the renal cortex of the horse and is characterized by its low molecular weight (> 9000 Da), cysteine-rich, metal-binding protein. Mammalian MT contains 61 amino acids. Metals bind to MT in metal–thiolate complexes exhibiting tetrahedral (cadmium, zinc) or trigonal (copper) geometry. The toxicity of the cadmium–metallothionein complex precludes any consideration of the clinical use of this natural metal ligand to enhance excretion of metals.

In addition, there are many other natural polymers exhibiting chelating ability. They can immobilize metals ions, which can cause chemicals to decompose and are highly toxic to the ecosystem. In short, we can say 'chelates, can't live with 'em, can't do without 'em'[11].

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HYPOTHESIS

Anoxia during the Late Permian binary mass extinction and dark matter

Samar Abbas, Afsar Abbas and Shukadev Mohanty

Recent evidence quite convincingly indicates that the Late Permian biotic crisis was in fact a binary extinction with a distinct end-Guadalupian extinction pulse preceding the major terminal end-Permian Tartarian event by 5 m.y. In addition, anoxia appears to be closely associated with each of these end-Palaeozoic binary extinctions. Most leading models cannot explain both anoxia and the binary characteristic of this crisis. In this paper we show that the recently proposed volcanogenic dark matter scenario succeeds in doing this.

Recently, Knoll *et al.*[1] have suggested a new model wherein the overturn of anoxic deep oceans and the consequent introduction of carbon dioxide into surficial environments led to the end-Permian Tartarian extinction. This model could explain the selectivity of the extinction, with organisms tolerant to elevated carbon dioxide levels exhibiting higher degrees of survival across the P/T boundary. The C-isotope record also indicates that another anoxic event occurred at the end of the Guadalupian, approximately 5 m.y. before the Tartarian extinction. Knoll *et al.* state that it is possible that the Siberian flood basalt volcanic episode[2] could have led to the Tartarian overturn by means of tectonic realignment[3]. It has also been realized that this P/T extinction was in fact a double extinction[4], with each extinction apparently associated with an anoxic event, and the work of Knoll *et al.* is consistent with this fact. In this paper we extend the recently proposed idea of volcanogenic dark matter[5] to consistently explain the binary nature of the extinction and the associated anoxia.

Dark matter may constitute more than 90 per cent of the matter of the universe, and ample evidence in favour of its existence occurs in the form of galactic rotation curves, the stability of galactic clusters, etc. Several candidates for the enigmatic dark matter have been proposed[6,7]. This dark matter envelopes galaxies in a uniform halo. However, the nature of the dark matter is unknown, with candidates ranging from neutrinos to Jupiter-sized brown dwarfs. This paper considers the class of dark matter candidates generally known as WIMPs (weakly interacting massive particles). In addition, it is very likely to form compact clusters as well. During the occasional passage of such a 'clump' through the earth, dark matter would accumulate in the core and annihilate, producing vast quantities of heat[8]. Abbas and Abbas[5] estimate that the heat output can exceed present-day terrestrial heat production by five orders of magnitude. These large quantities of heat would lead to the creation of a superplume that initiates, upon arrival at the surface, a flood basalt volcanic episode, of which Siberia is an example[5]. Inherent in this model is the concept that all giant flood basalt provinces, including the Deccan, Parana and Ethiopian plateaus, were produced in this manner. This volcanism may lead to changes in oceanic circulation patterns by tectonic realignment or the creation of new oceanic plumes above submarine eruption sites. Such a change would also lead to anoxia with the consequent terminal P/T mass extinction as envisaged by Knoll *et al.*[1]. In addition, Vermeij and Dorritie[9] pointed out that it is possible that the Siberian volcanic episode may have released vast quantities of methane from permafrost and continental shelves, which, on oxidation, would have yielded carbon dioxide, drawing down atmospheric and oceanic oxygen in the process and leading to anoxia. However, different P/T sections from across the globe do not show redox patterns similar to those seen by Isozaki[10]. For example, Chinese sections show acid volcanism; more work needs to be done to establish whether the anoxia patterns discovered by Isozaki are global or local events.

