Linking teaching and research in the undergraduate fieldwork training programme at the University of Adelaide

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Abstract

Fieldwork is recognised as a significant medium through which to link research and teaching in the geosciences. In this short paper, we provide three case studies demonstrating how these links are applied in our undergraduate curriculum. Level 1 geoscience students are introduced to geology research, fieldwork and mapping in complex terrains in an exercise involving grid sketching of small areas of polydeformation and metamorphism. A second study examines the integration of postgraduate research topics and areas with exploration geophysics techniques training in the Adelaide Hills. Finally, the links between consultancy, research and teaching are shown in a programme of exploration drilling for gold in an emerging mineral field in remote South Australia.

The Value of Fieldwork in Linking Teaching and Research

Fieldwork in the earth and environmental sciences is highly valued both as a critical educational element (Kern and Carpenter, 1984, 1986; Locke, 1989;James and Clark,1993) and as a link between teaching and research (Edwards, 2003; McCaffrey et al 2003; Shah and Treby, 2003). Field exercises, tours, excursions and camps allow close encounters between active researchers and their students,often in areas where the current research activity is being carried out. Field teaching is inherently motivating, effective, interesting, enjoyable and rewarding and is valued both by the students (Fuller et al 2003) and by academic staff (Andrews et al 2003).The linking of teaching and research in the field makes both activities more relevant,in that research informs and affects the teaching, and the teaching provides a reality check and critical appraisal of the research.

The University of Adelaide has consistently used local and regional fieldwork and the research activity of its academics as the underpinning rationale for its undergraduate geoscience education programme. From the earliest arrival of Ralph Tate (1840-1901), Professor of Natural Science from 1875, the University teaching programs used local field areas such as the remarkable Permian glaciation and unconformity at Hallett Cove (discovered in 1877), to the spectacular Tertiary cliffs of the coast south of Adelaide and of the Murray River basin, as natural teaching laboratories. The die was cast with Professor Sir Douglas Mawson who inducted Adelaide students and future famous and pioneering academics such as Dr Reg Sprigg,and Professors Alan White and Brian Skinner in the fascination of the Flinders Ranges, the Barrier Ranges and the vast "empty"South Australian desert regions. This took place through much of the first half of the 20th century, while he was actively researching the structure, stratigraphy, petrology and mineralisation of these areas (Cooper, 2000). Reg Sprigg, the well known South Australian explorer, entrepreneur, environmentalist and philanthropist, later highlighted the value of this undergraduate experience by championing the use of field teaching in his noteworthy popular book "Geology is fun" (Sprigg, 1989).

Fieldwork has thus long been a fundamental component of the undergraduate experience at Adelaide at all levels. At stage one, field tours and excursions to local sites of spectacular geology provide the large class sizes an insight into not only the description and classification of geological features and processes, but also the research and scientific methods that must be applied to understand their development. At stages two and three longer excursions introduce students to training in field-based skills and include week-long field geological, geomorphological and regolith mapping camps, where integration of geoscience processes is learnt.Almost all of these field activities occur in areas where the academic staff who lead and teach on the excursions are engaged in active research either through final-year dissertations or postgraduate projects. The three following fieldwork examples show where the links between research and teaching are most closely developed in the undergraduate training programme.

Stage 1 Introduction to Geological Mapping

In the early part (Semester 1) of the stage 1 geoscience training, students are taken on a weekend introductory camp to the southern Yorke Peninsula,about 250km southwest of Adelaide. This is the closest site to Adelaide where complex Palaeoproterozoic basement gneisses are exposed along a narrow shore platform at a safe, local fishing and tourist site called Corny Point.This area lies at the eastern margin of the Proterozoic Gawler Craton of South Australia and is the subject of considerable research interest into the isotopic age and origin of the approximately 1900-2000 Ma Corny Point paragneisses and their complex tectono-metamorphic evolution during the early stages of the Kimban Orogeny at 1845 Ma (Zhang and Fanning, 2001). The rock exposures are subhorizontal, flat, bare and water-washed with 100% outcropping sheets of tens of meters square. These outcrops reveal an array of layered metasedimentary (para-) and massive metaigneous (ortho-) gneisses with intrusive, amphibolite, aplite and pegmatite veins, migmatite lenses and folded intense foliations. The geology is polymetamorphic and multiply deformed, but although the area as a whole is very complex, on a small scale simple concepts and relationships are revealed.

