Geo.Alp, Vol. 4, S. 123–126, 2007

LARGE HOLOCENE MASS MOVEMENTS IN THE DOLOMITES (VAL GARDENA AND VAL BADIA)

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Introduction

The Val Gardena and Alta Badia are located in the Dolomites of South Tyrol. During the excursion participants will sightsee some remarkable examples of landslides affecting weak clayey rocks, limestones and porphyry. Insight on some monitored test sites will also be provided. Three main stops are planned: Main stop 1: Mt. Rascesa landslide (Val Gardena); Main stop 2: Passo Gardena landslide (between the Val Gardena and Val Badia); Main stop 3: Corvara landslide (Val Badia) (Fig. 1).

The Geology of the Dolomites is dominated by dolomitic rocks which form isolated peaks or high standing plateaus rising above an altitude of 3000 m (Fig. 2). These rocks result from recrystallisation of Triassic organic reefs in the subsiding ancient Tethys Sea. These reefs grew over earlier crystalline basement rocks, now locally represented by porphyry. Reefs in many cases interfinger at the margin with basinal deposits of volcanic, carbonaceous or calcareous origin, mainly deposited as turbidites. These basinal deposits are now layered weak rocks composed of marl or limestone strata alternating with thin clay shale and claystone strata, outcropping on slopes underlying dolomite scarps.

Geomorphological features are strictly related to the climatic vicissitudes of the Quaternary. Glacial deposits related to the Würm Pleniglacial phase can be found at elevations above 2000 m. Cirques, suspended valleys and glacial deposits are found in both areas at lower elevations, witnessing the presence and progressive disappearance of valley glaciers which developed during the Würm Lateglacial phase and the Holocene. Scree talus and fans which border the foot of the dolomite slopes are the result of periglacial and gravitational processes which have been active since the disappearance of the Pleniglacial ice cap.

In the area, landforms and deposits due to slope movements triggered in the Lateglacial to early Holocene period are widespread (Fig. 3). Landslide deposits are mainly ascribable to vast rock falls from the dolomite cliffs and rotational-translational slides occur in correspondence with slopes made up of pelitic rock types. In the latter case, landslide bodies are sometimes characterised by a thickness exceeding 100 m and an extension of several square kilometres. In some cases, deep rotational slides affecting the pelitic formations are associated with lateral spreading processes in the overlying dolomites.

Fig. 1: Field trip itinerary.

Radiocarbon dating of samples collected from drill cores and outcrops, showed a certain cluster of events in two distinct temporal phases. The first phase was observed in the Preboreal and Boreal (about 11,500 to 8500 cal BP) and includes, on the one hand, large translational rock slides, which affected the dolomite slopes following the withdrawal of the Würm glaciers and the consequent decompression of slopes and, on the other hand, complex movements (rotational slides and flows) which affected the underlying pelitic formations and were probably favoured by high groundwater levels resulting from an increase of precipitation and/or permafrost melt. A second

Fig. 2: Overview of part of the Val Badia.

