European Journal of Applied Sciences – Vol. 13, No. 05
Publication Date: September 10, 2025
DOI:10.14738/aivp.1305.19381.
Herndon, J. M. (2025). Protoplanetary Formation of Earth: Explanation of Magnesium, Calcium, and Aluminum Enrichment in the Upper Mantle and Crust and in the Moon and the Retention of Primordial Water. *European Journal of Applied Sciences, Vol - 13(05).* 59-71.

Protoplanetary Formation of Earth: Explanation of Magnesium, Calcium, and Aluminum Enrichment in the Upper Mantle and Crust and in the Moon and the Retention of Primordial Water

J. Marvin Herndon, Ph.D.
Transdyne Corporation
Dewees Island, SC USA

ABSTRACT

In 1944 Arnold Eucken showed that the first primordial condensate from a cooling gas of solar composition at high-pressures, high temperatures would be molten iron, followed at lower temperatures by silicate minerals, and at still lower temperatures, by ices and gases. I validated the protoplanetary origin of Earth in the following ways: 1) By thermodynamic considerations I connected high-pressure, high-temperature primordial condensation with the oxidation state and minerals of the enstatite chondrites and; 2) By ratios of mass I connected the minerals of the Abee enstatite chondrite to the components of Earth's interior. According to Eucken's paradigm, at high-pressures, high-temperatures iron metal first condenses as a liquid followed by mantle silicates. However, at the next step of his paradigm, following lower mantle condensation, there appears to be no thermodynamically feasible way to account for the "excess" elements, magnesium, calcium, and aluminum remaining in the gas phase (for subsequent condensation), at least none I have been able to ascertain in decades of investigation. Here, I propose an Eucken paradigm shift, provide petrologic evidence for it, and briefly discuss concomitant implications on planetary and lunar formation, and planetary retention of primordial water resources with focus on the formation of Earth's oceans. According to the Eucken paradigm, molten iron first condenses, followed by condensation of the lower mantle silicates. I propose instead that virtually all of the elements of the endo-Earth (lower mantle plus core) are contained in that first liquid condensate, defined as *endo-E condensate*. Such a circumstance would provide a means for incorporating primordial water into mantle silicates and leave the three "excess" elements, magnesium, calcium, and aluminum in the gas phase to condense later as part of the matter that formed the outer portion of Earth and the Moon.

INTRODUCTION

In 1755, Kant [1] set forth a hypothesis on the origin of the sun and planets that was modified by Laplace [2] four decades later. Laplace's nebula hypothesis was the forerunner of the modern protoplanetary theory of planet formation in which planets are thought to form within giant gaseous protoplanets. The protoplanetary theory attracted scientific attention in the 1940s-50s [3-5], but was abandoned and ignored by computer-model makers in the early 1960s-70s who favored the planetesimal theory [6, 7].

In 1944, Eucken [3] published a scientific article entitled "*Physikalisch-chemische Betrachtungen ueber die frueheste Entwicklungsgeschichte der Erde*" [Physico-Chemical Considerations about the Earliest Development History of the Earth] (Figure 1). From thermodynamic considerations, Eucken investigated condensation from a gas of the composition of the outer part of the sun. That solar-matter consists mostly of hydrogen and helium, but contains small amounts of nearly all of the chemical elements, and is thought to resemble the primordial matter from which the planets formed.

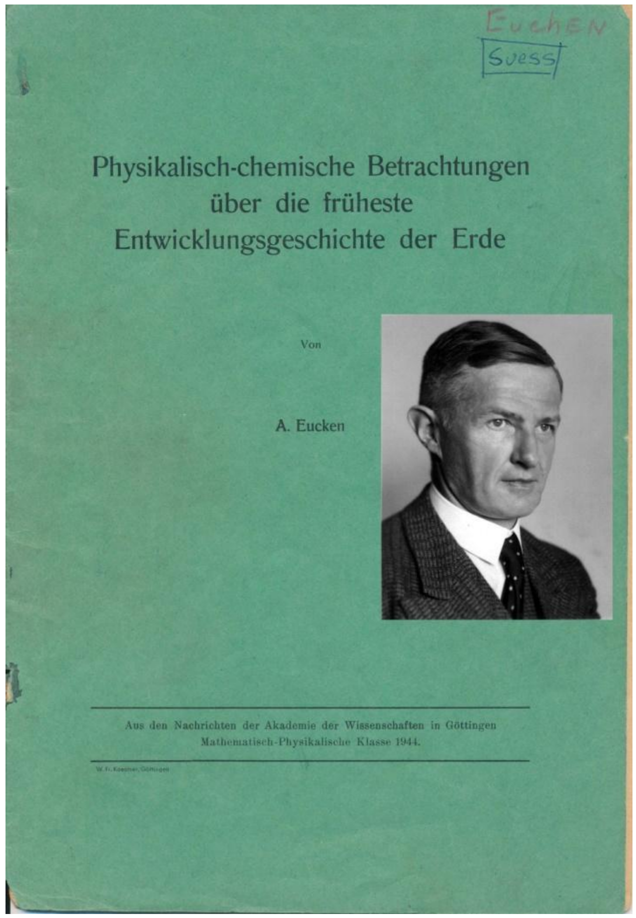

Figure 1: Rare copy of Arnold Eucken's 1944 scientific article [3] with his photograph added. Courtesy of Hans E. Suess.

