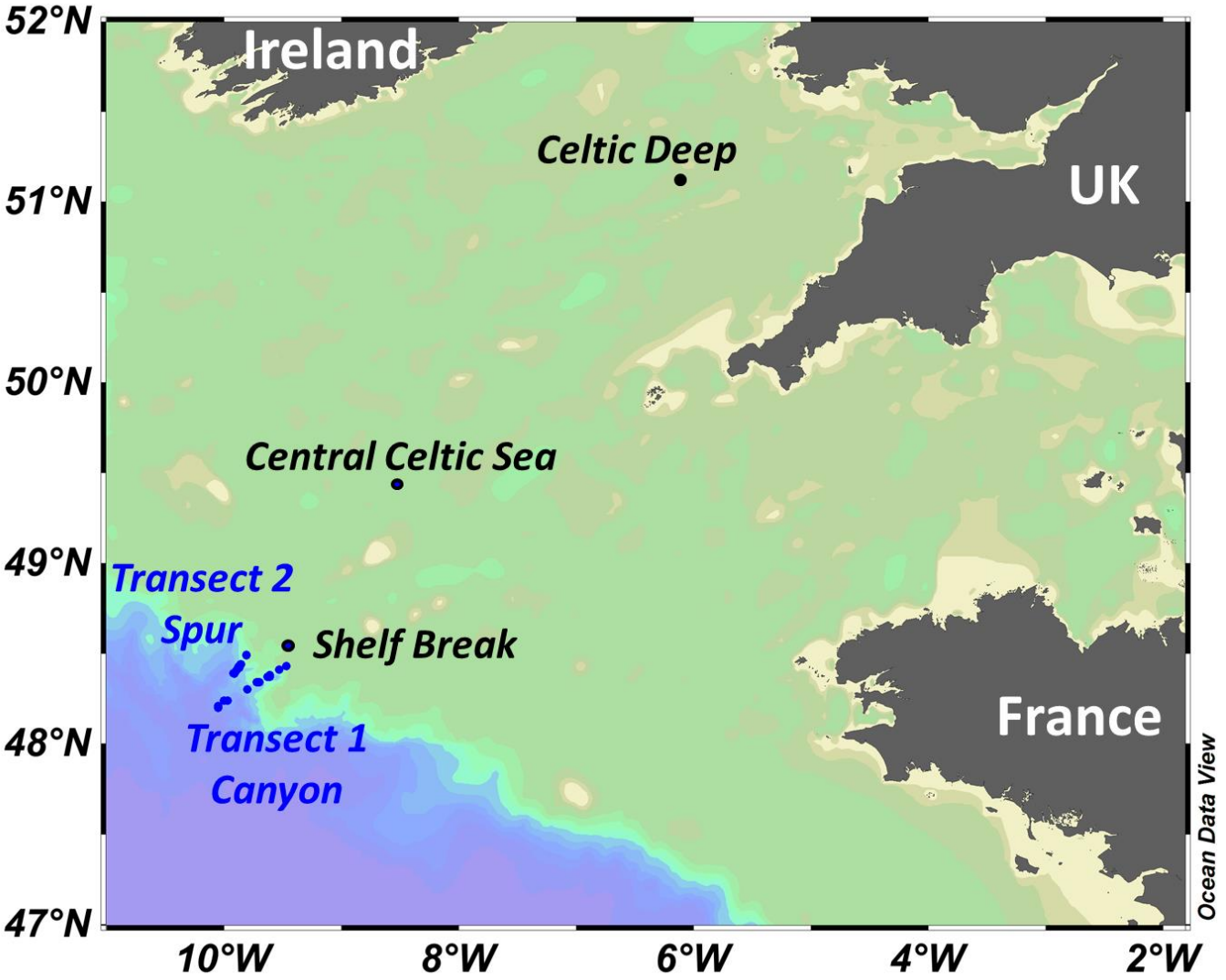
UNIVERSITY OF Southampton

THE UNIVERSITY OF EDINBURGH

PLYMOUTH UNIVERSITY

Transect Locations

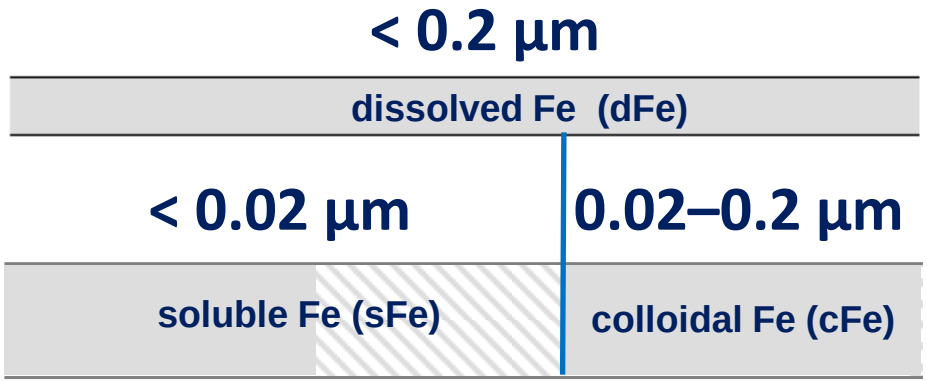


Iron Fractions

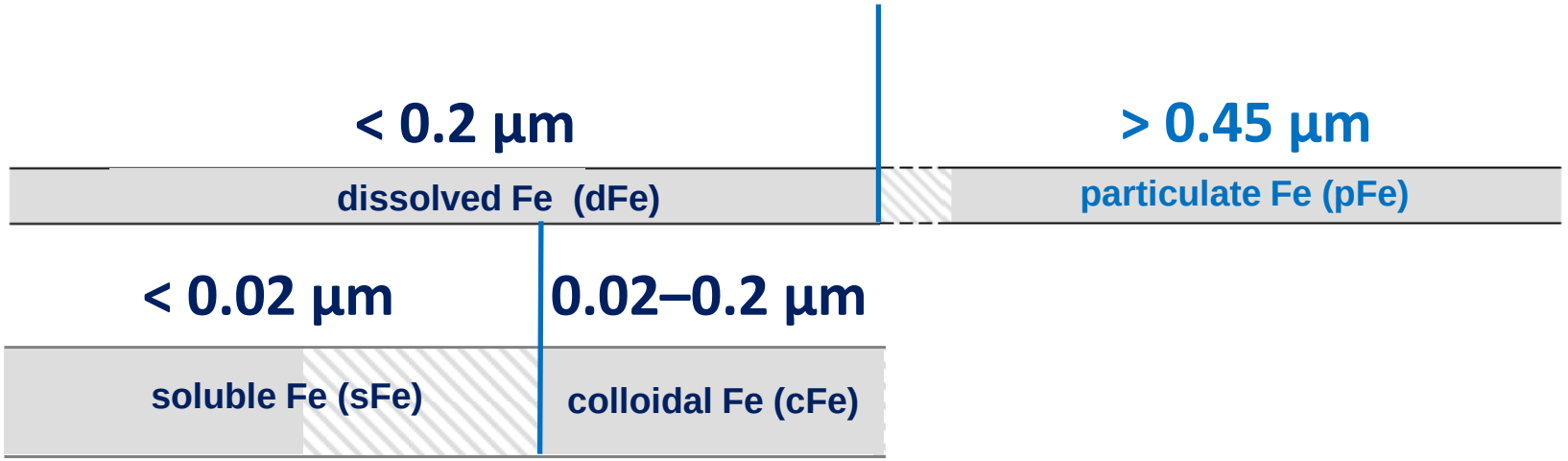
< 0.2 µm

dissolved Fe (dFe)

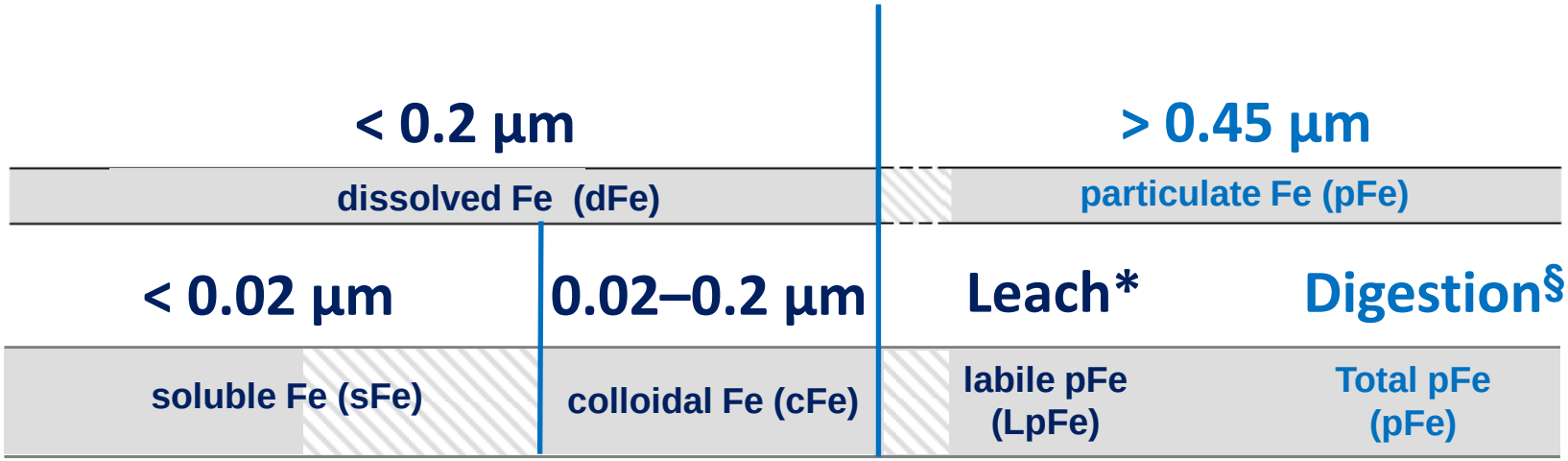
Iron Fractions



Iron Fractions



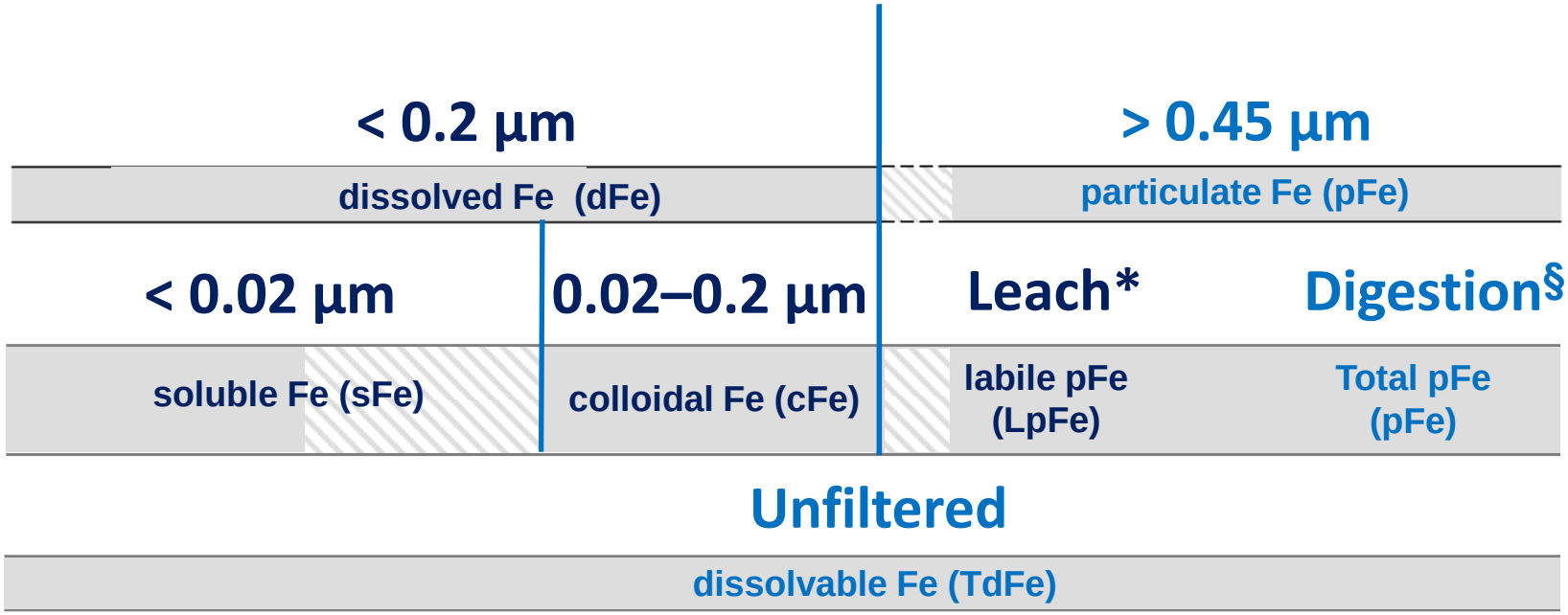
Iron Fractions



*Leach: 25% Acetic acid + reducing agent

§ Digest: HNO_3/HCl/HF

Iron Fractions



Acidified (pH 1.8) for >3-6 months
Analysed by FI-CL

Analysed by ICP-MS

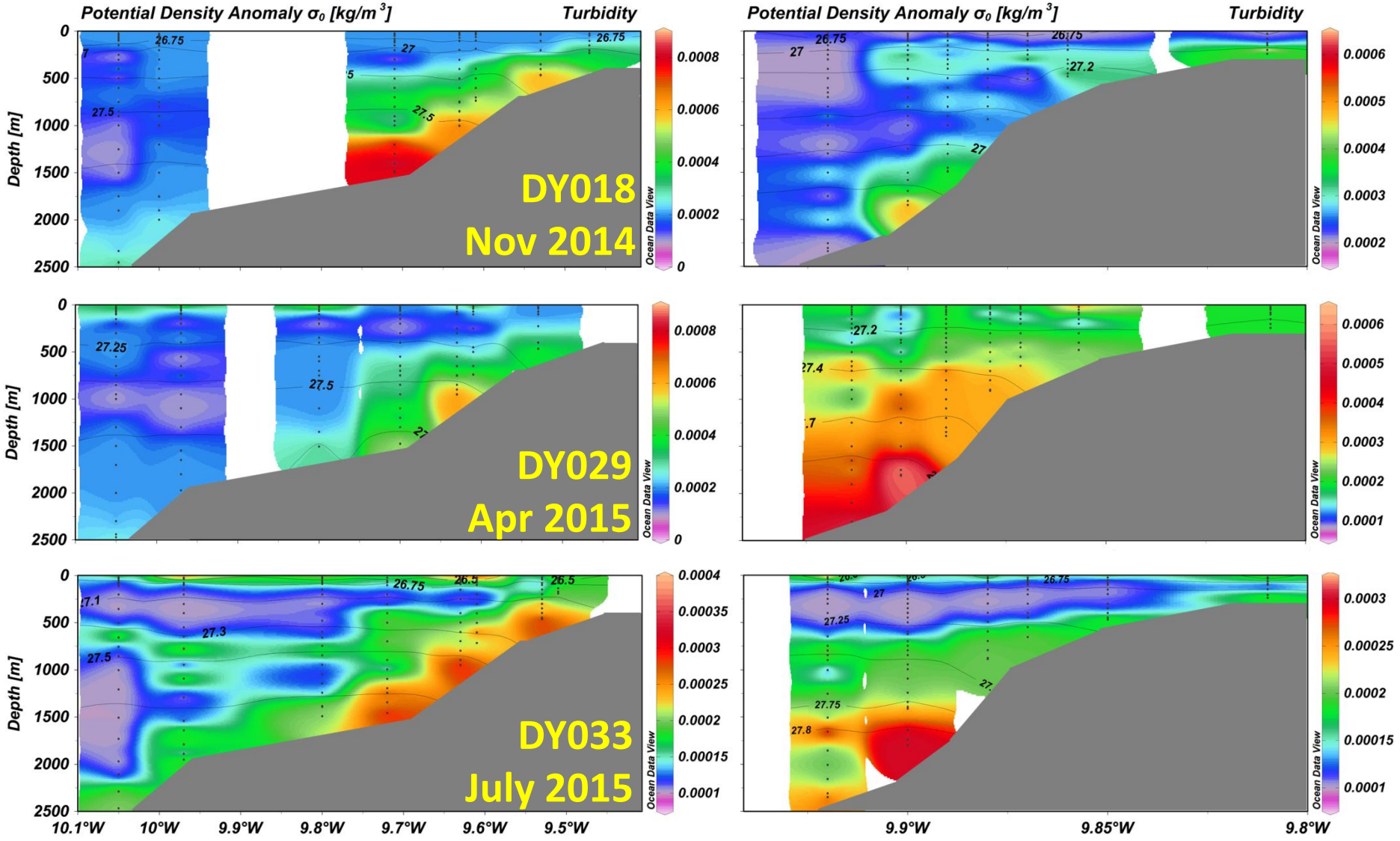
*Leach: 25% Acetic acid + reducing agent

