INTRODUCING THE INVISIBLE WATER ROUTES OF KARSTIC SYSTEMS TO PUPILS: AN EDUCATIONAL PROJECT OF PSILORITIS GEOPARK.

Charalampos Fassoulas[1,2], George Iliopoulos[2], Catherina Voreadou[2] & Kleonikos Stavridakis[3]

[1] *Psiloritis Natural Park, AKOM-M SA, Anogia, Rethimnon, Crete, Greece*

[2] *The Natural History Museum of Crete, University of Crete, Heraklion 71409, Crete, Greece*

[3] *Environmental Education Office, Directorate of Primary Education of Rethimno, Rethimno, Crete, Greece.*

Abstract: Psiloritis geopark in collaboration with the educational dep. of the Natural History Museum of Crete and the environmental office of the Directorate of Primary education in Rethimno have developed a new educational project for primary and secondary schools on the water routes in karstic landscapes. The project focuses on the invisible water processes that interact with carbonate rocks to form distinct landscapes and natural ecosystems such as plateaus, gorges, caves and springs. In most cases, although not visible, water links the geological environment with life and this is the objective to be understood by pupils. After a short introduction to karstification and landscape formation, pupils are encouraged to visit certain landforms, to explore geology, relief and rocks, to make simplified scientific observations on the living environment and finally to compare the different ecosystems in the classroom. The close relations between geo-environment and adaptations or appearance of life then become obvious.

Keywords: Water cycle, environmental education, karst, geoparks

1. Introduction

The water cycle is an attractive topic for environmental education at all educational levels and surface water is the most suitable environment to establish such projects. However, in many cases, water does not remain on the surface either because of evaporation or infiltration in the rocks. Carbonate rocks (limestone, dolomite or

marble), are common rock types widespread in orogenetic zones as is Crete (Skiner et al. 2004).

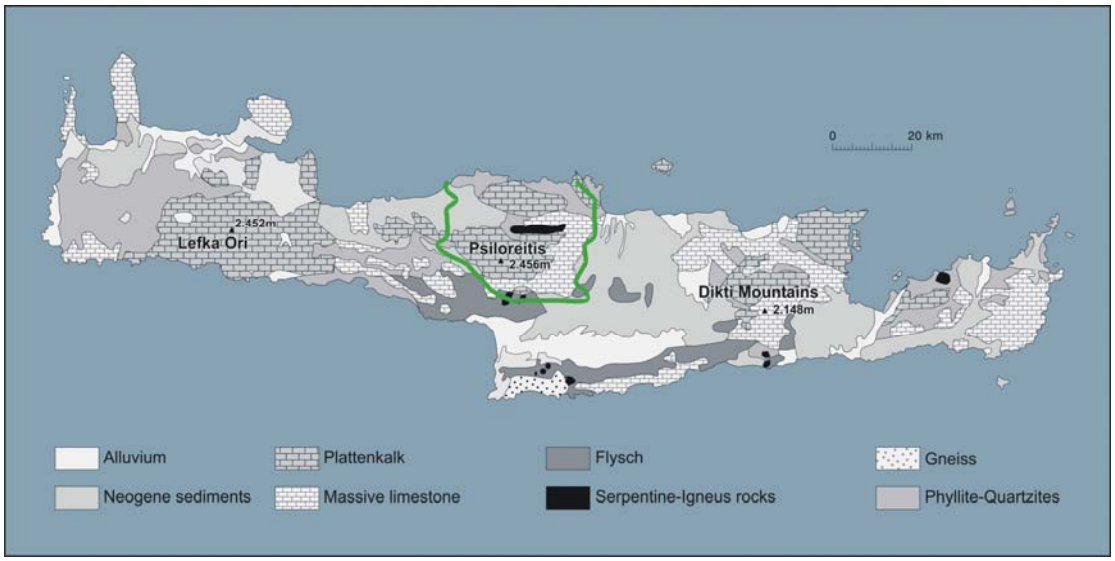


*Fig.1-**General geological map of Crete.** With blocks carbonate rocks, green line defines the geoparks boundary. After Creutzburg et al. (1977).*

These rocks however are very sensitive to erosion, mainly because of water that tends to dissolve calcium both on surface as well as on underground conditions, forming surface depressions, caves and gorges. This process is called karstification and is responsible for the majority of the landscapes that appear in such bedrock (Skinner et al. 2004).

