Option 1 – Tectonic Activity and Hazards

What are tectonic hazards and what causes them?

1. Introduction

Tectonic hazards have to be distinguished from tectonic events. Hazards tend to refer to those events or items that pose a threat to humans and their lifestyle. Therefore, a tectonic hazard is one which involves tectonic processes being hazardous to humans. In the first part of my essay I will be explaining exactly what is meant by tectonic processes and will be referring to the relatively new concept of Plate Tectonics which, although being presented as a theory in 1912 by Alfred Wegener, was not actually taken as the standard model until the late 1960's and even then was being criticized by many learned scholars into the 1980's. I will then explain what the main types of hazards are in tectonics, namely volcanoes (openings in the earth crust from which material from below the earth's surface can be ejected) and earthquakes (movement in the earth's crust that causes shaking of the ground above). However, there are many more hazards that can be associated with these two, namely tsunamis and from volcanoes, pyroclastic flows, lahars and volcanic gases. What causes these hazards should be explained in my explanation of plate tectonics.

Throughout my assignment, I will be using many examples of tectonic hazards from around the globe, but will be focusing on certain case studies to try and explain exactly what causes tectonic hazards. I will be using the San Andreas Fault in the western part of North America as an example of transform plate margins*, the Himalayas as an example of fold mountains created by collision zones of convergent plate margin* between two continental plates, Krakatoa as an example of hazards that can be caused at convergent plate margins where oceanic and continental plates meet and the Mid Atlantic Ridge (including Iceland) as an example of a divergent plate margin*.

* See glossary for definitions

Research and Methodology

To do this report I have used a range of secondary research including Bill Bryson's simple to read but epic 'Short History of Everything'. The endless array of websites available to me were invaluable but I found the USGS (United States Geological Society's) website probably the most useful with all the links it had. I also watched all of the relevant episodes of 'How the Earth Was Made' on the History Channel which allowed me to use, in details the case studies of the Mid-Atlantic Ridge, the Himalayas, the Hawaiian Islands, San Andreas Fault and Krakatoa; all of which were included in this series.

Primary evidence was difficult to access due to the lack of volcanic activity in the local region. However, I managed to interview a number of people in the school who had actually visit some of the places mentioned in my essay. In particular, I interviewed Mr. Williams, our Geography teacher who actually witnessed a lahar on Mt. Ruapehu in New Zealand in 2008. I also interviewed Dan Anderson, a student in school who has recently been to Iceland and examined some of the rock samples he brought back (lacking in silica – very dark coloured) and was able to access his extensive photo collection of this trip.

Part 1 - What Causes Tectonic Hazards - The Theory of Plate Tectonics

As I mentioned in my introduction, the Theory of Plate Tectonics is a relatively new concept. The idea is that the lithosphere is broken into a number of different plates with the plates being divided at areas known as plate margins or plate boundaries. These plates can either be oceanic crust which is thinner (between 5-10km thick) but more dense, and continental crust, which is thicker but less dense(between 40-95 km thick). In most cases, it is the plate margins where tectonic events occur and of course, if they are hazardous to humans, then this is where most tectonic hazards occur. The Ring of Fire around the Pacific Ocean for example, is an area in which some of the world's most prevalent tectonic hazards occur. However, tectonic events can also occur at places away from these plate margins, namely at areas known as 'hotspots' such as the Hawaiian Islands and those unusual tectonic hazard that occur intraplate (i.e. within the middle of a tectonic plate) such as at New Madrid in Missouri in 1812. *(Bill Bryson: A Short History of Everything – Chapter 14)* Very little is known about the latter and indeed, I have done very little reading on them, so these will not be mentioned in my essay.

The Theory of Tectonic Hazards explains what causes about 95% of tectonic hazards on our earth today. There are, however other less scientific theories such as those of the indigenous peoples of Indonesia who believe that volcanic eruptions and earthquakes are the wrath of the gods. The main types of tectonic hazards are volcanoes and earthquakes, but with each of these are various different dangers to people which will be discussed later in this essay. It is what occurs at the plate margins which explains what causes tectonic hazards;

- ***Convergent Plate Margins***

Where plates move towards each other are known as convergent plate margins. If oceanic crust moves towards continental crust, then the oceanic crust will be forced to submerge under the continental crust at an area known as a Subduction Zone. Here the oceanic crust will melt as it is forced deeper into the asthenosphere and the crust will melt down to form molten rock. This can cause huge earthquakes and stresses in the rock above which can lead to the formation of volcanoes *(See Figure 1).*

