

Large diamond education mechanism

Abstract

The article shows the conditions for the formation and existence of both polymorphic modifications of carbon in natural conditions. The formation of diamond and carbon can be realized in the presence of carbon-containing rocks in near-surface and surface reducing conditions with a low partial pressure of oxygen. The formation of explosion tubes is carried out due to a chain reaction between deep hydrogen and oxygen in the air with the release of a huge amount of heat, increasing the temperature to 3000°C during a typical exothermic reaction.

Keywords: diamond formation, explosion tubes, reducing conditions, temperature, pressure, hydrogen, carbon, chain reaction

Volume 3 Issue 6 - 2019

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Received: October 1, 2019 | **Published:** November 22, 2019

Introduction

A literature analysis of the existing basic hypotheses of the origin of diamond made it possible to establish several theories proposed by numerous researchers: magmatic, mantle, fluid, cavitation, meteorite, metamorphic, impact, electric discharge, etc. According to the presented theories, there is no single opinion on the conditions for the formation of diamond. However, many researchers acknowledge that it is carbon in kimberlite pipes under extremely high pressures and temperatures that can be the source of diamond formation. This is the so-called mantle (high pressure) hypothesis.^{1,2} The basis for such an assumption was the results of the first attempt to determine the stability fields of polymorphic carbon modifications by calculating the carbon – diamond phase equilibrium.³ Subsequently, a number of specifying theoretical works appeared on the determination of the carbon – diamond phase equilibrium.^{4,5} As a result of these works, the role of pressure and temperature in the formation of diamond was adopted as the main one.

Hypothesis of diamond formation conditions

From the material of numerous published works, some arguments on this issue are mutually exclusive and even contradict each other, in particular, on the conditions for the transfer of diamond crystals from depths to the Earth's surface. They are carried to the surface by volcanic magma during the formation of the so-called “explosion tubes”. It is assumed that the introduction and speed of movement of diamond-containing magma occurs as a result of a “lumber” of the sedimentary stratum and was a “projectile” moving at a speed of up to 300km/h.⁶ However, after diamond formation in the region of high P and T, the crystal will be in a supercompressed state (in the form of a dense crystalline structure). And in order for this diamond crystal to appear in near-surface conditions or on the surface of the earth, it must, as many researchers suggest, move from the depths at high speed. Its rapid rise to the earth's surface along faults at a speed of 30-50meters per second from a depth of 200-220km should be 3.5-4hours. Therefore, the speed of movement of magma with diamond-containing components can reach 100km/h.⁷ As a result of such “transportation”, accompanied by a sharp pressure drop, the diamond crystal is decompressed (dilatancy, a phenomenon as a function of time). This precedes the destruction of the diamond, and it can simply disappear like a crystal. In the case of a slow movement of a diamond crystal from depths to the earth's surface, according to the conditions of the phase diagram of the graphite – diamond equilibrium,³ it would simply turn into graphite, accompanied by an energy release of 1.9kJ/mol.

Other diamond finds

Unexpected findings of diamond in fundamentally different from the generally accepted high-pressure hypothesis are of not only scientific, but also practical interest. Thus, diamond manifestations were found and studied in detail in various metamorphic minerals of the rocks of the ore zone of Kumdykol and the Barchinsky diamondiferous province of the Kokchetav massif of Northern Kazakhstan.^{1,8} The diamonds of these deposits turned out to be very small and have no industrial value. Therefore, it has been proposed to consider such diamonds as a possibility of their genesis by a different mechanism.^{8,9} As evidence of this, there are cases of finds of wood replaced by calcite, as well as partially by opal and chalcedony, in kimberlite pipes of the Yakut, South African and North Russian provinces. Indeed, sometimes even thin branches of plants were found inside the crystals of Siberian diamonds, which confirms the formation of diamonds in the surface layers of the earth's crust.¹⁰ In this regard, it is assumed that the process of diamond formation may have occurred under surface conditions, at lower pressures and temperatures.¹¹

