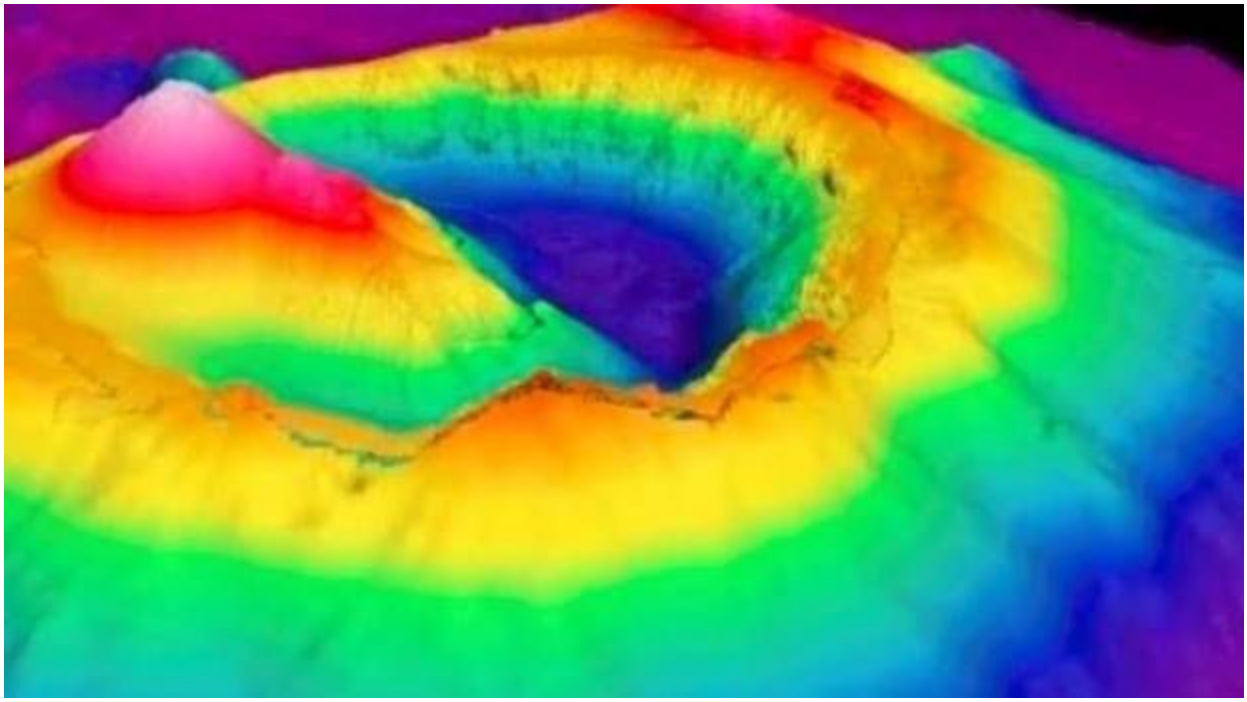
IODP Augmented Reality Sandbox: Brother's Volcano, Expedition #: 376

Teacher guide

Credits: Dieuwertje Kast and Tammy Orilio



Background:

"From May - July 2018, scientists aboard *JOIDES Resolution* Expedition 376 collected core and borehole data from various sites in Brothers volcano. Brothers volcano, located approximately 300 miles northeast of New Zealand and more than 4,000 feet under the ocean surface, formed at a subduction zone where the Pacific Plate and Australian Plate are colliding together, and is part of the larger Kermadec volcanic arc system. Brothers volcano (and the rest of the arc volcanoes) is unique in that it is hydrothermally active, releasing heat, metals, and other dissolved chemicals into the surrounding seawater.

