**LANDFORM EVOLUTION AND MORPHOTECTONIC STAGES: A FUZZY APPROACH**

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**ABSTRACT**

The landform evolution is a function of the geological parameters and the erosive processes. The most discussed model of the landform evolution is the old Davision one using geomorphological stages. In this paper a redefinition of the 'stages' of landforms using a fuzzy approach, has been attempted. This is based on fuzzy set theory and the attempt to model a long-term evolution of the landscape.

**KEYWORDS:** Geomorphology, Fuzzy sets, Morphotectonic stages

**INTRODUCTION**

The landscape evolution is a function of two groups of variables defining the internal and external processes of earth respectively. The first ones are usually called tectonic forces and depend on the structural context of the region. The second group represents the external factors, which control the earth surface such as weathering-erosion processes.

In the theories of landscape evolution the Davision model (18999) is certainly the most important. The so-called 'cycle of Erosion' provides a general framework for understanding landform evolution. Fuzzy set theory (Zadah, L.A., 1965, Zadeh, L.A., 1987, Klir, G.J. & Yuan, B., 1995) can be used to redefine the Davision stages: youth, maturity, and old. This redefinition is necessary because of the relative imprecision of original stages.

Finally, our current knowledge concerning both the diastrophic and the exogenic factors is much better now than in the past (Clark, S.P. & Jager, E., 1969, Ahnert, F., 1970, Bishop, P., 1985)

Thus, landform units must include tectonic forces and as a consequence we define the morphotectonic stages.

<u>Methods of Davision stages:</u>

The first step is to consider that each stage is characterized by:

-The percentage of flat or rounded divides
-The percentage of rectiligne or curved slopes
-The percentage of narrow or U valleys

The above variables take fuzzy sets of values (high, medium and low) (Fig. 1).

The second step is the formulation of the proper logical rules for the transformation of the input variable (a landform) into the output (classification stage).

These rules are of the following form:

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|---|---|---|---|---|---|---|
| If (High or Medium percent of flat divides) | & | Low percent of Narrow Valleys | & | Low or Medium percent of Rectilinear slopes | ➔ | Youth stage |
| If Medium or High percent of U valleys | & | Medium or High percent of convex slopes | | | ➔ | Mature Stage |
| | | | | | ➔ | Old Stage |

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After defining the fuzzy stages 'Youth' (Y), 'Mature' (M), 'Old' (O), we introduce in our notation the UPLIFT and the subsidence movement denoted $I^1$ and $I_1$ respectively for the youth stage and thus defining the morphotectonic stage. For example, the normal sequence of morphotectonic stage without vertical movement will be Y➔M➔O but if there is vertical movement, the probable evolutionary sequence is more complicated (Fig.2).

A Markov chain model to predict landform evolution

Having defined the morphotectonic stages I, M, O, M1, etc, we can develop a probabilistic model in order to estimate the evolution of the stages (Gournelos,

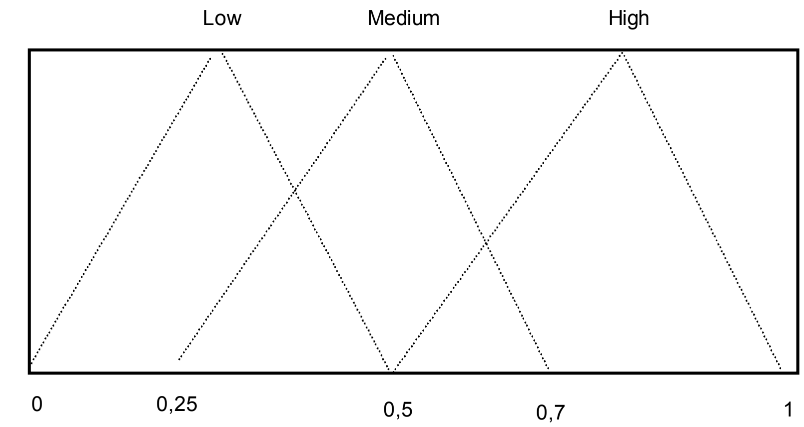


*Fig. 1:* Fuzzy sets of values (high, medium and low) for the used parameters.

1997).

We can distinguish transient recurrent and absorbing stages. Absorbing stages can be considered when relief is under the sea and no erosive process is active.

The basic structure of the Markov initial chain is the transition probability matrix. In our case it is the probability from one morphotectonic stage to another. Considering homogeneous Markov chains, we can easily treat the time evolution of these chains (Frechet, 1938, Bhat, 1972, Iosifescu, 1979). Then by accepting an initial morphotectonic stage and using this probability model an evolutionary sequence of stages is possible (Gournelos, 1997). In order to apply such a model, we must define the transition probability matrix, which correctly represent the morphotectonic position of a landform.

Accepting a fractal distribution of various landforms orders, this model can be applied to different scales (macro, meso and micro morphotectonic stage).

**DISCUSSION**

The aim of this paper is to interpret the mechanism of the variety of landforms. The old Davision model is not well defined and it does not take into account tectonic forces. The fuzzy set theory (Zadeh, L.A., 1965, Zadeh, L.A., 1987) is adopted so as to redefine the Davision stage. In these new stages the subsidence-uplift movements of the relief are introduced, and the landform evolution can be predicted using Markov chain model.

We must recognize that some areas present very complicated evolution. In these cases we face a multi-stage superposition and the prediction the future evolution becomes more difficult. In such cases the knowledge of spatial and time distribution of the involved variables is necessary.

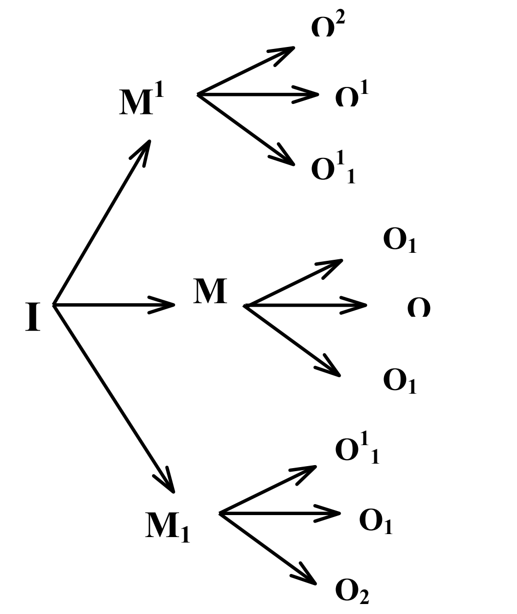


*Fig. 2: Definitions for the morphotectonic stage.*

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