*Suppl. Geogr. Fis. Dinam. Quat.*
*III, T. 2 (1997), 143-150, 6 figg.*

FOURTH INTERNATIONAL CONFERENCE ON GEOMORPHOLOGY - Italy 1997

**Guide for the excursion**

# MEDITERRANEAN EROSION

Meeting Igu 1997 in Italy, Rende (CS), August 22-27

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## INTRODUCTION

The Meeting M1 - Mediterranean Erosion - has been convened by Maria Sala and Marino Sorriso-Valvo in the frame of the activities of the Igu - Working Group on Mediterranean Erosion and Desertification (chairperson Maria Sala), now «promoted» to the rank of Commission on Land Degradation and Desertification (chairperson Maria Sala).

The three-days excursion will take the participants through the beautiful landscapes of northern Calabria, in different environments where erosion (either by running water or mass movement) is acting at very different rates and with very different effects.

An insight to the recent past conditions will be given through the forms that witness a much higher magnitude of dismantling processes - valley fills and fans, and try to learn a lesson on what could be expected if such conditions would be restored. The determinant role of human activity, however, though extremely difficult to size precisely, is clearly apparent either from field evidence or historical chronicles.

Numbering of chapters refers to the sites in fig. 1.

## 1 - THE TURBOLO WATERSHED
(O. Terranova)

For a number of years various interdisciplinary studies have been conducted in the experimental basin of the Turbolo creek. It is a left-hand tributary stream to the Crati River. The principal aim of these studies is to set up a data bank to use in both rainfall-runoff models and sediment transport models at the basin scale.

The geology of the basin consists of metamorphic and sedimentary rocks. Metamorphic units crop out in the horst of the Catena Costiera range, thus making the mountain zone of the basin; they are of different grade because they are made of different tectonic unit piled up in Middle Miocene. Sedimentary rocks occupy the River Crati graben that sides the Catena Costiera horst; they are Upper Miocene to Quaternary detritic deposits ranging from clay to conglomerate.

The surface of the basin is ca. 29 $km^2$ and the divide length 28 km. The relief is 940 m, and the average altitude is ca. 290 m a.s.l.; the average slope gradient is 26%.

The climate is typically Mediterranean with wet winter. A marked difference, however, exists between the valley and mountain parts:, average annual rainfall and temperature are 1,000 and 1,600 mm, and 17 and 10 C°, in the valley and mountain parts, respectively.

### MODELING FLOOD EVENTS

In order to model the flood events in the Turbolo basin it is sufficient to model those events whose effective rains and surface runoff are known. Two problems, however, remain to be solved:
1 - selection of rain events to be used as input in the rainfall/runoff transformation model, and
2 - separating the components of hydrograms.

The first problem has been faced analyzing 350 rainfall profiles recorded at two sites. Selected rainfall events have been grouped according to the following criteria: i - period of occurrence (from November to April or from May to

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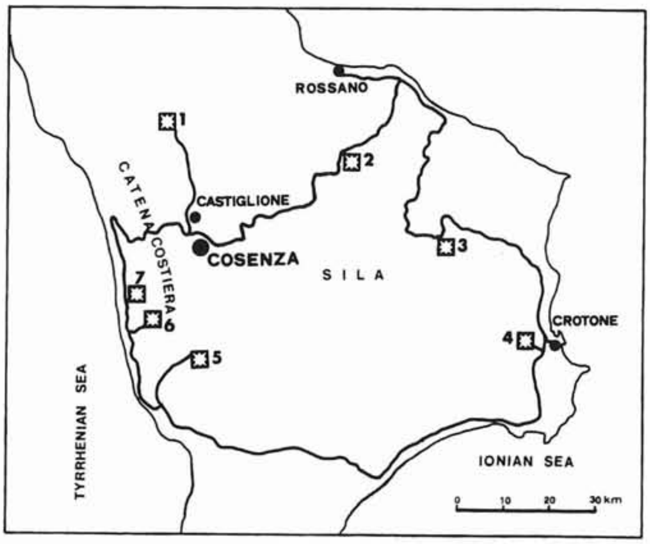


FIG. 1 - Sketch map of the field excursion itinerary. Figures refer to visit sites: 1 = Turbolo Torrent instrumented reach; 2 = Trionto River; 3 = Grave Grubbo cave; 4 = Crepacuore canyon instrumented basins; 5 = Savuto River alluvial fans; 6 = Pizzotto canyon active fan; 7 = Tyrrhenian coast fans.

