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RIVER VALLEYS AND GEODETIC MEASUREMENTS

Two natural sciences, geomorphology and quaternary geology, are engagend in the description of the superfical formations and in the origin of present forms of relief. They both are convinced this formation is caused by the so called erosion agents — water, air, changes of temperature, etc. The current water activity is supposed very important in this process; not only erosive disintegration of solid rocks, but also transporting of weathered and dispersed material as well as its deposition are due to it.

The process of erosion-transportation-sedimentation has thus become the basis of all explications of the earth relief genesis, and up to now nobody has doubted its course. It is evident, as we can observe quite well the work of the current water. It seems thus hat the geologic-geographical science has finally found out both the characters and the proper concept of one of the basic natural processes. The explications of all geological and geomorphological textbooks convince us about it.

The erosive work of running water, as we know from texbooks, is illusory, however. One can doubt neither the transportational activity of water currents, nor the sedimentation of transported material, but the beginning of the process, i. e. erosive activity of water streams can be rightly supposed he weak point of the whole cycle.

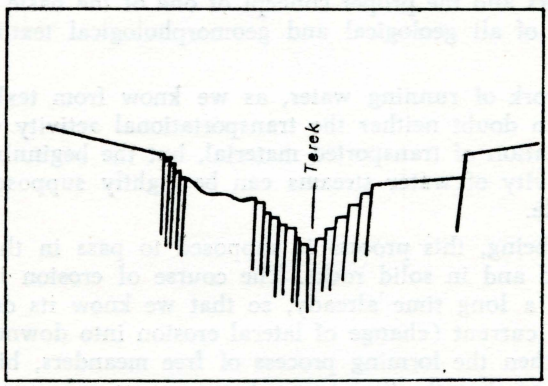
For the time being, this process is supposed to pass in the same way both in unconsolidated and in solid rocks. The course of erosion in loose rocks has been studied for a long time already, so that we know its dependence on the velocity of water current (change of lateral erosion into downcutting and its reversion again), then the forming process of free meanders, bifurcation of river channels and so on. For the time being, however, we only suppose the existence of erosion in solid rocks (especially in igneous rocks and crystalline schists). We cannot rely on direct observation, as it is with erosion in unconsolidated sediments and therefore, we do not know at all the relation between the velocity of water current, the resistance of rocks and the time of erosive action supposed.

The presence of water current on the valley bottom has led us always to the idea the river valleys have originated in the same way as erosion furrows formed by rain water in unconsolidated sediments. Therefore, on the ground of this analogue in the relation between the valley and the water current, we always suppose causality, as well: these are water currents that form present valleys by their erosive activity. According to common opinion, current water is the active factor, whereas valleys are only its passive result. Causal relation is acceptable also in reverse, and it can be supposed therefore that water runs quite naturally to the lowest parts of the earth's surface (present valleys), that may have originated in a tectonic or in any other way.

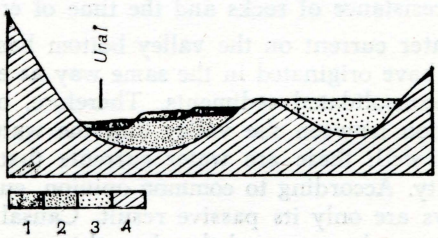
Both explanations mentioned -- the erosive and the tectonic one — have not yet been well documented. Nevertheless, the erosive explanation is supposed to be correct, whereas the tectonic one was refused a century ago. Its author (O. Peschel, 1869) could not defend it and since that time the concept of river valleys origin has not yet been investigated.

