

# ADAPTATION OF THE KARST LAND FOR THE AGRARIAN USE IN THE MEDITERRANEAN. PROBLEMS OF RESEARCH AND OF CONSERVATION (A SURVEY)

by Ivan GAMS \*

## Resum

En aquest article es revisen els següents mètodes de recerca:

1. Anàlisi de la part superior dels afloraments rocosos. En esser tallats a nivell del sòl, la terra s'emprava com a prat. Quan els tallaven més amunt, la terra s'emprava com a terreny de pastura o com a prat. En el darrer cas, emperò, si la superfície rocosa és llisa, el nivell del sòl ha estat rebaixat per l'erosió; aquest tipus de superfície només es pot formar en contacte amb el sòl. La superfície d'una calcària compacta, exposada a la corrosió causada per les precipitacions i per la meteorització mecànica per damunt del sòl, és cantelluda, clivellada i aspre.

2. Anàlisi de les pedres acumulades per l'home a parets, marges, a la vora inferior de les terrasses a camps rostos, o enterrades sota el sòl en aquestes terrasses o sota els prats. La mesura de llur volum i pes, efectuada en algunes illes iugoslaves, ha mostrat que centenars de quilograms de pedres, en casos excepcionals més d'un tona, han estat excavats i trencats per cada metre quadrat de terra «netejada».

3. Les formes com cocons (*Kamenitza*), xaragalls de dissolució (*Rundkarren*), tubs de dissolució, solcs de dissolució (*Korrosionskehle*), i especialment els forats de parets llises (*Kavernosen Karren*), si són trobats a la superfície indiquen una erosió soterrada.

4. Els fragments de pedra amb caires vius deixats en el sòl després de «netejar» la superfície rocosa en alguns camps representa més del 10 % del pes del sòl. Això indica l'extensió de la «netejada», fins i tot quan les pedres majors s'han retirat de la superfície.

Els ocasionals anàlisis professionals realitzats a algunes zones càrstiques de la Mediterrània, han mostrat que les zones habilitades per ús agrícola en èpoques antigues eren més grans del que sabiem per la bibliografia. L'època de la netejada no és segura i abarca des de l'època fenícia (Malta) als temps més recents.

A molts de països les modernes tècniques agrícoles destrueixen les antigues formes de preparació de la terra per al conreu amb aixada i càvec. L'article insisteix en la necessitat de l'estudi dels valors ecològics i històrics d'aquests antics testimonis de l'esforç dels nostres avantpassats pel proveïment de menjar per llurs vides, i de la conservació d'aquesta herència natural i cultural.

## Abstract

The following methods of research are reviewed:

1. Analyses of the outcropping tops of stones. When cut off at the level of the soil, the land was used as meadows. When the tops are cut off in higher position, the land was used as a pasture ground or as a meadow. In the latter case, however, the soil level has been lowered by erosion if the stone surface is smooth. This can develop only in contact with the soil. The surface of solid limestone, exposed to corrosion caused by the precipitations and by the mechanical weathering above the soil, is sharply fissured and rough.

2. Analyses of the stones accumulated by man into walls, side walls at the lower edge of the slope field terraces, or buried under the soil in such terraces or under the meadow. Measurements of their volume and weight, made on some Yugoslav islands, have shown that several hundred of kilograms, in exceptional case even more than one ton of stones have been dug out and cut off for one m<sup>2</sup> of the «cleared» land.

3. Subsoil forms, such as *kamenitza*, solution runnel (*Rundkarren*), solution pipe, solution notch (*Korrosionskehle*), and especially the rocky holes with smooth walls (*Kavernosen Karren*) are, when on surface, an indicator of the soil erosion too.

---

\* Prof., Department of Geography, University of Ljubljana, Aškerčeva 12, Yugoslavia.

4. The stone fragments with sharp edges left in the soil after the «clearing» of the stony surface represent in some field more than 10 % of the soil weight. They indicate the extent of the «clearing» even when the bigger stones are removed from the surface.

The occasional professional analyses, made so far in some Mediterranean karst areas, have shown much larger adapted areas for agrarian use in ancient times than this is known in the literature. The time of clearing is uncertain and reaches from the Phoenician (Malta) to the recent time.

In many countries the modern agricultural techniques, destroy the old forms of land adaptation for the cultivation by hoe and spade. The article stresses the need for the study of the ecological and historical value of these old evidences of the ancient endeavour of our ancestors to provide food for their life and for the conservation of this natural and cultural heritage.

