DEGLACIATION IN THE HIGH TATRA MOUNTAINS (BIAŁA AND SUCHA WODA VALLEYS AS EXAMPLE)

M. BAUMGART-KOTARBA and A.KOTARBA

Institute of Geography and Spatial Organisation, Polish Academy of Sciences, Department of Geomorphology and Hydrology, 31-018 Krakow, św. Jana 22, Poland

Abstract: The aim of this paper is to discuss the maximal extent and recessional stages, their number and age in largest glacial systems in the Tatra Mts. The use of isotopic and luminescence methods on glacial chronology is substantial. The age of recession corresponds to the Austrian Alps chronology.

Key words: glacial landform, deglaciation chronology, TL, OSL, SAR methods.

On the northern slope of the High Tatra Mountains Biała Woda and Sucha Woda valleys produced the largest glaciers. The last glacial maximum lasted 21 – 19 ka and after this time recession started. Probably the smallest glaciers persisted till 8.3 ka BP.

The reason for the maximal extent of Biała Woda and Sucha Woda glaciers is related to supply by system of hanging tributary glaciers. Thus, it is also topographical, not only climate impact for the longest glaciers formation (Biała Woda 12.5 km, and Sucha Woda 8 km). For W✧rm cold period in the Tatra Mountains system elaborated by Lukni✶ (1968, 1973) is used; WA and WB for maximum stages and WC, WD, WE, HW, and H for recessional stages. Partsch (1923), Halicki (1930) and Klimaszewski (1988) distinguished maximal extent and I –V recessional stages. Lindner et al. (1990) used TL method, and suggest two older stadials (Sucha Woda and Bystra Stadials) and Białka Stadial with oldest Hurkotne phase (32 –25 ka). No morphological and geological arguments for such chronology, probably modern OSL and SAR method may be useful in this case.

Problem is with stadial WA (Rakytovce) sensu Lukni✶. Halouzka (1993) included WA to Riss II. For Biała Woda glacier authors of this paper document one older stadial with about 1 km longer extent. The age of this stadial was discussed using archeological sites in Obłazowa Cave. This old stadial seems to be older than 60 ka BP (Baumgart-Kotarba, Kotarba 1997).

Age of last maximum stadial (WB)

System of Toporowe Stawy terminal moraines of Sucha Woda with Pańszczyca glacier is interpreted in term of dead-ice morphology (Fig. 1). The moraine ridges pattern indicate the crucial role of confluent Pańszczyca glacier. The oldest cosmogenic ^{36}Cl datation comes from morainic block of younger ridge WB2 and indicates age 21±1.3 ka BP (Dzierżek and al. 1999). The most external morainic ridge could be older in age. The maximal extent of this stadial could be compared with Leszno Stadial on Polish Lowland. According to A.Bluszcz opinion the result of cosmogenic isotopic datation are more realistic than radiocarbon conventional result concerning of Leszno Stadial chronology. A new data were obtained by use luminescence dating methods (TL and OSL and SAR) (Baumgart-Kotarba, Bluszcz, Kotarba 2001)(Fig. 2). Recessional morainic ridge WB3 was dated: 19, 15.5, and 11.5 ka BP. It is interpreted as mixture of grains related to recession (19 ka BP), oscillation (15.5 ka BP) and dead-ice melting (11 ka BP). It is also interesting that fluvioglacial sediments related to morainic ridge WB3 were deposited on eroded older sediments, which were also dated. OSL datation from silty-sand intercalation indicates 49±4 ka. This intercalation was deposited within massive rather angular granite gravel series with some imbricated pebbles. This sediment can be interpreted as periglacial river deposit corresponding with cold stage characterized by strong weathering and massive transport (without well rounded material). TL datation 150-130 ka BP indicate provenance of crystalline material from Riss morainic blocks. Probably the origin of angular material can be interpreted as frost weathering action during older cold part of Würm. Geological and morphological relation make it possible to formulate such conclusion. No evidence for glacier stadial(s) between 50 ka and 22 ka BP in the Sucha Woda and Pańszczyca valleys. Another sample was collected from erosional undercut near the most external morainic ridge of Toporowe Stawy, but cca. 25 m below surface. OSL datation (28.5±5.3 ka BP) indicate inter-pleniglacial age of sedimentation with well rounded blocks and pebbles.

