LESSON 2 Mountains, Valleys, and Plains, Oh My!

Lesson at a Glance

In this lesson, students will learn about the basic topography of the ocean bottom (bathymetry when under water), and compare some of the major bathymetric features under the ocean with major topographic features on land.

Lesson Duration

Two 45-minute periods

Essential Question(s)

What are the major bathymetric features of the ocean?
How are bathymetric features and topographic features similar and different from each other in terms of size and formation?

Related HCPSIII Benchmark(s):

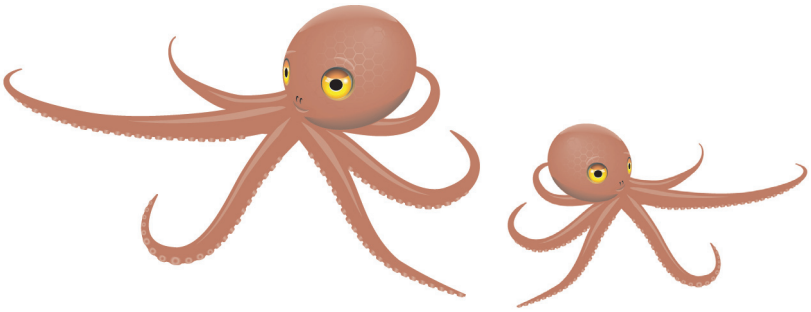
Science SC.5.2.1
Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world.

Key Concepts

- Bathymetry (underwater topography) is predominantly created by tectonic and volcanic forces, whereas continental topography is created by both tectonic and volcanic forces as well as the effects of weathering and erosion by wind, water, and glaciers.
- Mountains and trenches formed in the ocean depths may be as large as, or even larger than those we see on land.

Instructional Objectives

- I can use scale models and graphs to compare and contrast underwater features with those on land.
- I can describe how bathymetric features and topographic features are similar and are different from each other in terms of size and formation.



Assessment Tools

Benchmark Rubric:

Topic		Unifying Concepts and Themes	
Benchmark SC.5.2.1		Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world	
Rubric			
Advanced	**Proficient**	**Partially Proficient**	**Novice**
Consistently select and use models and simulations to effectively represent and investigate features of objects, events, and processes in the real world	Use models and/or simulations to represent and investigate features of objects, events, and processes in the real world	With assistance, use models or simulations to represent features of objects, events, or processes in the real world	Recognize examples of models or simulations that can be used to represent features of objects, events, or processes

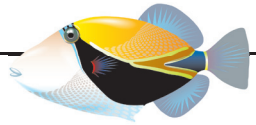
Assessment/Evidence Pieces

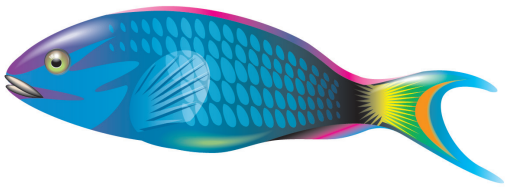
Lesson

- Formative assessment will be done through participation in reading and discussion questions as well as Reading Review Questions. Students' grasp of the comparative sizes, shapes, and origin of formations underwater with similar continental features will be assessed through participation and performance in the two activities.

Materials Needed

Teacher	Class	Group	Student
• Method to project PowerPoint • Teacher Answer Key: *Mountains High and Trenches Low*	• None	• None	• Student Reading: *Mountains, Valleys and Plains, Oh My!* • Student Worksheet: *Mountains, Valleys and Plains, Oh My! Student Reading Review Questions* • Student Worksheet: *Mountains High and Trenches Low* • Pencil • Ruler • Colored pencil





Instructional Resources

Student Reading: *Mountains, Valleys, and Plains, Oh My!*
Student Worksheet: *Mountains, Valleys, and Plains, Oh My! Student Reading Review Questions*
Student Worksheet: *Mountains High and Trenches Low Activity*
Teacher Answer Key: *Mountains High and Trenches Low*

Student Vocabulary Words

atoll: ring-shaped low island made of coral reefs enclosing a central lagoon over a submerged extinct volcano.
bathymetry: the underwater topography of the ocean floor with features such as seamounts, guyots, and submarine canyons.
continental shelf: submerged extension of a continent made of same crust materials as the continent.
continental slope: sharply sloping underwater area that forms the true edge of the continent; transition to oceanic crust material.
guyot *(ge-oh)***:** submerged, flat-topped, inactive volcano.
Mid-Atlantic ridge: a long ridge of low undersea mountains cut by numerous transform faults; it runs from Iceland in the north almost to Antarctica in the south. It is caused by the spreading apart of two great plates, adding approximately 6 inches per year to the width of the Atlantic ocean.
oceanic ridge: new seafloor created at the boundary of diverging plates, forming low undersea mountain ranges.
seamount: circular or elliptical volcanic mountain at least 1 kilometer in height from seafloor, with steep slope.
submarine canyon: deep V-shaped underwater valley, which cuts through continental shelf and slope; caused by erosion from land runoff and underwater landslides.
topography: the surface features of land; mountains, valleys, and others.

