FK171110 30-day Post Cruise Report

1. **Ship name**: Falkor
2. **Cruise Dates - Day Departed**: 11/10/2017
3. **Cruise Dates - Day Returned**: 12/18/2017
4. **Cruise Number**: FK171110
5. **Departure Port**: Apia, Samoa
6. **Arrival Port**: Apia, Samoa
7. **Mid-Cruise Port Call (if any)**: Apia, Samoa
8. **Mid-Cruise Port Call (if any)**: None
9. **Participating Organizations, Institutions, Foundations, Government Agencies, etc.**: SOI, NOAA-OER, NSF, GNS (New Zealand)
10. **Funding Sources**: a. NOAA-OER (direct support to Chadwick, no award number or title); b. NSF-OCE-1538121 to Ken Rubin (PI) title "Temporal/spatial scales of mantle wedge composition and processes investigated with young boninites and basalts from the unusually active NE Lau Basin"
11. **Describe all of the geographical area(s) where the science occurred**: Northeastern Lau Basin and adjacent Tofua segment of the Tonga Arc.
12. **Name of Chief Scientist**: Ken Rubin
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13. **Cruise Objectives**: This was a multidisciplinary expedition aimed at investigating volcanic landforms, how they formed, how they change in time and space, the hydrothermal systems they support, and vent related ecosystems. The study site is arguably the highest density (most volcanoes) active volcanic province known in today's ocean. A

series of tools were assembled along with an expert science team to explore, characterize, evaluate data in real time, and make additional targeted observations of volcanic eruption deposits and at hydrothermal vent sites to study the development of, and interactions between, volcanic landscapes/ecosystems in a site of several dozen active and dormant closely-spaced submarine volcanoes .

On leg 1, we planned to use CTD vertical and transit casts to quantify and locate chemical indicators of hydrothermal activity and the AUV *Sentry* to echo sound the sea bed, take photos of the sea bed, and measure water column properties close to the seabed. Mapping of the study area with *Falkor's* EM302 system was planned, to both increase the extent and quality of existing site coverage and also to identify changes that had happened since earlier mapping efforts (to find areas of recent geologic activity).

On leg 2, the objectives were to examine sea bed features (especially young eruption deposits and vent hydrothermal systems) using ROV SuBastian missions, and to continue nighttime multibeam mapping using *Falkor*. The whole gambit of observations as well as shore-based analysis of physical samples obtained from the sea bed and in the overlying water on the expedition will be used to explore the range of conditions and their driving parameters for geological, biological, hydrologic, and geochemical process in active submarine volcanic sites.

14. **Cruise Summary**: Summary of leg 1 and 2 activities:
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Leg 1:

1. AUV *Sentry* Deployments – 6 dives with data collected, plus 1 engineering dive to test a different sonar.
    a. 2 Deployments at West Mata volcano and 1 that visited East and West Mata volcanoes collected useful sonar data and some photos of the sea floor.
    b. 3 other deployments had faulty or failing sonar, so there is little to no useable sea floor multibeam data. These include deployments at Mata Fitu, Mata Ua+Mata Tolu, and the southwest base of West Mata. We do have photos from those dives.
    c. an autonomous MAPR integrated on the vehicle collected some sea water properties (nephelometry, ORP) which we subsequently used to help localize sites of hydrothermal venting.
2. CTD deployments
    a. two types of CTD package deployments were done. Vertical casts (13 of them) and “to-yo” casts (4 of them) where the CTD package is dragged along a horizontal track and moved up and down in the water column.

3. Multibeam sonar mapping from Falkor.

Leg 2:
1. ROV SuBastian Deployments
a. 21 total deployments at 11 Volcanoes
    7 dives at West Mata
    2 each at Mata Ua, Mata Ono, Mata Fitu, Mata Tolu and Tafu
    1 each at Mata Fa, Mata Taha and 2 large unnamed dacite lava flows)
b. 250 rock samples, 59 sediment samples, 31 sulfide samples
c. 56 Vent fluid samples (of which 24 were for gas)
d. > 470 biological samples
e. 12000 km2 of seabed mapped

2. Multibeam mapping
a. new areas previously lacking MB data in global public databases were mapped on the Tofua Arc/forearc south of Niua and west of the Northeast Lau Spreading Center.

