episode_1_volcanology.mp3

Speaker 1 [00:00:04] Hello and welcome to the Talking Geosciences Podcast, brought to you by the School of Geosciences at the University of Aberdeen. Over the course of this series, we will hear staff and students discuss how their teaching and research is helping us understand and address contemporary global challenges, including sustainability and climate change. In this episode, Dr. Malcolm Hole from the Department of Geology and Geophysics tells us about volcanology and how studying volcanoes not only help scientists predict and mitigate the risks of eruptions, but also helps us understand the impact volcanoes have had on the history of the earth and how volcanic activity affects society and the environment today. So, Malcolm, why don't we begin by. Can you explain to me what, what is volcanology and what does it entail?

Speaker 2 [00:00:55] Well, volcanology is the study of volcanoes, volcanic processes and the products of volcanic eruptions. It covers an enormous range of different disciplines in the geosciences. It covers everything from physics through to chemistry of eruptions, but also expands into the human impact of volcanic eruptions, hazards in particular, and management and mitigation of hazards. To understand those processes, we need to understand things like population dynamics. How many people are actually living in the shadow of this volcanic hazard? There's also the economic side of it. Volcanoes can cause terrible economic catastrophe and hardship, so we need to understand that as well. So of all the subjects and geoscience volcanology has one of the biggest, broadest expanses of different disciplines that we need to understand.

Speaker 1 [00:01:48] Great, and from the perspective of the geosciences or physical sciences, how do scientists actually go about studying volcanoes?

Speaker 2 [00:01:56] Well, there's a whole lot of different approaches. For someone like me who is a trained geologist, my approach is to go up the volcano very, very simple, making observations of volcanic processes as they happen. Very importantly as well, looking at the products of extinct volcanoes. If we understand how volcanoes have operated in the past, that gives us a bit of a head start in understanding how they might operate in the future. So as a geologist, I will go to volcanoes, look at them and study them. We also have to take into account things like remote sensing that's now become very, very important. Satellite imagery. The United States Geological Survey do an enormous amount of satellite monitoring. We also have things like earthquake monitoring, earthquakes, any always precursors to volcanic eruptions. And we also monitor things like gases that volcanoes are producing. Sometimes changes in composition of gas are a really important precursor to a major eruption happening. So the actual study of volcanoes can be anything from satellite images to actually standing on the top of one.

Speaker 1 [00:03:06] And here in Scotland, how much evidence is there in the landscape of volcanic activity, either either current or historic?

Speaker 2 [00:03:15] Well, we haven't got any current activity in Scotland. There's very good reason for that. And that's because volcanoes are distributed in a very, very organised way around the planet. And Scotland is not one of those volcanic belts. So the main volcanic belts around the second Pacific region, sometimes known as the Ring of Fire, but also a curious thing that people don't realise is that the centre of the oceans, the Atlantic, Indian Ocean, Pacific Ocean, there are very large mountain chains submerged which are entirely volcanic in origin and are erupting present day. Now in Scotland, the last evidence we have of major volcanism is about 60 to 65 million years ago. And people might be familiar with this because it gives us the landscape of places like Sky and Mull. But we don't have any active volcanism in this part of Europe at the moment. I guess our nearest active volcanoes are going to be those in Italy. And of course Iceland is quite an important one because that is the only place in the world where we can see what would normally be a submarine eruption taking place at the surface.

Speaker 1 [00:04:24] Right. And you mentioned earlier about mitigation and, you know, the impact that volcanoes can have on on people and society. Do all volcanoes represent hazards, to humans and to society?

Speaker 2 [00:04:40] Well, no, they don't. And in fact, volcanoes, we have to also remember, are quite beneficial. One of the products of volcanoes that's important is volcanic ash. Volcanic ash actually gives us lots of minerals that provide very fertile soils. So this is a major, major important thing, particularly in. Places like Southeast Asia. Indonesia relies on these very fertile soils. Some places, of course, we can think of Hawaii. We can think of Iceland and in fact, some of the Mediterranean islands. It's a tourist attraction to go and look at erupting volcanoes. But they are of a specific type. They have what we call a effusive eruptions. So they produce molten lava, but they don't tend to be terribly explosive. Now, the issue comes when you start going to places like South America or Indonesia or Japan, where the volcanoes tend to be intensely explosive and they are really high magnitude hazards to anybody living in the local vicinity. But on top of that, a major volcanic eruption in places like Indonesia or Japan can actually have an effect on global climate.