The established conditions for the formation of diamonds

Based on our theoretical physicochemical studies, the possibility of crystallization and the existence of both polymorphic modifications of carbon in the system kyanite-sillimanite-andesite (Ky-Sill-And) and the region of metastable diamond with graphite was shown.^{12,13} The calculation results allowed us to assume that the formation of diamond in the aluminosilicate system really indicates a relatively low-temperature conditions for its formation (at temperatures within 1000°C and pressures slightly above five kilobars). In connection with the above material it is possible to consider the possible existence of other ways of synthesis of the diamond under natural conditions; high P and T. consider a few unexpected our proposed scheme of formation of diamonds in nature.

Conditions for the formation of large diamonds

Recently, the media are full of very interesting information that in 2014 on the Yamal Peninsula have discovered a giant black hole – a mysterious crater (Figure 1). From the information obtained from the herders know that “first came a thick smoke, followed by a bright flash, the earth shook, and at this place formed a hole.” Locals in the area the appearance of the crater saw a bright flash gas. With the help of ground-penetrating radar was installed at a depth of 35meters and

having the shape of a giant mushroom, narrowing towards the bottom and extending closer to the surface. The inner diameter of the funnel is about 40metres and external, external – 80. The alleged reason for the formation of a funnel is associated with possible explosion of natural gas. The explosive process was accompanied by the release of pieces of rock that frames the funnel in the form of a roller, a width of 12meters. The true reason for the formation of this (and another there) of the funnel while it is not established.



Figure 1 Yamal crater explosive (e-mail: arctic-rf.ru).

The depth of the Yamal Peninsula are a rich hydrocarbon Deposit. Therefore, the first assumption can be considered eye-catching explosion of hydrocarbon gas (methane). This way to explain the

same explosions in the mines, mine workings, tunnels. It is known that when the concentration of methane gas to 4.5-9%, it explodes. Below we present the calculation of its “combustion” as a model of a methane explosion. The (Table 1) is three of the most likely chemical reactions in this process. These reactions can occur simultaneously at different speeds. When explosion (combustion) of methane with the greatest amount of heat will be allocated according to the third chemical reaction with the formation of carbon (thick smoke!) and water. However, the products of the first two chemical reactions are the formation of hydrogen.

Indeed, with the explosion of the methane gas (the first stage) hydrogen is formed which in the second stage in the interaction with oxygen may flow chain process.¹⁴ General theory of chain chemical reactions of combustion and explosion are common in various fields of science and technology. According to the study of the process of degassing from the depths of the Earth are very intense filtering of the deep hydrogen to the surface).¹⁵⁻¹⁸ At achievement of pressure of hydrogen and oxygen a certain critical value the process (H_2+O_2) is developing very quickly and, in certain concentrations flows typical branched (chain) exothermic reactions.¹⁴ The active centers for this reaction are the hydrogen atoms (H), oxygen (O) and free radical – hydroxide H. Released during this heat is partially dissipated to the external environment, the rest is spent on heating and temperature rise in the system. The intensity of this process increases the heating rate due to secreted even greater amounts of heat. In the absence of rapid removal of allocated heat to the external environment, there is a progressive autoradiograph, where the ambient temperature will rapidly increase, further boosting this process. Upon reaching a certain critical temperature, the rate of reaction will increase to a value that will occur a thermal explosion.¹⁴

Table 1 An example of the amount of heat by oxidation reactions of methane oxygen in a wide temperature range

T°C	$CH_4 + O_2 = CO_2 + 2H_2$ -ΔH, kJ/mol	$CH_4 + O_2 = CO + H_2O + H_2$	$CH_4 + O_2 = C + 2H_2O + H_2O$
25	318.699	278.115	409.99
200	313.672	273.873	407.44
400	308.959	272.59	409.148
600	306.163	275.523	416.672
800	304.618	281.854	429.329
1000	303.758	291.241	446.831