October); ii - duration (up to 1:00 hr, 1:04 - 3:00 hr, 3:04 - 6:00 hr, 6:04 - 12:00 hr, 12:04 - 24:00 hr, more than 24 hr; iii - intensity (lesser or greater that the average intensity). The rainfall profiles showed a marked scattering increasing proportionally to the rainfall intensity or decreasing proportionally to the rainfall duration. As far as rainfalls longer than 24:00 hr are concerned, rainfall profiles assume the shape that characterizes constant intensity rainfalls. For high intensity and short duration rainfalls, the profiles become asymmetric and scattering increases.

Investigation on the second problem was conducted through calibration techniques on the basis of the best results obtained with conceptual or black box models. It has been possible distinguish surface from underground contribute to hydrograms characterized by one or more discharge peaks. In particular, defining the exhaustion curve has been an extremely crucial phase; once defined this curve, it resulted that: i - it must be extended to the time at which the last rehearsal of the hydrogram occurs; ii - it must be joined with the end point of the exhaustion curve of the previous flood event (fig. 2).

The infiltration capacity of soils on the entire basin have been investigated by means of the Munz apparatus, notwithstanding the drawbacks and limitations of this measurement method. The range of the infiltration capacity resulted to be very extended: from a maximum of $1.8x10^{-2}$ cm/s for the breccia with sandy matrix, to a minimum of $5.5x10^{-6}$ cm/s for fractured clays. All rock types have been grouped into four ranked classes of infiltration capacity, namely: high, intermediate, medium and low. Combining the infiltration capacity with slope gradient and land use, by means of a Gis., it has been possible defining homogeneous sub-basins and use them to validate rainfall-runoff transformation models.

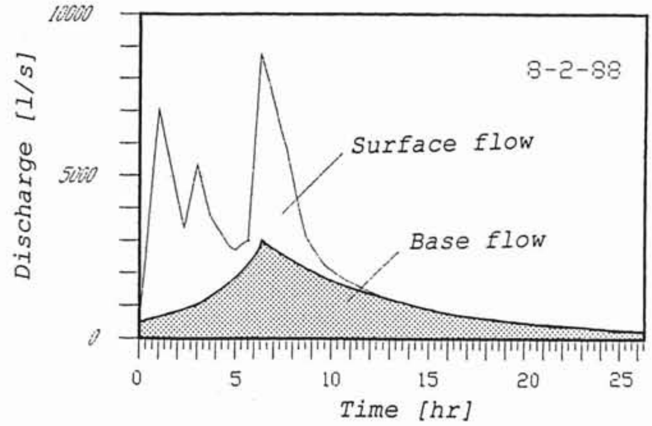


FIG. 2 - Identification of base flow: the descending separation line is rectilinear in the semi-log plane.

## RIVERBED MORPHOLOGY, SEDIMENT TRANSPORT AND SURFACE EROSION

Hydraulic regime of the Turbolo Torrent is typically rain-dependent, thus highly seasonal and with skewed flood hydrograms. Dry periods are in summer, wintry floods are in the order of tens. Sediment transport, either as suspended or as bed load, is relevant, and after each flood the geometry of the stream bed is substantially modified (fig. 3). In order to monitor stream bed modifications, we installed:
i - 7 transversal topographic sections in the natural channel, and
ii - 60 sections in the terminal reach, made by a concrete-coated channel with double-trapezoidal section, 1050 m long, with a slope of 0.3%. This channel is made by two rectilinear branches connected by a curve with a radius of 222 m. When the study began, in 1988, the stream was in strong aggradation: deposit was 1m thick or more; sediment grain size ranged from sand to pebbles, with strong prevalence of the latter; river bottom had a slope of 0.45%. All the channel was cleaned thus permitting to monitor from the beginning the new phase of modifications. After one year, a 30-cm thick layer was deposited, this situation remaining unchanged until the 1996-97 winter, when situations were turned again like in 1988. It is remarkable that this winter has been a relatively dry winter, but in October and November there occurred intense rains that triggered a great deal of small landslides, providing the sediment budget for re-aggradation. In the same time, antropic activity, consisting in ground levelling and earth moving , had been much more intense than usual, enhancing the effects of exceptional rains.

Besides landslides and human activity, diffused erosion (sheet wash, rill and gully, at places true badlands erosion) on slopes is also responsible for sediment budget. In order to size this process, sprinkling experiments have been initiated and are still in course in different sites of the basin.

Visitors will be taken to the instrumented reach of the main stream channel.