Summary of Leg 1 and Leg 2 findings (preliminary):
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Leg 1.
1. repeat multibeam mapping uncovered a new lava flow near the summit of west Mata volcano, which formed sometime after the last multibeam surveys here by Falkor, in early 2016. We also identified two new lava units that happened in the past 7 years at Tafu seamount on the Northeast Lau Spreading center
2. lava units we were able to map with Sentry at West Mata have very different shapes and textures indicating different eruption conditions
3. no new hydrothermal plumes were identified in the area, but in detail, the chemistry of existing plumes has changed to include more methane and less hydrogen at West Mata, suggesting nothing is erupting right now. Plumes at Mata Ua, Fitu, and Tolu remain strong.

Leg 2.
1. West Mata is the most active volcano in the area (8 to 10 eruptions in last 10-15 years). Diffuse flow systems continue at the summit and new ones are established at two of the most recent eruption sites. There is still no focused flow hydrothermal venting at West Mata
2. Two new eruptions in the last 5 years were discovered and documented at Tafu seamount (NELSC), as well as a diffuse flow hydrothermal site discovered at its summit
3. New active hydrothermal system discovered at Mata Ono, much expanded size of previously-known vent fields at Mata Ua and Mata Fitu, better defined vent field at Mata Tolu, extinct chimneys found at Mata Taha, and no venting observed at Mata Fa

4. Youngest volcanism at Matas Talu and Ua discovered to be on satellite cones, Mata Fa has a wide mixture of volcanic age across several small cones, Mata Taha appears to be the least active (recently) and Mata Fitu is largely tectonized, but with some young volcanism at the eastern base of the summit cone.
5. Large scale production of volcanic sands from explosive phases of volcanism at West Mata and Tafu, sands also discovered and sampled at Tolu, Fa and the large dacites (the dacites also appear to have produced pumice deposits).
6. Large variety in lava eruption styles at most volcanoes, particularly surprising was high flow-rate lavas at West Mata, Mata Tolu and Mata Fitu, and an intrusion into sediment that subsequently erupted at West Mata,
7. Distinct differences in chimney size, shape, ecology and community structure at different hydrothermal vent sites. Vent fluid compositions are broadly similar to what has been observed in the past. Vent fields are located in different areas of the volcano at each site, with only two of them being at the volcano summits (Tolu and Ua).

Logistics summary:
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Roughly 85% of the cruise objectives were met. We were incredibly lucky with the weather (no lost operations and only a few minor delays). All ship's systems worked as advertised, as did SuBastian. Coordination between the two teams (Falkor and SuBastian) was effective and contributed to a successful cruise. The engineering team (ROV+Falkor teams) improved some of the things we were deploying from SuBastian, which was also appreciated. The one major disappointment with respect to SOI equipment was the lack of a working magnetometer. A second major failing on Falkor was the USBL pole used for mission navigation. This was operable or semi-operable for about half of ROV our dives and effectively inoperable for the other half. Dive results collected without navigation data (or with extremely noisy and unreliable navigation data) are significantly less useful in the context of our current study. Our other main failure was with the WHOI AUV *Sentry* sonar system. We did not get usable data on 3 of 6 missions plus a single line on a 4th mission. This had a negative impact on ROV dive execution and has left us without information about the size and overall structures controlling the location of hydrothermal systems at three of the volcanoes we tried to map with Sentry (Fitu, Ua and Tolu). We put 2 ROV dives each into these spots to try to compensate but the ROV data is fundamentally different and does not replace the AUV bathy.

Did you collect Measurements or Samples, including biological specimens? Yes

15. **Did you deploy and/or recover any Moorings, Bottom Mounted Gear, or Drifting Systems?** No
16. **Equipment Used**: 1. ROV SuBastian mixed application dives (probably the most stuff deployed or used on a single dive to date, including manipulators for geo and bio

samples, two types of water bottle samplers activated by manipulator, sediment scoops, suction sampler, temperature probe, sediment depth probe, and open and closed sample baskets. 2. CTD-rosette with large Niskins and associated water filtration system set up in the ROV hangar 3. AUV Sentry with external MAPR fitted 4. Squidle+/SOI data logger 5. Slack workspace for ship-to-shore interaction with shore-based colleagues (worked great but it would be even better if we had a way to periodically share the ROV NAV besides taking periodic photos by cell phone) 6. Live video stream of full dives on FB live and YouTube (huge numbers of participants).