PHOTOGRAMMETRIC METHODS IN GEOMORPHOLOGICAL PROCESS STUDIES. A CASE STUDY FROM ROMANIAN SUBCARPATHIANS.

N.Neguţ, D.Bălteanu, G.Mihaiu, L.Căplescu, P.Bălănescu, Cornelia Săvulescu.
Institute for Studies and Design of Land Reclamation Projects, Institute of Geography Bucureşti
Romania
Comission VII

Résumé.
On présente les possibilités offertes par les méthodes photogrammétriques (la combinaison de l'interprétation des photographies aériennes et des photogrammes terrestres) pour l'étude des processus géomorphologiques actuels dans les territoires à grande mobilité de relief.Dans le cas etudié on a etabli les phases d'évolution d'un petit bassin-versant affécté par des glissements et des coulées boueuses, pendant une période de 3o années.

Introduction. The Curvature Subcarpathians are knowm in the geomorphological literature as one of the regions affected by very intense denudation processes in Europe. Their slopes are subjected to intense gully erosion, landslides, mudflows,while their river network carries yearly great quantities of alluvia estimated at 25 - 4o t/ha year.
What causes this strong denudation of the relief and the conditions in which it takes place are the following:
- the relief, with altitudes of 3oo - 8oo m a.s.l., consists of nonconsolidated Mio-Pliocene folded and faulted rocks (marls, clays, sandstones);
- the region corresponds to the „Vrancea epicentral area" affected by strong earthquakes; shocks of magnitude M > 7 have a recurrence interval of 3o - 4o years. The characteristic neotectonic uplift movements permanently favour the deepening of the hydrographic network;
- the annual average amount of precipitations is 575 - 65o mm, having a marked torrential character, especially in summer;
- most slopes are bare and used as pastures, orchards and arable land.
Our investigation were conducted on a monoclinal slope affected by strong relief modelling processes,and divided into first-third order secondary basins. The hydrographic basin studied covers an area o.62 km^2 and presents, in its lower sector, thick colluvial deposits subjected, periodically, to movements.
Methods. We based our researches on the study of three sets of aerial photographs and four sets of terrestrial photographs taken over the years 1954 - 1978 and 1979 - 1982, respectively.
There were executed photogrammetric markings air triangulation, geomorphological photo-interpretation and analytical and analogical restitution (orthophotograms included).
Relaying on the aerial photographs, orthophotograms and field investigations, we selected three representative samples for different present-day geomorphological processes (Fig 1 and 2) These areas were studied in detail with the help of terrestrial photogrammetry. Three concrete-built photogrammetric

Fig. 1

1 2 3 4 5 6 7a b 8 9 10

Study area with photogrammetric bases and points of measurements 1, photogrammetric bases; 2, areas with repeated terrestrial photographs; 3, rain recorder; 4, stake lines; 5, points to measure concentration of dissolved and suspended matter; 6, measurement of ground water level; 7a, mudflow; 7b, mudflow fan; 8, active landslides; 9, steep slopes, landslide scars; 10, piping processes.

Southern slope of Blidişel Hill in 1968 (same legend with fig. 1)

bases were placed in the field, where from the four series of terrestrial photographs were taken over in the interval March 1979 - April 1982. The photographs were taken with PHOTHEO 19/1318, UMK 1o/1318 and SMK 5,5/o8o8/4o; an electronic tacheometer EOT 2ooo and RECOTA was used for photogrammetric marking.

Processing the terrestrial photographs consisted in analogical exploitation on a plotting apparatus type TEHNOCART without automatic recording and, in this way, the plans of reference and transversal profiles were obtained. The analytical exploitation was achieved on a STECOMETER or TEHNOCARTC(coupled with a COORDIMETER G, which yielded the coordinates of points, of characteristic elements of the investigated area. The data obtained were taken as a basis for vertical and horizontal movements. Noteworthy both the digital and graphic informations were processed by means of the automated cartographic and computation system INDEPENDENT I loo - M 118 - ARISTO.