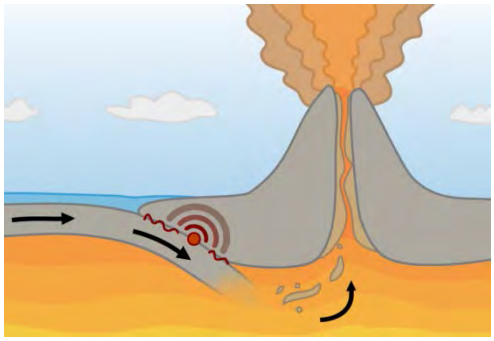

Figure 1 – Convergent Plate Margin

Krakatoa, for example in Indonesia is located where the Capricorn Plate is moving towards the Eurasian plate and in 1883, this caused one of the biggest volcanic explosions ever to occur in recent history. *(DVD – How the Earth was Made)* If convergent plate margins occur between two continental crusts then this can lead to a collision zone and the formation of fold mountains such as the Himalayas between the Indian Plate and the Eurasian Plate.

- ***Divergent Plate Margins***

Here, the tectonic plates are moving apart from one another, and usually, on earth between oceanic crust, leading to the formation of new crust as magma rises up to fill in the space left as the plates move apart (*See Figure 2).* Earthquakes are relatively shallow in these areas and are usually of a magnitude of 8.0 and below on the Richter Scale. Due to the low amount of pressure in these areas, volcanoes tend to be of the Hawaiian type or the even less destructive Icelandic type.

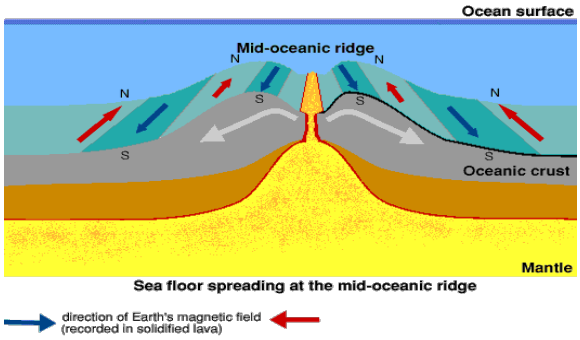

Figure 2 – Divergent Plate Margins

The most famous divergent plate margin is the Mid-Atlantic Ridge that separates the Atlantic Ocean and has led to the formation of Iceland. However, divergent plate margins can occur between two continental crusts leading to the formation of Rift Valleys as can be seen at the African Rift Valley between the African Plate and the Somali Plate.

- ***Transform Plate Margins***

Here, the two plates are moving side by side and crust is neither created nor destroyed. Therefore, volcanoes are rare in these areas but earthquakes can be very severe due to the immense pressure that can build up as the two plates move along side each other. *(See Figure 3)*

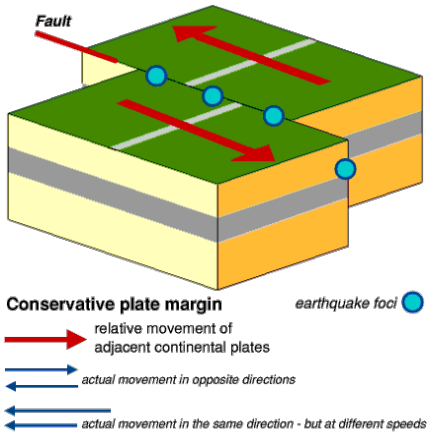

Figure 3 – Transform Plate Margin

The San Andeas Fault is Western North America is a classic transform fault. It was movement in this fault that created the disastrous 1906 and 1989 San Francisco earthquakes.

- ***Hotspots***

Hotspots are areas where the earth's crust is thin leading to the penetration of magma up weak points in the earth's crust leading to the formation of volcanoes as those found in the Hawaiian Islands. Volcanic Eruptions tend to be prevalent but not very explosive. Bill Bryson is his book, 'A Short History of Everything' discusses the fact that the area now comprising Yellowstone National Park in modern day USA is actually a 65km across caldera from a super-volcano that last blew about 600,000 years ago.

Part 2 – What are Tectonic Hazards?

