Mould of Deposited Snow

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Abstract

If snow is moulded with material which is tough above the melting point of ice, the texture of snow can be conveniently studied at room temperature. Thus, plaster of Paris (powder of gypsum) was dissolved in salt water containing 3% NaCl at −2°C. A small lump of snow was soaked in a solution of gypsum thus made and was left standing until the gypsum hardened. This lump was immersed in tepid water to melt away the snow. The remaining gypsum gave, when dried, a negative mould of the snow.

The positive mould was obtained by letting a solution of polyester resin solidify in the negative mould. A special method to dissolve off the gypsum after the solidification became necessary. A method was devised with some success.

I. Introduction

The problem of fixing deposited snow has been a problematic point considered by various workers (Shimizu, 1958). Among these methods the aniline method by Kinosita and Wakahama (1959) seems to be the most excellent.

The method introduced here is a simple devised for field work. This method while not having the accuracy of the aniline method, is sufficient to obtain an outline of the texture of snow.

A negative mould is made by dissolving plaster of Paris in salt water and pouring it into snow block. If the temperature is lower than −2°C, it can be prepared anywhere, and the time required is very short, *i.e.* 1 or 2 hours. When this mould is filed down gradually and observed, the cubic linking in ice grains composing the snow can be investigated.

The positive mould is made by placing the negative mould into a solution of polyester resin which is the embedding medium for electron microscopy. This fixes it and dissolves the gypsum. When the solution of polyester resin penetrates minute gaps in the crystals of gypsum, it is quite difficult to remove the gypsum, and so when the negative mould is placed in a solution of polyester resin, a problem arises. Here we seem to have found a solution to this problem.

There is considerable difficulty in using this and at the same time considerable skill is required to dissolve the gypsum away, but the use of this mould leads to the possibility of making various interesting observations and experiments under normal temperature.

II. How to Make the Mould

1) *How to make the negative mould*

This process must be carried out in the shade at a temperature lower than −2°C, and in most cases it is successfully done if the density of snow is more than 0.25 or so.

(a) At first plaster is dissolved into water. The water is a 3% solution of salt, kept cold by an addition of a handful of snow in it. Plaster is sprinkled in until the sediment reaches the surface of water, taking care that it should not lump. The time required is about 1 minute.

(b) After the plaster is added into water, it is held still for about 2 minutes.

(c) The supernatant is decanted, and the plaster and water is mixed several times with a stick. Soon after, this solution of plaster is sprinkled over a snow block. It is desirable to repeat the sprinkling several times successively, because when the ice grains composing the snow are large the solution penetrates too fast. And when the ice grains are small, the whole block may be immersed in the solution.

(d) It is left standing for 1 or 2 hours.

(e) The whole block is placed in tepid water and the snow melts.

(f) The gypsum is dried as fast as possible.

2) *How to make a positive mould*

(a) A proper-sized block is cut out of the negative mould and is kept in water.

(b) A solution of polyester resin which is used for embedding specimens in electron-microscopy is prepared. Rigolac 2004 and 70 F made by Oken Industry Company are mixed at a ratio of 3 : 1. And to this Benzoylperoxide, an accelerator for fixing, five times as much as the quantity to be fixed *i.e.* 5% wt/vol is added and mixed.

(c) The block is dipped in a thick solution of soap for about 1 or 2 minutes.

(d) The block is wrapped in a piece of gauze and is dehydrated with a centrifugal filter.

(e) The block is immersed in a solution of polyester resin. This together with the receptacle is placed into a vacuum desicater and is kept under depression for about 10 minutes.

(f) The solution and the block are moved into a receptacle made of aluminium foil, and placed in an electric drying oven. The temperature is kept at 70 to 80°C and the solution of polyester resin is fixed after 3 or 4 hours.

(g) A part of the block is cut off with a saw.

(h) The block is dipped into a saturated solution of sodium hydroxide. Then the gypsum becomes colloidal.

(i) This block is put into a saturated solution of Dotit 2NA and is churned with a magnetic stirrer with a heater attached to it. The temperature is set at 40°C.

(j) The procedure on the items (h) and (i) is repeated 2 or 3 times and in 2 or 3 hours a positive mould can be made. This is washed with water and dried.

