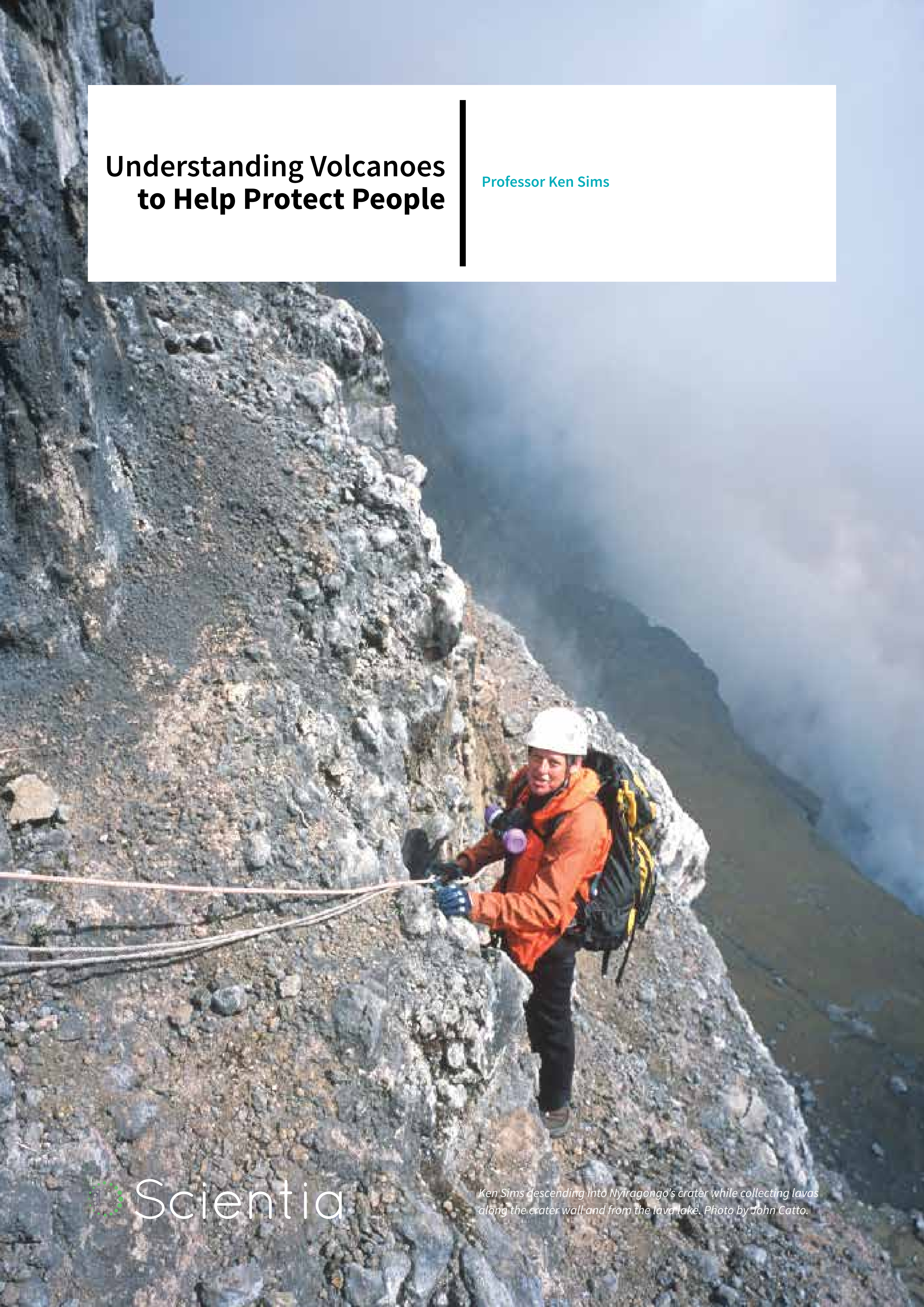
Understanding Volcanoes to Help Protect People

Professor Ken Sims



Ken Sims descending into Nyiragongo's crater while collecting lavas along the crater wall and from the lava lake. Photo by John Catto.

Nyiragongo Lava Lake in 2007. Photo by John Catto.

UNDERSTANDING VOLCANOES TO HELP PROTECT PEOPLE

Geologist and volcanologist **Professor Ken Sims** and his colleagues from across the globe want to improve our understanding of active volcanoes in an effort to advance the science of volcanology. But they also want to protect the lives of people living near these dramatic geologic phenomena.

