GEOLOGICAL CONSEQUENCES OF LARGE METEORIC BODIES APPROACHING THE EARTH – THE ELECTRICAL FACTOR

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Abstract: Kimberlite genesis is linked to disruptions in the Earth's electrical field caused by the approach of large meteoritic bodies, as well as their mechanical impact with the Earth. Previous work suggests that subterranean electrical discharges may not only cause earthquakes but also trigger the eruption of kimberlite. Here it is proposed that these disruptions of the Earth's internal electrical field are the result of external factors affecting the Earth's electric field, such as the close approach of a large meteoritic body. It is also suggested that crypto-ring structures may have a similar genesis, as they appear to have a spatial association with kimberlite diatreme fields.

Keywords: *kimberlite, meteorite, electric field, diatreme, ring structure*

The proposed model of kimberlite genesis by near-Earth intruder interaction suggested by the author is based on four separate groups of data. Until recently, each particular group showed no logical connection with the other three, but when considered collectively all appear related.

Group 1. **Subterranean electrical discharges**

Finkelstein and Powell **[1]** were the first to propose that subterranean electro-discharges ("subsurface thunderstorms") are the true cause of some earthquakes. Alekseevsky and Nikolaeva **[2]**, specialists in diamond geology, expanded on this idea and first suggested that the cavities of kimberlite diatremes may be the breakdown channels of a "giant condenser" between the Earth's surface and mantle. Both of these hypotheses were supported by Vorob'yev **[3]**, who suggested the presence of strong electric fields and discharges within the dielectric rocks of the Earth's crust. Diatremes (channels from the Earth's interior) are the result of subsurface electrical discharges, their explosive effects, the mechanical fluctuations of rock destruction under conditions of strong electrical fields ($>10^4$ V/cm), and the melting of channel walls. The melting of the rocks produces hot gases (possibly plasma), which escape from the Earth's upper mantle at great velocity, destroying the tops of the channel and forming explosive, funnel-like craters. Molten magma then ascends the channel behind the plasma.

According to Vorob'yev [op cit] these electrical processes and the electrical explosions are a possible explanation of the formation of pipes and some ring structures. This research was continued by Stepanov **[4]** and Balasanyan **[5]**. They suggested that the power of electrical discharges in the Earth's crust, with their energy concentrated in a small area, is sufficient to form explosive structures. The conclusion drawn by Balasanyan **[5]** is worth noting: ***A necessary condition for electrical discharges in the Earth's crust acting like a trigger is a sharp increase of negative charges on the Earth's surface affected by atmospheric electricity.***

Group 2. **Meteoritic bodies (MBs) as sources of electric fields**

Astapovitch and Solyanik **[6, 7]** considered the process of accumulation of positive charges on the surface of MBs moving through the Earth's atmosphere. MBs induce negative charges on the Earth's surface within zones of influence called "tension spots", in the same manner as thunderstorm clouds. Solyanik **[7]** and later Nevskiy **[8]** made calculations that showed electrical discharges between MBs and the Earth's surface are possible. Both of them suggest, for example, that the explosion of the famous Tunguska body was caused by electrical discharges. For a long time these explanations did not gain support in scientific circles, and only recently have they started to attract attention.

These data are well known by specialists in the field of electrophonic fireballs, but have still to be recognized by geologists. Data that have been accumulated point to the influence of the energy of MBs on objects on the Earth, including the following:

(i) People and animals exhibit signs of fear and a sense of danger (before observing MBs).

(ii) Damage to TV, electrical and radio equipment, bulbs catching fire in switched-off electric networks, formation of St. Elmo's lights, e.g. during the time the Chulym and Vitim fireballs passed over Siberia in February 1984 and September 2002 respectively.

(iii) Activation of seismic processes.

The effects identified in (ii) above form the basis for supposing that the main causes of the energy influence are electric (i.e. electromagnetic) fields. All of these effects were observed in connection with the appearance of small MBs (approximately 1 to 40 meters in diameter) that burned or blew up in the atmosphere. Imagine the scale of the effects that might occur if the MB entering the Earth's atmosphere was a huge asteroid more than one kilometer in diameter.

