THE LAND BENEATH THE ICE: THE PIONEERING YEARS OF RADAR EXPLORATION IN ANTARCTICA. By DAVID J. DREWRY. Princeton: Princeton University Press, 2023. ISBN: 9780691237916. 464 p., maps, colour and b&w illus., index. Hardbound. US$39.95. Also available in ebook format.

The Land Beneath the Ice is a highly readable account of the development of radar for measuring the thickness of ice sheets in the early 1960s and the consequent major airborne program by a UK/US (and later Danish) partnership from 1967 to 1979, which produced the first reliable maps of the surface and bedrock topography of the Antarctic, the world's largest ice mass.

This book is not just about the science. As one of the largest "big science" projects of its day in the Antarctic, geopolitics played a large part both in its birth and development. The US was keen to conduct major projects in the Antarctic to support the international framework of the Antarctic Treaty they had worked to create. The scientific results of the program were considerable, indeed transformative to our understanding of the Antarctic continent. Even today its results remain very pertinent—the widely quoted statistic that global sea levels would rise by around 200 feet if the Antarctic ice sheet was to disintegrate because of global warming comes directly from the measurements of ice volume produced by this program.

The author was one of the principal investigators of this program, and the many challenges of this early airborne fieldwork are brought to life by his engaging style and colourful stories of long and arduous flights across the ice sheet. This was not comfortable armchair science. In fact, the very technique of radar or radio-echo sounding (RES) of ice sheets had come about because of a series of fatal accidents—crashes of aircraft flying over ice sheets caused by misleading radar altimeter readings that returned the range of bedrock rather than the ice surface because ice is transparent at radio wave frequencies.

The book also describes, often entertainingly, the politics at play between the British developers of the RES technology (Scott Polar Research Institute [SPRI], Cambridge) and the Americans who provided funding and logistical support (US National Science Foundation, NSF). It therefore provides both an insight into how large multinational science projects can work as well as something of an adventure story in its own right. The tales of the hurdles the team faced each year both in haggling for flight hours with the NSF and in dealing with military bureaucracy in the shape of the US Navy who operated the C-130 Hercules aircraft, remind us that overcoming operational challenges in a harsh polar environment is sometimes only half the battle.

In 1967 when the program began, knowledge of the ice sheet surface and bedrock topographies was limited to a handful of profiles from seismic traverses, showing only the ice sheet surface elevation in general terms and the existence of a few subglacial mountains. The difference that 129 flights and 400,000 kms of radar data lines yielded was enormous. Whole mountain ranges were revealed in unprecedented detail. The flow regime of the ice sheet was properly understood for the first time. The west Antarctic ice sheet was found to be inherently unstable, with much of its base lying below sea level. Substantial lakes of water were discovered beneath the thicker parts of east Antarctica, the product of both pressure and geothermal heating. Faint stratified echoes within the ice itself were shown to be caused by thin layers of acids deposited by volcanic eruptions, providing valuable information about internal ice flow and (later) a means of correlating deep ice cores to one another. Even basic statistics such as the volume of the ice sheet could be properly calculated for the first time. In a period of a little over ten years our understanding of this continent, which is so influential on the planet's climate, increased a hundredfold.

Today, the RES technique that the team pioneered is still the primary method of surveying the thickness of ice caps and cold high-latitude glaciers. The book gives a useful summary of developments after the SPRI/NSF/Technical University of Denmark program ended in 1979, both in terms of improvements to the technology and the many countries who have developed their own RES programs. Among these is Canada, which contains the largest area of glacier ice in the world outside Greenland and Antarctica, and where RES of the Devon Island ice cap in 2018 revealed the existence of the first subglacial lakes to be found in the Canadian Arctic. The usefulness of the technique is not even confined to Earth: the polar ice caps of Mars have now been surveyed by an ice-sounding radar mounted on the Mars Express orbiter, showing that they are up to 3.7 km thick and with indications of liquid water at the base, roughly the same size and thickness as the Greenland ice sheet.

The overall production quality and editing of the book is good, particularly the black-and-white photographs, which are very clear. The sheer number of maps, diagrams, and photographs is unusually generous and enriches the science and history described.

The Land Beneath the Ice is recommended for glaciologists, geoscientists concerned with the polar regions, and those interested in climate change and understanding how some of the key parameters are estimated. It would also be useful reading for anyone participating in Arctic fieldwork. Although it is an academic book, it is very accessible and does not assume an in-depth knowledge of glaciology or geophysics.

David Millar, FRGS
175 Hidden Creek Gardens NW
Calgary, Alberta T3A 6J4, Canada
dhm.millar@gmail.com