Magnificence and Deadliness All in One Spectacular Mountain

Volcanoes have fascinated humans since prehistoric times. Primitive peoples feared them as deities, such as the fire goddess Pele, who lives – according to Hawaiian mythology – in the active Kilauea volcano on the island of Hawaii. Volcanoes are fearsome to us moderns as well, enough to be memorialised in modern culture. For example, the 1968 epic adventure movie Krakatoa: East of Java is set against the backdrop of the catastrophic 1883 eruption of Krakatoa in the Dutch East Indies. Notwithstanding the fact that Krakatoa is actually west of Java, the explosion and eruption of that volcano, along with the tsunamis it generated, killed an estimated 40,000 people and had global impact. More recently, the movie Pompeii dramatised ill-fated lovers caught in the eruption of Mount Vesuvius, just north of Naples, Italy, that totally obliterated the Roman city of Pompeii and several neighbouring villages in 79 AD. It is estimated from excavation of the ruins that well over 1,000 people died, many almost instantly from the heat of at least 250°C. It is the height of understatement to say that it is dangerous to live near a volcano.

Human beings are stubborn, however, and live where they will. Visitors to the city of Catania in Sicily can see evidence for themselves that people do not like to move, even after repeated destruction by a volcano. Catania lies on the sunny slopes of the Mount Etna, the tallest active volcano in Europe. Modern construction excavations reveal layer upon layer of destroyed ancient buildings, then lava, then destroyed buildings, then more lava. Over the centuries Catania and the towns around it repeatedly have been totally or partially covered with lava. Yet the inhabitants return to rebuild in the same spot, perhaps due to the fertile soils that result from volcanic activity. Not that the people do not try to defend themselves. In the deadly eruption of 1669 resulting in over 20,000 deaths, the people refused to evacuate, trying instead to divert the flow of lava. Their efforts were in vain. But these unfortunates were trying to play catch up – the lava was already on the move. What if they had advance warning? Couldn't the people in Pompeii, for example, have evacuated well in advance of the eruption if they had sufficient warning? Forewarned is forearmed, and that is just what Professor Ken Sims is trying to do with his research of volcanic activity – predict volcanic activity with enough lead time to prevent loss of human life. An important focus of one of his current studies is the African volcano, Mount Nyiragongo.

‘This research addresses both basic science, as magma genesis is a fundamental dynamic process; but it is also societally relevant, as a volcanic crisis on Nyirangongo would create a humanitarian crisis in this war-torn region of the world’

Volcanologist Jacques Durieux (1949–2009) and Ken Sims on the summit of Nyiragongo looking down into the crater before descending in 2007. Photo by John Catto.

A Million Souls Living Near a Time Bomb

Professor Sims has always loved being outdoors and challenging himself. Early on he became a climbing and mountaineering guide in Peru, Alaska and Antarctica. ‘I eventually tired of guiding as I saw a bigger picture when guiding so many interesting people up big mountains,’ he tells us. ‘My work as an isotope geologist and volcanologist enables me to pursue both the intellectual and physical challenges of our natural world.’ But learning about volcanoes means learning about the human toll volcanoes can exact on those living near them. According to Professor Sims, ‘One aspect of how my work inspires me is the knowledge that the research my volcanologist colleagues and I are pursuing has the potential to save many people’s lives.’

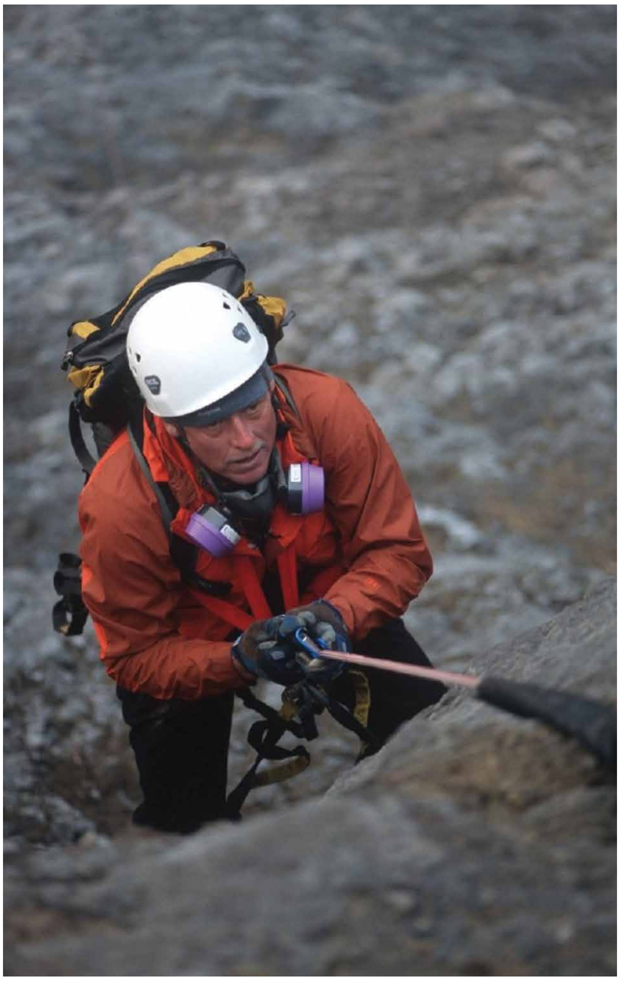
Professor Sims has taken a special interest in the volcanoes of the East African Rift system, an area in Eastern Africa where two tectonic plates – the Nubian Plate and the Somali Plate – are diverging. The rift has produced a number of volcanic mountains, including the legendary Mount Kilimanjaro. He is particularly interested in a spectacular volcano in the Democratic Republic of the Congo, Mount Nyiragongo. Mount Nyiragongo is a stratovolcano – a steep, conical volcano made of layers, or strata, of lava, pumice, ash and other material – that reaches almost 3,500 feet high. Notably, Mount Nyiragongo boasts perhaps the world’s largest lava lake. Professor Sims claims it was one of his favourite field experiences, ‘descending into the volcano Nyiragongo and climbing 15 meters up the vertical spatter cone to see the world’s largest lava lake from just a few feet away.’

