Supplemental information for AQUATIC SCIENCES

Human impact on the transport of terrigenous and anthropogenic elements to peri-alpine lakes (Switzerland) over the last decades

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Lake Brienz age model (Fig. S1)

The age model for core BR03-10 is described in details in Anselmetti et al. (2007). It is based on the stratigraphic correlation with core BR98-16 (Fig. S1) situated at ~300 m distance in the deep part of Lake Brienz. The age model for BR98-16 relies on the linear interpolation between four tie points: the coring year (1998), the large turbidite event layer of 1996 (Girardclos et al. 2007), and the ^{137}Cs activity peaks of 1986 and 1963 due to the Chernobyl event and to the maximum radionuclide fallout related to atmospheric weapon tests, respectively. In core BR03-10, the deposition of the 1996 large turbidite eroded a sediment sequence of 17±1 years, corresponding to a ~22-cm-thick layer, thus inducing a hiatus in the sediment record. Another large turbidite, dated by extrapolation to 1942±2 (Anselmetti et al. 2007), interrupts the sediment record near the bottom of core BR03-10 at 72 cm depth (Fig. S1).

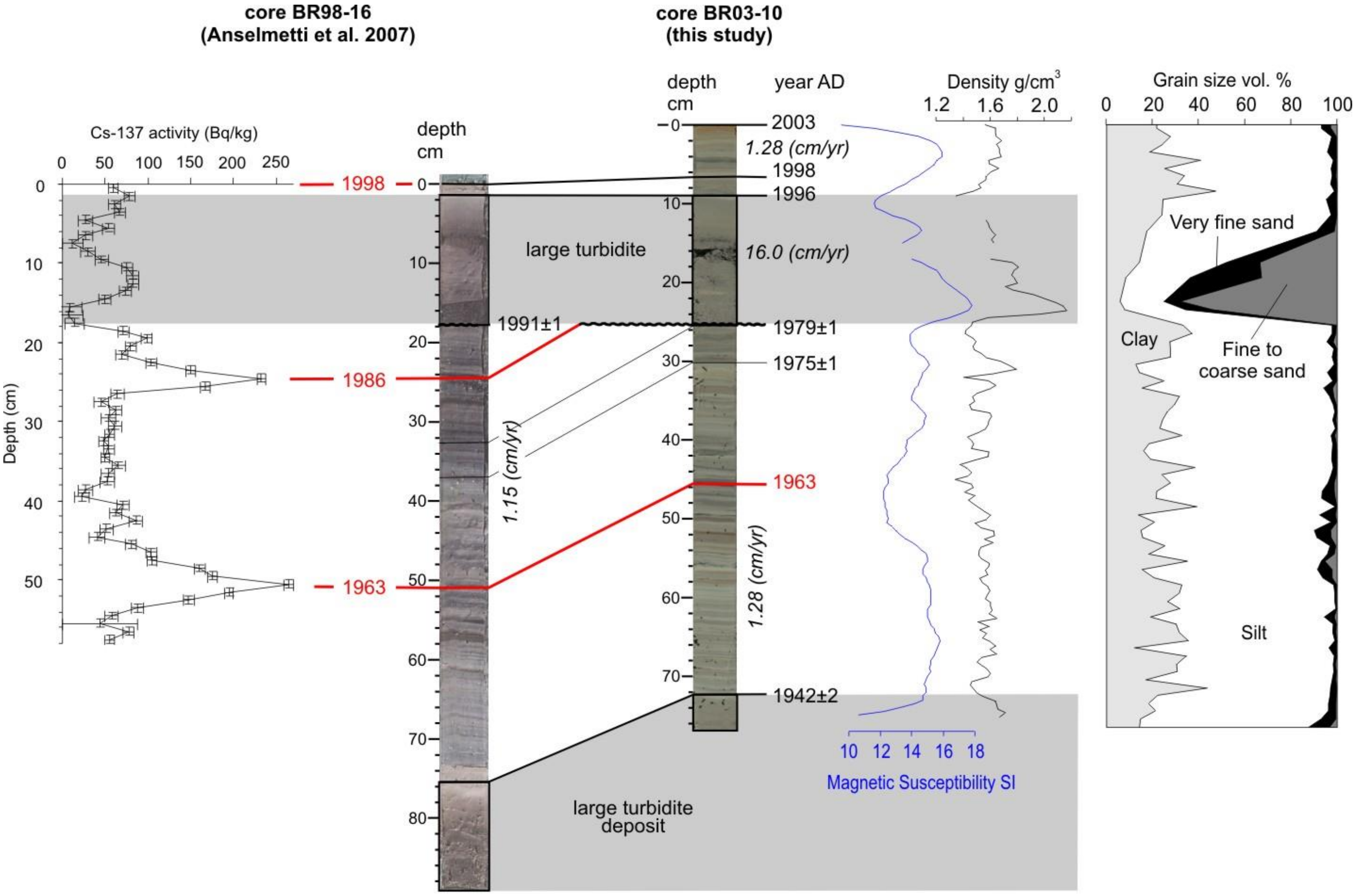

Fig. S1. Lithological correlation between core BR98-16 and BR03-10 with resulting age model and sedimentation rate based on the ^{137}Cs activity profile (Anselmetti et al. 2007). The density, magnetic susceptibility and grain-size profiles of core BR03-10 show that a large turbidite layer