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978-0-521-63555-4 - Exploring Geology on the Isle of Arran: A Set of Field Exercises that Introduce the Practical Skills of Geological Science

C. J. Nicholas

Excerpt

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Part 1

An introduction to the field work

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1 About the exercises

The exercises in this book are based as far as possible on the geology that can be seen in the field in order to keep specialised knowledge to a minimum. Because of this it is intended that they can be attempted by any enthusiast with an elementary knowledge of geology. Typically the geological content in the field exercises is at a level that would cover A-level to first/second year single or combined honours undergraduate courses.

WHAT YOU ALREADY NEED TO KNOW

To keep this book small enough to be useable in the field it is not possible to provide background information on all the topics touched upon during the exercises. Indeed, its real purpose is to put into practice what can be learnt indoors. So although specific ideas involved in each exercise are explained before field work commences, it must be assumed that the user of this book has at least a very basic prior knowledge of geological processes and principles. However, below is a brief guide to what this knowledge should perhaps include.

- 1 An awareness of relative and absolute geological time scales.
- 2 A grasp of the concepts behind plate tectonics and the internal structure of the Earth.
- 3 An idea of where magma originates and how it might produce intrusive and extrusive igneous rocks.
- 4 An awareness of basic structures such as faults, folds and how they might form.
- 5 Some idea of the processes at work in modern-day marine, fluvial, glacial and aeolian sedimentary environments.
- 6 Some experience of identifying invertebrate fossil groups and interpreting their mode of life.
- 7 An awareness of at least some of the more common rock-forming minerals in hand specimen. Ideally this should include quartz, feldspars (alkali and plagioclase), micas (biotite and muscovite), pyroxenes, amphiboles, olivine and calcite.
- 8 Some experience of outdoor activities and basic skills such as how to take and read grid references, how to navigate from a topographic map and how a magnetic compass works.

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THE STAR RATING SYSTEM (*)

Each field exercise has been allocated a star, or number of stars. This is intended to show the user at a glance how difficult the exercise is likely to be. The 'difficulty' can be thought of as a combination of three factors:

- 1 The complexity of the geological concept(s) behind the exercise.
- 2 The subtlety and detailed nature of the field observation and interpretation needed.
- 3 The overall time and effort that an exercise requires to complete.

The exercises become more complex in a practical sense from numbers 1 to 5, requiring additional and more varied skills in the *collection* of field data. From exercises 6 to 10, the emphasis changes to the *interpretation* of field data and this increases the intellectual demand. Therefore, the stars allocated to exercises reflect this relative measure of difficulty within the confines of the book.

EXERCISE FORMAT

Ideally geological field work should be a logical, thorough and objective exercise in data collection, concluding with an interpretation of the evidence. Typically the data will be in the form of observational evidence or structural measurements and so maintaining impartiality can be a problem. However, when conducted effectively, field work still maintains a central role in the geological sciences of today and can often be the only means of understanding data generated later in the laboratory.

Learning how to order thoughts and ask the right questions in the field is difficult and is generally taught by 'trial and error'. The problem is addressed in this book by each exercise setting a specific aim or '*Task*'. Subsequent instructions are geared towards what needs to be investigated in order to solve the problem or achieve that task. Consequently, the layout of all exercises is designed to show the beginner how to approach field work in a number of different situations, what to look for and what sort of questions they should be using the rocks to answer before drawing a conclusion from the work. Below is a guide to this format; all exercises are arranged in the same way.

1 Title (*exercise name*). Each exercise has a title followed by its approximate location on the island in brackets. Titles for the first five provide an immediate idea of the broad subject of the geological sciences involved in the field work. The last five exercises have headings that reflect the theme behind each.

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2 Task (*what is the point of the exercise?*). This is the aim of the exercise and is stated as briefly as possible.

3 Logistics (*where is it set and how do I get there?*). Each exercise has a 'Start Point'; in all cases this is either a car park or lay-by on the main road that circumnavigates the island (A841) or the central road known as the 'String' (B880). Also, these are all at or within walking distance of a bus stop. Instructions about how to get onto the exercise area and find the first locality begin from this point and it is a useful rendezvous at the end of the day. The remainder of the comments in this section describe how to find the exercise area on the map and where the nearest village is, and then finally there are directions off the road to begin work.

