

$^{18}\text{O}/^{16}\text{O}$ Ratios of Quartz Grains as a Proxy for Source Areas of Atmospheric Detritic Dust: The Case of the Eolian Erosion of the Sahara Desert

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Clayton et al. (1972) have demonstrated the eolian provenance of marine sediments in the Pacific Ocean through the oxygen isotopic signature of their quartz grains. In fact the $\delta^{18}\text{O}$ values of bulk quartz fractions in those samples exhibit a marked increase with decreasing size fractions. This increase was interpreted to be due to a higher proportion in the small size fractions of quartz originating from low temperature source rocks (cherts, diagenesis) relative to magmatic quartz formed at high temperatures, since mineral-fluid isotopic fractionations favour the incorporation of ^{18}O in minerals at low temperatures. The same effect was also observed in bulk fractions of quartz grains from North American tropospheric dust (Gillette et al., 1978). The purpose of the present study is to investigate the frequency distribution of $\delta^{18}\text{O}$ values of single micron size quartz grains in soils in order to test whether the frequency distribution of $\delta^{18}\text{O}$ values in atmospheric dust can be a powerful tracer of its source area. The case study chosen here is that of Saharan dust transported over the Tropical Atlantic Ocean episodically in spring or summer. Four Saharan soils were studied, these soils being previously suspected from meteorological studies to be located in some of the major source areas for desertic Saharan mineral dust. The $\delta^{18}\text{O}$ values in these soil samples will be compared with that of atmospheric dust collected over the Cape Verde islands in order to try to better constrain the source areas of atmospheric Saharan dust.

Measurement were done using the high sensitivity Cameca IMS 1270 ion microprobe at CRPG-CNRS in Nancy. Two different analytical modes were used in this study. For particles having sizes above 20 μm , a punctual mode combined with multicollection was used on flat polished sections. In this mode a primary Cs^+ beam of around 15 μm diameter and 10 nA intensity is used to sputter the sample. ^{16}O and ^{18}O ions are counted simultaneously on two Faraday cups with counts rates around 1×10^9 cps (counts per second) and 2×10^6 cps, respectively. In such conditions a precision around ± 0.3 – 0.5% can be

obtained after 3 minutes counting. Charging effects are compensated using a normal incidence electron gun. Particles $< 20 \mu\text{m}$ were incrustated in an indium foil and analysed using a scanning imaging mode described elsewhere (Aléon et al., 2000) with a finely focussed $< 1 \mu\text{m}$ Cs^+ primary beam of low intensity (1–5 pA). In such conditions count rates of 1 – 5×10^5 cps and 2×10^2 – 1×10^3 cps are obtained for ^{16}O and ^{18}O , respectively. In this mode pixel intensities represent ion counts, thus quantitative data could be extracted from the images by image processing. A precision down to $\pm 5\%$ for 2 μm particles and of $\pm 3\%$ for 5 μm particles can be obtained after 1 hour of counting.

The first results obtained on three size fractions of the erodible part of two soil samples from Agadez (Niger) and Tadrara (Morocco), fraction 20–100 μm (30 and 29 grains analysed respectively), fraction 100–500 μm (44 and 38 grains analysed respectively) and fraction 500 μm – 5 mm (33 measurements in Agadez sample, not present in Tadrara sample), demonstrate that (1) different oxygen isotopic signatures are present in quartz grains in one soil depending on their size (Figure 1) and (2) different soils exhibits different oxygen isotopic signatures in similar size fractions (Figure 1). An increase in the range of variation of the $\delta^{18}\text{O}$ values is observed in quartz grains as their size decreases. As the erodible fraction is mainly of eolian origin in this soil, this could be interpreted as a larger contribution of distant sources having various lithologies. It is interesting to note the strong decrease of the granitic contribution and the shift towards higher values of the maximum peak in the finest fraction yet analysed in both cases. A chert / diagenetic contribution with $\delta^{18}\text{O}$ values from +25% to +35% is anticipated in the finest size fractions which could thus be clearly identified from $\delta^{18}\text{O}$ values in the aerosol grains. This possibility will be evaluated by comparing several soil $\delta^{18}\text{O}$ distributions to that measured in the aerosols sampled over Cape Verde islands.

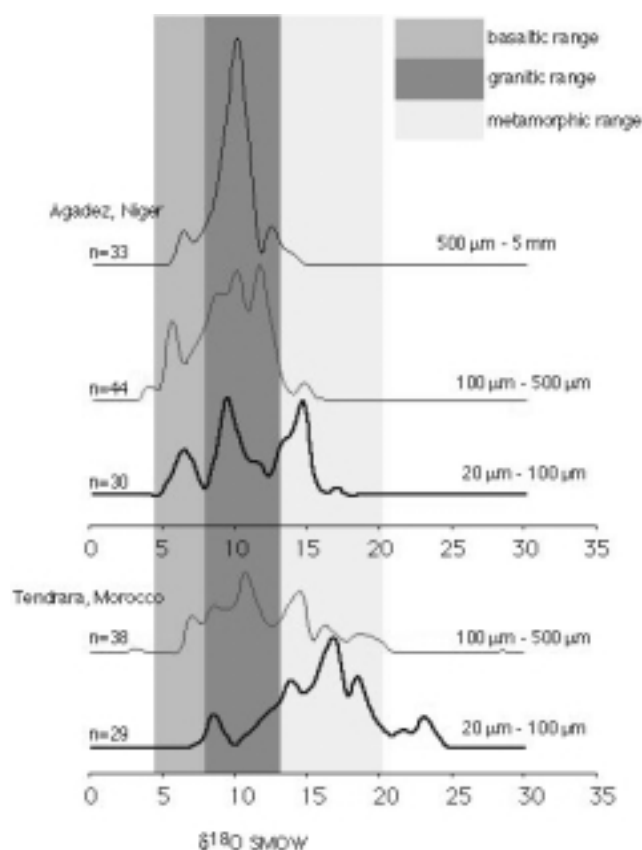


Figure 1: Cumulate probability histograms of $\delta^{18}\text{O}$ in several size fractions of the $> 20 \mu\text{m}$ part of the Agadez (Niger) and Tendirara (Morocco) soil samples. n is the number of grains analysed per size fraction. In Agadez the distribution is dominated by a peak attributable roughly to granite rocks. However a size decrease shows an increase of other sources: basaltic rocks and metaorphic or hydrothermal rocks. In Tendirara a much larger range is observed even in the $> 100 \mu\text{m}$ fraction. The $> 500\mu\text{m}$ fraction is represented by carbonates and thus has not been analysed.

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