Development of a High-School Geology Course Based on Field Trips

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ABSTRACT

The traditional use of field trips at the end of a geology course does not realise their learning potential. An introductory geology course for high school students in Israel has been tried as a method of integrating a course syllabus with a field geological inventory of the surrounding area. The course consists of three modules, each of which has a preparatory unit, a field trip and a summary unit. This structure takes into account the didactic desirability of: (1) a gradual move from the concrete to the abstract, (2) first-hand experiences, and (3) a learning cycle and the novelty factors that influence learning ability in the field.

Key words: Education - secondary; field trips; geology teaching; geology - introductory course.

INTRODUCTION

Field trips are used, in general, for enrichment of classroom teaching. Thus they usually occur at the end of the course, often as a sort of summary or "prize" for the students.

The purpose of this article is to present a method of inserting field trips into a geology course. The course is introductory and deals with basic earth science concepts for high school students in Israel. The approach suggested here views the field trip as a learning event which is an integral and indispensable component of the learning process.

PLACE OF THE FIELD TRIP IN THE TEACHING STRUCTURE

The educational justification for field trips is to provide opportunities for observation and first-hand experience with materials and phenomena not available in the classroom. Basic geological concepts (for example, bedding structures, faults, folds, rock-soil relation, karst and dune) become concrete and clear to students through their direct observation and hands-on experience. Because the field trip provides a unique opportunity for concretization, the field trip should come at an early stage of the learning process (Piaget, 1970).

Falk and others (1978) have suggested that there is a relationship between student ability to learn in the field and the novelty of the field environment. They showed that the learning performance of students acquainted with the field trip location was better than that of students not so acquainted.

Orion and others (1986) have suggested that the learning ability of students in the field is also influenced by previous knowledge and previous outdoor experience. In light of the above three factors (novelty of field environment, previous knowledge, and field experience), it is suggested that the learning ability in the field is influenced by a novelty space (Figure 1).

This hypothesis leads to the suggestion that students with a large novelty space will have difficulties in performing learning tasks during a learning field trip. Thus, in order to increase the educational effectiveness of the field trip, the novelty space should be reduced. This can be achieved by a preparatory unit in the classroom. Of the three components of the novelty space, the previous-knowledge factor can be influenced

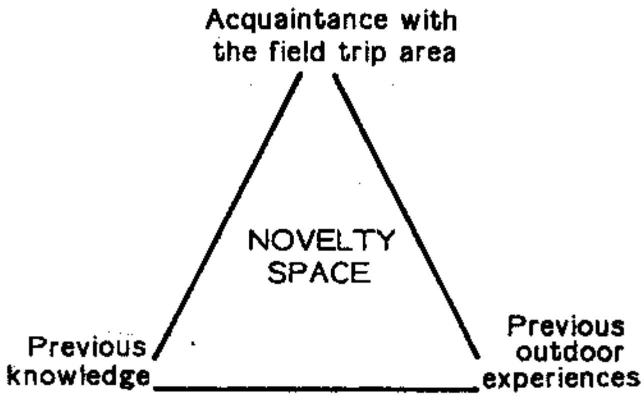

Figure 1: The major components of the novelty space.

