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Facies characterization based on physical properties from downhole logging for the sediment record of Lake Van, Turkey

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ABSTRACT

Lake Van (Turkey) is the 4th largest terminal lake in the world and is located at a key position for climatic reconstruction. The ICDP project 'PALEOVAN' is a deep-drilling campaign initiated in the summer of 2010 to enhance the understanding of paleoclimatic and paleoenvironmental conditions in the Middle East for a period of 550,000 years. Multiple coring of two sites (Northern Basin and Ahlat Ridge) at a water depth of up to 360 m has been performed. The sedimentary record is mainly composed of clayey silts and tephra deposits that were supplied by four volcanic sources: 1) the Süphan volcano, located on the northern shore, 2) the Nemrut volcano, 15 km west of the westernshore, 3) the Incekaya volcano, on the southwestern shore and 4) intralake eruptive centers. The dominant chemical composition of the volcanic sources is known from studies of land deposits.

High-quality downhole logs have been acquired from both sites. To construct a continuous lithological profile, 180 m of downhole logging data from the Ahlat Ridge have been analyzed by cluster analysis. To improve the differentiation of the sediments, two elemental intensity profiles from x-ray fluorescence core-scanning (calcium and zirconium) performed on the composite profile core material were added to the cluster analysis. Five cluster units were derived and transformed into three tephra and two clayey silt units.

To compare the two clayey silt units with the composite profile from the visual core description (VCD) that showed 15 lithological units, the composite profile was classified into two major groups of lacustrine sediments: banded clayey silts (interpreted as glacial deposits) and laminated clayey silts (interpreted as interglacial deposits). Despite this simplification, no correlation between the two clayey silt units derived from cluster analysis and the banded and laminated clayey silts could be found. The following reasons are proposed: (a) the comparability of the datasets was limited by significant depth shifts of up to 2.5 m between the composite profile based on the VCD and the downhole measurements in hole 2D of the Ahlat Ridge, (b) a correlation was difficult to ascertain from the vertical resolution of the downhole logging data and the extremely detailed core description in mm-scale, (c) mixed signals were obtained because of prevailing thin layers and intercalations of different lithotypes and (d) cluster analysis was difficult to perform because the contrast within the input data is too low (possibly background sedimentation) to distinguish between glacial and interglacial deposits.

Tephra units are characterized by contrasting properties and differ mainly in their magnetic susceptibility, spectral gamma ray components (uranium, thorium and potassium) and XRF-intensities of calcium and zirconium. Tephra units have been linked to the dominant volcanic composition of the deposited tephra layers and partly to the volcanic sources. Depth trends are derived with prevailing basaltic deposits in the bottom part (128 m–210 m below lake floor) and are gradually outweighed by the highly differentiated (dacitic and rhyolitic/trachytic) products towards the top of the record.

1. Introduction

Lake Van in eastern Anatolia, Turkey, is the 4th largest terminal lake (surface area >3500 m^2) and the largest soda lake worldwide, with the soda-characteristic likely controlled by volcanic CO_2-input into the lake (Degens et al., 1984). This lake is

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located at the transition between prevailing arid and humid areas; therefore, it is sensitive to climatic changes, which have been recorded in the hydrological system and are evident in the lake-level terraces around the lake (Landmann et al., 1996; Litt et al., 2009).

Extensive studies that included shallow coring and surface geophysics were started in the 1970s. These cores (length of 8–9 m) document that the Lake Van record has sediment with a high (annual) resolution during at least the last 15 ka (Landmann et al., 1996).

A drilling campaign was initiated in the summer of 2010 by the ICDP project 'PALEOVAN' with the objective of enhancing the understanding of the paleoclimatic and paleoenvironmental conditions for a period of 500,000 years in the Middle East. A site at the Ahlat Ridge (AR) and at the Northern Basin (NB) have been multiple cored. Nevertheless, the core recovery after combining all the cores amounts to 91% and 71%, respectively.

When coring into unconsolidated sediments and an incomplete core recovery occurs, downhole logging is of extremely high value because the only possible method of reconstructing the complete record is by lithological interpretation of continuously recorded downhole logging data. This is especially true for the challenging sedimentary record of Lake Van, which consists primarily of clayey silts and tephra deposits. The low stability of these tephra layers leads to low core recovery in the vicinity and thus produces gaps in the core record.

In this work, a dataset of downhole logs has been acquired and interpreted. The objectives of this work are to identify the lithological units and their borders, interpret the lithological properties and their links to sediment characteristics and fill in the gaps for sections without adequate core recovery (e.g., thick tephra layers).