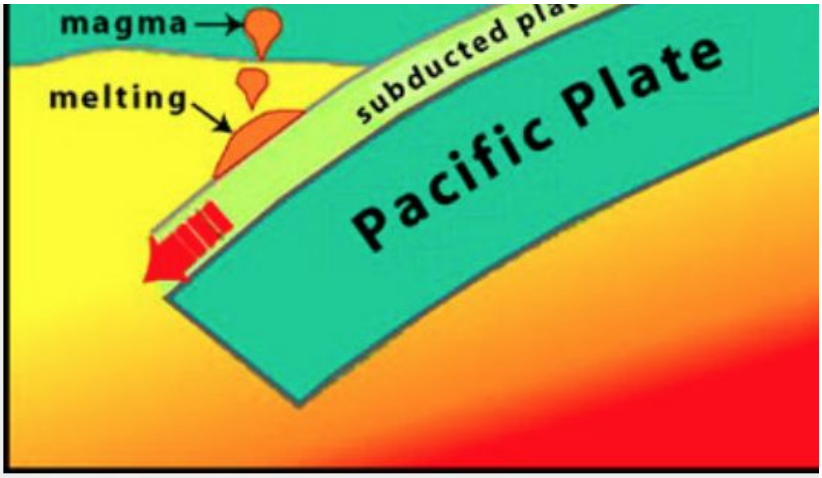
The aim of Expedition 376 was to clarify the key processes that distinguish hydrothermal systems of submarine arc volcanoes from those of mid-ocean ridge (spreading center) volcanoes. Fluid and rock samples will be used to determine the composition of hydrothermal fluids, the chemical reactions that take place on the way to the seafloor, how various metals are transported and deposited within the seafloor, and to assess the consequences of toxic and

acidic environments for the microorganisms that live in and around the hydrothermal systems. This expedition was the first time the JOIDES Resolution (or any research vessel) drilled into an active underwater volcano!"

<Link into this: https://joidesresolution.org/expedition/376/>

Key words-

- Convergent boundaries - type of tectonic plate boundary where the plates are moving towards each other.
