Novel Method for Radioactive Waste Disposal

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Abstract:

A remarkable novel method to treat radioactive wastes safely for fauna and flora is proposed. This method uses the plate tectonics to convey the radioactive wastes into magma flowing deep in the Earth. This method is believed to be extremely valuable for all creatures on the Earth: The plate tectonics tells us that the Earth is covered with many plates. At each of the boundaries between the two plates, one is gradually sinking, while the other is rising, and *vice versa*. The radioactive wastes may be buried in the sinking plate in terms of a remote-control robot equipped by a submarine probing for the deep-sea. In this novel method, it is critical to note that radioactive wastes will be brought into the magma with no artificial energy, even those speeds are quite slow, 0.1 m/year(say). Non the less, radioactive wastes must be naturally carried into the magma, which is a heated fluid flowing in the mantel. It is essential that the crews' safety against the rays of radioactive wastes should be guaranteed.

Keywords: Radioactive Wastes, Fauna and Flora, Plate Tectonics, Nuclear Power, Plutonium, Magma

1. Introduction

Plutonium in radioactive wastes is indispensable for producing atomic bombs (Fig.1).

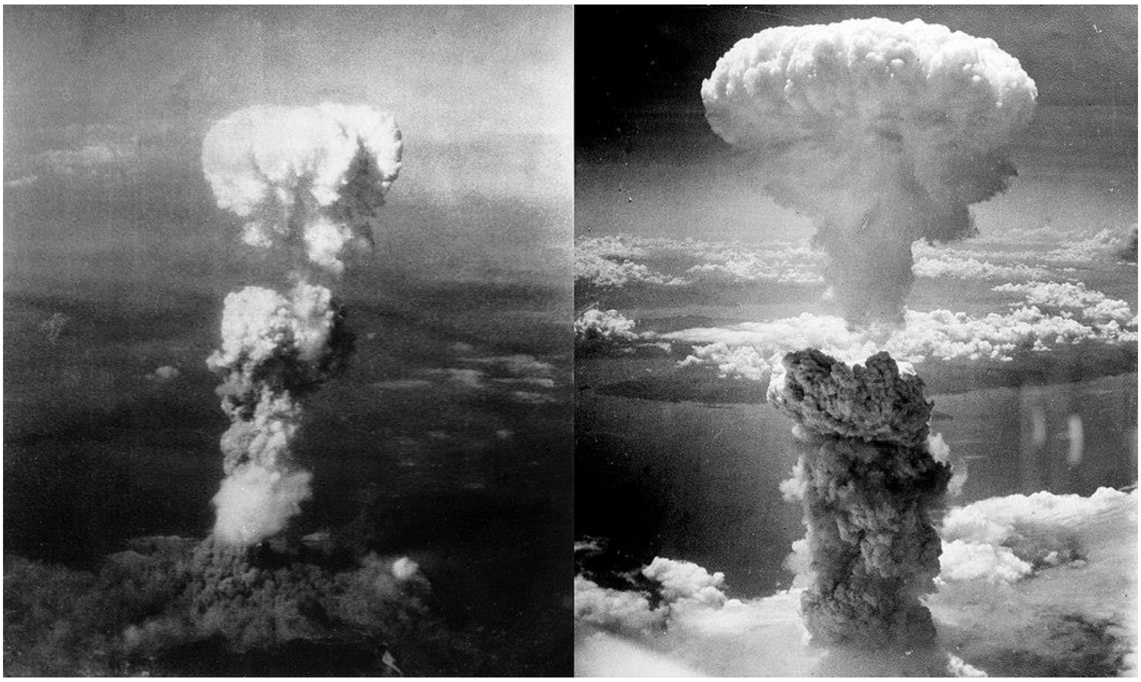

Fig.1: Atomic bombs over Hiroshima(left) on 6 August, 1945 and Nagasaki(right) on 9 August, 1945, respectively.

It is, therefore, necessary for us to establish a standard reliable procedure to dispose radioactive materials in order to avoid new production of atomic bombs any more.

