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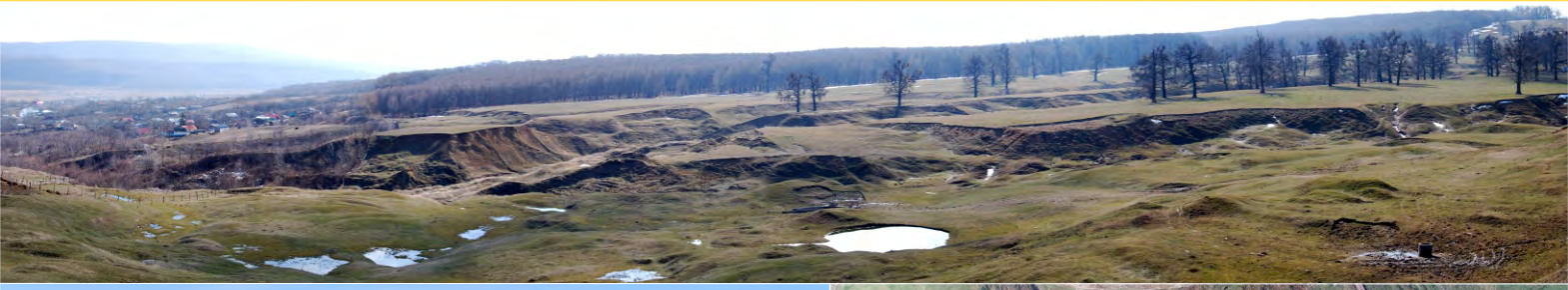

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Geomorphological restitutions for the geomorphological regionalization of Romania: the Moldavian Plain case

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ABSTRACT

In Romanian geomorphology, there are a series of inadvertencies induced socio-politically by the oppressive regime before 1990. Among these, we exemplify in this paper the use of the notion of plain for an area in Romania, which although exhibits characteristics of a hilly area, both geomorphologically and geomorphometrically: the Moldavian Plain. To support this position, we applied the Hammond and Iwahashi and Pike landform types classifications on the global GMTED DEM for Romania. We added an argumentation of the geology and geomorphological evolution of the study areas together with a history of its geomorphological regionalization. I hypothesize that the communist regime that implemented the collectivization of the arable lands influenced the geographers to introduce some areas in Romania to the plain category to argue for their collectivization. Another hypothesis might be that the inclusion of the plain landform typology increased the allocation of mechanization for agriculture. While the further study might reveal which of the theories is correct, the critical part is the restitution of the valid typology. In this sense, I support the elimination of the plain term to designate the landforms of this region and the reintroduction of the terms used before 1945, like Jijia Depression or of the term Jijia Hills, since the global geomorphometric classifications of landforms support this category.

KEYWORDS geomorphological regionalization; plain; hill; Jijia Hills; Jijia Depression

1. Introduction

In Romanian geomorphology, there are a series of inaccuracies in the regionalization, which we consider that appeared due either to a limited knowledge from the moment of their study or a socio-political context that imposed a particular vision. We refer here to the oppressive regime before 1990, which probably argued the need for collectivization or for increasing the mechanization of agriculture, thus establishing the criteria for areas that, although they did not fit typologically and geomorphometrically to the "plain" category, had to be declared this way.

The most typical situation of this kind is the plains in the hilly regions (Fig. 1): the Moldavian Plain (Fig. 2) and the Transylvanian Plain. These are neither geomorphological nor geomorphometric plains, but

they have been imposed as a name for other reasons. I will not treat the Transylvanian plain problem, but I will stop at the Moldavian Plain. Initially, I will show the evolution of the knowledge about it and then show the geomorphometrical reality with the help of several classifications of the landforms on geomorphometric bases. An initial study on this problem was made by Niculiță (2020).

I also emit several hypotheses for such evident wrong labeling by showing the historical evolution of the terms used to label this region.

Someone might ask why we need to resolve this issue now since, in the geomorphological literature, regionalization is no longer a key research direction. My answer is twofold. First of all, we need a "restitution" of the scientific reality, which was distorted for a political reason. And second, actually, there are real issues of geomorphological research that pose problems if we keep the distorted reality:

- while an outsider of Romanian geomorphology performs peer-review, it might look unrealistic to study landforms (cuestas) or processes (soil erosion, gully erosion, and landslides) that are not normally associated with a plain area with all the consequences that appear from this;

- the regional extension of some geomorphological units is used, for example, in landslides hazard assessment for susceptibility and risk (Günther et al. 2013, 2014, Wilde et al., 2018; Bălteanu et al., 2020; Grozavu and Patriche, 2020) so from the geological (lithological and structural) and geomorphological (genesis, evolution, and geomorphometry) point of view, geomorphological regions (sub-divisions) have distinct characteristics from each other that are reflected in the typology, density, age and recent dynamics of landslides and this can have an impact when especially European or global approaches take these regions from the literature, without knowing the reality from the field.