§ Digest: HNO_3/HCl/HF

Persistent Nepheloid Layers

Transect 1 - Canyon

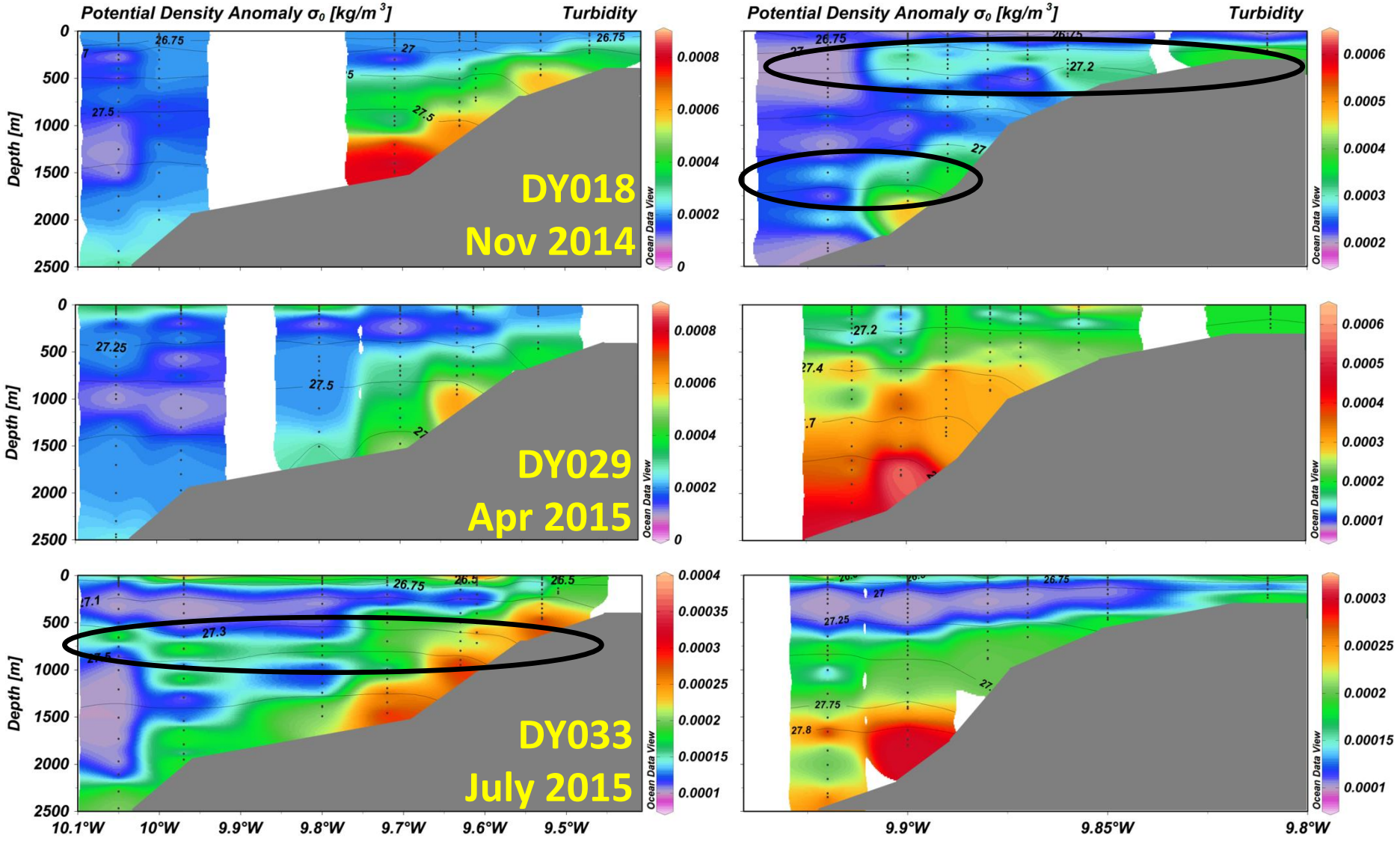
Transect 2 - Spur



Persistent Nepheloid Layers

Transect 1 - Canyon

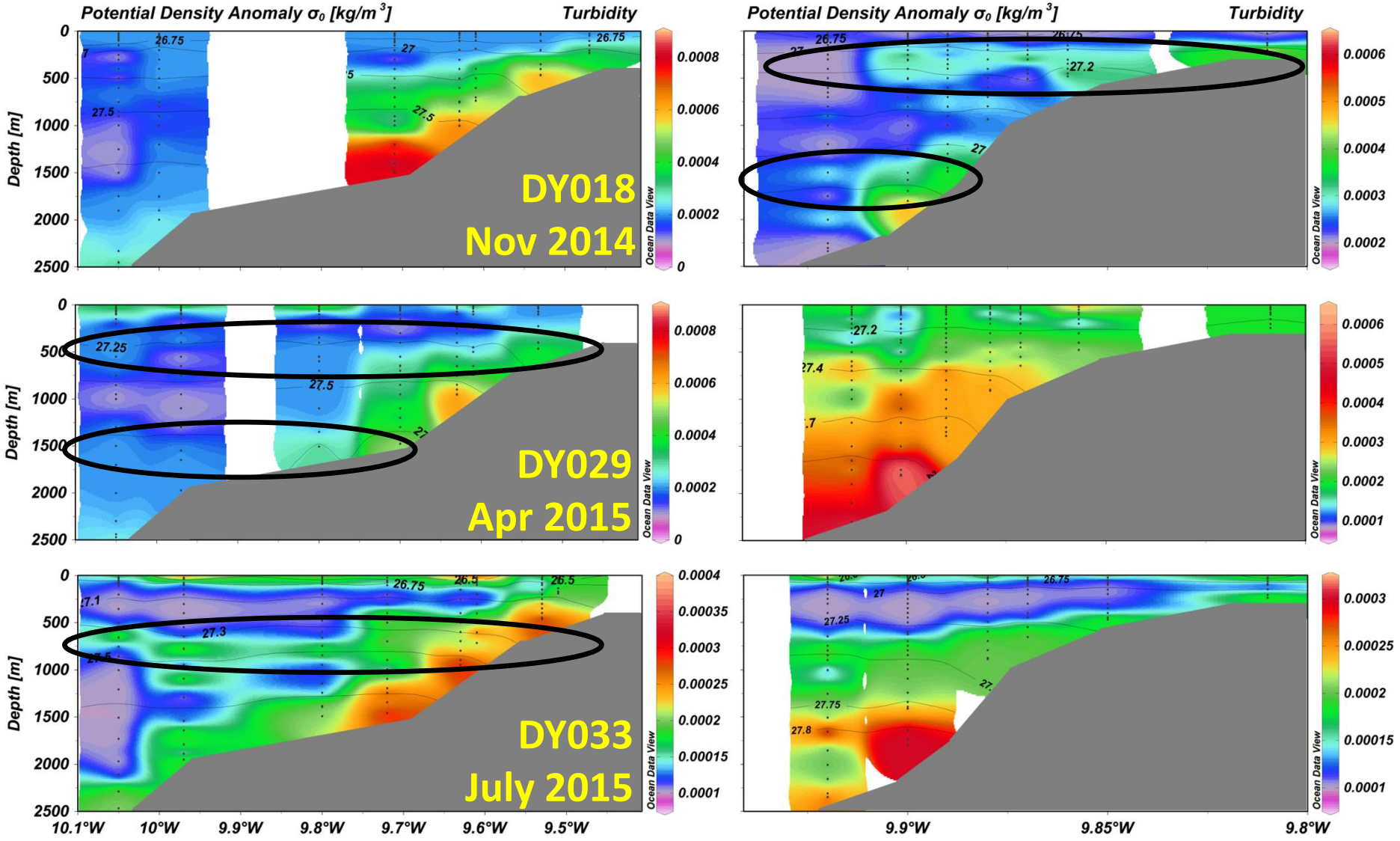
Transect 2 - Spur



Persistent Nepheloid Layers

Transect 1 - Canyon

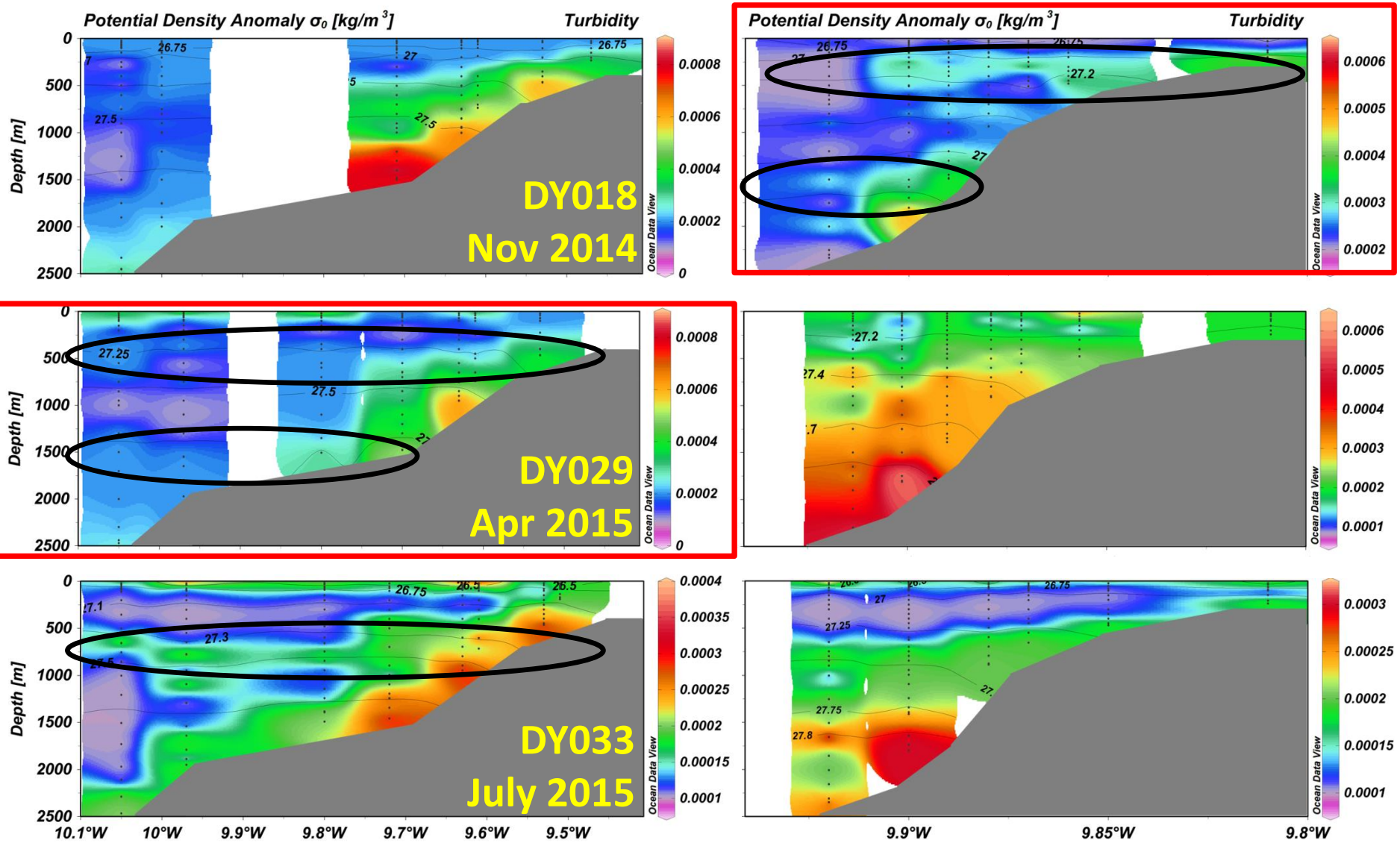
Transect 2 - Spur



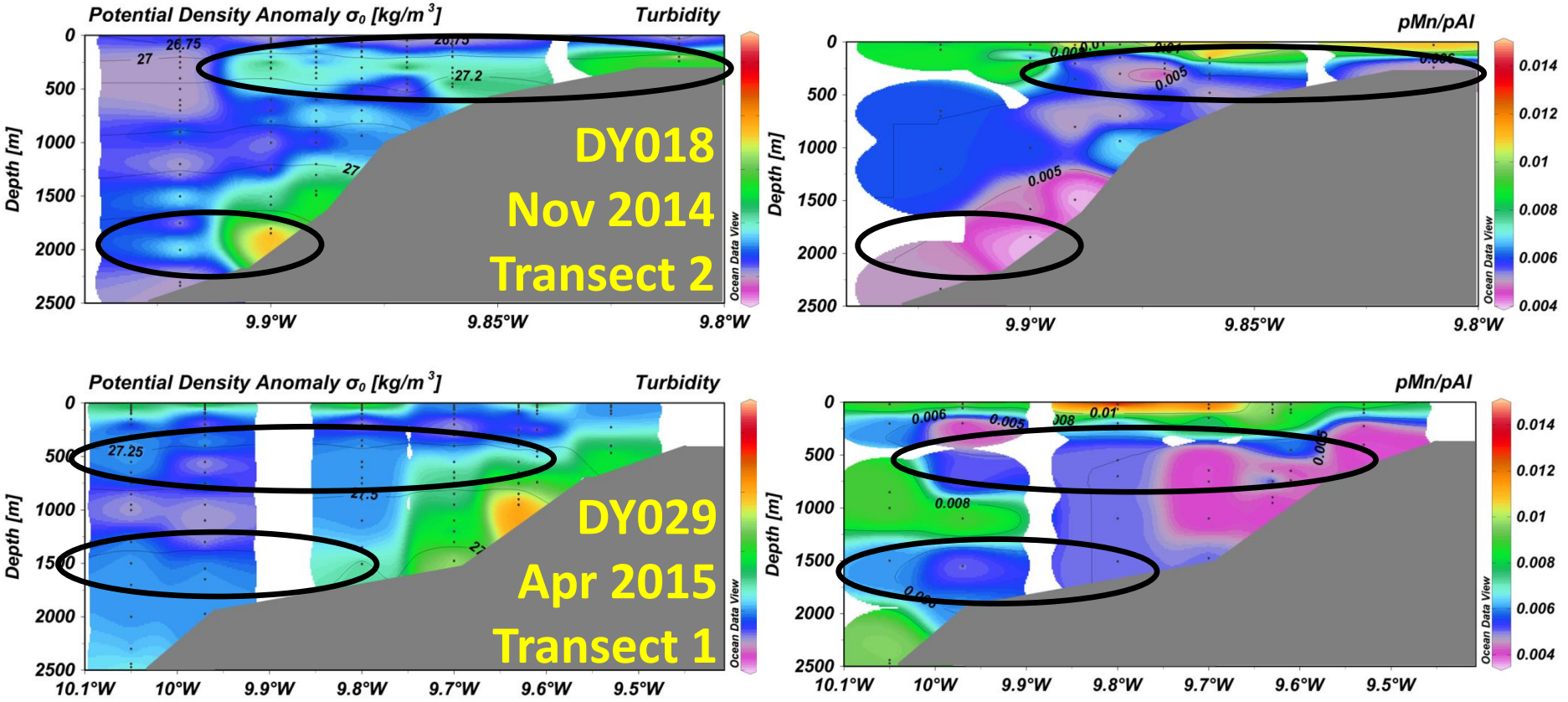
Persistent Nepheloid Layers

Transect 1 - Canyon

Transect 2 - Spur

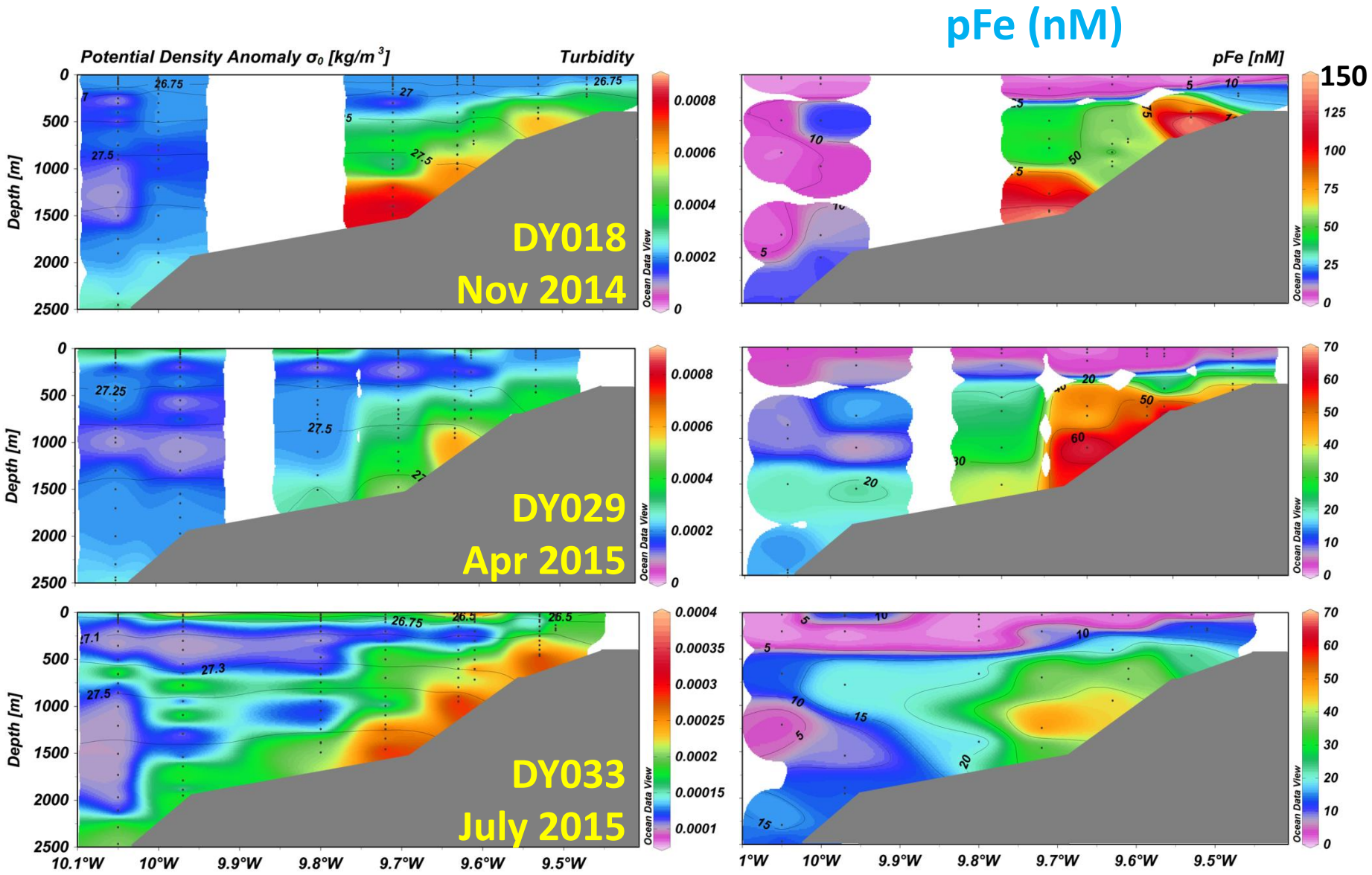


Persistent Nepheloid Layers

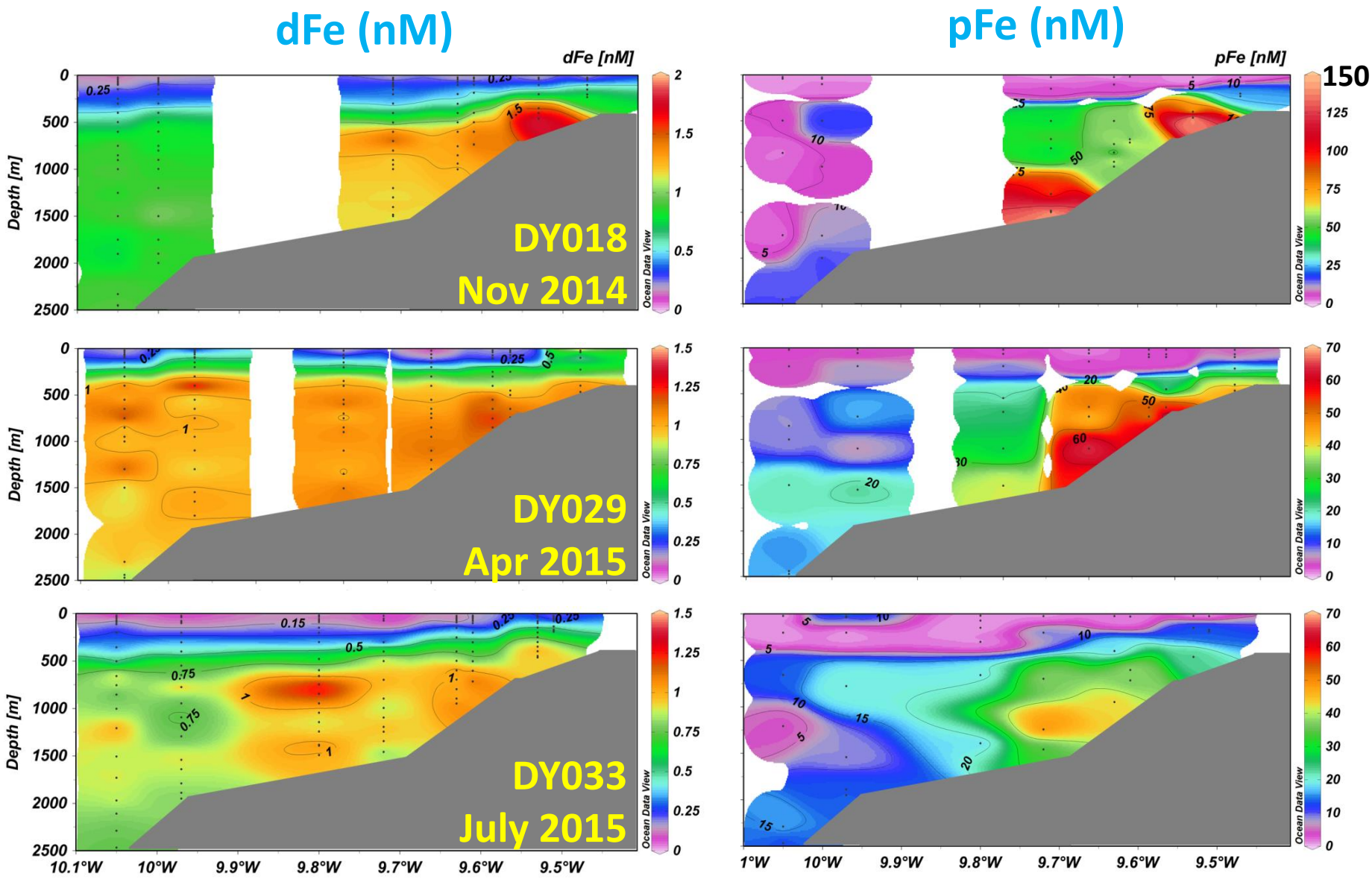


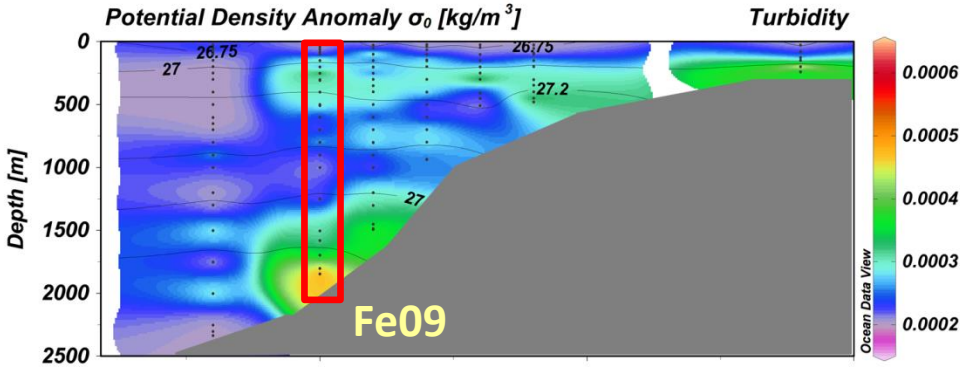
- INLs evident in ratios of particulate elements (e.g. Mn/Al)
- Off-shelf transport

