Age dating volcanic springs in the Western Highlands of Cameroon, along the Cameroon Volcanic Line: a multi-tracer approach

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The Western Highlands of Cameroon (WHC) is located mid-way along a chain of volcanoes (ca. 1600 km), cutting diagonally across Cameroon, called the Cameroon Volcanic Line (CVL). The area forms the main watershed in the country and consists of mineralised springs (MS) and numerous less mineralised springs (LMS). Despite the significance of such subsurface waters in volcanic processes, little hydrological data is available on the origin and age of these fluids along the CVL. Such data can provide information on the interaction of subsurface fluids along the CVL. In this study, a preliminary multi-tracer technique has been conducted on 18 LMS (mean TDS of 1542 mg/l) and 6 MS (TDS of 45 mg/l) in the WHC to determine their origin and time of circulation in the upper crust. Except for one MS (hot spring, T >33oC), all other springs are cold (T <27oC). Field observations revealed emanations of an unknown gas at the MS, which may be CO2 based on related studies along the CVL. Regardless of their discharge at relatively low altitudes, all MS are isotopically depleted (mean delta O-18 of -5.67 per-mille) in relation to high altitude discharging LMS (mean delta O-18 of -4.04 per- mille) suggesting recharge of MS under relatively cold climatic conditions. However, both plot along the Local Meteoric Water Line, suggesting their meteoric origin. Tritium values in MS are low, ranging from >0.3 TU (4 samples) to 2.3 TU, compared to 2.4 to 3.1 TU in LMS, mainly indicating pre-1957 recharge of the former and post-1957 recharge of the later. The CFC-12 (like CFC-11 and CFC-113) and SF6 in MS are low, ranging from 6 to 85 pk/kg and from 0 to 0.34 fmol/lg, respectively. On the contrary, LMS show high values in CFC-12 and SF6, ranging from 28 to 239 pk/kg and 1.01 to 7.23 fmol/lg, respectively. Based on the known concentrations of CFCs and SF6 in the atmosphere, CFC-12 versus CFC-11, CFC-113 and SF6 plots of samples show a binary mixing model in MS and mainly an exponential mixing model, of uniform areal recharge, in LMS. CFC-12 versus 3H and delta O-18 versus delta-D plots show different degrees of binary mixtures of old MS and young LMS. Thus, based on the multi-tracer approach, the estimated ages of MS and LMS range from 51 to 35, and 45 to 19 years, respectively, indicating the long residence time and deep circulation of MS which may explain their enriched mineralization. Conclusively, the MS may represent a portion of magmatic fluid that mixes with old deep circulating groundwater, upon its upward movement it further mixes with shallow and cold young groundwater.

Key words: spring water origin, residence time, subsurface circulation, The Cameroon Volcanic Line