A GENERAL THEORY OF MASS EXTINCTIONS IN THE PHANEROZOIC, II. A BRIEF OUTLINE;

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"Any physical theory is a kind of guesswork" Richard P. Feynman*

In Part I of my previous paper [1], I listed 24 observations and constraints associated with the K/T (Cretaceous/Tertiary) boundary at 66.4 Ma and other extinction boundaries throughout the Phanerozoic that must satisfy any general theory of mass extinctions. This paper will briefly outline a general theory that, in my opinion, satisfies the above [1] criteria. Not only must these 24 criteria be satisfied, but all other phenomena associated with mass extinctions. References in [ ] are found in the Reference section; references in ( ) refer to the numerical observations and criteria listed in [1].

1. A 32±2 Ma extinction pattern throughout the Phanerozoic [1] is attributed to the interaction of extraterrestrial swarms at 32±2 Ma intervals of ~0.5-2 km diameter cometesimals [2] (arrival interval of 1-3 Ma [3] or a larger ~30-40 km diameter comet ejected from the Oort Cloud of comets (~10^4-10^5 AU) [2-6] by a "Nemesis" star. Cometary nuclei are assumed to have a ρ ~0.3 g/cc of Halley's cometary nucleus [7] and to consist of ice, carbonaceous matter, and rock [8] (C1 chondritic-like primitive solar nebular matter) (2,3,4,5).
2. Cometesimals (16-70 km/s) intersect the earth at random angles and explode (~50%) and completely volatilize 1-100 km above the earth's surface [2,9]. A large ~40 km comet will likely fragment into smaller cometesimals upon entry into the earth's atmosphere, not within the earth's Roche limit before tangential approach to the earth [10]; ~50% of these fragmented cometesimals will subsequently explode, leaving signatures of primitive solar nebular ratios at selected K/T sites. These signatures are dependent upon the local chemical regimes [11] (2,3,4,5,6).
3. Steep angle cometesimal cratering (SACC) events (~50%) (e.g. Manson crater) result from direct cometesimals cratering on continents and oceanic crust [10]. Larger shock quartz grains will be found nearer to crater sites, while smaller grains will be ejected worldwide (7,9).
4. Cometesimal explosions in the earth's atmosphere (CEEA), each equivalent to ~10^6-10^8 Hiroshima Atomic Bombs, are followed by interaction of hot gaseous spheres with continental surfaces for microtektite generation [2] and by randomly torching ~3% of the earth's global biomass to account for soot and charcoal phenomena at 11 sites (10,18).
5. Random CEEA and SACC events will result in variable amounts of Ir (>0-580 ng/cm^2) and other selected trace elements in boundary sediments [10]. The number of CEEA and SACC events at K/T time greatly exceeded the number of events at other extinctions times (4,5,6,11,12,13).
6. Absence of terrestrially cratered Fe in pristine S.R. (Shatsky Rise) carbonate coatings of Fe-Mn-Al-Ti-oxyhydroxides, other than net Fe associated with net Ir of the cometesimals, rules out a direct impact of a large comet or ~8 km asteroid [12] into either the earth's oceanic crust and mantle or the continental crust because of the absence of a 10-30X dilution of cometary Fe by the terrestrially cratered Fe [11]. No postulated [12] 100-200 km diameter K/T crater has been observed (5).
7. Because of the projected low K_{sp}s of Ir oxyhydroxides relative to $Fe(OH)_3$, Ir coprecipitates with $Fe(OH)_3$ from CEEA fallout and is deposited in a veneer above the pristine carbonates. The stability of ReO_4^- and $OsCl_6^{3-}$ in seawater and the higher indigenous oceanic concentrations of Re by ~10^3X and the lower deficiencies of Os by <10^{-2}X and Ir by ~10^{-5}X relative to CEEA fallout account for the observed Re/Os/Ir ratios in pristine S.R. carbonates (5).
8. Absence of C1 abundances of Mn, Co and Ni relative to Ir in pristine S.R. carbonates and the presence of appreciable and relative C1 abundances of Cr is consistent with the K_{sp}s of their insoluble hydroxide compounds (21).
9. SACC events into the oceanic crust (~70% of the earth's surface) [10] produced appreciable crustal fractures and triggered extensive hydrothermal-smoker activities from cold seawater percolating through the fractures, attaining ~300°C, thereby leaching major, minor, and trace elements from bulk and accessary minerals in oceanic basalts. (Hydrothermal-smoker vents were discovered in 1977 by J. Corliss and J.H. Van Andel (Oregon State University) et al. [13].) Hydrothermal-H_2S rich smoker solutions, pHs of 3-4, are highly enriched by ~10^2-10^4X in Be, Al, Co, Cu, Zn, Ag, Cd, Ba and Pb and by ~10-40X in As [14,15]. Significant enrichments of Sb, Hg, Bi, and REE are also expected. Pb enrichments in seawater will mask any cometary Pb additions from CEEA and SACC events (20). Lower oceanic pHs, a more reducing oceanic environment, and pulsed or extended trace element enrichments will be obtained in the oceans (13,14,15,16,17,20,22). Local anoxic regimes in shallow seawater environments will favor large trace element enrichments in both clayey and carbonate sediments (23).
10. Hydrothermal-smoker poisoning of the oceans by enrichments of Co, Cu, Zn, As, Ag, Cd, Sn, Sb, Hg, Pb and Bi and lowering of the oceans' pH by -0.1 to -0.4 units KILLED selected marine families and genera and their food chain dependents. Continental fresh water families and genera are affected insignificantly (1,15,16,24).

