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# Lutao Hydrothermal Field: a Tidal-influenced System Temporarily Cooled by a Tropical Storm

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**Abstract:** The Lutao hydrothermal field is an intertidal arc-volcanic system located offshore southeast Taiwan, hosting a Zhudanqu (ZDQ) vent and a Huwaichi (HWC) spring with strongly contrasting fluid chemistry. Low Mg, moderately enriched chloride, and $H^+$ with respect to seawater indicate that the ZDQ endmember was derived from the brine phasethat was formed during low-degree subcritical phase separation. In contrast, the endmember for the HWC vent fluids must be related to the vapor phase. Temperature and pressure of the phase separation were estimated as ~ 150 °C and ~ 5 bar, respectively. The water/rock ratio was calculated as about 2.

The Lutao hydrothermal system was slightly affected by semi-diurnal tides, either by tidal loading, or tidal currents, or a joint effort of both (Fig. 1). The active circulation period of the

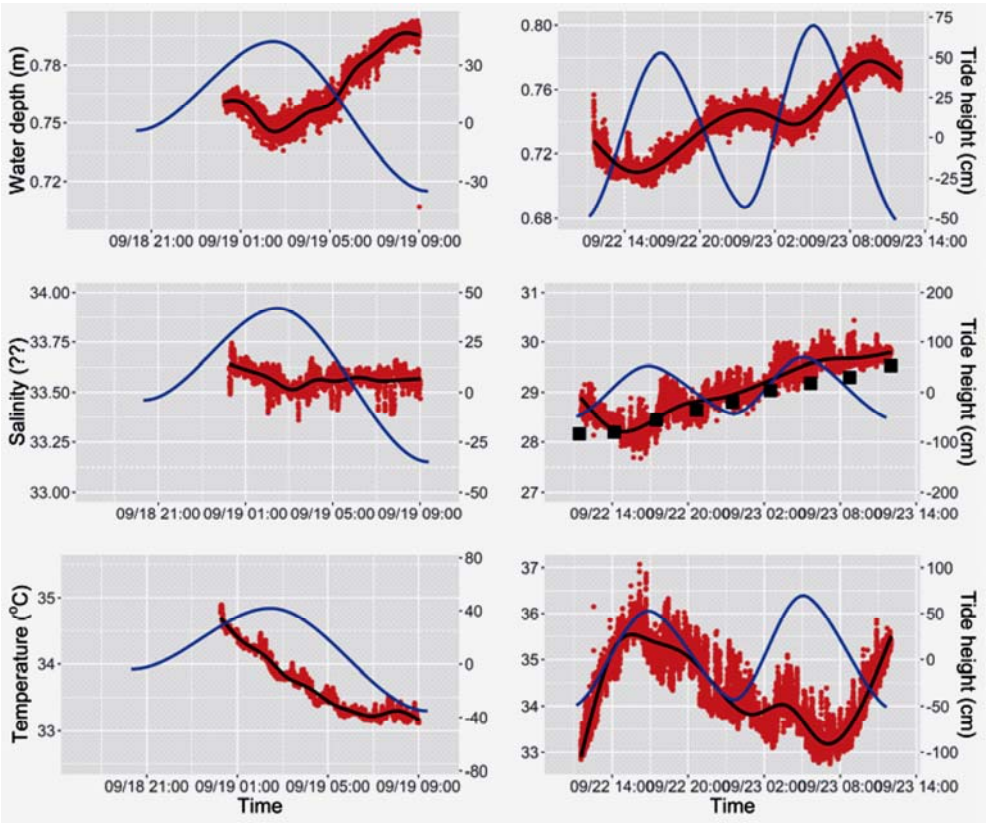


Fig. 1. The pressure, salinity, and temperature of the HWC pool water recorded by a Castaway CTD during Sep 18th and Sep 23th, 2014.

The salinity was calculated from the measured conductivity according to the 1978 Practical Salinity Scale. The smoothed lines following a generalized additive model (gam) method using R package 3.5.1. The tidal heights were obtained from the Central Weather Bureau of Taiwan and were shown in spline curves (blue lines). The black cubes indicate the salinity of the HWC vent fluids.

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Lutao system was about 3 h according to the time delay of its response to tides. While freshwater was almost absent in the HWC vent fluids at normal conditions,the typhoon Fung-wong that attacked the island on Sep 21st, 2014, led to intrusions of freshwater into the vent fluids with a percentage of ~ 16%. Both the ZDQ and the HWC endmember compositions showed some changes after the typhoon event, suggesting a cooling of the reaction zone (Fig. 2). Presumably, the seawater was cooled by the tropical storm by 2-5 $^{o}$C which consequently quenched the reaction zone and declined the degree of phase separation. After the typhoon passing by, the hydrothermal system began to recover, evidenced by increasing percentages of the HWC endmember and decreasing freshwater contributions. The flux of the HWC endmember was estimated as ~ 500 L $h^{-1}$ based on these observations. This study, for the first time, reports a shallow-depth hydrothermal system that was cooled by a tropical storm and affected by tides.

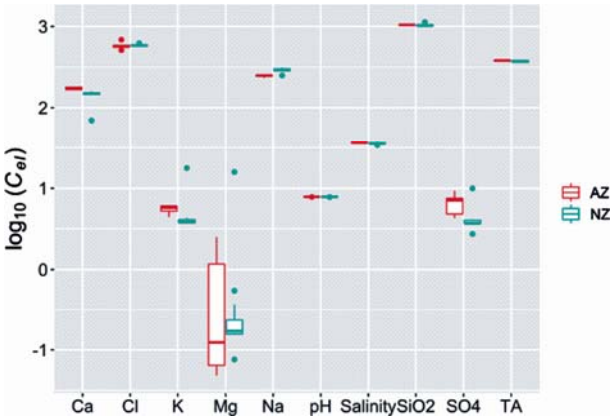


Fig. 2. The measured chemical compositions of the ZDQ vent fluids collected after the typhoon event (AZ) and at normal conditions (NZ).

**Key words**: Hydrothermal vents, Tide, Typhoon, Phase separation, Fluid chemistry

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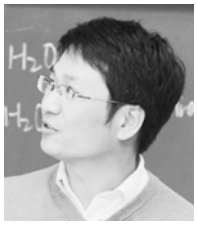
## About the first and corresponding author



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