

Factors Influencing Type & Rate of Weathering (Priority: High)

Remember R³C²!

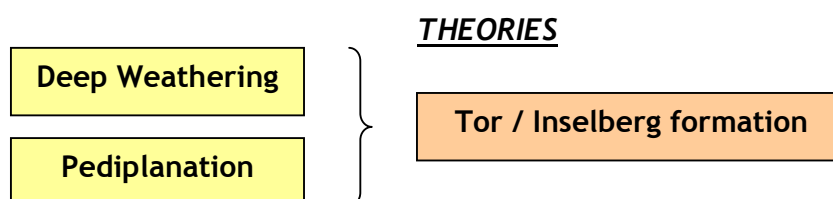
R	Rock hardness	<ul style="list-style-type: none"> ✓ <u>Igneous rocks harder</u> (presence of feldspar & quartz bond rock tightly) ✓ <u>Sedimentary rocks softer</u> ✓ Less important in determining weathering resistance ✓ <u>Slows down frost weathering & insolation</u> ✓ <u>Does not influence chemical weathering!</u>
R	Rock jointing	<ul style="list-style-type: none"> ✓ <u>Important influence</u> on ALL types of weathering ✓ <u>Increase rock surface area available to chemical attack</u> (water & oxygen ingress) ✓ <u>Lines of weaknesses used by mechanical agents</u> (frost action) ✓ <u>Overriding factor</u> in determining weathering resistance in frost climate
R	Relief	<ul style="list-style-type: none"> ✓ Not usually taken into account but has influence ✓ <u>Steep slope, weathered products transported away, exposing fresh bedrock to renewed attack</u> ✓ <u>Gentle slopes, water retained, weathered products not easily washed away, protect from mechanical weathering & enhances chemical decomposition</u>
C	Chemical composition	<ul style="list-style-type: none"> ✓ <u>Key factor influencing resistance of rock to chemical decay</u> ✓ Quartz, mica & k-feldspar (light colored) most stable ✓ Olivine & augite (dark colored) least stable
C	Climate	<ul style="list-style-type: none"> ✓ <u>Most significant long-term control of weathering</u> ✓ <u>Freeze-thaw cycles increase → frost shattering increase</u> ✓ <u>Precipitation & infiltration amount / distribution increase → chemical weathering increase</u> ✓ <u>Vant Hoff's Law: rate of chemical weathering X2 for every temperature increase of 10°C</u> ✓ <u>Weathering more intense, deeper in warm moist climate than in cold dry climate</u>

Granite Weathering: Theories & Landforms (Priority: High)

Granite: Igneous rock containing quartz, mica & feldspar → great physical strength, resistance to erosion

Main process of weathering: freeze-thaw & hydrolysis

Landscapes: inselbergs & tors



Deep Weathering: Ruxton & Berry, 1957**(Priority: Medium)**

Production of thick regolith by prolonged / intense chemical weathering, of which regolith thickness can reach 30m

Ruxton & Berry suggested gradual decomposition of granite from surface downwards producing 4 identifiable zones, each older than that beneath it

- ✓ Essentially associated with low relief in humid tropical environments due to high temperature & rainfall and dense vegetation

Zones	Characteristics
1	Residual debris, 25 m thick
2	Residual debris with corestones, 60 m thick
3	Corestones with residual debris, 17 m thick
4	Area of partially-weathered rock, 30 m thick
BSW	Basal surface of weathering: <u>limit of zone of weathering of bedrock beneath land surface</u>

- ✓ Deep weathering develops when weathering rates at basal surface > surface removal of weathered products
- ✓ Through uplift, climate change or vegetation destruction, surface erosion will outpace weathering, removing deep weathered layers
- ✓ BSW then revealed at land surface, changing as landforms develop
- ✓ Sequence of development in stripping of deep weathering layers:
 1. Pediplain forms
 2. Deep and selective weathering of surface
 3. Valley incision following uplift
 4. BSW exposed on highland between valleys stripped of regolith
 5. Exposed fresh rock then forms domed inselbergs & tors

Pediplanation: King, 1948**(Priority: Medium)**

King proposed cycle of erosion accounting for low relief plain cutting across isolated rock structures in arid, semi-arid & savanna Africa

Theory explains formation of landforms via scarp retreat (mass movement & weathering) & pedimentation through 3-stage development

Stage	Characteristics
1	Stage of youth: <ul style="list-style-type: none"> ✓ Initiated by <u>uplift of previous pediplain</u> ✓ <u>Streams cut rapidly downwards → valleys form</u> ✓ <u>Downcutting becomes less active → pediments form</u> ✓ <u>Pediment extends as upland areas consumed by scarp retreat</u> ✓ Forms inselbergs, then tors
2	Stage of maturity: <ul style="list-style-type: none"> ✓ <u>Inselbergs decrease as pediments in adjacent valleys widen</u>
3	Stage of old age: <ul style="list-style-type: none"> ✓ <u>Residual hills rare, relief diminished by low-angle pediments</u>

- ✓ Weathering causes free face to retreat slowly
- ✓ Waxing slopes become smaller as pediments develop, till pediments merge to form extensive pediplain
- ✓ Original land eventually reduced to isolated inselbergs that are finally eroded vertically and disappear

Inselbergs: Types & Models of Development (Priority: High)

Inselberg: Large residual hill surmounting an eroded plain, found in humid & semi-arid regions, domed-shaped steep sided, consisting of granite & gneiss

