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To cite this version:
Guillaume Jouve, L. Vidal, Rachid Adallal, E. Bard, Abdel Benkaddour, et al.. Recent hydrological variability and flood events in Moroccan Middle-Atlas mountains: micro-scale investigation of lacustrine sediments. European Geosciences Union, Apr 2016, Vienne, Hungary. hal-01875548

HAL Id: hal-01875548
https://hal-univ-tlse2.archives-ouvertes.fr/hal-01875548
Submitted on 1 Oct 2018

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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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Methods

1- Geochemistry
    - XRF and mineralogy
    - X-ray fluorescence
    - X-ray diffraction - 30 kV and 25 mA - 15 s time exposure - Resolution: 500 µm

2- Microsedimentology
    - Thin sections (acetone exchange technique)
    - SEM and energy dispersive spectroscopy
    - Flatbed transparency

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

Results

Figure 6: Microsedimentology

a. Facies 1: sediment rich in wood and calcite shells, with several erosive structures.

b. Facies 2: homogenous sediments composed of autochthonous calcite and quartz grains

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. 6a, Facies 1) is deposited when lake shorelines are close to the vegetation line and step slopes (Fig. 1). This facies is characterized by light brown sediments, less organic/more mineralic (Fig. 5, 25 cm depth), with several erosive structures containing wood fragments and calcitic 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 supercritical 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 lower precipitations (Fig. 5), low lake level facies (Fig. 6b, Facies 2) is deposited when shorelines are close to unmovable bank slopes, Fig. 1: This facies is represented by homogenous sediments composed of autochthonous calcite and quartz grains, with substantial decreases in the XRF detrital proxies (Si, K, Ti and Fe, Fig. 5). Autochthonous calcite is not revealed in the CaCO3 and Ca-XRF signal because calcite shells of ostracods are highly present in Facies 1. Facies 2 is deposited during periods of lower 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 hydrochemical system is sensitive to rapid (floods), as well as slower-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.

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 (T rehabalby et al, 201). 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 hundred years. The second objective is to detect and count flood events.

Results

Figure 4: Laser diffraction grain size distribution

Lake photographs, available in Fig. 3

Figure 7: Mineralogy (XRD)

Major peak calculations: Calcite: 45%; Quartz: 38%; Dolomite: 10%, Aragonite: 3%, Kaolinite: 2%; Pyrite: 2%, Illite: 1%; Gypsum: 0.5%