As far as the present authors are aware of, currently there is no acceptable method to dispose radioactive wastes(International Atomic Energy Agency 2017, 2020abc), though Plutonium itself is increasing day by day while the atomic power plants are operating: At the moment, in case of low level radioactive wastes, the flammable materials such as papers and/or cloths are burned, while inflammable materials such as metals are compressed, and fluid materials are condensed to reduce the volume. Moreover, these wastes may be packed into drum cams, and consolidated sometimes with cement and/or asphalt to store at each the power stations. On one hand, in case of relatively high-level radioactive materials such as moderator sticks are normally stored in pool at each the power stations with no hope to be disposed safely. So far, we have no proper technology to treat radioactive wastes. Once power station is full by the radioactive wastes, it may be inevitable that they are thrown into either ocean or underground, for we cannot throw them in space. Currently, the international consensus seems to be that radioactive wastes should be geological disposal （Karadbhuje 2014, Gurban & Laaksoharju 1999).

Safe disposal of radioactive wastes is a typical example of "unreliable and incompleteness of science", and so scientists inquire seriously the answer but cannot answer it properly. This is current situation that we human beings are fearing for the miserable outcome since the start of nuclear power generation, especially after Chernobyl disaster on 26 August 1986. It is already evident that this problem is not merely geology, geography or other physical sciences, but it is one of the central problems in social sciences, which are concerned with social problems for fauna and flora including human beings.

It is evident that this problem is caused by the initial mistake for us to accept the atomic power plant as the energy source with no perspective to dispose the radioactive wastes safely (Adam 1995, Glazov et al 2007, National Research Council 1992, Weinberg & Hammond 1970). However, incidentally, we have noted that there exist many counter moving plates each other along the East and Southern rims of Eurasia continent and the West rim of American continent. Tectonic geology being concerned with the structure of the Earth and the theory of plate tectonics, derived from the continental drift, assures that the plates of the crust are always moving. There must be some hope to find several suitable spots, where radioactive wastes can be disposed safely, if the following conditions are satisfied: 1. Tectonic activity is stable, 2, There is no active volcano near the spot, 3. Subduction plate at ocean trench is not too deep in the ocean, 4. Radioactive wastes are firmly packed by every possible means, and 5. Every disposal process is properly managed and audited by ISO standard at least(say).

The main purpose of the present communication is to propose a unique and novel method to dispose the radioactive wastes in magma of mantle convection by putting them into the ocean plate diving under the continental plate without damaging fauna and flora including human beings.

2. Proposition how to dispose the radioactive wastes

This method is to dispose the radioactive wastes by putting them into the ocean plate diving under the continent plate as depicted schematically in Fig. 2. The following necessary cares must be however made to prevent from any disaster to be caused by radioactive materials.

