CHAPTER 1

Introduction to Field Geology

It is late morning on a crystal clear day in the Livingstone Range of the Canadian Rockies, and you have traversed uphill over the past several hours through a sequence of well-bedded sedimentary units. You have determined that you are moving up section through the units towards younger strata, and that the layers all **dip** in the same direction. As you catch your breath at the top of a ridge and admire the view, you notice that the dip of the layers has reversed. A great discussion ensues between the members of your field party concerning possible reasons for the dip reversal (Figure 1.1). What is going on geologically? Is there a **fold**? Have you crossed a **fault**? Can you constrain the timing of the deformational event that caused the dip reversal? Many ideas are suggested to account for the dip reversal, and there is no consensus. How, then, do you resolve the problem? After some discussion, the group concludes that there are several feasible interpretations, and several possible directions to travel to sort out the fold versus fault question. After a snack, you and your mapping partner set off in one direction, while other mapping teams head off on other routes to see if they can resolve the problem.*

The previous example highlights the use of the **scientific method** to solve field problems. You make careful observations of geologic relationships, record them accurately in your field notebook, develop ideas (hypotheses) about the stratigraphy and structure of an area, and set about testing those ideas. Finally, you must create a **geologic map** that accurately portrays your observational data and your resulting interpretations.

Now imagine that you have been hired for the summer as a geological field assistant. This will likely be your first job in geology, and you are understandably anxious about what challenges await you over the summer. You have completed a couple of years towards a university degree in geology. A fundamental course background in geology has prepared you for this summer job. If you perform well,

* If you are wondering how the problem in the Livingstone Range was resolved, further observations and measurements demonstrated that the dip reversal was due to the presence of a syncline.

Figure 1-1

Discussing a field geology problem in the Livingstone Range, Canadian Rockies.

you might even be asked to stay on part-time with your employer over the university year to continue working on the project. Certainly, a period of experience working in the field will make you much more marketable in the future. But what will you do every day in the field? What will be expected of you? This book will help you to answer those questions.

It is difficult to describe a typical day in the field because there is such a range of possible projects to be involved in, all with different objectives. On any given day you might hike a great distance, moving up and down over mountains, or you could be delivered directly to a targeted area by a helicopter. You might create a geologic map by measuring **strikes and dips** in folded layers and plotting geologic contacts, or use an existing geologic map to locate and sample rocks or sediments for chemical analysis. There may be logistical challenges associated with the weather, terrain, or wildlife. In the evening, you will be reviewing what you did that day, updating your map and notes, perhaps packaging samples for shipping, and discussing your observations and questions with other geologists, as well as preparing for the next day in the field.

The main focus of this book is on standard methods of doing geology in the field, including digital techniques used during field work and for map production. In addition, there is brief coverage of several subsurface techniques that supplement traditional mapping methods.

WHAT IS FIELD GEOLOGY AND WHY IS IT IMPORTANT?

Field geology involves integrating spatial, descriptive, structural, petrologic, and temporal data to understand the geological makeup and history of an area. Geologic maps, **cross sections**, and written reports of an area are the tangible results of this synthesis. Many field geology projects focus primarily on making geologic maps. However, other field tasks include sampling of rock types for specific reasons (e.g., elemental analysis, geochronology, fossil identification), measuring the orientation of particular structures in an area, or describing the core at a drill site.

Geologic maps are used to guide the search for mineral and energy resources, to assess and mitigate potential natural hazards, and to assist in land use planning. A geologic map is the clearest and most concise way to communicate geologic information about a portion of Earth's surface; it represents an interpretation by the author(s), based on data available at the time of publication, as to the nature of and spatial distribution of rock units in an area. Standardized symbols, patterns, and colours are used to depict rock units, their ages, structures, and important localities, such as fossil and mineral occurrences. Any cross sections and geological reports that accompany a geologic map represent additional ways of presenting geologic data and interpretations.

Field data are commonly incomplete, and can be interpreted in more than one way. Taking the purpose of a mapping project, the budget, and the time allotted to the project into account, you have to come up with your best interpretation of the geology based on available data, and you must trust your own observations and conclusions. In some cases, there is no single correct answer to a field problem. Successful completion of field projects builds self-esteem, decision-making capability, and other professional skills. All geoscientists, even experimentalists and theoreticians, need to have some basic field geology experience.

WHAT MAKES A SUCCESSFUL FIELD GEOLOGIST?

Table 1.1 lists some of the attributes that government geological surveys, mineral exploration companies, oil and gas exploration companies, and environmental and engineering consulting firms seek in a potential field geologist.

A successful field geologist is a multi-tasking "jack of all trades" who has a firm grasp of geological principles, but also has a number of supplementary skills, such as being well-organized, possessing common sense, and having the ability to maintain a positive attitude in numerous situations. He or she realizes that thorough preparation before a project commences, including becoming familiar with previous work in the area and talking to others who have worked there, is as important as doing the field work. A field geologist must have excellent observational skills, have the ability to take accurate measurements and estimate lengths and quantities, and have at least some background in petrology and mineralogy, structural geology, geomorphology, stratigraphy, and paleontology. The ability to translate a three-dimensional representation of map data into a cross section and the capacity to write technical reports are also vital parts of a field geologist's repertoire.