4 Length (*how long will it take?*). This gives a total recommended time to be spent on the exercise, including getting from and then returning to the 'Start Point'. There is also a breakdown of the time spent walking to the first locality and then back at the end.

5 Field skills required (*what will I have to use to do it?*). The field skills taught for the first time or re-used in the exercise are given in square brackets. Each is numbered in order of its appearance in the book and can be found described in Part 4. Skills that are being met for the first time are in bold type, whereas those previously introduced are written in plain type.

6 Background information (*the theme, or, why do the exercise?*). Any further information that may be useful to know before beginning the field work is laid out in this section. For the first five exercises (Part 2) this consists of relatively brief comments on the geological processes and principles to be encountered. However, this section in exercises of Part 3 will explain the background to the task in hand, often expanding on the theories or concepts explored during the field work, and so it is vital to read this before proceeding. This section should also help any decisions about choice of exercise if they are being attempted in a different order from that given.

7 The Field Exercise (*how do I go about the field work?*). This is the main part of each exercise and contains full instructions for the field work. It begins by listing a series of steps that, when followed, should lead to a solution of the problem or achieve the task set.

The instructions then continue by leading the user through each major step in field work at a time. Included in these steps are questions that should be answered using field observation and interpretation. The answers should be written in the blank field note pages provided at the back of each exercise

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before moving on to the next question. Any work-sheets or base maps needed are included in this section and should be annotated as required.

In order to keep the exercise instructions simple and uncluttered, practical field skills and geological terms are not explained or expanded upon in this section unless they are particularly critical to the understanding of the concepts behind the exercise. Those familiar with them can proceed about the work without delay, whilst any who are unfamiliar with the techniques or terms will find them explained at the back of the book in either Part 4 or the Glossary respectively.

8 Help! (*which localities or features should be seen during the field work?*).

This is not an *answers* section as such, but it does point the user of this book in the right direction if the clouds of confusion have well and truly descended. The contents of this section will vary depending on the exercise. For instance, it may be photographs and locations of vital outcrops that provide key evidence, or descriptions of features that, when considered together, will point towards a particular solution to a task. It may be that after consulting the 'Help!' section some localities have to be revisited.

'Help!' is only provided for the more complicated exercises (those with *** or more), but solutions to most practical problems for any of the ten exercises can be found in Part 4. It is worth remembering that this deals with a variety of geological features that might be encountered on Arran. So if problems are being encountered in interpretation of some structure for instance, it may be that it is described in Part 4 somewhere.

To print a full set of answers to each exercise alongside the questions would destroy one of the primary aims of this book, which is that the users discover the geological field evidence for themselves. But the book is deliberately constructed so that if the text is read carefully, the rocks are examined in detail and the field skills are referred to where indicated; then hopefully the user will be guided towards a geologically acceptable solution. Ultimately, this will depend on what has been seen and what is made of it. Therefore, the philosophy behind this book is not for the user to search in vain for 'the right answer', but for them to learn how to reach a scientific solution that others will accept. Finally, if sleep is still being lost weeks after returning from the Isle, then the author can be contacted *c/o* the Editor (Physical Sciences), Publishing Division, Cambridge University Press, the Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU.

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2 Equipment

All exercises require the same basic equipment outlined below. It is best to go fully equipped to Arran, but there are shops in Brodick where most of this can be bought if vital items are forgotten or lost during field work.

ESSENTIAL OUTDOOR EQUIPMENT (*You will need to wear or carry these items at all times*)

- 1 Walking boots with non-slip 'Vibram' soles. Wellington boots can be used ('Hunter' wellies are particularly good); but be aware that they can slip easily on wet rocks.
- 2 Lightweight trousers to walk in; 'tracksuit' trousers are fine but not jeans; they hasten the onset of hypothermia when wet.
3. Waterproof jacket and trousers; these days 'Goretex' fabrics are popular, but they are expensive and jagged rocks have no respect for how much your clothes cost.
4. Spare jumper, gloves and hat. Synthetic 'fleece' jackets, etc., are particularly warm but are generally not wind-proof.
- 5 Small first aid kit.
- 6 Emergency polythene survival bag, whistle and torch.
- 7 High energy food (chocolate bars!) and drink (at least 1 litre, preferably with sugar in it).
- 8 1:25 000 Ordnance Survey Leisure map, Isle of Arran (yellow cover). Whilst the maps drawn in this book are as accurate as possible, they only show relatively small areas and it is easy to walk off them. Therefore, it is vital to carry this large-scale map of the whole island at all times.

