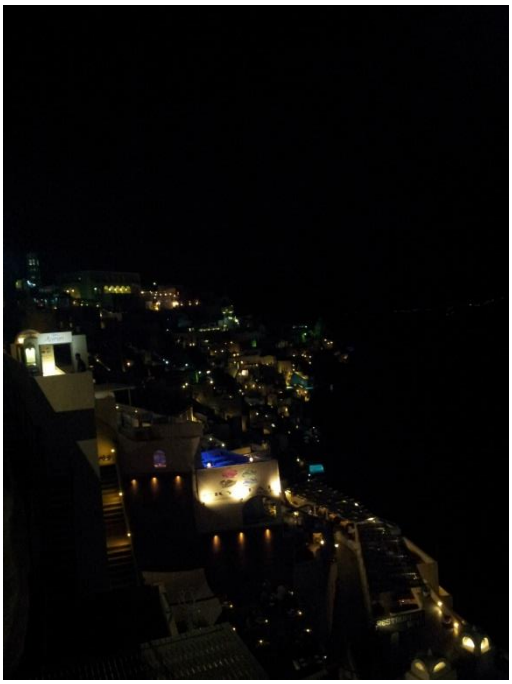
Katie Wilkinson Scholarship Report.

An Investigation into the Chemistry of Hydrothermal Fluids at Palea Kameni, 'Red water bay' Hot Springs (Santorini, Aegean Sea).

By Richard Hughes.

Figure 1 Red water Bay. The sampling point for my water collection.

An overview of the fieldwork

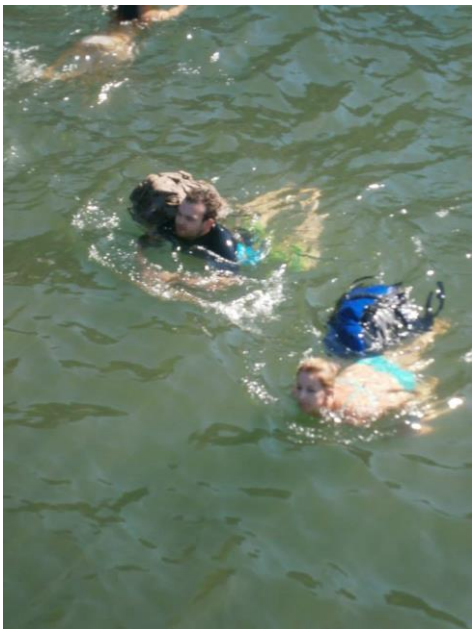


On the 31st of August 2013 we embarked on our journey to Santorini from Heathrow, London. However one did not simply fry direct, as it was significantly cheaper to travel to Athens and then catch a boat ride to Santorini. This lead to the short, one night stay in Athens on the 31st of August to the 1st of September. Traveling down from Athens airport to the port where we had booked a hostel for the night, it became clear how beautifully bleak the landscape was, with its barren dusty landscape. Upon arrival at the port we swiftly made our way to the Hostel where we were greeted by true Greek hospitality, which made us feel very welcome. After a short sleep we awoke

at 3am to catch our boat across to Santorini. The boat trip was 16 hours long so we knew we could catch up on our sleep then, however this did not happen, with the 30 degree heat it was hard to sleep up on deck so instead site seeing was the main priority, taking in the island landscape. Later that day we were greeted by the beautiful sites of Santorini, with Thira town taking pride of place on the flanks of the caldera wall. On arrival we disembarked of the ship and was greeted by a member of staff from villa Manos to take us up to the hostel itself. Once at the hostel we unpacked and braced ourselves for the next day where we would head to the research site on a reconnaissance visit to make sure the site was accessible and safe enough to work at.

