The Martin Curve

Paraphrasing Tom Trull from the VERTIGO website… *it’s the Law, but is it a good Idea?*

\[
F_z = F_{100} \left( \frac{z}{100} \right)^{-b}
\]

Does it fit the data any better than other functional forms, for instance that proposed by **Lutz et al. (2002)**:

\[
F_z = F_{labile} e^{-\left( \frac{D}{W} \right)z} + F_{refrac}
\]

If flux attenuation is completely due to in-situ remineralization, then degradation rates of unpoisoned material can be used to estimate sinking rates through comparison of remineralization length (time/space) scales…

define remineralization length scale as e-folding scale (time or depth over which flux changes by 1/e):
The Martin Attenuation Curve is matched with exponential decay to zero, while Lutz Attenuation Curve is matched with exponential decay to a constant.

Lutz Curve matches the data better (esp. if you include deep trap data)...but Martin Curve appears to require increasing bulk sinking rates, which is consistent with increasing importance of ballasting biomineral phases.

**Is Reality somewhere in between?**

$$1 = \frac{F_{100} \left( \frac{z_2}{100} \right)^{-b}}{e} = \left( \frac{z_2}{z_1} \right)^{-b}$$

$$\therefore \frac{z_2}{z_1} = e^{-b}$$

$$L_{\text{depth}}^{\text{Martin}} = z_2 - z_1 = z_1(e^{-b} - 1)$$

$$F = F_{t=0}e^{-kt}$$

$$L_{\text{time}}^{\text{Martin}} = \frac{1}{k}$$

$$S_{\text{Martin}} = z_1k(e^{-b} - 1)$$

sinking rate accelerates with depth!
VERTIGO Unpoisoned Particulate Degradation Experiments

1. quarter filter washed into incubation bottle using 0.2 µm filtered 500m water

2. water/particle mixture occasionally agitated, incubated at depth appropriate temperature in dark. 150m: 25 ºC; 300m: 15 ºC; 500m: 4 ºC

3. at particular times, incubation bottle agitated and aliquot removed by clean syringe. mixture is filtered on 0.2 µm PC, with liquid subsamples going for nitrification experiments (\(^{15}\text{NH}_4^+\)), ICPMS and DOC. filters rinsed and dried for ICPMS. half PC filter washed onto Ag filter for POC.
Unpoisoned Remineralization Rates

More elements showed remineralization in these experiments than in the poisoned experiment, but not all…
Sinking Rates for Comparison of Remineralization Rates and Attenuation Lengths (deployment 1)

<table>
<thead>
<tr>
<th>Element</th>
<th>Apparent sinking Rate (m d⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ba</td>
<td>114 - 233</td>
</tr>
<tr>
<td>Mg</td>
<td>slow - 294</td>
</tr>
<tr>
<td>Al</td>
<td>undefined</td>
</tr>
<tr>
<td>P</td>
<td>14 - 43</td>
</tr>
<tr>
<td>Ca</td>
<td>51- fast</td>
</tr>
<tr>
<td>Sc</td>
<td>fast</td>
</tr>
<tr>
<td>Mn</td>
<td>slow</td>
</tr>
<tr>
<td>Fe</td>
<td>fast</td>
</tr>
<tr>
<td>Co</td>
<td>Slow - 107</td>
</tr>
<tr>
<td>Ni</td>
<td>undefined - slow</td>
</tr>
<tr>
<td>Sr</td>
<td>77 - 219</td>
</tr>
</tbody>
</table>

For elements where attenuation and remineralization both seen, the analysis suggests sinking rates comparable to those observed directly…remineralization can explain the vertical profiles!

For the others, analysis suggests constrained fast or slow rates…either approach is breaking down or perhaps other factor important (particle type, grazing)

slow=attenuation in flux profile seen, but little remineralization on 5 day timescale.

fast=vertical profile doesn’t show much attenuation, but some remineralization seen.

Martin, Lutz give comparable results.