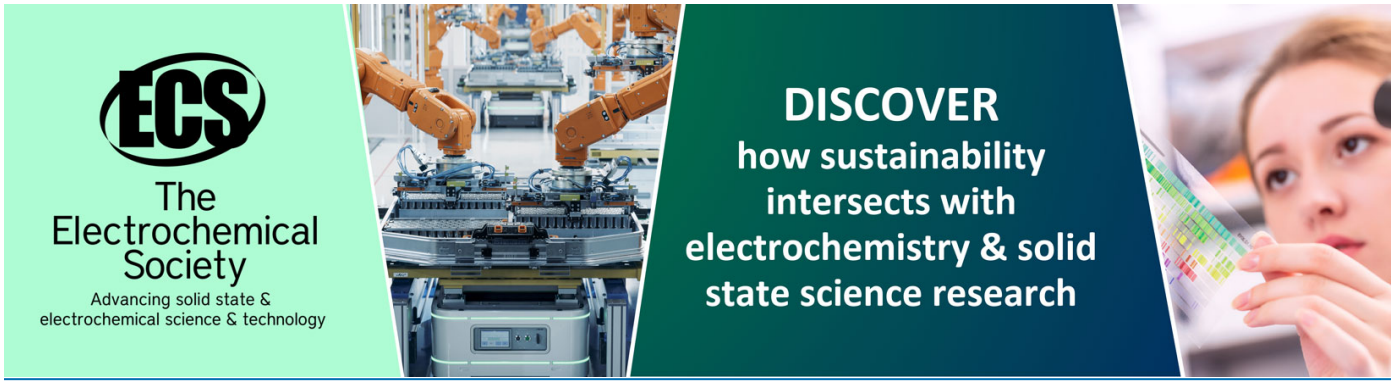
The Pacific Ring of Fire is Working as a Home Country of Geothermal Resources in the World



The Pacific Ring of Fire is Working as a Home Country of Geothermal Resources in the World

Mohammed Masum*, Md. Ali Akbar*
***Geological Survey of Bangladesh**
153, Pioneer Road, Segunbagicha, Dhaka-1000.

Abstract. Geothermal or earth's heat is a thermal energy dominant countries have been located along the plate boundaries where volcanism or earthquakes are concentrated. One of the world largest geothermal activities has been found in the region of Pacific Ring of Fire/ROF. More than 40% geothermal energy resources are stored in that region. The Ring of Fire that rims the Pacific Ocean and is bounded by Japan, the Philippines, the Aleutian Islands, North America, Central America, and South America etc. United States is still global geothermal energy leader which are located in that volcanic belt, Philippines is second-largest geothermal energy producer in the world, Japan is currently large geothermal power producer in the world, Indonesia that has around 29000 MW of untapped geothermal power. Most of the countries of that region have been stored huge geothermal energy resources. The above explanation of geothermal energy resources of Pacific Ring of Fire which working as a home country of geothermal resources in the world.
Key words: volcano, geothermal, plate boundary, etc.

1. Introduction

Large number of the geothermal fields around the world has been found in the area of Pacific Ring of Fire/ROF. Geothermal resources are highly associated with the active plate boundary (divergent or convergent plate type) where volcanism or frequently earthquakes have been occurred (fig. 1). The zone of Pacific Ring of Fire is tectonically very much active and active or dormant volcanisms are very common phenomena in there. As a result, the zone has been stored lots of heat which can be used as geothermal resources. Actually, world largest and prime geothermal resources are in that region.

2. The Pacific Ring of Fire

This area is geographically high volcanic and seismic activities within the edges of the Pacific Ocean which is called Pacific Ring of Fire/ROF. This is a long chain of volcanoes and other tectonically active structures that surround the Pacific Ocean (fig. 2). The chain runs up along the western coast of South and North America, crosses over the Aleutian Islands in Alaska, runs down the eastern coast of Asia past New Zealand and into the northern coast of Antarctica. The Ring of Fire is one of the most geologically active areas on Earth and is a site for frequent earthquakes and powerful volcanic eruptions. There are more than 450 active and dormant volcanoes located within the region. Many of these volcanoes were created through the tectonic process of subduction whereby dense ocean plates collide with and slide under lighter continental plates. The material from the ocean floor melts as it enters the Earth's interior and then rises to the nearby surface as magma (fig. 2). The deepest part of the ocean on Earth, the Mariana Trench is located along the Ring of Fire in the western portion of the Pacific Ocean Basin. The majority of Earth's earthquakes occur in the Ring of Fire too. These earthquakes are caused by the sudden lateral or vertical movement of rock along plate margins. About 81%of the world's largest earthquakes have occurred along that region of Ring of Fire.

