



Activity 3: Observing Lava Flows

Overview:

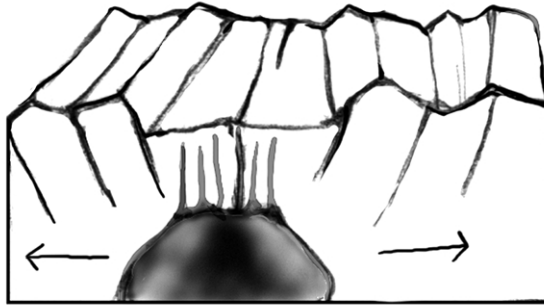
In this activity, student groups will look at photographs of lava flows taken by a towed camera on a transect across the East Pacific Rise in the same area that they have been mapping. They will identify lava forms and locate the Axial Summit Caldera Trough (ASCT) using a map of the transect and visual cues in the photos.

Background:

The flow of lava along the mid-ocean ridge creates the topography of the region. Geologists believe that shape and events at the ridge are affected by the heat and amounts of magma near to the ocean floor.

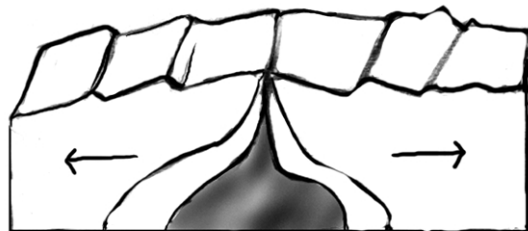
In slow-spreading

areas (10-50 mm/year), like the Mid-Atlantic Ridge, magma is being supplied at a slow rate. The oceanic plates cool and the crest of the ridge subsides, creating a rift valley running along the summit. The valley can be more than 10 kilometers (6 miles) wide and 3 kilometers (2 miles) deep. The topography is rough and the rift valley is dotted with small, cone shaped volcanoes called seamounts. Lava flow is primarily from the seamounts which rise between 50 and 600 meters (150-1800 ft) tall, although most are around 60 meters (180 ft.) high.



Mid-Ocean Ridges with **medium-spreading** rates (50-100 mm/year), like the Juan de Fuca ridge, have some features of both fast and slow spreading ridges. The rift valley is only 50-200 meters (150-600 feet) deep and the rift is only 5 km wide.

At **fast-spreading** ridges (100-200 mm/year), like the East Pacific Rise, the rift running along the ridge axis is narrow or even absent in some areas. Instead of flowing from multiple small volcanoes, most of the lava flows from long cracks in the crust, called fissures. There are also off-axis seamounts, usually forming linear chains away from the spreading center. Those closer to the spreading



(continued on next page)

Essential Concepts:

- The shape of solidified lava flows is affected by the makeup and rate of flow of the lava, as well as by the slope that it is flowing over.
- When studying remote, distant places, photographs provide very useful data.

Learning Objectives:

Students will be able to:

- discuss the difference between fast and slow spreading zones.
- identify three types of lava flow and some factors under which they form.
- discuss the use of photographs as way of collecting data.

National Standards:

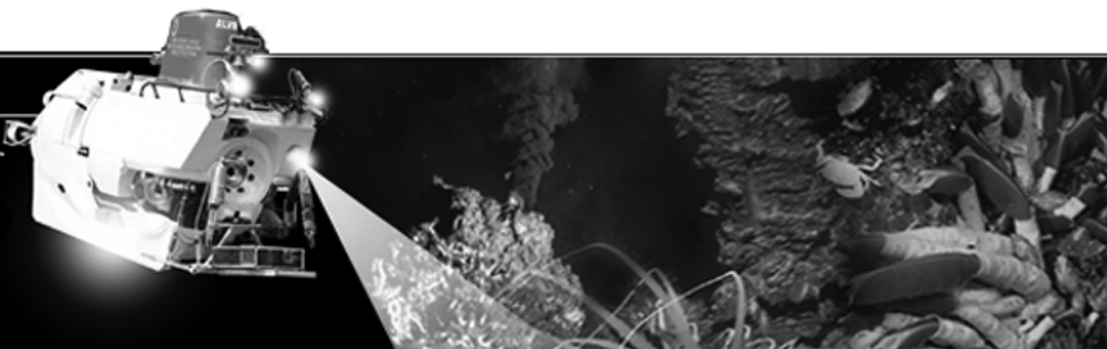
Unifying concepts and processes:

- Evidence, models and explanation.
- Science as inquiry:
 - Understandings about scientific inquiry.
- Earth Science:
 - Structure of the earth system.

