2017 American Samoa Expedition

Creatures of Change

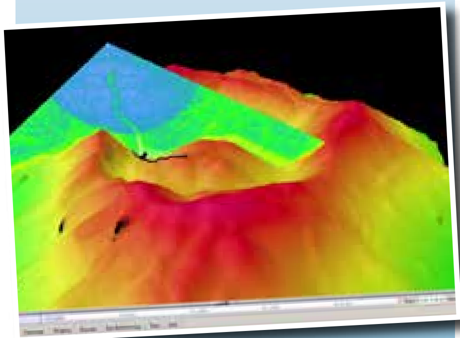


Image captions/credits on Page 2.

lesson plan

Focus
Vailulu'u seamount ecosystems

Grade Level
6-8 or 9-12 (Life Science/Earth Science)

Focus Question
How do physical and chemical processes on Vailulu'u seamount affect empirical observations of living organisms in Vailulu'u ecosystems?

Learning Objective
- Students will create physical models that illustrate changes in Vailulu'u seamount topography over time, and use these models and other evidence to make inferences about the relationship between physical and biological components of Vailulu'u seamount ecosystems.

Materials
- ❑ Copies of *Vailulu'u Seamount Bathymetry*, one copy for each model layer (see Learning Procedure, Step 1c)
- ❑ Pieces of cardboard, 8.5 in x 11 in, 1/16-inch thick; one piece for each model layer
- ❑ Glue, preferably spray type used for mounting photographs
- ❑ Sharp scissors or X-Acto knives for cutting cardboard
- ❑ (Optional) copies of Levin *et al.* (2016), and/or Bernardino *et al.*, (2012), and/or Hsing (2010), and/or Cordes (2006); see Learning Procedure, Step 5

Audio-Visual Materials
- ❑ (Optional) Equipment to show images or video from 2017 American Samoa expedition website *http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/welcome.html*

Teaching Time
Two or three 45-minute class periods

Seating Arrangement
Groups of two to four students

Maximum Number of Students
30

Key Words

Vailulu'u
American Samoa
Volcano
Seamount
Succession

Background Information

NOTE: Explanations and procedures in this lesson are written at a level appropriate to professional educators. In presenting and discussing this material with students, educators may need to adapt the language and instructional approach to styles that are best suited to specific student groups.

In March 2005, scientists participating in the Ocean Explorer Vailulu'u 2005 Expedition made an unexpected discovery. As they prepared to make their first submersible dive on the Vailulu'u underwater volcano, a multi-beam sonar image showed a submarine volcanic cone in the middle of the Vailulu'u caldera (the volcano's "crater") that had not been present when Vailulu'u was visited five years earlier. More surprises were in store for the scientists as they investigated the new cone (which they named Nafanua for the Samoan goddess of war), including features that they named "Eel City" and "Moat of Death."

Vailulu'u lies approximately 20 miles east of Ta'u Island in American Samoa. Like the Samoan Islands, Vailulu'u (and Nafanua) are believed to be the result of a hotspot; a sort of natural pipeline to reservoirs of magma in the Earth's mantle. Hotspots are relatively stationary, and produce volcanic eruptions on tectonic plates as the plates pass over the hotspot. Two well-known examples of hotspot volcanic activity are Yellowstone Park and the Hawaiian Islands. The geologic history of the Samoan Islands (which were formed by hotspot activity) and the recent emergence of Nafanua make it very likely that Vailulu'u will continue to erupt at intervals and eventually emerge from the sea surface as a new member of the Samoan Island chain (for more information, please see "Volcanic Islands and Seamounts in the Samoan Region" by Matt Jackson *http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/background/geology/welcome.html*).

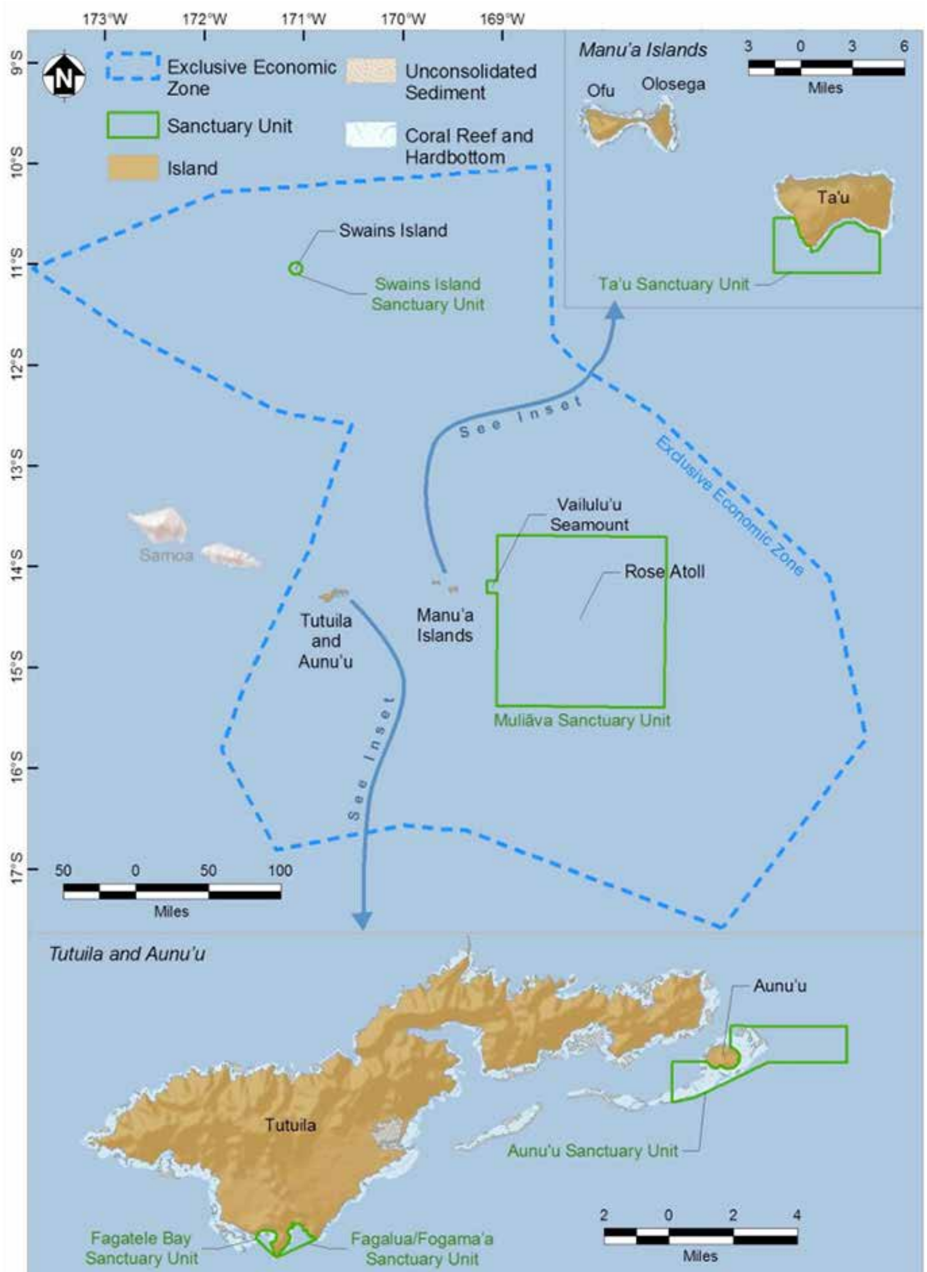
The overall goal of the 2017 American Samoa Expedition was to provide information needed to manage marine resources in American Samoa, with particular attention to management needs in the National Marine Sanctuary of American Samoa,

Images from Page 1 top to bottom:
A plume of bubbles is shown rising from the seafloor at Vailulu'u Seamount in the mid-water multibeam sonar data. Image courtesy of the NOAA Office of Ocean Exploration and Research, 2017 American Samoa.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/logs/feb22/media/vailulu2.html

The ROVs are prepared for deployment on the aft deck of NOAA Ship *Okeanos Explorer*. The dual-body ROV is dedicated to the ship and includes the camera sled Seirios (left) and ROV *Deep Discoverer* (right). Both vehicles are outfitted with powerful lighting, high-definition imaging, and sensors to collect in situ environmental information on habitats being explored. *Deep Discoverer* is also equipped with a temperature probe, and two manipulator arms, coral cutters, and storage boxes for sample collections. Image courtesy of the NOAA Office of Ocean Exploration and Research.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/background/plan/media/rovsunrise.html

The jelly (hydromedusa) is in a family of hydromedusae called Rhopalonematidae, which is known for the canals running vertically on the inside of the bell, gonads attached to these canals, and sometimes having two sets of tentacles.Image courtesy of the NOAA Office of Ocean Exploration and Research, 2017 American Samoa
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/dailyupdates/media/video/dive06_jellyfish/jellyfish.html

