SO-267: ARCHIMEDES I Expedition with RV SONNE

Weekly Report No. 2 (17 to 23 December 2018)

After a week of deploying instruments, establishing watches for the seismic shooting, and successful deployment of GEOMAR's two large G-gun arrays, the first reflection/refraction profile was completed on line BGR2018-203/2R3 (P3). This is the longest of 6 planned seismic lines across the arc-to-backarc transition of the NE Lau Basin. The OBSs were shot at a distance interval of 150 m spacing at 4 kn resulting in a total of 1960 shots (~36 hour deployment). Continuous high-resolution towed magnetics and ship-based gravity were recorded simultaneously. P3 spans the entire history of the southern margin of the Niuafo'ou microplate. The magnetics have revealed old back-arc crust in the west, corresponding to the time of opening of the Lau Basin, while active rifting in the S-FRSC is confirmed by the young volcanic edifices in the rift valley observed in backscatter.

After completing BGR2018-2R3 in the early morning of Monday 17 December, BGR's 4-km streamer (3900 m of active length and 200 m lead) was deployed for the MCS reflection survey (line BGR2018-203). The OBSs were left on the seafloor for the MCS. This was a unique opportunity to shoot the same instruments twice – something that has not been attempted previously on such a long profile. By shooting the same instruments twice, the profiles can be stacked, resulting in greatly improved resolution. The MCS profile was conducted during Monday and Tuesday (~36 hours), shooting every 50 m at 4.5 kn from west-to-east. After a brief interruption to repair 4 guns that were not firing on the starboard array, the MCS was completed on Tuesday evening. Preliminary assessment of the data recorded in the reflection and refraction experiments is very encouraging, with only one out of 50 instruments failing to record. The raw data already show the deep crustal architecture of the basin and arc crust to the Moho.

During the MCS, the sub-bottom profiler (Parasound) revealed a number of 15-20 km wide subbasins in the Niuafo'ou microplate between the FRSC and ELSC. Clear growth faults showed a number of possible fluid channels rising through the sediment from ~80 mbsf. Heat flow measurements were conducted in 3 of the basins, with partial penetration and temperature measurements in 2 deployments; one up to 1.8 m with a successful heat pulse. The calculated heat flow of 62 mW/m^2 is consistent with the regional background.

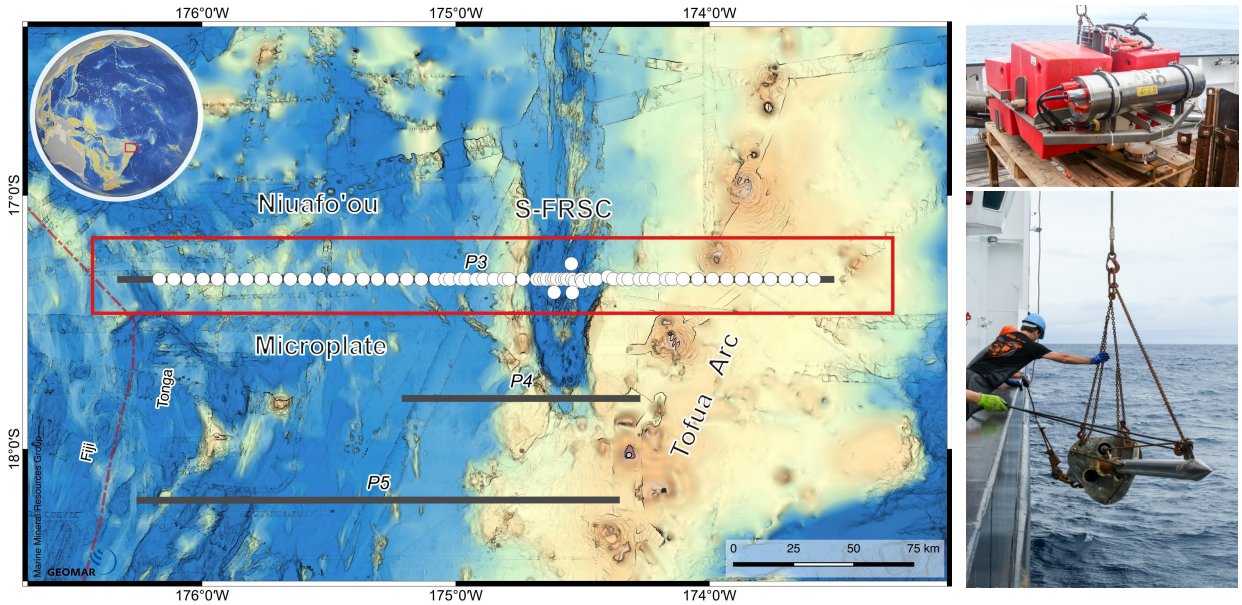
On Wednesday and Thursday the OBSs were recovered from P3. Three instruments were left on the seafloor as part of a microseismicity network that will measure earthquakes down to magnitude 2 on the east and west bounding faults of the S-FRSC, and 17 additional instruments were redeployed north and south of the line to complete the network (approx. 10 x 30 nm). Two additional refurbished OBMTs were also deployed to supplement the 16 already at the seafloor. A total of 33 recovered instruments now cover the aft deck of the ship, ready for deployment on P5 in several days time. The recovery operation was flawless, except for a temporary failure of the ship's transducer, which required the use of a backup for pinging the releasers on the OBS instrument. The ship's transducer has since been repaired.

