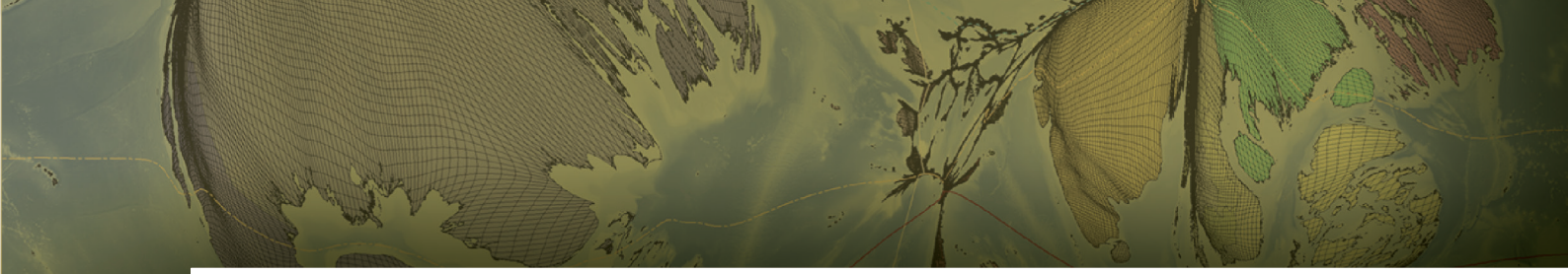

CHAPTER 6

The Earth is changing

Key words: Geomorphology, landscapes, landforms, dynamic systems, weathering, erosion, drainage systems, coastal dynamics, sea level changes, desertification, climate change, global warming, Palaeoclimatology.

Introduction

On a very dynamic Earth landscapes evolve. Natural landscapes are a complex interaction between landforms produced through erosion and sedimentary processes and the control of plate tectonics and climate. The evolution of landscapes is controlled by a balance between tectonic uplift (or subsistence) and climate change. Geomorphology is the branch of Earth Sciences that studies landscape forms and their evolution.

6.1. The Earth as a dynamic system

Earth is a dynamic planet because its composition in different layers or “spheres” moving and interacting each other. Loss of Earth’s internal heat energy drives moving of plate tectonics that influences all of the structure features of our planet.

6.2. How landscapes are changing

Landscapes are dynamic systems determined by tectonics, erosion, climate and the geodiversity of the bedrock. Changes such as mountain uplift or subsidence, the motion of lithospheric plates, opening or closing of ocean basins and sea level changes, as well as rock response to tectonics or weathering agents, can take millions of years.

6.3. About the interaction between the lithosphere, hydrosphere, biosphere and atmosphere

Geological landscapes result from the interaction of the Earth’s different subsystems. The main components affecting the climate system are the atmosphere, hydrosphere, lithosphere and biosphere.

6.4. About major landforms (mountains, plains, plateaus, hills, valleys, coasts, etc.

Landforms are natural physical features of the Earth's surface formed as a result of the interaction between major constructive geological processes (tectonics, volcanism, etc. and surface destructive processes (weathering, erosion, etc). The scale of landforms ranges from few metres or hundreds of metres (e.g. sand dunes) to hundreds of kilometres (e.g. mountain belts).

6.5. About weathering

Weathering is the effect of all the chemical and physical processes that break up and decay minerals, rocks and other geological materials on the surface of the Earth into fragments of various sizes, or soluble minerals. Weathering processes include heat, water, pressure and organisms.

6.6. About erosion

Erosion is the set of processes that loosens *in situ* rocks, soft sediments and soils, leading to their *transport* to another location where they may be deposited as layers of sediment. Agents of erosion agents include flowing water, glaciers, wind and gravity.

6.7. How water shapes landscape

Water reacts chemically with many minerals, typically altering them into more soluble or weaker materials and thus contributing to the weathering of rocks, as well as changing soil properties. Rain water flows down slopes, eroding gulleys and then valleys, hence shaping the land. Waves and sea currents shape coastal areas. Freezing water breaks rock as it expands to become ice and glaciers and ice sheets shape mountains and high-latitude lands with a powerful grinding action as they move.

6.8. How mountains are eroded and worn down

Erosional agents such as flowing water, ice and wind can act intensively on a mountain. Different resistances of different rock types to weathering and erosion, as well as tectonic discontinuities such as major faults, will dictate the shape of the mountain.

6.9. About river basins

Beyond the glaciers and ice sheets, river drainage systems are responsible for the physical weathering and erosion of mountains and ultimately sedimentation in lowlands or the sea. Riv-

ers evolve from a fast flowing 'youthful' stage in the mountains towards a slow moving 'mature' stage in the lowlands depending on tectonic uplift rates and sea level changes. Erosion and sedimentation is largely dependent on climatic factors such as rainfall and vegetation cover.

