Climatic signals recorded in snow avalanche-dominated colluvium in western Norway: depositional facies successions and pollen records

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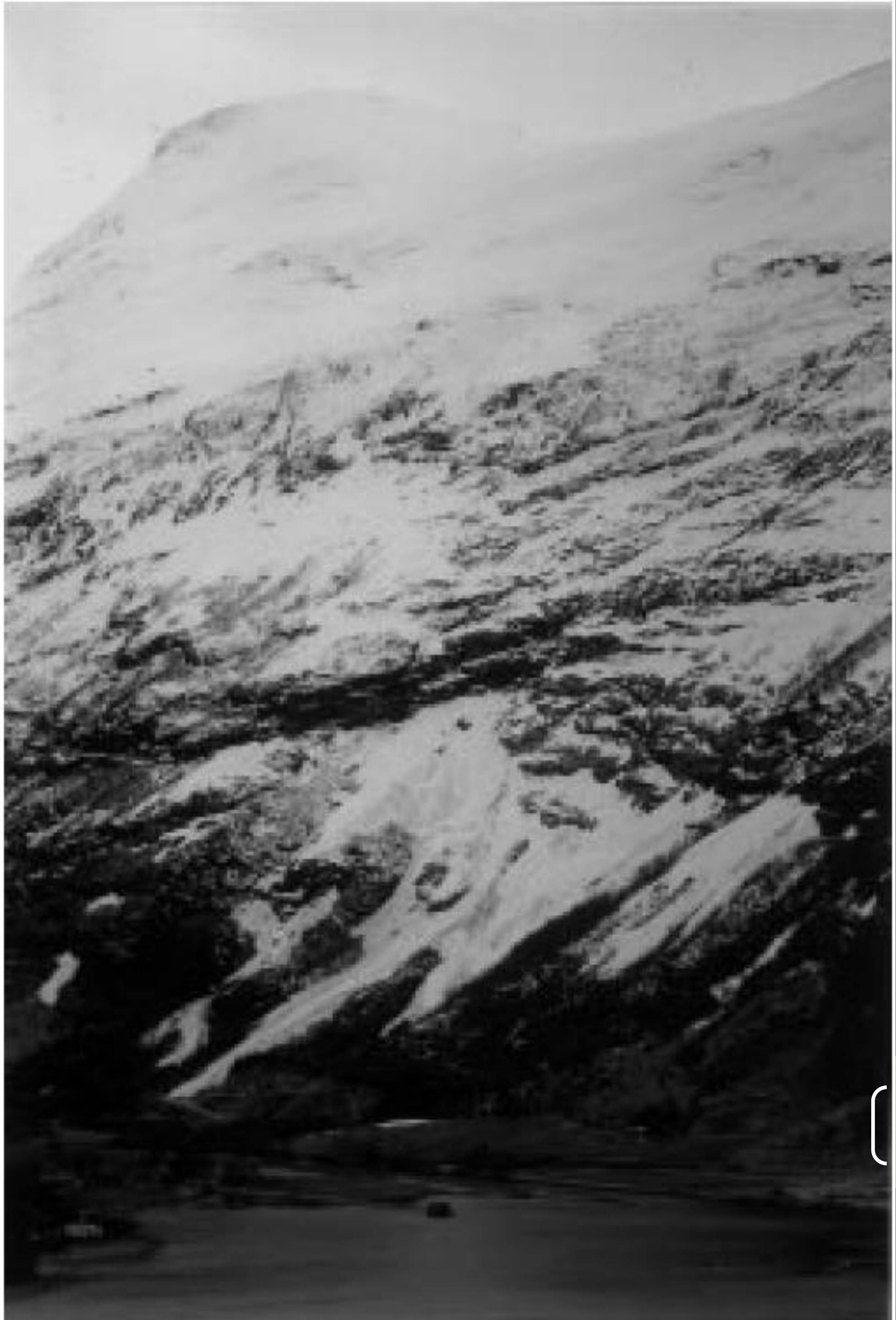
1998



Overview

- Study based on depositional processes and ^{14}C dating of paleosol
- Focus on the palaoeclimatic significance of snow flows
- Variations in winter/extreme climate recorded in avalance deposits

Contents

METHODS

Collovium

- Collovium (talus, scree, debris slope)
  - Clastic sediments (coarse grained and immature texture)
  - Deposit at the foot of a mountain slope or a cliff
  - Brought there by gravitational forces (mass movement)

