Teacher notes lesson three

In this lesson, students will study the **global-scale** changes in **zonal soil** type found in Russia. Differences in soil type can be explained with reference to the changing balance between **evapotranspiration** (linked with temperature**)** and **precipitation.** This lesson aims to build student geographical capabilities, as follows:

- ✓ They will continue to consider important **interconnected** ways in which different geographical elements - climate, vegetation and soil - are linked together and influence one another.
- ✓ In terms of **skills**, they will further identify the defining characteristics of different **landscapes** and **places**, with special reference to soils.
- ✓ They will make use of a **transect** in order to study how the environment changes from place to place.
- ✓ They will gain an insight into the development of geography as an academic discipline.

Key terms for teachers

Podsol A Russian term for an acidic soil of limited fertility, typically found in northern forest environments. Podsols develop naturally in the coniferous (boreal or taiga) forest zone, around 60^{o} North. Podsols have strongly developed horizons or layers due to the downwards leaching of nutrients by water.

Chernozem A Russian term for a dark, fertile soil, often associated with grassland. Chernozems have developed naturally in the grassland steppe zone, around 30-40^{o} North, in southern Russia. This area is sometimes called the 'black earth region' on account of its soils (the black colour is a product of a high level of organic matter, thanks to grass roots). Water is drawn upwards towards the soil surface by high summer temperatures. It evaporates, leaving deposits of calcium behind.

Gley soils are waterlogged soils found below the Arctic tundra of northern Russia, around 70^{o} North. They may have a blue-grey tint, suggesting a lack of oxygen in the soil due to the waterlogged conditions.

Permafrost A cold climate condition of unstable, seasonally frozen ground that limits vegetation and causes problems for road and rail development, and other forms of construction.

Taiga The coniferous forest zone that dominates a large portion of the Russian interior. Also known as **boreal** forest.

Soil The uppermost layer of the earth, the transformation of rocks under the influence of live and dead organisms, climate, age, forms of relief, and the activities of human beings. Soil has solid (minerals such as sand and clay), biotic (dead organic remains and living biota), liquid (water) and gaseous (air) components. Water and air occupy the spaces (pores) between solid particles. Soil performs an important regulatory function maintaining the exchange of energy and matter between the biosphere, atmosphere, hydrosphere and lithosphere, which is essential for the development of life. Human beings exploit soil in different ways, e.g., to produce food or to filter water and recycle waste. (*Source*: nsicd.org)

Soil fertility A measure of how much **biomass** production can take place under natural or managed conditions. Fertility is a product of substances in the soil and the local water-air and temperature regimes.

Soil zoning is driven by natural factors that can be mapped on a global scale. In the vast land area of Russia, soil changes closely follow changes in the dominant vegetation which in turn link with broad changes in temperature and precipitation. Moving from north to south along a **transect**, you will see gradual changes of the major natural zones and their associated soil types: polar desert, tundra, coniferous forest, steppe and hot desert.

Starter: Russian soil science (and soil scientists)

What is soil? **Bedrock** is weathered by the elements (physically **disintegrating** and chemically **decomposing**) to become soil under the influence of a series of soil-forming factors: *climate, vegetation, country, relief and age*. Decomposing vegetation adds the **biotic** material to a soil that distinguishes it from **regolith** (purely mineral deposits, such as sand).

Much early, ground-breaking work in soil science took place in nineteenth century Russia. In particular, Dokuchaev (1846-1903) discovered the relationship between soil and the natural factors that help to form it. Today, we still use names for soil types that Dokuchaev popularised: **podsol** (or podzol, first used in 1879, and meaning 'under ashes'), **chernozem** (1900) and **gley**.

Along with Neustruev, Prasolov and Polynov, Dokuchaev carried out soil surveys in different regions of Russia and made the country's first soil map. The resulting theory of global soil zones, later called **zonal soils** by US geographers, was a major scientific contribution which played a significant role in the development of the soil geography of the world.

In the tradition of Dokuchaev, global mapping of soil is linked with global maps of vegetation and climate. Thus, in Russia the black-earth belt (or chernozem soil belt) stretches in a broad band north-east from the Romanian border through the Ukraine all the way towards south-western Siberia. This area has always been associated with cereal production and Dokuchaev was keen to discover the geographical conditions that governed the distribution of the fertile chernozem soil. Indeed, his most famous work was called *Russian Chernozem* (1883).

Other early Russian Earth scientists, such as Middendorff, were involved in mapping the extent of the frozen soil that lies beneath much of the country. The severe cold climate of the Arctic and its fringes has led to extensive **permafrost** beneath nearly 70% of the country.

Main activity

The most important factor affecting the distribution of soils in Russia is climate. In turn, this also affects the vegetation type, as students learned in Lesson two.

In this lesson, there are two important influences for students to investigate.