III. Examination of the Method

1) *Salt water and plaster of Paris*

The reason why plaster of Paris must be melted in salt water and not in plain water is explained by the two following reasons. One reason is that even old humid plaster of Paris is fast setting and when the salt is thicker, the setting time is shorter, but the product is apt to be fragile and the suitable concentration for practical purposes is about 3%. The other reason is that snow should be kept unmelted. When plaster is dissolved in water, the temperature of water rises a little. Thus, 3% salt water which has a freezing point equal to about −2°C, was kept below 0°C. Plaster was dissolved in this saline solution. This mixed material did not melt the snow sample appreciably when the air temperature and snow sample were kept below −2°C, namely, the freezing point of 3% salt water.

2) *Time for stirring*

The longer the time of stirring after decanting the supernatant is, the more viscous plaster becomes. The surface tension and coefficient of viscosity vs. stirring time is illustrated in Fig. 1. The results of this experiment shows that the time for stirring

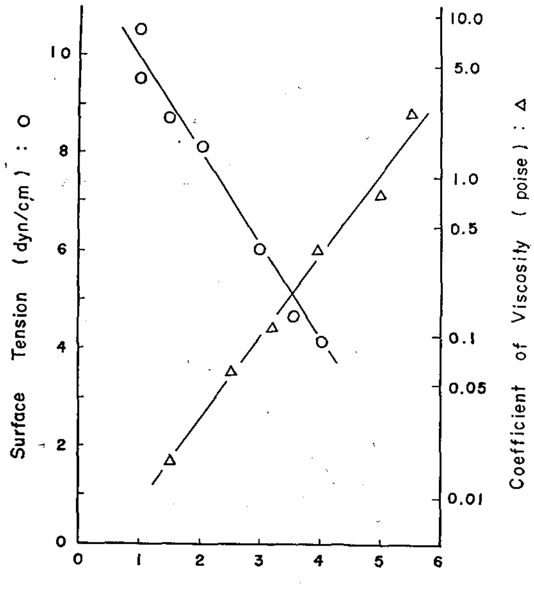

Fig. 1. Surface tension and coefficient of viscosity of plaster solution vs. stirring time

is regarded as not to be related to the hardness of the product. Then the solution is poured into the snow block, in such a way as to fill (the block) completely after a short period of stirring.

The solution of plaster penetrates and fixes the surface of the snow block 1 or 2 cm in thickness. Intervals from the surface to the section vs. the number of grains in one unit area of a section is illustrated in Fig. 2. Judging from this it may be considered that the solution has evenly filled the whole block.

3) *Method of drying*

The drying should be done an electric drying oven at about 80°C. When it dries following its natural course, it is more or less fragile and when it is heated at more

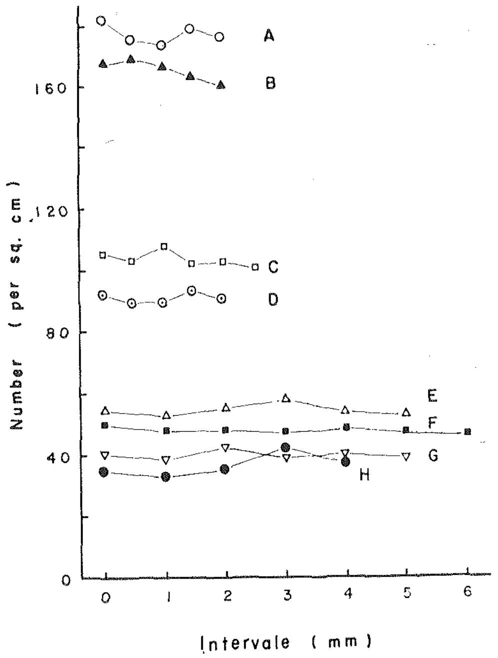

Fig. 2. Intervals from surface to section vs. number of grains in a unit area

than 105°C it converts back to plaster of Paris.