- Subduction- occurs at a convergent plate boundary where continental crust and oceanic crust are colliding, and the denser oceanic crust slides underneath the continental crust. Here at the location of Expedition 376, the Pacific Plate (oceanic crust) is colliding into the Australian Plate (continental crust).



(Fig. 1) The Kermadec-Tonga Arc is the r

Plate subducting beneath the Australian

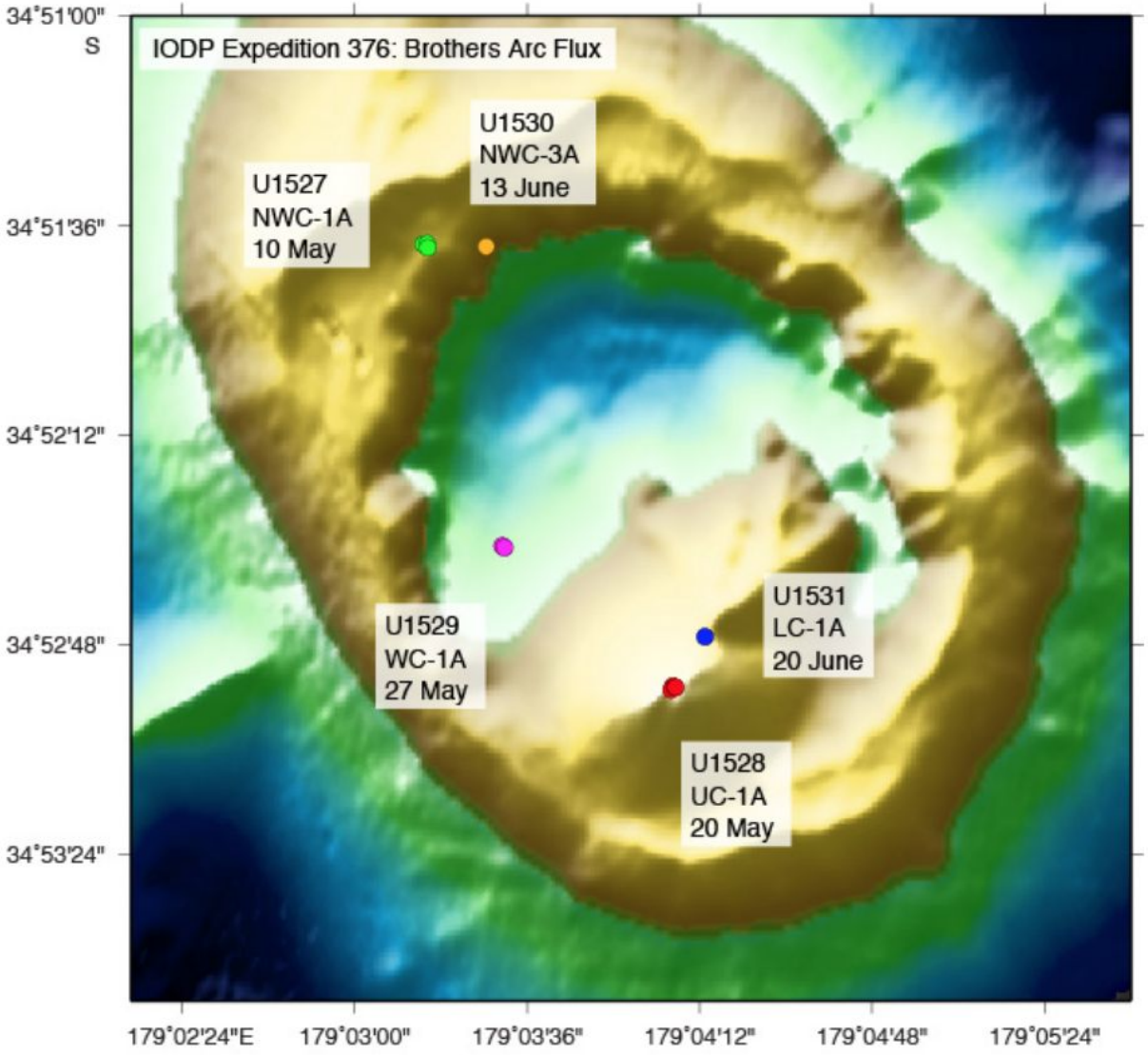
- Underwater volcano - underwater vents or fissures in the Earth's surface from which magma can erupt.
- Caldera- volcanic crater
- Hydrothermal vent systems- underwater geysers that form when seawater interacts with magma in the mantle. Seawater seeps into cracks/fissures in the seafloor, and is heated up by the underlying magma. Minerals from the crust are dissolved in the super-heated water, and that fluid is eventually discharged at a vent.
- Chimneys- form when the hot fluids (seawater + minerals leached from rocks in the crust) are released at a discharge point. The particulates that were dissolved in the hydrothermal fluid mix with the cold surrounding seawater and precipitate out of solution, building up structures called chimneys.

