

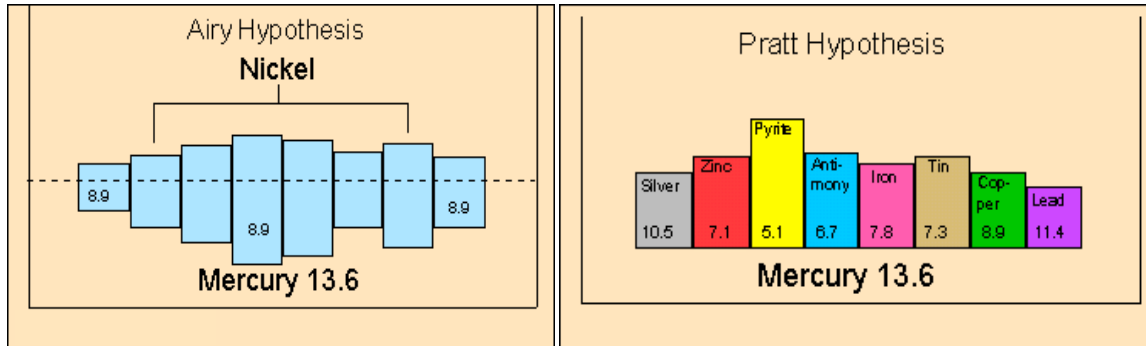
## Lab 3 – Structures of the Earth and Physiography of the Oceans

### Isostasy

To start with, the oceans are quite large. Indeed, the oceans cover some 2/3 of the earth's surface. Now it doesn't take a rocket scientist to figure that out - all you need is an accurate map of the world and the size of the oceans becomes clearly visible (but then, most maps are derived from satellites, which *do* take rocket scientist in order to get them into space...). Anyway, one of the first questions that you might want to know might be, **how deep is the ocean?** Well, the mean depth of the ocean is 3790 m (12,430 ft). But is that an accurate picture of the depth of the oceans? How is the depth of the ocean distributed throughout the earth? For example, consider a class of 10 students, five of whom are failing miserably with a 50% and the other five score a 100%. Although the class average is 75%, this is clearly not an accurate figure representing the class as a whole. In the case of the oceans, on the other hand, the mean depth is quite representative of the oceans as a whole. In other words, a large percentage of the ocean floor is reasonably close to 3790 m deep. Obviously, there are some areas of the ocean that are quite shallow, and others that are quite deep. We'll get into those later on.

Okay, so we know that ~1/3 of the earth's surface is land. The mean elevation of the land is 840 m, and, like the oceans, most of the land is reasonably close to that elevation. These observations - the mean depth of the ocean and the mean elevation of the land - led earth scientists to the hypothesis that the earth must have two types of crust; continental crust and oceanic crust. Although it took several decades to actually test this hypothesis, it was found to be the case that there are indeed two types of crust on the earth's surface. Continental crust is referred to as **andesite** (like the Andes Mountains in South America) or alternatively as **granite**. Oceanic crust, on the other hand, is **basalt**. Interestingly, the Hawai'ian Islands are made up of basalt, not granite. The reason for this will be discussed in a later lab.

Now that we know that there are two types of crust, the question remains, why do the continents sit higher than the oceans? Is it because the continents are thicker than the oceans, and therefore sit higher? Or is it because the oceanic rock is more dense, causing it to sink? This question was attacked by two scientists during the mid-1800's who were struggling with an explanation of gravitational anomalies associated with large mountains. Both of them set up experiments in which they placed various objects in a pool of liquid Hg (mercury). Pratt placed objects with different densities into the liquid and observed that the densest objects sink the lowest. Airy, on the other hand, took objects of the same density but different sizes, and found that the smallest objects sink the lowest. A diagram of the two can be found below.



In the end, it is now understood that *both* processes control the surface earth elevation and ocean depth. The continents are thicker and less dense, whereas the oceans are thinner and denser. This concept of thick, light (i.e. less dense) continents "floating" higher than the thin, dense oceans is referred to as **isostasy**. From this concept, it can be assumed that the earth's crust is less dense than whatever lies beneath (the mantle) and that there must be some layer of the earth that is somewhat flexible (the asthenosphere), allowing the continents to "float" higher than the ocean basins.

Land masses that are not moving up or down in relation to one another are said to be in **isostatic equilibrium**. One example of a location that is not in isostatic equilibrium is the northeast of Canada. Only about 10,000 years ago (the blink of an eye in geologic time scales) during the last glacial maximum, there was a huge mass of ice sitting on a good portion of North America. That mass of ice subsequently pushed Canada farther down into the asthenosphere. Now that the ice has melted, Canada is still rebounding from the enormous weight lifted from its shoulders. Thus, sea level rises slower in Canada than in other parts of the world.

### Physiography of the Ocean Floor

Earlier, it was stated that the average depth of the ocean is quite representative of most of the ocean floor. It was also noted that some areas are quite deep, and others are quite shallow, and that these features would be explored later. Most of the shallow areas of the ocean are found close to the continents, on the **continental margins**. **Atlantic-type**, or **passive** continental margins, are seen to have a broad, shallow **continental shelf**. The continental shelf is usually up to ~150 m deep and may be as wide as 350 km. After the shelf, there is a break in the slope (the **shelf break**) and the sea floor gets very deep very quickly. This region is called the **continental slope**. Although the incline of a typical continental slope is only about 4° (quite gradual in comparison to the dramatic cliffs seen in the Hawaiian Islands), it is still much steeper than what is found on the shelf. Often, the continental slope is followed by a gradual decrease in depth, referred to as the **continental rise**. As the name implies, Atlantic-type continental margins are typical of what is found in the Atlantic Ocean.

**Pacific-type** or **active** continental margins also have a continental shelf and slope, but usually much smaller than those found in the Atlantic. In very close proximity to the

continental shelf often lies a **deep-sea trench**, usually 3-6 km deeper than the surrounding ocean, but may be as deep as 11 km (Challenger Deep in the Mariana Trench). Trenches are usually quite narrow and hug either the continent or the island arc with which they are associated.

Perhaps the most salient feature of the sea floor is the **mid-ocean ridge** system. Although the ridges in different oceans are given different names (e.g. Mid-Atlantic Ridge, East Pacific Rise), they are actually all connected to one another. The mid-ocean ridge system accounts for nearly as much of the surface of the earth as do the continents.

Between the continental margins and the mid-ocean ridges lie primarily the **abyssal plains** and the **abyssal hills**. As their names imply, these are deep regions that are either flat (the plains) or hilly (the hills).

**Seamounts** are any feature that would be called a mountain if it were on dry land (in other words, underwater mountains). If seamounts are large enough to poke through the surface of the ocean, they become **islands**. Most islands in the ocean are not randomly distributed - they are either island chains or island arcs. An **island chain** is a linear (straight) assemblage of islands found virtually anywhere in the oceans. A good example of an island chain is the Hawaiian Islands. An **island arc** is a series of islands that looks curved when viewed from above. The island arcs usually occur close to the continents and are found primarily in the Pacific Ocean. The area between the island arc and the continent behind it is referred to as a **back-arc basin** or **marginal sea**. Seaward of the island arc is usually a deep-sea trench. A good example of an island arc is the Aleutian Islands in Alaska.