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Discussions

Interactive comment on "Mass extinctions past and present: a unifying hypothesis" *by* S. A. Wooldridge

Anonymous Referee #3

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The paper by Wooldridge presents an original hypothesis tempting to explain pass and present mass extinctions. If the author recognize that several trigger mechanisms may explain the five major mass extinctions, it is suggested that they can be all explained by a single underlying "Kill mechanism". A large body of arguments based only on a bibliographical data is presented to argue that a single enzyme, the urease that catalyze the hydrolysis of urea to form ammonia and carbon dioxide, may be this unifying kill mechanism.

To support this hypothesis, the author argues that the enzyme has a "wide biological distribution", is "important during the early stages of development", may facilitate "biomineralisation of calcium carbonate by invertebrates". Based on the fact that the major extinctions were linked to change in seawater pH (figure 1), it is suggested

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that urease function may be impaired since this enzyme is highly sensitive to pH and present "a strong pH-dependent activation".

The author presents this hypothesis as testable, which is right. However, if I think that putting theoretical hypothesis forward may fertilize the research by opening new doors, they have to be realistic, however, I think that the urease hypothesis, while highly attractive, poses some problems.

1. Distribution of Urease among eucaryotes Urease is mainly a prokaryotic enzyme, and no genes or proteins were found in database from animals. If some authors measured urease activity within invertebrates (corals, mollusca, crustaceans), a bacterial contamination cannot be ruled out (as already noted by authors of these measurements themselves). It should be noted that except the paper by Pedrozo et al. (1997) all other studies were published in the seventies. Therefore the author has to first demonstrate the reality of the suggested "wide distribution among invertebrates"; before hypothesizing that urease play a major role as a unifying kill mechanism.

2. pH sensitivity The author bases a large part of his theory on the "strong pH-dependent activation"; of urease. For this, he used the data of Barnes and Crossland (1976) who demonstrated "two pH optimum (7.6 and 8.2) identified in the urease activity profile of the scleractinian coral Acropora acuminata". A figure, adapted from these data is presented (Fig 2). However, if Barnes and Crossland (1976) effectively studied urease activity in function of external pH, they did not found two pH optimum on a single preparation as suggested by Wooldridge, but rather several pH optimums depending on the buffer used for extraction and/or measurements (TRIS, HEPES, PBS). Figure 2 is therefore misleading.

3. Adaptation of pH-dependent enzyme Excepted for instantaneous catastrophic events for which a pH-dependent process may be a good kill mechanism, one may suppose that seawater pH changes during a "trigger mechanism"; would take a long period of time during which adaptative process would occur.

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4. Why Urease? Why the common kill mechanism would be supported only by urease although a strong pH-dependence is a mechanism widely distributed among enzymes? Probably other enzymes would satisfy the three conditions presented by the author (explain all of the losses, explain why particular groups died while other survived, based on a process that happened).

5. Urease and biomineralization Although the hypothesis of urease playing a role of hydrogen ion acceptor during the calcifying process is attractive, it is until now mainly a working hypothesis not generally accepted.

6. Urease and evolution The author suggests that higher vertebrates lack urease since "previous mass extinction events appeared to have guided the evolutionary process away from urease-dependence"; (Paragraph 6). Selective pressure is applying during the course of evolution of all organisms, not only vertebrates, which underwent the same evolution than "lower invertebrates".

Interactive comment on Biogeosciences Discuss., 5, 2401, 2008.

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