D R A F T
Mass extinctions triggered by terminations of earth's magnetic field superchrons

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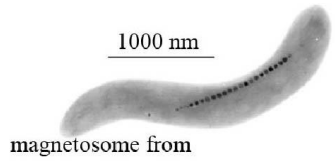
A hypothesis is presented to explain the principal cause of the four or five largest mass extinctions in the earth's history, when up to 90% of species disappeared, suddenly with limited evidence for the cause of their demise. The hypothesis draws upon evolutionary pressure, unstable behavior of the earth's magnetic field and the presence in all species of animals since the Precambrian of an organelle that responds to the earth's magnetic field for local and long distance navigation, orientation and homing, otherwise called *magnetotaxis*. Magnetic positional information has been reported in several tens of phylogenetically varied life forms and appears to function over a wide range of spatial scales. Organisms would naturally incorporate such magneto-orientation, absent any subliminal restraints, as one of the fundamental senses and thus grant themselves a competitive evolutionary advantage.

This mechanism is suggested to utilize a magnetosome-based magnetolith in a lagena chamber or the vestibular mechanism, or its equivalent, with the brain integrating the sense with vision and general positional information in their interactions with the outside world—not specifically a cardinal magnetic direction, but rather inclination, relative horizontal and to some degree, intensity. For these magneto-receptors to be functional, it would be critical for the earth's magnetic field to be stable over long periods. During most of the earth's modern 550 million year history of the Phanerozoic, though, the earth's magnetic field completely reverses itself at random times in a bi-stable equilibrium manner every few hundred thousand to a million years or so, making it unlikely that organisms would successfully and totally depend upon such magnetic navigation–constrained by some unexplained evolutionary long-term influence that keeps species from such dependence on an unstable natural reference.



magnetosome from
Magnetospirillum magnetotacticum

However, in four (possibly five) anomalous instances, the earth's magnetic field has remained stable, that is, it did NOT reverse, for extended periods of 35 to 50 million years each. These periods, called superchrons, each such quiet period terminating suddenly, perhaps episodically (e.g., near end of Cretaceous), marked by the otherwise frequent periodic reversals. *The abrupt terminations of these superchrons generally coincide with the major mass extinctions.* In fact, the longest (50 million years) of these superchrons ended at about the time of the greatest mass extinction—at the Permian-Triassic boundary. These superchrons are hypothesized to have lasted long enough, say, 10 million years or so, to have allowed, evolutionarily-speaking, species to attempt to exploit (even totally) magnetotaxis senses to their great advantage.

Evolution will select for those species which derive competitive benefits from a specific behavior, the more critical the benefit, the more likely it is to be adopted. Consider, then for example, marine species, where navigational assistance would be a great asset and therefore faced strong pressure to try and then adopt magnetotaxis (i.e., in the late Permian). Land-based dinosaurs need greater assistance that their airborne cousins (i.e., in the late Cretaceous) and were likely taking advantage of the navigational benefits of magnetotaxis.

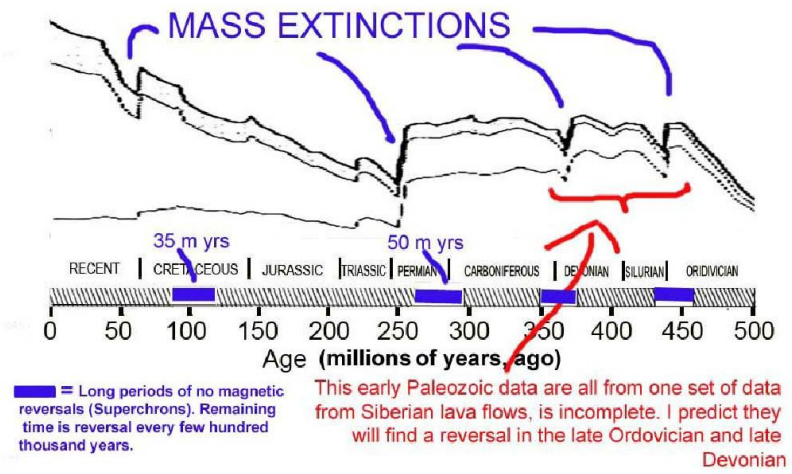
If this is true, those species which did indeed exploit magnetotaxis would demonstrate greater diversity of families, genera and species. *But, the very advantages conferred on these organisms that so benefited them was also their weakness in the face of the sudden and profound disruption of their connection to their surrounding environment.* The magnetic field reversals would sever this sense resulting in a profound loss of equilibrium and their ability to navigate, find food and propagate and this state of affairs thus doomed them. The more dependent upon their magnetotaxis, the more likely they would not survive.

Thus, the return to the otherwise normal, but bi-stable behavior of the earth's magnetic field also marked the end of these bountiful evolutionary periods. It was very likely that the magnetic field reversals that

marked the end to the superchrons may have been episodic, but such granularity or resolution in magnetic field reversals is not clear in the paleomagnetic record. The episodic behavior, if it could be discerned in the paleomagnetic record, could explain the longer delay time between the supposed 'end' of the Cretaceous Superchron and the mass extinction at the end of the Cretaceous.

This explosive growth cycle repeated itself using magnetotaxis several more times from among the surviving species to blossom once again in the next superchron.

The length of time between the end of each superchron and the subsequent mass extinction increased and the number of species terminated decreased for subsequent mass extinction events. It is tempting to explain these correlations as *long-term* evolution selecting *against* those species who attempt to exploit such seemingly advantageous *sense-du-jour*.



The earth's main or dipole magnetic field originates in the liquid outer core below the core-mantle boundary (CMB). The end of these long, stable but anomalous states of earth's magnetic field conditions have been shown to be associated with cataclysmic convection events at the CMB. These CMB eruptions also produced the superplumes and other surface expressions of volcanic and tectonic events such as the massive Siberian Trap and Deccan Trap volcanic flows, opening of the Atlantic basin at the breakup of Pangaea, etc. Some also produced noxious gases and global warming effects. Therefore, the termination of the superchrons and the volcanic events are correlated as both are consequences of the same cataclysmic events in the outer core.

These volcanic events, along with a meteor impact at the end of the Cretaceous, have been singled out as among the principal causes of mass extinctions. While it is possible that some of these effects may have contributed to these extinctions events, I propose that it is largely the putative magnetic-field dependence of these species and the abrupt termination of these quiet magnetic periods that is the principal cause of their demise. Perhaps the best evidence in support of this hypothesis would be much greater and more rapid diversity of those species which experienced extinction compared to other species which survived.

The timing of superchrons are not that well established. None has been observed (thus far) in the Triassic, for example, and thus that mass extinction event has no superchron association. Then, the mass extinction in the Triassic did not appear as significant in terms of loss of genera as the other four such events.

This is a draft summary of the basic idea and is intended only for drawing comments and input before, and if, it is to be submitted for peer review. Ample references would then be included, of course.

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