However, this has been taking a turn in the last 10—15 years. Arguments for validity of the tectonic opinions has been more and more frequent, while erosion explanations have not yet been sufficiently documented. The presence of block-type movements in the river valleys is confirmed by changes of ftream gradient, by variations in river meandering and especially by differences in thickness and composition of river sediments (Lunev, 1967, etc.). It was found out in this way that e. g. in large ereas of Siberia, the river valleys are only of tectonic origin (Piotrovski, 1968, Voskresenski, 1968, etc.). Also many African rivers (especially in Sudan) do not form valleys and their beds lie on the level with the surrounding area. In this case all erosive assumpions fail. The explanation is not difficult, however. On the old shield which is very stable, no larger tectonic movements have occured, and no grabens developped lately. Surface water cannot drift thus into linear trenches and flows only through small depressions in the almost flat or slightly undulated relief.

The origin of tectonic grabens is caused evidently by earth crust spreading. Variously sunken blocks form the valley bottom and its slopes which are often stepped, e. g. in the Terek River valley in the Caucasus Mts. (Fig. 1). Each



1. The tectonic valley of the Terek River in the Caucasus Mts. (after Rastvorova, Scherbakova, 1968)



2. The lateral migration of the Ural River channel near the Suunduk River mouth (after Voskresenski, 1968)

of these blocks moves separately, but most intensive are the movements of blocks within the valley bottom. Owing to the unevenness of these partial movements, water stream beds should be therefore shifted to places of the strongest subsidence of blocks. This theoretical assumption is confirmed by well-known migrations of river channels on the bottom of broad walleys (Fig. 2).

Geology and geomorphology can only describe the consequences of a tectonic movement which passed in the past. But the present movement, its course and character cannot be observed. Hewever, its existence and some features can be found out and observed by exact geodetic measurement. Repeated levelling is therefore its only direct, as well as exact verification.

Results of these measurements have not been so frequent up to now, however, so that they cannot be always available while solving problems concerning the genesis of valleys. Geodetic networks were founded for quite different purpose; levelling principally observes its own problems till now, i. e. precision of measurement. Only a simple map with a drawing of the river system enclosed with the drafts of repeated measurements shows surprisingly that the majority of anomalous values is just connected with river valleys.

Thus we can complete the Waalewijn's (1960) drafts of repeated levellings from South Netherlands with a schematic map of the river system (Loyda, 1971). In the first case the Tilburg — Valkenswaard levelling line crosses four small rivers: the Leij, the Reusel, the Beerze and the Dommel river. Measurements carried out in 1932 and 1951 show especially intensive subsidence of bench marks just in the area of these rivers.

Measurements of the second levelling line along the right bank of the Maas River were repeated in 1923, 1937—39, 1954 and 1960. The subsidence of bench marks is more intensive where the Swalm and the Roer River empty themselves into the Maas. From this we can draw the fault lines connect or cross here and this crossing is accompanied by more intensive subsidence of blocks forming the bottom of these graben-like valleys.