Time Frame: 1 period

Materials:

- A set of paper print outs of the series of ocean bottom photos and key from camera tow AT7-10 for each group.
- “Spreading Ridges”
 - an over head copy
 - a copy for each student.
- “A Key to Lava Forms”
 - an over head copy
 - a copy for each student.
- “Observing Lava Forms,”
 - 3 copies for each student.
- “AT7-4 Camera Tow #10 Transect” a copy for each student.



Activity 3 (cont.)

Materials (cont.):

Preparation:

- Make copies of lava flows from the PDF file (1 per 2 students)
Or
- Set up computer to project Power Point presentation of “Lava Transect”

Resources:

Dive and Discover

Go to: Expedition 2: Deeper Discovery: Slide Show: Towed Camera images 1-8. These annotated slide sets offer an excellent way to introduce the concepts in this activity as well as prepare students to recognize various features they will see in the pictures. The lava ID images provided in this activity are from these slide shows.

Go to: Expedition 5-7: Daily Update: Hot topics: Lava Flows for more information on lava and how it flows.

<http://www.divediscover.whoi.edu/>

Hawaii Mapping Research Group EPR Index

This site contains the full set of photos and cruise reports for the expedition from which this lesson was built. The selected photos used in this activity were taken from this site. If students are interested in learning

(Continued on next page)

center are more active but they can erupt up to 80 kilometers (50 miles) away. Most off-axis seamounts are 60 to 300 meters high but they can range from 50-2500 meters (150-7,500 feet) high. Some scientists believe that mini-hotspots feed these volcanoes, but the volume of lava that erupts from them is small compared to hot spot volcanoes like Hawaii. Some scientists believe that broad mantle upwellings below the ridge provide magma to the off axis seamounts.

To study lava flows and ridge formation, scientists document the seafloor surface with photographs. The shape of the solidified lava deposits is one piece of the puzzle scientists are assembling to understand the history of the lava flow. Scientists also measure magnetic fields and use seismic waves to investigate what is going on below the seafloor surface at the ridges. This activity focuses on the shape of lava flows. Lava shapes are affected by:

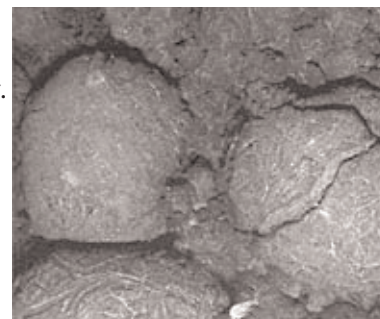
- Slope
- “Roughness” of the terrain
- Lava effusion rate (how fast is the lava coming out?)
- Viscosity of lava (Viscosity refers to the stickiness of the lava. It is affected by the make-up or composition of the lava.)

There are three major underwater lava forms: pillow lava, lobate lava, and sheet lava. The conditions under which they are likely to occur can be predicted.

