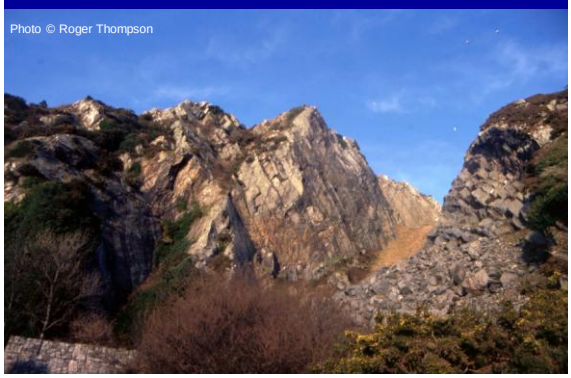
Topic 12: GEOLOGIC STRUCTURE

STRUCTURE

Tilted Rocks

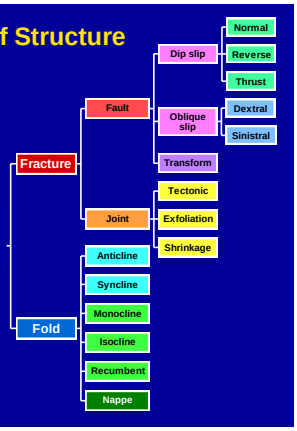


Geologic Structure

- **STRUCTURAL FEATURES** are features formed by the displacement or deformation of rocks
  - eg faults, folds, joints
- Often caused by large scale crustal deformations called **TECTONICS**
  - eg produced by plate tectonics movements & interaction

Types of Structure

Photo © Roger Thompson



Geologic Structure

- The main types of structures are **FOLDS** & **FRACTURES**
  - most of the fractures are caused by stress in the rocks
  - some of the cracking may also be caused by other processes such as cooling or drying (eg mud cracks)
- There are two types of fracture - **FAULTS** & **JOINTS**

Faults

- A **FAULT** is a fracture, or fracture zone, along which there has displacement of one side relative to the other (parallel to the fracture)
  - displacement may be few centimetres or many kilometres
- Faults & joints may be in response to compressive, shear, & tensile stresses
  - directed forces in the earth's crust

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Faults

- Movement across a fault is generally relative - cannot generally tell which side moved, even though geologists talk about upthrown & downthrown sides
- Fault may not be a clean fracture or it may be a FAULT ZONE up to hundreds of thousands of metres wide
  - consisting of numerous interlacing small faults
  - OR a confused zone of gouge, breccia, or mylonite
- Can get an abrupt bending of strata as approach fault (DRAG)
  - may get feather joints - en echelon (extension) fractures intersecting a fault plane

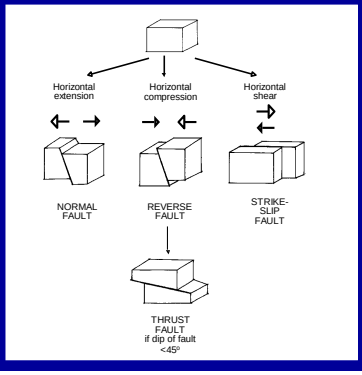
Recognizing Faults

- Faults displace lithological boundaries
- Faults bring units of different ages into contact
- Polished & striated surface that results from friction along fault plane
  - slickensides give best evidence for SLIP (movement) direction
- Faults may form SCARPS
  - most fault scarps have been modified by erosion since faulting

Recognizing Faults

- Fracturing of rocks adjacent to fault plane makes them less resistant to weathering
  - outcrop of a fault is commonly marked by an erosion feature -stream, valley, lake, escarpment, coastline, - particularly if straight
- Large faults which juxtapose rocks of different lithologies may be further marked by contrast between areas of differing topography, vegetation, land-use, etc
- Fault traces on maps indicate the downthrown side of the fault,& the direction of dip of the fault plane where known
  - ACTIVE FAULTS are generally shown in RED on maps

Faulting & Stress



Fault in East Coast Bays Formation

Photo: Roger Thompson

Fault in East Coast Bays Formation

Photo: Roger Thompson

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Fault & Fold (Castlepoint)

Photo © Roger Thompson

Fault & Fold (Castlepoint)

Photo © Roger Thompson

Fault with Drag (Green Bay)

Photo: Roger Thompson

Fault with Drag (Green Bay)

Photo: Roger Thompson

Active Faults

Active Faults are faults that have moved within the last 35,000 - 50,000 years

(the maximum age of C14 dating)