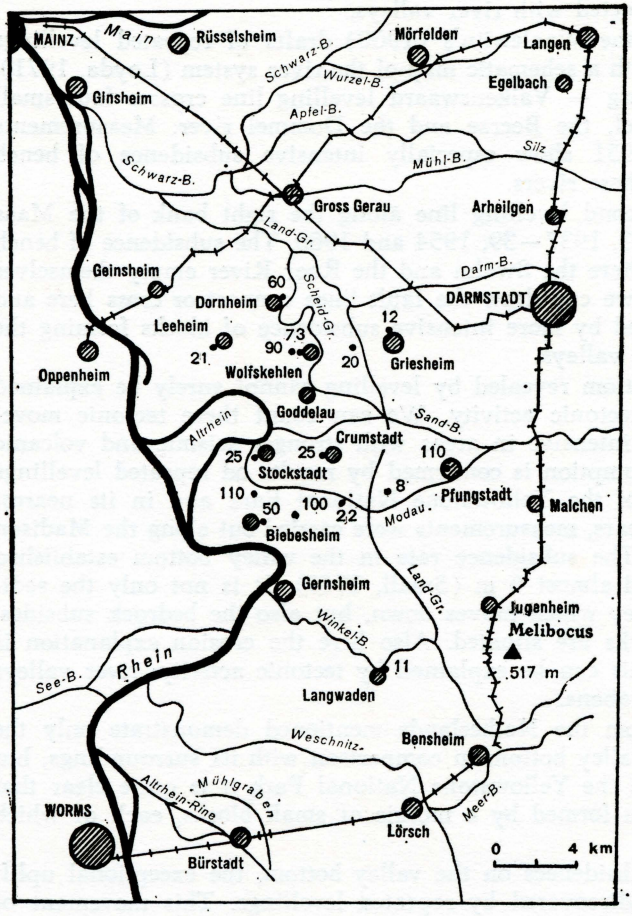
Subsidence of walley bottom revealed by levelling cannot surely be explained by erosion, but only by tectonic activity. We can count these tectonic movements will be much more intensive in areas with stronger seismic and volcanic activity. This theoretic assumption is confirmed by results od repeated levellings in the northwestern part of the Yellowstone National Park and in its nearest surroundings. Within 25 years, measurements were carried out along the Madison River (1934 and 1959). The subsidence rate in the valley bottom established here in this period reached almost 6 m (Small, 1965). It is not only the sedimentary filling of the valley which moves down, but also the bedrock subsides, on which some bench marks are situated. Also here the erosion explanation is out of question, so that this can be explained by tectonic activity: river valleys seem to be only narrow grabens.