Recessional stages

Due to detailed geomorphological mapping of moraine pattern (frontal and lateral ridges) it was possible to distinguish recessional and oscillation phases. In some cases was also possible to establish the periods of reduction of glacier thickness without distinct recession. In such situations the systems of parallel lateral ridges were produced. The number of recessional stages are related not only to direct climatic influence. In the bottom of main valley an additional stays (halts) were related with lost of supply from tributary glaciers. Thus in the Biała Woda Valley was possible to distinguish 10 recessional stages (BW 1-BW10), while in the Sucha Woda and Pańszczyca valleys only 7 (SW1 – SW7, P1 – P7) (Fig. 3). For deglaciation chronology the most important is radiocarbon datation 12 550?450 ka BP (Gd-4540), which comes from lacustrine core in Czarny Staw Gąsienicowy Lake (Baumgart-Kotarba, Kotarba 1993). This data was interpreted in terms of deglaciation as post-Gschnitz Stage. Thus, double recessional morainic ridges at the height of 1540 m. a.s.l. were correlated with Gschnitz Stage in the Austrian Alps (13 ka BP – Patzelt 1975). Geomorphological studies suggest oscillatory readvance for this system of double moraines (Baumgart-Kotarba, Kotarba 2001). Very similar pattern of morainic ridges gave rise to possibility to recognise this stage in different Tatra valleys. The Gschnitz Stage in the Sucha Woda valley was marked as SW4, in the Pańszczyca valley as P4 (Baumgart-Kotarba, Kotarba 2001). In the Rybi Potok valley this stage is manifested also as double morainic ridge (RP2-RP3) with frontal position on 1360 m. a.s.l., but reduction of thickness and width of glacier tongue (Fig. 4). The authors of this paper are obligated to criticize severely interpretation of these ridges (RP2-RP3) as Holocene in age on *Geological Map of the Tatra Mountains,* 1:50 000 (1993). The same remark concerns Gschnitz moraines below Czarny Staw Gąsienicowy Lake dated by radiocarbon as 12 550 BP. According to Baumgart-Kotarba and Kotarba (1993, 1997) Morskie Oko moraine ridge corresponds to Daun Stage in the Austrian Alps (12 ka BP).

The youngest glaciers in the Tatra Mountains were correlated with Venediger Stage in the Austrian Alps (Baumgart-Kotarba, Kotarba 1997). The end of glacial epoch was dated by radiocarbon data 8330‽120 BP (Gd-2799) from the bottom sediments within dead-ice hollow – Małe Żabie Oko near Morskie Oko Lake. Palynological analysis by A.Obidowicz (1993) indicate that at this time the upper timber line was rather close to this site (1390 m. a.s.l). It was radical climatic amelioration. Direct evidence for prove end of glaciers in the Tatra Mountains require samples of bottom lacustrine deposits from the lakes located in the uppermost position, on altitude of 2000 m, i.e,. Velke Hincovo Pleso Lake.

Conclusion

Simultaneous use of geomorphological, sedimentological and various dating methods make it possible to obtain more precise chronology of W✧rm glaciation events in the High Tatra Mountains. Application of OSL and SAR techniques allow to determine cold and dry periods around 50 ka BP, interpleniglacial period around 28 ka BP and maximal glacial stadial around 21-19 ka BP (conventional C-14 timescale) than according to A. Bluszcz corresponds to calendar ca. 25.0 – 22.5 ka BP.

