

DOMENICO ARINGOLI (*), BERNARDINO GENTILI (*) & GILBERTO PAMBIANCHI (*)

THE ROLE OF RECENT TECTONICS IN CONTROLLING THE DEEP-SEATED GRAVITATIONAL DEFORMATION OF MOUNT FRASCARE (CENTRAL APENNINES)

ABSTRACT: ARINGOLI D., GENTILI B. & PAMBIANCHI G., *The role of recent tectonics in controlling the deep-seated gravitational deformation of Mount Frascare (Central Apennines)*. (IT ISSN 0391-9838, 1996).

The Authors describe a detailed geomorphological investigation of a part of the right-hand slope of the Fiastrone stream (right tributary of Chienti River) deformed by evident mass movements, whose evolution could have affected the stream, which is occupied by an artificial basin.

The analyzed area is located on the roof unit of the Sibillini Mountains thrust and includes the formations belonging to the Umbro-Marchean sequence, which shows a complex plicated setting structured by the compressive tectonic phase extending from Tortonian to Lower Pliocene, and then resumed in Upper Pliocene. Calcareous, marly-calcareous and marly sediments of the Lower Lias - Oligocene, affected by different joint sets, crop out. Some of these (shear joints) correspond with the field of compressive stress and are compatible with the plicated structures trending mainly N160°-180°E, N80°-100°E, and N40°-60°E, subvertically.

The analysis allowed the Authors to hypothesize a recent reactivation of the compressive structures occurring, however, by inversion of kinematics; besides, they also observed disjunctive elements of recent genesis such as extensional joints and high angle normal faults to which are associated modest individual displacements (decimetric), but with a notable general lowering trending mainly N140°-160°E and N60°-80°E.

In this stratigraphic-structural setting, there developed gravitational phenomena of different typologies responsible for the continuous modeling of the studied slope; the prevailing movements are represented by translational slides and by subordinated collapses; mountainward, the slope has been affected by an imposing phenomenon of deep-seated gravitational deformation. Favorable conditions for this kind of phenomena were the rapid and general uplifting of the area (very intense from the end of Lower Pleistocene) and, in the related hydrographic pattern, a downcutting which generated high relief values; the activation of mass movements is probably connected to particularly intense seismic events, both past and recent; in fact, in connection with the 1996 seismic sequence, fractures have been revealed in the upper part of the slope. The shear planes and/or zones are located in the mainly marly levels of the Marne a Fucoidi formation and, at some points in the retonized band observed in the Scaglia rosata limestones. Moreover, an important role both in the activation and kinematics of the movements, seems to have been played by the presence of disjunctive elements created by recent tectonics and/or connected to normal reactivation of ancient compressive structures.

A further aim of the present work is to evidence the high hydrogeological risk represented by the artificial basin of the Fiastrone, which in extreme climatic conditions could interfere, or above all with high intensity seismic events, could interfere with the active or quiescent mass movements, and lead to a possible landslide evolution of the deep-seated slope deformation of Mount Frascare.

KEY WORDS: Deep-seated gravitational deformation, Neotectonics, Geomorphological risk, Central Apennines, Italy.

RIASSUNTO: ARINGOLI D., GENTILI B. & PAMBIANCHI G., *Il ruolo della tettonica recente nel controllo della deformazione gravitativa profonda del Monte Frascare (Appennino Centrale)*. (IT ISSN 0391-9838, 1996).

Viene illustrata un'indagine geomorfologica di dettaglio relativa ad un tratto del versante destro del torrente Fiastrone (affluente di destra del fiume Chienti), deformato da evidenti movimenti di massa la cui evoluzione potrebbe interessare il citato corso d'acqua, occupato da un invaso artificiale (Lago del Fiastrone: diga ad arco).