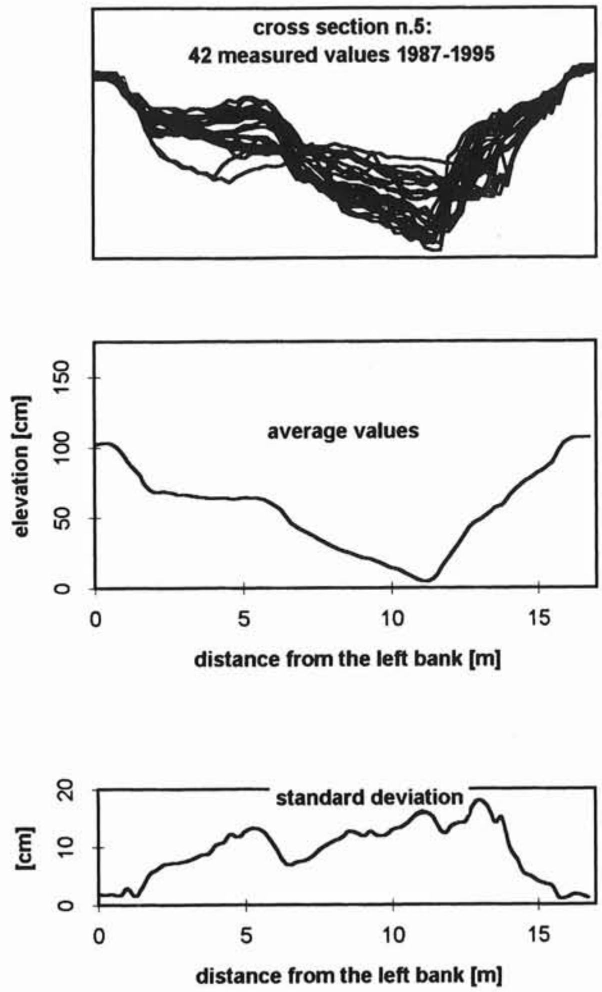


FIG. 3 - Modification of the riverbed geometry relative to the n° 5, natural, cross section.

## 2 - THE RIVER TRIONTO BASIN
(S. Gabriele, O. Petrucci, M. Sorriso-Valvo & C. Tansi)

The Trionto River basin drains the Ionian side of the Sila Massif. In its first 7 km of course, strolls eastwards on the rolling landscape modeled in the Paleozoic granites of the Sila, and characterized by convex slopes and rare thors. The granite is deeply weathered so that a saprolitic cover may reach over 100 m in thickness. This is an old landscape dating back to upper Miocene, and slightly modified by block faulting consequent to the orogenic uplift of this part of Calabria. This uplift began in Pliocene, but surged in lower Pleistocene. Estimated average uplift rate for the Quaternary era is ca. 0.8-1.0 mm/yr. Lacustrine deposits 31,000 years old are present in this part of the basin, just before its equilibrium profile abruptly increases its slope, entering the gorges cut in a horst apparently inactive, cut by the Trionto in antecedence. The gorges deepen progressively and all the drainage system dissects deeply the granites, but here slopes are much steeper and more rugged than in the headwaters. Slopes are convex-rectilinear or convex, soil is truncated in the ridges, and accumulated in the hollows. Downstream the confluence with the Macrocioli torrent, a right tributary, the morphology of the basin changes because of two reasons: first, outcropping rocks change from granite to phyllite and a flysch-type complex. Second, the right-hand side tributaries become suddenly much larger than the left-hand ones, probably due to tectonic regional tilting to the North. As a consequence of that, the slopes become predominantly rectilinear or bi-rectilinear, indicating a two-cycles dissection development; landsliding becomes much more frequent and the river bottom is aggraded with coarse deposits. Evidence of different cycles of valley filling and dissection is present mainly in the main course, where they form convergent terrace flights for each of which the source area has been reckoned in a limited part of the watershed. The periodic reactivation of landsliding is the cause of these valley fill-and-cut sequences that can be linked indirectly with climatic conditions responsible for the increment of landsliding.

The main tributary of the Trionto, the Laurenzana Torrent, joins the river at nearly 8 km from the mouth, where the river exits the deep gorges and enters in the terminal branch that displays the characters of a *fiumara*: relatively small drainage basins (in general less than 100 $km^2$) , very broad river bottom, still steep gradient, braided drainage, coarse grain deposit. The Laurenzana is a peculiar stream, as it dissects the old morphologic surface with deep meandering gorges, evidently superimposed. Relict meanders higher that the present riverbed witness the fast dissection consequent to uplift. In this terminal section of the basin, the slopes are gentler as they are carved out from Tertiary and Quaternary sedimentary rocks, mainly clayey, with gypsum and sandstone layers, resting on a clayey melange made of Cretaceous-Oligocene terranes, very prone to landsliding and easily erodible. Terrace flights and remnants of an old morphologic surface characterize the watersheds and the typical delta area of the river. Sea erosion is causing a strong beach depletion.

