

MARINE GEOSCIENCE: JUST A DROP IN THE OCEAN

Professor Bram Murton



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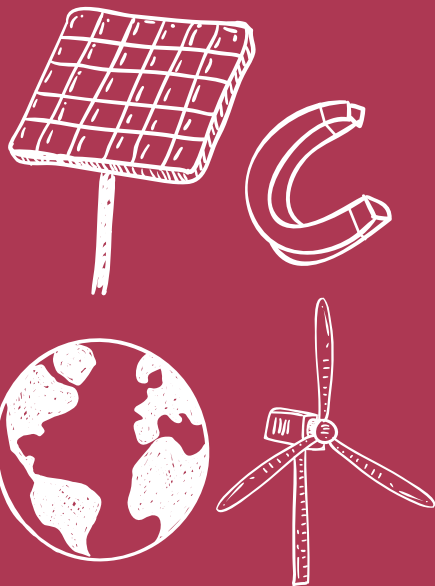
PROFESSOR BRAM MURTON IS THE ASSOCIATE HEAD OF MARINE GEOSCIENCE AT THE NATIONAL OCEANOGRAPHY CENTRE. IN THE UK. HIS RESEARCH COVERS MANY AREAS, INCLUDING THE DEEP OCEAN MINING OF MATERIALS SUCH AS TELLURIUM, WHICH CAN BE USED TO PRODUCE RENEWABLE ENERGY TECHNOLOGIES

IMAGINE THIS

You don't have to go into space to be the first human being ever to explore an area: 70% of our planet is covered by water and yet only 2% has been explored.

With the help of submarine robots, Bram and his team are finding new ways to mine for minerals and metals under the sea. These materials can be used to build solar panels, rechargeable batteries (for electric cars) and magnets needed for wind turbines.

Could deep sea mining be the solution we need to reduce mankind's reliance on carbon-based fossil fuels?



Our planet is an extremely vast place with an apparent abundance of riches. However, as the global population continues to grow rapidly, the demand for materials is outstripping our ability to recycle existing sources and replace what has been used. In addition, the burning of carbon-based fossil fuels has damaged Earth and significantly contributed to global warming and climate change. For these reasons, it is important for us to find new minerals and metals, particularly those that are essential to building low-carbon technologies.

One exciting, and surprisingly underutilised, potential source of new minerals and metals is the seas and oceans. Seventy percent of the Earth's surface is covered by water and the deep seafloor contains mineral deposits in the form of manganese and iron-rich nodules, cobalt-rich crusts and massive sulphides.

It is these cobalt-rich crusts that are the focus of Professor Bram Murton's research. As the Associate Head of Marine Geoscience at the National Oceanography Centre, in the UK. Bram leads a team of scientists who are interested in cobalt, tellurium and rare earth elements.

WHAT ARE THESE ELEMENTS USED FOR?

Cobalt is used in many materials, from special alloys in aircraft to machine tools, and more recently in rechargeable batteries. At the moment, 70% (90,000 tonnes per year) of cobalt comes from the Democratic Republic of Congo, a war-torn country in

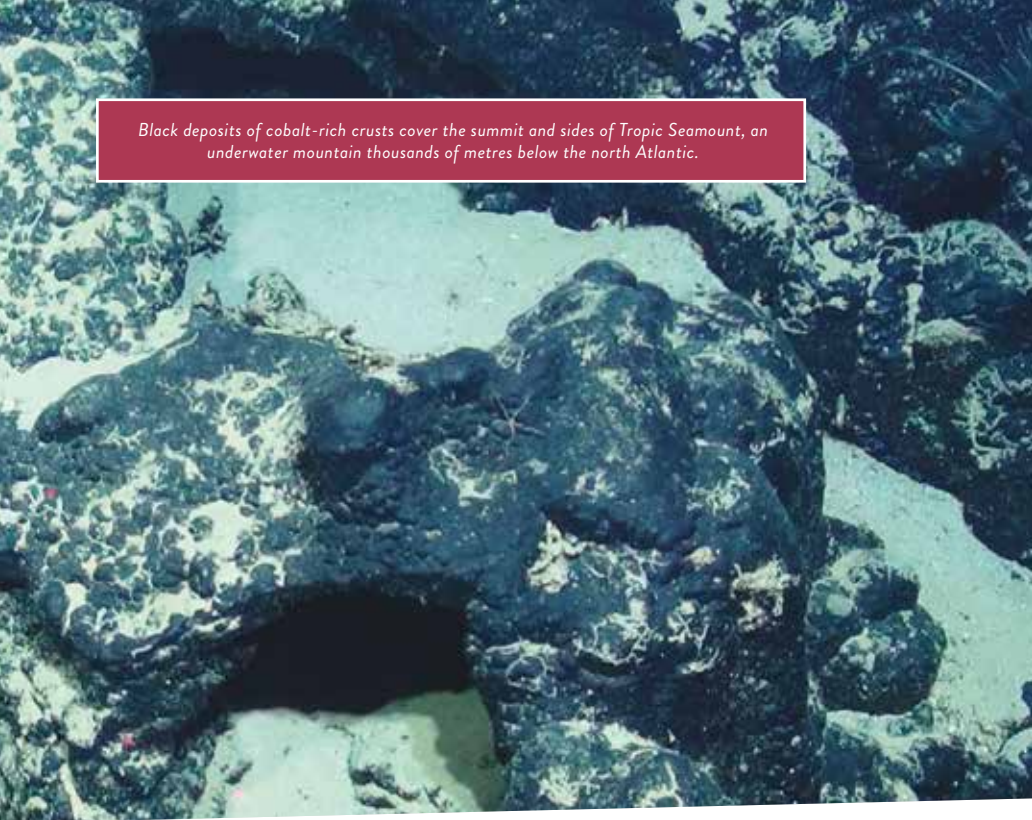
central Africa. Cobalt is not mined directly but is a by-product of copper production. In the future, demand for cobalt will be driven by electric cars.

