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Dmitri Sobolev and other forgotten forerunners of mass extinction science and volcanic catastrophism

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Some paradigms in the impact-volcanic controversy that we regard as having first been established in the 1980s in fact can be traced much farther back in time, as exemplified by the heuristic neocatastrophic concepts proposed by Dmitri Sobolev and other progressive Russian scholars (Aleksey P. Pavlov, Mikhail A. Usov) of the early 20th century. They were truly conceptual forerunners of the global catastrophe model in Earth history which is now widely accepted as the volcanic/greenhouse scenario, even if preceding thought-provoking concepts of some leading European scholars (e.g., Svante Arrhenius, Jacques J. Ėbelmen) were unknown to them.

From time to time, scientific society is astonished by the discovery that supposedly modern concepts originated many decades ago. For example, mass extinction themes are still the subject of intense debate in mainstream science, but some paradigms have a beginning that can be traced far back in time.

Dmitri Sobolev's model of mass extinction

Dmitri N. Sobolev (1872–1949; Fig. 1) was a fairly noted Russian geologist and paleontologist, best known today as an unsuccessful propagator of the non-Darwinian saltational model of phylogeny and a "heretic" ammonoid taxonomy (Kolchinskiy 2002; Dzik 2003; Popov 2008). Although Russian, his scientific career, as a graduate of the University of Warsaw, was inextricably linked to today's Poland and Ukraine. Sobolev made a major contribution to our understanding of the Paleozoic and Quaternary geology of Poland, and beginning in 1914, he continued his scientific activities at the University of Kharkov, working on tectonics, geomorphology, and mineral resources of the western Soviet Union (Racki 1979; Ozonkowa 1980; Dzik 2003; Solovyev et al. 2014; see also http://geologia.univer.kharkov.ua/index.php/about-us/vidatni-spivrobitniki).

During the years 1926–1928, Sobolev published in Kiev a three-part, in-depth treatise entitled *Zyemlya i zhizn*, also outlined in two popular-science articles in *Priroda* (Sobolev 1915, 1927). In the third part, he discussed the issues related to the causes of organisms' extinction and recognized several Phanerozoic mass extinctions; four of these great biotic crises are accepted today: the end Ordovician, Late Devonian, end Triassic, and end Cretaceous. Sobolev put forward a theory of cyclic (diastrophism-related) volcanic cataclysm as the main trigger of these biotic revolutions. He stated (1928: 74): "The environment is persistently and continuously formed and converted by the life and other terrestrial forces, in harmony with diastrophism in their activity. These large-scale paroxysms, which accelerate the beating pulse of the Earth and increase the energy of the breath of the Earth, radically reconstruct and renew both the land and the sea bottom, change properties and composition of the atmosphere, hydrosphere and stratosphere, with which is connected terrestrial life. Disturbing the balance of life setting, they oscillate the equilibrium between the Earth and life and the equilibrium in life itself (…)".

Sobolev recognized the perturbation in the dynamic equilibrium of gaseous exchange between the atmosphere and biosphere, i.e., carbon dioxide/oxygen imbalance, as a direct effect of increased volcanic emission of CO_2 (probably also H_2O, H_2S, and NH_4). As an ultimate killing factor for animals, he considered "oxygen starvation", in effect a massive oxygenation of injected volcanic gases that removed atmospheric oxygen,

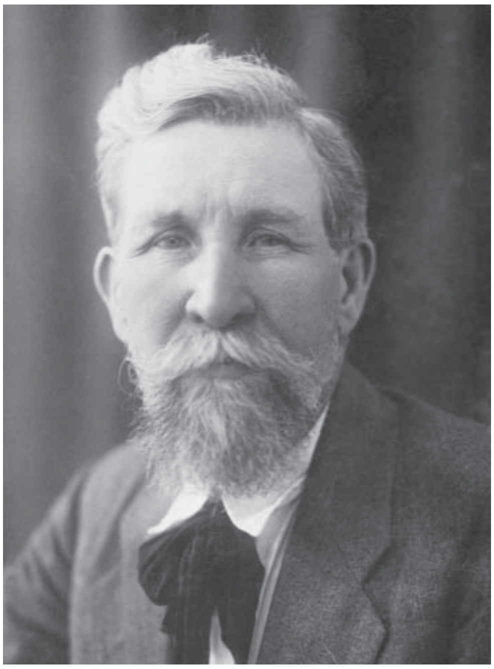

Fig. 1. Dmitri Nikolayevich Sobolev as the Professor of Geology at the University of Kharkov (photo courtesy of the University of Kharkov).