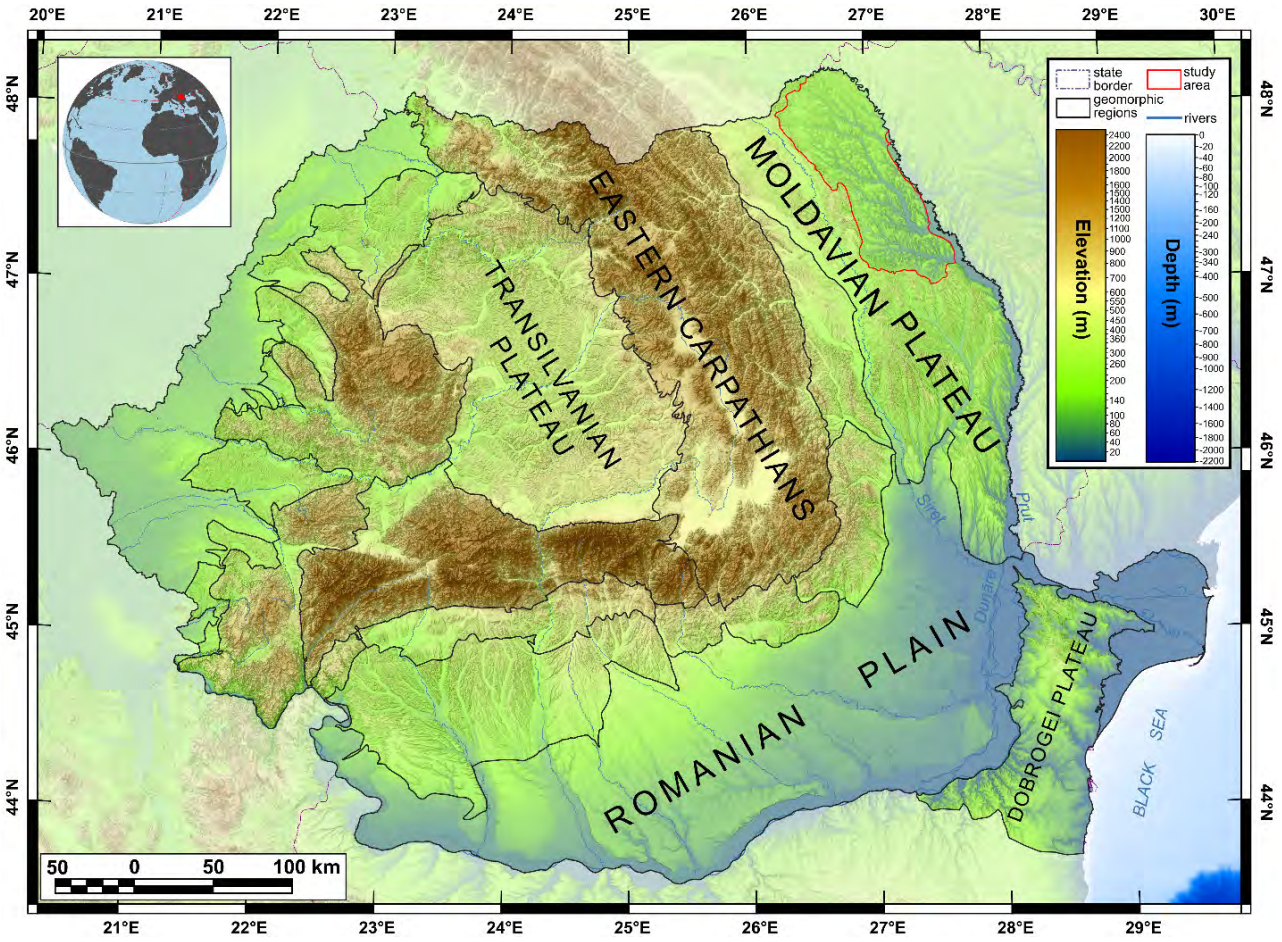

Figure 1 The position of the study area in Romania

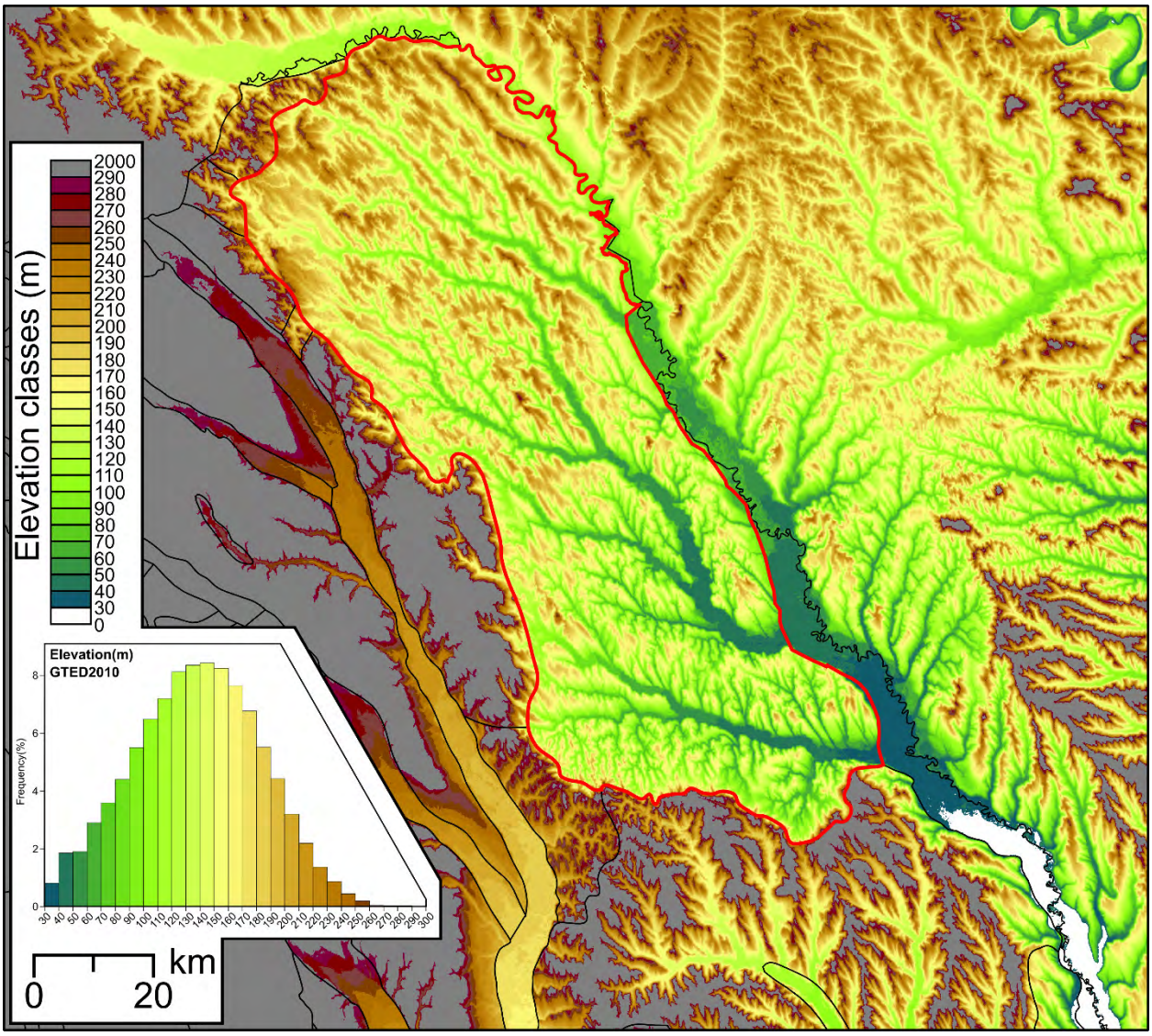

Figure 2 The hypsometry of the study area (GMTED 2010 DEM at 250 m)

2. Methods

2.1 Definitions and differentiations

First, I review the literature regarding the landforms in general and the plains in particular. In the incipient modern geographical literature even (Von Humboldt, 1849, 1856), there is talk of high plains, from the Asian and South American mountain ranges, compared to the low plains, close to sea level, so there is no threshold defined for the absolute altitude of a plain. Penck (1894) dedicates a lot of space to the discussion about plains and their genesis: he points up to the existence of accumulation plains, some of which are coastal, other tectonic, while others can be aggraded by human intervention through river regulation (Po, Rhin, Mississippi). He also mentions the valley fan plains at the base of mountains. Also, in the context of the davisian theory of cycles of erosion, the peneplains are considered to have high-altitude plains (Johnson, 1916; Fenneman, 1936), which are also considered "interior plains" (Fenneman, 1917) and categorized sometimes as basins or plateaus. Plains can be both erosional (plains of denudation – Gregory et al., 1910, "East Gulf Coastal Plain ... by gradation" – Fenneman, 1917), depositional ("Snake River Plain ... lava plain" – Fenneman, 1917), and aggradational (alluvial plain - Gregory et al., 1910, "Mississippi Alluvial Plain", "desert aggraded plains" of Nevada – Fenneman, 1917), even abyssal (Dunkerley, 2016), but in no

geomorphological typology, the land use is a criterion. An extensive literature is also dedicated to the marine planation plains (coastal plains) and subaerial denudation plains (Davis, 1896; Johnson, 1916, 1919; Cotton, 1955; King, 1963). Dissected plains with a moderate relief ("Dissected Till Plains" – Fenneman, 1917) are also recognized.

What is a landform in general and how we can define them is still a problem in progress in geomorphology and geomorphometry (Hammond, 1962; Weaver, 1965; Hammond, 1965; Evans, 2012). This applies even to landform which might be easy to grasp geomorphometrically, like mountains (Mark and Smith, 2004 – ontological analysis; Derruau, 1997 and Fairbridge, 1997a, mention relief of over 700 m and massiveness, and separate isolated mountain from mountain ranges; Kapos et al., 2000 use absolute elevation over 2500 m and slope and elevation range bellow; Meybeck et al., 2001 used relief roughness in m/km, but computed as the range of altitude; Fisher et al., 2004 used curvatures; Sayre et al., 2018 uses Hammond classification extended by Karagulle et al., 2017) which requires additional criteria to be used, like geology and tectonics (Murphy, 1968; Fairbridge, 1997a), climate and vegetation (Gerrard, 1990, which also points out that dissection is important; Slaymaker, 2003; Körner et al., 2017).

In Romanian on the Latin route, the term plain (lat. campos = field, infield) refers to an area without major level differences. In English, the term is self-descriptive ("a large area of flat land"[1]). Still, the allusion to the agricultural field in the Romanian language can confuse the untrained people by using the term plain for agricultural fields.

The geomorphologic and physiographic plain is an area with flat shape and with low variations of altitude (Finch and Trewartha, 1942). Penck (1894) used qualitative criteria: "Plains are extended stretches of the land surface in which the height differences between neighboring parts are so small that they are almost entirely beyond our immediate perception," but point also to 0.4% for flat plains and up to 10-20% for inclined plains (up to 9°), the focus being on the lack of relief, even though there is a general inclination or there is a concave shape. When the valleys incise the plain, it becomes a plateau, and when the valleys incise more than 200 m in the plateau level, it becomes tableland, although the threshold is fuzzy between plains and plateaus. He extends the discussion about the difference between plain and plateau by mentioning the flatness of the ridges. When an area is dissected, so the flatness is removed, and relief over 100 m appears, he considers it to become a hilly area. His discussion points also toward the difference between lowland and upland by mentioning that lowland should not be associated necessarily with plains, although in the areas under 200 m elevation, high relief is not possible: the north German lowlands and the interior of Russia are not plains (the first is a tableland while the second is hilly area) and the Danube/Upper Germany and Podolia are plateaus. Penck shows that using vegetation criteria for separating plains can be problematic. Finch and Trewartha (1942) define a threshold for a plain relative relief of 150 m. Further, by relative relief, plains can be classified as (a) flat plains, with relief under 15 m, (b) undulating plains with relief between 15 and 46 m, (c) rolling plains with relief between 46 and 91 m, and (d) rough dissected plains with relief between 91 and 150 m. The area of a plain has to have an order of magnitude given by its size bigger than ~6200 km2 in the hierarchy of Linton (1948) and represents a section in the landform unit hierarchy. Considering this, the plain is an area wider than a floodplain, which is a tract unit, and from a flat, that is a site unit (Linton, 1948, 1951; Savigear, 1965), but smaller than a province (>39000 km^2). Considering the size order of relief units proposed by Ahnert (1988), the plain is a mesorelief to macrorelief order type of site with widths of at least 10 000 m and an area of at least 100 km^2. Mescherikov (1968) defines a plain as "an area of land surface featuring small differences in topographic elevation and uniform from the geomorphological point of view" in a strict sense, and gives as a synonym the term "flatland" or "platform plain" in a broader sense as territories with a "combination of plains of various origins" linked to the geotectonic areas of shields and platforms (the

[1] https://www.oxfordlearnersdictionaries.com/definition/english/plain_2#:~:text=%E2%80%8Ba%20large%20area%20of%20flat%20land

North American Plain and the Eastern European Plain).