The Psiloritis European Geopark, located in central Crete, is dominated by carbonate rocks that support water percolation and underground water transportation, rather than stream development (*Fig. 1*). It is therefore not possible to develop ordinary stream related projects in most areas of the Park, whilst it is also difficult to introduce the underground water cycle, especially to younger ages.

The Psiloritis European Geopark in collaboration with the educational dep. of the Natural History Museum of Crete and the office of environmental educational at the Directorate of the Primary Education of Rethimno, have developed an educational project for pupils that aims to explain how surface water penetrates carbonate rocks, what are the effects of this penetration, how it finally reaches surface and how is life related to all these procedures. The project is also addressed to older pupils of the Secondary education.

The project was implemented in three schools during the European Geoparks' week, on June 2005. The pilot implementation of the project, the effectiveness of the applied methods, as well as the selection of the field areas, were tested and the results are presented in this article.

2. Design of the project

Richness of natural environment in Psiloritis mountains, expressed by rich flora and fauna, high endemism and biodiversity, is mainly related with the high geodiversity and abrupt alternations of landscapes in the area (Rackham and Moody 1996). For the people of the Geopark this is apparent but not for the rest of the scientific and public community (Fassoulas 2004).

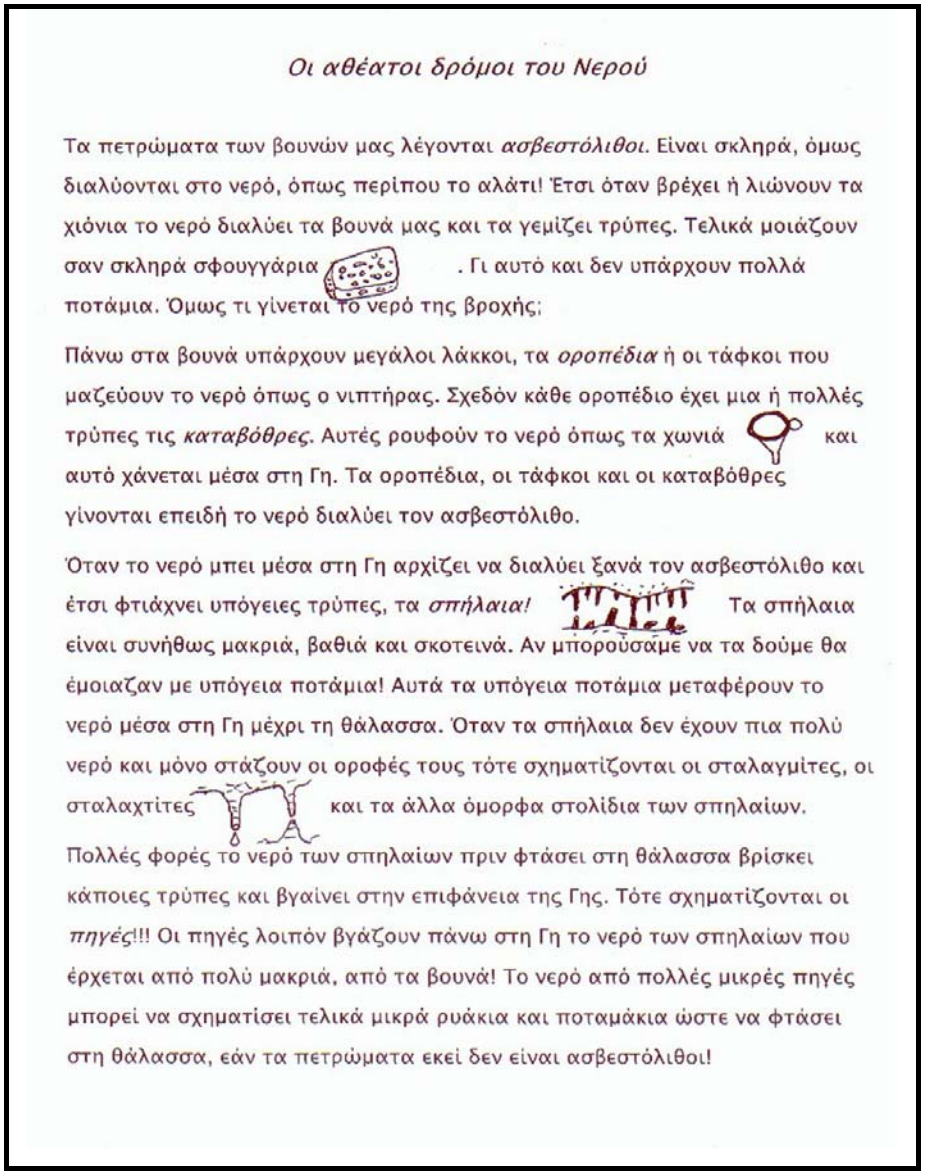
This project was designed due to the necessity to promote these issues to pupils. The aim of the project is to show how geological environment controls not only landscape formation, but also life appearance and adaptations, ecosystems development and human environment. This knowledge is generally underestimated by the broad scientific community and is less envisaged under the framework of natural environment (Gray 2004).

