Uranium-series and ^{14}C dating of salar sediments in the High Atacama

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The Atacama Desert is a key site for the study of Quaternary climatic changes in the Southern Hemisphere. Recently the regional chronology of lake-level fluctuations from the late-glacial/early Holocene humid phase along a high altitude transect (3500 to 4500 m) between 18°S and 28°S in the Southwestern Altiplano of Northern Chile has been revised substantially [1].

The results of ^{14}C dating of organic and inorganic carbon from lacustrine sediments of lake cores in the Atacama Altiplano yielded apparent ages which are too large due to the reservoir effect. The correction is in the order of 100 to 1000 years for organic carbon and in the order of 1000 to 10,000 years for inorganic carbon. The reservoir correction is specific for each lake and varies through history of the lake with changing lacustrine conditions [2]. ^{210}Pb ages of modern sediments confirmed the calibration of the corrected ^{14}C time scale.

The reservoir effect is reflected by ^{14}C dates from a large number of organic and inorganic samples from paleolakes in the Atacama Altiplano between 18°S and 25°S. According to the new late-glacial/early Holocene chronology the paleolake transgression began after 13,000 - 12,000 ^{14}C BP, and culminated between 10,800 and 8800 ^{14}C BP interrupted by a dry event of unknown duration. The paleolakes fell between 8800 and 8100 ^{14}C BP, and had disappeared by around 8000 ^{14}C BP. This new chronology [1] agrees with the lake level history and the regional history of human occupation in the Atacama [3]. It is broadly synchronous with vegetation changes in subtropical continental South America, and with the onset of wetland expansion in the northern hemisphere tropics.

This new chronology for the late-glacial/early Holocene period significantly differs from the old chronology as established for the Titicaca-Uyuni basin in Bolivia (beginning 15,400 ^{14}C BP, maximum 13,500 to 12,000, ending at 11,900, and the Coipasa Event between 9500 and 8500 ^{14}C BP; [4-6]). The old chronology is based on ^{14}C dates and several $^{230}Th/U$ dates obtained from the inorganic fraction of paleolake sediments from southern Bolivia. Only for the Coipasa Event a reservoir correction of -2000 years has been applied. One explanation for the deviation between the new and old chronologies are methodological difficulties of the radiocarbon dating of lake sediments. Reservoir-corrected ^{14}C ages and $^{230}Th/U$ ages on Tauca samples from Bolivia show better agreement (Servant, M., Causse, C., Sylvestre, F., personal communication; Geyh, 1997) although an arbitrary detrital correction with an initial $^{230}Th/^{232}Th$ activity ratio of one was applied to correct $^{230}Th/U$ ages. This approach leaves an uncertainty in the accuracy of the $^{230}Th/U$ ages.

The reliability of the data may be questioned as verification for closed system conditions has not been reported.

To improve ^{230}Th/U dating of Atacama lake sediments, we applied the approach of combining ^{14}C and ^{230}Th/U dating to the same sample fractions of lake sediments from different regions of the Atacama Altiplano, applying the 'isochron method' and checking for closed system conditions. Measurements of ^{230}Th/U and ^{14}C have not yet been completed, and therefore the interpretation of the results is still preliminary. The dating range has been extended from the Tauca/Copiasa Phase to the Minchin Phase which might have ended around 20,000 ^{14}C BP. The 'isochron' method [7-12] delivered accurate detrital correction factors. Closed system conditions were checked with an improved approach after Ivanovich and Harmon [13].

Sediments of the Laguna Lejía have large ^{230}Th/^{232}Th activity ratios. Although the Lejía samples apparently behaved as a closed system, detritally corrected ^{230}Th/U ages scatter widely depending on the mathematical treatment. Several of these different corrections yielded ^{230}Th/U ages showing an age inversion with depth. Sediments from the exposure of the Laguna Pozuelos in Argentina are highly detritally contaminated which is indicated by the small ^{230}Th/^{232}Th activity ratios. They also apparently reflect closed system conditions. The ^{230}Th/U ages range from the Minchin to the Tauca Phase and decrease with growing depth. A similar observation was made for sediments from the terrestrial core 'Goutierez' at the shore of Laguna Pozuelos.

Summarizing, we can state, that there are still methodical problems in geochronology, indicated by the inversion of the ^{230}Th/U ages, which have to be solved. Probably the applied test for closed system conditions does not reflect uranium mobilization in all cases and therefore must be improved. The establishment of precise and accurate chronologies by means of reservoir-corrected ^{14}C and detritally corrected ^{230}Th/U ages remains a complex task. It can only be successful if limnologists and geochronologists closely work together taking into account field and analytical observations.

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