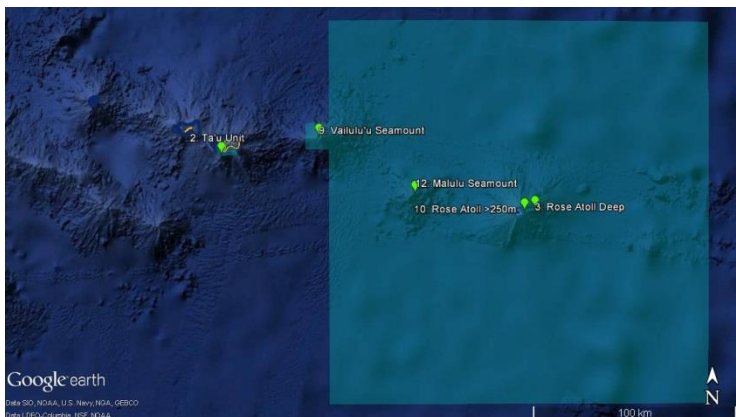




Ocean Exploration and Research

Okeanos Explorer ROV Dive Summary

Dive Information			
Dive Map			
Site Name	“Vailulu’u” seamount crater		
ROV Lead(s)	Karl McLetchie		
Expedition Coordinator(s)/ Mapping Lead	Kelley Elliott Meme Lobecker		
Science Team Lead(s)	Santiago Herrera (Biology) and Matt Jackson (Geology)		
General Area Descriptor	Eastern Samoan region		
ROV Dive Name			
Cruise	EX1702		
Leg			
Dive Number	09		
Equipment Deployed			
ROV	Deep Discoverer (D2)		
Camera Platform	Seirios		
ROV Measurements	☒ CTD	☒ Depth	☒ Altitude
	☒ Scanning Sonar	☒ USBL Position	☒ Heading
	☒ Pitch	☒ Roll	☒ HD Camera 1
	☒ HD Camera 2	☒ Low Res Cam 1	☒ Low Res Cam 2
	☒ Low Res Cam 3	☒ Low Res Cam 4	☒ Low Res Cam 5

	☒ LSS	☒ ORP	
Equipment Malfunctions			
ROV Dive Summary (from processed ROV data)	In Water:	2017-02-24T19:28:56.796000 14°, 12.494' S ; 169°, 03.397' W	
	Out Water:	2017-02-25T05:32:46.012000 14°, 13.102' S ; 169°, 03.739' W	
	Off Bottom:	2017-02-25T05:07:13.743000 14°, 12.972' S ; 169°, 03.581' W	
	On Bottom:	2017-02-24T20:44:47.678000 14°, 12.642' S ; 169°, 03.515' W	
	Dive duration:	10:3:49	
	Bottom Time:	8:22:26	
	Max. depth:	928.5 m	
Special Notes			
Scientists Involved (please provide name, location, affiliation, email)	Asako Matsumoto, PERC, Chiba Institute of Technology, Japan Bruce Mundy, NOAA PIFSC Christopher Kelley, University of Hawaii Craig Young, University of Oregon Deborah Glickson, NASEM Diva Amon, University of Hawaii at Manoa Jasper Konter, University of Hawaii Manoa Kristen Mello, Center for Coastal and Ocean Mapping Les Watling, University of Hawaii at Manoa Matthew Jackson, UC Santa Barbara Natalie Summers, University of Hawaii at Manoa Santiago Herrera, Lehigh University Scott France, University of Louisiana at Lafayette Tara Harmer Luke, Stockton University William Chadwick, NOAA/PMEL		
Purpose of the Dive	The goal of this dive was to explore the volcanically active crater of Vailulu'u seamount. The dive planned to target a location previously know to be the locus of hydrothermal venting, which is located near a plume in the water column (extending above the crater) that was detected to emanate for a region of the crater that is near the site of previously-observed hydrothermal venting. There is also significant interest in understanding the deep sea habitats and biological communities associated with the hydrothermal activity and the hard-substrate areas on the volcano to better understand their diversity and distribution.		