Tellurium is a very rare element, even rarer than gold. Its traditional uses are for lead-acid batteries, as a pigment in ceramics (needed to create beautiful colours), and as a catalyst in hydrocarbon refining (an industrial process where crude oil is transformed into useful products such as petrol). Bram's interest in tellurium is in its use for improving the efficiency of solar panels to convert sunlight into electricity.

There are 15 rare earth elements listed in the lanthanide series (a group of elements in the periodic table) and, in spite of their group name, are not particularly rare – especially when compared with tellurium. But they have special properties that make them in high demand. For example, the heavy rare earth elements neodymium and praseodymium are used in strong electric magnets that are essential for electric motors and wind turbines. Rare earth elements are also used as catalysts in chemical reactions, in mobile phones and computer memory.

HOW AND WHY DO RESEARCHERS MINE UNDER THE SEA?

The grade of the metals is higher for many elements in seafloor minerals than on land. That means less rock has to be removed to get the same amount of metal. Then there is the fact that seafloor mines do not need infrastructure like roads, railways, or the relocation of people from their homes.



Black deposits of cobalt-rich crusts cover the summit and sides of Tropic Seamount, an underwater mountain thousands of metres below the north Atlantic.

However, there are technological challenges to deep-sea mining: exploring for the ore deposits, assessing their value and grade, extracting the ore from the seabed, lifting it thousands of metres to the surface, weathering storms, and shipping the ore to shore. Deep-sea mining has only been done in small scale trials so far, but the technology is advancing fast and it is only a matter of time before large commercial-scale operations are underway.

WHAT ARE THE MAIN CHALLENGES OR HURDLES IN THIS FIELD OF RESEARCH AT THE MOMENT?

The bottom of the ocean is a hostile and extreme environment. "There is no light, the ocean floor is full of corrosive seawater under high pressure, and it is very remote. Navigation is difficult – there is no GPS, no radio signals and no landmarks," explains Bram. "We have to use sound to navigate. Seeing is very difficult – we can only see for 20 metres or so and we have to use echosounders to build a picture of what

is there." Bram's team spends five or six weeks each year on a ship in the middle of the ocean, deploying robot submarines, collecting samples and analysing rocks. These data and samples are bought back to Bram's lab where the research group continue with more sophisticated analyses.

Another important consideration is to reduce the environmental impacts of mining for these materials. One of the more important environmental impacts of deep-sea mining is the effect of plumes of water that carry dust and sediment away from the mined area into other areas of the seafloor. So, Bram's team has conducted experiments to study the effects of the sediment plumes, both on the seafloor and on the sea surface.

Their results so far show that the plumes settle much quicker than previously thought and the chemicals are not as poisonous as believed. This allows people in the future to better design the mining plans to minimise any environmental damage.



PROFESSOR BRAM MURTON

Associate Head of Marine Geoscience
National Oceanography
Centre, UK

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FIELD OF RESEARCH

Marine Geoscience

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RESEARCH PROJECT

Bram's work focuses on deep ocean mining of minerals and metals. His interests are varied, but one key project involves attempting to address problems associated with the burning of carbon-based fossil fuels. As such, his team are investigating cobalt-rich crusts to find cobalt, tellurium and rare earth elements, all of which are critical to building low-carbon technologies.

