OXYGEN ISOTOPIC COMPOSITION AND FORMATION PROCESS OF SNOW UNDER ANTICYCLONE AT SYOWA STATION, EAST ANTARCTICA (EXTENDED ABSTRACT)

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Snowfall under anticyclone was observed in 1974 at Syowa Station. The oxygen isotopic composition ($\delta^{18}O$) of snow formed under anticyclone was smaller than those under the other meteorological conditions, even at the same temperature of formation of snow (KATO, 1978, 1979). This fact indicates that the transportation process of water vapor to the sphere of influence of an anticyclone and the formation process of snow under an anticyclone are different from the transportation process of water vapor by a circumpolar cyclone and the formation process of snow under such a cyclone, respectively.

However, we do not yet have enough information about these relations to anticyclones. The relationships have been investigated between the $\delta^{18}O$ of fallen snow and the transportation process of water vapor or the formation process of snow (KATO, 1978, 1979; KATO and HIGUCHI, 1979; KATO *et al.*, 1977, 1978).

Syowa Station is located on East Ongul Island off Prince Olav Coast, at lat. 69°00′S and long. 39°35′E. The $\delta^{18}O$ was measured for 38 samples of fallen snow, 14 samples and 5 samples of which are considered to be formed under circumpolar cyclones and under anticyclones, respectively (KATO, 1978, 1979).

Figures 1 and 2 show $\delta^{18}O$ of fallen snow with respect to the temperature range in the corresponding cloud layer, which was determined as the layer with relative humidity of 100% from surface synoptic and aerological data (JAPAN METEOROLOGICAL AGENCY, 1977). From these figures it is seen that the $\delta^{18}O$ values of fallen snow are much higher under cyclones and much lower under anticyclones, even at the same temperature of formation of snow. The $\delta^{18}O$ of fallen snow is increased by the supply of ^{18}O-rich water vapor resulting from the approach of a circumpolar cyclone. The temperature of formation of fallen snow is not so extraordinarily low in August as $\delta^{18}O$ of fallen snow suggests. The amount of ^{18}O-rich water vapor supplied by the cyclones is smaller in August, which has a very high atmospheric pressure, than in the other months. Hence it becomes understandable why the $\delta^{18}O$ of fallen snow is so low in August. The variation of $\delta^{18}O$ of fallen snow is caused not only by its temperature of formation but also by the transportation process of water vapor.

Taking into consideration the supply of ^{18}O-rich water vapor from the cyclone, $\delta^{18}O$ of fallen snow in December–May is higher than that in July–November even

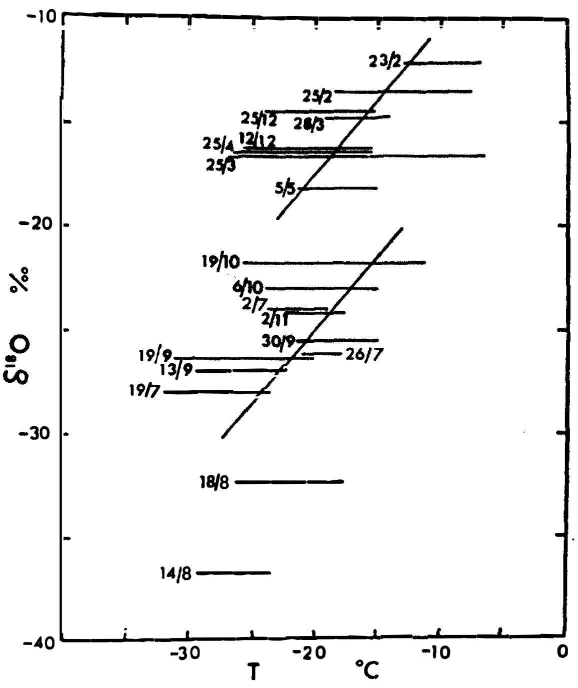

Fig. 1. Oxygen isotopic composition of fallen snow at Syowa Station with respect to the temperature range in the corresponding cloud layer in 1974, excluding fallen snow formed under cyclone or anticyclone.

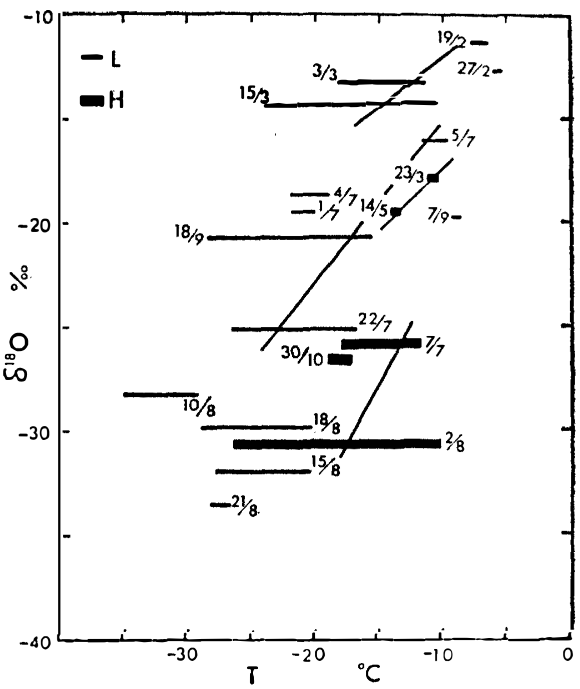

Fig. 2. Oxygen isotopic composition of fallen snow formed under circumpolar cyclone (L) and under anticyclone (H) at Syowa Station with respect to the temperature range in the corresponding cloud layer in 1974.

at the same temperature of formation of fallen snow. This means that supplied water vapor is richer in ^{18}O in December–May than in July–November. The variation of distance from the coast of the open sea to the sampling station shows two abrupt jumps between May and July and between November and December (KATO, 1978), as TRESHNIKOV (1967) pointed out. The difference of transportation process of water vapor between the two above periods may cause the appearance of 'isotopic summer' (December–May) and 'isotopic winter' (July–November).