In order to check the photogrammetric marking as well as the homogenization of the different sets of aerial photographs processed under different conditions and on various scales and in order to obtain some photogrammetric landmarks that can hardly, or not at all be established in the field, we used air triangulation with restricted couples. For some couples, when momentary conditions did not allow the collection of all basic data we resorted to reconstructions by means of their isolated analytical exploitation.

The technological flow of exploitation of photographs and the results obtained are shown in figure 3.

The final geomorphological materials involved also detailed field investigations, which had started in 1968, based on detailed geomorphological mapping, measurements of some stake profiles, measurement of ground water level, chemical analyses of water and determination of suspended matter, as well as geotechnical analyses (Fig 1).

In this paper we shall discuss only some data yielded by a comparative study of air and terrestrial photographs using the other results in so far as they correlate with the photogrammetric investigations.

Results. Our investigations have revealed that the studied slope has been affected by a succession of distinct modelling phases within a 3o-year period, which can partially be correlated with the rainfall regime.

In the years 1954 - 1968 the slope shows, in general a relative stability. The main valley is affected by small lateral landslides and the thalweg is deepened down to the bedrock. The area is used as pasture land and the water drainage is organised on older landslides (Fig 2).

In July - August 1975 a sudden change in the relief modelling regime becomes obvious. After a period of heavy rainfalls that had reached a maximum of 177.8 mm within 24 hours (on July 2, 1975) a 425 m long mudflow occurred in the main valley, radically changing the pre-existent relief. The material carried by mudflow originated from old, reactivated landslides, and piping - induced low stability deposits. The total quantity of displaced deposits by various mass movements was estimated at 48.ooo m^3, of which 18.ooo m^3 have been included in the mudflow.

