WAL THORNHILL

Formation of Chondritic Meteorites and the Solar System

Article from *Chronology & Catastrophism*
***REVIEW* Vol. X, 1988 - Editor: Bernard Newgrosh**

NOTES

Most errors found post-publication of the original article will have been noted in a subsequent SIS publication and as far as possible such errors (and any other errors found) will have been corrected in this PDF edition.

Within limits, original formatting style and layout has been retained.

Page numbers are those in the original article.

VJP - 29.4.2013

Formation of Chondritic Meteorites and the Solar System

by

WAL THORNHILL

'It is the thunderbolt that steers the Universe'
- Heraclitus, *c.*500 BC

Introduction

This paper examines some of the puzzling features of the largest class of meteorites, the stony chondritic meteorites, or chondrites. Chondrites are so named because they contain chondrules or small spherules of olivine, enstatite or another of the meteoritic materials. The chondrules are embedded in a matrix of similar material. A new theory of chondrite genesis is outlined here and an experiment proposed which may test its most important aspects. The implications of this theory for the formation of the Solar System is discussed, and also wider topics.

Current theories on the formation of chondrites see them as products of the condensation of the solar nebula, very early in the history of the Solar System. Their irregular form, different sizes and evidently complex history create many problems for the nebular hypothesis. However, despite their wide range of composition and structure, there are regularities that suggest a common origin.

It is of fundamental importance to understand the process of formation of meteorites because it is believed that such information will shed light on the dynamics of the formation of the solar planetary system.

Peculiar Features of Chondrites

The results of meteoritic studies over many years, and recent work by Dr David Wark, at the Lunar and Planetary Laboratory, University of Arizona, Tucson [1] have provided the following puzzles which must be answered by any theory of chondrite formation:

1. There are 4 identified concentric zones within the asteroid belt which yield 4 distinct types of chondritic meteorite. Each type has few, if any, components that are identical to those in other types [2].

2. Chondrites contain refractory inclusions (calcium-and aluminium-rich inclusions, or CAI's) which characteristically have thin shells or rims surrounding them.

3. All refractory components appear to have suffered some 'flash' heating event of unknown origin [3] and consequently show a complex and 'unearthly' chemistry and morphology.

4. The high and low temperature components of chondrites are well mixed, generally as separate entities. They have not grown from a refractory core outwards to a less refractory rim. The chemistry of the components is complementary and must have originated in a closed system [4].

5. The thickness of the CAI shells does not seem to vary much from one inclusion in a specimen to another.

6. Despite the often complex shape of the inclusions, the shells follow the surface faithfully with little variation in thickness.

7. The rare earth 'signature' of the CAI shells indicates that they have been formed from the body of the inclusion rather than being deposited from some external source [5].

8. The CAI shell is enriched up to 5 times in the refractory rare earths and have a europium/ytterbium (Eu/Yb) anomaly which indicates that the inclusions have been strongly heated and 80% of the surface layer sublimed away.

9. The heating was brief, <100 sec [6], as evidenced by the sharp inner edge to the CAI shells and the fact that CAI cores are largely unaffected by the heat pulse. The retention of volatiles in chondrules also indicates that the heating was of very short duration, measured in seconds [7]. Therefore the zone of formation must have been highly localised; it

---

Wal Thornhill is an Australian, aged 46, currently working in London for the Australian Government. The holder of a degree in Physics at Melbourne University, he has had a lifelong interest in astronomy and Velikovsky's theories. The talk he gave at the AGM of the Society in April 1988 was based upon this article: an earlier version of this paper was also presented at the 13th National Australian Convention of Amateur Astronomers in Sydney during Easter 1988.