Forms of adaptation and research problems described here are not limited to the Mediterranean karst countries only. The results reported here are limited to this area because the author is more acquainted with it.

First a brief review of the research methods.

1. Cutting off the tops of the stones sticking out from the land surface.

Surface of the stone cut off is more rough than the natural one and this difference is noticeable even after many hundred years. In the northwestern part of the Dinaric Karst in Yugoslavia and on the Adriatic islands, where a larger part of the results reported here is derived from, the stones cut off appear mostly on the pastures. This kind of cutting presumably occurred in the transition time from goat and sheep grazing to cattle grazing. The stones cut off appear also in the forests that have occupied the abandoned pastures.

The stone tops cut off are usually higher than the soil surface around them. But originally they have been mostly cut off on the level of the ground nearby. The present difference in the height can be considered as an effect of later soil erosion. But this method is useful first of all when the stones cut off appear in a larger area.

2. Smooth stone surface formed in contact with soil and rough one formed in the open air.

The surface of limestone, formed by corrosion of the precipitated water and (or) by the mechanical weathering, is sharp and rough. On both sides of the top ridge of some stones *Reggenkarren* occur. Contrary to that the surface of the compact limestone below the soil cover is smooth. It is smooth even in case the pebbles are thin and narrow. This difference has become more obvious, especially when the soil around the same stone sticking out from the surface has been recently removed in the lower level. The fresh surface that has recently been unearthed is lighter because the old one is darker due to the lichen and microorganisms. The calcite inlayers are more resistant to the corrosion and less to mechanical weathering. Therefore under the soil the salients, sticking out from the stone surface, are formed, and in the open air the fissures appear in them.

There are some exceptions in the mentioned rule. The surface of the homogeneous limestone becomes smooth also under the snow cover if it lasts until summer (in the alpine belt). In the dense deciduous forest the dead leaves and from them derived humus cover the larger massive stones

Photo 1.

The big Karren prove with their smooth stone surface their subsoil formation. The top *Regenkarren* (solution flutes) generated later after the soil was washed away due to the agrarian land use (Trieste Karst near to the village Brišćiki).

Photo by I. Gams.





sticking out from the ground and form the smooth stone top surface high above the ground.

3. Smoothness of the surface of the stone has been diminishing in hundreds of years, but the proper origin of the initial surface still can be recognized after a long time. It is often accompanied by special stony forms as solution pans from which on the surface *kamenitzas* can be developed, as well as covered solution runnels (*Rundkarren*), solution pipes, solution notches (*Korrosionskehlen*), covered *bogaz*, filled funnel-like doline, filled pothole (Gams 1971, 1976, Jennings 1985). The most important of them is the hole (*Kavernosen Karren*) with smooth walls which can penetrate the whole stone mass.

When estimating the soil erosion rate by means of the two mentioned methods one has to take into account that the sunshine after the deforestation reaches the ground and accelerates the photochemical weathering of the top humus soil horizon. This and leaching (eluviation) downward after the decay of the roots cause the lowering of the soil level, too.

4. Analyses of the anthropogenic stone accumulations on the karst surface.

The stone accumulations typical of the proper Mediterranean karst are a by-product of the clearing of the land for different, mostly for agrarian land use. The karst is characterized by the thin interrupted soil cover with stones sticking out from the surface and by deep soil pockets in the fissures. In the natural circumstances such a karst surface is suitable only for pastures of sheeps and goats. Cutting off the stones on the surface makes possible to cut down grass with scythe. For tillage it was necessary the stones to be removed 15-25 cm below the arable land surface.

Forms of the accumulated stones are different and typical of regions. Stones can form irregular heaps or elongated rows. Systematically so called dry walls or karst walls are built. If the pebbles are compounded of one serie, the width of wall is the same as the length of pebble. Larger are the walls with two series of pebbles. Some of them have the inner part between two series filled up by minor particles. The accumulations are seldom in form of quadrangular tower or pyramidal elevations. In the past centuries the stone accumulation has been in some places removed or concentrated in big formations to get more cultivated land. The stones cut off have also been used for buildings, roads, lime-kiln, they have also been thrown in the potholes, chasms etc. A part of them had been buried under the soil what was proved by bore-holes and excavations (Gams 1973, 1974, 1977). The buried pebbles have been found: a) In the lower belt of the so called cultural terraces. When constructing them on the inclined surface the rubble has been

