Introduction
The earth is broken into layers according to their physical properties. The outermost layer is known as the lithosphere, and is approximately 100 km thick. This relatively thin layer is the brittle shell of the earth that overlies the more ductile asthenosphere, and is the layer that makes up the tectonic plates studied further in this research.

When two pieces of lithospheric plates converge, the older and denser plate typically is subducted, the subducting lithosphere is called a subducted slab, or slab for brevity. As the slab continues to subduct, increasing pressure and temperature dehydrate the slab, which lowers the melting point of the overlying mantle wedge and causes partial melting to occur. Melting generates magma that rises to form a chain of volcanoes along the front of the converging plates; this chain of volcanoes is called a volcanic arc. The location of the volcanic arc, or arc for brevity, depends on the angle that the slab subducts. Figure 1 is an idealized representation of a subduction zone.

Methods

The observed arc-trench gap data (Jarrard 1988) are plotted against the expected arc-trench gap (graph 1). Expected arc-trench gap assumes that partial melting occurs at 100 km depth (Takemura, Y. 2005) and that intermediate slab dip (dp angle from 60-100 km) best represents the angle of subduction. The expected arc-trench gap is calculated using Arc-Gap = 127K - 0.24dp. This relationship can be seen in Figure 1.

Using Google Earth mapping software, the spacing of volcanoes over the length of an arc was found for 35 out of the 39 modern subduction zones. Sulawesi, New Britain, Palaus, and Yap arcs were omitted owing to lack of reliable and complicated plate geometry. Figure 2 represents a typical subduction zone with labeled volcanoes, and the length of the subducting plate was obtained by tracing the clearly defined trench. Google Earth labels only volcanoes with a known or inferred volcanic history in the past 10,000 years [5].

Volcanic concentration was found by noting the number of volcanoes divided by the length of the subduction zone obtained. This was added to a table of all the parameters discovered in Jarrard (1988) as to test the correlation of each parameter to the observed volcanic concentration. Since class, maximum earthquake moment, and maximum earthquake moment were shown to be weakly correlated to the observed volcanism, while slab dip, age, and many other variables appear to have no effect on volcanoes concentration at the surface. Maximum earthquake moment was the largest contributing factor (R^2=0.19), suggesting that no one factor can be attributed to observed volcanism, but likely many factors have an impact.

Results

Graph 1: By the right depicts the variance in the observed versus expected arc gap. Though a good correlation is present, there is a gap in the data that is not represented by the expected arc-trench gap for all data sets.

Graph 2 (below) illustrates the relationship between subduction parameters and magmatism. The data includes both modern and ancient arcs. It is calculated using Arc-Gap = 127K - 0.24dp. This relationship can be seen in Figure 1.

Graph 3: Maximum earthquake moment was the variable with the largest contribution to the observed volcanism (R^2=0.19), suggesting that one factor is controlling the amount of volcanoes at the large volume, but likely many factors joint to influence.

Discussion

• The observed arc-trench gap was compared with the expected using a simple geometric relationship. Though the relationship is somewhat of interest by assuming a constant dp angle, the variance is large enough to suggest the somewhat counter-hypothesis expressed in England (2003); Partial melting occurs at a range of depths beneath volcanic arcs.

• The density of volcanoes (spacing of volcanoes) as a function of trench length (graph 2) shows a lack of correlation. No one factor was found to explain the variance in the data; however, maximum earthquake moment shows a weak positive correlation. This is taken as evidence that many variables determine the observed volcanism; since the moment magnitude scale is based on length of fault rupture, trough depth, displacement, and rock strength.

• Perhaps a more ideal variable that would explain the concentration of volcanoes is the frequency of earthquakes: an increased number of earthquakes would provide a greater number of volcanic conduits feeding volcanism. Determining a time series for seismic events is impossible owing to the very limited range of records; earthquake history goes back no more than 50 years with any reliability. Researchers at the University of Münster, while looking to determine the rate and method with which magma travels upward, speculate that magma flow is facilitated by earthquakes, or even propelled ‘like a jet’; research is still needed regarding this mechanism [6].

• Future research is needed to better understand plate dynamics, the process of subduction, and magmatism. While this research uses very general physical observations to speculate about Earth’s processes, geophysical evidence gained through detailed field work can lend further insight into the processes that generate active volcanism.

Abbreviations:

Bibliography