Palaeoclimate evolution of the eastern Mediterranean region during the last 60,000 years: chemical and isotopic systematics of cave deposits (Soreq cave, Israel)

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Our understanding of palaeoclimatic variability has been considerably increased by the many recent studies of global climatic change. It is well appreciated that the climate system is very complex and is affected by forcing factors and feedbacks related to polar ice bodies and to oceanic and atmospheric circulation. But the palaeoclimate of the Eastern Mediterranean region has received relatively little attention despite its unique position in a transition zone between humid climate in the north and arid climate in the south, and despite the fact that this area is densely populated and was so in the past. The climate of this region is influenced by the inter-relationship between the climatic pattern of Europe and those of the adjacent countries of North Africa and Asia. In Israel, most of the storm tracks that reach the northern and central parts of the country originate in the Atlantic Ocean and pass over northern and eastern Europe and/or the Mediterranean Sea. As in other climatic transition zones, this region was very sensitive in the past to changes in natural environmental parameters, such as temperature, amount of rainfall, origin and pattern of storm tracks, vegetation type, and location of the desert boundary.

Oxygen and carbon isotope ratios in calcite cave deposits (speleothems) from the Soreq cave (Israel) were determined for the last 60 Ky and are found to reflect the climatevariations which have occurred in the Eastern Mediterranean region. The high precision of the accompanying TIMS ^{230}Th-^{234}U ages permits correlation of the isotopic time-series from the Soreq cave with other global records. Speleothems that were deposited during the period ~60 to 17 Ky have in average δ^{18}O (PDB) values of ~−3 to −4 land δ^{13}C (PDB) values of ~−9 to −11‰, and in both cases are ~2‰ higher thanspeleothems younger than 14 Ky, and those forming under present-day conditions. The isotopic compositions follow a periodic cyclicity similar in age and duration to those of the Dansgaard-Oeschger cooling cycles, reflecting oscillations in temperature (~12−16°C) and in annual rainfall (~250−400 mm/yr). Maximum oxygen isotopic values occur at 46 and 35 Ky, the approximate ages of Heinrich events (H) 5 and 4, respectively, andat 19 Ky, the approximate age of the last glacial maximum. The correlation between the oxygen isotopic events of the Soreq cave speleothems and the events recorded in ice cores and in marine sediments from the North Atlantic indicates that the Atlantic Ocean's >great conveyer belt= circulation was probably the cause of rapid climatic change in the Eastern Mediterranean region. The time period from 17 Ky to 8.5 Ky (equivalent to the period of deglaciation) includes an isotope peak that can be correlated with H1, and is followed by a sharp drop of ~3‰ in δ^{18}O and of ~4‰ in δ^{13}C, and another isotopic peak that can be correlatedwith the Younger Dryas event. The more than 3‰ drop in δ^{18}O during deglaciation was caused by a sharp change in the oxygen isotopic composition of precipitation due to a change in the moisture source, warming and an increase in the annual rainfall from ~250 to ~800 mm/yr. A unique combination of minimum δ^{18}O values (~−6.5‰) together with maximum δ^{13}C values (~−5 to −4‰) occurred during deluge periods from 8.5 to 8.2 Ky and from 8 to 7 Ky. Though this is probably due to the rapid movement of water through large fracture systems during heavy rainstorms, it may also be due to a major change in the carbon isotopic composition of atmospheric CO_2 during this time. The isotope ratios of speleothems which formed during the last 7000 years are similar to those of the present-day, but are characterized by many short-lived fluctuations.

In addition to oxygen and carbon isotopes, other proxies have been recognized as being climate-related and are very significant for the understanding of palaeohydrological-palaeoclimatic conditions. Among these proxies are U and Sr concentrations in calcite speleothems and their isotopic ratios. A marked drop in U and Sr concentrations and their isotopic ratios is observed to occur at the time equivalent to the transition from the last glacial to the Holocene. U concentrations decrease from the range of 400–800 ppb to 400–200 ppb and Sr concentrations drop from 100–200 ppm to 50–100 ppm. The $(^{234}U/^{238}U)o$ ratios change from 1.06–1.14 to 1.02–1.04 and $^{87}Sr/^{86}Sr$ ratios drop from 0.7081–0.7085 to 0.7078–0.7080. These variations occur in response to changes in the amount and composition of the drip water and in the moisture conditions of the overlying soil. The composition of the drip water reflects changes in the mixing proportions among the various sources (sea water, host rock, salts and dust) which accumulate in the soil and dissolve in vadose water. The sharp drop in Sr concentrations and isotope ratios suggest that there was a greater input of sea spray droplets and dust particles at the end of the last glacial period relative to the Holocene, but that during the period of deglaciation increased temperature and rainfall intensity caused weathering reactions to become more dominant, and thus enhanced the host rock signal in the mixing proportions of trace elements and radiogenic isotopes.