interrupts the sedimentary record from 9 to 26 cm depth. This layer, deposited in 1996, eroded underlying layers. Another turbidite dated by extrapolation to 1942±2 is recorded from 72 to 77 cm depth, as detailed in Girardclos et al. (2007).

Lake Thun age model (Fig. S2)

The age model for core THU07-06 is based on the stratigraphic correlation with core THU06-04 (Fig. S2) situated at ~100 m distance in deep Lake Thun. The age model of THU06-04 is presented in detail in Wirth et al. (2011). It consists of a three steps analysis. For the 1951 to 2006 time period, the age model of core THU06-04 is based on the linear interpolation between four tie points: the coring year (2006), the ^{137}Cs activity peaks of 1986 and 1963 (Chernobyl event and maximum radionuclide fallout due to atmospheric tests, respectively), as well as the last level of zero activity attributed to 1951. For the sediment sequence older than 1951, the tie points consist of prominent flood turbidites that correlate to major historically and/or instrumentally documented flood events since 1850 (events A to L). The resulting combined age model is verified with the ^{210}Pb activity profile and shows a very good agreement between the two methods. For this study, the ^{137}Cs activity and flood-event tie points were stratigraphically correlated from THU06-04 to core THU07-06 (Fig. S2). The resulting age model gives a 0.60 cm/yr sedimentation rate for the 1852 to 1930 interval and 0.64 cm/yr sedimentation rate for 1930 to 2007.