Lava Morphology	Slope Angle	Viscosity	Effusion Rate
Pillows	Low	High	Low
Lobates	High	Low	High
Sheets	High	Low	High

Graph from Volcanic Morphology of the East Pacific Rise Crest (See Resources)

Pillow lavas form when slope angles are low, viscosity is high and effusion rate is low. They are rounded lumps formed when the outer surface of a lava flow cools, solidifies quickly and forms a glassy skin over the molten rock inside. The hot lava on the inside stretches the solidified skin and expands it. New pillow lavas form when the lava breaks the skin. They can form piles a few meters high or tens of meters high and



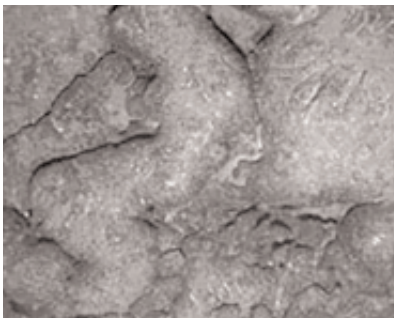
Pillow lava image from Dive and Discover (see Resources)



Activity 3 (cont.)

many hundreds of meters to kilometers long. They are very common on the Mid-Atlantic Ridge and the Juan de Fuca Ridge, which are spreading at slow to intermediate rates (about 2-5 centimeters/year), however, some examples of pillow flow can also be found at the East Pacific Rise. Pillow lavas can also form in ponds or rivers on land.

Lobate flows form when slope angles are moderate. Viscosity is high and effusion rates are moderate. They are common at fast-spreading mid-ocean ridges like the East Pacific Rise. They look like inflated pahoehoe flows that occur on land.



Lobate lava flow image from Dive and Discover (see Resources)

Sheet flows form on high slope angles, from lavas with low viscosity and high effusion rates. Rivers of sheet lava form that flow across the seafloor. They can fill depressions and create lava ponds. Sheet flow can be smooth or ropy. Rough fragmented sheet flow surfaces are referred to as “hackly.” Hackly surfaces may occur when the surface of a sheet flow solidifies while lava continues to flow below, shattering the brittle surface above. While not as common as lobate flow, sheet flows can be found at the East Pacific Rise.



Sheet lava flow image from Dive and Discover (see Resources)

The photos that the students will be classifying in this activity were taken from an expedition to the EPR in November 2001. The purpose of the mission was to collect data that would further our understanding of the history and nature of lava flows in the area. Questions scientists are trying to answer about deep-sea lava flows include:

- When lava erupts, how far does it travel from the fissure or crack where it started?
- Does the lava always erupt in the same place at the ridge axis?
- How do seafloor lava flows build up over time to form the ocean crust?

Students need to keep in mind that a new lava eruption will flow over the top of an older lava flow.

more about the phenomena that the scientists were investigating, they can read their reports and findings.

- The complete set of photos can be found in the side bar under: “Still photos”: towed camera: AT7-4: photos: tow 10
- The cruise report can be found in the sidebar under: Cruise Report: AT7-4: text.
- The scientists’ notes on tow 10 can be found in: Cruise Report: AT7-4: Appendix 2

<http://imina.soest.hawaii.edu/hmrg/EPR/index.htm>

University of North Dakota Volcano World.

Spreading Plate Boundaries: Fast Spreading, Slow Spreading and Medium Spreading.

<http://volcano.und.nodak.edu/vwdocs/Submarine/plates/diverg/>

NeMO New Millennium Observatory

On Spreading Zones:

<http://www.pmel.noaa.gov/vents/nemo/explorer/concepts/spreading.html>

On Lava Morphology

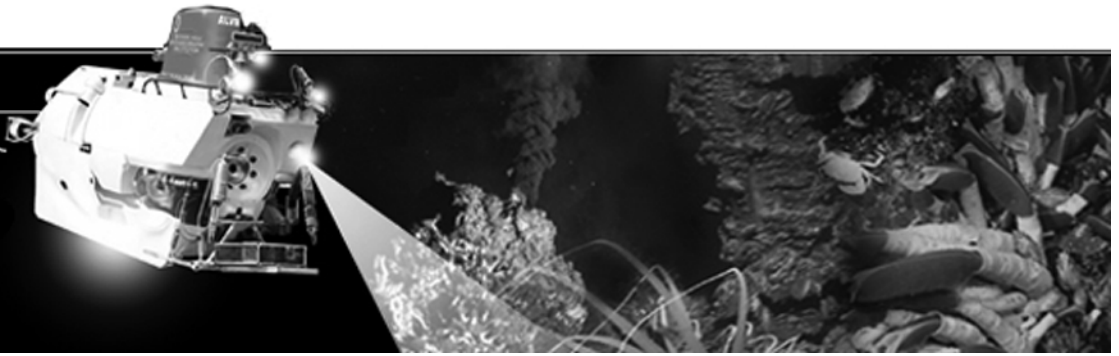
<http://www.pmel.noaa.gov/vents/nemo/explorer/concepts/lavamorph.html>