Mount Nyiragongo lies a mere 20 kilometres north of the city of Goma, as well as nearby Gisenyi, Rwanda, with an area population of at least a million. In spite of destructive eruptions in 1977 and 2002 in which more than 400 people died and tens of thousands were left homeless, there is little scientific knowledge addressing magmatic cyclicity at this volcano. In other words, nobody knows when the next calamitous eruption could occur. However, just as did the people in Catania, Sicily, the people of Goma have since rebuilt on both the 1977 and 2002 lava flows.

The Nyiragongo volcano is particularly dangerous because the lava it releases is unusually low in silicon dioxide. This makes the lava very fluid and results in lava flows that can reach speeds of up to tens of kilometres per hour. It is imperative that eruptions be predicted, rather than for the residents to try to outrun the lava. Professor Sims intends to provide the concrete scientific framework for hazard assessment and risk mitigation. In his words, his work is ‘both basic science, as magma genesis is a fundamental dynamic process; but it is also societally relevant, as a volcanic crisis on Nyirangongo would create a humanitarian crisis in this war torn region of the world.’ For one thing, Goma is the centre for the UN peacekeeping mission in this area and houses more than a million residents and refugees from civil war in the Eastern Congo and genocide in Rwanda. How does Professor Sims plan to analyse this volcano? By taking samples.

Investigating Volcanoes… By Climbing into Them

Recently, in 2015 Professor Sims, mountaineer that he is, along with one of his similarly trained colleagues, John Catto, and his graduate student, Erin Phillips, took an expedition to Mount Nyiragongo. There they collected rock samples from Nyiragongo’s lava flows and parasitic cones. Parasitic cones are those cone-shaped accumulations of volcanic material, separate from the central vent of a volcano, formed from eruptions through fractures on the sides or flanks of a volcano. Funded by the National Science Foundation, that research expedition was primarily designed to sample the parasitic cones that surround Nyiragongo, both in the city and in the surrounding countryside. These samples were not taken in isolation, however. On two previous expeditions supported by the National Geographic Society, one in 2007 and one in 2010, Professor Sims collected numerous samples from the vertical walls in the summit crater, the outer flanks of the volcano, and even samples from the lava lake. This last daring exercise, descending within feet of the molten lake, was reported in National Geographic magazine. This earlier data gave Sims and his team a leg up on understanding the volcano’s long-term and short-term eruptive history as evidenced by material in



Ken Sims coming out of Nyiragongo's crater while collecting lavas along the crater wall and from the lava lake. Photo by John Catto.

the crater walls.

Professor Sims' most recent expedition, in August 2016, was capped off with yet another descent to the lava lake for sampling. However, this time Professor Sims saw a marked difference in the lake from his 2010 visit. This time the lake was smaller and has sunken deep into the crater – in 2010 it was perched perhaps 100 feet higher. In this most recent 2016 expedition, it was completely impossible to get right to the edge of the lake to get a fresh sample like in 2010. The bottom crater, or third terrace had a new vent that started erupting while Professor Sims was camping down there. It started with a Strombolian type of eruption sending lava bombs near to their camp on the second terrace in the crater and culminated with massive lava flows that poured back into the sunken lava lake. Fortunately for Professor Sims these lava bombs provided another fresh lava for his research. He wasn't surprised, however. As he perceives it, 'It is after all a volcano: one of Earth's "crucibles of change".'