L'area analizzata si colloca nell'unità di tetto del sovrascorrimento dei Monti Sibillini e comprende i terreni appartenenti alla successione umbro-marchigiana, la quale mostra un complesso assetto di tipo plicativo strutturato dalla fase tettonica compressiva estesa dal Tortoniano al Pliocene inferiore. Vi affiorano i sedimenti marini cretaceo-paleogenici della Maiolica (Titonico superiore-Aptiano inferiore), delle Marne a Fucoidi (Aptiano inferiore-Cenomaniano inferiore) e della Scaglia bianca e rosata (Cenomaniano medio-Eocene medio); essi mostrano giaciture con deboli inclinazioni degli strati verso nord (area sommitale della piega), maggiori pendenze nella fascia più orientale (fianco rovescio della piega) e sono interessati da diverse famiglie di joints. Alcuni di essi (joints di taglio) risultano disposti secondo il campo di stress compressivo e sono compatibili con le strutture plicative: direzioni prevalenti N160°-180°E, N80°-100°E, N40°-60°E, subverticali.

I rilevamenti hanno permesso, inoltre, di ipotizzare una recente riattivazione delle strutture compressive avvenuta però mediante inversione della cinematica; inoltre, sono stati anche osservati elementi disgiuntivi di recente genesi, quali joints d'estensione e faglie dirette ad alto angolo alle quali sono associati singoli modesti rigetti (decimetrici), ma notevoli ribassamenti complessivi: direzioni prevalenti N140°-160°E e N60°-80°E.

In tale contesto stratigrafico-strutturale, si sono sviluppati fenomeni gravitativi di tipologie diverse responsabili del continuo rimodellamento del versante oggetto di studio; i movimenti prevalenti sono rappresentati da scorrimenti traslazionali e, in subordine, da crolli; più a monte il versante è interessato da un imponente fenomeno di deformazione gravitativa profonda. I fattori predisponenti detti fenomeni vengono individuati nel rapido e generalizzato sollevamento dell'area (particolarmente intenso dal-

(*) Dipartimento di Scienze della Terra, Università di Camerino.
Work supported by Murst 40% fund.

la fine del Pleistocene inferiore) e nel conseguente approfondimento della rete idrografica che ha generato elevati valori dell'energia di rilievo; la loro attivazione è connessa con ogni probabilità a sismi particolarmente intensi, sia passati che recenti; in concomitanza della sequenza sismica del 1996 si sono manifestate fratture nella porzione superiore del versante. I piani di taglio e/o le zone di deformazione duttile sono impostati nei livelli prevalentemente marinosi delle Marne a Fucoidi e, localmente, nelle fasce tettonizzate riconosciute all'interno della Scaglia. Inoltre, un importante ruolo, sia nell'attivazione che nella cinematica dei movimenti, sembra essere rivestito dagli elementi disgiuntivi di neof ormazione e/o associati alla riattivazione in senso diretto di preesistenti strutture compressive.

Con il presente lavoro si intende evidenziare l'elevato rischio idrogeologico rappresentato dall'invaso artificiale del Fiastrone, in quanto sullo stesso potrebbero interferire, in condizioni climatiche estreme o in occasione di eventi sismici di elevata intensità, i movimenti di massa in atto e/o quiescenti e l'eventuale evoluzione in fenomeno franoso della deformazione gravitativa profonda di Monte Frascare.

TERMINI CHIAVE: Deformazione gravitativa profonda, Neotettonica, Rischio geomorfologico, Appennino centrale, Italia.

INTRODUCTION

A detailed geomorphological analysis of the part of the right-hand slope of the Fiastrone stream (upper Chienti basin), deformed by evident gravitational phenomena of different size, depth and type, is reported. This river transversally cuts the southern portion of the Marche an marly-calcareous ridge in the Central Apennines (figs 1 and 2).