Scientific Paper on Volcanic Morphology:

Kurras, Gregory J., Daniel J. Fornari, et al. “Volcanic Morphology of the East Pacific Rise Crest 9°49' - 52',” *Marine Geophysical Researches* 21 23-41, 2000.

SEAS

Student Experiments At Sea



Activity 3 (cont.)

Development of Lesson

1. Tell the students that they are going to make observations from photos of lava flows from an area on the EPR. Lava flows create the ridges and ocean floor. Ridges can be slow-spreading, fast-spreading or medium-spreading. The spreading rate affects the shape of the ridge.
2. Distribute the “Spreading Ridges” handout. Point out the features associated with each type of spreading zone. Have students look at the maps and models that they have created of the East Pacific Rise and predict what sort of spreading zone it is. (It is one of the fastest spreading zones in the world).
3. Distribute the handout “A Key to Lava Forms” and introduce the three types of lava flow. Discuss the variations within each type of flow.
4. If you have internet access we highly recommend orienting students to this activity by viewing the slide show of camera tows found on Dive and Discover: [<http://www.divediscover.whoi.edu/>] Go to: Expedition 2: Deeper Discovery: Slide Shows: Towed Camera Images 8. Time permitting, you may want to also show one or more of the other seven “Towed Camera Images” Slide Shows.

[NeMO is also a good site for information on lava morphology, however it classifies the lava slightly differently than the expedition from which this lesson was taken and some of its explanations are a bit complex. Depending on the needs of the class, NeMO could be a good extension or good teacher reference.]

5. Explain to the students that the photos they will be observing are just one set of data collected by scientists as they try to answer the following questions:

- When lava erupts, how far does it travel from the fissure or crack where it started?
- Does the lava always erupt in the same place at the ridge axis?
- How do seafloor lava flows build up over time to form the ocean crust?

6. Have the students get into groups. Distribute copies of “Observing Lava Forms,” the “AT7-4 Camera Tow #10 Transect” and the photo sets of “Images from Camera Tow # 10.” Explain to the students that the series of images was taken by a camera system (digital and 35 mm) towed from a ship along a transect at 5-7 meters above the seafloor (altitude). Each picture taken along the transect was time stamped.

7. Have students locate the position of each image on the transect marked on “AT7-4 Camera Tow #10 Transect.” They will do this using the time stamp on each image. Example: 16_39_40 stands for 16:39 or 4:39 and 40 seconds in the afternoon. There are time stamps marked at various intervals along the transect. Students will need to approximate the location of each image on the transect. Point out that the transect starts to the east of the ridge axis, continues in a west-northwesterly direction and eventually crosses the Axial Summit Caldera Trough (ASCT).



Camera System that took the pictures we are examining.
(From *Hawaii Mapping Research Group EPR Index*)





Activity 3 (cont.)

8. On the “Observing Lava Flows” handout, have students:

- note the time stamp on the photo for reference.
- identify the main type of lava shown in each image image (some will have more than one).
- identify which images cross the Axial Summit Collapse Trough (ASCT).
- describe what they observe in the photo.

Some of the key features shown in this selection of images include sediment cover (sediment cover is an indication that the flow is older), flow margins (the boundary between one flow type and another, indicating two different flows), collapse features (sections where the flow collapsed after it hardened, usually indicated by a drop), “skylights” (scientists’ nickname for collapse features that are circular and resemble skylights), and various textures to the lava surfaces.