ESSENTIAL GEOLOGICAL EQUIPMENT (*You will need the first four items for all exercises*)

- 1 Hand lens (10× or 15× magnification is best).
- 2 Compass–clinometer (Silva or Suunto models are student-priced). If you cannot afford one, you can buy a compass quite cheaply and make your own clinometer (see Part 4, field skill [10]).
- 3 Pencils (a propelling 0.5 mm HB and a range of coloured pencils) and drawing pens (Pilot or Edding disposable 0.1 mm pigment ink pens are cheap and excellent).

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4 Penknife for hardness tests (any small blade will do, or you can improvise with the side of a metal hand lens).

Optional extras:

5 Calculator.

6 Hard hat (advisable if working near any cliffs or overhangs).

7 A geological hammer may be of occasional use, but the sad truth is that a freshly hammered surface can now be found on almost every outcrop on Arran so please do not add to this erosion.

8 Small bottle of 10% hydrochloric acid (as a test for the presence of calcium carbonate).

9 Small (5 m) retractable metal tape measure.

10 Camera and colour print film (200 ASA or faster).

11 1:50 000 Geological map of Arran (1987) (available from British Geological Survey, Keyworth, Nottinghamshire, NG12 5GG).

12 British Museum (Natural History) Handbook, *British Palaeozoic Fossils*.

3 Safety

Personal safety and that of other members in a group is of paramount importance in field work. No exercise in this book is located in a particularly dangerous or isolated area, yet accidents can and will still happen if appropriate precautions are not taken. For instance, do not go into the field alone. This book can be used perfectly well in a pair or a small group and if anything it is more rewarding to discuss field observations and their interpretation with others at the time that they are made.

Each member of a field party should be aware of basic mountain skills and safety before going to Arran. These are laid out clearly in the booklet *Safety on Mountains: An Approach to Mountain Adventure for Beginners* (1988), published by the British Mountaineering Council, Crawford House, Precinct Centre, Booth Street East, Manchester, M13 9RZ. In addition, anyone taking a group of students to Arran as a field course should obtain and comply with the Committee of Heads of University Geoscience Departments (CHUGD) pamphlet *Safety in Geoscience Fieldwork: Precautions, Procedures and Documentation* (1994), available from the Geological Society, Burlington House, Piccadilly, London, W1V 0JU.

There is not sufficient space here to discuss all of the points raised in these two publications, but those principal hazards which might be

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encountered during geological field work on Arran are outlined below (these are drawn from the CHUGD pamphlet).

COMMON OUTDOOR HAZARDS

- 1 Lack of adequate equipment. Always carry a compass, map, simple first aid kit and survival bag. Wear proper boots and *not* shoes.
- 2 Lack of adequate clothing. The weather on Arran at any time of year is variable to say the least. The temperature can drop sharply if you walk into cloud, or if the wind picks up. Getting wet will have the same effect, so wet and windy conditions are the fastest way to get hypothermia. Carry some spare, dry clothing in case.
- 3 Isolation. Never go into the field alone. Common injuries such as a sprained ankle could easily require help to get down to the main road or the nearest house. It has already been stated that the exercises in this book should be attempted in pairs. Even so, it is still important to make sure that someone knows the days' itinerary and the expected time of return.
- 4 Illness and allergies. It is important to be aware that some illnesses, allergies or disabilities may prove hazardous in potentially cold mountain terrain. Ask your doctor if you are in any doubt.

POSSIBLE HAZARDS IN FIELD WORK ON ARRAN (*With exercises where this hazard is most likely to be encountered*)

- 1 Steep, unstable or slippery rocks such as cliffs (exercise 10), screes (exercises 6, 7, 10) and intertidal areas with seaweed-covered boulders (exercises 3, 4, 6, 8, 10).
- 2 Falling rocks. Be particularly careful under any overhangs or near cliffs. A hard hat should be worn in any such areas (exercises 6, 10).
- 3 Disused mines, quarries and caves. Never enter any of these under any circumstances (exercises 5, 6).
- 4 Rapid changes in the local weather, which are particularly common in the upland areas on Arran and may include sudden loss of visibility and falling temperatures (exercises 1, 5, 7, 9).
- 5 Hypothermia. This can be from inadequate clothing, getting wet, high winds, exhaustion, or a combination of these factors. It could apply to any exercise, but particularly the longer ones (exercises 9 and 10).
- 6 Bogs. They often look like solid ground but can be over 1 m deep. Always test the ground ahead before shifting your body weight forward in a boggy area (exercises 1, 5, 9).

