Field geology

Unit IV

Unit IV :SYLLABUS

Brief account of the following: Use of Aerial Photographs in geological mapping – Structural mapping – Stratigraphic mapping methods. outline of mapping methodology for – igneous terrain, sedimentary terrain and metamorphic terrain. Methods of mapping in areas with sparse outcrops. Outcrop structural features common to all rocktypes. outline of use and applications of GPS in field geology. Sample location techniques in digitalbase maps.

Use of Aerial Photographs in geological mapping

Aircraft

Aerial photography has been one of the first remote sensing techniques performed by aircraft. Orthophotos are geometrically corrected or "ortho-rectified" that can be handled in the same way as a map. Stereo-photographs form the basis of photogeology and the interpretation of geological features based on their surface expression. Aerial photographs from consecutive years allow to identify major landforms and their evolution (e.g., Evans et al., 2007). Photogrammetry, on the other hand, allows the generation of high resolution DSMs which have largely contributed to improve and accelerate conventional geological field work. Photogrammetric DEMs from archived aerial photographs permit to recover the history of landslides occurrences in remote areas (e.g., Prokešová et al., 2010).

Since the early days of aerial photography, airplane-based remote sensing has matured into a truly advanced form of geological data acquisition. Hyperspectral and LiDAR sensors have been deployed on aircraft since the advent of these devices. Information ranging from the VNIR to LWIR part of the electromagnetic spectrum has been acquired with high spectral and spatial resolution. A wide range of minerals can be mapped at the sub-meter scale because of high spectral and spatial resolution. Airborne hyperspectral data can aid to map inaccessible or remote lithologies using the characteristic spectral information of rock types (e.g., Bedini, 2009) or typical alteration minerals (e.g., Kruse et al., 2006; van der Meer, 2004).

ALS has been the preferred airplane-based method to produce high quality DEMs since its development. Geologist use the DEMs produced with ALS to map prominent relief features such as fault scarps, elevated dikes, or circular bodies outcropping on the surface such as pipes. DTMs from airborne LiDAR can support lithological discrimination by using morphometric variables

The significant and salient steps from discovery of mineral deposits to delivery of finished products to end users have been articulated in a cycle of 1–13 with emphasis on the cyclical nature of the mineral industry:

1.Mineral exploration to discover a deposit: reconnaissance,prospecting, and modeling
2.Exploration via geology, geochemistry, geophysics, photogeology: remote sensing and geographic information system
3.Sampling, reserve/resource estimation, and precision by geostatistical applications
4.Feasibility study to prove commercial viability.
5.Mine development, infrastructure, and extraction of ore from the ground.
6.Mineral processing: milling and separation of ore from gangue to produce concentrates, refinement of industrial mineral product.
7.Smelting: recovery of metals from mineral concentrate.
8.Refining of metals to 99.99% purity.
9.Marketing: shipping the product (concentrates, metals, and minerals) to the buyer (in-house or custom smelter and manufacturer.
10.Caring for the ecosystem and ensuring a sustainable future.
11.Experience from exploration and mine case studies.
12.The continuing search for minerals.

13.Cyclical natural of global mineral industries creating new challenges and opportunities for today's metals organizations.

Structural mapping

All of the structures encountered so far in this book have been analyzed using monoscopic imagery data. It was noted, however, that the accuracy of reconstructing exposed geological structures diminishes as they approach the extremes of being highly or mildly deformed. In these cases, the variable relationships between geological structures and their topographic expressions as well as the lack of diagnostic features from inclined bedrock strata create a need for some sort of stereo mapping. Such efforts can be done by using satellite stereo data directly or by supplementing monoscopic interpretation of satellite imagery data with local mapping of structures with stereo aerial photography or radar. This chapter provides a brief introduction to the principles involved in creating stereo imagery data, specific applications to structural mapping and the equipment used for this analysis.