To achieve this goal complex geological and biological processes had to be explained to pupils, a hard effort even if addressed to older ages. Thus, we decided to incorporate these processes to a game of scientific performance, where students had to react like scientists who had to work with literature, collect data in the field, discuss and compare them in the classroom and finally reach into simple conclusions.

The objectives of the project are related thus with, 1) the introduction to carbonate rocks and karstic weathering, 2) the explanation of landscape and how it is formed, 3) the presentation of the main ecosystems of the area of implementation, 4) the familiarization of kids with scientific methodologies and 5) the comparison of different ecosystems and geotops.

3. Implementation

Several steps were followed in order to implement the project. First of all three primary school classes from the broader geopark area that were involved in environmental education projects, were chosen to participate. In collaboration with teachers the pupils were introduced to basic concepts such as rocks, landscape and ecosystems, whereas thematic lectures were given to them. Secondly, an activity sheet



Οι αθέατοι δρόμοι του Νερού

Τα πετρώματα των βουνών μας λέγονται *ασβεστόλιθοι*. Είναι σκληρά, όμως διαλύονται στο νερό, όπως περίπου το αλάτι! Έτσι όταν βρέχει ή λιώνουν τα χιόνια το νερό διαλύει τα βουνά μας και τα γεμίζει τρύπες. Τελικά μοιάζουν σαν σκληρά σφουγγάρια . Γι αυτό και δεν υπάρχουν πολλά ποτάμια. Όμως τι γίνεται το νερό της βροχής;

Πάνω στα βουνά υπάρχουν μεγάλοι λάκκοι, τα *οροπέδια* ή οι τάφκοι που μαζεύουν το νερό όπως ο νιπτήρας. Σχεδόν κάθε οροπέδιο έχει μια ή πολλές τρύπες τις *καταβόθρες*. Αυτές ρουφούν το νερό όπως τα χωνιά και αυτό χάνεται μέσα στη Γη. Τα οροπέδια, οι τάφκοι και οι καταβόθρες γίνονται επειδή το νερό διαλύει τον ασβεστόλιθο.

Όταν το νερό μπει μέσα στη Γη αρχίζει να διαλύει ξανά τον ασβεστόλιθο και έτσι φτιάχνει υπόγειες τρύπες, τα *σπήλαια!* Τα σπήλαια είναι συνήθως μακριά, βαθιά και σκοτεινά. Αν μπορούσαμε να τα δούμε θα έμοιαζαν με υπόγεια ποτάμια! Αυτά τα υπόγεια ποτάμια μεταφέρουν το νερό μέσα στη Γη μέχρι τη θάλασσα. Όταν τα σπήλαια δεν έχουν πια πολύ νερό και μόνο στάζουν οι οροφές τους τότε σχηματίζονται οι σταλαγμίτες, οι σταλαχτίτες και τα άλλα όμορφα στολίδια των σπηλαίων.

Πολλές φορές το νερό των σπηλαίων πριν φτάσει στη θάλασσα βρίσκει κάποιες τρύπες και βγαίνει στην επιφάνεια της Γης. Τότε σχηματίζονται οι *πηγές*!!! Οι πηγές λοιπόν βγάζουν πάνω στη Γη το νερό των σπηλαίων που έρχεται από πολύ μακριά, από τα βουνά! Το νερό από πολλές μικρές πηγές μπορεί να σχηματίσει τελικά μικρά ρυάκια και ποταμάκια ώστε να φτάσει στη θάλασσα, εάν τα πετρώματα εκεί δεν είναι ασβεστόλιθοι!

