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Essay: Plate tectonics

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Plate tectonics as a theory suggests states that the Lithosphere is split up into a series of rigid plates. At current, seven major plates have been identified, as well as a number of smaller plates. The boundaries were found to coincide with features upon the Earth's surface, these include, orogenic belts, mid-ocean ridges, transform faults and trenches. The boundary of each of these plates can be defined and characterized by the way that the plates move. These are known as, convergent, divergent and conservative plate boundaries. Figure one shows the main plates as well as a few of the smaller plates that lay on the Earth's surface. Furthermore, it shows the direction of plate movement as well as the distribution of earthquakes of nine years. Evidence from earthquakes, volcanoes and the features mentioned above help to identify where the boundaries of each plate is. Convergent plate boundaries are commonly known as destructive margins. This is

where two plates move towards each other. The difference in the combination of lithospheres involved can result in a different type of convergence of boundary. These two types of convergent plate boundaries include, subduction and collision. Firstly, at a subduction zone the oceanic plate bends down into the asthenosphere (Marshak, 2008). Thus, when the combination of lithosphere is ocean-ocean or ocean-continent at a destructive margin, a subduction zone is created. Due to the density of the continental lithosphere, the oceanic lithosphere is always subducted at a subduction zone. At this type of convergent margin, volcanoes and earthquakes occur. The earthquakes at this margin tends to have shallow, intermediate and deep origins. These margins are the only places where earthquakes have deep origins. The subducting plate follows a stick and slip pattern, causing mass friction between two plates leading to particularly large earthquakes. A key example of an earthquake at a destructive margin is the case of the Boxing Day earthquake, 2004 which eventually resulted in a tsunami situated in the Indian Ocean. The two plates responsible at the boundary were the Indian plate and the Burmese plate. The earthquake was associated with major thrust events at the subduction zone (Holden, 2012). With a magnitude of 9.3 ('Rapid Earthquake Viewer', n.d) it helps to show that earthquakes at these types of boundaries are particularly large. Alongside earthquakes, destructive margins can be associated with volcanoes. These tend to be explosive due to volatiles e.g. water causing the silicates in magma to break up leading to partial melting of the asthenosphere and overlying lithosphere. This therefore results in andesitic and rhyolitic magma which is explosive. The most famous region of these sorts of volcanoes is the 'Ring of Fire' forming the outline of the Pacific plate, as shown in both Figure one and two. However, Figure two shows all types of activity including volcanic and earthquakes. A key example of an explosive volcanic eruption as part of the ring of fire includes Mount St Helens, Washington, USA. This had typical of the ring of fire, andesitic eruption, showing that the upwelling of magma had melted due to the subduction of the oceanic lithosphere. Dissimilarly to the ocean-continent margins, ocean-ocean margins resulting in volcanic island arcs occurring. These originally form from basaltic volcanoes before turning into island arcs (Holden, 2012). An example of this is the Caribbean Islands on the Caribbean plate which can be identified on figure one. Some of these volcanic islands are still active and are composed of a series of composite volcanoes, whilst some islands were formally active (Jackson, 2013).

Eventually all oceanic crust will become subducted, therefore resulting in two continental crusts colliding together to create a collision zone. The continental margin sediments which are buoyant do not sink and subduct but instead become compressed, crumpled, deformed and begin to uplift, resulting in the creation fold mountains (Holden,2012). Eventually this creates an orogenic belt. This is called tectonic deformation. (Smithson et al., 2008). Key examples which can help identify the whereabouts of this type of destructive margin is almost all of the Alpine-Himalayan system. This is the collision of the Indian-Australasian plate and the Eurasian plate, some of which can be identified in figure 1. This example of an orogenic belt is formally known as the Tethyan Orogen (Smithson et al., 2008).

A boundary which occurs in the opposite way to the convergent margin is called a divergent plate boundary. This is also known as a constructive plate margin. This is due to new oceanic lithosphere always being constructed. At this tectonic boundary the plates move apart. Basaltic volcanoes and shallow earthquakes characterise the convergent margins alongside formations such as mid ocean ridges and continental rift valleys occur can be used to identify the boundaries of the margin. Ridges and rift valleys can rise 2km above the adjacent abyssal plains. The two most famous mid-ocean ridges are the East Pacific Rise and the Mid-Atlantic Ridge (Holden, 2012). The East Pacific Rise lines the boundary between the Nazca plate and the Pacific plate. This boundary can be identified on figure one by looking at the marked line showing earthquakes in the area. As well as earthquakes, the reduced pressure at these ridges causes the melting point to lower significantly within the asthenosphere causing basaltic magma to rise (Smithson et al., 2008) causing the creation of many volcanoes situated on the sea floor. Using the example of the Mid-Atlantic Ridge, we can see the way that eventually the volcanic activity can result in volcanic islands, for example Iceland. As well as mid ocean ridges there are rift valleys. This is when there is the divergence as well as considerable thinning of the continental crust (Holden,2012). A present day example is the African rift valley. Continental rift valleys are responsible for the previous break-up of land masses (Holden, 2012).