Lesson Plan

Lesson Preparation

- Review the Science Background provided in the Unit's Overview.
- Review and make copies of the Student Reading *Mountains, Valleys and Plains, Oh My!* and Student Worksheets *Mountains, Valleys and Plains, Oh My! Student Reading Review Questions* and *Mountains High and Trenches Low Activity*, one per student.
- Write out Instructional Objective *I can* statement for this lesson and post them.
- Suggested sources for additional information
  - Oceanography (3rd ed.). Tom Garrison, Wadsworth Publishing Co. (1999), pp. 90–91, 96–109
  - The Mariana Trench:
    http://www.marianatrench.com/mariana_trench-oceanography.htm
  - Science and the Sea: The Abyssal Plain:
    http://www.scienceandthesea.org/index.php?option=com_content&task=view&id=108&Itemid=10%20-%2013k
  - Wikipedia: Continental Shelf:
    http://en.wikipedia.org/wiki/Continental_shelf

- BNET: Hidden Canyons: Vast Seabed Chasms Are Carved By Riverlike Processes:
  http://findarticles.com/p/articles/mi_m1200/is_1_167/ai_n8702930
- NOAA: Seamounts and hot spots:
  http://www.pmel.noaa.gov/vents/nemo/explorer/concepts/seamount.html
- National Park Service: Grand Canyon:
  http://www.nps.gov/grca/naturescience/geologicformations.htm
- Encarta: Himalayas:
  http://encarta.msn.com/encyclopedia_761573695/Himalayas.html
- Earth Science World: Image Bank:
  http://www.earthscienceworld.org/images/search/results.html?Keyword=Ocean%20Floors

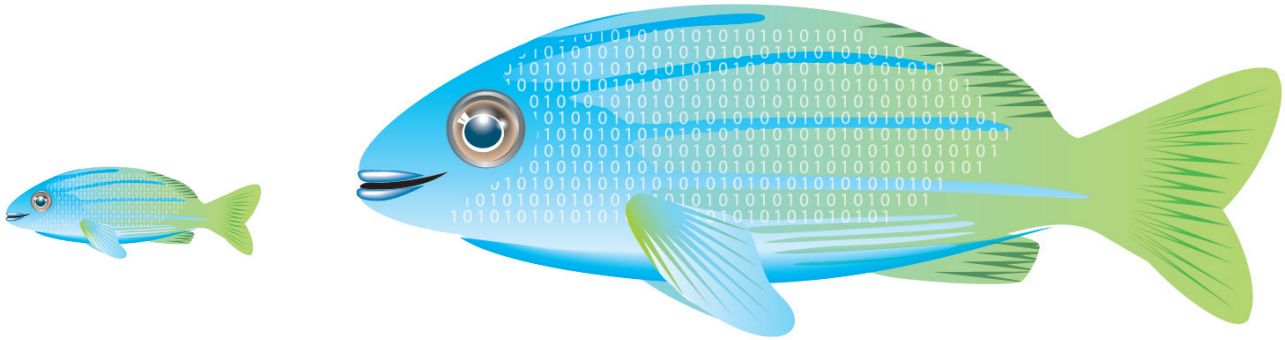
I. Mountains, Valleys and Plains, Oh my! Reading and Review Questions

A. Distribute Student Reading: *Mountains, Valleys and Plains, Oh my!* to students. Students read and then answer the questions on the student worksheet. Student reading for background information is best done in whole groups, with choral reading where students take turns reading aloud. Alternatively, the teacher may read part, or all of the materials aloud, or students may read independently or in small groups. Pause for discussion questions. Discussion questions interspersed in the reading are to provoke dialogue, discussion, and thought, and are best asked and answered in whole group settings.

B. Distribute Student Worksheet: *Mountains, Valleys and Plains, Oh My! Student Reading Review Questions* to students, and ask them to answer the questions in the review in writing. Results of this activity can be collected as a formal assessment, or you can walk around the classroom as students work to gather information about troublesome questions for an informal assessment.

II. Mountains High and Trenches Low Activity

A. Distribute Student Worksheet: *Mountains High and Trenches Low Activity* to students, and lead students in describing how they will graph the features in terms of height on graph paper that is provided. Ask students why they think graphing of these features might be important. Students will be able to compare the features on the ocean floor to those on land.



LESSON 2 - Student Reading

Mountains, Valleys and Plains, Oh My!