Flat surfaces, as I have shown, are mentioned for higher elevations, cases in which sometimes are considered as plateaus (convex features with a flat top – Derruau, 1977; "an elevated tract of the comparatively flat or level ground" – Fairbridge, 1997b; "an elevated area of relatively smooth terrain, frequently separated from adjacent areas by steep slopes" – Shaw, 2016) or tablelands (Fairbridge, 1997b). Sometimes, these landforms are considered high plains.

Second, I present the evolution of the terminology for the study area in the Romanian geomorphological literature. The early geologist that studied the geology of the Moldavian Plateau (Cobâlcescu, 1862; Simionescu, 1902; Sevastos, 1903, 1907, 1908, 1911, 1922; David, 1914) use terms like "small" and "big" hills, colines, plateaus and tablelands. David (1919, 1921), describing the Sarmatic Plateau, mention that its neighbor to the north is the Prut "bigger" Depression, an intracoline depression. Martonne (1924) mentions that in the field, the area between Siret and Nistru does not fit the definition of a plateau but rather of hills and large valleys. Porucic (1928) geomorphologically regionalizes two Plains, the Moldavian (on both sides of the Middle Prut river) and the Pontic Plains (the coastal plain of Black Sea between the Chilia branch of Danube and Odessa), in the area east of the Carpathians. Mihăilescu (1929, 1931a,b) uses the term depression and characterizes the landforms as low hills: "a region of low hills (the Middle Prut Depression)". Rick (1931) gives a detailed description of the landforms in the study area, which he names Jijia Depression. He remarks on the hills, their asymmetry with the presence of cuesta[2] scarps (called in Romanian "coaste"[3] a notion used in the popular language for steep hillslopes) and dip slopes, the plateaus from the northern part, the wide floodplains, and the widespread presence of landslides and soil erosion.

Tufescu (1935, 1937) mentions both the Moldavian Plain and the Jijia-Bahlui Depression. However, sometimes it seems to refer to Porucic's Moldavian Plain, with the Jijia-Bahlui Depression as a subdivision of the previous one. Tufescu is much more interested in the boundaries between this low region and its higher neighbor to the west, the Siret Plateau, than in the criteria for framing in a certain typology of the region itself. Tufescu (1935) mentions that the area's inhabitants call the area "plain"[4]. Later, he returns with an aspect that might seem valid, but is nothing more than the trap of the panoramic method and on the literary style of the description: "Viewed from a dominant point on edge, the relief of the depression appears aged, not far from the stage of peneplain. The gaze rests on wide peaks, beasted in the form of low platters (150-200 m) that are lost in the washed sky like weak pencils on frosted glass." (Tufescu, 1935) also reveals endless surfaces, platforms, levels of erosion based on data from Mihăilescu (1929). Of course, the lack of remote sensing data made the geographer and geomorphologist of the interwar period dependent on the panoramic vision and the topographic map in coarse interpolated level curves, so that the typological framing from a geomorphological point of view was made on the basis of the visual analysis of morphology. The planation surfaces that were described also point to the Davisian perspective of the landform interpretation, so a peneplain, which is "almost a plain", easily can be classified as a plain, without taking into consideration its geomorphometry[5]. So, if in 1935 he considered the term depression as a scientific one, and the term plain as a popular one, Tufescu (1941, 1945) comes back to the problem and argue for the usage of the term of plain, including in the school textbooks, because he is considering that the people are not able to grasp the scientific technicalities of the

[2] Altough the recognition of cuestas is only given since Tufescu (1945)

[3] A detailed discussion is given by Sîrcu (1956)

[4] It is worth mentioning that through the latin, în Romanian, "câmp" and its derivation of "câmpie" refers to the arable use and not to the flatness as in English

[5] It is worth mentioning that in the majority of the Romanian geographical literature Davis was cited through its german translated books, so probably "almost a plain" was interpreted as „surely a plain"

depression notion which becomes "artificial". He also argues that geographically the vegetation and land use can be considered in order to name a region, and since the locals use the term "câmp" (which can be translated in English as field), then "antropogeographically" is natural to name the area as a "câmpie" (which can be translated in English a plain).

Simionescu (1937) uses the term intracoline depression probably after David (1921) but do not cite him. He considers this intracoline depression for both sides of river Prut, separating the Jijia Depression to the west and Răut/Bălți Depression to the east. While in the text, he uses depression for both of them, in the map showing the morphologic regions of Moldavia, he mentions in the legend these areas as plains (for the map he mentions Tufescu and Mihăilescu as sources). There is also a note saying it can also be named the Moldavian Plain, being similar to the Transylvanian Plain.

Martiniuc (1955) uses the term Moldavian Plain and shows how we can compute the mean landform depth of fragmentation (a variant of relief used in Romanian geomorphology) on topographic maps based on the Chentsov (1948) method. He also shows a relief map for the Iași District. The method uses the number of contours, valleys and ridges, and echidistance along with several profiles for a certain region. The value computed with this method is too generalized since the values reported for Jijia and Bahlui Plain are only 50 to 70 m, while for the Repedea-Păun Plateau to the south is only 100 to 120 m. I invite the reader to see Figure 2 from Niculiță et al. (2018), where a swath profile (15 km wide) for the same area shows relief values over 150 m for the Jijia-Bahlui over 300 m for Repedea-Păun.

Sîrcu (1956) discusses the problem of the tectonic and geologic genesis of the depression, stating the lack of tectonic and structural control and proposing the lithology and river network control on the quaternary lowering of the study area with rates higher than the areas that have a protective caprock of arenitic and biomicritic limestone facies. Sîrcu is the single researcher that opposes the usage of the term plain for the study area: "far from representing a plain ... the use of either the term plain or hilly plain is nonsense, by plain is meant a region with flat and cumulative relief[6] and not a region of hills, whatever they may be of age".

Coteț and Martiniuc (1960) use the term of coline[7] plains (hilly plains), mentioning the verbal information given by L.G. Kamanin (a Russian geomorphologist that participated in the Romanian-soviet field trips from 1955 and 1956) for areas like Liteni Depression, the area of the Moldavian Plateau south of Central Moldavian Plateau and Jijia Plain which together with Bălți Plain is included in the Erosional Plain of the Middle Prut. These authors acknowledge the relief values up to 200 m (considered maximum values) in these areas and mention the Jijia Plain mean relief values of 70 m. In the Figure 40 of their paper, the caption is saying: "Landslides in the Hilly <<Plain>>[8] of Transilvania with the aspect of mud torrents". In the main landform types of Romania section of their paper, the Jijia type of Hills and Plateaus from platforms is considered to contain low hills and hilly plains, with very active landslides. Its subdivision is the Săveni erosional-structural Plain and the Iași sculptural-accumulation[9] Plain. Further, Demidovici et al. (1960), in the physio-geographic regionalization of Romania, uses this statement: "The forest-steppe land of the Jijia Depression, known as the Plain of Moldova".

I have to mention here that after 1945 in the Romanian geomorphological literature, there was an infusion of soviet literature. The most cited Soviet geomorphological paper is Markov (1948) and its translated version from 1957. The Soviet literature (Markov, 1948, 1957) reviews all the international

[6] Although this is not necessarily true as I have shown in the review of the international literature, information which seems that was not available to Sîrcu

[7] In the same paper, there is a note (page 219) where Martiniuc proposes colines as hills with incipient fragmentation by elongated ridges, and hills as fragmented areas by short hills

[8] So, they somehow emphasized this term, with which purpose I cannot tell

[9] Considerred as accumulation because in some geological text from before 1930, geological formations from the top of the hills in this area were considered to be “levantine” (the old name of Pontian) lake deposits; this was later refuted

literature but adapt their view to Penck[10] and the regional studies from Russia, introducing the sculptural and structural plains (for the first, the topography cut the geologic structure at a certain angle, while for the second the topography coincides with the geological layer[11]).

Mihăilescu (1966) predominantly uses the term Jijia Depression but on the map from Figure 29 of his book, splits the depression into three plains: Bahlui Plain, Upper, and Lower Jijia Plains. In Mihăilescu (1977), there are some interesting thresholds for which the author does not always specify the source: the "typical" plains are under 150 or 200 m elevation and have relief under 30 m (low dissected plains) or 75 m (for the heavily dissected plains).

Băcăuanu (1968) geomorphologically studies the region (in his published Ph.D. thesis) and explains the assignation to the plain typology of a region with the relief of cuestas, landslides, and hilly geomorphometry, by mentioning that:

- Tufescu (which was the official referent for the thesis) argues for the land use and popular tradition, which Băcăuanu accepts as valid;
- Geomorphologically the plain is a concept that is wider "now" than in the "past", considering the view of the Russian geomorphologists (Markov, 1948, 1957) which name as Russian Plain an area similar to the entire Moldavian Plateau;
- The altitudes are 80% of the surface lower than 200 m which is considered the upper limit of the plains[12], the mean relief is ~70 m, maximum relief values over 200 m are only a few, the ridges have low slopes (1-3‰), the landforms are denudational, the geology is monoclinic and the lithology is clayey-sandy.

