Creating digital resources for teaching innovation in Structural Geology and Tectonics

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Abstract

This project consisted of developing a series of teaching resources in digital format to teach the subjects of Structural Geology and Tectonics in degree programmes related to the Earth Sciences. The goal was to improve students' training and performance by developing out-of-classroom support activities that foster independent learning and self-regulation on the part of the students. The activities aim to take advantage of the new IT tools available and to foster their access via the Web. The material that was developed in this project consisted of: 1) a documentary collection of images related to Structural Geology and Tectonics with explanations, available on the Web and accessible from specific search engines, 2) a series of exercises and practical case studies, some of them already solved, and 3) virtual field trips to a geological region that enabled us to propose activities prior to a visit to the field or to develop the practice totally independently.

General area of interest of this innovation

«The best geologist is the one who has seen the most rocks»
H. H. Read, 1889-1970.

This project aimed to provide support to teaching of the core subjects on Structural Geology and Tectonics in the Bachelor's in Geology programme at the UAB, although it might also be of interest to university students who are studying these subjects in the Geological or Mining Engineering and Environmental Sciences degree programmes. It is also targeted to the faculty in the field of Geodynamics, both nationally and internationally, for whom it might be useful to have an interactive archive of images and exercises on geological structures.

1. Objectives

Structural Geology and Tectonics are sciences with a heavy visual component which are based on analysing and interpreting geological structures (folds, faults, rock textures, etc.). The first steps in this analysis consist of properly identifying and describing the geometric characteristics of the structures. These skills are not easily acquired by students in traditional classroom teaching, as they mostly require the cumulative experience of observing and synthesising nature's diversity. With these premises, the overall goals of the project can be summarised as:

1. To adapt the format of the graphic material used in teaching to the new technologies by creating databases of digital images with several ways to access them.
2. To develop new teaching materials such as exercises that are available on the Web and virtual field trips.
3. To foster students' capacity for analysis and to augment their experience by means of methodologies based on independent learning

The skills we want the students to develop are the following:

1. The capacity to observe, identify and synthesise the information from natural geological structures.
2. Skill in drawing and portraying the basic geometrical traits of the structures, which will serve as the foundation for later analysing and interpreting them.
3. The ability to progress in their scientific knowledge and experience by means of independent study and self-evaluation.
4. Skill in the use of digital resources linked to the new technologies.

2. Description of the project

This project originally emerged within the context of teaching Structural Geology and Tectonics in the Bachelor's of Geology programme taught by several members of the Internal Geodynamics area within the Faculty of Sciences at the Universitat Autònoma de Barcelona. The specific courses that the team members teach and where the material developed in this project is being applied are the following:

1. Endogenous Geology field camp of (second year in the Bachelor's of Geology)
2. Introduction to Rock Mechanics (second year)
3. Structural Geology II (third year)
4. Geotectonics (fourth year).

The point of departure in terms of how these subjects were taught was a high degree of classroom teaching coupled with professor-led field trips. Currently, the teaching takes place in the traditional way with the support of projections of images and graphs, and using practices based on exercises that are conducted in the laboratory.

When the project started, we had a documentary collection of geological structures from the field that included almost 2,000 photographs, only a tiny fraction of

which was used in the classroom in the form of slides. Part of the teaching innovation consisted of making use of the new information and communication technologies, especially the Web, to make the majority of these photographs available to students.

The working plan of the project included several activities sequenced over time:

- digitalisation of the images from the documentary collection (photographs and graphs)
- development of explanatory materials for the images and graphs
- classification and organisation of the images into different categories and different ways of access them (depending on the type of geological structures, regardless of the context, or grouped into virtual field trip itineraries)
- preparation of exercises or practical case studies that include graphs and photographs of structures
- preparation of a collection of exercises with solutions
- creation of a website where the resources developed would be available

The digital collection is used by both the professors, who have an extensive database from which to draw materials for their classes, and the students, who have at their disposal extensive documentation on natural geological structures that they may use for independent learning activities and studying.

The material is presented in an informative way (the image collection per se), as well as in the guise of exercises and practical case studies to be solved, which may have to be handed in to be evaluated or which students may do independently to evaluate themselves.

With regard to the innovation in the fieldwork, a series of virtual field trips are being developed, meaning an interactive set of geological maps, geological transects and photographs linked to each other. This resource makes possible a geological survey of a specific zone, which may be more or less complete depending on whether it is being used as an exercise prior to a real field trip or whether the aim is to describe a particularly educational field area to be studied just virtually.

