Scientific Drilling at Darwin Crater and Lake Selina: Long Continental Sedimentary Archives from Tasmania

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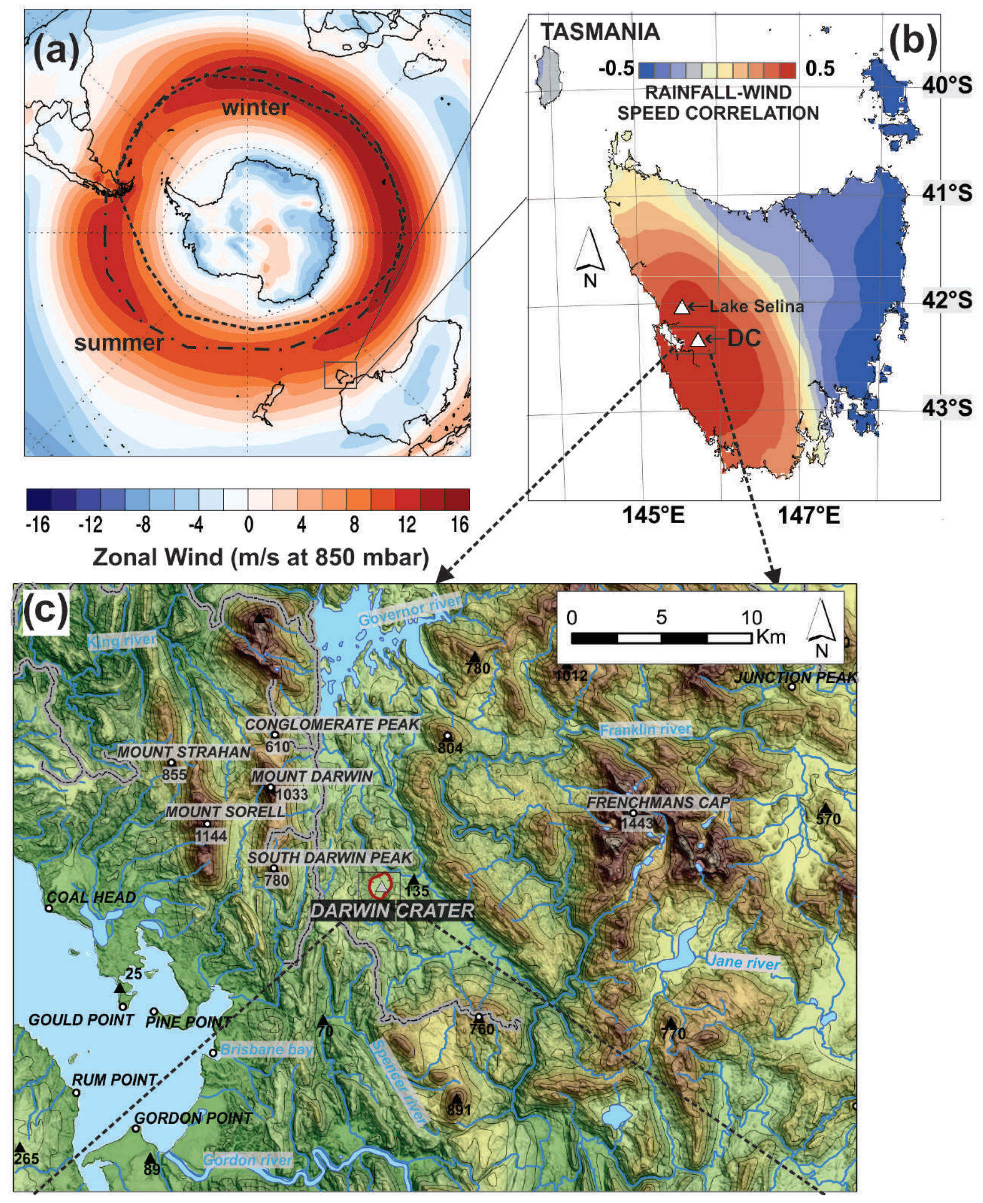


