Meteorites and Earth's Layers
Teacher Notes

AUSTRALIAN EARTH SCIENCE EDUCATION

Meteorites and the formation of Earth

Earth and the solar system formed by accretion of small particles into larger ones. Earth was formed by millions of particles accreting to form a molten mass. Density layers formed in the molten Earth, leading to the layers we have today.

Some of the rocky material of the early solar system did not become part of a planet. The leftover material orbits the Sun as asteroids or meteoroids. When a meteoroid is captured by Earth's gravity and hits the ground, it is called a meteorite. Meteorites allow scientists to examine material from the early solar system.

Analysing the layers

1. The density of the continents is 2.8 g/cm^3, but the density of the whole Earth is 5.5 g/cm^3.

   Explain why the whole Earth is more dense than the continents. The crust of the Earth is the least dense portion of the planet. The more dense material is in the centre because of the density layers formed when Earth was molten.

2. Use the information in Table 1 to state TWO trends that occur as you move from the outside toward the centre of Earth. 1. The composition of the layer changes from silicate rocks to iron and other metals. 2. The density increases as you move to the centre.

3. Explain how these trends are related. Metals like iron and nickel are denser elements than silicates (Si and O). Thus, the denser portions sank to the centre when Earth formed.

Table 1: Composition and density of Earth's layers

Earth Layer	Composition	Density (g/cm^3)
Continental crust	Felsic silicate rocks (granite)	2.7 – 3.0
Oceanic crust	Mafic silicate rocks (basalt)	3.0 – 3.3
Mantle	Ultramafic rock (peridotite) rich in magnesium and iron	3.4 – 5.6
Outer Core	Iron, nickel and traces of lighter elements	9.9 – 12.2
Inner Core	Iron (80%), some nickel and heavier elements such as gold, platinum, silver and tungsten	12.6 – 13.0

Table 2: Meteorite abundance, density and composition

Type	Percentage of all meteorites found	Average density (g/cm³)	Composition
Stony chondrite	86	3.2 – 3.4	Mainly silicate minerals with internal round mineral structures called chondrites
Carbonaceous chondrite	3.3	2.1 – 3.5	Chondritic meteors with traces of carbon compounds
Enstatite chondrite	1.2	3.6 – 3.7	Chondritic meteor with small amounts of magnesium silicate (enstatite)
Achondrite	3.6	2.8 – 3.3	Stony meteorites without internal chondrites (indicates that they were once fully molten)
Stony-iron	0.7	4.2 – 4.8	Mixture of 30 – 70% metals (iron and nickel) with silicate material or peridotite
Iron	5.2	7 – 8	Composed of iron-nickel alloys, averaging 10% nickel

4. Use the data from Tables 1 and 2 to complete Table 3. Justify your choices with reference to composition and density.

Table 3: Meteorites relating to Earth's layers

Earth Layer	Meteorite type(s) relating to layer	Justification for choice of meteorite(s)
Continental crust	Carbonaceous chondrites, Achondrites	These meteorites have a density like that of the continents and have silicate minerals like the continents.
Oceanic crust	Stony chondrites, Achondrites	The density and mineral composition are like that of the oceanic crust.
Mantle	Stony-iron meteorites	Stony-iron meteorites have peridotite and a density similar to the mantle.
Outer Core	Iron	Iron meteorites are the most dense and contain mostly iron, like the core.
Inner Core	Iron	Iron meteorites are the most dense and contain mostly iron, like the core.

*Answers may vary, but should have a basis in composition and density

5. Explain a difficulty you encountered in choosing appropriate meteorites for a named layer. The outer and inner core are much more dense (10 – 13 g/cm^3) than the iron meteorites (7 – 8 g/cm^3). Heavier elements found in the core are not found in any of the meteorites.

6. During the formation of the solar system, denser rocky materials were drawn closer to the sun. Based on this information, explain how the layers of Mercury (closest to the Sun) would differ from those of Earth (shown in Figure 1)? If denser material is nearer to the Sun, I would expect that Mercury will have a density greater than that of Earth (5.5 g/cm^3). It would have a larger core and have formed from a greater proportion of the denser iron and stony-iron materials. The outer layers will still have some silicate minerals, but more of Mercury would be iron-rich.

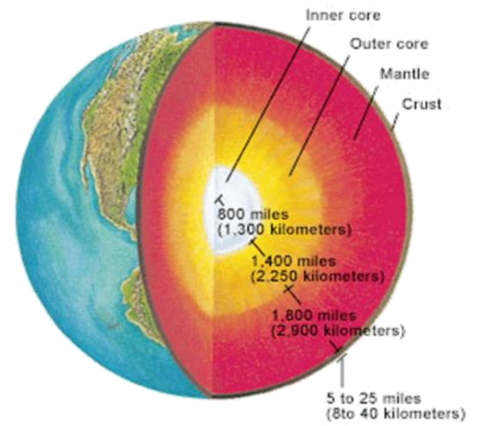

Figure 1: Earth's layers (NASA, public domain)

References:

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