Note: several images have more than one type of lava although the scientists have classified each image with a predominant lava type. The PowerPoint presentation of these camera tow images with scientists’ notes is provided as a key, as is the “Lava Flow Key” printout in which the photos are listed by time stamp.

Discussion Questions

1. What types of lava flow were most prevalent? Which were most rare? What does that tell you about this area? (lobate most prevalent, pillow rare, that we are in an area with increasing elevation, and perhaps rough terrain, and perhaps that the lava is coming out (“effusion rate”) faster closer to the ASCT)
2. Why are pillow lavas so rare along this transect? (pillow lavas are found in areas with gradual or no slope, further away from the ridge)
3. Which photos showed the ASCT? What did it look like? (17:28, 17:32, 17:33; like a cliff or ledge)
4. Why is it important to know where each of these photos was taken? (to help us understand what the flows look like at various distances from the ridge and to help us confirm what we are seeing close up)
5. What can these photos tell you about this section of the EPR? (that the slope was greater than would allow for a pillow lava).
6. What questions do you have about the lava flows and the EPR? How might you use these photos to help answer the questions scientists are trying to answer?

Extensions:

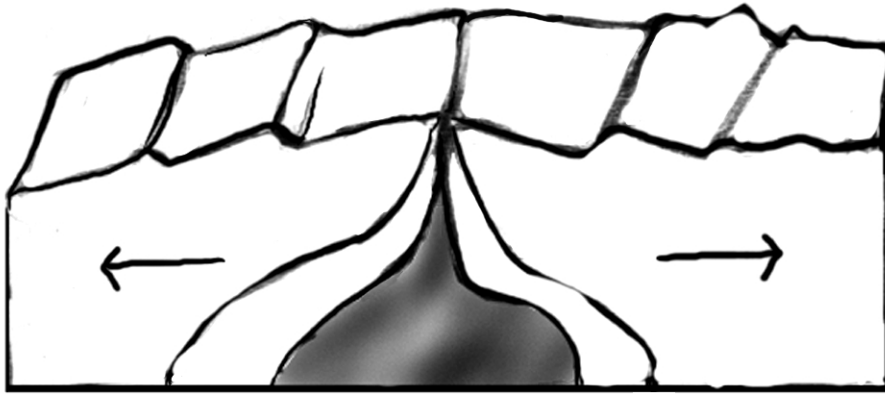
1. Scientists making these photos were also charting small variations in the magnetic and gravitational fields and doing microbathymetry in the same area.

Molten rock that cools rapidly, as lava hitting the near freezing ocean water does, quickly solidifies. It is made up of tiny crystals because the crystals have no time to grow. This deep sea lava has a lot of iron in it and when it crystallizes, it becomes magnetic. The magnetic crystals all point in the direction of Earth’s magnetic field at the time the lava solidifies. The more magnetic crystals in the solid rock, the stronger the magnetic signal. The magnetic field fades over time, so newly formed lava has a stronger magnetic charge than older lava. In contrast, solidified lava that lines the dikes that deliver magma to the surface, cools very slowly. Crystals in that rock have a long time to grow, consequently that rock does not have a strong magnetic field. Knowing what you do about the East Pacific Rise, what do you predict that the scientist found when they tested the strength of the magnetic charge across the area?

