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CASUALTIES IMMERSED IN GLACIER ICE. CLEAR AND DOUBTFUL CASES FROM GLACIOLOGICAL VIEW

Abstract: AMBACH W., AMBACH E. & TRIBUTSCH W., *Casualties immersed in glacier ice. Clear and doubtful cases from glaciological view.* (IT ISSN 0391-9838, 1992).

Five fatal accidents which happened on glaciers in Tyrol are discussed. For forensic examination it is important that the site of accident and the site of discovery are not identical. While three cases are clear from the glaciological point of view, two other cases are doubtful. In these latter the question arises as to whether one person or two persons were involved in the accident.

KEY WORDS: Corpses in glacier ice, Fatal accident, Austrian Alps.

Riassunto: AMBACH W., AMBACH E. & TRIBUTSCH W., *Corpi immersi nei ghiacciai. Casi chiari e casi dubbi dal punto di vista glaciologico.* (IT ISSN 0391-9838, 1992).

Vengono discussi cinque incidenti avvenuti sui ghiacciai del Tirolo. Dal punto di vista medico legale è importante che i ritrovamenti avvengano in zone diverse dai luoghi degli incidenti. Mentre tre casi di quelli presentati sono chiari dal punto di vista glaciologico, altri due sono dubbi. In questi ultimi, il problema è principalmente dovuto al fatto che non si sa se una o due persone siano state coinvolte negli incidenti.

TERMINI CHIAVE: Corpi nei ghiacciai, Incidente, Alpi Austriache.

INTRODUCTION

Generally, fatal casualties on glaciers remain immersed in firn and glacier ice for many years. They are moved along the flow lines from the site of the accident to the site of discovery. Five cases of fatal accidents on glaciers in Tyrol and the discovery of the respective corpses are being examined from the glaciological point of view. From the forensic view the fact is important that the sites of accidents and of discoveries are not the same. In addition, in some cases the discussion is left open as to whether or not the accidents occurred through fault of another person. It is possible to reconstruct both site and scene of an accident by glaciological facts.

ANALYSIS

Five cases are analysed: three cases (cases 1-3) which are clear from a glaciological point of view. These cases are described in a previous report (AMBACH & *alii*, 1991a). In the present paper two doubtful cases (cases 4 and 5) which are not clear from the glaciological point of view are added; they are discussed in detail and a possible interpretation is given. Hence, this report represents a certain progress over the previous one. Fig. 1 shows the locations of the glaciers in Tyrol where corpses or bones have been discovered.

Case 1

The accident occurred on August 25th, 1965, close to Wildspitze (3 770 m a.s.l., Oetztal Alps). The casualties (a married couple) left the common path and fell down a 260 m high rock wall, after a snow cornice had collapsed following fall in temperature with snowfall. They landed near the foot of the rock wall at an altitude of 3 400 m a.s.l. in the topmost area of Mitterkarfener. The corpses were discovered in September 1990, after 25 years at distances of 150 m and 180 m, respectively, from the foot of the rock wall. The upper most casualty was still immersed in glacier ice, and the lower was exposed at the surface on a glacier table about 0.45 m high (AMBACH & *alii*, 1991b).

In spite of the fact that the accident had happened in the accumulation area, the corpses were exposed above the

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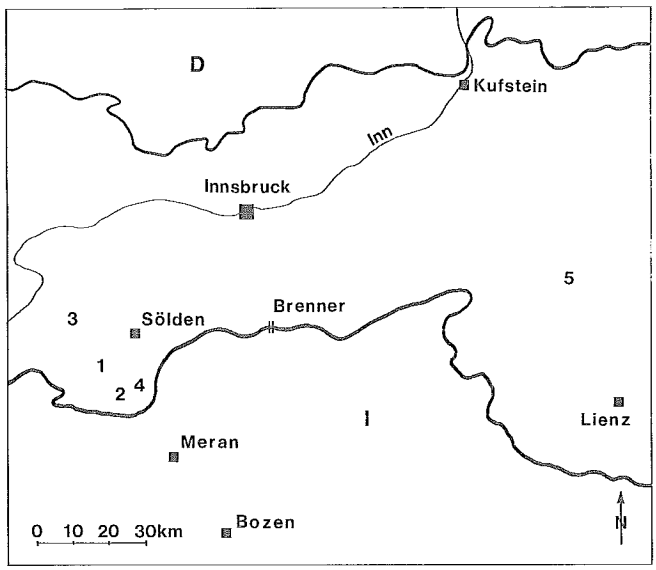

FIG. 1 - Map of the locations of the glaciers. 1) Mitterkarfener (case 1). 2) Gurgler Ferner (case 2). 3) Madatschferner (case 3). 4) Rotmoosferner (case 4). 5) Prägrat Kees (case 5).

equilibrium line. Generally, the flow lines would only permit a discovery in the lower part of the ablation area. From time and distance, a rate of <6m/year was calculated, which is in agreement with data obtained from Kesselwandferner, located close to Mitterkarferner and in a similar exposure Lower values for velocity would result if it were assumed that the casualties slid along the glacier surface immediately after the accident.