Group 3. **Structural independence of diatreme zones and fields**

Analysis of the distribution patterns of diatreme zones and fields reveals a common independence relative to the crustal structure, including the magma controlling faults described by various authors **[9-13 and many others]**. For example, the well-studied Markha-Olenek kimberlite zone, with a length of about 750 km, shows no spatial-genetic connections with major structures of the northeastern Siberian platform (pre-Vendian faults, relief of crystalline basement, main fold structures of the cover, and basite-controlling zones) **[9]**. The recognition of this structural independence led to the idea of their origin in terms of a "hot spot" by Zhitkov **[14]**. This hypothesis has now received serious acknowledgement in the east of the USA by Heaman and Kjarsgaard **[15]**. However, as the quoted authors note, it is not universal and is not applicable to kimberlite fields elsewhere in North America. Besides, it can't explain the deficiency of magmatic melt in the diatremes that is the main distinctive feature of those structures.

Group 4. Spatial-temporal connections of ring explosive structures and diatreme fields and zones

Bucher **[16]** was the first to pay attention to the spatial-temporal connections of some ring explosive ("cryptovolcanic") structures on the one hand, and diatreme fields and zones on the other. He illustrated this with some examples from the USA and Germany. His ideas were developed later in the publications of Vaganov et al. **[17]**, Nicolayesan and Fergusson **[18]**, and many others. The most convincing argument for the relative connection of these structures are the ring explosion structures of Ries (24 km in diameter) and Steinheim (3 km) in southern Germany. These structures are along the same straight 100-kilometer-long line as the explosive pipe field Urach. The K-Ar age of these formations are identical, namely 14.8 Ma.

Khazanovitch-Wulff **[19a]** gave other examples of the spatial connection between diatreme fields and ring structures. In particular, the above-mentioned Markha-Olenek kimberlite zone (~365 Ma) forms the "train" of the large Olenek ring structure with a diameter 250 km (D_3). The author also knows of eight examples in North America, three examples in Europe, five examples in Asia (including three with alkaline massifs on astroblemes), three in Africa and four in Australia – a total of 23 so far. It is thought that further detailed analysis of the geological structure of continents should result in the discovery of more occurrences of this type.

Bucher and his followers have used some of these examples as evidence of the endogenic (non-meteoritic) origin of ring explosive structures but as there is conclusive evidence for the meteoritic origin of some of these structures, how can these be explained?

The following mechanism, initially proposed by **[19a]**, links the four main groups of data into one logical chain, by the addition of one extra factor – electricity.

Consider the entry into the Earth's atmosphere of large MBs accompanied by the accumulation of electrical charge on their surface that induces a zone of electrical "mirror charge" or tension spot, on the Earth's surface. This electrical tension spot moves with the MB along its projected trajectory and may even lead it.

This tension spot is the "driving force" of the geoelectrical activity in the Earth's crust and upper mantle.

In areas with a strong electrical field in the Earth's crust or upper mantle, diatreme fields or earthquakes could be triggered when the electric discharges either reach or fail to reach the Earth's surface respectively (Figure 1). In both cases, if the MB accumulates an extremely large electrical charge or reacts electrically with the Earth, then it can be destroyed by the electrical stresses produced by the encounter. The Tunguska and Sikhote-Alin events are possible examples of such explosions.

Therefore the Urach diatreme field could also be interpreted as a "diatreme train" of a large MB which was split into two parts by electrical stresses. The smaller part formed the Steinheim crater and the larger one, the Ries crater.

Naturally, the flight trajectory of an MB in the Earth's atmosphere is independent of geological structures in the area and could explain the random geological position of diatreme fields and zones on the Earth's crust.

Ring explosive structures can form in at least two ways. Firstly, as the result of the interaction between high electric fields induced by an MB and zones of accumulations of electric charge in the Earth's crust (for example, zones of deep faults). Examples of these structures are Zhamanshin (Kazakhstan) and Ternovskaya (Ukraine), centered on deep faults that cannot be regarded as impact fractures of a cosmogenic body **[19b]**.

Secondly, as a result of the MB's impact with the crust. In both cases, the reasons for the spatial-temporal connections between the diatreme "trains" and ring explosive structures are clarified by this MB electrical link.

It has been noticed that not all diatreme fields have associated astroblemes and vice versa. There are several possible explanations.

