What does (/do variations in) the CCD ‘mean’?

University of California, Riverside
University of Bristol, Bristol, Europe

+ as of 08/27/2016
East/West CCD basin asymmetry during the LGM?

Sediment composition (wt% CaCO₃)

Archer [1996] n = 4447
East/West CCD basin asymmetry during the LGM?
East/West CCD basin asymmetry during the LGM?

Sediment composition (wt% CaCO$_3$)
What is the CCD?
What is the CCD?

Sediment composition (wt% CaCO$_3$)

Depth (km)

Hypsometric curve
What is the CCD?
Increased weathering and solute supply to the ocean == deeper CCD???
What is the CCD?

Decreasing atmospheric CO$_2$ and reduced ‘ocean acidiciation’
==
deeper CCD???
What is the lysocline?
What is the lysocline?

“The lysocline is the depth in the ocean below which the rate of dissolution of calcite increases dramatically.”

[Wikipedia]

‘a dissolving or loosening’ of [carbonate content that] ‘possesses or exhibits gradient’ [from the Greek: ‘lyso’ and ‘cline’]
Where is the saturation horizon?
Where is the saturation horizon?
Characterizing the marine-pelagic carbonate sink

![Graph showing depth (km) vs. wt% CaCO₃ with markers for the lysocline and saturation horizon (Ω = 1).]
Characterizing the marine-pelagic carbonate sink

wt% CaCO$_3$

Depth (km)

saturation horizon ($\Omega = 1$)

lysocline

CCD (base of the ‘calcicline’)

‘calcicline’
Characterizing the marine-pelagic carbonate sink [Earth 2.0]
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wt% CaCO$_3$ vs. Depth (km)

- Saturation horizon ($\Omega = 1$)
- 'Calcicline'
- Lysocline
- CCD (base of the 'calcicline')
Characterizing the marine-pelagic carbonate sink [Earth 2.0]

Cumulative sea-floor area
Cumulative CaCO₄ burial
Area per 100m depth
Cumulative sea-floor area
Burial per 100m
Cumulative CaCO₄ burial
Mean CaCO₃ preservation

Depth (km)
wt% CaCO₃

0 20 40 60 80 100
0 20 40 60 80 100
CCD variability (or not) in shallow-time

Farrell and Prell [1989]
Increased weathering and solute supply to the ocean
==
deeper CCD???
CCD variability (or not) in deep-time ('LPEE')

✓ ~9 Ma interval of pronounced (~4°C) and progressive warming of the Earth's surface.
✓ (We want to test the link between warming, increased weathering, CO2 draw-down, and Earth system regulation.)
Increasing atmospheric $p\text{CO}_2$. 

**Beerling and Royer [2011]**
Mostly ... characterized by declining $\delta^{13}C$ values, consistent with net input of isotopically light carbon (if we take a hypothesis of increased volcanic CO$_2$ input as the driver).
Slightly deepening CCD ... but much less than box models predict (e.g. Komar et al. [2013]).

Very sparse data coverage, not meaningfully updated since 1975.
CCD variability (or not) in deep-time ('LPEE')

Three data slices spanning LPEE interval (and avoiding PETM).

Greene et al. [in revision]
CCD variability (or not) in deep-time ('LPEE')

Site distribution (and existing crust older than 55 Ma).

Greene et al. [in revision]
CCD variability (or not) in deep-time ('LPEE')
CCD variability (or not) in deep-time (’LPEE’)‘CCD’ plots.

H₀: warming (=> increasing weathering?)

NP12-13 (~53-49 Ma)          NP10-11 (~55-53 Ma)          NP8 (~58-57 Ma)

wt% CaCO₃  wt% CaCO₃  wt% CaCO₃

Atlantic ▲ Indian ● Pacific ▼

Greene et al. [in revision]
CCD variability (or not) in deep-time (’LPEE’)

‘CCD’ plots.

H₀: warming (=> increasing weathering?)

NP12-13 (~53-49 Ma)  NP10-11 (~55-53 Ma)  NP8 (~58-57 Ma)

Contours are of relative data density within a sliding time-window (and wt% bin). Red contour delineates 50% of the data.

Greene et al. [in revision]
increased CO₂ out-gassing

\[ \text{variable } p\text{CO}_2 \]

\[ \text{~3x } \text{pre-industrial } p\text{CO}_2 \]

\[ \text{~6x } \text{pre-industrial } p\text{CO}_2 \]

\[ \text{~12x } \text{pre-industrial } p\text{CO}_2 \]

\[ \Rightarrow \text{ higher atm } p\text{CO}_2 \text{ and weathering @ steady state} \]
The CCD cannot be used on its own as an indicator of global weathering rates or climate.

#deadproxy
Conclusions

Farrell and Prell [1989]

60% CaCO₃
‘Conclusions’
Credits

Sarah Greene, Daniela Schmidt [Bristol]
Sandy Kirtland Turner [UCR]
Ellen Thomas [Yale]
Heiko Päike [Bremen]

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