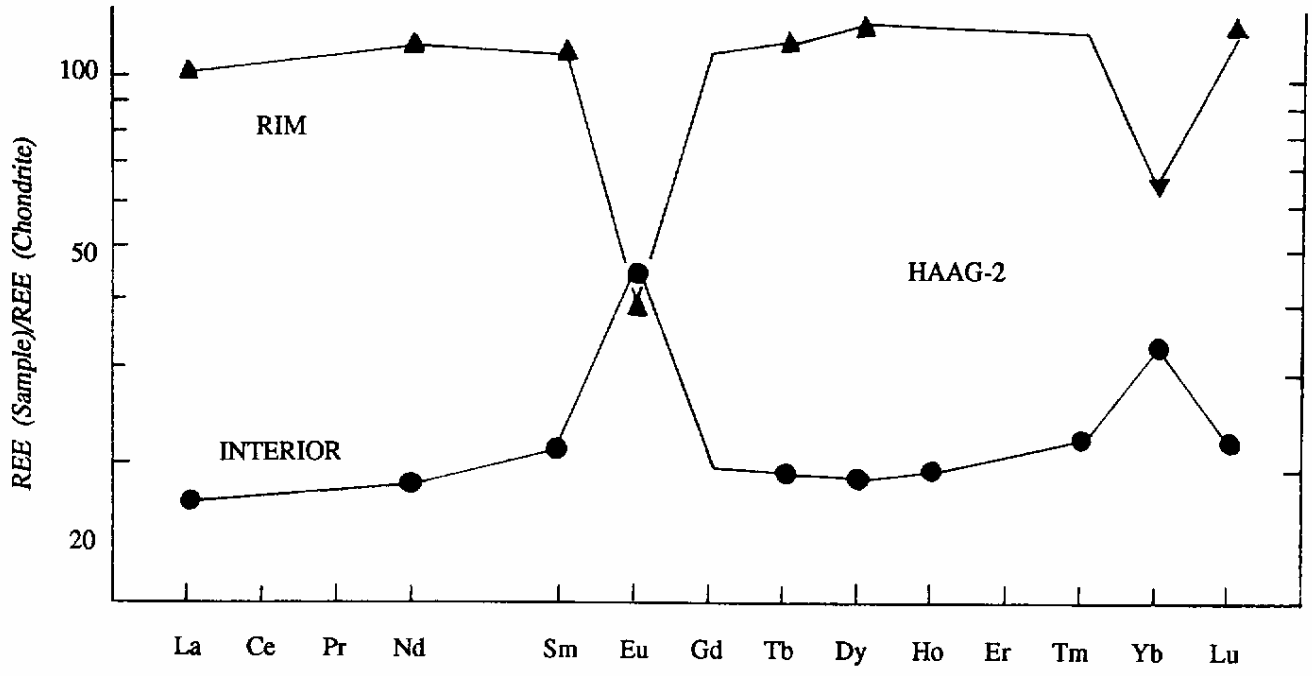

Figure 1. Rare earth element patterns of sample from Type A CAI HAAG-2. The rim is more enriched in rare earth elements and hence more refractory than the interior. *(J. Abery, after W. V. Boynton & D. A. Wark, Meteoritics **19**, 1984, pp. 195-197)*

could not have taken place in an extensive solar nebula [8].

10. The growth of the refractory components (CAI's) was interrupted while they were still at high temperature.

11. The temperature required to give the observed Eu/Yb anomaly in the CAI shells is 1500 degrees Centigrade, or more.

12. Since the most refractory components are found in the most distant chondrites from the Sun, solar radiation was evidently not the source of heat for their formation.

13. The cooling period must be measured in minutes or hours. It should also be noted that the chondrules, which are glassy drops of silicate, show evidence of rapid chilling. Strangely, they are almost all non-spherical [9].

14. The inclusions are surrounded by a halo of very fine grained matrix material for several millimetres, then the chondrules and coarser, more volatile components that enclose that halo.

15. The core of the inclusion has an excess of heavy magnesium (Mg) isotopes, while the shell has normal Mg isotope ratios.

16. Many chondrules contain relict grains, indicating that they are not formed by condensation. Relict grains larger than 0.2mm are inconsistent with formation from interstellar dust which is believed to have a very small percentage of grains of such size [10].

17. The existence of compound chondrules is evidence for collisions between molten chondrules. Also some relict grains may have been incorporated into fully or partially molten chondrules by collision.

Currently there is no single theory that can account for these observations.

Proposed Mechanism for the Formation of Chondritic Meteorites

Introduction

Current main-stream astronomical theory has not been able to offer a fully satisfactory explanation of the puzzling message from chondrites which is assumed to concern the formation of the Solar System. In order to break through such an impasse, three guiding principles have been used: - Firstly, it is necessary to refer to experts who in the past have argued against currently fashionable theories.

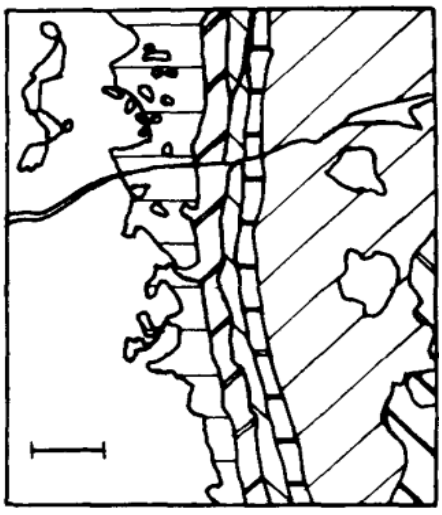

Figure 2. Backscattered electron image of area 271 of the rim of type A Allende meteorite CAI 20A,B. Scale bar represents 20 microns. *(A. Beal, after D. A. Wark & J. F. Lovering,* Proc. Lunar Sci. Conf. ***8** [1977], p. 97)*]

- Secondly, Newton, genius though he was, is not assumed to have given us all we need to describe the formation of the Solar System when he published his *Principia.* He did not take into account electricity or its associated magnetism. - Thirdly, some of the most important breakthroughs come about by taking an interdisciplinary approach. In this instance, electrical engineering provides the major clue as well as a possible test for the correctness of the theory.

Origin of Meteorites

According to this scenario, comets, asteroids and meteorites have a common origin. It is not assumed that these bodies have anything to do with a highly problematical primordial solar nebula. Therefore, for example, the 'Oort Shell' hypothesis of comets surrounding the Solar System is considered an unnecessary fiction. Indeed, Professor R. A. Lyttleton has described the Oort Shell theory as 'a piece of trash' [11].

