End-Mesozoic Climatic Changes in Tethyan Marginal Seas

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Summary: The absence of marine halite and potash deposits from marginal seas of the Tethys Ocean in latest Cretaceous to earliest Tertiary time is deemed to have been caused by a change in solar radiation and not by structural alteration of the coast line.

Resume: L'absence des depots de halite et de potasse des mers marginaux a l'ocean tethysien de la periode Cretacee terminale jusqu'au commencement du Tertiaire est juge etre causee par un changement en radiation solaire et non pas par une alteration structurelle dans la ligne de la cote.

Cretaceous and Tertiary pole positions for ponts around the north rim of the Tethys Sea vary only a few degrees from present values. Polar wandering and continental drift can, therefore, be neglected in considering climatic changes in this area.

Marine evaporites have accumulated in various embayments over and over again throughout the Phanerozoic eon. The source of these evaporites has often been no more than leached older deposits exposed to erosion by ground and surface waters.

Lower and Middle Cretaceous evaporite occurrences show an arcuate distribution from southeastern Europe to central Asia. If we superpose the present-day dry belts, particularly the areas of winter rains, we find a surprising overlap. The dry belts strike today N25E and that is not only caused by the lower specific heat of the interior of the Eurasian land mass. They strike S25E in the southern hemisphere. This strike is probably a function of the average inclination of the earth's axis to the ecliptic, if we take the Chandler wobble into consideration. The same strike of dry belts seems to have pertained to Cretaceous evaporites.

The distribution of marine evaporites in Oligocene and younger beds shows the same arcuate distribution as that indicated by Lower to Mid-Cretaceous deposits. In many cases, the same embayments were the loci of evaporite deposition in both periods. That would suggest that these embayments were also in existence in the intervening interval, when the sediments were muds, sands, occasional limestones, but not marine evaporites.

A close scrutiny of evaporite deposits of Maestrichtian, Danian, Paleocene and Eocene age reveals a lack of marine halite and potash deposits, not only along the north rim of the Tethys Sea, but anywhere in the world. True enough, there are large-scale gypsum and Na/Ca sulfate deposits of Eocene age scattered through western Europe, the Pamirs, the Tien-Shan and to South China. However, sodium sulfates are typical continental deposits and merely prove that the dry belts had not vanished or migrated to the Arctic Circles. For some global reason they were not able to produce saturated, hypersaline brines in seas marginal to the Tethys Ocean.

It is this interval of time that produces drastic changes in the composition of both terrestrial and marine faunas, but hardly affects the plant life. Coal and lignite seams, scattered all over the northern hemisphere, are singularly unsuited to delineate the Cretaceous-Tertiary boundary. The faunal response to some adverse changes in the environment is staggered and spasmodic. Major changes affect both land and aquatic faunas in each stage beginning with mid-Senonian time. The sequence is all too well known:

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By the end of Senonian time, both ichthyosaurs and flying pterosaurs bow out. The end of Maestrichtian time sees the sharp reduction in number of species of dinosaurs and related reptiles, but the expansion of snakes. By the end of the Cretaceous, the dinosaurs die out, but so do plesiosaurs, rudists, ammonites and several families of gastropods. The foraminifera were almost eradicated. Among insects, the social forms suddenly blossom forth, such as ants and termites, as well as the spinning Emboidea and the parasitic forms, such as the Strepsiptera and the Siphonoptera (fleas), which utilize the microenvironment of a host, be it a grasshopper, a wasp or a dog.

We now know that belemnites and Inoceramus, some brachiopods, scaphopods and hagfish, as well as the still surviving Crossopterygians or lobefin fish, simply moved at the end of the Cretaceous to colder or deeper waters. They are only found in late Cretaceous sediments that indicate much higher water temperatures than registered by their own oxygen isotope ratios. Belemnites and Inoceramus died out in Eocene time, when on land the primitive eosuchian reptiles and the multituberculate mammals disappear.

The Paleocene represents the peak of whatever inimical conditions had affected the earth. The appearance of worm-like burrowing lizards, the sudden diversification of snakes and of belly-dragging lissamphibians indicates that there seemed to have been a distinct advantage to being close to the moist ground. Of all marine and terrestrial animals only the placentals lack photo-reactivating enzymes to repair damage to DNA induced by exposure to ultraviolet light. Instead, they have a thick, multi-layered, pigmented skin that tans readily and absorbs almost all the UV-light within the uppermost 100 microns.

The placentals seem to have originated in mid-Senonian time in the interior of the land mass to the north of the Tethys Sea, in a desert environment with red beds, concretions, flash-flood conglomerates, and thus also high rates of insolation. They continued to eke out an existence, until they suddenly diversified in Eocene time into a multiplicity of adaptations. Many abortive attempts were also made to respond to the adverse environment, judging by the number of orders and families that failed and died out again in Eocene or early Oligocene.

This adds up to a picture of plants, immune to UV-radiation, being unaffected by the adverse conditions setting in; terrestrial animals with either protection against UV-radiation damage of sensitive nucleic acids, able to burrow, or build their own internally climatized communal mounds and nests, appear to have a decided advantage over others; eurythermal swimmers and floaters appear to replace more stenothermal forms in shallow-water domains which absorb most of any radiation increment hitting the waters.

It is suggested that between late Senonian and late Eocene time the earth's magnetosphere was damaged to the extent that high energy solar particles were intermittently able to penetrate and scavenge the ozone layer by ionizing upper atmosphere nitrogen. This event did not take place during the brief period of any one reversal of geomagnetic polarity, but was spread in varying degrees of intensity over a period of about 40 million years. It led to high levels of ultraviolet radiation reaching the earth's surface, heating up land masses and oceans alike.

The presence of continental evaporite deposits all along the northern margin of the Tethys proves that air circulation had not changed its pattern. The equatorial Walker cells, the Intertropical Convergence Zone, the Hadley cells of Trade and anti-Trade circulation, the subtropical Horse Latitudes of descending, parched air masses, and the Prevailing Westerlies had not changed their locale. They had merely tightened their vorticity, increased their kinetic energy and their ability to export solar energy into high latitudes. With tighter coils of tropical high pressure cells, the surface area subject to high evaporation rates is reduced, saturated winds travel a longer path between parallels, rain showers become more frequent and are spread over wider areas. The establishment of density stratification, hypersaline brines and of anoxic bottom waters in embayments of the Tethys Sea is therewith stalled.

This explains the absence of marine halite and potash deposits from latest Cretaceous to earliest Tertiary sediments in marginal seas of the Tethyan Ocean, so abundantly endowed by such precipitates in periods either preceding or succeeding this interval of time. No changes in geological structure of these basins need be postulated or invoked to account for this absence.

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