Băcăuanu also accepts the usage of Jijia and Bașeu Depression (since Bahlui is already included in the Jijia catchment), which he believes will supplement the study area characteristics used together with Moldavian Plain. In the Geography of Romania, volume 1 (1983) instead he mentions as a footnote to the Moldavian Plain: "The name of <<plain>> does not refer to the relief, which is generally represented by slightly whitewashed hills, but reflects the characteristics of the geographical landscape, derived from the agricultural function of this region".

Martiniuc and Ungureanu (1970), Coteț (1973)[13] and Ungureanu (1993) take from Băcăuanu (1968) the term "coline/hilly plain" and consecrates it for some areas of the plateau, a term that we consider nonsense, challenging to digest and which has no argumentation except in the context of the desire to please the pre-and post-communist visions.

2.2 Geomorphometric classifications of landform type

Third, I present the methodology to derive the geomorphometric classification of the Romanian landforms.

At the continental and global scale, the initial landform types that were defined (Penck, 1894; Gregory et al., 1910; Finch and Trewartha, 1942) are: (a) plains, (b) plateaus, (c) tablelands, (d) hills, and (e) mountains. Hammond (1954) mentions four quantitative "attributes" that characterize the land surface and that can be used for landform identification at the continental scale: "local relief, flatness", "characteristic profile", and "characteristic pattern of ridgelines or valley floors". Local relief is the amplitude of elevation in a certain area. Flatness is the "fraction" of a certain "area with inclination less than some chosen boundary value". The characteristic profile is complex, defining the extension from drainage axis to divide, the location along the profile (over or under the median, so in

[10] I was not able to find in Penck's papers the mentions of "Schnittfläche" and "Schichttfläche" for plains; these notions are used in the mountainous areas indeed to separate topography which is purely denudational, from structural influenced topography; probably the soviet authors have translated this approach to plains also

[11] From my reading of Penck's papers actually I think that he was referring to the accumulation plains when he was saying that the topographic surface coincides with the geological strata boundary

[12] This view appears in the Romanian literature without a source; this value appears indeed in Penck (1894) but is not considered a threshold, but rather a statement, that many plains appear under this value

[13] Although Coteț also has also in paranthesis the Jijia-Balui Depression term and propose the Săveni and Iași Plains as subdivisions

upland or lowland) of the flat land is a good approximation. Characteristic patterns are even more complex, but the average spacing of drainage lines is a good indicator of the texture. Using the first three "attributes", Hammond (1954) proposed a classification in seven categories: nearly flat plains, rolling and irregular plains, plains with widely-spaced hills or mountains, partially dissected tablelands, hills, low mountains, and high mountains. Hammond itself mentions that statistical analysis might be needed to choose boundary values. The calculation of the "attributes" was performed on 13.88 km side squares, which were moved one near each other without overlap. Later, 9.65 km side rectangles were used only for US conterminous (Hammond, 1964a,b). Hammond schema did not use all the possible combinations of the three variables, but a selection was performed using the classes that appeared in the conterminous US Hammond remarked differences between his results and the literature landform type delineations.

Dikau et al. (1991) is the first raster-based implementation on DEMs of Hammond methodology. This implementation modified some thresholds of Hammond (Table 2) and applied all the 96 possible landform types. The rectangle size was 9.8 km, and the pixel size of 200 m. The validation of the results was performed quantitatively against Hammond maps, differences being remarked.

Gallant et al. (2005) adapted the Dikau et al. (1991) implementation in a focal filter (kernel) approach with square size. The DEM was 1 km in spatial resolution and the kernel size of 10 km. Some modifications of the profile type computation were proposed to resolve inconsistencies that appeared in comparison with the Hammond manual drawn maps.

Karagulle et al. (2017) adapted Dikau et al. (1991) implementation, adding the 50% to 50% percent gentle slope in lowland and upland (Table 3), and removed the plains with other types classes. The circular focal filters were used to compute slope fractions, relief, and profile type fractions but different sizes. The slope was computed using mean values in eight directions with a 3 km kernel, as well as relief. Profile type was computed with a 6 km kernel. The DEM spatial resolution was 250 m. Because the plains were reduced in extension due to the edge inclusion of the focal filters, a post-processing step was introduced to add over the classification of the plains based on a 5% threshold. Minimum area and noise filtering were applied for the classification and the added plains.

I adopted a circle focal filter on the GMTED 2010 250 m spatial resolution DEM (Danielson and Gesch, 2011) with the 14.5 km original size of the Hammond (1954) and the 9.65 km size used by Hammond (1964a,b). I used a modification of the implementation in GIS proposed by Morgan and Lesh (2005) and Karagulle et al. (2017). I kept the thresholds of Karagulle et al. (2017), which are different than the ones of Hammond (1954, 1964a,b), but similar to the one of Dikau et al. (1991). The classes were modified, their modifications and argumentation being treated further in the discussion section. I did not perform the flat areas optimizations of Karagulle et al. (2017), which requested the modifications of thresholds and kernel windows.

A logical extension of the Hammond approach, also considering its comments (Hammond, 1954, 1962, 1964a,b, 1965) was performed by Iwahashi and Pike (2007) that used slope gradient (in degrees), local convexity (four-neighborhood 3x3 Laplacian filter of DEM grey scaled brightness values that identify the convex areas) and surface texture (a measure of topographic grain, computed as the number of pits and peaks within a radius of 10 cells; pits and peaks are identified by comparing the DEM to a median filter, as the negative and positive differences) to obtain a nested classification using thresholds of mean global values, or in lowland vs. upland (by considering the mean as the boundary between upland and lowland). Their classification is mainly qualitative in naming terrain classes, which mix texture (fine or coarse) with convexity (low or high) and slope (steep or gentle). A mountain will have a steep slope, fine texture, and high convexity, while a plain gentle slope, coarse texture, and low convexity. This classification is different from Hammond's due to the inclusion of texture. It does not consider flatness in the neighborhood, although the computation of the input variables is done in kernel windows (with a size of three pixels for slope, five for concavity, and ten for texture). Since the

classification is unsupervised, the authors did not expect equivalence from traditional landform types. Nonetheless, the density of the classes in a certain area and their arrangement could be used to recognize landform types. The nesting approach allows a certain control of the scale in the sense that on low resolution, it can be applied only to the first level of 8 classes, on the medium resolution the second level of 12 classes, and on higher resolutions, the third level of 16 classes.

3. Results

In Figure 3, the Hammond classification of Karagulle et al. (2017) based on GMTED 250 m data and adaptation to a GIS raster implementation is shown for Romania[14]. Our implementation of the Hammond landform classification on GMTED 250 m data is presented in Figure 4 for the 14.5 km focal filter size and in Figure 5 for the 9.6 km focal filter size.