This volcano-induced extinction would occur after a time interval representing the duration between creation of the superplume at the core/mantle boundary and arrival of this plume at the surface[5]. With a migration rate of a few cm per year, this should be approximately 5 m.y., and this is in fact the observed interval separating the Guadalupian and Tartarian extinctions[4]. However, these calculations are order of magnitude estimates; any change in the migration rate will change the time interval. In addition, the timing of the P/T anoxia is not precisely known as no proper geochronological data exist for various P/T sections.

According to Isozaki[10], results from Japanese and British Columbian deep sea cherts indicate that the onset of anoxia marked the Guadalupian extinction, while the climax of the anoxia, also designated the superanoxia, coincided with the Tartarian crisis[11,12]. This is consistent with the volcanogenic dark matter model; the initial anoxia would persist until the final superanoxia instead of disappearing after some time. The duration of anoxia in this picture is dependent on how rapidly ocean circulation patterns can re-oxygenate the seas. In the model outlined herein Siberian volcanism may have released vast amounts of methane from permafrost which on oxidation would have consumed oxygen and led to anoxia; or oxidation of organisms that died as a result of dust, blockage of sunlight, noxious gases (e.g. sulphur dioxide, nitrogen oxides) would have drawn down oxygen, thereby leading to anoxia. Further palaeontological work is required to clarify whether anoxia is the cause or an after-effect of extinctions.

Here we suggest that the direct passage of a dark matter clump itself would lead to the first extinction step by causing lethal carcinogenesis in organisms. Zioutas[13] studied the effect of dark matter on living organisms, and concluded that dark matter may be responsible for mutation and cancers in living beings. Changes of biorhythms depending on the direction of flight have been recorded for humans as well as fungi during flights across different time zones, and these may be due to dark matter. Background radiation can only explain 1 in 20,000 of the observed spontaneous mutations in Drosophilia; the remainder may be due to dark matter interactions. Subsequently, Collar[14] analysed the effect that highly clumped dark matter may have on the biosphere. He discovered that such an event could be highly detrimental to life on earth. The dosage imparted to organisms during the passage of a clump core would in principle be roughly comparable to the neutron radiation from a close nuclear explosion protracted over a time required for a clump core passage. This dose protraction would further aggravate the detrimental effects. Thus the passage of a clump core would induce a large dose of highly mutagenic radiation in all living tissues, thereby causing palaeontological extinctions.

The dark matter, which in the present paper is taken to be weakly interacting, does not decrease in intensity during passage through the oceans and hence immediate extinctions on land and sea would result from the clump passage through the earth. The oxidation of the resulting organic matter would deplete oxygen from the oceans and atmosphere, while simultaneously increasing the levels of carbon dioxide. Normally, as organic material descends through the ocean, it is oxidized on the way down. However, the full-scale destruction of life would lead to even the surface waters becoming anoxic[15]. Thus the first pulse of anoxia would have been a consequence of extinctions. The introduction of anaerobic life would further toxify the oceans as some of these organisms produce toxins like hydrogen sulphide, and further extinctions of those species that survived the clump passage would take place. In addition, for low dosages of dark matter the mutations engendered would take several generations to cause fatalities. Hence this first extinction need not necessarily be a sharp peak; it may very well be extended and drawn out.

Thus the passage of the earth through a clump of dark matter would be highly detrimental to life. This would lead to mass extinctions of phytoplankton and/or larger marine animals and other types of marine biota. Their destruction gradually depletes dissolved oxygen at a faster rate than can be replaced by dissolving from the atmosphere, thereby removing the oxygen even from the surface waters. Thus, anaerobic conditions set in and microbes that can respire anaerobically thrive. Anaerobic sulphur bacteria produce hydrogen sulphide, which is toxic to most marine life[15]. After this would have followed the terminal extinction engendered by large-scale volcanism as outlined above. This process would have also occurred on the other planetary objects as well. The recent discovery of a magnetic field on Ganymede[16] indicates the existence of a partly molten interior, whilst Mariner 10 colour images suggest Mercury has undergone complex differentiation like the earth[16]. Indeed, one of the testable predictions of this model is the occurrence of as yet undiscovered relics of recent heating episodes on planetary bodies. This model is admittedly speculative, yet manages to present a unified solution to several distinct problems.