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but also "carbon dioxide starvation", owing to large-scale CO_2 storage in carbonate and coal deposits. Thus, Sobolev finally proposed a prolonged, stepwise biotic crisis scenario in both animal and plant kingdoms during the orogenic cycle, with feedbacks that feature prominently in modern-day extinction scenarios. The lethal feedbacks include, among others, pH changes (and crucial ion ratios, such as Na+K to Ca+Mg) and anoxia in marine settings, and a cascade effect in the trophic pyramid after vegetation demise. Considering the physiologic and biogeochemical aspects of his thinking, Sobolev was mainly guided by the observations of the American biologist, Jacques Loeb (i.e., a kind of actualistic conceptual foundation), and the Gaia-like model of Vladimir I. Vernadsky (e.g., Loeb 1916; Vernadsky 1926). Thus, Sobolev struggled with uniformitarianism using actualistic arguments. The Lilliput effect and extinction selectivity were announced in his papers, as well as augmented chemical weathering in a CO_2-enriched moist atmosphere, resulting in the enhanced input of Ca and Mg from land to sea. In the crucial climatic context, Sobolev ruled out cooling as a mechanism (e.g., Schuchert 1914), instead stressing, following Loeb's experiment results, increased animal mortality with increased temperature. In consequence, he suggested volcanically-induced warming in CO_2 enriched atmospheres along lines similar to the volcanic summer scenario (see review in Bond and Wignall 2014).

Other Russian pioneers of volcanic catastrophism

An overall analogous concept of the volcanic catastrophe at the end of the Cretaceous (K–T boundary), an alternative to the bolide impact cataclysm, is usually thought as founded in the pioneering work of American geologists, such as McLean (1985), although the preceding less known South African contribution by Oelofsen (1978) is noteworthy. McLean (1985: 235) summarized the K–T scenario thus: "gradual (…) bioevolutionary turnover during a period of disequilibrium between the rate of mantle CO_2 degassing and uptake by sinks", in harmony with Sobolev's (1927, 1928) paradigm. On the other hand, the hypothesis of fatal volcanic eruptions in the Deccan peninsula was actually proposed in 1924 by the Professor of Geology and Paleontology at the University of Moscow, Aleksey P. Pavlov (1854–1929), and similar K–T boundary "ridiculous notions" were at that time published also in Poland (Łoziński 1927) and USA (Marshall 1928; see also Müller 1928). Sobolev himself underlined the inspiring importance of the geological revolutions predicted by Pavlov (1924), who first proposed the possibility of ecosystem devastation by volcanogenic acidification (HCl and H_2SO_4). Furthermore, he clearly recognized a magmatic trigger of the end-Permian mass extinction, unexpectedly undervalued by Sobolev. Pavlov (1924: 97) mentioned even the Siberian traps, although due to the imprecise dating of these flood basalts, he did not make a causal link between their emplacement and any biotic crises.

A similar model of non-actualistic worldwide cataclysm, initiated by trap-type volcanic activity, was first discussed in 1916 in the popular-science article, entitled "Catastrophes in Earth History", by Mikhail A. Usov (1883–1939), a young Siberian geologist from Tomsk University. Unlike his contemporaries, Usov entertained notions of an extraterrestrial trigger for some biotic crises, guided by the only the incipiently known meteorite crater in Arizona! He illustriously introduced his main approach in these words: "(…) much exists reasons for assuming that between the history of the Earth and the life of individual representatives of the organic world exists a significant analogy. And, if in the lives of the organisms, which are developed gradually, there are manifested occasionally of shocks of diverse kind, then is possible to expect, that also the Earth, calm generally on the people memory, it was not always the same; that occurred sometimes a rapid and pronounced change on the surface or in its depths, (…) that they would generate on us, so adapted to see entire that surrounding in seemingly solidified forms and to step confidently on the firm ground, the terrible impression of catastrophes" (Usov 1916: 437).