Professor S. Vsekhsviatskii, Director of the Kiev Observatory and Head of the Faculty of Astronomy, University of Kiev, has concluded from his studies of comets [12] that:

i) Celestial mechanics, the distribution and statistics of cometary orbits, and consideration of the kinematics of the cometary system leave *no doubt whatsoever* that all comets, and therefore the products of their decay, were formed inside the Solar System, and were formed a little later, on the average, than were the planets.

ii) The existence of the families of short-period comets of Jupiter, Saturn, Uranus, and Neptune, and the peculiarities of their motion and nature - their chemistry, the presence of ice in their nuclei, their close association with Jupiter prior to discovery, etc. - demonstrates the recent origin of comets.

This is in accord with the theory of the eruptive development of planets, as developed by Lagrange, Proctor, Crommelin and Vsekhsviatskii. Recent, comprehensive investigations by Everhart (1969) confirmed once more that peculiarities of the observed distribution of short-period comet orbits cannot be explained on the basis of the 'gravitational capture' hypothesis. Indeed, Fred Whipple in his recent book, *The Mystery of Comets,* writes:

> A plot of the orbits of the short-period comets projected on the plane of Jupiter's orbit shows a remarkable clustering. The ring of their aphelion curves outlines Jupiter's orbit beautifully. The conclusion has been clear for more than a century! Jupiter's huge attractive mass has *somehow* collected two-thirds of all the short-period comets into a family.' [emphasis added]

On March 7, 1979, Voyager 1 unexpectedly discovered a faint ring of dark rocky debris circling the planet Jupiter. In the words of Dr Bradford A. Smith, head of the Voyager photography team; 'Now Jupiter is found to have a ring and we must invent a theory to explain it.'

Two months after the discovery of the ring around Jupiter, the Soviet Union claimed joint credit for the discovery, contending that Vsekhsviatskii had predicted the ring's existence as early as 1960 in a journal called *Izvestia of the Armenian Academy of Sciences.* The passage from the relevant paper is as follows:

> The existence of active ejection processes in the Jupiter system, demonstrated by comet astronomy, gives grounds for assuming that Jupiter is encircled by comet and meteorite material in the form of a ring similar to the ring of Saturn. [13]

Despite the fact of his priority, Vsekhsviatskii's name has remained conspicuously absent from the scientific literature pertaining to comets and planetary rings. Given that mathematicians seem to be the final arbiter on astronomical theory in this age, it is not surprising that Vsekhsviatskii's work has been ignored because they immediately calculated that the energy required to *explosively* erupt matter from Jupiter would be sufficient to totally atomise the ejected material. A more scientific approach would have been to examine his promising findings and consider other mechanisms.

In the event, it has been left to two astronomers with a particular interest in electric discharge phenomena to propose a promising ejection mechanism which may explain the features of comets and meteorites.

But first, here is a brief word about the state of electrical discharge theory in astronomy, from a recognised authority. Professor Hannes Alfven, when he received his Nobel Prize in Physics in 1970 spoke of studies of the electrical discharge phenomenon:

> ... most theoretical physicists looked down on this field, which was complicated and awkward... not at all suited for mathematically elegant theories.

Alfven felt that:

> ... the cosmical plasma physics of today ... is to some extent the playground of theoreticians who have never seen a plasma in a laboratory. Many of them still believe in formulas which we know from laboratory experiment to be wrong ... several of the basic concepts on which theories of cosmical plasmas are founded are not applicable to the condition prevailing in the cosmos. They are "generally accepted" by most theoreticians, they are developed with the most sophisticated mathematical methods, and it is only the plasma itself which does not "understand" how beautiful the theories are and absolutely refuses to obey them ....

It is for this reason, I believe, that the burden of explanation for all energetic events observed in the universe falls to Newton and his simple theory of that weakest of forces, gravity, which although mathematically tractable, leads to the somewhat weird idea of 'black holes' and the problem of 'missing mass' when applied uncritically. Fred Whipple seems to have recognised this situation when he wrote:

> Alfven's theory has great bearing on all hot plasmas in astronomy-stars, black holes, and even interstellar gases - but the theory is almost unmanageable in practice. It is a challenge to theorists; it must be mastered, however, if further progress is to be made in understanding the universe. [14]

Instead, the astronomers mentioned have attempted to explain various enigmatic and particularly energetic astronomical phenomena in terms of the phenomenology of electric discharge in a plasma.

The Mechanism of Ejection

Dr C. E. R. Bruce (1902-1979) who was a member of the Electrical Research Association, England, set out a number of laws concerning electric discharges [15], two of which are of importance in explaining the formation of comets and

