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Table 1 :The Lateglacial Stadials in the Austrian and Swiss Alps

Stadial	Moraine morphology	Regional situation	ELA depression	Time-stratigraphic position
Kromer / Kartell	Well-defined, blocky, multi-walled moraines, small rock glaciers. Type localities in the Ferwall group (Kartell cirque (10)) and Silvretta group (Kromer valley (7)).	Cirque and valley glaciers, clearly larger than LIA, but smaller than innermost Egesen phase.	-120 to -60 m depending on location (7, 11, 24).	Unclear, perhaps early Holocene (24). Time-stratigraphic equivalence of Kromer and Kartell presently under discussion.
Egesen	Sharp-crested, often blocky, multi-walled moraines (2). Three-phased readvance of valley glaciers and cirque glaciers; development of extensive rock glacier systems during later parts of the stadial (22, 24, 25), well documented in wide areas of the Alps. Type locality in the Stubai valley SW of Innsbruck (2).	Cirque and valley glaciers, few dendritic glaciers (23).	-450 to -180 m for the maximum advance, depending on location (22).	Younger Dryas (e.g. 4, 17, 18).
Bølling-Allerød Interstadial	No field evidence for glacial advances, although various climatic fluctuations (colder phases) should have caused glaciers to advance. Deposits of the advances were probably overrun during Younger Dryas (20).	Cirque and valley glaciers (?).	less than Egesen /YD (20).	Bølling-Allerød.
Daun	Well-defined but smoothed moraines, relatively few boulders, solifluction overprint during YD (Egesen) (2); moraines usually missing in more oceanic areas of the Alps (overrun by Egesen ?) (23). Smaller than Clavadel / Senders, perhaps "appendix" of Clavadel / Senders (indirectly 1). Type locality in the Stubai valley SW of Innsbruck (3).	Glaciers slightly larger than local Egesen glaciers.	ca. -400 to -250 m depending on location (7)	Before Bølling (11,12).
Clavadel / Senders	Well defined, often sediment-rich moraines (11, 12, 13, 14). Clearly smaller than "Gschnitz". Type localities near Davos (Clavadel (11)) and Innsbruck (Senders (14)), probably equivalent to Zwischbergen stadial at Simplon Pass (15, 16).	Cirque and valley glaciers, some dendritic glacier still intact.	ca. -400 to -500 m depending on location (15, 16).	Before Bølling.
Gschnitz	Steep-walled, somewhat blocky, large single moraines, no solifluction overprint below 1400 m. Widespread readvance of large valley glaciers on a timescale of several centuries (21). Glaciers advanced over ice-free terrain (8, 9, 14). Type locality in the Gschnitz valley South of Innsbruck (3).	Many valley glaciers, some large dendritic glaciers still intact.	ca. -650 to -700 m (7).	Before Bølling (5, 6, 8, 15, 16).
Early Lateglacial ice recession	General downwasting after collapse of piedmont glaciers in the foreland with some minor oscillations of the glacier margins. Mainly ice marginal deposits, few moraines. Glacial advances often due to ice-mechanical causes (26). Comprises "Bühl" and "Steinach" stadials (1, 3, 8, 26).	Downwasting dendritic glaciers (5), increasing number of local glaciers.	largely undefined, between ± LGM and -800 m.	Before Bølling.
LGM	Ice domes in the high Alps (27, 28, 29), outlet glaciers and piedmont glaciers on the foreland.	Piedmont lobes.	-1000 to >-1200 m.	Final collapse 21-19 ka (19).

Principal sources: Senarclens-Grancy (**1** 1958), Heuberger (**2** 1966), Mayr/Heuberger (**3** 1968), Patzelt (**4** 1972; **5** 1975, **6** 1995a, b), Gross *et al.* (**7** 1977), van Husen (**8** 1977; **9** 1997), Fraedrich (**10** 1979), Maisch (**11** 1981,**12** 1982,**13** 1987), Kerschner/Berktold (**14** 1982), Müller (**15** 1982, **16** 1984), Kerschner (**17** 1986), Ivy-Ochs *et al.* (**18** 1996, **19** 2004), Ohlendorf (**20** 1998), Kerschner *et al.* (**21** 1999; **22** 2000), Hertl (**23** 2001), Sailer (**24** 2001), Sailer *et al.* (**25** 1999), Reitner (**26**-oral communication), Florineth and Schlüchter (**27** 1998, **28** 2000), Kelly *et al.* (**29** 2004). References before early 1950s see Kerschner (1986).

References:

Florineth D, Schlüchter C. 1998. Reconstructing Last Glacial Maximum ice surface geometry and flowlines in the central Swiss Alps. *Eclogae Geologicae Helvetiae* **91**: 391 - 407.

Florineth D, Schlüchter C. 2000. Alpine evidence for atmospheric circulation patterns in Europe during the Last Glacial Maximum. *Quaternary Research* **54**: 295 - 308.

Fraedrich R. 1975. Spät- und postglaziale Gletscherschwankungen in der Ferwallgruppe (Tirol/Vorarlberg). *Düsseldorfer Geographische Schriften* **12**: 1-161.

Gross G, Kerschner H, Patzelt G. 1977. Methodische Untersuchungen über die Schneegrenze in alpinen Gletschergebieten. *Zeitschrift für*

Hertl A. 2001. *Untersuchungen zur spätglazialen Gletscher- und Klimageschichte der österreichischen Silvrettagruppe.* Universität Innsbruck Ph.D. dissertation.

