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Medieval fan aggradation in the wetland fringe of Lake Shkodra, Albania

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ABSTRACT

The analysis of sediment cores and auger holes from the wetland fringe of Lake Shkodra were used to interpret Late Holocene shoreline fluctuations in northwestern Albania. Dry bulk density, organic carbon, magnetic susceptibility, particle size determination, sediment composition, X-ray diffraction, and AMS ^{14}C dating provide the basis for interpretation. The Kir River may have sourced the 50 km^2 Late Pleistocene-Holocene Shtoj alluvial fan at the terminus of the 372 km^2 Kir River drainage basin on the western slopes of the Bjeshkët e Namuna Mountains. However, the Kir River has not transected the fan since at least the first century BC. The vertical succession of facies in sediment cores from peat to lacustrine clay and then to over 1.1 m of alluvial silt and sand documents an expansion, then contraction of the lake to its current size after 1390 cal yr BP. Sand influx off the fan is attributed to sheetflow, rill, or gullying related to increased anthropogenic activity across the fan during Medieval time. Archaeological surveys support abandonment of hill fort dwellings for the plain around 500 CE. Since 1390 cal yr BP, the Lake Shkodra shoreline has fluctuated at least 1.5 km to the east of the present shoreline.

1. Introduction

Lake Shkodra has received considerable attention in recent years. It is the largest lake in the Balkan Peninsula and was declared a wetland of international significance in both Montenegro (1995) and Albania (2006) (RAMSAR, 2016). It was also declared a Managed Natural Reserve by the Albanian government in 2005 (Dedej et al., 2010). In an effort to better understand the history of Lake Shkodra and climate in the Balkan region, significant multi-proxy research has been conducted on a suite of lacustrine sediment cores from Lake Shkodra that date back 4500 yr.

The multi-proxy analyses conducted on Lake Shkodra cores have yielded a wealth of valuable paleoclimatic and paleoenvironmental information. However, these studies are based only on lacustrine cores and do not fully account for geological processes occurring on the shoreline of Lake Shkodra.

Mazzini et al. (2015) cite historical documents that support the formation of Lake Shkodra between the fifth and fifteenth century. A fifth century road map of the Roman Empire featured only wetlands, but in two accounts related to sieges of Shkodra written in 1474 and 1479 the existence of a lake was noted. Results from two cores, SK13 and SK19, yielded the bulk of the information and are summarized here (Fig. 1). Core SK 13 was primarily carbonate-rich silts comprised of calcite and quartz with trace amounts of dolomite (Zanchetta et al., 2012). Core SK19 featured carbonate-rich silt, clay, silty clay, and gyttja. The clay mineralogy in core SK19 contained chlorite, illite, and kaolinite clays (van Welden et al., 2008). No sand was reported in any of the lake cores. Sulpizio et al. (2009) identified four tephra layers in core SK13 and five in SK19 which aided in determining a 0.2 cm yr^{-1} average rate of sedimentation. The most recent tephra was produced during the Somma-Vesuvius, 472 CE Pollena eruption.

Based on an increase in the occurrence ostracoda and decrease in the occurrence of Characeae, Mazzini et al. (2016) placed the transition from wetland to permanent lake at 1200 cal yr BP. Palynology by Sadori et al. (2015) reported a decrease in riparian vegetation at 1300 cal yr BP and an increase in pollen associated with both *Pediastrum* an aquatic algae, and cultivated *Olea* and *Castanea* (olive and chestnut) trees after 1200 cal yr BP. The increase in *Pediastrum* is closely correlated with a decrease in the C/N which reflects higher concentrations of N flux to the lake likely related to an increase in pastoral activity.

Zanchetta et al. (2012) completed $^{18}O/^{16}O$ ratio analyses on bulk carbonate sediment throughout core SK13. Results indicate an approximate 130 yr wet interval beginning at 4400 cal yr BP, and a 500 yr interval beginning at approximately 2500 cal yr BP. Four relatively wet phases were identified at 1800–1500, 1350–1250, 1100–800, and 90 cal yr BP.

