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SHORT NOTES

A NOTE ON THE CONTRIBUTION OF RIME AND SURFACE HOAR TO THE ACCUMULATION ON THE ROSS ICE SHELF, ANTARCTICA

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Abstract. Observations and measurements made on the Ross Ice Shelf during 1974 suggest that rime and surface hoar deposited on the surface during fogs may contribute 5–10% of the annual accumulation. Layers formed during such fogs may be mistaken for depth hoar layers in the snow-pack.

Résumé. *Note sur la contribution du givre dur et du givre de surface à l'accumulation sur le Ross Ice Shelf en Antarctique.* Des observations et des mesures conduites sur le Ross Ice Shelf pendant la campagne 1974, font penser que de dépôt de givre dur et de givre de surface pendant les périodes de brouillard, peuvent contribuer pour 5 à 10% à l'accumulation annuelle. Des niveaux formés pendant de telles périodes de brouillard, peuvent être, à tort, prises pour des couches de givre de profondeur dans le manteau neigeux.

Zusammenfassung. *Notiz über den Anteil von Rauh- und Oberflächenreif an der Akkumulation auf dem Ross Ice Shelf, Antarktis.* Beobachtungen und Messungen auf dem Ross Ice Shelf im Jahre 1974 lassen vermuten, dass Rauh- und Oberflächenreif, die sich auf der Oberfläche bei Nebel niederschlagen, 5–10% zur jährlichen Akkumulation beitragen. Schichten, die sich während solcher Nebelperioden gebildet haben, können eventuell als Tiefenreifschichten in der Schneedecke missdeutet werden.

Stratigraphic studies in the snow of Antarctica have been directed at determining annual accumulation and defining factors which produce stratigraphic horizonation (e.g. Mellor, 1964; Crary, 1971). Low, but highly variable accumulation rates, the redistribution of snow by winds, and shifting surface topography complicate the use of stratigraphic methods in Antarctica. Accumulation is generally attributed to snowfall, and Taylor (1971) attributed the formation of stratigraphic reference horizons to metamorphic processes rather than a reflection of variations in the originally deposited snow. Benson (1961) indicated the importance of deposition and diagenesis as a continuum in the formation of recognizable stratigraphic sequences. Recent observations on the Ross Ice Shelf suggest that rime and surface hoar make a significant contribution to annual accumulation and *may* produce horizons in the snow-pack which are difficult to distinguish from some depth-hoar layers.

Both ice and supercooled fogs are common in Antarctica. Table I summarizes some observations of the occurrence of fog on the Ross Ice Shelf for various years since 1929. Monthly values at Little America ranged from 3% for June to 20% for April and 24% for December (Grimminger and Haines, 1939). Fogs are also a frequent occurrence in the Antarctic interior (Astapenko, 1960).

Table I. Summary of observations of fog on the Ross Ice Shelf

	Location	*Reference*	*Period*	*Fraction of time with fog* %
Brockton Station	(lat. 80° 01′ S., long. 179° 52′ W.)	A	October–February 1966–72	13
Little America	(lat. 78° 34′ S., long. 163° 56′ W.)	B	1929–30, 1934–35	12*
	(lat. 78° 11′ S., long. 162° 12′ W.)	A	October–March 1956–58	9*
RISS Traverse	(Traverse)	C	October 1962–January 1963	14*
C-7	(lat. 79° S., long. 177° W.)	D	November–December 1974	29

References: A—Bilello and Bates (1975); B—Grimminger and Haines (1939); C—Hofmann and others (1964); D—This note.

* Percentage of days with fog.

Rime and surface-hoar deposition accompanied all fog events at Camp C-7, and surface hoar grew on three occasions when there was no clearly visible fog. Fog most commonly occurred with light (0–5 m/s) south-easterly winds. Sustained snowfall accompanied the fogs when the winds were from the

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north. The fogs were clearly cellular in character, being marked by frequent temperature oscillations (as rapid as 0.5 deg/min), involving changes of up to 5 deg.

Nine measurements of the mass being added to the surface by rime and hoar were made on three separate days by measuring the volume of melt water from deposition on one meter square sheets of clear plastic which had been spread on the snow. This method yields minimum values because:

(a) Rime and hoar accumulated preferentially on the rougher than on the smoother natural surfaces and less collected on the plastic than on the surrounding snow;
(b) There was a small loss by evaporation during the melting of the samples; and
(c) Not all of the melt water flowed from the plastic into the graduated cylinder.

The first factor is the most significant and is estimated to produce undermeasurement of the mass being added to the snow surface by a factor of two or more.

Measurements made at C-7 ranged from 0.5 to 2.0 mg/cm² h, with a mean of 1.0 mg/cm² h. If fog and associated deposition of rime and hoar occur 10% of the time at any given location on the ice shelf (see Table I), and if the rate measurements taken at C-7 are typical, then an estimate of the minimum mass addition through this mechanism is 1 g/cm² year. Limitations in the measurement technique suggest that the actual addition may be twice that. With an annual accumulation of 18.7 g/cm² year at

Fig. 1. An example of a surface deposit of rime and surface hoar at Camp C-7 following a super-cooled fog. The prominent rise, visible in the right foreground, is approximately 18 cm high. The rime–hoar layer ranges from 1 to 2 cm in thickness.

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C-7 (Crary and others, 1962), rime and hoar deposition would comprise 5–10% of the total. Using air humidity and air and surface temperature data to calculate the magnitude of moisture exchange between the air and the surface, Rusin (1959) estimated that rime contributes 10–15% of the annual accumulation over large portions of Antarctica.

Rime and hoar deposited at C-7 grew in distinct clusters and would often form a 2–3 cm thick layer (Fig. 1). The layer was usually either buried by a subsequent snowfall or redistributed to the small-scale topographic lows by gentle to moderate winds. The redeposited material commonly maintained its low density and was, at times, in excess of 5 cm thick. However, when subjected to high winds, the rime and hoar was quickly broken and compacted.

Twenty distinct stratigraphic horizons were visible in a pit 2 m deep excavated at C-7. Some of the low-density layers, especially those associated with crusts, were clearly the result of depth-hoar formation. Others, however, are thought to record the deposition of rime and/or hoar on the surface. Up to 10% of the profile *could be* interpreted to be such layers. Layers which contained a surface hoar component might be interpreted to represent depth hoar. Although ". . . the interpretation of snow strata is based more on the recognition of similar layered sequences than on the positive identification of specific layers" (Benson, 1971, p. 341), the potential existence of horizons which derive some of their primary characteristics from their mode of deposition and which may resemble depth-hoar layers is of particular interest because some stratigraphers do attach temporal significance to depth-hoar occurrence (Shimizu, 1964; Koerner, 1971; Rundle, 1971).

Satellite photographs of the Ross Ice Shelf are normally received on a regular basis, and fogs can generally be distinguished provided there is no higher cloud cover over the same area. This is often the case; hence, the surface areal extent of these fogs and the approximate temperature conditions associated with their existence could enable further estimates to be made of their contribution to the annual accumulation on the Ross Ice Shelf.

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