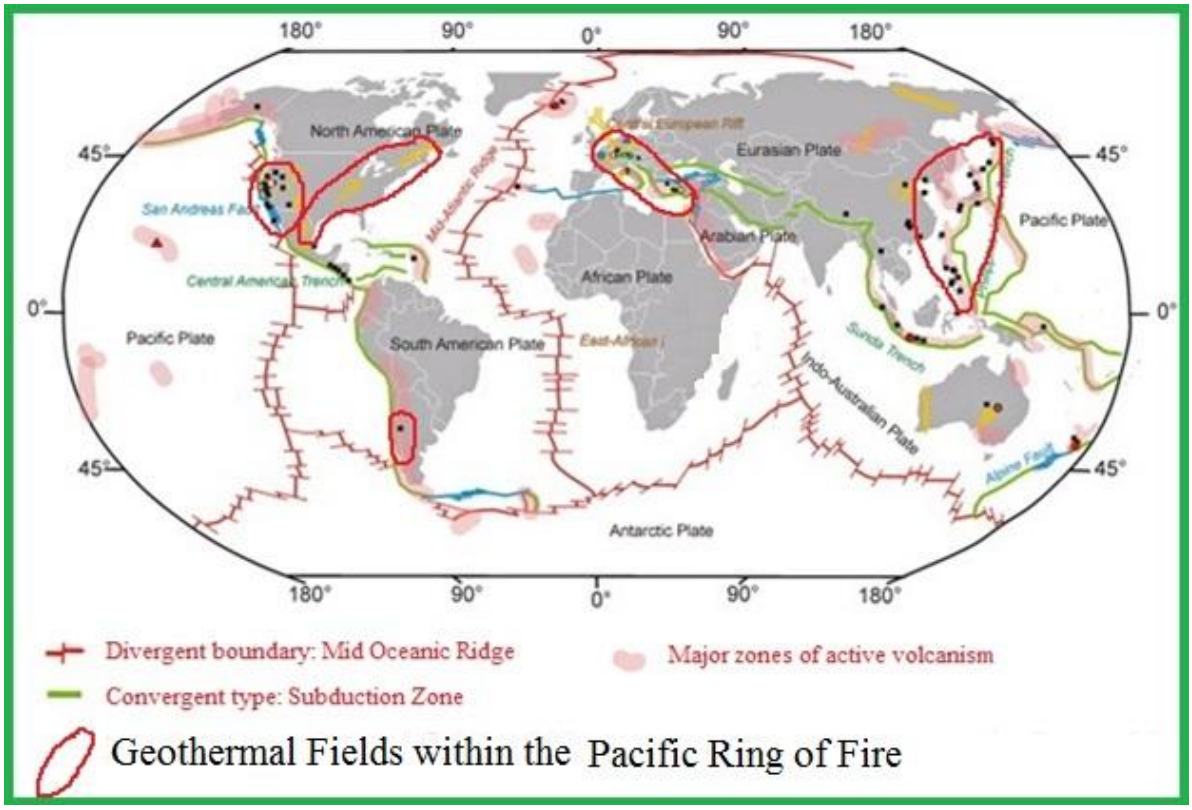


Figure 1: Figure showing divergent and convergent plate type, volcanoes and world geothermal fields in the region of Pacific Ring of fire/ROF. (Modified from Moeck. 2014)

Figure 2: Map showing the Ring of Fire and adjoining plate boundary as well as some active volcanism.

3. Ring of Fire holding countries and Their Geothermal Energy Resources

The Pacific Ring of Fire stretches across 15 more countries including Indonesia, New Zealand, Papa New Guinea, Philippines, Japan, United States, Chile, Canada, Guatemala, Russia and Peru etc (fig. 3). There are so many volcanoes and earthquakes all around the rim of the Pacific Ocean where the subduction zones are located. The area also has a group of volcanoes at Hawaii. The volcanoes in Indonesia are among the most active of the Pacific Ring of Fire. Geothermal energy resources are highly prospective in the region of volcanic activity. So, the region of Pacific Ring of Fire has significant prospects of geothermal energy resources of both electricity generation and direct uses.