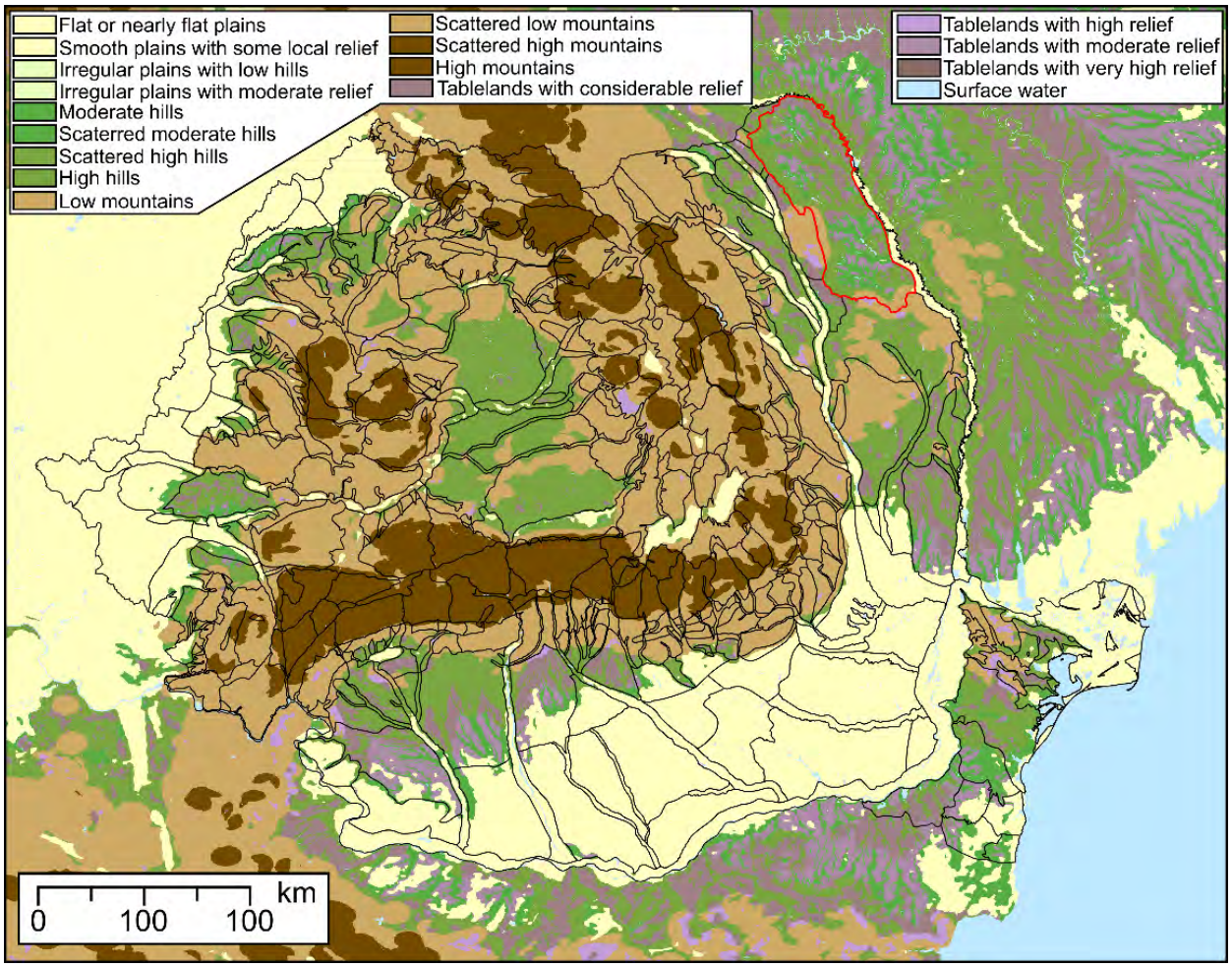

Figure 3 Karagulle et al. (2017) implementation of Hammond's classification for Romania

The Iwahashi and Pike (2007) first level with eight classes is presented in Figure 6. In Figures 3 to 6, over the landform classification was overlain a generalized geomorphological regionalization based on Posea (2006), but retraced in terms of boundaries based on the 1:200 000 geological maps[15] and the SRTM1[16] DEM shading. The idea of a hierarchy of Posea (2006) is welcome in order to be able to distinguish between regions and to be able to apply different criteria, but at present, the criteria are questionable from a

[14] https://www.arcgis.com/home/item.html?id=cd817a746aa7437cbd72a6d39cdb4559

[15] http://geo-spatial.org/vechi/download/harta-geologica-a-romaniei-scara-1-200-000

[16] https://doi.org/10.5066/F7PR7TFT

hierarchical point of view, requiring a rather geomorphometric methodology, in order to separate the different landforms: plateau, hill, hill, depression, and to merge them in hierarchical units. Otherwise, the hierarchy is subjective, and I have chosen the most used units because the material is also used for students[17].

5. Discussion

Discussing the definitions from the international literature, it can be seen that every author used their own experiences to define the plain: Humboldt (1849, 1856) the field knowledge from several continents that he has visited, by proposing high-altitude plains, Penck (1894) the European continent and Mescherikov (1968) the Russian Plain[18]. Even the authors that proposed thresholds of relief, applied those to their regional knowledge: Penck (1894) to Europe and Finch and Trewartha (1942) to the Fenmann physiographic regionalization. Hammond (1954, 1964a,b) used in his classification relief values under 300 m, but allowed even more relief when used plains with hills or mountains classes. Anyway, all definitions and thresholds are characterized by a certain degree of low slope, flatness, and low relief. Nonetheless, no threshold is based on statistical analysis but rather is inferred from the repartition of regions considered called plains and their appearance on maps. Dikau et al. (1991) are the first that modify the thresholds based on the resolution of the data source (although Hammond was aware of this need), and further modifications are used by the GIS implementation of Gallant et al. (2005), Morgan and Lesh (2005) and Karagulle et al. (2017).

Table 1 Hammond (1954) boundary values for the three terrain attributes; the codes are added for the GIS implementation proposed by Morgan and Lesh (2005)

Flatness			**Local relief (m)**			**Profile**		
code	class	% gentle*	code	class	relief	code	class	profile
1000	0	0-10	10	A	0-30	1	a	near all gentle lowland
900	1	10-20	20	B	30-90	2	b	50% gentle lowland and 50% upland
800	2	20-30	30	C	90-300	3	c	>60% gentle lowland
700	3	30-40	40	D	300-900	4	d	>60% gentle upland
600	4	40-50	50	E	>900			
500	5	50-60						
400	6	60-70						
300	7	70-80						
200	8	80-90						
100	9	90-100						

*% gentle slope in the focal filter, the gentle slope being considered the slope <8%

Table 2 Dikau et al. (1991) boundary values for the three terrain attributes; the codes are added for the GIS implementation proposed by Morgan and Lesh (2005)

Flatness			**Local relief (m)**			**Profile**		
code	class	% gentle*	code	class	relief	code	class	profile
100	A	>80	10	1	0-30	1	a	>75% gentle lowland
200	B	50-80	20	2	30-90	2	b	50-75% gentle lowland
300	C	20-50	30	3	90-150	3	c	50-75% gentle upland
400	D	<20	40	4	150-300	4	d	>75% gentle upland
			50	5	300-900			
			60	6	>900			

*% gentle slope in the focal filter, the gentle slope being considered the slope <8%

[17] http://www.geomorphologyonline.com/students_materials/GFR/RegionareFizicoGeografica_poligon.kmz

[18] Where the extensive presence of geological platforms coincide with their low altitude and low relief

Table 3 Karagulle et al. (2017) boundary values for the three terrain attributes; the codes are added for the GIS implementation proposed by Morgan and Lesh (2005)

Flatness			**Local relief (m)**			**Profile**		
code	class	% gentle*	code	class	relief	code	class	profile
400	0	0-20	10	A	0-30	0	a	<50% gentle slope lowland/upland
300	1	21-50	20	B	30-90	1	b	>75% gentle lowland
200	2	51-80	30	C	90-150	2	c	50-75% gentle lowland
100	3	81-100	40	D	150-300	3	d	50-75% gentle upland
			50	E	300-900	4	e	>75% gentle upland
			60	F	>900			

*% gentle slope in the focal filter, the gentle slope being considered the slope <8%

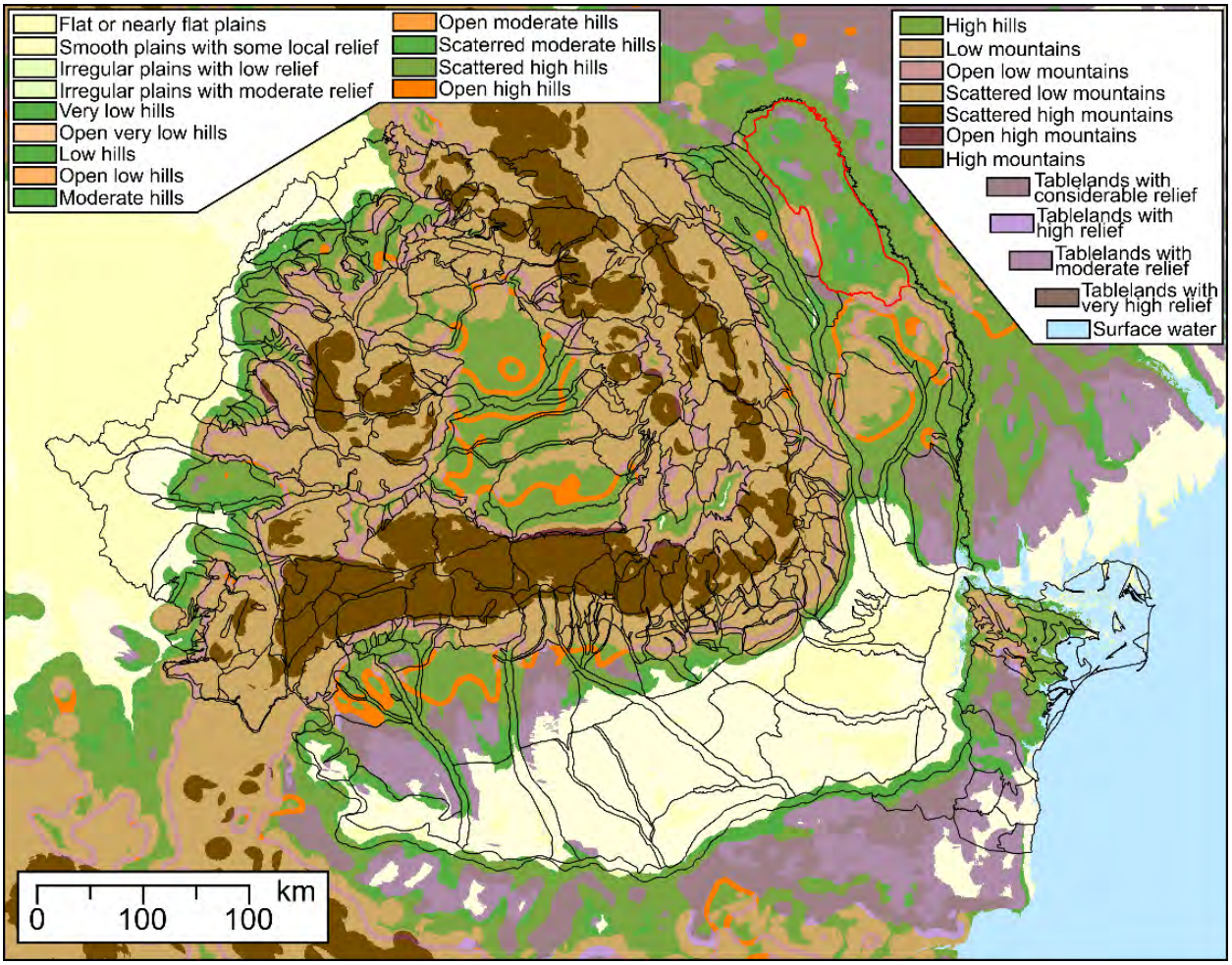

Figure 4 Hammond's (1954) classification for Romania

While Dikau et al. (1991) needed the landform type classification for landslide studies, all the other cited papers were using landform type for ecological classification.