(i) In some regions with a large cover of surface glacial deposits (for example, Canada and northwestern Russia), incomplete geological knowledge may mean that existing associated diatreme fields and astroblemes may not yet have been identified.
(ii) In some cases, it is possible that no electric discharge occurred between the Earth's lower crust and the Earth's surface. For example, if the MB had a near vertical trajectory there might have been no time for a large charge to accumulate or there may have been no zones in the Earth's crust inside the MB's tension area with electric fields strong enough to cause an electrical discharge to the Earth's surface. In this case, "underdeveloped" explosion structures could form inside this area, for example Stopfenheim dome northeast of the Ries crater, Hatzium Dome inside the Gibeon kimberlite and meteorites, Namibia **[19c],** and others.
(iii) A diatreme field without an associated astrobleme may be the result of an MB which accumulated its maximum possible charge before impact but was destroyed in the atmosphere as a result of internal electrical stresses.
(iv) In uplifted districts astroblemes could be completely eroded while the roots of the diatremes connected with them could remain.

Additional new information shows that not only MBs, but even aircraft, may produce seismic activity in certain districts. In 1992, re-entry of the Space Shuttle into the Earth's atmosphere produced seismic signals that were recorded by the Washington RSN and described by Qamar **[20]**.

Conclusion

Thus, the geological consequences of the interaction between large MBs with the Earth are not limited to mechanical impact, but may also result from electrical stresses in the atmosphere and the Earth's crust, producing seismicity, local partial melting of the mantle and the eruption of kimberlites to the Earth's surface.