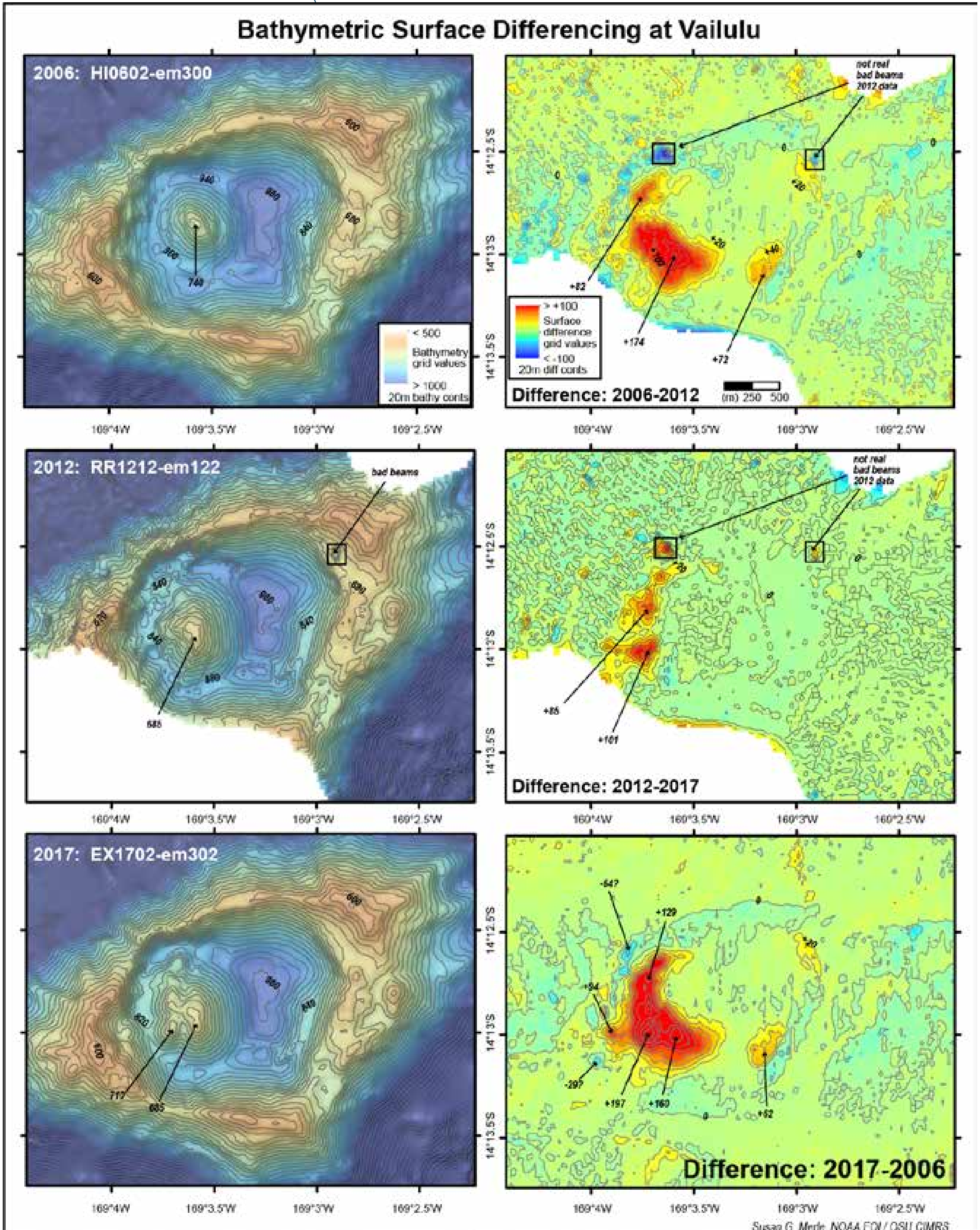
In the control room of the NOAA Ship *Okeanos Explorer* the ROV pilot controls *Deep Discoverer's* grasping arm, while the co-pilot points the main camera. Image courtesy of William J. Clancey.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/logs/feb25/media/sampling-hires.jpg



Management designations within Samoan Archipelago with Sanctuary Units Identified. The sanctuary is comprised of six protected areas, covering 13,581 square miles of nearshore coral reef and offshore open ocean waters across the Samoan Archipelago. Image courtesy NOAA.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/background/nmsas/media/nms-map.html

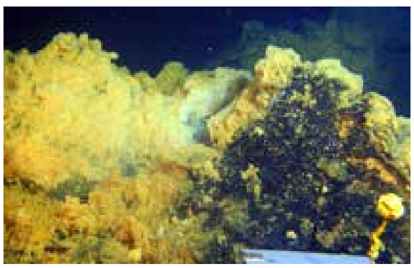
one of 14 federally designated areas within United States waters that protects areas of the marine environment that are of special importance because of conservation, recreational, ecological, historical, cultural, archeological, scientific, educational, or aesthetic qualities. Key objectives of the expedition include identifying and mapping vulnerable marine habitats, exploring the diversity of benthic habitats and features, and investigating the geologic history of Pacific seamounts.

To accomplish these objectives, the expedition team worked around the clock. At night, high-resolution multibeam sonar maps were made as the ship moved from one location to



Maps comparing three bathymetric surveys collected at Vailulu'u in 2006, 2012, and 2017 (left) and depth comparisons between them (right). Red areas show positive depth changes due to eruptions at Nafanua cone between the surveys. Image courtesy of Susan Merle, Oregon State University and NOAA/PMEL.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/logs/feb22/media/vailulu-3diffs-hires.jpg

Dense beds of soft octocorals, *Anthomastus sp.*, colonize the highest points around the rim of the volcano. Image courtesy of Vailulu'u 2005 Exploration, NOAA-OE. *http://oceanexplorer.noaa.gov/explorations/05vailuluu/media/hirez/octocoralbeds_hirez.jpg*



The summit of Nafanua was covered with thick microbial mats, indicative of low-temperature venting. Image courtesy of Vailulu'u 2005 Exploration, NOAA-OE. *http://oceanexplorer.noaa.gov/explorations/05vailuluu/media/hirez/summit_mats_hirez.jpg*

One of numerous dead fish that has succumbed in the acidic waters of the "Moat of Death" Note the small red polychaete worms that are grazing on and near the fish carcass. Image courtesy of Vailulu'u 2005 Exploration, NOAA-OE. *http://oceanexplorer.noaa.gov/explorations/05vailuluu/media/hirez/moat_of_death_hirez.jpg*

the next. During the day, high-resolution visual surveys were carried out at depths between 250 and 6,000 meters using a dual-body remotely operated vehicle (ROV) system consisting of the *Seirios* camera sled and the *Deep Discoverer* vehicle. Both *Seirios* and *Deep Discoverer* are fitted with powerful lighting, high-definition imaging, and sensors to collect environmental information on habitats being explored. *Deep Discoverer* is also equipped with a temperature probe, and two manipulator arms, coral cutters, and storage boxes for sample collections.

On February 24, 2017, the ninth ROV dive of the expedition explored the Vailulu'u seamount. Multibeam sonar data showed that the Nafanua volcanic cone had grown substantially since the seamount was last mapped in 2012. Video recordings from the dive show older areas of the cone as well as portions of the newer cone. Lava pillows in the newer areas looked "fresher" and also had biological communities that were not as well-developed as those in older areas.

In this lesson, students will construct three-dimensional models of the Vailulu'u seamount based on multibeam sonar data from 1999 through 2017, and use video observations to make inferences about the interrelationships between physical and biological features in Vailulu'u ecosystems.

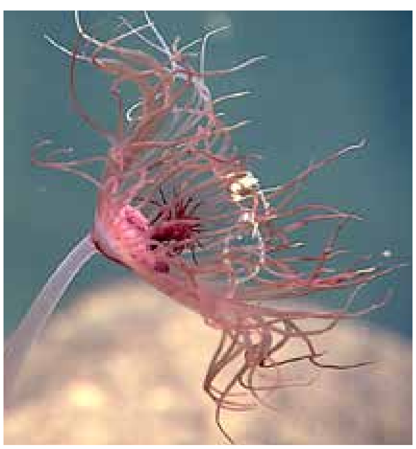
Learning Procedure

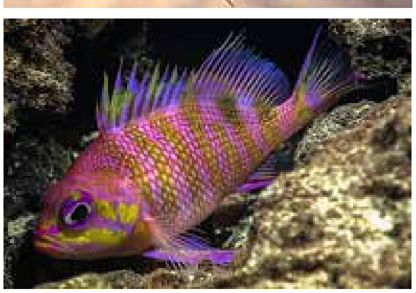
1. To prepare for this lesson:

a. Review background information about the 2017 American Samoa expedition [*http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/welcome.html*], and background information about Vailulu'u habitats in the lesson, "Return to the Moat of Death" *http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/background/edu/media/AmSam2017_MoatofDeath.pdf*. Review the Daily update from February 24, 2017 *http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/dailyupdates/dailyupdates.html*, and video from the ninth expedition dive *http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/dailyupdates/media/video/volcano/volcano.html*. You may also want to review "Eel City and the Moat of Death: An Active Volcano on the Samoan Hotspot" *http://oceanexplorer.noaa.gov/explorations/05vailuluu/welcome.html* which discusses relationships between physical conditions and living organisms at Vailulu'u.

b. Review the Multimedia Discovery Mission, Plate Tectonics (Lesson 1) *http://oceanexplorer.noaa.gov/edu/learning/welcome.html#lesson1* and Seamounts (Lesson

Photographs taken by *Serios* of various animals. From Top to Bottom: Crinoids, a sponge, a hydroid and a type of sea bass. Image courtesy of the NOAA Office of Ocean Exploration and Research, 2017 American Samoa





14) *http://oceanexplorer.noaa.gov/edu/learning/welcome.html#lesson14*, and decide whether you want to use these in your lesson plan.

c. Refer to Figures 1 - 10. Figures 1 - 5 are color images from processed multibeam sonar data, while Figures 6 - 10 are black and white vector images from the same data that may be enlarged or reduced for the model-making activity described in Step 3. Prepare copies of Figures 6 - 10 for student-constructed seamount models. The contours in the figures represent intervals of 20 m. Each model will require one copy of the figure for that model for each layer in the model. So, a model of a feature that is 200 m high will require ten copies of the figure if one layer is constructed for each 20 m contour.

200 m ÷ 20 m/layer = 10 layers

You may reduce the number of copies needed by instructing students to include two or more contours in each layer. For example, if each layer represents a depth intervals of 40 m, the 200 m feature can be modeled with only 5 layers:

200 m ÷ 40 m/layer = 5 layers

Prepare enough cardboard sheets to provide one sheet for each layer in each model.

d. Review Step 5, which is an optional discussion related to relevant Next Generation Science Standards. Depending upon learning objectives and available time, you may want to have students read and discuss one or more of the resource materials listed. You may also want to have students investigate carnivorous sponges, which provide an unusual example of animals adapted to underwater volcanic and deep-sea vent habitats.

