Why Japan and Italy Have the Severest Geohazards?

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Abstract

Why Japan and Italy have the severest geohazards? For many years, various researchers have tried to give various answers to this question. This paper presents a new hypothesis to answer the question. The hypothesis is that a thin spherical methane gas CH_4 layer exists between the crust and mantle. This gas-sphere layer separates and protects the cold crust rocks and the hot mantle and core materials. The methane gas is produced by the mantle and core materials and is stored by the spherical trap of the compressive lower crust rock. Because of various deep crustal faults in some special regions including Japan and Italy, the gas mass of extremely high density and pressure can escape its deep traps and flow to the shallow crustal ground, which causes the severest geohazards including volcano, earthquake, tsunami, land subsidence, ground faulting, and landslide in these regions. The methane gas can provide both the mechanical energy and the chemical energy to make the geohazards. In particular, this paper examines the gas cause of active volcanos that are present in the ground surface and upper crustal rocks. The volcano cone-shaped mountain is used to estimate the gas chamber volume below the cone-shaped mountain because the volcano cone rocks come from the rocks originally infilling the gas chamber. The chemical reaction of the methane gas with the crustal rocks surrounding the chamber produces new gases, lavas and ashes.

Keywords: Crust, mantle, earthquake, volcano, tsunami, landslide, methane gas, gas-sphere

1. The question

People in some regions on the Earth’s crust such as Japan and Italy have always been suffering the severest geohazards. They include earthquake, volcano, tsunami, land subsidence, ground faulting, sinkholes, landslides and debris flows. These geohazards show that their crusts are not stable. Why are these special regions of the Earth’s crust always not stable? Why do the severest geohazards have been always occurred in these special regions?

For many years, various researchers have tried to give various answers or hypotheses to explain questions and interpret the geohazards phenomena. The most widely accepted hypothesis is the plate tectonics theory which points out these special regions are located on the active boundaries of major tectonic plates.

But, these existing hypotheses and/or theories sometimes cannot be used to resolve these geohazards problems. For example, it has been a consensus that our human beings are still incapable to predict the next damaging earthquakes and/or next damaging volcano eruptions.

A damaging earthquake suddenly releases a large to extremely large amount of kinetic energy over area of hundreds kilometer long and ten kilometer wide in the Earth's crust and on ground surface within a few tens to two hundreds seconds. However, such kinetic actions in the Earth's crustal rocks cannot be pre-known or predicted by people at few months, weeks, days, hours, minutes, and/or seconds before they happen. Similarly, a volcano eruption usually can explode a tremendous amount of compressed gases, fire, lightening, dusts and rock debris over many hours and days. These gases include steam water H_2O and carbon dioxide CO_2. However, such massive eruption in the upper crustal rocks also cannot be accurately predicted by people.

Why do we have the problem?

2. My answer

My answer to the question is that our human beings still do not know the existence of a thin spherical methane gas layer (or a highly compressed gas-sphere) as the interface gap material between the crust and the mantle.

For many years, people have believed that the Earth is a sphere with the radius of 6380 km. Its surface is covered by the crustal rocks. Beneath the crust, it has another three main spherical layers. They are the mantle, the outer core and the inner core. The mantle and core materials have extremely high temperature, pressure and density. The outer core materials are in the state of liquid. The inner core and mantle materials are mainly in the state of solid with extremely high density and pressure. The inner core is believed to generate the Earth's magnetic field. The radial depth boundaries between crust and mantle, between mantle and outer core, and between outer core and inner core are respectively at about 30 km, 2889 km, and 5153 km depth from the ground surface. On the other hand, people have classified four great earth realms forming the upper portion of the Earth and outside the crustal rocks. They are the atmosphere, the hydrosphere, the lithosphere and the biosphere.