Theoretical substantiation of diamond formation conditions

The formation of explosion tubes due to the chain reaction of the incoming deep proton and hydrogen ($H+H=H_2$) with near-surface air oxygen ($2H+1/2O_2=H_2O$ and $2H_2+O_2=2H_2O$) (Table 2) can cause local volume a sharp (instantaneous) increase in temperature to 3500°C, as well as an instantaneous change in pressure to very high values, which contributes to the course of reactions. Upon reaching the appropriate concentration of hydrogen and oxygen in the mixture, the chain reaction is accompanied by an explosion. Destructive explosions and the formation of explosive funnels (for example, with

a diameter of 5meters, a depth of 15meters or more) are the cause of hydrogen degassing. Such funnels are installed in the vicinity of the city of Sasovo (Ryazan region). As a result of powerful explosions in the city’s houses, all the glass flew out.¹⁶ Numerous explosive funnels were also installed in some central regions of the European part of Russia and in a number of countries abroad.

An example of a heavy-duty explosion is the result of the interaction of external rocket tanks isolated from each other (a tank with hydrogen of 1720000 liters and a tank with oxygen of 640,000liters), which exploded like a small atomic bomb.¹⁹ The contents of the tanks were pumped into three rocket engines, where

it mixed and burned, forming superheated steam with a temperature above 3000°C, which created a huge rocket thrust. With this Shuttle crash (Challenger explosion January 28, 1986) killed seven American astronauts with a teacher. A similar explosion of the Space-X (Falcon 9) rocket on April 16, 2015 is the result of the interaction of hydrogen

and oxygen in connection with a violation of the sealing of the two outer tanks of the carrier rocket (commission conclusion). Another example, there was a hydrogen leak when recharging batteries on a diesel submarine Sindhurakshak.¹

Table 2 An example of the amount of heat generated by reaction reactions hydrogen with oxygen in a wide temperature range

T°C	$H + H = H_2$ -ΔH, kJ/mol	$2H + 1/2O_2 = H_2O$	$2H_2 + O_2 = 2H_2O$
25	435.97	678.37	484.8
200	438.19	681.963	487.546
400	440.642	687.466	494.413
600	442.978	695.586	505.215
800	445.19	704.653	519.935
1000	447.275	716.561	538.572

The result was a powerful explosion and fire. The boat immediately sank in the port of Mumbai in eastern India on 08.14.2013. The gradual flow of hydrogen to the Earth's surface can even cause periodic explosions, which could be observed during the eruption, for example, Tolbachik (September, 2013). As a result of such explosions, a huge amount of thermal energy is released (Tables 1&2) as a near-surface source that causes rock melting. It also causes a significant increase in the temperature of the released magmatic melt, a decrease in its viscosity and an increase in fluidity during the outflow of magma. The area of gas evolution from depth has a great influence on this process.¹⁶ The burning of hydrogen on the melt surface of a number of cratering volcanoes in the form of "blue flames" was observed many times by many volcanologists. So, pale blue and bluish translucent tongues of the flame of hydrogen combustion were recorded in the crater Erta-Ale (Ethiopia).²⁰ Depending on the distance of the ongoing chain process (explosion) in near-surface conditions from the Earth's surface, the shape of the resulting natural object determines the shape of the crater. The explosion funnel is a consequence of a powerful explosion of a gas mixture. As a result, a sphere with a smooth surface or a funnel-shaped cavity with fused edges (the surface of a sphere) is formed, similar to the chambers left after underground nuclear explosions.¹⁸

Discussions

In our opinion the power and depth of flow of the explosion from the Earth's surface depends on the value of the resulting voids of spherical shape or surface craters. Their space after the explosion is filled with fragments of host rocks, the melting of newly formed minerals, metal native secretions, volatile components, and synthetic organic compounds.²¹ Indeed, traces of melting pipes, and the presence of "zones of school" in some kimberlite pipes has been noted by many researchers.^{2,15,22} The size of the resulting craters and spheres at a depth directly dependent from the depths of the amount of hydrogen.