It is true, levellings from the Netherlands mentioned demonstrate only the general movement of the valley bottom in comparison with its surroundings, but from repeated levellings in the Yellowstone National Park it is quite clear that the valley bottom has been formed by a mosaic of small blocks, each of which mowes separately.

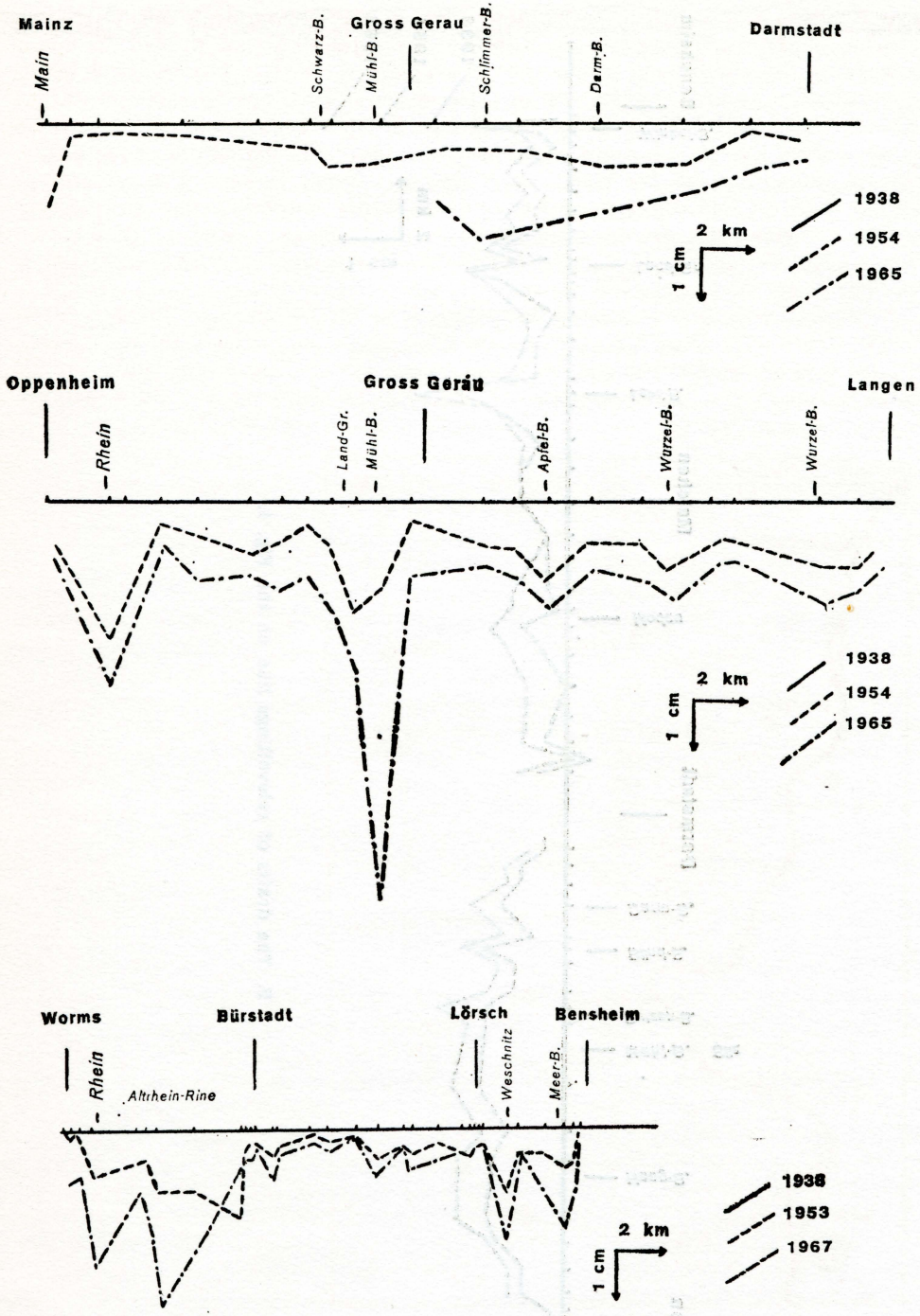
Besides these uneven subsidences on the valley bottom, the exceptional uplift of some blocks has been discovered by repeated levellings. This movement of isolated blocks was stated e. g. by repeated measurements carried out on the Garm experimental polygon established on the margin of two mountain ridges — the Pamir and the Tyan-Shan Mts. The levelling line crosses here the Surk-