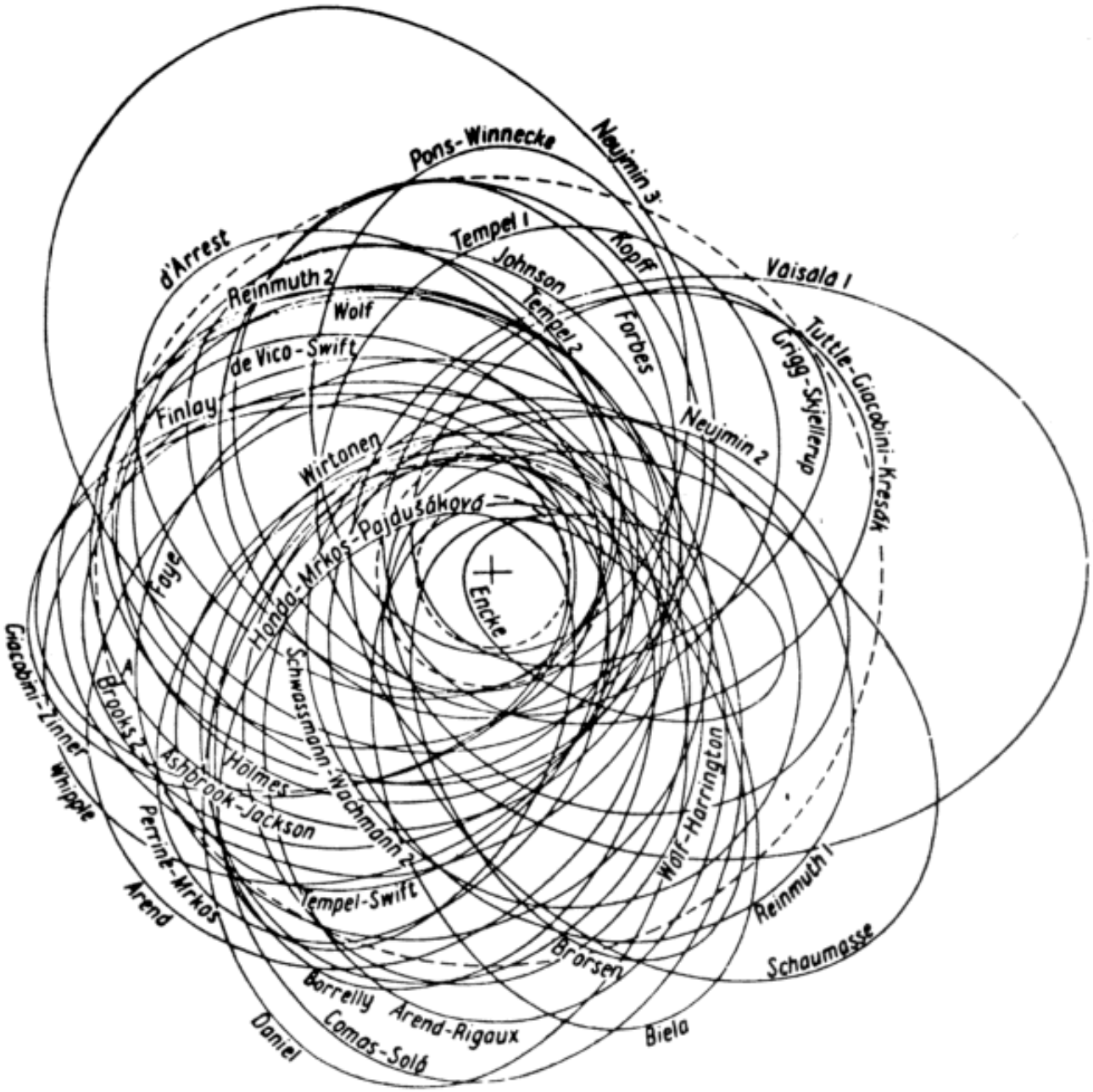

Figure 3. Orbits of typical short-period comets. The dashed orbits are those of Jupiter (outer) and Earth (near centre). Reproduced from Fred L. Whipple, *The Mystery of Comets* (Cambridge 1985) p. 75 with the kind permission of the Cambridge University Press

meteorites:

A). Aggregation of atmospheric matter
Slow accumulation of electrical charge takes place in astronomical atmospheres and the subsequent relatively rapid electrical atmospheric discharges similar to lightning produce a magnetic field which compresses the channel of the current. When this occurs in a prolonged discharge in astronomy it causes aggregation of large volumes of thinly distributed gas and matter into relatively narrow channels, so that when the current dies away the compressed gas expands and cools, condensing into stars in galactic atmospheres and either planets or companion stars in stellar atmospheres. (Orthodox astronomy, as Prof. G. Burbidge has pointed out, has no physical understanding of the situation where dense objects condense out of an initial cloud of matter and radiation which is expanding.)

B). The generation of gas jets
Variation in the discharge current or current density along the discharge channel will give rise to variations in the axial pressure and hence to a flow of gas. As both of these parameters will decrease outwards in atmospheric electrical discharges, all will thus give rise to gas jets.

Following on Bruce's work, Eric W. Crew claims that the longitudinal voltage gradient, acting on positive ions, is probably an adequate mechanism for producing jets. He also

suggested [16] that large quantities of matter could be ejected from the solid or liquid cores of large gaseous planets (this also applies on stellar and perhaps galactic scales). A brief description of this theory in relation to large gaseous planets is that the core becomes highly positively charged by a gravitationally driven pressure ionisation process, akin to the piezo-electric effect. The high temperature and pressure in the planet's core strips an outer electron or two from each atom causing partial degeneracy of the core [17]. The free electrons, being considerably more mobile than the positive ions, would tend to migrate away from the high pressure region of the core towards the planetary surface and some would be neutralised by positive charge from cosmic rays - in other words, the planet will acquire a net positive charge. While it is at the centre of the gaseous planet the growth of the core in mass and pressure will cause its total charge and the voltage gradient at the core boundary to increase steadily. Only the high pressure of the un-ionised material surrounding the largely ionised core prevents an explosive expansion of the core, but eventually a condition of breakdown may be attained.