4) *Negative mould and a solution of soap*

Figure 3 shows an enlarged negative mould. A is where ice grains were; B is the gypsum filling the gaps. B is a collection of granular crystals where minute gaps are seen, these gaps are penetrated by polyester resin and then the gypsum becomes hard to be dissolved later. But polyester resin does not penetrate an area occupied by water. Hence it is necessary to fill the gaps of B with water by dipping in water. Then the negative mould is dipped in a solution of soap in order to cover the surface of gypsum with a colloidal film. Since the solution of soap remains also in A, it is removed by

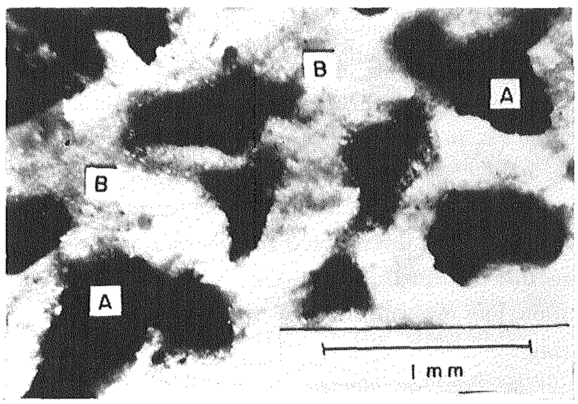

Fig. 3. Enlarged photograph for negative moulds

a centrifugal separator.

5) *Depression*

The negative mould is immersed into the polyester resin. The system is depressed or evacuated in order that the polyester resin may penetrates the above-mentioned part of A. When air remains in the part of A, its volume increases because of the depression of atmospheric pressure and it rises up to the surface of the solution of polyester resin. Polyester resin replaces the air and fills. The time required is 10 to 20 minutes.

6) *Fixation of polyester resin*

The receptacle for fixation of polyester resin is made of aluminium foil, *i.e.* the advantage is that the container may be torn and discarded. The fixation must be done in a short time as possible in order to prevent the polyester resin from filling the gaps of B in Fig. 3. This is the crucial point in producing a good positive mould, and a large amount of accelerating substance must be used and temperature held at 70 to 80°C. With methods used hitherto at 55°C the fixing requires 24 hours but the present method requires only 3 or 4 hours. If the block is turned once or twice before it fixes air bubbles escape.

7) *Removal of gypsum*

First, a part of the mould is cut off from the lump of polyester resin. If the two remaining polyester faces are left intact they support the positive mould and make unbreakable. The block is placed in a saturated solution of sodium hydroxide for 20 to 30 minutes for the gypsum to become colloidal. This is put into a saturated solution

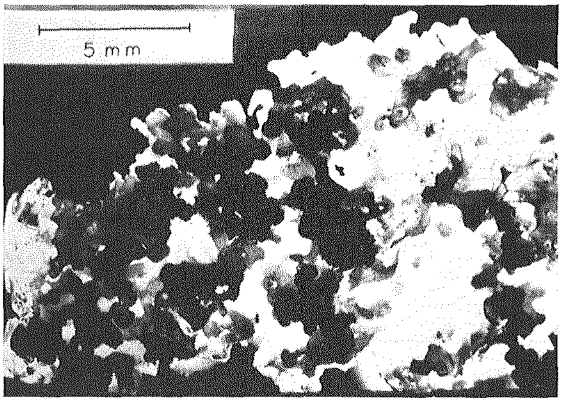

Fig. 4. Positive mould photographed under polarized light

of P. H. 10 Dotit 2NA and softly churned with a magnetic stirrer. The same operation is repeated a few times and in 2 or 3 hours the positive mould can be obtained. Figure 4 shows the positive mould photographed under polarized light.

IV. Utilization

Figure 5 shows a cross-section of the negative mould. This is a horizontal section of the deposited snow. The block (negative mould) is polished with a piece of sandpaper, washed with water, and then polished with water and red oxide of iron on plate glass.

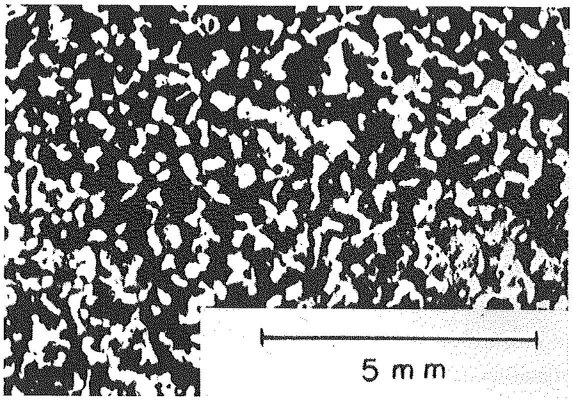

Fig. 5. Section of the negative mould

Red oxide of iron enters the minute gaps, and clear photographs result. When the block is continued to be polished, figure in three dimension of ice grains composing the snow can also be caught.