TYPICAL CHARACTERISTICS	colluvial fan	alluvial fan
Geomorphic setting:	mountain slope and its base (slope fan)	mountain footplain or broad valley floor (footplain fa
Catchment:	mountain-slope ravine	intramontane valley or canyon
Apex location:	high on the mountain slope (at the base of ravine)	at the base of mountain slope (valley/canyon mouth
Depositional slope:	35-45° near the apex, to 15-20° near the toe	seldom more than 10-15° near the apex, often less than 1-5° near the toe
Plan-view radius:	less than 0.5 km, rarely up to 1-1.5 km	commonly up to 10 km, occasionally more than 100
Sediment:	mainly gravel, typically very immature	gravel and/or sand, immature to mature
Grain-size trend:	coarsest debris in the lower/toe zone	coarsest debris in the upper/apical zone
Depositional processes:	avalanches, including rockfall, debrisflow and snowflow; minor waterflow, with streamflow chiefly in gullies	debrisflow and/or waterflow (braided streams)
EXAMPLES	 The Brotfonna colluvial fan, Trollvegen near Romsdal, Norway; one of the world's largest colluvial fans, with a height of 830 m and a plan-view radius of 1.5 km.	 The Badwater alluvial fan, eastern side of Death Vall California; a modest fan, with a radius of c. 6 km.

Fig. 2. A comparison of the distinctive features of colluvial fans and alluvial fans.

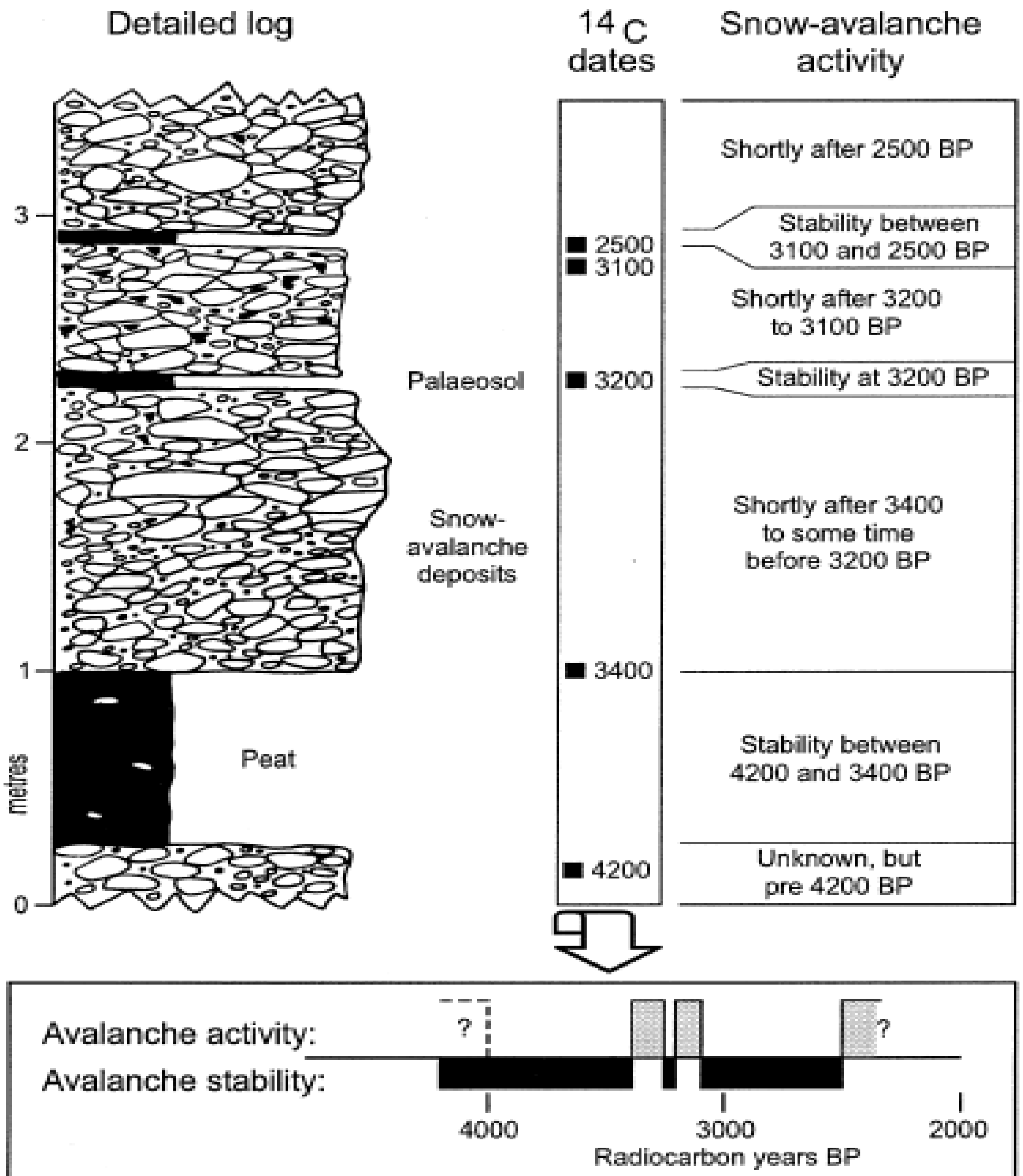
(Blikra and Nemec, 1998)