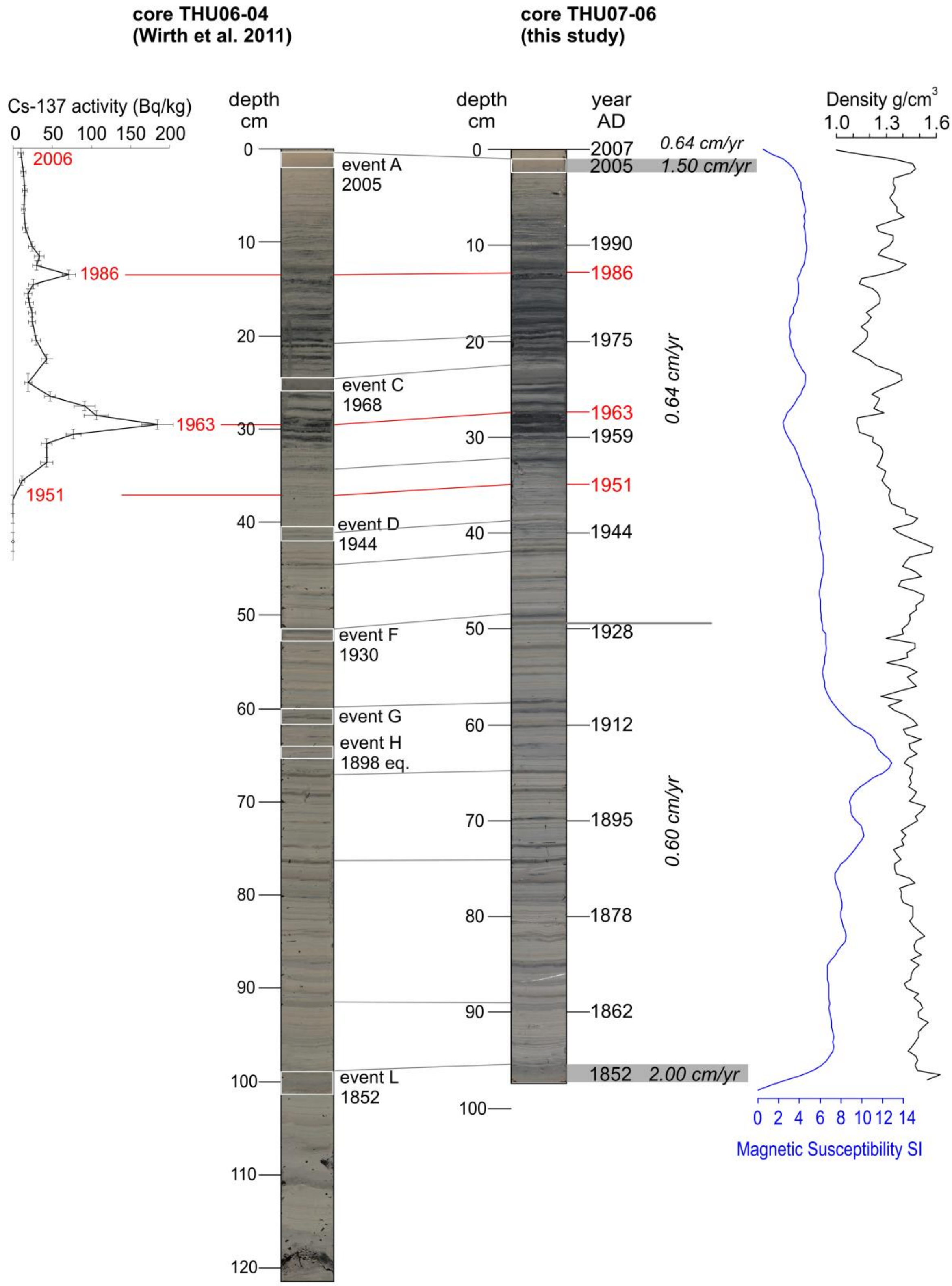

Fig. S2. Lithological correlation between core THU06-04 (Wirth et al. 2011) and core THU07-06 (this study) showing the resulting age model and sedimentation rate. The density and magnetic susceptibility profiles of THU07-06 indicate only little variation in the sediment record.

Lake Biel sediment record (Fig. S3)

The water content of core BIE10-3 decreases from 67 to 44 % from core top to bottom, and inversely, the density increases from 1.01 to 1.44 g/cm^3. This downwards long-term decreasing water content and increasing density trends are linked to enhanced sediment compaction with depth. The magnetic susceptibility values increase downcore from 5.6 to 11.0 10^{-5} SI, which is partly due to a volumetric effect due to the above-mentioned compaction. The lithology of the 119.5-cm-long core is quite monotonous and shows a layered, clayey to silty sediment with slightly coarser grain-size from 12 to 22 cm and from 94.5 to 119.5 cm core depth. Looking in more detail, the pronounced magnetic susceptibility increase of 8 to 11 from 92 cm downwards, as well as the coarser grain size and lighter coloured sediment facies from 94.5 cm down to the core bottom, point to enhanced clastic influence in this sediment interval. These properties are probably characteristic for pre-Hagneck dam conditions (Fig. S3). The ^{210}Pb-based age model for core BIE10-3, as described in this study (Fig. 2), provides a mean sedimentation rate of 0.86 cm/yr from 2010 to 1932, and by extrapolation dates this magnetic susceptibility, sediment facies and grain size change to 1900 AD, which corresponds exactly to the inauguration year of the Hagneck hydroelectric dam, thus strengthening our hypothesis that clastic influence was markedly reduced from 94.5 cm upcore.