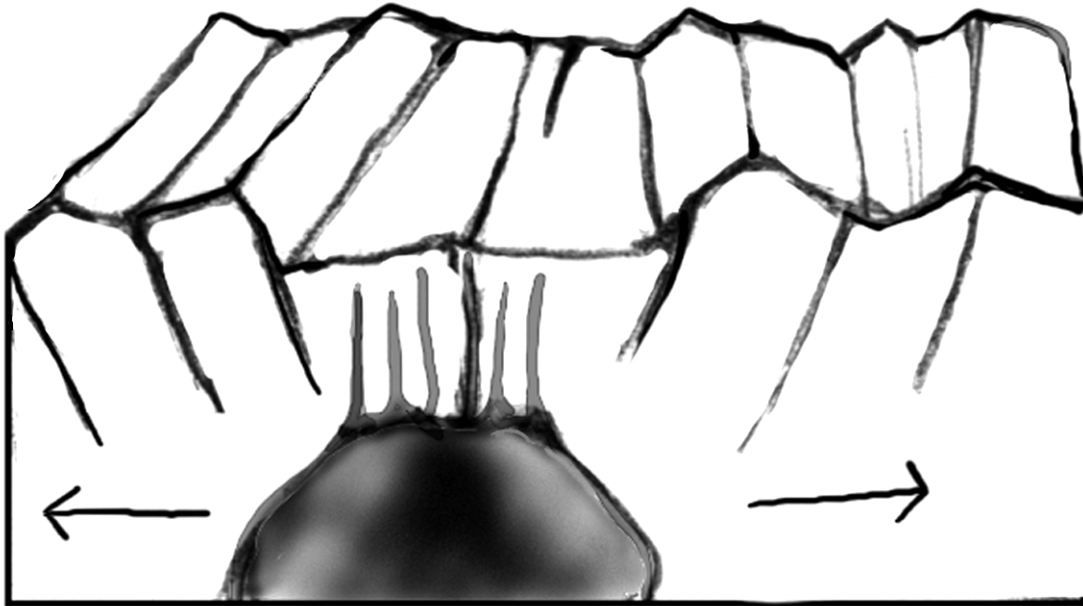
For more information on how small variations in magnetic fields and gravity help geophysicists learn about the crust below the ocean floor go to Dive and Discover [<http://www.divediscover.who.edu/>] and click on Any Expedition[from 2 on]: Daily Update: Hot Topics. Then choose “Seafloor Gravity” or “Seafloor Magnetics.”

Fast-Spreading and Slow-Spreading Ridges

Describe the differences between fast spreading ridges and slow-spreading ridges.



Fast-Spreading Ridge



Slow-Spreading Ridge

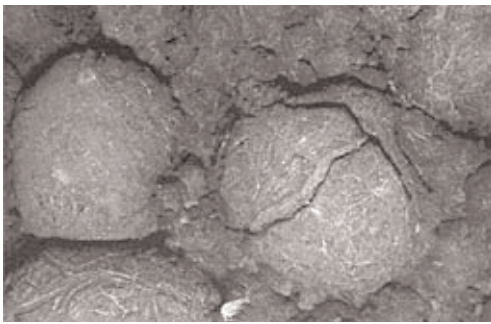
A Key to Lava Flows

Lava flow shapes are affected by:

- Slope
- “Roughness” of the terrain
- Lava effusion rate (how fast the lava is coming out)
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Lava Morphology	Slope Angle	Viscosity	Effusion Rate
Pillows	↓ Low	↑ High	↓ Low
Lobates	↓ High	↑ Low	↓ High
Sheets			

There are three major underwater lava forms: pillow lava, lobate lava, and sheet lava. The conditions under which they are likely to occur can be predicted.

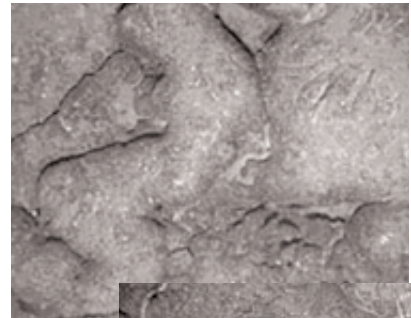


Pillow lava

Pillow lavas form when slope angles are low, viscosity is high and effusion rate (how fast the lava is pouring out) is low. They are rounded lumps formed when the outer surface of a lava flow cools, solidifies quickly and forms a glassy skin over the molten rock inside. The hot lava on the inside stretches the solidified skin and expands it. New pillow lavas form when the lava breaks the skin. They can form piles a few meters high or tens of meters high and many hundreds of meters to kilometers long. They are very common on the Mid-Atlantic Ridge and the Juan de Fuca

Ridge, which are spreading at slow to intermediate rates (about 2-5 centimeters/year), however, some examples of pillow flow can also be found at the East Pacific Rise. Pillow lavas can also form in ponds or rivers on land.