Where did IODPôs JOIDES Resolution sample.

5 sites:

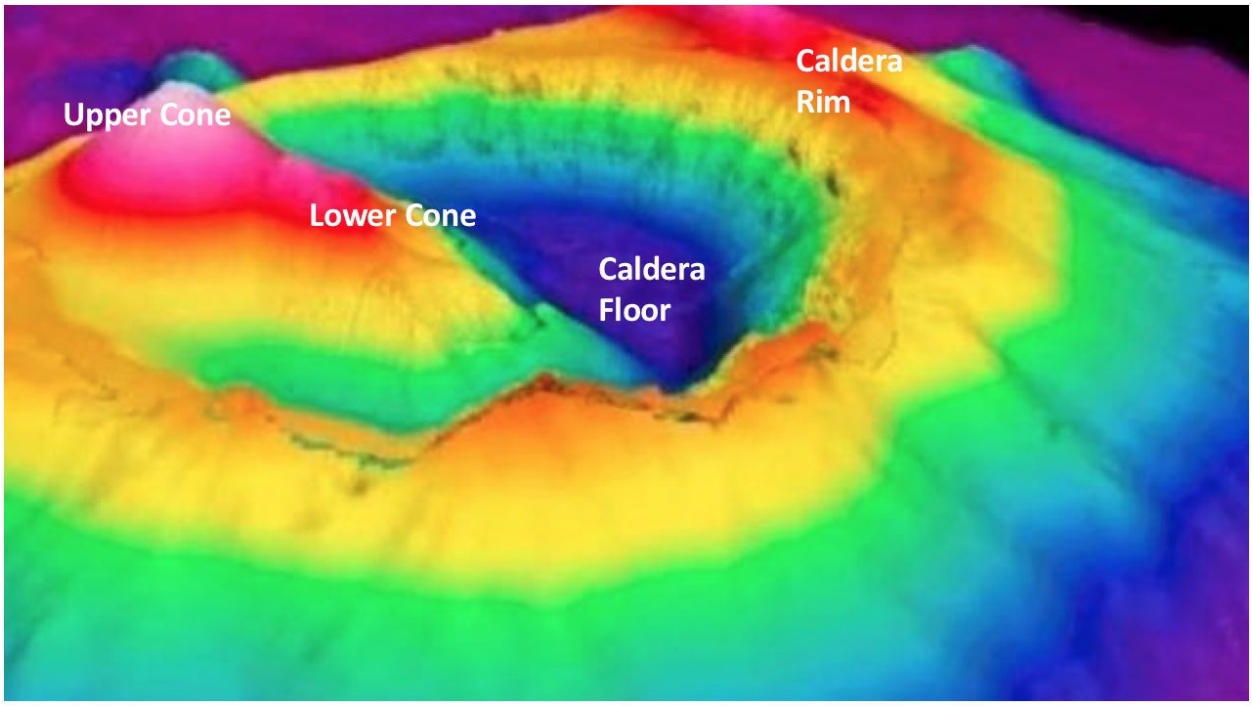
- Site 1527: Northwest Caldera (NWC) → rim of caldera wall; 1464 m depth
- Site 1528: Upper Cone (UC) → inside a pit crater at the summit of the upper conel 1228 m depth
- Site 1529: West Caldera (WC) → west side of the caldera floor; 1735 m depth
- Site 1530: Northwest Caldera (NWC) → narrow “bench” on the northwestern caldera; 1595 m depth
- Site 1531: Lower Cone (LC) → on a “saddle” between the upper & lower cones; 1355 m depth

