Geogr. Fis. Dinam. Quat.
19 (1996), 395-408, 2 figg., 3 tabb., 1 tav. f.t.

MARINO SORRISO-VALVO (*) & CARLO TANSI (*)

GRANDI FRANE E DEFORMAZIONI GRAVITATIVE PROFONDE DI VERSANTE DELLA CALABRIA. NOTE ILLUSTRATIVE DELLA CARTA AL 250.000

ABSTRACT: SORRISO-VALVO M. & TANSI C., *Large-scale landslides and deep-seated gravitational slope deformation in Calabria. Explicative notes for the 1:250,000 scale map.* (IT ISSN 0391-9838, 1996).

Large-scale landslides and deep-seated gravitational slope deformations (dgsd) are frequent in the Calabrian territory, where they cover ca. 2% of the territory surface (300 km^2). In the 1:250,000 scale Map of Large- scale Landslides and Deep-Seated Gravitational Slope Deformations of Calabria (fold-out plate, referred to as the «Map» from here in the text) have been mapped phenomena with at least one side equal or exceeding 500 m. Large-scale landslides are landslides whose size is determinant in regard to the development of the phenomenon, or in regard to the intervention feasibility. They include scale-effect landslides, whose deformation mechanism is modified by scale effects that influence mechanical properties of deforming rocks (e.g. the friction reduction in large rock avalanches). Deep-seated gravitational slope deformations (dgsd) are slope movements for which it is not essential postulating the presence of a continuous shearing surface. Their mechanism can be modified by scale factors (e.g. the brittle-ductile transition in creep deformation).

The mapping base consists of the topography with contour lines cities and lifelines, and of the lithology. Lithologic units are characterized by their mechanic behavior in relation to the studied phenomena, thus they can be considered as Litho-Technical Units (LTU). In the Map, all units have been grouped into eight LTU, herein ordered according to the slope movement increasing frequency.

1 - Carbonates. It includes thick Mesozoic-Paleogene limestones and dolostones in the Northern Calabria and Jurassic limestones covering crystalline allochtonous nappes in South Calabria. Faulting and jointing from rare to extremely frequent (shattered dolostone).

2 - Paleozoic, medium to high-grade metamorphim and igneous rocks. It includes different types of gneiss and rocks of the granite family forming thick allochtonous nappes emplaced during Middle-Upper Miocene. Jointing and weathering intensive.

3 - Neogene hard sedimentary rocks. It includes sandstones, conglomerates, limestones banks, with layers of softer rocks. They were deposited in different sedimentary cycles (Lower Miocene, Tortonian-Messinian, Messinian-Lower Pliocene). Jointing from rare to frequent; weathering moderate.

4 - Pliocene and Pleistocene soft marine and continental deposits. They include sand, clay and subordinate gravel thick beds that fill the tectonic depressions. Faulting and folding moderate, locally intensive .

5 - Mesozoic, ophiolite-bearing low to medium grade metamorphic rocks, derived by the metamorphism of basic lavas with silicanch limestones of the old Tyrrhenian oceanic crust. They include three tectonic units emplaced during Upper Miocene. Tectonic structures (principally multiple duplex and joints) are pervasive and frequent to very frequent.

6 - Tertiary (Messinian-Lower Pliocene) clayey and marly terranes with evapontic levels. It is a heterogeneous unit made of relatively thin levels with very different lithologic nature, so that the proprieties of the unit essentially depend on the weakest beds. Jointing sand folding from moderate to intensive. Gypsum levels heavily attacked by karst erosion.

7 - Paleozoic and Mesozoic very low to low grade metamorphic rocks. They include essentially slates and phyllitic rocks of oceanic and continental crust, arranged in tectonic nappes piled up in Middle Miocene. Jointing and weathering intensive.

8 - Mesozoic and Tertiary flyschs. They include the Mesozoic quartzitic flysch of the north-eastern Sila mountains the MesozoicTertiary flyschs of the north-eastern Calabria, and the Cretaceous-Oligocene Varicolored shales cropping along the Ionian side of the region. Tectonic deformation from intensive to extremely intensive.