Speaker 1 [00:05:58] So what of the, let's say, the last 100 years or so, which volcano, volcanic eruptions have been the most significant or have had the biggest impact on on humans and on human society?

Speaker 2 [00:06:13] Well, it's quite a big catalogue of them, actually. If we look at the 20th century, some really famous ones. Mount St Helens, 1980, that was a major explosive eruption. And there's a scale of explosivity, which is known as the volcano explosivity index, which runs from 1 to 7. And Mount St Helens was about a five on that. And that scale works very much the same way as wind speed scales. So an eruption of five is ten times that of an eruption of four magnitude. So Mount St Helens was a big one. What's interesting about Mount St Helens is because of the mitigation and monitoring that went on, there were only about 57 casualties of that eruption. A few years later, in 1985, there was an eruption in Colombia of a volcano called Nevado Del Ruiz. And the thing about that was that was a less a magnitude eruption. It produced a slightly different type of hazard. But believe it or not, 25,000 people were killed in the space of 45 minutes. So these are major, major effects. Another one that affected the Northern Hemisphere more recently is Iceland, the Eyjafjallajökull in 2010. It erupted. It wasn't a particularly violent eruption. But what he did is it put an awful lot of ash into the atmosphere in the northern hemisphere and it put that ash into the atmosphere at a relatively low level. So that ash was in direct competition with aeroplanes. And that meant that in 2010, the spring of 2010, most of European airspace was shut for several weeks.

Speaker 1 [00:07:47] So going back to that example of the two examples there of where we had two volcanoes with, you know, different impact on on in terms of the death toll and the impact was that down to the accuracy or the sophistication or effectiveness of the mitigation efforts themselves? Or was it down to other you know, was it down to look in some instances or what were the reasons behind that?

Speaker 2 [00:08:11] In those particular cases, it wasn't a question of luck. In fact, the Mount St Helens eruption. There was a very good hazard management programme in place. People were told to avoid the area when the eruption was due. The casualties were actually people who didn't heed the information that they were given. And in fact, some of the casualties, very unfortunately, were the volcanologists studying the eruption, because it was unpredictable and it happened one day. The Nevado Del Ruiz one was a real problem. It's in the central part of Colombia. At the time, Colombia was fairly unstable politically, didn't have a particularly vibrant economy. And one of the things that was lowest on the on the list for the population was monitoring a volcanic hazard. Consequently, there was virtually no information about what should be done in the event of this eruption. Oddly, a few years later, the United States Geological Survey were contracted to produce maps of the area, and now they have very good hazard maps of that region done by the Americans. So there's a lot of economic and political side to the disasters that take place as a result of volcanic eruptions.

Speaker 1 [00:09:31] And you mentioned earlier too, about the relationship between, you know, volcanic eruptions and climate change or the impact of volcanic eruptions on climate change. Can you tell me a little bit more about that?

Speaker 2 [00:09:44] Yeah, the one of the things we have to remember is that when a volcano erupts, we're taking material from deep in the earth. Sometimes that material is coming from originating at depths of more than 80 kilometres. And as it rises to the surface, this material melts. That's a huge amount of energy. And on transit to the surface as well, we tend to find that the magma that's form the molten magma also acquires quite a lot of what we refer to as volcanic volatiles. That's actually sulphur dioxide, carbon dioxide, water, water vapour, two halogens, fluorine and chlorine. And when you have a major explosive eruption, those go in only one direction, and that's into the atmosphere. So if you can imagine, you have a lot of sulphur dioxide coming out of a volcano and it's a damp day. The sulphur dioxide reacts with the moisture in the atmosphere and produces sulphuric acid rain. That's a pretty big hazard that has a devastating effect on ecosystems. Similarly, carbon dioxide, as we know, is greenhouse gas. So that's significant. The there was one eruption in 1991, Mount Pinatubo in the Philippines. And because it was the early nineties, for the first time, there was very high resolution satellite imagery available for this area. And they were able to track the cloud of sulphur dioxide going around the whole of the southern hemisphere. And it didn't disperse within a period of two years. One of the results of that is if you put large amounts of ash, SO2 and all these volcanic products into the atmosphere, it has an effect on reflecting the sun's light back into space. So you end up with what we call a volcanic winter. And there's documented evidence from the 1991 eruption of Mount Pinatubo of temperatures in the southern hemisphere dropping by an average about half a degree centigrade. Just as a result of a single eruption in June 1991. Now, historically, way back in 1815, one of the biggest recorded eruptions was Tambora, which is a volcano in Indonesia when it first erupted. 11,000 casualties, as far as we are aware, from historical records. But there was the the years of no, there was the years of no summer and there was famine, there was a global famine as a result of that eruption. And it's reckoned that that famine alone caused at least 100,000 casualties. That was post eruption. So these are quite devastating effects. So the climatic effect is very important. One of the things we don't understand at the moment is we can't really say whether the earth at the moment is in a period where we have very few volcanic eruptions or whether it's in a period where there's lots we don't know that we can't predict it, we can't tell from the geological record. So a few large eruptions of the size of Mount St Helens or Pinatubo in the next few decades could have a devastating effect on global cooling.