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10

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- 7 Mountain streams. They have more energy than you think. Always use a bridge to cross them. A glance at the large boulders in the stream bed should demonstrate the potential energy of a mountain river in flood (exercises 1, 5, 7, 9).
- 8 Tides. Purchase or check a tide timetable (available from bookshops/newsagents on Arran; for instance 'Brodict Books' near the ferry terminal). Always be aware of the state of the tide and avoid isolated promontories and headlands when it is coming in (exercises 3, 4, and *especially* 8).
- 9 Waves. Stormy weather can cause freak waves, so avoid standing right at the waters' edge on coastal sections (exercises 2, 3, 4, 6, 8, 10).

Finally, it is up to the user of this book to decide whether a situation is potentially dangerous. The author accepts no liability for any injury incurred whilst in pursuit of field work using this book.

4 Logistics and itinerary

The Isle of Arran is a fifty-five minute ferry journey from Ardrossan harbour on the mainland Ayrshire coast. There are five regular daily sailings Monday to Saturday (but only four on Sundays) and the ferry can carry coaches as well as minibuses and cars (vehicles should be booked in advance with Caledonian MacBrayne Ltd, The Ferry Terminal, Gourock PA19 1QP). Foot passenger tickets can be bought at the harbour terminal before boarding. Ardrossan harbour is served by a rail-link to Glasgow Central Station (the journey time is just over an hour).

The ferry arrives at Brodict on the east coast of Arran where there is also a bus station. The local bus routes regularly serve all of the villages closest to the exercise areas in this book such as Corrie, Sannox, Lochranza, Catacol, Pirnmill, Machrie and Blackwaterfoot. Details of where to stay on Arran and a bus time-table can be obtained from the tourist information centre located at the Brodict ferry terminal (Isle of Arran Tourist Board, Tourist Information Office, Brodict, Isle of Arran KA27 8AU). At the time of going to press there were three main bus routes on the island: one around the north of the island, one around the south and one over the String road in the centre. These are supplemented by the post bus (which can carry some passengers).

Figure (i) shows the simplified geology of Arran and the location of each field exercise area with its proximity to the nearest village and bus route. For

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the age and stratigraphic relationship of each unit see Figure (ii). Exercises in this book are arranged so that all ten can be attempted in sequence over the course of about seven days. The timings for each exercise are only suggested and need to be flexible if public transport is used on the island. However, if two are attempted in order each day until exercise 9 then the morning and afternoon's work should complement or contrast to give some variety to the day. These pairs are also arranged to keep a minimum of journey time between them. Below is a suggested itinerary for attempting all ten exercises during a week on Arran using public transport.

NIS 324 = North Island bus service, SIS 323 = South Island bus service, S322 = String road bus service. In addition, all exercise areas can be reached using the Post Bus.

Day 1 *NIS 324 to Sannox*

am: 1. Present day processes *

walk or NIS 324 Sannox to Corrie

pm: 2. Clastic sedimentary rocks *

Day 2 *NIS 324/S322 to Machrie*

am: 3. Intrusive igneous rocks *

NIS 324 Machrie to Catacol

pm: 4. Changing the record: metamorphism and deformation **

Day 3 *NIS 324 to Sannox*

am: 5. 3-D Thinking in time and space **

walk or NIS 324 Sannox to Corrie

pm: 6. Cuvier's catastrophies ***

Day 4 *NIS 324 / SIS 323 / S322 to Heritage Museum*

am: 7. Prof. Speyside's theory ***

NIS 324 Heritage Museum to Catacol

pm: 8. The curious case of 'Catacol cairn' ***

Day 5 *NIS 324 to Sannox*

am and pm: 9. Dr Hutton's dilemma ****

Day 6 *NIS 324 to Sannox*

am: 9. Dr Hutton's dilemma ****

NIS 324 Sannox to Blackwaterfoot

pm: 10. Pluto's revenge ****

Day 7 *NIS 324 / SIS 323 / S322 to Blackwaterfoot*

am and pm: 10. Pluto's revenge ****