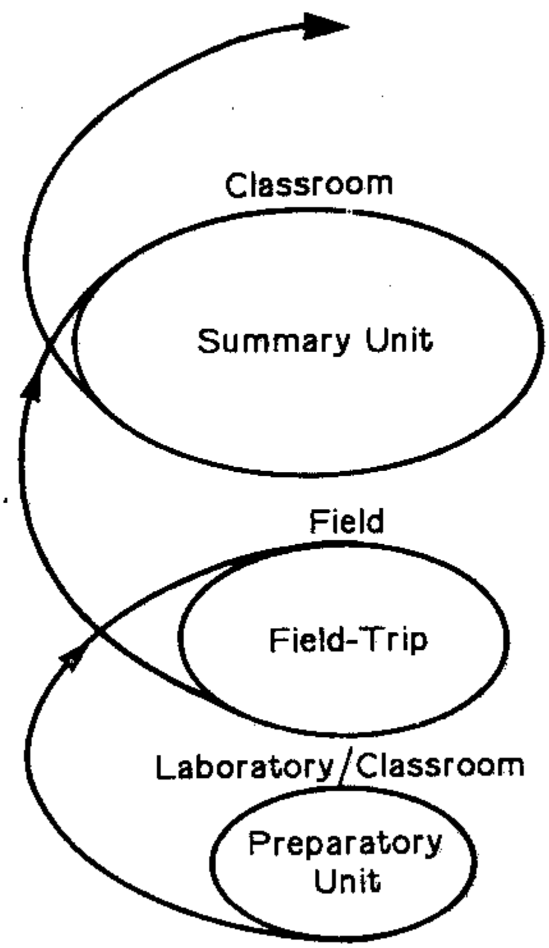

Figure 2: The learning structure of the field trip module.

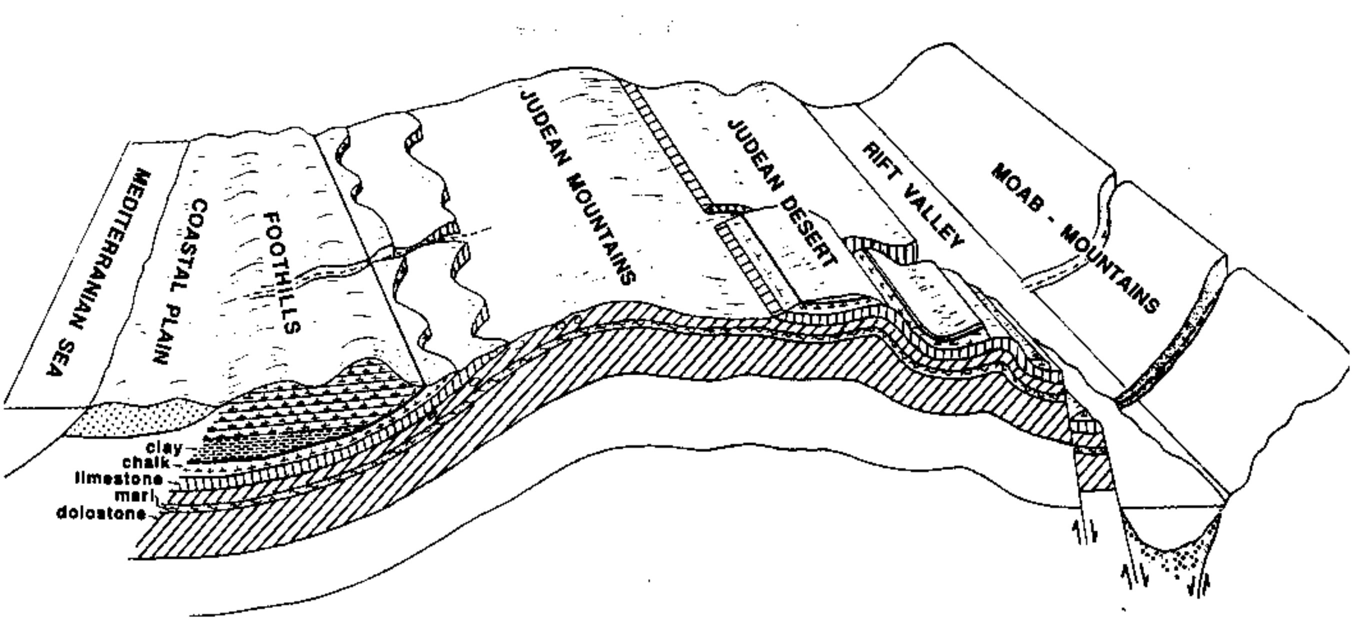

Figure 3: Geological transect from the Mediterranean Sea to the Rift Valley.

directly in the classroom (the other two factors can be treated in the classroom only indirectly).