Fig. 2 – ***Introductory page of the activity sheet.***

had to be prepared for the field excursions. Third, after the effectuation of field trips and collection of data, the treatment of data and final conclusions had to be achieved.

3.1 Preparation in classroom

The first step for the implementation of the project took place in the classroom. After discussions with the people of the geopark and consulting the relevant literature, teachers introduced pupils to main geological and ecological concepts. In two cases, scientists from the Natural History Museum of Crete gave lectures related to the geological evolution of Crete, the formation of Psiloritis

mountains, the characteristic fauna and flora and the ecosystems of the mountainous areas.

For older pupils this stage included visits in local libraries and search for related articles or books. In this way, the intense study of certain earth processes and rock types, as well as the introduction to basic ecological processes, like adaptation and natural selection, was provided.

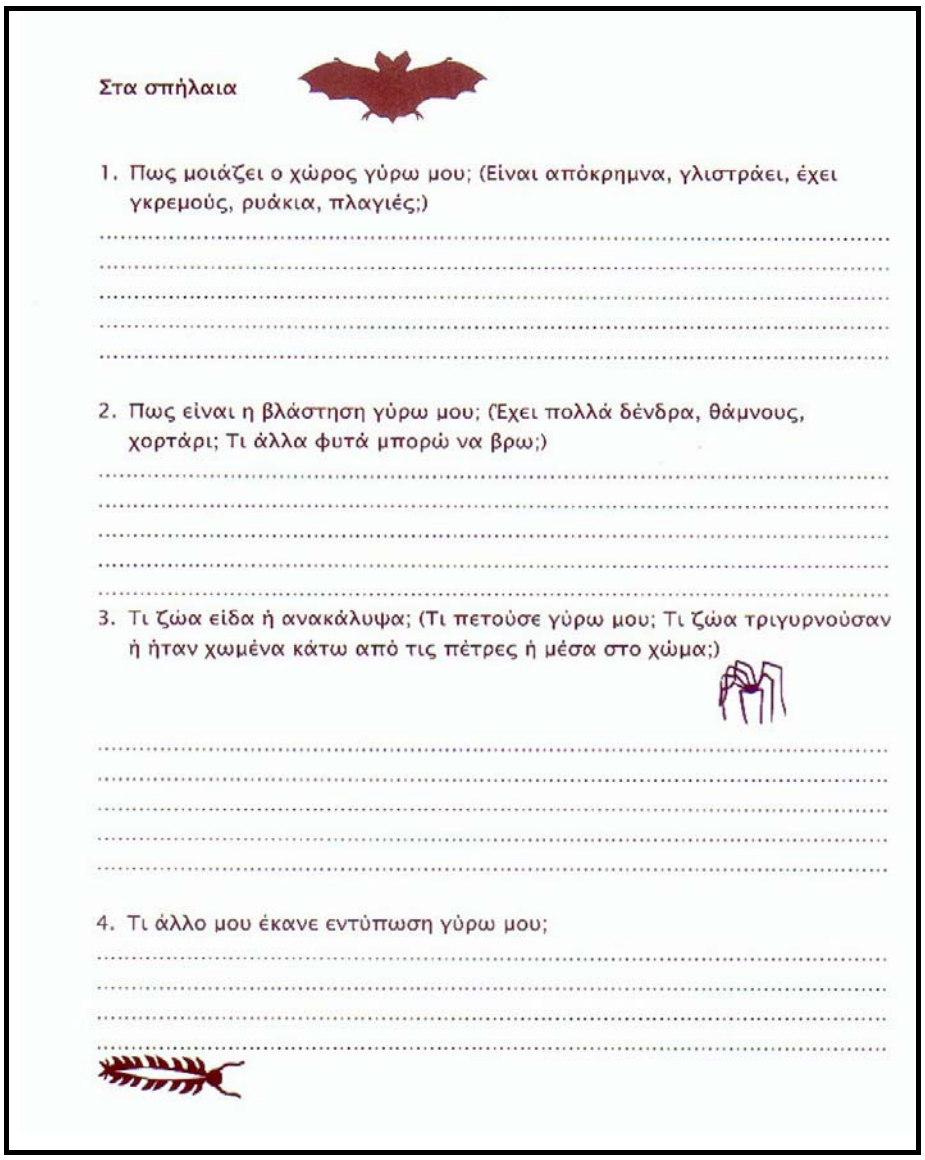


Fig. 3 – ***The cave page of the activity sheet.***

3.2 The activity sheet

An activity sheet was prepared for the field trips in order to guide kids to their observations and data collection. The main idea was based on an earlier project of the Natural History Museum of Crete in the frame of which an educational material

friendly to the kids, illustrative and interactive that could guide kids to make observations in the main ecosystems of Crete was produced (Voreadou et al. 2004).

