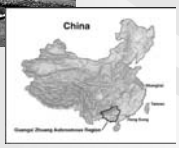
Stolen Land :
Famous erosional landforms



The ancient paintings aren't as stylized as one might think – the mountains actually do look like this !

Guangxi Province, Southern China

A popular landscape depicted in Chinese art is that of the limestone karst mountains of Guangxi Province of southern China.

In many of these paintings, the landscape appears almost surreal, the peaks of the hills being very high, but having an exaggerated roundness.

Generally high mountain peaks (= relatively young) are quite angular and rugged, certainly not well rounded as in this case.

Gao Kegung
Mountains after Rain in Spring.
?13th century

Why does this landscape look like this ?

There are several factors which have contributed to the evolution of this landscape:

1. The region is underlain by pure carbonate rocks (limestone and dolostone) which are readily dissolved by weak acids.
2. The area has a moist, warm climate (chemical weathering rates high).
3. The rocks are cut by joints, along which weathering has been enhanced.
4. The sequence of carbonate rocks is over 3000 metres thick (allowing for very deep dissolution).
5. Dissolution of the bedrock has produced a maze of underground streams. Also, the rooves of cave systems through which older underground streams flowed, collapsed and produced deep gulleys along which further dissolution was focused.
6. The entire region has undergone gentle uplift, enhancing the rate of stream downcutting.

Karst and Karst Topography

Karst is the term applied to landforms and other features produced principally by chemical erosion (dissolution) of terrains containing an abundance of bedrock soluble in weakly acidic ground waters.

Karst landforms may be generated in extensive evaporite deposits to some degree, but are most commonly associated with carbonate bedrock (limestones, dolostones and marbles), within which the production of large-scale landforms (e.g. karst "mountains" and large karst cave systems) is a possibility.

Karstification explains the existence of disappearing streams, sinkholes, large subterranean cave systems and underground rivers and lakes in areas of extensive and thick carbonate bedrock, as well as solution pits and clint (carbonate block) and grike (solution enhanced joint) topography visible on the upper surfaces of carbonate pavements (e.g. the Bruce Peninsula).

Roadrunner-Coyote Scenery
(Colorado Plateau Southwestern U.S.A.)

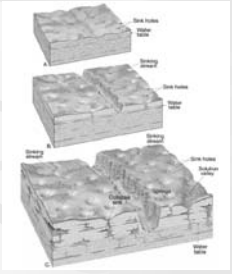
Throughout the arid U.S southwest we find flat-topped structures known as mesas and buttes that tower above the surrounding, relatively flat terrain.

A mesa (Spanish for "table") is an isolated, table-shaped, high plateau with a flat top and steep sides.

A butte (French for "hill") is like a mesa, but is smaller in it dimensions and often pinnacle-shaped.

These features are typically capped by rock which is more resistant to erosion than that below, though this does not completely explain the origin of these features.

Karst Topography



This is a possible sequence of early karst development in Guangxi Province, China:

A Near-surface dissolution of limestone (sinkholes developed due to collapse of near-surface caverns).

B Uplift, increasing downcutting of streams and lowering of water table. Sinkholes act as drainage conduits.

C Further uplift, downcutting of streams and deep dissolution occurs (necessary to produce high relief of the pillars).

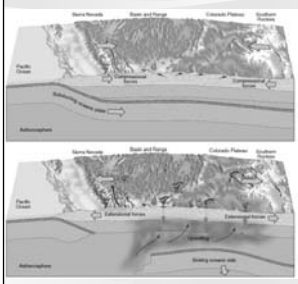
- Pillars remaining between the caverns are left behind as the Guangxi mountains.

Map of the Colorado Plateau

So why is this region a plateau?

Plateau: An relatively flat expanse of land which is elevated above the surrounding region.

Uplift of The Colorado Plateau



In relatively recent geological history (late Cenozoic), much of the U.S. southwest was gently upwarped into a broad plateau (Colorado Plateau) due to extensive regional magmatic activity. Magmatic heating of the lithosphere underlying the Colorado Plateau area resulted in thermal doming of this region.

Extensive generation and upwelling of magma here was possibly related to the detachment of a subducted slab of oceanic lithosphere which floated under this area, producing a much closer source of new magma than otherwise would be the case.

How Mesa-Butte Topography is Produced

The Colorado Plateau has been dissected by a network of deep stream valleys.