Digital maps and associated databases that store large amounts of geological data in layers (see Chapter 12) are now standard in the professional workplace, and make it

Table 1.1

WHAT EMPLOYERS WANT YOU TO KNOW ABOUT FIELD GEOLOGY

How to read a topographic map or air photo and locate yourself
Pace and compass skills
Use of Brunton or Silva compass for measuring linear and planar structures
How to locate by compass resection
Use of portable GPS receivers, and knowledge of their limitations
Know how to locate and plot geologic data accurately on a geologic map or air photo
Ability to recognize and measure sedimentary structures, structural features (folds, faults — sense of movement, lineations, foliations; use of stereonet)
How to measure a stratigraphic section (use of Jacob's staff or pogo stick)
Rock identification skills (hand sample and thin section; fresh and altered rocks; mineralized assemblages)
Ability to take organized, coherent, and legible notes
Ability to collect properly trimmed rock and fossil specimens; ability to recognize the appropriate rock to sample depending on the purpose (e.g., microfossil age determination, radiometric age determination — which accessory minerals for which dating technique, alteration assemblages)
Ability to visualize and think in three dimensions
Some familiarity with mapping software, but no particular programs as they evolve so rapidly; we will teach you our system
Ability to independently plan, execute, and accurately plot the results of a traverse
Ability to synthesize data into the big picture; to recognize what are the most important geological observations in an area, depending on the problem to be solved
Ability to write reports in a timely manner; write reports that are complete yet concise
Field safety
Have a positive attitude (every day, in all conditions, on all projects)

Based on a survey of government, industry, and consulting firms who hire field geologists conducted by M.L. Bevier in Vancouver, British Columbia, 1994.

possible for anyone to create derivative or thematic maps by selectively querying a database. Today's student needs to be able to integrate traditional mapping techniques with digital data capture and manipulation. However, the employer responses listed in Table 1.1 suggest that your ability to rise to the particular challenges of a specific field project, be they scientific, personal, or logistical, is more important to employers than the fact that you are particularly familiar with a specific computer mapping program that might be superseded in the near future (although that skill will be a bonus).

Heath (2000, 2002) surveyed geoscience employers for the most important technical and non-technical skills that they want to have in their employees. Results of a similar survey, specifically applicable to the petroleum geology industry, are available on line at http://www.aapg.org/education/vgp/survey.cfm.

HOW DO YOU LEARN FIELD GEOLOGY?

To be a successful field geologist, you must gain practical experience in a variety of rock assemblages, terrains, and climates. There is great satisfaction involved in producing a map that shows the distribution of rock units and structures in an area, especially after you have hiked over most of it. Field work can be an exasperating business — it is normal to be frustrated on some occasions because there is not necessarily a simple answer to a field problem. There is only your best interpretation, based on available data and your geologic knowledge.

The major change in field geology over the 1990s and into the 21st century is the increased use of digital methods for recording data, producing geologic maps, and selectively querying map data, but geologists continue to traverse, describe strata, measure structures, and enjoy (or endure) the weather and the terrain. A good geologic map still depends mainly on the skills of the field geologist who makes it, and not on flashy graphics or presentation.

For background, you need a combination of specific courses in sub-disciplines of geology, such as mineralogy, petrology, structural geology, and geomorphology, but you must also have basic outdoor skills and a lot of common sense. Above all, you need to be comfortable working with incomplete data sets because a successful field geologist is a generalist who can synthesize a vast amount of seemingly disparate data into a coherent and reasonable geological interpretation of an area.

Your first geologic maps are unlikely to be works of art. You may have gaps in your data that you do not know how to deal with, but you will still have to make geologically reasonable interpretations that are consistent with available data to finish your map by a deadline. With more and varied experience, and critiques from mentors, your skills at describing rocks and field relationships, at measuring structures, and at interpreting complex data sets will improve, and so will the geologic maps that you generate.

FIELD SAFETY AND ETIQUETTE

Heat exhaustion, a serious cut requiring stitches, influenza, an infected spider bite, and a twisted ankle — these are examples of maladies suffered by students in the field that have necessitated visits to the emergency ward. Students have been killed in the field by slipping off the tops of cliffs or by drowning in rivers and lakes. Vehicle accidents while travelling to and from the field have also caused injury and loss of life. Although you may not be able to avoid every emergency, many field mishaps can be prevented with careful planning and attention to safety procedures (Appendix A). These procedures cover field work, camp life, and travel to and from a field area, and should be read in detail. Adhering to them will make field work a safe and enjoyable experience for all involved.

Distinct from safety but just as important is field etiquette, which includes topics such as environmental impact, personal behaviour, obtaining permission to access private property, and proper field sanitation (Appendix B). Always remember that you are an ambassador for the profession every time that you go into the field, and act accordingly.

CHAPTER SUMMARY

Field geology can be a lot of hard work, but it is satisfying to use a wide range of geologic knowledge and skills to solve field problems. Working in the field provides opportunities to use and integrate knowledge from many sub-disciplines in geology.

You are encouraged to take every possible opportunity to increase your field experience and skills, and to expand and enhance your abilities to make and interpret geologic maps. The ability to solve field problems is fundamental to a career as a geoscientist. Work safely, and be a good representative for your profession.