Impact on Fe – Transect 1 (Canyon)



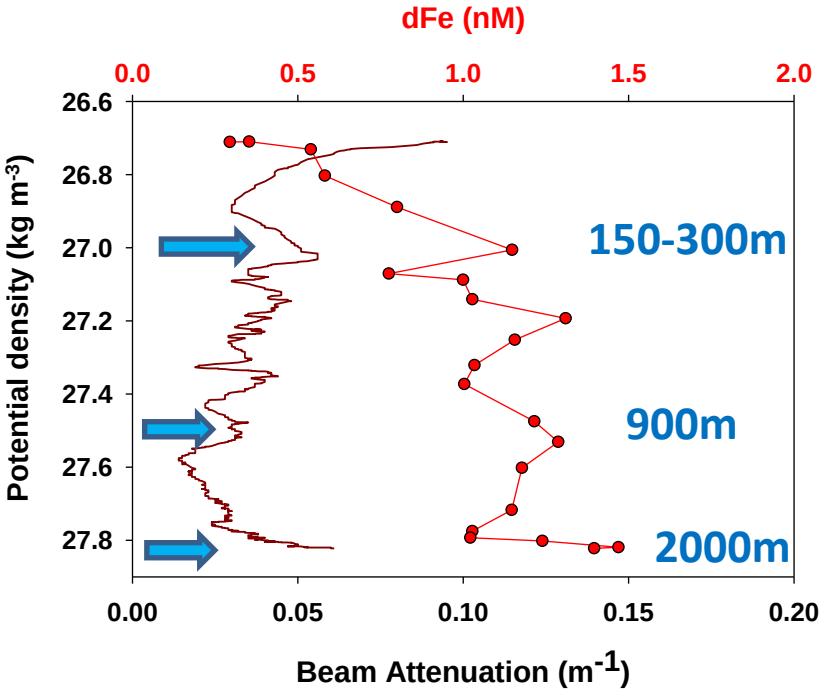
Impact on Fe – Transect 1 (Canyon)





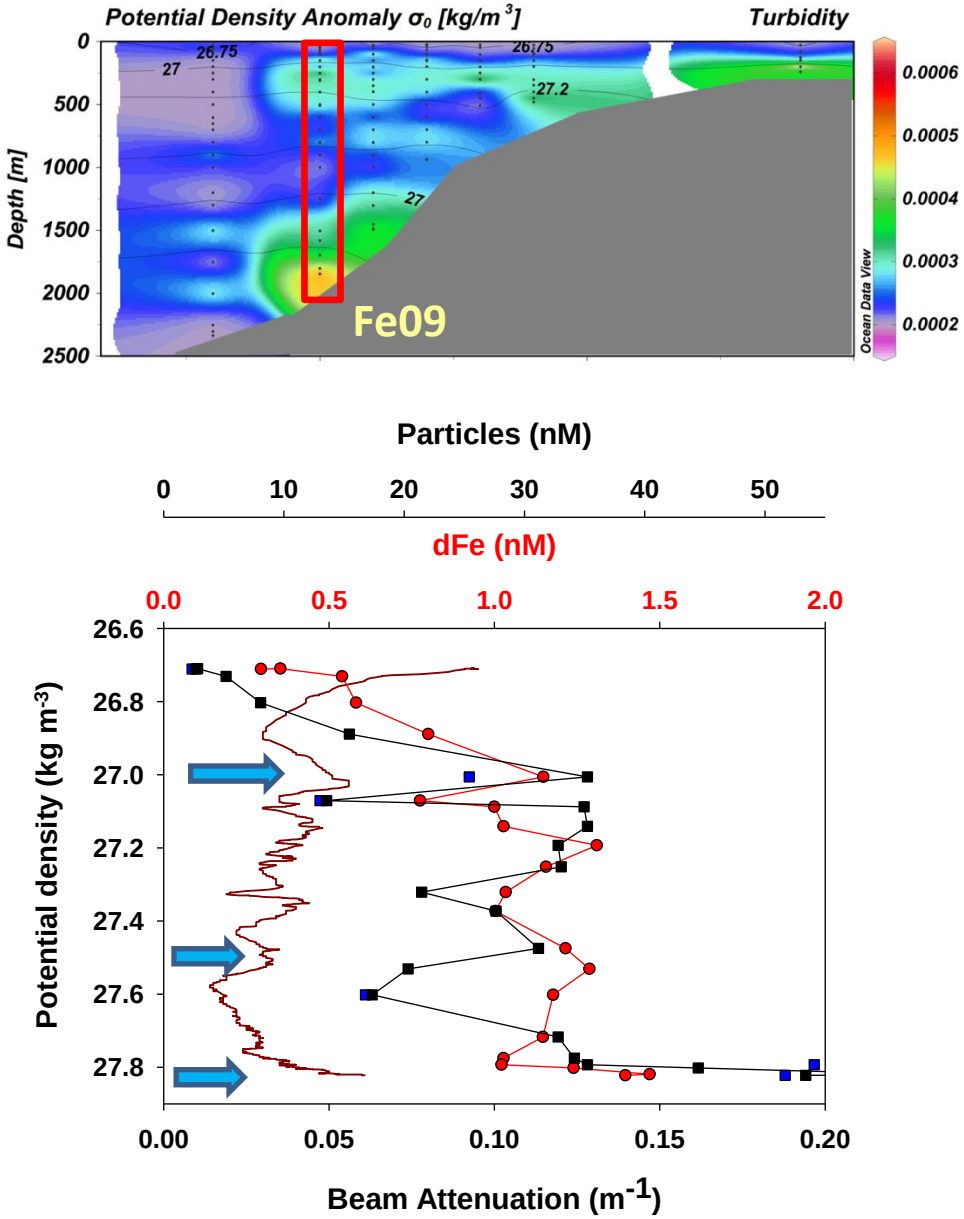
DY018 (Nov 2014) T2

Beam Attenuation
dFe
pFe
TdFe



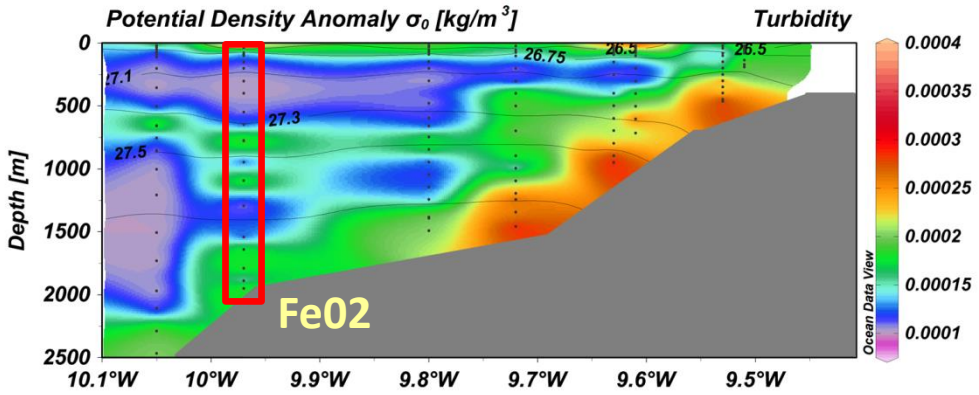
- **Increases in dFe correlate with peaks in beam attenuation**

DY018 (Nov 2014) T2



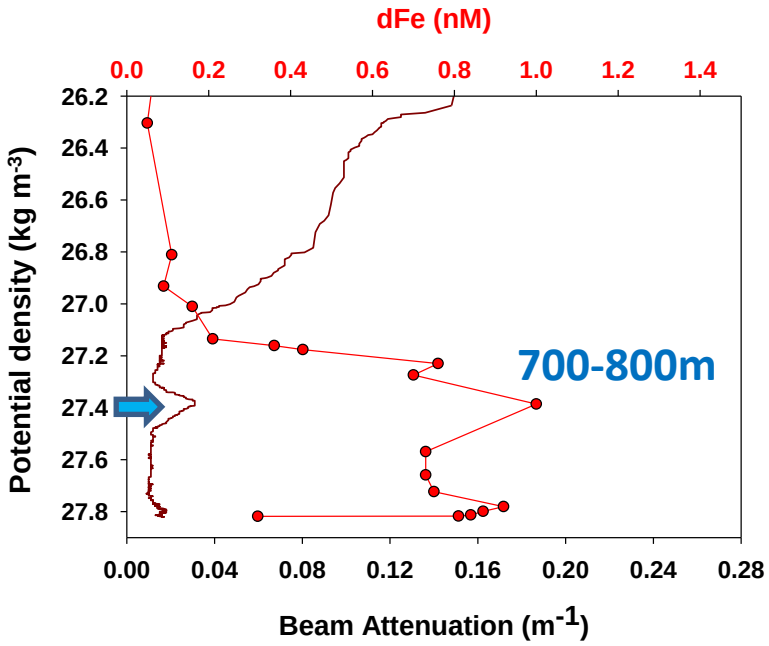
Beam Attenuation
dFe
pFe
TdFe

- Increases in dFe correlate with peaks in beam attenuation
- Similar increases are observed for particulate Fe



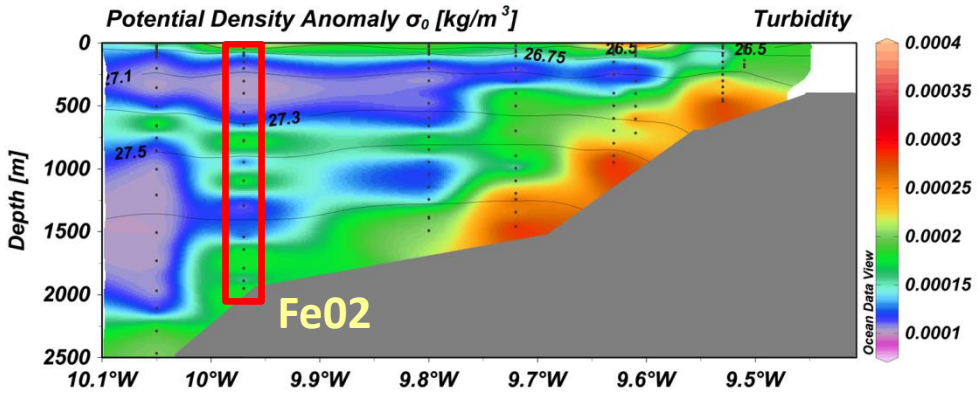
DY033 (July 2015) T1

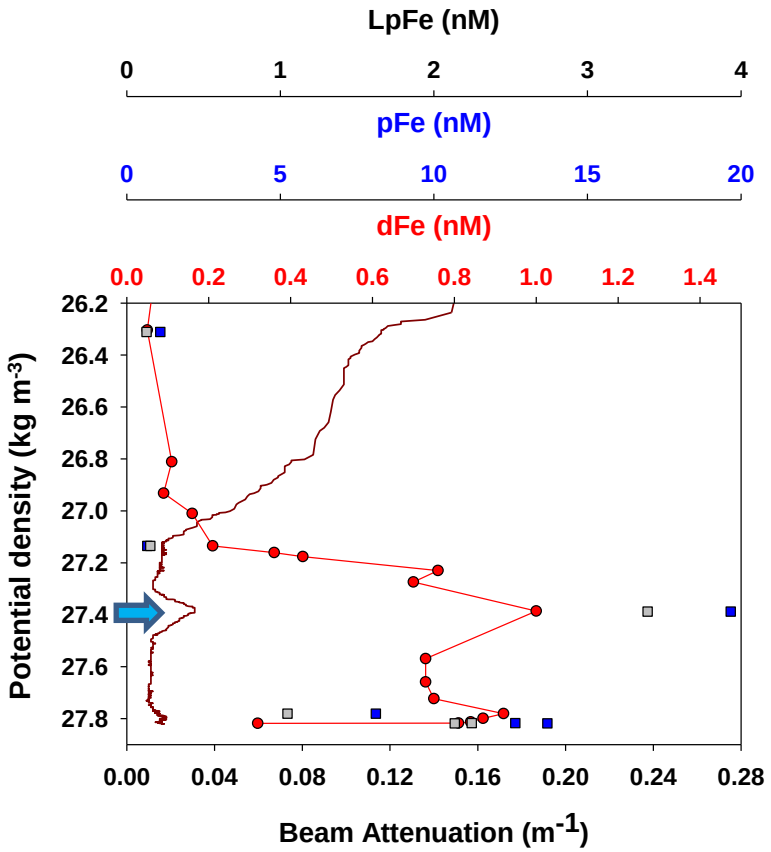
Beam Attenuation
dFe
pFe
LpFe

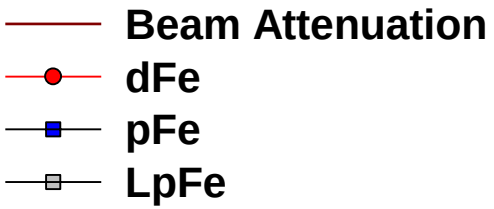


- **Even though dFe is raised, still evidence of additional input corresponding to INL at σ = 27.4**

DY033 (July 2015) T1



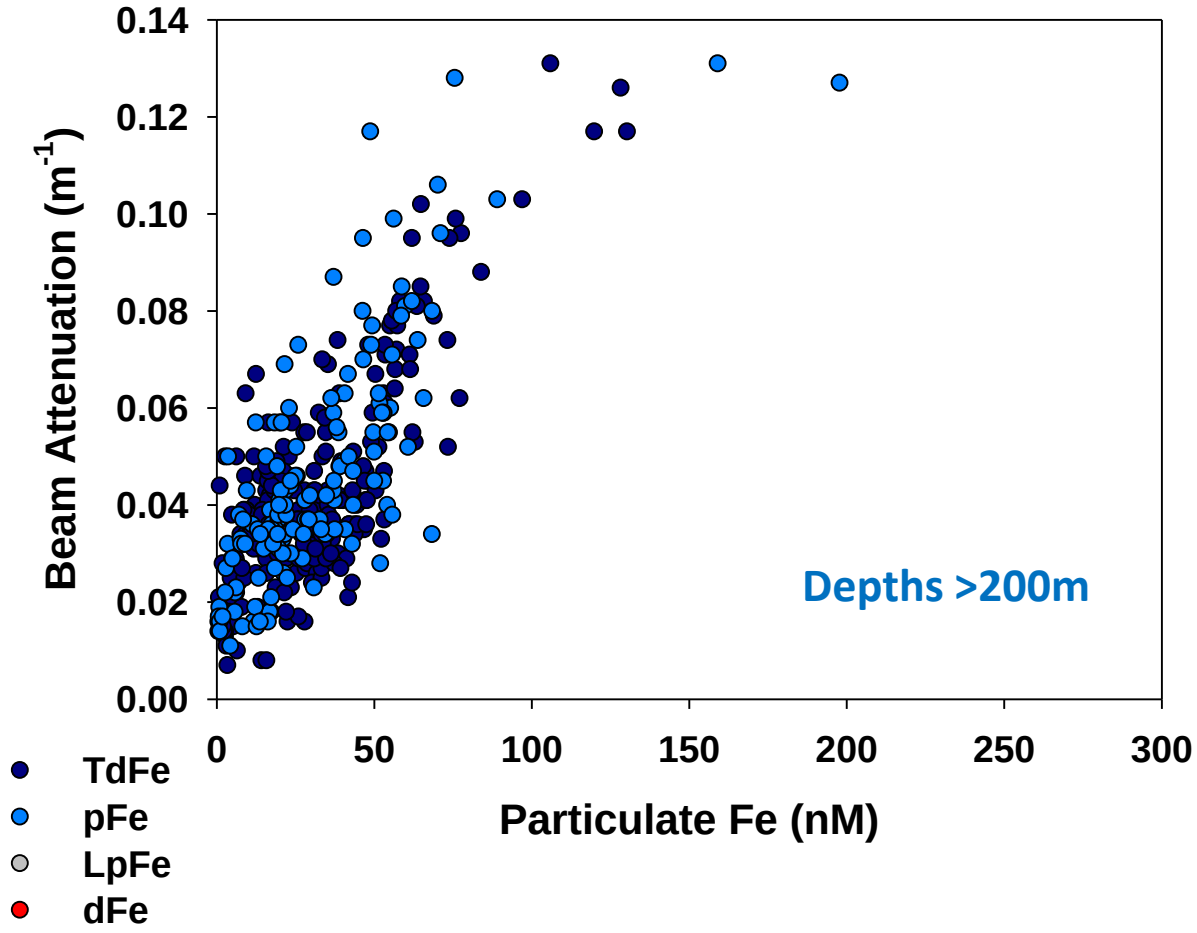


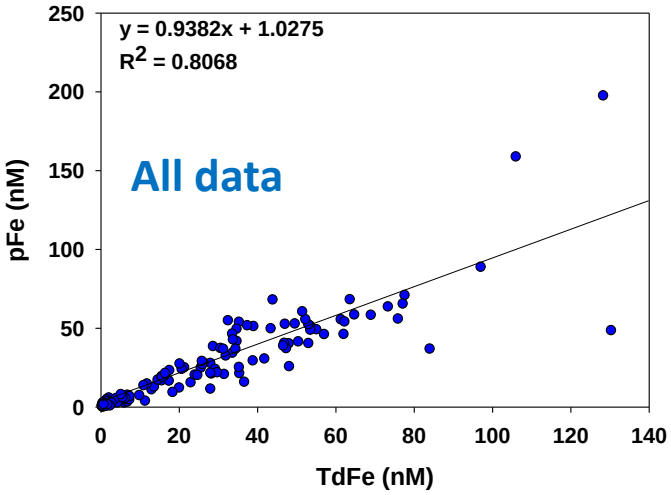


- **Even though dFe is raised, still evidence of additional input corresponding to INL at σ = 27.4**
- **Similar increases observed for particulate Fe fractions**