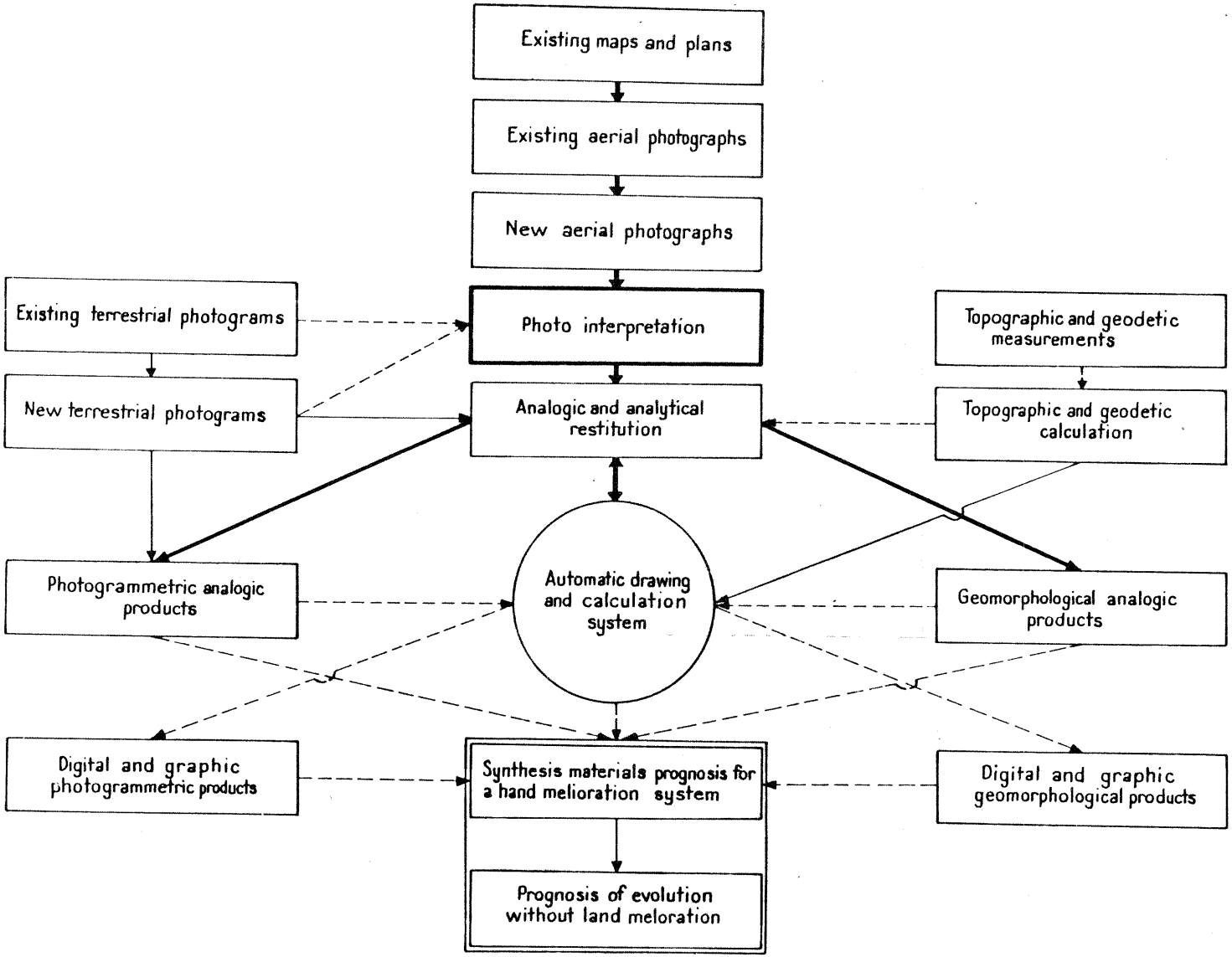

Fig.3 – Simplified flow chart for photogrammetric methods in geomorphological process studies

