3

Till – When is it an Inappropriate Term?

> *I am not optimistic that all the different tills in the present classification can always be recognized in the field, even by meticulous descriptions and laboratory analysis.*
>
> Elson (1989, p. 85)

Before progressing, we need to digest the implications and subsequent developments that stemmed from the proposition by Lawson (1979a, 1981a, b) that a till is a sediment that has been deposited directly from or by glacier ice and has not been subject to subsequent disaggregation and resedimentation. Lawson (1989) summarised the implications of his Matanuska Glacier work in Goldthwait and Matsch's (1989) volume by highlighting the logic of sub-dividing glacigenic deposits into primary and secondary categories; primary deposits include those laid down uniquely by glacial agencies, whereas secondary deposits include those which have undergone reworking by non-glacial processes. Till in its various guises of lodgement, deformation and melt-out fits the definition of 'primary' but all other forms of glacigenic diamicton, because they are remobilised by a combination of gravitational mass flow and fluvial processes are 'secondary'. However, the dividing line between primary and secondary diamictic deposits is notoriously blurred, as is inherent within the deliberations of the Till Work Group, who arrived at its definition of till as 'a sediment that has been transported and is subsequently deposited by or from glacier ice, with little or no sorting by water' (Dreimanis and Lundqvist, 1984; Dreimanis, 1989), thereby side-stepping the 'flow till' problem despite Lawson's (1989) strong case to deal with it at that stage. Nevertheless, the unease with which the term 'till' was used to classify supraglacially deposited diamictons had developed quickly after Boulton's Svalbard-based verifications of Hartshorn's (1958) 'flow till'. This was communicated not only in Lawson's (1979a, b; 1981a, b) process-based classification scheme for mass flows (Figure 3.1a) but also in the development of alternative terms aimed at acknowledging a non-primary origin for glacigenic diamictons. For example, Eyles (1979) proposed the term 'supraglacial morainic till complex' (Figure 3.1b), and more recently efforts have been made to remove the term 'till' completely to arrive at 'supraglacial mass flow diamicton' or 'glacigenic mass (or debris) flow diamicton', the latter being a form of 'sediment flow diamicton' (Lawson, 1989). In subglacial settings, the flow of diamictic and associated materials into cavities at the ice–bed interface produced a crudely stratified deposit that was named 'lee-side till' by Hillefors (1973) and Haldorsen (1982) but regarded as 'flow till' by Boulton (1971) and later incorporated by him into the lodgement process–form regime (Boulton, 1982). Hence, the term 'flow till' has gradually been retired; although glacial researchers knew what the term 'flow till' tried to communicate (*sensu* Boulton, 1967, 1968, 1970a, b, 1972a, b), it was nevertheless fundamentally flawed simply because it implied the characteristics of both primary and secondary deposits. More significantly,