*Fiumaras* are an equilibrium form between sediment budget provided by mass movement and erosion on the slopes, and sediment transport capacity along the drainage network. Tendency towards aggradation or degradation may alternate. It is commonly observed that after major meteorological events, that cause major floods, stream beds tend to aggradation for a more or less long period, and when the excess debris is exhausted they tend towards degradation. As major floods have a return period of 20-25 years and more, the degradation tendency may remain for a time enough to encourage the invasion, with cultivation and sometimes buildings, of the 25-year-flood riverbed, with easy to figure out consequences. The Trionto riverbeds have a width greater than 1km downstream the confluence with the Laurenzana torrent. The riverbeds here are some 50 m thick. In summertime more than 95% of the water flows as groundwater flux. From Fifties to Seventies, 24% of the basin surface has been forested; ca. 100 check-dams have been built, and 6,000 m of banks have been interested by hydraulic works. At present, a huge earth dam is under construction in the Laurenzana Torrent. This will surely induce problems of salt-water intrusion along the coastal aquifer in the delta of the Trionto River.

The use of remotely detected imagery (fig. 4), and electronic raster images of topographic maps of different times, permitted to follow the modifications of the terminal reach of the Trionto River at different times (1870, 1943, 1954, 1983, 1087). The delta was a wet area in 800's. At the end of last Century, the section of the riverbed was strongly reduced in order to permit the building of a railroad bridge. The area over which the stream was allowed to stroll freely was reduced progressively and the areas protected by levees have been occupied by buildings. The narrowing of the river bottom eases the transport capacity of the terminal reach, as indicated by the protruding of the river mouth into the sea.

Data concerning 22 flood events in historical times, indicate that hydraulic works proved effective in reducing erosion and damage of major events, while resulted non effective in occasion of intermediate magnitude events.

Stops during visit will permit to observe the dramatic morphologic change at the plateau-gorge boundary, the terraced deposits of the valley fill-and-cut cycles, the sedimentary and morphologic structures of the old and very recent landslide-related fans, the high-frequency landsliding in Mesozoic flysch and in the clayey melange of the lowlands, and the characters of the *fiumara*-type reaches. Visitors will be given a 1:50,000 scale geomorphologic map of the Trionto River basin.

Participants will be shown the high-plateau morphology of the Sila mountains, the dramatic morphologic bang at the edge of the main Ionian slope, the 100 m high terrace flights of the Trionto midcourse, the landslide landscape of the Trionto lowlands, the «*fiumara*» features of the Trionto River terminal reaches, and the coastal features of the eroding delta.

## 3 - THE CREPACUORE CANYON EXPERIMENTAL MICRO-BASINS
(F. Iovino & G. Callegari)

The three experimental micro-basins of the Institute of Forest Ecology and Hydrology (Ieif) of Cnr are located within the watershed of the Crepacuore canyon whose basin drains Pliocene to Quaternary sandy marls outcropping in the Ionian side of Calabria, few kilometers north of Crotone. The slopes are affected by badlands-type erosion, even though not very intensely.

These basins were implemented in 1978 in order to study the efficiency of eucalyptus trees in reducing erosion in badlands. Eucalyptus trees were selected in order to obtain both a protection effect against erosion and a wood production on short terms.

Basin #1 is covered with spontaneous grass and bush vegetation; sheep are allowed to graze. Its slopes are very prone to landsliding.

Basin #2 is covered with coppice of *Eucalyptus occidentalis* (Endl.); the coppice has a 12-year turn. At present it is in its second agamic cycle.

Basin #3 too is covered with *Eucalyptus occidentalis* (Endl.). It was coppice until 1986; since then it is left to grow as forest.

In each basin, a mechanic clockwork raingauge station and an hydrometric measure station are installed. Recording of rainfall data occurs every 20 minutes. The hydrometric station has a siltation pool made of reinforced concrete, with a H-Flume type weir that drives the water flux to a turbidity sampler of the Coshocton type (Parson, 1954). The measure gauge has an operative range of 0.469 to 309 liters per second. The sampler takes 1/200th of the flux volume; the variations of the hydrometric level are measured every 30 minutes and recorded with a paper mechanical recorder. Water samples are flushed to a pool


FIG. 4 - Comparasion between two airphotos of the Trionto River delta. The photos were shot in 1943 (top right) and 1983 (Istituto Geografico Militare, authorization n° 4150, 1995.3.15, Permission S.M.A. n° 049, 1995.2.13). In the 1943 photo, tracks of a recent flood are evident on the left side of the river bed. The same tracks are less visible in the 1983 air photo.

from where 1-liter samples are taken at the end of each rainfall event.