Heuberger H. 1966. *Gletschergeschichtliche Untersuchungen in den Zentralalpen zwischen Sellrain und Ötztal.* (*Wissenschaftliche Alpenvereinshefte* **20)**. Universitätsverlag Wagner: Innsbruck.

Ivy-Ochs S, Schlüchter C, Kubik PW, Synal H-A, Beer J, Kerschner H. 1996. The exposure age of an Egesen moraine at Julier Pass, Switzerland, measured with the cosmogenic radionuclides ^{10}Be, ^{26}Al and ^{36}Cl. *Eclogae Geologicae Helvetiae* **89**(3): 1049-1063.

Ivy-Ochs S, Schäfer J, Kubik PW, Synal H-A, Schlüchter C. 2004. The timing of deglaciation on the northern Alpine foreland (Switzerland). *Eclogae Geologicae Helvetiae* **97**: 47-55.

Kelly MA, Buonchristiani J-F, Schlüchter C. 2004. A reconstruction of the Last Glacial Maximum ice-surface geometry in the western Swiss Alps and contiguous Alpine regions in Italy and France: *Eclogae Geologicae Helvetiae* **47**: 57-75.

Kerschner H. 1986. Zum Sendersstadium im Spätglazial der nördlichen Stubaier Alpen, Tirol. *Zeitschrift für Geomorphologie, Supplementband* **61**: 65-76.

Kerschner H, Berktold E. 1982. Spätglaziale Gletscherstände und Schuttformen im Senderstal, nördliche Stubaier Alpen, Tirol. *Zeitschrift für Gletscherkunde und Glazialgeologie* **17**(2): 125-134.

Kerschner H, Ivy-Ochs S, Schlüchter C. 1999. Paleoclimatic interpretation of the early late-glacial glacier in the Gschnitz valley, Central Alps, Austria. *Annals of Glaciology* **28**: 135-140

Kerschner H, Kaser G, Sailer R. 2000. Alpine Younger Dryas glaciers as paleo-precipitation gauges. *Annals of Glaciology* **31**: 80-84.

Maisch M. 1981. Glazialmorphologische und gletschergeschichtliche Untersuchungen im Gebiet zwischen Landwasser- und Albulatal. (Kt. Graubünden, Schweiz. *Physische Geographie* **3**.

Maisch M. 1982. Zur Gletscher- und Klimageschichte des alpinen Spätglazials. *Geographica Helvetica* **37**(2): 93-104.

Maisch, M. 1987. Zur Gletschergeschichte des alpinen Spätglazials: Analyse und Interpretation von Schneegrenzdaten. *Geographica Helvetica* **42**(2): 63-71.

Mayr F, Heuberger H. 1968. Type areas of Lateglacial and Postglacial deposits in Tyrol, Eastern Alps. In *Glaciations of the Alps*, Richmond GM (ed). University of Colorado: Boulder, CO. (*Series in Earth Sciences* **7**), p. 143-165.

Müller HN 1982. Zum alpinen Spätglazial: Das Zwischenbergstadium. *Zeitschrift für Gletscherkunde und Glazialgeologie* **17**(2): 135-142.

Müller HN 1984. *Spätglaziale Gletscherschwankungen in den westlichen Schweizer Alpen (Simplon-Süd und Val de Nendaz, Wallis) und im nordisländischen Tröllaskagi-Gebirge (Skidadalur)*. Küng: Näfels.

Ohlendorf C. 1998. *High alpine lake sediments as chronicles for regional glacier and climate history in the Upper Engadine, southeastern Switzerland.* ETH dissertation No. 12705.

Patzelt G. 1972. Die spätglazialen Stadien und postglazialen Schwankungen von Ostalpengletschern. *Berichte der Deutschen Botanischen Gesellschaft* **85**: 47-57.

Patzelt, G., 1975. Unterinntal -- Zillertal -- Pinzgau -- Kitzbühel. Spät- und postglaziale Landschaftsentwicklung. In *Tirol - ein geographischer Exkursionsführer,* Fliri F, Leidlmair A (eds). *Innsbrucker Geographische Studien* **2**: 309-329.

Patzelt G, Sarnthein M. 1995. Late Glacial morainal arc at Trins in the Gschnitz valley/Tyrol -- "Krotenweiher" peat bog; 12. Alpine Traverse, Max Maisch. In *Quaternary field trips in central Europe*, Schirmer W (ed). Vol. 2: 669-670.

Patzelt G. 1995. The pollen profile of the peat bog at the Lans lake. 12. Alpine Traverse, Max Maisch. In *Quaternary field trips in central Europe*, Schirmer W (ed). Vol. 2: p. 670-671.

Sailer R. 2001. *Späteiszeitliche Gletscherstände in der Ferwallgruppe.* Universität Innsbruck Ph.D. dissertation.

Sailer R, Kerschner H, Heller, A. 1999: Three-dimensional reconstruction of Younger Dryas glaciers with a raster-based GIS. *Glacial Geology and Geomorphology,* **1999/rp01** (http://ggg.qub.ac.uk/ggg/).

Senarclens-Grancy, W.v. 1958. Zur Glazialgeologie des Ötztales und seiner Umgebung. *Mitteilungen der Geologischen Gesellschaft Wien* **49**: 257-313.

van Husen D. 1977. Zur Fazies und Stratigraphie der jungpleistozänen Ablagerungen im Trauntal (mit quartärgeologischer Karte). *Jahrbuch der Geologischen Bundesanstalt* **120**: 1-130.

van Husen D. 1997. LGM and Late-glacial fluctuations in the Eastern Alps. *Quaternary International* **38/39**: 109-118.

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