The two world landform type classifications used, with their different implementations, show the difference between the Moldavian Plain's geomorphologic region and other typical plains from Romania (Fig. 3-6). While this conclusion is very clear, if we look at the maps, some emphasis should be made on several aspects.

First, for regional applications, the thresholds should be adapted (Dikau et al., 1991; Hrvatin and Perko, 2009). There is a great dependence of the slope and relief values on the DEM resolution and focal filter size. Both the variables relate to the limitation of the

rise as the run increase. So, as we use lower resolutions, the slope and gradient decrease, but this reality that was already shown by others (Zhang and Montgomery, 1994; Iwahashi and Pike, 2007) can be resolved by the bigger focal filter sizes, which increase the gradient that can be found in the neighborhood, until the characteristic levels are reached. In Figure 7, I present the variability of relief values for various kernel windows sizes in the case of the study area.

It is clear from this figure that using bigger neighborhood sizes, the majority of the relief is between 100 and 200 m while using smaller neighborhood sizes, the majority of the relief is under 100 m. From the distribution of relief computed using a 15.25 km diameter circular kernel, the study area's characteristic relief is between 100 and 200 m since relief over 200 m appears as minor frequencies at the border with the higher neighborhood areas.

In Figure 8, I show 15 km swath topographic profiles[19] through the study area on which it can be understood which is the main distribution of relief in the study area.

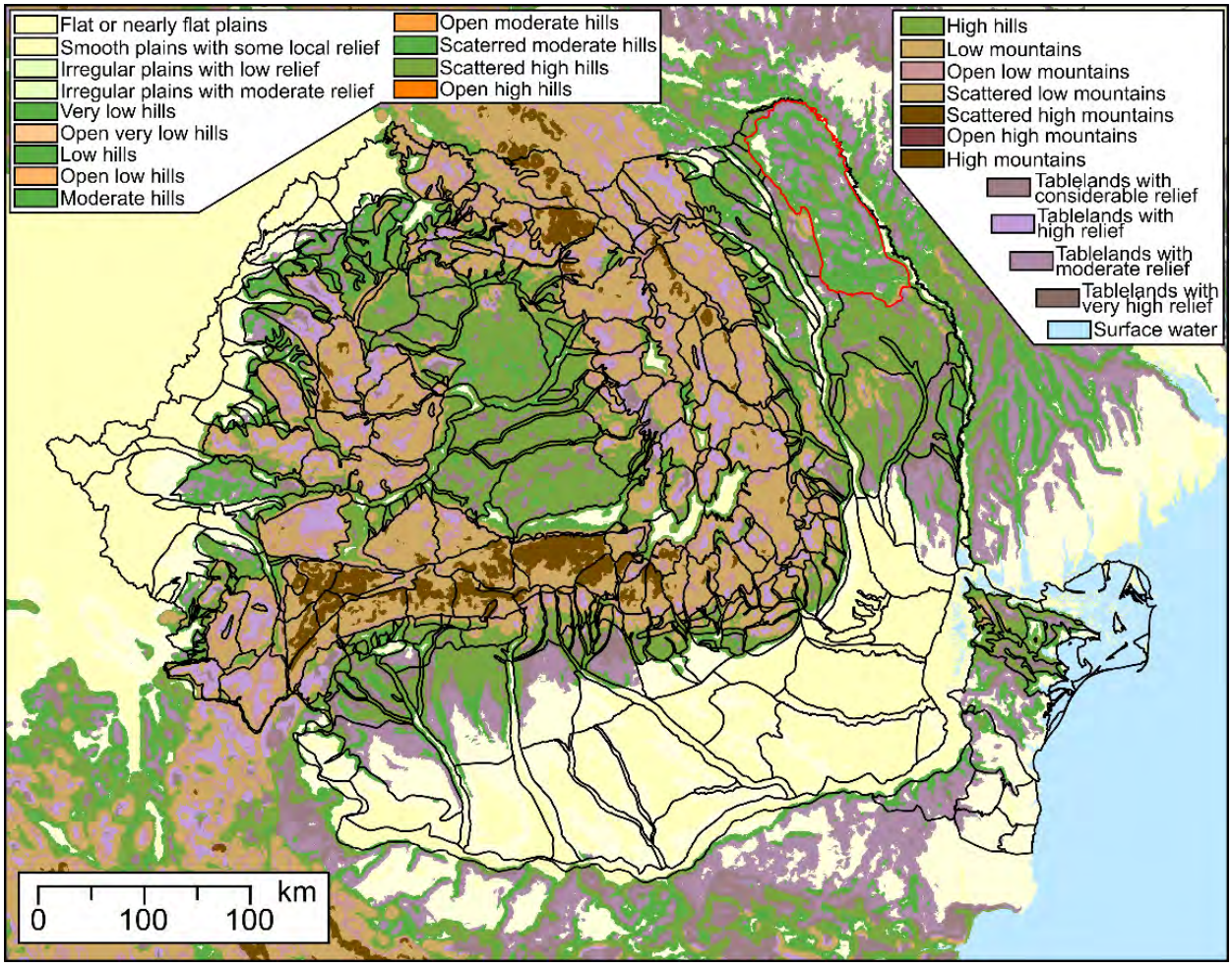

Figure 5 Hammond's (1964a,b) classification for Romania

The 15 km value of the swath width was chosen because this is the width of the interfluves between the main rivers (Prut, Jijia, Bahlui, Miletin, Sitna). I have also purposely shown the mean values to show how easily this measure can distort reality. Martiniuc (1955) and Băcăuanu (1968) used mean and maximum values to argue for the low values of relief. Still, the maximum value in the search area

[19] As mentioned by Grohman (2004) the swath profiles are used from the 1920's to derive minimum, mean and maximum elevations from the surrounding area along a profile path

considered is the definition of relief recognized in the international literature and not the mean value.