The correlation of isotopic composition with temperature of formation of precipitation is theoretically controlled by the cooling process, under equilibrium Rayleigh conditions (*i.e.* a slow process with immediate removal of the condensate or sublimate from the vapor after its formation in a closed system), as pointed out by FRIEDMAN *et al.* (1964) and DANSGAARD (1964). The formation of snow around and in Antarctica is considered to be very suitable for the equilibrium Rayleigh conditions, because of low temperatures and ice- or snow-covered surface around and in Antarctica. However, the theoretically developed results have not been proved, with the only available actual finding between $\delta^{18}O$ and temperature of formation of snow having been collected in 1958 at Roi Baudouin Station, near Syowa Station (PICCIOTTO *et al.*, 1960), as pointed out by FRIEDMAN *et al.* (1964). This is because the transportation process of water vapor to the Antarctic ice sheet was not taken into consideration, before KATO (1978) found that it largely controls the $\delta^{18}O$ of fallen snow.

Taking into consideration the transportation process of water vapor to the Antarctic ice sheet, the $\delta^{18}O$ values of fallen snow samples should be grouped into 'isotopic summer' and 'isotopic winter'. The straight line corresponding to the mean vapor pressure in the temperature range of cloud layer was traced for each group, except for samples in August in Figs. 1 and 2. The slopes of two lines in Fig. 1 are almost same and nearly equal to 0.7‰ per °C (mean value of change per degree cooling of $\delta^{18}O$). Those in Fig. 2 are about 0.5‰ per °C for 'isotopic summer' and about 0.7‰ per °C for 'isotopic winter'. These values in the temperature ranges shown in Figs. 1 and 2 mean theoretically that the fallen snow is formed by a moist-adiabatic cooling process.

Fallen snow at Syowa Station is formed by a moist-adiabatic cooling process except for that formed under an anticyclone, judging from the aerological data (JAPAN METEOROLOGICAL AGENCY, 1977). Thus, taking into consideration the transportation process of water vapor, the theoretically developed correlation between the isotopic composition and the temperature of formation of precipitation is proved with actual findings. This also proves that the isotopic composition of precipitation is controlled not only by its temperature of formation but also by the transportation process of water vapor, as found by KATO (1978).

WHITE and BRYSON (1967) showed the seasonal variation of vector of wind above the meridian along the Hallet Station–Byrd Station–South Pole. KOBAYASHI (1978) observed the wind direction above the surface inversion layer on the Mizuho Plateau, East Antarctica. However, we do not yet have useful information about the transportation process of water vapor to the sphere of influence of anticyclones in Antarctica. Therefore it is not known whether fallen snow samples under anticyclone at Syowa Station should be grouped into 'isotopic summer' and 'isotopic winter' by abrupt jumps in the variation of $\delta^{18}O$ of fallen snow.

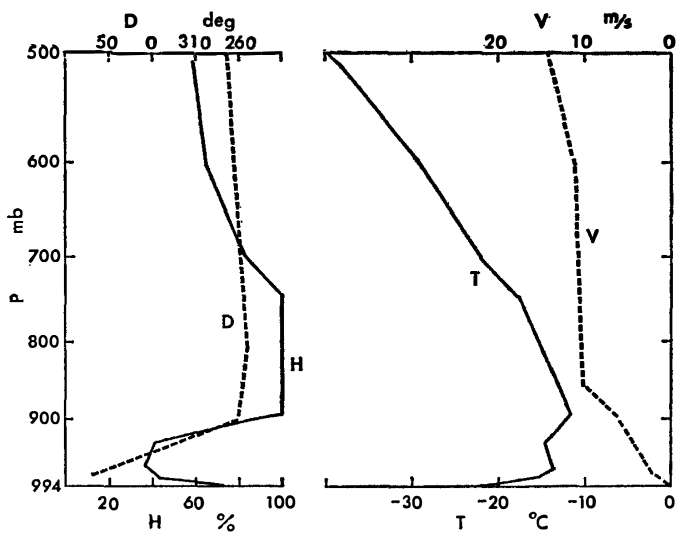

Fig. 3. Profiles of air temperature (T), relative humidity (H), wind velocity (V) and wind direction (D, north 0° in true) above Syowa Station on July 7, 1974, under anticyclone.

Now a straight line corresponding to the mean vapor pressure in the temperature range of the cloud layer is traced for all fallen snow samples formed under anticyclone in Fig. 2, the slope of this straight line is about 1.2‰ per °C. Though samples are too few to trace each straight line for each group, the slopes of traced lines are about 0.8‰ per °C for 'isotopic summer' and about 1.1‰ per °C for 'isotopic winter'. These values in the temperature ranges shown in Fig. 2 mean theoretically that the fallen snow is formed by an isobaric cooling process under the anticyclones. This should be proved with the actual findings.

Figure 3 shows the profiles of air temperature, relative humidity, wind direction and wind velocity above Syowa Station on July 7, 1974 when it snowed under an anticyclone. Whenever it snows under an anticyclone, the upper inversion exists above the surface inversion as shown in Fig. 3. The relative humidity is 100% around and above the upper inversion.

HIGUCHI (1962) observed snowfall from a thin cloud layer around the subsidence inversion under an anticyclone above Hokkaido, Japan. The upper inversion above Syowa Station is considered to be the subsidence inversion. Cloud may successively be formed by mixing and/or radiative cooling around the subsidence inversion. If snow is successively formed mainly from a thin cloud layer formed aroud it, it becomes understandable that snow is formed by an isobaric cooling process under an anticyclone.

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