# Tectonic Fissures on Mars

Cyber Village Academy
Mars Student Imaging Project

## Introduction

- **Science Question**

  Is there evidence of magma and lava similar to what we see in the Hawaiian Islands, or Yellowstone, and parallel fissures with new crust forming in Image #V13300013?

- **Importance and Interest**

  This question is important because if it is answered it could indicate plate tectonics on Mars, allow us to begin mapping plate boundaries, and also possibly help us discover if the fissure is formed by divergent plates.

- **Hypotheses**

  If the fissure in Image #V13300013 was formed by divergent faults, then it will be similar to the great rift valley or the Mid Ocean Ridge, and we will see evidence of magma and lava similar to what we see in Yellowstone, or the Hawaiian Islands.

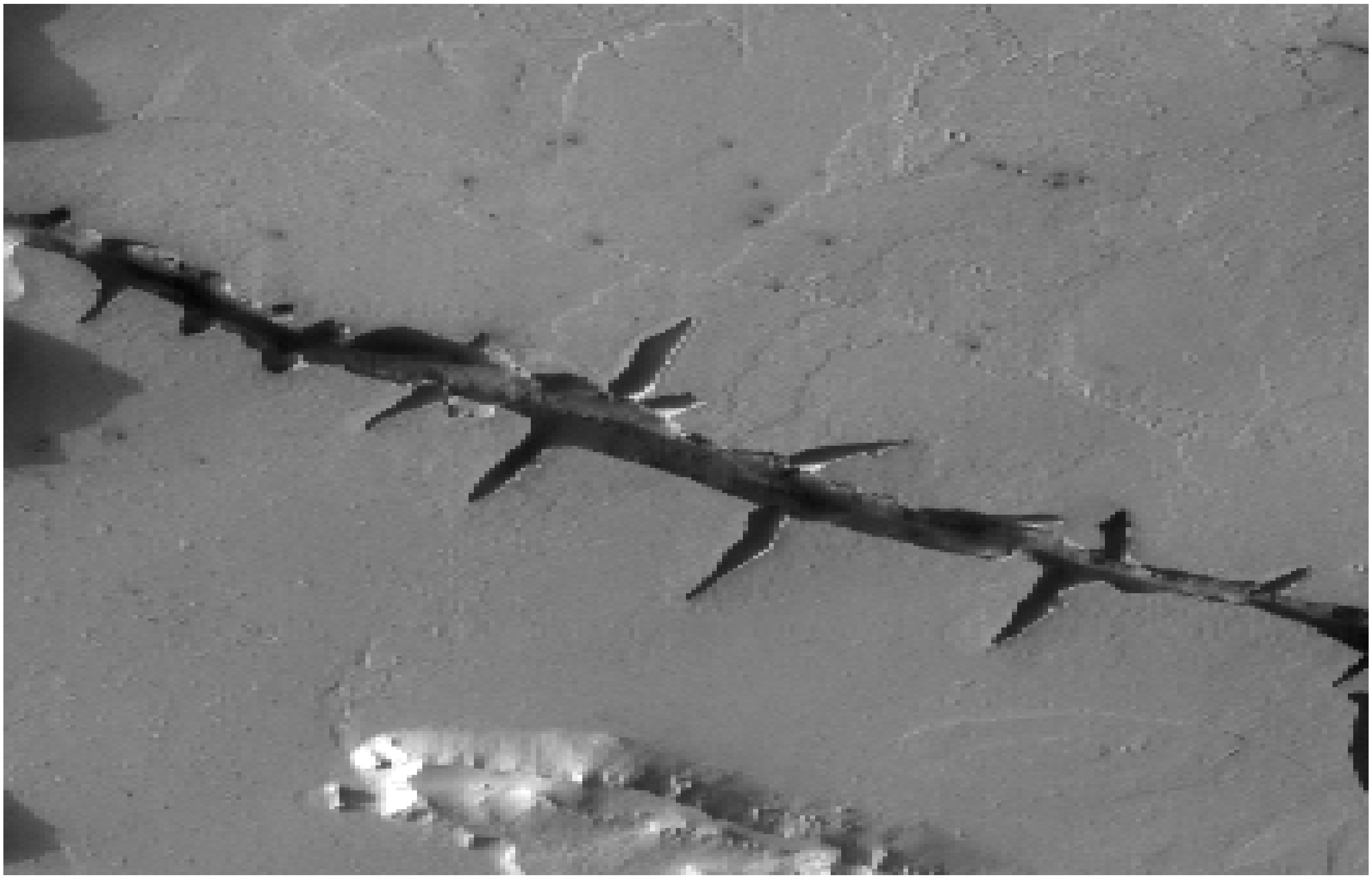