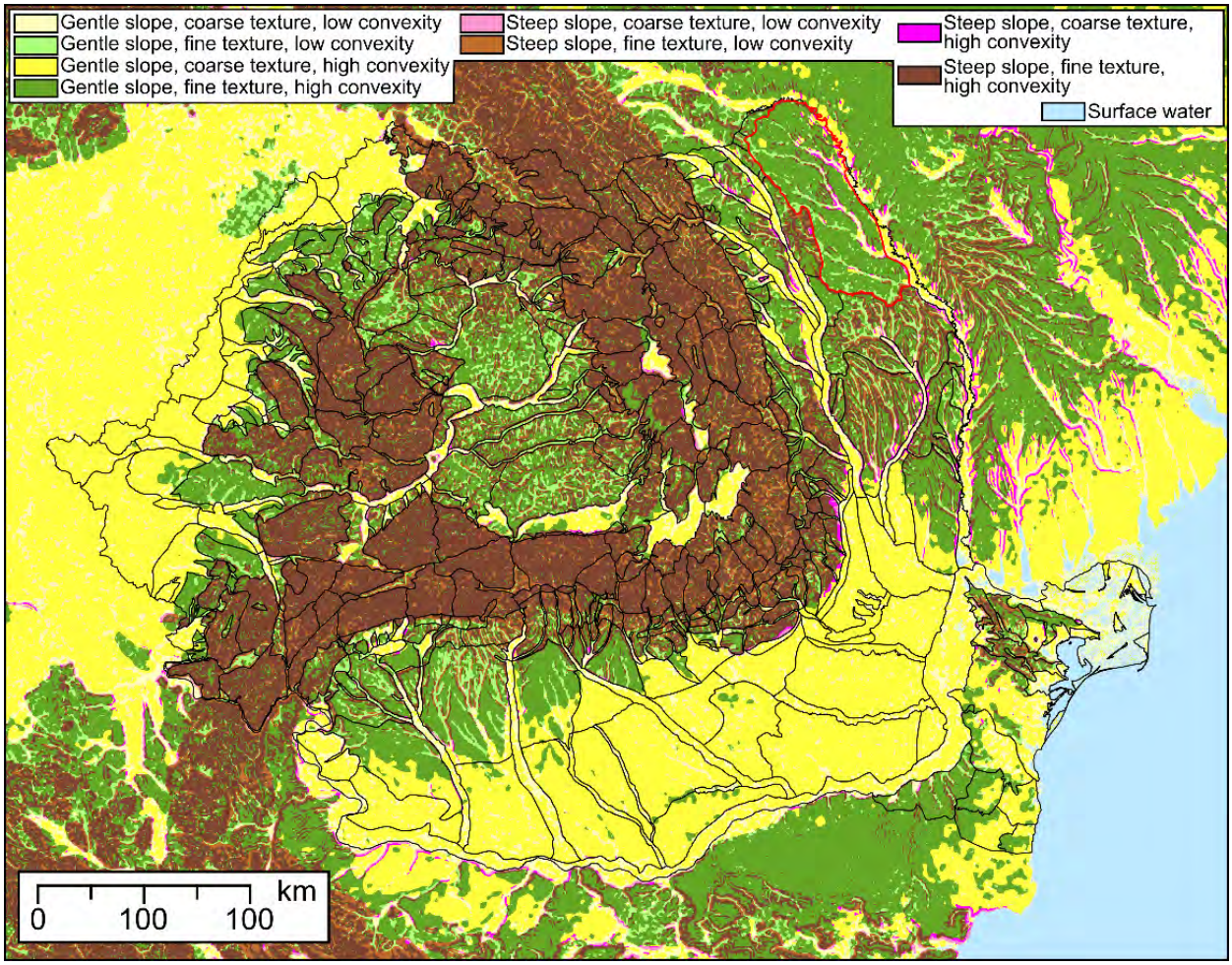

Figure 6 Iwahashi and Pike (2007) classification in eight classes for Romania

Increasing the focal filter size will create unrealistic and spurious features in the classification, especially at borders. Still, it will also find the characteristic gradient values of the area, given by the difference in the regional highest ridges and lowest channels, and not the local gradient as in the case of small focal filter sizes. Using a focal filter reduces the artifacts, but the sensitivity to width remains. Considering the 150 m local relief threshold of Finch and Trewartha (1942), the Moldavian Plain is a plain at 250 m resolution and 3x3 focal filter. Still, it is not at focal sizes higher than 5 km. A 3x3 focal filter will conclude similar to Tufescu's (1935) panoramic view of the Moldavian Plain. The Iwahashi and Pike (2007) classification is not affected by these issues.

Second, the thresholds and the classes proposed by Hammond might be problematic for some areas. Hammond did not use an objective assignation of the class to the squares used for computation but interpolated the spatial boundaries between classes manually on the map. In the case of objective assignation of the classes by applying the thresholds, as in the case of the raster implementation, some inadvertences appear. In the raster implementations (Fig. 3-5), we can see how all the Subcarpathian areas and some portions of the Someșan Plateau and Moldavian Plateau are classified as low mountains. This is due to the inability of the thresholds to separate high hills from low mountains, especially at bigger kernel size (the low mountains from the enumerated regions are reduced in the 9.8 km kernel size version compared to the 14.65 km one). Also, the plains with moderate relief class occupy considerable areas in the Getic Plateau, Dobrogea Plateau the

Western Hills, where there should be low hills. The plain with hills and mountains class of Hammond that was adapted by Karagulle et al. (2017) as open hills and mountains was a reality only when Hammond interpolated the classes manually. Still, it does not make sense when a raster implementation is used. If a hill or a mountain is rising in a flat area, the 250 m resolution and the ~10 km focal filter size can identify and classify the convexity according to its morphometry and the flat area as a plain. Only in the situation when there is a parity between flat areas and convexities, or these have small widths, the reality of the class of plain with hills or mountains might be discussed, but, in this case, the flat areas might not be plains but floodplains, and if their width is not big enough the focal filter will remove their influence in the computation of the class.

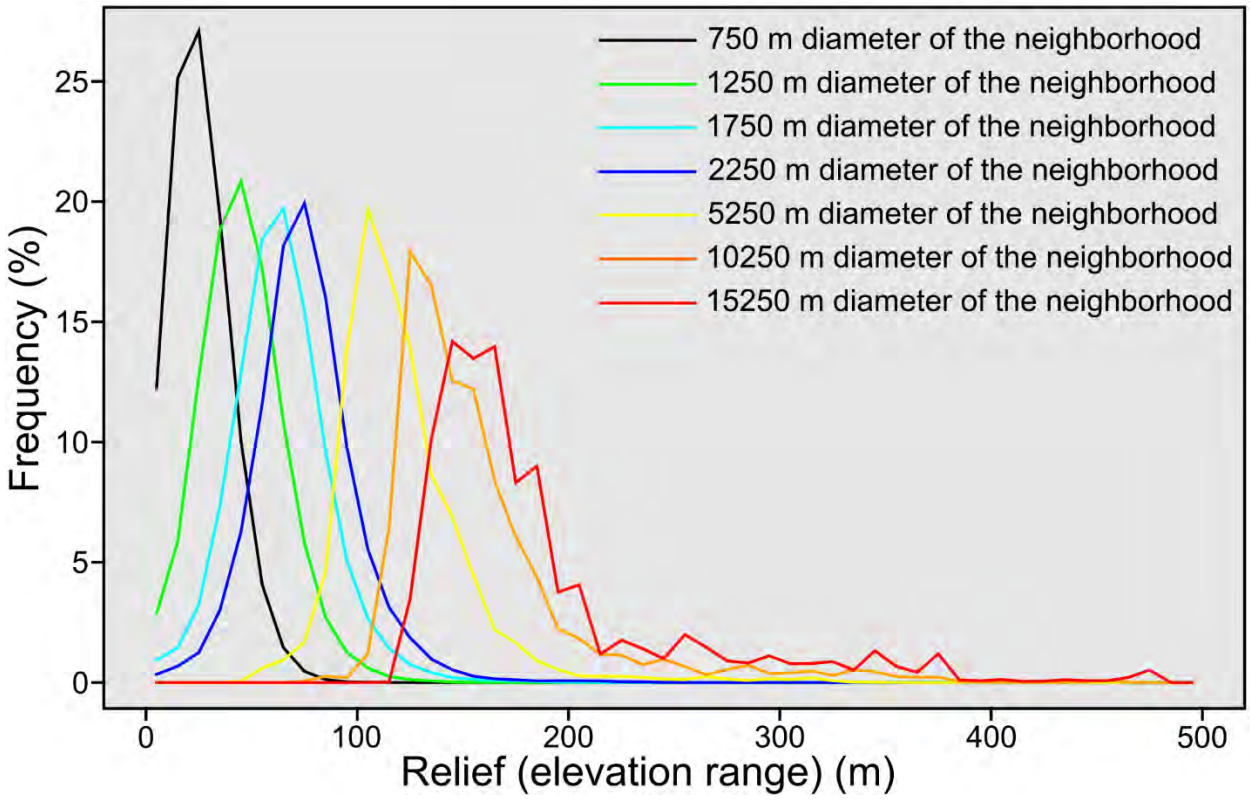

Figure 7 The relief distribution of the study area as a function of the kernel size used for computation

In Figures 3 to 6, it can be seen that the area (the boundary is emphasized with red color) considered as "plain" or "hilly plain" do not meet the geomorphometric conditions of plain, having high slopes over 3° and relief energies that frequently exceed 90 m, and the profile is an upland one. The conclusion of the above is that this geomorphological region should be considered according to its morphometry and geomorphological criteria, the plain attribute being completely wrong. Besides the geomorphometry also the geomorphological processes are not typical for a plain. The cuesta landforms (Ioniţă, 2000; Niculiţă, 2011), the intense soil erosion, the gullies and the landslides associated with steep cuesta scarps and other incised hillslopes, the presence of the epigenetic Prut incised floodplain meanders between Rădăuţi-Prut and Stânca-Costeşti (~60 m of incision) are all geomorphologic aspects not characteristic for a plain. From a geological and palaeogeographical point of view, the area is the morphological result of intense (several hundred meters) erosion of the mudstone facies of the Lower to Middle Miocene sedimentary cover of the Moldavian Platform, being considered by Băcăuanu

1967) a sculptural[20] plain, so equivalent to the denudation plains of Fenman (1919) and Finch and Trewartha (1942). The sedimentary cover consists of foredeep deposits folded near the orogen and gently sloped toward the exterior. In the central and northern part of the foredeep basin, the exhumation progressed gradually to the south (from 12 Ma in the north, 10 Ma at Iași latitude, and 7 Ma to the south - de Leeuw et al., 2020) as the basin fill was gently tilted to South-West due to the Northwetsern-Southeastern migrating slab detachment (de Leeuw et al., 2020) that also controls today's subsidence in Focșani Basin (Tărăpoancă et al., 2003). In the last 5.8 Ma since its filling (since Pontian), the area was incised by the river network that was constantly developing toward the south due to the prograding of the Black Sea coast ~ 100 km (de Leeuw et al., 2020). The timing of the post-Pontian river incision is not established, only the 20-25 m terrace of Bahluieț river at Mădârjești being dated to 20.2 ky BP (Niculiță, 2020). At the border of the study area with the hilly area to the west, there is dated a terrace also on Bahluieț river, related to a fossil landslide that is the oldest date in the Moldavian Plateau: 44-46 ky BP (Niculiță, 2020). Other Pleistocene dates are related to the loess deposits from Mitoc Malu Galben that at 13.5 m thick are dated to ~33 ky BP (Haesaerts et al., 2003).