Major tectonic structures which generated or are generating topographic relief are mapped. Calabria is, indeed, a territory whose relief has been tectonically built during Quaternary era. Block-faulting style is predominant even though regional tilting and folding is present in the Ionian (eastern) side. Generally speaking, each range is a longitudinal (with respect of the land elongation) horst, each valley is a longitudinal graben (in general symmetrical), and each isthmus is a transversal graben. Transversal horsts are also present. The whole structure is an arc-shaped sector of the Alpine S-shaped orogenic belt that extends from Northern Africa, to Apennines and Alps, to remain in Italy. Four morphotectonic sectors can be distinguished in Calabria (fig. 2):

1st - Apennine range (Mount Pollino) and north-eastern Sila. Characterized by a set of normal/strike-slip faults striking N 120-130°, plunging to the SW and to the NE, and in part active. Maximum tectonic uplift ca. 0.7 mm/yr.

2nd - Basin and range system of the Catena Costiera Tirrenica, river Crati Graben, and Sila range. The present relief is due essentially to N-S striking block-faulting sets, with a dextral strike-slip component. The termination of the fault sets is against the faults of Sector 1 to the north, and against a N 30° striking set to the South. On the eastern side of the Sila, tectonics consists of tilting and folding, combined with block faulting. Strike of structures is roughly NE-SW, with parts striking E-W and N-S. This system is active, with an average Quaternary tectonic uplift of 1mm/yr in the Catena Costiera range and ca. 0,8 mm/yr. in the Sila range.

3rd - This sector includes the Catanzaro isthmus, due to a N 120° trending transversal graben that separates the Sila range, to the north, from the Serre-Aspromonte range, to the South.

(*) Cnr-Irpi, *87030 Roges di Rende, (CS).*

4th - The last sector includes the NE-SW trending fault sets that uplift the Serre-Aspromonte range with a rate of ca. 1mm/yr. A wide tectonic depression in the Tyrrhenian side initiated uplifting in the Upper Pleistocene forming at present a large terrace of Tyrrhenian age. In the Ionian side, compressive deformation (folds, thrust faults) present a degree of shortening much higher than in the sector 2, with hogbacks trending parallel to the range.

In the Map appear 172 phenomena. They are subdivided into five groups according to the type of deformation: slide-flow, block slide and lateral spread (large-scale landslides); Jahn-type lateral spread and Sackung (dgsd). Few cases of subsidence are also mapped, but they represent a non-well studied small population of phenomena, most of which of karstic origin. They are much more frequent when smaller phenomena are concerned.

For each studied case a data form has been compiled and filed in a data-base used for statistical analysis. In the record, siting, slope gradient, lithological composition and geological structure, and slope movement area, length, width, height, width/length ratio, and presence of natural dams are recorded, along with information on causes when known. Six types of geological structures could be distinguished which characterize the affected slopes (refer to the Map).

Mapped phenomena are territorially concentrated along the scarps surrounding the ranges. They are more frequent along the Ionian side. The reason can be twofold: in this side, due to the more developed compressional character of tectonics, the rocks are more pervasively deformed, in addition, meteorological trigger events act with higher intensity and frequency. Average values of main morphometric attributes and other distinctive characters of phenomena are shown in table 1.

Slope geologic structure seems to be a determinant factor for both the frequency and typology of phenomena. Brittle layers overlying ductile terranes, and intensively jointed rocks, present indeed the highest frequency of studied phenomena. At the same time, sackungs are more concentrated on brittle jointed rocks and on ductile rocks, and lateral spreadings on brittle layers overlying ductile terranes.

As regards the characters of the different types of large-scale landslides (tab. 2), slide-flow phenomena are the only with an average width-length ratio >1; the debris avalanches develop on steepest slopes. A peculiar group of landslides are those triggered by the 1783 earthquakes principally in South Calabria, while a few cases have been found in northern Calabria. These landslides have been marked in the Map by «T 1783». They did not show any activity after the trigger event, except in one case on the north Tyrrhenian coast.

Dgsd phenomena (tab. 3) are present principally along the Ionian side. Lateral spread of the Jahn type are confined in this territory. The tectonic past regime, here characterized by a pervasive and intensive compressive deformation, is probably a major cause for this uneven distribution of dgsd phenomena. Sackung are present on slopes that are the steepest and, at the same time, seem never to exceed 850 m in height.

KEY WORDS: Large-scale landslides, Deep-seated gravitational slope deformation, Morphotectonics, Mapping, Calabria.

RIASSUNTO: SORRISO-VALVO M. & TANSI C., *Grandi frane e deformazioni gravitative profonde di versante della Calabria. Note illustrative della Carta al 250.000.* (IT ISSN 0391-9838, 1996).