Influence 1: the balance between precipitation (rainfall and snow) and evapotranspiration (combined evaporation and transpiration, or **ET**)

- If **precipitation > potential ET** then rainwater soaks down through the soil taking dissolved nutrients with it (also known as **leaching**). This **run-off** of rainwater can lower soil fertility.
- However, if **potential ET > precipitation** then run-off is less likely to occur. Instead, rain water evaporates from plant or ground surfaces. Rain water which has **infiltrated** downwards into the soil may also be drawn back upwards towards the surface of the soil by a process called **capillary rise.** This is a process which takes place under high summer temperatures. Dissolved nutrients form solid deposits as the water evaporates. In very dry areas, you can see white calcium deposits in the upper layers of the soil. These show that capillary rise has happened. High levels of plant **transpiration** (the loss of water vapour through plant leave pores) also reduces potential run-off and soil nutrient loss through leaching.

Using the transect map provided, students will identify two contrasting soil types that demonstrate how soil water movements in differing climatic zones influence soil characteristics (and resulting soil fertility), as follows:

Podsol (B)	Northerly, cooler parts of Russia, soils suffer badly from leaching (the loss of nutrients dissolved in run-off). The cold conditions have also favoured the growth of coniferous forest. Conifer needles acidify the soil further. **Highly visible soil horizons** (layers) provide evidence of nutrients being washed downwards through the soil by rainwater, lowering soil fertility. Dokuchaev called this soil type a **podsol**. *See photograph A and soil profile A*
Chernozem (C)	In southern parts of Russia, far from the sea, summer temperatures are very high and as a result little runoff occurs. Capillary rise, due to high temperatures, can bring **deposits of calcium** to the upper soil. This helps explain why the chernozem has a high level of soil nutrients. Provided there is sufficient water for plants to grow, then this is a very productive place for agriculture. The Russian steppes are used for cereal farming for this reason. Dokuchaev called this soil type a **chernozem**. *See photograph B and soil profile B*
Brown earth	Note that in-between the two extremes of podsol (B) and chernozem (c) we might find **brown earth** soil on the transect, below deciduous forest. This soil type is also found throughout the UK.

Influence 2: frozen ground and permafrost

- Large areas of Russia lie within or close to the Arctic Circle. As a result, temperatures are below freezing for 3 or more months of the year, resulting in permanently frozen ground called **permafrost**.
- In Spring, the top layer of soil thaws. Lower levels, however, can remain frozen all year round. The thawed upper layer can become very wet, especially when overlying snow melts in the Spring. The water cannot drain away due to the icy layer below.
- The result is muddy, boggy conditions and a lack of any air in the soil (usually, some of the gaps, or pores, between soil particles are occupied with air). A lack of any soil air deters soil organisms such as worms and can prevent plant growth.
- The soil (type A on the transect) can take on a **blue-grey colour**, due to the lack of oxygen on account of the waterlogged conditions (this is an aspect of the chemical process called **reduction**).

Dokuchaev called this soil type a **gley** soil. *See photograph C and soil profile C*

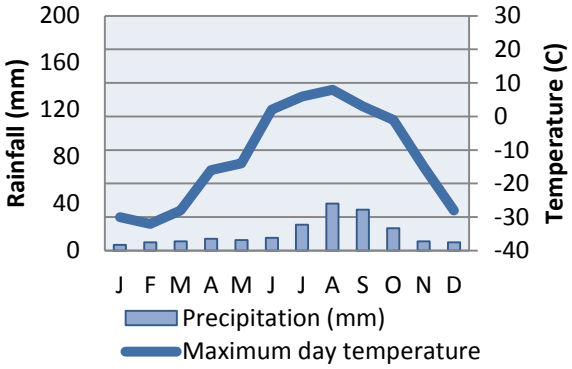
Classwork exercise

A transect is a pathway that geographers make use of when carrying out fieldwork. It often takes the form of a straight line, drawn on a map, along which gradual changes in the surrounding environment can be observed and recorded. A transect across a city might be no more than a few kilometres long. Whereas a transect across a continent, or large country such as Russia, can be thousands of kilometres long.

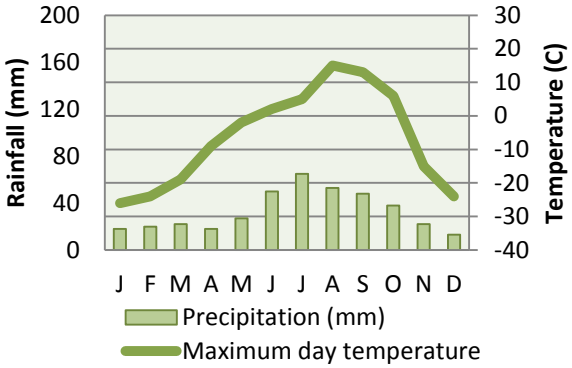
Students will be using an A3 map which shows a transect across Russia and is accompanied with climate data. Soil photographs and vegetation photographs are also included.

For students to complete the exercise, they will need their teacher to provide them with basic information about how to identify three soil types (chernozem, podsol, gley). They will also need to gain some basic understanding of how precipitation and evapotranspiration have influenced soil forming processes, as explained above. This can be achieved either by adapting this document into an age-appropriate photocopied hand-out, or through note-taking.
Extra references for teachers See the National Snow and Ice Data website:
https://nsidc.org/data/docs/fgdc/ggd601_russia_soil_maps/russian_soil_desc.html

Climate for A (Tundra)



Climate for B (Taiga)



Climate for C (Steppe)