Lobate flows form when slope angles are moderate. Viscosity is high and effusion rates are moderate. They are common at fast-spreading mid-ocean ridges like the East Pacific Rise. They look like inflated pahoehoe flows that occur on land. They are often hollow and can collapse leaving gaping holes.

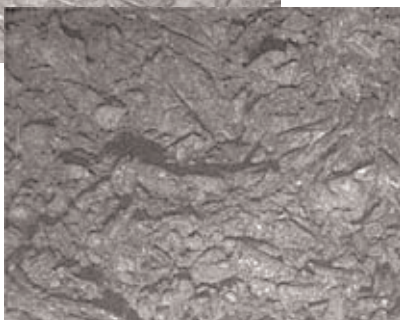


Lobate lava flow

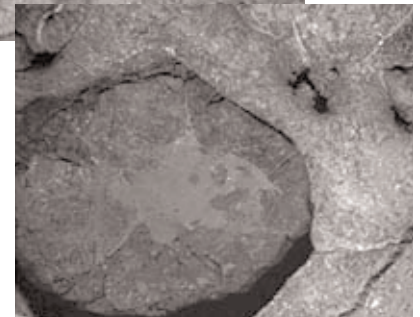


Sheet lava flow

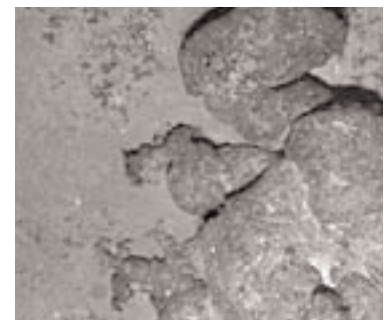
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Hackly sheet lava flow



Collapsed lobate Lava flow



Sedimentation on lobate flow

Sedimentation is found on older lava flows.

Images from Dive and Discover (see Resources)

Key to the Lava Flows in Camera Tow 10

15:38

- LOBATE
- Knobby lobes with small elongated lobes, cracked flat broad lobes
- Low sediment cover

15:39

- LOBATE
- Knobby ball lobes

15:55

- LOBATE
- Transition to hackly sheet flow.

16:05

- SHEET (HACKLY)
- Hackly (right) with curtain folded sheet flows (left)

16:12

- SHEET (HACKLY)
- Hackly (left) with curtain folded sheet flows (right)
- Collapse feature (bottom of collapse feature is curtain folded sheet)
- Low to Medium sediment cover

16:30:10

- SHEET (LINEATED SHEET)
- Straight folds sheet flow
- Medium sediment cover

16:30:55

- SHEET (LINEATED SHEET)
- Broad wavelength folds in curtain sheet flow

16:39

- SHEET (CURTAIN SHEET)
- Flow margin between curtain fold and smooth ropey sheet flow
- Medium sediment cover

16:47

- SHEET (HACKLY)
- Hackly curtain flow

17.22

- LOBATE
- ALVIN Weights! (lower left) on lobate crust
- Low sediment cover
- Bright white material in cracks (biology?)

17:23

- LOBATE
- “Alligator Collapse Pit”
- Crenulated, sedimented lobes in deep collapse feature

17:28

- LOBATE
- ASCT!! (deep bottom ~3 m)
- Collapse feature in glassy lobate (middle right)