On Friday morning, 21 December, the program shifted to mapping and sampling of the southern tip of the FRSC. Multibeam and magnetic were carried parallel to P3 en route to the area. In the morning of Saturday 22 December, the first dredging was done on the western wall of the S-FRSC, with successful recovery of arc dacites from 1500-1300 m (upper portion of the wall) and arc basalt from 2300 m (base of the wall), confirming that the western side of the FRSC is old arc crust.

On Saturday, we launched the AUV *Abyss* to map the southern propagating tip of the S-FRSC in two areas on opposite sides of the rift, inferred to be the partially buried extensions of the rift bounding faults. Both areas were flown at an altitude of 60-80 m in sidescan mode and with an onboard magnetometer. During the dive, heat flow stations and gravity coring were carried out in the rift valley. Additional weight was added to the heat flow probe to improve penetration into the sediment. Two deployments recorded temperature data, and the analysis is pending. Five attempts to collect sediment cores were unsuccessful, despite clear sedimentary cover in the Parasound. Gravel and fresh-looking glass shards were recovered in the core catcher at one station; otherwise it appears that the substrate is mostly coarse volcaniclastics, which are difficult to core. We also tested an autonomous sediment sampler provided by Nautilus Minerals, but the device has so far not resurfaced after 8 hours. In the afternoon of Sunday 23 December, we returned to recover the AUV and commenced a second dredging program in the southernmost part of the rift.

During the week, we completed an intensive multiparameter geophysical section of the arc-backarc transition – one of the first of its kind at this scale. The entire scientific crew of 39 participated around-the-clock in the deployment of the instruments and monitoring of the data acquisition, including building and tear-down of the OBSs and OBMTs, recording and analysis of the hydroacoustic data, deployment and maintenance of the air guns, streamer and magnetometer, and continuous daylight mammal watches. All together more than 1300 person-hours were invested in the line, highlighting the intensity of the work and the dedication of the team and the ship's crew.

With best regards and Christmas Greetings from RV SONNE,
Mark Hannington and Heidrun Kopp



***Left*:** Location of the 300-km long seismic line P3 (BGR2018-2R3) crossing the volcanic front of the Tofua arc, the southern Fonualei Rift Spreading Centre (S-FRSC), and the arc-to-backarc transition of

the Niuafo'ou microplate. Symbols indicate the locations of 50 OBS and 18 OBMT stations deployed during week 2. ***Right*****:** One of 50 OBSs deployed on P3 and the 3-m probe used to determine heat flow in the sediment-filled sub-basins.