When **aerial photographs** are **used** in the field as a base map for plotting dips, strikes, attitudes of joints, faults and contacts, their utilization involves few problems additional to those encountered in using a topographic or planimetric base.

A **plan** (two-dimensional) **geologic map** shows the locations and shapes of the outcrops at an appropriate scale and indicates, through a variety of geologic symbols, features such as folds, faults, contacts between different rock units, and strike and dip. A **geologic cross section**, a vertical slice across the map area, can be constructed from the structural information on a geologic map. It depicts the spatial relationships of the rock units and structures beneath the surface (Figure). A cross section supplies a third dimension to the plan geologic map. A good geologic map is critical to understanding and interpreting structures, when they formed, and how they fit into the overall geologic picture.

Stratigraphic mapping methods

Aerial photography is a new tool having value to stratigraphic geology in approximately the manner and almost the degree that a telescope serves astronomy. Although geologists studied, described, classified, measured, and mapped rock formations before the airplane was invented, just as astronomers studied heavenly bodies before the days of Galileo, few geologists or astronomers today would care to dispense with the modern equipment at their command.

Photostratigraphy, a new method of aerial photo interpretation, establishes local photostratigrphic correlation frameworks with relative chronostratigraphic significance. This method is based on the analysis of strata geometry, their relationships, and the photographic aspect of the rocks for identification and hierarchic organization of photostratigraphic units. The definition of these units does not presuppose any a priori genetic implications. The units represent volumes of rocks bounded by surfaces with chronostratigraphic significance. Photostratigraphic units contain time-transgressive photofacies and photofacies units, which record lithologic and depositional characteristics of the strata. The procedure for establishing photostratigraphic correlation frameworks is illustrated through examples from the south-central Pyrenees. Direct integration with field data allows the comparison of photostratigraphic frameworks with frameworks based on other stratigraphic criteria. Photostratigraphy is proposed as an independent and relatively rapid, preliminary approach to the study of a basin.

Mapping methodology for Igneous rock,Sedimentary and Metamorphic rocks

Geological interpretation is one of the critical works in the geological field. To get a geological interpretation that’s closer to the truth, we need adequate data and important geological data packaging. Geological mapping is one geological data presentation that’s most competent and is used for various purposes either for science or exploration of natural resources. A geological map is a map that consists of geological information of the outer layer of earth crust; they are a variation of lithology, distribution of geologic structure, stratigraphy and geomorphology. All of that information read by symbols and colors. Details of geological map depend on the its scale, and the density and accuracy of observations in the field. The final result from all geological methods is a geological map.

To make a good geological map, a geologist must have skill in geological mapping and know about how to read geological map. Basic steps of geological mapping consist of observation and measurement in the field, taking samples, and analyzing samples in a laboratory. Geological mapping is a multidisciplinary method that combines petrology, structural geology, geomorphology, paleontology, stratigraphy, sedimentology, etc. Geological mapping consists of two kind based on selection trajectory:

- Systematic mapping is done by mapping technically only, without considering geomorphology, distribution of geomorphology, or geological structure pattern. While smart mapping is done by considering the results of satellite image or topographical maps analysis, so it would be more efficient in geological mapping according to the desired scale. In this paper we are more focus on the method of smart mapping because this method is most often used by geologists.
- Smart mapping is used for several reasons, such as that the mapping area is too large, mapping time is too short, or lithological variations are relatively homogeneous. While systematic mapping is used when variations of lithology are very complex so observation of some point isn’t enough to represent all lithologies and structures in the mapped area and the availability of sufficient time. Therefore it is very important to know the purpose of geological mapping before doing the mapping to desired area.

The Lithological Mapping theme (1984-1988) was devoted to image processing and field control of satellite imagery as part of the GARS Africa Project. improved the interpretation of the lithology, structure and mineralisation of the Kibaran and Ubendian fold belts in Africa using advanced remote sensing technology. The research established a link between fundamental geological investigations and metallogenic research in the Kibaran region. Our understanding of the Kibaran cycle sedimentary formations across the region was greatly improved as a result.