## Background

Scientists have strong evidence of plate tectonics on Mars. UCLA scientist An Yin has shown that Earth isn't the only planet in the solar system with plate tectonics. By examining images of geological examples on Earth and comparing them to Mars, the discovery has been confirmed. Examples are comparing California's Death Valley Faults to smooth flat sides of canyon walls on Mars. This analysis confirms how Valles Marineris was formed, as part of a plate boundary that has very slow horizontal separation. Major tectonic shifts do not occur often, but are expected to happen around every million years. The slower plate movement on Mars could be accounted for by less thermal energy than Earth, fewer main plates than Earth, or a more primitive stage of plate tectonics.

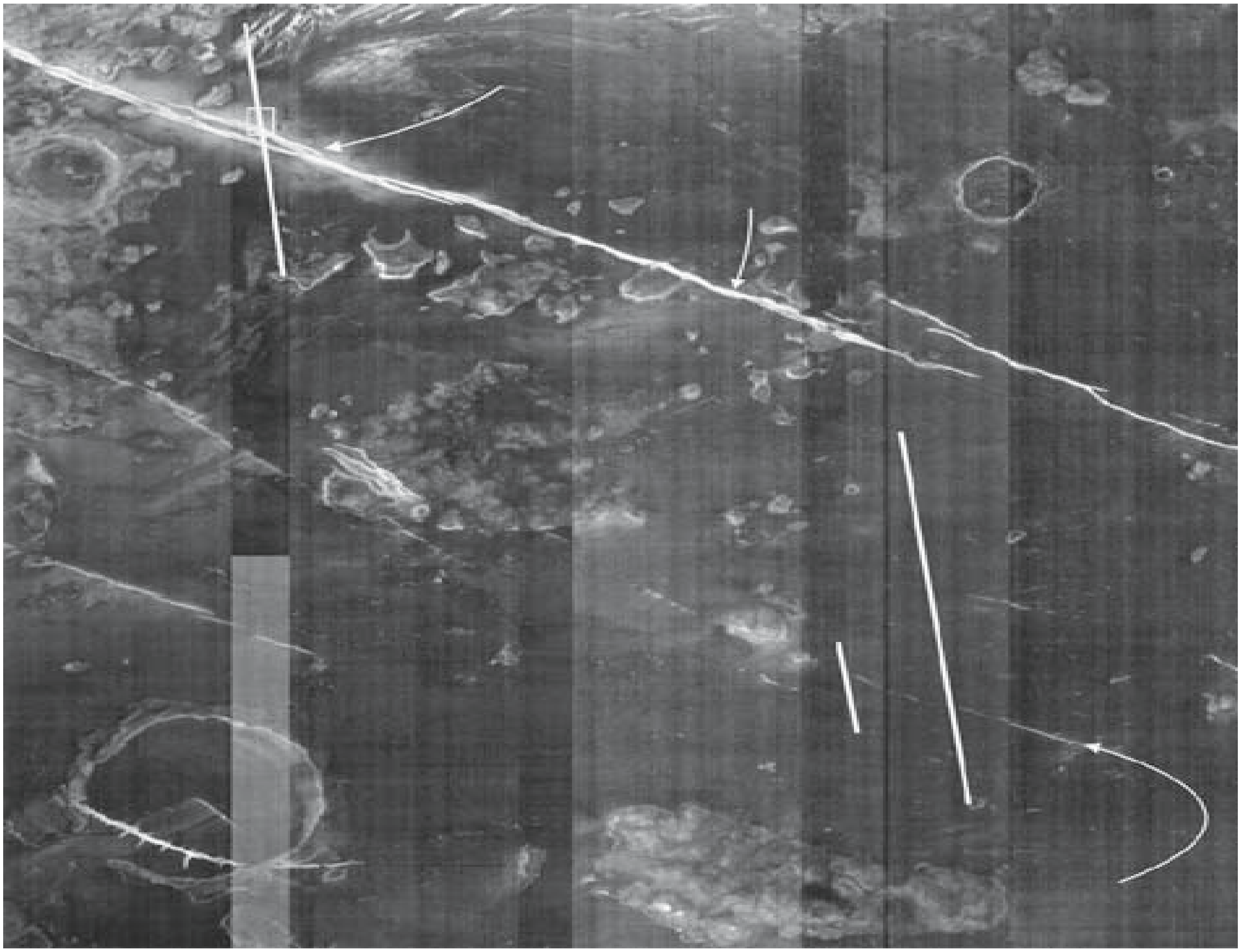
In our experiment, looking at geological examples on Earth will most likely be critical to discovering if our fissure is formed by plate tectonics.