2. Briefly introduce the NOAA Ship *Okeanos Explorer*, which is the only U.S. ship whose sole assignment is to systematically explore Earth's largely unknown ocean for the purposes of discovery and the advancement of knowledge, and describe the objectives of the 2017 American Samoa Expedition. Show the video from the ninth expedition dive *http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/dailyupdates/media/video/volcano/volcano.html*. You may also want to provide

copies of the Daily update from February 24, 2017 *http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/dailyupdates/dailyupdates.html* or give students the Web link to read on their own.

3. Construct models of Vailulu'u bathymetry, 1999 to 2017.
   a. Give each student group copies of Vailulu'u Seamount Bathymetry for one of the survey years and one piece of cardboard for each contour they are to construct. Groups should have one copy for each layer to be constructed, but a single layer may include more than one contour (see Step 1c).

   b. Have students glue the bathymetric images to the cardboard. Be sure to use enough glue to cover the entire surface of the cardboard.

   c. Have students carefully cut away all of the contours that are deeper than the contour they are constructing. If students are using X-Acto knives, be sure to have a suitable backing (heavy cardboard, cutting board, etc.) to protect work surfaces.

      When cutting away the deeper areas, it is important to visualize the actual topography being modeled. Figures 11 through 15, for example show the five deepest contours for the 2005 multibeam sonar image. The black areas in these figures are the portions that should be cut away. Notice that the 900 m depth contours enclose two areas. To model this contour layer, first cut out the larger (black) area, then cut the smaller yellow area from the cutout piece. The two yellow pieces should both be glued onto the 920 m contour layer. Figure 16 shows how the five layers would look when assembled in order.

   d. Starting with the deepest (largest) contour, carefully glue successive layers together to build the three-dimensional model of the seamount. Some layers will have several pieces to glue in place. Use the appropriate contour lines on the deeper layer to locate the individual pieces.

4. Using the models the students have produced, discuss changes that took place at Vailulu'u between 1999 and 2017. The presence of a new cone (Nafanua) inside the crater is particularly conspicuous, as well as the appearance of new features on the Nafanua summit. Ask students to use their models to estimate how long it would take for the summit of Vailulu'u to emerge from the

ocean, if the rate of growth between 1999 and 2017 were to remain constant. Comparing Figures 1 and 5, the Nafanua summit grew from a depth of about 1000 m in 1999 to about 720 m in 2017; roughly 280 m in 18 years, or an average of 15.5 m per year:

280 m from 1999 to 2017 ÷ 18 years = 15.5 m/year

At this rate, to grow an additional 720 m (the distance from the summit to the sea surface) would require about 46 years:

720 m ÷ 15.5 m/year = 46.45 years

Note that the narration for Dive 9 states that "if the volcano continues its present rate of growth, it could potentially summit on the order of thousands of years." Be sure students understand that the preceding calculation assumes the average growth rate for the next 46 years will be the same as for the last 18 years. If we consider how long the volcano has taken to reach its present height since its FIRST eruption, the time period is much longer, and hence the growth rate will be much smaller.

You may also want to have students consider how their models might be used to plan diving missions. Depending upon mission objectives, the models could help explorers focus on areas of recently deposited lava, or alternatively to plan a mission that included as many different habitats as possible. Flat regions, for example, are more likely to have accumulations of sediment, and will provide different habitats than very steep areas.

Models made using Figures 6 - 10 and 1/16 in-thick cardboard have a significant vertical distortion. This is common in topographic and bathymetric models and illustrations, because the horizontal scales in these models are often much larger than the vertical scales. The Vailulu'u seamount, for example covers an area roughly 60 nautical miles in diameter, which is about 111,120 meters. The Nafanua cone is roughly 280 meters high. If we model the cone at 20 m contour intervals, we will have 14 layers. If we construct each layer with 1/16 in cardboard, we will have a total height in our model of 14/16 in to represent an actual height of 280 meters; so 1 inch of model height will represent about 320 meters of actual height. The overall diameter of Vailulu'u in Figures 6 - 10 is about 7 inches. So, 1 inch of model distance represents about 15,874 meters of actual distance. The vertical exaggeration of our model, then, is 15,874 divided by 320; an exaggeration factor of about 50.

5. (Optional) Discuss connections to Next Generation Science Standards:
   MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

   or

   HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

   Video from the ninth expedition dive, and audio commentary accompanying the video, provides students with access to a limited amount of empirical evidence about ecosystems associated with Nafanua and the Vailulu'u crater. When the video was made, all lavas on Nafanua (and all associated ecosystems) were less than 18 years of age since Nafanua did not exist when the crater was mapped in 1999. Additional empirical evidence is provided in the "Eel City and the Moat of Death: An Active Volcano on the Samoan Hotspot" by Young and Staudigel from the Vailulu'u 2005 Ocean Explorer Expedition. It is reasonable to infer that living organisms in the vicinity of the crater have been strongly influenced by major physical and chemical changes accompanying volcanic eruptions and hydrothermal activity.

   To begin the discussion, ask students to describe some ways that physical ecosystem components affect biological components. Shelter, substrates (hard surfaces for attached organisms, sediments for burrowing organisms, etc), and energy sources (food) should be identifed fairly quickly. You may need to prompt students to consider extreme conditions: Obviously, physical conditions must be within the tolerance range of living organisms; otherwise, the organisms cannot exist. Tolerance range, though, varies widely among species, as shown by the presence of thriving ecosystems in the vicinity of hydrothermal vents. Sudden changes in physical conditions, though, can result in mass mortalities such as those seen at the "Moat of Death."

If you are focusing on MS-LS2-4, you may want to have students read portions of the essay by Young and Staudigel (2005), and then construct oral or written arguments supported by empirical evidence and scientific reasoning to explain some of the observations described in the essay, and how changes in one part of the seamount ecosystem (such as a localized volcanic eruption) might cause larges changes (such as death) in another part (Science and Engineering Practices: Engaging in Argument from Evidence; and Crosscutting Concepts: Stability and Change).

If you are focusing on HS-LS2-6, you may want to have students read portions of the paper by Levin *et al.* (2016) that discusses transitions in space and time, and apply these to 2017 observations at Vailulu'u. This discussion may include consideration of the limits of ROV-enabled visual observations. For example, such observations obviously do not include microbial species, which are known to be very important in other hydrothermal ecosystems. These observations also may not include mobile species that can swim away to avoid the observing vehicles. On the other hand, even though ROV observations may not offer a complete picture of biological components of the seamount ecosystem, the species seen may give important clues about physical processes that influence living organisms (Science and Engineering Practices: Engaging in Argument from Evidence; and Crosscutting Concepts: Stability and Change).

Levin *et al.* (2016) describe four major stages of succession in hydrothermally-influenced ecosystems: Initiation (sudden eruptions or release of fluids), Transition (rapid cooling in some areas); Equilibrium (relatively stable conditions, but still with regular fluid release); and Senescence (fluid release subsides and conditions are similar to surrounding ocean). During the Initiation stages, physical and chemical conditions are deadly to most species, and there is often a release of organic material that may benefit deposit or filter feeders.

Organisms living on recently-erupted lava at Vailulu'u include carnivorous sponges, anemones, ophiuroid brittle stars, and stalked hydroids. Discuss the nutritional strategies used by these organisms. Sponges, anemones, and hydroids are all sessile and are adapted to capture particles and small animals from water flowing over the lava surface. Adaptations of carnivorous sponges are particularly interesting (see Lundsten *et al.*, 2014, for more information), and the images of partially digested prey species captured by the sponges provide evidence that a variety of other species are present in addition to those directly observed in the video. Ophiuroids may also feed on suspended material, as well as detritus, small crustaceans or worms. The prevalence of suspension feeders in the video supports inferences about the importance of currents around Vailulu'u in supplying food to resident species. In general, current flow is often a key factor that contributes to unusually high productivity and biodiversity in seamount ecosystems.

Organisms living on older lava on the summit of Nafanua included the same species, as well as Anthomatus soft corals. Expedition scientists commented on the more extensive sediment cover on the summit, as well as higher biological diversity and the larger size of many organisms. These observations are consistent with a lack of recent volcanic activity (*i.e.*, more stable conditions) on the Nafanua summit.

For additional discussion related to MS-LS2-4, you may want to have students read and discuss "Gas-powered Circle of Life – Succession in a Deep-sea Ecosystem" by Pen-Yuan Hsing [*http://oceanexplorer.noaa.gov/explorations/10lophelia/logs/oct18/oct18.html*], and/or "The Ecology of Gulf of Mexico Deep-sea Hardground Communities" by Erik E. Cordes [*http://oceanexplorer.noaa.gov/explorations/06mexico/background/hardgrounds/hardgrounds.html*].

For additional discussion related to HS-LS2-6, you may want to have students read and discuss "Transitions in Time (Succession)" in Levin *et al.* (2016), and/or portions of Bernardino *et al.*, (2012).

The BRIDGE Connection

www.vims.edu/bridge/ – Enter "volcano" in the search bar to access resources about the underwater volcanoes.

The “Me” Connection

Have students write a short essay about how they might be personally affected by changes in their ecosystem. Changes may be extreme, such as volcanic eruptions, or more modest biological or physical changes, such as a seasonal flood.

Connections to Other Subjects

English/Language Arts, Mathematics

Assessment

Seamount models and participation in class discussions provide opportunities for assessment.

Extensions

Visit *http://oceanexplorer.noaa.gov/okeanos/explorations/explorations.html* for links to individual voyages of discovery by NOAA Ship *Okeanos Explorer*.

