Two billion year old salt rock reveals rise of oxygen in ancient atmosphere[1]

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The new study by an international team of researchers, led by the Universities of St Andrews and Princeton, finds that salts left over from ancient seawater reveal new information about the oxygenation of the Earth's atmosphere more than 2 billion years ago.

The team, which includes Cambridge Earth Sciences' Dr Sasha Turchyn, found that the rise in oxygen that occurred about 2.3 billion years ago, known as the Great Oxidation Event, was much more substantial than previously indicated.

"Instead of a trickle, it was more like a firehose," said Dr Clara Blättler, a postdoctoral research fellow in the Department of Geosciences at Princeton and first author on the study. "It was a major change in the production of oxygen."

The evidence for the profound upswing in oxygen comes from crystalized salt rocks extracted from a 1.2-mile-deep hole in the region of Karelia in northwest Russia. These salt crystals were left behind when ancient seawater evaporated, and they give geologists unprecedented clues to the composition of the oceans and atmosphere on Earth more than 2 billion years ago.

The key indication of the increase in oxygen production came from finding that the mineral deposits contained a surprisingly large amount of a component of seawater known as sulfate, which was created when sulfur reacted with oxygen.

"The story is the salts," said Dr Mark Claire, School of Earth and Environmental Sciences at the University of St Andrews. "Decades of geologic observation by researchers at St Andrews (in collaboration with colleagues in Norway and Russia) led to the discovery of a 600-metre-thick pile of evaporated 2-billion-year-old seawater, in a drill core 2.5 km below the surface in Russia's Karelia basin. These are by far the oldest salt deposits ever discovered, and the well-preserved sulfate salts archive the aftermath of Earth's most dramatic transition ever – the 'Great Oxidation Event."

After demonstrating that the sulfate salts had not been re-dissolved since they were originally deposited, researchers at St Andrews and Princeton

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University used state of the art geochemical measurements and modelling to show that the chemistry of the ancient seawater was similar to modern seawater. One of the supporting lines of evidence was the isotope ratios of sulfur in the sulfate, which were done in the Department of Earth Sciences in the Turchyn group.

"The results provide strong evidence for high marine sulfate concentrations at this time," said Sasha Turchyn. "There has never been anything precluding high marine sulfate concentrations but we have very few windows into the geological past in terms of the chemistry of the oceans. Most of our understanding of past ocean chemistry comes from mineral 'proxies', while these evaporite minerals came directly from seawater, meaning they offer direct evidence in a way that mineral proxies can't. Our contribution to the study was to analyse sulfur isotope ratios which showed consistent and slightly elevated values that supported the overall interpretation"

Oxygen makes up about 20 percent of air and is essential for life as we know it. According to geological evidence, oxygen began to show up in the Earth's atmosphere between 2.4 and 2.3 billion years ago. Until the new study, however, geologists were uncertain whether this build up in oxygen - caused by the growth of cyanobacteria capable of photosynthesis, which involves taking in carbon dioxide and giving off oxygen - was a slow event that took millions of years or a more rapid event.

Two-billion-year-old evaporites capture Earth's great oxidation, C L Blättler, M W Claire, A R Prave, K Kirsimäe, J A Higgins, P V Medvedev, A E Romashkin, D V Rychanchik, A L Zerkle, K Paiste, T Kreitsmann, I L Millar, J A Hayles, H Bao, A V Turchyn, M R Warke and A Lepland is published in *Science*.

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