References: (Dvorsky, 2012), (Villard, 2012), (Wolpert, 2012).

- Show what your features **look like** on Mars in selected images, sketches, or pictures.

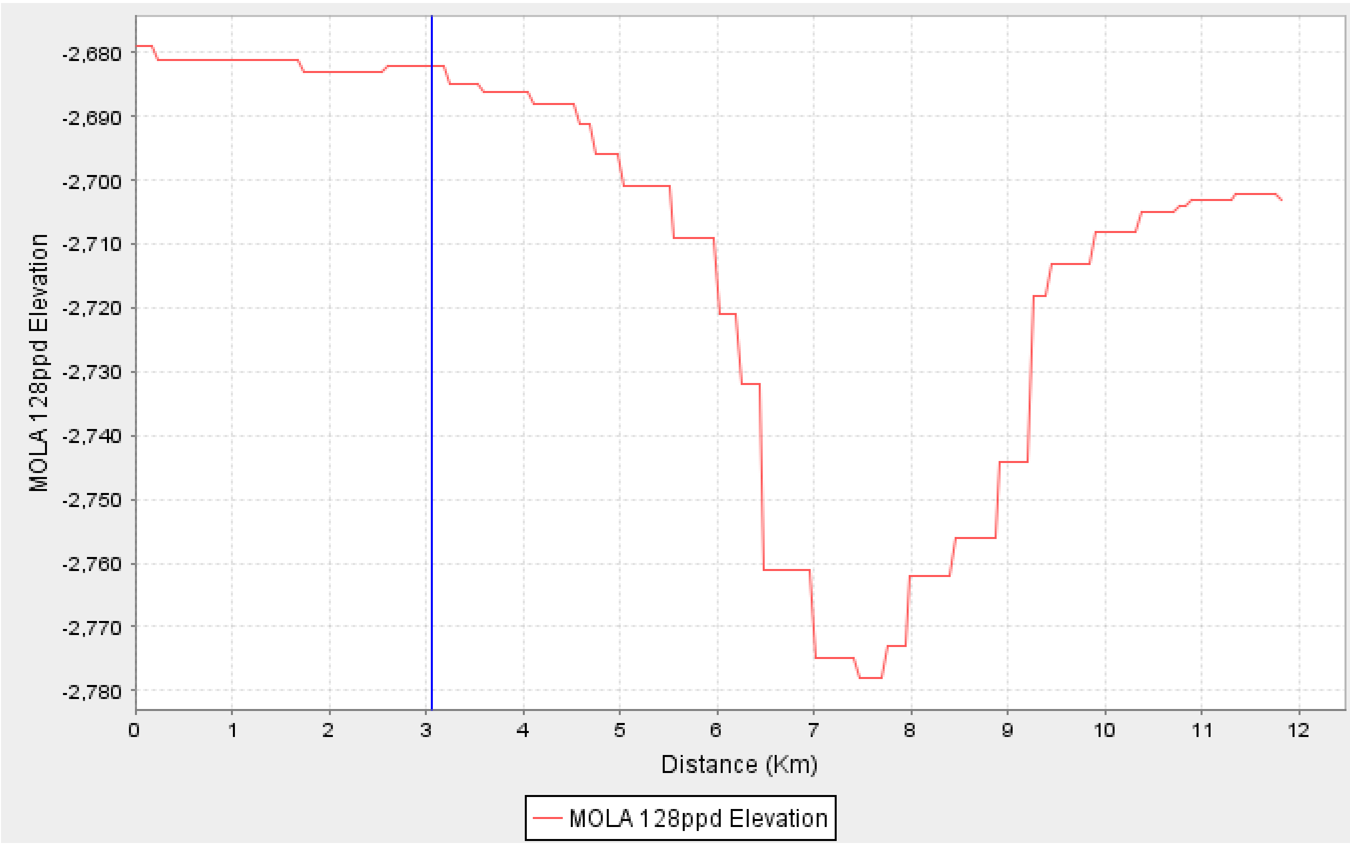


The main fracture we are studying -- part of Cerberus Fossae -- is shaped like a zipper, in that there are numerous channels cutting across the main channel perpendicularly. It is 31.6 kilometers long and approximately 1 kilometer wide (though it varies), and the depth is shown in the graph on page four. Nearby, to the north, there is a much smaller fissure, as well as lava fields, which suggests that this is a volcanic feature or a crack in the martian crust (see hi-rise