Palaeosol

- Sediment layers from in-situ vegetation/transported material
- Possible to use for ^{14}C dating
- Indicate a stable phase

Avalanche deposits

- Avalanches deposits often contain not only snow but also a lot of debris and rock fragments
- Dense/cohesive snow flows are capable of transporting larger amount of debris



Detailed log
14 C dates
Snow-avalanche activity
Shortly after 2500 BP
Stability between 3100 and 2500 BP
Shortly after 3200 to 3100 BP
Stability at 3200 BP
Shortly after 3400 to some time before 3200 BP
Stability between 4200 and 3400 BP
Unknown, but pre 4200 BP
2500
3100
3200
3400
4200
Palaeosol
Snow-avalanche deposits
Peat
metres
0
1
2
3
Avalanche activity:
Avalanche stability:
?
?
4000
3000
2000
Radiocarbon years BP

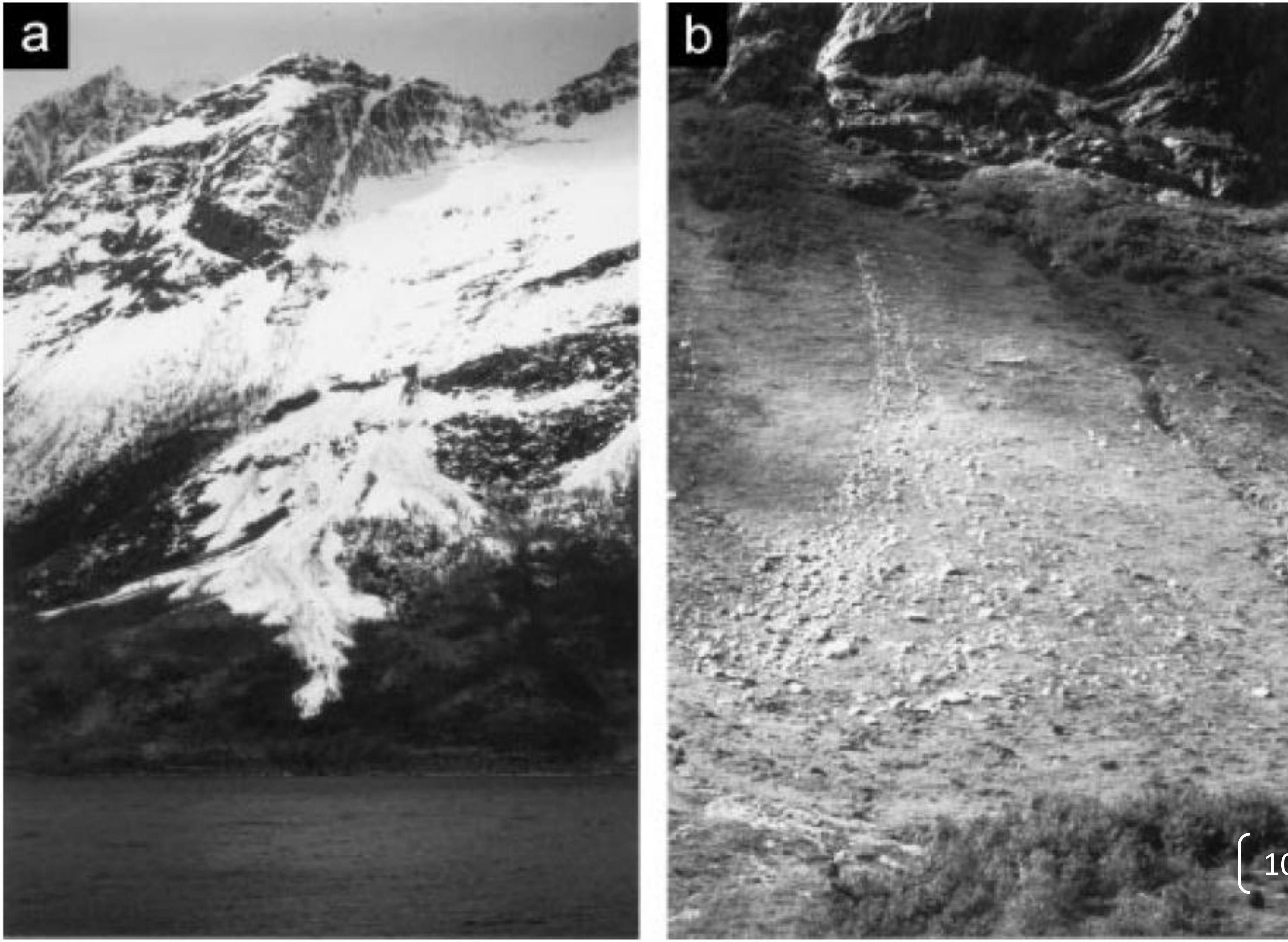
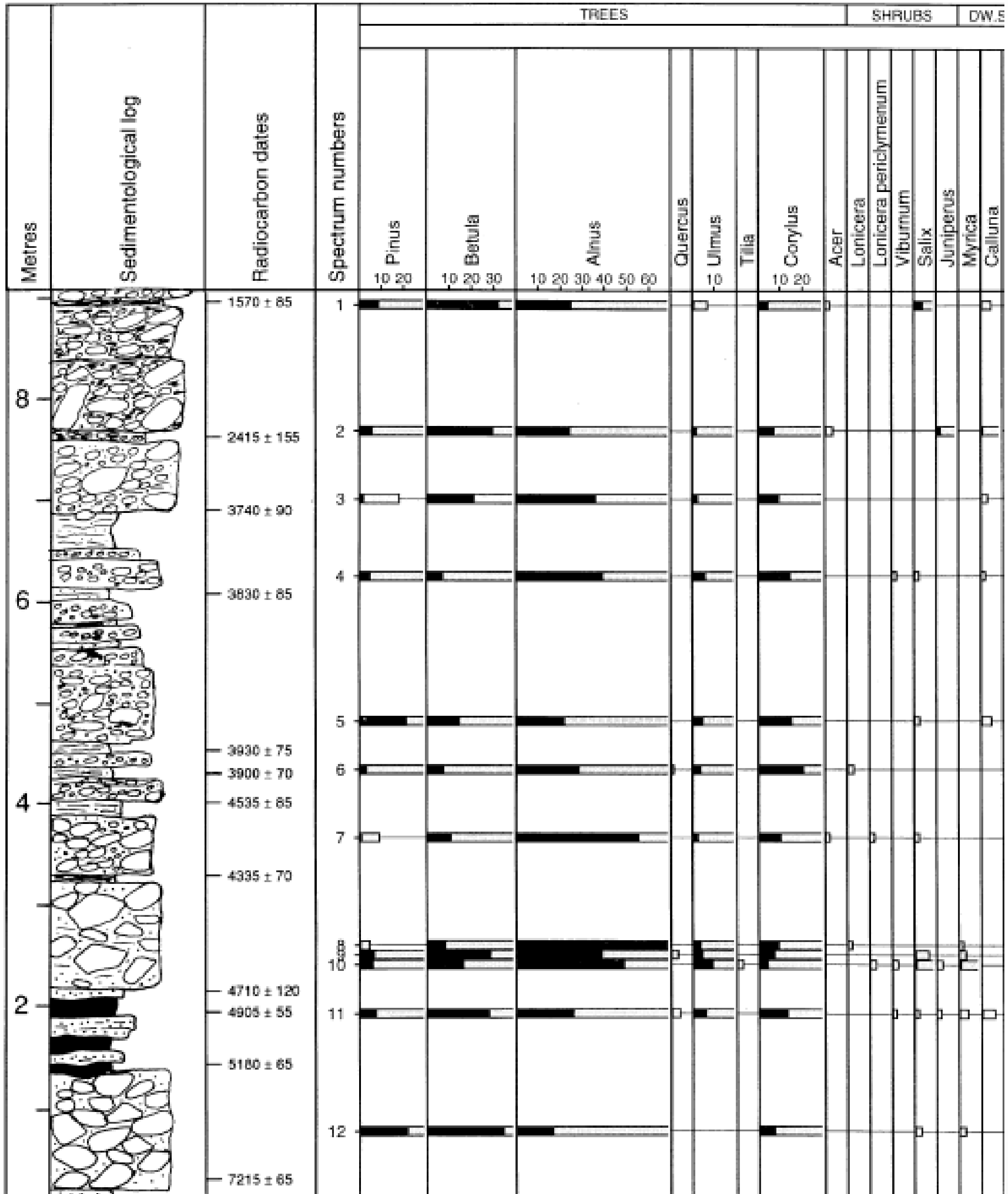