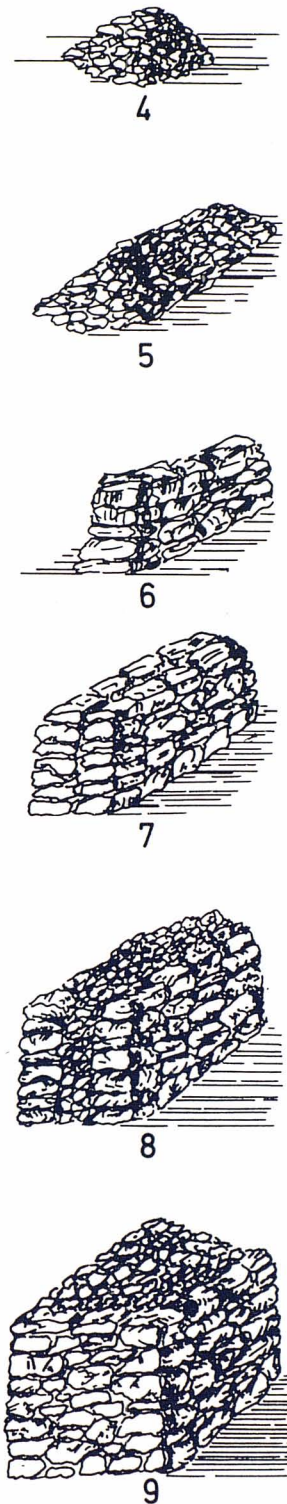
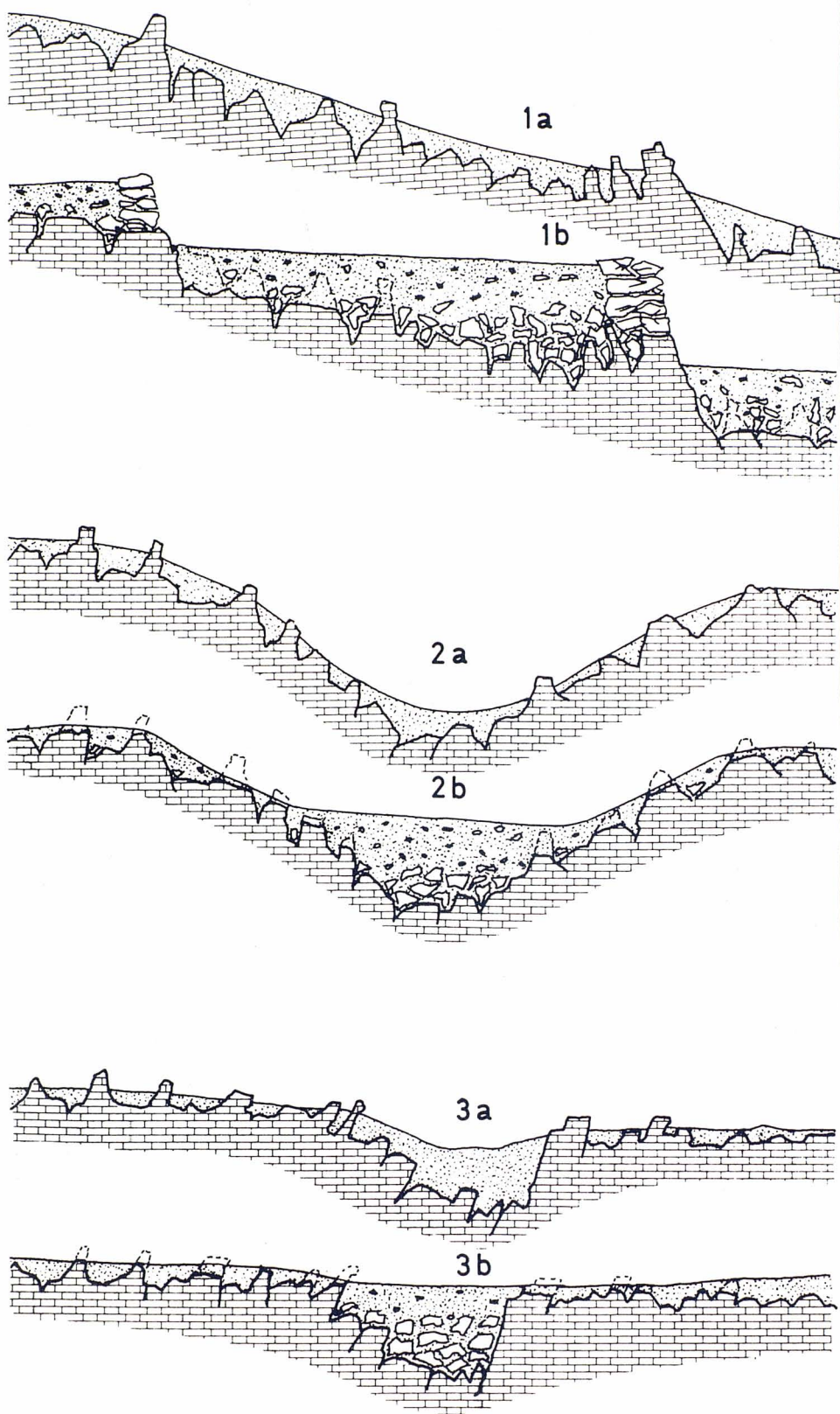