From a boat or an airplane, or up on a mountain side, the ocean looks flat and featureless covering almost three-quarters of the Earth's surface. However, beneath the surface of the ocean, there are tall mountains, deep valleys, and vast plains, taller, deeper, and vaster than any we find on the surface of our continents.

This underwater terrain for centuries remained cloaked in darkness and mystery. Humans could not survive or easily explore this vast area. Only in the past few decades, with modern deep-sea **submersibles** and other advanced technology, such as **multibeam sonar**, have scientists been able to reveal some of what lies beneath the surface.

While much about the ocean depths remains unknown, we do have a good bit of knowledge about the **bathymetry** of the ocean bottoms. For example, we know that the deepest part of the ocean is the Mariana trench near Guam, which lies 11,022 meters — more than 6.8 miles — below the ocean's surface. The trench is also approximately three times as wide, and four times as long as the Grand Canyon in Arizona!

The tallest mountain on any land continent is Mount Everest in the Himalayas, which is being pushed upward from the shoreline by the convergence of the Indian and Eurasia plates to more than 8,830 meters (28,970 ft.) above sea level, and still growing.

Even though Mount Everest is the tallest mountain on the continental crust, measuring from sea level, there is an even taller mountain on Earth, one that rises almost 6,000 meters (19,685 ft.) up from the floor of the ocean to the surface, and then reaches another 4,200 meters (13,796 ft.) from the sea surface into the sky. And this gigantic mountain is still growing! That mountain is Mauna Kea on the island of Hawai'i.

Besides these enormous undersea volcanic mountains and deep trenches, the ocean has many other interesting features. It has **submarine canyons**, some of which rival the Grand Canyon in size. These canyons start forming near the surface by erosion, when river water runs off the edge of the continents. They are then deepened by landslides and underwater earthquakes along the steep canyon walls. One such undersea canyon that has been explored a lot is Monterey Canyon, off the coast of central California. It is about the same depth as the Grand Canyon, one mile deep, but approximately only one-third as long.

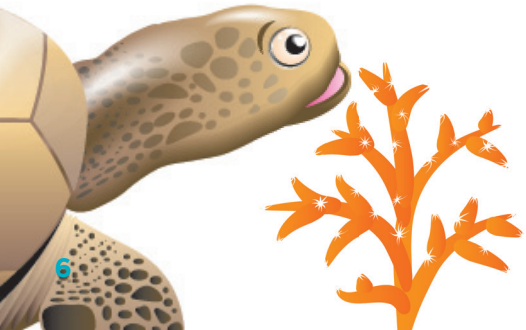
Along the edges of all continents, there is a relatively flat area underwater called the **continental shelf**, which gradually increases in depth from 0 to approximately 500 meters (1,640 ft.). This shelf then begins to plunge steeply downward into the abyss, 4,000 – 5,000 meters (13,123 – 16,404 ft.) below. This steep incline is called the **continental slope**. At the bottom of the slope is the flat, mud-covered seabed called the abyssal plain.

On the edge of a continent where two plates are coming together – a **convergent boundary** – the continental shelf is very narrow and the slope very steep. On the edge of a continent where no plates are converging, the continental shelf is very flat, extending for many miles into the shallow sea before sloping downward.

In places beneath the ocean where two plates are moving away from each other, the magma bubbles up to form low mountain ranges called **oceanic ridges**. The largest and best known of these is the **Mid-Atlantic ridge**, which runs down the center of the Atlantic Ocean from Iceland in the north to below the tips of South America and Africa in the south, ending at the Antarctic plate. This ridge forms a low mountain range, approximately 2,000 meters (6,561 ft.) high, with a deep rift valley down the spreading center in which deep sea hydrothermal vents may be found. These ridges and hydrothermal vents are located along every underwater divergent plate boundary on Earth.

Finally, there are **volcanic islands**, **seamounts**, **guyots** *(ge-ohs)* and **atolls**. All of these have their origin as undersea volcanoes. Seamounts, such as *Lō'ihi*, just south of the big island, and the MacDonald seamount in the South Pacific, have simply not grown high enough to reach the surface yet. Both of these, like our own Hawaiian islands, have formed over hot spots beneath the Earth's crust. Other volcanic island chains form over places in the oceans where two plates are converging, with one sliding under the other.

Guyots are also underwater mountains, but unlike seamounts, they are old, dead volcanic islands whose tops were flattened by erosion before they sank beneath the ocean surface. Atolls, as we learned in an earlier lesson, are also former volcanoes that sank beneath the ocean, but as they sank, the coral reefs fringing their shores continued to grow upward toward the light, so that now the coral reefs form a circular low island surrounding a central lagoon. Deep below the surface of the lagoon is the top of the extinct volcano.