Eucken showed that the first primordial condensate from a cooling gas of solar composition at high-pressures would be molten iron at high-temperatures, followed at lower temperatures by silicate minerals, and at still lower temperatures, by ices and gases. In other words, condensing from within a giant gaseous protoplanet, the formation of Earth began with liquid iron metal raining out to form its core, followed by the condensation of minerals to form its mantle, and further condensation of ices and gases yielding a planet similar in mass to Jupiter.

In 1976, Suess and I [8] verified Eucken's calculations and additionally showed that high-pressure, high-temperature condensation from solar-matter would not only lead to molten iron being the most refractory condensate, but lead to a highly-reduced (oxygen-starved) condensate similar to certain enstatite chondrites, provided the condensate was isolated from reaction with ambient gases at low temperatures.

I validated the protoplanetary origin of Earth in the following ways [9]: 1) By thermodynamic considerations I connected high-pressure, high-temperature primordial condensation with the oxidation state and minerals of the enstatite chondrites [8], and; 2) By ratios of mass I connected the minerals of the Abee enstatite chondrite to the components of Earth's interior [10-13], as shown in Table 1. For details, see [13].

Table 1. Comparison of fundamental Earth mass ratios with corresponding ratios for the Abee enstatite chondrite

Fundamental Earth Ratio	Earth Ratio Value	Abee e.c. Ratio Value
Lower Mantle Mass to Total Core Mass	1.49	1.43
Inner Core Mass to Total Core Mass	0.052	theoretical 0.052 if Ni_3Si 0.057 if Ni_2Si
Inner Core Mass to Lower Mantle + Total Core Mass	0.021	0.021
D" CaS + MgS Mass to Total Core Mass	0.09	.011
ULVZ of D" CaS Mass to Total Core Mass	0.012	0.012

Earth's initial formation as a Jupiter-like gas giant, codified as *Whole-Earth Decompression Dynamic*s [14, 15], is the replacement for problematic plate tectonics.

Whole-Earth Decompression Dynamics [14], the underlying basis of most geology, geophysics and surface phenomena, is predicated upon the understanding that Earth had fully condensed as a Jupiter-like gas giant. When the sun's thermonuclear reactions ignited, the resulting T-Tauri solar winds stripped the ices and gases from Earth's surface [14-18] leaving Earth compressed to about 2/3 its present diameter and fully surfaced by continental rock.

Two powerful, previously unknown energy sources follow from Earth's protoplanetary origin, a central nuclear fission breeder reactor [17, 19-23] and the much more powerful stored energy of protoplanetary compression [14, 24, 25]. An intrinsic relation between the two exists that is manifest in connection with their response to changes in solar activity and geodynamic consequences [26].

As described by *Whole-Earth Decompression Dynamics* [14], during whole-Earth decompression, as Earth's volume increases, its surface area increases by the formation of decompression cracks. *Primary decompression cracks* with underlying heat sources extrude hot basalt-rock, which flows by gravitational creep until it falls into and infills *secondary decompression cracks* that lack heat sources.

The chains of volcanoes that form the mid-ocean ridge system, encircling Earth's surface like stitching on a baseball, represent a major system of primary decompression cracks. Basalt extruded from these volcanoes forms new seafloor, and flows by gravitational creep across the ocean basins until it falls into and infills secondary decompression cracks that are often located on continental margins. Prominent examples of secondary decompression cracks include the circum-Pacific trenches.

Whole-Earth Decompression Dynamics [14] explains the myriad submarine geological features, usually attributed to plate tectonics theory, without requiring physically impossible mantle convection [13]. Plus, *Whole-Earth Decompression Dynamics* [14] explains oceanic troughs, inexplicable in plate tectonics, as partially-infilled secondary decompression cracks.

As described by *Whole-Earth Decompression Dynamics* [14], during whole-Earth decompression, as Earth's volume increases, its surface curvature must change. The manner by which surface curvature alteration takes place, illustrated in Figure 2, explains, in logical, causally related ways, major Earth geological features, including mountain chains characterized by folding [16], fjords, and submarine canyons [27].

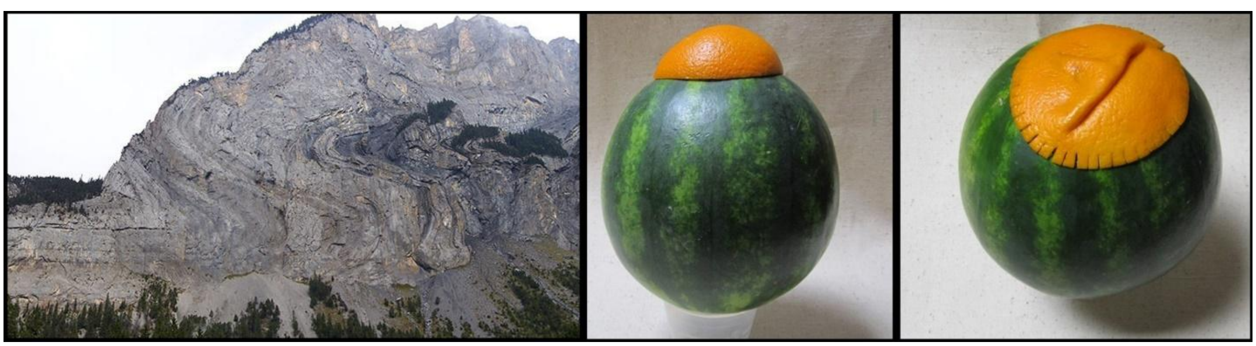

Figure 2: Left: Example of mountain folding; Center: The necessity for surface curvature change during whole-Earth decompression. The un-decompressed Earth is represented by the orange, while the larger, decompressed Earth, is represented by the melon. Note the curvatures do not match; Right: Two causally-related curvature-change mechanisms that naturally result in surface curvature change, namely, major curvature adjustment by folded-over tucks, minor curvature adjustment by continental-perimeter tears.