	From a geological standpoint, this seamount is volcanically active and is likely the youngest volcano in the Samoan region. Therefore, further data on this seamount provides a critical window into the geochemistry and volcanology of the early stages of the evolution of a Samoan volcano. From the biological perspective this dive provides information about the successional changes in the biological communities associated with changes in the environmental setting product of active volcanism. We aim to collect information that will inform the biogeographic identity of the hydrothermal and hard-substrate communities at bathyal depths in this region.
Description of the Dive	The seamount explored in this dive, Vailulu'u seamount, lies in the eastern region of the Samoan hotspot. The seamount has been mapped in high resolution by multibeam in prior years (1999, 2005, 2006, 2012). Since the 2012 mapping expedition to Vailulu'u, new bathymetric data show that the volcanic cone in the crater, called Nafanua, has grown substantially. Additionally, a mapping effort in mid-February 2017 aboard the <i>Okeanos Explorer</i> identified plumes (likely composed of CO₂ gas) rising from the location of previously identified hydrothermal vents. The dive track was designed to start at ~908 m water depth at a location of ~50 m east of previously noted locations of hydrothermal activity. After exploring the hydrothermal field, the ROV was to traverse to a feature on the north side of Nafanua that was generated in the 5 years since the 2012 mapping effort. The ROV dive was designed to move progressively upslope, along a series of new volcanic features, and finish at a depth of ~715 m. The following geological description provides a chronological summary of the major geological features, or changes in the geology of the ocean floor, over the course of the dive: 20:22:00 to 20:44:12 UTC. The ROV arrived in the moat near hydrothermal field. During the dive, turbidity increased substantially with depth; the turbidity meter showed that at ~720 m water depth, the turbidity increases rapidly. One scientist notes that the crater is more turbid than in the 2005 dive in the crater; in 2005, the ROV was able to navigate through the water at the base of the crater as the turbidity was not too severe, but on this dive the turbidity is so severe in the same location that <i>Seirios</i> cannot get a visual of D2. The ROV team made a decision to try to move out of the turbidity plume in a direction to the southeast, which is moving against the current (the current is weak, and moves from southeast to northwest). 20:45:08. The seafloor in the crater is visible for the first time. Spectacular pillow basalts are the first objects in the field of view; the pillows are approximately 30 to 50% covered with sediment. The turbidity limits the field of view. ROV depth is ~928 m. 20:50:25. We have moved several meters away from the "on bottom" site and ~80% of field of view is covered by sediment, possibly flocculent material. The remaining 20% consists of basalt boulders. 21:13:25. After a long delay, the ROV is finally moving slowly along bottom, without a visual <i>Seirios</i> (owing to high turbidity). Occasional cobbles and boulders are visible, and all are partially covered with sediment. Between the boulders, sediment covers 70 to 80% of the surface. A number of worms feasting on a dead fish constituted the first biological sample of the dive (the fish was not sampled, as it fell out of the scoop). 21:35:00. Due to the very high turbidity severely limiting visibility, the ROV moved

up the nearest cone feature that is unlikely to be generated by the youngest (<5 years old) volcanic activity.

21:13:25 to 23:17:20. Santiago Herrera and I participated in an online telepresence interaction with 170 students in American Samoa. Thus, our ability to make observations during this period was limited. However, as the ROV moved toward Nafanua, spectacular pillow lavas were observed and noted. One pillow was sampled by the ROV, the first geological sample of the expedition, while Santiago and I were engage in outreach activities (the samples was placed in the portside rockbox): D2_DIVE09_SPEC02GEO

23:42:24. The ROV is transiting toward WP5 so that the youngest volcanic features (i.e., generated since the last mapping cruise in 2012) on Nafanua can be sampled; WP5 is located near the summit of the first and northernmost of the two largest volcanic cones that have formed on Vailulu'u since 2012.

23:43.24. Pillow basalts are observed consistently as the ROV moves along bottom. The surfaces of many pillows show a high degree of vesiculation, and owing to the young nature of the flows (all flows on Nafanua have formed since 1999), it is not surprising that ferromanganese crusts are absent. Light colored and dark (black) colored sediment covers the seafloor between the rock outcrops.

00:09:42. ***The third biology sample of the expedition was taken (a mushroom coral) and a bit of rock was attached.*** The rock was a "crumbly" basalt block, but should be considered for future research purposes: D2_DIVE09_SPEC04BIO

00:15:13 to 00:40:07: The ROV has been moving downslope for the past ~5 minutes, so the ROV is facing water with occasional peripheral views of views of volcanic pillows.

00:40:07. The ROV passed a vertical wall composed of textbook pillow basalt structures.

00:40:15: ROV showing some spectacular pillows. The excessive sediment cover visible on the pillows from the older portions of Nafanua are not present at this site; note that this site is located near the summit of the first and northernmost of the two largest volcanic cones that have formed on Vailulu'u since 2012.

Absolutely beautiful pillows that look like "toothpaste". A really nice pillow feature, likely the leading edge of a pillow, broke off the main pillow structure and constitutes the 2nd geological sample of this dive (placed in the starboard rockbox): D2_DIVE09_SPEC05GEO

01:02:05. We continue to see an abundance of young pillows with very little sediment cover. Additionally, there are few animals on the pillows (and the animals that are seen are smaller) compared to the older pillows observed on Nafanua observed earlier in the dive. Some of the flow surfaces are dark brown, suggesting some degree of oxidation (Fe oxide).

