Gas venting from the seafloor between Vladivostok, Russia and Nome, USA RUSALCA Leg 1
Acoustic and atmospheric measurements

Anatoliy Astakhov, Boris Li, and Maxim Ivanov
V.Il'ichev Pacific Oceanological Institute, Vladivostok, Russia

Our program aimed to establish the flux of water and gas via hydrothermal vents from the Kurile Volcanic Arc seafloor (specifically Piips volcano), through the water column to the atmosphere above. In addition, samples of the volcano were collected for petrological analysis. To carry out this program, we:

- collected acoustic imaging of the water column and seafloor (continuous along Leg 1 of the RUSALCA cruise track and over Piips volcano);
- carried out sampling of mercury in the air and water along the entire Leg 1 cruise track;
- monitored meteorological conditions(wind speed and direction, pressure, temperature etc;
- sampled rocks and sediments on Piip submarine volcano.

Acoustic Monitoring: To acoustically image the water column and bottom layers we used an ELAC echosounder. The acoustic imaging was carried out during the entire Leg 1 of the RUSALCA expedition (10 days). Gas flares erupting from the seafloor were detected in many locations near the Kurile and Kommandorskiy Islands (of the Aleutian Arc) (Fig. 1).

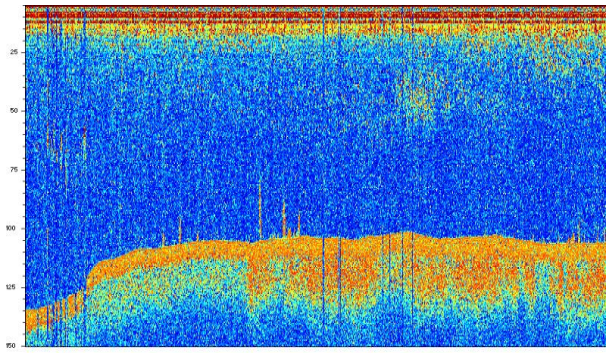

Figure 1. Acoustic images of gas (methane) flares emanating from the north-eastern shelf of the Kurile Islands, (North-West Pacific)

The most substantial gas flare was detected rising from the summit of the Piips Volcano (at a depth of 360 m) to the sea surface. (Fig 2). Other members of the Professor Khromov scientific party sampled within and adjacent to the Piip gas plume using a SeaBird CTD and rosette system.

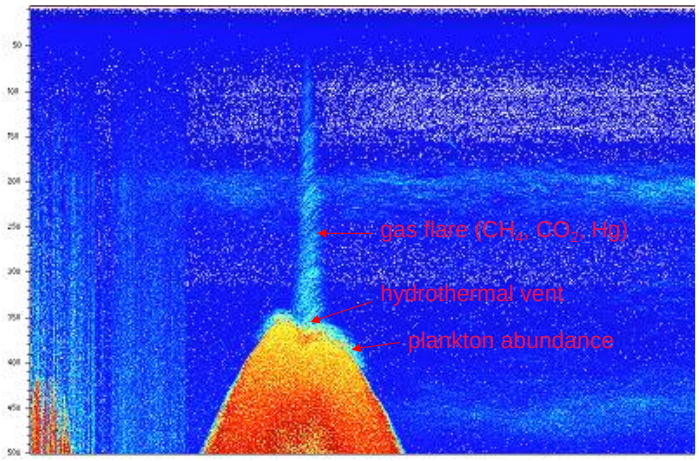

Figure 2. Acoustic image of water column and gas flare venting from the northern peak of the of the Piip Volcano, Aleution Island Arc, Bering Sea

Mercury flux Our team was uniquely set up to monitor the flux mercury from the volcano to the atmosphere above. To analyze the atmospheric samples, we used a mercury Zeeman atomic absorption spectrometer with high frequency modulation of light polarization RA-915+ (manufactured by Lumex Ltd, Russia) for direct on-line measurements of the mercury concentration in air. The use of the Zeeman background correction and a multipath analytical cell provides high selectivity and sensitivity of measurements. Therefore, analyses can be carried out with the low detection limit (0.1 ng/l) in real time.

