**Earth and Life**

*Volcanoes: Flood Basalt and its effects*

**Voice Over**
Scaling up yet again takes us to an area of about 100,000 square kilometres between Washington State and Oregon in North Western USA. It's known as a continental flood basalt. Each of the long, flat layers is a single basalt lava flow, erupted from a fissure, similar to the Laki eruption in Iceland in 1783. About five flows are piled on top of each other here in this view of the Columbia River gorge. Most are 10-30 metres thick.

**Caption: Stephen Self, University of Hawaii**
Flood basalt provinces are extremely important in earth sciences; they tell us about processes that occur when mantle plumes come up and impact the surface of the Earth; a lot of the large, dark patches you see on the Moon are flood basalt provinces so hopefully by working out the details of the emplacement of flood basalts on Earth, we can have applications to other planets as well. These so-called flood basalt provinces have punctuated Earth's history; one seems to come every few tens of millions of years. The theory is that a hot spot came up from the mantle and pierced its way through the lithosphere and erupted through the crust, forming this large pile of lavas, about 17.5 to about 15.5 million years ago.

**Caption: Stephen Reidel, Consultant Geologist**
Total accumulation is roughly about 174,000 cubic kilometres and in this general area here we're looking at probably close to three kilometres of the salt below us. As you go farther east it thins to maybe one kilometre. There are at least 300 flows that we know of and probably at least 50 beyond that that we're starting to get a fair idea about right now. What we envision happening is that major pulses coming down in a fairly short period of time, maybe between months and years, and then perhaps long periods of time, as much as 20,000 years between the next pulse of eruptions.

**Voice Over**
But the eruptions themselves – were they relatively quick events?

**Male Voice Over**
A newer theory, one that we're working on right now and testing out, is that they were in fact erupted very slowly, gradually covering great distances and very wide areas, much as the lava flows in Hawaii are doing at the moment, but on a much, much larger scale.

**Voice Over**
Watching a slow eruption is a bit like waiting for paint to dry, but gradually these pahoehoe flows, as they're called, build up the massive stacks of lava we see in the flood basalts.

**Male Voice Over**
We see many stacks, or several stacks within one eruptive unit, so the inference is that each one of those took probably months to a few years to form, and the whole pile many years to possibly decades.

**Voice Over**
Occasionally the lava is brought to the surface in a much more spectacular way. Here the lava is being erupted along a long linear crack, or fissure. But whether fast or slow, the result is a huge sheet of lava, often stretching many thousands of square kilometres. In the Columbia River province these basalts were thought to have erupted onto a terrain we can envisage as a gently sloping billiard table, basically going from the Idaho border down to the Pacific. But what was the environment like?

**Stephen Reidel**
In the Pacific North West today we find oak and conifers, and a fairly temperate climate, but back 15 million years ago, when the Columbia River basalt lavas were being erupted, fossil tree remains from between the lava flows show that there were walnuts, spruce, Douglas Fir, gingko trees, large trees, bigger than today, showing that there was a luxuriant forest at the time, supported by a milder climate than we have at present. This is one of the Columbia River basalts huge lava flows about 2,500 kilometres. Where I've been looking at the flow it's 80 metres thick, yet it's about 200 kilometres from its source. At the base of the lava flow there was some tree moulds, and in the wall of the tree moulds you can see box work. This is a modern piece of carbonised wood, also showing the same box work, and the lava takes the impression of the box work and leaves it on the wall of the mould. This shows that there were really large trees, about a metre-and-a-half across this tree, growing in the path of the lava flow, and the lava gradually enveloped the tree and then carbonised it.

**Voice Over**
Only exceptionally do we find such splendid tree fossils. Most often the best evidence of the dense forest devastated by the lavas is found in a carbon-rich layer, a bit like coal, right at their base, formed when the flow advanced over a mass of fallen trees.

**Stephen Reidel**
I've reached in and pulled out this twig here; the twig is deformed by the weight of the lava above, and you can even see the tree rings that grew in this twig before it was destroyed by the lava flow and carbonised.
This is one of the great basalt lavas of the Columbia River province, and it was erupted 14.7 million years ago. We've been measuring the sulphur content of this lava and we find that the lava contains about 300ppm of sulphur. By other measurements we know that while it was down in the mantle, this had about 2,000ppm of sulphur, so therefore we can show by simple calculations that 1,700ppm of sulphur was erupted into the atmosphere as sulphur dioxide gas when this lava was vented. The volume of this flow is about 1300 cubic kilometres, a staggering figure, very large, and therefore we can show that the mass of sulphur dioxide being put out into the atmosphere by the eruption was about 1.2 times 10-13 (?) kilograms, enormous amount of sulphur, so a big eruption like this could really have a significant effect on the atmosphere.

**Voice Over**
In 1991 Pinatubo produced 20 mega-tonnes of sulphuric acid aerosol. In comparison, just one of these big lava outpourings in the Columbia River sequence released something like 1,000 mega-tonnes a year.

**Stephen Reidel, Voice Over**
I think if we can understand the climatic effect of the large flood basalts here in the Columbia River, then we go on to future studies to look at the significantly bigger Dekan province in India which of course was erupted at about the same time that the dinosaurs that died out at the end of the Cretaceous period, and then we can address some of the major questions about mass extinctions the role that flood basalt provinces have, or might have had in causing mass extinctions.