Analysis Will Be the Key to Predicting Future Catastrophes

The city of Goma is actually built on a lava flow that was laid down sometime between 1208 AD and 1374 AD, as closely as can be told by Carbon-14 dating technology. Because these lavas are extremely fluid, this flow is speculated to have quickly covered the area where today's Goma is built. If this type of lava flow happened today, hundreds of thousands of people could be killed. But since the modern city of Goma was founded around 1941, there have been the two deadly eruptions and, like in Catania, Sicily, Goma has been rebuilt after each of these eruptions. It looks like the people of Goma want to stay where they are. They need some help – some warning about the volcano in whose shadow they are living.

Besides these early known lava flows, hundreds of parasitic cones of unknown age surround Nyiragongo's main cone. Some of Nyiragongo's cones have erupted within the actual city of Goma. The Goma Volcano Observatory is actually located directly on one of them. Many very large flows on the flanks of Nyiragongo seem to be relatively young based on morphology, but their age has not yet been determined. This is where Professor Sims and his team are trying to make some headway. By analysing their samples with mass spectrometry, to determine the chemical and isotopic composition of these samples, and radioisotope dating, using proportions of radioactive decay products to estimate age, they intend to map out the chronology of the extensive flows and eruptions around Nyiragongo's neighbourhood. This can greatly improve the predictive power of any predictions of Nyiragongo's future activity. 'Essentially, the past is the key to the future in understanding this volcano,' Professor Sims tells us.

Up until now, current hazard maps for this region are based only on data taken from the 1977 and 2002 Nyiragongo eruptions. But this assumes that no other lava flows were produced in the last few hundred years. Professor Sims knows that this is an inaccurate assumption and a limitation in the present hazard evaluation. Assuming that future venting will follow patterns observed in the 1977 and 2002 eruptions – without taking into account older eruptions – is not scientifically reasonable. Without knowing Nyiragongo's magma cycles and the ages of the flows and parasitic cones in the Goma region, scientists cannot make accurate estimates as to possible future flows. Professor Sims' research recognises the urgent need to provide a concrete scientific framework for hazard assessment of Nyiragongo and to plan ways to mitigate its risk for Goma and Gisenyi. When the analysis and calculations are complete, the team can hopefully give some security to the inhabitants of Goma and surrounding environs. A better and more accurate hazard map could literally save lives.

What Are the Plans for the Future?

Professor Sims and his colleagues hope to get the samples from their project analysed and correlated to better understand and predict the Nyiragongo volcano. But looking to the future, Professor Sims says he 'wants to expand the toolbox of isotope systems' that he is applying to his studies. Volcanoes produce a variety of materials when the lava cools. A myriad of crystals and compounds results from the cooling of magma and lava, many of which lend themselves to isotopic analysis. Professor Sims wants to branch out from his current set of isotopic by-products and find others that can be used to further expand his analytic repertoire. He is also starting to collaborate with microbiologists in the hopes of collectively better understanding the nexus between geology and life. After all, evolutionists theorise that life arose on this planet in the caldron of a volcanic Earth. And now life – including human life – can be snuffed out by volcanic activity. It behoves scientists to put their heads together and put all their energies into finding ways to avoid that possibility.

Meet the researcher

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Professor Ken Sims did his undergraduate studies at Colorado College where he received his B.A. with Honours in Geology in 1986. He then received a M.Sc. from the Institute of Meteoritics, Earth and Planetary Sciences, from the University of New Mexico in 1989. In 1995 he received his Ph.D. in Earth and Planetary Sciences from the University of California at Berkeley, where his thesis was entitled Magma Genesis in the Earth's Mantle. From UC Berkeley Professor Sims was awarded a Woods Hole Oceanographic Institution Post Doctoral Scholar fellowship and was subsequently taken on as a research scientist. After spending 12 years as a tenured scientist at the Woods Hole Oceanographic Institution, he joined the faculty of the Department of Geology and Geophysics of the University of Wyoming in 2009, where he is currently Professor at the Department of Geology and Geophysics.

Professor Sims' research interests include the application of Uranium-series disequilibria, radiogenic isotope geochemistry, major- and trace-element geochemistry and the principles of physics and chemistry to a variety of fundamental problems in Earth and planetary sciences. He has authored or co-authored over 70 articles published in peer-reviewed journals. His field research has covered the globe and spanned a wide range of elevations including diving to the bottom of the ocean to sample the East Pacific Rise (4k meters beneath sea level) to climbing and sampling the world's highest active volcanoes (6k meters above sea level) in Ecuador. Professor Sims has also been a mountain climbing guide and instructor, a wilderness instructor and has received numerous academic awards, including the Fulbright US Scholar Award in 2016–2017.

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