01:10:49. The pillows are among the largest observed by the ROV. The pillows are darker in color than pillows observed earlier in this dive, and they also have less sediment cover. However, the sediment cover in crevasses between the pillows is reasonably thick, possibly several centimeters.

01:32:37. The ROV shows more of the same geological features, consisting of textbook pillows with minimal sediment cover, that were observed earlier in the dive. Again, all the pillows are <5 years in age.

01:45:54 to 2:00:14. The same pillow structures (from the two prior observations) continue to dominate the field of view. At this point the turbidity is increasing significantly.

02:13:21. The turbidity continues to be elevated. The lavas flow morphology and sediment cover has remained little changed for the past hour as we continue along the ridge (the ridge that joins the two largest volcanic cones that have

formed on Vailulu'u since 2012). The lack of significant sediment likely owes to the youthfulness of the structure (<5 Ma) on Nafanua.

02:39:21. There is a much greater abundance of sediment between the pillow structures, which may relate to the higher turbidity on this region of Nafanua. The ROV has been heading slightly downhill for the past 10 or 15 minutes. However, it is also possible that the ROV is now passing over an older portion of Nafanua, and this may help explain the enhanced sediment cover.

03:02:09. The ROV team leader has indicated that the ROV will be heading upslope until the ROV reaches the "south point", which is one of the two volcanic features (we explored the first one over an hour ago, from which the second geologic sample was taken) that has experienced significant volcanic growth in the past 5 years.

03:16:41. The ROV is showing a significant change in the morphology of the flows. Instead of the classical pillow basalt structures, the flows have chaotic "broken" structures that have more of the appearance of "submarine a'a". It is not clear what is responsible for this change in lavas morphology.

03:20:59. The ROV is moving over fresh pillow basalt structures again.

03:34:34. The ROV is now transiting over some of the rough basaltic terrain similar to that observed at 03:16:41. The turbidity is now quite low as the ROV continues to climb higher onto the southern peak (the second peak that has experienced the most significant volcanic growth in the past 5 years).

03:37:38. The ROV has reached the summit of the second large volcanic structure that was generated in the past 5 years. The first of the two large volcanic structures was sampled about 2 hours ago (i.e., the second geologic sample of the dive). The lava is angular, with no clear pillow structures. There appears to be significant orange-colored biological material covering the surfaces of the rocks. A loose portion from this summit basalt outcrop was selected as the third geological sample of the dive. The rock is 20 cm long on the long axis, but the sample broke before it was placed in the starboard box, but two portions of the same rock sample were recovered and placed in the rockbox (both in the starboard rock box):

D2_DIVE09_SPEC06GEO

04:19:37. The ROV has been heading downslope for the past ~15 minutes, and as a result, the view has been of blue water. The ROV is heading for the highest point on Nafanua, a peak that may represent the original summit of Nafanua observed for the first time in 2005.

04:21:58. The seafloor is back in view again. The ROV field of view again shows some spectacular pillow structures. There is some sediment cover. The turbidity remains relatively high.

04:30:50. The ROV moved back downslope again, and the view has been of blue water for the past ~5 minutes as the ROV transits toward the 700+ meter tall summit of Nafanua.

04:38:13. The seafloor has come into view again. The ROV view shows talus composed of large (up to 2 meter wide, estimate) pillow fragments.

04:46:34. Intact pillow flows are coming into view, likely the source rock for the talus blocks below. A darker colored sediment covers the talus and pillows in the field of view.

04:54:16. The surfaces of the rocks have an orange-brown color, suggesting significant hydrothermal alteration. Fresher (grey) surfaces are juxtaposed with the orange-brown surfaces, suggesting a recent disturbance, possibly a landslide. The large degree of sediment cover, in addition to the greater degree of biological diversity and the larger size of the fauna, similar to the location where the first geological samples was recovered; both locations are outside of the regions

suggested to have experienced growth between 2012 and 2017. Thus, the enhanced sediment cover and change in biological communities is consistent with a lack of recent growth on the summit of Nafanua.

04:59:54. The ROV has just summated the highest point on Nafanua. The ROV reached 677 meters water depth at the summit.

The biological perspective is as follows:

Began detecting plume signals in turbidity, oxygen and ORP sensors at ~720m also visible in the main ROV cameras. Slowly tried to descend to the seafloor, however, turbidity was extremely high, and the vehicles could see each other. Turbidity also interfered with the sonar of the ROV. Turbidity values hovering around 11-13 FTU.

