

## Unit 3 The Lithosphere

**Recommended Prior knowledge.** The fundamental principles of tectonics and weathering may have been introduced at IGSCE. However no previous knowledge is essential to this unit.

**Context.** Weathering processes are influenced by climatic factors and there is a close relationship between fluvial and slope processes. Therefore there are clear links between all three units within the physical core.

**Outline** This unit covers basic principles of tectonic activity and weathering and slope processes. Although the human impact is designated as a sub-unit it seems advisable to include human activities as a factor influencing weathering and slope processes rather than teaching it as a separate sub-unit.

Content	Objectives	Terminology	Teaching Strategies (TS) and Activities (A)	Resources
<b>The Lithosphere</b>  Elementary Plate Tectonics 3.1	<ul style="list-style-type: none"> <li>Knowledge of global distribution of lithospheric plates</li> <li>Knowledge of different types of plate boundary</li> </ul>	<b>Crust</b> <b>Mantle</b> <b>Core</b> <b>Lithosphere</b> <b>Asthenosphere</b>  <b>Divergent/constructive margins</b> <b>Convergent/destructive margins</b> <b>Conservative margins</b>  <b>Convection currents</b> <b>ridge pull</b> <b>slab push</b> <b>Sea floor spreading</b>	<p><b>TS.</b> Begin with basic structure of the earth Then map of global distribution of plates- describe-linear on continental margins/coastal i.e. <b>not random or scattered.</b> The map could be annotated.</p> <p><b>Define a tectonic plate</b>-two key points- it is a slab of lithosphere and it moves!</p> <p><b>Explain reasons for movement</b>- convection currents in the mantle. Brief reference to evidence that plate movement has occurred in the past – use of atlas maps, especially the S. America /Africa “fit”</p>	<p><b>Maps</b>            Waugh p.10 fig.1.2            Guinness and Nagle P.93 Fig. 4.1 and 4.2            Nagle p.8Fig 1.7            Prosser p.10-11 Fig 1.5            Hart P.86 fig. 4.2            Ross P.29 fig.2.4            Guinness and Nagle p.95 Fig 4.5</p> <p>Ross p.30 fig.2.9</p>

