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Bedrock fracture and landscape development in frost-susceptible permafrost

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A new conceptual model of landscape evolution is proposed to explain some major elements of the Quaternary landscapes and regoliths of central and southern England. By the end of the Tertiary, erosion had largely reduced these landscapes to low-relief surfaces close to sea level. Such erosion surfaces are underlain mostly by porous, fine-grained sedimentary rocks that show variable degrees of frost susceptibility. Those rocks that are most frost-susceptible (slates, silty clays, chalks, siltstones) began to fracture near the ground surface by growth of segregated ice as, first, seasonal freezing and then perennial freezing (permafrost) developed in the Quaternary. The commencement of bedrock fracture broadly coincided with initiation of uplift near the Tertiary-Quaternary boundary, ~2.4 Ma. Uplift and fracture were accentuated during the last 800 ka, as the 100 ka glacial-interglacial cycles led to deeper and colder permafrost in southern England. During each permafrost cycle, low-lying and therefore wetter bedrock became preferentially fractured by ice segregation in the upper metres of permafrost, producing a regolith of fractured ice-rich bedrock. Subsequent climate warming during glacial-to-interglacial transitions led to rapid thermal erosion of the regolith, much like a cheesewire slicing cheese. As uplift continued during cycles of permafrost rock fracture and permafrost thaw, thermal erosion cut strike-oriented streams and dipslope valleys, producing limestone scarps such as the Chilterns, the North Downs and the South Downs, and the myriad valleys – now mostly dry – on the chalklands of southeast England and the slate lowlands of Devon and Cornwall. Beneath the ground surface, the record of Quaternary ice segregation is widely preserved as brecciated bedrock beneath flattish ground and as reworked regolith (so-

lifluction and river deposits) beneath hillslopes and valleys. In short, the key drivers of landscape evolution in these non-glacial regions are (1) ice segregation in permafrost bedrock, (2) thermal erosion and solifluction of the fractured regolith, and (3) uplift. Similar landscape processes operate today in Arctic regions underlain by moist Mesozoic sedimentary rocks, just like they do in the better-understood case of ice-rich frost-susceptible soils.