*Lots of black smoker chimneys located at NW Caldera; more diffuse venting of hydrothermal fluids at Upper Cone

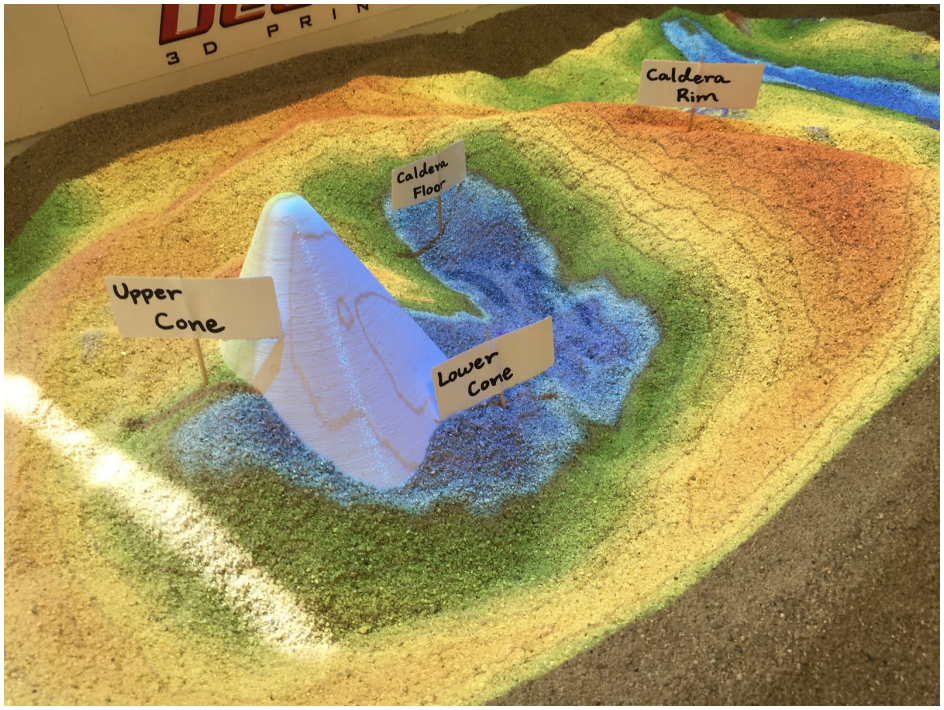


Activity Summary

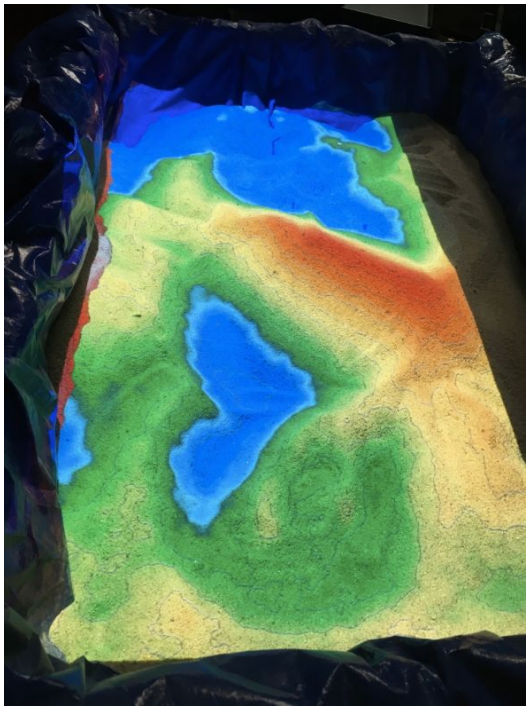
Students use an Augmented Reality sandbox to understand several earth science processes and specifically create representations of the authentic multibeam sonar projections from the expeditions of the JOIDES Resolutions as part of the International Oceanic Discovery Program (IODP).



Caption: Real multibeam sonar view of Brothers Volcano.



Caption: Inverted colorization but setup in the AR sandbox.



Next Generation Science Standards

NGSS Essential Standards and Clarifying Objectives:

4-ESS1-1. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. [Clarification Statement: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and, a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.] [Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.]

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features. [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* [Clarification Statement: Examples of solutions could include designing

an earthquake resistant building and improving monitoring of volcanic activity.] [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.]

Middle School Standards:

MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

Target Audience: **Upper Elementary and Middle School**

Time Required:

- **Ŏ Hours for setup for the Sandbox**
- **Ŏ 1 hour to teach this lesson when its been built**

Materials Needed

- Moveable cart or permanent tabletop surface
- Projector
- XBox 360 Kinect with power adaptor
- Linux computer with specific graphic cards for water simulations
- Sand containment area
- "Play" sand with three-dimensional objects
- Square tubing/ other structure for mounting the projector and XBox 360 Kinect above the sandbox
- Computer program to run on LInux OS: SARndbox (AR Sandbox), XBox SDK drivers

Activity Description

Lesson Objective(s): Students use an Augmented Reality sandbox to understand several earth science processes.
Differentiation Strategies to meet Diverse Learner needs: - Think-pair-share, for students that learn best when engaging with classmates. - Multisensory learning, to accommodate students that are auditory learners and visual learners, as well as encourage students to engage their senses in the learning process. - Awareness of social and cultural backgrounds of students, in order to reinforce the real-life application of what they are learning.

ENGAGEMENT:

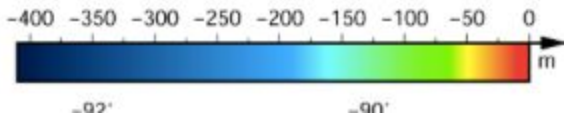
Background Information for Educators

What is Augmented Reality (AR)?

ñ**Augmented reality (AR)** is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data.With the help of advanced AR technology (e.g. adding computer vision and object recognition) the information about the surrounding real world of the user becomes interactive and digitally manipulable." **(Graham 2012).**

"**Deezmaker** built a hands-on activity combining a real sandbox, and virtual topography and water created using a closed loop of a Microsoft Kinect 3D camera, powerful simulation and visualization software, and a data projector. The augmented reality (AR) sandbox allows users to create topography models by shaping real sand, which is then augmented in real time by an elevation color map, and topographic contour lines. The AR Sandbox can be used to demonstrate bathymetry and other watershed capabilities. It allows students to model different land structures and demonstration how event like erosion and weathering changes a landscape." **(Deezmaker 2017).**

Bathymetry: Generating a heat map of elevation.