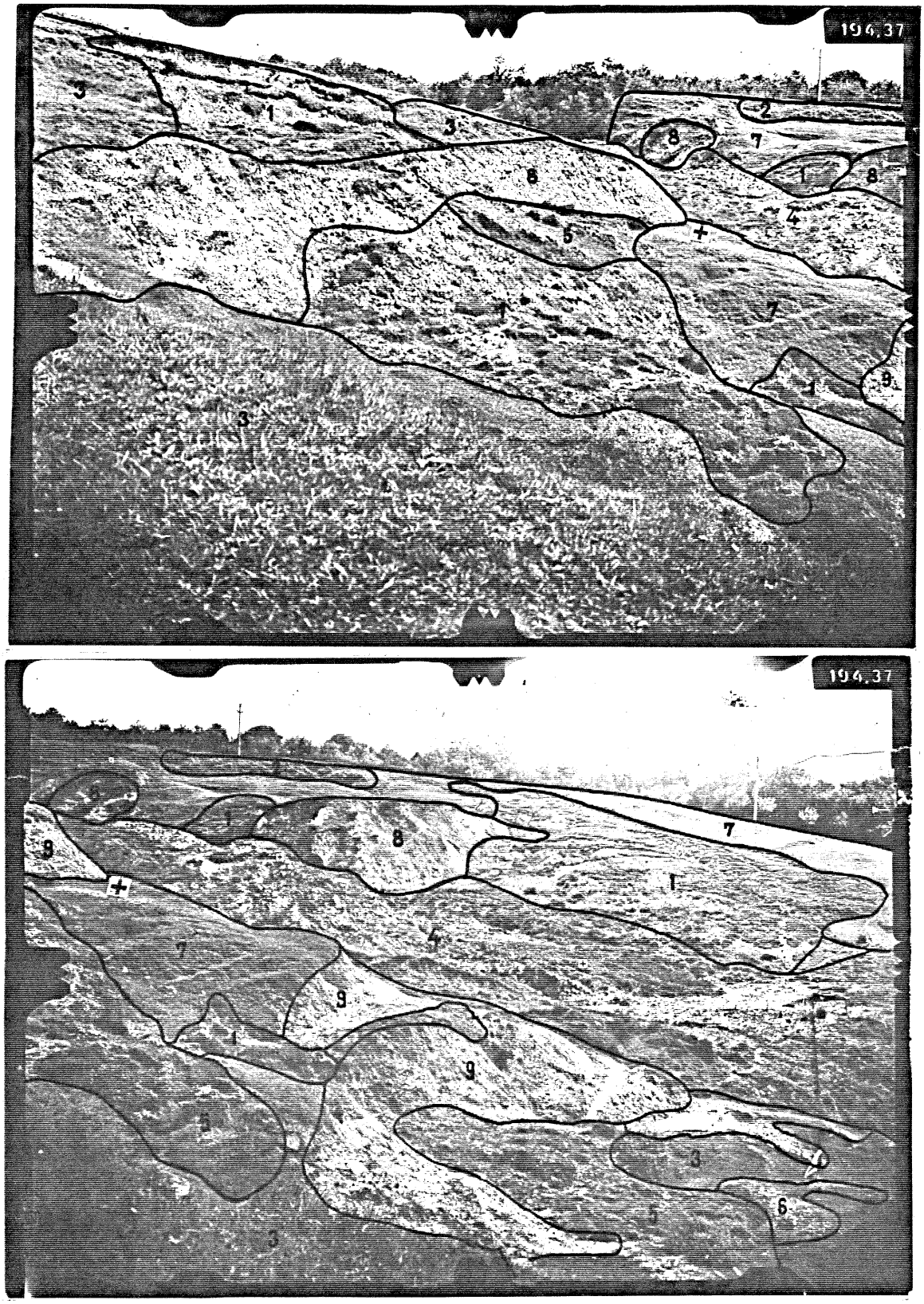

Fig.4

Terrestrial photographs of the sector B 1 (legend at fig.5)

