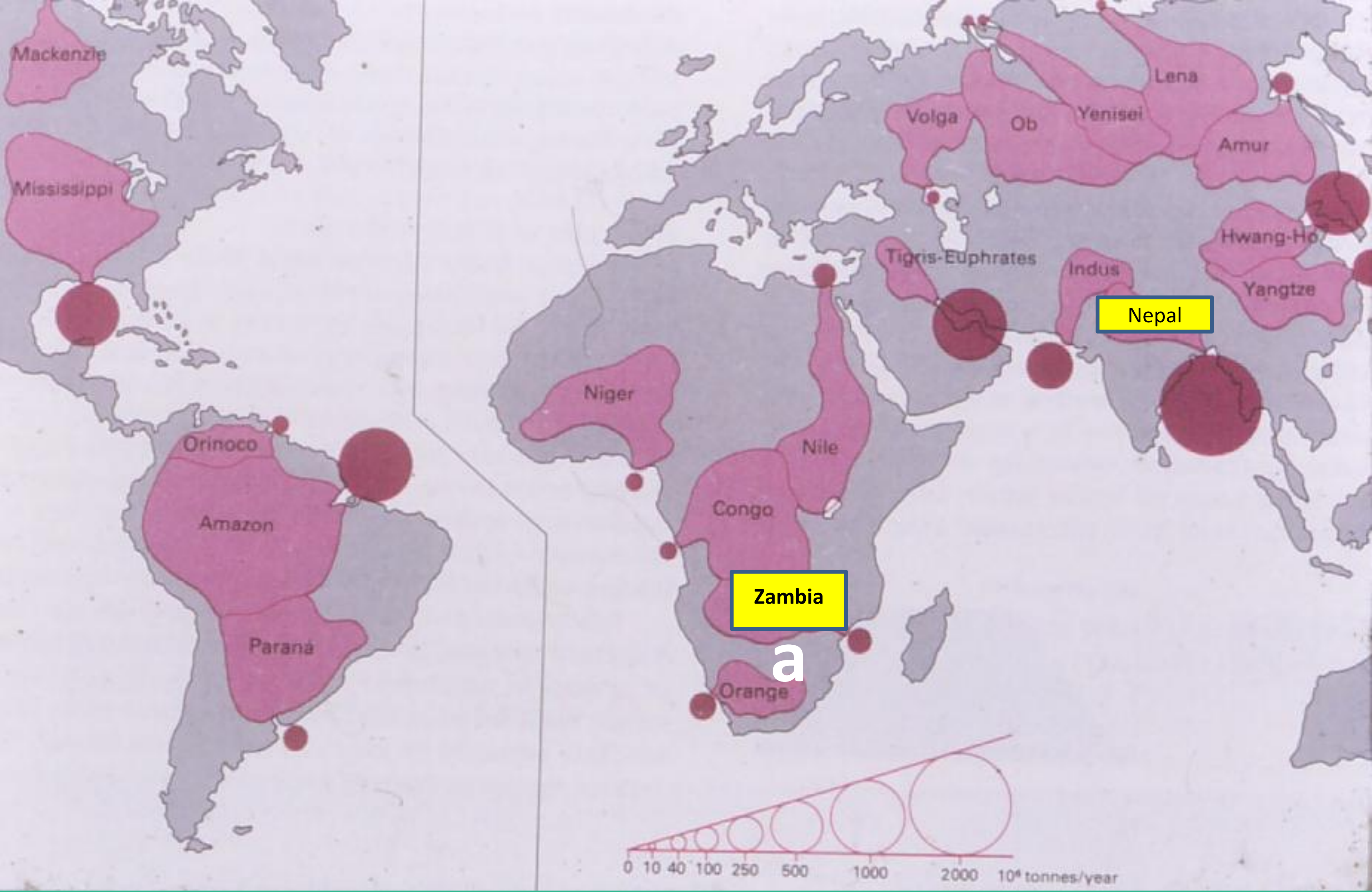
GGY4089

STRUCTURAL GEOLOGY AND TECONICS

B.N. Upreti

Professor, School of Mines University of Zambia
Academician, Nepal Academy of Science and Technology (NAST)
Fellow, World Academy of sciences
Former Dean, Institute of Science and Technology, TU
Former Head, Department of Geology, TU

e-mail: bnupreti@gmail.com



Mackenzie
Mississippi
Orinoco
Amazon
Parana
Niger
Nile
Congo
Zambia
a
Orange
Volga
Ob
Yenisei
Lena
Amur
Hwang-Ho
Yangtze
Tigris-Euphrates
Indus
Nepal
0 10 40 100 250 500 1000 2000 10^6 tonnes/year


China
TIBET
Pakistan
NEPAL
Bangladesh
INDIA
India
Arabian Sea
Bay of Bengal
South China Sea