In accordance with the idea of gradually proceeding from the concrete to the more abstract, the preparatory unit should be built mainly on concrete experiences (for example, identification of specimens of minerals, rocks, fossils and soils, and laboratory experiments). Through these concrete activities the students can acquire the knowledge needed for the field trip.

Acquaintance with the locality(ies) to be visited can be obtained indirectly through slides and films and by working with maps and aerial photographs. The third novelty factor, lack of previous field-trip experience, cannot be solved in the classroom, but the teacher can at least prepare the students psychologically by describing the situation. In theory, the preparatory unit serves as an advanced organizer for the field trip. In turn, the phenomena observed during the field trip serve as advanced organizers for the more abstract parts of the course, such as geological processes, geological periods and the chemistry and physics underlying the phenomena (Figure 2).

Thus, the learning strategy suggested here has three stages: (1) a preparatory unit, (2) the field trip, and (3) a summary unit. Each stage serves as a bridge to the next one. This strategy is similar to the learning cycle suggested by Karplus and Lawson (1974). Since the reader may not be familiar with the geology of Israel, a short description of the geological inventory of the course terrain is given in the next section, after which I will describe the field trip module.

FIELD GEOLOGICAL INVENTORY OF THE AREA

A west-east cross section through Israel, from the Mediterranean to the Dead Sea, cuts across a complex geological structure (Figure 3) and, as a result of the arid climate, geological phenomena are well exposed.

The Coastal Plain: This area is characterized by Pleistocene continental sediments, mainly calcareous sandstone (locally called kurkar) and quartz-sand dunes. The exposures demonstrate continental processes such as wind sedimentation and soil formation (Figure 4).

The Foothills: This area is characterized by low hills of horizontally bedded chalk (Figure 5).

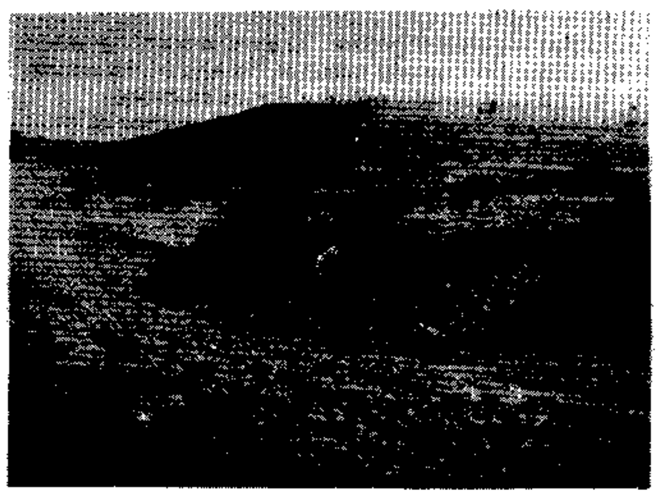

Figure 4: Aeolic sand dune in the Coastal Plain.

Judean Mountains: The exposures of this area include marine sediments, mainly dolomite and limestone, as well as chalk, clay, marl, phosphorite, chert, and porcellanite. The beds are folded into an anticlinarium (Figure 6).

Judean Desert: This area lies on the eastern flank of the anticline. It is characterized by secondary folds that are superimposed on the main structure. The synclinal exposures include a thick section of chalk, chert, bituminous chalk, phosphorite, and high-temperature metamorphic rocks. The difference in elevation between the Judean Mountains and the Rift Valley has led to intensive erosion. The rivers dig through the chalk and the hard limestone beneath and create deep canyons. In some of these canyons, karstic springs have developed (Figure 7).

