GCSE Geology 4.2: Earth resources and engineering

Resources – naturally occurring useful geological substances such as coal, oil, gas, copper, iron, lithium and silver.
Reserves – the proportion of resources that can be extracted economically.

Mineral resources are important in construction, industrial manufacturing and energy generation.
Limestone (including chalk) for aggregate in the construction industry – concrete, cement, road bases and building stone.
Haematite in the steel industry – buildings, infrastructure, tools, ships, trains, cars, machines, electrical appliances, and weapons.
Uranium in the generation of nuclear energy.

Geologists prospecting for new reserves use a variety of **prospecting techniques:**

Geological mapping to determine size, shape, surface exposure and orientation beneath the ground of geological bodies – coal seams, beds of limestone, mineral veins. Borehole correlation using microfossils to match up horizons and to determine previous temperatures in oil and gas bearing strata at different locations. Geophysical methods (including seismic, magnetic and ground penetrating radar) to indirectly measure the physical properties of rocks at depth and in turn to interpret the geological structures present.
Geochemical methods (soil and river sediment) involve taking samples of soil and river sediment and analysing their chemistry in terms of mineral and metal content. Soil analysis reveals the chemistry of bedrock beneath, while river sediment reveals the chemistry of the drainage basin upstream from the sample point.

There are characteristic structures and rock properties associated with the migration and accumulation of **oil and gas** in potential gas/oilfield resources.
Source rock – the rock from which the oil/gas is derived, typically black shale with a high organic content (from marine plankton) of up to 50%.
Reservoir rock – the rock in which the oil/gas can accumulate, ideally with a high porosity (large volume of oil/gas can accumulate) and permeability (oil/gas is able to flow through the rock so extraction rates are economical). Desert sandstones are ideal with porosity values of up to 30%.
Cap rock – rock overlying the reservoir rock which is impermeable and prevents the oil/gas from migrating up to the surface (shale, mudstone, clay, rock salt).
Oil and gas traps – natural geological structures that allow oil/gas reserves to accumulate (anticline [most common], fault, unconformity, salt dome).

There are technological difficulties and environmental issues involved in **exploring for and extracting oil and natural gas** including fracking.
Many operations are offshore, and there is a danger of wells leaking and contamination of the marine environment by oil and gas leaks.
Fracking involves the hydraulic fracturing of rocks on land such as shale to release the natural gas stored in the micro-pores between clay particles.
Fracking is achieved by pumping fluids with sand at high pressure into the rocks at depths of 1.6 to 3.2 km. Sand grains help to keep the fractures open so that the gas can escape. Problems with fracking include the generation of minor earthquakes and the contamination of groundwater due to fracking fluid leakage.

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Factors affecting the extraction of underground water from aquifers:
Aquifer – a rock capable of storing water. Ones with a high porosity and high permeability are most suitable, such as desert sandstone limestones including chalk.
Water table – the level below which the ground is saturated with water. This varies seasonally, with it usually being higher (closer to the surface) in winter and lower (deeper) in summer. Natural springs occur when water is forced to the surface by gravity and water pressure because of the presence of impermeable rock such as shale. The number and distribution of wells have an effect on how much water can be safely abstracted. If abstraction exceeds natural recharge, then the water table falls which may result in subsidence or saline water being drawn in to contaminate the aquifer with salt.

The impact of **domestic and hazardous waste disposal** on vulnerable aquifers depends on a number of factors:
Domestic waste (household waste/garden waste for landfill sites). Hazardous waste is medical, industrial and radioactive waste needing specialist disposal.
Geological factors – ideally any waste disposal site should be located in impermeable rocks such as shale, clay or mudstone to prevent any leakage of leachate.
Engineering factors – in areas where impermeable rocks are not present, clay linings or artificial geomembranes are used to make the site secure/impermeable.
Toxic leachate is collected in a sump and removed for treatment. Landfill sites monitor local rivers, ponds, wells and springs to ensure that water quality is of an acceptable and safe standard.
Contaminated ground can be restored by either removing the soil and replacing it with a cleaner alternative or employing bioremediation using microbes and/or plants to extract the toxic materials from the ground. These can then be removed/harvested and treated so that they are safe.
Toxic waste can be stored in sealed drums either underground in impermeable rocks, such as in disused salt mines, or at the surface in secure repositories.

Geological factors affect **the siting of engineering projects** such as reservoirs, dams, cuttings and tunnels.
Permeability of bedrock – permeable rocks absorb water, increase in mass and also increase pore water pressure which can lead to slope failure.
Stability of bedrock – limestone, sandstone and granite are mechanically strong and can support steep slopes. Rocks such as clay, mudstone and shale are mechanically weak and unable to support steep slopes, often collapsing or slumping after a period of heavy rainfall or removal of basal support by erosion.
Dip of strata – engineering projects should try to avoid locations where strata dip towards the excavation. This will result in expensive slope stabilisation methods being needed. Locations where strata dip away from the excavations are naturally stable.
Presence of faults and joints – both of these increase the ability for water to enter the rock, increasing both mass and pore water pressure that may lead to slope failure. Fault reactivation may also occur, and expensive engineering solutions will be needed to make these areas stable.
Methods to overcome these geological factors/problems include rock bolts, shotcrete, gabion baskets, slope re-profiling and drainage.