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FUNDERS

Natural Environment Research Council
and UKRI

You can read more about what Bram's team has been doing at sea on their blog: [Marine E-tech Research Expedition](#).



The arm of a robotic submarine breaks off a piece of cobalt-rich crust for later analysis.

ABOUT MARINE GEOSCIENCE

Marine geoscience is a form of planetary science which involves studying the Earth. Seventy percent of our planet is covered by ocean and, similar to space exploration, there is so much that we still do not understand. Marine geoscientists aim to fill in these knowledge gaps using a wide range of tools and methods. Both robotic and manned vehicles are used to explore the deep-ocean floor down to 6,500 metres below the sea surface. It is possible to explore even deeper – down to 11,000 metres – the deepest places on Earth!

WHAT IS IT LIKE TO BE A GEOSCIENTIST?

Being a marine geoscientist is extremely exciting as you have to be an expert in lots of different areas: technology (sometimes designing your own vehicles and machines), geology (to understand the formation of

the rocks and minerals), geophysics (to understand the remote sensed data and sonars), geochemistry (to analyse the rocks in the lab), a mariner that is happy to go to sea on expeditions for weeks at a time, and an enthusiast for the unknown (only 2% of the world's oceans have been explored – so wherever you go, you are nearly always the first human being to see it and explore it).

WHAT CAREER OPPORTUNITIES ARE AVAILABLE WITH A DEGREE IN MARINE GEOSCIENCE?

Careers in marine geoscience research are hard to get, but far from impossible. If you follow your dreams and have a little bit of luck, then a career in this field could be within your grasp. Other related career opportunities are on the rise: offshore surveying is growing fast with the drive for renewable energy

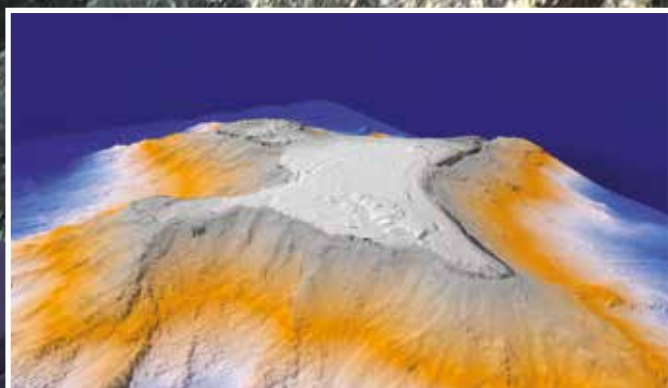
from offshore wind and wave, or oil and gas – and this requires marine geophysicists; marine-protected areas require surveyors to monitor for changes; cables cross the oceans and require marine geoscientists to survey where to lay them; and in the near future, deep-sea mining will require deep-sea mineral exploration.

WHY SHOULD YOUNG PEOPLE WANT TO STUDY MARINE GEOSCIENCE?

For many reasons! Geoscience is an adventure and has the power to make a huge difference to people and mankind – from understanding the history of climate change, to providing resources and materials from which we can build a sustainable future civilisation. It is varied, and never boring.

OPPORTUNITIES IN GEOSCIENCE

- The British Geological Survey has an entire area of its website dedicated to training within the field of geoscience: www.bgs.ac.uk/training/home.html
- The Geological Society says that a starting salary for a geoscientist can vary anywhere between £28,000 and £35,000, with senior geoscientists earning between £40,000 and £75,000 per year
- The Geological Society has also created a wonderful Geology Career pathways webpage, which allows you to explore your career pathway by clicking on animated characters. Have a go and see where a geology career could take you! www.geolsoc.org.uk/Geology-Career-Pathways



Multibeam sonars from the surface ship and deep-diving robotic submarines map the shape of Tropic Seamount, which is 40 km wide and between 1 and 4 km deep.



At 50 parts per million, cobalt-rich crusts are 50,000 times richer in tellurium, a very scarce element used in photovoltaic solar panels, than continental crusts!

ASK PROF BRAM MURTON

WHAT DID YOU WANT TO BE WHEN YOU WERE GROWING UP?

I was interested in everything technical, scientific and to do with space. We lived in the west coast of Scotland and I remember trying to build an underwater lab from an old large metal water tank. Luckily it floated away! My heroes were the *Tomorrow's World* presenters. However, it would be untrue to say that I dreamt of being a scientist or that I plotted a path to be a professor at an early age. I followed my curiosity and developed my interests in our natural world, and the rest came from serendipity and blind enthusiasm.