Le grandi frane e i fenomeni di deformazione gravitativa profonda di versante (dgpv) sono diffuse sul territorio calabrese del quale occupano circa il 2%. Nella carta al 250.000 delle Grandi Frane e delle Deformazioni Gravitative Profonde di Versante, qui illustrata, sono riportati fenomeni con almeno una dimensione (lunghezza o larghezza) superiore o uguale a 500 m.

La base cartografica comprende la topografia e la litologia. Le unità litologiche sono individuate in base al loro comportamento meccanico, per cui possono assimilarsi a Unità Lito-Tecniche (ULT). Si sono individuate otto ULT. Sulla carta sono riportate anche le più importanti strutture geologiche che hanno prodotto energia di rilievo. I fenomeni gravitativi di versante sono suddivisi in base al tipo di deformazione in cinque gruppi: grandi frane per scorrimento-colata, scorrimento in blocco e spandimento laterale; dgpv per spandimento laterale tipo *Jahn* e per *Sackung*. Sono riportati anche sporadici casi di subsidenza, alcuni di origine carsica, che però costituiscono una casistica non ben studiata e molto più diffusa a scala dimensionale minore.

Per ogni fenomeno è stata compilata una scheda che costituisce un *record* di una base di dati. Nei *record* sono riportate informazioni tipologiche, morfometriche e sulla struttura geologica del rilievo interessato. Si sono riconosciuti sei tipi principali di struttura geologica. Appare evidente che la struttura del rilievo, ed in alcune condizioni la morfologia del versante, determinano la tipologia del fenomeno gravitativo mentre le caratteristiche meccaniche delle ULT e l'energia del rilievo determinano la frequenza dei fenomeni studiati.

TERMINI CHIAVE: Grandi Frane, Deformazioni gravitative profonde di versante, Morfotettonica, Cartografia, Calabria.

1. PREMESSA

La Carta delle Grandi Frane e delle Deformazioni Gravitative Profonde di Versante della Calabria (citata come Carta, da questo punto in avanti nel testo) è stata compilata su una base litologica ottenuta condensando e rivedendo in base a dati più recenti anche inediti la Carta Geologica della Calabria al 25.000 dell'ex-CASMEZ. I fenomeni cartografati sono quelli noti in base agli studi, anche inediti, degli Autori e ricavabili dalla letteratura. Le due categorie di fenomeni verranno descritte tra breve. La scala della Carta pone un limite alla rappresentazione cartografica dei fenomeni di interesse. Per uniformare i criteri di rappresentazione, si è convenuto di rappresentare gli elementi con almeno una dimensione non inferiore a 500 m (2 mm sulla carta). L'individuazione, fra tutti i fenomeni di deformazione gravitativa, di quelli appartenenti alle categorie del tema, è chiaramente un'operazione affetta da un notevole grado di soggettività. Per una discussione dettagliata sull'argomento, si vedano gli articoli: NEMCOK (1972), RADSRUCK-HALL (1978), GOGUEL (1978), SORRISO-VALVO (1988, 1994), DRAMIS & SORRISO-VALVO (1994). In questa sede, è sufficiente richiamare i seguenti criteri di identificazione:

Frana: massa costituente una parte di versante naturale o artificiale dislocata per gravità verso il basso e verso l'esterno del versante, lungo una o più superfici o zone di deformazione.

Grande frana: frana in cui le dimensioni giocano un ruolo determinante per l'evoluzione del fenomeno di deformazione (p. es.: lo spessore rilevante richiede l'instaurarsi di condizioni di flusso idrogeologico possibile solo in condizioni meteorologiche particolari) o per la realizzabilità di opere di intervento. Quest'ultimo criterio è strettamente pragmatico, ma è di indubbio interesse per la previsione di massima dei costi di intervento. La grande frana diviene **frana con effetto di scala** se il meccanismo di deformazione è influenzato da fattori di scala che determinano variazioni delle proprietà meccaniche del materiale (p. es. viscosità dell'ammasso) o l'insorgere di fenomeni secondari (forte riduzione o annullamento dell'attrito lungo la superficie di scorrimento per vaporizzazione dei fluidi sotterranei, dissociazione termica dei carbonati, fusione).

Deformazione gravitativa di versante: movimento guidato dalla gravità di una massa costituente un versante naturale o un rilevato artificiale, senza apparente soluzione di continuità macroscopica tra la massa deformata e la roccia in posto. L'entità della deformazione è piccola rispetto alle dimensioni della massa.