# OXYGEN ISOTOPIC COMPOSITION OF FALLEN SNOW IN 1977 AT SYOWA STATION, EAST ANTARCTICA (EXTENDED ABSTRACT)

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The isotopic composition of fallen snow in Antarctica was only related to its temperature of formation in the previous studies (GONFIANTINI and PICCIOTTO, 1959; PICCIOTTO *et al.*, 1960; GONFIANTINI *et al.*, 1963; EPSTEIN *et al.*, 1963; ALDAZ and DEUTSCH, 1967). KATO (1978) found that the transportation process of water vapor to Antarctica also largely controls its isotopic composition, by investigating the factors controlling the oxygen isotopic composition ($\delta^{18}O$) of fallen snow at Syowa Station in 1974 (KATO, 1977).

GONFIANTINI and PICCIOTTO (1959) and PICCIOTTO *et al.* (1960) determined the isotopic composition of fallen snow samples collected at Roi Baudouin Station near Syowa Station in 1958. The $\delta^{18}O$ values of fallen snow are grouped into 'isotopic summer' and 'isotopic winter' (November–April and May–October, respectively) by abrupt jumps in the variation of $\delta^{18}O$. PICCIOTTO *et al.* (1960) pointed out that two periods of such abrupt jumps of $\delta^{18}O$ correspond very well to those of abrupt jumps in the variation of the monthly mean air temperature in the middle troposphere, where the precipitating clouds are formed.

Two abrupt jumps are observed between March and April and between October and November in the monthly mean air temperature of the middle troposphere above Syowa Station in 1974 (JAPAN METEOROLOGICAL AGENCY, 1977). However, the 'isotopic winter' of 1974 at Syowa Station did not begin from May (KATO, 1978, 1979). Even at Roi Baudouin Station, the 'isotopic winter' of 1960 did not begin from May (GONFIANTINI *et al.*, 1963). KATO (1978, 1979) concluded that the difference of transportation process of water vapor between the above two periods causes the appearance of 'isotopic summer' and 'isotopic winter'.

However, the results found by KATO (1978) should also be confirmed. Therefore, $\delta^{18}O$ was determined for fallen snow samples collected at Syowa Station in 1977 and the factors controlling the $\delta^{18}O$ of fallen snow have been reinvestigated.

Syowa Station is located on East Ongul Island off Prince Olav Coast, at lat. 69°00′S and long. 39°35′E. The snow samples were kept in polyethylene bottles, transported to Japan under refrigeration and melted only just before the oxygen isotope determination. The experimental procedures are essentially the same as those described by EPSTEIN and MAYEDA (1953). Analytical results are expressed in $\delta^{18}O_{SMOW}$ notation (CRAIG, 1961) and analytical error is $\pm 0.2‰$.

Figure 1 shows the variations of $\delta^{18}O$ of fallen snow and meteorological conditions (JAPAN METEOROLOGICAL AGENCY, 1980) during the course of 1977. In 1974 the variation of $\delta^{18}O$ of fallen snow follows fairly faithfully that of monthly mean surface air temperature, except for August which had a very high atmospheric pressure and very low $\delta^{18}O$ values. This is because the amount of $^{18}O$-rich water vapor supplied by circumpolar cyclones was smaller in August than in the

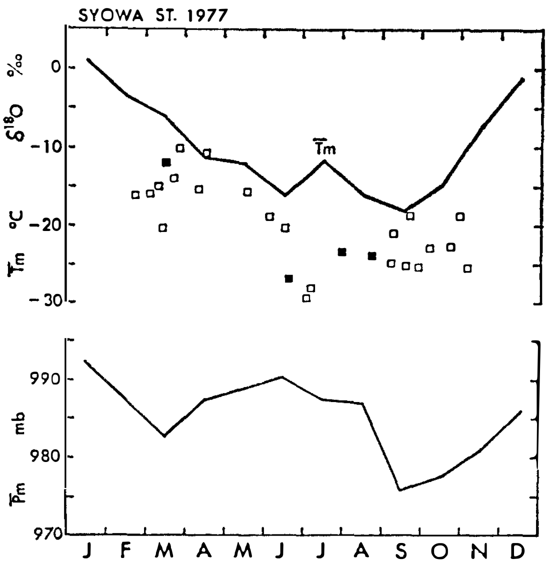


*Fig. 1. Variations of oxygen isotopic composition of fallen snow ($\delta^{18}O$), monthly mean surface air temperature ($\bar{T}_m$) and monthly mean atmospheric pressure at station level ($\bar{P}_m$) during the course of 1977, at Syowa Station. □, Fallen snow without drifting snow; ■, fallen snow partly including drifting snow.*

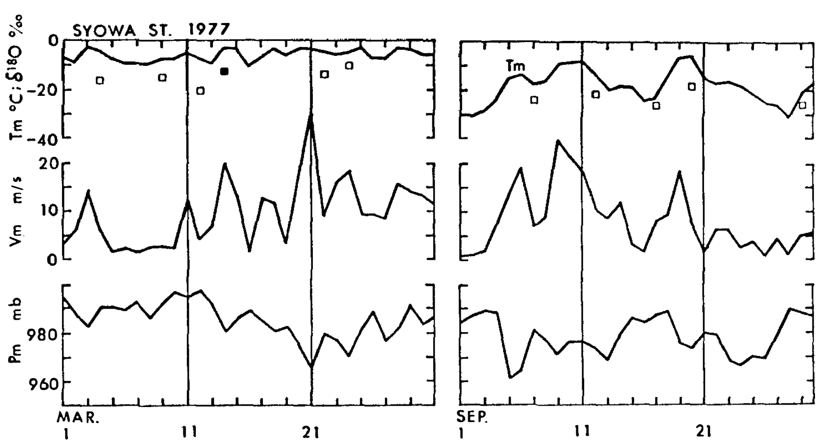


*Fig. 2. Variations of oxygen isotopic composition of fallen snow ($\delta^{18}O$), daily mean surface air temperature ($T_m$), daily mean wind velocity ($V_m$) and daily mean atmospheric pressure at station level ($P_m$) in March and September 1977, at Syowa Station. □, Fallen snow without drifting snow; ■, fallen snow partly including drifting snow.*

other months in 1974.

