Porewater salinity: the key to reconstructing 250,000 years of Lake Van's history

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The sediments of Lake Van in Eastern Anatolia (Turkey) are a valuable climate archive. Now, using the salinity measured in sediment porewater, scientists have reconstructed the huge lake-level fluctuations that occurred over the past 250,000 years. This approach – based on simple physical concepts – is likely to be more widely applied in the future.

In 2010, an international research team collected sediment cores from the bottom of Lake Van in Eastern Anatolia. Since then, scientists at Eawag and the Universities of Bern, Bonn and Istanbul have used core samples to reconstruct 600,000 years of climatic and environmental history. The sediments of Lake Van – a waterbody seven times the size of Lake Constance, with no outflows and remaining ice?free even during ice ages – provide a record not only of seasonal changes but also of volcanic eruptions, earthquakes, and extended glacial and interglacial (warm) periods, as well as other environmental data. Lake Van is the world's largest soda lake. With a salinity (salt concentration) of approximately 23 grams per litre and a pH of 10, its water can be (and is, by local communities) used directly for washing.

Fluctuations of more than 300 metres

Further light has now been shed on the lake's history by a group of scientists led by Eawag and the University of Bern. Based on variations in the salinity of porewater extracted from sediment cores, major changes in lake level over the past 250,000 years have been reconstructed – ranging from 200 metres below to 105 metres above the current lake level. In the study, published in Nature's Scientific Reports, the authors explain the essentially simple principle underlying their analysis: as the amount of salt dissolved in the lake, in absolute terms, remains constant, the salinity of the lake water is inversely

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proportional to the volume of water in the lake basin. Because the morphometry of the basin is known, once the water volume has been calculated, the lake level can also be determined. Two major lake-level increases (248,000 and 135,000 years ago) and one major decrease (30,000 years ago) were thus identified. Earlier lake-level changes could not be determined, as the measurements in older sediments reflect the long-term steady-state lake salinity.

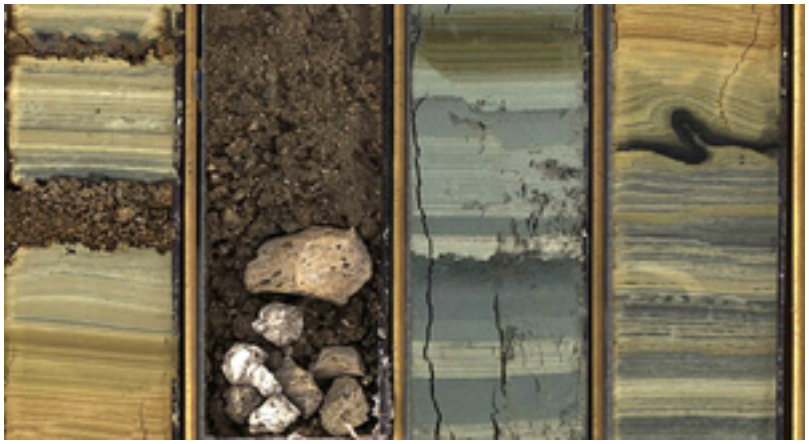
Periods of freshwater conditions

The lake levels estimated using porewater salinity are in agreement with other indications, such as lake terraces still visible high above the current lake surface, or erosive channels now submerged. Previously it was not possible for these structures to be precisely dated, as the lake lies within a highly active tectonic zone – at the junction of the Eurasian, Afro-Arabian and Persian plates. When the lake was at its highest level, there must have been an outflow into the Tigris, in the southwestern part of the basin. As salt was thus exported, salinity must have declined sharply – a finding supported by other evidence, e.g. the occurrence of unbroken shells of freshwater mussels in lake terraces.

Insights into past climatic conditions, but not the future

As the water balance of Lake Van is mainly controlled by river discharge and evaporation, the lake?level reconstruction also provides insights into past precipitation regimes in the lake catchment. Not far from the lake is Mount Ararat, where Noah’s Ark is supposed to have come to rest after the biblical flood. First author Yama Tomonaga comments: “We cannot, of course, identify individual wet years or decades, but changes that lasted for ten thousand years are evident.”

Unfortunately, Tomonaga adds, no conclusions can be drawn from the study as to whether the lake level is likely to rise or fall in the future. The authorities in Van would welcome a projection, as the lake level has risen by around two metres since 1960 (see chart). However, Tomonaga emphasizes the fascinating prospect that the straightforward methodology and the model developed for this study could also be applied to other landlocked salt lakes, such as the Caspian Sea. Indeed, if the ocean is regarded as the Earth’s largest closed-basin system, the model offers a completely new approach for estimating – at least in an order-of-magnitude approximation –the oceanic salinity balance and average global sedimentation rate.



Each 20-centimetre core section reflects up to 400 years of Lake Van’s history. The fine, brown-beige layers are typical seasonally laminated sediments.

Porewater is extracted from samples by squeezing at a pressure of up to 170 bar.

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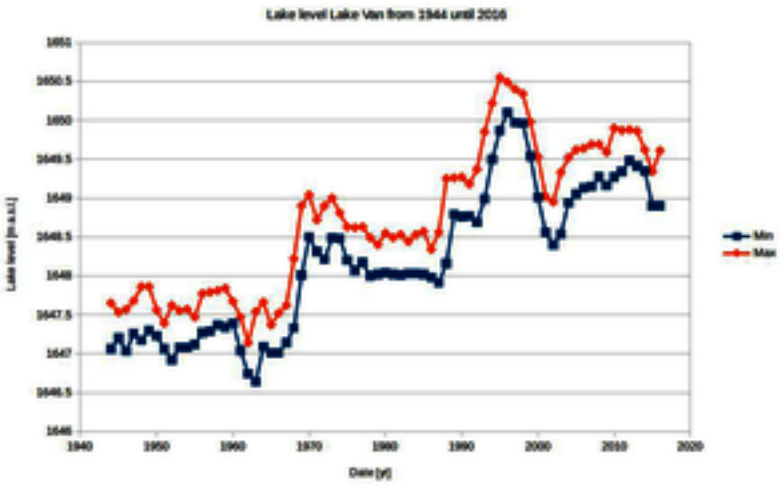
Drilling platform on Lake Van (2010). The volcano Mount Süphan (elevation: 4058 metres) can be seen in the background.



The level of Lake Van has been rising since 1960, by around 2 metres to date – enough to cause problems for the airport and a military site near the earthquake-hit city of Van (population: 350,000).

Map created with Generic Mapping Tools (GMT) version 5.3.0.

Original publication

Porewater salinity reveals past lake-level changes in Lake Van, the Earth's largest soda lake. Yama Tomonaga et al.; Scientific Reports 7, Article number: 313 (2017); http://dx.doi.org/10.1038/s41598-017-00371-w

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