The theme assessed the feasibility of using advanced remote sensing data for detecting mineral assemblages, alteration zones and geobotanical indicators for a range of litho-structural analyses:

- Discrimination of lithological units within metasedimentary complexes
- Recognition of different types of intrusive rocks
- Influence of tropical weathering on characteristic mineral assemblages of rocks and soils
- Recognition of mineral alteration zones
- Differentiation of Precambrian and overprinted Cenozoic structures
- Recognition of structural control on mineralization
- Determination of spectral properties of geologic materials by radioetric measurements

Methodology

Lithological mapping was performed using a combination of field survey data and spectral analysis of remote sensing data from Landsat MSS, Landsat TM and SPOT for two sites in Africa – the Ubendian fold belt in Tanzania and the Precambrian terranes of the Kibaran fold belt in Burundi. Both sites are dominated by lateritic soils and vegetation that varies from tropical rain forest to savannah. Initial investigations focused on the Ubendian fold belt because it consists of a variety of lithological units covered by a relatively homogeneous vegetation layer. The Kibaran fold belt (Middle Proterozoic) has a more complex character and the research focused on discerning granites, basic rocks and shear zones in northern Burundi, and the use of geobotanical indicators to discern mineral alteration zones in central Burundi.

Methods of mapping in area with sparse outcrop

One of the major problems faced by the application of geological remote sensing is its potential limitation in areas of a temperate climate with agricultural cultivation, limited outcrops and vegetation cover. This was the issue experienced when it was attempted to use the multi-spectral satellite Advanced Spaceborne Thermal Emission Reflectance Radiometer (ASTER) imagery to assist the updating of 1:100,000 geological mapping with the Ardlethan/Barmedman map sheets of central New South Wales (NSW), Australia. Most successful applications of geological remote sensing have been achieved in arid to semi-arid environments where vegetation and cultivation is minimal. Typically, day-time acquired ASTER visible to shortwave surface reflectance derived map products has extracted useful mineral related compositional information in such areas however in the studied areas of central NSW these techniques proved limited, particularly when using large mosaicked products such as the National Australia ASTER Geoscience Maps. Some improvement in geological discrimination was achieved using individual ASTER scenes, masked by high slope angle and processed into spectrally unmixed products. An alternative approach to extracting geoscience related products, utilised, night-time acquired ASTER thermal products. Their surface kinetic temperature products showed some potential for identifying the limited and sparse outcrops useful for field mapping geologists. Overall this study also showed the importance of the image spatial resolution in vegetated and cultivated areas with limited outcrop. Ideally a finer spatial image product than available with ASTER's VNIR-SWIR combined products at 30 m is required.

Outcrop structural features common to all rock types

Outcrops do not cover the majority of the Earth's land surface because in most places the bedrock or superficial deposits are covered by a mantle of soil and vegetation and cannot be seen or examined closely. However, in places where the overlying cover is removed through erosion or tectonic uplift, the rock may be exposed, or *crop out*. Such exposure will happen most frequently in areas where erosion is rapid and exceeds the weathering rate such as on steep hillsides, mountain ridges and tops, river banks, and tectonically active areas. In Finland, glacial erosion during the last glacial maximum (ca. 11000 BC), followed by scouring by sea waves, followed by isostatic uplift has produced many smooth coastal and littoral outcrops.

Bedrock and superficial deposits may also be exposed at the Earth's surface due to human excavations such as quarrying and building of transport routes.

Outcrops allow direct observation and sampling of the bedrock *in situ* for geologic analysis and creating geologic maps. In situ measurements are critical for proper analysis of geological history and outcrops are therefore extremely important for understanding the geologic time scale of earth history. Some of the types of information that cannot be obtained except from bedrock outcrops or by precise drilling and coring operations, are structural geology features orientations (e.g. bedding planes, fold axes, foliation), depositional features orientations (e.g. paleo-current directions, grading, facies changes), paleomagnetic orientations. Outcrops are also very important for understanding fossil assemblages, and paleo-environment, and evolution as they provide a record of relative changes within geologic strata.