As shown by the data of Table 1, the endo-Earth, defined as lower mantle plus core, has a relatively simple structure and a composition that matches the Abee enstatite chondrite. Does that mean that the inner 82% of Earth formed from Abee-like enstatite chondrites? No, not necessarily. It means that there was some commonality in the processes these objects experienced. The virtually identical compositions of these two objects (Table 1) connects these objects to high-pressure, high-temperature primordial condensation [3] which resulted in their oxygen-starved, highly-reduced, chemical state [8]. In other words, the interior 82% of Earth formed by condensing and raining out from the interior of a giant gaseous protoplanet.

But what of the upper mantle, crust, and Moon. The evidence for these is not as clear-cut and unambiguous as for the endo-Earth. Within the upper mantle, above the seismic discontinuity at a depth of 660 km, which separates it from the lower mantle, there is at least one well-established discontinuity at a depth of 410 km. There may be one or more controversial, less well-defined discontinuities [28].

Moreover, for the upper mantle, it has not yet been possible to make quantitative comparisons with a single meteorite such as was done for the endo-Earth. One reason is that the upper mantle is composed of more than one fundamental component. The oxidized iron observed at Earth's surface is evidence of different added matter. Nodules trapped in volcanic ejecta from a depth of about 100 km have been observed to contain an undifferentiated chondritic component [29].

Eucken's fundamental mechanism for Earth's condensation from a giant gaseous protoplanet, as derived from thermodynamic considerations, has been the basis for subsequent discoveries as described above. Notably, his recognition that at high-pressures, high-temperatures iron condenses first as a liquid subsequently led to the inner core being recognized as nickel silicide [30], uranium concentrating at Earth's center and functioning as a nuclear fission breeder reactor [17, 19-23] that produces the geomagnetic field [22, 31], and the matter at the core-mantle boundary being CaS and MgS precipitates from the fluid core [12, 25]. Nevertheless, one glaring short-coming is the absence of a logical and causally related explanation for the enrichment of magnesium, calcium, and aluminum in the upper mantle, crust, and Moon.

The purpose of this article is to disclose a correction to Eucken's fundamental mechanism which overcomes that shortcoming, and as well provides an explanation as to the means for incorporation of water in Earth's mantle and in enstatite chondrites.

SHIFTING EUCKEN'S PARADIGM

The oxygen-rich Orgueil carbonaceous chondrite and the oxygen-poor Abee enstatite chondrite have quite similar corresponding elemental abundance ratios in the sun, at least for the less-volatile elements, as shown in Figure 3 [32-37]. The question arises: Aside from the differences in oxygen and sulfur content, how are these similar chondrites dissimilar? Recall: Three elements, magnesium, silicon and iron, plus oxygen and sulfur comprise 95% of the mass of each chondrite. Add to those elements aluminum, calcium, sodium and nickel and that composition raises to 98%.

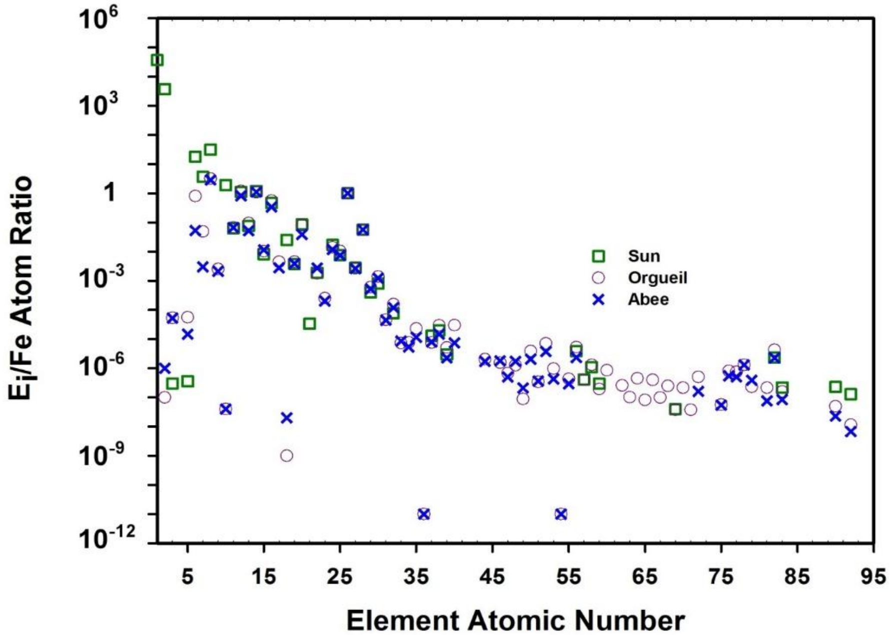

Figure 3: Comparison of relative element atom-abundances, normalized to iron, in the sun and in the Orgueil carbonaceous chondrite and in the Abee enstatite chondrite.

Figure 4 is an expanded version of an originally published image [38, 39] which is also shown as the inset of Figure 4. Note the molar or atomic ratios Si/Fe and Mg/Fe. Clearly, the plotted ratios for the Abee enstatite chondrite show significant depletion relative to the Orgueil carbonaceous chondrite ratios when normalized to iron. Similar depletions are observed for a few minor elements, but not for all.