Speaker 1 [00:13:03] And is there any evidence or do scientists have any thoughts on, or yourself, have any thoughts on if there's a reverse relationship between climate change and volcanoes in that in a situation where there is global warming? Could that in any way affect the likelihood or the severity of volcanic eruptions?

Speaker 2 [00:13:24] It's unlikely that there'll be any enhancement of most of the important volcanoes around the Pacific Rim. There's an interesting thing to think about, though, and that is that in Iceland in particular, Antarctica and Antarctica is an area I've worked extensively. There are some glacial volcanoes there sitting there. Some of them are active, but most have dormant. There's a lot of volcanoes sitting under ice in Iceland. The ice is very thick in the Antarctic. It can be three or four kilometres. If the ice melts, you release some pressure off the top of the volcano that can enhance eruptions. And there is actually some very good scientific evidence to show that during the last deglaciation, the rate at which Iceland erupted was much greater than it is now.

Speaker 1 [00:14:14] Okay, so I want to go back to talk a little bit more about mitigation efforts around volcanic hazards. So obviously, understanding the behaviour of volcanoes is crucial. Can you tell me a little bit more about the methods that scientists use to to monitor volcanic activity and then how that actually translates into actual mitigation efforts, whether it's around, you know, the built environment infrastructure or, you know, planned evacuations and things like that.

Speaker 2 [00:14:50] Yeah. I mean, one of the things that we have to remember about volcanoes is wherever you get a volcano, you'll get an earthquake. The two go hand in hand and, in fact, earthquakes are really good predictors of a likely eruption. So one of the things we can very, very simply do and this has been done for more than 100 years, is we have devices called seismometers. You can that in the present day. What we tend to do is deploy these remotely on the side of a volcano and record signals from the some of the location. And what they will do, they will start to pick up what we call earthquake swarms. And this is a sudden change in earthquake activity that is a precursor to an eruption. And that's one of the early, early, earliest indicators. So that's something that we can actually do quite well because we can put these things, the small devices side of a volcano and monitor them from somewhere else. So you're limiting the hazard to the people trying to do the monitoring. So that's one. The other thing that we use quite a lot now is GPS Global Positioning System. And in fact, the Icelandic eruption I mentioned earlier, the Eyjafjallajökull that was one of the first eruptions where GPS live GPS. monitoring was used. And what they were able to measure was the ground inflating and deflating as the magma rose towards the surface. This is a really good indicator that that something was going to happen. So that we can also do a very similar thing using satellites and you can actually measure from space the defimation that's taking place on a particular volcanic edifice. The United States are the leaders in this, and it's been used to some effect in various volcanoes. The other things we can do, which are really useful, is we can go to the top of our volcano and we can sample the gases. If we sample the gases, the gases tend to change composition as magma rises towards the surface. So we have a lot of things that we can do. How do you manage it if there's an eruption? Well, you have to have a plan. Some countries spend a lot of money on plans. Iceland do. One of the biggest hazards in Iceland is likely to be what we call debris flows, which is a mixture of volcanic detritus, ice and mud that forms as the ice cap melts when the volcano erupts. These can be devastating. So they map the potential pathway of these things and have evacuation plans. Simple thing in Iceland. In North America, there's some of the most monitored volcanoes on the planet because there is a will and there is the economy to support monitoring. So that's very important as is Hawaii some volcanoes on in Indonesia, which are really dangerous. The hazard warning can be something as simple as a man banging a gong in the village. That is actually part of the way they work. So it's a huge range of things that we can do.