* The Feynman Lectures on Physics, R.P. Feynman, R.B. Leighton, and M. Sands (1963).

11. Lowered oceanic pHs (relative to present pHs), initiated before K/T, say ~0.2 Ma, by enhanced hydrothermal-smoker activities, will result in appreciably lower pHs in bottom ocean waters relative to the lower pHs of the upper ~150 m mixed layer, thereby increasing the $\delta^{13}C$ of carbonate ions in bottom water. The lower pHs of the upper oceanic layers will increase the P_{CO_2} and lower the $\delta^{13}C$ of the atmosphere (19).
12. Sufficient energetic rattling of the oceanic crust and mantle via CEEA but principally SACC events at 34, 66, 130, 194, and 258 Ma perturbed the earth's integrated continental-oceanic-crust-mantle system and caused the initiation of major flood basalts such as the activation of the incipient Reunion hot spot [16] and associated vigorous hydrothermal smoker activities for causing extinctions (2,8).
13. At K/T time, ~2000 SACC events from the peak of the cometesimal swarm may have occurred in the oceanic crust-mantle over a $\sim 10^3$-10^4 a interval, as inferred from the Ir dispersions observed in both clayey sediments deposited rapidly (>100 m/10^6a) in shallow seas and carbonates, deposited slowly (<10 m/10^6a) in deep oceans (11,12,13).
14. Energetic rattling of the oceanic crust via SACC events at four times in a 32±2 Ma cycle, i.e. at 2, 98, 162, and 226 Ma, caused enhanced hydrothermal-smoker activities for subsequent seawater poisoning, lower oceanic pHs, and mass extinctions but not initiations of extensive flood basalts (3).
15. Mass extinctions at 370, 440, 505, 550, and 650 Ma, coinciding with a 32 Ma cycle extrapolation beyond 250 Ma, are attributed to hydrothermal-smoker seawater poisoning and lowered oceanic pHs from energetic SACC perturbation of the oceanic crustal-mantle system but with no initiation of flood basalts (3).
16. The absence of both flood basalts and extensive mass extinctions at 282, 314, 346, 410, 474, 570, 602, and 634 Ma on a 32 Ma cycle is attributed to an insufficient number (below threshold) of SACC events for triggering hydrothermal-smoker events and flood basalt initiations (3).
17. The absence of flood basalt initiations from 280-666 Ma is attributed to a lower comet density traversed by the Nemesis star through the Oort Cloud on its elliptical orbit. Conversely, a higher comet density was traversed by Nemesis from 250-2 Ma (2,3).
18. Some mass extinctions off the 32 Ma cycle (with or without flood basalt initiations; e.g. the 14±3 Ma extinction with the Columbia River basalt flood initiation at 17±1 Ma) are caused by hydrothermal-smoker poisoning and lowered oceanic pHs resulting from "random" initiations of plate migrations and associated tectonic reorganization of mid-oceanic ridges [17,18] (1,2).
19. The irregular passage of the solar system and Oort Cloud through galactic clouds may perturb sufficient comets for subsequent CEEA and SACC events, resulting in off cycle extinctions (1,2).
20. Subdued hydrothermal-smoker activities during the ~75-58 Ma interval (Maastrichtian through the Paleocene) lowered seawater pH, resulting in higher trace element concentrations in seawater (e.g. REE by ~2X) and higher P_{CO_2} levels ("greenhouse effect") in this ~17 Ma interval (15).
21. Enhanced pulses of hydrothermal-smoker activities before K/T time, e.g. ~0.2-0.3 Ma, at K/T time, and after K/T time, e.g. 0.3 Ma, 1.2 Ma, may be generated by SACC triggering events related to early and late arrivals of cometesimals over a 1-3 Ma interval [3] (1,13,16).
22. Worldwide climatic changes occurred from the voluminous emission of SO_2, CO_2, and other gases from extensive flood basalts. Ensuing environmental stresses caused the demise of selected land families and genera and their dependent families and genera; e.g. plant-eating dinosaurs, and in turn, their carnivorous cousins [e.g. 19].
23. Some "random" and localized extinctions may result from global climatic, sea level, and other changes [e.g. 20,21].
24. A red or brown Nemesis dwarf, the Sun's companion, is expected to be ~2 Ma beyond perihelion and ~0.5-1.5 light years distant.

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Any merit in this theory is dedicated to the memory of the late Prof. Luis W. Alvarez, whose keen insights about Ir at the K/T have stimulated interdisciplinary studies of extinction phenomena.