To perform a measurement, the spectrometer is placed on the top deck in the front part of the ship. Air flows continuously through the analytical cell. The blank signal is regularly checked by passing the gas through a special filter with the Hg-adsorption efficiency of 98-99%. The mercury concentration is measured once per second and is processed by a computer with a simultaneous data display. Occasionally, a simple device is mounted upstream of the instrument to separate the gas from water.

We sampled the concentration of Hg in air 840 times during Leg1 of the RUSALCA expedition from Vladivostok, Russia to Nome, Alaska (Fig. 3). Atmospheric monitoring of mercury along this leg track revealed high concentrations in the Japan Sea near the Asian coastline (2.8 ng/m^3). By contrast, Hg in air values in the Okhotsk and Bering Seas averaged 1.6-1.7 ng/m^3.. The very high level of Mercury concentration detected during this investigation over the Japan Sea is a likely reflection anthropogenic sources from mainland Asia and matches the analyses made by *A.P.Dastoor and Y. Larocque [2004].*

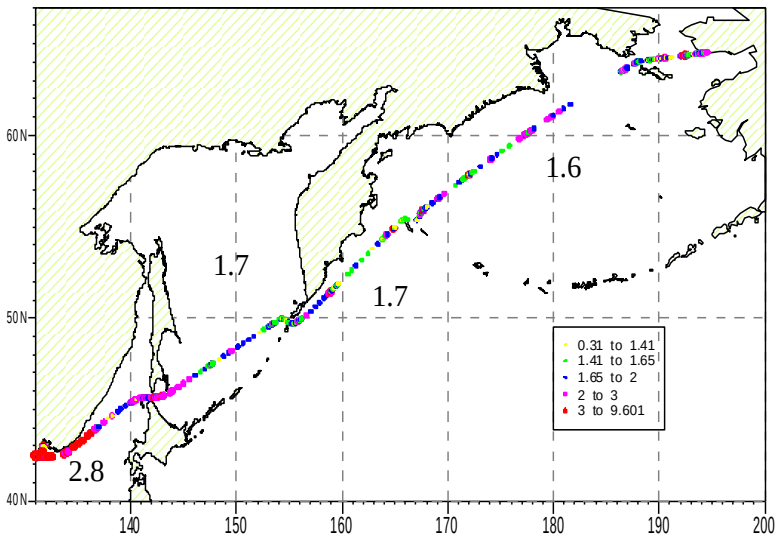

Figure 3. Mercury content in air (ng/m^3)
Leg 1, Vladivostok – Nome, RUSALCA cruise, July 22 – August 5 2004. Numbers on the map show average Hg contents in air at sampling stations along the RUSALCA ship track.

Local atmospheric Hg anomalies in excess of 15 ng/m^3 were detected after the ship crossed through the La Perouse Strait, the body of water that separates Sakalin from Hokkaido Islands (and Russia from Japan) (Fig. 4). This body of water lies just to the east of a plate boundary that separates the Amur and the Okhotsk Plates, The strait is characterized by volcanic seafloor shallower than 60 m in some places. In this location a fast warm water current pours from the Sea of Japan into the Okhotsk Sea, probably driven in consequence to the sea level differences between these two bodies of water. Because we have no mercury in water data for this area it is not certain if the very large atmospheric anomalies are a consequence of outgassing of volcanically or hydrothermally active seafloor below or are related to atmospheric conditions which may be related to the oceanography in the regions.