Accurate description, mapping, and sampling for laboratory analysis of outcrops made possible all of the geologic sciences and the development of fundamental geologic laws such as the law of superposition, the principle of original horizontality, principle of lateral continuity, and the principle of faunal succession.

When **weathering** and **erosion** expose part of a rock layer or formation, an outcrop appears. An outcrop is the exposed rock, so named because the exposed rock "crops out." Outcrops provide opportunities for field geologists to sample the local geology—photograph it, hold, **touch** , climb, hammer, map, sniff, lick, chew, and carry it home. Classes often visit outcrops to see illustrations of the principles of **geology** that were introduced in lecture. You often can see geologists or students identifying **rocks** in roadcuts, outcrops along the road where highway construction exposed the rocks.

Mountainous regions, where any loosened **Earth** material swiftly washes away, contain some of the best outcrops because a greater percentage of the rock formation lies exposed. Rocks crop out especially well across steep slopes, above the **tree** line (elevation above which trees cannot grow), and on land scraped free of **soil** by bulldozer-like **glaciers** . Sediment collects and plants grow in flatter areas, obscuring the rocks. In some areas soil and sediment may completely cover all the underlying rock, such as in the southeastern United States. However, in the **desert** southwest, the opposite is often the case. Outcrops cut the cost of mapping for geologists. The greater expense of geologic mapping in an outcrop-free area results from high-priced drilling to sample the rocks hidden below the surface

Use and application of GPS in field geology

Global Positioning System (GPS) is a fast, accurate and cost-effective tool that became an integral part of any geological mapping. In the present study, we have used GPS for a precise and quicker geological & structural mapping of a gabbro pluton, emplaced along the Terrane Boundary Shear Zone (TBSZ) situated between the Eastern Ghats Belt and the East Dharwar craton, Andhra Pradesh, India. A hand-held GPS was employed during the mapping of Pasupugallu gabbro pluton to record the locations of several structural measurements, the extents of dolerite dykes within the pluton, and the pluton boundary. The real-time preliminary geological map, prepared from the GPS software, has been conveniently used for plotting the voluminous structural data and reduced a large amount of time and work. In addition, the application of remote sensing technique has greatly enhanced the existed data. The observed structural features of the pluton strongly suggest its syntectonic nature with the TBSZ kinematics.

The surveying and mapping community was one of the first to take advantage of GPS because it dramatically increased productivity and resulted in more accurate and reliable data. Today, GPS is a vital part of surveying and mapping activities around the world.

When used by skilled professionals, GPS provides surveying and mapping data of the highest accuracy. GPS-based data collection is much faster than conventional surveying and mapping techniques, reducing the amount of equipment and labor required. A single surveyor can now accomplish in one day what once took an entire team weeks to do.

GPS supports the accurate mapping and modeling of the physical world — from mountains and rivers to streets and buildings to utility lines and other resources. Features measured with GPS can be displayed on maps and in geographic information systems (GIS) that store, manipulate, and display geographically referenced data.

Sample location techniques in digital base map

Digital mapping, by definition, is performed through some kind of digital interface, typically a computer system with a graphical user interface (GUI). Whilst GUIs have been available for some considerable time, it is worth stressing that image interpretation requires *graphical* display and the greater the size and number of pertinent displays, the easier interpretation potentially becomes. It is also essential for all work to be performed within a geographical information system (GIS) in order to ensure that input imagery and interpreted data sets maintain the same geographical coordinate system. This allows data export into other geographic products and facilitates accurate map production and quantitative analyses. Interpreters need to be familiar with the operation and use of a GIS, and familiarity with the principles of remote sensing is beneficial.

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