Landforms and Rock Structure

Structure
- Structure is probably the most powerful control on landform development
- Landforms therefore tell us something about the underlying structure and geology
- Rock resistance plays an equally important role and is controlled by climatic conditions

Landform development
- How does rock resistance influence landform development?
- How does climate influence rock resistance?

Landforms
- Landforms produced directly by volcanic activity, folding or faulting are referred to as initial landforms
- Landforms converted by denudation to something that is no longer an initial form are referred to as sequential landforms
Granitic landscape, Namaqualand

Granite landscape, Yosemite National Park, California, USA

Structural control

Structural control
Structural control

Limestone, humid environment, Spain

Tower karst (limestone in a humid environment)

Landforms of horizontal strata

- Horizontal strata normally associated with vertical cliffs, escarpments and plateaus
- Associated landscapes are composed of one or more of the following elements
  - A near vertical free-face
  - Debris slope (30° - 35°)
  - A lower concave slope or wash slope
Description of rock layers

- How can we describe rock layers in three dimensions?
- We use a system of *dip* and *strike*.

Tilt and orientation of rock layers

- The *dip* of a rock layer is defined as the acute angle formed between the inclined rock plane and an imaginary horizontal plane and is given as an angle between 0º and 90º.
- The *strike* is defined as the line of intersection between the inclined rock plane and an imaginary horizontal plane and is given as a compass direction between 0º and 360º.

Moab National Park, Utah

Arches National Park, Utah
Weisrand, Namibia (limestone in an arid area)

Schwarzrand Escarpment, southern Namibia

Blydeverwacht escarpment, northern Cape Province (Nama Group sandstone cap rock)

Grand Canyon
View from the southern rim, Grand Canyon

Southern rim Grand Canyon

Mesas and Buttes

Mesa with dolerite cap rock, Karoo
Mesa, Etendeka lava, Kaokoveld, northern Namibia

Fish River Canyon, southern Namibia

Buttes, near Clarens, eastern Free State

Navajo Sandstone, Zion National Park, Utah
Drainage on horizontal strata

- Usually a dendritic pattern develops – that is a branching pattern with no definite direction or orientation.
- Streams that flow parallel to the dip of strata are called consequent streams, i.e. their flow is a consequence of the dip of the strata.
- Streams that follow a zone of weakness such as a joint or fault or along the contact between hard and soft rock are called subsequent streams.

Drainage on horizontal strata (cont.)

- Obsequent streams are streams that follow a direction opposite the dip of strata.
- Consequent, subsequent and obsequent streams very often develop into a trellis drainage pattern.
- Trellis drainage patterns show main streams with tributaries arranged at right angles to them.

Folded Strata

- We have seen in the previous slides what areas dominated by horizontal strata normally look like.
- What about areas with folded strata?
Folded strata

Folded sedimentary rocks, Tunisia.

Folded strata, England

Folded sedimentary rocks, Tunisia.

Folded strata

Axial plane

Axial plane

Hinge line

Hinge line

Open folds, tight folds and plunging folds

Open fold

Tight fold (upright)

Vertical axial plane

Plunging fold

Nonplunging fold

Hinge line refers to that portion of the fold where greatest curvature occurs.

Axial plane is an imaginary surface that encompasses the hinges of successive layers.
Landscape with plunging folds, hogback ridges (Great Basin USA)

Synclinal valley, Hex River

Folds in alternating hard/soft layers
- In folded areas of alternate hard and soft strata, a reversal of topography is possible with the formation of synclinal mountains and anticlinal valleys
- Piketberg is a good example of the former and the Eendekuil lowland a good example of an anticlinal valley

Homoclinal Ridges in Bokkeveld Group, Calitzdorp
Structurally-controlled valley, northern South Pass City, Wyoming

Effect of folded strata

- Playa, La Grand Salar in northeastern Chile, near the Bolivian Border. Small variations in lithology lead to differing rates of weathering and erosion. The feature is not a dyke but rather part of a folded structure.

The Hel, Gamkaskloof

- Tight folding in alternate hard/soft strata leading to the formation of subsequent valleys along the contact of hard and soft strata

Poorts

- Where larger streams cross a ridge, a watergap or poort is formed. Good examples are Seweweekspoort and Meiringspoort through the Swartberg Range near Oudtshoorn and Kogmanskloof near Montague
Complex fold structures, Swartberg Range, Meiringspoort, near Oudtshoorn

Pseudo inclined schist, Khomas Hochland, Namibia.

Tombstone weathering on folded Dwyka tillites, near Touws River

Unconformity

Geologic unconformity, Galesburg, Ontario, Canada. The Canadian Shield, comprised of Precambrian igneous and metamorphic rocks, is unconformably overlain by Ordovician limestones in this road cut.
Superimposed drainage

- Streams that have developed on horizontal strata that overlie folded strata maintain their original pattern even after removal of the horizontal strata. They therefore ignore the structure of the folding.

Antecedent drainage

- When tectonic action causes a mountain range to rise up beneath an already established stream pattern, some streams can maintain their course and will cut right across the range. They are called antecedent rivers.

Faulting in limestone, Pennsylvania

- Normal faulting produces fault scarps, which are sharp surface breaks in slope.
- Fault line scarps are scarps that develop due to erosion of the original fault scarp but they occur away from the original position of the fault.

Landforms produced by faulting

- Fault scarps, which are sharp surface breaks in slope.
- Fault line scarps, which are scarps that develop due to erosion of the original fault scarp but they occur away from the original position of the fault.