<p>Weathering and Rocks 3.2</p>	<ul style="list-style-type: none"> <li>Knowledge and understanding of the processes and landforms associated with each type of boundary</li> <li>Knowledge and understanding of major physical and chemical weathering</li> </ul>	<p><b>Island arcs</b> <b>Subduction zones</b> <b>Ocean trenches</b> <b>Benioff zones</b> <b>Transform faults</b> <b>Seismic activity</b> <b>Volcanic activity</b> <b>Shallow/deep focus earthquakes</b> <b>Fold mountains</b> <b>Mid-oceanic ridges</b></p> <p><b>Conservative margins</b> <b>Collision zones</b></p> <p><b>Freeze-thaw action/Frost shattering</b> <b>Exfoliation</b> <b>Wetting/drying</b></p>	<p><b>TS. Consider each plate boundary.</b> Describe and explain processes. Consider landforms associated with each type of boundary/margin. Diagrams are the best way of keeping the material manageable and easy to understand.</p> <p>Students should see how the two major types of margin are complementary. i.e. ridge push and slab pull balance each other out so that the crust does not become progressively larger! Idea of a system once more! Rates of movement equivalent of the growth of a finger nail!!</p> <p>This part of the unit could and probably should be illustrated by reference to specific plate boundaries. E.g. Nazca-South American plate, mid Atlantic ridge, Pacific-Eurasian-Philippine (island arcs/trenches)</p> <p>San Andreas Fault. Although not specified conservative margins and collision zones can be useful additions to this section but will not be examined. (Will be useful for the Hazardous Environments in A2)</p> <p><b>TS.</b> Introduce the classification of weathering processes. <b>Define weathering-</b> 'breakdown of rocks in situ'. Emphasise the idea that no transport is involved. Also the importance of moisture being present. Can</p>	<p>Nagle p.9-10 Prosser p.12-3 Hart p.88-94</p> <p>Ross p.31-37 p.38-48</p> <p>Case Study of East African Rift Prosser p.17</p> <p>Guinness and Nagle p311, fig 9.12</p> <p>Prosser P.15 Himalayas p.16 San Andreas Fault Ross p.37 Fig 2.18 Nagle p22</p> <p>Ross P.49-52 Waugh P.40-43 Hart p.95-98 Prosser p.26 Nagle p.30-32</p>
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	<p>processes</p> <ul style="list-style-type: none"> <li>• Appreciation of the role of biological agents in weathering processes</li> <li>• Related end products of the processes</li> <li>• Knowledge and understanding of the factors which influence</li> </ul>	<p><b>Spheroidal weathering</b>  <b>Dilatation</b>  <b>Salt crystallisation</b>  <b>Hydration</b>  <b>Hydrolysis</b>  <b>Carbonation</b>  <b>Solution</b>  <b>Oxidation</b></p> <p><b>Chelation</b></p> <p><b>Effects of Acid Rain</b></p> <p><b>Granular disintegration</b>  <b>Block disintegration</b></p>	<p>go on to develop the idea of <b>erosion</b> and then <b>denudation</b> so that students see the processes in context. Annotated diagrams where possible. <b>Fig 1</b></p> <p>Photographs can help hugely in explaining how the processes operate.</p> <p>Can be reinforced by a matching exercise – process and description – a simple but often effective means of generating discussion and encouraging thought about the processes, especially when produced on slips of paper which can be physically rearranged and classified into physical/chemical/weathering/erosion sets</p> <p>Discuss whether biological agents justify a separate category of weathering or whether these agents carry out physical/chemical processes. e.g. Tree roots, humic acids, organisms etc.</p> <p>Can introduce the human element here and discuss increased carbonation-solution on buildings etc to cover part of 3.4</p> <p>End products should be linked. (This is important because it is often forgotten by candidates). Therefore physical weathering tends to produce block disintegration, chemical-granular disintegration.</p> <p><b>TS.</b> Introduce the ways in which factors such as climate, vegetation, soils, rock lithology, relief and time may influence these processes. Fundamentally climate</p>	<p>See <a href="http://www.regolith.com">www.regolith.com</a> for photographs of landforms</p> <p><b>Fig. 1 Example of an annotated photograph</b></p> <p>Ross p.49 Fig 2.37</p> <p>Prosser - Very good on weathering rates p.29-30  Ross P.53 Fig.2.42  Ross P.55 Fig.2.44*  Hart p.98-100  Waugh P.44 Fig 2.10  Nagle p.32-3</p> <p><b>Fig. 2 Peltier Diagram</b></p>
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	<p>weathering processes</p> <ul style="list-style-type: none"> <li>• A detailed appreciation of the role of climate as a factor</li> </ul> <ul style="list-style-type: none"> <li>• Appreciation of the relationship between lithology and weathering with reference to Granite and Limestone</li> </ul>	<p><b>Tor</b>  <b>Massive rock</b>  <b>Joints</b>  <b>Igneous rocks</b>  <b>Core-stones</b></p> <p><b>Limestone pavements</b>  <b>Underground caverns</b>  <b>Stalactites</b>  <b>Stalagmites</b>  <b>Grykes clints</b>  <b>Scars and edges</b></p>	<p>and rock lithology are the two key factors - climate plays an overarching role because it influences other factors like vegetation and soils.