Particle Relationships

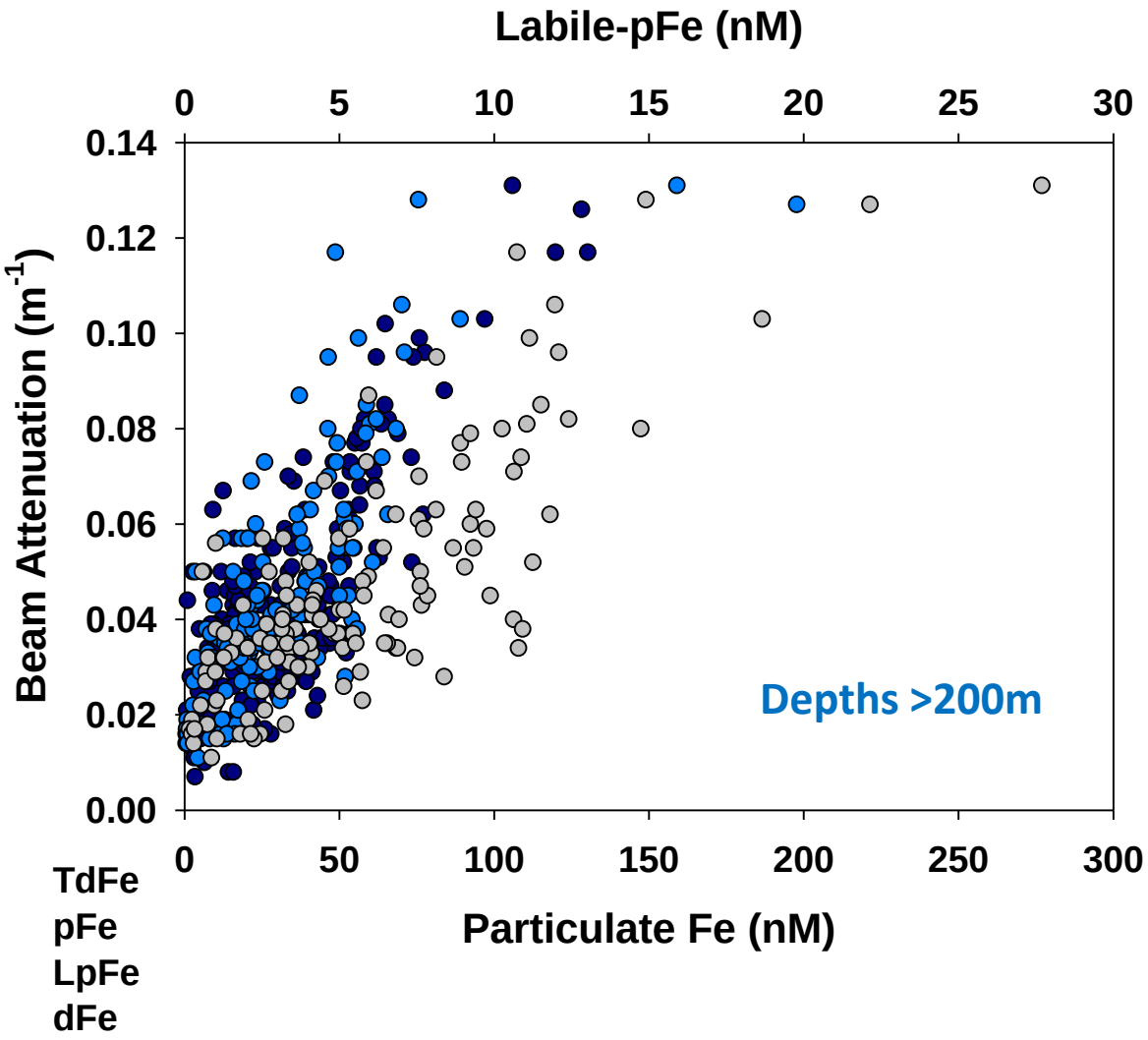
- Strong relationship with particulate Fe (R^2 = 0.6368)
- Strong correlation between TdFe-pFe

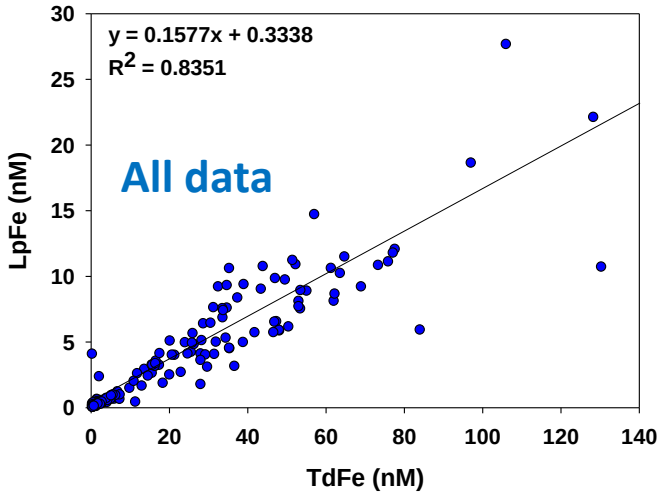




Particle Relationships

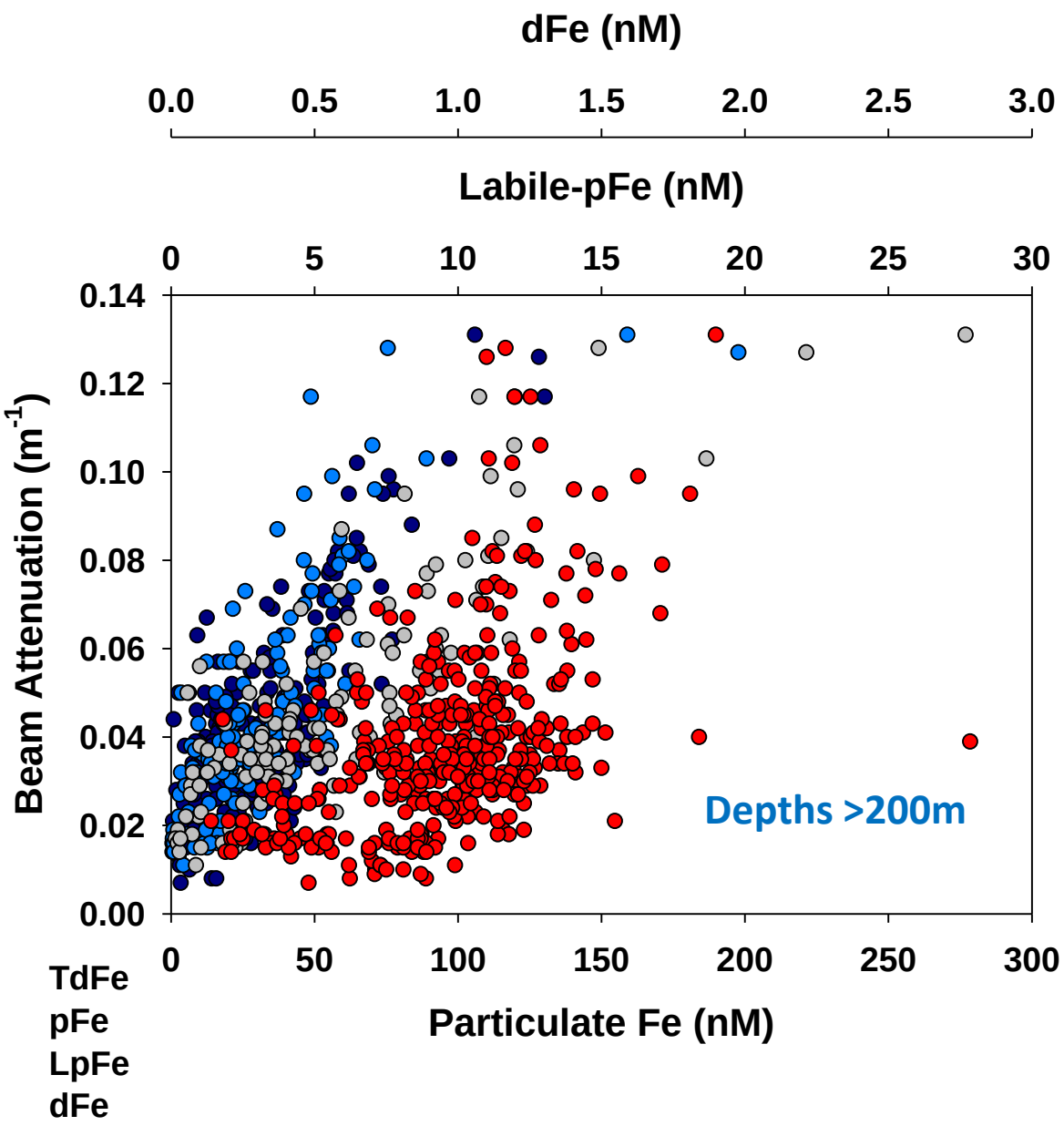
- Strong relationship with particulate Fe ($R^2 = 0.6368$)
- Strong correlation between TdFe-pFe
- Equally strong relationship with LpFe ($R^2 = 0.6516$)
- Strong correlation between TdFe-LpFe





Average of ~16% labile Fe

Particle Relationships



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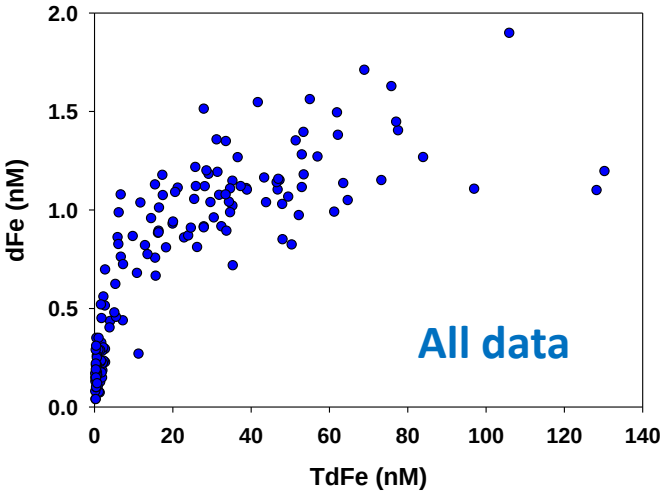
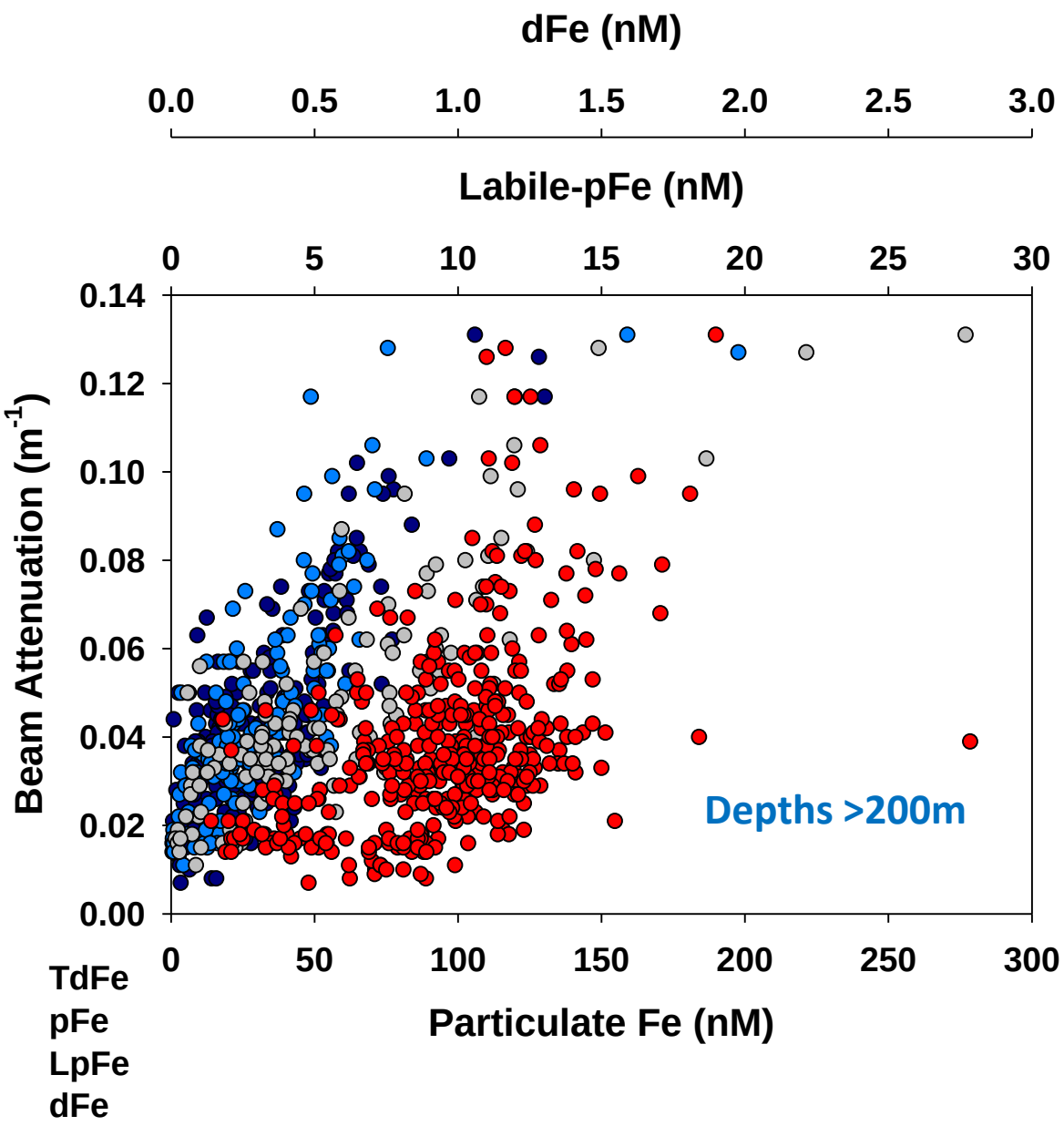
- Influences dFe - capped



Particle Relationships



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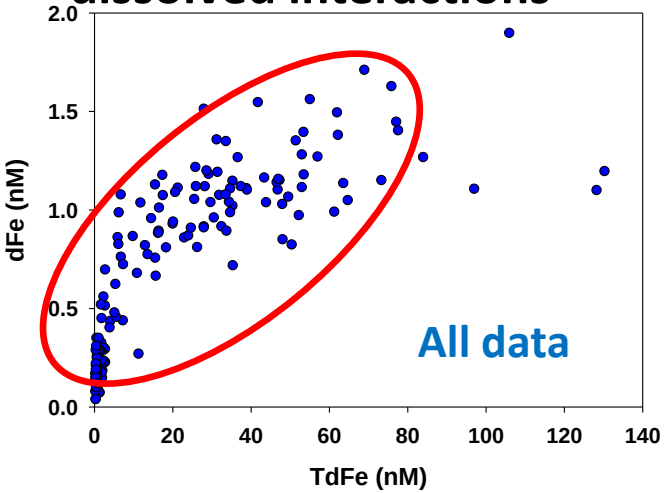
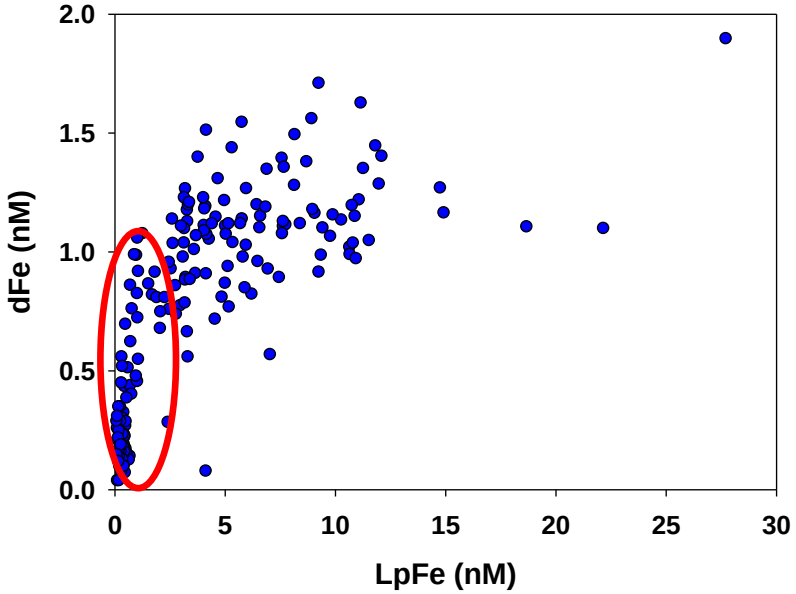
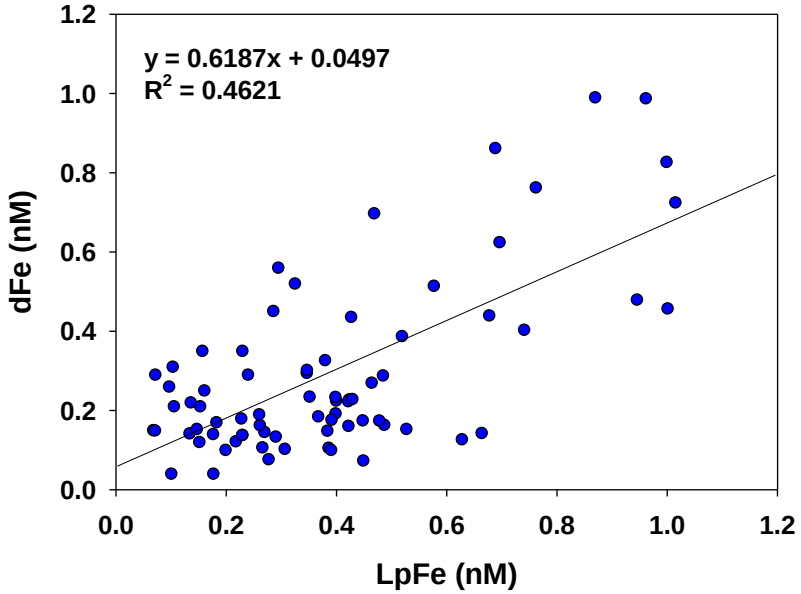
- Influences dFe - capped
- Look closer at particle – dissolved interactions