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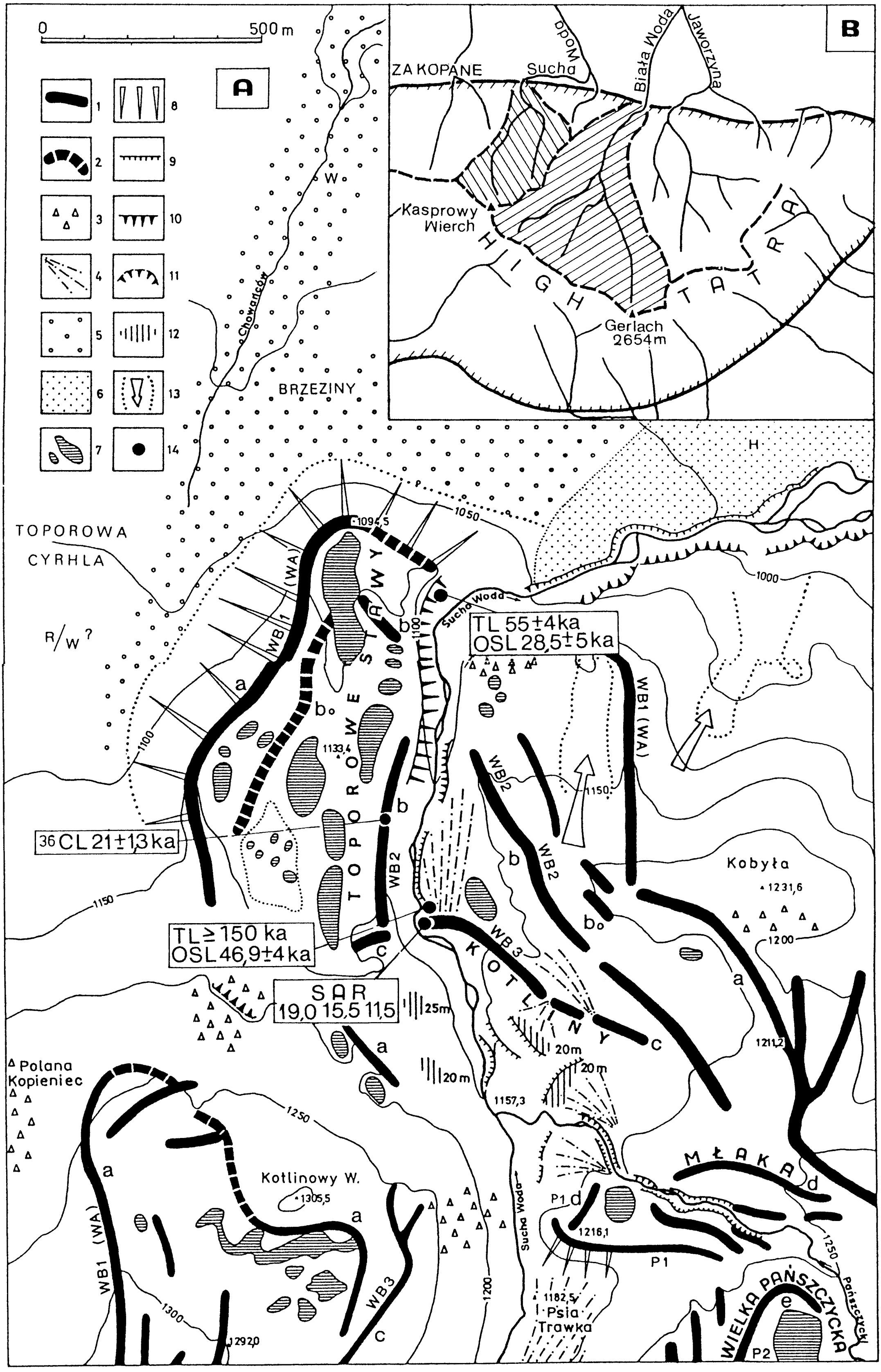
Fig. 1. A – Terminal Toporowe Stawy moraine system of the Sucha Woda and Pańszczyca valleys. **1** – distinct moraine ridges, **2** – reconstructed romaine ridges, **3** – glacial boulders, **4** – glacifluvial cone, **5** – main glacifluvial cone, **6** – Holocene terrace, **7** – dead-ice depressions, **8** – steep slope of moraine ridge, **9** – terrace edge, **10** – erosion scarp, **11** – landslide niche, **12** – glacifluvial terrace, **13** – reconstructed outflow of meltwater during maximum stand of W✧rm glaciation, **14** – TL, OSL, SAR and ^{36}Cl sampling sites, **LG** – Late Glacial terrace, **H** – Holocene terrace, **W** – W✧rm glacifluvial cone from maximal stadial. **B** – location of the Biała Woda and Sucha Woda valleys.