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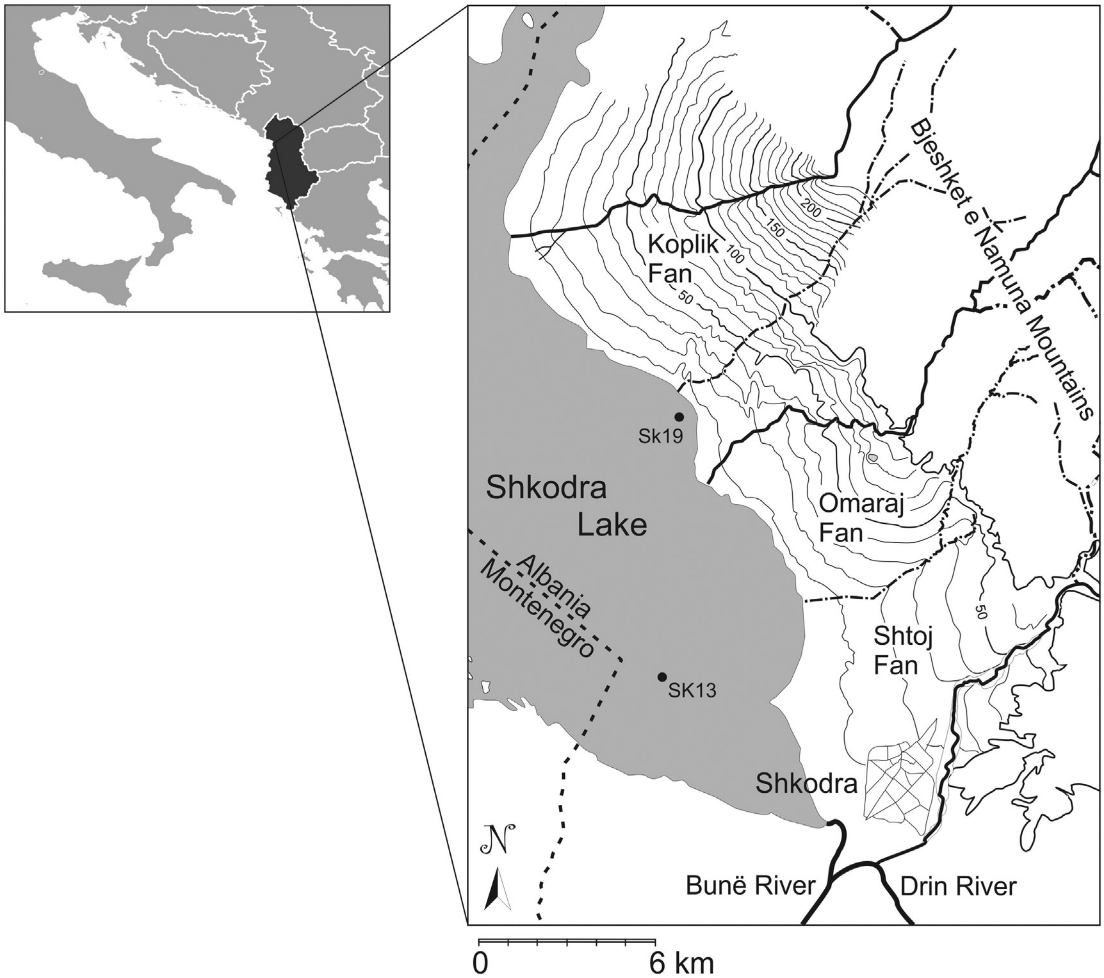

Fig. 1. Regional map with fan names, contours, and location of lacustrine cores taken from Lake Shkodra.

physical analyses of multiple sediment cores, auger holes drilled in the distal margins of the Shtoj alluvial fan in the fringing freshwater wetlands of Lake Shkodra. One 1.4 m deep trench was also excavated in the mid fan area. Between 2010 and 2014 PASH surveyed 2518 tracts over 16 km^2 northeast of Shkodra, Albania. The project documented 93 prehistoric tumuli on the proximal zone of the Shtoj alluvial fan 5 km east of the village of Shtoj and several large settlements in the foothills ringing it.

The geological and geomorphic objectives include correlating fan stratigraphy to the sedimentary record established in Lake Shkodra and integrating the sedimentary record with evidence for historic land use on the fan using indicators such as magnetic susceptibility (MS), dry bulk density (*dBD*), organic carbon content (OC), sediment composition by X-ray diffraction (XRD), particle size distribution, and ^{14}C Accelerator Mass Spectrometry (AMS) dating.

2. Study area

The eastern shore of Lake Shkodra features three alluvial fans (Koplik, Omaraj, and Shtoj) that have formed the western slopes of the Bjeshkët e Namuna Mountains in northern Albania (Fig. 1). The Pleistocene and Holocene age Shtoj alluvial fan is the smallest of the three and associated with the Kir River watershed. The northern half of the Shtoj fan is dated as Pleistocene and the southern half dated as Holocene (Xhomo et al., 2002). A distinct promontory on the coast of Lake Shkodra is visible 10 km WSW of the debouchure of the Kir River at an elevation of 60 m asl. The current course of the Kir River displays an anomalous shift southward approximately 3 km ESE of the village of Shtoj midway across the fan. The Shtoj fan is separated from the Omaraj fan to the north by a small fan created by the catchment basin of the Vrakës River.

The catchment areas of the Thatë, Rrjollit, and Kir rivers are primarily composed of Late Paleozoic and Mesozoic schist, radiolarite, cherty limestone, sandstone, conglomerate, and dolomite (Xhomo et al., 2002).

Lake Shkodra is 45 km long and 15 km wide with an average depth of 5 m (Zanchetta et al., 2012). The lake's average surface elevation is 5 m above sea level. The present Lake Shkodra watershed incorporates 5500 km^2 in Montenegro and Albania. The primary surface inflow is via the Morača River in Montenegro with annual discharge over six times the volume of all other rivers currently entering Lake Shkodra. Precipitation ranges between 2000 and 2750 mm annually (Keukelaar et al., 2006; World Bank Group, 2013). Despite abundant precipitation, the Thatë, Rrjollit, and Vrakës rivers discharge to Lake Shkodra is seasonal and often negligible. The River Bojana (Buna) is the only surface outflow for the lake. The River Drin joins the Bojana from the east, 2.8 km from Lake Shkodra. The Kir River joins the Drin 1.3 km upstream of the Drin's confluence with the Bojana. The combined Drin and Kir watersheds include over 14,500 km^2 in Albania and Kosovo. Frequent back flooding occurs on Lake Shkodra because the outflow of water from the lake is impeded during periods of high runoff or increased discharge from three hydroelectric dams in the Drin River basin (World Bank Group, 2013). The complex hydrology, due to the convergence of multiple watersheds in such close proximity to the outflow of the lake, causes the average lake elevation to fluctuate up to 3.3 m per year (1950–1984 average). The water level variations can correspond to an annual change in lake area from 350 to 500 km^2 (Keukelaar et al., 2006).