image ESP_012260_1875_RED). The side cliffs of this "zipper" are very sharp, and they almost look "crumbled away." In one part of the fissure, the center floor rises slightly -- it looks different from the nearby lava field, though. The floor of the fissure, which is not as deep as it may appear at first glance, is slightly eroded, perhaps by wind, water or lava (see hi-rise images /PSP_007566_1875_RED, PSP_003518_1875_COLOR, and PSP_007566_1875_COLOR).

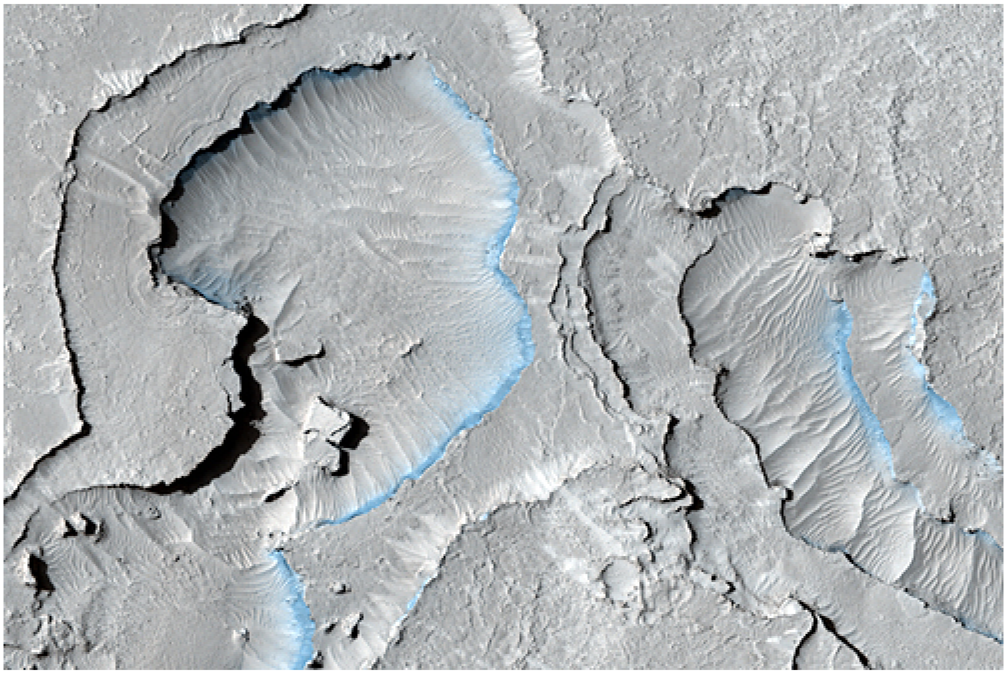


Interestingly, when viewed through night IR (above, in the lower left corner), this fissure looks like a crack of light, which suggests extreme heat.
(Robert et. al., 2007)