Other Relevant Lessons from NOAA’s Ocean Exploration Program

The Volcano Factory (Grades 5-6)
from the 2006 Submarine Ring of Fire Expedition
[*http://oceanexplorer.noaa.gov/explorations/06fire/background/edu/media/ROF06.VolFactory.pdf*]

Focus: Volcanism on the Mariana Arc (Earth Science)

Students explain the tectonic processes that result in the formation of the Mariana Arc and the Mariana Trench; and explain why the Mariana Arc is one of the most volcanically active regions on Earth.

It’s Going to Blow Up! (Grades 7-8)
from the 2006 Submarine Ring of Fire Expedition
[*http://oceanexplorer.noaa.gov/explorations/06fire/background/edu/media/ROF06.BlowUp.pdf*]

Focus: Volcanism on the Pacific Ring of Fire (Earth Science)

Students describe the processes that produce the Submarine Ring of Fire; explain the factors that contribute to explosive volcanic eruptions; identify at least three benefits that humans derive from volcanism; describe the primary risks posed by volcanic activity in the United States; and identify the volcano within the continental U.S. that is considered most dangerous.

Other Resources

The Web links below are provided for informational purposes only. Links outside of Ocean Explorer have been checked at the time of this page's publication, but the linking sites may become outdated or non-operational over time.

http://oceanexplorer.noaa.gov/okeanos/explorations/ex1702/welcome.html Web page for the 2017 American Samoa expedition

http://oceanexplorer.noaa.gov/okeanos/edu/welcome.html – Web page for the NOAA Ship *Okeanos Explorer* Education Materials Collection

http://oceanexplorer.noaa.gov/edu/learning/welcome.html – Multimedia Discovery Missions, a series of 13 interactive multimedia presentations and learning activities that address topics ranging from Chemosynthesis and Hydrothermal Vent Life to Deep-sea Benthos to Plate Tectonics

Hsing, Pen-Yuan. 2010. "Gas-powered Circle of Life – Succession in a Deep-sea Ecosystem;" *http://oceanexplorer.noaa.gov/explorations/10lophelia/logs/oct18/oct18.html*

Cordes, E., 2006. "The Ecology of Gulf of Mexico Deep-sea Hardground Communities;" *http://oceanexplorer.noaa.gov/explorations/06mexico/background/hardgrounds/hardgrounds.html*

Lundsten, L., Reiswig, H.M., and Austin, W.C. (2014) Four new species of Cladorhizidae (Porifera, Demospongiae, Poecilosclerida) from the Northeast Pacific. Zootaxa 3786 (2): 101–123; *http://www.mapress.com/zootaxa/2014/f/zt03786p123.pdf*; a news article based on this paper is also available: "Researchers describe four new species of 'killer sponges' from the deep sea." MBARI News. April 14, 2014. [*http://www.mbari.org/researchers-describe-four-new-species-of-killer-sponges-from-the-deep-sea/*]

Hydrothermal Vents and Methane Seeps: Rethinking the Sphere of Influence. Levin. L., Baco, A., Bowden, D., Colaco, A., Cordes, E., Cunha, M., Demopoulos A., Gobin, J., Grupe, B., Le, J., Metaxas, A., Netburn, A., Rouse, G., Thurber, A., Tunnicliffe, V., Van Dover, C., Vanreusel, A., Watling, L. 2016. Hydrothermal Vents and Methane Seeps: Rethinking the Sphere of Influence. Frontiers in Marine

Science 3:1-23. [*http://journal.frontiersin.org/article/10.3389/fmars.2016.00072/pdf*]

Bernardino, A., Levin, L., Thurber, A., Smith, C. 2012. Comparative Composition, Diversity and Trophic Ecology of Sediment Macrofauna at Vents, Seeps and Organic Falls. PLoS ONE 7:1-17. [*http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0033515*]

Young, C. and H. Staudigel, 2005. Eel City and the Moat of Death: An Active Volcano on the Samoan Hotspot. Available online at: *http://oceanexplorer.noaa.gov/explorations/05vailuluu/welcome.html*

Next Generation Science Standards

The primary purpose of this lesson is to assist educators with incorporating information about the Vailulu's seamount and the 2017 American Samoa expedition into their instructional program. While they are not intended to target specific Next Generation Science Standards, activities in this lesson may be used to address specific NGSS elements as described below.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.

Science and Engineering Practices

Engaging in Argument from Evidence

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

Crosscutting Concepts

Stability and Change

- Small changes in one part of a system might cause large changes in another part.

HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
[Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

Science and Engineering Practices

Engaging in Argument from Evidence

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

Crosscutting Concepts

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1.
Earth has one big ocean with many features.

Fundamental Concept h. Although the ocean is large, it is finite, and resources are limited.

Essential Principle 2.
The ocean and life in the ocean shape the features of Earth.

Fundamental Concept e. Tectonic activity, sea level changes, and the force of waves influence the physical structure and landforms of the coast.

Essential Principle 6.
The ocean and humans are inextricably interconnected.

Fundamental Concept f. Much of the world's population lives in coastal areas. Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change, and storm surges).

Essential Principle 7.
The ocean is largely unexplored.

Fundamental Concept b. Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes. Our very survival hinges upon it.

Fundamental Concept c. Over the last 50 years, use of ocean resources has increased significantly; the future sustainability of ocean resources depends on our understanding of those resources and their potential.

Fundamental Concept f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, physicists, animators, and illustrators. And these interactions foster new ideas and new perspectives for inquiries.

Send Us Your Feedback

In addition to consultation with expedition scientists, the development of lesson plans and other education products is guided by comments and suggestions from educators and others who use these materials. Please send questions and comments about these materials to: *oceanexeducation@noaa.gov*.

For More Information

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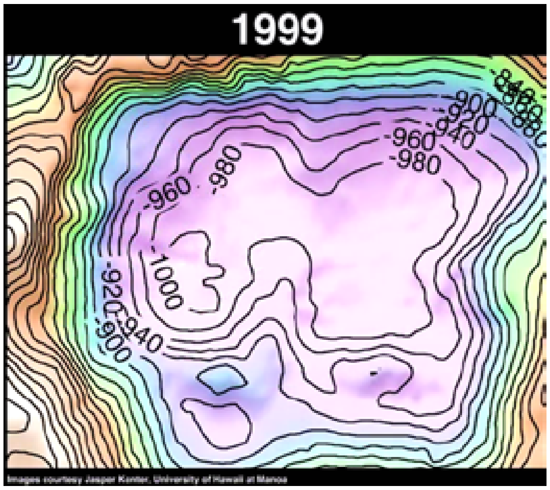
Design/layout: Coastal Images Graphic Design, Mt. Pleasant, SC.

Credit

Multibeam Sonar Data for Vailulu'u

Figure 1:



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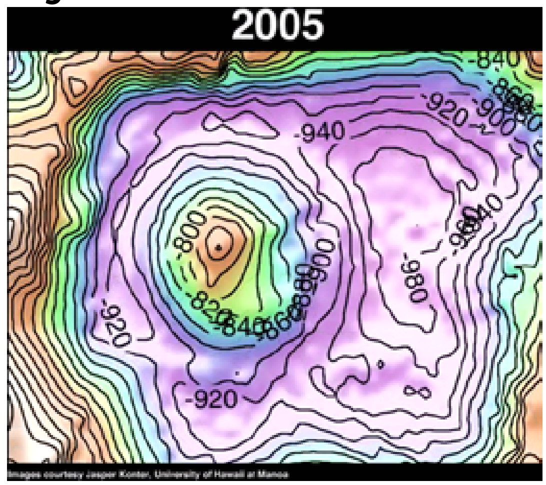

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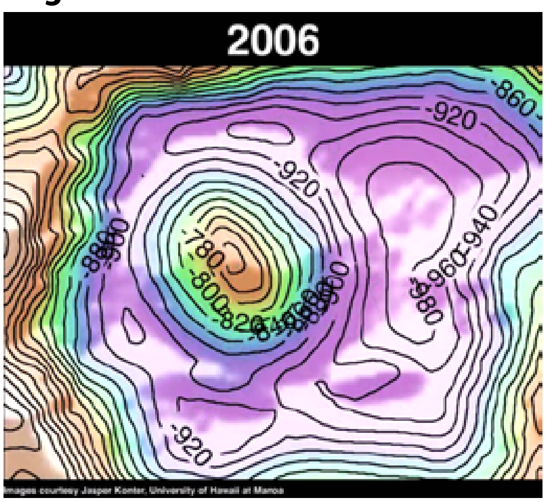

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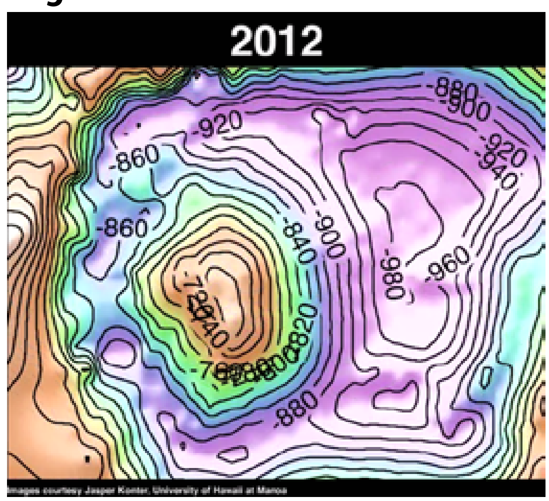