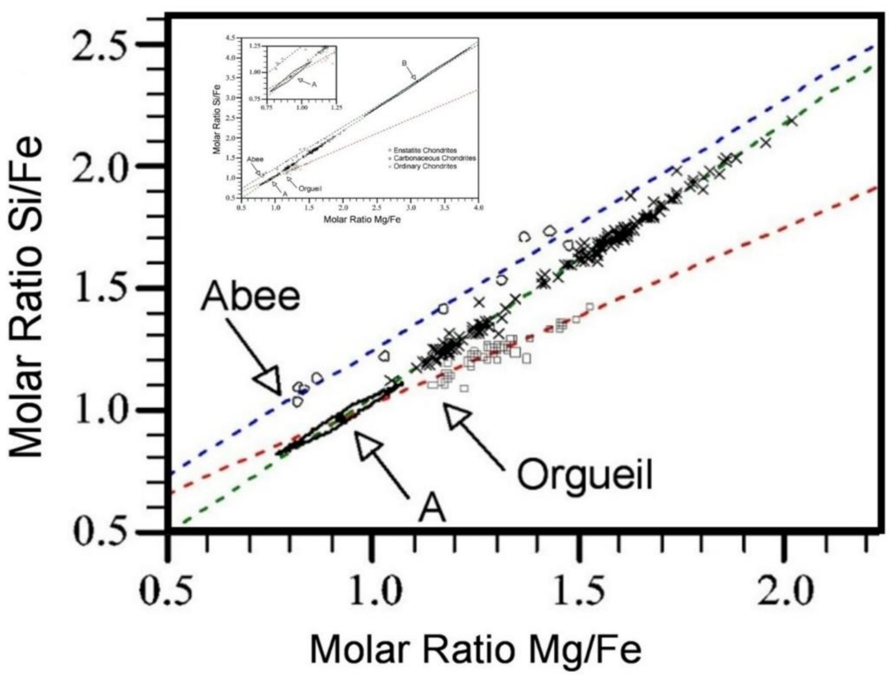

Figure 4: Corner expansion a published figure shows major cationic elements of chondrites [38, 39]. The inset is a reduced-size representation of the complete original figure.

Figure 5 shows the seven major and minor cationic elements plotted as mass ratios normalized to iron plotted in green for the Orgueil carbonaceous chondrite from the data of Figure 3. Figure 5 also shows similar element mass ratios plotted in red for the Abee enstatite chondrite overlying the Orgueil ratios. Four of the element mass-ratios, iron, silicon, nickel, and sodium are virtually identical for each chondrite. Three of the element mass-ratios, magnesium, calcium, and aluminum, however, show significant reductions in Abee relative to Orgueil. Notably, those three Orgueil "excess" elements, magnesium, calcium, and aluminum, are the very same elements that are enriched in the outer portion of Earth and Moon.

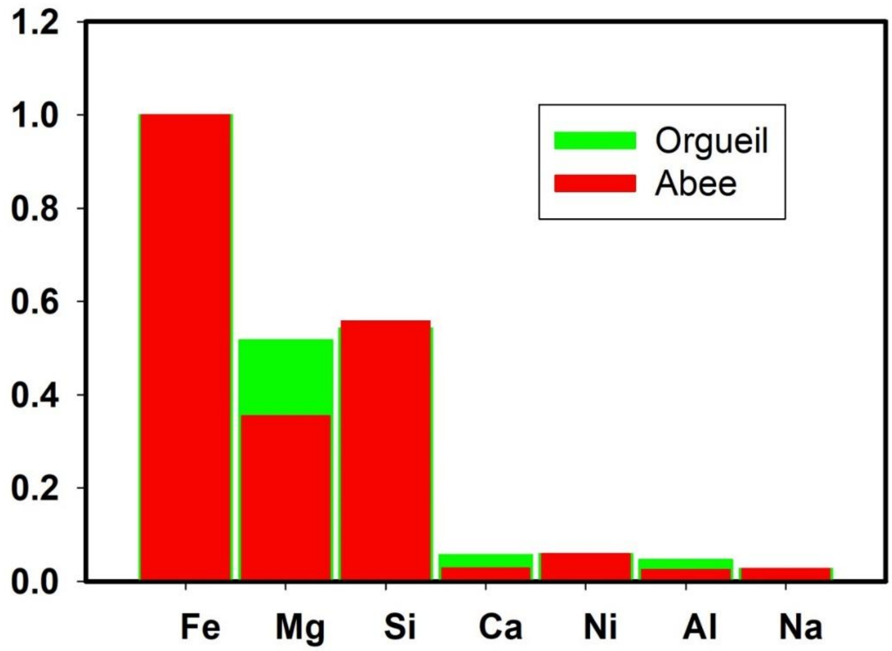

Figure 5: From Figure 3, the seven major and minor cationic elements as mass ratios normalized to iron plotted in green for the Orgueil carbonaceous chondrite and similar element ratios plotted in red for the Abee enstatite chondrite overlying the Orgueil ratios. Recall that these seven elements plus associated oxygen and sulfur comprise 98% of the mass of each chondrite and by implication, 98% of Earth.

Element ratios in the Orgueil carbonaceous chondrite have long been thought to most closely resemble corresponding ratios observed in the photosphere of the sun [34-36, 40-42] *ipso facto* in primordial solar-matter.