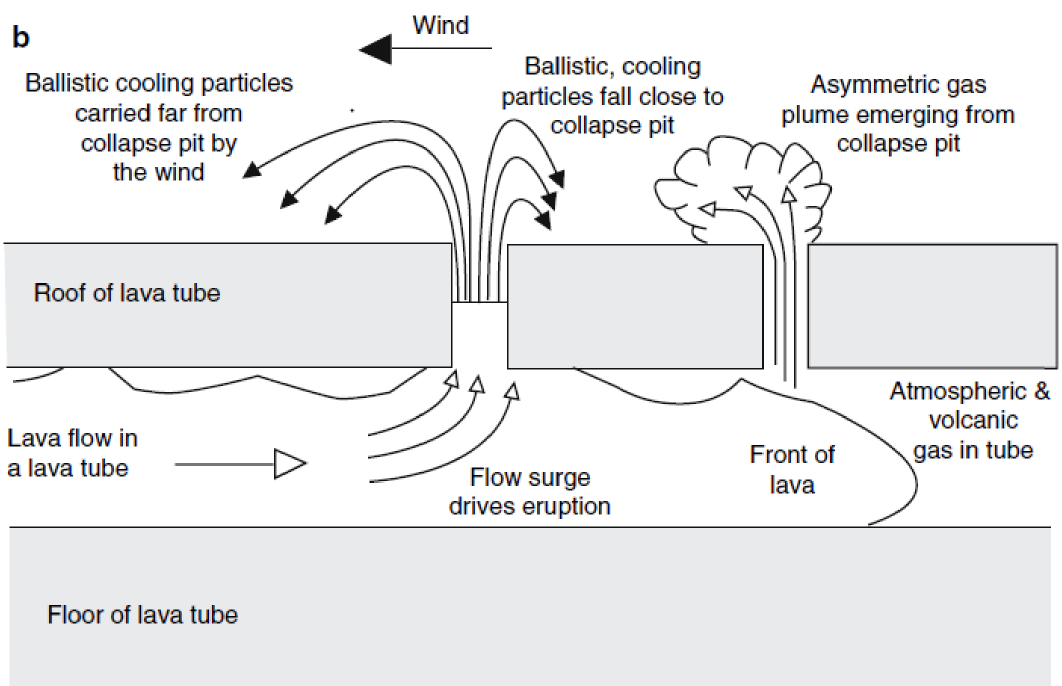
Depth of our fissure (elevation line graph, generated through JMARS):




Currently Scientists are debating about how fissures are thought to form; there are two popular models. The information in the next few pages focuses on the volcanic model.

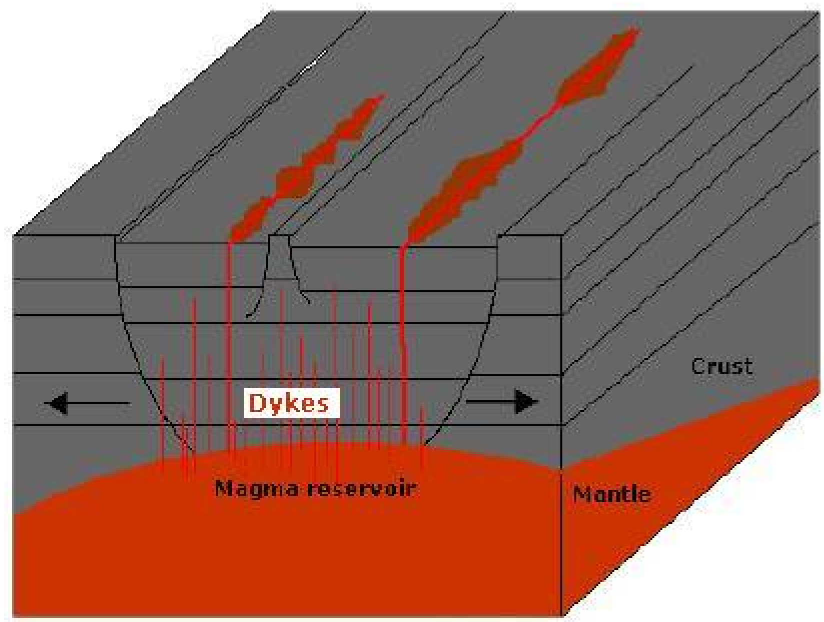


Above is a fissure that is thought to form via a volcanic process. Volcanic fissures are thought to form from explosions of pressurized lava that rupture the surface. The below image shows the formation of the a Volcanic Fissure:




(Robert et. al., 2007)

Below is a diagram of a fissure volcano.

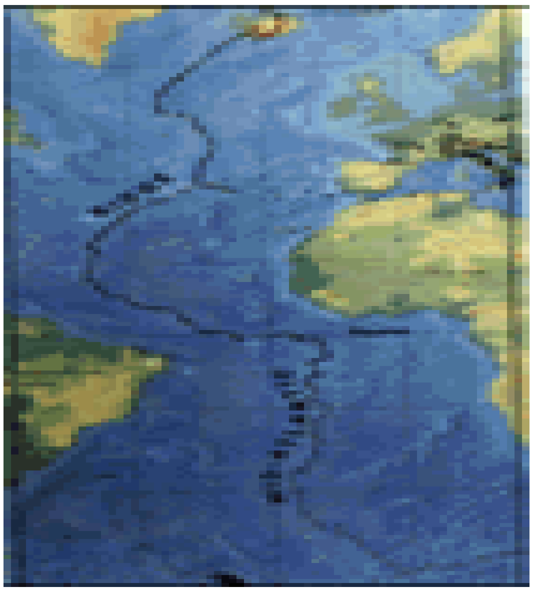



(“What on Earth,” 2013)

- If the features you are studying are found on Earth, how are they thought to be formed?