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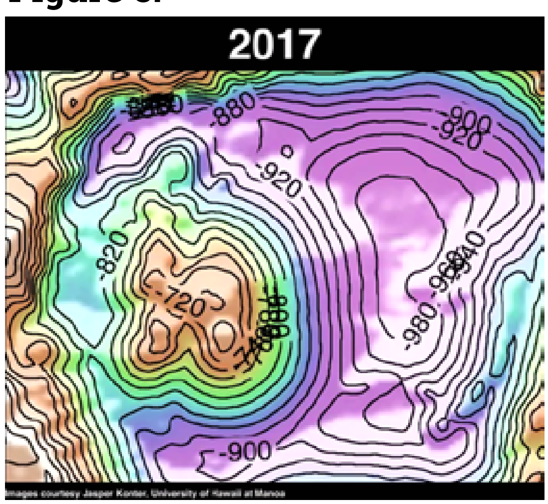
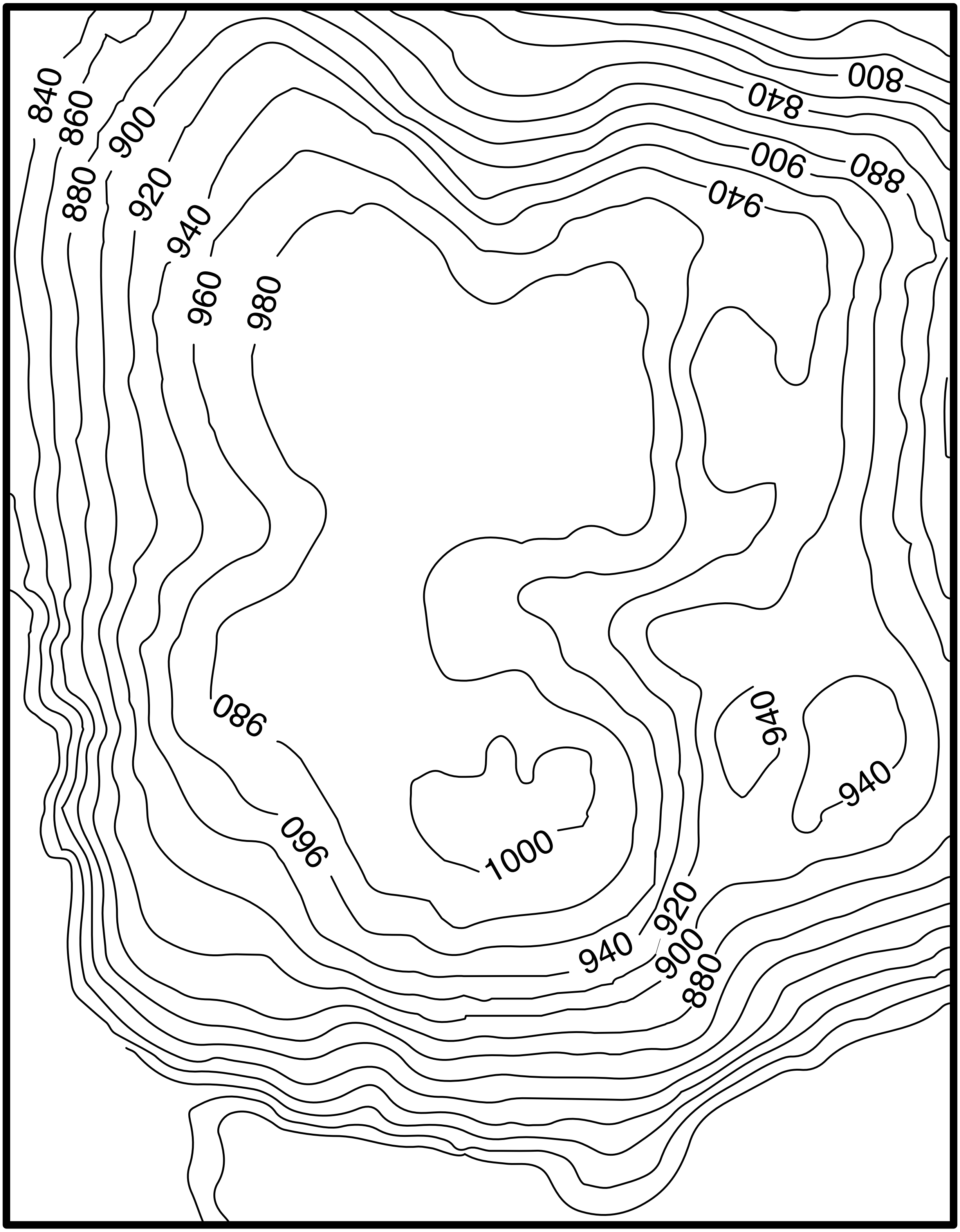
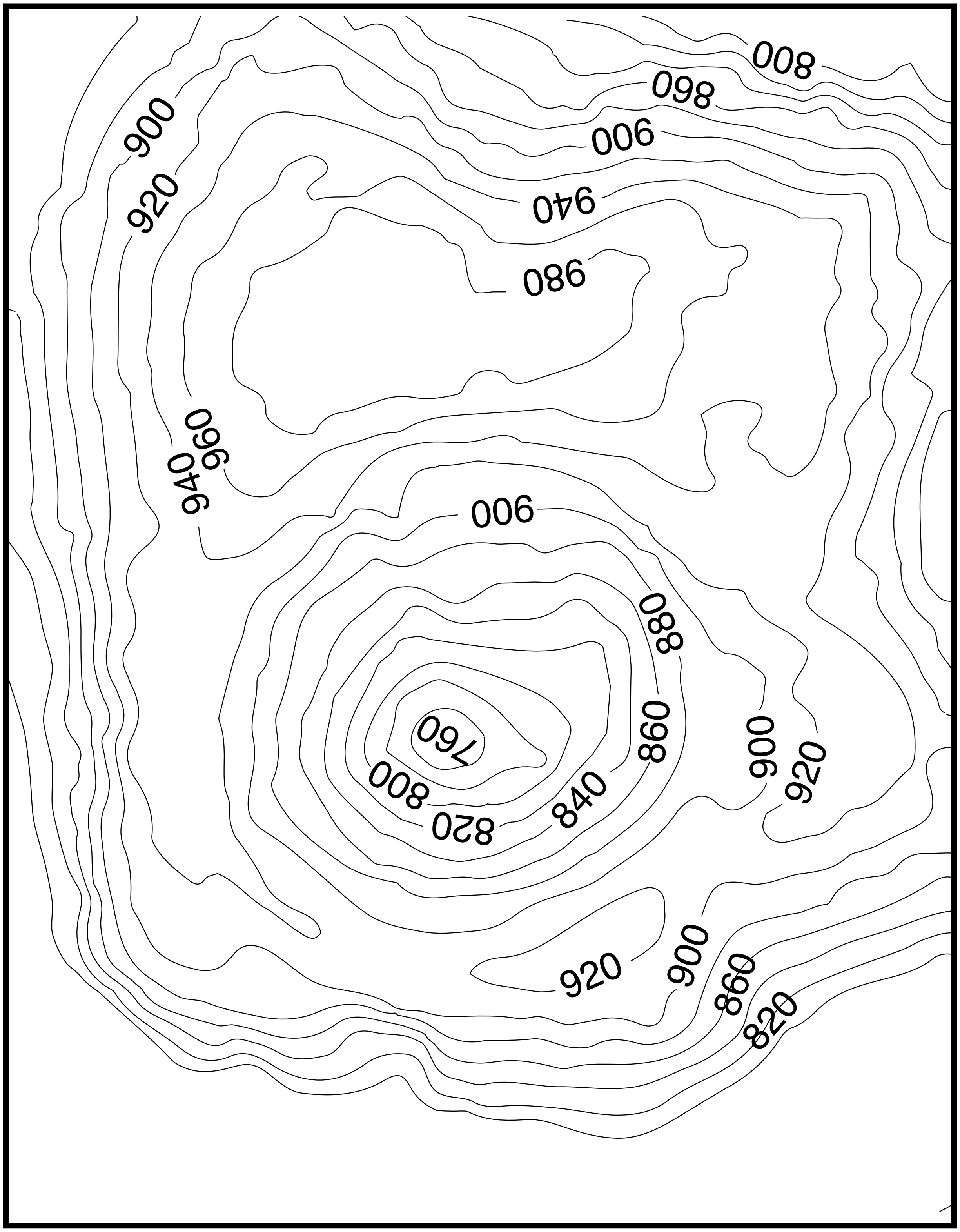