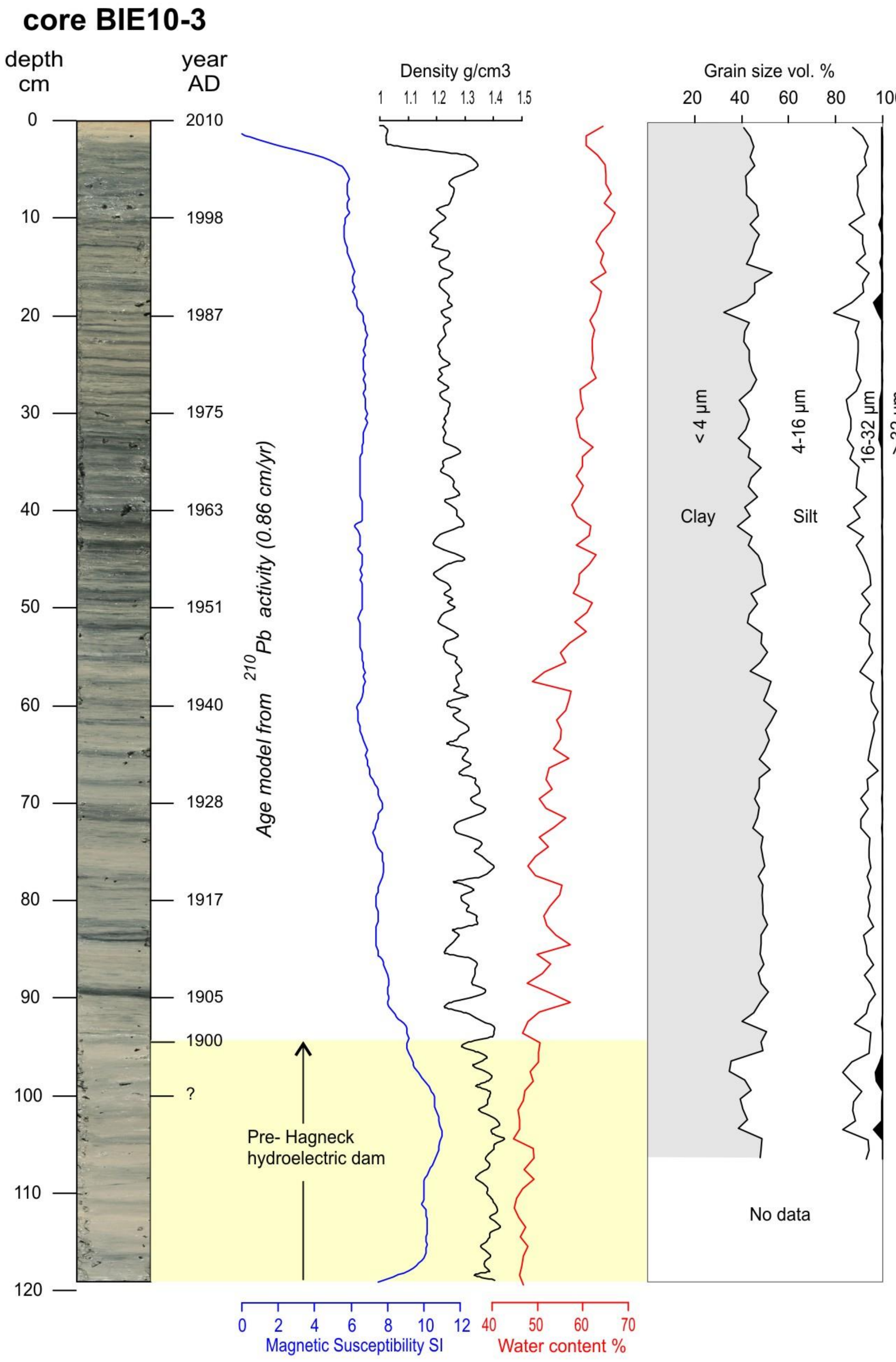

Fig. S3. Magnetic susceptibility and density profiles of the 119.5-cm-long Lake Biel sediment record (BIE10-3) showing an increasing trend from top to bottom. This drift is mainly due to downcore compaction as shown by decreasing water content and steady grain-size profiles. The lighter coloured sediment, marked increase in magnetic susceptibility and coarser sediment in the lowest 25-cm section, points to a more pronounced clastic influence in the lowest part of the record. The age model, described in detail in the article (Fig. 2), indicates a mean sedimentation rate of 0.86 cm/yr and dates the sediment facies change to 1900 which corresponds to the Hagneck hydroelectric dam inauguration.

Concentration of trace elements as a function of sediment depth (Fig. S4)

Complementary to Fig. 3 in the main article that plots the trace element fluxes as a function of time, Fig. S4 reports the concentration of trace elements as a function of sediment depth.

