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DEBRIS FLOWS TRIGGERED BY THE 29 AUGUST 2003 CLOUDBURST IN VAL CANALE, EASTERN ITALIAN ALPS.

Domenico Tropeano[1], Laura Turconi[2]
in co-operation with Sebastiano Sanna[3]

ABSTRACT

Torrential rains (300 to 400 mm in 10 h) fell in the Val Canale, where prevailing bedrock lithologies are Triassic Dolomite, limestone and marls. As many as 300 debris flow processes and shallow slides were detected. The debris amount set in motion accounted for several hundreds of thousands of cubic meters; single debris flow deposits accounted for between a few hundred to some ten thousand cubic meters, with peak values of 100,000 m^3. Small tributaries fed by newly formed debris flow fans widened almost five-fold their channel sections or produced temporary sediment overloads that destroyed or buried roads along narrow valley floors. According to field samples and laboratory analyses, the density of the debris-water mixtures ranged between 1.7 and 2.2 kg/dm^3. Three bridges were destroyed and the main routes of communication damaged. Villages or isolated houses were invaded by muddy debris flows and water flood deposits, often 2 metres thick; 2 persons died. The estimated mean recurrence interval of such events is between 3 and 8 years.

Key words: Debris flow, Carnian and Julian Alps, debris fan analysis, historical flood

INTRODUCTION

Almost every summer or early autumn, the Italian Alps are struck by thunderstorm-triggered debris flows of various geographical extent. In some year-intervals they may assume disasterous proportions, affecting a range of catchments and important valleys where settlements and structural networks are of crucial interest for life and production. Over 2,000 alpine torrents are known to have wrought damage in the distant and the recent past. As recently witnessed, the number of concave-shaped heads of slopes or slope incisions where debris flows may occur has increased almost tenfold (Tropeano & Turconi, 2003a). Depending on their geology, geomorphology and climate, some areas appear to be somewhat more prone than others to such processes. Certain valleys in the Eastern Alps are struck relatively often by intense, heavy rainfall. Intense precipitation on the bare and deeply fractured rock exposures in these areas, which are characterized by widely outcropping carbonatic sequences (especially Dolomite) with a large debris production forming talus

1 Research director, Consiglio Nazionale delle Ricerche, Istituto di Ricerca per la Protezione Idrogeologica (CNR-IRPI), Sezione di Torino, Strada delle Cacce 73, 10135 Torino, Italia (Tel: +39-011-3977-291; Fax: +39-011-343574; email: d.tropeano@irpi.to.cnr.it)
2 Research co-operator, CNR-IRPI, Sezione di Torino, Strada delle Cacce 73, 10135 Torino, Italia
3 Functionary, Regione Friuli-Venezia Giulia, Direzione Foreste, Via Cotonificio 127, 33100 Udine, Italia

slopes, may unleash torrential processes that rapidly carry downslope large amounts of the stony debris storage present. The Val Canale in the Carnian Alps (formerly part of Southern Carinthia) is representative of the relative frequency and magnitude of likely debris flow events. Short communications about recent and past floods in the valley have been published by the IRPI Institute (Arattano et al., 1991; Tropeano et al., 1999). In this article, we describe and comment on the last extreme event to hit the area.

