

be subducted again — yet that is what is implied by these widely separated ages of eclogite formation in a single sample.

The work by Herwartz and colleagues³ provides a fascinating glimpse into the history of one enigmatic sheet of rock in the Alps. At the same time, it raises the question of whether there is a systematic process by which the edges of continents can be subducted repeatedly into the mantle during the closure of one or more ocean basins⁴. □

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From isotopes to ice

Without the deep ice cores from Greenland and Antarctica, the climatic and environmental changes over the past 800,000 years would be much less precisely documented. The key tools for reconstructing continuous palaeotemperature records are measurements of the oxygen and hydrogen isotope ratios in ice, even though they are now complemented by other methods. Willi Dansgaard, who died on 8 January 2011 at the age of 88, spear-headed the use of the stable isotopes of water in climatology and palaeoclimatology, especially as applied to deep ice cores.

This scientific adventure started in 1952. On 21 June, Willi Dansgaard collected rain samples as a low-pressure system was passing over Denmark. He was intrigued by their isotopic composition and decided to investigate. Eventually, he showed that isotopic values of warm-front rain reflect the formation temperature in the cloud.

Over the next 12 years, he systematically collected and analysed water samples from all over the world. In 1964, these data and their interpretation were published in a seminal article 'Stable isotopes in precipitation' (*Tellus* **16**, 436–468; 1964). Most important was the confirmation that, for mid- and high-latitude sites, the colder the climate, the lower the isotopic values. This observation is the founding principle of climate reconstruction from measuring water isotopes in ice cores.

Already in the 1950s, Willi Dansgaard wanted to study old ice. However, the technique of ice-core drilling had not yet been developed. So he started with analysing ice from marginal glaciers and from icebergs. His subsequent work benefited from drilling activity led by the US Cold Regions and Engineering



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Laboratory at Camp Century in northwest Greenland. Together with Chester Langway and the American team, Dansgaard and colleagues obtained the first continuous profile of ¹⁸O/¹⁶O ratios along a deep ice core, and a few years later, along the US Byrd ice core from West Antarctica. Joined by Hans Oeschger of the University of Bern and co-workers, the ice-core enthusiasts recovered the Dye 3 deep ice core from south Greenland in 1979–1981. This core led to the discovery of abrupt climate changes during the last ice age, now termed Dansgaard-Oeschger events.

As a young scientist, I was extremely impressed by Willi Dansgaard when I first met him in the late 1960s. But what I remember most vividly is a meeting we had in Boston in January 1987, with the

hope of launching a joint US-European drilling project in central Greenland. It was a surprise to all when Dansgaard, disappointed by the difficulties in getting the collaboration with the US off the ground, told the meeting we should go for two cores, instead of a joint project. The decision is history: two cores were drilled 30 km apart, GRIP and GISP2. In hindsight, the information gained by comparing the records provided by these two cores proved invaluable. I also distinctly remember Willi's excitement at the GRIP bedrock party on 12 July 1992. The success of this European drill project was the crowning achievement in the career of a scientist who is today recognized as the founder of modern ice-core climate research.

When he retired that same year, Willi Dansgaard had built a strong research group, including a team dedicated to drilling technology. His style of leadership was marked by his hot temper, his very short patience with what he called 'details', and his strong focus on the scientific goals. He was great at including everybody, senior as well as very junior, in important decisions and created a strong team spirit. Members of his group will remember his dedication and determination, always towards progress of science.

Willi Dansgaard's legacy survives in the Centre for Ice and Climate in Copenhagen, which has been very active in the large European ice-drilling projects in Antarctica and has led international projects in Greenland such as NGRIP and NEMO.

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