1) *Forms of ice grains*

The forms of ice grains composing snow are very complicated. Therefore it seems impossible to determine what factors should be selected and how to express it. Here as in Fig. 6, l, the length of the central line, d, the average width, L, the length of the boundary line, and S, the area, respectively of the cross-sections of ice grains, are taken as the four factors.

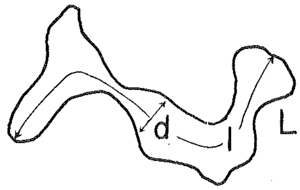

Fig. 6. Definition of l and d for the ice grain

Now in the case of 100 ice grains of the snow (density 0.42) the mean value and the standard deviation of these four factors are derived as follows:

	l (mm)	d (mm)	L (mm)	S (mm^2)
Mean value	0.84	0.32	2.7	0.36
Standard deviation	0.71	0.13	2.2	0.34

From this we find that the factors except for d are distributed very irregularly. Then two factors, $f=l/d$ and $m=L/S$ are introduced. In metallurgy f is called the form factor and is used as a beginning for the study of grain (Masuda, 1959, p. 16). The factor m is called the meander factor. In the above-mentioned 100 ice grains the distribution of f is illustrated in Figs. 7 and 8. From there results following conclusion is derived:

(a) On the whole, f increases with l. It shows, as mentioned above, that d, the width of ice grains, is closely distributed around its mean value.

(b) Generally f increases with S, which shows that larger ice grains have a remarkable meander value and take complicated forms.

Next, the meander factor m vs. area S is shown in Fig. 9. The straight line a shows the relation S and m in a circle. Lines b, c and d show the relation between S and m

