TEACHER NOTES – ASTRONOMY IN THE NEWS #35

WATER ON EUROPA

Slide 2 – Background Science: Europa

Europa is the smallest of the four Galilean moons of Jupiter. Europa is the smoothest object in the Solar System, with no known mountains or craters. There are few surface-impact craters as the surface is very active and too new to display impact craters from millions of years ago, unlike our own Moon.

The most interesting feature, or at least potential feature, of Europa, though, is the subterranean ocean. It is postulated due to tidal heating that would occur because of the eccentric orbit and the interaction with the other Galilean moons. The favoured model for this ice is a thick ice model, where the ice layer is 10-30 km thick. This is because any large craters that do exist are fairly flat and filled with fresh ice. At this thickness, it would lead to an ocean approximately 100 km deep. If a thin ice model was favoured, these large impacts may have exposed the liquid ocean below.

IMAGES:

1. (Left) Image of Europa, in almost true colour, from the Galileo satellite that orbited Jupiter between 1995 and 2003. You can see fractures in the surface, some of which are 3000km long.
2. (Top right) Amount of water postulated to be in the Europa and Titan systems compared to the amount of water on Earth. Titan is also expected to have the subterranean ocean, as theorised on Europa.
3. (Bottom right) Proposed structure of Europa. The surface, white, is an ice shell with a subterranean ocean, shown in blue. Below this is a layer of rock (brown) which is surrounding a metallic core of iron and nickel.

Slide 3: Double Ridges and Subterranean Water

As mentioned above, the thick ice model is favoured for the structure of Europa. Evidence for this has come from an unusual source, as outlined in the article and paper here. Double ridges were discovered on an ice sheet in Greenland. A double ridge was discovered on this ice sheet, with this ridge occurring on top of a water sill. This sill lies under an ice crust, and a layer of porous ice. Below this sill is a layer of impermeable ice.

In this model, the ice in the sill begins to freeze, and this makes it way to the surface either through damage from the surface, or the internal pressure causes damage to the ice sheet. This water then makes it way up to the surface. This water then freezes, filling up the conduit. However, the water in the sill is still freezing, and causing more overpressure. The water in the sill then forces its way to the surface again via the weakened ice to the sides of the frozen conduits. As this happens on both sides of the conduit, you are left with a symmetrical double ridge system.

This mechanism supports multiple theories about Europa. Firstly, the evidence for the thick-ice model with the impermeable ice layer, and secondly, the evidence for an underground ocean since that would be a method for producing these underground sills. These sills could form in Europa from either direct injection from the subterranean ocean or from shear heating of the ice.

The article that this resource is built on can be found here:

https://www.theguardian.com/science/2022/apr/19/jupiters-moon-europa-may-have-water-life-could-exist

A free version of the research article can be found here:

https://www.nature.com/articles/s41467-022-29458-3

IMAGES:

1. (Top left) Overhead image of the double ridge on Europa (panel (a)) and Greenland (b). The pixel scales in each are 20 m/pixel and 0.31 m/pixel.
2. (Top right) Computer-generated 3D model of an example double ridge on Europa.
3. (Bottom) Formation mechanism of a double ridge. A sill is under the ice crust (a), and then the sill fractures either from internal pressures, and water from the sill fills the hole (b). This water then freezes (c), but this causes more internal pressure and water is forced out at the sides of this frozen conduit. As this occurs on both sides, it produces the symmetrical double ridge (d).

Slide 4 – Activity: Why is life possible on Europa?

This week's activity is a discussion activity regarding the biology and chemistry of Europa and why it might be possible for life to be on Europa. There are three, general, things needed for life, or at least life as we know it: water, chemistry and energy. Europa has the water (in the subterranean ocean) but where does the chemistry and energy come from, especially when photosynthesis might not occur? It could be from the carbon, nitrogen, sulphur that are present on Earth, that are likely to be on Europa as they were present in the at the formation of the Solar System.

The energy would come from the charged particles emitted by Jupiter as Europa is too far from the Sun to get a significant amount of energy from that source.

GCSE Specifications:

Specification	Knowledge Point
Pearson Edexcel Astronomy	11.26, 11.27, 12.5