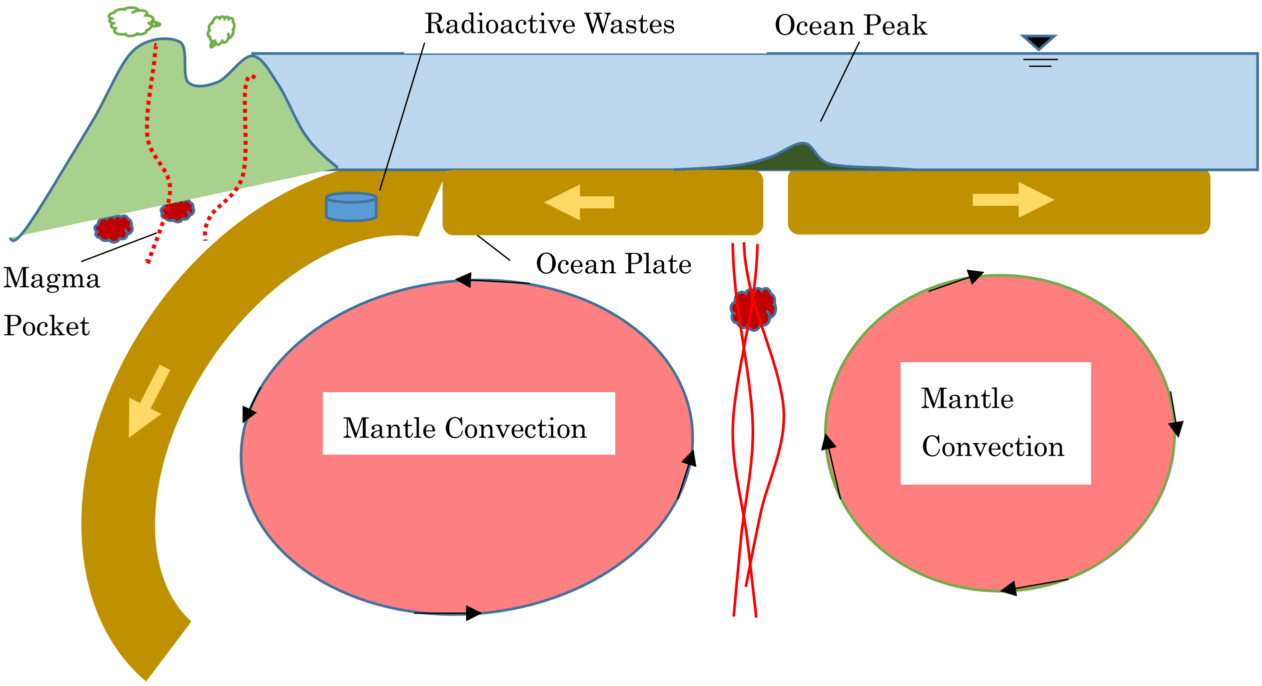

Fig. 2: Schematic diagram for the possible diving mechanism of the ocean plate with packed radioactive wastes under the continental plate.

In brief, surface of the Earth consists of many plates on land and sea bed, and at each boundary between two plates, one plate is diving under the other plate and *vice versa*. Fig. 2 is a rough sketch of the subduction of the ocean plate under the continental plate. This situation may roughly illustrate the process that Philippines ocean plate are diving under the Eurasia continent plate near Japan. This infers that there are lots of places where radioactive wastes can be disposed by the present proposed method. During the radioactive waste disposal, stringent technical support based on the relevant the international law either by IAEA (International Atomic Energy Agency) or alike is indispensable to treat them properly for fauna and flora. We cannot overemphasize the important of the relevant techniques to defend health of people who might engage in disposing radioactive wastes.

3. Flow from Uranium at atomic power station to the radioactive waste.

First of all, natural Uranium containing only 0.7 % of ${}_{92}U^{235}$, is condensed to Uranium dioxide containing 3~4 % of ${}_{92}U^{235}$. Then, Uranium dioxide is consolidated by baking in a factory and will be carried to light water reactor. After generating electricity in terms of atomic power station, amount of ${}_{94}Pu^{239}$ increases with time according to (1)-(4) as explained in Appendix 1. In the high-speed breeder reactor, by impacting neutrons ${}_{0}n^{1}$ against ${}_{92}U^{238}$ in the mixture of ${}_{94}Pu^{239}$ and ${}_{92}Pu^{238}$, we can enhance the chain fission reaction, to gain heat (Beiser 1963).

Theoretically, the high-speed breeder reactor can produce 60 times more energy than conventional thermal reactors for a similar amount of uranium fuel, together with burning Plutonium (Conner 2011, Hiraoka et al. 1991, Water & Reynolds 1981). In fact, it is expected that a fast reactor acts like a nuclear-waste incinerator that also generates electrical power. However, the high-speed breeder reactor uses dangerous Natrium as coolant, which may be liable to burn easily (Ramna & Schneider 2010). Pillai & Ramana (2014) have pointed out problems about metal corrosion and sodium leaks in breeder reactors.

