Micro-scale sensor array-enabled hot spring mapping

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Micro-scale temperature and electrical conductivity sensor arrays were fabricated. The linear temperature array consisted of 15 temperature sensors with separations of 1 cm. The linear conductivity array consisted of 5 conductivity sensors with separations of 1 cm. Both arrays were deployed in hot springs at Yellowstone National Park, USA. At one site, two geochemically different hot spring outflow channels converged. One channel was acidic (pH ~3.3, temperature ~36 °C, conductivity ~900 μS/cm). The second channel was alkaline (pH ~7.8, temperature ~60 °C, conductivity ~4200 μS/cm). Where the two streams mixed, visually distinct bands of photosynthetic pigments were observed that were not seen elsewhere in either stream.
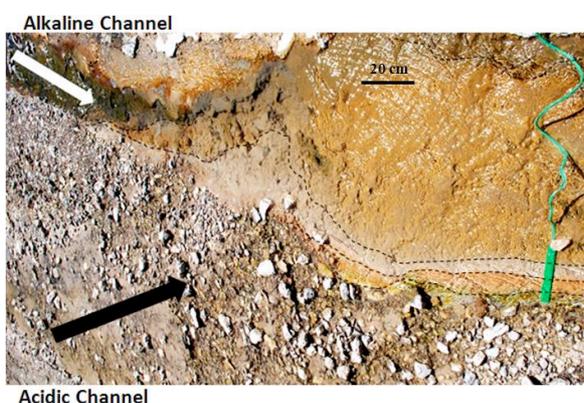

Figure 1: Photograph showing the confluence of two hot spring outflow channels. Where the alkaline channel (top – white arrow) and the acidic channel (bottom – black arrow) mix, bands of color are observed. The location between colors is assisted with dashed lines.

More than 700 temperature and 90 conductivity measurements were taken within the mixing zone using the arrays. Extremely high spatial resolution mapping of temperature and conductivity in the mixing zone was performed. The temperature color map traces out distinct regions that match the shape and width of many of the photosynthetic pigment bands. Furthermore, the temperature data were used to predict the conductivity at a higher sampling density than was measured, providing a new technique for mapping conservative constituents at high spatial resolution in mixing zones.

Development of ETV-MC-ICPMS technique for W isotope analysis

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Hf-W chronometer is based on the negative beta-decay of r-process nuclide ^{182}Hf to ^{182}W with a half-life of 8.9 ± 0.1 Myr [1]. Hafnium is strongly lithophile elements, whereas W is moderately siderophile elements, and therefore, it has been well recognized that the Hf-W age provided critical information about the timing of metal-silicate differentiation (core formation) processes at the early stage of the planetary formation. Moreover, both the Hf and W is strongly refractory elements, the Hf-W age can reflect the timing of condensation or segregation of the metallic nuggets from chondritic reservoir at the early sequence of the solar system.

In this study, we have developed a new sample introduction system using an electrothermal vaporization (ETV)-MC-ICPMS technique in order to measure the isotope ratio from ng-amount of W. Compared to the conventional nebulization sample introduction technique, the ETV technique has significantly higher sample introduction efficiency. ETV-ICP technique has been accepted as a one of the most powerful tool to measure the small sample sizes[2]. With the conventional ETV system, despite the better sample introduction efficiency could be achieved, signal stability for the refractory elements, including W, was deteriorated. To obtain stable signal intensity profiles for W isotopes, He, instead of Ar, was used as carrier gas.

In our experiments, W sample in 0.5 - 1.0 μL of 2wt% HNO_3 solution was loaded onto a Re filament. The filament was set into the small glass chamber (~25 mL), and then, temperature of the Re filament is controlled by the incident current (0 – 4 A) under the He gas. W signal was observed at ~1100°C. Compared to Ar gas environment, W signal stability was dramatically improved under the He gas condition. W standard solution (JMC22841) was measured several times, and the obtained ^{182}W/^{184}W ratios were 0.864691 ± 0.000024 from 75 ng W (n = 9) and 0.864693 ± 0.000044 from 25 ng W (n = 9) (corrected using exponential law using ^{186}W/^{183}W = 1.9859 [3]). In this presentation, ^{182}W/^{184}W ratios obtained from meteorite samples will be discussed.

[1] Vockenhuber et al. (2004) Phys. Rev. Lett., 93, 172501. [2] Nixon et al. (1974) Anal. Chem., 46, 210-213. [3] Kleine et al. (2004) Geochim. Cosmochim. Acta, 68, 2935-2946.