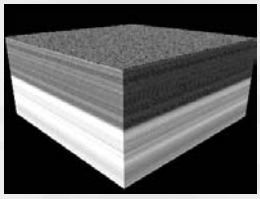
These were produced as a result of the uplift of the region. The streams want to maintain their gradient and travel along the shortest course possible to their ultimate destination. To do this following uplift, they must further incise their valleys (I.e. erode the material underlying their beds). A straight linear flowcourse will always be preferred, but this is not always a possibility (streams generally also take a path of least resistance). Consequently, streams will tend to meander in most cases. The actual course of these streams may change radically over thousands of years.

Separating the deep valley systems are broad flat regions.

With time and further erosion, the stream valleys widen and change position, leaving small remnants of the original plateau "stranded" well away from the latest position of the stream valley.

Later, wind and rain act to further erode these large elevated features. Due to the lack of extensive vegetation in this arid region (which would serve to protect and bind the surfaces of the rock), these forms of erosion are more effective than they otherwise would be. These areas experience periodic torrential rainstorms which can result in very high rates of erosion over a comparatively brief interval of time.

Summary of the Sequence of Events for the Development of Mesa and Butte Topography



- Sedimentary strata deposited
- Sedimentary strata uplifted and exposed at surface
- Dissection of land by rivers
- Widening of meandering stream valleys and isolation of mesas
- Further dissection and isolation of buttes through actions of wind and rain

Mesa and Butte Topography in the making: Canyonlands National Park, Utah

Badland Topography

A less extreme version of erosion in arid lands results in the formation of landforms know as "Badlands".

Valleys of rivers such as the Red Deer River and the Milk River in southern Alberta are deeply cut and have produced a deeply gullied "badland" topography

Badland Topography in Dinosaur Provincial Park (Red Deer River Valley, Near Brooks, Alberta)

This distinctively runnelled topography is the result of rapid erosion of poorly consolidated (cemented) sedimentary strata by water runoff. Erosion is also enhanced due to the scarcity of vegetation.

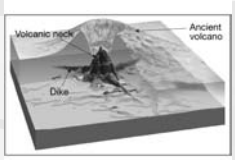
The term "badlands" finds its roots in the language of French settlers of western North America. It is derived from the term "terres mauvaises à traverser", which means bad lands to travel through.

An example of badland development in Ontario

You don't have to go to Alberta to see badlands

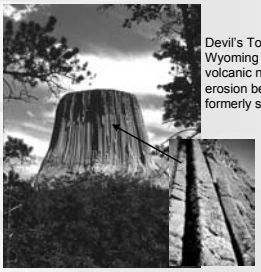
The Cheltenham Badlands, located 15 km northwest of Brampton, Ontario were produced as a result of improper farming practices. Uncontrolled erosion has stripped away the soil and has exposed the soft Queenston Formation claystones below.

Differential Weathering and Erosion: Ship Rock, New Mexico



The famous Ship Rock in New Mexico (a volcanic neck) stands high above the surrounding terrain because the intrusive volcanic material of the volcanic neck weathers less readily than the overlying pyroclastic rock and surrounding sedimentary rock.

Devil's Tower, Wyoming



Devil's Tower in northeastern Wyoming is another example of a volcanic neck that has resisted erosion better than the rock that formerly surrounded it.

An odd characteristic of Devil's Tower is the columnar jointing pattern within the andesitic igneous rock (a result of contraction as the rock cooled).

Sugarloaf (Pao de Acucar) , Rio de Janeiro

The Sugarloaf in Rio de Janeiro is an exfoliation dome-
The erosional remnant of an igneous body weathered via unloading

Half Dome, Yosemite Valley, California

Half Dome is another example of an exfoliation dome.

In this case, the dome was part of a larger igneous body. However, a river and glacial action have since carved out the lower part of the dome (v-shaped valley formed by river modified into a u-shaped valley by glacier).

The sheer cliff at the top of the dome was produced by the collapse of rock along a vertical joint (the collapsed material later transported away by the glacier).

Hoodoos of Alberta

Hoodoos are small scale, pillar-shaped features produced by the erosion of layered rocks with differing characteristics of weathering. The famous Hoodoos near Drumheller, Alberta were formed primarily by water-related erosion, but wind has influenced their development as well.

Soft layers of shale at the base of the Hoodoos weather and erode more quickly than the more strongly cemented sandstone layers that cap the Hoodoos.

The result is an odd mushroom-shape.

Hoodoos at East Coulee
(Near Drumheller), Alberta

Another Popular Photo Subject
Stone Arch, Arches National Park, Utah

Stone arches are formed when thin walls of freestanding sandstone erode on each side, and eventually a 'window' or hole in the rock appears.

With continued erosion, arch eventually collapses.

Another Interesting Example of a Hoodoo:
Balanced Rock, Arches National Park, Utah

And while we're at Arches National Park…

END OF LECTURE