LESSON 2

Name: _____ Date: _____

Mountains, Valleys and Plains, Oh My!
Student Reading Review Questions

1. What features are found under the ocean's surface?

_____

_____

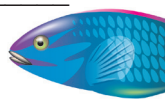
_____

2. Where is the deepest part of the ocean?

_____

_____

_____

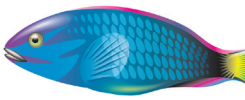


3. What is the tallest mountain on Earth, measured from the seafloor?

_____

_____

_____



4. How do submarine canyons form?

_____

_____

_____

5. Where is the continental shelf very narrow and the continental slope very steep?

_____

_____

_____

6. Where do ocean ridges form?

7. Name two active volcanic seamounts in the Pacific:

8. What is a guyot (ge-oh)?

9. What are two ways volcanic island chains form?

LESSON 2

Name: _____ Date: _____

Mountains High and Trenches Low Activity

Materials per student:

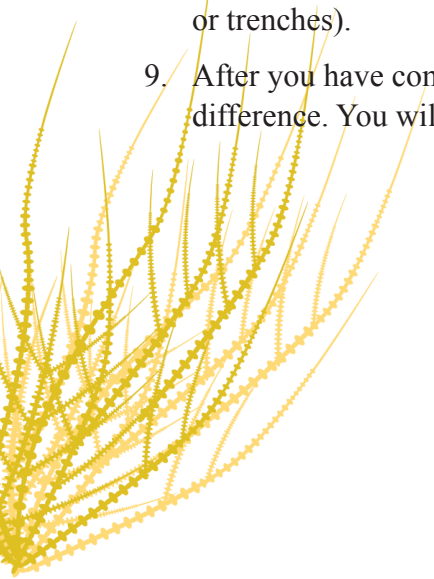
- Copies of all 4 pages of this worksheet
- Ruler or straight edge
- Pencil

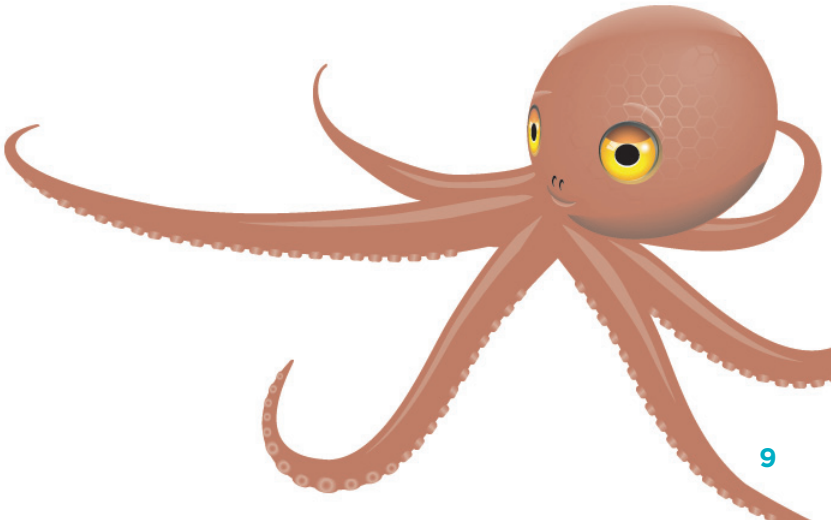
Directions:

