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The contribution of dendroglaciology for the reconstruction of historical fluctuations of Madaccio Glacier (BZ, Italy) and the definition of its scientific attribute and ecological value

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INTRODUCTION

Reconstruction of recent glacial history constitutes an important element to understand past and present-day climatic trends. As it is well known, climate is what supplies the input for changes in glacier mass balance and frontal variations. However, the climatic events that are responsible for glacier fluctuations are also recorded by natural "archives", among which tree vegetation, which is a source of precise, detailed data with reference to time. In Trafoi Valley, near Madaccio Glacier, studies aimed at a reconstruction of glacial history covering recent centuries have been in progress for years, with a considerable contribution being offered by dendroglaciological investigations. On the one hand, tree rings chronologies has made it possible to reconstruct the climatic variations responsible for some of the phases of glacial advance. On the other hand, the presence of very old trees on moraines, has permitted attribution of the latter to a minimum age of deposition. A recent contribution has come from the retrieval of two trunks buried by the outermost lateral moraine of Madaccio Glacier and from old trees found outside the area occupied by the glacier during the LIA. In this area a very detailed geomorphological survey has been carried out in order to identify glacial erosional and constructional landforms and ice-contact drift landforms. These glacial evidences will be placed in a chronological sequence on the base of dendrochronological and historical data. The aim of this work is to underscore the contribution of the dendroglaciological investigations in: 1. the identification of early

phases of the LIA; 2. the reconstruction of phases immediately preceding the peak of the LIA; 3. identifying the interval of climatic phases responsible for the death of the trees; 4. the collection and analysis of elements useful to define Madaccio Glacier and its proglacial area as a geomorphosite, with a particular focus on its paleoclimatic and ecological value.

SURVEY DATA

As it is well-known, the LIA maximum advance was reached by most glaciers in the first two decades of the 19th century. Reconstruction of the advances preceding that peak phase is quite problematic. In fact, moraines deposited during the LIA maximum have generally erased traces of glacial deposits related to previous advances, except for rare cases in which some remnants of lateral moraines remain. In Madaccio valley, it was possible to document an advance preceding the LIA peak through the minimum age of a larch (1624) situated on a lateral-frontal moraine, and the chronology of another larch, situated on the upper part of the same lateral moraine. The year of germination has been estimated as 1535 and its chronology shows a marked minimum in the first decade of the 17th century. At that time, Madaccio Glacier probably had a wider tongue that was probably a bit shorter in length compared to its length in the 19th century. The dendrochronological curve for the tree could not document an advance phase, but only adverse climatic conditions for growth. However, the negative interval on the dendrochronological curve for the larch growing on the moraine and the age of the tree in the frontal position together makes it possible to date an advance of Madaccio Glacier in the first two decades of the 17th century (Pelfini, 1999 a,b; 2003). As regards the phases leading up to the LIA maximum, a considerable increase in the advance speed was observed in the second half of the 18th century. This advance phase has been documented for example in the western sector of the Alps (Pelfini, 2003) and evidence is provided by a tree (Picea abies) that is still living at the base of the outermost frontal moraine dating back to 1790. Taking into consideration the time required for re-colonization, the moraine could have been abandoned around 1770. However, the glacier front seems to have maintained a rather advanced position up until the end of the 18th century, possibly with positive minor variations in the last decade of that century. The frontal moraine could have been definitively built around 1820-21, as also documented by historical evidence. Again, in the 18th century, the death of trees occurred on a large scale, as documented throughout the proglacial area of Madaccio Glacier, where semi-buried trunks are found dating between 1678 and 1790 (Pelfini, 1999). The samples collected recently, particularly the retrieval of the trunks buried in the lateral moraine, will make it possible to describe the recent evolution of Madaccio Glacier in further detail.

DISCUSSION AND CONCLUSIONS

The extensive documentation obtained permit us to define Madaccio Glacier and its proglacial area as a unique geomorphosite (Panizza, 1988, 2001). In fact, the generalized increase in the tourist influx in recent decades and the intrinsic rapidity of the evolution of geomorphological assets in high-mountain areas, has led to an intensification of the need for their valorization and protection in this zone as well. As it is known, the identification of a geomorphosite should be based on cumulative value derived from the summation of values deriving from four types of attributes (scientific, cultural, socio-economic and scenic). The value of each attribute is based on several specific valences, which can acquire a different weight depending upon the rarity of the form considered (Panizza, 1992, 2001; Pelfini & Smiraglia, 2003). Like many glaciers, Madaccio Glacier stands out for spectacularity in the high-mountain setting of Alto Adige. As concerns the cultural attribute, Payer's descriptions (1867) or those of various other authors who have dealt with wartime events that took place on Ortles-Cevedale massif will suffice. As for the socio-economic attribute, there is no doubt about its importance as a center attracting tourists. It should be noted that the upper part of the glacier is part of the area used for summer skiing at Stelvio Pass (Diolaiuti et alii, 2002; Belò et alii., 2002). The scenic attribute is also of indisputable importance, documented by the beauty of the setting that is observable for example from the trail Stelvio Pass-Trafoi, which offer a general view of the north of the Ortles-Cevedale Group. Lastly, as regards the scientific attribute, Madaccio Glacier presents all the valences as indicated by Panizza (1992) (as a model of geomorphological evolution, didactic exemplarity, paleogeomorphological evidence and ecological value) (Pelfini and Smiraglia, 2003). In fact, it can be considered to be a model of evolution, as witnessed by the recent history documented by the dated moraines. Valence as didactic exemplarity automatically relates back to the model of evolution, as the glacier tells its own story through the series of moraines deposited and makes it available through easy utilization of the geomorphosite, which is located very close to the road. As in the case of all glaciers, its valence as paleogeomorphological evidence is mainly important in terms of paleoclimatic evidence, which is legible through geomorphological and dendroclimatic documentation. For the Madaccio geomorphosite, glacier and periglacial area, the ecological valence deserves special emphasis. In fact, the rich dendrochronological documentation and the presence of easily observable buried trunks and trees that have been damaged and deformed by geomorphological and atmospheric processes, offer an added value to the geomorphosite itself.

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