Figure 6: 1999 Data in Black and White



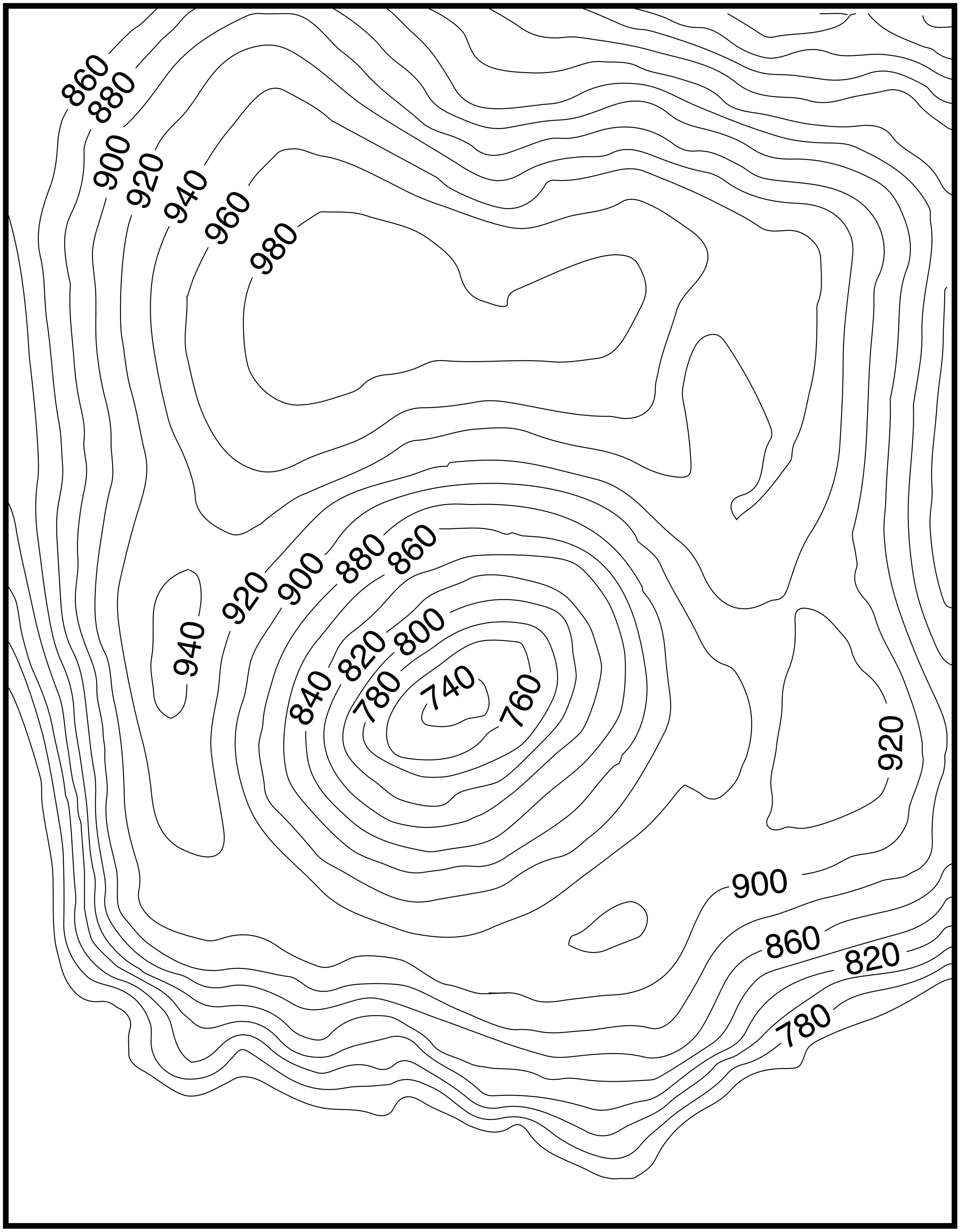
1999

Figure 7: 2005 Data in Black and White



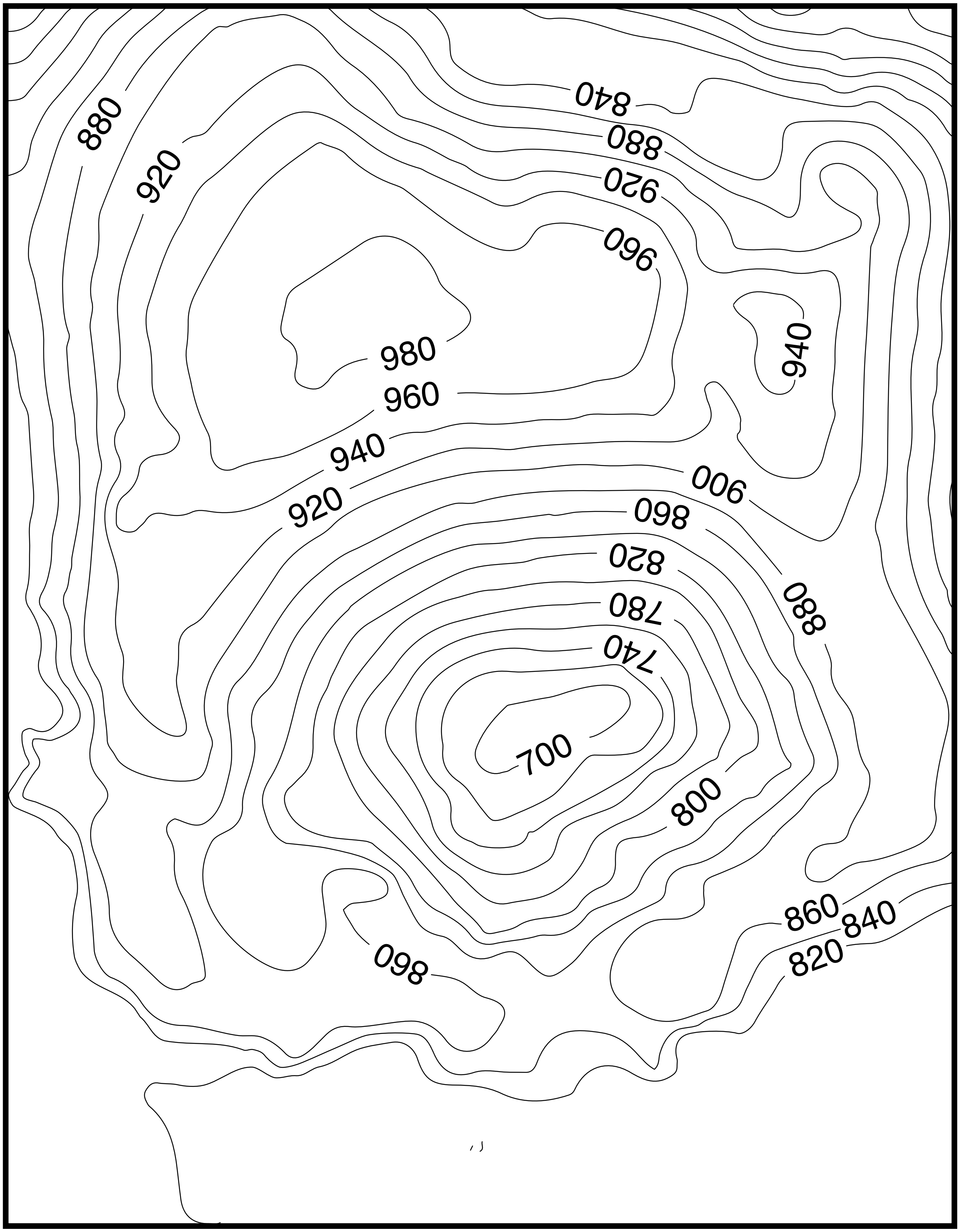
2005

Figure 8: 2006 Data in Black and White



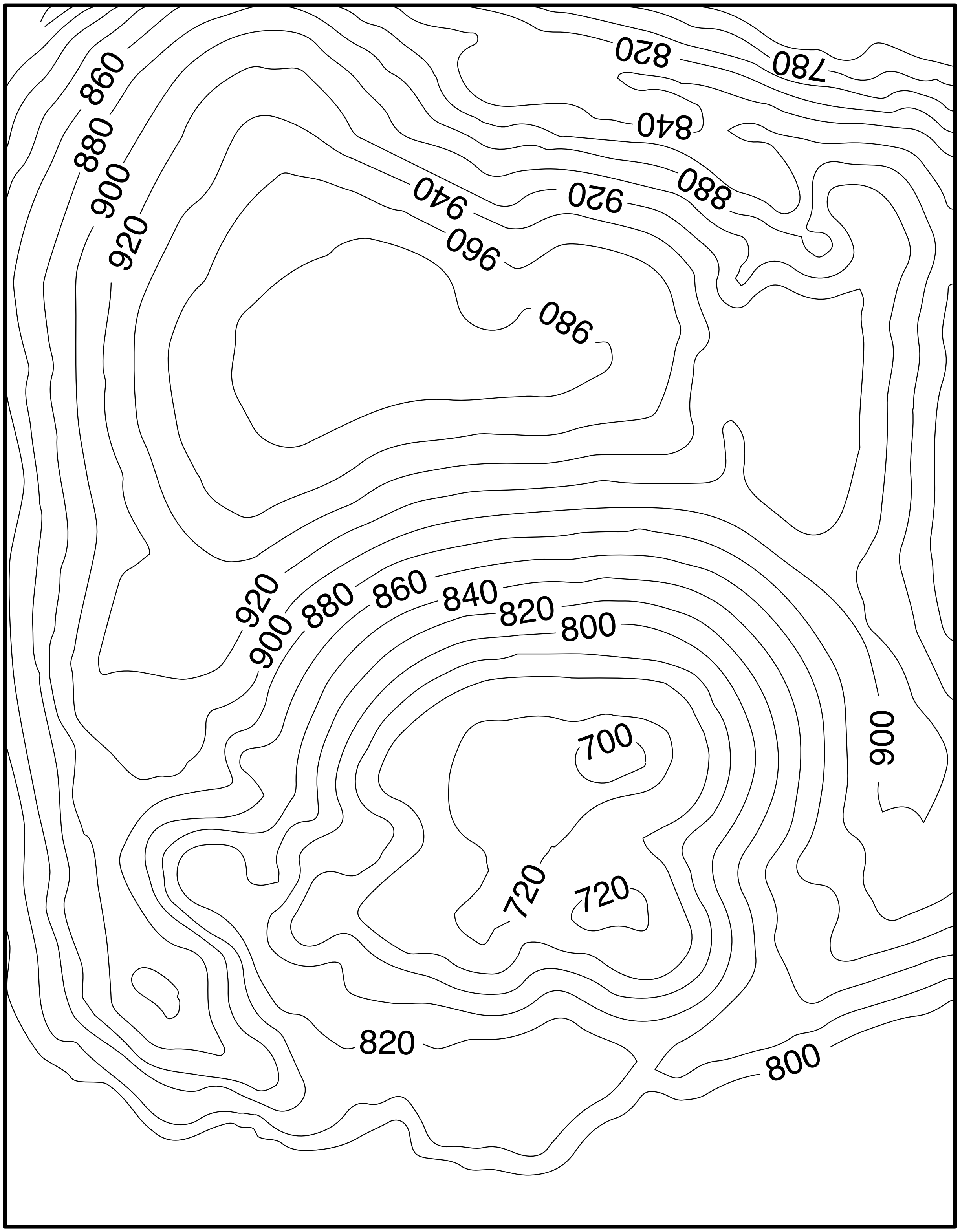
2006