Regarding the motives for which the geomorphologists accepted and used the term plain for the study area, I argue the influence of political factors based on two reasons.

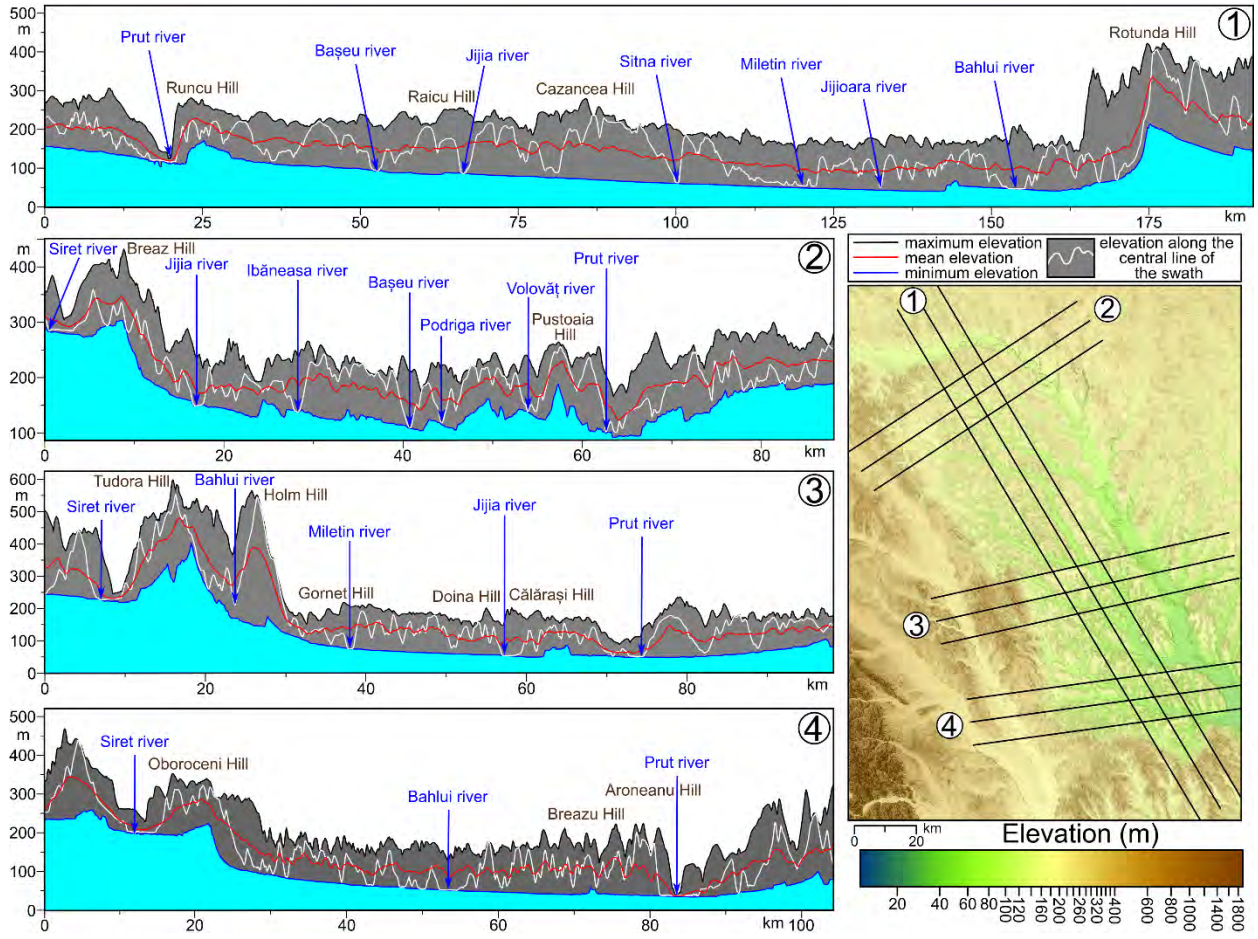

Figure 8 The swath topographic profiles through the study area

[20] This term is borrowed from the Soviet geomorphological literature as I have shown bellow

First, while historically, the first that used the notion of plain is Porucic (1928), the researcher that studied the region and used both terms of depression and plain was Tufescu. He mentions in the 1935 paper on the Jijia Depression boundaries that while previous studies considered the Moldavian Plateau as a region with slight variations in topography (idea argued by Simionescu), actually the area from the Middle Prut River Catchment is lower at the level of the ridges with 150-300 m to the neighboring units. This aspect argues for the consideration of the area as depression or plain. He does not bring further arguments for any of the two categories. Still, the paper keeps the idea of depression as a scientific one and the idea of a plain as a popular one because the locals use the term in connection with agricultural use. But vegetation and land use cannot be used for geomorphologic landform regionalization, even since Penck (1894) being shown that vegetation is not a valid proxy. In 1941, Tufescu comes with the argument that the area should be named as a plain in the geographical regionalization, I think as a way to introduce in the Romanian regionalization popular terms[21]: "It could be said that, compared to the poverty in regional names of our toponymy, the creation of new terms was necessary. And indeed, if for small units the Romanian toponymy is quite rich (and I emphasize that it is infinitely richer than those who drew up our topographic maps, who did not make a purpose out of it), for the name of the larger natural regions, it seems to be quite poor. And I remember in connection with this, the words of a French geographer, who, accustomed to the rich regional nomenclature of France, finds with surprise that there are almost no names of natural regions in Romania. Asking the villagers where they are from, from which region, they only answer by naming their village or county. << Ainsi la Roumanie est pauvre en noms de lieux, en noms de pays>> (Ficheux, 1929)." (Tufescu, 1941). Further, in the papers, he published after 1945, Tufescu, while using the term depression for Jijia and Bașeu catchments, also use plain as Jijia Plain[22] and Moldova Plain[23] (Tufescu, 1966). Suppose we consider the advances of the Romanian language after the Second World War is really not understandable from a geomorphological point of view why to continue using a popular term, the single explanation being the fact that the communist regime pushed for the use of plain in order to argue the need for collectivization of this agricultural area. This is only a hypothesis for which I have no proof at the moment. Another hypothesis is that the geographers tried to please the regime or to increase the study area's agricultural mecanization[24]. The history, timeline and interpretation of the collectivization can be read in Kligman and Verdery (2011) and Borșa (2013). Tufescu does not bring geomorphologically and geomorphometrically valid arguments for the plain category for the study area, so the conclusion of Sîrcu (1956) of nonsense for the usage of this term I believe is valid.

Second, the note of Băcăuanu in the Romanian Geography volume dedicated to the hilly and plateaus areas (Băcăuanu, 1983) can be seen as an attempt to explain this "anomaly" since in three works regarding the geomorphology of the Moldavian Plain (Băcăuanu, 1958, 1968) and the geography of the Moldavian Plateau (Băcăuanu et al. 1980), despite the relief over 150 m is acknowledged, still, the area is considered a plain. In the case of Băcăuanu's work, considering his geomorphological expertise, I cannot explain the usage of the plain term unless (i) he wanted to please Tufescu, which was an official referent of his thesis, and (ii) the communist party politic was followed, to consider a hilly

[21] After 1945 Tufescu actually dealt more with human geography than with physical geography, and even before that the geography was seen as a whole so it is not necessarily non-understandable the need to comply with both natural and human criterias; anyway since then this emphasis has changed so there is no need to follow that

[22] p. 154

[23] p. 237

[24] Here I could mention the personal communication of Grigore Posea during the 30th National Symposium of Geomorphology fieldtrip (Orşova, 29 to 31 May 2014) as the reason for considering plains the Moldavian and Transylvanian low areas, that the number of tractors per surface was assigned based on the landform type; so, for a predominant arable area like the study area the consideration as a hilly area would have been decreased the assigned number of tractors per hectare

agricultural area as a plain to argue for collectivization or (iii) to manipulate the official assignation of tractors based on the landform type (see note 24 on Posea's personal communication). The geomorphologic and geomorphometric arguments that Băcăuanu uses in 1968 can be also refuted since (i) he used for computation of relief 1:100 000 topographic maps and a five by five km square area to compute "maximum" relief as the maximum minus minimum elevation, and further considered as mean relief half of the maximum values, and (ii) used the Markov (1948) views of what is a plain, ignoring the rest of the international literature. The genesis of an area (denudational) and its lithology cannot be used as a criterion since plains are various in genesis, structure, and lithology (Markov, 1948). Here I would add that also the Soviet supervision could have been played a role in the decision of using and arguing for the term plain, considering the note of Coteț and Martiniuc (1960) that L. G. Kamanin informed them verbally in the field about the typology of coline plains that can/should(?) be attributed to area from the Moldavian Plateau.

6. Conclusions

The main conclusion is that in the case of the geomorphologic region in the discussion, called Moldavian Plain (Băcăuanu, 1968, 1983), the attribution to plain should be removed, at least from the geomorphologic regionalization. I propose the use of the geomorphologic terminology from before 1945: Jijia Depression or Jijia Hills. Restitution refers to the acknowledgment that political/subjective decisions influenced the decision regarding the typology and refuted all geomorphologic arguments.

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