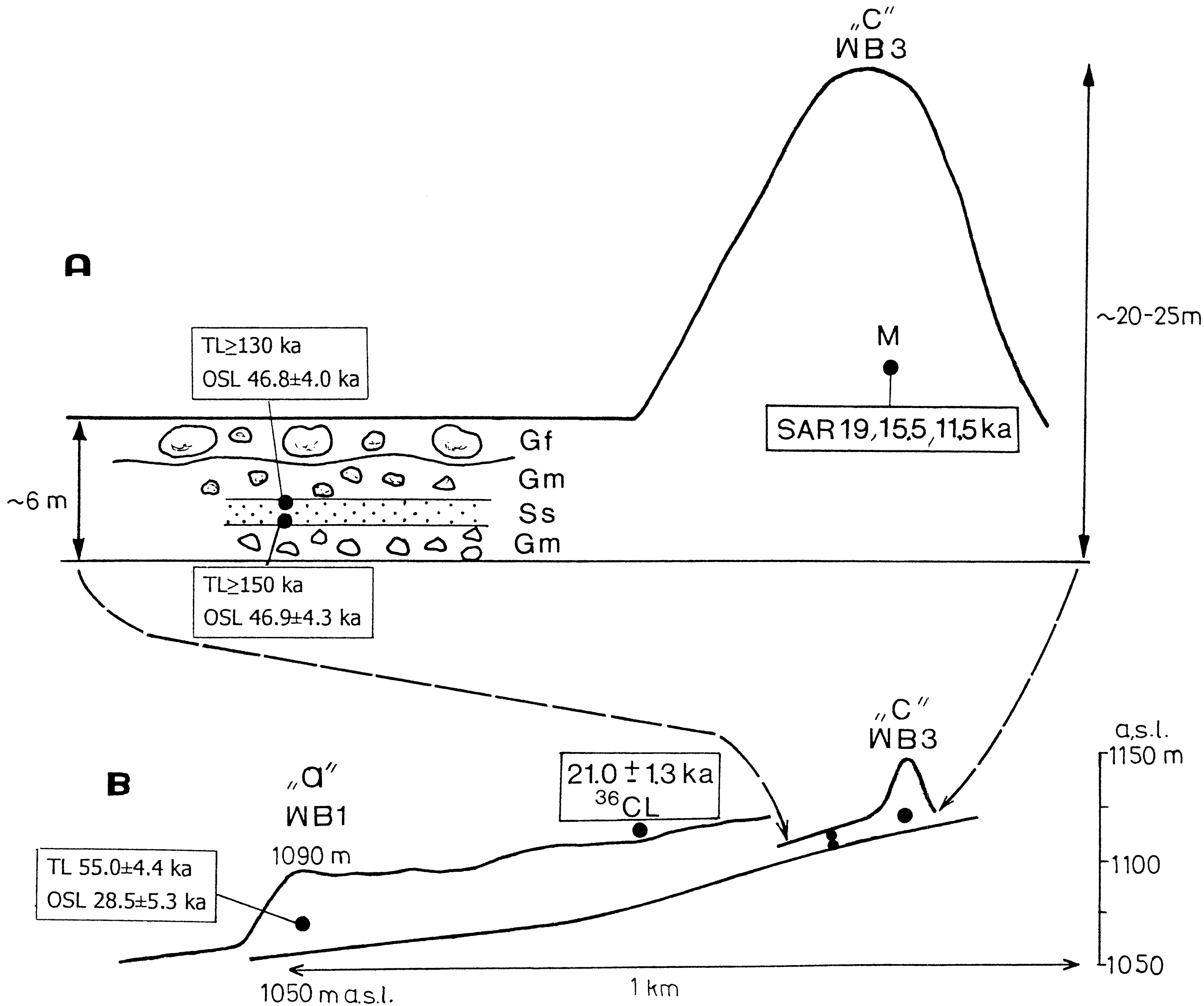
Fig. 2. Schematic profiles along the Sucha Woda valley. A – below WB3 morainic ridge, B – in zone of maximal extent of the Toporowe Stawy moraine upland. **1** – site of sampling, **GL** – glacifluvial deposits, **Fm** – fluvial massive angular series, **Ss** – silty sand insert, **M** – moraine till with rounded boulders.

Fig. 3. Recession of the glaciers in the Sucha Woda and Pańszczyca valleys. Correlation with Austrian Alps deglaciation phases (Patzelt 1975) and Polish Lowland

