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Giant pockmarks in Lake Neuchatel (Switzerland): new evidence for sublacustrine karst groundwater discharge

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Four giant lacustrine pockmarks (80 to 160 m in diameter) are located along the northern shore of Lake Neuchatel adjacent to the karst system of the Jura Mountains and in the extension of tectonic faults. Two of the four pockmarks are characterized by a ∼60 m deep sediment suspension representing the liquefied lacustrine sediment succession connecting the pockmark surface to the karst system in the Mesozoic bedrock. The other two pockmarks exhibit a funnel shape without sediment suspension.

Here we present new evidence for presently active sublacustrine karst groundwater discharge. A Remotely Operated Vehicle (ROV) with a HD camera, a 360° sonar, and equipped with a probe logging temperature and electrical conductivity was deployed at three of the four pockmarks. At all studied locations anomalies in temperature and electrical conductivity characteristic for groundwater were registered when cruising just above the suspension-lake water interface (lutocline) or in the interior of one of the funnel-shaped pockmarks. In addition, the surface of the sediment suspensions were covered by mini mud volcanoes (approximately 0.2 to 1 m in diameter), indicating that groundwater is indeed penetrating through the lutocline.
Furthermore, in June and September 2017 the sediment suspension was sampled at depths of 2, 12, 26 and 41 m for sedimentological and hydrochemical analyses. The density of the sediment suspension increases from ∼1.2 g/cm3 just below the lutocline to ∼1.5 g/cm3 in 41 m depth, and the sand fraction also increases with depth. Both observations suggest that the sediment is kept in suspension by a vertical fluid flux from below. The hydrochemistry (major ions, stable water isotopes) confirms the presence of groundwater. In addition, the sediment suspension was characterized as anoxic with O_2 concentrations of ∼0.1 mg/l and dissolved ferrous iron (Fe(II)) concentrations of 77 μM.

After active sublacustrine groundwater discharge could be confirmed, the quantification of the groundwater flux into the lake via the pockmarks is envisaged by installing a monitoring system. This data will be interpreted in close combination with hydrological changes in the Jura Mountains. In addition, the sediment suspension will be further investigated for its microbiological gene pool, and the age of the groundwater will be evaluated using noble gases allowing us to better constrain the origin and flow path of the groundwater reaching the pockmarks.