WHAT MADE YOU WANT TO STUDY GEOLOGY AND MARINE GEOSCIENCES?

As a kid, I was once taken on a gold-panning trip by a famous Antarctic explorer and geologist who was on holiday in my village. I asked lots of questions about the mountains, the minerals we could see, and how the Earth formed. The answers were fascinating, and I longed to understand how an apparently unique planet like the Earth was formed. After tossing a coin to choose between studying geology and geophysics at Edinburgh University (geology won), I went on to do a PhD at the Open University under the supervision of Professor Ian Gass FRS, researching the Troodos Ophiolite – an

uplifted fragment of 90 million year-old oceanic crust that now forms the mountains of Cyprus.

Fascinating as this was, I became increasingly aware that the 70% of Earth covered by the ocean is almost unknown, and I wanted to find out more about plate tectonics in action. I was invited on an oceanographic research cruise mapping the seafloor in the West Pacific with new sonar systems. Being the first to see the seafloor in this region, and the first to see new volcanoes and faults, got me hooked.

YOUR RESEARCH FOCUSES ON FINDING MATERIALS THAT ARE USED MAINLY FOR LOW CARBON AND RENEWABLE ENERGY TECHNOLOGIES (SOLAR PHOTOVOLTAIC, WIND TURBINES AND ELECTRIC VEHICLES). ARE YOU AN ECO-WARRIOR?

I am not a warrior of any kind – except maybe for the rational truth. But I am deeply concerned about the planet; it's our only one and will always be unique for us. I am concerned that people are consuming it without regard for the future. I want people to have a happy and healthy life, without destroying everything around us. This leads us to a dilemma: to become more sustainable, people must recycle and use more renewable energy, but there aren't

enough of those materials to make this happen. So, we need more raw materials. This sounds contradictory, to reduce consumption we need to consume more, but it is about consuming the right sort of materials that ultimately enable us to consume less. Deep-sea mining has a lot of potential advantages over land-based mining. To realise the full potential, we need to find out a lot more about the nature of the mineral deposits, where they form and are most concentrated, and the effects of mining them. I am motivated by helping people to have a sustainable future, reducing poverty and preserving our planet.

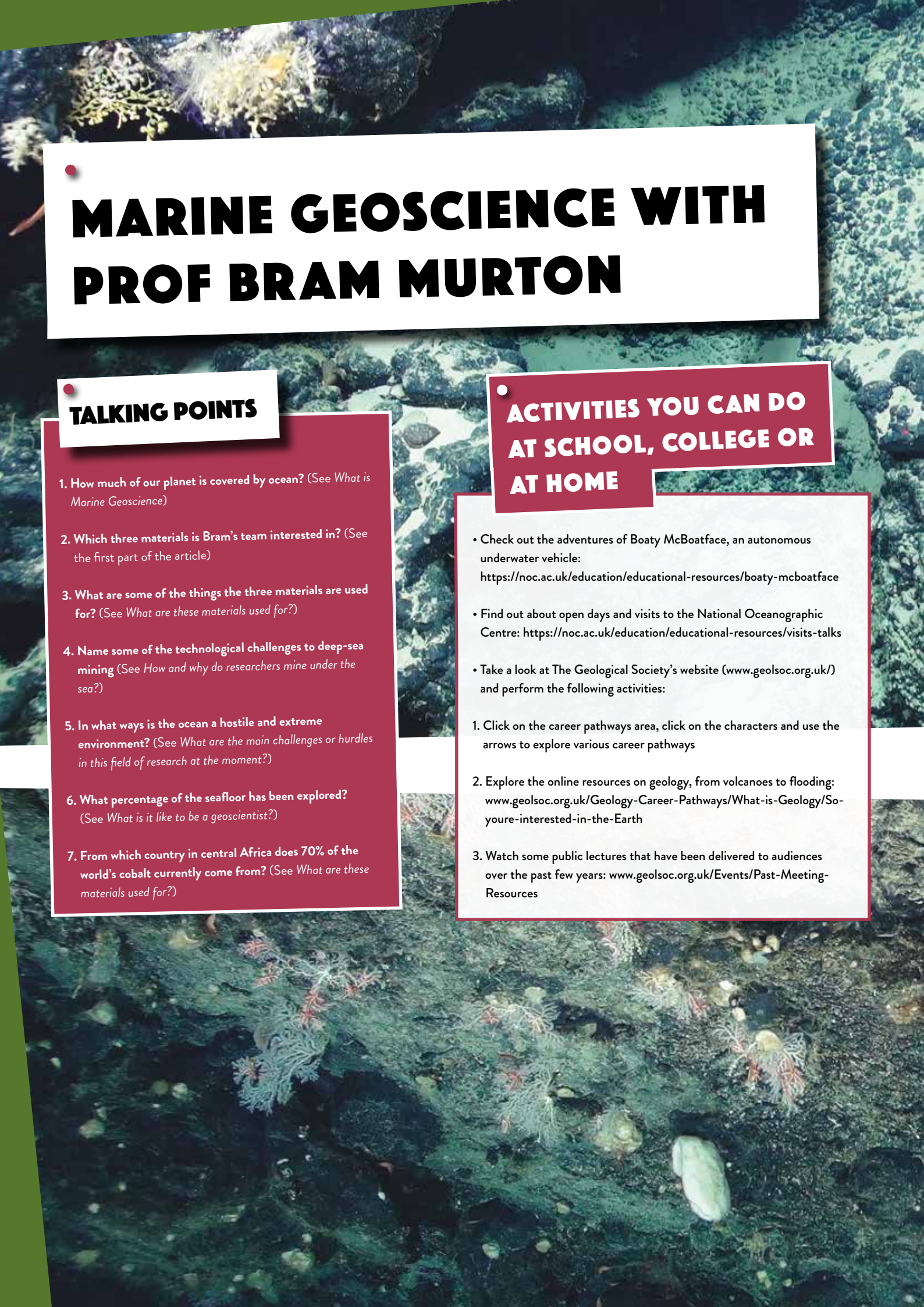
FINALLY, WHAT DO YOU LOVE MOST ABOUT YOUR JOB?