We have focused our interpretation on the downhole logging data acquired at the AR site for several reasons: 1) it is the longest drilled sedimentary section in the lake, 2) the sedimentary record covers the longest time frame and is assumed to be continuous, 3) the AR site is the main focus of the PALEOVAN project and the evaluations are the most detailed and 4) compared to the NB site, the AR site has additional downhole logging data, which favors the success of the lithological reconstruction.

2. Regional setting

Lake Van is situated between the Black Sea, Arabian Sea and Red Sea (38° 38′ N, 42° 54′ E) and its age is assumed to exceed 550,000 years (Cukur et al., 2013). The lake is located in the Bitlis thrust zone and the tectonic setting is influenced by underthrusting of the northwards moving Afro/Arabian plate with the Anatolian/Eurasian plate (Litt et al., 2009). The lake basin is the eastern continuation of the Muş Basin and is separated by the Nemrut volcano (Cukur et al., 2013). The basin of Lake Van formed from the tectonic setting and fills a depression within this active fault system (Litt et al., 2009). The region is still tectonically active,

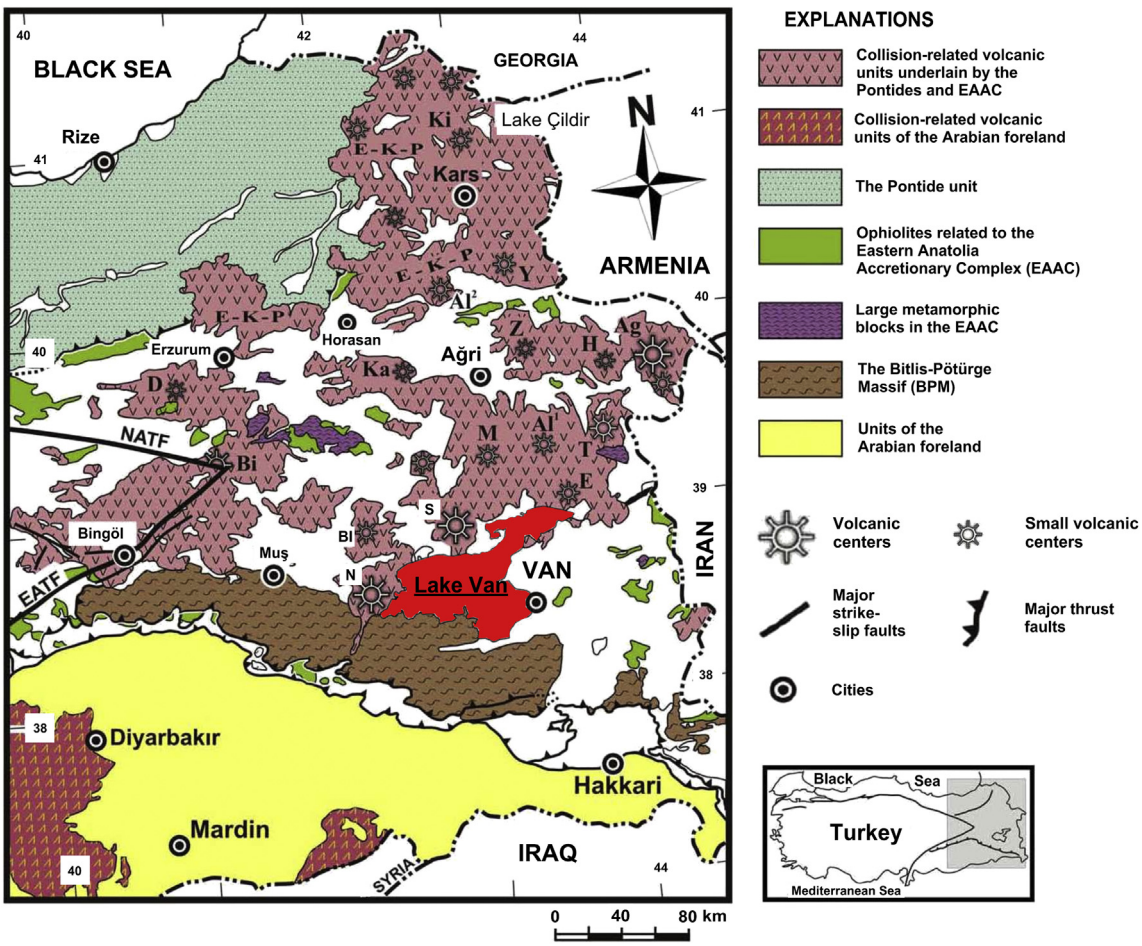

Fig. 1. Geological map of the area around Lake Van (modified after Litt et al., 2009). Several volcanic centers are marked. N – Nemrut volcano, S – Süphan volcano, NATF – North Anatolian Fault, EATF – East Anatolian Fault.

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