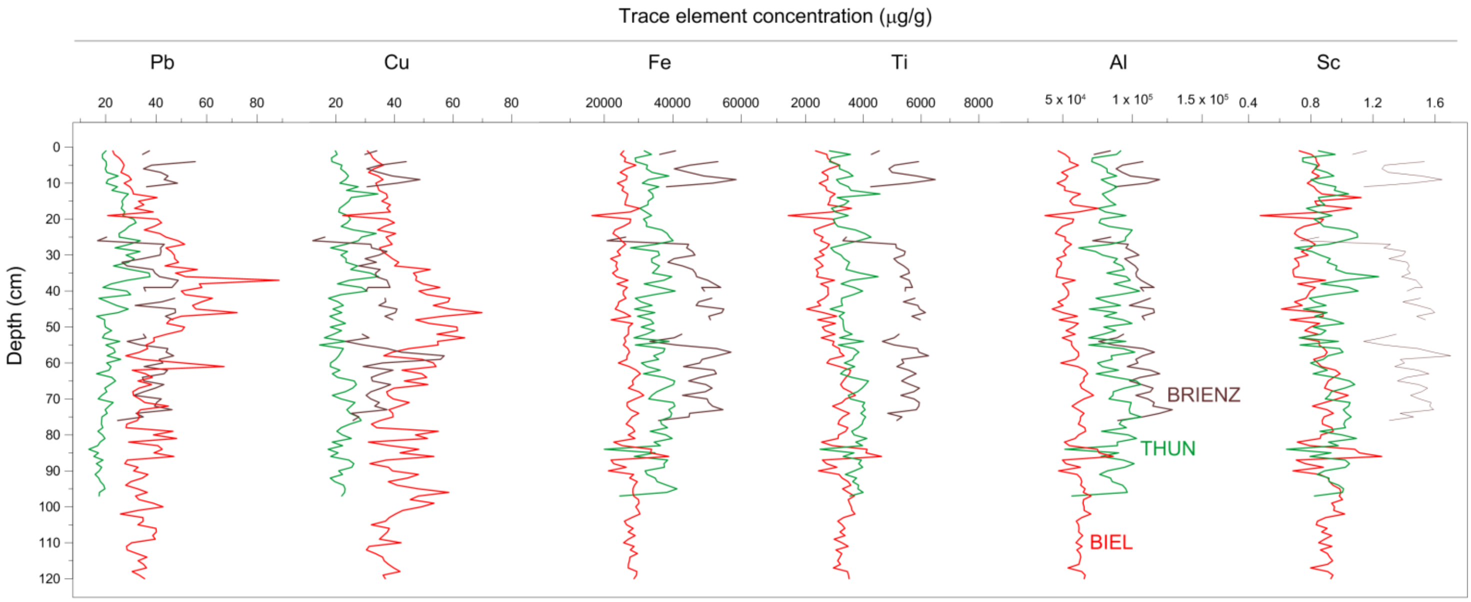

Fig. S4. Concentration of lead (Pb), copper (Cu), iron (Fe), titanium (Ti), aluminium (Al) and scandium (Sc) as a function of depth for sediment cores from Brienz (BR03-10), Thun (THU07-06) and Biel (BIE10-3).

Sedimentological features: density, granulometry and sedimentation rate (Fig. S5)

The decrease in titanium (Ti) concentration observed in our three study sites and in the deepest part of Lake Geneva (Thevenon et al. 2011) is associated to a decrease in bulk density (determined by gamma-ray attenuation on whole-round cores using a GEOTEK multi-sensor core logger) and in the (fine) terrigenous sediment input (grain-size < 4µm; determined using a Mastersizer 2000 laser-optical grain-size analyser). The inferred sedimentation rate for Lake Brienz gives a constant 1.28 cm/yr for the regular 'background' sediment, and a peaking value of 16 cm/yr for the 1996 large turbidite event (not shown in Fig. S5). Concerning Lake Thun, the sedimentation rate peak values of 2.0 and 1.5 cm/yr correspond to sediment layers deposited during the largest detected flood events in 1852 and 2005, respectively. For Lake Biel, sedimentation rate is constant over the studied period (2010-1900; 0.86 cm/yr).

