A CD-based courseware package for the teaching and consolidating of geological field skills

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Abstract

This article explores a CD-based courseware package for the teaching and consolidating of geological field skills used for the interpretation of folding sequences in deformed rocks, focusing on examples from Anglesey in North Wales. The article briefly considers the advantages and disadvantages of virtual field work and then discusses the rationale, structure, development and production of the CD-ROM courseware package.

Introduction

A wealth of information relating to Earth's history, what Holmes (1965) called the 'pages of earth history' may be read by geologists from the rocks and minerals of our planet's crust and mantle. The degree of detail which can be read from the rocks is generally underestimated both by non-scientists and more worryingly, by scientists outside geology. The most powerful interpretation comes from a combination of field-based studies with analytical, computing and remote-sensing techniques based on modern instrumentation and underpinned by the principles of the physical sciences. Field-based studies are therefore absolutely fundamental to the geosciences, as field work supplies raw data for detailed interpretation (e.g. of relative time relations, sedimentary environments, conditions of formation of minerals and ores, etc.) and, on the larger scale, allows the testing of theories proposed as a result of the synthesis of this detailed evidence. Further, these data are potentially invaluable for allowing extrapolation into our planet's future, something which looks ever more important in the context of possible global environmental change. Professional geologists, trained in field skills amongst others, are required to do this work for society.

An important example of a field technique required by professional geologists is the need to erect relative time scales. One of the situations where this arises occurs when we study rocks from the roots of ancient mountain belts. These rocks contain data about the deformation, metamorphism, magmatism, fluid-rock interactions, exhumation and other processes which were involved in the mountain building events. A powerful technique for determining the number and sequence of deformation events uses the overprinting relationships of minor structures (folds, cleavage/schistosity, crenulation fabrics, lineations, veins, faults) in the deformed rocks (e.g. Cosgrove 1980). Once the sequence is determined, it can be used as a structural time scale (e.g. Johnson 1962) and all of the other information (depths, temperatures, intrusion, fluid migration and ore-forming events, etc.) can be related to it. Erecting such time scales, therefore, constitutes an important skill for professional geologists. This is the subject addressed in the CD-ROM discussed below.

How do we teach this skill?

The technique is best taught in the field and illustrated by the University of Derby field course which takes place in Anglesey and is part of the structural geology module for second year Geology undergraduates. This field trip is long established and has been running for twenty years. Since the mid 1980s it has been coordinated by two of the authors, NFCH and JFWS (latterly APW), who have been responsible for developing the teaching materials and approaches which form the basis of the CD-ROM package. Some of the teaching is based on our own research (Hudson and Stowell 1997). The field course is immediately preceded by lectures (APW) setting the scene and is followed by mapmaking and other workshops (e.g. fractal analysis). The field course has no look-see element. It is entirely devoted to the development of interpretation and structural-mapping skills. It has a field-based assessment in which candidates produce a field notebook, from observations on a small group of rock exposures, under examination conditions and in a controlled amount of time.

Field teaching is essential for students intending to be professional geologists; however, students' understanding can be improved by other delivery methods when used in conjunction with field teaching. The CD-ROM package discussed in this paper aims to enhance the learning experience through improvements to pre-field work preparation and field work follow-up studies. The material addressed in the CD-ROM is only a part of the curriculum of field skills taught on the course.

The package will eventually contain three CD-ROMs, which will take three years to develop and test. This article will focus on the first CD-ROM, 'Geological field skills for structural geologists I: interpretation of deformation sequences from minor structures, a virtual field-instruction package based on the rocks of Anglesey, N. Wales'. Its contents include: recognising and differentiating bedding and cleavage, folds, axial-plane cleavage, cleavage fans, lineations and crenulation fabrics. It also covers identifying overprinting relationships of minor structures in deformed rocks including folded cleavages and lineations, refolded folds and refolded crenulation fabrics. Planned for the future are 'Geological field skills for structural geologists II: interpretation of major structural geometry from minor structures' and 'Geological field skills for structural geologists III: use of the stereographic projection'.

Advantages and disadvantages of virtual field learning and teaching (VFLT)

While the pros and cons of VFLT have already been discussed elsewhere (e.g. Stainfield et al. 2000), we consider the main advantages and disadvantages as:

1. improving the efficiency of learning and teaching in the field;
2. relieving pressure on time during field courses through better preparation;
3. relieving pressure on resources by reducing the number of preparatory field days; and
4. informing non-geologists about geological techniques and methods.

It was the first of these that attracted us. The specific advantages for teaching and for informal and formal assessment from our point of view are that VFLT:

1. gives an opportunity to prepare using pictures of actual field trip outcrops;
2. allows graphics and text to be added to photographs of the structures;
3. gives the opportunity for formative practice and testing of field (i.e. close up space) skills; and
4. allows computer-based assessment to be built into the package.

The main disadvantage of VFLT is that development time is quite intensive. The need for planning well in advance cannot be over stressed and the time commitment should be balanced against other competing activities (Research Assessment Exercise (RAE) publications, grant applications and other teaching commitments) before beginning such a project. Some dangers, real or perceived, are that managers might think VFLT replaces field teaching or even replaces staff.