Final remarks

It is surprising that even such a multi-language erudite as Sobolev did not know (or ignored?) several benchmark papers that considered themes similar to his own. The greenhouse effect of volcanogenic CO_2 was conspicuously highlighted by the famous Swedish chemist Svante Arrhenius already in 1896. Regarding this stimulus in the global carbon cycle, Arrhenius stressed significance of another Swedish mineralogist and geologist, Arvid G. Högbom (Högbom 1894). Again, if truth be told, this credit in carbon cycle matters should be referred to the French visionary geochemist (in a recent sense), Jacques J. Ėbelmen (1845, 1847), as revealed by Berner and Maasch (1996). Ėbelmen (1847: 652) surprisingly hypothesised that the biosphere could collapse as a consequence of total volcanic quiescence that eventually led to a CO_2 deficiency due to chemical weathering. However, the concept of fluctuating atmosphere composition in geological history, as a major control of biotic evolution, may be traced many decades earlier, because it was delineated by the pre-Darwinian Scottish evolutionist and horticulturalist Patrick Matthew in 1831 (see Rampino 2011). Matthew (1831: 382) rationally deduced: "When we view the immense calcareous and bituminous formations, principally from the waters and atmosphere, and consider the oxidations and depositions which have taken place, either gradually, or during some of great convulsions, it appears at least probable that the liquid elements containing life have varied considerably at different times in composition and weight; that our atmosphere has contained a much greater proportion of carbonic acid or oxygen and that our waters aided by excess carbonic acid, and greater heat resulting from greater density of atmosphere, have contained a greater quantity of lime and other mineral solutions".

In the last years of his life, Sobolev summarized his scientific career with a frustration: "What of [my] works is overall accepted, it does not present the scientific merit, but what I consider to be the most important, this is not acknowledged by others or indeed is rejected" (quoted from an unpublished manuscript dated 1943; Ozonkowa 1980: 140). His cyclic concept of Earth history was even criticized in 1935 from a "dialectic" viewpoint (see reply in Sobolev 1935). In fact, Sobolev and other creative Russian scholars were truly conceptual forerunners of the global catastrophe model in Earth history which is now widely accepted as the volcanic/greenhouse scenario, in particular for the end-Permian ecosystem collapse (Bond and Wignall 2014).

These progressive ideas of "crazy catastrophists" were evidently overlooked in mainstream science and forgotten for many generations (although see Hoffman 1989 for an exception). Kolchinskiy (2002: 306) remarked: "Now, when the publications, scoped on the possibility of sudden speciation and global turnovers by some planetary factors of cosmic (asteroid explosion, collision with a comet, supernova blast) or terrestrial origin (volcanism, orogenesis, transgression), they are calculated by the thousands, it is appropriate to recall name D.N. Sobolev". Therefore, the nearly unacknowledged intellectual contribution of many European countries in developing ideas on mass extinction science, highlighted herein, significantly predate the North American renaissance in this field over the past 30 years.

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References

Arrhenius, S. 1896. On the influence of carbonic acid in the air upon the temperature on the ground. *Philosophical Magazine* 41: 237–276.

Berner, R.A. and Maasch, K.A. 1996. Chemical weathering and controls on atmospheric O_2 and CO_2: fundamental principles were enunciated by J.J. Ėbelmen in 1845. *Geochimica et Cosmochimica Acta* 60: 1633–1637.

Bond, D.P.G. and Wignall, P.B. 2014. Large igneous provinces and mass extinctions: an update. *In*: G. Keller and A.C. Kerr (eds.), Volcanism, Impacts, and Mass Extinctions: Causes and Effects. *Geological Society of America, Special Paper* 505: 339–352.

Dzik, J. 2003. Rodowód polskiej szkoły paleontologii. *Ewolucja* 1: 14–21.

Ėbelmen, J.J. 1845. Sur les produits de la décomposition des espéces minérales de la famile des silicates. *Annales des Mines* 7: 3–66.

Ėbelmen, J.J. 1847. Sur la décomposition des roches. *Annales des Mines* 12: 627–654.