Tried to move the ROV up current (very slight current moving from SW to NE) to try to improve visibility by getting out of a possible focused plum. Moved ~100m SE and dropped to seafloor (20:45, 927 m) into the axis of the Moat of Death. Observed lava pillows with a very thick flocculent material cover. Attempted to collect polychaete worm crawling on flocculent seafloor with the scoop, but failed. Proceeded to explore the seafloor for other polychaete worms that may be feeding on fish carcasses in the moat of death. Encountered dead fish with polychaete worms scavenging (21:15, 924 m) and sampled the flocculent material under the dead fish and some of the polychaete worms (20170224 21:25:47, D2_DIVE08_SPEC01BIO).

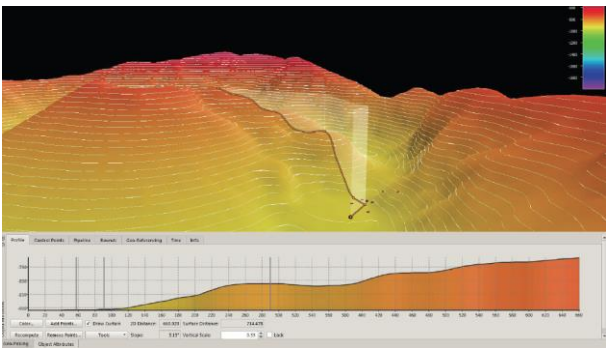
21:30 Brought the ROV off the seafloor to ~700 m to attempt reach the NE peak of the central cone feature in the center of the crater in order to raise above the turbidity plume and improve visibility. The mid-water transit took ~40 min.

Regained view of the seafloor after moving to the top area of the cone at ~700m. Observed several collapsing lava flows. Carnivorous sponges, anemones, and ophiuroids on some of the pillows. Observed an eel at 23:17. Observed abundant small anemones (less than 3 centimeters in diameter on collapsing lava pillows). Also observed *Anthomastus* octocoral and stalked hydroids at 23:39 700 m. Collected stalked hydroid (20170224 23:41:40, D2_DIVE05_SPEC03BIO, 699 m).

Observed larvaceans with house, as well as a large colonial salp pyrosome 22:46 at 705 m. Two eels at 23:48 (C. Young "look like the eels in eel city *Dysommia rugosa*"). Continued to observe more eels, ophiuroids, anemones, *Anthomastus*, and stalked hydroids. Collected *Anthomastus* at (20170225 00:11:10, D2_DIVE09_SPEC04BIO, 702 m).

Went down hill to reach the western high-grounds of the central cone to explore the newer areas 00:19 708. Observed more larvacean houses. Turbidity increased as we moved ~30 meters deeper and towards the east. 00:40 Regained seafloor view as we reached the NE slope of the NW peak of the central cone in the crater of Vailulu'u. Lava flows had much lighter sediment cover. Collected rock (D2_DIVE09_SPEC05GEO, 20170225 00:50:12, 730).

Seafloor on this slope looked younger, with less sediment cover and less orange flock. Observed several sessile organisms, including cladorhizid carnivorous sponges, anemones and solitary hydroids, but all very small in size. Went down a

	slope heading southward after reaching the top most part of the NW peak. Apart from small anemones and cladorhizid sponges there was not much else here. Observed one eel at 02:20 720m. Another eel, lantern fish and thresher shark 02:52 727 m as we moved along southward. Reached the SW peak at 03:38 700 m. Went out of the turbidity layer. Collected a rock, which was likely to be the youngest from this dive. (20170225 03:56:01, D2_DIVE09_SPEC06GEO, 702m). Did a mid-water move after rock collection while we moved to the SE peak of the cone. Observed several larvaceans, a jellyfish, red ctenophore, shrimp, and siphonophores. Re-entered turbidity plume at 04:20 712m. Re-gained visual of the seafloor at 04:22 718 m. Lifted into the water column again and continued mid-water move, observed more jellyfishes and larvaceans. Reached the SE cone at 04:40 733m, observed broken down pillow basalts. Steep slope here. Started observing intact pillow flows intermixed with broken off pillows 04:48 718, continue to observe more broken off pillows intermixed. Observed several <i>Anthomastus</i> corals, larger carnivorous sponges and anemones, as well as hydroids. More abundant communities <700 m larger Anemones, solitary hydroids, sponges. Reached the highest point at 677m 05:07 at which point the dive ended.
Overall Map of the ROV Dive Area	Close-up Map of Main Dive Site
	