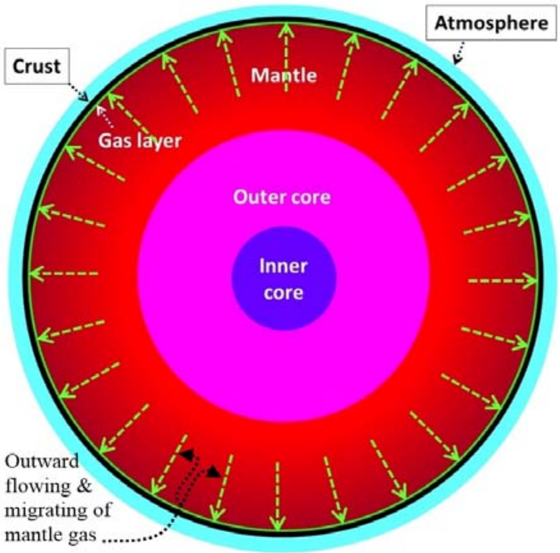

Fig. 1 Idealized sketch for gas generation in the mantle and core of the Earth and outward migration to the thin spherical gas layer beneath the crust

Since 1979, the author has studied and examined many aspects of geology, geophysics, geochemics, geomechanics, geotechnics, seismology, applied mathematics and mechanics. Since 2008, the author has found by induction that there is a thin spherical gas layer between the crust and the mantle of the Earth (Yue, 2008a, b; 2009; 2010; 2011a, b; 2012; 2013a, b, c, d; 2014). This highly compressed gas-spherical layer has high density and pressure and separates and protects the crust and the mantle. This gas layer is the main source for ensuring the entire crust to be stable for the majority of time and/or for causing the crust unstable sometimes and locally. This hypothesis can logically and systematically explain and interpret many phenomena of the Earth observed by people on the ground. This paper gives a brief introduction of this thin highly compressed gas-spherical layer and uses it to explain the cause and mechanism of volcanoes.

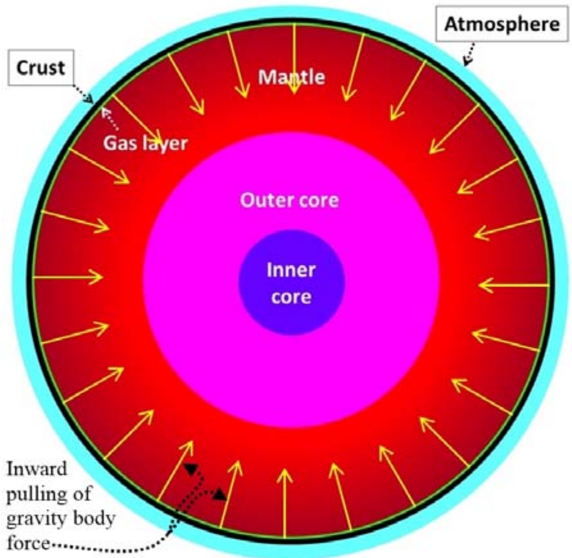

Fig. 2 Idealized sketch for the lower crust to form a complete spherical trap due to inward gravity body force to seal and keep the gas from the mantle and core

3. The Gas-sphere

3.1 Gas generation in mantle and cores and outward migration

The mantle and core materials are substantially different from the crust rocks (Figs. 1 and 2). They have extremely high temperature, pressure and density. The mantle rocks may be partially melted. The upper mantle temperature can be about 1300 °C to 2000 °C. At the core-mantle boundary, the temperature can be 4000 °C. The deeper the depth is, the higher the temperature, pressure and density are. The facts, phenomena and laws about the mantle and cores are extremely limited or rare.

Therefore, I make the assumption that the mantle and core materials (minerals) can have chemical reactions due to the high temperature and pressure and the chemical reactions would generate heat and can produce mainly methane gas CH4 and few other gases including Hydrogen gas H2, Helium gas He, and Argon gas Ar. Accordingly the following processes and results can be induced.

The generated gases must be much lighter than the general materials forming the core and mantle, under the same surrounding high pressure and temperature in the interior of mantle and the core. They have to migrate and flow outward and in the opposite direction of the inward gravitation to upper lower pressure zone, according to the second law of thermodynamics (Fig. 1). Because of the decrease in their surrounding pressures, the outward migrating gases would expand and absorb heat from the core and mantle materials, which may balance the temperatures there.

