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Mapping and Structural Geology in Metals Exploration

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INTRODUCTION

Fieldwork and mapping are fundamental activities in almost every branch of geology, but perceptions vary widely as to what makes a good map and what constitutes appropriate fieldwork to produce a good map. The realities of modern University courses are such that many graduates have received only perfunctory training in the very basics of mapping even though they may have done considerable fieldwork in more advanced subjects. Geological mapping is a subset of fieldwork but other subsets are commonly presumed by some training institutions as being sufficiently synonymous with 'mapping' to provide the basic field training of a geologist. Systematic petrological sampling surveys, geophysical surveys, and compilation of stratigraphic transects are important activities, but none of them is a substitute for training in geological mapping.

In exploration and mining, geological mapping is the process of producing a 2D interpretation of the distribution of rock units and structures across an area that might be as small as a quarry floor or as large as an entire mining district. One important aspect of the process is the production of a map showing the raw observational data (commonly known as a 'fact map' or 'outcrop map'). A fact map alone is not the end product of geological mapping. At all scales the interpretation map is the target product. Thus geological mapping is **always** interpretive. Even when your assigned task is to produce a raw fact map alone, elements of interpretation should still appear in your raw field data (either in your field book or on the map). Mapping should never be treated as simply a task of identifying rock types but of identifying the position of the local outcrop in a stratigraphic or structural sequence of units. A common problem in many exploration and mining companies is that the urge to produce database-friendly standardised codes for field observations also tends to suppress the very important interpretive aspect of the fieldwork. The time for starting the interpretation process is while on the outcrop, and by the person making the observations – not at a later date by that person, or by someone else analysing their factual data from a distance.

Thus interpretation is intrinsic to mapping, and an interpretation map is the ultimate product. In a nutshell my view of a good interpretation map is one that is accurately located, geologically viable, clearly identifies fact from interpretation, and contains sufficient data to allow a cross-section to be drawn. In short it is a map that can be usefully interpreted by any geologist, now or in the future, perhaps using new concepts that are currently not available.

Modern digital production of maps, and storage in GIS databases, adds a level of professionalism but also adds complexity to mapping. Similarly the advent of GPS units with metres-level precision has largely eliminated the use of 'local' grid coordinate systems but has added the need for geologists to fully understand the fundamentals of geodetic datums and projections, once the sole province of surveyors and cartographers.

The skills and knowledge required to produce a geological map are both geological and technical:

Geological (scientific) issues:

- contact recognition
- reading outcrops
- thought processes in the field
- interpretation processes
- geological basics

Technical issues:

- geodetic basics
- structural measurement techniques

- oriented drill-core procedures
- cartographic considerations
- mapping procedures
- topographic effects
- digital aspects
    - file and folder structure and names
    - GIS and software fundamentals
    - database fundamentals
    - issues of 'standardisation'

Technical issues relate to cartography, data presentation, and mapping design. They are aspects that are common to all maps and mapping activities and are skills that can be easily acquired.

The most important aspect of mapping is the geological thought that goes into it, and by far the most important aspect listed above is the process I call 'reading' outcrops. This is the process of combining practical training, experience, and background theoretical knowledge to understand and interpret every subtle feature in an outcrop, particularly when it contains features that do not quite resemble textbook examples. Ore bodies, by definition, are geologically anomalies that occur in geologically anomalous situations. So it is the lot of the exploration and mining geologist to be routinely confronted by non-textbook geology that they must understand if they are to be successful. To do so they must draw quite deeply on both experience and background knowledge.

In practice, outcrop limitations, structural complexity, and mapping scale vary the emphasis between observation (fact) and geological interpretation. The more these activities move toward interpretation, the more geological knowledge and experience is required. Thus there is a management issue balancing the duties of the most experienced geologists between supervisory roles and hands-on fieldwork, yet allowing the less experienced geologists to acquire experience. Too often I see middle level geologists push all fieldwork, irrespective of complexity, on to the most inexperienced, thus raising the level of exploration risk to the company.

The material in this manual reflects my personal view as to what makes a good map and how to map. Mapping and nomenclature conventions vary considerably and the emphasis, the views expressed, and the conventions used in this manual need to be merged with in-house conventions.

The manual is aimed at the practising geologist, particularly in exploration, and particularly working in orogenic areas with folded sedimentary and metamorphic rocks at various scales and in areas that can be mapped and solved by the average geologist. It does not enter very far into the world of advanced structural analysis required for the very complex areas, although many of the observations and principles required to solve such areas are outlined. It is born out of my experience that many of the projects I am called on to troubleshoot do not require anything more than the application of basic techniques obtained from a conventional training background.

The manual is divided into five successive parts:

Part 1: A moderately concise outline of the geological and technical issues of mapping.

Part 2: Expansion of some of the technical aspects of mapping and map production.

Part 3: Expansion of some of the geological techniques used in field mapping.

Part 4: Review of basic geological structures and geometrical concepts.

Part 5: Review of deformation, flow, and advanced structures.

The assumption has been made that the reader already has a geological background and this manual is intended as a way to focus and revise that background. It has been arranged in reverse order to a conventional University text in that the early sections explain how and when to apply particular techniques in the context of fieldwork and mapping, and the last sections explain the theory behind those techniques.

This text is a work in progress. It is incomplete in some theoretical aspects and will be added to from time to time as I find new ways for professional geologists to forget their basic training.

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2009

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September 28th 2009