According to Eucken's paradigm, at high-pressures, high-temperatures, iron metal first condenses followed by mantle silicates. And indeed the data represented in Table 1 strongly support molten iron condensation. However, at the next step of his paradigm, following lower mantle condensation, there appears to be no thermodynamically feasible way to account for the "excess" elements, magnesium, calcium, and aluminum remaining in the gas phase (for subsequent condensation), at least none I have been able to ascertain in decades of investigation. Below, I propose an Eucken paradigm shift, provide petrologic evidence for it, and briefly discuss concomitant implications on planetary and lunar formation, and planetary retention of primordial water resources with focus on the formation of Earth's oceans.

According to the Eucken paradigm, molten iron first condenses, followed by condensation of the lower mantle silicates. I propose instead that virtually all of the elements of the endo-Earth are contained in that first liquid condensate, defined as *endo-E condensate*. Such a circumstance would leave the three "excess" elements, magnesium, calcium, and aluminum in the gas phase to condense later as part of the matter that formed the outer portion of Earth and the Moon.

There is in fact petrologic data from the Abee meteorite that attests to fluid-core plus lower-mantle matter co-condensing as a single liquid, defined as *endo-E condensate*. In Figure 6, masses of iron metal typically embay crystals of enstatite thus indicating that enstatite crystallized *in situ* while the iron-bearing liquid was molten. A few of the many examples are highlighted by green rings.

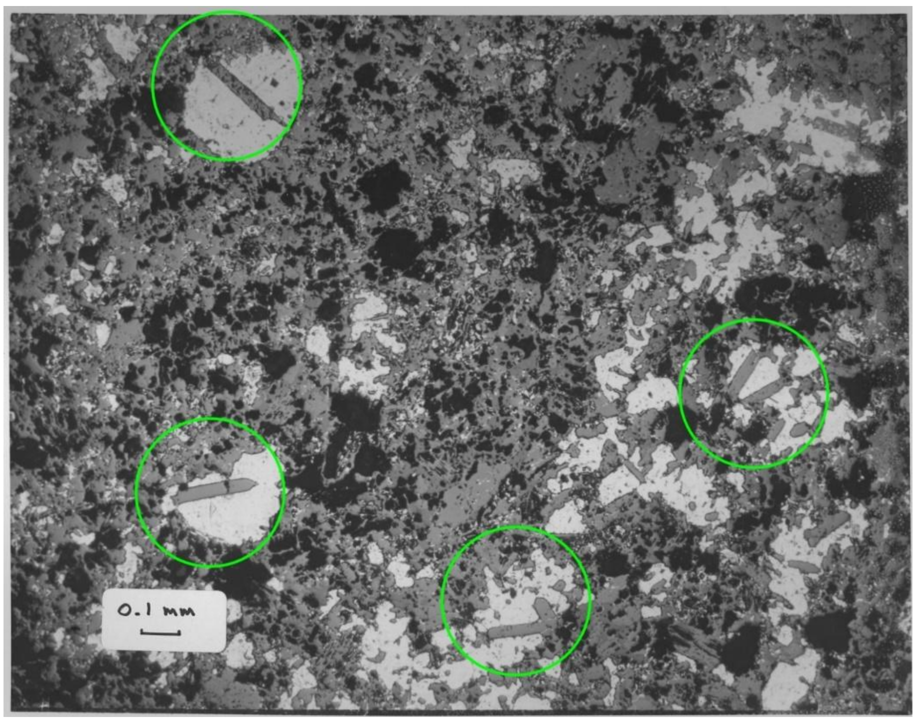

Figure 6: Photomicrograph of a portion of the Abee enstatite chondrite showing areas of previously molten iron embaying enstatite crystals that precipitated from the fluid iron-bearing melt. Several of the many examples are highlighted by green rings.

The volatile element content of the clearly high-temperature Abee meteorite is similar to that of the clearly low-temperature Orgueil meteorite. Relatively volatile elements, such as cadmium and thallium, existing in the Abee meteorite are evidence that its high-temperature components formed within the primordial gas at high-pressures, high-temperatures.

It is instructive to calculate the mass of "excess" magnesium, calcium, and aluminum, shown in Figure 5, relative to components of the upper portions of Earth and the Moon. Because the endo-Earth is virtually identical to the Abee meteorite (Table 1), the total mass of iron of the endo-Earth is equal to the fractional mass of iron in the Abee meteorite, 0.3035 [43] times the mass of the endo-Earth, 4.855 x 10^{24} kg [44]. The "excess" of each element mass is just the fractional "excess" times the total mass of iron of the endo-Earth. These results, shown in Table 2, are of appropriate magnitude to be significant components of the upper mantle and crust of Earth as well as the Moon.

Table 2.

"excess" magnesium	2.41×10^{23} kg	mass of upper mantle	1.9×10^{24} kg [44]
"excess" calcium	4.39×10^{22} kg	mass of crust	1.6×10^{21} kg [44]
"excess" aluminum	3.09×10^{22} kg	mass of Moon	7.35×10^{22} kg

In an atmosphere of solar composition at high-pressures, high-temperatures, the circumstances within giant gaseous protoplanets, can force individual elements toward a state where their properties become more similar to one another. This happens because the unique electron shell structure that defines each element's chemical behavior begins to break down under extreme compression. As a consequence, all of the elements that comprise the Abee meteorite, including hydrogen and oxygen, I submit, are soluble in the molten *endo-E condensate*.