N
W
E
S
0
200
400 Km
CHINA
PAKISTAN
KATHMANDU
BHUTAN
NEPAL
INDIA
BANGLADESH
BAY OF BENGAL
ARABIAN SEA
MYANMAR


Photo courtesy: M. Yoshida

Structural Geology and Plate Tectonics

GEOLOGY DEPARTMENT
FIRST AND SECOND TERM TIME TABLE

FOURTH YEAR	**08 -09**	**09 - 10**	**10 - 11**	**11 - 12**	**12 - 13**	**13 - 14**	**14 - 17**
MONDAY	GGY 4070 (120) AA	GGY 4070 (120) AA	GGY 4090 (016) BM	GGY 4090 (016) BM	GGY 4125 (120) SN	**L**	GGY 4070 (120) AA
TUESDAY	GGY 4101 (120) SM	GGY 4101 (120) SM	GGY 4070 (120) AA	GGY 4070 (120) AA		**U**	GGY 4089 (016) BU/**SN**
WEDNESDAY	GGY 4089 (016) BU	GGY 4089 (016) BU	GGY 4090 (016) BM	GGY 4090 (016) BM	GGY 4125 (120) SN	**N**	GGY 4125 (120) SN
THURSDAY		GGY 4119 (120) CP/DCWN	GGY 4119 (120) CP/DCWN	GGY 4101 (120) SM	GGY 4101 (120) SM	**C**	GGY 4090 (016) BM
FRIDAY	SEMINARS AND FIELD TRIPS					**H**	SEMINARS

Third Year Semester: I

GG335: Structural geology and mapping techniques
Foundation Courses: *GGY....*

Objectives

On completion of the course, students should be able to:

- **Understand how rocks deform under stress**
- **Recognize and describe the various rock structures**
- **Understand the concepts of strain**
- **Understand concepts in structural geology**
- **Conduct geological mapping**

(Third Yr. Semester I)

Course Content

Structural Geology

1. Stress and strain in two dimensions
2. Rheological properties of rocks
3. Folds and folding & their origin, mechanisms of formation & classification
4. Joints & faults & their origin, mechanisms of formation & classification
5. Minor structures, their origin, mechanisms of formation & classification
6. Tectonic significance of folds, fractures & minor structures in rocks
7. Structures of igneous rocks; Salt tectonics; Gravity structures

Semester IV

Course: GGY4089
Structural geology and plate tectonics
Foundation Courses: *GG3049 and ???*

Objectives:

On completion of the course, students should be able to:

1. **Understand the concepts of stress and strain;**
2. **Recognize and analyze structures related to stress and strain;**
3. **Apply geometrical techniques of analysis in resolving structures;**
4. **Identify and analyze petrofabrics of metamorphic processes and deformation**

(Semester IV) Course Content

Part I (Structural Geology)

1. Behaviour of rocks under stress;
2. Superimposed folding;
3. Geometrical techniques of structural analysis;
4. Petrofabrics of metamorphic processes and deformation;
5. Physical nature of Earth´s interior;
6. Modern theories on structural evolution of the Earth´s crust;
7. Structural framework of Africa;
8. Structural associations;
9. Shear Sense indicators and Shear zones;
10. The Use of geochronology in structural interpretation.

Part 2 (Tectonics):

10. Subduction zone environments-rock assemblages and mechanisms;
11. Arc-related assemblages and exhumation processes, Back-arcs, fore-arcs and rift environments and attending assemblages;
12. Supercontinent cycle, both from an exploration point of view and to conceptualization of earth evolution history

Assessment

Continuous Assessment – 40%
Assignments 10%; Laboratory Practicals 10 %; Tests 20%

Final Examination – 60%
Theory 40%; Practical 20%

Course Content
Part I

1. Behaviour of rocks under stress (4hr)
2. Superimposed folding (1 hr)
3. Shear Sense indicators and Shear zones (2 hrs)
4. Geometrical techniques of structural analysis (3 hrs)
5. Petrofabrics of metamorphic processes and deformation (3 hrs)

6. **Physical nature of Earth´s interior (2 hrs)**
7. **Modern theories on structural evolution of the Earth´s crust (2 hrs)**
8. **Structural framework of Africa; Structural associations (1)**
9. **The Use of geochronology in structural interpretation (1)**

Part II

1. Recapitulation on Plate tectonics (2 hrs)
2. Subduction zone environments- rock assemblages and mechanisms (3hrs)
3. Arc-related assemblages and exhumation processes (3 hrs)
4. Back-arcs, fore-arcs and rift environments and attending assemblages (3 hrs)
5. Supercontinent cycle, both from an exploration point of view and to conceptualization of earth evolution history (2 hrs)

Structural Geology

Introduction to Structural Geology

Concepts and objectives

Structural geology:
A study of Earth's Architecture

Earth is a dynamic planet. Tectonic forces deform rocks in the crust.

Evidence demonstrating the operation of enormous forces within Earth includes thousands of kilometers of rock layers that are bent, contorted, overturned, and sometimes riddled (mysterious) with fractures.

