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Recent hydrological variability and flood events in Moroccan Middle-Atlas mountains: micro-scale investigation of lacustrine sediments

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Scientific context and objectives

Since the 1990s, the Mediterranean basin undergoes an increase in extreme precipitation events and droughts likely to intensify in the XXI century (IPCC, 2013). Regional climate models indicate a strengthening of flood episodes at the end of the XXI century in Morocco (Tramblay et al, 2012). To understand the recent hydrological variability in North Africa, our study focuses on geochemical and microsedimentological analysis of a short sedimentary sequence from Azigza lake (Fig. 1; 2). This endoreic lake is located in the Middle Atlas karst system.

Limited data on past lake level changes during the last decades are provided by Gayral & Panouse (1954), Flower et al. (1989) and Flower & Foster (1992). To refine our knowledge of past hydrological changes in this region, the first objective is to reconstruct high and low lake levels throughout the last hundreds of years. The second objective is to detect and count flood events.

Methods

1- Geochemistry (XRF) and mineralogy
- X-ray fluorescence (XRF)
- X-ray diffraction (XRD)
- Backscattered electron microscopy (BSE)
- Optical microscopy
- X-ray fluorescence (XRF)
- SEM and energy dispersive spectroscopy
- Flatbed transparency scanner

Results

Figure 5: Geochemistry (XRF intensity) VS lake level changes

- TOC %
- CaCO3 %
- Mn
- Ti
- K
- Si (1 cm)

Discussion and perspectives

Lake level changes during the past hundred years are recorded in the geochemistry and the microfacies of the sedimentary sequence. High lake level facies (Fig. 5a, Facies 1) is deposited when lake shorelines are closer to the vegetation line and steep slopes (Fig. 1). This facies is characterized by light brown sediments, less organic/more minerogenic (Fig. 5, 25 cm depth), with several erosive structures and calcite shells of ostracods (Fig. 6a, Facies 1). Its geochemical signature is defined by higher Si, K, Fe and Ti that indicates more detrital input. Since (1) Si covary with K (Fig. 5, PCA), and since (2) sands are poorly present in the sediment (Fig. 4), we interpret the Si signal as indicator of the finest detrital fraction (clays and fine silts) brought by superficial runoff (SEM-EDS images of silty quartz are available in Figure 6b, Facies 2). Flood events are marked by Mn peaks, which is interpreted as manganese oxides precipitation under well-oxygenated deep water after flood events. Facies 1 is deposited during periods of higher precipitations (Fig. 5).

Lake levels after the 1950s are associated with lower lake levels (Fig. 5b). This sediment is characterized by a higher Mn and lower K content compared to the high lake level facies. It is deposited after flood events, which slow down the lake level. Facies 2 is deposited during periods of low precipitations (Fig. 5).

These results demonstrate the high potential of Azigza lake to help understanding the past hydrological variability of the Middle-Atlas. Indeed, its water level and hydrosedimentary system are sensitive to rapid (floods), as well as long-term (dry and wet periods during several decades) changes in the precipitation regime. The two meters-long sedimentary sequence, recently retrieved from the deeper basin, would allow the reconstruction of the hydrological variability of Azigza lake for the past few hundred years.