Figure 9: 2012 Data in Black and White



2012

Figure 10: 2017 Data in Black and White



2017

Figure 11: Deepest contour for 2005

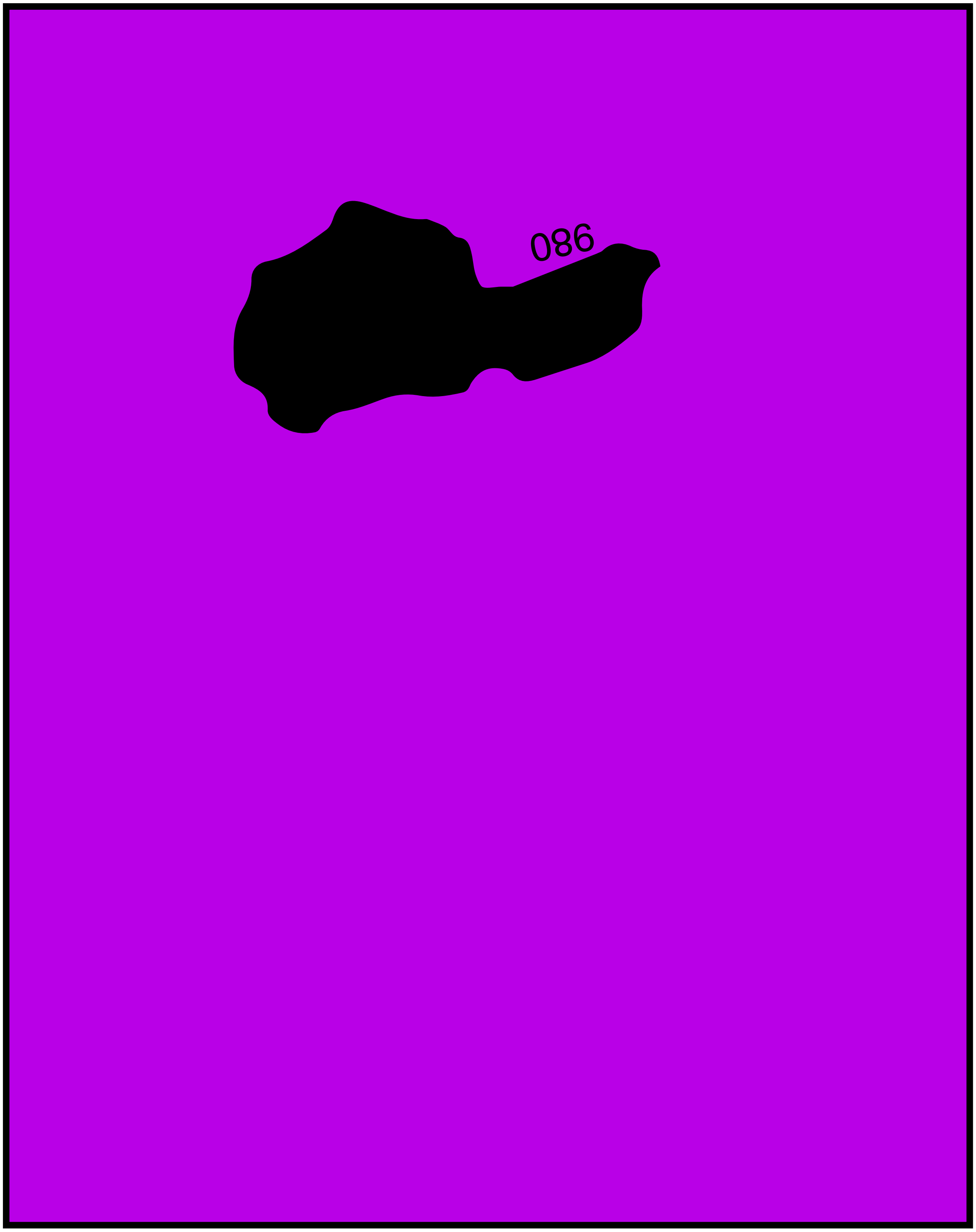


Figure 12: Second deepest contour for 2005

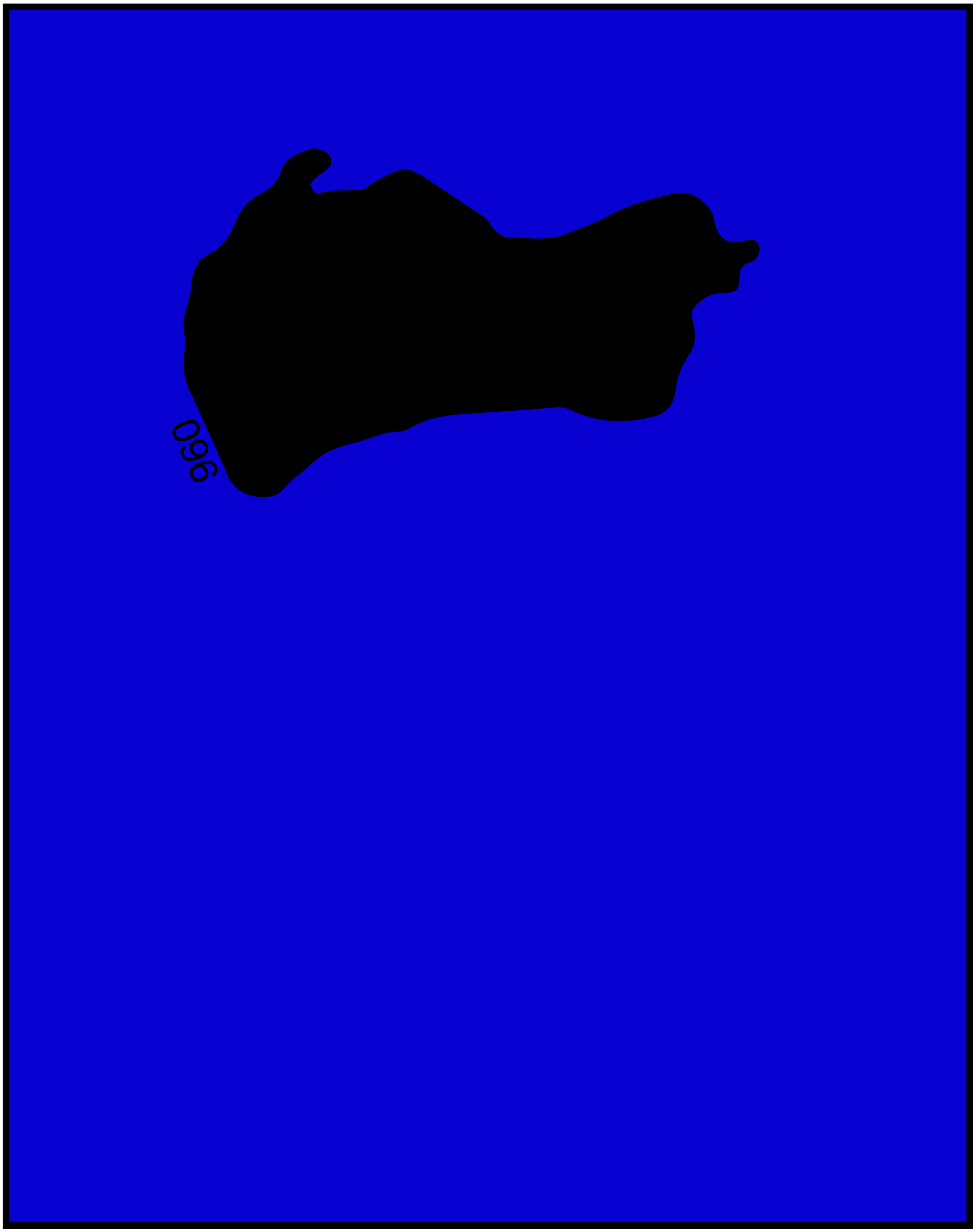


Figure 13: Third deepest contour for 2005