3. Methodology

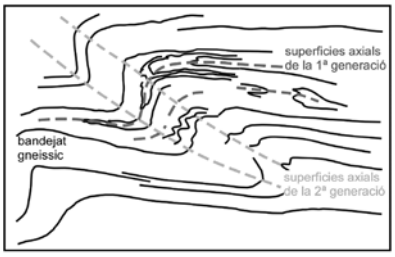
The actions and means used to develop the project are as follows:

1. Digitalisation of the documentary collection on Structural Geology and Tectonics, consisting of 2,000 slides on geological structures from many different regions on the planet which have been amassed by the faculty in the area of Geodynamics over the past 50 years. The collection was digitalised by scanning slides with high image resolution (approx. 2000 ppm). From each of the images we have made a copy with a lower resolution that is accessible on the Web. An explanation has been written for each image, and in some cases supplementary illustrations are also provided.

2. Organisation of the digital collection using a variety of criteria: subjects (type of structures), regions (illustrating the geology of a given region), etc.
3. Development of a search engine for the image collection that can work using several different criteria and used by the faculty/students when doing exercises, studying, etc.
4. Online publication of the image collection with the supplementary illustrations and explanations so that they can be used by the students as an independent learning resource (http://einstein.uab.es/c_geotectonica/reditec/2008). Adaptation of the search engine to the spatial characteristics of the Web. Figure 1 shows an example of a file from the documentary collection, with the image of the geological structure being studied, its explanation and the supplementary illustrations.

Figure 1. Example of a file from the documentary collection with additional explanations and illustrations

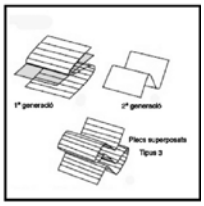
FOLD SUPERIMPOSITION (CARIÑO BEACH, LA CORUÑA)



Observation:
The folds seen in the photograph deformed to so-called Cariño Gneissos formation of metamorphic quartz-feldspathic rock with a compositional banding defined by the alternating psamitic-pelitic layers. These gneisses probably derive from sedimentary rocks, and are therefore paragneisses.

Description of the structures:
In the centre of the image the lighter layers define isoclinal folds appear. If the axial surface of these folds were drawn, it would be seen to be deformed by more open folds.
In the bottom right corner of the image folds with a short vertical limb and a longer horizontal limb can be seen.
If we stretch out the axial surfaces of these open folds we can see that the axial surfaces deform from the isoclinal folds in the centre.

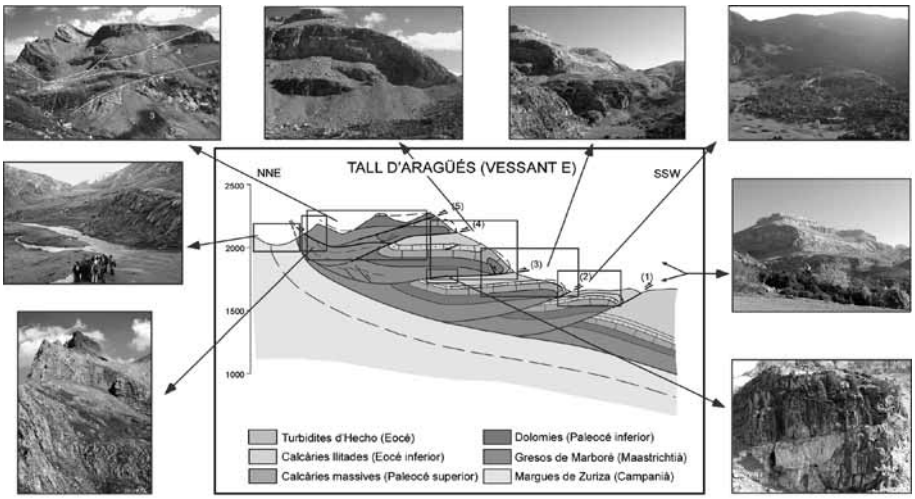
Interpretation:
This is an example of a two-phase fold superimposition. The first generation isoclinal folds are deformed by the asymmetric folds of the second generation. The orientations of the axes of the folds for both generations are close but the axial planes are oblique: this geometry corresponds to type 3 interference of Ramsey's fold classification.



5. The development of a series of practical case studies and exercises to be solved by students. These exercises, which will be distributed online, might contain both the solution and a self-evaluation scale adapted to the level of the course so that students can track their own progress. For this purpose, there is a collection of exercises commonly used by the faculty in non-digital format.

6. Creation of virtual field trips which enable students to observe the structures within their geological setting without having to travel, or as an activity prior to a real field trip. For this reason, they include documentation on a variety of tectonic units in the geological setting, including maps and geological transects, photographs, rock samples, etc. Figure 2 shows an example of this latter activity, corresponding to a geological transect in a sector of the Pyrenees illustrated with a set of images. The complete virtual field trip can be found in the enclosed CD and is part of the core course on Geotectonics in the Bachelor's in Geology at the UAB.

