Revisiting earliest Cambrian skeletal fossil first appearance ages with a $\delta^{13}C_{carb}$ alignment algorithm

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Abstract: $\delta^{13}C_{carb}$ chemostratigraphic correlation facilitates the interpolation of age models developed at adiometrically calibrated, carbonate-bearing stratigraphic sections to others lacking temporal constraints. For Cambrian applications, this practice commonly assigns ages to fossil first appearances, thereby constraining the tempo of early animal evolution. The robustness of the resulting evolutionary insight relies, in part, on the identification of a single, unique alignment solution between a time-calibrated and time-uncertain section, yet visual based correlation methods cannot evaluate this premise. Here, we review the dynamic programming method for obtaining globally optimal alignments (in a least squares sense) between two $\delta^{13}C_{carb}$ records subject to penalties on the insertion of hiatuses (that stretch and squeeze the time axes) and the similarity of the duration of the two records. We employ dynamic programming to assess alignments between a radiometrically calibrated Cambrian Series 1–2 $\delta^{13}C_{carb}$ reference curve (Maloof et al., 2010) and uncalibrated, fossiliferous sections . We present a library of $\delta^{13}C_{carb}$ alignments that both support the statistical significance of published visual alignments between the $\delta^{13}C_{carb}$ records and also yield additional, significant correlation solutions. We conclude that each valid alignment between a reference and time-uncertain section predicts a distinct age for a hypothetical fossil first appearance at the latter; for the Cambrian Series 1–2 case study, this range of ages can exceed 4 Myr. We advocate that the age uncertainty in a fossil datum arising solely from multiple valid chemostratigraphic alignments should propagate into error estimates for inferred tempos of animal evolution.