The increasing pressure and temperature is likely to cause a sudden change of state, followed by a contraction and increase of spin of the core. The peripheral friction and turbulence would increase the local voltage gradient and where it exceeds the breakdown value there would be a radial discharge in the form of a flow of positive ions. In other words, a discharge jet would result.

It is worth considering the fate of the electrons displaced from the core in more detail. Even if they largely remain surrounding the core, once the discharge begins, electrons under high pressure conditions will not be able to move rapidly enough from other parts of the planet to quench the outburst. In the low pressure regions of the planet's upper atmosphere, where the electrons are more free to move, the acceleration and recombination of electrons with positive ions in the region of core discharge, and probably also a cascade ionisation process caused by encounters of relativistic electrons with atmospheric atoms, would produce a planet wide steep rise in radiation output. In other words, the planet (or star) would undergo a nova phase. There is interesting evidence that a nova is associated with an electric discharge as indicated by the broadening of spectral lines from such an outburst. The broadening follows the lambda square law of the Zeeman (magnetic) effect and not the lambda law of the Doppler effect. It should also be noted that radial velocity data show most novas to be invisible companions of ordinary stars [18]. Also, several novas have been observed to virtually extinguish around maximum brightness. This is easily explained by another of Bruce's laws which concerns the self-extinction of a discharge at maximum current due to the high pressures generated by it in the discharge channel.

To continue, once the discharge starts, it would be self-sustaining, fed by the charge stored in the core until most of its charge is dissipated and the electrical field in the discharge channel falls below a critical value. The stream of positive ions represents a massive flow of material out of the central regions of the planet and a conversion of much of the charge energy into kinetic energy of the discharged matter. Some of the material at the head of the column would be discharged by free electrons in the surrounding medium, so the neutral material would cease to accelerate in the voltage gradient, causing the following material to pile up against it, forming a steadily growing mass proceeding to the outer regions of the planet's atmosphere and eventually emerging from the atmosphere.

The ejected material would arc away from the planet. The variation of velocity and position of the arc would cause material to go into different orbits. Some would be captured by the parent as a ring of debris, some would follow asteroidal orbits, and other objects would become comets, meteorites and interplanetary dust.

Formation of Meteorites

The arc of material leaving the fissioning parent body would be composed of ionised gases, liquids and solids ranging in size from microns up to asteroid or planetoid dimensions. Electric discharges would take place between the parent planet and the highly charged departing matter. These powerful plasma discharges would give rise to a number of effects:

1. Heating would be most intense along the axis of the discharge, falling off with radial distance from the axis.

This might explain some of the chemical differences between CAI's by varying degrees of vaporisation of precursor solids [19]. Such differential heating would have the more refractory type A CAI's condensing and cooling last along the discharge axis and having inclusions of less refractory type B CAI's, which formed and cooled earlier, further from the axis. The magnetic 'pinch' effect of the discharge would accelerate the type B CAI's radially inwards and thus cause implantation by collision of type B CAI's within type A, as has been discovered. The converse has never been seen.

2. At some distance from the discharge axis low melting point minerals would melt to form chondrules, trapping relict grains or partially melted solids. The consensus is that chondrules are formed by melting of pre-existing solids.

3. Refractory particles would have their exterior surfaces evenly 'flash-heated' to temperatures of the order of thousands of degrees Celsius for the short period of the discharge, probably measured in seconds or minutes.

4. Volatile elements would be preferentially vaporised in the discharge channel and accelerated along the discharge axis, causing some refractory/non-refractory element zonation along the channel as well as radially. It is found that some chondrites are rich in volatiles while others are depleted in a complementary fashion. The gaseous 'blast' along the discharge channel would also deform cooling molten droplets. Chondrules are found almost without exception to be non-spherical.

5. On quenching of the discharge, cooling would follow rapidly, in minutes, giving rise to the sharp inner boundary between the refractory particle shell and its core. It is difficult to provide such rapid heating and cooling in an extended nebular cloud, as is widely believed to be the birthplace of meteorites. Also, when the discharge ceases the magnetic 'pinch effect' ceases, accompanied by an explosive fall in gas pressure leading to the observed interruption to growth of the CAI's while still at high temperature [20].

6. By the electric discharge mechanism all shells should be formed at the same instant, under fairly uniform, highly localised conditions, thus giving rise to shells of a thickness which does not vary much from one specimen to another.

7. The plasma discharge heating would be uniform over all exposed surfaces, unlike ballistic heating in a gas, and therefore the observation that the shells follow the complex surface features of the refractory inclusions may be explained.

8. After the discharge has extinguished, the sub-micron particles will cool most rapidly and have their charge neutralised by solar wind electrons, before that of larger particles. They will then be electrically attracted to the charged larger particles, thus giving rise to the observed halo of very fine grained matrix material surrounding the inclusions. Electrostatic attraction between the very smallest particles before the discharge takes place might also help explain the observation that the CAI formation mechanism discriminates against small bodies.