The order of elevation on a surface is defined by color:

- Blue (corresponds to the lowest elevation, such as deep-sea oceans in the AR Sandbox))
- Green
- Yellow
- Orange
- Red
- White (corresponds to the highest elevation, such as snow-capped mountains in the AR Sandbox)

Begin the lesson by introducing the vocabulary terms related to earth science that students will be observing using the AR Sandbox:

- **Erosion** refers to the removal of surface material from Earth's crust, primarily soil and rock debris, and the transportation of the eroded materials by natural agencies from the point of removal. (Illustration below is modeled with AR Sandbox)

- **Deposition** is the geological process in which sediments, soil and rocks are added to a landform or land mass. Wind, ice, and water, as well as sediment flowing via gravity, transport previously eroded sediment, which, at the loss of enough kinetic energy in the fluid, is deposited, building up layers of sediment.
- **Weathering** is the disintegration or alteration of rock in its natural or original position at or near the Earth's surface through physical, chemical, and biological processes induced or modified by wind, water, and climate. This process is illustrated in the AR Sandbox with straws and water flow program modeling.
- **Watersheds** are the land and water areas, which contribute to runoff to a common point. A watershed is an area of land and water bounded by a drainage divide within which the surface runoff collects and flows out of the watershed through a single outlet into a larger river or lake.

EXPLORATION:

Prior to beginning the AR Sandbox demonstration, make sure that all the necessary equipment is calibrated appropriately:

Calibration Procedure: Create a target that lines up on the sand and targets the Sandbox program that's running. Match up the crosshairs on the target 12 times across the whole sandbox.

Once the AR Sandbox is calibrated and ready-to-go, begin simulating different landforms at various elevations and ask students to identify these two properties:

1. What type of landform are the students viewing/ interacting with in the AR Sandbox?
2. At what elevation is this landform (based on the heat map generated by the AR Sandbox software)?

EXPLANATION:

Ask students these “Follow-up Questions” to gauge what they learned about various earth science processes, as well as the merits of using AR technology to simulate these processes:

- How were you able to tell if a landform or watershed was high or low in elevation in the sandbox?
- What types of erosion processes did you observe in the sandbox?
- What happened to the landmass or watershed after erosion occurred?
- How do you think the real-life processes compare to the simulations you observed in the sandbox?

Record the responses generated from the class, and have students record their own observations in science journals, if these are a part of the classroom.

ELABORATION:

To expand upon this activity, students can consider other ways that augmented reality technology can be used to help us understand our environment, or other scientific processes:

- What other simulations would you like to see using augmented reality? How do you think this simulation would work?
    - Insert IODP scans of the ocean that can also be simulated in the Sandbox
- Why do you think that it is helpful to use augmented reality to understand complicated and large-scale processes such as weathering and erosion?

EVALUATION:

Students may be evaluated based on the extent of their participation in the AR demonstration, a well as the quality and quantity of observations and notes taken in their science journals and/or their responses to the activity questions.

Additional Resources

- *Introducing the International Ocean Discovery Program*
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- *How Science Works*
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- *PNN Special Report Life on Board*
    - *https://www.youtube.com/watch?v=n0bcIoALDFg&list=PLroDmZEKRHPMCtFMzjx-Zg7plqnIqWMjI&index=4&t=341s*