They are usually indicated as red or brown lines on geologic maps

Photo © Roger Thompson

Importance of Active Faults to Engineer

- Movement on fault may generate earthquake
  - shock waves
  - displacement
- Restrictions on certain buildings within certain distance of active fault
  - hospitals
  - emergency services
- Structures may need to be engineered to allow movement on fault
  - eg Clyde Dam
- Active blind thrust faults are often difficult to detect

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Fault Nomenclature

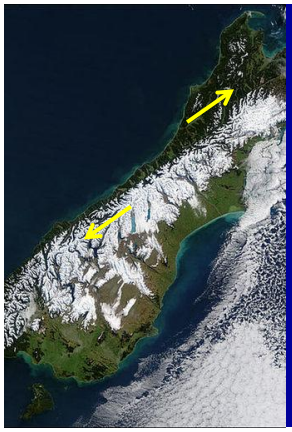
- Faults - specially smaller ones - are frequently planar surfaces
  - fault planes have **dip & strike**, just like beds
- **HANGING WALL** is the mass of rock above a fault plane, vein, lode, or bed of ore
- **FOOT WALL** is the mass of rock beneath a fault plane, vein, lode, or bed of ore

Dip Slip Faults - Up/Down Movement

- A **NORMAL FAULT** is downthrown in the direction of dip of the fault
- A **REVERSE FAULT** is upthrown with respect to the direction of dip of the fault
- A **THRUST FAULT** is a reverse fault with a low angle of inclination
  - less than 45° to horizontal

Strike Slip Faults - Sideways Movement

- A **STRIKE-SLIP** or **WRENCH FAULT** is one in which almost all the movement is horizontal
  - the fault plan is commonly vertical or nearly so
  - a strike-slip fault may be either **SINISTRAL (Left lateral)** or **DEXTRAL (Right lateral)**
- A **TRANSCURRENT FAULT** is a strike-slip fault on a regional scale
- A **TRANSFORM FAULT** occurs where two tectonic plates slide past each other
  - eg Alpine Fault, San Andreas Fault



Alpine Fault

Transform fault with 450km lateral displacement

Source: NASA

Joints

- A **JOINT** is a fracture in rock along which no apparent movement has occurred
  - generally more or less vertical or transverse to bedding
- Joints form in response to:
  - tension & shearing
  - compression
  - shrinkage or contraction
  - unequal uplift or subsidence
- Joints weaken rocks

Jointing

Photos © Roger Thompson

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Jointing

Joints in dacite (Mangawhai)

Photo © Roger Thompson

Joints

- Joints are sites of water ingress & movement (particularly tension joints)
- Joints are sites of precipitation of minerals, eg limonite, calcite, quartz, ore minerals
- Joint patterns may be radiating, concentric, or conjugate

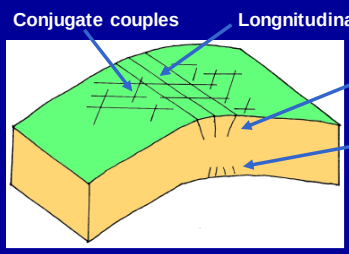
Joints

- Joints may be either tectonic or non tectonic in origin
  - compression causes tightly closed joints
  - tension causes open joints
- Non-tectonic joints
  - SHEETING, UNLOADING, EXFOLIATION joints
  - shrinkage or contraction on cooling of igneous rocks, causing COLUMNAR JOINTING

Exfoliation Fractures

Photo © Roger Thompson

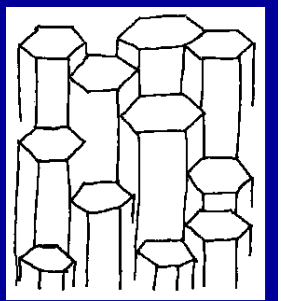
Joints and Folding



- Folding commonly causes two sets of joints to form
  - conjugate couples
  - tension joints parallel to fold hinge
- Compressional joints may occur on inside of fold

Columnar Jointing

- As lavas cool they shrink radially away from centres of cooling & develop six-sided columnar joints
- These joints extend througout the entire lava flow, forming a series of pillars



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Columnar Jointing

Columnar Jointing - Giant's Causeway

Photo courtesy Joanne Williamson

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Columnar Jointing – Mt Somers

Photo courtesy Tim Rimmer

Columnar Jointing – Mt Somers

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Columnar Jointing – Mt Somers