Data so far collected confirm that runoff and erosion depend on the land use type and on the intensity of vegetation cover. Indeed, if the cover with eucalyptus trees is complete and uniform, it reduces runoff and turbidity of water flow more effectively than grass cover can; coppice does not substantially effect hydraulic and erosion processes, except immediately after logging. If logging litter is left on the ground, resistance against rain erosion is increased, even if fire hazard is increased.

Lastly, the value of the cultural factor (C=0.164), obtained applying the model by williams (1975), confirm the effectiveness of eucalyptus plantations against erosion.

The excursion will take participants through an easy walk to the study micro-catchments.

## 4 - THE GRAVE GRUBBO CAVE
(G. Ferrini & A. Moretti)

Upper Miocene evaporitic deposits are widespread in the Neogene tectonic depressions in Calabria. The most extended outcrops are of gypsum, at places in one single bank 5 to 30 m thick, at places in different banks alternating with detrital deposits, making a total thickness of 200 m at maximum.

In the Ionian side of Calabria, extensively crop out late Miocene terranes deposited in extensional basins formed subsequently to the piling-up of crystalline tectonic nappes (TORTORICI, 1982). The geodynamic conditions controlled the detrital and evaporitic contributes to the deposition and generate different sedimentary sequences marked by sedimentary unconformities. In this part of the Ionian side of Sila mountains, evaporitic sequences are very well developed. Tectonics and groundwater circulation have originated karst systems among which the Grave di Gubbo-Vallone Cufalo one is the best developed and best known so far.

The karst system (fig. 5) develops in a thickness of 50 m, Messinian gypsum formation made of rudite beds at the base and arenite beds towards the top. The deposits are resedimented. This formation rests on a impermeable substratum, made by the Maradera Clays formation, over whi-

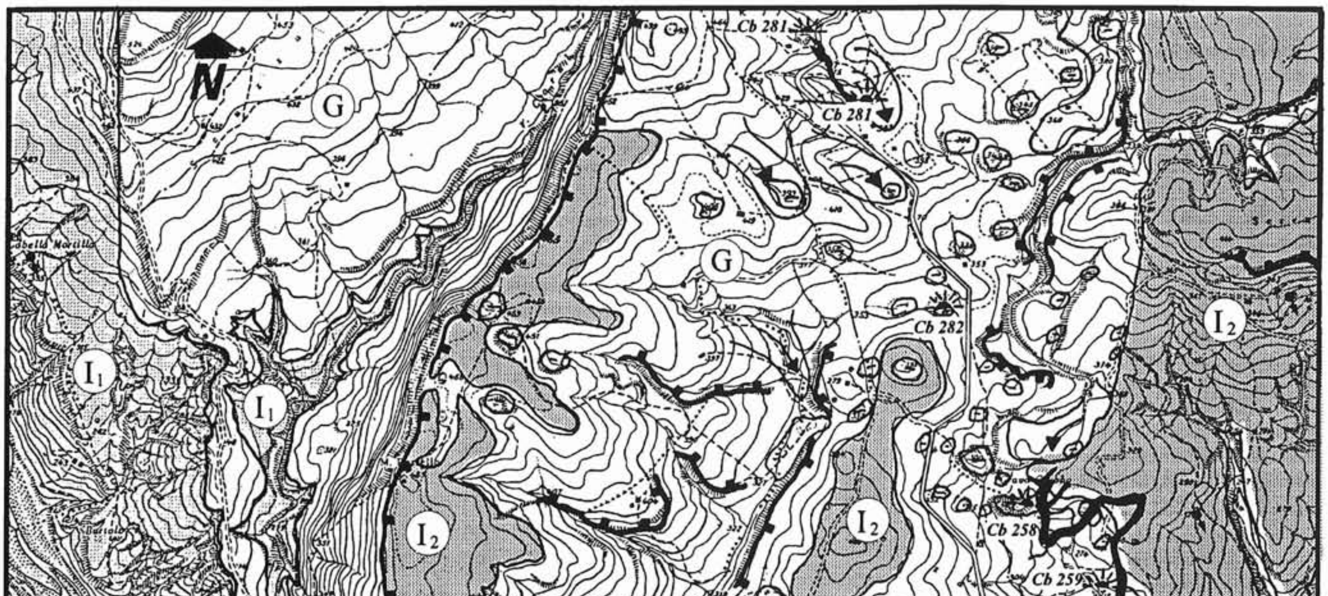


FIG. 5 - Geomorphologic map of the Grave Grubbo cave area. Key to the symbols: I1: impermeable base formations; I2: impermeable top formations; G: karst complex (gypsum, salt); 1: spring; 2: scarp; 3: doline; 4: cave inlet; Zigzag black features are the plan view of the explored caves.

ch lie discontinuous diatomite beds (named «*Tripoli*» in Southern Italy); ca. 70% of Tripoli is represented by silica sponge skeleton. Both Maradera Clays and *Tripoli* are Messinian in age. The contact between the gypsum formation and the substratum is erosional. The first 5-6 meters of the rudite beds include coarse gypsum, *Tripoli*, and evaporitic limestone clasts; they are debris flow deposits; such layers are present in the upper part of the sequence, but they thin and fine progressively.