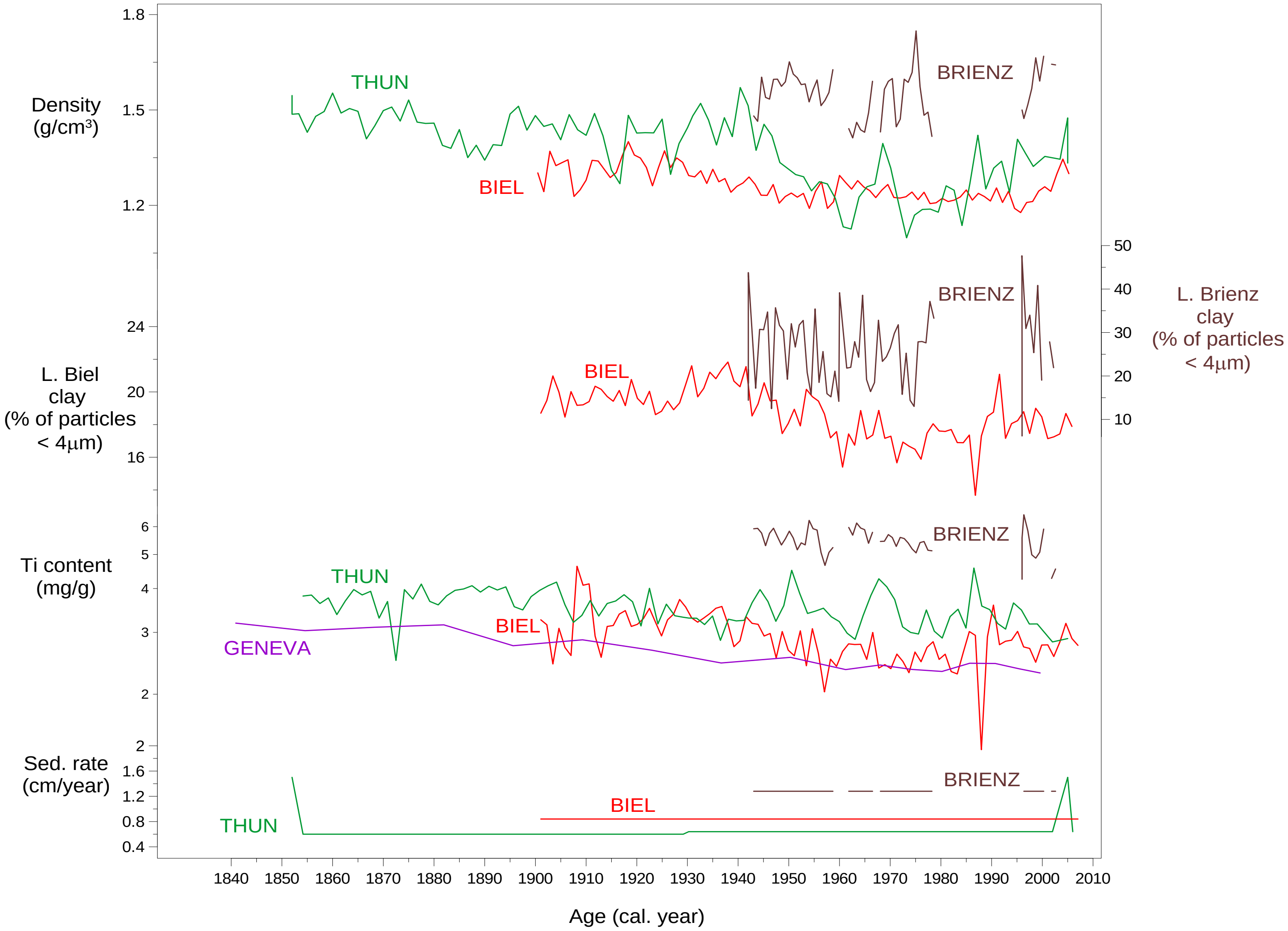

Fig. S5. Density, granulometry (% of particles <4 µm), titanium (Ti) concentration, and sedimentation rate of the studied cores; with the Ti content of Lake Geneva (Thevenon et al. 2011) for comparison.

Reservoirs built on the Aar River (Table S1)

Table S1. Name of the dams, rivers, and catchment basins, with the year of construction and the stored water volume (cumulated) in million m^3 (Mm^3). The data of the dams built upstream of Lake Brienz (in the Grimsel area) are in bold.

Dam name	River name	River catchment	Year	Water volume Mm^3	Water volume Mm^3 cumulated
Maigrauge (Lac de Pérolles)	Sarine	Sarine	1872	0.40	0.40
Hagneck	Aare	Aare upstream Lake Biel	1900	-	0.40
Simmenporte	Simme	Kander	1908	0.25	0.65
Monsalvens	Jogne	Sarine	1920	12.60	13.25
Mühleberg (Wohlensee)	Aare	Aare upstream Lake Biel	1920	25.00	38.25
Gelmer	**Diechterbach**	**Aare upstream Lake Brienz**	**1929**	**14.00**	**52.25**
Grimsel	**Aare**	**Aare upstream Lake Brienz**	**1932**	**95.00**	**147.25**
Arnensee	Tscherzisbach	Sarine	1942	10.50	157.75
Rossens (Lac de Gruyère)	Sarine	Sarine	1947	220.00	377.75
Räterichsboden / Totensee / Mattenalpsee	**Aare**	**Aare upstream Lake Brienz**	**1950**	**31.70**	**409.45**
Oberaar / Trübtensee	**Aare**	**Aare upstream Lake Brienz**	**1953**	**62.00**	**471.45**
Schiffenen	Sarine	Sarine	1963	65.00	536.45
Sanetsch	Sarine	Sarine	1965	2.80	539.25
Hongrin	Hongrin	Sarine	1969	53.20	592.45
Rossinière (Lac du Vernex)	Sarine	Sarine	1972	2.90	595.35
Lessoc	Sarine	Sarine	1976	1.50	596.85

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