From Fig. 1 it is seen that the $\delta^{18}O$ of fallen snow during the maximum of monthly mean pressure was also very low in the austral winter of 1977, but not so extraordinarily low as that in August of 1974 which had an extraordinarily high atmospheric pressure. This fact indicates that the variation of $\delta^{18}O$ of fallen snow is caused by the supply of $^{18}O$-rich water vapor resulting from the approach of circumpolar cyclones, as found by KATO (1978).

Figure 2 shows the variations of $\delta^{18}O$ of fallen snow and meteorological conditions (JAPAN METEOROLOGICAL AGENCY, 1980) in March and September 1977, because more fallen snow samples were collected in those months than in other months. The variation of $\delta^{18}O$ seems to follow fairly faithfully that of daily mean surface air temperature. But this does not mean that $\delta^{18}O$ of fallen snow is controlled mainly by its temperature of formation. A surface inversion layer exists in the air over the Antarctic ice sheet. The strong wind destroys the surface inversion and causes the mixing of the surface cold air and the upper warm air. This mixing results in an increase in the surface air temperature but not in the upper air temperature.

Figure 2 may indicate that the $\delta^{18}O$ of snow formed under cyclone is higher than that formed under anticyclones, even at the same temperature of formation of snow. During a circumpolar cyclone passes, wind velocity and surface air temperature usually increase and decrease with decreasing and increasing pressure, respectively. On the other hand, surface air temperature and wind velocity usually decrease under an anticyclone. It is seen from Fig. 2 that the $\delta^{18}O$ values of fallen snow samples collected on March 14 and 24 and September 20 under cyclone increased, whereas those on March 12 and September 7 under anticyclone decreased. These facts may confirm that the variation of $\delta^{18}O$ of fallen snow in 1977 was also caused by the transportation process of water vapor as well as its temperature of

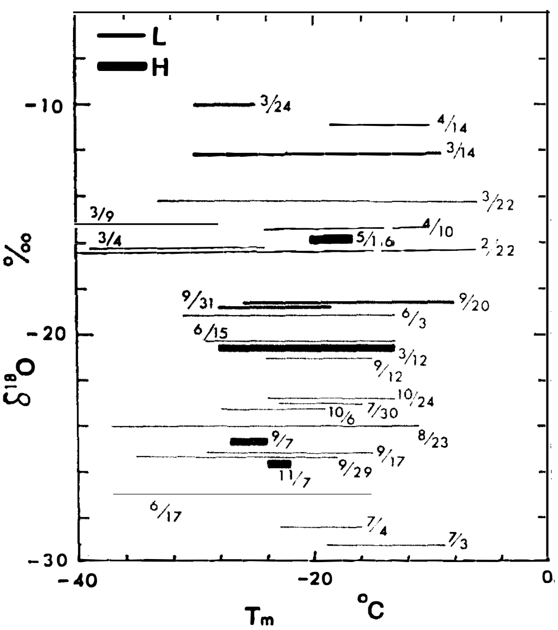


*Fig. 3. Oxygen isotopic composition of fallen snow at Syowa Station with respect to the temperature range in the corresponding cloud layer. H, Under anticyclone; L, under cyclone.*

formation.

Figure 3 shows the $\delta^{18}O$ of fallen snow with respect to the temperature range in the corresponding cloud layer in 1977. The corresponding cloud layer was determined as a layer with relative humidity of 100% with respect to ice from the aerological data (JAPAN METEOROLOGICAL AGENCY, 1980). The remarkable relationship between the $\delta^{18}O$ of snow and its temperature of formation as observed at Roi Baudouin Station in 1958 (PICCIOTTO *et al.*, 1960) is not seen in this figure. As KATO (1978) found, the $\delta^{18}O$ of snow formed under a cyclone is higher than that formed under anticyclone, even at the same temperature of formation of snow. This fact confirms that the variation of $\delta^{18}O$ of snow is caused by the transportation process of water vapor to the Antarctic ice sheet as well as its temperature of formation.

From Fig. 3 it is seen that the temperature of formation of fallen snow was not as extraordinarily low on July 3 and 4 as the $\delta^{18}O$ of fallen snow. This is because the amount of $^{18}O$-rich water vapor supplied by circumpolar cyclones was very small in the latter part of June, which has a very high atmospheric pressure (JAPAN METEOROLOGICAL AGENCY, 1980).

Taking into consideration the supply of $^{18}O$-rich water vapor from the cyclone, the $\delta^{18}O$ of fallen snow in February–May was higher than that in June–November, even at the same temperature of formation of snow. This shows that supplied water vapor was richer in $^{18}O$ in February–May than in June–November. This is strongly related to the shorter distance from the coast of the open sea to the sampling station in December–May than in June–November, as found by KATO (1978). The difference of transportation process of water vapor between the above two periods causes the appearance of 'isotopic summer' and 'isotopic winter', as KATO (1978) pointed out.

It was confirmed that the variation of isotopic composition of precipitation is controlled not only by its temperature of formation, but also by the transportation process of water vapor to the Antarctic ice sheet, which was found by KATO (1978). Taking into consideration the transportation process of water vapor, the isotope relationships of precipitation should be investigated.

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