3.2 The lower crust rock as a spherical trap

On the other hand, the gravitation toward to the center of the Earth always acts as a body force on the crust rock and the gas, and forces them to move and deform along the radial inward direction of the Earth. Similar to a beam or an arch in bending, the lower crust rock would be always in compression both along the radial direction and the lateral hoop direction. The upper crust rock can be in compression along the radial direction but in tension along the lateral hoop direction. The lower crust rock mass must be in a state of extremely tight and compact because the compressive principle stresses can be 300 MPa to 600 MPa. Its voids in the solid rocks must be very tiny, little and/or zero. Therefore, it becomes an extremely impermeable solid rock geo-spherical layer and seals the highly compressed gas. It forms a spherical trap and prevents the seeping out of the gas generated in and migrated from the mantle and core (Fig. 2).

3.3 The thin highly compressed gas-sphere

Consequently, the outward and upward migrations and flows of the gases produced in the core and mantle would be blocked, contained and impeded by the impermeable spherical trap of the lower crust solid rocks with high compressive stresses. The gases would be accumulated and stored beneath the lower crust rock spherical trap. With time, more and more gases would be accumulated and stored beneath the spherical trap. The gases would separate the bottom of the lower crust rock with the top hot mantle materials.

With time, the gases eventually form a thin spherical gas layer separating the crust rocks and the hot mantle materials (Figs. 1 and 2). The gases are dominantly the methane gas CH_4. The gases in the thin spherical layer could have an extremely high density of from 1.3 kg/m^3 to 2.0 kg/m^3, an extremely high pressure of 300 to 500 MPa.

Its temperatures immediately beneath the crust rock and immediately above the mantle respectively are about 300 °C and about 700 °C. Such temperature difference along the radial depth causes the dense gas to have electric voltage/charges due to the thermoelectric effect. So, it can have relatively high conductivity. Its thickness is about several hundred meters beneath oceanic crust to a few kilometers beneath mountainous plateaus of elevations in thousand meters above the sea level. The gas-spherical layer beneath the Tibetan Plateau is the thickest region. This thin gas-spherical layer is the gap material forming the Moho discontinuity.

Besides, this thin gas-spherical layer is an ideal foundation footing to flexibly support and uplift the up spherical crust rocks and to balance the crust rock weight. It is also an ideal insulation layer to prevent the crust rock from melting by the hot mantle materials and also to prevent the heat of the mantle and cores from leaking into the crust rocks and the atmosphere. As a result, the mantle and cores can keep their hot temperatures for millions to billions years.

It is estimated that the methane gas mass is about 10 to 240 times of the mass of the atmosphere and is equal to a mass of 5×10^{19} kg to 125×10^{19} kg.

4. Phenomena of the Gas-sphere

Many phenomena and facts observed by people on the ground of the Earth can be consistently and logically explained and interpreted and/or predicted with the cause of this thin gas-spherical layer forming the gap seam between the spherical crust and the spherical mantle. These phenomena include earthquake, volcano, tsunami, huge landsides, gas/oil in upper crust rock mass, atmospheric air, fresh water/seawater, land subsidence, continental drift, ground rupture, weather and atmospheric changes after earthquake, the Moho discontinuity, continental rifts-subsidence basin, deep faults, continental plains, ocean basins, gravity anomaly and Bouguer anomaly, earth tide or body tide, mantle surface waves, free oscillations of the Earth, seismic waves, earth expansion and/or contraction, geosyncline, uniformitarianism and catastrophism, and evolution of life.

As an example, the phenomenon of present volcanos is given and discussed in the ensuing.

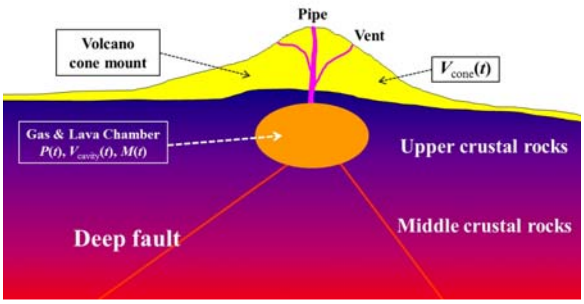

Fig. 3 Sketch showing the cause and mechanism of volcano in upper crustal rocks by the gas migrated from the deep gas-sphere via deep faults

5. The Gas Cause of Volcanos

5.1 The gas cause

As shown in Figure 3, a volcano usually forms a cone-shape mountain and has a crater with vertical pipe conduit to allow hot lava, volcanic ash and gases to escape or erupt from its underground chamber. The chamber locates several kilometers below the ground rock strata or rock mass in the upper crust. For many years, people have believed that the chamber contains magma that comes and migrates directly from the mantle via various channels such as faults or ruptures in deep crust rocks. In fact, this mechanism is mechanically impossible. Because of the extremely high compressive stresses along the lateral hoop directions and vertical directions at the lower crustal rocks, the mantle magma cannot flow outward passing through this compressive lower crustal rock layer.