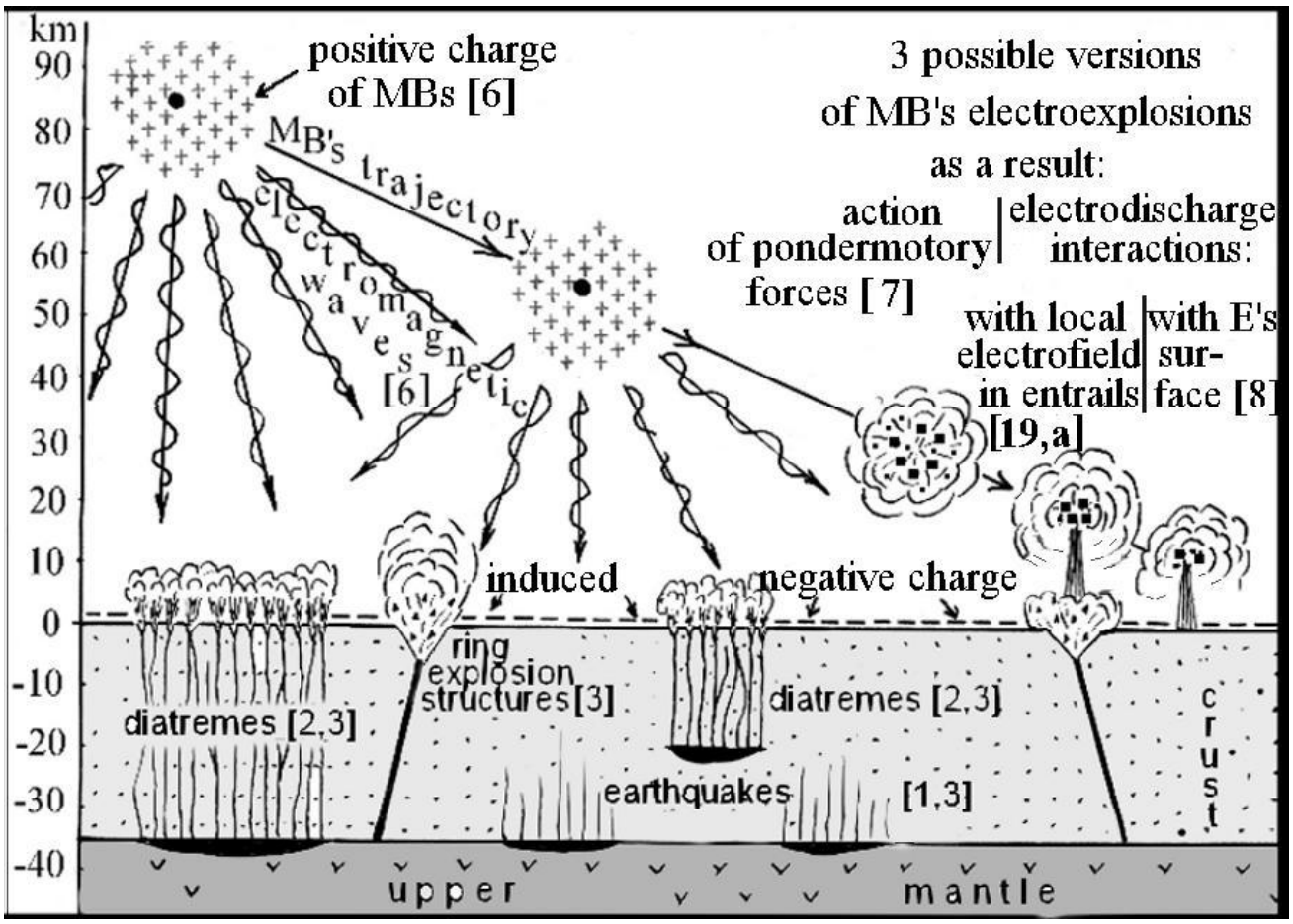

Figure 1. Main events in the Earth's atmosphere and lithosphere associated with intruding large MBs (diameter >1 km?). Black lenses – zones of strong, localized electric charge. Black bold vertical lines in the crust – faults with strong electric fields. Thin vertical lines – channels of electrical discharges associated with magma (diatremes) or internal short circuits (earthquakes) from failure to reach the Earth's surface.

References: **[1]** Finkelstein, D. and Powell, J. (1971) XV Gen. Assembly Int. Union of Geodesy and Geophisics, Moscow, part 8, 35. **[2]** Alekseevsky, K. and Nikolaeva, T. (1972) Journal "Znaniye-Sila", N. 4, 30. **[3]** Vorob'yev, A.A. (1975) Physical Factors Governing the Occurence and Properties of Plutonic Material: Strong Electrical Fields in the Earth's Interior (in Russ.), Tomsk University Press, 296p. **[4]** Stepanov, O. (1989) Sov. Geol., No. 12, p. 95-104. **[5]** Balasanyan, S. (1990) Dynamic Geoelectric Theory (in Russ.), Nauka Press, Novosibirsk, 232p. **[6]** Astapovitch, I.S. (1958) Meteoric phenomena in the Earth's atmosphere (in Russ.), Fismatgiz, 640p. **[7]** Solyanik, V.: **a)** (1959) Yuniy Tehnik, N. 3, p. 64-65; **b)** (1980) Vzaimodeystviye meteoritnogo veschestva s Zemlyoy. Novosibirsk: Nayka, 178-188. **[8]** Nevskiy, A. (1978) Astronom. Vestn., No. 5, p. 206-215. **[9]** Brakhfogel', F.F. (1984) Geological Aspects of Kimberlite-Igneus Activity in the Northeast of the Siberian Craton (in Russ.), Yakutsk, 128p. **[10]** Milashev, V. (1984) Explosion pipes (in Russ.), Nedra Press, 284p. **[11]** Vladimirov, B.M., et al. (1990) Kimberlites and Kimberlite-Like Rocks (in Russ.), Novosibirsk: Nauka, 264p. **[12]** Mitchell, R.H. (1986) Kimberlites: mineralogy, geochemistry, and petrology. NY, 442p. **[13]** Skinner, E.M., et al (1992) Geol. and Geophis., No. 10, p. 33-40 (in Russ.). **[14]** Zhitkov, A.N. (1995) Extended Abstracts of 6-th International Kimberlite Conference. Russia, p. 692-694. **[15]** Heaman, L.M., Kjarsgaard, B.A. // EPSL, 178 (2000), p. 253-268. **[16]** Bucher, W.H. (1963) Am. J. Sci, vol. 261, No. 7, p. 567-649. **[17]** Vaganov, V.I., Ivankin, P.F., Kropotkin, P.N., et al. (1985) Explosive Ring Structures of Shields and Cratons (in Russ.). Nedra Press, 200p. **[18]** Nicolayesen, L. and Fergusson, J. (1990) Tectonophysics, vol. 171, No. 1/4, p. 303-335. **[19]** Khazanovitch-Wulff, K.K.: **a)** (1991) Transactions of USSR Academy of Sci., Earth Sci. Sections, vol. 320, No. 7, p. 127-131; **b)** (1994) Doklady Akad. Nauk, vol. 337, No. 1, p. 83-87; **c)** (2001) Abstracts of the 64-th Annual Meteor. Soc. Meeting, 78. **[20]** Qamar, A. (1993) Seismol. Research Lett., vol. 64, No. 1, p. 46.