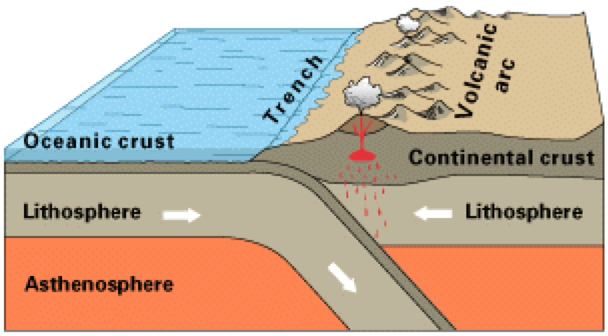
On Earth, plate tectonics cause massive earthquakes and create majestic mountain ranges near plate boundaries, or the places where the Earth’s crust is fragmented into several different plates. Floating on a sea of magma, the plates slowly yet deliberately crush each other, with the process being called plate tectonics. According to the United States Geological Survey, there are four different types of plate boundaries: Divergent boundaries, where plates move in opposite directions; convergent boundaries, where plates move towards each other; transform boundaries, where plates slide in opposite directions beside one another; and, finally, plate boundary zones, where the interaction between two or more plate boundaries is unknown.

One example of a divergent boundary on Earth is the Atlantic Mid-Ocean Ridge, an immense plate boundary stretching thousands of miles from north to south, splitting apart at the leisurely speed of 25 kilometers in one million years. The two plates that comprise the boundaries are splitting apart, the cooling magma creating new crust material in the center of the gap, much like Earth’s own recycling system. One place in particular, Iceland, is directly in the center of the Mid-ocean Ridge, where the constant splitting creates violent volcanoes and the cracking of the Earth's crust in the process, also called "rifting".This splitting is also present in the deep in the center of Africa, where three divergent plates, pulling in opposite directions, are tearing apart the continent itself and creating the East African Rift Zone.



Above: The Atlantic Mid-Ocean Ridge, an example of divergent plate boundaries on Earth. Source: United States Geological Survey

On the other sides of the Earth, this constant spreading by the Mid-Ocean Ridge and East African Rift Zone is compensated by the opposite of divergent plate boundaries, the convergent plate boundaries. Convergent plate boundaries are places where the Earth's crust is being pushed together, forming either mountains or trenches. In the case of trenches, their formation is closely tied with a type of convergent plate boundary, called subduction. Subduction happens when one plate slips under another. A demonstrative example of this is off the coast of South America,where the subducting convergent boundaries of the Pacific have created a trench off of the coast. Because the Nazca plate is being subducted under the South American plate along this boundary, the resulting force upon the South American plate in turn created the Andes Mountain Range, a mountain range stretching across the South American coastline. Another example of convergence is the Himalayan Mountain Range, home of Mount Everest, whose peak is the highest point in the world, stretching over 8,000 meters above sea level. This type of convergence is called continental-continental convergence by the USGS, as the two plates, the Eurasian and the Indian plates, are converging in the middle of the Asian continent.