Rationale and structure of the VFLT CD-ROM package

A) The preparation section of the CD-ROM deals with background information setting the geological scene for the field course and presents a bibliography. This material was originally addressed in a pre-field course lecture. Figure 1 shows a touch sensitive map of Anglesey from this section which provides a summary of the geology of the rock units by clicking on each of them. More detail can be obtained for Holy Island where most of the field locations occur, through a second larger-scale touch sensitive map.

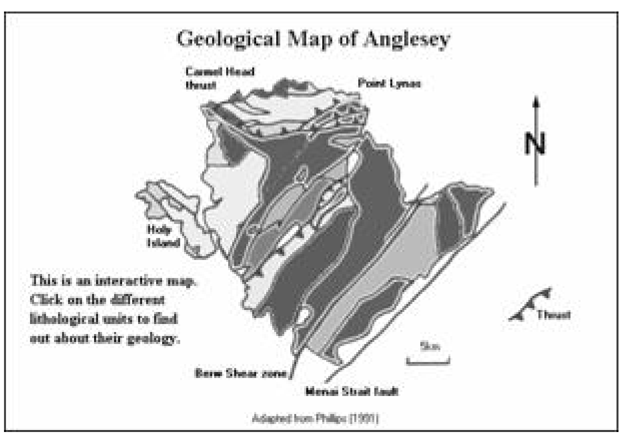

Figure 1. Touch sensitive map from the introductory section

B) Teaching and learning structure of main sections

1) Pre-field work sections are based on key field trip locations and address terminology, identification of particular structures, notation systems and the interpretation of overprinting relationships. Figures 2 and 3 are screen grabs showing an annotated teaching exposure and an example field sketch of that exposure from one of the tutorials. These tutorials build up in difficulty, starting with a location where only one deformation event has occurred and ending with three deformations. They can also be used for revision after the field course.

2) Post-field work sections are based on locations which have not been seen on the field trip. Students can access these via hot spots on maps (Figure 4) to try out their skills and receive feedback from the VFLT package. Tutorials have text entry responses (Figure 5) and label positioning.

3) The pre-assessment section is formative and is based on an *Authorware* quiz format using the built-in question styles (Figure 6) which are quick to program. This tests general knowledge of the appropriate techniques and offers feedback.

C) An assessment section of the VFLT package could be accessed by password on the CD-ROM but it is more likely that we will deliver this across the Web for our own students using our well-tested methods (Mackenzie et al., in press - see next edition of PLANET).

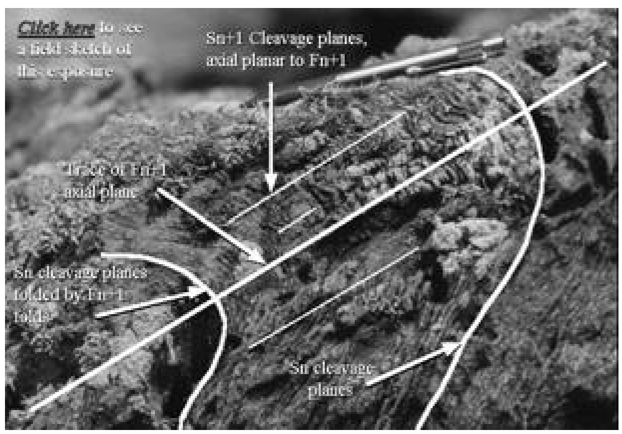

Figure 2. Annotated exposure

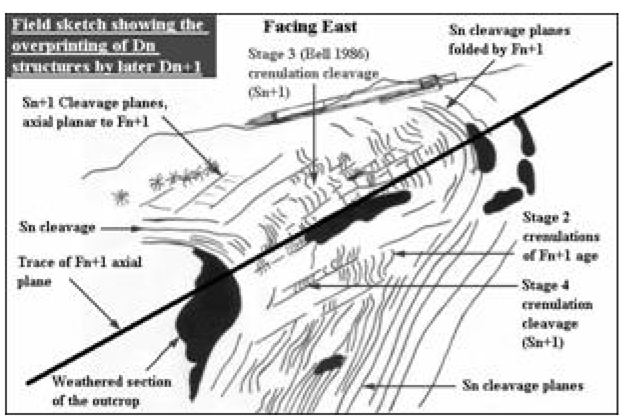

Figure 3. Example field sketch, from the pre-field course section showing the overprinting relationships of the structures

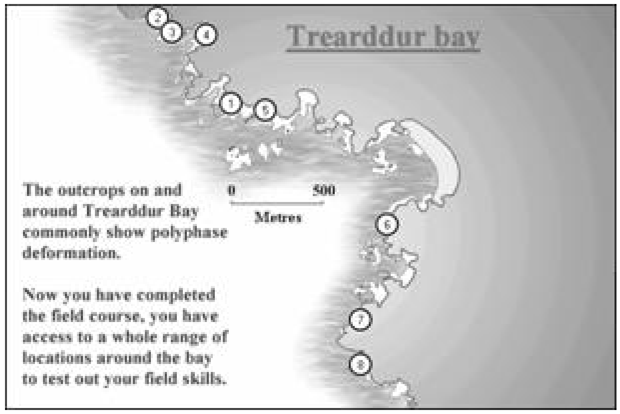

Figure 4. Map with hot spots giving access to the exposures for the post-field course section of which Figure 5 is an example