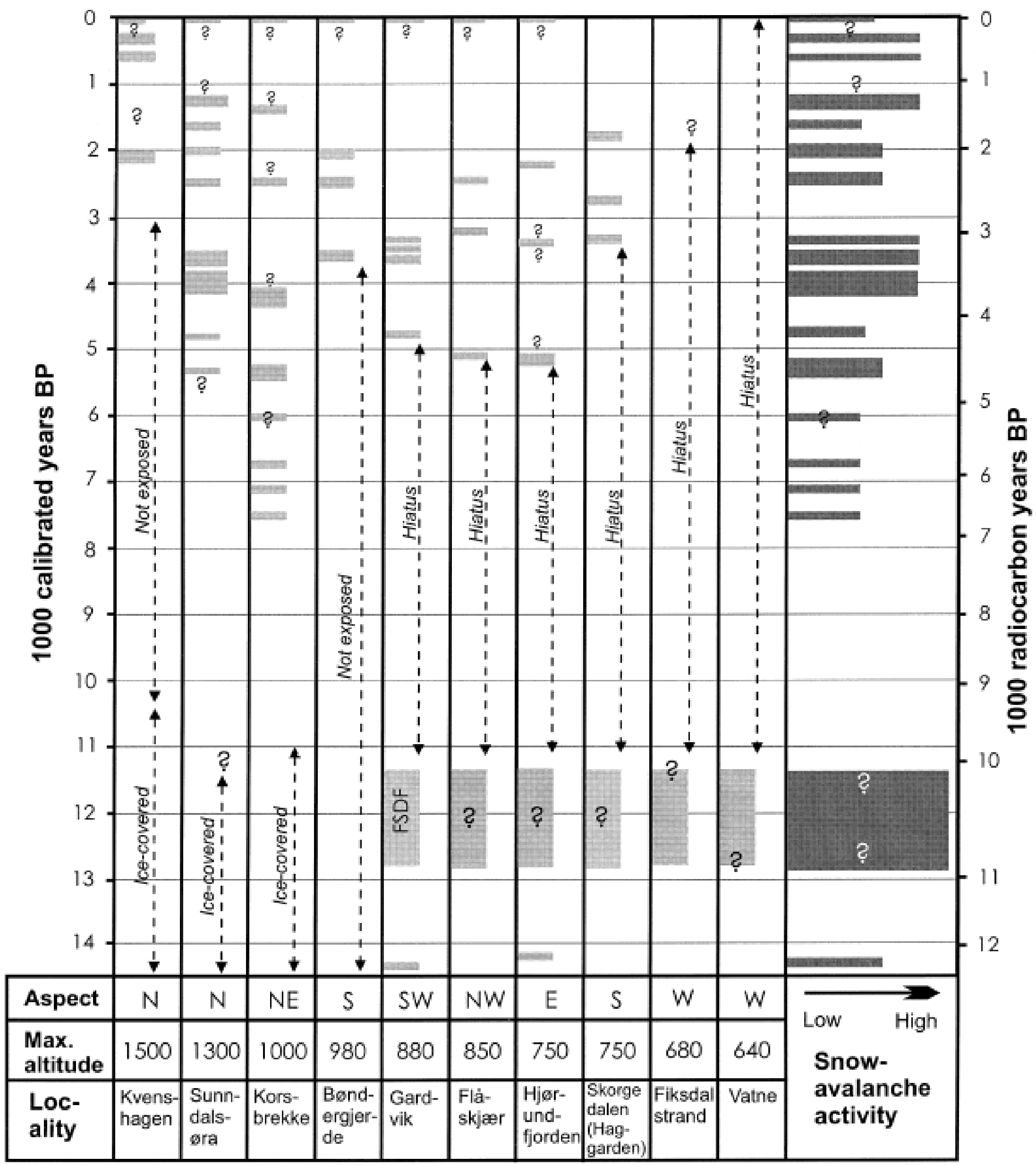
Figure 3 Features of recent snow-flow deposits. (a) Snow-flow avalanches showing distinct snow lobes and levees on a colluvial fan; (b) Fresh, snow-avalanche deposits on a grass-covered surface of a colluvial fan. Photographs taken in early spring 1993 (a) and early fall 1993 (b).