The late Miocene extinction has recently been found to be binary[17], with a five million year interval between them. The scenario depicted above may be applicable to this case also. In fact the volcanogenic dark matter scenario[5] provides a natural explanation for binary extinctions, the first one due to direct interaction of the dark matter particles with organisms and the second one around 5 m.y. later caused by volcanism induced by dark matter in the core of the earth. It has been shown that anoxia is a natural consequence of this scenario.

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SCIENTIFIC CORRESPONDENCE

Lightning return stroke electric field escaping out and giving rise to optical and associated emissions

In connection with lightning, two new terminologies, namely 'Sprites[1]' and 'Elves[2]' have appeared in many of the papers on the topic. It did attract the attention of readers but the use of the nomenclatures for optical phenomena arising due to the upward propagation of lightning generated electric field continues to be a riddle for workers in this field of research. These phenomena are not at all new and are occasional manifestations of lightning that has been known for over a century[3]. Scanning through the scientific literature in this area, one finds scattered anecdotal descriptions of lightning popularly known as 'blue' or 'green' pillars and rocket discharge-like columns of optical emissions[4–7] which continue to be an occasional feature. Wilson[8] discussed the possibility of lightning discharges propagating upwards from the cloud-top and undergoing occasional multiple reflections between the cloud and the ionosphere. Vaughan *et al.*[9] and Bell *et al.*[10] have reported television observations from the space shuttle and showed that a large number of upward-directed cloud discharges, either 'red' or 'blue', are observed at altitudes around 60 km and above. Using a low light level All Sky Television System (ASTS), Sentman and Wescott[11] recorded a large number of upward-directed optical emission phenomena during NASA's single airborne DC-flight over thunderstorms in Iowa, Nebraska and Kansas. Initially, they estimated the most probable terminal heights of the events to be 60 km with error bars extending up to 100 km. The duration of this optical phenomenon was found to be 16 m sec or less, and brightness was estimated to be 25–50 kR, which is almost the same as that of bright aurora. The occurrence rate of this optical phenomenon was found to vary from time to time and region to region, and was estimated to occur once for every 200–300 cloud-to-ground strokes[12]. In addition, the 'Red Sprites' and the 'Blue Jets' were also video-recorded[13] and their properties studied. Further refinements in the ongoing measurements are being made and the results are being reported.

Continued observations have shown that high altitude luminous phenomena do take place and are thought to be arising due to the escaping part of the cloud-to-ionosphere lightning discharges[6,14]. The observed phenomenon is simple enough and occasionally it is seen to be generated and extending upwards and, at times, undergoing multiple reflections between the cloud and the ionosphere. A state of non-judgment prevails when it is observed by aeroplane flights[11]. The first definite observation with supporting details has been made by using the aeroplane 'Sprite-94', although the detailed mechanism of the optical features extending from cloud-to-troposphere and ionosphere was not known. The phenomenon of escaping out of the ground-to-cloud generated electric field and the generation of optical emission into the upper atmosphere is confined to the cloud-to-ionosphere[12,15] region and is known as 'Sprites'. Recorded features have shown that many of these events are spatially varying and one event is different from the other. It has been further shown that the 'Sprites' appearing at different altitudes[15] are 'Red Sprites' and 'Blue Jets'. The escaping out of the positive cloud-to-ground leader stroke and the geometry of the return stroke is schematically illustrated in Figure 1. The most prevalent lightning phenomenon is the cloud-to-ground discharge in which the negative charge is lowered giving rise to positive return stroke. However, 'Sprites' are associated with less frequent phenomena of positive cloud-to-ground discharges. The upward-directed electric field is known to generate this optical emission around 60 km. Depending on the cloud features and details of the cloud-to-ground