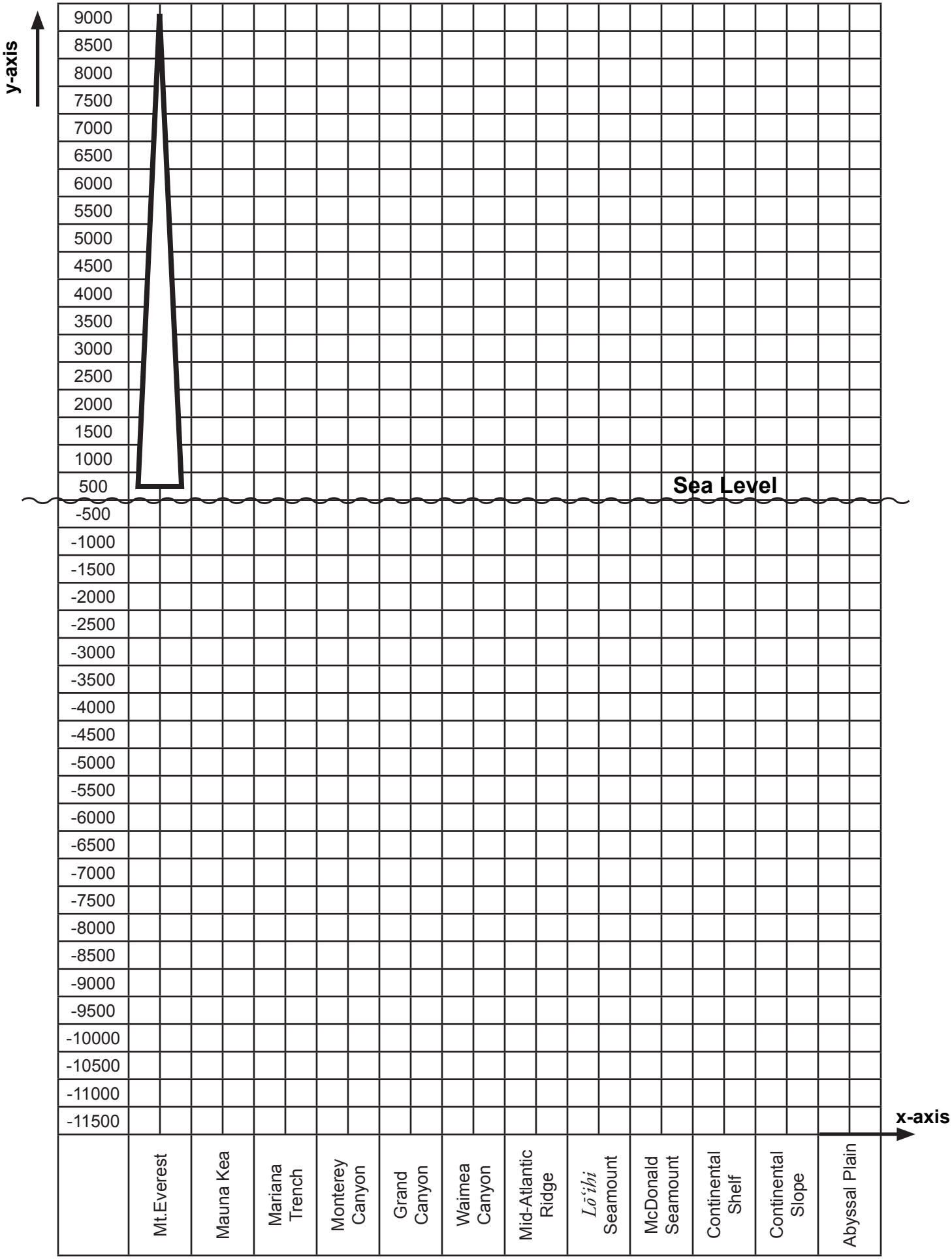
1. On the graph paper, plot the heights and/or depths of each of the Earth features given in the table.
2. Each square on the Y axis represents 500 meters.
3. You will graph each figure in the shape of a triangle. The first number is the base of the triangle, which will be two columns wide. The second number is the point of the triangle and can face either up or down. The point should be plotted midway between the two columns.
4. If the number starts high and goes lower – whether it is above sea level or below – that is a valley and should look like an inverted triangle on your chart.

   For example, Grand Canyon starts 2,000 meters above sea level and goes down to 400 meters above sea level at the bottom, then back up to 2,000 meters again.
5. If it starts low and goes high, that is a mountain, and the point should be at the top.

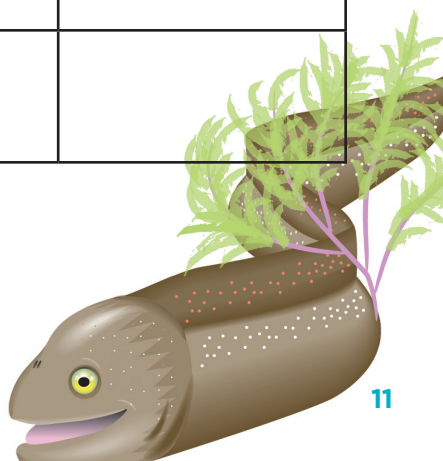
   For example, see Mount Everest data.
6. As you graph each figure on the chart, color, and label it.
7. Write the height or depth by each point.
8. On your data table, fill in the Height or Depth of each feature (height for mountains, depth for canyons or trenches).
9. After you have completed all the features, rank them from highest (1) to the lowest (10) amount of difference. You will have to subtract positive and negative integers.






y-axis
9000
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
Sea Level
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000
-4500
-5000
-5500
-6000
-6500
-7000
-7500
-8000
-8500
-9000
-9500
-10000
-10500
-11000
-11500
x-axis
Mt.Everest
Mauna Kea
Mariana Trench
Monterey Canyon
Grand Canyon
Waimea Canyon
Mid-Atlantic Ridge
Lo'ihi Seamount
McDonald Seamount
Continental Shelf
Continental Slope
Abyssal Plain

Earth's feature	From	To	Height or Depth	Rank Amount of Difference*
Mt. Everest	0	+8,800	8,800 meters high	2
Mauna Kea	-4,000	+ 6,000		
Mariana Trench	-4,000	-11,000		
Monterey Canyon	0	– 3, 600		
Grand Canyon	+2,000	+400		
Waimea Canyon	+1,000	0		
Mid-Atlantic Ridge	-5,000	– 2,500		
***Lō'ihi* Seamount**	-4,000	-1,000		
McDonald Seamount	-4,000	0		
Continental Shelf	0	-500		
Continental Slope	-500	-4,000		
Abyssal Plain	-3,900	-4,100		