Geologically, the area lies between the Carnian and the Julian Alps, to the West and the East, respectively; northward, the *Carnain Chain*, a large mountain band, shows three main structures: 1) *Linea della Gail*, with an EW trend, 2) *Linea Tropolach-Camporosso*, a NW-SE trend and 3) *Linea Fella-Sava* extends sub-parallel to the first (Zanferrari, 1982; Martinis, 1993). Within this complex system of structural discontinuity (Gortani, 1935), with its densely fractured bedrock and extreme slope instability, together with the high seismicity of the Friuli region, the risk of landslides is high (Querini, 1977). In the Carnian Alps, the Mesozoic is represented by a Triassic lithology (*e.g. Formazione di Werfen*, a calcareous-marly sediment) near the village of Pontebba (Bianchin et al., 1980) and a polygenic conglomerate referable to the *Breccia di Ugovizza* (Anisic), shading off into terrigenous sediments (*Torbiditi d'Aupa)*. In the Aupa Valley, eruptive rocks outcrop (*Formazione di Buchenstein*, Ladinic). A thick calcareous-dolomitic formation, the *Dolomia Principale* (*Hauptdolomit*, Noric), widely outcrops all over the Carnian Alps. The Julian Alps are represented by calcareous-dolomitic and marly rocks (Mesozoic), as *Formazione di Werfen* and *Formazione di Lusnizza* (the latter outcropping on the left slope of the Fella River), and *Breccia di Ugovizza*; the last is poorly fossiliferous (Assereto et al., 1968). Fossil-rich outcrops have made other stratigraphic settings easier, *e.g.* the *Calcari a Bellerophon* (Palaeozoic). Also in the Julian Alps, the *Hauptdolomit* widely outcrops, sometimes heteropical to other lithologies (*e.g. Calcare di Dachstein*) (Martinis, 1993).

THE 29 AUGUST 2003 EVENT. PROCESSES AND EFFECTS

On 29 August 2003, at the end of a climatic anomaly of prolonged drought and warm conditions in the Mediterranean, a large atmospheric disturbance affected some areas in the Central and Eastern Alps, from the Tessin Valley (Switzerland) to Lower Carinthia (Gail Valley, Austria). Rapidly travelling from West to East, local heavy rain fell in the morning in Tessin (Frasco locality) (185 mm with a return period of some 200 years), provoking randomly-distributed debris flows, one of which killed a person (Gaia M. & Kappenberger G., 2003). At Locarno Monti, 33.6 mm of rain were recorded in 10 minutes, the maximum value ever observed by the ANETZ network (SUPSI-IST & Cantone Ticino, 2003). In the lower Mera Valley (Northern Lombardy), at around 15.30, after 85 mm of rainfall (26 mm in 1 hour recorded by the Edison Company at Novate Mezzola, Sondrio) a debris flow from the Vallone stream interrupted National Road No. 36 and the Colico-Chiavenna railway line. In the afternoon, between 14.00 and 19.30, a cloudburst struck some localities in the Val Canale-Canal del Ferro (East Tagliamento Valley) in the Carnian Alps (Friuli-Venezia Giulia) (rainfall depth up to 285 mm in 4 hours; maximum intensity 90 mm/hr; cumulative rainfall 390 mm in 10 hours). At some stations, the amounts measured in just half an hour were close to or higher than the maximum values of the past 30 years. In the localities of Pontebba and Malborghetto, very heavy rainfall was recorded until 18.00, after which most of the instability processes began. Within 2 hours, the bulk of the disaster had run its course. In the nearby Tarvisio area, a much more attenuated cloudburst (72 mm in 90 min.) occurred 1 hour later.

Rainfall (spatial distribution and depth) was measured by 9 automated rainfall recording stations (part of the monitoring network of the Region of Friuli-Venezia Giulia), from which an isohyet map was drawn using the *Surfer*® 7.0 program (see below).

Most of the phenomena and their effects took place right of the Fella River, affecting the slopes and channels of 6 major tributaries (Uque, Malborghetto, Bombaso, Pontebbana, Gleris, Aupa) and 20 sub-catchments or ravines, including the Rio Argento (Silber), Rio Cucco (Kuk), Rio degli Uccelli (Vogelbach), already known from past chronicles for the damage caused by the debris flows they provoke at a few years intervals. Stream activity also interrupted National Road No. 13, Highway A-23 and the Udine-Tarvisio railway line. A total of about 300 site-events were detected and mapped on the Regional Cartography (1:5000) to evidence the origin, the direction, and the dimension of soil slips, muddy and stony debris flows, newly created debris flows and debris flood fans, major occurrences of streambank erosion or channel deposits and main bank failures due to stream undermining (Fig. 1).

