

*Fig. 1 (top). Monte Rosa. The black dot near the summit shows the position of the tunnel
 Fig. 2 (bottom left). The tunnel entrance is seen to the right of the large rock near the bottom of the picture
 Fig. 3 (bottom right). Looking out through the tunnel entrance*

THE COLD ICE TUNNEL ON THE SILBERSATTEL,
MONTE ROSA
PRELIMINARY REPORT

By JOEL E. FISHER

DURING the summer of 1952 a horizontal tunnel at the 4200 m. contour was driven 65 m. into the Monte Rosa Glacier, heading south-east toward the Silbersattel. (Swiss co-ordinates 632·65, 87·70, *Landeskarte der Schweiz*, Blatt 284, *Mischabel*.) The tunnel is 2 m. high by 1 m. wide, and its floor is level. The black dot in Fig. 1 (p. 194) shows its location; Fig. 2 (p. 194) shows the portal, as seen from Point 4203 on the Swiss map (*Mischabel* sheet); Fig. 3 (p. 194) shows a view from within the tunnel, looking north-west, and Figs. 4 and 5 (p. 193) are flashlight photographs taken inside the tunnel. Fig. 6 (below) is a profile of the tunnel and slope.

The object of driving this tunnel was to obtain a complete sounding right through to bedrock of a truly cold Arctic-type glacier, including data on density and temperature, as well as on possibly

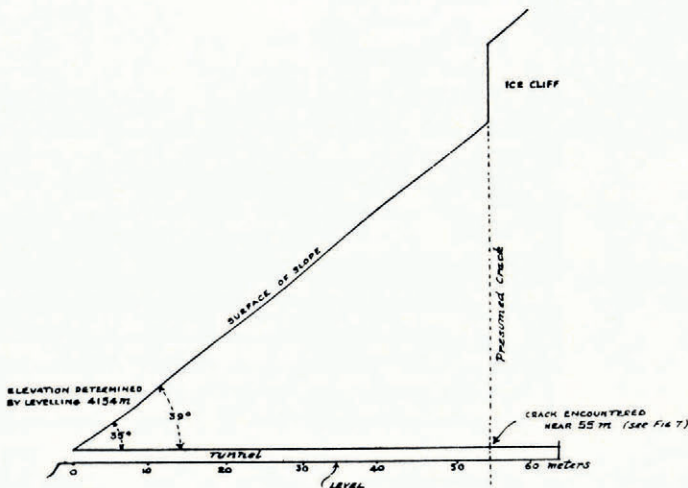


Fig. 6

varying velocities within the ice; and, indirectly, on relative viscosities, at different temperatures below 0° C. A further object was the visual exploration of the basal region of an active cold glacier, where the pressure on the bed is many hundred pounds per square inch.

It is pertinent to comment that the major discharge of this Monte Rosa Glacier is through a gap leftwards in Fig. 1, as a glacier superimposed on top of the wide Gorner Glacier (left of the photograph), rather than, as suggested by the location of the words "Monte Rosa Gletscher," on the Swiss map, towards the Gornersee (bottom right in the photograph). The continuation of this inlay of Monte Rosa Glacier ice, in the Gorner Glacier, produces its centre lane of remarkably white ice, so well seen from the Gornergrat, a whiteness due to the "bubbly" (snow-like) nature of that particular lane (density about 0·85) compared to the darker non-bubbly normal glacier ice on either side of it, density about 0·90. (See *Journal of Glaciology*, Vol. 1, No. 7, 1950, p. 373-77, for a description of this particular white lane of ice by the writer.)

It is well known that bubbly ice in glaciers is typical of high Arctic glaciers. It is rare in temperate zone glaciers (except in the Himalaya), suggesting that the formation of bubbly ice is the result of firnification of snow under unusually cold conditions (*i.e.* without presence of rain or melt water). Of all continuous glaciers in the Alps this Monte Rosa Glacier possesses the *coldest* area of accumulation—as any climber or guide will agree. Exposed to the north, shaded by the Dufourspitze—a

notably "cold" peak—this particular location, some 1000 m. above the firn line, promised genuinely cold conditions—and observations in the tunnel most assuredly have fulfilled these expectations.

Density. After penetrating the 10 m. of surface (fairly recent accumulation of snow), the density is about constant, about 0.75, compared with 0.85 for this ice, years later, in the lower glacier. No blue bands whatever were noted.

Occasional air pockets, up to 10 litres volume, were pierced.

The material is apparently hard, compressed *névé*, with no suggestion of further crystal growth.

At 55 m. in, a vertical crack 10 cm. wide, was crossed. This appears to be the downward continuation of the vertical ice cliff, seen above the portal in Fig. 2; if so it is convincing evidence that a cold glacier moves over steps in its bed by vertical cross-glacier faulting. This crack was clean-sided, and a powerful draft of air circulating through it, gave welcome ventilation this far inside the tunnel.

Temperatures. These were noted as follows:

TABLE I

Distance from portal in meters	Temperature	
	° F.	° C.
10	16	- 8.9
20	14	-10.0
30	13	-10.6
40	12	-11.1
50	11	-11.7
60	8	-13.3

The tunnel crossed the crevasse at 55 m. and here the sudden drop in temperature took place.

There was no appreciable change in the temperatures over a period of two months. Four alcohol Fahrenheit thermometers were used, inserted 15 cm. into the ice as a check on each other.

Another tunnel has been driven 28 m. in the Signalkuppe *névé*, at an altitude of 4300 m., as a check on observations made in this main tunnel. A comparable temperature gradient was found there.

The portal of this tunnel has now been well marked by poles, as well as by bearings and staining of snow, so that there is no doubt about recovering the entrance next spring, when it is hoped to continue the tunnel right through to bedrock, perhaps 100 m. further. A rope has been laid loosely along its floor in case of any dislocation across the floor.

Even without further advance of the project, changes in the location of the portal with reference to fixed Point 4203 on the map, changes in the grade of the tunnel, and the rate of deformation of the 2 × 1 m. cross-section of the tunnel (compared to that of similar tunnels in isothermal glacier ice) will produce, by next spring, useful data on the rate of flow of cold ice *névé* * and in the viscosity of cold ice. No confirmation, or otherwise, of extrusion flow at this altitude can be expected until a year or so after the tunnel shall have been extended to near bedrock. It is expected by the writer (the sponsor of the tunnel) that the temperature of the ice may rise on approaching bedrock, due both to concentration there of internal heat of the earth and friction.

The physical work involved in the tunnel excavation was very considerable. No mechanical aids were used. Credit is due to Felix Julen, the writer's guide at Zermatt for (now) 41 years, who, at the age of 69, took charge of the operation and inspired many other younger fellow guides to join in the labour. Also, to Messrs George C. Band, Roger Chorley, Ian MacNaught Davies and other Cambridge friends of theirs who put in the better part of the 1952 summer on this project.

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* Observations at the bergschrund, altitude 4500 m., at the very head of this *névé* field, showed an opening of 1 m. in 2 months (July and August), the movement being directly in line with the bearing of this tunnel, so that a velocity of perhaps 5 to 10 m. per annum at the tunnel can be expected.