</p> <p><b>A. Peltier Diagram Fig 2</b> should form the basis for class discussion and then questions can be set on it. Can be annotated with processes.</p> <p><b>A Analysis of Fig 3 Latitudinal variation of regolith depth illustrates role of climate in weathering processes and can be related to the regions on the Peltier diagram</b></p> <p><b>TS. First the characteristics of granite and limestone followed by studies of granite and karst</b> scenery. The syllabus is not specific and the questions may be open ended but given time both tropical and temperate versions of each would be ideal.</p> <p>Granite- deep weathering in the tropics/etch-planation to produce inselbergs etc. Tors on Dartmoor-two theories of formation Linton-deep weathering and Palmer and Neilson- frost shattering and solifluxion.</p> <p>Limestone- contrast between Tower karst in the tropics e.g. China and Temperate latitudes e.g. Yorkshire Dales. Impact of human activity in areas like the Yorkshire Dales would provide material for the human impact on weathering and mass movement here. Footpath erosion, removal of clints from limestone pavements for landscape gardening are useful additions for 3.4</p>	<p><b>Fig 3 Latitudinal variation of regolith depth</b></p> <p>Hart p.104-5  Prosser P.27</p> <p>Nagle 40-1</p> <p>Hart P.100-2  Nagle p.34-5, 38-9  Prosser p.29  Ross 71 - 75</p>
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<p>Slopes Processes and Development 3.3</p>	<ul style="list-style-type: none"> <li>• Understand that slopes are systems</li> <li>• Knowledge of slope form</li> </ul> <ul style="list-style-type: none"> <li>• Understanding of mass movement</li> <li>• Knowledge and understanding of processes of mass movement</li> </ul> <ul style="list-style-type: none"> <li>• Understanding of the relationship between process and form</li> </ul>	<p><b>Sinkholes</b>  <b>dolines</b>  <b>Spring line</b>  <b>Gorge</b>  <b>Dry waterfalls</b>  <b>Tower karst</b></p> <p><b>Internal strength</b>  <b>Shear stress</b>  <b>Boulder controlled slopes</b>  <b>Concave convex slopes</b>  <b>Free face</b></p> <p><b>Heave</b>  <b>Flow</b>  <b>Fall</b>  <b>Slide</b>  <b>slump</b>  <b>Soil creep</b>  <b>Landslide</b>  <b>Mudslide</b>  <b>Avalanche</b>  <b>Rotational slip</b>  <b>Debris slide</b></p>	<p><b>Although the syllabus does not specify landforms it is implicit in the wording. Therefore they should be studied and will be examined.</b></p> <p><b>TS</b> Introduce via a diagram the slope as a system-inputs/outputs. Consequent form is dynamic as the result of processes. Look at relationship between internal strength v. external forces producing shear stress. If stress greater than strength then movement occurs. <b>Critical angle of rest for different particle sizes/shapes.</b> Result a slope form.</p> <ul style="list-style-type: none"> <li>• Definition of mass movement  Movement of material downslope <b>under the influence of gravity.</b> There is no other agent of movement but slope wash and/or the presence of soil water may assist the process. Understanding of the role of water</li> </ul> <p>Classification of slope processes - a triangular diagram is the best way of discussing the variety of processes. Conditions for each type of process. A. The students can then plot some of the processes for themselves to demonstrate their understanding</p> <p>Students need to learn about each of the major processes and be aware of the resultant slope forms. E.g. Rotational slip may be a slide along a slip plane with a flow at the toe if there is clay at the</p>	<p>Ross P.59  Waugh P.46 Fig 2.12  Prosser P.34 Fig 1.37  Hart P. 106 Fig. 4.37  Hart P.107  Nagle p.46</p> <p>Hart p.115  Nagle p.49  Waugh P.46 Fig 2.13  Ross P.59  Hart 108-113 Detailed catalogue of processes</p> <p>Waugh P.47-9  Good case studies p.52-57  Prosser P.32-38 Very good on how slopes develop</p>
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<p>The human impact 3.4</p>	<ul style="list-style-type: none"> <li>• Knowledge and understanding of the factors that influence the processes</li>   <li>• Understanding that human activity may have a significant impact on weathering and slope processes</li> </ul>	<p><b>Debris avalanche</b></p>	<p>base of the slope. So there will be a compound slope profile possible with a concave and convex profile.</p> <p>The factors are similar to those that influence weathering-<b>climate, soil, and vegetation, rock lithology</b> especially <b>mixed lithology</b> (e.g. Chalk overlying clay.) <b>Gradient</b> (influences the shear stress), aspect.</p> <p>Human activities which affect weathering and slope processes may be</p> <ul style="list-style-type: none"> <li>• intentional(e.g. mining, quarrying, spoil heaps, stabilising slopes, coastal management)</li> </ul> <p>or</p> <ul style="list-style-type: none"> <li>• unintentional (e.g. effects of acid rain, deforestation overgrazing by flocks, landslides where favelas have been built on steep slopes)</li> </ul>	<p>Hart p.114 Case Study of Holbeck Hall Ross P.58 Good diagrams and explanation</p> <p>Ross P.59 – 62 including case study Nagle p 54 - 55</p> <p>Hart p.115-7 Good material on human activities</p>
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