Speaker 1 [00:17:55] Okay. So if you were advising a student or prospective student interested in and studying volcanoes, what are the kind of subjects that school or particular strengths a student might need to study volcanoes? So, for example, does it require, you know mathematics, geology, obviously, you know, people might have studied geography, I'm thinking, maybe chemistry, physics, like what kind of subjects would be good? A good background to study volcanology.

Speaker 2 [00:18:28] Well, I think the first the first prerequisite for studying volcanology is to be curious about volcanoes that inate curiosity drives us all. I believe from my point of view, my background training is in the basic sciences. So when I was doing A-levels all those years ago, I was doing chemistry, physics, biology, and that set me in a good stead for going into volcanology eventually. Other subjects areas, which are terribly important, are the skills that we now use developed in courses like geography, particularly for geographic information systems, because the satellite born imagery that we use, it's all GPS base material and that is very much a geographical thing. But it's also important to point out that the only sort of more art side volcanoes have less impacts on human population and they have an impact on economy. So you can see really there's a whole load of different subjects. And if you've got a basic background in some of these in some science plus some of these other subjects, it's absolutely no reason why you can't channel energy and enthusiasm into volcanology.

Speaker 1 [00:19:43] That's really interesting. So in terms of careers that a study of volcanoes or volcanology might lead into. There's the physical sciences. There's probably people like yourself and colleagues who work in in labs and who, as you said, also others who might spend a lot of time out up on, you know, literally climbing up volcanoes, studying the deposits, etc.. And then you said there's people who might go into more on the human economy, economic side. I mean, is it a case that it might be a mix of all of these, or would people tend to specialise in either lab based or field based? Or is it usually a mix?

[00:20:26] Yeah for most volcanology studies, you do end up being slightly specialised. So what I do is I concentrate on the chemical composition of volcanic products. So but that's my specialisation that I've developed over a period of, you know, 35 years, people I work alongside who study a very similar area to me. I actually do. I actually work with palaeontologists who are interested in fossil pollen. One of the reasons we do that is because lava fields in the geological record produced these very fertile soil and we get forests and we want to understand the forest ecosystems. So there's a lot of different directions you can go in, but it tends to be particular specialisations. So for example, the earthquake monitoring and that sort of thing, that tends to be done by specialised geophysicists who have a very specific training in that area. But of course these strands you can study all those, but you can study them here, no problem. We provide background knowledge in all these basic subjects.

Speaker 1 [00:21:36] So that's interesting. In terms of the actual for an undergraduate student here at Aberdeen studying geology or geosciences, at what point in their programme would they actually get to study volcanoes? And can you tell me a little bit about the teaching that you do at in the programme here at Aberdeen?

Speaker 2 [00:21:56] Well, unfortunately for the students, I kick off the first year course in first term and of course the first thing I talk about is volcanoes. Why do I do this? Because volcanoes are the thing that drive the dynamic Earth, Earth's dynamic planet. It's the only one we know of in our solar system. And part of the reason it's dynamic is because it has volcanism. So it's absolutely fundamental to the way the earth works. So we put that in a sort of a global context in first year. In first term. Second term in first year, we actually spend quite a lot of time in the science teaching lab Science Teaching Hub, with our brand new microscopes and equipment. And we use those to examine the mineral compositions and the rock properties of volcanic products. It's one of the fundamental things we do at first and second year. Fast forward then. Well, volcanoes pop up again in second year because we run a field course to the Isle of Arrran in the Firth of Clyde. One of the reasons we go there and I go on that trip is because we can see some of the 65 million year old volcanic products, some of the youngest rocks we have in Scotland. So we do that at level three. We take it a stage further. I do a specialised course in the chemistry of igneous rocks. But also I run a course called 'Just Volcanology'. And in the volcanology course, we deal with a whole range of things, right the way from complicated measurements of viscosity, of melts all the way up to hazards and human impact of volcanoes. So if you come here, you can't get away from volcanoes. And to make it even more exciting when we get to fourth year, we talk about volcanoes on other planets. So we're going to planetary geology. We talk about the moon and Mars, and they are really quite interesting things. I could go on for a week about Moon and Mars, but I won't.

Speaker 1 [00:23:56] You've been listening to the Talking Geosciences Podcast from the School of Geosciences at the University of Aberdeen. For more information about our teaching and research, visit our website www.abdn.ac.uk/geosciences or follow us on Twitter on Facebook.