From your graph and your data table, answer the following questions:

1. If you were standing at sea level, which mountain appears to be taller?

_____

2. Why is it that Mount Everest is almost 18 squares high?

_____

_____

3. Looking at the bar graph, what do you conclude is the depth of the normal ocean floor around most of these features?

_____

4. From your table, what is at this level?

_____

5. If the Mariana Trench is 11,000 m deep and Everest is only 8,800 m high, why isn't the trench greater from top to bottom than Mount Everest?

_____

_____

_____

6. From the graph, one could conclude that _____ is the highest point on Earth, however from top to bottom _____ is the largest mountain.

7. From the graph, are we able to calculate the volume of each feature (area of a triangle equals one-half Height times Width). This is just a yes/no question. Explain your answer.

_____

_____

_____

_____

_____

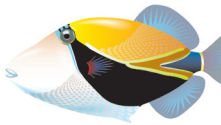
LESSON 2 - Teacher Answer Key

Mountains High and Trenches Low Activity

Reading Discussion Questions:

Discussion Questions:

What causes ocean trenches to form? *Subduction zones pull the oceanic crust steeply downward.*
What caused the Grand Canyon to form? *Erosion.*
Are the processes similar in any way? *No.*



Discussion Question:

If you, being superman, were to pick up Mount Everest and shove its top down into the Mariana Trench, how deep would the bottom of the mountain still be below the ocean's surface?
The bottom of the mountain would still be 2,192 meters (11,022 – 8,830 meters) below the ocean's surface.

Discussion Question:

On which side of the continental United States do you think the near-shore water would be shallow for miles, and on which side do you think it would drop off into deep water within a mile or so of shore? Why?
It would be shallow for miles on the Atlantic side, because there is no subduction zone there. It would drop off steeply on the Northern Pacific side because of the subduction zone from Oregon to British Columbia, and the other transform faults along the southern coast.

Discussion Question:

What do you think caused guyots to sink below the surface without forming the coral reef around their shoreline as atolls did?
Guyots may have formed in waters too cold for coral to grow, or sank too rapidly for coral growth to keep up.

Student Reading Review Questions:

1. What features are found under the ocean's surface? *Mountains, canyons, slopes, plains, and deep trenches.*

2. Where is the deepest part of the ocean? *The Mariana Trench in the Western Pacific near Guam.*

3. What is the tallest mountain on Earth, measured from the seafloor? *Mauna Kea*

4. How do submarine Canyons form? *By erosion from land runoff, and underwater landslides.*

5. Where is the continental shelf very narrow and the continental slope very steep?
   Wherever convergent plate boundaries and subduction zones are near the edge of a continent, such as in the Western United States, Western South America, and almost the entire Eastern borders of island nations along the Western Pacific and Southeast Asia (Japan, the Philippines, Indonesia, Tonga, and others.).

6. Where do ocean ridges form?
   Wherever there are two divergent plates under the ocean (Mid-Atlantic ridge, Atlantic-Indian ridge, Pacific-Antarctic ridge, and others.).

7. Name two active volcanic seamounts in the Pacific. *Lōʻihi and MacDonald seamounts.*

8. What is a Guyot? *A submerged extinct volcano with a flat top.*

9. What are two ways volcanic island chains form?
   One way is along a trench where two oceanic plates converge; the other is over a stationary hot spot over which a plate moves.

Activity 2: Mountains High and Trenches Low

Earth's feature	From	To	Height or Depth	Rank Amount of Difference*
Mt. Everest	0	+8,800	8,800 meters high	2
Mauna Kea	-4,000	+ 6,000	10,000 meters high	1
Mariana Trench	-4,000	-11,000	7,000 meters deep	3
Monterey Canyon	0	– 3, 600	3,600 meters deep	5
Grand Canyon	+2,000	+400	1,600 meters deep	9
Waimea Canyon	+1,000	0	1,000 meters deep	10
Mid-Atlantic Ridge	-5,000	– 2,500	2,500 meters high	8
Lōʻihi Seamount	-4,000	-1,000	3,000 meters high	7
McDonald Seamount	-4,000	0	4,000 meters high	4
Continental Shelf	0	-500	500 meters deep	11
Continental Slope	-500	-4,000	3,500 meters difference	6
Abyssal Plain	-3,900	-4,100	200 meters difference	12

From your graph and your data table, answer the following questions:

1. If you were standing at sea level, which mountain appears to be taller? *Mount Everest.*

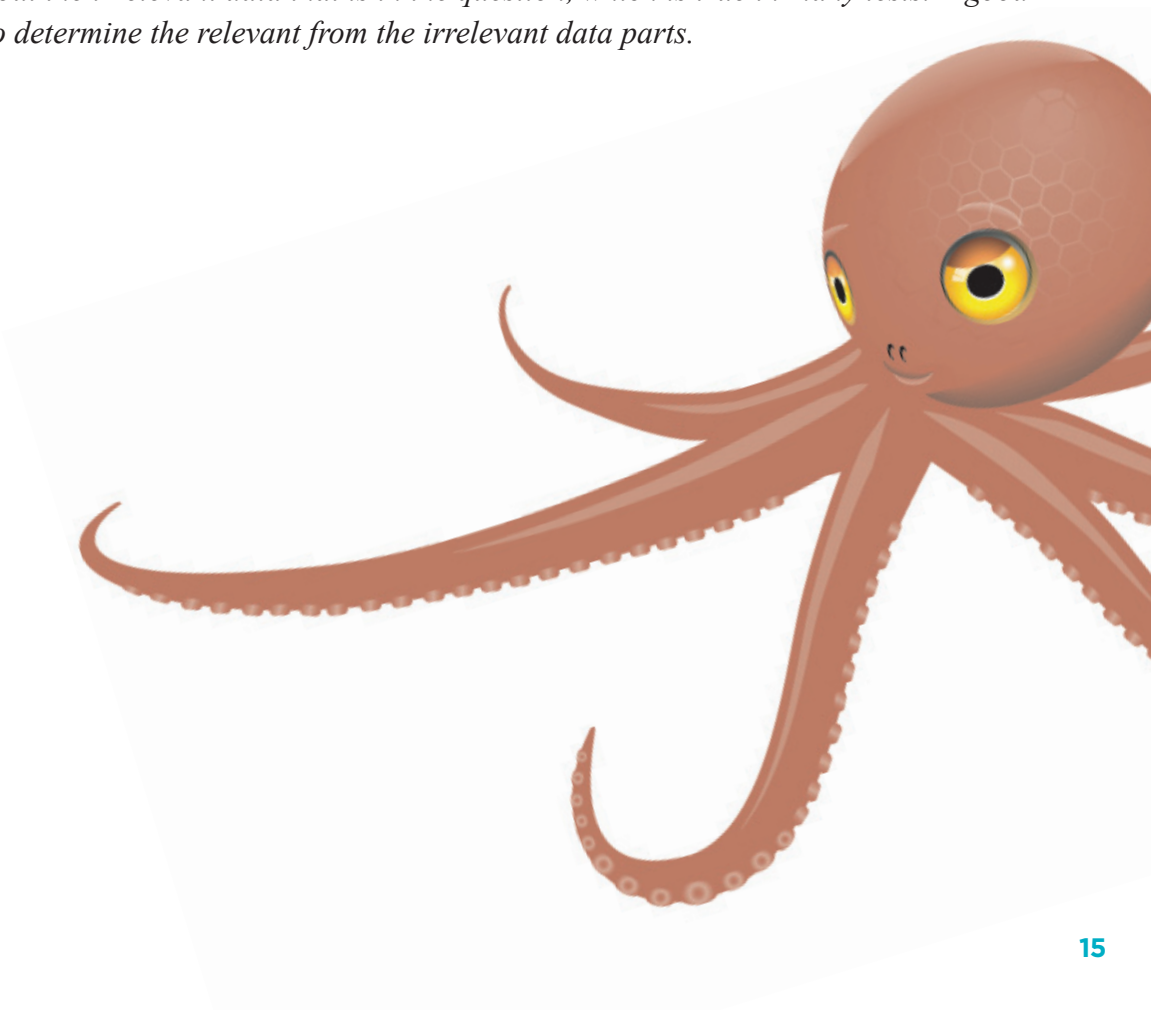
2. Why is Mount Everest almost 18 squares high?
   Mount Everest is 8,800 meters above sea level, each square equals 500 meters; therefore, 8,800 divided by 500 equals 17.6 squares (just under 18 squares).