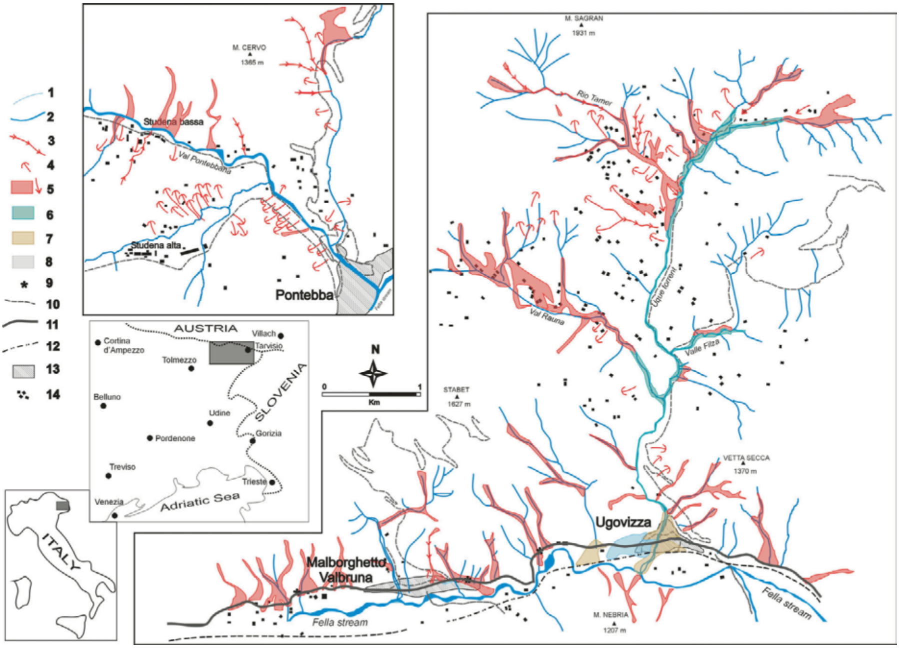

Figure 1. Partial sketchmap of the rainfall-induced geomorphological processes of 29 August 2003 in the Valcanale area. Legend: (1) minor streamwork, (2) main streamwork, (3) severe rill or gully erosion, (4) shallow landslide, mainly soil slips, (5) debris flow/debris flood deposit and main flowpaths, (6) bank erosion and channel deposit, (7) flooded area; (8) inundated area, (9) sampling site, (10) local road, (11) national road, (12) railway, (13) major settlements, (14) houses and isolated buildings.

It can be argued that in the epicentre(s) of the cloudburst, two thirds of the small catchments or ravines mapped on the IGM 1:25,000 cartography were refreshed, bearing evidence of re-activation of paroxysmal torrential transport processes that had been quiescent for years or decades. Massive sediment transport from the early (slope debris flow) to the developed stage (intense bedload) represents the bulk of the phenomenology observed at all hierarchies of the stream network. The debris and sediment mass set in motion and deposited downslope and over the valley bottoms can be roughly estimated at 1 million m^3; almost one half of this amount came from minor catchments or head of slopes, by tens of ???, which, in longer or shorter intervals on a chronological scale, conferred the “surplus” of overloaded debris to the large mixed fans they feed or directly to the inflow in the streams. The large liquid volumes created by the rainfall rapidly drained and conveyed at the head of the catchments that are often formed by steep rocky walls and relatively narrow drainage areas, but still noteworthy considering the natural outcrop surfaces. This may explain the rapidity of the processes. Due to the immediate saturation capacities of highly permeable talus detritus and in-channel deposits, the debris-release processes were easily triggered at the head of the catchments and along entire channel reaches. A good fit between the processes and the effects of the event was obtained by superimposing the isohyet map (illustrated above) over a map created from the data on spatial frequency (intensity) of the direct indicators of rainfall amount and intensity, as effects on topsoil (rills and gullies, soil slips) and in the stream network (torrential deposits, slope debris flows). This enabled us to check the reliability of the instrument indications (Fig. 2).