In the Himalaya and the Canadian Rockies, for example, some rock units have been thrust for hundreds of kilometers over other layers.

On a smaller scale, crustal movements of a few meters occur along faults during major earthquakes.

In addition, rifting (spreading) and extension of the crust produce elongated depressions and over long spans of geologic time may even create ocean basins.

Structural Geology deals with the study of deformation in rocks at scales ranging from:

(1) Submicroscopic to
(2) Regional (micro-, meso-, and macro-scale)

Structural geologists study the architecture of Earth's crust and "how it got this way" insofar as it resulted from deformation.

In other words, the aim of structural geology is to determine and explain the architecture of rocks as observed in the field;

laboratory investigations are supplementary means to attain this primary objective.

Thus, structural geology deals with:

1. **ways in which rocks respond to the application of deforming forces, and,**
2. **the structure that resulted from deformation**

The ultimate aim of structural geology is to:

1. **Establish the history of displacement,**
2. **Stress, strain rates,**
3. **Temperature and pressure that the crust and associated upper mantle of the earth have experienced.**

By studying the :

(1) orientations of faults and folds, as well as

(2) small-scale features of deformed rocks,

Structural geologists can often reconstruct the original geologic setting and the nature of the forces that generated these rock structures. In this way, the complex events of Earth's geologic history are unraveled.

In structural geology we examine the:

(1) Forces that deform rocks, and

(2) the structures that result.

The basic geologic structures associated with deformation are:

Folds, faults, joints, and foliations (including rock cleavage).

Tectonics and tectonic geology are terms that may consider to be synonymous with structural geology.

To some however, structural geology is concerned primarily with the geometry of the rocks, whereas tectonics deals with the forces and movements that produced the structure.

The movements that affect solid rocks result from forces within the earth, causing folds, joints, faults, and foliation.

The movements of magma, because it is often intimately associated with the displacement of solid rocks, is also a subject that lies within the domain of structural geology.

The deformation of the rocks of extraterrestrial bodies is also the concern of structural geology, as well as the effect of collision between bodies in the solar system.

Importance of Structural Geology

An understanding of rock structures is not only important in deciphering Earth history; it is also basic to our economic well-being.

For example, most occurrences of oil and natural gas are associated with geologic structures that act to trap these fluids in valuable “reservoirs”.

Furthermore, rock fractures are sites of hydrothermal mineralization, which means they can be sites of metallic ore deposits.

Moreover, the orientation of fracture surfaces, which represent zones of weakness in rocks, must be considered when selecting sites for major construction projects such as:

> **bridges, hydroelectric dams, and nuclear power plants.**

Objectives of structural geology

The structural geologist is concerned with three major problems:

1. What is the structure,
2. When did it develop
3. Under what physical condition did it form

1. In general, the first question must be answered first. It is essential to determine the shape and size of the bodies.

Geological field work is indispensible to investigate structures, and it is this fact that distinguishes most phases of geology from many of the other sciences.

2. A second objective of the structural geologist is to relate the structure to some chronology.

One phase of this study is to determine the sequence in which the structural features developed.

For example, we may find an anticline a fault, and a dike. What are their relative ages? The anticline may be the oldest and the dike may be the youngest, and so on.

The structural geologist is interested not only in the sequence of events in the area in which he is studying but he also wants to fit them into the geological history of the whole earth.

This can be done by paleontological methods or by radiometric dating (geochronology).

3. A third objective of the structural geologist is to determine the physical processes that produced the observed structure.

(1) What was the temperature and pressure at the time the structural feature formed, and

(2) what was the stress distribution?

It is desirable to answer these questions before we try to deduce the ultimate cause.

Without knowing the stress distribution at the time the structural feature formed, it is difficult to decide whether a given fold was the result of sub-crustal convection current or the forceful injection of magma.

Structural geology provides information about the conditions during regional deformation using structures.

Field Studies

Many tectonic problems are approached by studying structures at outcrop scale, and smaller (microscopic) or larger (100's to 1000's of km) scales.

Systematically observe/record the patterns of rock structures (e.g., fault, fold, foliation, fracture).

This gives the geometry of the structures.

Structure

A geometric feature in a rock whose shape, form, and distribution can be described

Microstructure

The small-scale arrangement of geometric and mineralogical elements within a rock

Texture

Preferred orientation of crystallographic axes in the sample

Microfabric

Comprises the microstructure and the texture of a material

Fundamental Structures

1. Contacts
2. Primary Structures
3. Secondary structures
   - ***Fractures (Joints, Shear Fractures)***
   - ***Vein -*** **Precipitated minerals from fluid flowing through fractures**
   - ***Fault***
   - ***Fold***
   - ***Foliation -*** **Preferred orientation of planar rock bodies and/or minerals**
   - ***Lineation -*** **Preferred orientation of linear minerals and rocks**
   - ***Shear Zone:*** **Zones of deformed rock that have accommodated movement**

Thank you