RESULTS

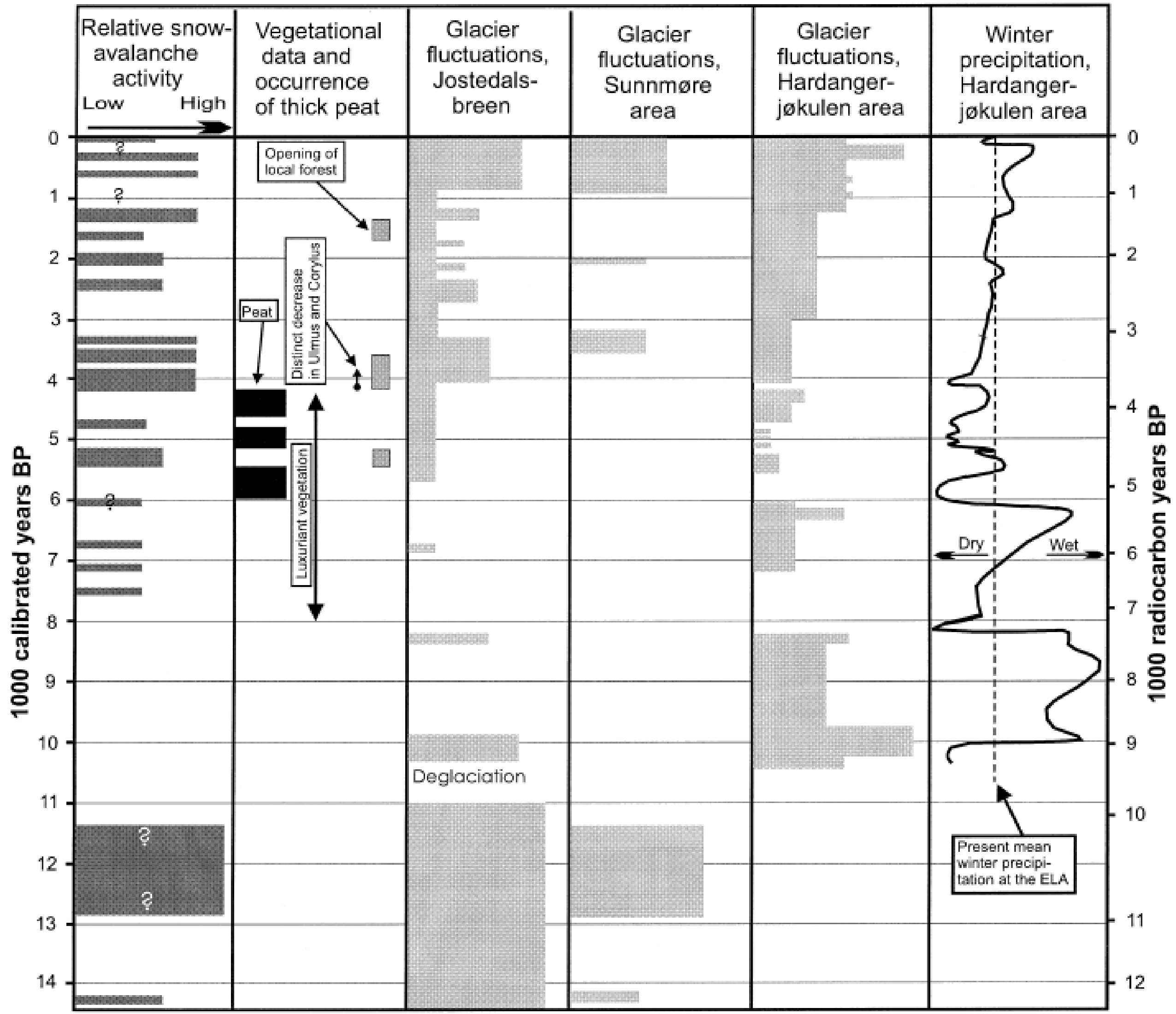
The Korsbrekke colluvial apron

DW.SH.=Dwarf shrubs, V=Varia





1000 calibrated years BP
1000 radiocarbon years BP
Not exposed
Ice-covered
Hiatus
FSDF
Aspect
N
N
NE
S
SW
NW
E
S
W
W
Max. altitude
1500
1300
1000
980
880
850
750
750
680
640
Loc-ality
Kvens-hagen
Sunn-dals-øra
Kors-brekke
Bønd-ergjer-de
Gard-vik
Flå-skjær
Hjør-und-fjorden
Skorge dalen (Hag-garden)
Fiksdal strand
Vatne
Low
High
Snow-avalanche activity



Relative snow-avalanche activity
Low
High
Vegetational data and occurrence of thick peat
Glacier fluctuations, Jostedalsbreen
Glacier fluctuations, Sunnmøre area
Glacier fluctuations, Hardanger-jøkulen area
Winter precipitation, Hardanger-jøkulen area
Opening of local forest
Distinct decrease in Ulmus and Corylus
Peat
Luxuriant vegetation
Deglaciation
Dry
Wet
Present mean winter precipitation at the ELA
1000 calibrated years BP
1000 radiocarbon years BP

Present situation

- Avalanche activity is high at several sites
- Winter climate and extreme weather events are moderate

- ''high snow-avalanche activity in the last century are more a rule than an exception in the geological record''