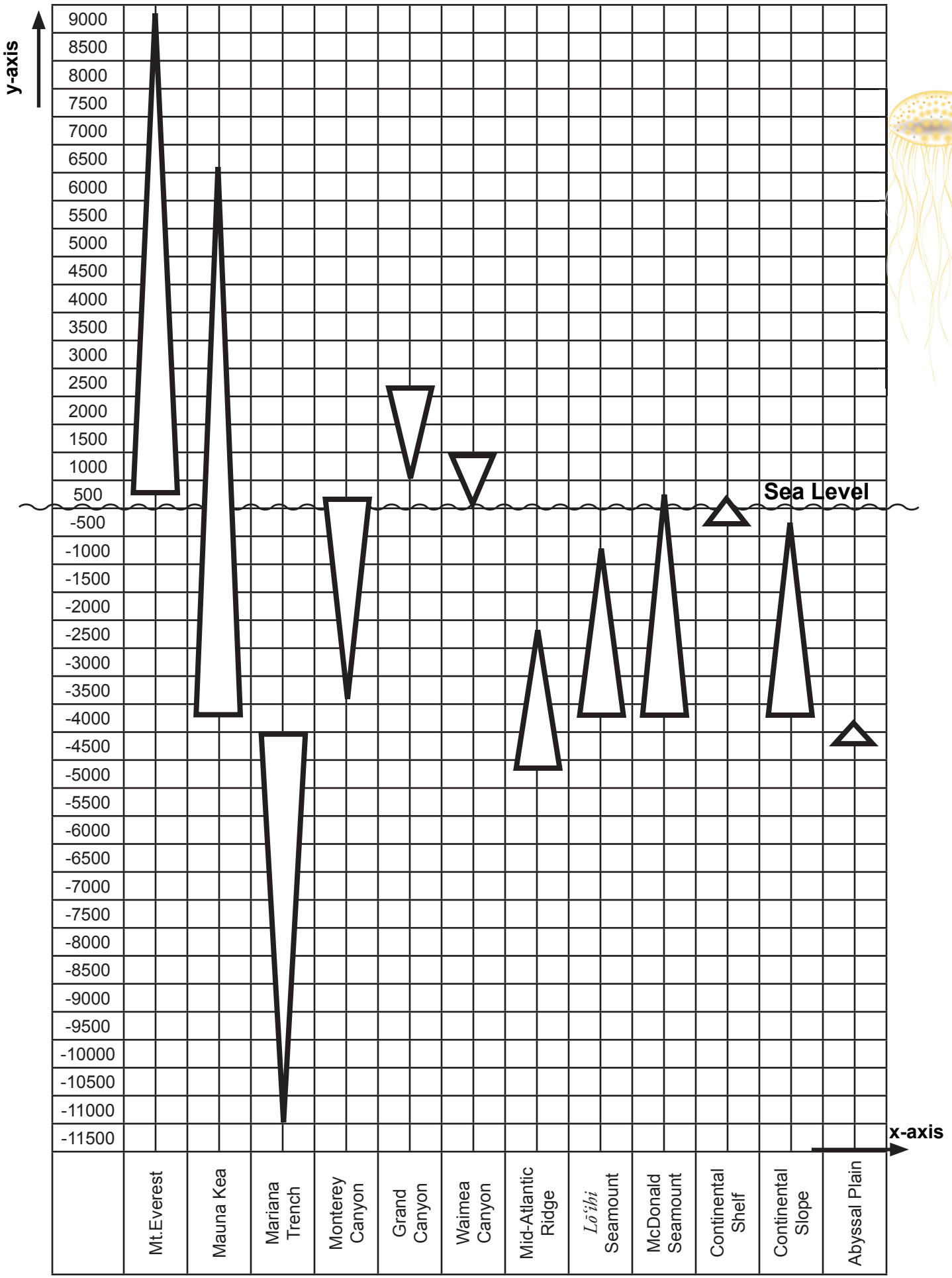
3. Looking at the bar graph, what do you conclude is the depth of the normal ocean floor around most of these features? *4,000 meters*. From your table, what is at this level? *Abyssal Plain.*

4. If the Mariana Trench is 11,000 m deep and Everest is only 8,800 m high, why isn't the trench greater from top to bottom than Mount Everest?
   The Mariana Trench starts 4,000 meters below sea level. Alternative answer: The first 4,000 meters from sea level down do not count.

5. From the graph, one could conclude that *Mount Everest* is the highest point on Earth; however, from top to bottom, *Mauna Kea* is the largest mountain.

6. From the graph, are we able to calculate the volume of each feature (area of a triangle equals one-half Height times Width)? This is just a yes/no question. Explain your answer.
   No. The triangles are only to represent symbols of mountains or canyons. To calculate the real volume, one would have to know the area of the base of a mountain times one-half its height. For a canyon or trench, one would need to know the average width times the length times one-half the depth. This is a great place to talk about reading too much into data and how people often jump to the wrong conclusions from data. Also, point out the irrelevant data that is in the question, which is true in many tests. A good student must be able to determine the relevant from the irrelevant data parts.




y-axis
9000
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000
-4500
-5000
-5500
-6000
-6500
-7000
-7500
-8000
-8500
-9000
-9500
-10000
-10500
-11000
-11500
Sea Level
x-axis
Mt.Everest
Mauna Kea
Mariana Trench
Monterey Canyon
Grand Canyon
Waimea Canyon
Mid-Atlantic Ridge
Lō'ihi Seamount
McDonald Seamount
Continental Shelf
Continental Slope
Abyssal Plain