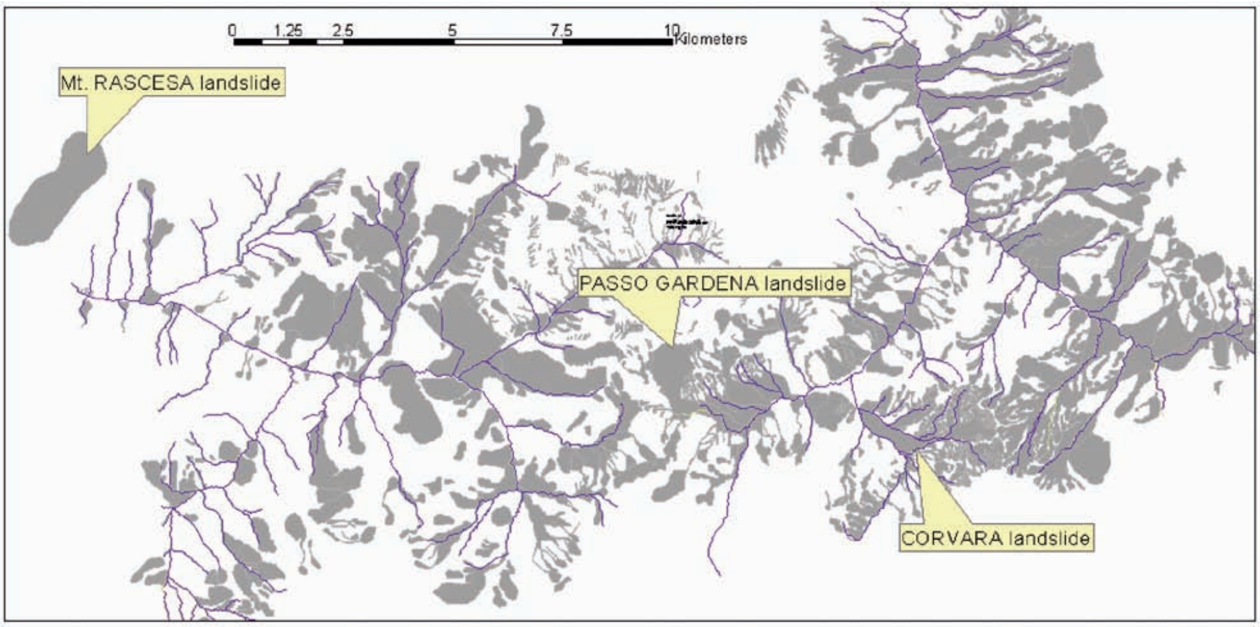

Fig. 3: Spatial distribution of landslides in the Val Gardena and Val Badia.

concentration of landslide events is found during the Subboreal (about 5800 to 2000 cal BP), when slope processes, mainly rotational slides and/or flows, took place in both study areas. These slides may be considered as reactivations of older events linked to the phase of increased precipitation, which has been documented in several European regions during the mid-Holocene period. On the other hand, during the Little Ice Age, the scarce number of landslides dated in the study areas does not enable an increased frequency of landsliding to be detected.

Main stop 1: Mt. Rascesa landslide (Val Gardena)

The Mt. Rascesa landslide is a roto-translational rock slide affecting porphyry rock masses and extending over an area of about 2 km^2 (Fig. 4). Rock blocks making up the toe of the landslides are found across the valley, pointing to an ancient (undated) event that dammed the Gardena torrent. Recently, L-band interferometric analysis has shown movements taking place in the crown zone, linked to activity of scree slopes. No other monitoring has been performed on this landslide so far.

Main stop 2: Passo Gardena landslide (between Val Gardena and Val Badia)

The Passo Gardena landslide is a complex-composite-type mass movement extending over an area of about 2.4 km^2. It starts off as a rock block slide affecting dolomite rock types (making up clean rocky and spiky outcrops) – that in turn have fallen into coarse boulders. This landslide evolves into a rotational slide affecting weak clayey rocks of the S. Cassiano and La Valle formations, and then becomes an earth slide – earth flow of some million m^3 of clay-rich material (Fig. 5).

Borehole investigations and a geophysical survey have shown that the thickness of the earth slide – earth flow portion ranges from 45 to 70 m. Concerning present day movements, the uppermost rock block slide does not show evidence of ongoing activity, whereas large sectors of the flow-like processes are active, damaging a strategic roadway connecting the Alta Badia Valley with the adjacent valley.

Recent monitoring data from inclinometers have shown that movements in the earth flow portion take place on sliding surfaces located at a depth of about 20 m. Downslope, movements are negligible, so at present the landslide is considered to be active-suspended or dormant. Seismic data have also shown that underneath the toe of the landslide, a 30 to 50 m thick level of glacial or fluvial-glacial gravel exists; this level probably acts as a natural drainage system, preventing the steeper portions of the earth flow from being active with higher displacement rates.

Main stop 3: Corvara landslide (Val Badia)

The Corvara landslide is an active slow moving rotational earth slide - earth flow, extending over an area of about 2.5 km^2 (Fig. 6). Present day movements of the Corvara landslide cause damage of the National Road 244 and other infrastructures on a yearly basis. The movements also give rise to more serious risk scenarios for some buildings located in front the toe of the landslide.

Fig. 4: Aerial view of the Mt. Rascesa landslide.

Fig. 5: Aerial view of the Passo Gardena landslide.

For these reasons, the landslide has been under observation since 1997 with various field devices that enable slope movements to be monitored for hazard assessment purposes. Differential GPS measurements on a network of 47 benchmarks showed that horizontal movements at the surface of the landslide have ranged from a few centimetres to more than one metre between September 2001 and September 2002, with the maximum displacement rate recorded in the track zone and in the uppermost part of the accumulation lobe of the landslide. Borehole measuring systems, such as inclinometers and TDR cables, recorded similar rates of movement, with the depths of the major

Fig. 6: Aerial view of the Corvara landslide.

active shear surfaces ranging from 48 m to about 10 m. From these data, it is estimated that the active component of the landslide has a volume of about 50 million cubic metres. The hazard for the Corvara landslide, considered as the product of yearly probability of occurrence and magnitude of the phenomenon, can be regarded as medium or high considering the velocity or alternatively the involved volume. Finally, the monitoring results obtained allowed developing numerical models to support the identification of viable passive and active mitigation measures.