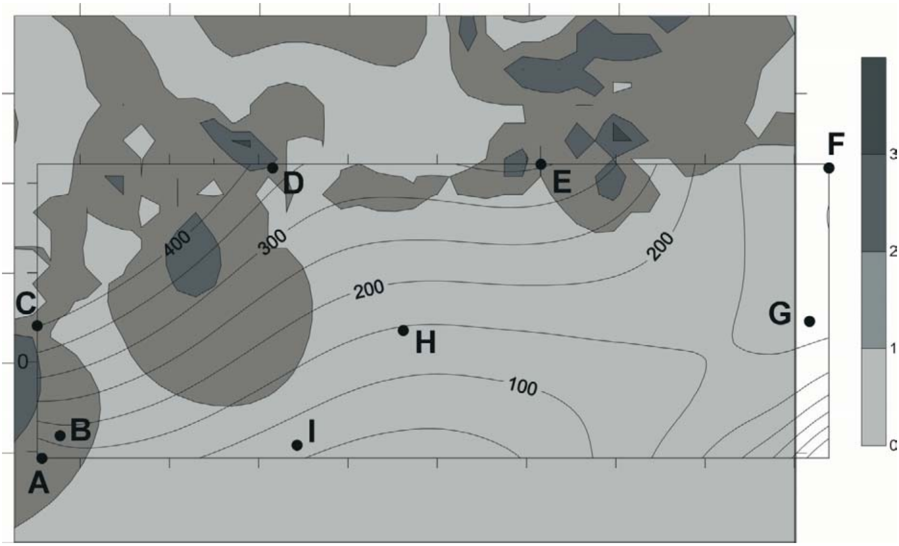

Figure 2. An 8-hour isohyet map of the rainfall event superimposed over an "isodensity" map of the slope and torrential instability processes triggered on 29 August 2003. The latter are interrupted above the graph due to the lack of recording stations northward. Nonetheless, a fairly good agreement can be seen between the two maps, also considering that more refined data are difficult to collect in a mountainous landscape like this one. The grey tones are shaded progressively darker: 1) Gully erosion, shallow slides (1-2 per ¼ km^2), debris flows (1-2 per ¼ km^2), bank erosion; 2) Gully erosion, shallow slides (3-4 per ¼ km^2), debris flows (3-4 per ¼ km^2); bank erosion, moderate flooding; 3) Gully erosion, shallow slides (>4 per ¼ km^2), debris flows (>4 per ¼ km^2); bank erosion, extensive flooding. Letters refer to rainfall recording stations.

Also, it is extremely difficult to obtain a good fit between rainfall data recorded at stations sparsely distributed in mountainous areas, although they may be representative, and the true rainfall distribution, as univocally witnessed by effects on soil.

Typical debris flows, bearing depositional forms reflecting their kinematical conditions, were observed in some 30 localities, many of which are located along the right slope of the Val Canale, along National Road No. 13 between Km 207 and Km 212. Severe damage also occurred when isolated houses were buried, claiming one victim who was overwhelmed by a flood wave passing beside his home. In the catchments or major size basins (from 1-2 km^2 to some tens of km^2), the predominant processes were channel overload and temporary channel clogging by medium- to coarse-grained sediments, with log jams or floating logs swept away by lateral cuts in some cases. On soil-covered slopes usually vegetated by forest (mainly conifers of the species *Abies rubra*, the common spruce that grows by superficially-expanding roots), soil slips occurred randomly, giving origin, as a rule, to muddy debris flows. Some grassland covered areas were equally affected by highly- concentrated soil slips (up to 10 slips per hectare in Studena, near Pontebba) (Fig. 3).

Figure 3. Soil slips on the left slope of Rio Studena, a right tributary of the T. Pontebbana stream above the village of Pontebba.

