TPO37L1 Soil Formation NARRATOR: Listen to part of a lecture in the geology class.

MALE PROFESSOR: So, we all know soil. It's important to plant growth, right?

And we know that there're different types of soil in different places and that some soils are more fertile than others. But what is soil? And how's it formed? Well, we're going to go into this in some depth, but for now let's just lay down the basics. **Soil** is composed of two kinds of material: inorganic material, basically small pieces of rock, and organic material, which is animal and plant matter.

OK. So, what do you think? If I mix bits of rock with composted vegetables, will I get soil? The answer is no, because the formation of soil is a dynamic process. It involves not only the initial inputs, the raw materials, but also the transformation of those materials, and the movement of some of the materials and the loss of others.

So, the inputs are bits of rock and organic matter. Now, the bits of rock—the inorganic input to soil? uh...they come from the breakdown of rocks on Earth's surface through a process called weathering.

**Weathering** can be either physical or chemical. Physical weathering, uh...that's when exposure to the elements over time causes a rock to break up and eventually disintegrate. Uh... of course, some rocks are more resistant to physical weathering than others. If you think of the *sand particles* in soil, those are the result of physical weathering, and they have the same chemical composition as the original rock. Now, chemical weathering, uh... that's the chemical breakup of rocks. It differs from physical weathering in that the chemical properties of the minerals are actually changed. The *clay minerals* you find in soil are the result of chemical weathering.

Clay minerals are called secondary minerals, because their composition has been altered. Okay. So we have weathered rock, which needs to be combined with organic matter. So what does the organic input consist of? It's the remains of plants and animals, but mostly plants. Now, just as rocks are broken down by weathering, the animal and plant residues are broken down, too. They're reduced to simple chemicals by microorganisms in a process called **mineralization**. And just as some rocks are more resistant than others to weathering, the compounds found in the soil's organic input resist mineralization at different rates. The compound cellulose is the major constituent of most plant tissue. It mineralizes relatively quickly. But there are woody substances in certain plants that strengthen the cell walls. They are found in smaller concentrations and their mineralization can take several years. Weathering and mineralization transform the inorganic and organic inputs in a number of ways. And it's partly from these transformations that soil gets its unique properties. How does it work? Uh... take the dark brown color of soil. After microorganisms have broken down the cellulose, we're left with two things: the microbe's waste and the more resistant plant material that microorganisms can't break down easily. These materials ultimately get transformed into a new material called **humus**. And when humus is combined with the clay minerals in soil, that's what gives soil its dark brown color. So now, if we've got clay and humus, these transformed materials, and we mix them together, we've got something very close to soil. But soil isn't static, and there're still other processes that go into the formation of soil: the movement and loss of materials.

The soil in any location isn't a uniform mixture. Its composition varies with depth. You see, mineral and organic materials move through soil vertically. Some materials move more easily than others. Water carries the more mobile materials from the upper level of soil to the lower levels. So the upper levels of the soil eventually get depleted of these materials, while the lower levels get enriched with them. And that creates distinct layers of soil as far down as the rock underlying the soil. And the materials that dissolve easily in water can get lost completely if the water carries them horizontally out of the soil and into rivers. Now, of course, new mineral and organic material will be deposited at the surface and become incorporated into the soil, but you see how the processes of movement and loss contribute to the formation of soil.

TPO41L4 Exoplanets

PROFESSOR: OK, we've been discussing the planets in our solar system, and how some of the ones farthest from the Sun were discovered. Well, today I'd like to turn to what are called exoplanets, and how researchers detect them. Maria?

F: Exoplanets are planets that orbit around a star other than our Sun, right? They're not in our solar system… PROFESSOR: Right. They have different, what're called host stars. The study of exoplanets has been getting more and more exciting; hundreds of them have been discovered so far. This is quite remarkable in view of the fact that the discovery of the first exoplanets was confirmed only in the mid-1990s. Now we’re finding new ones every few weeks or so.

F: So, uh—exactly why are we interested in these exoplanets, anyway? Is it to see if there's life on them? '

Cause it seems to me like the only exoplanets we ever hear about are gas giants, like Jupiter and Saturn, that couldn’t possibly support carbon-based life….

PROFESSOR: OK, well, let's talk about that. First, as for discovering life… well, I think that sort of discovery is pretty far in the future, but it is an eventual goal. For now, the focus is on locating planets within a host star's so-called habitable zone, a zone that's a certain distance from its star. Because only planets within this zone could conceivably support carbon-based life. So what would such a planet need? F: Water?

PROFESSOR: Yes, it'd need to be the right temperature to sustain liquid water.

M: And it would need to be a rocky planet…. I mean, as opposed to a gas giant….