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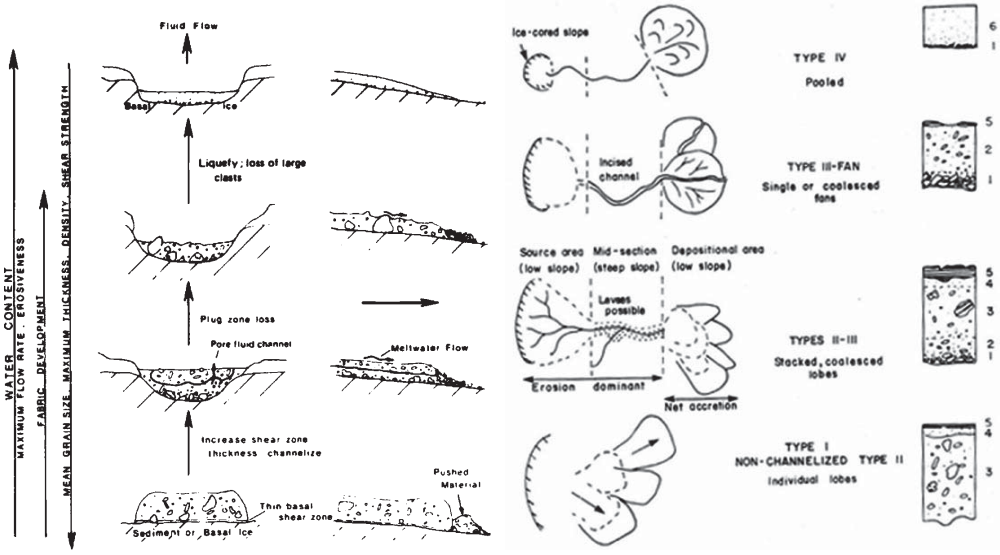
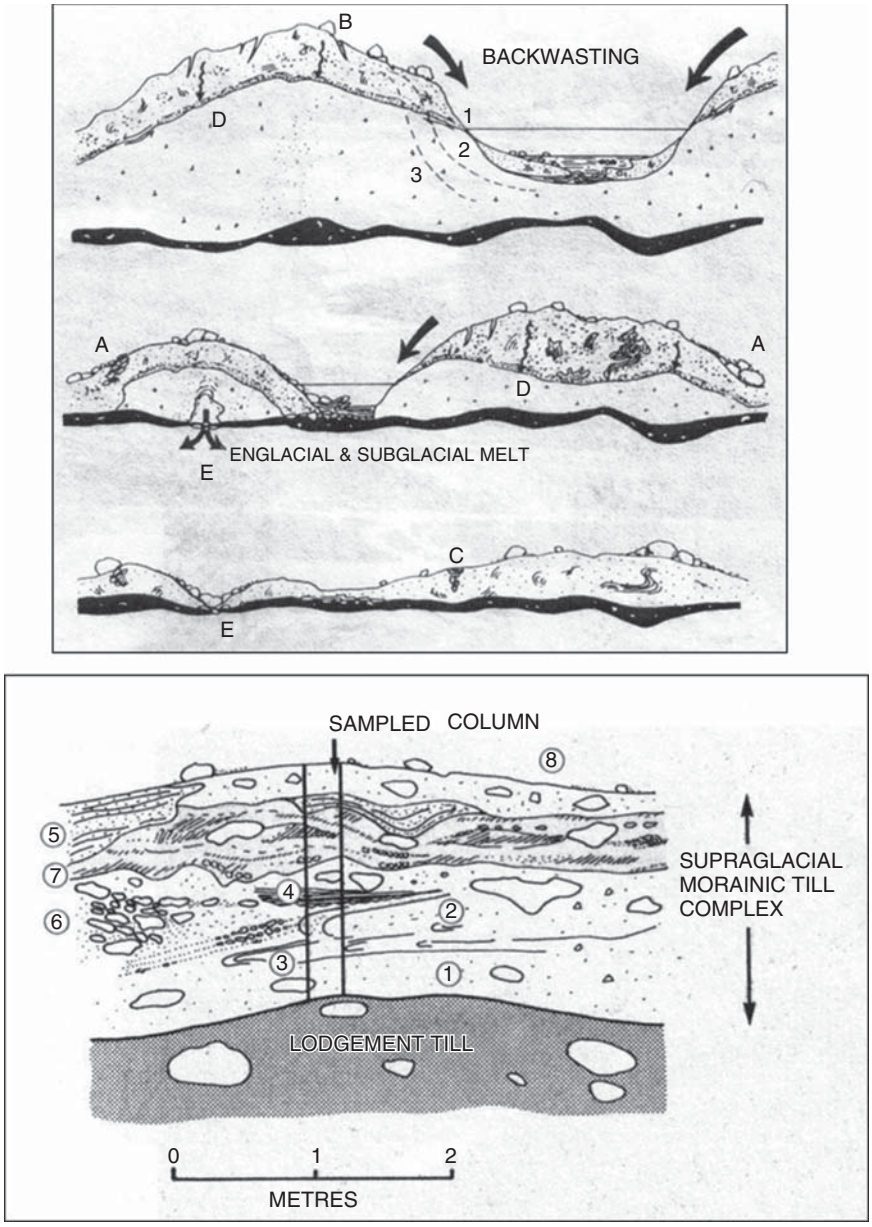


(a)

Figure 3.1 The sedimentary characteristics and process based classification schemes for supraglacial diamictons: (a) Lawson (1979a, b) classification scheme, showing four sediment flow types identified at the Matanuska Glacier, Aslaska.