Representative Photos of the Dive	

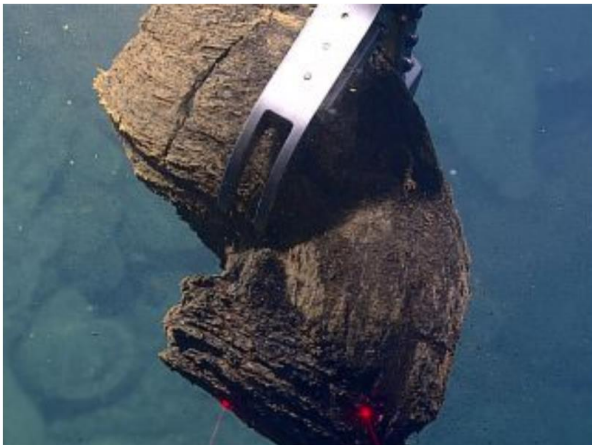
		
EX1702_IMG_20170224T205810Z_ROVHD.jpg	EX1702_IMG_20170225T010340Z_ROVHD.jpg	
Turbid water and flocculent material covering seafloor in the Moat of Death	Lava flows in the newest portions of the volcanic cone, little biological colonization or sedimentation on the newly-formed rocks.	
Samples Collected		
Sample		
Sample ID	D2_DIVE08_SPEC01BIO	
Date (UTC)	20170224	
Time (UTC)	21:25:47	
Depth (m)	925.4315	
Temperature (°C)	5.63332	
Field ID(s)	Flocculent material with polychaete worms	EX1702_IMG_20170224T211943Z_ROVHD.jpg
Comments	Sample is named “D2_DIVE08_SPEC01BIO” in error. Should be “D2_DIVE09_SPEC01BIO”	

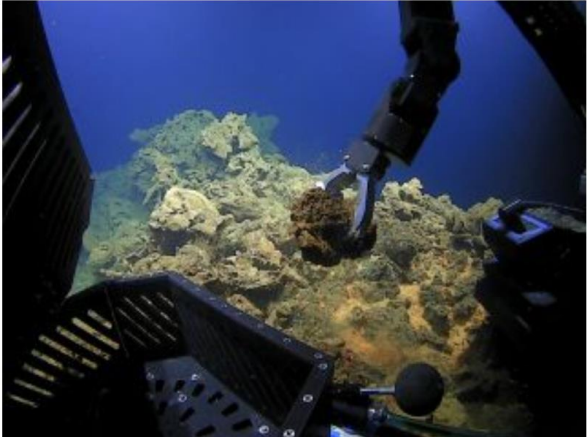
Sample		
Sample ID	DIVE09_SPEC02GEO	
Date (UTC)	20170224	
Time (UTC)	22:54:27	
Depth (m)	709.6877	
Temperature (° C)	5.73246	
Field ID(s)	rock	EX1702_IMG_20170224T225046Z_ROVHD.jpg
Comments		

Sample		
Sample ID	D2_DIVE05_SPEC03BIO	
Date (UTC)	20170224	
Time (UTC)	23:41:40	
Depth (m)	699.7877	
Temperature (° C)	5.76509	
Field ID(s)	Hydroid (stalked)	EX1702_IMG_20170224T233630Z_ROVHD.jpg
Comments	Sample ID “D2_DIVE05_SPEC03BIO” is in error, and should be “D2_DIVE09_SPEC03BIO”	

Sample		
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Sample ID	D2_DIVE09_SPEC04BIO	 EX1702_IMG_20170225T000741Z_ROVHD.jpg
Date (UTC)	20170225	
Time (UTC)	00:11:10	
Depth (m)	701.9167	
Temperature (°C)	5.70339	
Field ID(s)	Anthomastus	
Comments		

Sample		
Sample ID	D2_DIVE09_SPEC05GEO	 EX1702_IMG_20170225T004805Z_ROVHD.jpg
Date (UTC)	20170225	
Time (UTC)	00:50:12	
Depth (m)	730.3365	
Temperature (°C)	5.53999	
Field ID(s)	rock	
Comments	A spectacular pillow lava	

Sample		
Sample ID	D2_DIVE09_SPEC06GEO	
Date (UTC)	20170225	
Time (UTC)	03:56:01	
Depth (m)	702.1822	
Temperature (°C)	5.69937	
Field ID(s)	rock	EX1702_IMG_20170225T035506Z_D2_DIVE09_SPEC06GEO_04.j...
Comments		

Please direct inquiries to:

NOAA Office of Ocean Exploration & Research
 1315 East-West Highway (SSMC3 10th Floor)
 Silver Spring, MD 20910
 (301) 734-1014

