Radium 226 evidence for decreasing hydrothermalism at Pamukkale-Hierapolis (Anatolia) since Roman time

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The dating of travertine deposits at 10^3 to 10^6 yr time scales (i.e., at Milankovitch cycle scale) by $^{230}Th/^{234}U$ and $^{234}U/^{238}U$ disequilibria, has been instrumental for the documenting of travertine deposition and groundwater /hydrothermal seepages in relation to late Quaternary climatic changes. A much lesser attention has been paid to such processes at much shorter and recent time scales, notably from the late Holocene to present. These can be documented using shorter-lived isotopes of both ^{238}U and ^{232}Th series as illustrated here. Aside the dating of Holocene intervals characterized by intense travertine deposition in the Denizli area in Western Anatolia, we investigated changes in ground- and surface water chemical properties and budgets, as recorded by recent and on-going travertine deposition through $^{230}Th/^{226}Ra$, $^{226}Ra/^{210}Pb$, $^{232}Th/^{228}Ra/^{228}Th$ and $^{210}Po/^{210}Pb$ disequilibria. A special attention has been paid to the Pammukale-Hierapolis and Kelkaya travertine systems, located about 27 km apart in the Denizli and Baklan graben merging area. Water samples were collected at each site, as well as fourteen carbonate samples from the oldest travertines to the on-going carbonate deposits. ^{230}Th-ages of travertine samples range from ~ 3 ka to modern thus pointing to the development of the huge travertine depositional systems during the late Holocene. The most striking features observed are (i) the consistency of $^{234}U/^{238}U$ activity ratios in groundwaters and travertines (1.134±0.004) at both sites, pointing to similar U-sources feeding both spring, (ii) the strongly decreasing $^{226}Ra/Ca$ ratio in travertine deposits through time, with a decreasing rate of about 50%/kyr. A lesser contribution of the deep-geothermal system to the modern springs might be seen as the major cause although minor impact of recharge rates of the hydrothermal system by ^{226}Ra-poor meteoritic waters cannot be totally discarded.