The first page presents carbonate rocks, karstic weathering, formation of certain geotops (caves, plateaus, springs) and the way the water reacts with rocks and environment (*Fig 2*). Additional pages refer to certain visiting places, which were included for the implementation of the activity; a visit to a mountainous plateau, a visit to a cave and finally a visit to a small spring. Each page asks information about the landscape and the surface morphology, the vegetation and the individual species that could be recognized, the fauna and the characteristic animals that can be observed, as well as anything else worth noting in the visited areas (*Fig. 3*).

3.3 Field trips

Students from the three schools participated in a one-day field trip in the Psilotitis Mountains. Each one got an activity sheet and worked in groups of five to six individuals, under the supervision of their teachers.

The first visit was done in a small doline, where pupils were introduced to the limestone that was cropping out in the whole area, the water concentration in small streams and finally its percolation through sinkholes into the bedrock. The groups searched for animals and plants in the surrounding areas and tried to recognize some endemic species, making notes in their activity sheets. They used scientific equipment like butterfly nets, tweezers, rulers και magnifying lenses, they collected samples of plants and took many pictures.

The same process was followed in the next stop, which was Sfentoni cave. The specialties of this environment and the species surviving there were first discussed with the guides and the people of the geopark. Data were collected both inside and outside the cave.

The third stop was in a small karstic spring that was draining the limestone, where the cave was formed. Around this natural spring, a very distinct environment with hydrophilous species and rich vegetation has been formed.

By the end of the day the groups of pupils finished the necessary observations and wrote down all data in their activity sheets. Furthermore, they prepared the samples they had collected and sorted down their notes. A discussion followed about all the unknown or peculiar things they found and discussed their impressions from the field.