9. The magnetic pinch effect of the discharge will cause the dispersed material and gases to accelerate radially inward towards the axis of the discharge, so that after the discharge is quenched there will be collisions of molten chondrules, giving rise to the formation of compound chondrules and relict inclusions. This also fits the observation that regions of chondrule formation were homogeneous over small distances [21]. Gas pressures will be highest near the discharge axis, causing volatiles also to be included in some meteorite precursors. The meteoritic bodies may then be formed by agglomeration, near the spent discharge axis, of the various meteorite components; chondrules, refractory inclusions, volatiles, matrix material, etc. The mixing would be chaotic, with probable collision-induced splintering of the material, giving rise to the observed irregular forms of chondrites. This mechanism explains the mixing of high and low temperature components in chondrites as separate entities.

10. It is expected that some evidence of the electric discharge and its magnetic field would be found in remanent magnetism of some meteoritic components. Brecher (1977) showed that carbonaceous chondrites and ureilites had surprisingly large ancient magnetic field intensities [22].

11. Such giant electric discharges would probably be of sufficient power to cause nucleosynthesis, transmutation of elements and the formation of isotopes and radionuclides. Wood and McSween (1977) say that the chondrule evidence strongly suggests origin in an unspecified energetic event, definitely not pre-Solar System [23], and van Flandern (1978) confirms that:

> ... the presence of isotopic anomalies in carbonaceous meteorites implies the action of nuclear processes, not just chemical ones. [24]

The observed anomaly of isotopic composition of the shells of refractory inclusions when compared with the core might be explained by ion implantation of transmuted atoms. More importantly, meteorites exhibit many other isotopic anomalies, chief among them being the appearance of isotopes of xenon and iodine which are known to be the decay products of relatively short-lived, heavy, radioactive parents. This poses problems for the conventional view in that it requires the formation of meteorites shortly after a stellar nucleosynthesis event, possibly as remnant of a supernova [25]. Yet neither tektites nor meteorites have been found in any ancient geological formation, which suggests that most surviving meteorites are relatively quite young [26]. Also, it has been found that the quantities of spallation-produced neon-21 in irradiated grains from some meteorites exceed that plausibly attributable to either galactic or present-day solar cosmic ray irradiation, and associated solar wind neon seems to be underabundant [27].

12. The electric discharge mechanism would render radiogenic dating meaningless. It would further obviate the need to have chondritic components formed millions of years apart and 'parked' before somehow being brought together to form the final chondrule.

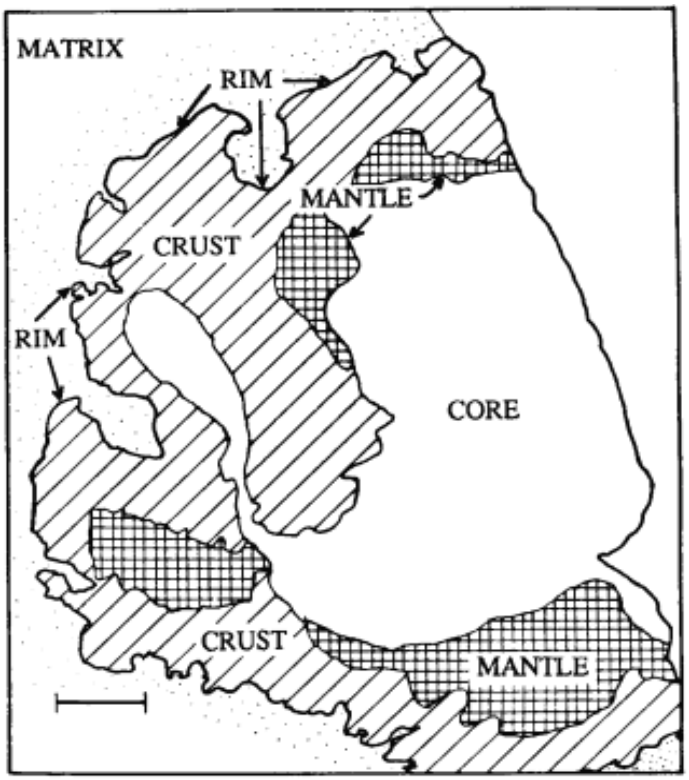

Figure 4. Backscattered electron photograph of polished section of CAI 3643 showing compositional and textural differences between core, mantle and crust. Note the sharp boundary of core, convoluted rim of CAI, and dark, altered, layer just below rim. Scale bar represents 1mm. *(A. Beal, after D. A. Wark, Earth and Planetary Science Letters 77 [1986], p.131)*

13. It should be noted in the case of chondrule formation that lightning within a solar nebula has been proposed as a plausible mechanism [28], but the argument betrays a lack of understanding of plasma discharges. The electric discharge theory does away with the problematic formation of bodies from a solar nebula and introduces a new evolutionary picture, with the birth of objects from the size of stars right down to meteors by electrical parturition. This is consistent with the fact that the non-volatile components of chondrites have approximately solar proportions.

14. T. van Flandern has proposed the formation of comets, meteorites, asteroids and tektites from the explosion of a larger former planet in the Solar System [29] by some unknown mechanism. He shows how many anomalies in the characteristics of our solar system may be simply explained by such an event. The stratification of chondritic types within the asteroid belt certainly indicates at least four separate events in that region of the Solar System. The differences in composition of meteorites from those regions may be diagnostic of the parent bodies.