Photo 2. Side-walls and cultural terraces in the Adriatic island Lošinj, near to the town Mali Lošinj where in some plots more than 1.000 kg/m<sup>2</sup> of cut off and accumulated stones have been found. Photo by I. Gams.

put on the rocky base along the lower edge of the terrace and with the rest of pebbles the vertical side-walls has been built. The new arable land in the terraces has essentially less inclined surface. b) At the clearing of the karst surface the rocky trenches with thick soil have been unearthed. After the pebbles had been deposited there the rocky surface was covered evenly with soil. c) The stones cut off on the doline slopes have been thrown in the trenches excavated in the bottom. Then all the available soil stripped off from the slopes was spread in the bottom to get a larger field (see sketch). d) The fragments of broken stones derived from clearing were left in the soil. Their weight takes 10 or more percent of the soil weight. These fragments prove the clearing in case all accumulated stones were removed from the surface.

5. Instead of cutting the stone there it was possible to make the soil thick enough with transportation it from near places. Near to these plots the unearthed stones are today usually the highest. Deep trenches and dolines have also provided the soil for transportation. It is proved by their unnatural forms. The soil was seldom stripped off from the whole nearby slopes and thus made infertile (example NW of St. Julians on Malta). The difference in soil structure in the doline bottom and around it is also an indicator for transportation (Lovrenčak, 1977).





Some forms of the alteration of karst surface due to cultivation:  
 a - natural surface, b - altered and cultivated surface.

1 - Field terraces on slope in semicovered karst. 2 - Alteration of the more funnel-shaped doline into the more bowl-like doline to get a larger acre on its bottom. 3 - Alteration of the semicovered karst into the covered karst in a meadow.

Forms of accumulated gravel (pebbles) collected at the process of cultivation:

4 - Heap of stones. 5 - Heap of stones arranged in a series. 6 - Wall built in one series. 7 - Wall built in two series. 8 - Wall built in two series with inner filling. 9 - Quadrangular tower (from: Gams, 1974).



Photo 3.

Form of accumulated stones used for temporary dwelling of peasant on the field near Stari grad where some side-walls still indicate the Greek field parcelling from the 2th century b.Ch.

Photo by I. Gams.



## 6. Historical development of the adaptation of karst surface.

The knowledge of it in single countries and in the whole Mediterranean world is deficient, the historical sources scarce and human memory lost. For example: The Polyglot guide-book entitled «Malta» reports that the Phoenicians (there from 14th-18th century b.ch.) «brought the fertile soil to Malta, covered the naked rocky surface with it and so acres, vineyards and cotton plants were introduced» (p. 8). The preliminary research showed that in this limestone country the soil had in reality been derived from the local clearing of stony surface. It was easy to be cleared due to the light and soft limestone. Importation of the soil could contribute only a negligible share to it. The guide-book has probably right in sense that the Phoenicians brought the culture of adaptation of karst surface already. East of the small town Stari grad on the Yugoslav island Hvar the Greek parcelling of the field (4th-2nd cent, b.Ch.) still can be seen in the form of walls. The regular Greek parcelling in «stadies» and «plethrones» was possible only in a plain area without blocks sticking out from the ground. Today this field is dotted with stones. Since the Phoenician and Greek epoches the adaptation has been continued till the present time. The new agricultural techniques brought also new adaptations and consequently the changes in cultivation of land using hoe, spade, later plough, and recently tractor. A deeper clearing of stones was necessary when the olive-trees replaced the fig-trees and later vineyards. Therefore the stones had to be cut off down to the depths of 80-100 cm. Every country has his own historical development. The walls in Pennins (England) were mainly built in the transition from feudal to private land tenure - it was in the 17th and 18th century (Raistrick, 1969).