6.10. How rivers and sea waves alter landscapes

Rivers are a balance between the actions of erosion, transport and sedimentation. These factors create a longitudinal equilibrium profile for the riverbed, whose shape is dependent on changes in water flow, geological characteristics, sediment characteristics and depositional processes - as well as tectonic factors and changing sea levels. The highest rates of erosion take place in the faster flowing upper reaches of the river and sedimentation takes place mainly in the lower reaches, such as on mature flood plain areas and in estuaries. River sinuosity depends on the rate of erosion and sedimentation in the river margins which can lead to the development of meanders.

6.11. About coastal dynamics (beaches, cliffs, cliff retreat, coastal evolution)

Sediments deposited in estuaries and river deltas are redistributed by sea waves and currents along the coast. Beaches are usually temporary accumulations of such sediments. Eroding coastlines result where waves are the major erosive agent, leading to shoreline retreat as the eroded sediment is moved away by currents.

6.12. How shorelines are changing

Sea level changes related to continental movement (including marine transgressions and regressions) and the rate of river sediment input into coastal areas are the main processes responsible for coastal evolution. Raised marine terraces (i.e. above present day sea level) and coastal sedimentary deposits document the past evolution of shorelines. Knowledge of these changes is very important for the management of human activities in coastal areas where more than 600 million people live today.

6.13. About desertification

Deserts are arid regions and comprise around one third of the Earth's land surface. The very low rainfall prevents significant plant growth. Wind processes are the major factors which shape desert landscapes. There are "hot" rocky and sandy deserts and "cold" deserts as in Polar regions. Desertification is a consequence of climate change that may transform semi-arid lands into deserts. The unrestrained growth of human populations and consequent agriculture expansion – including greater demands on water supply – may result in the expansion of deserts.

6.14. About climatic change

Climate change is a significant and lasting change in the distribution of weather patterns over

time. Forcing mechanisms include oceanic circulations, variations in solar heating of the Earth's surface, plate tectonics and volcanic eruptions - as well as major human impacts on natural systems.

6.15. About climate changes through History of Earth

Palaeoclimatology, or the study of the geological record of past climates, can help separate natural variations of climate from human-induced effects. To understand global patterns of natural variability in space and across time can help predict more accurately phases of global cooling (for instance leading to a Glacial period) or warming. On a more local scale, modelling geological hazards related to short-term climate change may help prevent or reduce the risk of loss of life or property with the improvement of land management plans.

6.16. About climatic changes in your region through geological time

The rocks and landforms of Europe record many climate changes through geological time. Three major phases of Ice Ages before our present phase are recorded in some of the older rocks across Europe, the oldest around 580 million years ago during the latest Precambrian, immediately preceded the first burst of Metazoan life in the seas, the second was around 150 million years later, at the end of the Ordovician Period (450 million years ago), and the third around 290 million years ago during the Carboniferous Period. The latter, however, is recorded in Europe mainly as massive changes in sea level which affected low lying areas (i.e. as a result of polar ice repeatedly freezing and then melting). At this time, however, Europe itself was dominated by equatorial forest and swamps which produced the Carboniferous coal deposits so important for industrial development in many countries.
Desert deposits dominate central and northern Europe in the Devonian and Permian-Triassic as continental drift took the region through desert latitudes first to the south, and then to the north of the equator. Deep weathering of the Carboniferous-Permian Variscan Mountain Belt under tropical climates during the Jurassic Period contributed to the plateau-like landscapes which are characteristic from the Iberian Massif. Cenozoic climates with semiarid conditions and torrential rains lead to the current erosive shapes of these major plateaus.
However, in parts of more northern Europe, sub-tropical weathering had a major effect in reducing more ancient topographies during the Cenozoic. Some of the most major changes across central and northern Europe occurred during the most recent ice ages of the Quaternary Period, with their alternating phases of warm, temperate climates and frozen permafrost or ice sheet covered phases. These phases created deep river valleys incised into upland areas and plateaus and the glacial U-shaped valleys in some of highest mountains. Tectonic and climate changes are also responsible for shaping coastal areas during the Quaternary, for instance producing raised marine platforms above modern sea level during warmer interglacial periods when ice melted.

Intended learning outcomes:

- Understand landscapes as a result of Earth Dynamics.
- Recognise major landforms.
- Understand the difference between weathering and erosion processes.

- Understand coastal dynamics and their importance for world populations.
- Understand the difference between “hot” and “cold” deserts and the human role in desertification.
- Develop an informed opinion on Global Warming and its relationship with Climate Change.
- Develop an understanding of the geological evidence for climate change and an appreciation of the possible causes within an Earth System context.
- Recognise that natural processes lead to changes in the environment.

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