The Rift Valley: This is a long narrow valley, with the Dead Sea in its deeper part (400 meters below sea level). The steep cliff forming the western border of the valley is a fault escarpment (Figure 8). The bottom of the valley is filled with continental sediments that represent a variety of environments: rivers,

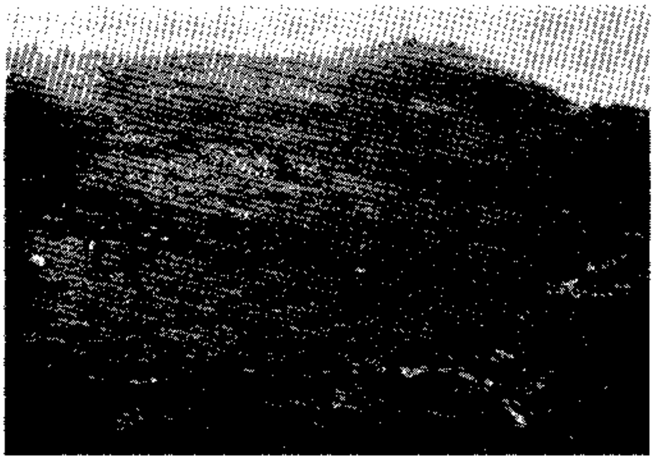

Figure 5: Typical chalky hill in the Foothills region.

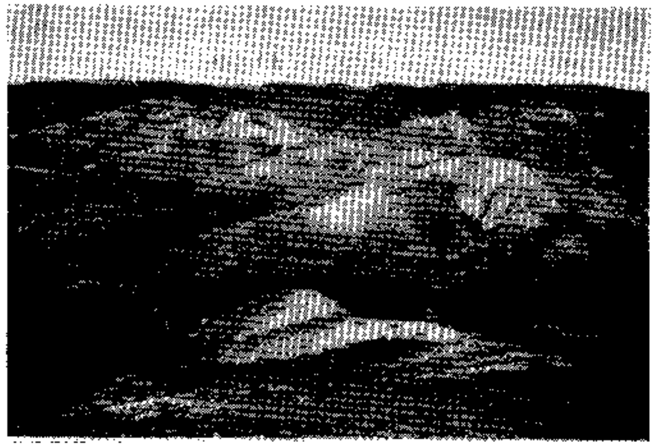

Figure 7: Typical view of the Judean Desert. Chalky hills above hard limestone.

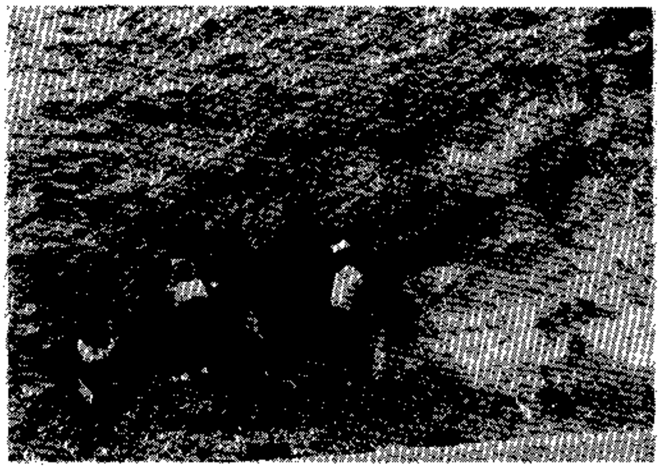

Figure 6: The western flank of the Judean anticline.

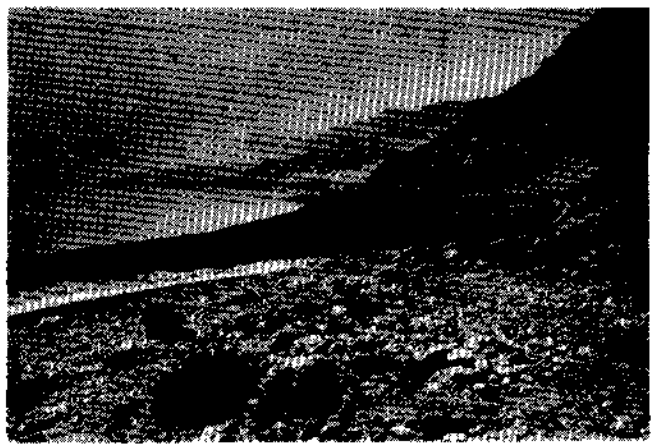

Figure 8: The Dead Sea and the western cliff of the Rift Valley.

lakes, and evaporitic environments. The Dead Sea is an example of a recent evaporitic environment. Some of the bedrock exposures show mini-structures of normal faults, grabens and horsts.