Indeed, experimental works of the last years confirmed that the formation of carbonaceous substances (and diamonds in particular), in accordance with the established and proven by numerous mechanisms, it is possible in a wide range of thermodynamic parameters.²³⁻²⁵ Some researchers believe that the determining factor for the formation of diamond in carbon system is not only pressure, but rather the instantaneous temperature rise in the "non-oxidizing environment with negative oxygen balance". The greatest effect is achieved when using CO₂^{26,27} Instantly create high temperature and pressure (chain process) do lead to strong destruction, transformation of the structure of the environment. Under these conditions there is an intensive process of decomposition of carbonates in accordance with the law of Hess. Indeed, the explosion pipe of Yakutia, including diamond, in contact with carbonate containing rocks.⁸ As a result of chemical decomposition reactions of carbonates under natural conditions their products are the newly formed calcium and magnesium minerals (diopside, monticellite, phlogopite, serpentine, etc.), fluid components (including numerous hydrocarbons, etc.).²¹

Conclusions

Thus, when deep hydrogen interacts with oxygen under near-surface conditions, the high P, T (as a model of the high pressure hypothesis) created by the chain process in isolated cavities of a spherical shape are quite sufficient for diamond formation due to carbon-containing compounds and, in particular, during the decomposition of carbonates. The time factor in this process is an important characteristic as a function of pressure and depends on the tightness of the volume of the formed spherical cavities. It is the time of their tightness that will affect the number and, especially, the size of diamond crystals. In the figure (Figure 2), the dependence of the generated pressure in the isolated volume on the amount of deep hydrogen and the volume of the formed spheres (Klaiperona-Mendeleev) is plotted. The basis of the calculation procedure was a temperature of 3000°C. From the presented graphic material, it follows that the smaller the volume of voids of a spherical shape and the more moles of hydrogen enter the system, the higher the pressure created for the formation of large diamond crystals.

¹The theory and mechanism of the chain process were developed and studied in detail experimentally in the last century N.N. Semenov and SN Hinshelwood - 1956 Nobel Prize in Chemistry laureates.

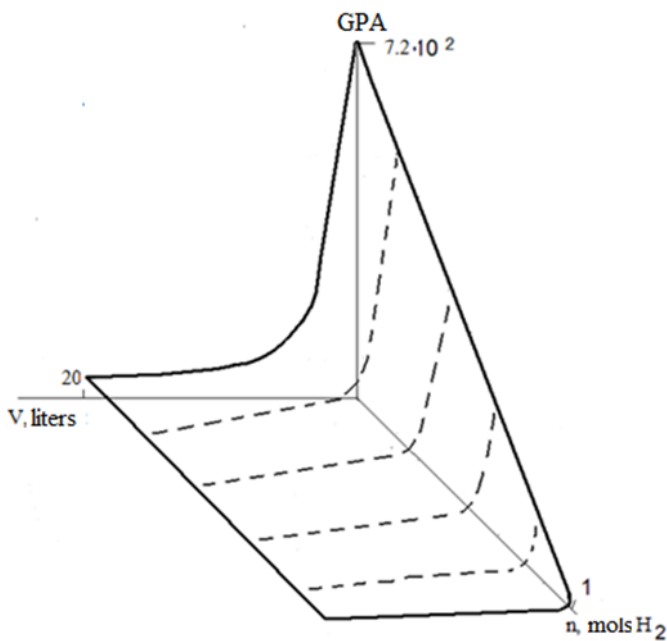


Figure 2 Dependence of the generated pressure in an isolated volume on the amount of deep hydrogen and the volume of the formed spheres as a result of a chain process ($T=3000^{\circ}\text{C}$).

Acknowledgments

None.

Conflicts of interest

The authors declare that there is no conflict of interest.

Funding

None.

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