Labile-pFe & dFe



Predominantly upper waters



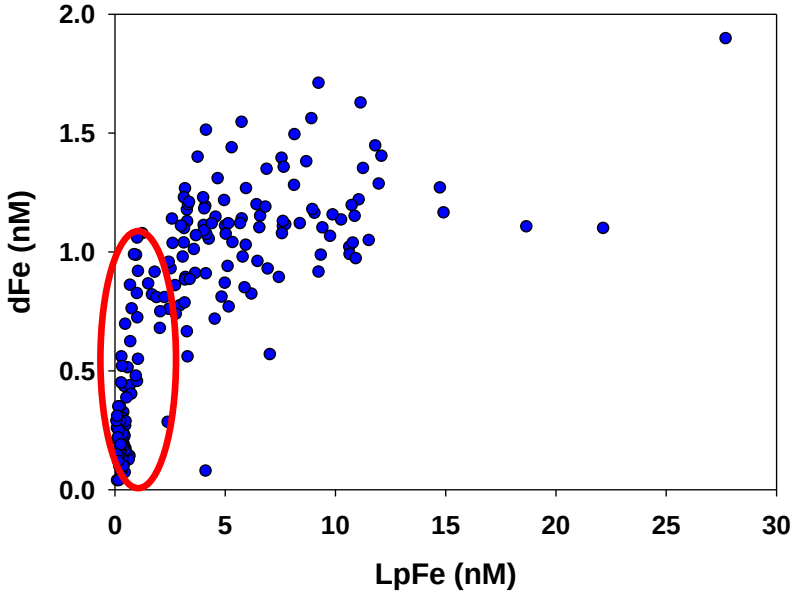
dFe concentrations

- Biologically controlled

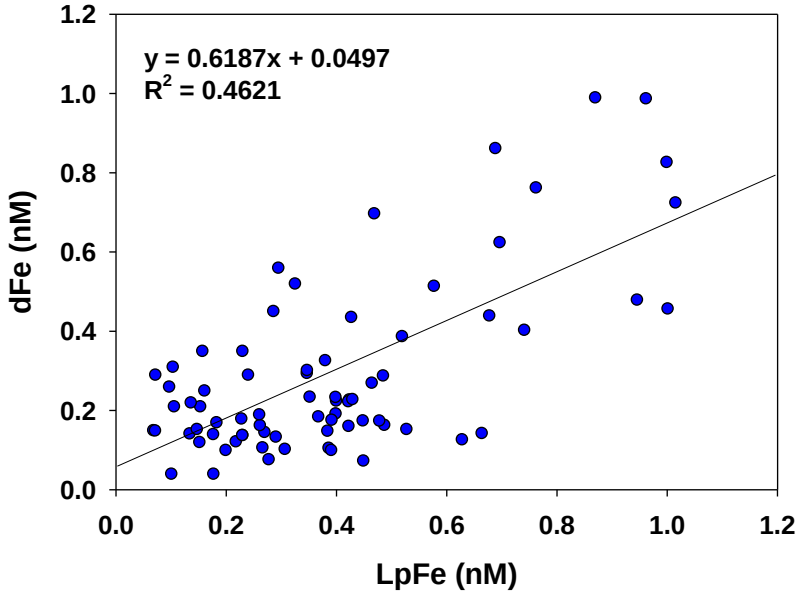
LpFe concentrations

- Biological influence
- Vertical inputs of pFe

Labile-pFe & dFe



Predominantly upper waters



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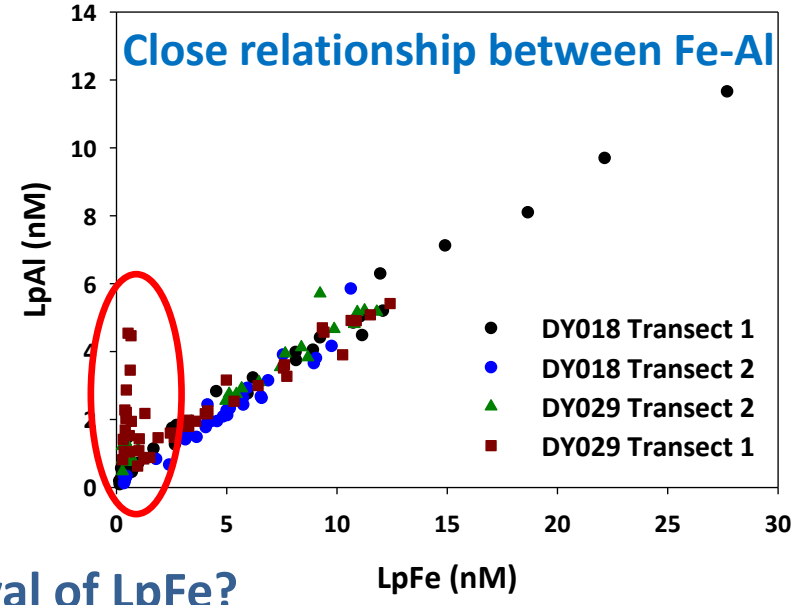
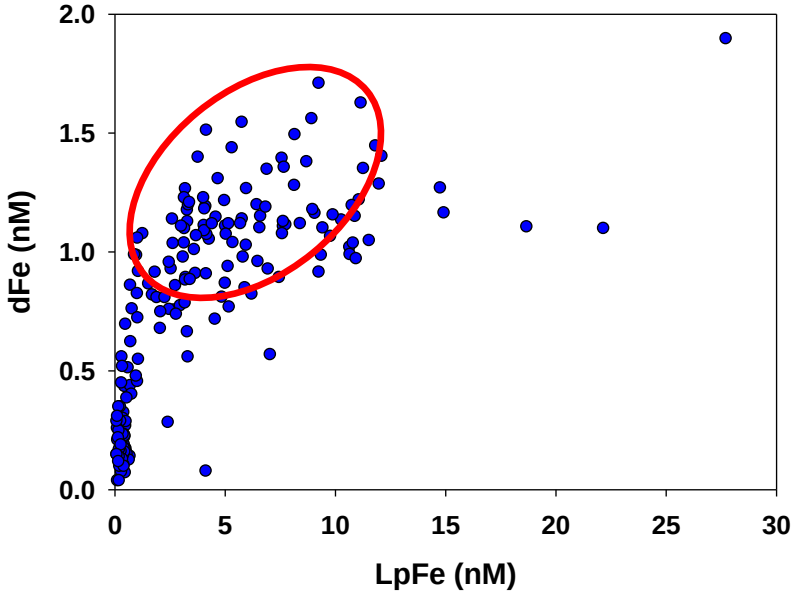
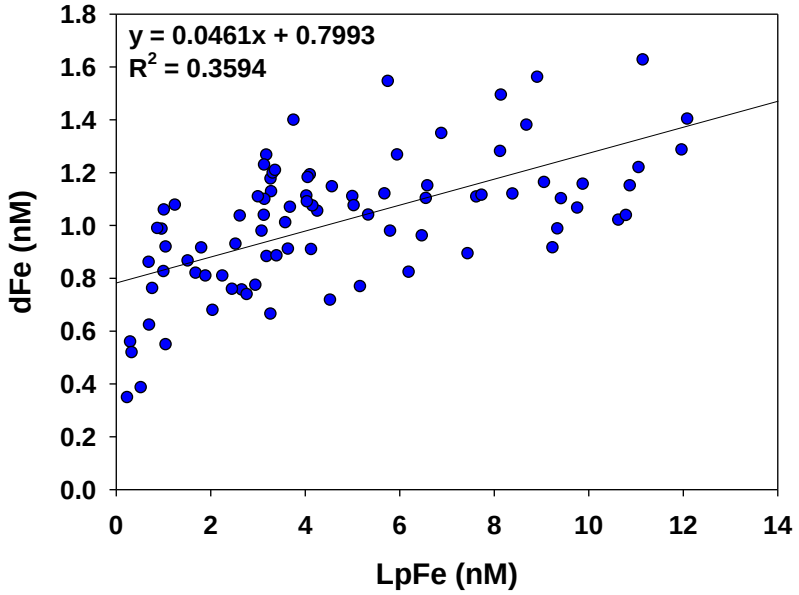


Low LpFe/LpAl in surface waters – removal of LpFe?

Labile-pFe & dFe



Intermediate depths



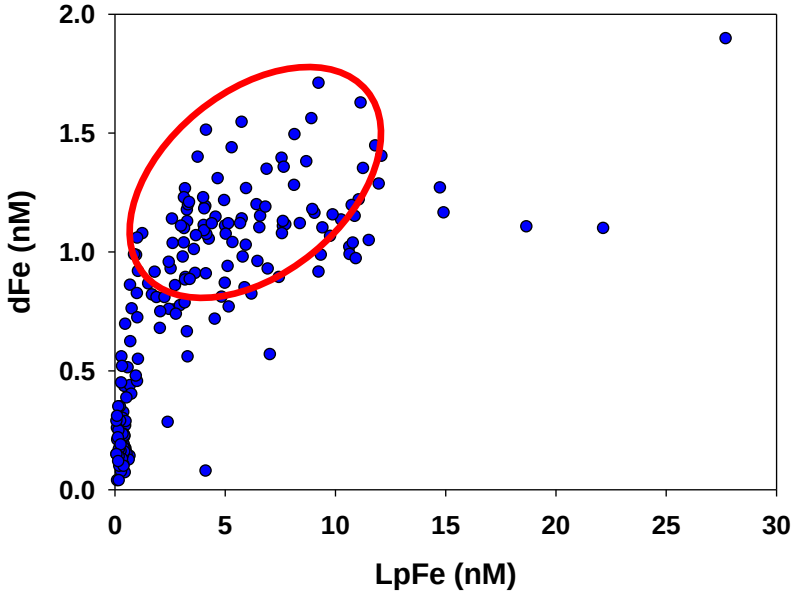
LpFe concentrations

- Sinking biogenic particles
- Vertical & horizontal inputs of pFe

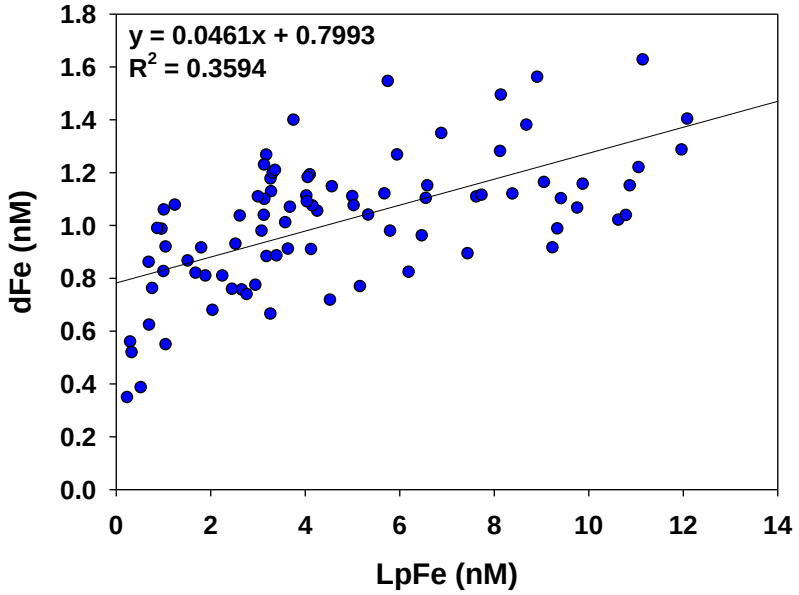
dFe concentrations

- Remineralisation
- Approaching ligand saturation
- Additional ‘buffering’ from pFe

Labile-pFe & dFe



Intermediate depths



LpFe concentrations

- Sinking biogenic particles
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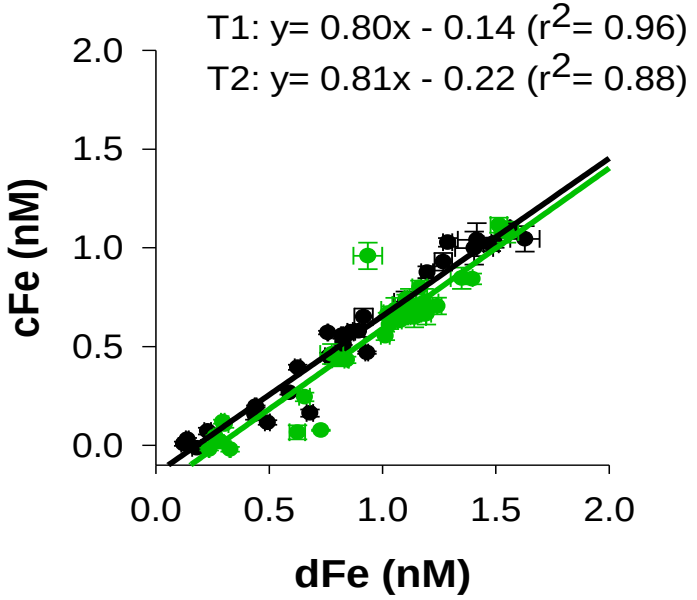
dFe concentrations

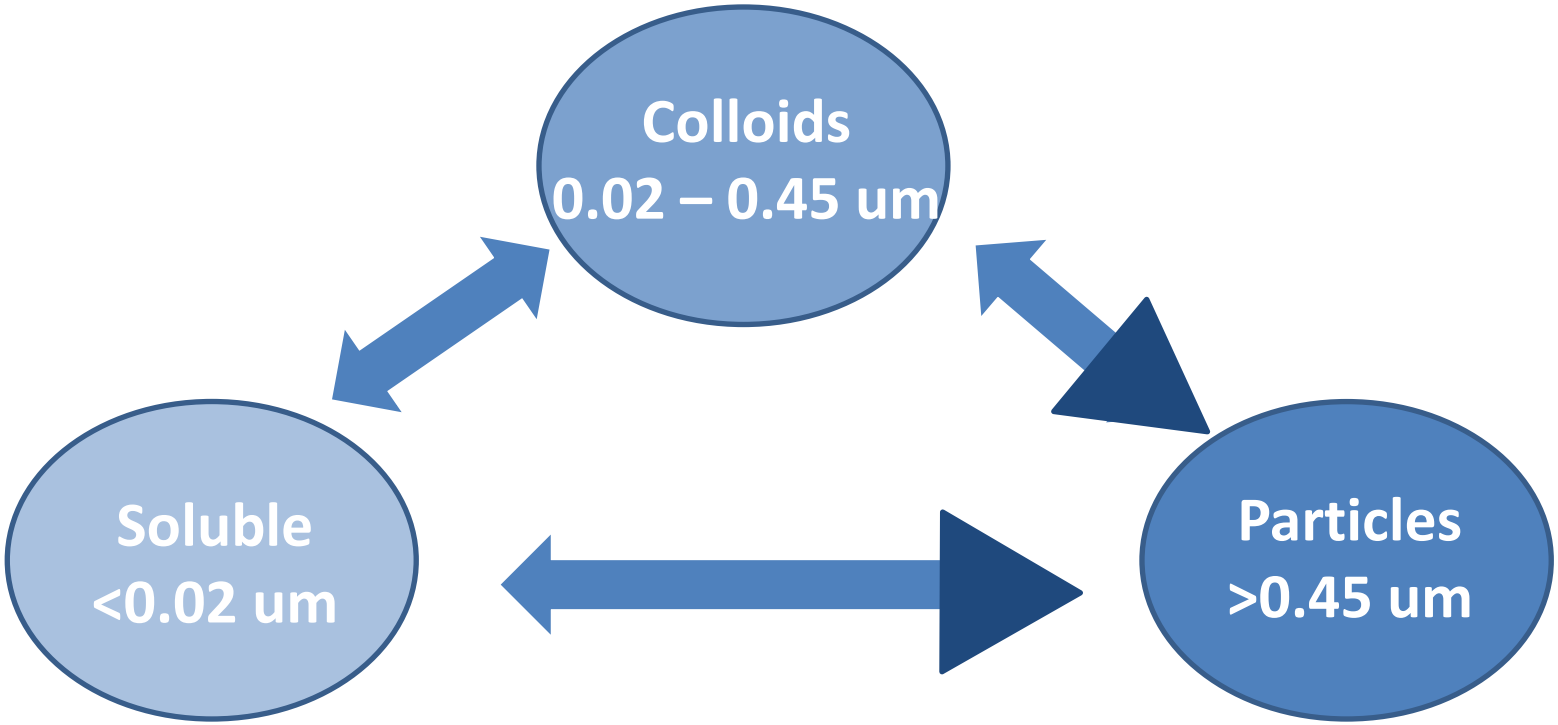
- Remineralisation
- Approaching ligand saturation
- Additional 'buffering' from pFe

cFe dominates at depth (>150 – 500 m)

Very small particles!



Exchangeable Fe



Conclusions

- INLs source of dFe and particulate Fe
  - Winter mixing will re-supply surface waters with dFe from shallow INLs.
  - dFe from deeper INLs will remain transported at these depths. Impact on deep water inventory of the North Atlantic will be dependent
    - on rapid transport
    - particle load and hence scavenging

- Need to consider all fractions of Fe (sFe, cFe, LpFe), not just dFe

Conclusions

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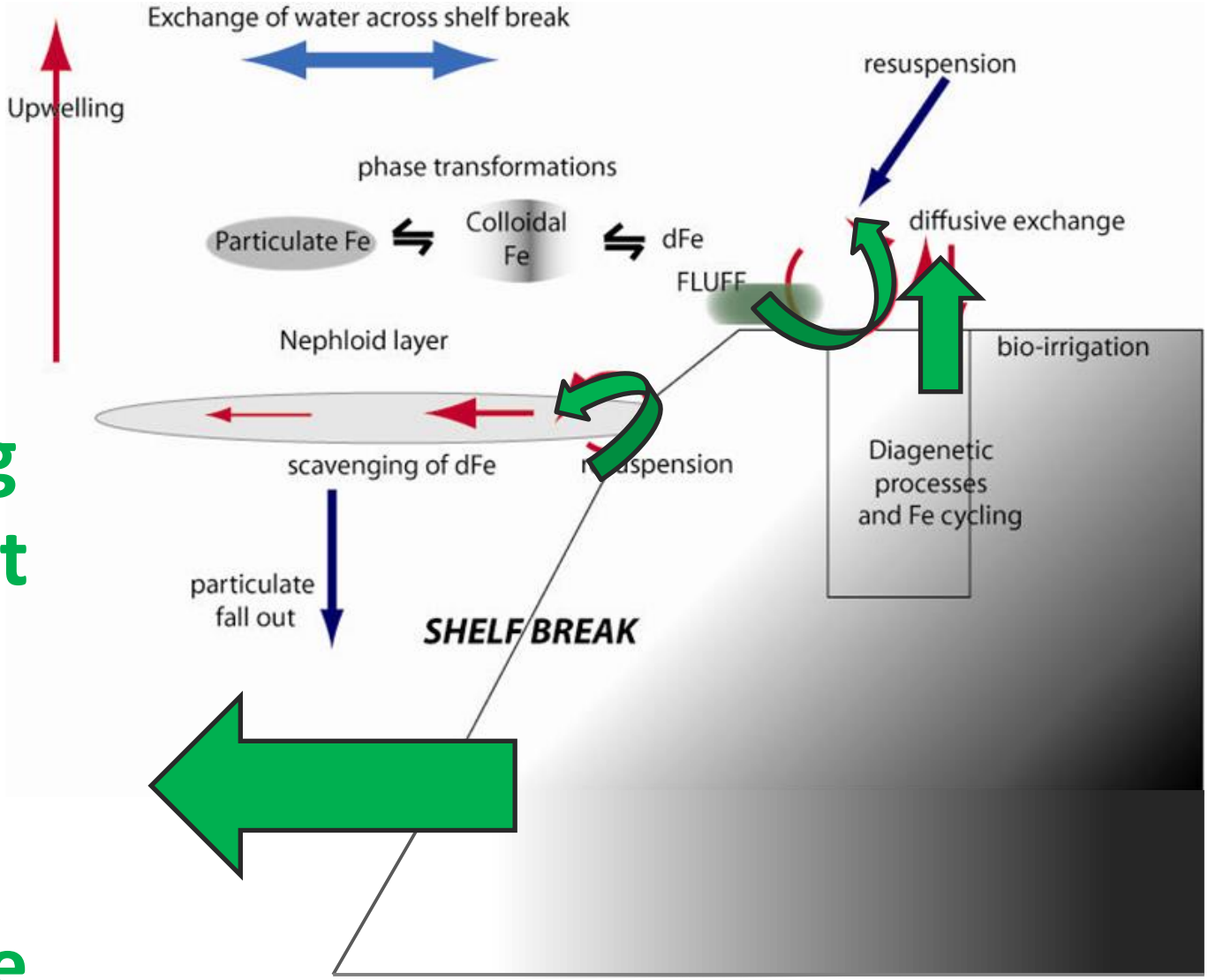
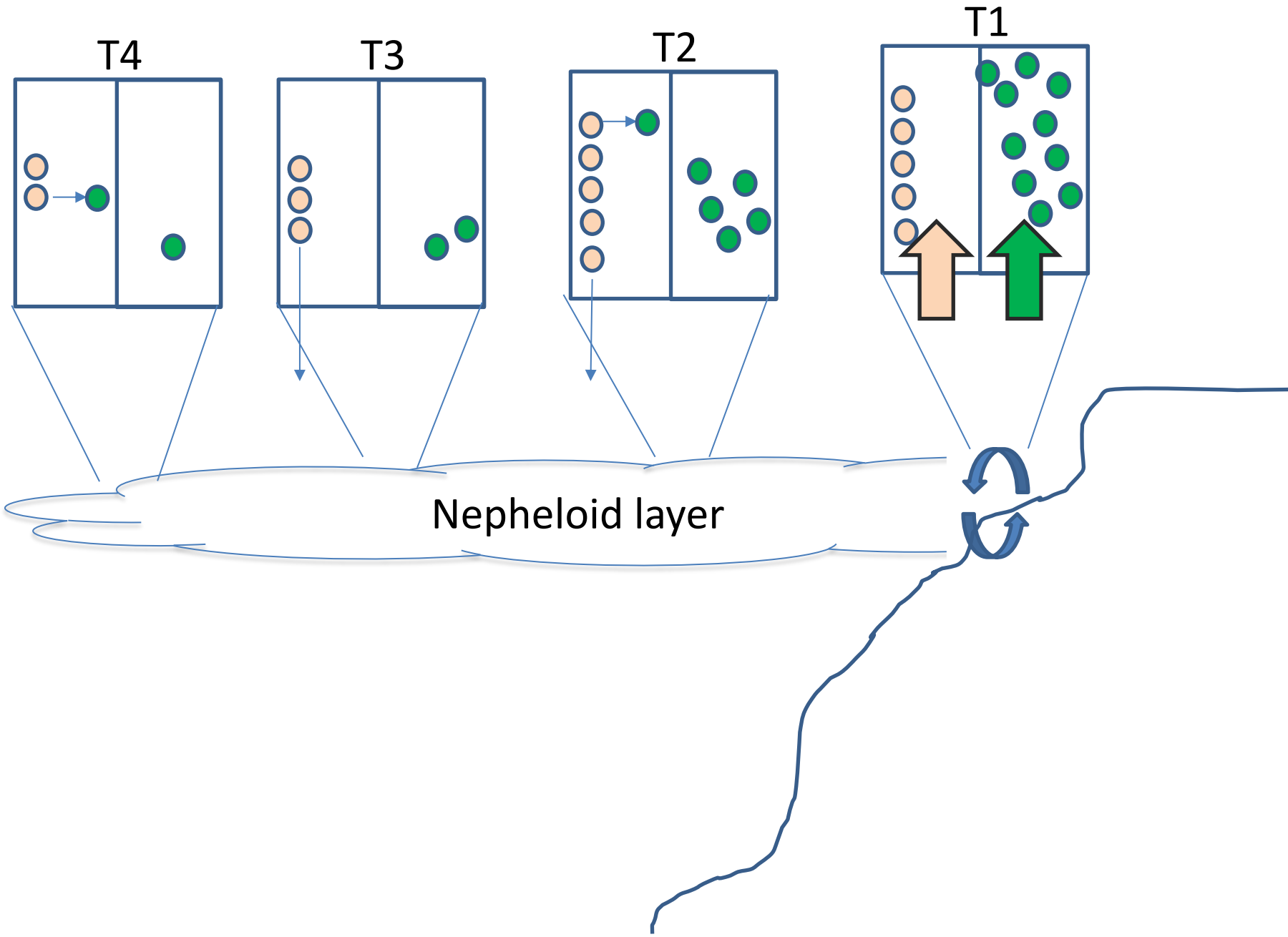
  - Winter mixing will re-supply surface waters with dFe from shallow INLs.
  - dFe from deeper INLs will remain transported at these depths. Impact on deep water inventory of the North Atlantic will be dependent
    - **on rapid transport – evidence from Ra**
    - particle load and hence scavenging