hob River valley, on whose bottom the uplift of the alluvial sediment base up to 55 m was found out even earlier. Repeated measurements have proved the continuation of this uplift even in our time (Pevnev et al., 1968). The principle of the river valleys tectonic origin is also verified by relevellings carried out in the Rhinegraben between the towns of Mainz, Worms and Darmstadt (Kutscher et al., 1968). On the one hand, levelling lines cross here the bottom of the graben several times, and on the other hand, they cross several brooks on its eastern slopes (Fig. 3). Results of repeated levellings in the Netherlands are fully accepted in the later case, as well. All bench marks in close vicinity of these small water currents have been moving down more intensively on the valley bottom as well as on its slopes (Fig. 4, 5).

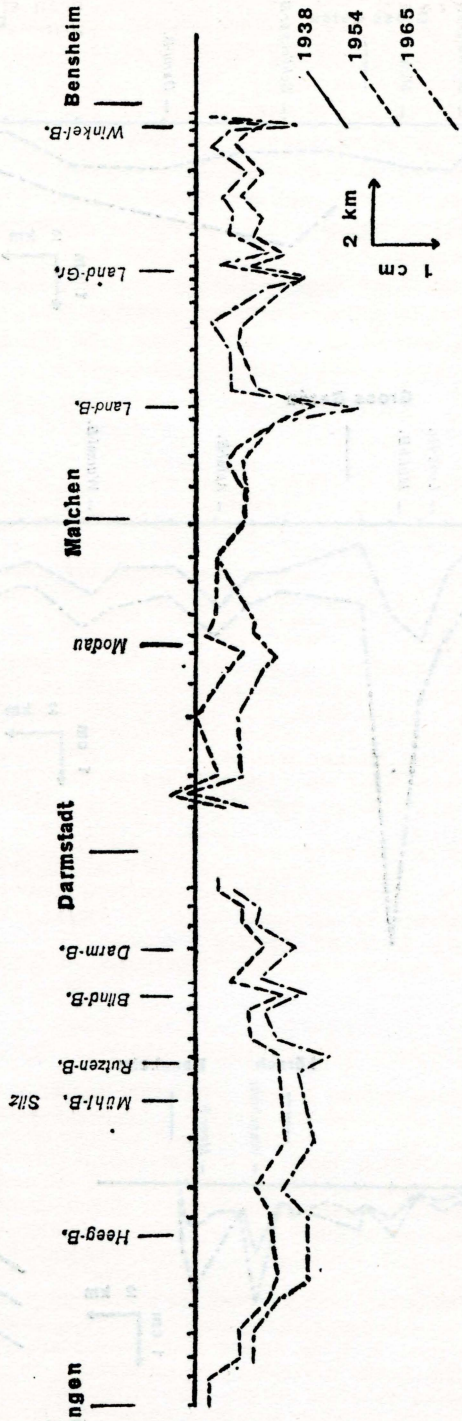
Geodetical measurements have found out thus the existence of tectonic movements where only erosive processes have been supposed till now. By geomorphological considerations and methods this valley bottom movement could not be hitherto found out. Therefore, when recognizing the character of natural actions,



3. The course of levelling lines on the Rhinegraben bottom



4. The drafts of relevellings after the lines on Fig. 3. Larger subsidence occur evidently where the levelling lines cross the water streams.



5. The drafts of relevellings like on the Fig. 4.

of their causes and connections, no modification and defence of old unapproved ideas are of use — even if these ideas become almost dogmas (by permanent repeating) in which we see neither their original form of idea and consideration, not their still existing problematics, as well.

When studying grabens and causes of their origin we get into the wide field of blocks tectonics, sea-flor spreading, continental drift etc. and thus into the sphere of not only geological, but also geophysical, geodetical, and astronomical investigations. It is necessary to point out we cannot expect subsidence of the bottom of all river valleys. Assuption of contemporaneous spreading of tll tectonic zones on which graben valleys have arisen does not seem real. Tectonic rest or activity in these mobile belts are usually changeable and depend on factors, by which these blocks are put in motion. Further investigations of tectonic movements in river valleys can thus be of great significance for recognizing present motion of larger earth crust blocks and of their global causes.

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ŘÍČNÍ ÚDOLÍ A GEODETICKÁ MĚŘENÍ

Dosavadní peřdstavy o erosním vzniku říčních údolí jsou založeny na nedokázaném předpokladu, že vodní toky se zařezávají do pevných i nezpevněných hornin stejným způsobem. V poslední době se však stále častěji objevují geologické i geomorfologické důkazy o tektonickém původu říčních údolí, potvrzující vlastně 100 let starý předpoklad O. Peschela. Tektonické pohyby se v říčním údolí projevují změnami spádu vodních toků a změnami v meandrování řek, rozdílech mocnosti a složení sedimentů ap., avšak jejich důkazem jsou i stupňovité svahy údolí (obr. 1), migrace říčních koryt (obr. 2) aj.

Nejnovějším potvrzením existence tektonických pohybů v areálu říčních údolí jsou výsledky opakovaných nivelačních měření. Publikované grafy je ovšem třeba doplnit mapkou říční sítě a zároveň lokalizací vodních toků do profilu nivelační linie. Ukazuje se potom velmi jasně, že většina anomálních hodnot, objevených opakovanou nivelací, se váže právě na říční údolí (obr. 3, 4, 5). Dna a stupňovité svahy říčních údolí jsou tedy zřejmě tvořena klesajícími krami a vznikla vlastně stejným způsobem jako mnohem větší grabenovité propadliny ve vých. Africe, jako rýnský prolom mezi Vogesami a Schwarzwaldem aj. Studium tektonických pohybů v oblasti říčních údolí proto může objevit pohybové tendence celých kontinentů nebo jejich částí.