On the 2nd of September 2013 we set of from Thira harbour on a boat to take us off to the sampling site 'A' on the central island of Nea Kameni. The boat ride was smooth although I did experience some sea sickness. After the 25min travel time we reached Nea Kameni. To get to the summit of the volcano involved a 30-40min hike up steep paths covered in volcanic debris. The landscape was a mixture of black and grey lava flows, these flows were rocky in nature, however the well-trod path allowed for relatively easy access to the summit. At the summit it soon became apparent the site 'A' was going to be inaccessible with, with large boulders in the lava flows on the decent down to the bay and a large ravine it would have taken 2 hours to get down to the site and 2 hrs to get back. With only having 4 and a half hours on the island each day it would have been impossible to sample this site. Thankfully I had planned for this and had selected a 'plan B site' on Palea Kameni, the small island to the west of Nea Kameni where hydrothermal springs were present but less active.

On the 5th of September myself and my research assistant Sarah Crowe once again embarked on a short voyage across the caldera to Palea Kameni this time (my plan b site) at Red water bay, via boat. Within the bay to access the hydrothermal spring area we had to disembark of the boat, into the water and swim 200m to the sampling site, with 100L rucksacks on this was quite a challenge, however we rose to this challenge very well and began sampling on that day at 1:30pm. When a vent was found, Acid cleaned, 250ml bottles were washed out 3 times in the seawater, they were then sealed, submerged and opened above the vent for water collection. After collection these bottles were sealed and removed to the shore. To ensure the bottles were water tight they were then wrapped in insulation tape, and labelled for future reference. This sampling continued every 10 minutes for a 2 hour and 20 minute window. At every 10 minute window sea level change was also collected using a ruler, placed on the sea bed. 30 water samples were collected in all as I took 2 samples at every interval in case any of the bottles were damaged in transport. As our boat arrived at 3:50pm we packed out bags and prepared for the swim back. The swim was hard with full rucksacks, but after all the efforts of getting the samples we were not going to give up easily, and made it back to the boat in 15 minutes.



On the 19th of September after the geosciences field course had ended we managed to bring my samples back in my own suitcase and the suitcases of many of my course mates, after being denied shipping due to the nature of the samples, even though I had been assured by Hellenic post beforehand that is was not going to be a problem.

The main findings of the Project

The principle aim of this project was to establish if there was a link between hydrothermal fluid concentration of; sodium, magnesium, calcium, strontium, sulphur, manganese, iron, nickel, copper, chloride and sulphate with tidal changes on the islands at Santorini. To measure the concentrations of sodium, magnesium, calcium, strontium, sulphur, manganese, iron, nickel, and copper ICP-OES was used, which is a type of analytical chemistry apparatus. To measure Chloride and sulphate IC was used which is again a type of analytical chemistry equipment. Once the data was collected it became quickly apparent that once these measurements were plotted on a graph against tidal changes that most of them did not show any correlation. However the results for manganese and sodium showed a high concentration at low tide and low concentration at high tide. These results are most interesting. At most hydrothermal systems high tide showed the highest concentrations as gravitational forces which expand the Earth allow for the opening and expansion of cracks in the rock and greater exchange of fluids in the plumbing of the hydrothermal system. My results give evidence of a contrast to this theory coined by Tadokoro et al. (2000). When copper was plotted against tidal data there was evidence of a phase lag. A phase lag is caused by the Earths tides being dampened by the friction which occurs within the Earth.

Another point of interest comes from the changes in the zoning of iron and manganese in red water bay. During my analysis I found that manganese was recorded at a concentration of 22.35ug/l and iron was recorded at 8.02ug/l. this was significantly lower than the expected values of 1198ug/l for manganese and 13476ug/l (Varnavas and Cronan, 2005). To determine how the zoning had changed I adapted an image of the 1973 zoning from Smith and Cronan (1983) and drew on the new observed zoning. As you can see from the picture below there has been a significant change in the areas were the concentration of both iron and manganese should be higher.