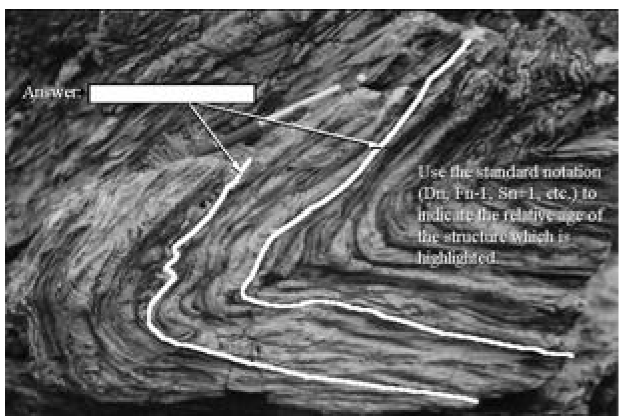

Figure 5. Tutorial with facility for text entry

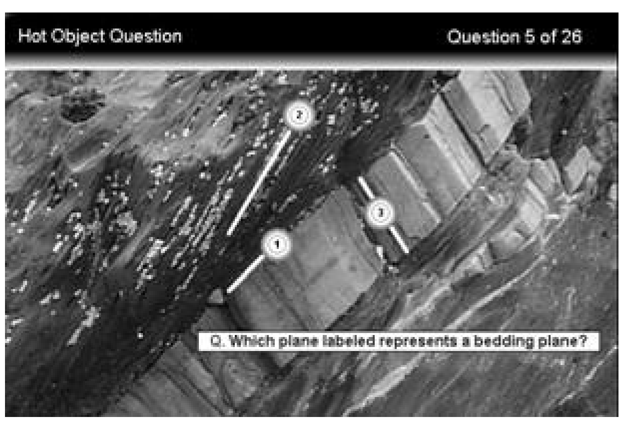

Figure 6. Example question from the pre-assessment quiz

Use of passwords

Pre- and post- field work tutorial sections and the quiz are protected by a series of passwords that must be accumulated by completing the sections. The passwords allow access to progressively more complicated material. The final assessment section can only be accessed by password after the quiz has been completed. The passwords will be generated randomly for each student to avoid them becoming student currency. We have considered using quiz questions instead of passwords to control progressive access to tutorials but rejected this because it can deter weaker students.

Developing and producing the package

We have been considering a package of this type for some years. Initial attempts (by JFWS and NFCH) to produce a teaching video in the early 1990s were unsuccessful when we discovered that the required image quality could not be achieved. Recently, DMM has encouraged undergraduates to undertake BSc projects that involve an element of tutorial production using *Authorware* and in 1999 MS elected to carry out such a project on structures in Anglesey, supervised by DMM and NFCH. The photography, the initial CD-ROM design and the primary programming were carried out by MS. The project involved structural geology, photography, tutorial design and programming and resulted in a project report and a CD-ROM. Feedback was sought at this stage from other students. The CD-ROM proved very illuminating because we had a student's eye view of the learning curve immediately. However, a significant amount of re-ordering, redrawing and reprogramming has been necessary. The following production sequence is based on this experience.

After producing a rationale for the package, as discussed above, the first production step was to carry out individual field work to select the best exposures for demonstrating the structures. It was not possible to do this task whilst simultaneously running the field course. In the event, MS used many of the field trip locations for the teaching sections and chose new ones for the follow-up section. NFCH strongly recommends next writing material in the form of a storyboard as used in the film industry. Each view required is sketched in sequence and given a frame number. The text is written out to the right of each sketch. The designer can then see the whole flow of the tutorial and the material is easily communicated to third parties, such as programmers. Photographs can then be collected specifically for each frame, preferably on an overcast but bright day when the light is diffuse. It is best to have photographs developed whilst you are still in the field as the failure rate can be high. MS began using digital photography but soon found the quality was inadequate and reverted to a SLR camera. Programming is the next step and we recommend *Authorware*, as it is user friendly and therefore efficient in terms of time. The package can then be tested on students who have already been through the course (third year in this case) to obtain feedback prior to full testing. Adjustments will probably still be required.

We believe that this VFLT package will make a significant contribution to our teaching. The package is also designed to 'stand alone' so that it can be used by others. We would be happy to communicate with any potential users and would welcome feedback. It will eventually be available to order through the Centre for Interactive Assessment Development (CIAD) web pages at the University of Derby. We also hope that it might bring some understanding of a small part of field geology to non-geologists through the GEES LTSN subject centre. Finally, we hope that the approach we advocate in this article will be of interest to others, including non-geologists, who are considering producing VFLT packages.

End note

The particular contributions of the authors to the project are indicated in the text by their initials: Smith (MS); Hudson (NFCH); Mackenzie (DMM); Watson (APW); and Gale (JFWS).

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