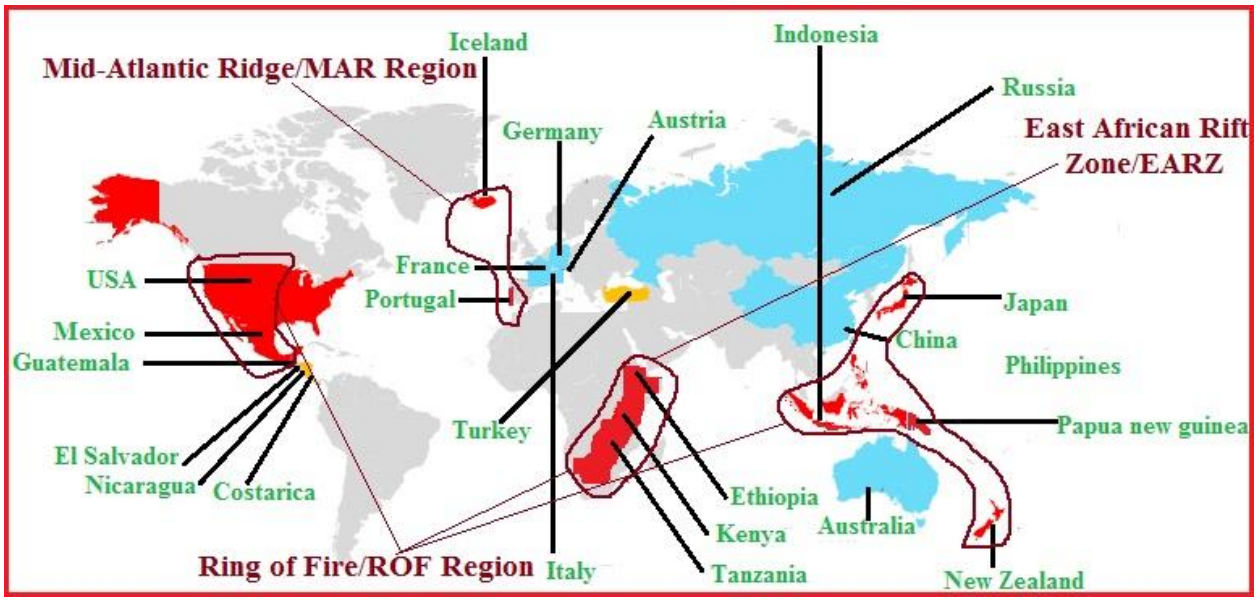


Figure 3: Figure showing geothermal dominant countries in the zone of ROF.

3.1. Geothermal Energy Resources in United States of America

Geothermal resources capable of supporting electrical generation and/or direct use projects are found primarily in the Western United States where most of the recent volcanic and mountain building activity have occurred due to the volcanic belt Pacific Ring of Fire. As a holding of Ring of Fire United States is the global geothermal leader and total geothermal capacity of around 3500 MW coming from about 86 more geothermal power stations around the country [8].The most famous and the world largest geothermal power plant complex is located in Geysers, California. Even despite being global geothermal energy leader United States generates only around 0.3% of its total electricity from geothermal power plants. Most of the U.S. geothermal production comes from the two states, California and Nevada California has plenty geothermal energy resources at its disposal thanks to its favorable geographical location, namely the Pacific's ring of fire. The U.S. has excellent geothermal energy potential and could theoretically produce around 22000 MW per year [2].

3.2. Geothermal Energy Resources in Indonesia

Indonesia is the country of Ring of Fire volcanic belt and holding about 40% of the world's geothermal reserves. More than 200 volcanoes are located along Sumatra, Java, Bali and the islands of eastern part of Indonesia, which is known as The Ring of Fire. It lies between the eastern end of the Mediterranean Volcanic Belt and western side of the Circum Pacific Volcanic Belt and is blessed with abundant geothermal resources. As a result, the calculations indicate that the geothermal potential is approximately 29 GW [3] and put this country as the biggest geothermal energy potential in the world. Geological Agency of Indonesia reported that Indonesia is composed of 312 geothermal potential

locations of which 58 locations (15,627 MW) of prospective geothermal have been issued. Of these, only around 1400 MW or about 6% of the total potential have been developed. Indonesia plans to increase geothermal capacity by 2025 as part of a plan to increase electrification in the country (Source-Eia).

3.3. Geothermal Energy Resources in Mexico

The areas of Mexico which have highest underground temperatures and geologically young or active volcanoes are located in the Ring of Fire. Most of the geothermal activities have been found at four areas as, Cerro Prieto, Los Azufres, Los Humeros and Las Tres Vírgenes that are associated with this volcanic belt. Mexico is holding fourth position of the countries with the largest installed geothermal power generation capacity with representing around 7% of total installed capacity worldwide. According to the International Energy Agency (IEA), geothermal power production is projected to grow 27.9% globally by 2035 [8].