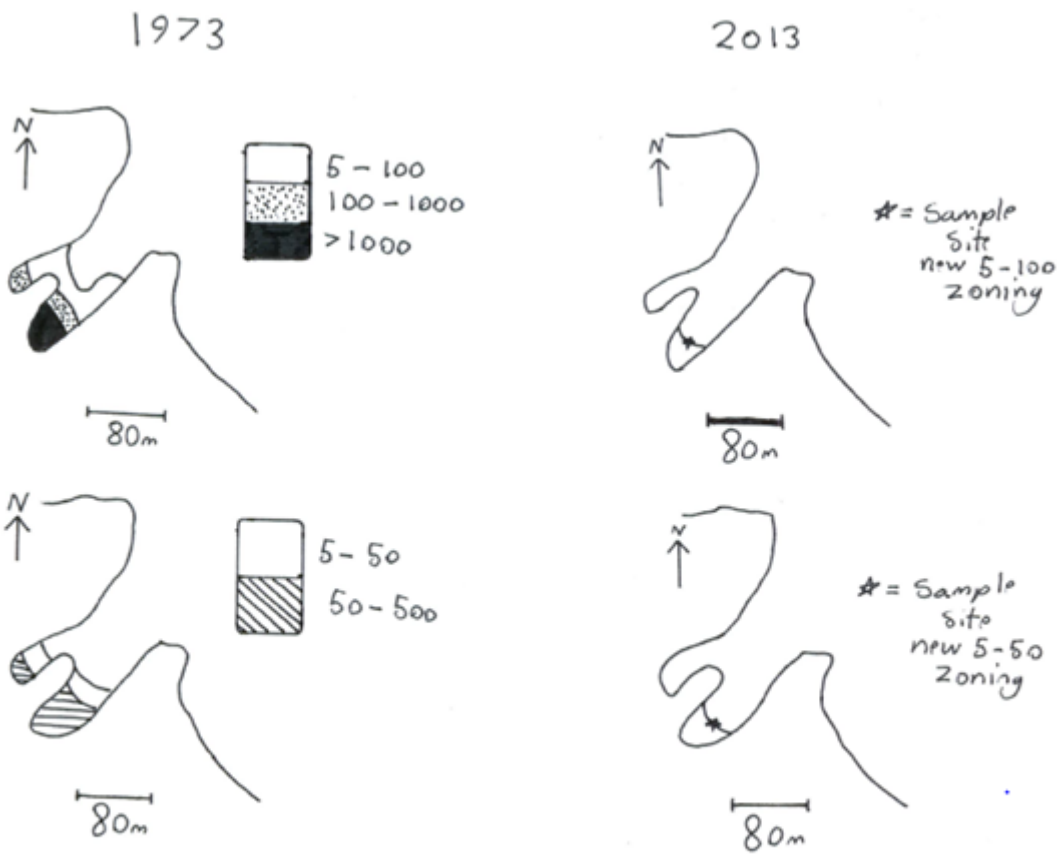


Figure 19 A map of Red water bay, showing the change in zoning of Iron (top images) and manganese (bottom images), from 1973 – 2013. It shows the zoning of moth dissolved metals moving to the southwest, into the bay, between the two dates. (ug/l). Adapted from Smith and Cronan, 1983.