Type / Name	Characteristics
<i>Domed / Bornhardt</i>	✓ Massive single domes 300 m tall, displaying sheet-jointing and convex summit
<i>Domed / Ruwares</i>	✓ Low domes of exposed bedrock 100 m tall
<i>Blocky / Tors</i>	✓ Small boulder heaps, rectangular jointing, 4-20 m tall, in groups of spheroidally weathered boulders
<i>Blocky / Kopjes</i>	✓ Accumulation of boulders in hill, more angular than tors, final stage of bornhardt collapse

Models of Inselberg Development

1. Pediplanation hypothesis (King, 1948)

- ✓ Inselbergs: late-stage residual hills from gradual destruction of interfluvial blocks by scarp retreat & pedimentation
- ✓ Criticism: no sufficient account of deep weathering's role in inselberg formation, and many domes far from retreating scarps

2. Exhumation hypothesis (Willis, 1936)

- ✓ Inselbergs: originate as domical rises in BSW, revealed at ground surface by stripping of overlying regolith
- ✓ Result from uplift, stream rejuvenation & climate change
- ✓ Criticism: can only account for ruwares 50 m tall and not inselbergs 300 m tall since subsurface domical rises not very high

Tors: Models of Development (Priority: High)

Tor: Exposure of rock in situ, upstanding all sides from surrounding slopes, formed by differential weathering of bedrock & debris removal by mass movement

Vary in scale and distinctive exposed rock jointing (horizontal & vertical) produce crude arrangement of rocks

Type	Development
<i>Tors of cuboid / partly rounded blocks</i>	Developed when vertical jointing is strong
<i>Tors of rounded / domed-shaped blocks</i>	Developed when pseudo-bedding is close-spaced & vertical jointing weak

Models of Tor Development

1. Pediplanation theory (King, 1948) **See Pg 2 for details*
2. Deep weathering theory (Linton, 1955)
 - ✓ Well-developed jointing chemically weathered under warm humid conditions, with decomposition most rapid along joints
 - ✓ Where distance between joints largest, masses of granite relatively unweathered, forming embryonic tors
 - ✓ Subsequent denudation remove weathering residues, leaving unweathered blocks as tors
 - ✓ 2 stage development:
 1. Extensive subsurface rock rotting along joints
 2. Exhumation by removal of fine-grained weathered products

Limestone / Karst Weathering**(Priority: High)**

Limestone: Sedimentary permeable rock containing 50% CaCO_3 → undergoes chemical weathering (carbonation & solution)

Karst: distinctive landforms produced by sedimentary rock (limestone) susceptible to chemical weathering by carbonic acid

Karst landforms: excavating effects of underground water on huge soluble limestone, found where limestone pure & thick and enough water for solution

Landscapes: cockpit & tower karst (TROPICAL), dolines & limestone pavements (TEMPERATE), caves

Conditions promoting karst development

1. *Geological (Rock type, characteristics & structure)*
 - ✓ Presence of large & thick soluble limestone near / at surface
 - ✓ Rock should have low porosity, high purity, widely-spaced joints
2. *Climatic*
 - ✓ Moderate rainfall, high temperature & dense vegetation providing organic matter & thus carbonic acid / carbon dioxide

Why tropical & temperate karst vary significantly

1. Variations in thickness & extent of limestone
2. Jointing pattern & bedding planes differ
3. Rainfall & vegetation variations
4. Undisturbed chemical weathering in geologic history

Why Southern China is most conducive to tropical karst development

1. Large amount of rainfall (2000 mm< per annum)
2. Long periods of slow uplift
3. Thick beds of limestone (3 km deep)

Temperate Karst**(Priority: Medium)**

Found in mid-latitudes in areas receiving less precipitation, often have underground features more accentuated than above-ground features and form more slowly than tropical karst

Characteristics: disappearing streams, extensive caves

Examples: Kentucky's Mammoth Caves, USA

- ✓ Temperate karst landscapes:
 - Limestone pavements
 - Dolines / sinkholes (*below*)
 - Caverns
 - Speleothems (stalactites & stalagmites)



<http://www.ulg.ac.be/geolised/processus/dolines.jpg> & http://www.limestone-pavements.org.uk/images/large_doline2.jpg

Tropical Karst**(Priority: High)**

Found in humid tropical regions with much topographical relief, larger features that develop faster

Characteristics: steep rounded hills & near-vertical rock formations

Examples: Yunnan's Stone Forest & Guangxi Guilin, China

1. Tower karst

- Landscape characterized by vertical rounded blocks about 60° - 90° separated by flat-floored depressions
- Towers 30 - 300 m tall, walls of bare rock, variable in size
- Occurs where tectonic uplift slow / negligible, limestone close proximity to non-limestone rocks, water table close to surface
- Occurs throughout Southeast Asia & South China, especially Guangxi Guilin, China (*right*) & Halong Bay, Vietnam (*left*)



<http://geoimages.berkeley.edu/Geoimages/Johnson/Landforms/MiscLandforms/TowerKarst01.html> &
<http://www.uwsp.edu/geo/projects/geoweb/participants/dutch/geophoto/grndh20/Guilin1.jpg>

2. Cockpit karst

- Landscape pitted with soil-covered depressions of smooth slopes (30° - 40°) & cone-like hills
- Developed from solution, occurs where tectonic uplift great & river downcutting most intense
- Spacing of cones related to original stream network
- Water continues to weather limestone as far down as water table



<http://img263.imageshack.us/img263/5723/scockpitcountryjpgui3.jpg>

Surface Karst Features

(Priority: Medium)

Limestone pavements

- ✓ Produced by removal of surface material & vertical fissures along joints widening & deepening
- ✓ Grooved & jagged terrain
- ✓ Clints: flat-topped dissected blocks between grikes
- ✓ Grikes: where joints reach surface & widened by acidic rainwater