On one hand, there are another two different reactors; to use mixed oxide ${}_{94}Pu^{239}$ and ${}_{92}Pu^{238}$, and to use ${}_{92}Pu^{238}$ in light water reactor. The latter is called pool-thermal project intending to reduce Plutonium ${}_{94}Pu^{239}$.

The used radioactive waste is cooled for several years in the storage pool to protect the unwanted attack by neutrons and will be conveyed to second treatment factory, where remained ${}_{92}U^{235}$, ${}_{92}Pu^{238}$ and ${}_{94}Pu^{239}$ are selected out for another use, and the rest becomes the radioactive waste.

However, the potential to treat the radioactive waste in Japan is too low to reduce it, so that currently the majority is sent to France for the further treatment. But, after that it will be sent back from France to store it at 'High Level Radioactive Waste Storage Management Center, Rokkasho, Aomori, Japan for 30~50 years under a cooled condition, with no vision how to treat it in future.

Because these wastes still emit strong radiation and heat as well, they will be compressed and solidified with glass having high- and heat-resistance. Thus, at present, an obvious method is to bury the radioactive wastes into a deep land layer, but Japanese government cannot find any site fit for the purpose so far: Very recently, at two sites, viz. Suttsu-Cho(寿都町), and Kamoenai-Machi(神恵内町) in Hokkaido, whether a preliminary literature survey by the government is acceptable or not, has been discussed among these local people. But,this is too primitive step for the radioactive waste disposal, so that it may be irrelevant to the present argument. On the contrary, as being proposed already in the above, we have got a remarkable novel method to bury these radioactive wastes into a stable diving ocean plate (rather than the underground of our land or ocean), to be conveyed naturally into the magma of mantle convection, as a promising permanent disposal technology treating safely the radioactive wastes(Fig.2).

Before disposing the radioactive wastes, the following points must be checked: 1. Are there such stable land layers within territories of Japan? 2. Is there any influence to fauna and flora on the land surface after burying the wastes? 3. Are time scales of a few or ten thousand years enough to guarantee the people's safety? 4. Whether will the ground water be polluted by the wastes or not? 5. Whether is the depth of the diving ocean plate not too much? It is desirable if the depth of the diving ocean plate is shallow, for the technicians can work for this easily. If the ocean is too deep, the necessary operation by the submarine to convey radioactive wastes to the diving ocean plate may become very difficult. 6. Whether are the radioactive wastes safe even if they are placed at high temperature in the magma? and 7. Is the technology to dig holes on the ocean plate surface reliable?

4. Concluding remarks

In this section, new findings and insight through the present study have been summarized.

1. A potential novel method to treat radioactive wastes safely for fauna and flora is found. This method uses the plate tectonics to convey the radioactive wastes into magma flowing deep in the Earth.

2. The radioactive wastes must be buried in the sinking plate in terms of a remote-control robot equipped by a submarine probing for the deep-sea. It is essential that the crews' safety against the rays of radioactive wastes during the operation should be guaranteed.
3. It is inferred that disposal of the radioactive wastes is a typical example of the "incomplete science", but to survive our human beings for future, it is absolutely necessary to overcome this unsurmountable difficulty by refining the technology how to implement the radioactive wastes in the sinking plate.
4. It is recommended that eminent scientists in this globe actively take part in this critical research topic for the sustainable development of all of human beings. Such an effort must contribute to avoid miserable outcomes caused by radioactive wastes for our descendants.

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Appendix 1: Plutonium as indispensable materials of atomic bomb

We shall consider the loss of neutrons through the reactor surface and by non-fission-inducing absorption: The former problem can be met simply by increasing the reactor size, since a larger object has less surface in proportion to its volume than a small one. The second problem is, however, more difficult, since natural uranium contains only 0.7 % of the fissionable isotope ${}_{92}U^{235}$.

The more abundant isotope ${}_{92}U^{238}$ readily captures of fast neutrons, but is usually rids itself of the resulting excitation energy by merely emitting a gamma ray rather than undergoing fission.