The amount of work for adaptation of the karst land for agricultural use can be elucidated by mea-

suring the weight of excavated stones. The measured volume of all the stones accumulated on the surface can be diverted (specific weight 2,7-2,8, value diminished by factor about 0,2 due to empty voids between the stones) into weight. This kind of measurements showed mainly less than one hundred kg/m<sup>2</sup> of land from where the stones had been taken away. On the Yugoslav islands in the Adriatic sea this value rises to many hundreds kg/m<sup>2</sup> and in some exceptional cases (Lošinj, - Gams 1974, 216) more than 1000 kg/m<sup>2</sup>. Invisible stones under the soil and those in the soil were neglected. After deforestation the decay of tree roots has lowered the soil level for some centimetres. In case of one thousand kilos of excavated stones the soil level has been equivalently to their volume lowered for 21,6 cm. Both factors have contributed to the general soil «erosion».

The study of alteration of karst surface is important for many reasons. It is useful for pedology since the natural soil horizons have been completely destroyed and mixed. It can be of great help to the archeological excavations in establishing the natural surface. The alterations have entirely changed the ecological conditions. The resilient rubble in the soil has a better heat conductivity than the soil particles. The altered soil is therefore warmer in summer. If the pebbles are lying below the soil it is more arid and colder rain provokes a smaller reduction of the soil temperature. The inwalled plots have a reduced wind speed and therefore a higher daily maximal air temperatures. The walls hinder the gliding of near-to-surface cool air layer on the slope. The karst depressions with the walls are therefore warmer in winter. The walls hinder the soil erosion and also spreading of forest and grass fires. But in the same time the soil of cultivated land without any grass on the surface is more liable to soil wash and vertical leaching. Peasants often say the stones «grow».

Beside the ecological advances of cultivated land also some difficulties are to be found there. The walls hinder the traffic and cultivation of land by means of all kinds of machines. They also hinder the creation of larger fields to be possessed by one farmer only. For this and the other reasons the agrarian use of the altered karst land is on the decrease in modern time. The intensive use is more and more limited to the vicinity of the settlements and to less inwalled and less inclined plots, that are mostly on the bottom of the depressions and in the valleys. But the ancient agricultural land is being rapidly destroyed there by the traffic, roads, railways, and by the other non-agrarian activities. The inwalled plots seems to be incompatible with the modern agrarian techniques. But with the decay of nearly one thousand years old cultural karst land the cultural heritage would be most affected. Thus an evidence of the year-long endeavours of our ancestors for their life and food should be lost. At least some samples should be conserved for our future generations. From this point of view we have to register the dying forms of cultivation, the remnants of human knowledge, and the effects of alterations before the agricultural land of new settlements is utilized and new techniques with tractor and harvester used.

## References

- GAMS, I. (1971): Podtalne kraške oblike (Subsoil karst forms). Geografski vestnik XLIII, Ljubljana.
- GAMS, I. (1973): A new method of determining of the karst soil erosion. Proc. 6th Int. Congress of Speleology, Olomouc 1973, ČSSR II.t., Praha.
- GAMS, I. (1974): Kras. Ljubljana.
- GAMS, I. (1976): Forms of subsoil karst. Proc. 6th Int. Congress of Speleology, Olomouc 1973, ČSSR, II.t., Praha.
- GAMS, I. (1977): Einige Arten der Umwandlung des halbbedeckten Karstes durch die landwirtschaftliche Bebauung. Proc. 6th Int. Congress of Speleology, Olomouc 1973, ČSSR, Praha.
- JENNINGS, J.N. (1985): Karst Geomorphology. Oxford.
- LOVRENČAK, F. (1977): Odeja prsti v vrtačah Slovenije (Boden-decke in den Dolinen Sloweniens). Zbornik X. jub. kongresa geografa Jugoslavije u Srbiji 1976. Beograd.
- MALTA: Polyglott-Reiseführer. München.
- RAISTRICK, A. (1969): Pennine Walls. Clapham.