My job has given me the opportunity to discover things, to explore places and to see things no one has ever seen before. Its variety and opportunity have been amazing. I have built machines that have discovered the deepest and hottest hydrothermal vents on Earth. I have dived in a mini-submarine 3,500 metres below the surface to discover new forms of life. I have built teams and made new friends around the world, from multiple different cultures, all enthusiastic about discovery. My work, I hope, will ultimately help solve some of the world's problems. I have been given the chance to make a difference for the better.

BRAM'S TOP TIPS FOR STUDENTS

- 01** One of the most important things is to remember that scientists are just like everybody else. It is perfectly normal to be enthusiastic, interested, questioning and unsure of one's self. Keep this in mind at all times.
- 02** Marine geoscience requires a wide range of skills. A grounding in chemistry and physics at A level is a good start. Plus, a wider range of skills including team work, independent and critical thinking, self-reliability and sociability are essential.
- 03** If you get the chance, meet people in the business, go to trade shows and talk with people from the industry and local geological society – and attend talks! They are often by experts in the field and can be inspiring.

If all the tellurium in the cobalt-rich crusts was used to make solar panels, they could provide two-thirds of the UK's electricity supply on a sunny day.



MARINE GEOSCIENCE WITH PROF BRAM MURTON

TALKING POINTS

1. How much of our planet is covered by ocean? (See *What is Marine Geoscience*)
2. Which three materials is Bram's team interested in? (See the first part of the article)
3. What are some of the things the three materials are used for? (See *What are these materials used for?*)
4. Name some of the technological challenges to deep-sea mining (See *How and why do researchers mine under the sea?*)
5. In what ways is the ocean a hostile and extreme environment? (See *What are the main challenges or hurdles in this field of research at the moment?*)
6. What percentage of the seafloor has been explored? (See *What is it like to be a geoscientist?*)
7. From which country in central Africa does 70% of the world's cobalt currently come from? (See *What are these materials used for?*)

ACTIVITIES YOU CAN DO AT SCHOOL, COLLEGE OR AT HOME

- Check out the adventures of Boaty McBoatface, an autonomous underwater vehicle:
<https://noc.ac.uk/education/educational-resources/boaty-mcboatface>
 - Find out about open days and visits to the National Oceanographic Centre: <https://noc.ac.uk/education/educational-resources/visits-talks>
 - Take a look at The Geological Society's website (www.geolsoc.org.uk/) and perform the following activities:
1. Click on the career pathways area, click on the characters and use the arrows to explore various career pathways
 2. Explore the online resources on geology, from volcanoes to flooding: www.geolsoc.org.uk/Geology-Career-Pathways/What-is-Geology/So-youre-interested-in-the-Earth
 3. Watch some public lectures that have been delivered to audiences over the past few years: www.geolsoc.org.uk/Events/Past-Meeting-Resources

