Crater palaeolakes in the Tibesti mountains (Central Sahara, North Chad) – New insights into past Saharan climates

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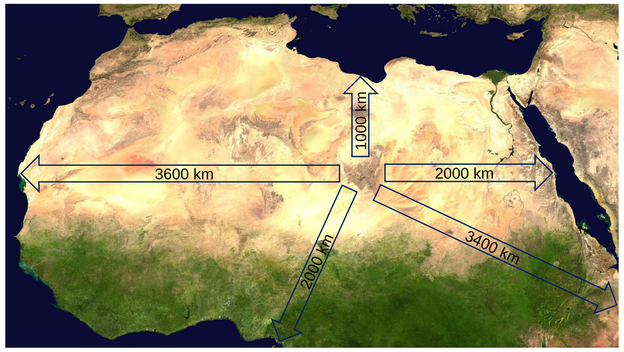

Fig. 1: Satellite-composite of N-Africa and the hyper-continental position of the Tibesti Mountains.

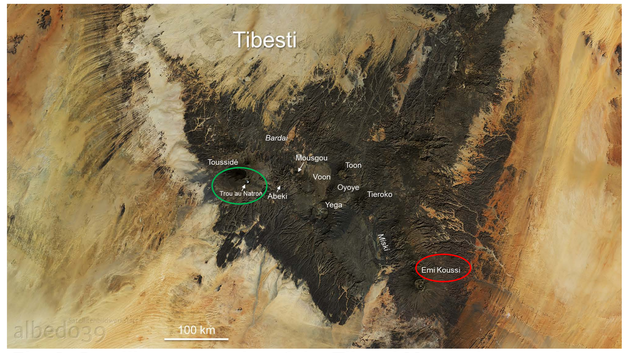

Fig. 2: Satellite-composite of the Tibesti Mountain complex with the sampling sites Trou au Natron and Emi Koussi.

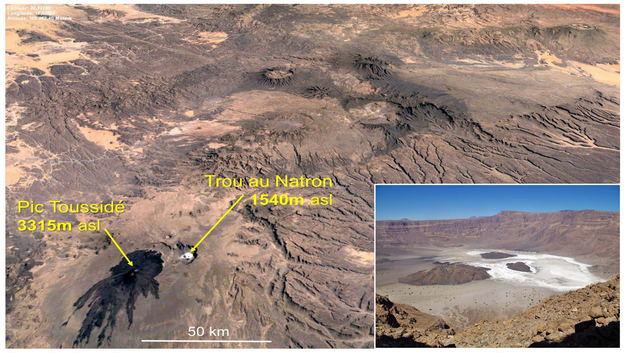

Fig. 3: Pic Toussidé with Trou au Natron, Western-Tibesti Mountains. The inlet photo shows the caldera of the Trou au Natron.

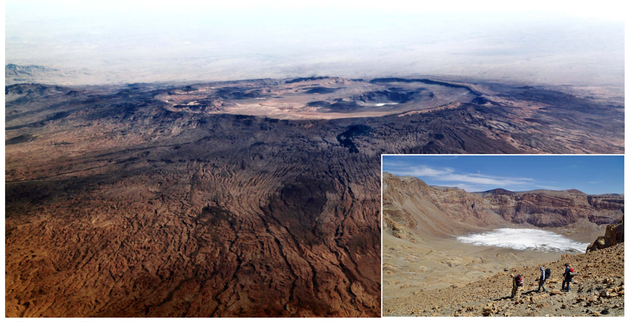

Fig. 4: The Emi Koussi, with 3445 m the highest mountain in the Sahara. The inlet photo shows the Era Kohor caldera.