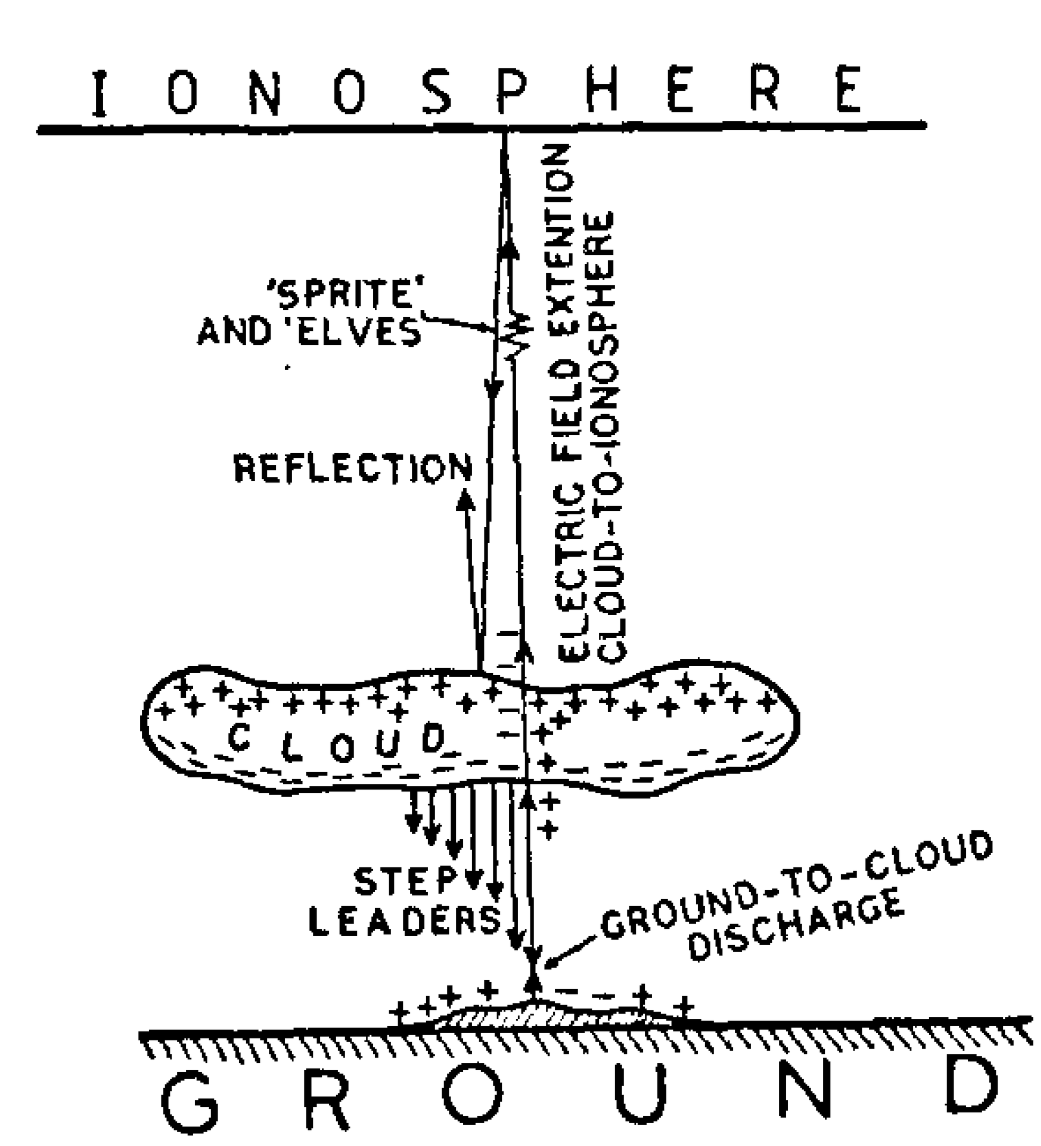

Figure 1. Schematic diagram of escaping out cloud-to-ground lightning discharges.