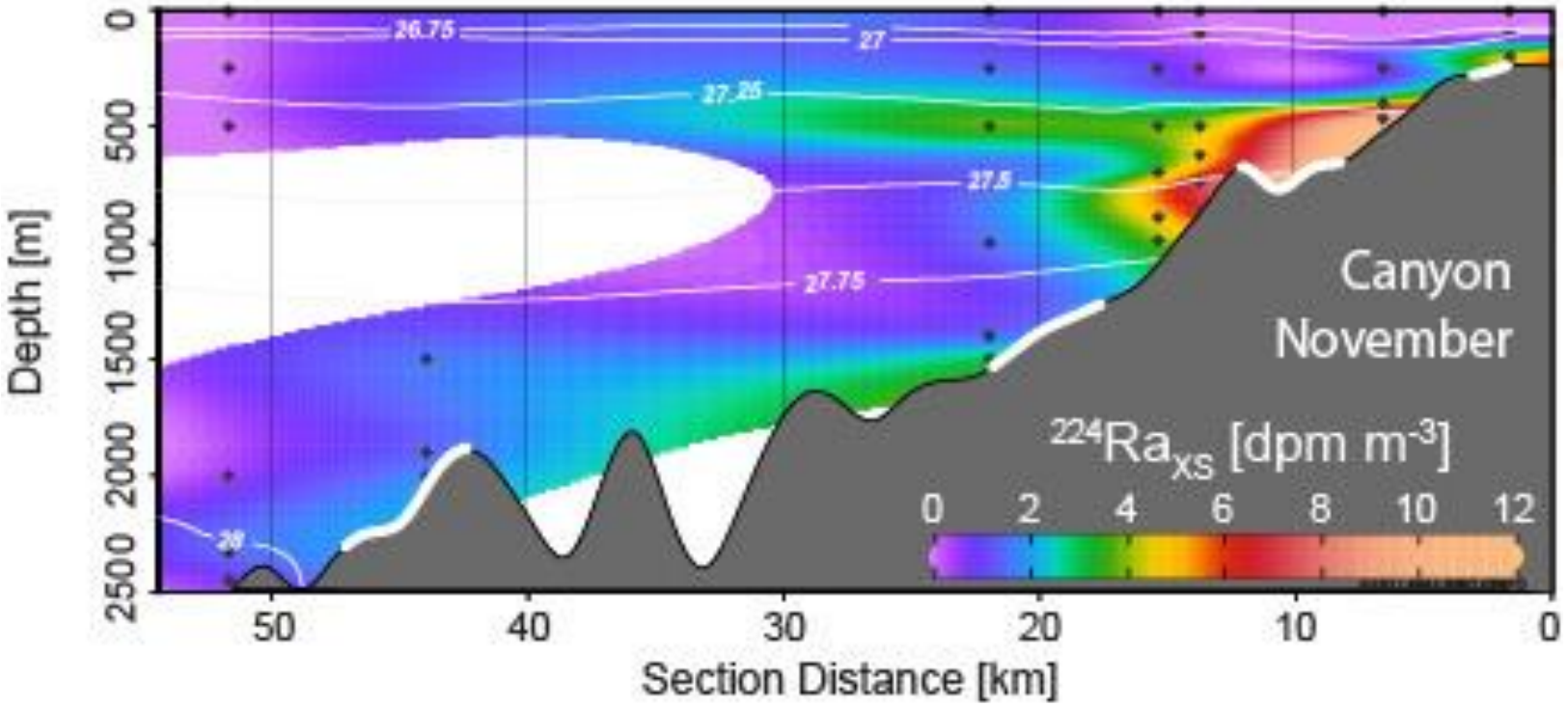
- Need to consider all fractions of Fe (sFe, cFe, LpFe), not just dFe

Iron cycling within the shelf system

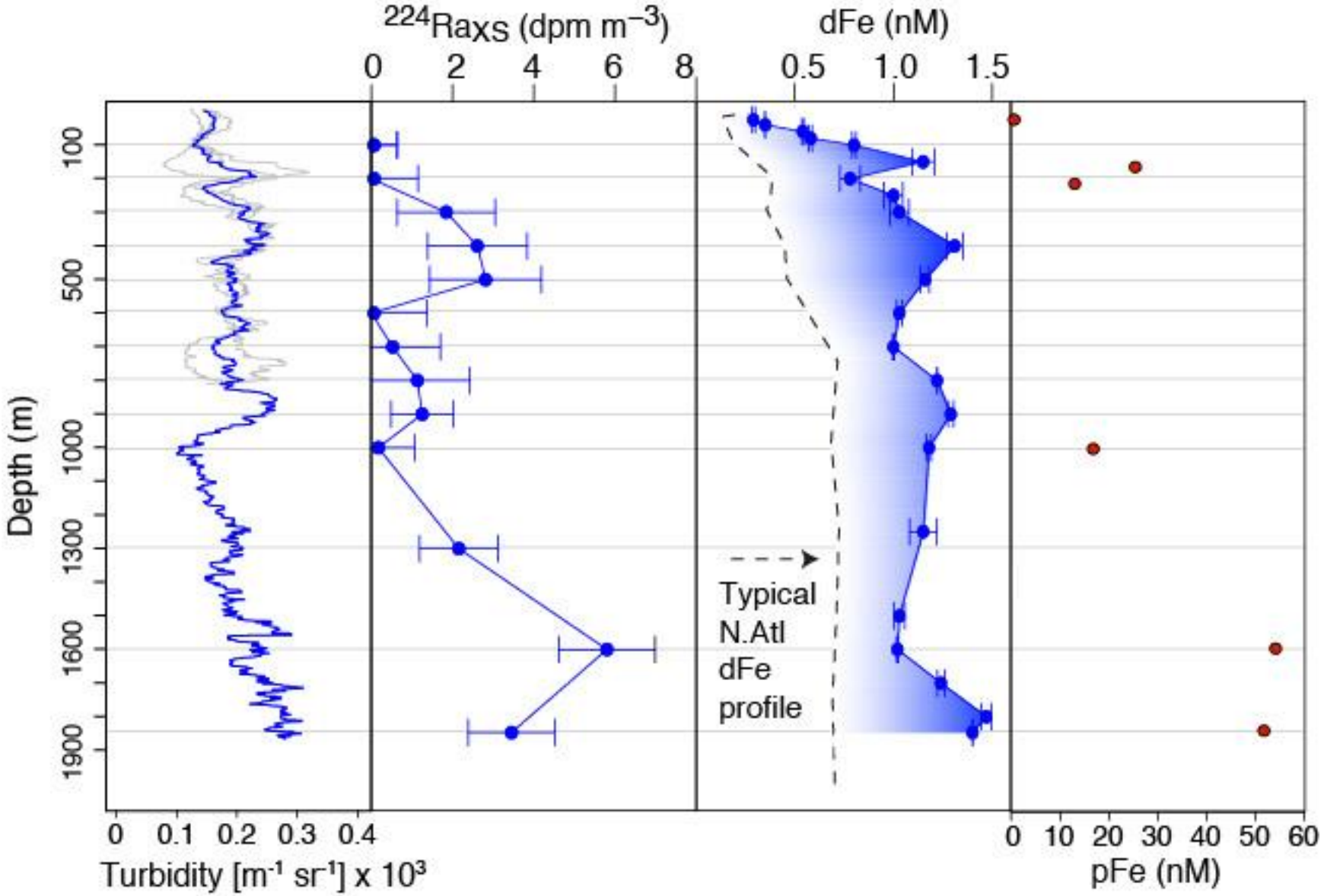
Any process involving sediment will also have a Radium signature




T4
T3
T2
T1
Nepheloid layer

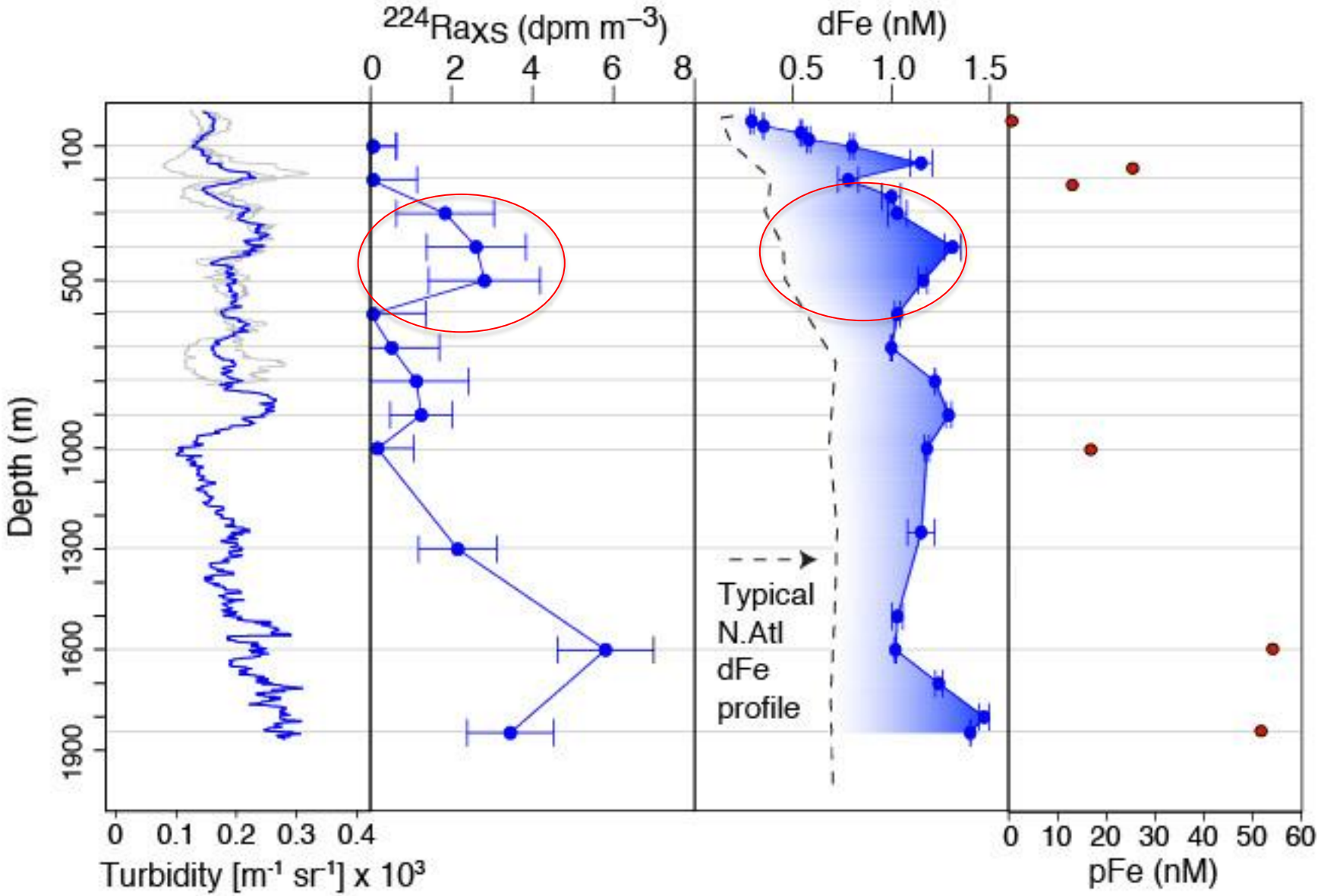

Depth [m]
0
500
1000
1500
2000
2500
26.75
27
27.25
27.5
27.75
28
Canyon
November
$^{224}Ra_{xs}$ [dpm m^{-3}]
0 2 4 6 8 10 12
50
40
30
20
10
0
Section Distance [km]

Radium and Fe in nepheloid layers



*North Atlantic profile from Rijkenberg et al. 2014

Radium and Fe in nepheloid layers



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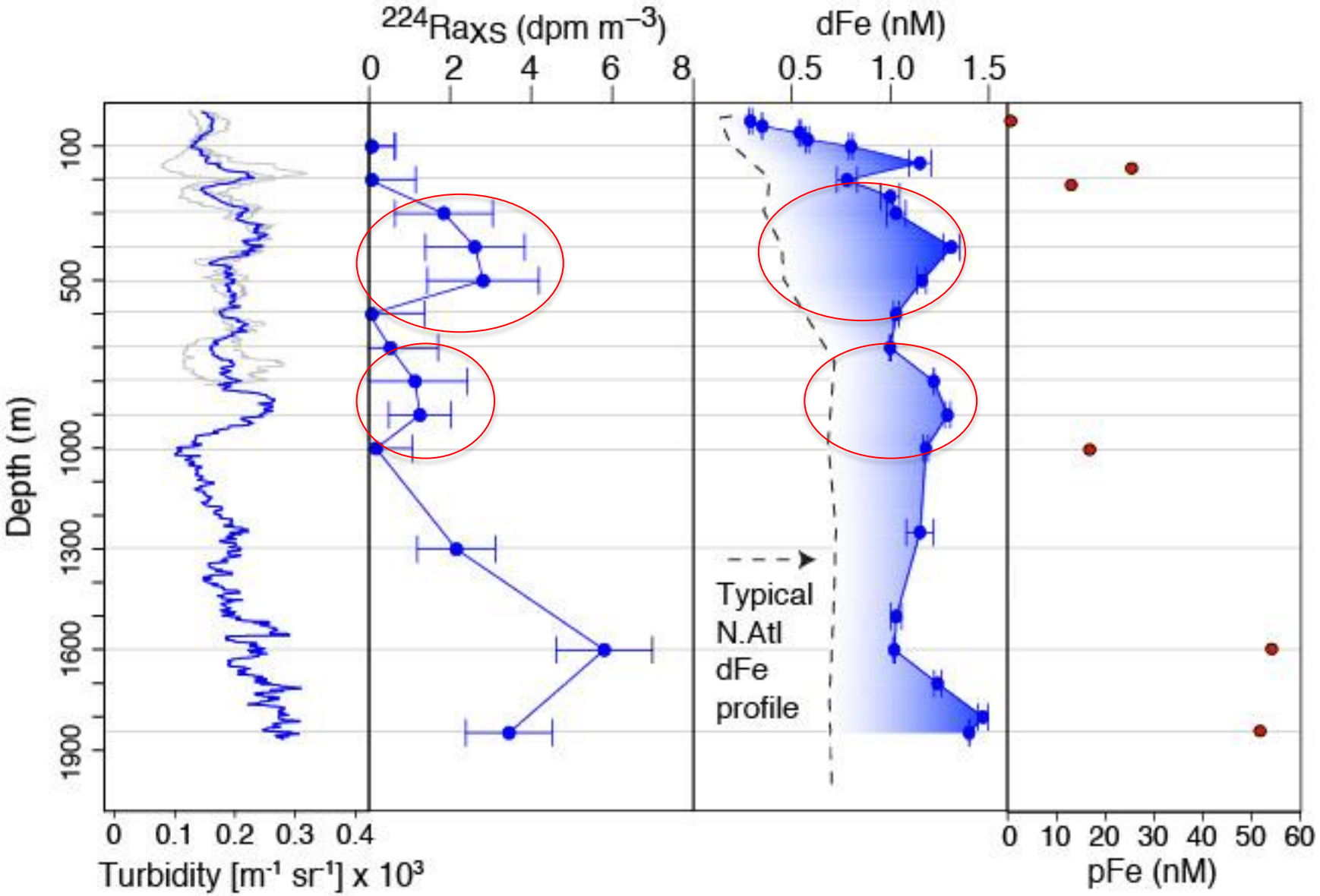
Radium and Fe in nepheloid layers