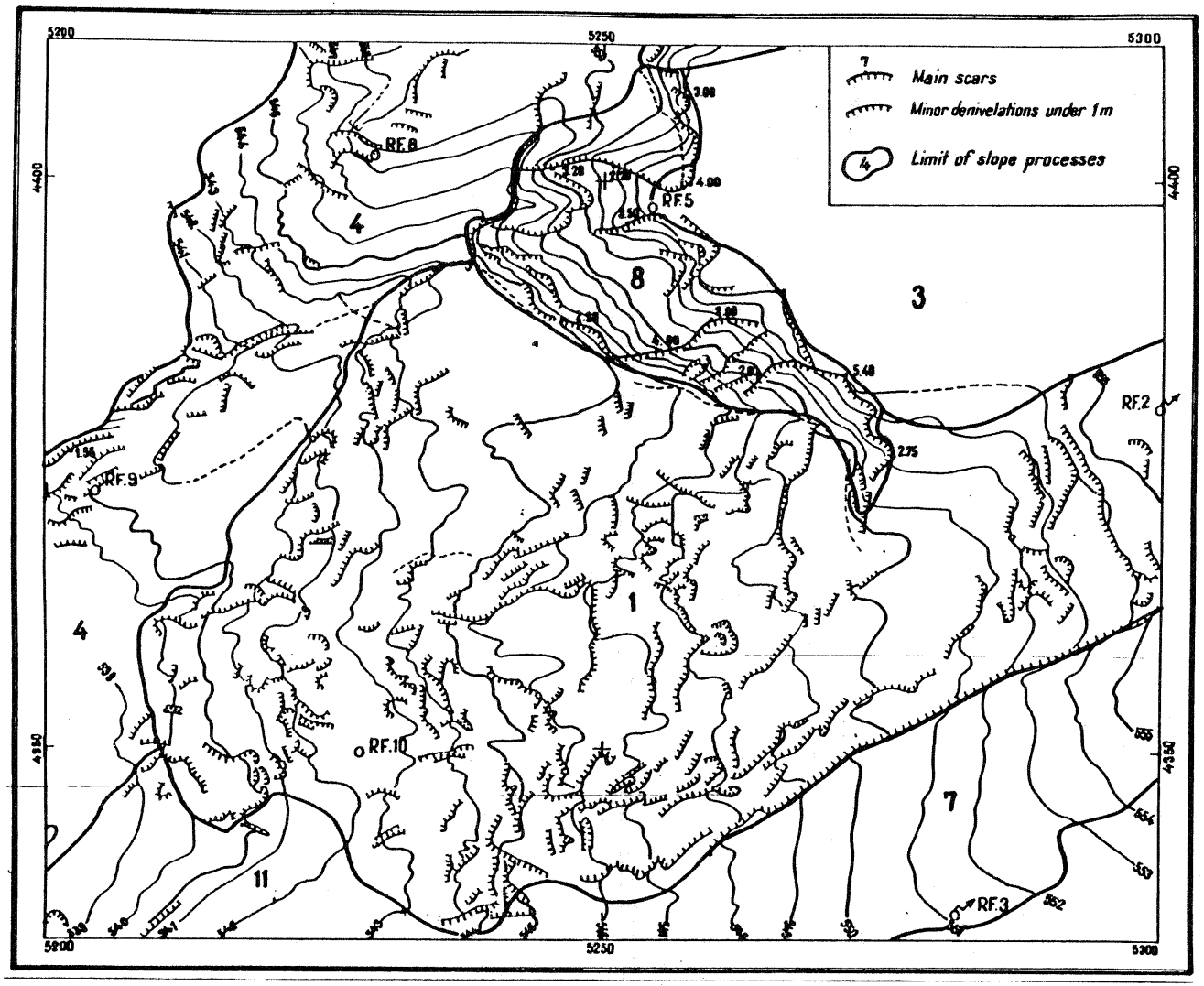

Fig.5

Geomorphological sketch of the sector B 1. 1, sheet slide; 2, active slump; 3, active landslide; 4, main mudflow; 5, recent colluvial materials on the grass; 6, recent deluvial materials on the grass; 7, relatively stable slope; 8, scar with slope wash and piping; 9, slope wash and piping.

Those extreme phenomena display some features that may be extended to the evolution of young regions with a marked mobility of their relief: total reactivation of mass movements in the source area; the existence of some by-source that supply the mudflow; the existence of pulsatory movements; temporal blockage of the channels.

September 1975 - 1982 .After the preceding phase of complete disbalance of slope stability, the relief began to readapt it self to the new conditions. In the recent weakly consolidated colluvia, gullies began to form, whose rate of deepening had initially been of o.5 - 1 m/year, the gully head withdrewing at rates of 5 - lo m yearly. This deepening rate went on until the longitudinal profile of these qullies reached the bedrock. As the hydrographic network began to reorganise through a unitary drainage, a phase of relative mass movement stability set in. In this phase piping processes become stronger, extending to the new landslides scars preparing in effect the materials for new mass movements.

Conclusions. Our investigations spanning a 3o-year period, enabled us to outline the varied type of mobile colluvia and the mechanisms of material transfers in different morphodynamic sections. Successive recordings revealed some distinct phases of slope modelling through the associations of different geomorphological processes. Proceeding from these findings it is expected that in some stage of research, prognosis of the future evolution of the slope as well as generalizations valid for limitrophe or similar zones, could be worked out enabling measures to be devised for the optimum use of these lands.

At the same time our investigations have proved the utility of photogrammetric products which can be fully evaluated only in the framework of a team activity, i.e.through a good cooperation between specialists in photogrammetry, geomorphology, geology, and land melioration.

References

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