Photo courtesy Tim Rimmer

Columnar Jointing - Mangawhai

Photo © Roger Thompson

Relevance of Joints to Engineering

Strength of Rockmass	Cause weakness in rock mass which becomes weaker and more compressible
Permeability & Groundwater	Allows water into otherwise impermeable rocks & can turn them into aquifers
Sites of Weathering	Accelerates movement of water & dissolved gasses into rockmass
Landsliding Slope stability	Provides fractures separating "blocks" of rock => wedge failures, rockslides, etc
Quarrying	Widely spaced joints => large masonary blocks More closely spaced joints => aggregate Very closely spaced joints => unsuitable for aggregate
Tunelling & Excavation of hard rock	Controls ease, stability, rockbreak in tunnels Allow ripping

Folds

- FOLDS are common structures in the rocks of mountain chains
  - range in size from microscopic crinkles to large structures more than 100km across
- Folds are formed by compressional stresses - usually in response to horizontal forces
- An ANTICLINE is an upwards arching fold
  - beds are folded into an inverted U-shape
- A SYNCLINE is a downwards sinking fold
  - beds are folded into a U-shape

Kink Fold (anticline)

[Photographer unknown]

Anticline in East Coast Bays Formation

Photo © Roger Thompson

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Anticline in East Coast Bays Formation

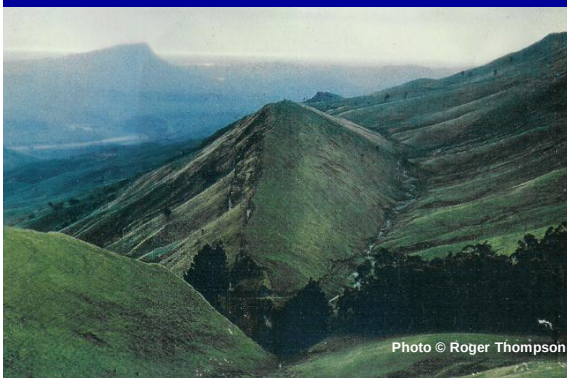
Syncline in East Coast Bays Formation

Photo: Roger Thompson

Syncline in East Coast Bays Formation

Photo: Roger Thompson

Fold



Fold - Whangaparoa

Folds

- **ISOCLINES** have parallel dips on both sides
- **OVERFOLDS** & **RECUMBENT FOLDS** have dips past vertical
- **NAPPES** are recumbent folds sheared along the central line with the development of a thrust fault, usually with large displacement

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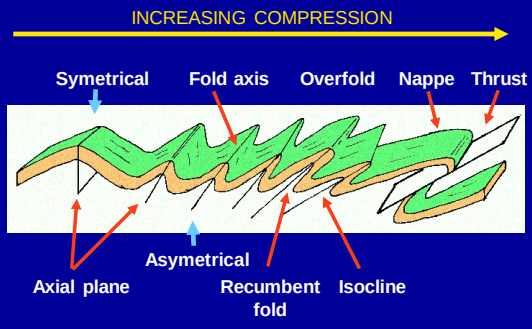
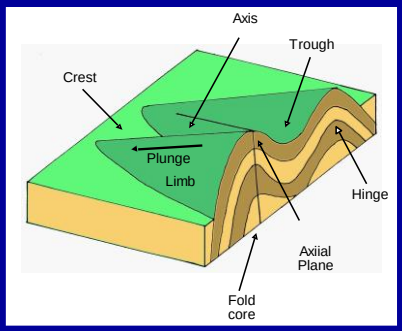
Folds



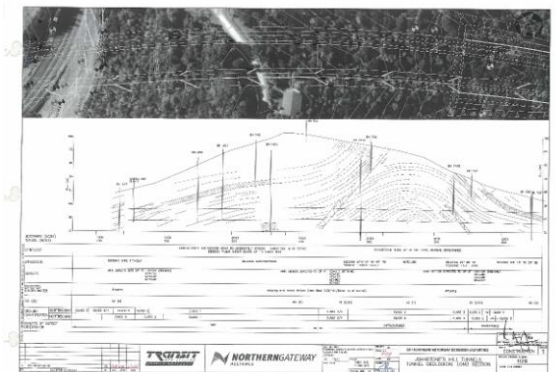
Plunging Folds



Relevance of Folds to Engineering

- Preferable to tunnel through an anticline rather than a syncline
- Synclines can cause waterflow into tunnels
  - eg Vectra tunnel at Newmarket and Penrose
- Anticlines tend to preclude water buildup

Folds & Engineering



Complex Structure, Chin Hill, N Gateway

Chin Hill, Northern Gateway

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Unconformities

Tertiary & Quaternary beds

Unconformity

Mesozoic sandstones

The unconformity represents a break in the formation of the rocks

Photo © Roger Thompson