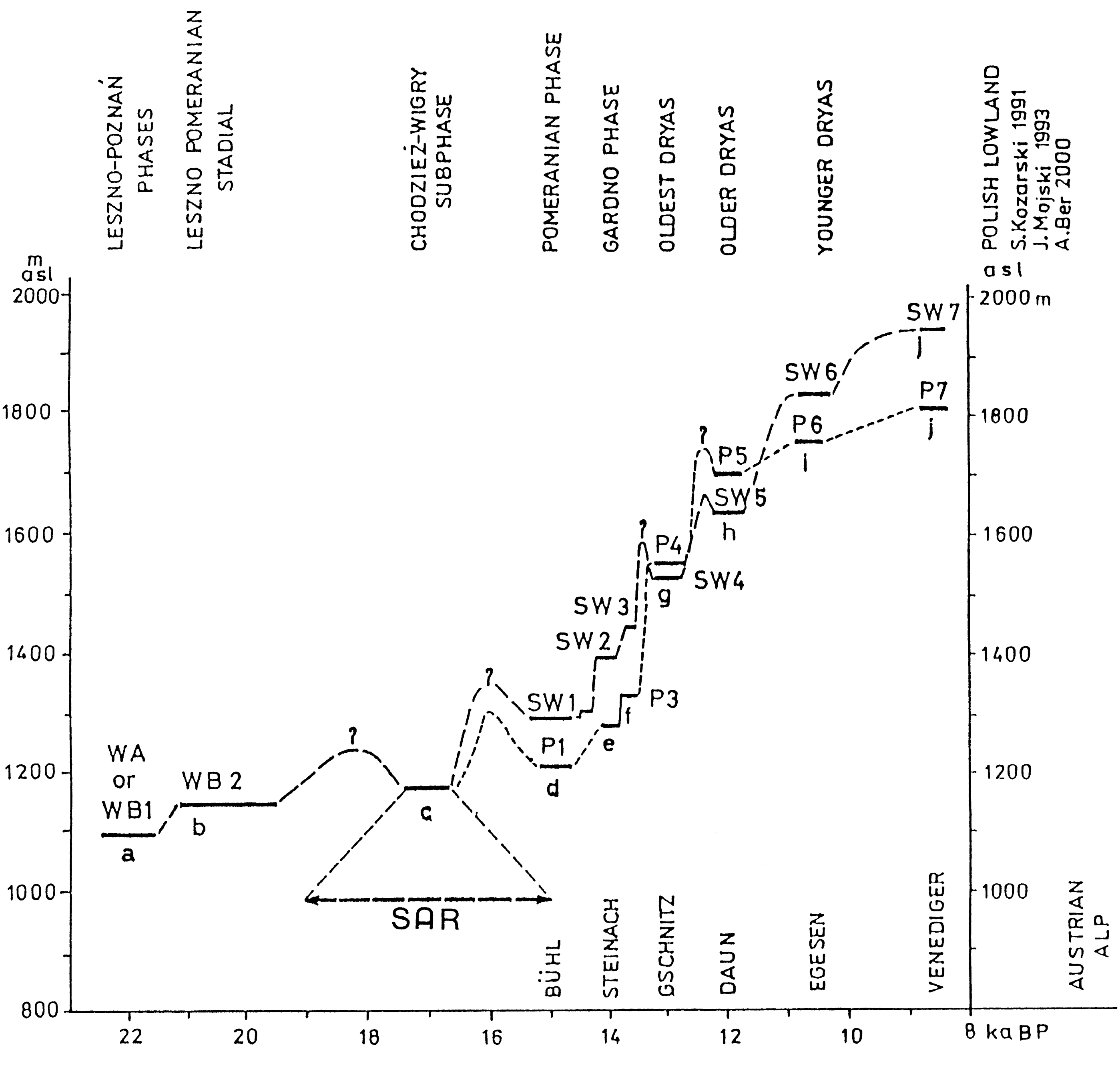
Fig. 4. Longitudinal profile of the Biała Woda valley and extents of frontal moraines WA (M I), WB1, WB2, WB3 (WM II) as well as recessional moraines. **1** – frontal moraine ridges, **2** – lateral moraines, **3** – boulder covers, **4** – moraines marking sites where tributary glaciers supplied main glacier, **5** – reconstructed extents of glacier.