Trou au Natron

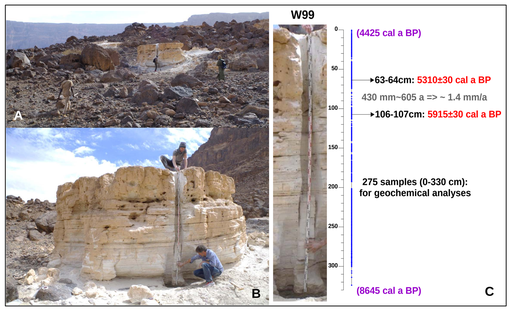

Fig. 5 (left): Section W99 (A-C) with first ^{14}C AMS-dates (charcoal) and tentative age estimates based on mass accumaulation rate of ~1.4mm/a.

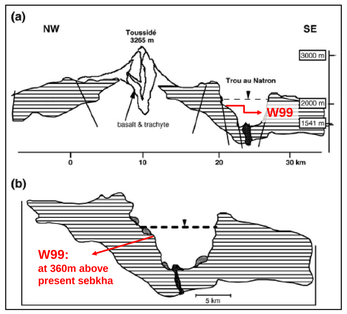

Fig. 6 (right):Schematic scetch of the Trou au Natron (Soulié-Märsche et al 2010 Global Planetary Change 72:334-340). Section W99 originates from a position ca. 360 m above the present sebkha floor.

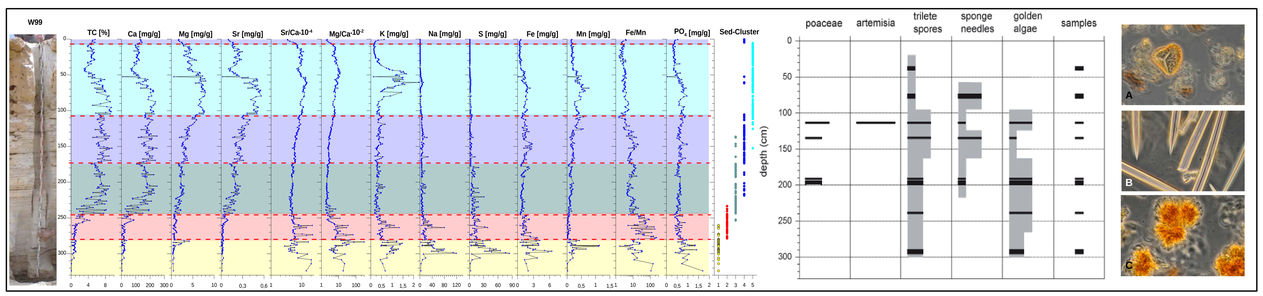

Fig. 7: Geochemical results for 3%hydrochloric acid dilutions for section W99 with the sedimentary-cluster / depth relation (cf. Fig. 8) and first results of palynologic analyses; A = trilete spore; B = needle-like spicules; C = golden algae.

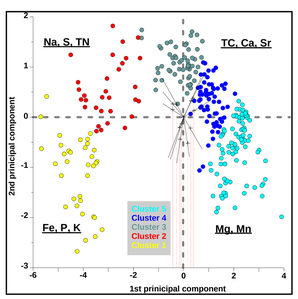

Fig. 8: Principal component biplot: the amount of the selected clusters is based within-error and elbow criteria.

Results Trou au Natron (sequence W99)

- carbonaceous diatomites (calcite up to 63%) ca. 360m above present sebkha (Figs. 5, 6)
- varying elemental concentrations (Fig. 7) show different stages of the palaeolake
- compositional data of the geochemical analyses were closed and center-log-ratio transformed before calculating principal components (colors correspond to clusters derived using kmeans algorithm)
- five differing clusters were identified that represent different stages of the palaeolake evolution:
  - Cluster 5: >Ca; higher Mg/Ca and Sr/Ca ratios; >Mg, >Mn-contents and lowest Fe/Mn ratios
  - Cluster 4: >Ca; low but increasing Mg/Ca and Sr/Ca ratios; enriched Mn-contents
  - Cluster 3: >Ca; steady and lowest Sr/Ca and Mg/Ca ratios
  - Cluster 2: low Ca; > Sr/Ca and >Mg/Ca; enriched in Na, S, K; highest Fe/Mn-ratio
  - Cluster 1: lowest Ca; > Sr/Ca and >Mg/Ca; enriched in Na, S, K, Fe, Mn