The third main type of tectonic plate boundary is the conservative plate boundary. This is commonly also known as a transform plate margin. Here, plate is neither created nor destroyed (Smithson et al., 2008). The plates involved slide past each other sideways (Marshak, 2008) causing earthquakes however very little volcanism. These earthquakes tend to be frequent, major and destructive (Holden, 2008). Transform boundaries can also be identified as transform faults created internally along plates (Smithson et al., 2008). The faults help to explain why there is offsetting at ocean ridges. These faults cause frequently shallow, severe earthquakes. The most famous example of a transform fault is the San Andreas Fault, which stretches from the East Pacific Rise to the Juan Fuca Rift.

Over time, many theories have been used to explain the cause of plate movement. One of the earliest ideas was the process of convection currents. This is where hot magma rises from the close to the core, cools and then sinks. Once repeated this causes a cell. These cells transfer heat and thus energy. This heat and energy is what was thought to have moved the plates above the rising limb of each cell in a particular direction. Although this was once thought to have caused the crustal plates to move, later examination of the theory suggests that the specific directions of the flow do not always coincide with the directions (Marshak, 2008). Although disregarded as the main cause the process is still central the understanding of origin of plate tectonics (Stadler et al., 2010). It is now believed to just assist the movement of plates instead of directly driving the movement of the plates. Instead, new ideas and theories such as Ridge-push force have been suggested. Ridge-push force develops due to the higher elevation of mid-ocean ridges compared to the adjoining abyssal plain. As a response to the ridge-push force, sea-floor spreading follows, allowing new asthenosphere to fill the space between the plates. (Marshak, 2008) This in combination with the convection currents accelerate the rate of movement. This was later thought to not have been the cause for plate movement, forcing an additional idea to be proposed. This is the dragging of old, cold, dense lithosphere at subduction zones to cause movement. Therefore, movement is thought to be primarily driven by the negative buoyancy of cold subducting plates (Rey, Coltice & Flament, 2014). This theory assumes that that the Earth's tectonics work in a similar way to a conveyer belt in the sense that whilst plate is being pulled due to gravity into the asthenosphere at a subduction zone, somewhere else there is lithosphere being created at the same rate. Therefore, trying to create an equilibrium. It is thought that this accounts for about half of the total driving force on the plates (Conrad, 2002).

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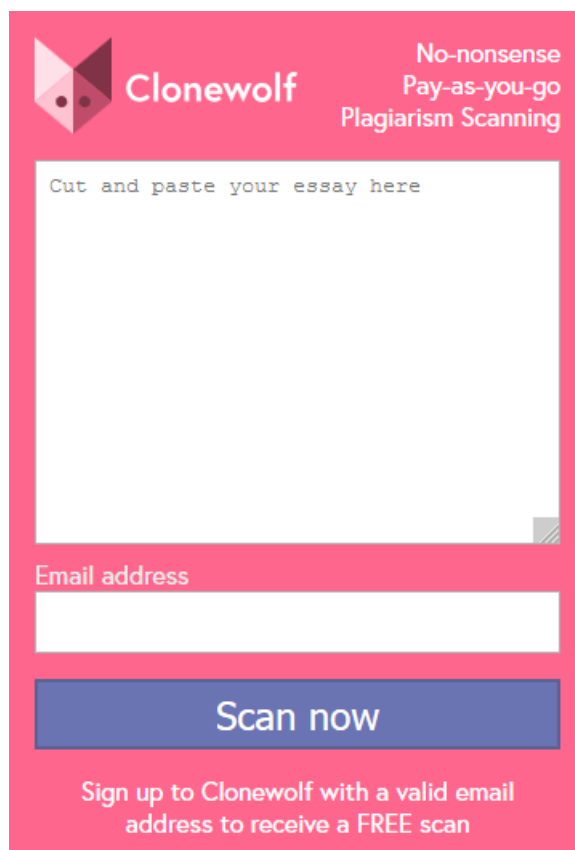
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