PROFESSOR: OK, good. An Earth-like planet. Now, as to that, there are some recently detected exoplanets that might actually be Earth-like. For example, there's a red dwarf star—that's what most stars are—uh, that's called Gliese 581. Gliese 581 is… well, it's a lot more interesting than that name makes it seem. This host star is considered a near neighbor of our solar system because it's only about twenty light-years away. That's pretty close, by astronomical standards. And being a red dwarf star, it's small and relatively cool, at least compared with the Sun. And researchers have discovered planets orbiting Gliese 581. These exoplanets have been

named—ready?— Gliese 581 b, c, d, e… in alphabetical order of their discovery. Gliese 581d and e are the planets I want to focus on now. See, in 2009 a group of researchers made an announcement: these two exoplanets, Gliese 581d and e, do have some Earth-like qualities. Gliese 581d had actually been discovered a couple of years earlier, and when its orbit was originally calculated, it was thought to be too far away from its host star to be warm enough to support a liquid ocean, let alone carbon-based life. But then its orbit was recalculated, and now we see that Gliese 581d is within its host's habitable zone.

M: So it might have an ocean? PROFESSOR: Well, conceivably. See, Gliese 581d weighs seven times what Earth weighs, and it's unlikely that it's made entirely of rocks… because it's so massive. The researchers studying it said that it could have a rocky core; an ice layer; a large, deep ocean; and an atmosphere. OK, and there was another announcement, along with the recalculated orbit of Gliese 581d. That was the discovery of another planet in the system, Gliese 581e. Compared with other exoplanets, its mass is quite small—only about twice that of Earth's. F: So is Gliese 581e a more Earth-like planet?

PROFESSOR: Well, we have to consider its orbit. Gliese 581e orbits its host star in a much shorter period of time than the other planets in the system, meaning it's very close to the star. And therefore too hot for water, for an ocean. However, the fact that it's relatively close to the size of Earth—small, in astronomical terms—that was pretty exciting. It's impressive that we have the technology to detect it. And it bodes well for future research. Who knows what we'll find the more we search?

TPO69L1 The formation of hydrothermal vents

So, we've talked about the plates that form the earth crust and their movements and how in some places they're separating. Now, when this happens in the ocean along a middle ocean ridge, some important things can happen, in particular you can get a hydrothermal vent. This is a lot like a geyser except it’s on the ocean floor. A **geyser** of course is a kind of eruption from underground hot spring. Water that’s been heated up in Earth’s interior, when under pressure, can erupt, sending that water and steam, shooting upwards through crack in the earth. A **hydrothermal vent** is essentially the same thing, but the water is emitted out of cracks or fractures in the ocean floor. If you’ve heard about hydrothermal vents at all, it’s probably because of the exotic life forms around them, uh, tube worms, giant clams, that kind of thing. Forms that don't depend on energy from the sun, but depend on chemical energy. But, the vents are also enormous significance for us.

From a purely geological perspective, because the chemistry of the oceans is affected by them.

To see how, let’s look at the process a little more closely. They typically occur in fields, so you might have an area with a dozen of them, but you need two things to get one of these fields, first, you got have heat.

And you’ve got have fissures in the ocean floor. So, in a vent field, you've got cracks in the ocean floor.

And cold water at the bottom of the ocean, we are talking, maybe two degrees Celsius, goes down into them, as it goes underground, it heats up because in these fields, there are magma chambers, only a few kilometers below the ocean floor. This hot molten rock heats the solid rock above it to as high as five hundred degrees Celsius. And this heated solid rock, then heats the ocean water that flows over it. Now remember, the high pressure of the deep sea, allows water to stay liquid at such a high temperature, so it can reach temperatures of, three or four hundred degrees Celsius. As the water heated, it rises up through other cracks and it shoots up back into the ocean, much like with geyser on land. Now, the important part, is what the water is carrying with it, as it emerges. The heated water draws minerals from solid rock. So, you get dissolved metals in the water, like iron and copper. When the water shoots up and re-enters the cold ocean, it quickly cools and these minerals precipitate out. They’re released and they are deposited into the ocean water, which affects its composition. And it also creates quite a site, these vents have a plume that looks like a smoke, likes smoke that’s coming up out of the vent in the earth. Remember some of the water coming out of the vents is over three hundred degree Celsius. When it’s this hot, it dissolves sulfur, iron and other metals in the rock and it interacts with. when these minerals precipitate out, the water forms of black plume, so these vents are called black smokers. It's the sulfur and metals precipitating out of the water that that's what causes black color.

But there are also white smokers, these emit what looks like a white smoke. That's because their water is relatively cool, above one hundred to three hundred degrees. Still pretty warm, but, not warm enough to dissolve sulfur or iron. Instead, they draw off different minerals from rocks. Things like silica and they give off different color, whitish color, when those minerals precipitate out. But in both black and white smokers as the waters emitted in the plume, the mineral that precipitate out, eventually build up around the vent, forming large, tower-like structures or minerals, build up layer upon layer, we call these chimneys, just like a chimney on a house. Different minerals will tend to build up at different places on the chimneys.

But, some of the minerals like silica, a form kind of cement, and they hold the whole structure together.

So, they can grow quite large and quite quickly. If you can believe it there was one chimney that reached forty-seven meters, that’s like fourteen story building. It collapsed, but it’s actually now rebuilding.