# Production rates of $^{10}$Be and $^{26}$Al in mid-latitudes and high altitudes

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### Site Production Rates

The inner Titcomb Lakes moraine (43.12°N, 109°W), Wind River Range, Wyoming, USA has the attributes of a site suitable for determining terrestrial cosmogenic nuclide production rates for late Pleistocene exposures. The moraine was deposited between 12.9 and 11.6 ka during the Younger Dryas chron (1.3 kyr duration). Assuming constant GCR flux, exponential attenuation of the production rate below the rock surface, and negligible erosion, shielding, and inheritance, measurements of $^{10}$Be and $^{26}$Al in ten boulders yield annual production rates at the site of 53.8±0.9 $^{10}$Be atoms_a$^{-1}$_g$^{-1}$ SiO$_2$ and 322±10.7 $^{26}$Al atoms_a$^{-1}$_g$^{-1}$ SiO$_2$ (uncertainties reflect 1.6% and 3.3% 1σ coefficient of variation about the mean).

Corrected for shielding due to topography and snow cover the rates are 55.9±2.1 $^{10}$Be atoms_a$^{-1}$_g$^{-1}$ SiO$_2$ and 335±6.0 $^{26}$Al atoms_a$^{-1}$_g$^{-1}$ SiO$_2$. The $^{26}$Al/$^{10}$Be is 5.94 ±0.26 (uncertainties include external error, reproducibility at U. Pennsylvania chemistry and AMS, standardization at U. Pennsylvania, random errors associated with thickness, snow cover, and exposure duration).

### Scaled Production Rates

Local production rates were converted to production rates at sea level and high latitude using the scaling approach of Lal (1991) as modified by Stone (2000) based on a geocentric dipole axis. The $^{10}$Be production rate at sea level and high latitude is 5.33 ±0.20 atoms_a$^{-1}$_g$^{-1}$ SiO$_2$ and for $^{26}$Al,. 32.0 ±1.9 atoms_a$^{-1}$_g$^{-1}$ SiO$_2$. When scaled with the approach of Dunai (2000; vers. 1.3; 15°C at sea level, 45° lat.), the rates are 4.71±0.18 $^{10}$Be atoms_a$^{-1}$_g$^{-1}$ SiO$_2$ and 28.2±1.7 $^{26}$Al atoms_a$^{-1}$_g$^{-1}$ SiO$_2$.

### Discussion

Because of the site's insensitivity to variations in geomagnetic dipole paleointensity and axis positions, the site's production rates remained within 5% of this value for the entire period from 22 to 6.0 ka. However, non-dipole field features in the region (e.g. persistent increase in inclination from the 13.5 – 0 ka Fish Lake record) could cause the time-integrated production rate at the site to be up to 3% lower than other sites for the same time. Effects of burial and erosion could also cause the scaled production rate to be lower than the others scaled similarly. Prevailing atmospheric effects in the Wind River Range may increase the site production rates by as much as 2% (Stone, 2000).

### References

Dunai, T. (2000), EPSL, **176**, 157-169
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# Volatile-rich brine and melt in Canadian diamonds

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Micro-inclusions in diamonds provide pristine information on the composition of mantle fluids. Following the identification of carbonate and hydrous-silicic melts in diamonds from Congo and Botswana and brine inclusions in South African diamonds, we explored the composition of micro-inclusions in ten diamonds from the Diavik mine, Slave Craton, Canada. Three main types of micro-inclusions were found: brine-bearing inclusions, melt-bearing inclusions and a few mineral micro-inclusions.

Melt inclusions were found in a single diamond. Their composition is intermediate between the hydrous-silicic end-member and the carbonatitic (Mg-Ca-Fe-Ba-rich) end member of Schrauder and Navon, (1994). The average melt composition is $(K_{26}Na_5)(Si_{25}Al_4Ti_2)(Ca,Mg,Fe)_{32}Cl_3P_3$ (water and carbonate could not be determined by IR in this opaque sample). The brine inclusions carry mostly water, Cl, K and Na and show variable enrichment towards the carbonatitic end member. The average brine composition is $(K,Na)_{10}(Si,Al)(Ca,Mg,Fe,Ba)_4Cl_{10}(H_2O)_{12}(CO_3)_4$, with K/Cl molar ratio of 0.64±0.05. We did not find inclusions with intermediate compositions between the hydrous-silicic and the brine end-members.

Schrauder and Navon, (1994) favored fractionation of carbonates and evolution from carbonatitic melt towards the hydrous silicic composition. However, such a model can not explain the compositions between the carbonatitic end member and the brine.

Johnson et al. (2000) found a wide range of Br/Cl and I/Cl ratios in Canadian diamonds (1 to 100 times the MORB ratio) and attributed it to fractionation of a Cl-bearing phases, such as apatite or mica from melts similar to those described by Schrauder and Navon (1994). We suggest that these diamonds trapped brine rather than melt and the high Br/Cl and I/Cl ratios are characteristic of the brine. If so, apatite or mica crystallization cannot explain the chemical evolution from carbonatitic melt to brine.

We favor a model where crystallization of carbonates from a carbonatitic melt leads to enrichment of the melt in silica, alkalies and chlorine and to its separation into two immiscible fluids: a hydrous silicic melt and a brine.

The source of the carbon, alkalies and chlorine cannot be easily identified as recycled or primordial. The carbon isotopic composition of fluid-bearing diamonds falls within the range of MORB and other mantle-derived melts. Br/Cl and I/Cl ratios converge towards the MORB values. The similarity of isotopic and chemical ratios to MORB values may reflect derivation either from subducted oceanic crust or from mantle reservoirs with MORB source signature.

**References:** Johnson et al. (2000) GCA **64**, 717-732.
Schrauder and Navon (1994) GCA 58, 761-771.