It should be remembered that all of the giant planets have ephemeral ring systems, which by this theory are indicative of past expulsion of matter. Saturn's rings would appear to be the most recent.

Proposal for an Experiment

There is a simple experiment which may be performed to validate two critical aspects of this theory: that is the mode of formation of the CAI shells and the creation of the observed compositional anomalies of such shells.

A) Isolate some refractory inclusions from a chondrite and remove carefully their outer, flash-heated shells.

B) Place the refractory 'cores' in a plasma furnace, such as that used by the TI Research Laboratory, Cambridge, England.

C) After heating in the plasma furnace, rapidly cool the cores and examine their surface structure and composition for the formation of shells with the observed depletion of volatiles.

D) Selectively introduce ions into the plasma furnace to see if the observed isotopic anomalies in the shells can be reproduced by ion implantation.

I expect, based on the current use for plasma furnaces to provide uniform toughened surfaces by ion implantation on complex metal shapes [30], that almost all of the observed features of the rims of refractory inclusions in chondritic meteorites may be reproduced in the laboratory.

Conclusion and Implications

The electric discharge hypothesis appears to offer, for the first time, the possibility of an explanation for all of the peculiar features of chondrites. By extension it offers a more plausible mechanism for the creation of asteroids, comets, moons, planets, planetary rings, and companion stars than does the nebular hypothesis. It follows that the history of the Solar System has been one of continual evolution rather than creation, roughly as we see it now, from a nebula 5 billion years ago followed by relative peace since that event.

The ubiquitous planetary rings of the gas giants are not explained by the nebular hypothesis. Micrometre sized grains in Jupiter's rings have a lifetime measured in thousands of years [31]. By the core discharge hypothesis, the material in the rings should provide a sample of the parent planet. Saturn, as evidenced by its extensive rings, may have been the last to erupt, or the most violent.

Meteorites and comets should provide us with data about the conditions in the cores and atmospheres of the outer planets rather than a hypothetical early solar nebula. It is interesting to note that organic molecules have been discovered in the tail of Halley's comet. This is to be expected by the ejection theory due to the presence of organic molecules in the atmospheres of the giant outer planets. Electric discharge fissioning of giant planets or stellar cores is an extremely effective mechanism for creating highly condensed planetary bodies. It also sidesteps the severe angular momentum problem of the solar nebula hypothesis. It should be noted therefore that geologists have proposed that Earth's mantle composition is comparable to that of chondritic or stony meteorites. Maybe in years to come we will be able to deduce the parentage of the inner planets and moons by comparing material from them with ring material from the outer planets?

On a larger scale, it may be seen that theories of neutron stars and black holes have been the result of an over-simplification of the fate of gravitating matter. Energetically it is infinitely more simple to strip off the outer electron of an atom in a stellar core than it is to force all of the electrons into the atomic nucleus. In other words, long before total degeneracy could set in, compression ionisation would lead to instability and fissioning. Pulsars, X-ray bursters and other periodic outburst phenomena should be looked at from the point of view of stellar tuned electromagnetic circuits, probably involving close binary partners in charge-discharge cycles. Explanations of pulsar periods in the millisecond range involving hypothetical single rotating degenerate objects stretch credulity to the limit. It is interesting that pulsars are associated with nova remnants and that radial velocity data show most novas to be invisible companions of ordinary stars [32]. It would be expected that nova fissioning of a partner in a close binary system is more likely than in single or loosely bound star systems since perturbation of the charged cores by external forces and consequent triggering of a core fission event would be a feature of such a system.

Confirmation of some kind of the discharge theory may be forthcoming from observations of the famous, recent Supernova 1987A where a bright object, the 'Mystery Spot', has been detected to the side of the supernova. The discharge theory predicts a highly directed, filamentary outburst as well as a possible shock front from the steep rise in radiant energy of the star's ionosphere. Of great interest is the very recent discovery that the bright blue star Sanduleak -66 41 at the centre of the supernova has been resolved into six tightly clustered component stars and the central star 'may itself be a binary or even a multiple star system' [33]. This observation is of particular importance for Crew's theory because compression ionisation should ensure that no super massive stars can exist. The report is headlined 'New observations deny the existence of super massive stars'. It should also be noted that the nova has taken place in a tightly coupled star system.

Electric discharge on a galactic scale removes the need to postulate invisible, supermassive, black holes to generate the energetic behaviour observed at the centre of galaxies. Quasars are presumably an indication of the power of a galactic discharge at or near maximum when the charging cycle has reached the point of breakdown. Evidence of galactic discharge along our arm of the galaxy is provided by the helical magnetic field discovered to be wrapped around it. The 'missing mass' problem, which appears when the orbits of stars about the galactic centre are considered gravitationally, may be found to disappear when electromagnetic forces are included. The non-gravitational interaction between some galaxies may be similarly explained as an attraction or repulsion between two parallel discharge paths. Long, thin strings of stars or galaxies and galactic jets can be interpreted as evidence of discharge channels.

It seems to make sense to invoke the strong electric force to mediate the formation of galaxies, stars and their planetary systems. Astronomers have restricted themselves to the infinitely weaker force of gravity despite the fact that magnetic fields in the cosmos are direct evidence of the net movement of charge, that is electric currents, which in turn imply potential differences over vast distances. A moving plasma with zero net charge will not give rise to a magnetic field.