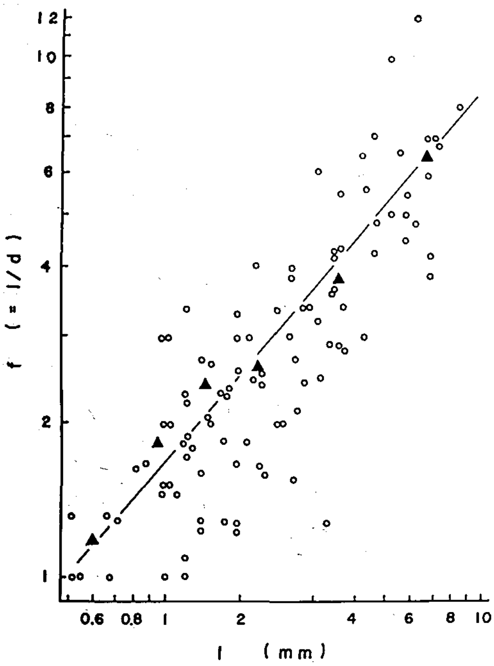

Fig. 7. Form factor f vs. l for ice grains in one section

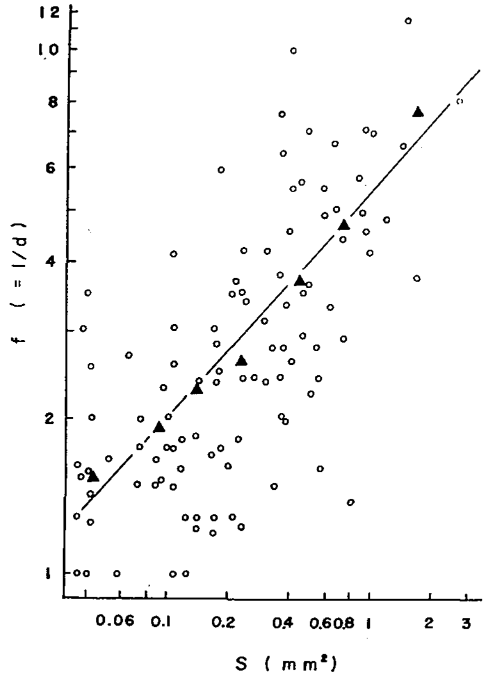

Fig. 8. Form factor f vs. S for ice grains in one section

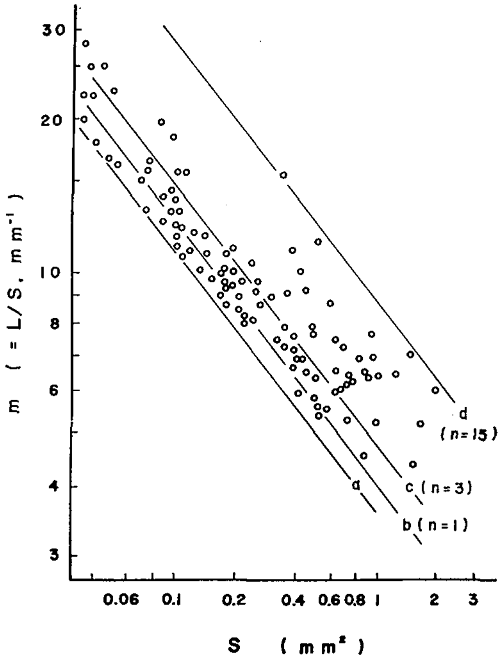

Fig. 9. Meander factor m vs. area S. Line a is for a circle. Line b, c and d are for rectangles 1 : 1, 1 : 3 and 1 : 15, respectively the ratio of length to width

in a rectangle which has the ratio of length to width n. Therefore line b shows the same in the case of a square because $n=1$. Line c almost equals the mean value of f of ice grains and $n=3$. From this figure the following points may be denoted:

(a) Generally ice grains with smaller cross-sections have simple forms.

(b) Ice grains with larger cross-sections have a remarkable meander value and complicated forms.

(c) The limit of complexity can be understood by imagining the meandering of a string of which the length is 15 times larger than the diameter.

When these factors are examined in snow of different density, generally the following tendency can be mentioned. The density of the snow used ranges from 0.22 to 0.50.

(a) The mean value of L is 3 to 4 mm and the difference in density makes hardly any difference, but S increases in accordance to density. Therefore L/S $(=m)$ decreases with the increase of density. In short, when density increases, the form of ice grains is more simplified.

(b) Mean value of l/d $(=f)$ is 3.0 to 4.0 and the difference in density makes little difference, but l and d increase with the density. In short, ice grains grow thick and long with the increase of the density.

2) *Three dimensional consideration*

Every time after the negative mould was polished a photograph was taken and the three dimensional connection in ice grains could be seen. The actual thickness of the part polished down in each time is 0.2 mm. The two serial films, up and down, are

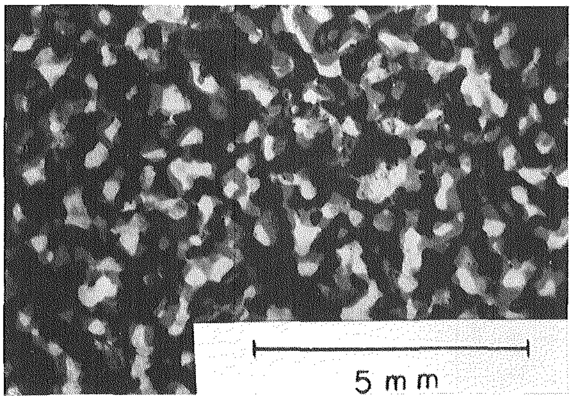

Fig. 10. Overlapped photograph of two sections at intervals of 0.2 mm

deliberately put together and Fig. 10 was obtained. The white part shows that upper stratum and lower stratum of ice grains are overlapped and the dark part shows only one stratum of ice grains. To study this overlapping, an overlap factor is introduced. On the cross-section of ice grains illustrated by a thick line in Fig. 11, the area of the part overlapping the other stratum of ice grains illustrated by a thin line is denoted by S_o, the area not overlapping

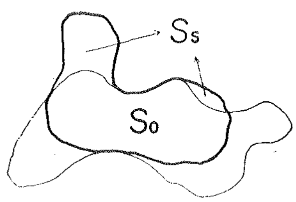

Fig. 11. Definition of S_o and S_s. All area $S=S_o+S_s$

by S_s, and entire area by S. The overlap factor O is defined by the following formula:

$$O = K\frac{S_o}{S_o + S_s} = K\frac{S_o}{S}.$$

Only K is the function of the interval between the two stratum and here the interval is 0.2 mm, and $K=1$. Thef ace of the part rubbed down is the horizontal plane of the deposited snow, so if the value of O is large the vertical linking becomes conspicuously stronger.