Hoffman, A. 1989. Changing paleontological views on mass extinction phenomena. *In*: S.K. Donovan (ed.), *Mass Extinctions: Processes and Evidence*, 1–18. Belhaven, London.

Högbom, A. 1894. Om sannolikheten for sekulara forandringar i atmosfarens kolsyrehalt. *Svensk Kemisk Tidskrift* 5: 169–176.

Kolchinskiy, Y.E. [Kolčinskij, I.E.] 2002. *Neokatastrofizm i selekcionizm. Večnaâ dilemma ili vozmožnost' sinteza?* 553 pp. Nauka, St. Petersburg.

Loeb, J. 1916. *The Organism as a Whole, from a Physico-chemical Viewpoint*. 379 pp. Putnam, New York.

Łoziński, W. 1927. Niewidzialny czynnik geologiczny (promienie nadfjołkowe). Ein unsichtbarer geologischer Fraktor (Ultraviolette Strahlen). *Rocznik Polskiego Towarzystwa Geologicznego* 4: 93–105.

Marshall, H.T. 1928. Ultra-violet and extinction. *American Naturalist* 62: 165–187.

Matthew, P. 1831. *Naval Timber and Arboriculture*. 391 pp. Adam and Charles Black, Edinburgh.

McLean, D.M. 1985. Deccan Traps mantle degassing in the terminal Cretaceous marine extinctions. *Cretaceous Research* 6: 235–259.

Müller, L. 1928. Sind die Dinosaurier durch Vulkanausbrüche ausgeratet worden? *Unsere Welt* 20: 144–146.

Oelofsen, B.W. 1978. Atmospheric carbon dioxide/oxygen imbalance in the Late Cretaceous hatching of eggs and the extinction of biota. *Palaeontologica Africana* 21: 45–51.

Ozonkowa, H. 1980. Problemy paleozoiku Gór Świętokrzyskich w pracach Dymitra Nikołajewicza Sobolewa. *Prace Uniwersytetu Śląskiego* 192, *Geologia* 2: 139–228.

Pavlov, A.P. 1924. On some still insufficiently studied factors of the extinction of the animals [in Russian]. *In*: M.V. Pavlova, *Pričini vimiraniâ životnih v prošedšie geologičeskie epoki*, 89–130. Gosudarstvennoe Izdatel'stvo, Moskva.

Popov, I. 2008. Orthogenesis versus darwinism: the Russian case. *Revue d'histoire des sciences* 61: 367–397.

Racki, G. 1979. Znaczenie prac Dymitra Sobolewa w świetle najnowszych badań dewonu Gór Świętokrzyskich. *Przegląd Geologiczny* 27: 608–611.

Rampino, M.R. 2011. Darwin's error? Patrick Matthew and the catastrophic nature of the geologic record. *Historical Biology* 23: 227–230.

Schuchert, C. 1914. Climates of geologic time. *In*: E. Huntington, The climatic factor as illustrated in arid America. *Carnegie Institution of Washington Publication* 192: 263–298.

Sobolev, D.N. 1915. Geological periods [in Russian]. *Priroda* 4: 809–832.

Sobolev, D.N. 1927. Diastrophism and organic revolutions [in Russian]. *Priroda* 26: 565–582.

Sobolev, D.N. 1928. *Zyemlâ i žizn'*. Part 3. *O pričinah vimiraniâ organizmov*. 75 pp. Knigospilki, Kiev.

Sobolev, D.N. 1935. On geological cycles and dialectics in geology [in Russian]. *Problemy Sovieckoj Geologiii* 5: 648–656.

Solovyev, V.O. [Solov'ev, V.O], Moskalenko, I.A., and Shcherbina, V.G. [Ŝerbina, V.G.] 2014. *Har'kovskaâ geologičeskaâ škola, ee rol' v izučenii i osvoenii neftegazovyh mestoroždenij*. 128 pp. National technical university, Harkov.

Usov, M.A. 1916. Catastrophes in Earth history [in Russian]. *Priroda* 5: 437–462.

Vernadsky, V.I. [Vernadskij, V.I.] 1926. *Biosfera*. 146 pp. Naučno-Tehničeskoe Izdatel'stvo, Leningrad.

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