The above geological inventory includes 15 different types of sedimentary rocks that represent marine and continental environments, fold and fault structures, soils and fossils. The rocks and their relationship to the specific field trips are summarized in Table 1.

THE FIELD TRIPS

The transect from the Mediterranean to the Rift Valley is divided into three full-day field trips:

(1) The Coastal Plain: This deals with continental sedimentary rocks, continental processes such as wind transportation and sedimentation, and the beach as a recent geological environment.

(2) From the foothills to the mountains: This deals with marine sedimentary rocks, fold structure, marine fossils, springs, karstic phenomena and the geological development of the Judean Mountains.

(3) From the mountains to the Rift Valley: This deals mainly with marine and continental rocks, fault structures, mapping units, a karstic spring and the development of the Rift Valley.

The concepts covered in the individual field trips overlap. However, each trip has its own emphasis and each can be taken as a separate and unique entity.

THE FIELD TRIP MODULE

Preparation for the field trip

The preparatory unit for each trip deals with basic concepts that are needed for that field trip. It includes only those concepts, processes, and rocks that will be observed in the field on that particular trip.

Minerals, rocks, soils and fossils workshop: The students work with kits that contain the minerals, rocks, soils, and fossils they will see in a specific field trip. They learn to characterize and identify the materials with worksheets.

Microscope laboratory: By using thin sections and microfossils, the students get an insight into the rock structures.

Laboratory experiments: Crystallization, chemical weathering, stratified spring, sedimentation processes are all discussed.

Working with maps: In order to become acquainted with the geography of the field trip area, the students are asked to

Trip Subjects	Coastal Plain	From the foothills to the mountains	From the mountain to the Rift Valley
Marine sedimentary rocks	beach rock	limestone, chalk, chert, phosphorite, porcellanite, clay, marl, dolostone	limestone, chalk, chert, phosphorite, porcellanite, bituminous chalk
Continental sedimentary rocks	calcareous sandstone	breccia, stalactite	sandstone, conglomerate, aragonite, clay
Evaporitic rocks		dolostone	gypsum, aragonite
Minerals	quartz	calcite	gypsum, clay
Soils	sand, red loam	rendzina, terra-rossa	rendzina
Bedding structures	cross bedding	horizontal bedding	horizontal bedding
Fold structures		anticline	anticline, syncline, anticlinorium
Fault structures	coastal cliff (?)	normal fault, graben, horst, Rift-Valley	
Fossils	roots	molluscs, shark teeth, dinosaur tracks	
Hydrology		stratified spring	karstic spring
Surface processes	abrasion, wind transportation and sedimentation	karst, soils, canyons, peneplain	canyons, river, transportation and sedimentation
Stratigraphy	superposition	superposition, initial horizontality	superposition, original lateral continuity
Mapping	columnar section	columnar section	columnar section, formation, member
Historical	Pleistocene	Cenomanian-Pleistocene	Cenomanian-Pleistocene
Economic geology	sandstone quarries	limestone quarries, phosphorite	phosphorite, bitumionous shale, Dead-Sea

Table 1. Subjects and concepts that are covered in the field trips.

locate the sites to be visited on a map and to prepare a topographic cross section of the field-trip area.

Films: One of the activities in the preparatory unit is watching a videotape that deals with topics included in the field trip. For example, the videotape "Karstic processes in the Judean Mountains" is viewed before the trip "From the foothills to the mountains," because the latter includes a visit to a stalactite cave.

The duration of the preparatory unit is about 15 teaching hours.

Teaching methods used on field trips

Each of the field trips is divided into about eight learning stations. The learning stations were selected according to the criteria suggested by Orion and others (1986):

(1) The exposure has to be clear enough "to speak for itself."

(2) The learning in the field should be conducted at well defined stations so that both teachers and students can locate them easily.