The Uque basin was affected by 30 such processes, concentrated in the right sector (Val Rauna and Rio Tamer sub-catchment) (Fig. 4, 5). Subsequent torrential processes deposited some 85,000 m^3 of sediments on the alluvial fan, where the village of Ugovizza is located (90% gravel, pebbles and boulders, while finer materials were deposited at the margins of the fan or flowed into the main stream).

Figure 4. Several soil slips, on the left slope of the Valle Rauna sub-catchment of the Uque basin produced widespread flowpaths and irregularly distributed debris flow deposits over prairies and pastureland.

Figure 5. The stream channel of the T. Patamar, a right tributary of the T. Uque, was widened (up to 5-fold) by lateral erosion, menacing mountain huts with serious damage. .

At around 18.00, flood waves struck all manmade structures, including the old bell tower of the village parish church, which had survived the September 1903 flood, and the adjoining cemetery. Within 2 hours, 100 houses were burried (3 were totally destroyed; 1 woman was killed by a muddy wave and carried for kilometres down the Fella River), as evidenced by layered deposits up to 2 m thick according to eyewitnesses. The average debris supply discharge issued from the basin was on the order of 12 m^3/s. To the West, the Rio di Malborghetto stream, largely fed by the left tributary Rio Vocadulina, totally filled its channel, partly contributing to the flooding of settled areas in the vicinity.

Some 20 small catchments located on the right slope of the main valley discharged proportionally high amounts of debris, attaining 50,000 m^3 for a supply area of 2 km^2 (Rio Cucco) (Fig. 6).

Figure 6. Huge debris flow deposits discharged from the dolomitic right slope of the Fella River invaded several houses in the village of Malborghetto, rapidly leading to the partial burial of buildings up to above 2 m, as illustrated here (Cucco locality).

On the left side of the valley, the Coran, Senata and Pirgler streams totally filled their artificial channels along the highway and the national road. The Pirgler (catchment area, 2.4 km^2) discharged some 2000 m^3 of muddy and gravely debris onto the highway toll square; the scene from an amateur videotape taken at around 18.00 shows an impressive sequence of pulsating debris flood waves.

Further westward, the "Rio degli Uccelli" stream (10.8 km^2) superelevated its channel up to 8 meters; the newly brought sediment load deposited over its fan totalled roughly 100,000 m^3 (Fig. 7).

Figure 7. A stretch of the Vogelbach stream, Val Canale (Carnian Alps, Pontebba), some 100 meters above the fan apex, looking downstream. The person standing in the photograph testifies to the extraordinary thickening of debris flood deposits (rising to 8 meters) over the last 4 years, most of which was produced by the flood of, 29 August 2003 (right). A photograph taken in 1999 (left) still shows a remnant of the old retaining dam built between 1862 and 1866, originally rising 23 m above the stream channel incision.

For many years, the floods of a stream that could alter the discharge conditions of the Fella River by its “enormous” sediment transport (Scimone, 1927) were regarded as dangerous for the village of Pontebba/Pontafel, located downstream. For this reason, 10 years after the tremendous flood of November 1851, the Austrians (until 1918 the national border with Italy ran through the village) built a dam across the stream gorge, which was raised 4 years later to 23 m in height to restrain the impetus of the sediment-laden flood waves. No retaining dam has existed for at least 50 years (as witnessed by aerial photographs classified in the IRPI archives). In modern times, the channel was artificially restrained to make space for the highway and the freight station of Pontebba. The railway, which today runs through a tunnel under the fan channel (the gorge was spanned by a railway bridge until about 1977, as witnessed by aerial photographs) was totally filled by finer materials that poured onto the right side and then flowed down the railway trench up to the Pontebba station more than 1 km westward.

In the middle-lower reach of the Val Pontebbana, the most important right tributary of the main valley, about 50 soil slips, mostly concentrated on the right slope in the lower valley reach, and 17 debris flows and debris floods were detected; several other processes (some 15 debris flows) were surveyed in the Gleris catchment, the upper portion of Rio Studena, and in the Rio Bombaso catchment,, the major right and left tributaries of the Pontebbana, respectively. In the middle valley reach, the Bombaso stream caused the entire collapse of a bridge along the road to the Pramollo Pass. At the inflow into the Rio Pontebbana, just above the village of Pontebba, a newly built fan (roughly accounting for 7000 m^3) raised the channel bottom of the mainflow, thus provoking the partial flooding of the built-up area and a significant contribution to the Fella River downstream (Fig. 8).