(b)

Figure 3.1 (b) the processes (upper panel) and resulting deposits (lower panel) of the 'supraglacial morainic till complex' of Eyles (1979).

glacially derived, flowed diamictons look like many other non-glacial gravitational mass-flow diamictons and hence the application of the word 'till' has a very high likelihood of being inappropriate in most stratigraphic settings and becomes less secure the longer the period of time since deglaciation. In other words, there is a very high likelihood that diamictons in a glaciated catchment, which are not interpreted as subglacial, automatically get classified as 'flow till' when their true origin is often from paraglacial gravitational mass wasting and hence they are 'sediment flow diamictons' (e.g. Eyles and Kocsis, 1988; Ballantyne and Benn, 1994, 1996; Harrison and Winchester, 1997; Curry and Ballantyne, 1999; Menzies and Zaniewski, 2003; Figure 3.2). Even in supraglacial settings, Lawson (1989) makes the strong case that 'glacigenic mass flow diamictons' are emplaced by repeated gravitational mass wasting and hence display the sedimentological signatures of the various mechanisms of secondary depositional processes (Figure 3.1a).

The inappropriateness of the term 'till' for deposits laid down subaqueously has also been recognised for some time (cf. Evenson *et al*., 1977; Dreimanis, 1979; Gravenor *et al*., 1984; Powell, 1984), resulting in a process-based nomenclature that recognises the disaggregation and/or remobilisation of glacigenic material once it is released into ice-contact lake and marine environments. The stratified nature of such materials, as well as their internal structures related to iceberg activity, have given rise to: (1) suspension settling and iceberg-related terms such as 'dropstone diamicton', 'undermelt diamicton', 'iceberg contact deposits' and 'ice-keel turbate'; and (b) mass-flow-related terms such as 'subaqueous fall deposits' or 'grain flows' and 'olistostromes', 'subaqueous slumps' or 'slides' (including soft-sediment deformation structures), 'subaqueous debris flows' (cohesive and cohesionless) and 'turbidites'.

Stemming from these proposed modifications to the nomenclature of both terrestrial and subaqueous glacigenic deposits, Evans and Benn (2010), following guidelines recommended by Evans *et al*. (2006b), compiled a classification scheme for primary glacigenic deposits that comprise only three end members: 'glacitectonite', 'subglacial traction till' and 'subglacial melt-out till'. This is compatible with a number of previous recommendations (e.g. Anderson *et al*., 1980, 1986; Kemmis, 1981; Bergersen and Garnes, 1983; Dreimanis, 1983; Lundqvist, 1983; Stephan and Ehlers, 1983; Ringberg *et al*., 1984; van der Meer *et al*., 1985; Rappol, 1985; Hansel and Johnson, 1987) that 'subglacial till' was an appropriate term to use in referring to those materials laid down by the processes of lodgement, melt-out, deformation and undermelt, because the sedimentological properties of such materials were not sufficiently unequivocally diagnostic to discern a specific process–form regime. Assessments of the conceptually pivotal Catfish Creek Drift Formation (specifically the 'till' component) in Ontario, Canada, have reflected this conundrum, specifically in the conclusion by May *et al*. (1980) and Dreimanis *et al*. (1987) that the imprint of processes like lodgement, melt-out and flow could be observed but not used to sub-classify the till. The following chapters are organised around, and expand upon, the case for the threefold classification scheme for till as proposed by Evans *et al*. (2006b), and hence the terms 'glacitectonite', 'subglacial traction till' and 'melt-out till' are employed as genetic terms beyond the descriptive nomenclature outlined in Chapter 4. We will nevertheless develop the case for 'subglacial traction till' as a genetic term in Chapters 9–11 before using it definitively in Chapter 17.