In my introduction, I explained what the two main types of tectonic hazard were in volcanoes and earthquakes. However, there are a range of hazards associated with each of these.

- ***Hazards from Volcanoes***

There are more than 500 active volcanoes *(Edexcel Geography – Byrne et al)* in the world today. Volcanoes are the openings to the underworld and from which many hazards can occur. The first is Lava itself which is the name given to magma that extrudes from the asthenosphere to the earth's surface. How this is put onto the surface of the earth is itself a hazard and some volcanic eruptions are far more hazardous than others. The most hazardous are called Plinian eruptions such as Krakatoa in 1883 and Pinatubo in 1991. The magma is highly viscous in these eruptions meaning that it does not flow far meaning that volcanic gases build up leading to huge eruptions. These eruptions can be so large that they can lead to tsunamis, especially if the volcano is in or near large areas of water. According to the 'DVD – How the Earth was Made', the Krakatoa eruption in 1883, caused a tsunami that led to the deaths of 65,000 people in the surrounding villages on neighbouring Sumatra and Java.

Also, from volcanoes can come another deadly hazard known as pyroclastic flows which are mixtures of superheated rock and hot gases that flow down the side of a volcano moving extremely quickly. Lahars are another hazard associated with volcanoes. These can happen where water, normally from a volcanic lake, mixes with volcanic ash and causes a deadly flow of volcanic materials as the water makes the volcanic material less viscous. Mr. Williams, our Geography teacher was one of the last people to see the volcanic lake on Mount Ruapehu in New Zealand before its volcanic rock dam burst leading to a devastating lahar in 2007. The only reason that there were few casualties were the fact that it is a sparsely populated area.

Finally from volcanoes can come volcanic gases such as carbon dioxide and sulphur dioxide which can cause injury and death.

- ***Hazards from Earthquakes***

Earthquakes themselves are measured on the Richter Scale and the larger an earthquake, the more destructive it will be. However, how hazardous an earthquake is depends on it's location and an earthquake such as the 1989 earthquake caused by movements in the San Andreas Fault will be very hazardous to people due to the proximity of large urban areas such as San Francisco.

The most obvious hazard is from the ground shaking itself which can flatten buildings and destroy infrastructure. Tsunamis, as well as being caused by earthquakes, can also be caused by undersea earthquakes. The most devastating one in recent history, was of course the Boxing Day Tsunami of 2004 which killed more than 200,000 deaths throughout the Indian Ocean Region. There is also the hazards resulting from ground displacement through landslides and

avalanches and liquefaction, which is when soils are turned into a water like material and means that the land can quite literally collapse.

Conclusion

What causes tectonic hazards has been effectively proven although the jury is still out on this one. The Theory of Plate Tectonics proves about 95% of all tectonic hazards on the earth but does not explain intraplate earthquakes so further research needs to be done here. However, it does explain the range of volcanoes and earthquakes found at the divergent (e.g. Mid-Atlantic Ridge), convergent (e.g. Krakatoa) and transform plate margins (e.g. San Andreas Fault) around the earth today.

Tectonic hazards themselves are numerous and although it would have been easy to stop at earthquakes and volcanoes, it was important to point out all of the different hazards that are associated with these two major types of hazard. I feel that we, in recent history have been subjected to the real terror of the hazards associated with tectonic events by the appalling loss of life in the 2004 Indian Ocean Tsunami that, here in Malaysia was a little close to comfort.

My research here has been extensive and hopefully I have answered the question to the best of my ability in the time provided. However, I realize that I have shortcomings with regards to my knowledge. I have never visited an active volcano, and until I do, I will not really grasp just how destructive these natural landforms can be. I have never been in an earthquake, However, I am part of an international environment and have been able to talk to people who have experienced both earthquakes, volcanoes and especially, tsunamis due to our proximity to Phuket here in Malaysia which was so devastated in the 2004 Tsunami.

Glossary

Plate Tectonics – A theory suggesting that the earth's crust is divided into separate tectonic plates. The boundaries between these plates are called **plate margins**.

Convergent Plate Margins – Where two plates meet. If oceanic plates meet continental plates then the oceanic plate will submerge under the bigger but less dense continental plate. If two continental plates meet then it is known as a **collision zone**.

Divergent Plate Margins – Where two plates move away from each other.

Transform Plate Margins – Where two plates move side by side.