CONCLUSIONS AND FUTURE RESEARCH

Conclusion

- Avalanche dominated colluvium in Western Norway : important for palaeo-climatic research
  - The impact of regional climatic change was stronger than varied local slope conditions
  - Avalanche activity mainly controlled by fluctuations in winter conditions

- The palaeoclimatic record from colluvial deposits has a higher resolution than glacier fluctuation proxy data

Conclusion

- Holocene climatic record from avalanche colluvium shows
  - Fluctuating winter climate
  - Colder conditions from 4700 yr BP
    - The phases 3900-3100 yr BP and post 1400 yr AD being the most severe

- Extreme weather events common through out the Holocene, some of them more severe than it is today

Future research

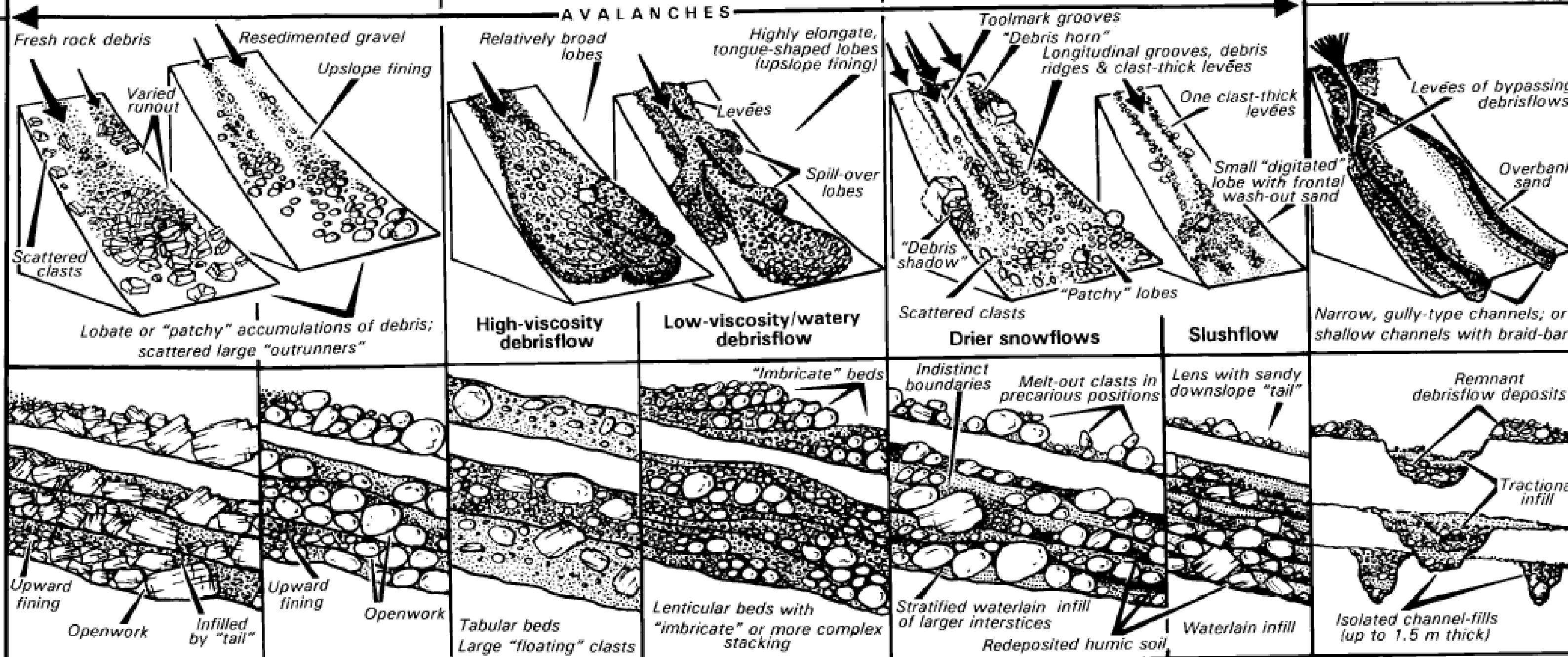
- Should focus on analyzing glacial and colluvial records situated in different geomorphological postions
- Resolve the controlling factors on a local scale
  - Variations in temperature and precipitation rates **vs.** prevalent wind directions and local slope conditions