Figure 8. Valley bottom deposits (looking upstream) left by the flood of the Fella River near Pontebba. The stream channel is hidden by the buildings in background, where a stretch of the A-23 Highway is also depicted.

Between Tarvisio and the village of Dogna, the Fella River channel caused severe flooding along its entire watercourse; the peak discharge near Dogna was estimated at around 800 m^3/s (*Regione Friuli Venezia Giulia, Direzione Regionale Ambiente*); the depth of the floodwaters rose up to 9-10 m downstream from the village of Pontebba, where the flow is restrained by rocky outcrops and/or road embankments. Several tens of metres of embankments were destroyed on both sides of the river, a bridge failed and several houses in the village of Chiusaforte were destroyed by deep erosion of the 10-m high left bank, where the village is located. A few kilometres downstream, the village of Dogna was almost entirely inundated by flood waves which rapidly arrived at around 17.30 and pushed the rise up to half a metre within a few minutes. Numerous eyewitness accounts suggest that the contribution of floodwaters by minor streams to the main channel produced a simultaneous flooding over the entire valley reach. Almost everywhere, the most dramatic event conditions were reported to have lasted for 2 hours.

The Aupa Valley, which ranks second in size of the right tributaries of the Val Canale, was much more severely affected during this event than by the cloudburst of 23-24 September 1990 (Arattano *et al*., 1991). On both slopes, some 40 soil slips and debris flows increased the sediment discharge of the main torrent which, because of channel widening at 5 sites, completely washed away several hundreds of metres of the road embankment.

The total damage in the Fella Valley was roughly estimated at between 0.5 and 1 billion Euro.

DATA COLLECTION AND RESULTS

During a 4-day field survey, based on aerial and field recognitions, the writers collected data in order to draft a preliminary inventory of the phenomena and related geomorphological processes and effects. As a valid integration of field notes, interviews, etc., some 650 photographs were taken, along with videotapes and uncut videotapes gathered from a local broadcasting company (RAI 3). In several cases, stream channel conditions and morphology before and after the flood were compared using the data from the stream channel surveys the writers had conducted in the same area to detect the morphological effects of a minor flood that had occurred just 4 years earlier (September 1999) . A summary map of the phenomena, processes and damages was then drafted, with special attention to source areas, sites of debris flows and their magnitude (Fig. 1). The relatively numerous simultaneous debris flow and

debris flood processes on a rather narrow strip of land, fairly uniform in geology and environmental conditions, allowed several samples to be taken from sediment deposits throughout the area affected by the cloudburst. The debris flow deposits and the debris flood fans were randomly sampled at 10 sites for grain size and other geotechnical analyses. After including the samples collected from previous flood events (September 1990; August 1999,) the resulting total of 20 samples was considered sufficiently reliable to explain some of the mechanical characteristics of the flow mixtures in the study area. Due to the overall moderate grain size of the deposits, a dry weight between 5 and 10 kg for each sample was selected for analysis. The density of the mixtures (δ) was carefully reconstructed in the laboratory; grain size and other geotechnical parameters were determined by several assays. It was found that δ values ranged from 1.74 kg/dm^3 to 2.20 kg/dm^3; a slight difference was noted between debris flow and debris flood deposits. Although no clear boundary between δ values emerged, on the whole, the former were marked by a greater mixture density than the latter. This explains the particular aptitude of such phenomena to easily carry even very large boulders downstream. It is, in fact, not surprising that during the 1966 flood in the Venetian Alps, near the study area, a gigantic boulder weighing 2700 tons was carried down some 800 metres as debris torrent load (Gorfer, 1967).
The grain size of the samples, usually taken from typical depositional forms of debris flow, as spreading lobes or lateral levees, or from cut terraces of debris flood layered deposits, showed a fair variety of sorting. In practice, no differences were found among the samples, which were generally characterised by a medium grain size: D_{50} is between 3 mm and 15 mm; gravel percent (58-90%) is largely dominant, sand ranges from 10% to 32%, pebbles are rather infrequent (0-8%).