In the case of Earth, and presumably other planetary interiors, the molten *endo-E condensate* rains out toward the planetary center. As cooling progresses, when thermodynamically feasible, the oxyphile elements strip the oxygen from the melt and float to the surface, forming the matter of the lower mantle. The portion of oxyphile elements, which was unable to find sufficient oxygen to escape as oxides, remains within the molten iron until thermodynamically feasible to precipitate as other chemical compounds. Magnesium and calcium combine with sulfur, and float to the top of the core as magnesium sulfide and calcium sulfide. Silicon combines with nickel forming the nickel silicide inner core, and the trace element uranium precipitates and makes its way to Earth's center, presumably as a sulfide, and forms Earth's georeactor.

Subsequently, the uncondensed portion of elements, including magnesium, calcium, and aluminum, mix with infalling matter, which condensed under low pressures in the outer part of the solar system or in interstellar space, and forms the outer regions of Earth and the Moon.

Although the Moon currently has no internally generated magnetic field, remanent magnetization of some of its surface material is indicative of an ancient internally-generated magnetic field [45, 46] that persisted at a very low level for half of the Moon's life [47]. Those observations indicate the incorporation of some quantity of *endo-E condensate* during formation of the Moon.

RETENTION OF PRIMORDIAL WATER

Numerous scientists have presented evidence that the water comprising Earth's oceans is mainly derived from matter within the mantle [48-52]. However, to date there has been no logical, causally related mechanism proposed for its origination. The multi-element composition, including hydrogen and oxygen, of *endo-E condensate* appears to be a plausible mechanism for emplacing water in Earth's deep interior. Moreover, release of water to the oceans over time is a natural consequence of whole-Earth decompression dynamics.

The geodynamics and geology of Earth are intrinsically related through my indivisible geoscience paradigm, *Whole-Earth Decompression Dynamics*. Ultimately, myriads of seemingly complex and theoretically unresolved observations can be resolved and understood in logical, causally related ways. For example, the apparent correlation of geomagnetic field reversals with species extinction [53, 54], with major episodes of volcanism [55, 56], and with drastic sea-level changes [57], is understandable as geomagnetic field collapse, in principle, can lead to a spike in georeactor output energy, and thus possibly trigger a decompression spike manifest, for example, by volcanism, earthquakes, continent splitting, species extinction, and more [58-60].

The progressive splitting of continental crust and concomitant opening of ocean basins necessarily causes lowering of sea levels, which over time is compensated by new ocean water additions. Continent fragmentation not only leads to the release of primordial water occluded in mantle minerals, but also exposes sea water to non-oxidized minerals, such as pyrite and arsenopyrite, that can acidify and toxify sea water, and potentially lead to massive species extinctions [61] (Figure 7).

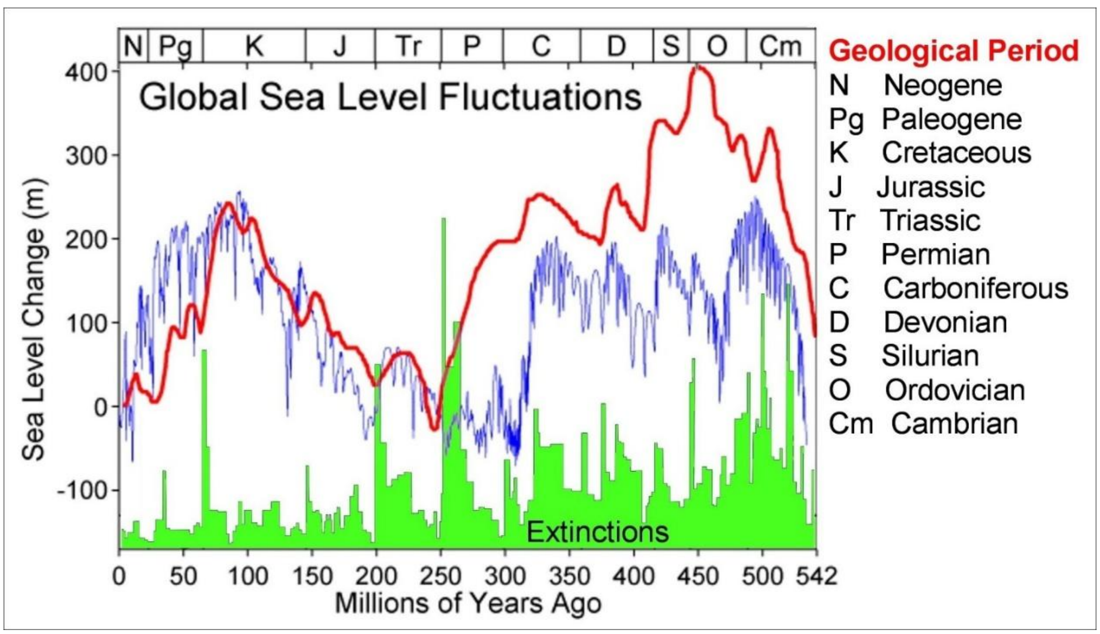

Figure 7: Spikes in seawater levels (red and blue) appear to correlate with spikes in species genus extinction intensity (green), and they correlate as well with boundaries of major divisions of geological time, abbreviated at top of graph. For details and data, see [62-69].

Evidence from the geological past is incomplete, but with the new *endo-E condensate* paradigm disclosed here, the confusion inherent to previous scientifically convoluted explanations for fundamental geological phenomena can be clarified and united. The hopeful result is that geoscientists can begin afresh to attain an understanding of Earth's history that is securely anchored to the known properties of matter and radiation.