Through a carefully staged training exercise in very detailed grid mapping, the students gain their first experience of a variety of geological concepts (e.g. field relationships, lithological description, intrusive contacts, folding), whilst learning the skills of both observation and field sketching (for a detailed description of the exercise see James and Clark, 1993).The students work alone, though as part of a loose group of 6-8 peers, together with a tutor. As the geology is complex, mapping is carried out on a very small area, which is redefined (and enlarged) during the exercise. Initially, a 1m by 1m square outline box is drawn with chalk on the surface outcrop (Plate 1). At this stage, students begin sketching on a piece of otherwise blank graph paper. Drawing the box as a 5cm by 5cm square in the middle of the graph paper introduces the concepts of scale (1:20) and orientation.While the students are sketching the principal geologic features (boundaries, folds, discordant sheets etc), and transferring the details into the box, the tutor enlarges the area by chalking in the surrounding eight 1m squares, which the students then progressively sketch.

Within about one hour, a simple (but inherently complex) geological map, is produced by each student. Comparisons between the sketches and the outcrop can be made and discussed immediately, and if necessary, a photograph can be taken of the whole area (3m by 3m). Students produce copies of the maps in later laboratory sessions, and write a short report including some rock descriptions made from samples collected during the excursion, and are also encouraged to read the current literature concerning research on the area. Students have been surveyed as to their attitude and generally agree that such field exercises improve their understanding of geological relationships, their confidence at producing results in the field, and their interest in Earth Science research in general.The short time needed to produce a map at an early part of their course is a significant benefit, as is the relative accuracy of the result caused by the use of such a small base map and the graph paper.This exercise has now been used successfully for more than ten years in the degree program.

Plate 1. Folded and foliated migmatised Corny Point paragneisses with a 1m square mapping grid outlined in chalk

Plate 2. The Herrmann's Catchment area with, from left to right in the foreground, an MSc and a PhD student with Lecturer Graham Heinson (bending) showing calibration of an EM 38 conductivity meter to interested undergraduate students. Note the recent Eucalyptus plantation in the revegetated creek area planted to overcome transient salinity.

Stage 3 Mineral and Environmental Geophysics field training in Pedo-Geophysics in the Adelaide Hills

A more recent innovation in using fieldwork to link teaching and research has been trialled for the first time in 2003 in the Mineral and Environmental Geophysics stage 3 course. The Herrmann's Catchment, an important field locality in the Adelaide Hills,is currently the research area of two University of Adelaide CRC LEME (Cooperative Research Centre for Landscape Environments and Mineral Exploration) -funded PhD students,and is being used to train undergraduate students in field geophysical techniques and exploration.

Herrmann's catchment is about 40 km northeast of Adelaide. The field-site geology hosts Cambrian massive sulphide mineralisation and a variety of related environmental problems, principally salinity, acid drainage and acid sulphate soils (Fitzpatrick et al 2003). The two PhD students who work in the area are Andrew Baker, an isotope geochemist mapping mineral pathways through cover sequences, and Mark Thomas, who is working on transient salinity effects using geophysics to map areas susceptible to salinity.

In May 2003, eighteen undergraduate students designed and carried out a geophysical investigation (Plate 2) to address some of the fundamental regolith issues in Herrmann's catchment, which had previously been defined within the research aims of the postgraduate student projects. In terms of environmental objectives these included the definition of near-surface hydraulic structure, mapping of clay concentrations, the identification of salinity pathways and areas of transient salinity and the relationship of geophysical signatures to pedological information. Mineralisation identification included definition of depth to basement, location of sulphides, fracture orientation as potential pathways for fluid flow and aquifer structure (Skwarnecki et al 2002).

