Assessment of Late Holocene sediment volume and accumulation rates in valley floors of the Swiss Alps: The Hasli valley and Lütschine Fan delta case study

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Introduction and Study area

Sediment accumulation in mountain deltas and alluvial fans is predominantly characterized by variations in discharge and sediment supply. These variables are controlled by a wide range of internal and external factors such as flow regime, morphology, land use, climate variability, etc. This work will center on two basins located in the Bernese Swiss Alps, the upper Aare basin and the Lütschine basin. Our study will focus on the sediment bodies of deltas located at the outlet of both basins. These bodies are the youngest fluvial deposits of the accumulation sequences of the valley fill, started in general terms after the retreat of the Lütschine and Aare glaciers at approximately 16 kyr. Both rivers flow into Lake Brienz and have glaciated areas in the higher lands. The main purpose of this work is to estimate the sediment volume and accumulation rates during the last 3000 years. We will also establish a comparison between these basins and identify the major trends in sedimentation rates.

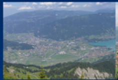


Fig. 1. Panoramic view of the Lütchine delta. Carvalho, 2010

Fig. 2. The Lütchine delta, view from the proximal section of the delta. Carvalho, 2009

Fig. 3. Aereal view of the Hasli valley. Schweizer Luftwaffe, 2007

Fig. 4. View from the valley floor of the Hasli valley. Schum, 2008

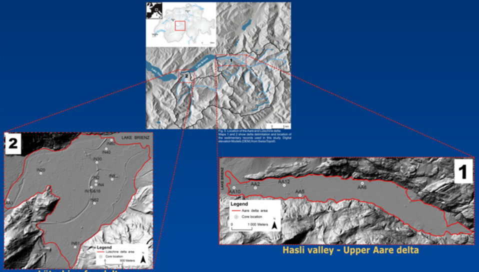
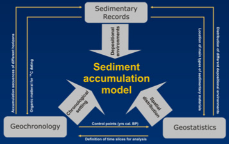


Fig. 5. Location of the Aare and Lütschine delta. Maps 1 and 2 show delta delimitation and location of the sedimentary records used in this study. Digital elevation Models (DEM) from SwissTopo©.

Materials and Methods

Sedimentary records were collected from numerous field campaigns. These records were acquired from boreholes in specific studied locations and from key sections made available in some construction sites. For the Lütschine fan delta we used a total of 9 boreholes and 3 key sections, whereas in the Hasli valley we obtained a total 5 boreholes. We also used several information from previous studies (Hinderer, 2001; Sturm and Matter, 1978) and geological surveys from the Swiss Federal Bureau of Water Management (WEA). The geochronology is based on ^{14}C dating of organic sediments, peat and wood taken from the mentioned records. For the estimation of sediment volume we used a geostatistical modelization of the paleo surfaces and applied this calculation for 500-years time slices. This method allows us to obtain a model of sediment deposition of both deltas from 3000 yr cal BP to the present day surface.



Sedimentary Records
Depositional environments
Sediment accumulation model
Chronological setting
Spatial distribution
Geochronology
Geostatistics
Control points (yrs cal. BP)
Definition of time slices for analysis
Accumulation sequences of different horizons
Organic material for 14C dating
Location of main types of sedimentary materials
Distribution of different depositional environments

Table 1. Some specifications of the sedimentary records used in this study.

	Identification	Type	Year	Max. Depth (m)	Distance to Lake (m)	Number of ^{14}C datings
Hasli	AA2	Sediment Core	2008	9	1315	4
	AA5	Sediment Core	2008	10	3540	6
	AA6	Sediment Core	2009	9	6620	6
	AA10	Sediment Core	2010	11	270	1
	AA12	Sediment Core	2010	9	2745	1
Lütschine	IN2	Key section	2001	3.2	1225	10
	IN4	Sediment Core	2001	3.2	1325	1
	IN8	Sediment core	2001	8.5	1025	4
	IN10&IN16	Key Section & Core	2002	7.9	1455	4
	IN20	Key section	2007	5	525	2
	IN30	Sediment Core	2008	3	785	3
	AA1	Sediment Core	2008	5	43	4
	IN40	Sediment Core	2009	5	320	3
	IN60	Sediment Core	2010	7	70	1
	IN61	Sediment Core	2010	3.4	3200	1
	IN62	Sediment Core	2010	4.8	1835	1

Fig. 6. Photo of IN40 core section with peat horizons

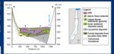


Fig. 7. Geological profile of a transversal section of the Hasli valley, addapted from WEA geological surveys (Valle, 1994)

Fig. 8. Lithological profile of cores AA2 and AA5. Location of 14C datings. Carvalho 2008

Fig. 9. Photo of drilling campain in the Hasli Valley. Schulte, 2008

Results and discussion

Our analysis shows that high accumulation rates can represent a increase in the accretion of delivered sediments, but can also be the result of specific depositional environments. Thus indicating that areas with coarser material (like sand and gravels) have higher accumulation rates than finer sediments (silts and clay) and organic horizons (mainly peat). The relation shown in Figure 3 is therefore a consequence of the existence of coarser materials in the proximal areas of the delta and progressively finer sediments towards the distal sections.

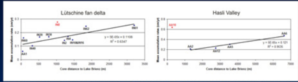


Fig. 10. Relation between each core distance to Lake Brienz and its mean accumulation rate. The data represented in red are cores that were removed from the regression equation due to particular deposition conditions. Carvalho & Schulte, 2011

In general, results show a decreasing trend of sedimentation rates during the last 3000 years. This decrease is mostly due to natural dynamics, particularly to the Holocene post glacial landscape adaptation and related changes of sediment production and storage. Regarding the last 3000 years we don't observe any considerable increase in the accumulation rates caused by human intervention. Only during the last 500 years we detect a moderate increase in sedimentation rates that breaks the downward trend of the 3000-years series. This final aggradation pulse can be explained by the expansion of land-use, as enhanced deforestation until the second half of the 19th century and the spread of alpine grassland.

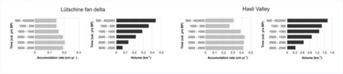


Fig. 11. Mean accumulation rates and volume of accumulated sediments for the Aare and Lütschine deltas during the last 3000 years. Volume is expressed in cumulative values. Carvalho & Schulte, 2011

Even though both deltas share similar accumulation trends, the Lütschine fan delta was subjected to at least 800 years of anthropic hydrological management, whereas the Aare delta kept its natural configuration until the mid 18th century. This fact explains the different distribution of aggradation and progradation of the deltas during the last 1000 years.

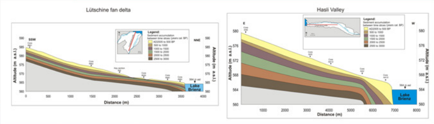


Fig. 12. Longitudinal profiles of both deltas with a modelization of accumulated sediments in the last 3000 years. Carvalho, 2011

Acknowledgements

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