References

1. Kant, I., Allgemeine Naturgeschichte und Theorie des Himmels (Universal natural history and theory of the heavens). Trans. by Ian Johnston. Arlington, VA: Richer Resources, 1755.
2. Laplace, P.S.d. Pierre Simon de Laplace. in Exposition du système du monde. 1796.
3. Eucken, A., Physikalisch-chemische Betrachtungen ueber die frueheste Entwicklungsgeschichte der Erde. Nachr. Akad. Wiss. Goettingen, Math.-Kl., 1944: p. 1-25.
4. Kuiper, G.P., On the evolution of the protoplanets. Proc. Nat. Acad. Sci. USA, 1951. 37: p. 383-393.
5. Urey, H.C., On the Dissipation of Gas and Volatilized Elements from Protoplanets. The Astrophysical Journal Supplement Series, 1954. 1: p. 147.
6. Cameron, A.G.W., Formation of the solar nebula. Icarus, 1963. 1: p. 339-342.
7. Goldrich, P. and W.R. Ward, The formation of planetesimals. Astrophys J., 1973. 183(3): p. 1051-1061.
8. Herndon, J.M. and H.E. Suess, Can enstatite meteorites form from a nebula of solar composition? Geochim. Cosmochim. Acta, 1976. 40: p. 395-399.
9. Herndon, J.M., Validation of the protoplanetary theory of solar system formation. Journal of Geography, Environment and Earth Sciences International, 2022. 26(2): p. 17-24.
10. Herndon, J.M., The chemical composition of the interior shells of the Earth. Proc. R. Soc. Lond, 1980. A372: p. 149-154.
11. Herndon, J.M., The object at the centre of the Earth. Naturwissenschaften, 1982. 69: p. 34-37.
12. Herndon, J.M., Composition of the deep interior of the earth: divergent geophysical development with fundamentally different geophysical implications. Phys. Earth Plan. Inter, 1998. 105: p. 1-4.
13. Herndon, J.M., Geodynamic Basis of Heat Transport in the Earth. Curr. Sci., 2011. 101(11): p. 1440-1450.
14. Herndon, J.M., Whole-Earth decompression dynamics. Curr. Sci., 2005. 89(10): p. 1937-1941.
15. Herndon, J.M., Whole-Earth decompression dynamics: new Earth formation geoscience paradigm fundamental basis of geology and geophysics. Advances in Social Sciences Research Journal, 2021. 8(2): p. 340-365.
16. Herndon, J.M., Origin of mountains and primary initiation of submarine canyons: the consequences of Earth's early formation as a Jupiter-like gas giant. Curr. Sci., 2012. 102(10): p. 1370-1372.
17. Herndon, J.M., Nuclear georeactor origin of oceanic basalt $^3He/^4He$, evidence, and implications. Proc. Nat. Acad. Sci. USA, 2003. 100(6): p. 3047-3050.
18. Herndon, J.M., New indivisible planetary science paradigm. Curr. Sci., 2013. 105(4): p. 450-460.
19. Herndon, J.M., Feasibility of a nuclear fission reactor at the center of the Earth as the energy source for the geomagnetic field. J. Geomag. Geoelectr., 1993. 45: p. 423-437.
20. Herndon, J.M., Planetary and protostellar nuclear fission: Implications for planetary change, stellar ignition and dark matter. Proc. R. Soc. Lond, 1994. A455: p. 453-461.
21. Herndon, J.M., Sub-structure of the inner core of the earth. Proc. Nat. Acad. Sci. USA, 1996. 93: p. 646-648.
22. Herndon, J.M., Terracentric nuclear fission georeactor: background, basis, feasibility, structure, evidence and geophysical implications. Curr. Sci., 2014. 106(4): p. 528-541.
23. Hollenbach, D.F. and J.M. Herndon, Deep-earth reactor: nuclear fission, helium, and the geomagnetic field. Proc. Nat. Acad. Sci. USA, 2001. 98(20): p. 11085-11090.
24. Herndon, J.M., Mantle decompression thermal-tsunami. arXiv: physics/0602085 13 Feb 2006, 2006.
25. Herndon, J.M., Solar System processes underlying planetary formation, geodynamics, and the georeactor. Earth, Moon, and Planets, 2006. 99(1): p. 53-99.

26. Herndon, J.M., Mechanism of solar activity triggering earthquakes and volcanic eruptions. European Journal of Applied Sciences, 2022. 10(3): p. 408-417.

27. Herndon, J.M., New Concept for the Origin of Fjords and Submarine Canyons: Consequence of Whole-Earth Decompression Dynamics. Journal of Geography, Environment and Earth Science International, 2016. 7(4): p. 1-10.

28. Shearer, P.M., Upper mantle seismic discontinuities. Geophysical monograph-American Geophysical Union, 2000. 117: p. 115-132.

29. Jagoutz, E., et al., The abundances of major, minor and trace elements in the earth's primitive mantle as derived from ultramafic nodules. Proc. Lunar Planet. Sci. Conf., 1979. 10: p. 2031-2050.

30. Herndon, J.M., The nickel silicide inner core of the Earth. Proc. R. Soc. Lond, 1979. A368: p. 495-500.

31. Herndon, J.M., Nuclear georeactor generation of the earth's geomagnetic field. Curr. Sci., 2007. 93(11): p. 1485-1487.

32. Aller, L.H., The Abundances of the Elements. 1961, New Your: Interscience Publishers. 283.

33. Anders, E. and M. Ebihara, Solar-system abundances of the elements. Geochim. Cosmochim. Acta, 1982. 46: p. 2363-2380.

34. Anders, E. and N. Grevesse, Abundances of the elements: Meteoritic and solar. Geochim. Cosmochim. Acta, 1989. 53: p. 197-214.

