Earth's Formation: How to explain the Formation of the Earth's Crust and Core

It is very poetic to say that the water we drink is as old as the planet. Amazingly, it's also true! Much of the materials found on our planet, are made of elements that were combined to form the planets. Let's examine how the Earth formed from these elements into the planet we know and love!

In early stages of Earth's formation about 4.5 billion (4.5×10^9) years ago, *melting* would have caused denser substances to sink toward the center in a process called **planetary differentiation** (*the iron catastrophe*), while less-dense materials would have migrated to the crust. The *core is thus believed to largely be composed of iron (80%),* along *with nickel and one or more light elements, whereas other dense elements, such as lead and uranium, either are too rare to be significant or tend to bind to lighter elements and thus remain in the crust*. This **differentiation** caused the heavy metals (iron, nickel and related elements) to be concentrated in the core of the earth, whereas the light elements (oxygen, silicon, aluminum, potassium, sodium, calcium etc.) were enriched in an outer layer of the earth that is now termed the mantle and the crust. Not everything, however, goes simply by density. Uranium and Thorium are very heavy elements, and we should therefore expect them to be enriched in the core. Yet, contrary to expectation they are concentrated in crust and mantle. The reason for this circumstance that ion size and chemical affinities of U and Th prevent them from being incorporated in the dense, tight crystal structures that iron, therefore they can fit much more easily into the more open crystalline structures of silicate and oxide minerals, they are concentrated in crust and mantle.

After **partial melting and differentiation**, the Earth would have also allowed the release of gaseous compounds formed and trapped in the interior. Modern volcanoes release gases as magma is brought to the surface. These gasses give us an indication of the composition of the Earth's earliest atmosphere: water vapor, CO_2, CO, N_2, H_2, and hydrogen chloride. Water vapor would have condensed in the atmosphere and rained down as liquid on the surface, covering the Earth with water.

It is also possible that the Earth has acquired some of its water **from comets colliding with the Earth** and melting in the upper atmosphere. Recently, some astronomers have argued that as many as 15 million small comets (house-sized and smaller) might be adding water to the atmosphere every year. As soon as the crust became cool enough not to remelt, **convection driven plate tectonics** probably began. Initially, because the Earth was much hotter than it was today, more heat would have been flowing up from the mantle. *This would have created numerous hot spots and rifts, resulting in many small plates and subduction zones, as well as vigorous plate movement.*

Pretty soon after the onset of plate tectonics, the first continents should have formed (we will get into the details of this towards the end of this course). *Re-melting of oceanic crust combined with water along subduction zones would have caused the formation of the first felsic magmas* (rich in silica , K, and Na) and the **resulting island arcs**. Also, re-melting of crust over **large hot spots** might also have created felsic magmas (such felsic magmas are seen erupting from beneath Iceland today). No matter how it exactly happened, the first continents were probably produced as small land masses that eventually accreted together as plates were subducted and brought these proto-continents into collision.

Earth's mantle extends to a depth of 2,890 km, making it the thickest layer of Earth. The mantle is composed of silicate rocks that are rich in iron and magnesium relative to the overlying crust. Although solid, the high temperatures within the mantle cause the silicate material to be sufficiently ductile that it can flow on very long timescales. Convection of the mantle is expressed at the surface through the motions of tectonic plates. The melting point and viscosity of a substance depends on the pressure it is under. As there is intense and increasing pressure as one travels deeper into the mantle, the lower part of the mantle flows less easily than does the upper mantle (chemical changes within the mantle may also be important).

Crust

The crust ranges from 5–70 km (~3–44 miles) in depth and is the outermost layer. Earth's crust is made up of several elements: iron, 32 percent; oxygen, 30 percent; silicon, 15 percent; magnesium, 14 percent; sulfur, 3 percent; nickel, 2 percent; and trace amounts of calcium, aluminum and other elements.

The thin parts are the oceanic crust, which underlie the ocean basins (5–10 km) and are composed of dense (mafic) iron magnesium silicate igneous rocks, like basalt. The thicker crust is continental crust, which is less dense and composed of (felsic) sodium potassium aluminium silicate rocks, like granite.

You will draw an illustration that shows the formation of our Earth. Explain through comic images or diagrams how the formed and what plate tectonics are and how they play a unique roll with continent and island formation. Then from the details include information that shows how these different events over time changed our Earth's surface. Include a short diagram of an Early earth atmosphers. Be sure to include all stages that are bolded and include call outs from what is happening at each phase (these are *italicized.*) Make this a creative exercise!