(3) There has to be enough room around the station for uninterrupted activity by at least 20 students.

(4) The microclimate of the station should not inhibit work. For example, lack of shade or the occurrence of strong wind or blowing sand are not conducive to careful observation by students.

Workbooklets that guide student activity at the station were prepared for each of the field trips. The booklets include instructions, assignments, and space to write the student's findings and conclusions. There are two types of assignments.

Firstly, questions that guide the students to investigate the exposure by using activities such as identification of rocks, soils and minerals, observation and drawing. The second stage includes more abstract questions that require the students to explain their findings: for example, "Which rock layer is the oldest and which is the youngest?" or "What can you conclude from the inclined position of the marine sedimentary rock layers?" After the individualized stage, a group discussion is conducted by the teacher. At this stage, the teacher shows colored mini-posters that present reconstructions of stages in the geological development of the area and geological cross sections. A series of eight mini-posters has been developed for each field trip. Each poster is 35x25cm, printed on thick paper, so that it can be used in the field conditions. On the front of each mini-poster there is a colored drawing and, on the back, are notes for the teacher. The notes explain the geological meaning of the drawing and include didactic suggestions and guidance of where and how to use the mini-poster.

The work at the station concludes with a question for further thought and discussion. For example, the station at which students observe a fold structure ends with the question, "How were those hard layers folded?". After the observation that Terra-rossa was developed over limestone and Rendzina over chalk, the question is "Why is the Rendzina similar to the parent rock and why is the Terra-rossa so different?" After observing a columnar section of five different marine sediment layers, the question is "What caused the change of sediment types?" These questions are asked in the field, but are discussed in the classroom after the field trip. Thus, the field trip serves as an advanced organizer for the more abstract concepts that are taught in the classroom.

Summary of the field trip

As mentioned above, field observations raise questions of "Why?","How?" and "When?" To answer these questions, it is necessary to go into the more abstract parts of geology, for example, sedimentation and lithification processes, geochemistry, tectonics, geophysics, and historical geology.

The teaching in this phase of the learning process takes the form of traditional-style lectures with classroom teaching aids. Only at this stage are the students exposed to the more complicated and difficult parts of the curriculum. The assumption is that the experiences and knowledge gained from the field trips will help to overcome the difficulties inherent in this part of the course.

SUMMARY

The course structure presents a gradual transition from the concrete to the abstract. It is based on field-trip modules, each of which consists of three stages: (1) the preparatory unit, (2) the learning field trip, and (3) the summary unit. These stages take place in three different learning environments: in the laboratory and workshop, outdoors, and in the classroom. In the course described, three day-long field trips cover a large portion of an introductory geology course. Some of the learning concepts arise directly from the field observations and others indirectly from the questions that they engender.

The field trip is the core of each module. It serves as a natural laboratory where students can touch the rocks, observe and investigate geological phenomena and figure out geological concepts and principles. The field trips cover a large portion of the curriculum, but not all of it. The rest is taught in the traditional way. The field trip is only a learning aid among many others. What we have described is one way of using this aid.

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Nir Orion is a PhD student in the Department of Science Teaching, Weizmann Institute of Science, Rehovot, Israel. He received his BSc from the geology department of the Hebrew University, Jerusalem and his MSc from the Weizmann Institute of Science. His PhD dissertation deals with the development and evaluation of geological learning field trips. In addition to his academic work, Nir Orion is a member of a group that has worked for the last few years to establish geology as an independent discipline in the Israeli education system.

Food for Thought

In the Middle Ages in western Europe, magic was not an obscurantist superstition hostile to scientific rationality, nor was it a challenge or even an alternative to science. This contrast arose only in modern times. However different medieval magic and science might seem at first glance, a closer look will reveal them as complimentary endeavors. While having different motives and employing different means, they shared common intellectual underpinnings and were often combined without conflict or tension.

Hansen, Bert, 1986, The complementarity of science and magic before the scientific revolution: American Scientist, v. 74, p. 128-136 (from p. 128).