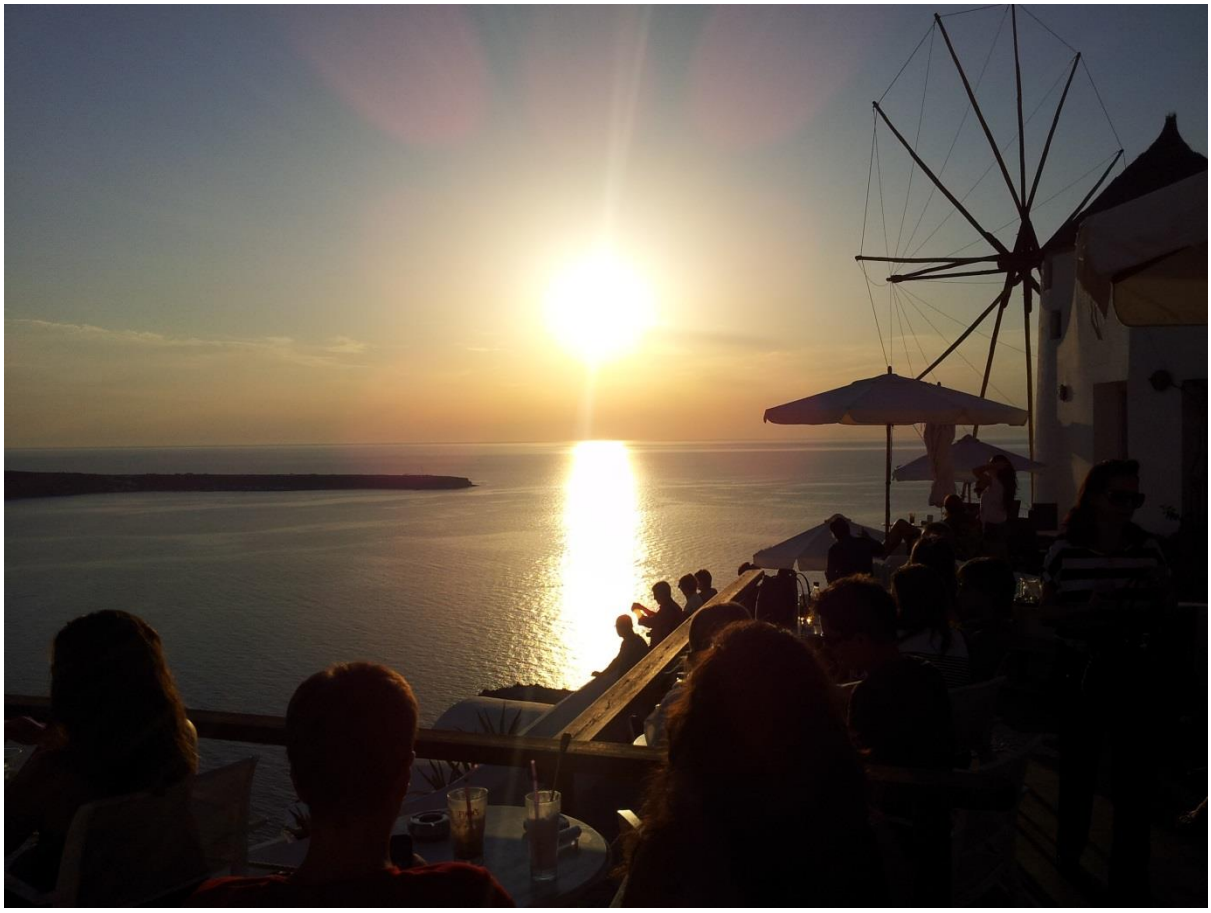
The reasoning for these lower than normal concentrations of Iron and manganese may be just that on this day the discharge from the vents were lower than normal, as these vents are known to be less active than its sister vents at Nea Kameni. However another reason for the low concentration may come from the presence of chemo-synthesising bacteria in the muds around the vents. These bacteria synthesis iron and manganese in their respiratory process, fixing them into the mud as a waste product. If the population of these bacteria has increased in the muds then this may offer an explanation for the lower concentrations.

Copper concentration was another one of the main findings in this study. Its concentration way 35.5ug/l, this concentration is the highest ever recorded at Santorini. There is no proven hypothesis to explain this. However during late 2011 to early 2012 there was a huge magma injection under Santorini volcano, this may have added a new enriched heat source for the fluids circulating in the plumbing system of the vents. This increased temperature of the fluids

would mean that copper is able to stay in solution for longer allowing for higher concentrations to be ejected at the vent. This is a possible explanation for the higher concentration of copper.

I know thank the Katie Wilkinson Scholarship for the contribution towards this amazing, once in a life time experience. During this trip it allowed me to really sink my teeth into real science, I loved every moment of it. It may have thrown up a few challenges but I came out of them even stronger than ever, removing every obstacle in my path to achieve the goal of completing my study, and putting this money to good use. Once again thank you so much I am incredibly grateful for this money which led to this amazing part of my life.

A few snaps.



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