Figure 2. Example from an illustration of a virtual field trip, showing the link between the graphic information (geological transect) and the field images of parts of the transect



The geological section at Puertos de Aragüés (Aragonese Pyrenees) shows an imbricate fan of 5 thrust sheets, affecting sedimentary rocks of late Cretaceous to Eocene age. Each thrust sheet presents fault-related folds, consisting of hanginwall anticlines and footwall synclines. The five imbricate thrust converge in a bedding-parallel basal detachment, and the whole formation is folded by a large-scale syncline, formed later (squares link to field images of different punts of the section).

7. Definition of the monitoring and evaluation mechanisms of the teaching innovations. This consisted of drawing up a series of criteria that enable us to quantify to what extent the students have acquired the target skills. It includes a compilation of the tasks performed by the students in order to record statistics on their progress in subsequent courses.

4. Preliminary results

As this article was being written, this project was in the development stage, so there are not yet any comprehensive results on its application. Nonetheless, it has been put into practice in the course «Endogenous Geology Field camp» during the second term of academic year 2007-08. This course is to a geological camp with the goal of initiating students into practical fieldwork. The material which was drawn up consists of a virtual guide to the fieldwork zone with an explanation of the goals and the geological setting, as well as a series of illustrative photographs on the thrust structures in other areas on Earth, structures that are the main subject of study in this course. In order to make use of the database of images during the fieldwork, a selection of photographs of thrusts were printed and laminated in order to distribute them among the students. Analysing these images should enable students to define the main elements for recognising this type of structure on the ground.

The mechanisms used to analyse the results consisted of: 1) the evaluation of a practical field exercise, and 2) distribution of a survey on the usefulness of the teaching resources in order to assess students' degree of satisfaction.

The practice consisted of an exercise in which students had to interpret a field outcrop by means of drawing a schema that includes its main elements. The practice was conducted in two stages: one prior to distributing the selection of images among the students and another after having distributed and analysed them. The work conducted in each stage was collected to be marked to be able to compare the results and assess the improvements in students' performance. A total of 33 students did the practice, divided into two groups. The results show that the average mark on the exercise rose 91 % after applying the innovation, with a significant drop in the number of interpretation errors considered unacceptable.

An analysis of the survey has shown that students' degree of satisfaction is high: the usefulness of the exercise with the digital resource was rated an average of 7.7 over ten. Among the aspects worth highlighting are the availability of the prior information on the geological setting of the field trip, which helped students to understand the exercise better, clarified concepts and reduced the interpretation time in the field. Among the strong points of using images from outside the working area, the students highlighted their usefulness when interpreting the real structures being studied and as a foundation for extracting the essential aspects to be observed and described. As a point needing improvement, the students pointed out that the images housed online did not yet have additional explanations and illustrations to make it easier to understand them, which shed light on the need to accompany the database of images with explanations of each structure. These results should be viewed as preliminary; however, they do give a positive idea of the usefulness of applying the methodologies being developed in this project.

5. Conclusions

The resources developed by the project will be used in the future in the new courses that are developed upon the remodelling of the curricula following the norms of the European Higher Education Area, a system in which personal study and independent learning have special prominence and for which the teaching innovation we have described has been particularly designed. Likewise, as mentioned before, our aim is for some of the material to be available online for other users outside the UAB.

The use of the digital material developed to date has enabled the classes in Structural Geology and Tectonics to be more participatory, facilitating students' discussion and interpretation of the structures being explained. This has been very positively rated by the students. Likewise, the virtual field trips as preparation for the real field trips on the ground and the pilot use of the database of images are experiences that have notably improved students' performance in the field.

In the future, the project will continue to be developed by drawing up study materials (exercises to be completed and examples that are already interpreted) and increasing the number of virtual field trips, both those linked to real ones and ones that stand on their own as teaching tools.

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Interesting links

- Innovation website: http://einstein.uab.es/c_geotectonica/reditec [2008]
- http://www.diogenes.ethz.ch/index.asp [2008]
- http://www.geo.uib.no/struct/index.html [2008]
- http://funnel.sfsu.edu/courses/geol102/ex2.html [2008]
- http://earth.leeds.ac.uk/learnstructure/ [2008]

Keywords

Structural geology, tectonics, digital resources, independent learning.

Financing
This project was financed by the AGAUR programme on Improving the Quality of Teaching at Catalan Universities (MQD) for 2006 (ID number: 2006 MQD 00002).

Supplementary materials on the CD-ROM
Virtual geological field trip, consisting of an itinerary described by images, graphs and digital photographs linked in an html environment.

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Presentation of the working group
The working group is made up of professors and researchers from the Geotectonics Unit of the Department of Geology. The group has extensive experience (more than 20 years in the cases of professors Teixell and Arboleya) in teaching and research in the field of Structural Geology, and it is primarily concerned with studying rock deformations on the Earth's crust at different scales, ranging from the texture at microscopic scale to the joint structure of the mountain ranges and their relationship with plate tectonics. The group's research has been published in the leading specialised journals, both Spanish and international.

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