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Criteria to discriminate between proglacial and paraglacial environments

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The definition of "periglacial" has drifted from the original meaning of "areas peripheral to Pleistocene ice sheets and glaciers" (Lozinski 1909) to one which stresses the distinctive processes of freeze-thaw and permafrost formation. In spite of the comment by Worsley (2004) that the term periglacial has no universally accepted definition, there are really only two options that are in common use:

a) an environment of frequent freeze-thaw cycles and deep seasonal freezing (encompassing about 35% of the earth's continental surface and/or
b) a permafrost environment (only 20%).

The international journal Permafrost and Periglacial Processes implies the broader definition. We therefore conclude that the definition of periglacial is not contentious. Not only are we comfortable with the idea of periglacial processes, but equally there is agreement over the approximate extent of past and present periglacial environments, depending on whether the narrower or broader definition above is used.

The situation is not so clear in the context of the terms "proglacial" and "paraglacial", especially since the publication of a major paper on paraglacial geomorphology (Ballantyne 2002a). French (2007) has a nice discussion on this issue in which he notes that the proglacial environment, which refers specifically to ice-marginal conditions, is a periglacial environment in the original sense of Lozinski.

Proglacial systems, sediment-landform associations and landform assemblages

There is no debate about the literal meaning of proglacial, which is "in front of the glacier" (Penck, Bruckner 1909) but its use has not been consistent in the literature. As pointed out by Embleton-Hamann (2004) there is a transition between ice contact, proglacial and paraglacial environments, processes and forms in space and over time (see Warburton, 1990; Hasholt et al. 2000).

It is also helpful to consider a scale hierarchy of proglacial environments (Benn, Evans 1998):

a) proglacial fluvial systems;
b) proglacial associations of sediment and landforms and
c) proglacial landform assemblages.

They further sub-divide proglacial landform assemblages into

a) ice sheet systems,
b) mountain valley systems and
c) subaquatic landsystems.

The question can be formulated in two parts "how far in front of the glacier does the proglacial environment extend?" and, when interpreting landforms and sedimentary facies "how does the proglacial signal differ from that of the paraglacial signal?".

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Paraglacial systems, sediment-landform associations and landform assemblages

Neither is there any debate about the literal meaning of paraglacial which is "beyond the glacier" but the use of this term has also evolved (Slaymaker 2004). The term was introduced by Ryder (1971) to describe alluvial and colluvial fans that had accumulated through the reworking of glacial sediments by rivers and debris flows following late Wisconsinan deglaciation in the interior of British Columbia. She showed that fan accumulation had been initiated soon after valley floors became ice free and continued until shortly after the deposition of Mazama tephra (6600 yrs. BP). The paraglacial concept was formalized by Church, Ryder (1972). They defined the paraglacial environment as one that is characterized by non-glacial processes that are directly conditioned by glaciation. They identified three aspects of the influence of paraglacial sediment supply on fluvial transport:

a) the dominant component of reworked sediment may shift from till to secondary sources, such as alluvial fans and valley fills;
b) regional uplift patterns will condition the timing of changes in the balance between fluvial deposition and erosion and
c) consequently the total period of paraglacial effect is prolonged beyond the period of initial reworking of glacigenic sediments.

Clague (1986), Slaymaker (1987), Church, Slaymaker (1989) and Muller (1999) refined the concept further.

Benn, Evans (1998) consider paraglacial activity under

a) terrestrial ice-marginal environments;
b) paraglacial associations of sediment and landforms and
c) the paraglacial land system.

They make the case that because there are no processes unique to paraglacial environments it would be better to think of paraglacial as referring to a period of time.

Ballantyne (2002a) points out that between 1971 and 1985 the paraglacial concept was largely ignored outside North America. Since 1985 he sees four trends:

a) an extension of the geomorphic contexts in which the paraglacial concept has been explicitly used;
b) a focusing of research on present-day paraglacial processes and land systems;
c) use of the paraglacial concept as a framework for research across a wide range of contrasting deglacial environments; and
d) a growing awareness of the palaeo-environmental significance of paraglacial facies in Quaternary stratigraphic studies.

He proposed a working definition of paraglacial as "non-glacial earth surface processes, sediment accumulations, landforms, land systems and landscapes that are directly conditioned by glaciation and deglaciation". Geomorphic contexts in which the term paraglacial is now being used include, in addition to the original debris cone, alluvial fan and valley fill deposits

a) rock slopes;
b) sediment-mantled slopes;
c) glacier forefields;
d) glacilacustrine systems and
e) coastal systems.

The problem which is becoming evident in the literature is that the term "paraglacial" is now being widely used without careful distinction between it and the long established traditional term "proglacial". Indeed, and in part as a result of Ballantyne's magisterial papers (Ballantyne 2002a, b), the term paraglacial is now being used to cover a bewilderingly large variety of circumstances, almost to the point of making the word redundant.

It is the confusion between proglacial and paraglacial and the lack of clarity of the use of the term paraglacial that forms the motivation for this paper. We review recent usage of the terms proglacial and paraglacial processes, landforms and environments.

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