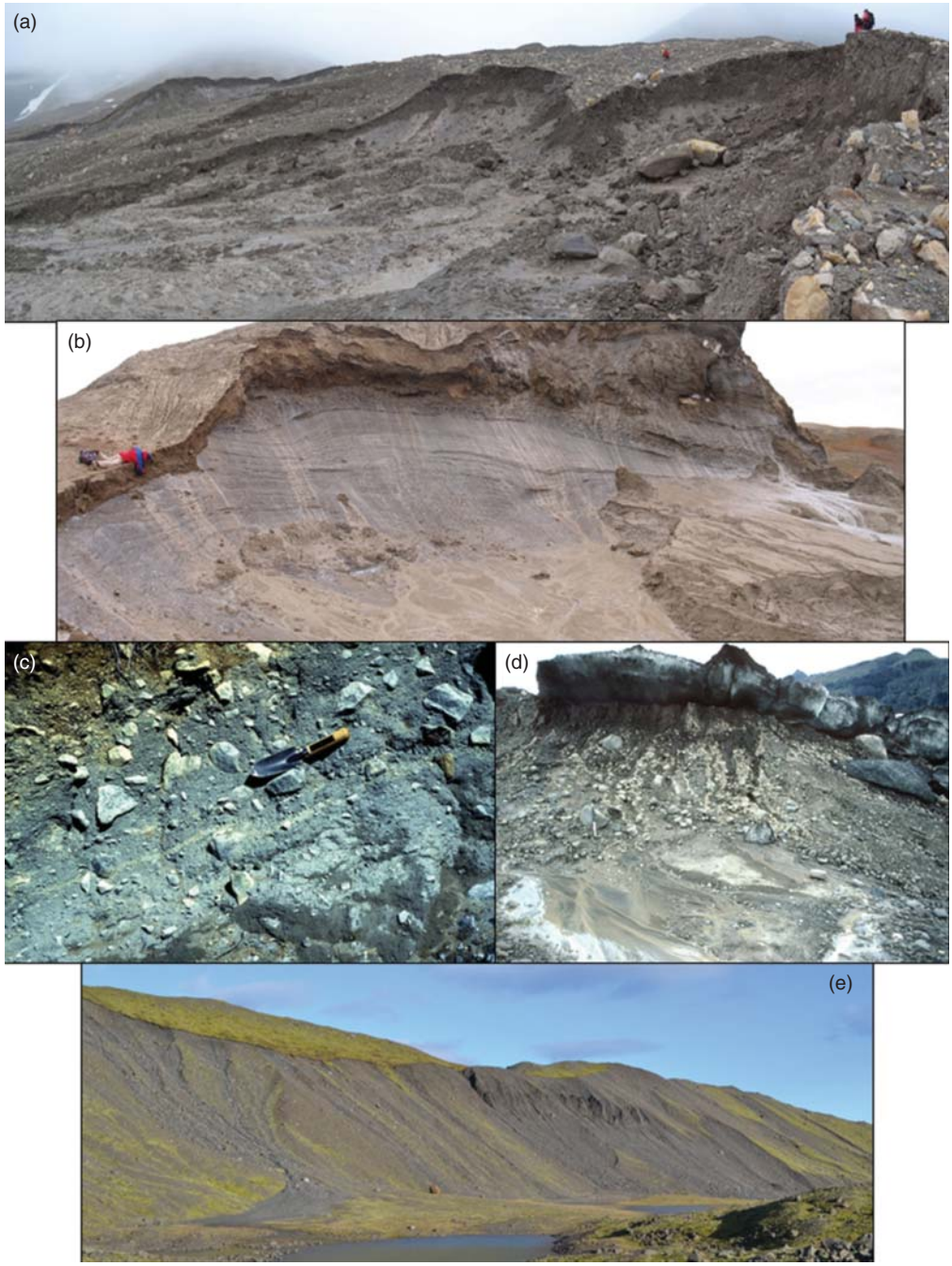


Figure 3.2 Modern-day examples of remobilisation and resedimentation of glacigenic deposits, including tills and their sedimentological products: (a) retrogressive flow sides in supraglacial debris on the ice-cored Little Ice Age lateral moraines of Horbyebreen, Svalbard; b) Late Wisconsinan debris-rich buried glacier ice creating debris flows in englacial and supraglacial materials, northern Banks Island, Arctic Canada; (c) crudely stratified diamicton created by paraglacial debris flows in former glacigenic deposits, Leirdalen, Norway (photo by A.M. Curry); (d) debris flows emanating from the distal face of a push moraine during its construction by the advancing snout of Fláajökull, Iceland; (e) debris flows on the proximal slope of the Little Ice Age lateral moraines of Kviárjökull, Iceland.