All the northern Ionian side of Calabria is interested by two fault sets with SW-NE and N-S trend. The NW-SE trending set controlled the deposition of late Messinian and early Pliocene terranes; N-S trending faults are more recent and still active. In the area of interest, the principal structure is a normal fault SW-NE trending, with displacement of some hundreds of meters, causing drag folds and intrastratal slip well developed in the gypsum formation. To the SE, the slip has become a true gravity detachment that has caused a thrusting and a duplication of the gypsum formation.

## THE GRAVE GRUBBO CAVE

The entrance to the Grave Grubbo cave system is located at the bottom of a collapse doline 115m in diameter. The entrance is nearly rectangular, at the base of a 20m high wall.

The entrance chamber is paved with large fallen blocks; from here , a 7m down jump leads to a large room from which three branches radiate:

a - the square tunnel
b - the Cinderella branch
c - the river's branch

In the caves two litofacies can be observed:

1 - the layered gypsum-arenite, and
2 - the massive pelite, with abundant organic fraction.

The first lithofacies is thinly layered with interspersed turbidite beds. The lack of layering in the second lithofacies suggests that the deposit has been biologically reworked.

The complex of the Grave Grubbo develops within a thickness of ca. 15 m. In particular, the main branch develops in correspondence of the pelitic beds that represent ca. 30% of the section of the cave. In the northern portion of the cave, the layered gypsum arenite makes the ceiling; at present, the cave is down-cutting into the pelite nearby the terminal reach.

Karst erosion in this zone shows its typical surficial expressions: collapse dolines, sink holes and disrupted drainage pattern are most frequent, as well as underground reaches of several stream branches. It results a landscape rather unique in this territory, and a relevant hazard to human activities. Similar situations are to be found in the left side of the Crati River valley, where Upper Miocene gypsum banks approach the ground surface.

Visitors will be led into the cave entrance room and into the square tunnel.

## 5 to 7 - FANS

(L. Antronico, E. Le Pera, M. Sorriso-Valvo & C. Tansi)

Fans can be considered as forms indicators of excess of debris budget, or reduction of transport capacity of streams, or increment of debris flow phenomena.

Main factors determining such events are: climatic and seismic crises, and human activity, especially modifications of land use, e. g. from forest to pasture or ploughing.

Climatic factors are territorially widespread and uniform over large territories, and may substantially change on the long and medium terms; seismic activity is widespread on regional-size territories and is clustered in time; human activity can be either widespread or localized, and either uniform or not uniform. The combination of the territorial and temporal distribution of causative factors, with susceptibility to landsliding and/or erosion, determines the distribution of physical land degradation and, ultimately, of the fans. The combination can be whatsoever, also because the same territory is differently susceptible to the different causative factors of land degradation.

## 5 and 6 - SAVUTO RIVER AND TYRRHENIAN CATENA COSTIERA FANS

Two main types of depositional processes can be active on fans which can be subdivided into those resulting from debris flows and those from sheetfloods (BULL, 1972 & NILSEN, 1982); in (fig. 6) they are designated as CI and CII-type fans, respectively (BLAIR & MCPHERSON, 1994). This distinction refers to their evolution and relations to dominant sedimentary processes and facies assemblages.

We described the sedimentologic character of the Savuto drainage basin and of the Catena Costiera fans. Our descriptive terminology for the studied alluvial fans includes the following grouping: 1) CI fans, generated by sediment gravity flows; 2) CII fans, generated by fluid gravity flows, and 3) Mixed type fans in which sediments include both debris flow deposits and sheetflood beds.

The Savuto River basin is characterized mainly by CI fans and minor CII alluvial intramontane valley fans. CI fans are built up by debris and mud flows, CII are sand-rich sheetflood deposits. CI fans are debris and mud flows very poorly sorted, with no internal organization of detritus including pebbles and large cobbles set in a fine sand or clay matrix. CII fans are layered bodies of fairly well-sorted laminated coarse sand and oriented pebbles. Few fans of this basin show both stream flow and debris flow intermixed character.