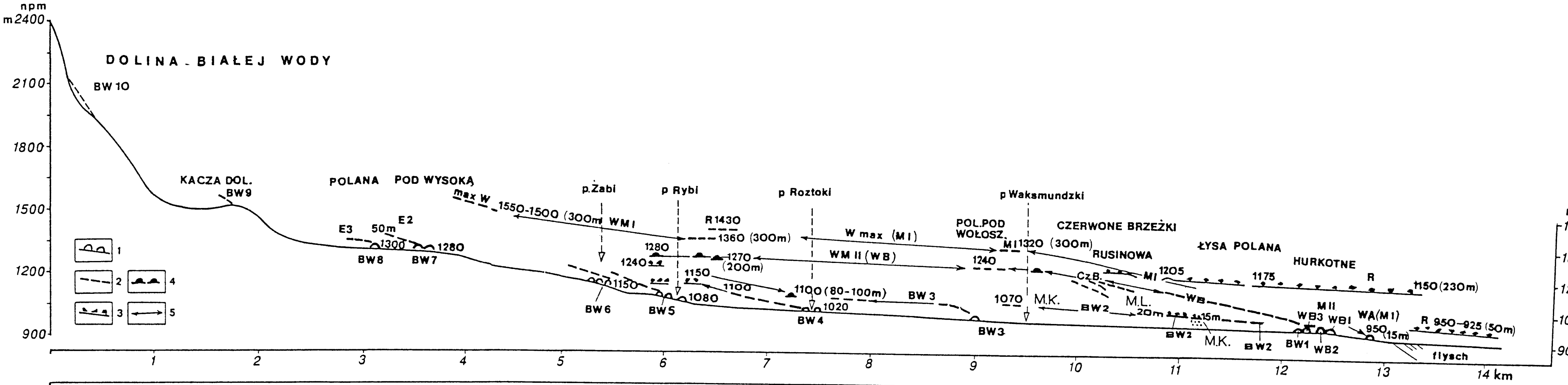
0 500 m
A
B
ZAKOPANE
Sucha Woda
Biała Woda
Jaworzyna
Kasprowy Wierch
HIGH TATRA
Gerlach 2654m
BRZEZINY
Chowańców
TOPOROWA CYRHLA
R/W ?
TOPOROWE STAWY
1094,5
1050
1000
1100
1150
1133,4
WB 1 (WA)
WB2
WB3
TL 55±4ka
OSL 28,5±5ka
36CL 21±1,3ka
TL ≥150 ka
OSL 46,9±4ka
SAR
19,0 15,5 11,5
25m
20m
KOTLINY
Kobyła
1231,6
1200
1211,2
Polana Kopieniec
1250
Kotlinowy W.
1305,5
1157,3
Sucha Woda
MŁAKA
P1
P2
1216,1
1182,5
Psia Trawka
1300
1292,0
WIELKA PAŃSZCZYCKA
Pańszczyca



„C"
WB3
A
~20-25m
M
TL≥130 ka
OSL 46.8±4.0 ka
SAR 19, 15.5, 11.5 ka
Gf
Gm
~6 m
Ss
Gm
TL≥150 ka
OSL 46.9±4.3 ka
„C"
WB3
a.s.l.
1150 m
B
„a"
WB1
21.0 ± 1.3 ka
36CL
1090 m
TL 55.0±4.4 ka
OSL 28.5±5.3 ka
1100
1050
1050 m a.s.l.
1 km



LESZNO-POZNAŃ PHASES
LESZNO POMERANIAN STADIAL
CHODZIEŻ-WIGRY SUBPHASE
POMERANIAN PHASE
GARDNO PHASE
OLDEST DRYAS
OLDER DRYAS
YOUNGER DRYAS
POLISH LOWLAND
S.Kozarski 1991
J.Mojski 1993
A.Ber 2000
m asl
asl
2000
1800
1600
1400
1200
1000
800
2000 m
WA or WB1
a
WB 2
b
c
SW1
P1
d
SW2
SW3
e
f
P3
P4
SW4
g
P5
SW5
h
SW6
P6
i
SW7
P7
j
?
SAR
BÜHL
STEINACH
GSCHNITZ
DAUN
EGESEN
VENEDIGER
AUSTRIAN ALP
22
20
18
16
14
12
10
8 ka BP



M. Lukniš	H	HW	E3	E2	E1			D2	D		C B			
M. Klimaszewski VII		IV 1600	III 1300	II 1280		I 1080						970		935
MA Kotarba	BW 10	BW9	BW8	BW7	BW6	BW5	BW4	BW3		BW2	BW1	WB	WA	
	Venediger? Schlaten?	Egesen	Daun		Gschnitz Gardno	Schlern II	Schlern I	Steinach		Bühl Pomeranian	Chodzież Leszno-Poznań			
	9.5 - 8.4 ka	10.7-10.2 ka	12 ka		13 ka			14 ka		15 ka	17.2	20-18	>60 ka	