17.32

- LOBATE
- Wall of ASCT
- Glassy lobate crust

17.33

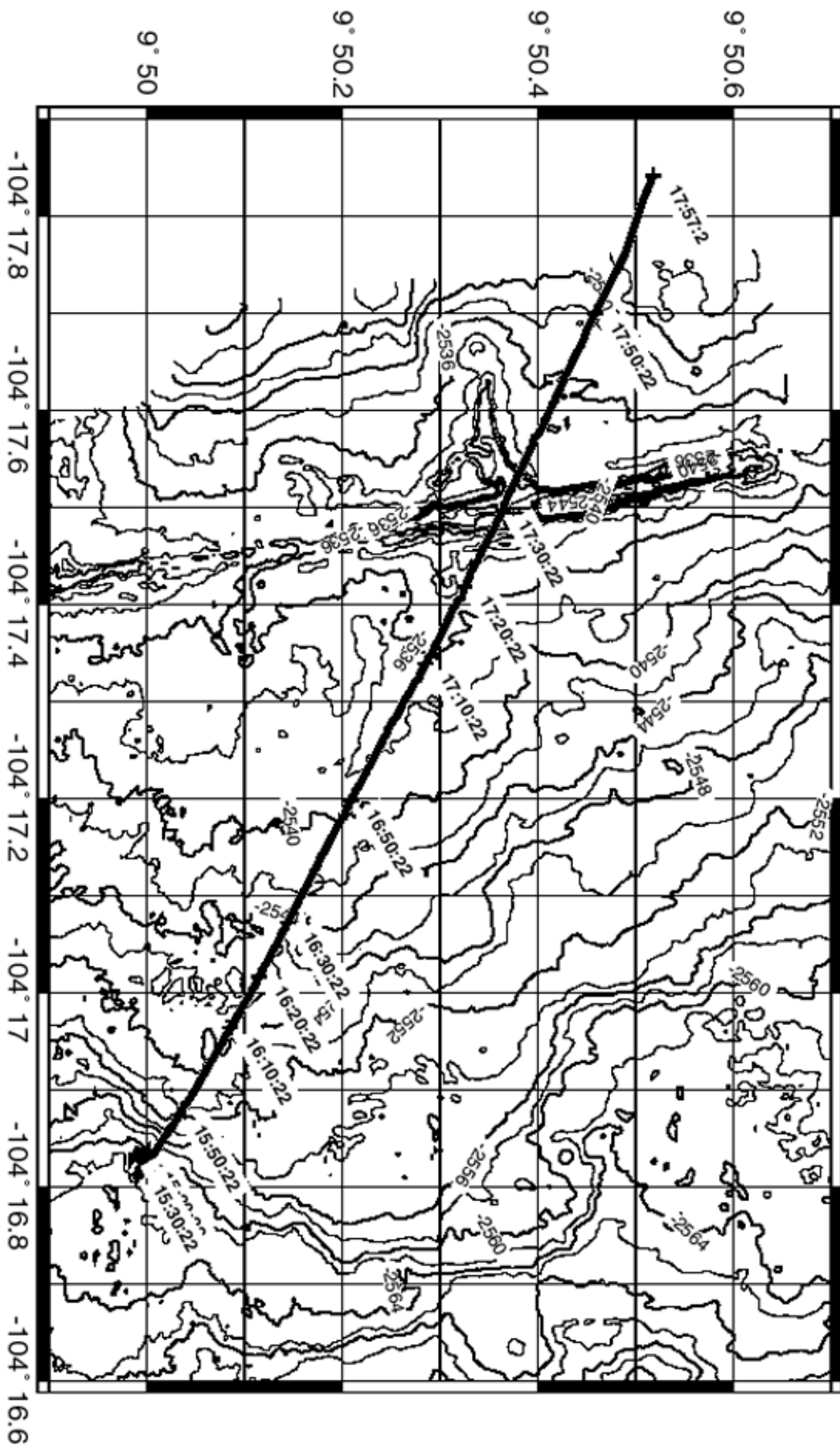
- LOBATES
- Scaly texture in lobate rim of ASCT
- High sediment cover over scaly sheet flow

17.34

- SHEET
- Scaly texture sheet flow (left), high sediment cover
- Curtain folded sheet flow (right)

17:36.55 and 17.36.40

- SHEET (HACKLY)
- Collapse feature
- “Skylights”
- Multi-level
- Bridge in collapse feature



CAMERA TOW#10 EPR 9°50 N