ASSESSING FREQUENCY AND MAGNITUDE OF DEBRIS FLOW EVENTS

Spatially and chronologically, torrential floods often with associated shallow landslides, more rarely with re-juvenated deep landslides, are widespread throughout the Alpine chain. Since 1500 CE, at least 1200 historic flood events in Northern Italy are recorded in the Archives of the IRPI Institute in Turin (unpublished documents, literature, newspaper reports) (Tropeano & Turconi, 2003b). Their magnitude and frequency fluctuate in time; broadly regular periods of quiescence alternate with periods of intensified flood activity. For major events a 25-year recurrence interval can be assessed, while for minor ones the “return period” shortens to 3-6 years. Such a rule is followed not only in the Alpine region as a whole but also in restricted geographical areas.

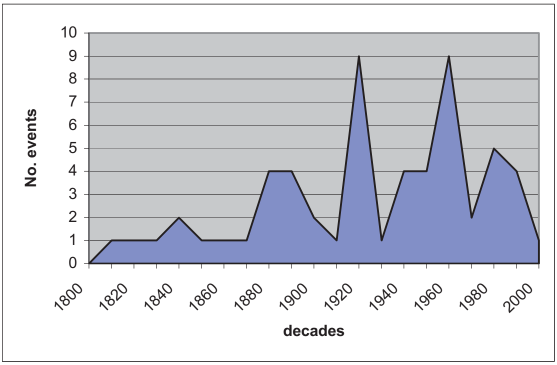

Figure 9. Frequency of damaging flood events of the last 200 years in the Val Canale (IRPI-CNR archival data).

In the Val Canale area, evenly distributed landslides, rock and debris falls in particular, or even major slope failures are well known. For the purposes of the present report, however, we

have taken into account in the historical sequence only streamflood processes, most of which are referred to debris flows.
Streamflood damages have been recorded in the region since 1348 CE and remembered throughout the following centuries. The record is fairly complete and without an apparent lack of data for the last 200 years. Since 1815, 56 damage occurrences by floods have been recorded. Particularly severe widespread effects were produced (on average) every 12-13 years, while minor flood consequences were felt every 3-4 years. Some of the largest floods took place on, 1-2 November 1851, 29 September 1885, 13 September 1903,, 21-22 September 1920, and 4 November 1966. Noteworthy effects, mainly caused by debris flow, were recently produced in 1990, 1996, 1999 and 2003.
In the past, the Uque basin was affected by floods that invaded the village of Ugovizza 5 times between 1885 and 1923; in 1933 the houses were still menaced but nothing more happened in the 80 years following the event of 1903, which is remembered as being particularly serious (Gariup, 1986), during which a woman died inside her house (Fig. 10).

Some streams are characterized by a fairly regular flood recurrence, like the Rio di Malborghetto, the Cucco and Vogelbach to the right of the Fella River; the Zolfo, Granuda, Koran and Pirgler streams to the left, which suffered severe flooding at least 16 times in the last 150 years and 4 times during the last 13 years.

Figure 10. An old photograph found in the village parish archives. The original caption reads: "Flood occurred at Uggovitz on 13 September 1903".

The graph in Figure 9 shows that one half of the events are concentrated in the second half of the 20th century. More and more, the effects of flood events have been exacerbated in recent years by the presence of newly built houses, increased road traffic (the A-23 Highway) and infrastructures. The exponential growth of information on the chronology of events is easily explained by the fact that historical and technical documents of flood damage records are better conserved, and that there is the "added value" of goods exposed to risk due to the particular sensitivity of some manmade artefacts to natural events. Furthermore, mass media coverage tends to heighten the drama of such events. Interestingly, compared with the size of the entire Tagliamento River valley (1930 km^2), the relatively small Fella basin (705 km^2)is at least partly responsible for 85% of the floods that hit the area.