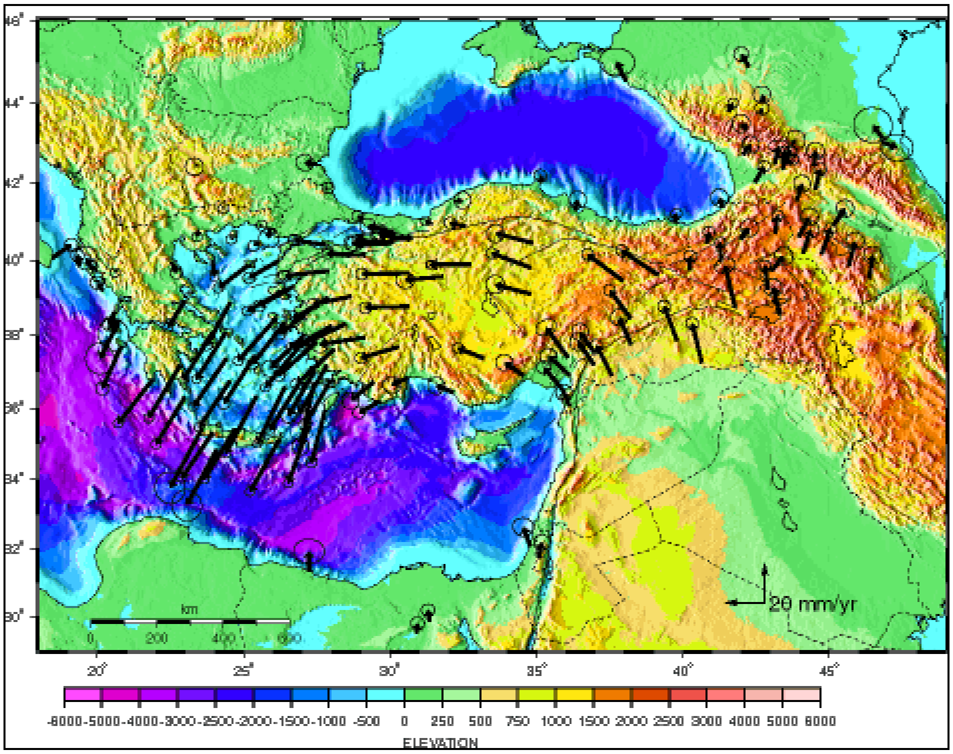



Oceanic-continental convergence

Above: Much like the Nazca plate subducting under the South American plate, convergent plate boundaries can create deep trenches and striking mountains. Source: United States Geological Survey

A relatively famous example of a transform boundary on Earth is the San Andreas fault in California. This fault is right in between two major divergent faults, causing stress to the surrounding area. This constant shoving up against one another builds up tension, making the San Andreas, along with other transform boundaries, perfect for earthquakes.

Finally, the plate boundary zones on Earth are still somewhat unknown, with the Mediterranean-Alpine region, where small, fragmented pieces of plates, known as microplates, are present, making this area and similar geological zones harder to study. The pressing of these microplates against two or more larger plates has led to a complex geological history of the region and others like it.




Above: the complex geography of the Mediterranean-Alpine region.

References: (“GPS scientific application”), (“Understanding plate motions,” 2012).

- During your preliminary background research of looking at THEMIS visible images, you may consider plotting points on a map of Mars that represent the location of each image you observe. If you do this, think about:

  -What geographic regions did you observe these features on Mars?

Small, straight and often parallel canals on Mars are called “fossae.” Most were probably either formed tectonically or volcanically. Not all are included here.

**In the Elysium Region. . .**

Cerberus Fossae, better known as OUR ZIPPERS, Locations of lines of similar parallel fissures: 156.625E-11.609N to 163.102E-8.852N, 155.320E-11.078N to 160.508E-8.973N, there are also some smaller fissures scattered south of this.

Albor Fossae (THEMIS Image #V26716020 and nearby)

Hyblaeus Fossae (THEMIS Image #V08259018 and nearby, including some very wacky geography on THEMIS Image #V14524012)

Zephyrus Fossae (THEMIS Image #V18018018 and nearby)

Elysium Fossae (THEMIS Image #V44398002 and nearby)

Stygis Fossae (THEMIS Image #V18804009 and nearby)

Galaxias Fossae (THEMIS Image #V10468014 and nearby)

Hephaestus Fossae (squiggly fissures and channels ala Gorgenous Chaos in THEMIS Images #V01581010, #V0892010, #V17844012 and nearby; Hi-RISE Images ESP_013303_2015_RED, PSP_006684_2020_RED and nearby)

**In the Northern Tharsis Region. . .**
Cyane Fossae (THEMIS Image #V18077023 and nearby)
Halex Fossae (THEMIS Image #V18077023 and nearby)

## Experiment Design

The purpose of the experiment design section is to show how you plan to design your experiment in order to allow other scientists to repeat it. This section includes the step-by-step process detailing exactly what you will do to collect your data to answer your science question.

This section can include the following:
(Note: Some of this information may not apply to all projects):

- What specific spacecraft and camera will you use to collect data for your research?

  We will use the THEMIS camera on the Mars Odyssey spacecraft.

- What specific geologic features will you focus on for your study and why?

  We will focus on fissures formed by tectonic processes, in order to try and prove that the fissures in Cerberus Fossae were.