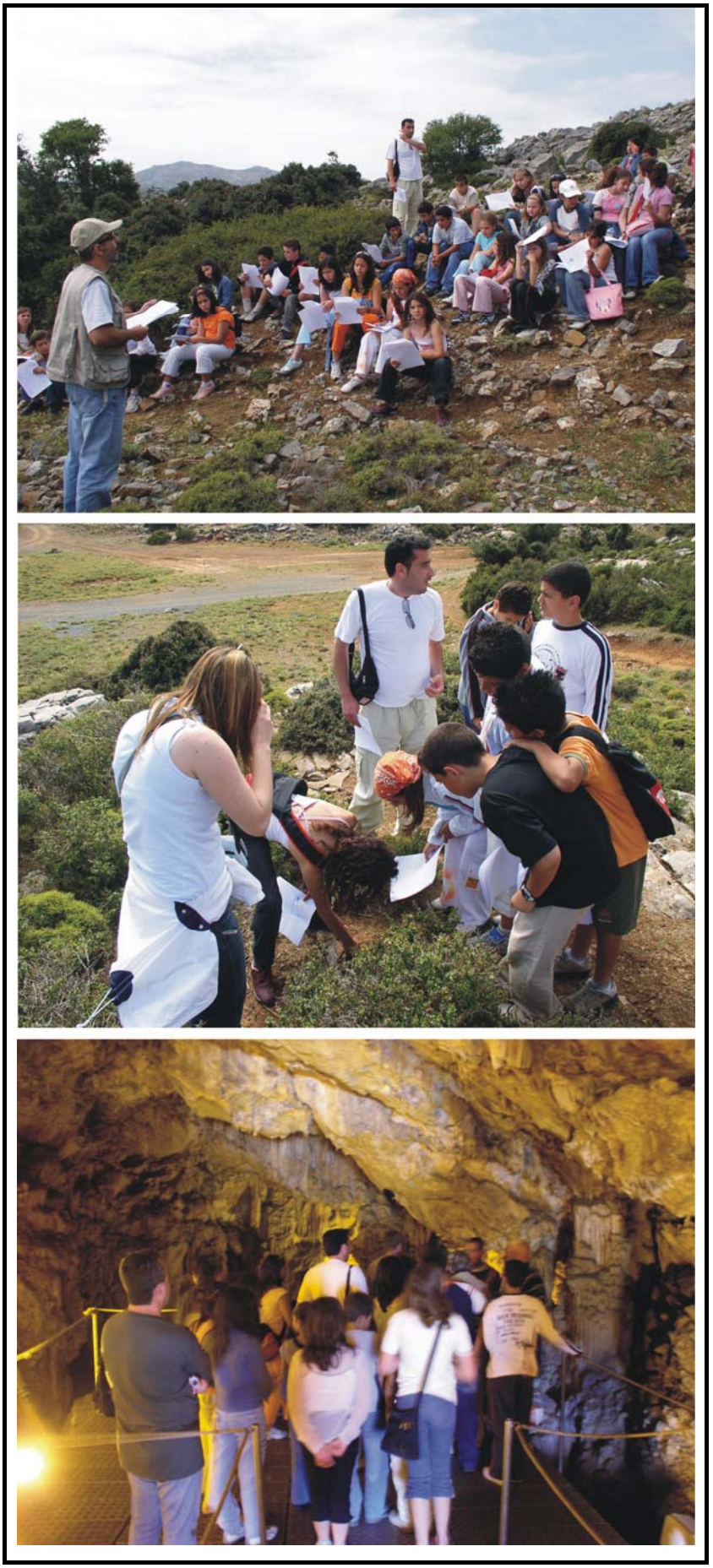


Fig. 4 – ***Pictures of the field activities.***

3.4 Data elaboration

The final stage of implementation took place in the classroom. Observations from different groups were combined together to build up an overall image for each landform they visited. Recalling theoretical knowledge, pupils tried to compare vegetation types, ecosystems and different landforms. With the assistance of their teachers they tried to interpret the recognized differences in respect to the different bedrock, water activity and geo-environment.

Some of those were obvious, as in the case of caves, where adaptations of animals were easy to be interpreted. Some others, like the endemism of plateaus had to be related with additional paleogeographic data that were provided by the Natural History Museum of Crete.

4. Conclusions

The incorporation of difficult scientific concepts such as karstification, life adaptations and landscape formation in the preparation of this educational project was a challenging topic for most of us. We tried to combine existing experience based on examples of simple and mainly more prominent issues of natural environment such as wetlands, rivers, or coasts with the experience of the geopark to promote the geo- and biodiversity of its territory.

The project was designed to be addressed to pupils already participating in environmental education, experienced thus in basic natural concepts. The three-stage implementation of the project: preparation in the classroom, field trips, and finally discussion in the classroom, appeared extremely useful for the success of the project, as both teachers and pupils became familiar with the topics that had to work with and discuss later.

Activities were scheduled to resemble normal scientific methodologies and practices such as literature search, collection, sorting and treatment of data, and elaboration of results, using laboratory instruments and techniques. The activity sheet forced pupils to make observations, collect data and be concentrated on their work. With the assistance of their teachers and people from the geopark, they discovered animals under rocks, observed others in darkness and collected samples and pictures. Landscape and life were in situ connected with earth processes and water cycle. The visit of nature became attractive and fascinating too.

Data elaboration, comparisons of different eco- and geo-tops, as well as, clarification of certain results appeared to be depended on pupils knowledge, classroom maturity and teacher's willingness/or time availability. In most schools and working groups, the main objectives of the project were achieved and pupils were able to recognize the reasons for the adaptations of some of the species and their occurrence in respect to certain environments and landforms.

In general, pupils managed to achieve the basic results and conclusions that their knowledge and age allowed to comprehend. The project was characterized by all participants as successful and in the future it is going to be offered to schools by the Geopark and the Natural History Museum of Crete.

Refferences

Creutzburg N., Drooger, C.W., Meulenkamp., J.E., Papastamatiou, J., Seidel., E. & Tataris, A. (1977) - Geological map of Crete (1:200.000). *IGME, Athens.*

Gray M. (2004) – Geodiversity : valuing and conserving abiotic nature. *J. Wiley & Sons, England,* 434 p.

Fassoulas, C. (2004) - Psiloritis Geopark: protection of geological heritage through development. *In: Parkes. M.A. (ed) "Natural and Cultural Landscapes: the geological foundation", Royal Irish Academy, Dublin,* 291-295.