The author has found and shown that the present volcanos on and in the upper crustal rocks are caused by the high compressed and dense gases escaped from the thin spherical gas layer. The escaped gas mainly CH_4 are further trapped in the upper crustal rock masses. They make chemical reactions with the surrounding rocks in the chamber. The chemical reactions are the types of reduction and decomposition. The reactions change the gas chemical compounds into steam water gas H_2O, CO_2, H_2S, SO_2 and others. For example, the following chemical reaction can take place.

$$CH_4 + 2O_2 = CO_2 + 2H_2O + \text{Heat} \quad (1)$$

The oxygen in the above chemical reaction comes from the surrounding crustal rocks. So, the other product of lava generally has a less amount of oxygen than that of the surrounding crustal rocks. Metal liquids can also be generated and can deposit in ruptures and form metal ore veins in the surrounding rock mass. The gas-rock chemical reactions also produce heat. The gas expansion and penetration power and the heat further break and crack the surrounding rock mass and make them into lavas, fragments, ashes or bombs.

5.2 The rock volume balance model

During earthquakes, some amount of the methane gas mass in the thin gas-sphere can rupture and escape the trap and rapidly migrate into the upper crustal rock. It can accumulate and store in the gas chamber within the upper crustal rock. The gas mass $M(t)$ in the chamber accumulates more & more and has higher & higher pressure $p(t)$. The gas can make chemical reactions with the surrounding rocks, which cause the chamber cavity space $V(t)$ larger & larger, and the original roof rock thickness $h_{roof}(t)$ thinner & thinner.

With time, some amounts of highly compressed gas can erupt and carry the broken and/or alternated surrounding rocks and molten rocks (lavas) out of the ground. The rock debris and lavas accumulate on the ground surface and gradually form a cone-shaped mountain. As a result, the $V_{cone}(t)$ can become larger and larger with time and more and more eruptions. The cone mount height $h_{cone}(t)$ can become higher & higher.

Eventually, the upper roof rock cannot support the upward expansion pressure from the highly compressed gas mass in the chamber and the overburden loading of the cone-shape rock mountain. Then, a huge amount of highly compressed gas mass can erupt powerfully and cause the chamber roof rock to collapse completely. The rock forming the cone-shape mountain can then fall into the cavity space of the gas chamber underneath. A lake can be formed at the previous place of the cone-shaped mountain.

The gas chamber volume can be estimated with the following equation.

$$V_{cavity}(t) = V_{cone}(t) + V_{lake}(t) + V_{ash}(t) \quad (2)$$

where V_{cavity} = the gas chamber volume, V_{cone} = the cone-shaped rock mount volume, V_{lake} = lake volume, V_{ash} = ash volume.

It is noted that there are more than 1500 active volcanoes on the Earth at present. Each volcano has a gas chamber with ongoing chemical reactions. They are mainly located in deep fault zones and crustal-plate contact zones including these along the Pacific Ring of Fire. On the other hand, nearby those active volcanos, there are usually many huge natural gas reservoir fields and strong earthquake.

5.3 The Lake Toba

Fig. 4 shows the Lake Toba in North Sumatra, Indonesia. It is the result of a super-volcanic eruption that occurred 69,000–77,000 years ago, a massive, climate-changing event. The lake has a maximum length 100 km and maximum width 30 km. Its surface area is 1130 km2. Its maximum depth is 505 m. its present water volume is 240 km^3 and surface elevation 905 m. Formation mechanism of the Lake Toba can be described and interpreted below with the gas cause of volcanos as shown in Fig. 3. Accordingly, the gas chamber volume below the original Toba volcano before its final eruption is much greater the present water volume 240 km^3.