Time for...

- Questions?

DEPOSITIONAL PROCESSES

SEDIMENTARY FEATURES	rockfall/debrisfall	debrisflow	snowflow	waterflow



SEDIMENTARY FEATURES	rockfall/debrisfall		debrisflow		snowflow	waterflow
TEXTURE AND STRUCTURE	Highly immature debris; mainly angular clasts	Mature debris; subrounded to rounded clasts	Matrix-rich to clast-supported. Sandy/muddy matrix. Common "coarse-tail" inverse grading and outsized cobbles or boulders.	Clast-supported, bouldery to cobbly "heads" and clast- to matrix-supported, pebbly upslope "tails". Common normal grading.	Unsorted, scattered clasts and gravel "patches" infilled with waterlain sand or pebbly sand. The sand in large interstices shows stratification, but is massive, very fine/silty and possibly shell-bearing in submarine deposits.	Clast-supported, pebbly to cobbly gravel interlayered with poorly sorted/stratified sand. Matrix-supported gravel occurs as debrisflow remnants.
	Boulder to sand size grade. Clast-supported and commonly openwork, with pebbly to sandy infill at the top. Deposits often infilled with waterlain sand and/or redeposited soil material.					
CLAST FABRIC	Boulders and large cobbles often show "rolling" fabric, *a*(t) or *a*(t)*b*(i), when emplaced frontally in isolation. Many large clasts upslope show "sliding" fabric *a*(p), but a disorderly "adjustment" fabric predominates; "shear" fabric *a*(p) often typifies the avalanche's overriding tail, when evolved into a grainflow.		Large clasts mainly aligned downflow, *a*(p) or *a*(p)*a*(i), but showing *a*(t) orientation along the lobe front.	Common "rolling" fabric *a*(t) in the frontal and top part of the debrisflow head; common "shear" fabric *a*(p) or *a*(p)*a*(i) in the flow's tail.	Mainly disorderly (chaotic "melt-out" fabric). Boulders and cobbles deposited from turbulent snowflows may have "rolling" fabric *a*(t), but the scattered debris is vulnerable to rotation by subsequent avalanches. Dense snowflows and slushflows may create "shear" fabric *a*(p), but this loses order during the melt-out.	Common tractional fabric; poorly developed in gullies due to clast pivoting and adjustment to banks. Many large clasts are rotated *in situ* to *a*(p) position by less competent waterflow.
DEBRIS SOURCE	Weathered bedrock.	Glacial till and valley-side kame terraces.	Glacial till, kame terraces and upper-slope colluvium.		Glacial till and upper-slope colluvium, including fresh bedrock. Common slope-soil erosion.	Upper-slope colluvium and glacial till.