In the snow of a density of 0.42 the relation beween O and S is shown in Fig. 12, *i.e.* the smaller cross-sections S of ice grains are wholly included in, or often come off,

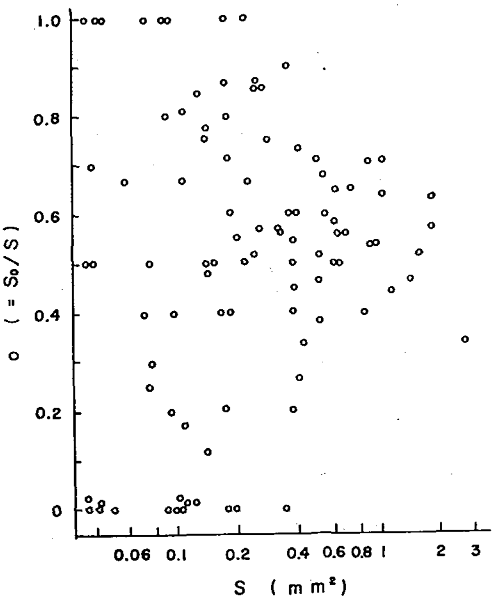

Fig. 12. Overlap factor O vs. area S for ice grains

the sectional area of ice grains of the other stratum. But O of ice grains with comparatively larger cross-sections is distributed in a certain range. In this case the mean value of O of 100 ice grains is 0.51, and that of 50 ice grains with a larger cross-sections is 0.57.

In snow of different densities, the value of O was examined but nothing worthy of note was found, perhaps because of want of data. But it seems that when the three dimensional consideration is made in the future this overlap factor may play a prominent role.

Next, based upon photographs of cross-section made with intervals 0.2 mm, an enlarged model of ice grains is made, in much the same manner as a model of topography is made out of contour lines. Figure 13 shows the model enlarged 20 times 5×5×2 mm. Its material is white clay.

3) *Positive mould*

Positive moulds can be made, if it is a cube with a side shorter than 1 cm or so. This mould breaks under a slight pressure and attempts to carry out a photo-elasticity

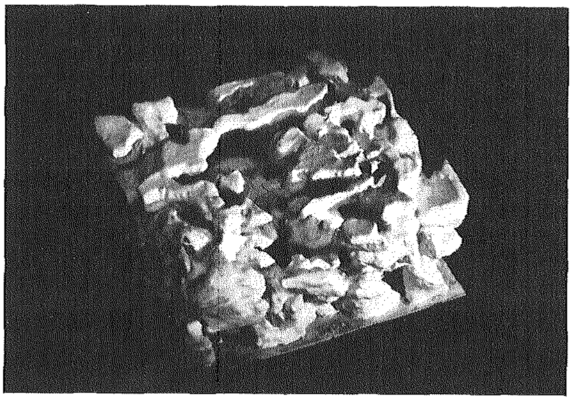

Fig. 13. Twenty fold scale large model for deposited snow

experiment failed. Positive moulds are expected to be of considerable use.

V. Conclusion

In snow with a density of more than 0.25, negative and positive moulds are made by using plaster of Paris and polyester resin. The merit of this mould lies in the fact that a study of the nature of deposited snow is possible to some extent under normal temperature. Actually from the cross-section of a negative mould, a clue to the study of the process of deformation of deposited snow can be found. The introduction of positive moulds was made, and future application is expected.

Acknowledgments

Author's thanks are due to Dr. Z. Yosida and the other scholars at the Institute of Low Temperature Science, Hokkaido University who advised and encouraged him in the course of this study. A part of expenditure necessary for this study were defrayed by the Grant-in-Aid from the Ministry of Education.

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* In Japanese with English summary.