Previous Draft

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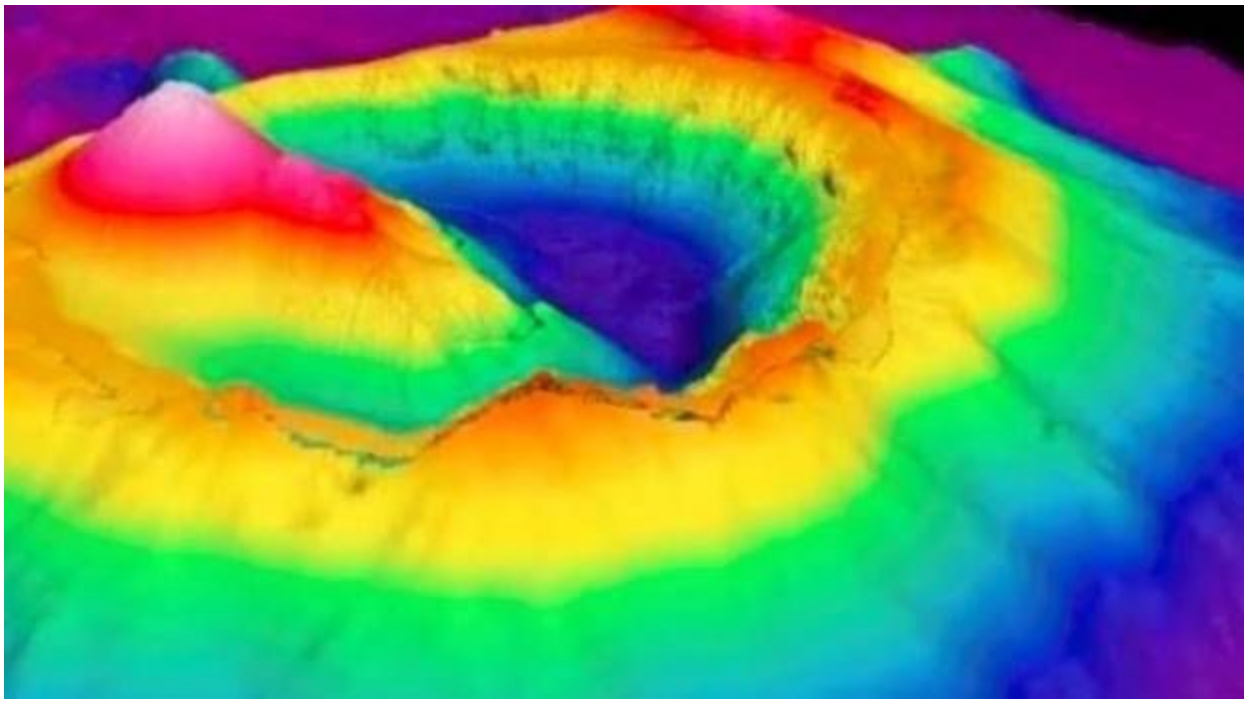

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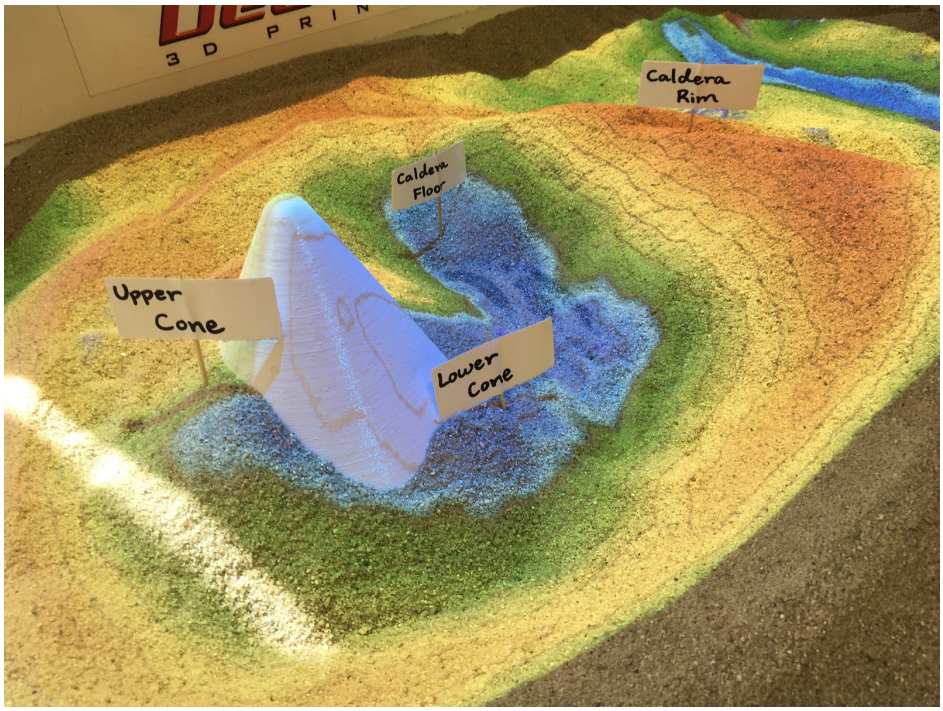