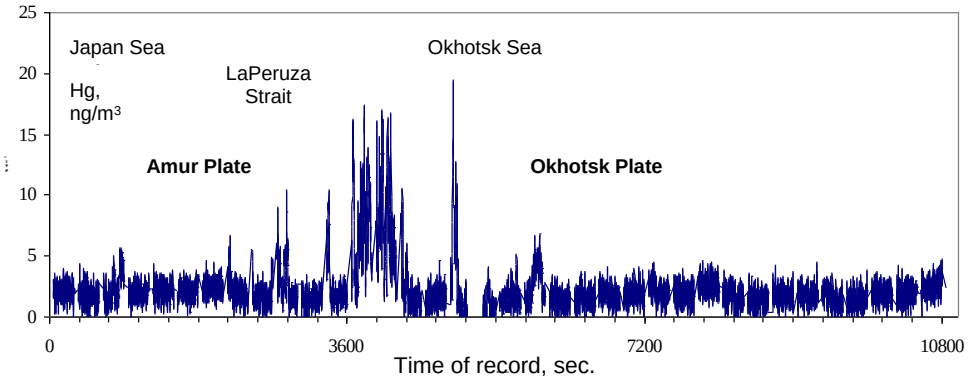

Figure 4. Mercury in air signature measured during RUSALCA Leg 1 The Boundary separating the Amur Plate from the Okhotsk Plate (between the islands of Hokkaido and Sakahlin) is the locus of high Hg concentration.

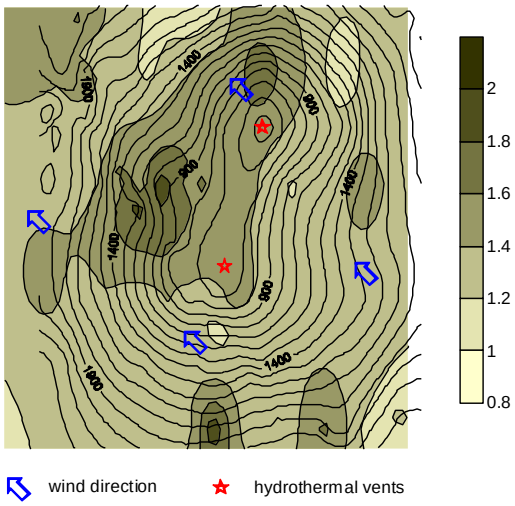

Figure 5. Mercury content in air (ng/m^3) above Piip Submarine Volcano (isobaths in m)

An additional Hg in air anomaly was detected at the boundary of the Pacific Ocean with the Bering Sea over and adjacent to the Piip Submarine Volcano, which lies at a depth of 360 m near the Kommondorskiy Islands. Acoustic data illustrated clearly that a gas plume rises from the crest of the volcano to or near the sea surface. Data were collected as the ship carried out seafloor investigations of the Piips Volcano. The contoured data illustrate that Hg in air accumulates in a lobate shaped region with two high Hg focal points (with concentrations in excess of 2 ng/m^3) situated just to the north west of the two submarine peaks (the loci of hydrothermal vents)(Fig 5). Wind velocity and direction information are superimposed and illustrate that the source of the Hg anomaly is most likely from outgassing of the volcano below and then blown to the northwest (Fig. 5).

From the Piips Volcano on the Aleution Arc (the southern boundary of the Bering Sea), the Hg in air concentration averaged 1.7 ng/m^3. At a longitude of –167.6 degrees west, between St. Lawrence Island and Nome, Alaska, the concentration increased to greater than 4 ng/m^3 (Fig. 6).

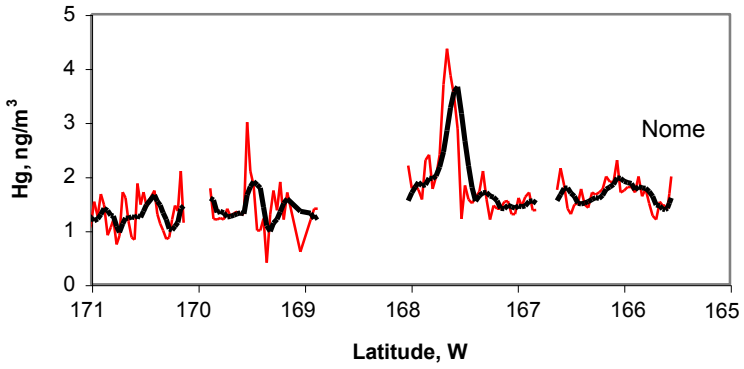

Figure 6. Mercury content in air of 5-minutes averages (red line) and trends (black line) in the northern part of RUSALCA Leg 1, North Bering Sea.

Reference: Dastoor A.P., Larocque Y. 2004. Global circulation of atmospheric mercury: a modeling study// Atmospheric Envir. V. 38. P.147-161.