Rackham O. and Moody J. (1996) - The making of Cretan landscape. *Manchester Univ. Press,* 238p.

Skinner B. J., Porter S.C. and Park M. (2004) – Dynamic Earth: an introduction to physical geology. *J. Wiley & Sons, England,* 584 p.

Voreadou A., Limberakis P., Poulakakis N., Paragamian, K., Fassoulas, C. and Michailidis P. (2004) – "The natural environment of Greece" An innovative educational product for Primary Environmental Education. *In: 2nd Inter. Conf. of Museology, Univ. Aegean, Lesvos (Abs).*

PSILORITIS NATURAL PARK

EUROPEAN GEOPARK

ENVIRONMENTAL EDUCATION PROJECT:

«The invisible water routes»

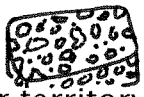
Student's Name

.....

Preparation: Dr Ch. Fassoulas
Natural History Museum

MAY 2005

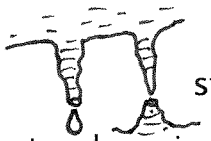
Introduction to rocks and landforms

Our mountains are mainly built up by rocks called ***limestones***. These are very hard rocks that are easily dissolved by water, like salt! Thus, when it rains or snow is melting the water dissolves the rocks leaving back small or big holes and cavities. Soon, the mountains look like a sponge  that sucks all water. This is the reason that no rivers exist in our territory. And, what about rain water? Where does it go then?

At the mountains big depressions, called ***plateaus*** or ***pot-holes***, drain water in the same way as our washbasin does. In each of these plateaus one can easily find many funnel-shaped holes  ,called ***sinkholes***, which take the water from the surface to the underground. These plateaus, potholes and sinkholes are the results of water activity on limestone!

However, as water flows further underground it continues its distractive role, dissolving limestone and forming underground holes,  which we call ***caves***!

Caves, as you probably know are often long, deep and dark. If we were able to look under the ground we would realize that caves are actually underground rivers! These "rivers" drive water directly to the sea!

When caves are no longer filled by water, then **stalagmites**,  **stalactites** and other beautiful natural decorations can be formed by water dropping from their ceilings.

In several cases, however, underground water can find its way out to the surface. Then **springs** are formed! These springs enable water that moves through mountains and caves to return to the surface before it reaches sea. If the rocks on which the water is flowing, are not limestone, spring-water usually forms smaller streams and gradually rivers, till it outfalls in the sea.

Observe and Note

On the mountain

1. What the place around me looks like? (Are there cliffs, gorges, streams, low-lands, depressions, terraces etc.?)

   .....
   .....
   .....
   .....
   .....

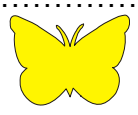
2. What the vegetation looks like? (Are there many trees, shrubs, grass etc.? What plants can I recognize?)

   .....
   .....
   .....
   .....
   .....

3. Which animals have I seen or discovered? (What was flying over me? What sort of animals have I found around or hidden under pebbles or in the soil?)

   .....
   .....
   .....
   .....
   .....

4. What else can I note?



   .....
   .....
   .....
   .....

In a cave

1. What the place around me looks like? (Is it steep, or slippery? Is there any water, light or special smell?)

   .....
   .....
   .....
   .....
   .....

2. What the vegetation looks like? (Are there many trees, shrubs, grass etc.? What plants can I recognize?)

   .....
   .....
   .....
   .....
   .....

3. Which animals have I seen or discovered? (What was flying over me? What sort of animals have I found around or hidden under pebbles or in the soil?)

   .....
   .....
   .....
   .....
   .....

4. What else can I note?

   .....
   .....
   .....
   .....

In a spring

1. What the place around me looks like? (Are there cliffs, gorges, streams, low-lands, depressions, terraces etc.?)

   .....
   .....
   .....
   .....
   .....

2. What the vegetation looks like? (Are there many trees, shrubs, grass etc.? What plants can I recognize?)

   .....
   .....
   .....
   .....
   .....

3. Which animals have I seen or discovered? (What was flying over me? What animals have I found swimming in the water or hidden under pebbles or in the soil?)

   .....
   .....
   .....
   .....
   .....

4. What else can I note?

   .....
   .....
   .....
   .....