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3.4. Geothermal Energy Resources in Philippines

Series of volcanoes (some active) encircling the Philippines are referred to as being part of the Ring of Fire and notorious for frequent earthquakes and volcanic eruptions which region are very familiar for geothermal energy production. Philippines has one of the positive examples of global geothermal energy development and thanks to geothermal power plants this country today gets 14 percent of its electricity supply, making it the second-largest geothermal energy producer in the world, after the United States [7]. Not only this, the country plans to harness geothermal energy even more in years to come and hopes to become the world's largest producer of geothermal energy by 2030, by increasing its currently installed capacity from around 2,000 MW to 3,293 MW [8].

3.5. Geothermal Energy Resources in New Zealand

Geothermal systems occur in many parts of New Zealand. High temperature geothermal fields are principally located in the Taupo Volcanic Zone, Ngawha in Northland. Geothermal energy produces about 20% of New Zealand's electricity supply. Most of New Zealand's installed geothermal generating capacity of about 750 MW is situated in the Taupo Volcanic Zone, with another 25 MW installed at Ngawha in Northland which are in the region of Pacific Ring of Fire volcanic zone (Source-NZGA). Still they are electricity production capacity is around 1000 MW [8].

3.6. Geothermal Energy Resources in Japan

Japan is country rich with geothermal resources which are also located in the Pacific Ring of Fire. About 200 volcanoes that is blessing of tremendous geothermal energy resources. The Japanese Ministry of Economy, Trade and Industry recently announced that the country will likely more than double its current geothermal power capacity by 2030, with currently installed 520 MW climbing to around 1300 MW in 2030. The country has plenty of untapped geothermal power resources. The 2011 government study estimated Japan's geothermal power potential to be at 19.14GW. The country has 50 year old tradition in producing geothermal power capacity that started in the 1960s [8].

3.7. Geothermal Energy Resources in Russia

Russia is the biggest country in the world where some areas are potential for geothermal energy utilization. Kamchatka and Kuril Islands are favourable geothermal prospects which are located adjoining area of Ring of Fire. The area have generating power capacity of up to 2,000 MW and of heat capacity no less than 3,000 MW utilizing a steam water mixture and hot water [8].

3.8. Geothermal Energy Resources in Peru

Peru is one of the countries in South America with greatest geothermal potential because it is located within the Pacific Ring of Fire, where the subduction process occurs between the Nazca and South

American Plates. This is the key factor in the formation of the Andes Cordillera (Andean Mountain Range) located in the southern part of Peru, where many active volcanoes can be found. Consequently, the magmatic and tectonic processes have allowed the development of geothermal environments in this region. Estimated capacity is around 3,000 MW from the geothermal resources [8].

3.9. Geothermal Energy Resources in Chile

Geothermal exploration in Chile is now very active which also is benefited from the Pacific Ring of Fire. The Chilean Andes host is one of the largest geothermal provinces of the world and occurs in close spatial relationship with active volcanism which is primarily controlled by the convergence of the Nazca and South American Plates. Geothermal resources could provide a clean source for electricity generation is estimated around 16,000 MW [6].

3.10. Geothermal Energy Resources in Canada

Canada has excellent geothermal energy potential by having abundant geothermal resources which are located (western part of Canada) in the area of volcanic belt Pacific Ring of Fire. It has been reported that the western and northern Canada have enough available geothermal resources to generate more electricity than the entire country now consumes. The federal Geological Survey of Canada estimated that there are at least 5,000 megawatts of geothermal electricity available in B.C., Alberta and the Yukon [5].

3.11. Geothermal Energy Resources in Guatemala

The country of Guatemala is located in the Pacific Ring of Fire which is called the country of volcanism or Fire Island. Geothermal resources in Guatemala are estimated around 5,000 megawatts (MW) capacity [1]. Considering that the country's current installed electricity generation capacity is 1,700 MW, geothermal energy could contribute significantly to a secure power supply to meet future electricity demands of the country.