The western seaward front of the Tyrrhenian Catena Costiera is characterized by single wedge-shaped alluvial fans made up of coarser sediment of the proximal portion of the fan. They are mostly debris flows CI fans although very few are characterized by both debris and stream flow deposits with intermixed layers (Mixed type). Debris flow related deposits of the Catena Costiera fans are poorly or not stratified, coarse-sand matrix supported and with no or

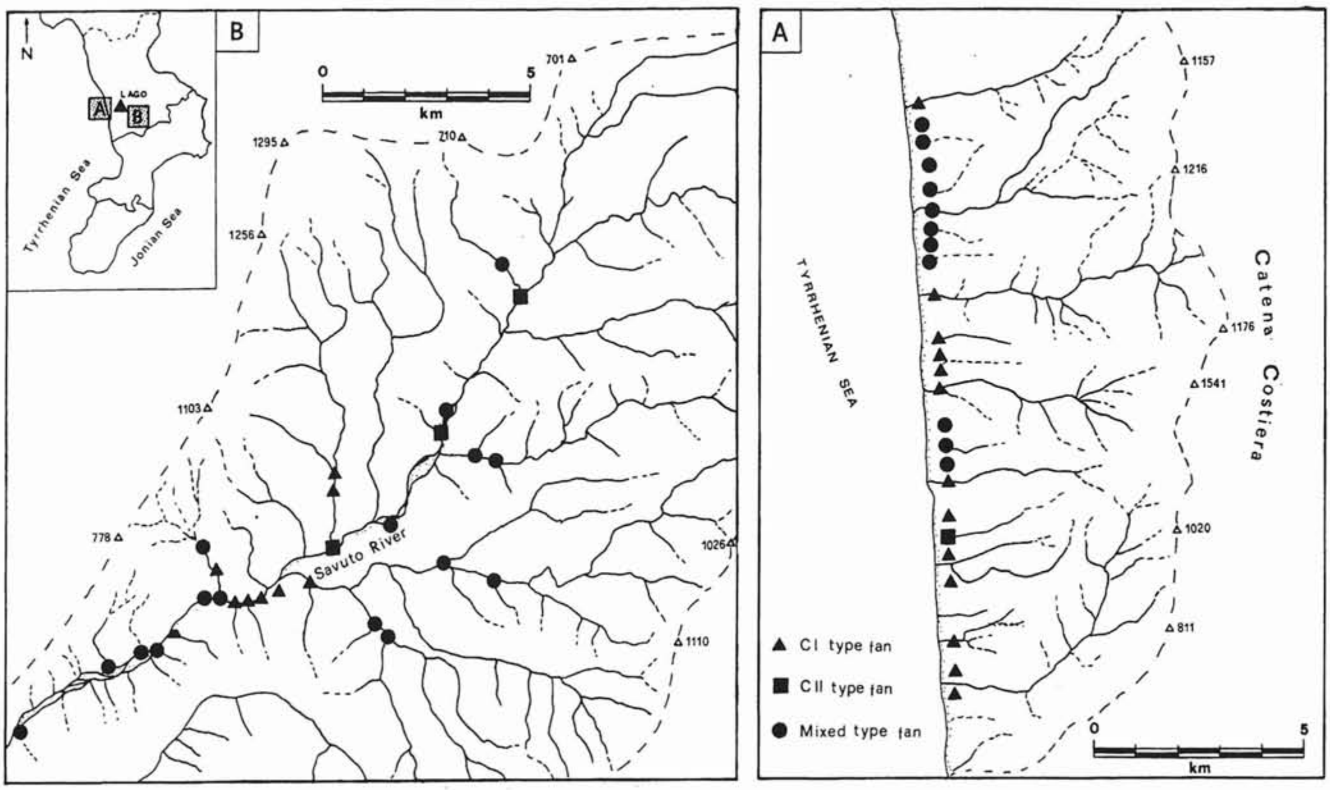


FIG. 6 - Location of the CI (debris-flow constructed), CII (sheetflow constructed), and undetermined (or mixed) alluvial fans in the Catena Costiera coastal zone (A) and in the Savuto River valley (B).

very little imbrication of clasts. Some fans show layers characterized by distinct depositional features of both debris and stream flow processes. These result in a vertical or in a lateral different arrangement of the fan deposits: some of them are complex depositional bodies in which stream and debris flow sediments interfinger as a result of sub-environment within alluvial fan setting. Since the beginning of this Century, these fans are non-active. As a consequence of this, since Sixties they became site of increasingly intensive building and quarrying, and a railroad and a highway cross some of these fans with tunnels. By means of radiocarbon dating and historical analysis, it is proved that in the preceding Centuries the Catena Costiera fans experienced periods of intense activity of construction processes, so that two or three generations of levees had to be constructed. The presence of buildings partially buried with debris, indicates that the phases of intense activity were periodical. They are serious environmental hazardous sites because of the high magnitude of debris flow processes.