- pollen preservation in eight test samples is bad or pollen are absent except for trilete spore (fern/moss spore; Fig. 7A)
- sporadically recorded grasses (Poaceae) and wormwood (*Artemisia*) may reflect the (regional) terrestrial vegetation
- continuously and frequently recorded moss/fern spores (trilete spores) point to local stands, suggesting a small sedimentation basin
- water organisms: - the lower part of W99 is dominated by golden algae (Fig. 7C)
  - in the upper part sponge needles (Fig. 7B) are frequent whereas golden algae disappear

Interpretation / Lake succession (sequence W99)

=>Section W99: a typical lake succession with an initial phase of varying water level (cluster 1 and cluster 2) ~8700 cal a BP:
- during this phase the sediments are dominated by fine sand (quartz/SiO_2), lowest $CaCO_3$ contents accompanied by efflorescences (Thenardite; Na_2SO_4)

=> from ca 250 cm upwards carbonates (calcite, aragonite, dolomite, magnesite) dominate that are accompanied by gypsum at the beginning of cluster 3:
- stable water conditions with slightly increased salinity but probably freshwater conditions
- gypsum, dolomite, and magnesite decrease (low Sr/Ca and Mg/Ca) towards the top => < salinity (cluster 4); freshwater conditions

⇒ from ~100 cm to the top calcitic sediments dominate with slightly >Sr/Ca and >Mg/Ca accompanied by aragonite formation and >K-contents:
- increasing salinity of the former lake water (cluster 5) towards the top
- the top of the section (tentatively dated ~4400 cal a BP) is truncated as a final lake stage is not recognizable

The new results disprove previously postulated late Pleistocene glacial high stands (14,970 - 12,400 yrs BP) and indicate an early Holocene lake phase at ~ 8645 - 4425 cal yr BP: => i.e. there was no earlier onset and end of humid conditions in the Sahara's dominating mountains than elsewhere in the surrounding lowlands.

Emi Koussi Mountains/ Era Kohor Caldera

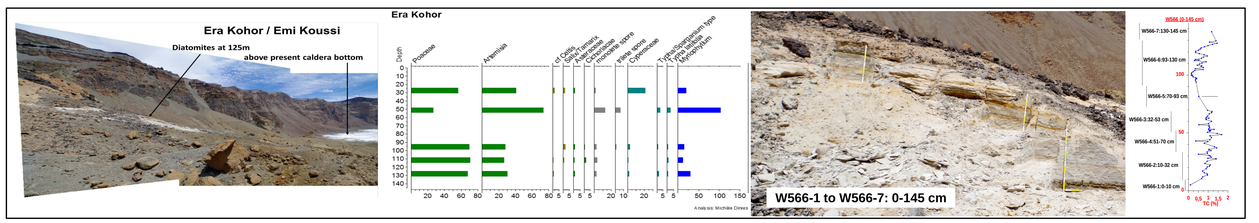

Fig. 9: The samples section W566 in the Era Kohor Caldera with first palynological results and total carbon (TC) contents.

At Era Kohor caldera an up to 1.4m thick layer of diatomaceous sediments situated 125 m above the caldera floor was sampled (Fig. 9) and first results point to:
- low total carbon (TC) contents as the sediments are dominated by diatoms (shallow water species)
- prevailing terrestrial vegetation with dominating grasses (Poaceae) and wormwood (*Artemisia*)
- abundant and continuous records of water milfoil *Myriophyllum* and riparian vegetation, eg cattail (*Typha*)

=> (lateral?) diatomites are remnants of a shallow freshwater lake, surrounded by cold steppe vegetation