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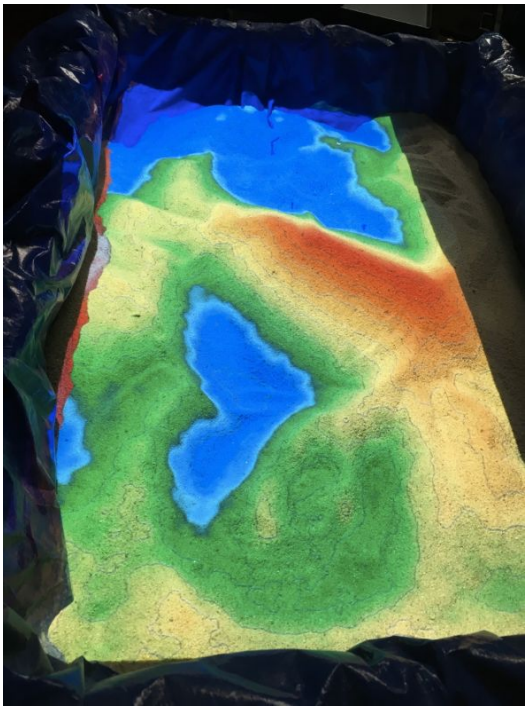
My AR Sandbox: 

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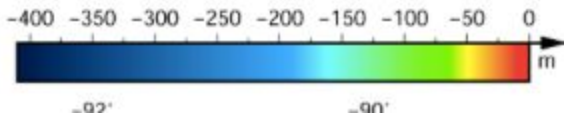

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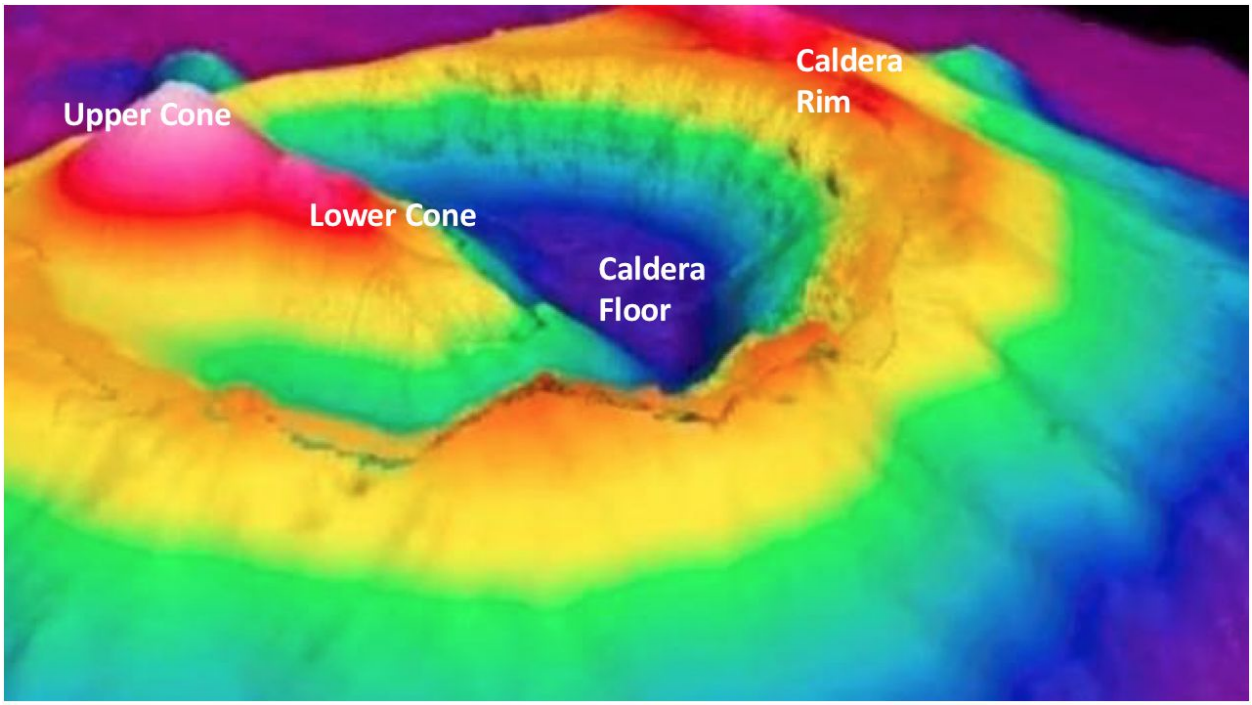
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Rim
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Floor