- What geographic regions, if any, will you focus on for your study? (For example, certain latitude bands, certain regions (northern or southern hemisphere), etc.). Note: It is not recommended to focus on one specific geographic location on Mars.

  We are focusing mainly on the Elysium region (such as Albor Fossae, Hyblaeus Fossae and Hephaestus Fossae) but also looking a bit at Vallis Marineris.

- What website(s) will you use to gather your data and how will you use it (them)? Be specific.

  For backgrounds on plate tectonic terms, we will use the USGS website and NASA's pages on Mars and Mars' geological features. The hi-rise site (http://hirise.lpl.arizona.edu/) would be good to use in addition to the THEMIS site for us to look at pictures of fissures. We also will use the ASU website.

- How many THEMIS images will you need to gather in order to answer your science question?

  We will need to gather at least 12 different Themis images and analyze them, and use as many useful HiRISE images as we can find in our areas. If we have that many images, we will be able to see several different types of fissures.

- As part of your experiment design, list the specific information you plan to record in a table from each image you observe, and why?

  We will record fissure length and depth. We will also record latitude and longitude. We will search for parallel fissures, nearby lava flows, and other signs of tectonic activity like convergence or microplates.

  List what you will record from each image here:

  We will record the age of each of the fissures in the images. We will also observe the different types of features, and the direction of the lava flows in the images. From this, we will speculate as to how the various features were formed.

- What measurements you will make, if any. Please include why and how you will make those measurements.

  The measurements that will be conducted upon said fissures will include length, depth, and width of the various fissures found on Mars, and comparing these qualities between the different fissures in graphs and maps.

## Analysis Plan

The purpose of the analysis plan section is to plan how to <u>list</u> and <u>display</u> your data in order to analyze it. This section may include:

- **TABLE:** Specific information (Image ID#, latitude, longitude, specific feature(s), measurements, etc.) you will record from each image you observe. [For your proposal, you should include the table outline you will use to display your information]

| Image ID (V #) | Lat. (N) | Long. (E) | Size of lava field in picture | Dir. of lava flow | Dir. of lava flow relative to fissure | Length of fissure | Depth of fissure |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

**What will your table look like?**

The table is data table that provides information about the image id number, the location of the image and the depth, length, and lava flow data.

The table will look like the previous table, in a more relevant order.

- **GRAPHS**: What specific pairs of information will you graph (including what type of graph you may use: bar, line, scatter, etc.; see examples shown below) and what will each graph tell you?

**List the pairs of information you plan to graph:**

Fissure depth versus length. (scatterplot)

Fissure depth versus adjacent lava field size (scatterplot)

Amount of fissures in a given area versus size of lava fields? (scatterplot)

**What types of graphs will you create?**

- **MAP**: Will you plot your data on a map? (2 examples below) If so, please explain why. How will you do this and what will this show you.

**Will you plot your images on a map? If yes, please explain why? (What will this show you?**

We will plot our images on the MOLA map because we want to see if there is a correlation between where the fissures that are similar to our “zipper” are.

- **OTHER**: Is there any other way you will display your results (Annotated images, etc.?)

  We may display some annotated images in the form of images with our observations marked on them.

## Conclusion

The purpose of the conclusion section is to summarize what your team is proposing to do. It should:

- Restate your science question.

  Our science question is: Is there evidence of magma and lava similar to what we see in the Hawaiian Islands, or Yellowstone, and parallel fissures with new crust forming in Image #V13300013?

- Restate your hypotheses (if you had any).

  Our hypothesis is: If the fissure in Image #V13300013 was formed by divergent faults, then it will be similar to the great rift valley or the Mid Ocean Ridge, and we will see evidence of magma and lava similar to what we see in Yellowstone, or the Hawaiian Islands.

- Restate why it is important to answer your question and why your proposal should be accepted for your team to use the THEMIS visible camera.

  It is important for us to answer this question because if it is answered it could indicate plate tectonics on Mars, allow us to begin mapping plate boundaries, and also possibly help us discover if the fissure is formed by divergent plates.

## References

Dvorsky, G. (2012, August 10). [Web log message]. Retrieved Wednesday, March 13th from http://io9.com/5933638/plate-tectonics-confirmed-on-mars

*GPS scientific application: Plate boundary zone*. Retrieved Wednesday, March 13th from http://www.dpc.ucar.edu/VoyagerJr/gpsplatebound.html

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