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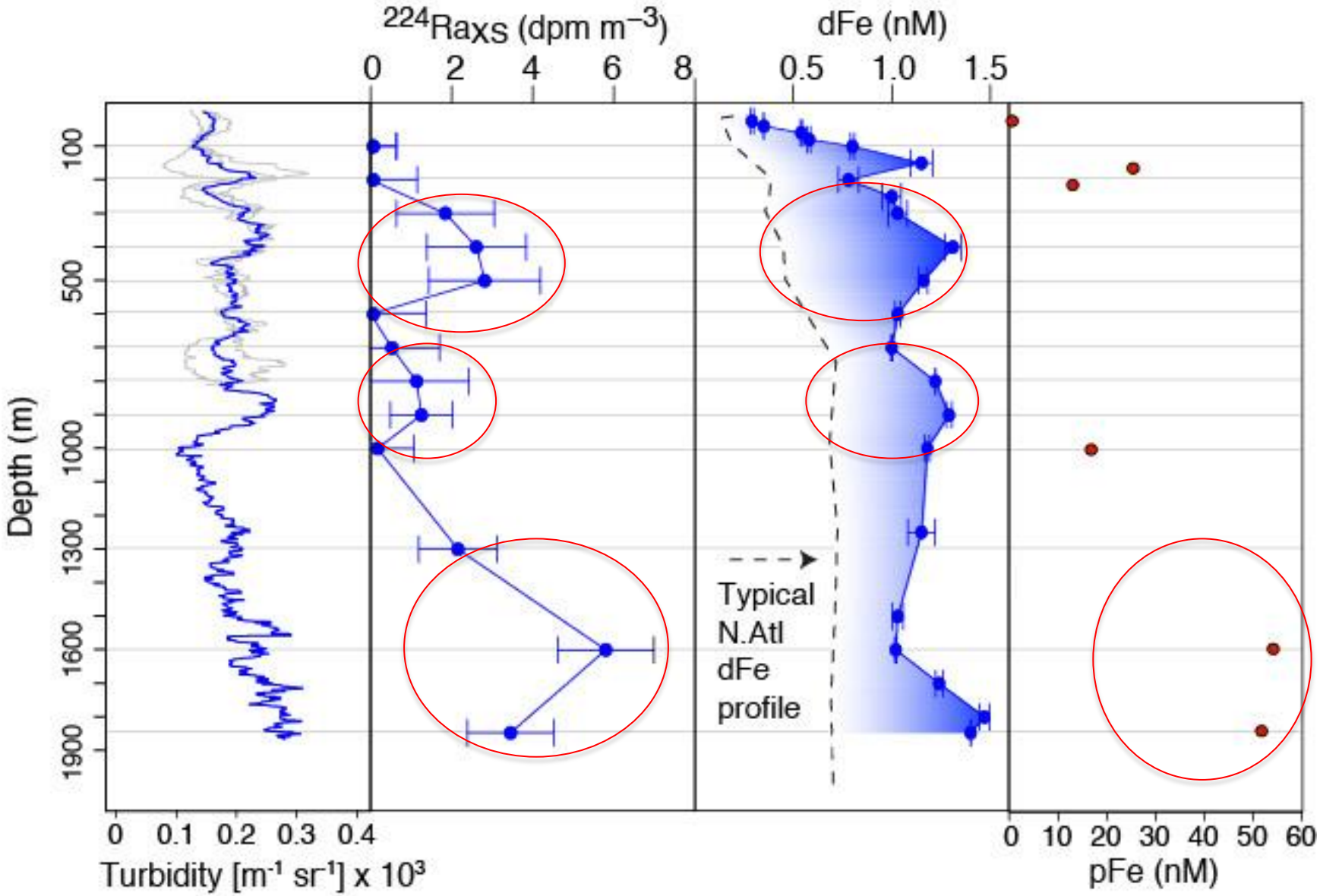
Radium and Fe in nepheloid layers



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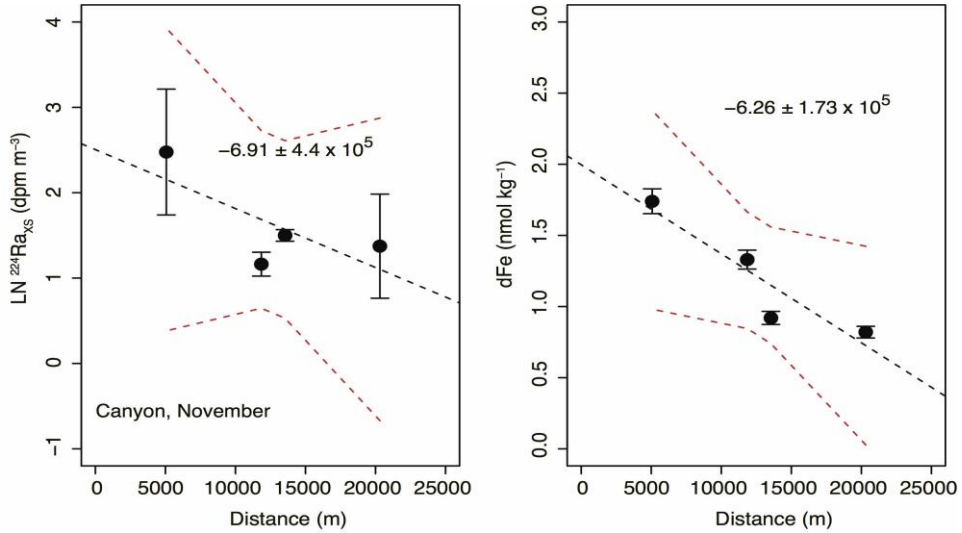
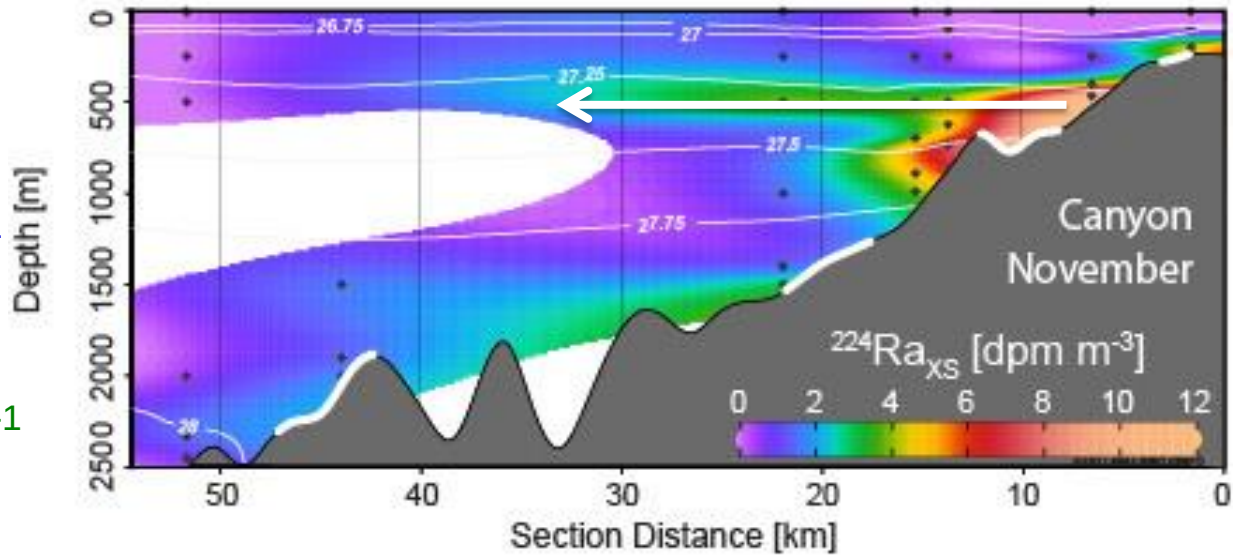
Radium-derived Fe flux estimates

November



170 ± 155
μmol dFe m^{-2} d^{-1}

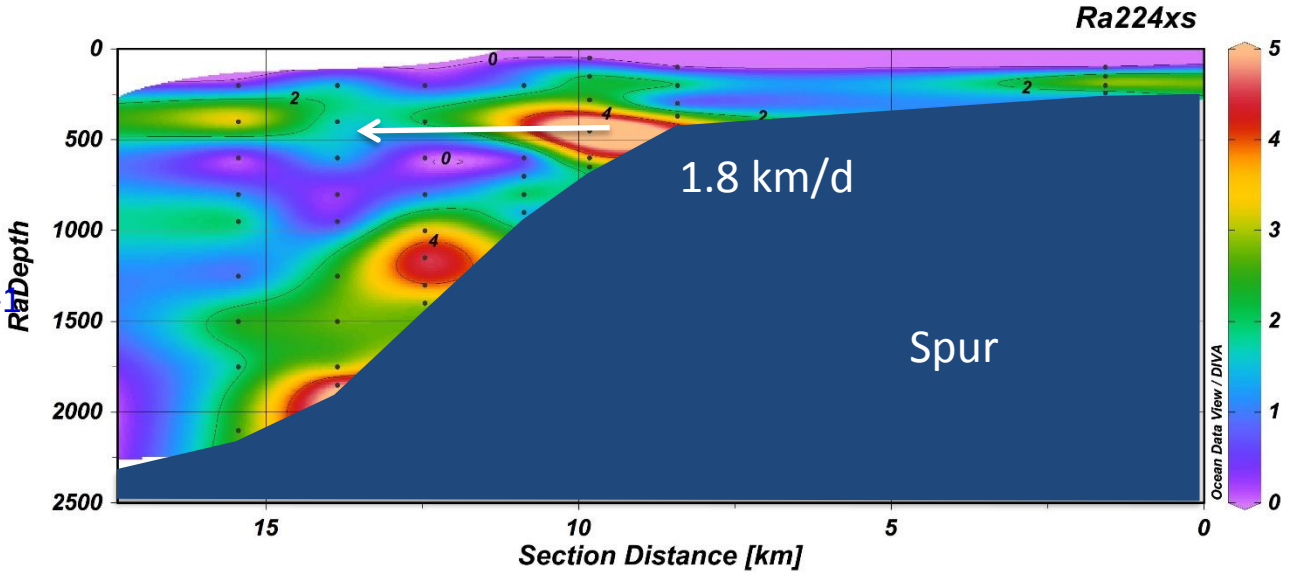
~ 4-24 mmol pFe m^{-2} d^{-1}



Radium-derived Fe flux estimates

April

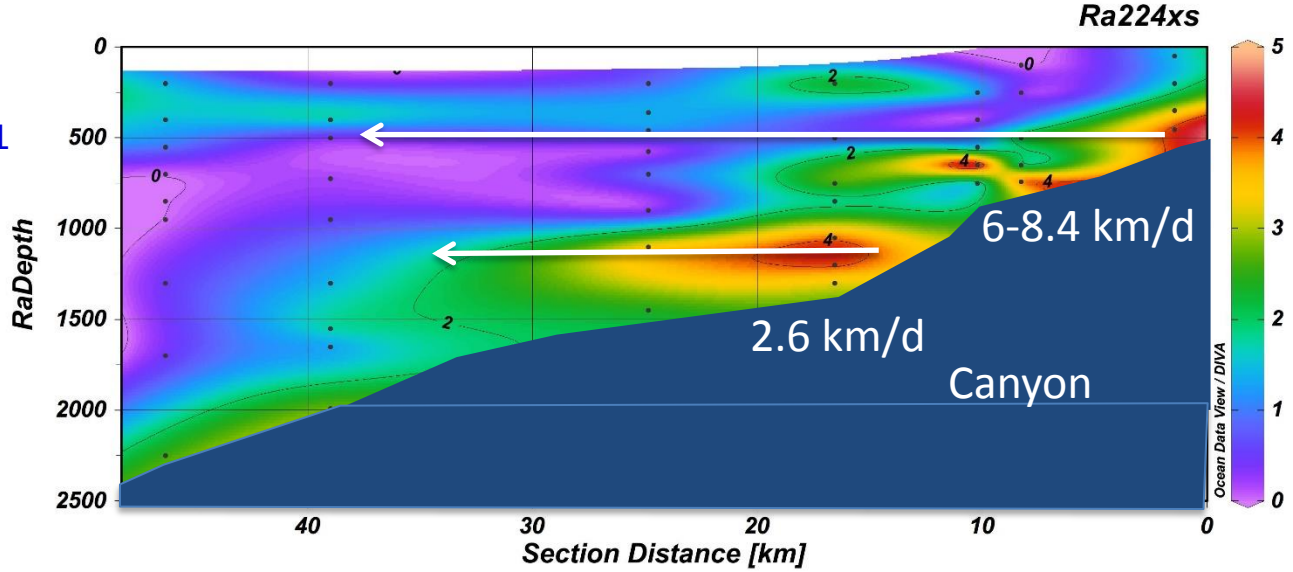
18 ± 17 μmol dFe m^{-2} d^{-1}



17± 24 μmol dFe m^{-2} d^{-1}

28 ± 8 μmol dFe m^{-2} d^{-1}

5 ± 2 mmol pFe m^{-2} d^{-1}



Comparison of sedimentary Fe flux

Chamber-derived flux:

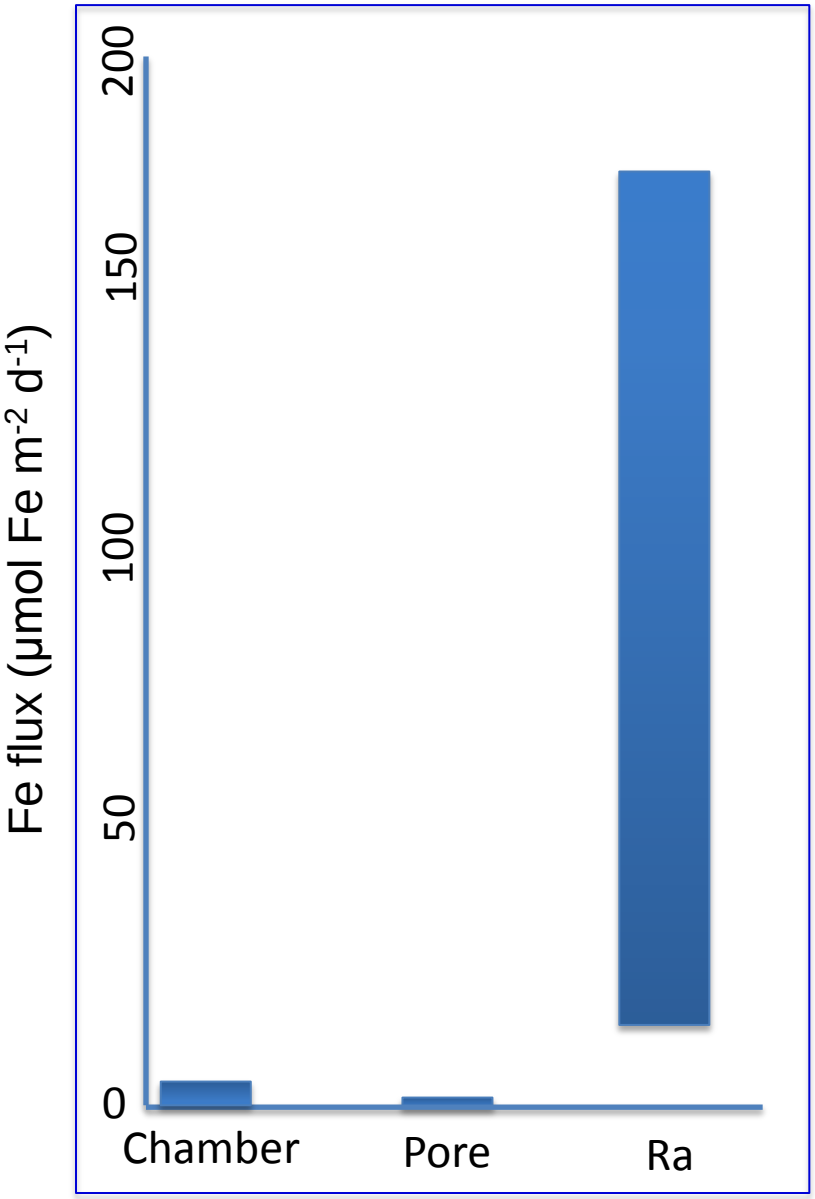
0.4 – 3.5 µmol Fe m^{-2} d^{-1}

Porewater-derived flux:

0.11 – 0.23 µmol Fe m^{-2} d^{-1}

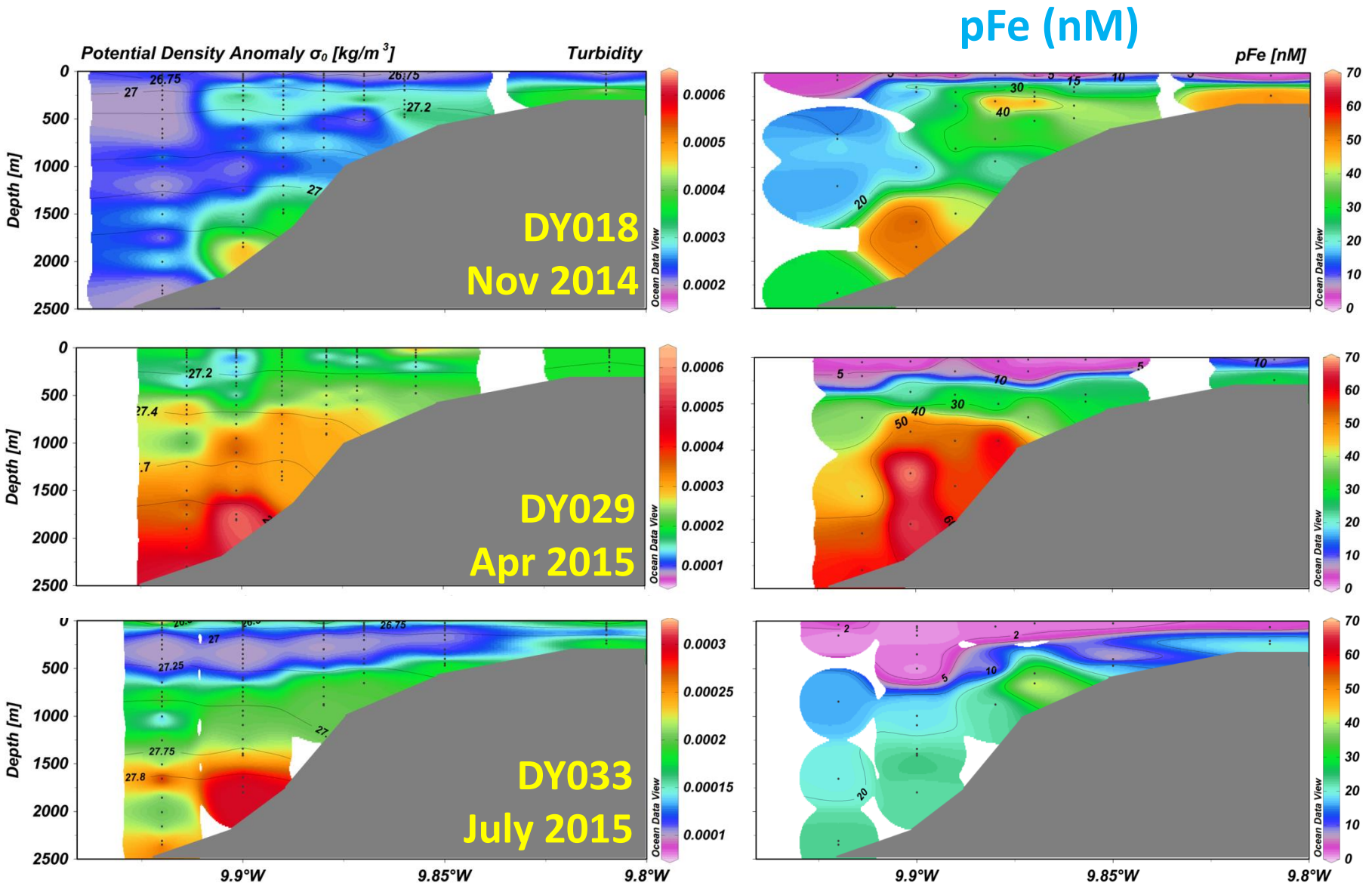
Radium-derived flux:

