**Plate Tectonics as Expressed in Geological Landforms and Events: An Exploration using Google Earth™ and GeoMapApp**

It is no coincidence that the theory of Plate Tectonics developed in the late 1960’s when, for the first time, large-scale remote sensing datasets for the Earth, in particular seafloor geomagnetic and gravity data sets, became widely available. To “see” and document a planet-scale process like Plate Tectonics, one needs to be able to observe geologic phenomena at very large length scales.

We’re going to do a little bit of this for ourselves, making use of global data for earthquakes and volcano distribution, and a couple of new global visualization tools: Google Earth™, a freely available “virtual globe” imaging package; and GeoMapApp, a Java-based “geographic information system” (GIS) focused on the marine setting, developed and maintained at the Lamont-Doherty Earth Observatory’s Marine Geoscience Data System. GeoMapApp is designed to generate Google Earth compatible kmz and kml files, so anything that can be imaged on a map base in GeoMapApp can be overlain and manipulated on the Google Earth virtual globe.

**Getting Started Instructions:**

1. Download Google Earth™ onto your home computer or laptop. Go to <http://earth.google.com> and follow the instructions.
2. Download GeoMapApp onto your home computer or laptop. Go to <http://www.marine-geo.org/> and follow the instructions for downloading.
3. Download the GOC-CENTAM folder of kmz files from our class Assignments page (or from the bottom of this page). These files were generated using GeoMapApp, and our first activities will involve them.

**Exercise 1:** Studying Earthquake and Volcano Distributions in Central and South America and the adjacent Pacific and Caribbean Oceans

1. Start up Google Earth, and open ALL the kmz files in the GOC-CENTAM folder on Blackboard, under Assignments. These will become part of your Temporary Places folder in Google Earth, and can be saved permanently in your My Places file.

1. Download the Smithsonian Global Volcanism Network’s Google Earth placemark file of global Holocene volcanoes, and open this file in Google Earth. <http://www.volcano.si.edu/world/globallists.cfm?listpage=googleearth>
2. Each of the above files can be turned on or off via the checkboxes in your Places menu, and/or it can be “faded in” or “faded out” by highlighting the filename and adjusting the horizontal scrollbar that appears below it. For now, uncheck or fade out all the kmz files except for “Earthquake Epicenters EPacific” (the Volcanoes placemark file should be left active). This file includes the epicenters of all earthquakes of magnitude 5.0 or greater in the region since 1964. If you double-click on this file in the menu, Google Earth will rotate and focus the globe on the area highlighted in this file.
3. Take note of the distributions of earthquake epicenters along the western margin of Mexico and Central America. The earthquake epicenters are color-coded by depth: green refers to shallow-depth quakes, yellow to intermediate-depth quakes, and red to deep earthquakes. If you zoom in slightly, red symbols denoting the position of recently active volcanoes should appear – these are derived from the Smithsonian Institution’s Global Volcanism database, which is now a bundled file with Google Earth 4.0 (if they don’t appear, be sure that the “Geographic Features” box under the Primary Database is checked).
4. What is the general spatial relationship between earthquake epicenters and volcano positions along the Pacific margin of Mexico and Central America? What sort of plate boundary does this relationship indicate?
5. Why are there a large number of earthquakes recorded in the Gulf of California, and what kind of plate boundary does this indicate?
6. Why is there a chain of earthquake epicenters cutting across Guatemala and continuing eastward south of Cuba? What sort of plate boundary may this indicate?
7. Based on the earthquake and volcano positions, try and sketch the plate boundaries evident in this part of the eastern Pacific
8. In your plate boundary identifications in d., did you discover any Microplates (i.e., small pieces of oceanic crust bounded on all sides by plate boundaries)? If so, where?

Fade out the “Earthquake Epicenters EPacific” file, and turn on and/or fade in the “CostaRicaandCocosRegion” file, which brings up a close-up view of the Pacific continental margin along Costa Rica and Panama.

1. What happens to volcano and earthquake distributions as one moves east in Central America from Costa Rica into Panama?
2. The cluster of volcanoes in the SW corner of the image are the volcanic centers of the Galapagos Islands, a volcanic “hotspot” offshore from Ecuador. Hotspots reflect high-volume basaltic volcanism, and often leave a “hotspot trace” of thickened ocean crust as oceanic plates move across them. Based on the observed bathymetry, identify the trace of the Galapagos hotspot, and tell me which direction the Pacific plate is moving in relative to Central America.
3. Try and identify the plate boundaries in this area, based on the earthquake and volcano distribution. What kinds of plate boundaries are they (divergent, convergent, transform), and what Triple Junctions do you observe?

**EXTRA CREDIT (lab grade only):**

**Exercise 2:** Exploring the tectonics of the Izu-Bonin-Mariana-Nankai MARGINS Focus areas

For this exercise, you will compile your own bathymetry images in GeoMapApp, and incorporate them into your Google Earth database. GeoMapApp can be downloaded at the Marine Geosciences Data Center website (<http://www.marine-geo.org/> ). Start the application as directed on your own PC after downloading.

1. To find the Izu-Bonin-Mariana region, select it from the MARGINS Focus Sites link under the Places drop-down menu. Expand the field of view if necessary to include southern Japan and the Nankai trench area.
2. On this map base, add Earthquake Epicenter data from the “Available Data” drop-down menu. (Look under “Custom Data viewers.” There are two links for earthquakes: one exclusively for Pacific submarine quakes, and a second more general one –the second is preferable, but you may wish to do both).
3. Save this image (bathymetry+the earthquakes overlay) as a kmz file using the Save As function on your computer.
4. Repeat steps 1-3 for several smaller, bathymetrically complex sites along the IBM arc-trench system or the various back-arc ridges and spreading centers, at your discretion. Use the Zoom In function (+ magnifier on the toolbar) to create close-up maps, and reduce the spot sizes for earthquake epicenters to 0.5 or less.
5. Open all of these files in Google Earth, and examine the earthquake and volcano distributions that they reveal to answer the following questions:
   1. Where are the divergent plate boundaries in this region, and how can one identify them?
   2. Where are the convergent plate boundaries, and what features (i.e., bathymetric, or earthquake/volcano distributions) distinguish them?
   3. In Central America, the active volcanoes along along the arc occur on land, while in the Izu and Marianas arcs, they exist largely as very small volcanic islands. What reason(s) might there be for this difference, based on what you see on the maps and overlays?
   4. Why are there no volcanoes in south-central Japan? Base your reasons on your observations from the maps and overlays, and your interpretations of them as regards the plate boundary arrangements in and around Japan.

* [KMZ file for earthquake epicenters in the eastern Pacific](http://serc.carleton.edu/files/margins/minilessons/earthquake_epicenters_e.kmz) ( 1.5MB Feb19 07)
* [KMZ file for the Costa Rica/Cocos area](http://serc.carleton.edu/files/margins/minilessons/costaricaandcocosregion.kmz) ( 1.6MB Feb19 07)
* [KMZ file for the Nicoya Peninsula close-up area](http://serc.carleton.edu/files/margins/minilessons/nicoya_focus_area.kmz) ( 1.4MB Feb19 07)