On Kesselwandferner, which is similarly exposed as Mitterkarferner, the equilibrium line was shifted approximately 100 m higher during the period from 1965 to 1990. The shrinking of the glacier surface was greater than the immersion rate. The casualties were thus released in 1990 after only 25 years. In a fictitious state of equilibrium, the bodies would have followed the flow lines from the accumulation area to the ablation area, then an exposure in the ablation area would have occurred only at a considerably later date.

Case 2

The accident happened in the ablation area of Gurgler Ferner (Oetztal Alps) in 1965. A mountaineer had been seen leaving the common path in an area of crevasses and seracs, obviously in order to take some photographs. After falling into a crevasse over 40 m deep, the casualty could not be rescued because of the exceptional depth and structure of the crevasse.

About 8 years later i.e. in 1973, the casualty was exposed on the glacier surface in the ablation area, about 150 m further down. Time and distance result in a rate of about 20 m/year, which is in agreement with glaciological experience.

Case 3

A corpse was discovered in 1952 at the very end of the Madatschferner (Kaunergrat Range, Oetztal Alps) on ice free terrain. Site and scene of the accident are unknown, but the accident probably happened in 1923, as determined from a report on a person missing. Hence, the casualty had been immersed in glacier ice for 29 years. At the topmost part of the accumulation area, a trail crosses the glacier. Assuming that the accident happened on this trail, from time and distance, a speed of between 25 and 35 m/year would result, which is too high for this small glacier. It is therefore likely that the accident occurred in lower zones of the glacier, but still in the accumulation area.

Case 4

In the ablation area of the Rotmoosferner (Gurgler Range, Oetztal Alps) at 2 700 m a.s.l., parts of a skeleton and objects of a casualty were discovered at the same site in 1982 and 1990. The objects found were spread over an area of approx. 70 to 80 m in length and 50 m in width. The first discoveries were related to a missing person who had done a sking tour of Rotmoosferner in 1943. The casualty had been therefore immersed in glacier ice for 39 or 47 years, respectively. The site of the discovery is situated below seracs with large crevasses. An accident due to falling into a crevasse close to the equilibrium line is very likely. The case is doubtful, however, because of the long interval of 8 years between the first and the second discovery of objects at the same site.

From the forensic point of view, therefore, the question of whether one or two persons were involved in this accident arises. If it were 2 persons, did the accident occur through fault of another person? From the glaciological point of view the question arises of how the long interval between the first and the second discovery be explained by the flow. It has to be taken into consideration that the corpse was torn by shear and extending stresses after having fallen into the crevasse and that an exposure of parts of the skeleton at subsequent times had thus been facilitated due to the high rates of ablation between 1982 and 1990.

Case 5

At the Prägrat Kees (Granatspitz-Range, Hohe Tauern) at the very end of the glacier, bones and objects of a casualty were discovered at the same site at 2 750 m a.s.l. in 1953 and 1990. Prägrat Kees is a glaciological speciality since the extension in width is larger than the down hill extension. Today this glacier is almost inactive as far as movement is concerned (estimated rate <1m/year) and is almost without crevasses. Because of the similarity with case 4, the same questions have to be asked both from forensic and glaciological points of view. On basis of a report on a person missing it is assumed that the accident occurred in September 1936 (AMBACH & *alii*, submitted). The casualty had therefore been immersed in glacier ice for 17 or 54 years respectively. A considerably larger ex-

tension of the glacier and crevasses could be determined only after inspection of a map dated 1932. Therefore the accident is likely to have occurred as follows: fall into a crevasse, action of stresses and consequent dismemberment of the corpse. The different moments of the exposure of bones and objects can be explained by the fact that considerable fluctuations of the glaciers have been documented for the period between 1936 and 1990 (PATZELT, 1985): (i) strong retreat with comprehensive areas becoming ice-free until 1964; this would explain the first discovery in 1953. (ii) from 1964 to 1980, strong advances with increased accumulation rates, which would facilitate a repeated immersion of the objects. (iii) Another strong retreat with enhanced ice melt from 1980 onwards, which would explain the second discovery.

FINAL REMARKS

On Alpine glaciers, time of immersion of casualties in the ice can range from a few years to centuries (KRÄMER & *alii*, 1988). In this respect glacier flow and variations in mass balance do play an important part. Therefore, glaciological facts are helpful for forensic examinations.

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