However, ${}_{92}U^{238}$ has only a small cross section for the capture of slow neutrons, while the cross section of ${}_{92}U^{235}$ for slow-neutron –induced fission is 550 barns (barn=10^{-24}cm^2)-many times larger than its geometrical cross section. Hence, it is necessary to rapidly slow down the neutrons that are liberated in fission both to prevent their acquisition by ${}_{92}U^{238}$ and to promote further fissions in ${}_{92}U^{235}$.

To accomplish the slowdown of fission neutrons, the Uranium in a reactor is dispersed in a matrix of a moderator, a substance whose nuclei absorb energy from incident fast neutrons that collide with them without capture occurring.

As being stated already, the cross section of ${}_{92}U^{235}$ for fission by slow neutrons is 550 barns, so that since this isotope composes 0.7 % of natural Uranium, the average Uranium nucleus has a fission cross section of 3.9 barns. On one hand, the cross section of ${}_{92}U^{235}$ for radioactive neutron capture, and γ decay,

${}_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{92}U^{236*} \rightarrow {}_{92}U^{236} + \gamma$,

is 101 barns, and so the average Uranium nucleus accordingly has for this process a cross section of 0.7 barns.

The 99.3 % abundant ${}_{92}U^{238}$ has a radioactive slow-neutron-capture cross section of 2.8 barns.

Because each fission in ${}_{92}U^{235}$ releases an average of 2.5 neutrons, no more than 0.5 neutron per fission can be lost if a self-sustaining chain reaction is to occur.

The actual operation of a reactor begins when a sufficiently large amount of fissionable material is brought together in the presence of a moderator. A single neutron strikes at ${}_{92}U^{235}$ nucleus and cause it to split, releasing two or three additional neutrons. These neutrons are slow down from energies of several M_{ev} to energies of less than 1 $_{ev}$ by collisions with moderator nuclei, and then proceed to induce further fissions. The period of time between the release of a fission neutron and its later absorption is within 0.001s. It is necessary to provide a means for controlling the chain-reaction rate: This is accomplished by means of rods made of a material, such as Cadmium or Boron, which readily absorbs slow neutrons, as these rods are inserted into the reactor, the reaction rate is progressively damped. The energy generated by a nuclear reactor is manifested as heat, and it can be extracted by circulating a suitable liquid or gaseous coolant through the reactor interior.

Elements of atomic number greater than 92 have such that half-lives that they would have disappeared long ago, for they had been formed when the universe came into being. Such elements called transuranic elements may be, however, produced in the laboratory by the bombardment of certain heavy nuclides with neutrons. This is the reason ${}_{92}U^{238}$ may absorb a neutron, or become ${}_{92}U^{239}$, which β-decays ($T_{1/2}$=23 min) into ${}_{93}N_p{}^{239}$, an isotope of the transuranic element Neptunium:

${}_{92}U^{238}+{}_{0}n^{1}\rightarrow{}_{92}U^{239}$, (1)

${}_{92}U^{239}\rightarrow{}_{93}N_p{}^{239}+e^{-}$. (2)

This Neptunium isotope is itself radioactive, undergoing β-decay with a half life of 2.3 days into an isotope of the transuranic element, Plutonium:

${}_{93}N_p{}^{239}\rightarrow{}_{94}Pu^{239}+e^{-}$. (3)

Then, Plutonium experiences α-decays into ${}_{92}U^{235}$ with a half-life of 24,000 years as follows,

${}_{94}Pu^{239}\rightarrow{}_{92}U^{235}+{}_{2}He^{4}$. (4)

It may be worth noting that ${}_{94}Pu^{239}$, like ${}_{92}U^{235}$, is fissionable and thus can be needed not only in nuclear reactor but also in producing atomic bombs (Fig. 1).

This is one of the reasons why we are strongly required to dispose the radioactive wastes including the Plutonium. We should not keep unnecessary Plutonium, for it is likely misused to produce atomic bombs: The international organization such as IAEA is wanted to treat unnecessary Plutonium properly for the international community.