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Kolumban Hutter's new text 'Fundamental glaciology' (Hutter, 2020) departs from established norms in glacier science; sets a new standard for glacier mechanics; and deftly collects flow and fracture under one roof. At the interface between theoretical continuum mechanics and glaciology, Hutter's subtitle captures the flavor: *Modelling thermomechanical processes of ice in the geophysical environment, engineering and material science*. In this way, Hutter's text is a focused effort on modeling the thermomechanics of ice and is a sequel to Hutter's previous text 'Theoretical glaciology' (Hutter, 1983). The target audience for 'Fundamental glaciology' is likely graduate students and other ice researchers of all career stages. Both of Hutter's books complement glaciology survey texts such as van der Veen (2013), Cuffey and Paterson (2010) or Hooke (2005). The book has a language and style of its own: the notation is elaborate, variables are decorated and the descriptions are precise. I have a lot to learn from Hutter's text 'Fundamental glaciology' and I plan to incorporate what I learn into the graduate fluid mechanics class I teach at Dartmouth College.

The first half of the text is on the topic of ice rheology and has significant conceptual as well as textual overlap with Hutter's previous text (Hutter, 1983). After a brief review of continuum mechanics and thermodynamics at the graduate level (chapter 1), Hutter describes ice rheology in general terms and, in particular, more general rheologies than Glen's law (chapter 2). Hutter starts with the elastic behavior of ice crystals, then adds in the inelastic response as a transition into a discussion of viscoelasticity. Then, following the thread of continuing to look at longer and longer timescales, Hutter discusses ice creep. He starts by describing ice as a Reiner–Rivlin viscous fluid. (Although there is a typo throughout the text whereby Hutter refers to 'REINER–RIWLIN fluid' yet refers to the 'RIVLIN–ERICKSEN tensors' and why they are capitalized in this fashion is beyond me.) I like the approach of starting with Reiner–Rivlin because, although ice rheology is an experimentally measured quantity, there is a lot that can be said about rheology from the properties of tensors alone (e.g. Meyer and others, 2017). The general overview of rheological principles and specific focus on ice makes chapter 2 a great reference for these topics and a natural pairing to Schulson and Duval (2009) or Cuffey and Paterson (2010, chapter 3). At the same time, the experimental data shown in chapter 2 are from Steinemann (1954), Glen (1955) and other contemporaries. These days, in thinking about ice deformation, the gold-standard experiments are Goldsby and Kohlstedt (2001). Hopefully, a discussion of the Goldsby and Kohlstedt (2001) experiments will find a home in a future edition of Hutter's text.

Chapters 3 and 4 focus on the steady creep of polycrystalline ice, directly applying the rheological ideas from chapter 2. In chapter 5, Hutter describes a viscoelastic solution for glacier flow down an inclined plane. The results follow Riesen and others (2010) and are a nice demonstration of the ideas presented in the book so far. Chapter 6 is the last chapter in part I of the text and concerns the application of rheological ideas to glaciology. It is where the rubber meets the road or, in this context, where the ice meets the till. Hutter continues to focus on the parallel-sided glacier flowing down an inclined plane, writing out the full field equations and boundary conditions. In this section, Hutter includes a discussion of polythermal glaciers, where a portion of the glacier is below the pressure–melting temperature and a portion of the glacier is temperate, i.e. at the pressure-melting point. Following material from his previous text, Hutter clearly lays out the thermodynamic internal and boundary conditions as well as the connection to rheology. Yet, gravity driven moisture flow is missing from the analysis (e.g. Schoof and Hewitt, 2016) and Hutter uses a diffusive moisture flux instead, an area for improvement that Hutter points out in the summary.

In the second half of the book, Hutter describes his foray into damage mechanics. Calving of icebergs at ocean-terminating glaciers is a great open problem in glaciology that has a large influence on sea level rise predictions (e.g. DeConto and Pollard, 2016; Clerc and others, 2019). Ice is clearly very damaged as it makes its way to the glacier terminus. Connecting the visible damage down to fractures on the microscale and calving on the macroscale is a worthwhile pursuit. Hutter begins chapter 7 with a short summary of fractures and a definition of damage, then quickly connects damage to ice rheology, building on part I of the text. Hutter derives an evolution equation for damage and then analyzes the thermodynamic consequences. Hutter briefly connects the damage discussion to experiments on ice and other materials before returning to damage thermodynamics. Chapter 8 is the last chapter in the book and describes a specific application of damage mechanics to polycrystalline ice. Here, Hutter treats damage as a collection of microscopic defects that can be upscaled by a damage function. Hutter then subjects this model to the same thermodynamic rigor of chapter 7. Given the pattern shown in part I of first theory – then applications, it seems that the text is missing a chapter 9, which would describe the implications for glaciers, crevasses and calving – it looks like we will have to wait for future papers and another edition of the textbook!

In sum, Hutter's text 'Fundamental glaciology' fills a void in existing textbooks on glaciology by diving deeply into continuum mechanics, thermodynamics, and damage mechanics. In parts, the textbook is close to an advanced graduate course in continuum mechanics and thermodynamics; in other places, a reference text for general ice rheologies; and still in other chapters, a research monograph. Reading the text is often effortful: Hutter has a way of explaining topics that I understand and know well in a manner that is unfamiliar and difficult to understand. Yet, the effort is fruitful and as I continue to look back at the book, new insights emerge. From flow to fracture, Hutter's new textbook gives new insight into the fundamentals of glaciology and will be a starting point for graduate teaching, research projects, and glacier mechanics self-study for years to come.

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