Philosophically it is pleasing to find an escape route from gravitational death, the notorious 'black hole' beloved of writers of science fiction and 'fact', particularly when that escape suggests the electrical fissioning and birth of new cosmic bodies. Nature propagates by 'budding' on our puny scale, and I feel confident that it does so on the grander scale of the galaxy.

Thomas van Flandern writes:

> As science progresses we will eventually unravel the mystery of our origins, and the solution will come

sooner if our minds are prepared to accept the truth when it is found, however fantastic it may be. It we are guided by our reason and our scientific method, if we let the Universe describe its wonder to us, rather than telling it how it ought to be, then we will soon come to the answers we seek, perhaps even within our own lifetimes.' [34]

References

1. D. A. Wark: presentation at a seminar, Research School of Earth Sciences, Australian National University, March 1986
2. D. A. Wark: 'Observational Constraints on Solar Nebula Models', *Lunar Planetary Science* **16** (1985), pp. 889-890
3. D. A. Wark: 'Evidence for successive episodes of condensation at high temperature in a part of the solar nebula', *Earth and Planetary Science Letters* **77** (1986), p. 147
4. *loc. cit.* [2]
5. Boynton & Wark: 'Refractory Rims: Evidence for high temperature events in the post-formation history of Ca-Al-rich inclusions', *Meteoritics* **20** (1985), p. 613
6. Bunch, Chang, Cassen, Hollenbach: 'Dynamic Thermal Episodes in the Protosolar Nebula: Development of Models from Observations on CAI's', *Meteoritics* **19**:4 (1984), p. 202
7. Wasson, Rasmussen, Grossman: 'A New Model for Chondrule Origin', *Meteoritics* **17**:4 (1982), p. 294
8. *ibid*
9. D. A. Wark & J. F. Lovering: 'Marker events in the early evolution of the solar system: Evidence from CAI's in carbonaceous chondrites', *Proc. of the 8th Lunar Science Conference* (1977), p. 102
10. *loc. cit.* [7]
11. R. A. Lyttleton: 'Journey to the Centre of Uncertainty', *Speculations in Science and Technology* **8**:5, pp. 342-343
12. S. K. Vsekhsviatskii: 'New Works Concerning the Origin of Comets and the Theory of Eruption', *Publications of the Kiev Observatory,* no.5, pp. 3-57
13. S. K. Vsekhsviatskii: 'Possible existence of a Ring of Comets and Meteorites Around Jupiter', *Soviet Astronomy - AJ* **6**:2 (Sept-Oct 1962), pp. 226-235
14. F. L. Whipple: *The Mystery of Comets* (C.U.P. 1985), p. 133
15. C. E. R. Bruce in S. Coroniti (ed): *Problems of Atmospheric and Space Electricity* (Elsevier 1965), pp. 577-586
16. E. W. Crew: 'Orbits of Core Material Ejected from Gaseous Planets', *Kronos* X:2 (1985), pp.13-31
17. K. H. Bohm: 'Pressure Ionization in White Dwarf Convection Zones', *The Astrophysical Journal* **162** (Dec. 1970), pp. 919-923; P. Savic: 'Comments on the Origin of the Earth-Moon System', *Earth, Moon and Planets* **36** (1986), pp. 139-143
18. T. C. van Flandern: 'A Former Asteroidal Planet as the Origin of Comets', *Icarus* **36**:1, pp. 71-72
19. D. A. Wark & J. F. Lovering: 'Evolution of Ca-Al-rich bodies in the earliest solar system; growth by incorporation', *Geochimica et Cosmochimica Acta* **46**, p. 2606
20. D. A. Wark: *op. cit.* [2], p. 889
21. Kracher, Scott, Keil: 'Relict Grains and the Significance of Collisions During Chondrule Formation', *Meteoritics* **18**:4 (1983), p. 329
22. A. Brecher: 'Some Genetic Constraints from Meteoritic Paleomagnetism', *Bull. Amer. Astron. Soc.* **9** (1977), pp. 505, 506
23. Wood, McSween: 'Chondrules as condensation products in comets, meteorites, asteroids; interrelations, evolution and origin', (A. H. Delsemme, Un. of Toledo, Toledo, Ohio 1977), pp. 365-373
24. van Flandern: *op. cit.*, p. 69
25. 'Isotopes in Meteorites', *Nature* **240** (15.12.72), pp. 378-379
26. van Flandern: *op. cit.*, p. 71
27. Caffee, Hohenberg, Swindle: 'Confirmation of Cosmogenic Neon from Precompaction Irradiation of Kapoeta and Murchison', *Meteoritics* **19**:4 (1984), p. 203
28. *loc. cit.* [7]
29. T. C. van Flandern: 'Exploding Planets', *Science Digest* (April 1982), pp. 80ff
30. *New Scientist* 6.3.86, p. 34
31. 'Discovery of Jupiter's gossamer ring', *Nature* **316** (8.8.85), pp. 526-528
32. van Flandern: *op. cit.* [18], p. 72
33. 'New observations deny the existence of super massive stars', *Journal of the British Astronomical Association* **98**:5 (August 1988), p. 223
34. van Flandern: *op. cit.* [29], p. 95