By means of statistical analysis (SORRISO-VALVO & *alii*, 1997), it can be inferred that fan morphology is controlled by constructional processes and is tightly linked to basin morphology, especially ruggedness. The ultimate controlling factor appears the geology of the basin, as fan and basin morphology are strongly dependent on the rock mechanical characteristics, with hard rocks imparting to the basin a high ruggedness and to fans a high gradient. Larger fans, however, are those where sheetflooding predominates. Results of discriminant analysis based on fan and basin variables are much more significant than those based on fan variables only. This means that the differences between characteristics of fan-and-basin systems are better defined than those between characteristics of fans only.

Debris flow fan deposits form the basis for inferences about environmental dynamics in terms of susceptibility to erosion and sedimentation. They characteristically are indicative of both an increase of slope erosion in the drainage area and climatic changes.

Visitors will be taken first to two quarries in the River Savuto valley where they could observe features of these mixed or CII fans. Then, the CII fans of the Tyrrhenian coastal chain will be visited and illustrated.

## 7 - THE ACTIVE CI-TYPE FAN OF THE PIZZOTTO CANYON

The Pizzotto canyon is a right-hand tributary of the Licetto torrent that debauches into the Tyrrhenian sea in northern Calabria. It dissects a 450-500 m high slope carved out of metamorphic rocks that for the lower 4/5th are phyllites, and for the top $1/5^{th}$ gneiss overthrusted upon the phyllites. Ramp-and-flat structures WSW-ENE trending, due to Miocene compressive tectonics, pervasively affects all the metamorphic units. Present active tectonics, linked to the currently active uplift, is however prevalently distensive and is generating N-S trending normal faults with a destral strike-slip component that generates transpressive and transtensive structures with oblique trends. In the study area, the Licetto torrent is adapted to this fault set, while the Pizzotto canyon is adapted to a E-W trending ramp.

The Pizzotto canyon was, until 1850's, a creek whose banks were affected by intensive erosion. In a 1872 1:50,000 scale map, the scar was some 500 m long and up to 150 m wide. At present, maximum scar length is 1300 m, width is 420 m, and depth more than 100 m; the scar covers an area of ca. 0.56 $km^2$ . The total eroded volume is ca. $15x10^6m^3$; this corresponds to an erosion rate of ca. $0.1x10^6m^3\ yr^{-1}$ . Of this volume, ca. 200,000 $m^3$ are stored in the CI-type fan at the mouth of the Pizzotto canyon, while some more 9.2 $x10^6m^3$ are stored as valley filling in the nearly 2 km reach of the Licetto torrent included between the fan and a set of three check dams the first of which was built in 30's . The missing $5.6x10^6m^3$ have been either washed to the Tyrrhenian sea or partially stored in the further downstream reach of the main riverbeds.

The scar is now a landslide zone with recurrent rock falls, slides and slab failures that expand the crown and the flanks, and provide material for the debrisflows that periodically reach Licetto torrent. These debrisflows are building the CI-type fan and a valley fill that extends upstream the Pizzotto bed for ca. 500 m. On the fan, the canyon is entrenched and the dissection extends to the tip; after a period of strong reactivation of debrisflows occurred in 1984, the canyon aggraded and a knick point formed ca. 300 m upsream the tip of the fan. At present entrenching depth is ca. 5m at maximum; the tip of the fan is up to 8 m high, and its height is increasing. During the last 50 years, the debris flows have been active several times, with maximum intensity in 1951, 1984 and in 1992-94.

This landslide and fan system is set along the upstream flank of a sackung affecting the metamorphic slope for all its length and beyond the ridge top, as inferable from Gps and seismic reflection data. On the sackung, landslides of the rockslide type affect mostly the lower and downstream parts of the slope. This combination of different types of mass-movement is typical of steep slopes carved in ductile and intensely jointed rocks. The presence of the landslide-related fans along the upstream flank of the sackung is due to the overall geometry of the slope and main stream, especially if the stream is steep. The slope gradient, in fact, results diverted downstreamward with respect of the perpendicular to the stream direction, thus tension stress is generated along the crown and the upstream flank of the deforming mass.

All information above comes from SORRISO-VALVO & *alii*, 1996.

Visitors will be led on the opposite slope to a general overlook of the Pizzotto-Greci slope & canyon, and on the fan to observe deposition structures in the CI-type Pizzotto fan.

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