Nine different geophysical techniques were carried out along profiles across the catchment including DC resistivity and induced polarisation (IP), seismic refractions, gravity, magnetics, magnetic susceptibility, electromagnetics (EM), self potential (SP) and elevation. Initial results of the surveys were very exciting for the postgraduate researchers as well as the undergraduate students. The most interesting features discovered were short-wavelength (< 20 m), but very highly magnetic responses within the valley. Such magnetic signatures are due to maghaemite concentrations, probably concentrated in palaeochannels within the valley. The source of maghaemite is likely to be colluvial accumulations after bushfires on the slopes of the valley. Similar morphologies in the magnetic signatures may indicate a meandering of the palaeochannels. There was also a clear correlation between the magnetic susceptibility from maghemite and electrical conductivity from salts and/or clays in the valley palaeochannels and the results show that high-resolution ground geophysical methods can be used to map regolith environmental systems and act as a proxy for soil toposequence processes.

Mapping mineralisation beneath cover was the second series of objectives. Locating sulphide mineralisation at the head the catchment is important in determining the controls on formation of acid sulphate soils, and sources of acid drainage. The resistivity and IP surveys found clear evidence for sulphides in basement beneath cover and although the formations have been drilled previously, profiles collected in one afternoon at very low cost, provided considerable extra detail on the depth and extent of the sulphides.

The Herrmann's catchment field geophysics has been valuable as a combined teaching and research exercise. Students were presented with real CRC LEME exploration and environmental problems, and developed field data collections to address some of the issues. The students developed teamwork skills and gained a better understanding of the importance of integrating geophysical, geological and geochemical constraints. For the LEME postgraduate researchers, the teamwork effort of the students provided new data and models that would have been time-consuming to achieve otherwise.

Stage 3 Economic Geology Gold Exploration Drilling Programme

The final example where research and teaching are being linked in the undergraduate geoscience education programme at the University of Adelaide is at the time of writing yet to take place, but is in the last stages of planning.In September 2003 twenty five students in the stage 3 Mineral Deposits course will be undertaking a week-long exploration drilling programme around the Barnes prospect in the newly named Central Gawler Gold (CGG) Province of South Australia (Ferris and Schwarz,2003),some 600km west of Adelaide.The Proterozoic Gawler Craton of South Australia contains the world class Cu-Au-U Olympic Dam mineral deposit, the newly opened Challenger gold deposit and many new and emerging gold prospects and targets. It is thus the site of intense research and exploration activity, much of which is being carried out by State and Federal geoscience organizations (Primary Industries and Resources South Australia and Geoscience Australia), mining and consultancy companies, research organizations (CRC LEME and CSIRO Exploration and Mining) and academic researchers.

Much of the research activity has been fuelled by the high-resolution geophysical (airborne magnetics, gravity, radiometric and spectral) surveys, and the success of geochemical sampling focused around using the widespread surficial calcretes as surrogates for buried basement mineralisation. The Barnes Gold Project (Drown, 2003) is a recently discovered gold prospect, where Adelaide Resources Limited have drilled a blind bedrock-hosted gold mineralisation target beneath a gold-in-calcrete geochemical anomaly (Plate 3). Company drilling so far has revealed mineralisation associated with phyllic and propylitic alteration, and quartz vein systems with significant gold intersections, including an 8m interval at 2.97 g/t and a maximum published intercept of 2m at 67.6 g/t gold.

Plate 3. Company drilling operations at the Barnes Gold Project. Photograph and copyright provided courtesy of Adelaide Resources Limited

The CGG Province is thus in the midst of an emerging resources boom and gold rush. Students on the excursion will work with the most modern and up-to-date research and exploration data.They will plan and carry out a variety of drilling and sampling procedures using a rotary diamond drill rig and percussion drill.Further definition and resolution of the gold-in-calcrete anomaly and its extension beneath transported and surficial colluvium and dune deposits will be investigated. As well as conducting the drilling and sampling, they will return the samples to the laboratory for assay and analysis, and it is hoped that many of them will continue to further study (Honours), research (Postgraduate) or exploration (company) within industry on related projects.

Conclusions

The University of Adelaide is developing and implementing innovative field-based strategies to further embed the research ethos into its undergraduate geoscience training programmes. Negative factors including time, cost and safety must be balanced against the significant advantages of supporting such a vigorous field programme. However, we feel that this is a powerful way of linking teaching with research in the department.

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