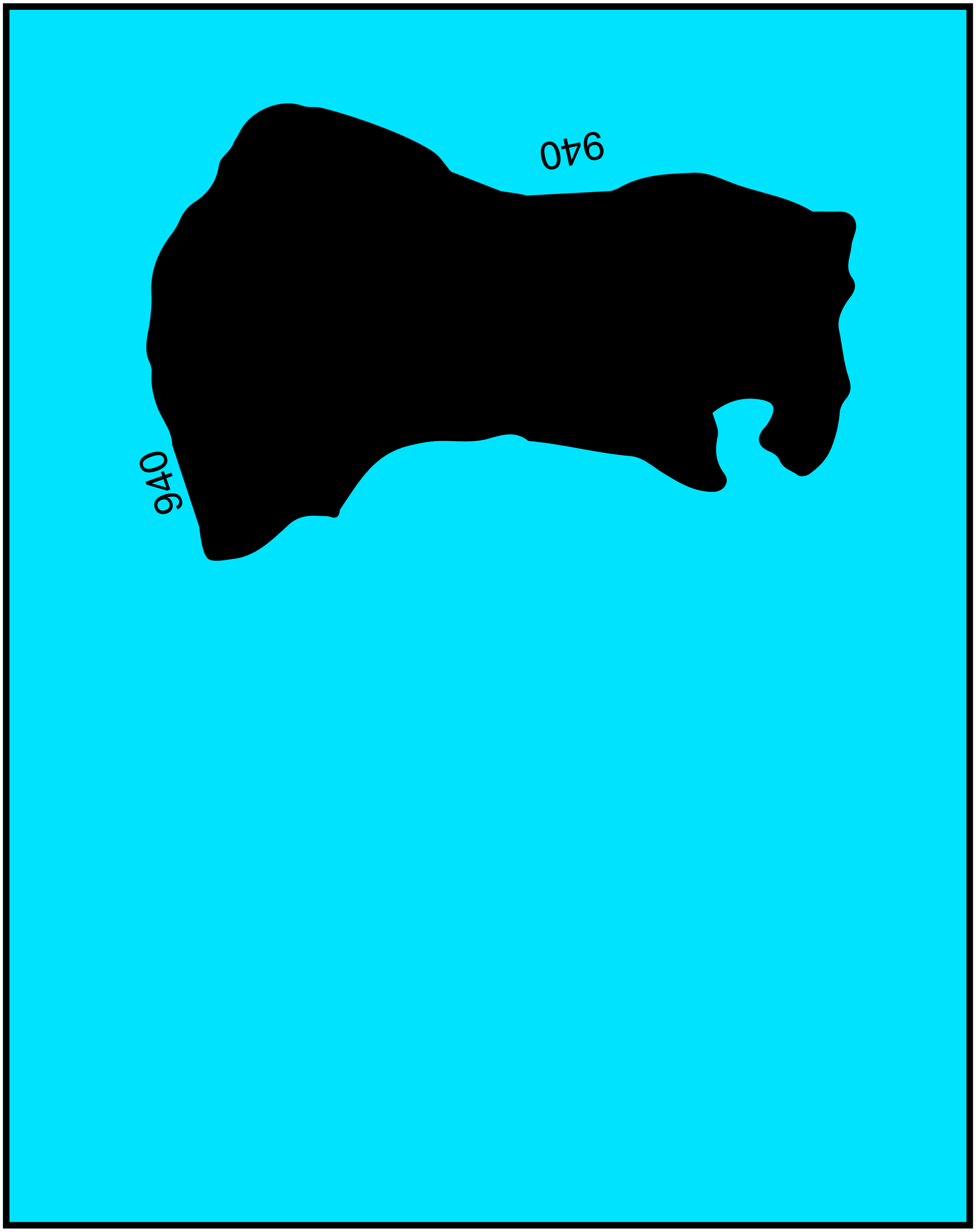


Figure 14: Fourth deepest contour for 2005

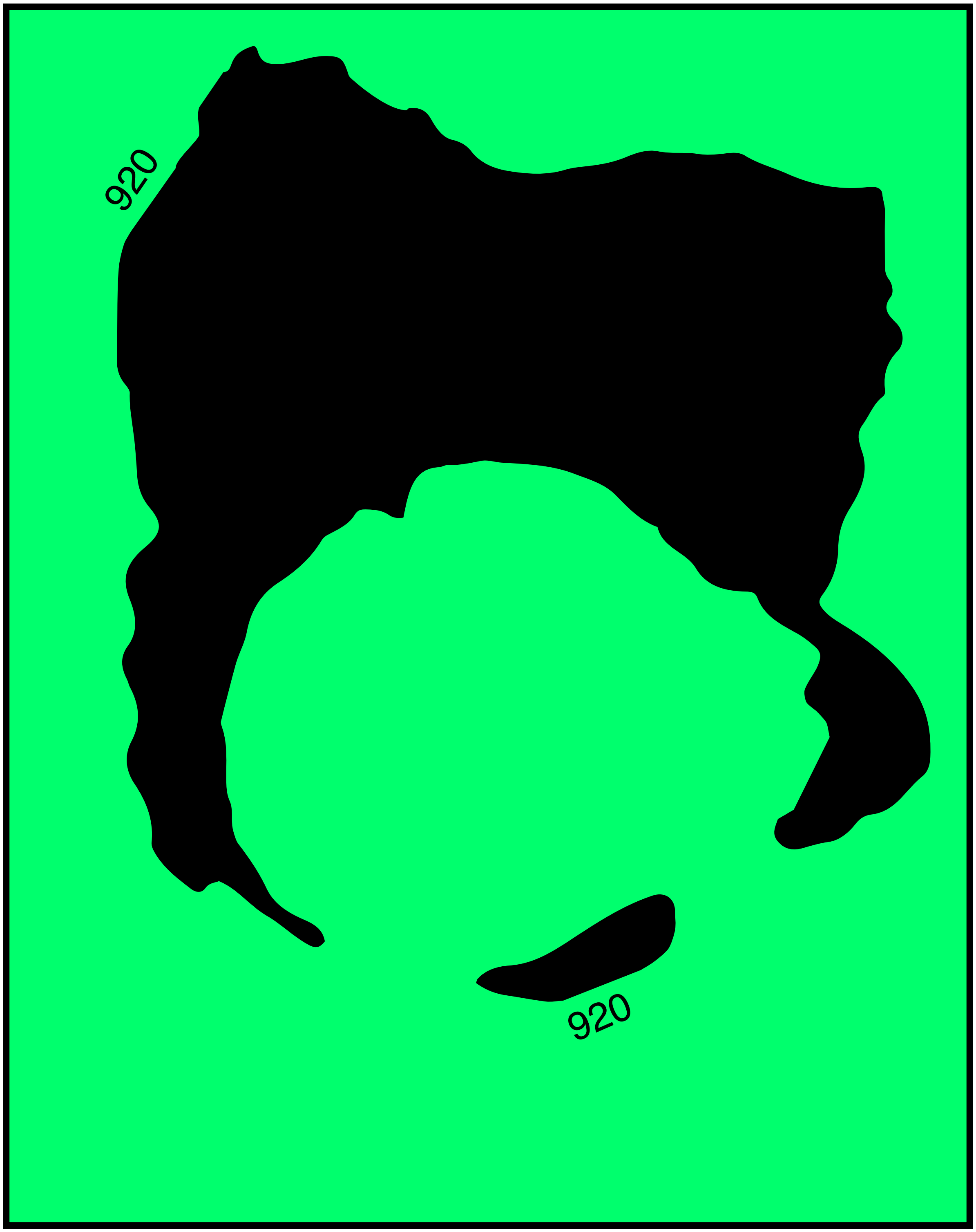


Figure 15: Fifth deepest contour for 2005

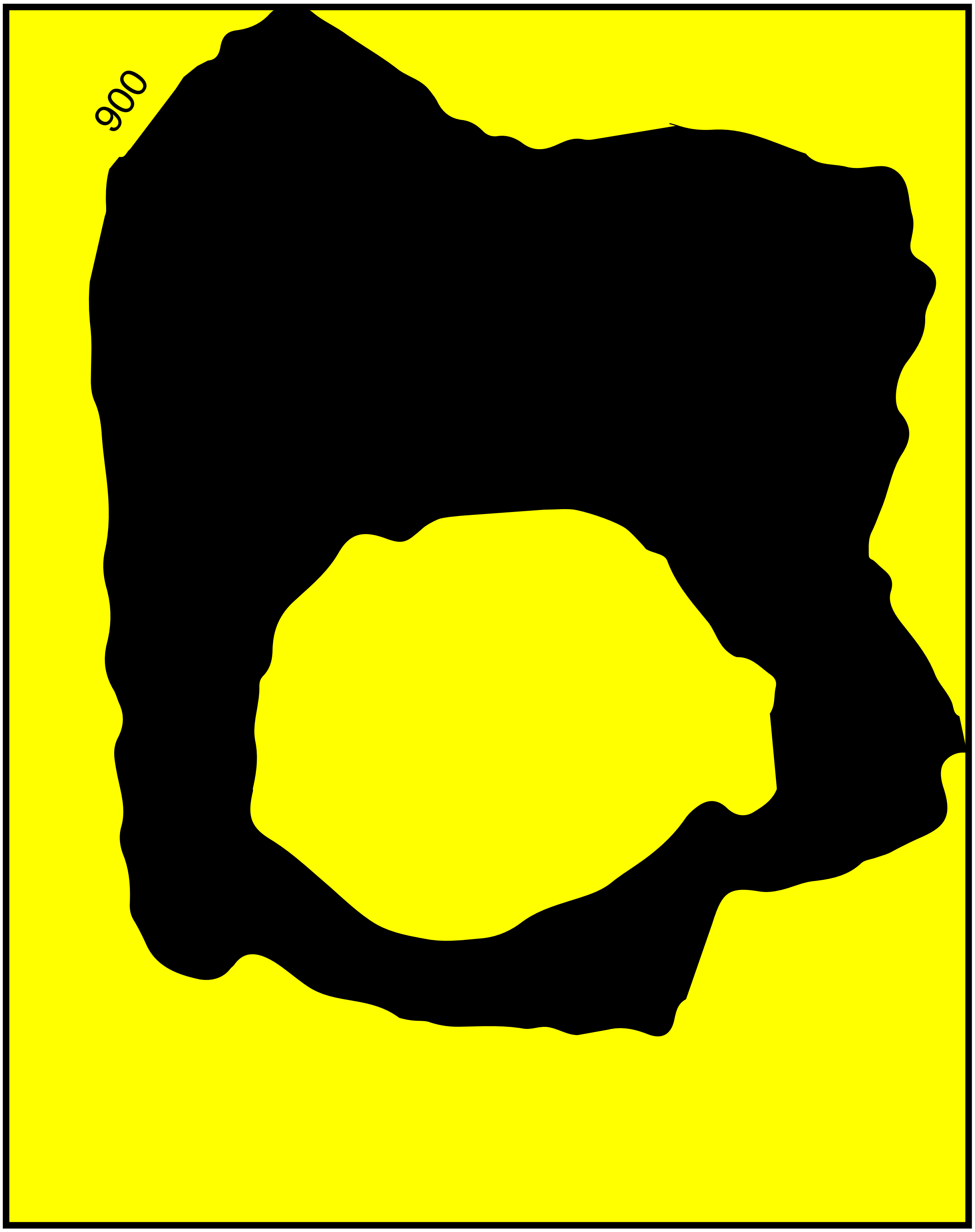


Figure 16: How the five layers should look assembled