35. Cameron, A.G.W., Abundances of the elements in the solar system. Space Sci. Rev., 1973. 15: p. 121-146.

36. Suess, H.E. and H.C. Urey, Abundances of the elements. Rev. Mod. Phys., 1956. 28: p. 53-74.

37. Asplund, M., et al., The chemical composition of the Sun. Annual review of astronomy and astrophysics, 2009. 47: p. 481-522.

38. Herndon, J.M., Whole-Mars Decompression Dynamics. European Journal of Applied Sciences, 2022. 10(3): p. 418-438.

39. Herndon, J.M., Making sense of chondritic meteorites. Advances in Social Sciences Research Journal, 2022. 9(2): p. 82-102.

40. Trimble, V., The origin and abundances of the chemical elements. Reviews of Modern Physics, 1975. 47(4): p. 877.

41. Manuel, O. and G. Hwaung, Solar abundances of the elements. Meteoritics, 1983. 18(3): p. 209-222.

42. Palme, H., K. Lodders, and A. Jones, Solar system abundances of the elements. Planets, Asteriods, Comets and The Solar System, Volume 2 of Treatise on Geochemistry (Second Edition). Edited by Andrew M. Davis. Elsevier, 2014., p. 15-36, 2014. 2.

43. Dawson, K.R., J.A. Maxwell, and D.E. Parsons, A description of the meteorite which fell near Abee, Alberta, Canada. Geochim. Cosmochim. Acta, 1960. 21: p. 127-144.

44. Dziewonski, A.M. and D.A. Anderson, Preliminary reference Earth model. Phys. Earth Planet. Inter., 1981. 25: p. 297-356.

45. Runcorn, S., An ancient lunar magnetic dipole field. Nature, 1975. 253(5494): p. 701-703.

46. Garrick-Bethell, I., et al., Further evidence for early lunar magnetism from troctolite 76535. Journal of Geophysical Research: Planets, 2017. 122(1): p. 76-93.

47. Cai, S., et al., Persistent but weak magnetic field at Moon's midlife revealed by Chang'e-5 basalt. arXiv preprint arXiv:2411.13719, 2024.

48. Stalder, R. and H. Skogby, Hydrogen incorporation in enstatite. European Journal of Mineralogy, 2002. 14(6): p. 1139-1144.

49. Hirschmann, M. and D. Kohlstedt, Water in Earth’s mantle. Physics Today, 2012. 65(3): p. 40-45.

50. Hallis, L.J., et al., Evidence for primordial water in Earth's deep mantle. Science, 2015. 350(6262): p. 795-797.

51. Kaminsky, F.V., Water in the Earth's lower mantle. Geochemistry International, 2018. 56(12): p. 1117-1134.

52. Piani, L., et al., Earth's water may have been inherited from material similar to enstatite chondrite meteorites. Science, 2020. 369(6507): p. 1110-1113.

53. Hagiwara, Y., Geocatastrophe Mass Extinction and Geomagnetic Reversal. Journal of Geography (Chigaku Zasshi), 1991. 100(7): p. 1059-1076.

54. Kennett, J.P. and N. Watkins, Geomagnetic polarity change, volcanic maxima and faunal extinction in the South Pacific. Nature, 1970. 227(5261): p. 930-934.

55. Irvine, T.N., A global convection framework; concepts of symmetry, stratification, and system in the Earth's dynamic structure. Economic Geology, 1989. 84(8): p. 2059-2114.

56. Marzocchi, W. and F. Mulargia, Feasibility of a synchronized correlation between Hawaiian hot spot volcanism and geomagnetiC polarity. Geophysical Research Letters, 1990. 17(8): p. 1113-1116.

57. Marzocchi, W., F. Mulargia, and P. Paruolo, The correlation of geomagnetic reversals and mean sea level in the last 150 my. Earth and planetary science letters, 1992. 111(2-4): p. 383-393.

58. Herndon, J.M., Cataclysmic geomagnetic field collapse: Global security concerns. Journal of Geography, Environment and Earth Science International, 2020. 24(4): p. 61-79.

59. Herndon, J.M., Causes and consequences of geomagnetic field collapse. J. Geog. Environ. Earth Sci. Intn., 2020. 24(9): p. 60-76.

60. Herndon, J.M., Humanity imperiled by the geomagnetic field and human corruption. Advances in Social Sciences Research Journal, 2021. 8(1): p. 456-478.

61. Hsu, K.J., The great dying. 1988: Ballantine Books.

62. Raup, D.M., Magnetic reversals and mass extinctions. Nature, 1985. 314(6009): p. 341-343.

63. Raup, D.M. and J.J. Sepkoski, Periodicity of extinctions in the geologic past. Proceedings of the National Academy of Sciences, 1984. 81(3): p. 801-805.

64. Hallam, A. and P. Wignall, Mass extinctions and sea-level changes. Earth-Science Reviews, 1999. 48(4): p. 217-250.

65. Hallam, A., Phanerozoic sea-level changes. 1992: Columbia University Press.

66. Miall, A.D., Exxon global cycle chart: An event for every occasion? Geology, 1992. 20(9): p. 787-790.

67. Miller, K.G., et al., A 180-million-year record of sea level and ice volume variations from continental margin and deep-sea isotopic records. Oceanography, 2011. 24(2): p. 40-53.

68. Raup, D.M. and J.J. Sepkoski, Mass extinctions in the marine fossil record. Science, 1982. 215(4539): p. 1501-1503.

69. Rohde, R.A. and R.A. Muller, Cycles in fossil diversity. Nature, 2005. 434(7030): p. 208-210.