FINAL REMARKS

In general, judging from the intensity of the effects connected with the 29 August 2003 event, the flood may appear on a local scale to have been one of the heaviest to hit the Val Canale area, but actually only a relatively minor strip of land (10% of the whole basin area) was affected, compared with the much wider effects provoked by the events of 1851, 1903, and 1927. The map of the processes evidences three major sub-zones: Malborghetto-Ugovizza (7 km^2), Val Pontebbana (2.5 km^2), Val Aupa (1.8 km^2) on a total area of about 70 km^2. The global volume of detritus discharged at the foot of the slopes and on the alluvial fans may be roughly estimated on the order of 1 million m^3, corresponding to a fictitious surface lowering of 18 mm.

The historical chronicle, however, evidences recurrence intervals of events of less intensity and/or less magnitude, which over wider or narrower portions of the landscape should happen every 3-8 years. This important finding takes into account the ongoing intensive urbanization (houses, roads, etc.) of recent years, particularly in areas sensitive to fluvial, torrential and slope processes. Torrential activity can sometimes remain quiescent for several decades, thus increasing natural hazard conditions and reducing historical memory. Statistically, damaging events, while, most likely to occur between September and November (66% of cases), are still frequent in summer months (27%). This must be taken into account when considering the potential threat to the safety of the seasonally increased road traffic and summer tourists to the area. As is proper of the Friuli population, the inhabitants are very attached to their native land, one of the most attractive areas of the Italian Alps, and they are accustomed to living with recurrent floods. In Ugovizza, a solemn procession commemorating the 1903 flood is held every September. In a nearby village, San Giovanni Nepomuceno, the patron saint believed to protect against flood hazards according to a Slavonic tradition, is still venerated. Despite the very rapid development times of some processes, like debris flows on steep slopes that have been colonized by randomly distributed houses and infrastructures, the civil protection procedures carried out just before and during emergencies have helped to minimize the consequences for both inhabitants and holiday makers.

As seen in other contexts, the methodology to reconstruct rainfall distribution as reflected by morphological effects on the soil and slopes , yields a good fit with the “officially recorded” values. So applied, the “effect detecting” method, permits assessment or verification of the spatial extent (in terms of “effectiveness”) of local thunderstorms, especially where rainfall stations, particularly those in mountain areas, are too sparse to represent true rainfall input.

Again, the need arises to correctly locate new buildings and infrastructures in such a changing landscape, where natural, unavoidable events at longer or very short intervals may happen. Proper land use is a good remedial measure, while suitably sized sediment storage basins can be regarded as effective structural preventive interventions. The data drawn from the 29 August event will allow us to improve the predictive model on debris flow magnitude, which has produced encouraging results at several sites elsewhere in the Alpine region (Tropeano & Turconi, 2003a).

Soil slips, their random occurrence over grass-covered or forested areas (often considered a warranty of soil and slope stability), connected with sudden, ephemeral springs issued by non-deterministic water overpressures, give proof of the impossibility to forecast such phenomena on a local scale. These processes are relatively easier to foresee (in space but not in time) when they originate in concave slopes and elementary stream networks.

The Carnian Alps, where the event took place, are emblematic of the case record of debris flow events and offer ideal situations for the study of intervention techniques to prevent and attenuate their consequences. For this reason, since 1990 the IRPI institute of Turin, in co-operation with the regional forestry management agency of the Region of Friuli Venezia Giulia has operated an experimental basin (T. Moscardo) to survey, analyze and measure the dynamic behaviour of debris flows with almost annual occurrence. The new data acquired after the 29 August 2003 cloudburst in Val Canale will allow new information to be obtained about such fascinating although life-hazardous processes that are so common in the Alps.

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