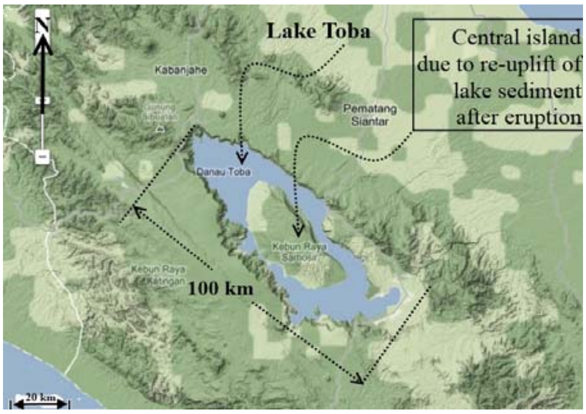

Fig. 4 Present topography of Lake Toba in North Sumatra, Indonesia (after Google Map)

5.4 Mount Etna Volcano

Fig. 5 shows the Etna Volcano in Zafferana Etna, Catania, Italy. Using the topography map (Fig. 5a), its cone mountain volume has a volume of 800 km^3 (Fig. 5b). Using equation (2), it can be estimated that the gas chamber space volumes for the Etna Volcano is greater than or equal to 800 km^3.

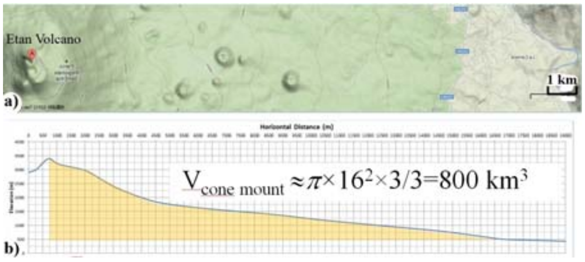

Fig. 5 Present topography of Etna Volcano after Google Map (a) and the estimation of the volume of the cone-shape mountain (b)

5.5 Mount Fuji Volcano

Fig. 6 shows the Fuji Volcano in Fujinomiya, Shizuoka, Japan. Using the topography map (Fig. 6a), its cone mountain volume has a volume of 900 km^3 (Fig. 6b). Using equation (2), it can be estimated that the gas chamber space volumes for the Fuji Volcano is greater than or equal to 900 km^3.

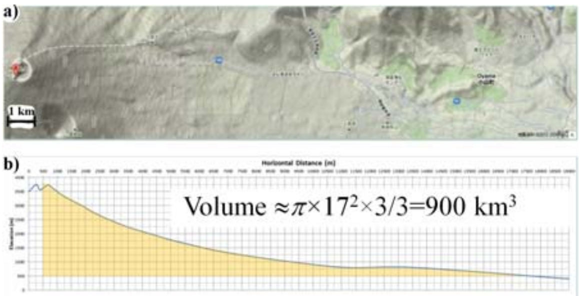

Fig. 6 Present topography of Etna Volcano in Zafferana Etna, Catania, Italy after Google Map; (a) and the estimation of the volume of the cone-shape mountain (b)

6. Conclusions

In this paper, the author has given his answer to the question why Japan and Italy Have the Severest Geohazards? His answer is that there is a thin and highly compressed gas spherical layer beneath the spherical crust rocks and above the spherical hot mantle materials. The one and only one assumption is that the general materials in the core and mantle of the Earth have extremely high temperature and pressure and density. Accordingly, the core and mantle materials can have chemical reactions producing the methane gas CH_4. The gases would migrate upward to the lower pressure zone according the second law of thermodynamics above the hot mantle materials.

Eventually, they would be blocked and contained and impeded by the dense solid rocks of the lower crust with extremely high compressive stresses. The lower crust rock functions and forms a spherical trap for the storage and accumulation of the gases from core and mantle. The gases then form a thin spherical layer separating and protecting the crust rocks and the hot mantle-core materials.

Further leaking and migrating and expanding of the highly compressed and dense gas along deep faults and orogens into the middle and upper rock crustal rock masses causes geo-disasters such as earthquake, volcano, landslides and tsunami, the oil and gas fields, the air in the atmosphere, as well as the water on the ground and in the oceans.

In particular, the gas cause of the present active volcanos has been examined with the three examples of the Lake Toba, the Etna volcano and the Fuji volcano.

In other words, there are huge amounts of methane gas CH_4 mass within and beneath the crust rocks of Japan and Italy. This natural resource has not been known and used by people in Japan and Italy.

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