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A Revised Value for the Production Rate of Cosmogenic ^{21}Ne in Quartz

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The interaction of cosmic ray particles with terrestrial rocks produces, among others, certain radionuclides and noble gas isotopes, providing a valuable dating tool for various processes acting on the surface of the Earth. One of the well-suited nuclides for such purposes is ^{21}Ne. Since surface production rates are not only dependent on the location (i.e. latitude and altitude), but also on the chemical composition of the target material, it is convenient to work with minerals having a simple and stable composition. One such mineral is quartz, in which ^{21}Ne is produced solely from Si and which has the additional advantage of being abundant in a wide variety of rock types. The production rate of ^{21}Ne in terrestrial quartz has been experimentally determined by Niedermann et al. (1994), using glacially polished granitic rocks from the Sierra Nevada, California. However, based on current knowledge three assumptions used in their work have to be revised. First, it has since been shown that glaciers have retreated earlier from that part of the Sierra Nevada, ~13 ka instead of 11 ka B.P. (Clark et al., 1995). Second, the present-day geomagnetic latitude of the sampling sites was used for scaling the measured production rate to sea level and high latitude, but indeed the geographic latitude represents the time-averaged position in the geomagnetic field much better over the relevant timescale of ~10 ka. Moreover, a recent revaluation of the altitudinal and latitudinal dependence of cosmogenic nuclide production (Dunai, 2000) has provided more accurate scaling factors than available in 1994.

Niedermann et al. (1994) report a ^{21}Ne production rate (P_{21}) in quartz of 243 ±45 atoms g^{-1} a^{-1} at an altitude of 3340 m and a geomagnetic latitude of 44 . Taking account of the longer exposure time, that value converts to 206 ±38 atoms g^{-1} a^{-1}. Using the geographic latitude of the sampling sites of ~38ºN and applying the scaling procedure of Dunai (2000), I obtain a revised P_{21} in quartz at sea level and high latitudes of 19.0 ±3.7 atoms g^{-1} a^{-1}, some 10% lower than the earlier estimate of 21 atoms g^{-1} a^{-1}. This value can be compared to the result of Masarik and Reedy's (1995) production rate calculations which are based on models describing the propagation of cosmic ray particles in the geomagnetic field and on measured or assumed cross sections for relevant spallation reactions. They have obtained P_{21} = 18.4 atoms g^{-1} a^{-1} in quartz at sea level and high latitudes, which is in better agreement to the revised value than to the earlier estimate.

It has been proposed that cosmogenic nuclide production rates vary with time. Several studies indicate that the geomagnetic field intensity has been higher throughout the Holocene than in the preceding epochs. If they are correct, average production rates over timescales >20 ka would be substantially higher than in rocks of more recent exposure. However, other investigations have questioned the applicability of methods used to derive palaeo-intensities or do not observe an increasing trend for the Holocene in their data. Clearly, more unequivocal evidence is required to decide whether production rates have indeed varied substantially in the past. One indication that variations may not have been too high comes from independent ^{3}He production rate determinations in Holocene lava flows (Licciardi et al., 1999) and in flows of 150-280 ka age (Dunai and Wijbrans, 2000), which are in perfect agreement. In view of the controversial nature of the issue, I believe that it would be premature to apply any corrections for production rate variations in the past and recommend to use the Holocene P_{21} value in quartz of 19 atoms g^{-1} a^{-1} for longer exposure times as well. It should, however, be kept in mind that exposure ages older than ~20 ka may turn out systematically too high by up to ~30% if the palaeo-intensity variations reported in some investigations are real.

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