17-170 µmol Fe m^{-2} d^{-1}



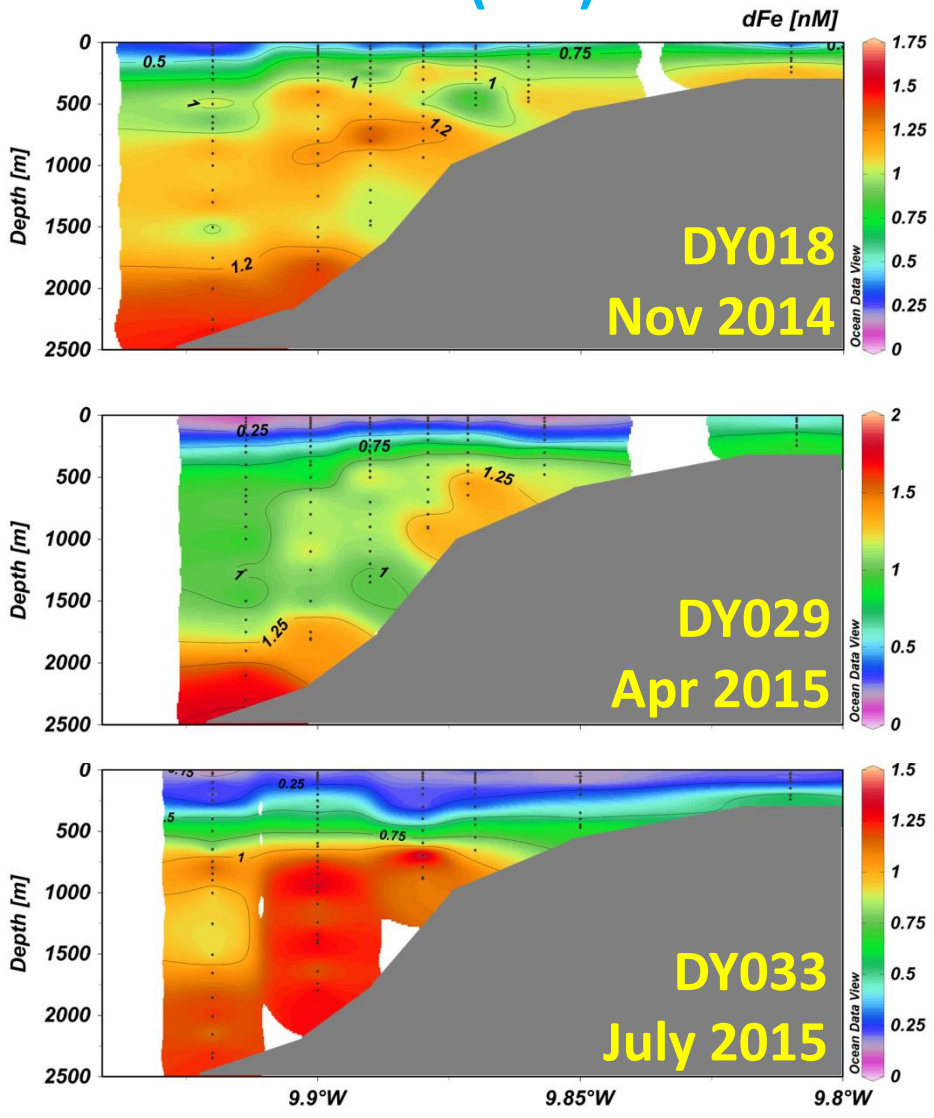
References:
Dale et al. 2015; Elrod et al. 2004;
Severmann et al. 2010; Marsay et al. 2014

Impact on Fe – Transect 2 (Spur)

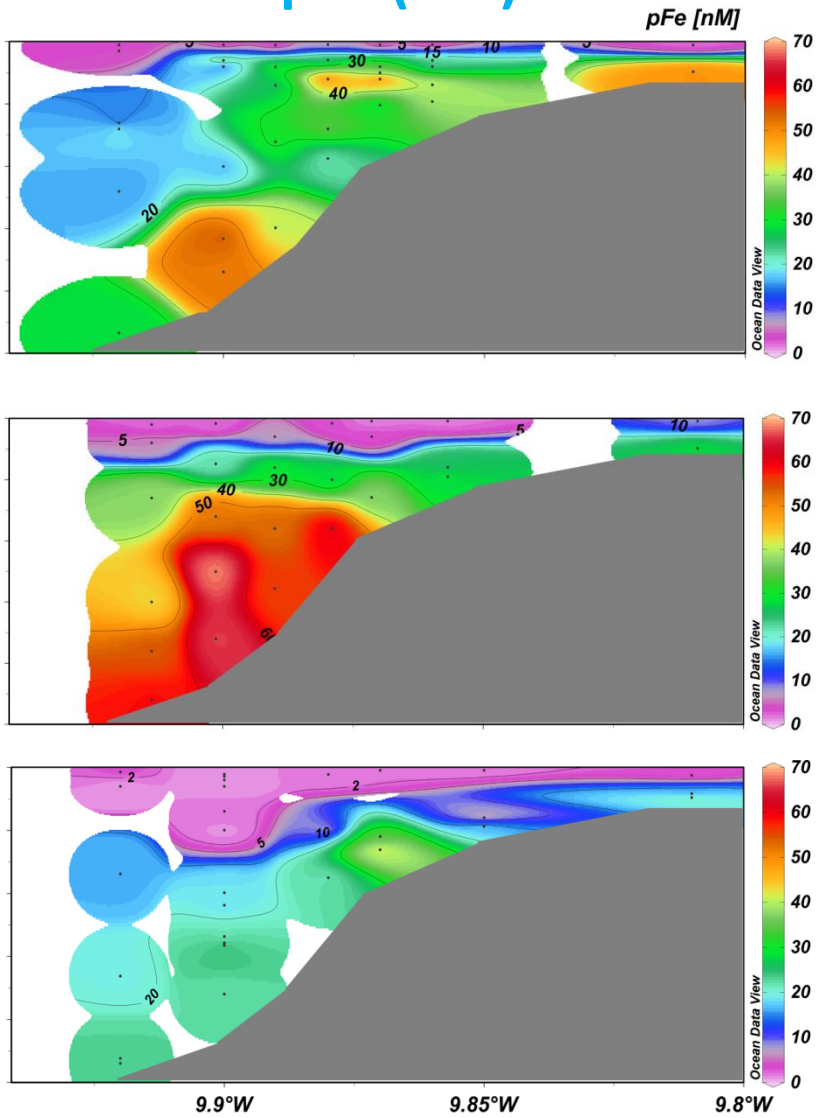


Impact on Fe – Transect 2 (Spur)

dFe (nM)



pFe (nM)



Sediment Fe(II) source

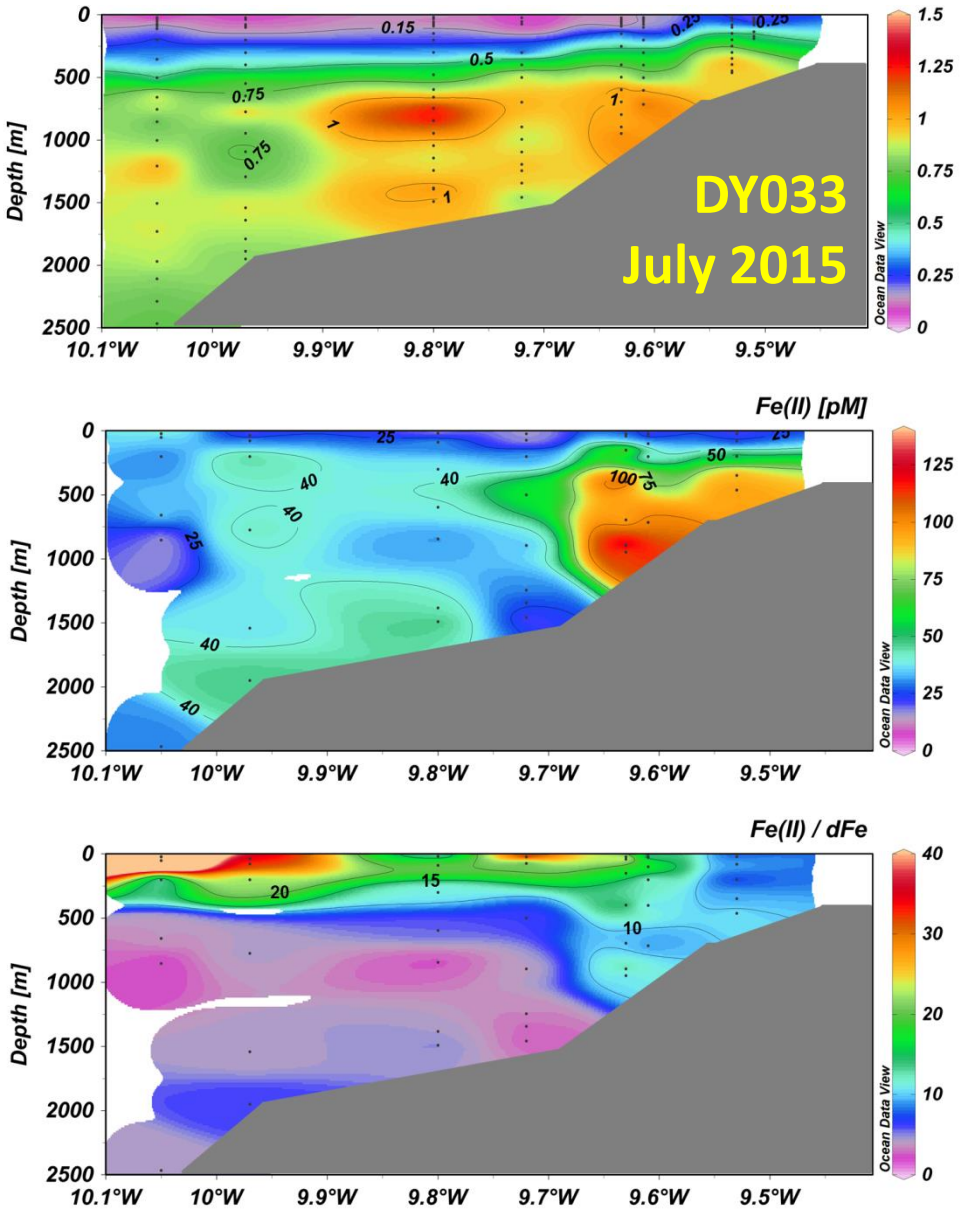
Highest concentrations found:

- Shallow depths on the slope
- Under highly productive waters
- Non-reduction dissolution in oxygenated sediments

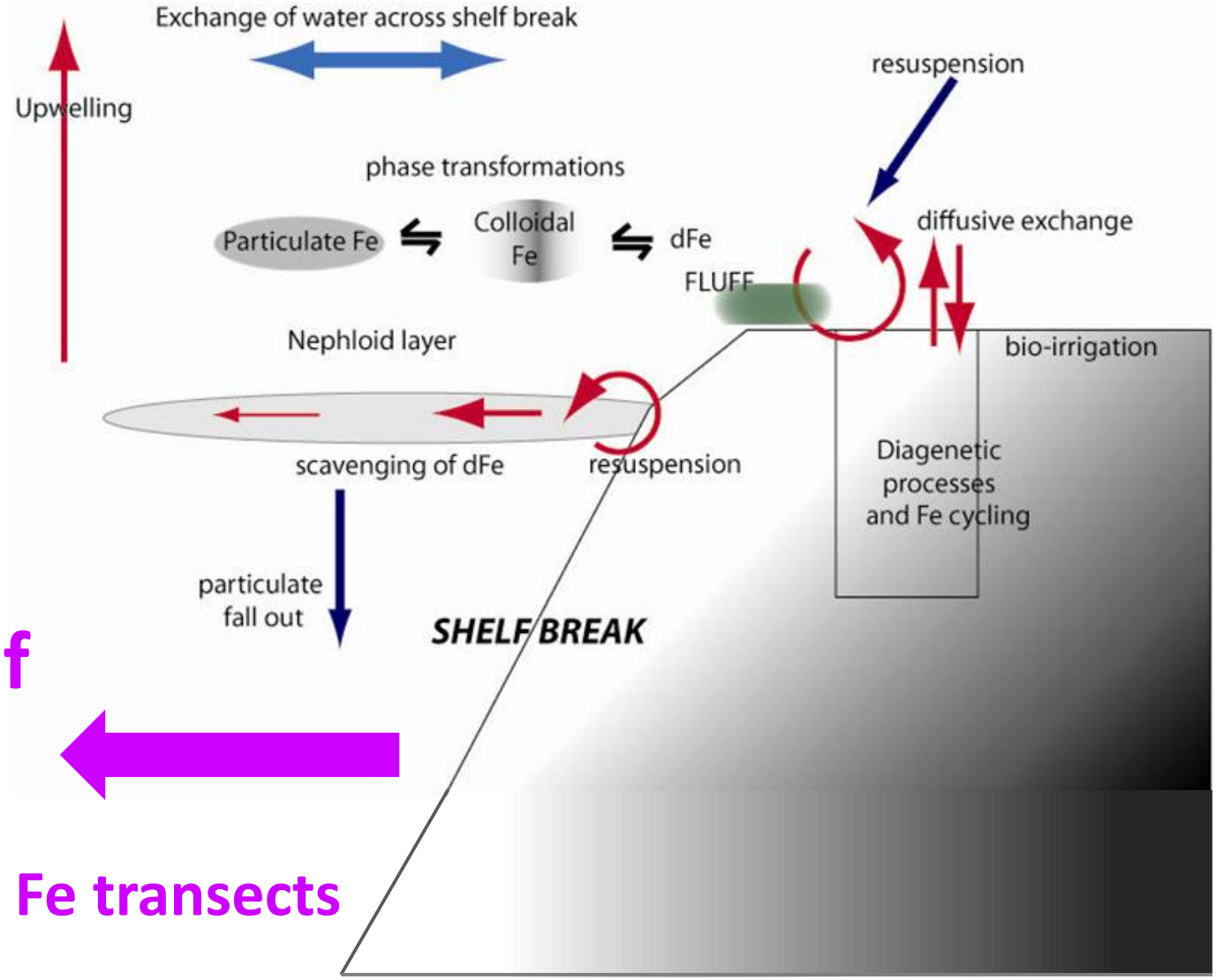
Contribute to raised dFe signal in deeper waters

Account for around 10-15% of dFe near slope

Higher percentage in surface waters – photochemical reduction



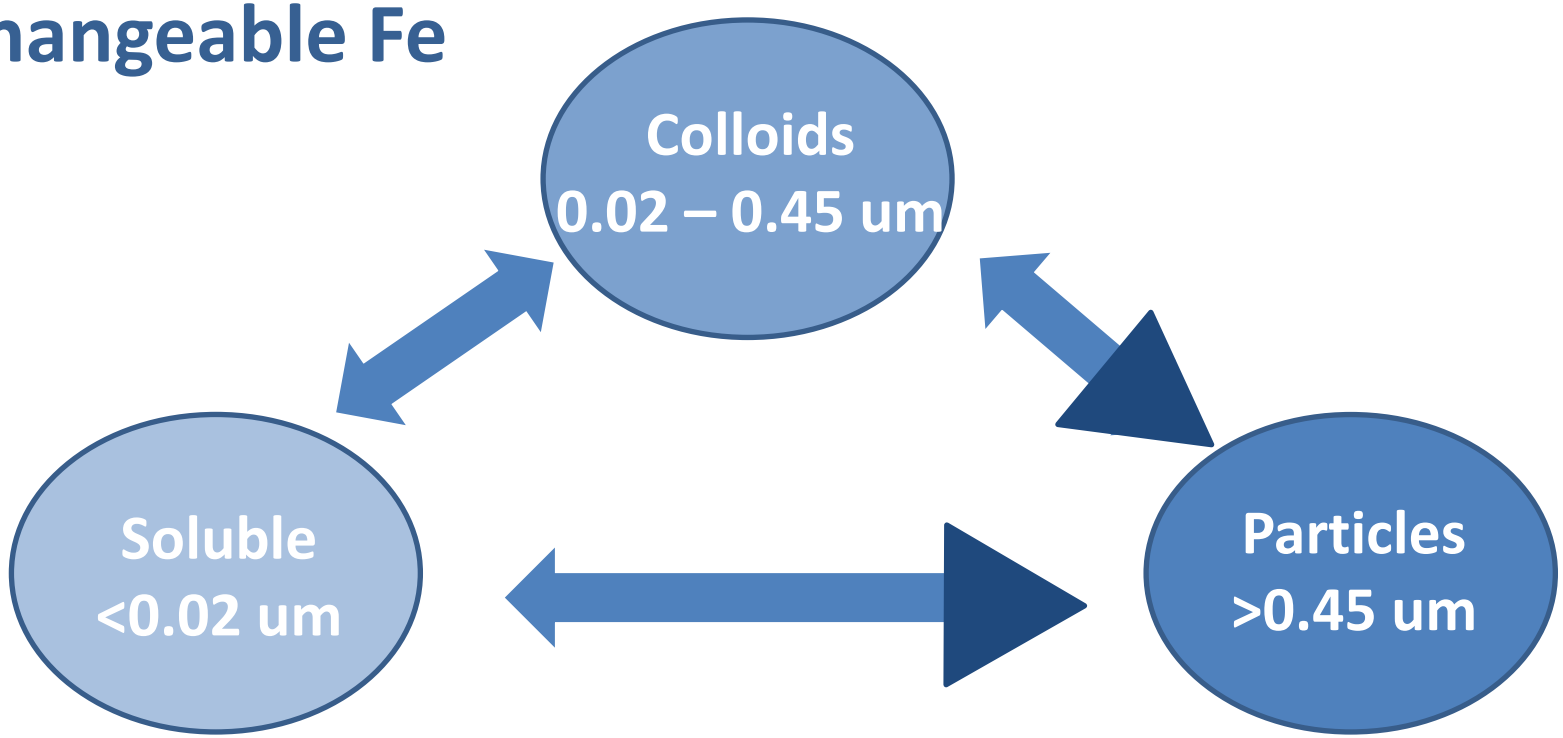
Iron cycling within the shelf system

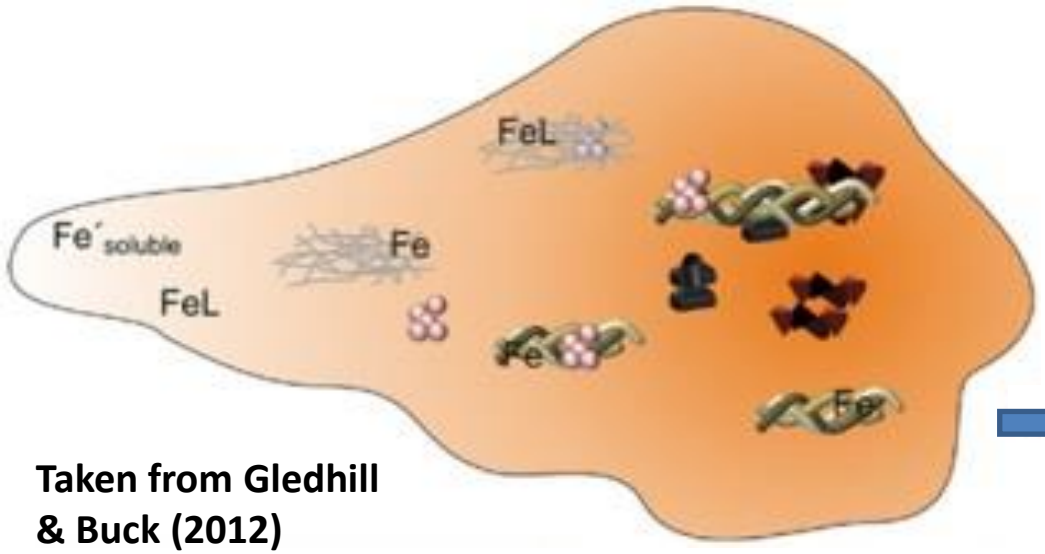


Deeper Off Shelf Waters

Data from Fe transects

Exchangeable Fe





Increasing particle size

Taken from Gledhill & Buck (2012)