4. Discussion

The Pacific Ring of Fire Volcanic belt is located in the highly active plate boundaries which are associated with active site for earthquakes and volcanoes. The tectonic plate boundaries of the Ring of Fire are so active because they are mostly subduction zones. This means that one plate, the heavier of the two, slides under the other plate at the boundary. A subduction zone creates trenches in the ocean and is just right for building mountains, for volcanic eruptions and for earthquakes (fig.4). The Ring of Fire has also produced three-quarters of all of the world's volcanoes. Mountain ranges in the Ring of Fire, produced by subduction of one plate under another include the Andes Mountains of South America, the Cascade Range in the Western U.S. and the Southern Alps in New Zealand. The Pacific Ring of Fire runs through 15 more countries in the world including USA, Indonesia, Mexico, Japan, Canada, Guatemala, Russia, Chile, Peru, Philippines. From the above description of geothermal prospects at different countries in the region of Pacific Ring of Fire it can be summarized that Pacific Ring of Fire holding all of countries have been stored huge amount of geothermal resources. The geothermal energy resources utilizing both electricity generation and direct uses. Roughly estimated more than 110 GW electricity generation capabilities of geothermal resources can be found the region of Pacific Ring of Fire.

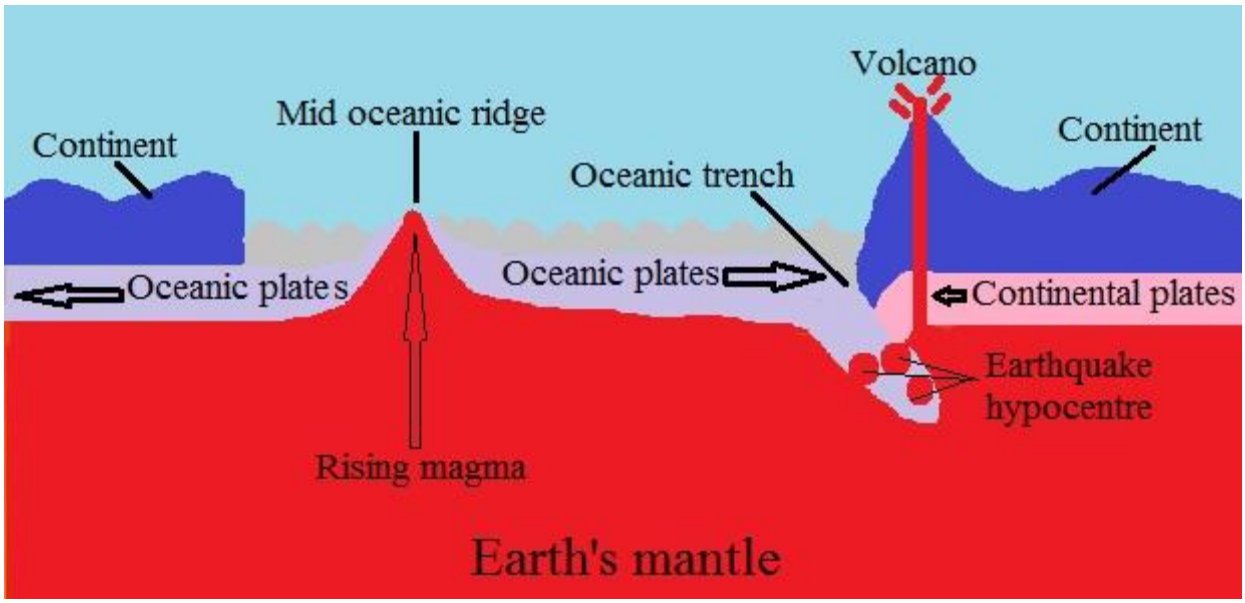

Figure 4: Diagram showing subduction zone where Oceanic Trench, Mid-Oceanic Ridge, Volcanism and Earthquake are concentrated.

5. Conclusion

Actually, the main source of geothermal heat is within the mantle. It is simply the thermal power derived from the Earth's mantle. This heat or thermal energy is come out from the mantle to the crust by fracturing, faulting or other cracking sources. This thermal energy is contained in the rock and fluids beneath Earth's crust. It can be found from shallow ground to several miles below the surface and even farther down to the extremely hot molten rock like magma. The zone of Pacific Ring of Fire is very much favourable for passing the thermal energy or geothermal heat from the mantle. This region has one of the highest underground temperatures with geologically young or active volcanoes that caused high potential geothermal resources. The Pacific Ring of Fire is tectonically very active region where heat energy/geothermal energy flow upward transported by hot springs and natural vapor emissions. Generally, geothermal power plants are commercially viable only in areas on the edges of tectonic plates. Geothermal energy development is progressing in almost all parts of the world but highly mentionable in the area of Pacific Ring of Fire. From the above descriptions it can be concluded that the area of Pacific Ring of Fire stored highest geothermal energy resources in the world. Around 13 GW (up to 2015) power generations have been installed on the basis of geothermal resources in the world where more than 6 GW have been found in that region. Indeed, the zone of Pacific Ring of Fire is working as home country of geothermal resources around the world.

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