In the high portion of the relief a deep-seated gravitational slope deformation is present; valleyward, this evolves in large-scale landslide phenomena, too. The deformational phenomena of Mount Frascare are already known in literature (COPPOLA & *alii*, 1978; CARRARO & *alii*, 1979; GENTILI & PAMBIANCHI, 1993; DRAMIS & *alii*, 1995), but the revealing in the area in recent times of new fractures has led the Authors to conduct new detailed geomorphological studies to understand better the deformational and morphoevolutive mechanisms and to define their activity. Such studies are supported by detailed meso- and micro-structural analyses, and by unpublished data (kindly supplied by the OSSERVATORIO GEOFISICO DI MACERATA) about the recent seismic events, with epicenters located in the study area or in neighboring zones.

In addition, the considerable geomorphological danger connected with the possible activation of the mass move-

ments of the slope should be emphasized; their interference with the underlying valleyfloor, where an artificial basin (Lake of the Fiastrone) is located, could lead to a condition of high risk in the area.

GEOLOGICAL-STRUCTURAL SETTING

The analyzed area is located in the roof unit of the Sibillini Mountains thrust that led to the contact of prevalently calcareous formations of the Lower Lias-Upper Eocene interval, on the Oligocene marls in a compressive tectogenetic phase of the Tortonian-Lower Pliocene (CALAMITA, 1990).

The mainly calcareous formations of this unit present a complex plicated setting with northward axial depression (direction of the axes N170°E). The formations have been affected by faults with the following directions: Apenninic-A = N150°-170°E, antiApenninic-B = N30°-50°E and, subordinately, around N-S (C = N10°E) (figs 2 and 3a). The first, probably generated during the compressive tectonic phase of Lower Pliocene, are subsequently renewed (Pleistocene) in normal sense, lowering the structure westwards. The second (B = N30°-50°E), belonging to the same compressive tectogenetic phase, have more complex kinematics: the main movement is inverse (left-transpressive), but, in the area affected by these gravitational phenomena, the recent kinematic indicators furnish elements that allow us to hypothesize, in that case too, a reactivation in normal sense of the movement (right-transpressive). The last ones (C = N10°E) are characterized by right-transpressive kinematics, are disposed en-echelon and could have been generated, because they interrupt the compressive structures above, during the reactivation (Upper-Pliocene), of the Sibillini Mountains thrust by a gravitational tectonics mechanism. Their right-transpressive movement caused a set of fractures: D = N40°-60°E.

This complex lithostructural setting was affected, in Quaternary times, by an extensional tectonic phase, with a general uplifting of the area, that generated new discontinuities including partly also the existing ones (AMBROSETTI & *alii*, 1982; DRAMIS, 1992; DRAMIS & *alii*, 1995).

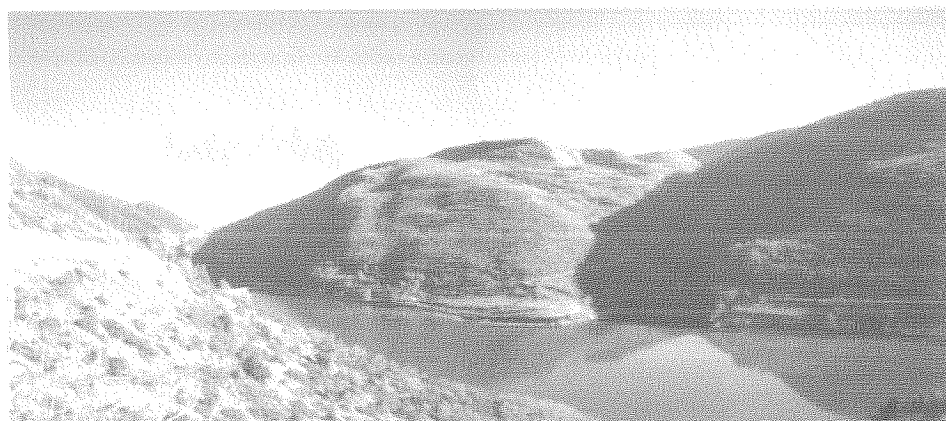


FIG. 1 - General view of the area.