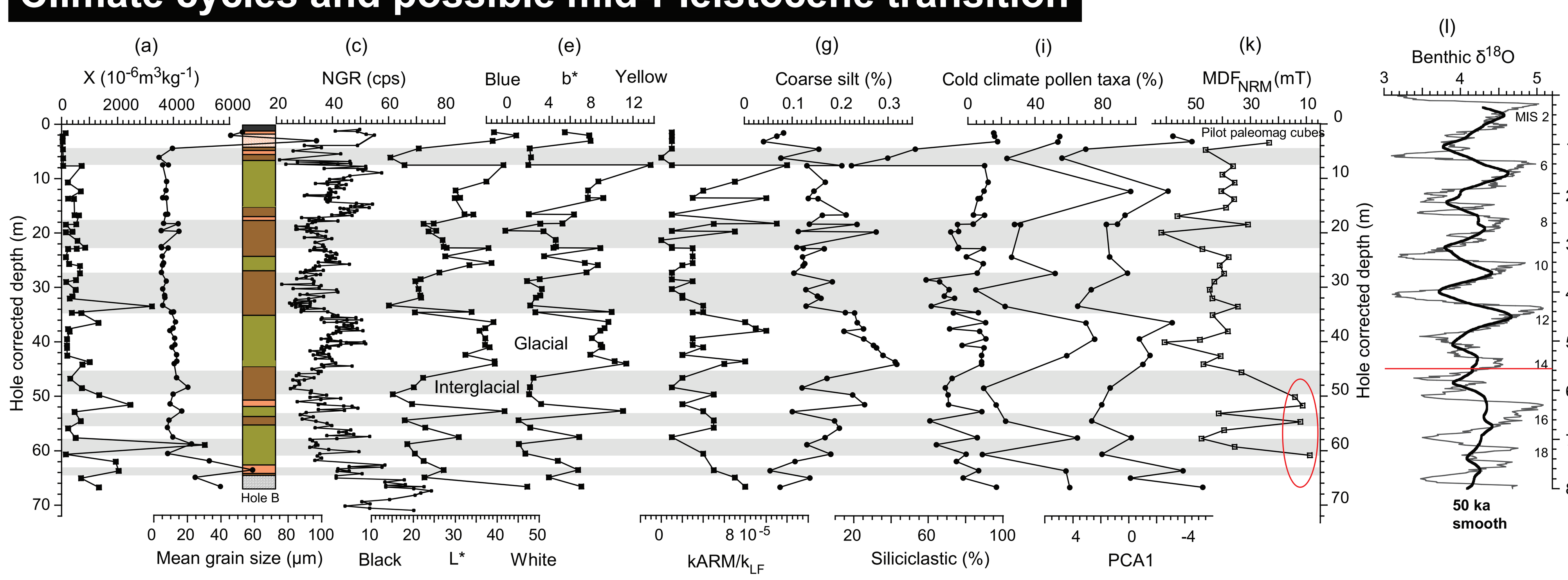
(a) Zonal wind speed at 850mb in the mid-latitude of the Southern Hemisphere and average winter and summer core position of the Southern Westerly Winds (SWW). (b) The SWW are a dominant climate control in western Tasmania, where rainfall is strongly correlated to wind intensity and orography. (c) Regional topographic map showing the location of Darwin Crater. Wind data from the NCEP/NCAR Reanalysis V1 (Kalnay et al., 1996).

Long sediment records of Pleistocene glacial/interglacial cycles were recovered from western Tasmania, including a 70 m core from Darwin Crater (left) and a 5.5 m core from Lake Selina (right). Lake Selina is still a lake today and Darwin Crater, at 50 km distance, is a meteorite impact crater and a paleolake now in a forested environment. The aim is to combine the two records to form the oldest continuous continental record in Australia, and one of the oldest in the Southern Hemisphere.

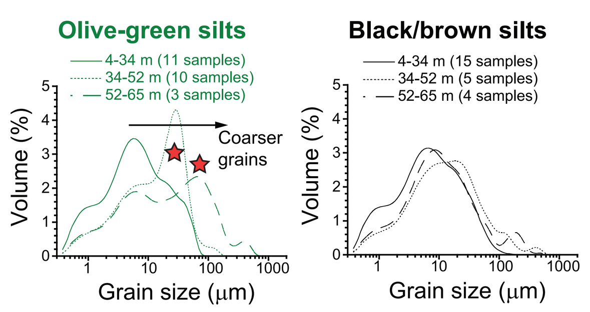
Darwin Crater/ We present results from multi-sensor whole core logging, sediment description and multi proxy pilot analysis of core end samples (including spectrophotometry, particle size, natural gamma ray, paleo- and rock-magnetism, loss-on-ignition and pollen analyses).

Lake Selina/ We present results including the chronostratigraphy (^{14}C, OSL Itrax, magnetic properties) and the paleomagnetic record, which is derived from depositional remanent magnetisation and cosmogenic nuclide beryllium-10 (^{10}Be).

Climate cycles and possible mid-Pleistocene transition

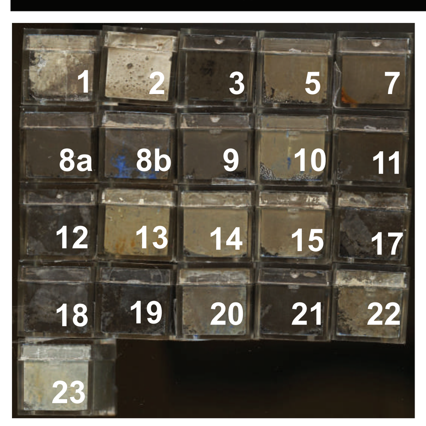


Darwin Crater TAS1803 selected parameters of the pilot multi-proxy analyses. (a) Mass-normalized magnetic susceptibility (χ), (b) Mean grain size, (c) Natural gamma ray (NGR), (d) Color data L* and (e) b*, (f) Magnetic grain size indicator kARM/kLF, (g) Coarse silt, (h) siliciclastic content, (i) cold climate pollen taxa, (j) PCA axis 1 from left (warm) to right (cold), and (k) magnetic coercivity indicator MDF_{NRM}. The start and end ages of the Darwin lacustrine sediment succession are unknown and will be identified by on-going dating work. (l) A benthic δ18O stack (Lisiecki and Raymo, 2005) and 50 ka moving average (Hughes and Gibbard, 2018) is shown as a reference for Pleistocene glacial and interglacial climate cycles. Hole B simplified lithology log is included. The horizontal grey shaded bars tentatively indicate interglacial periods. Different symbols are used for different sample types; square symbols for measurements performed on the same cube samples, large circles for core ends samples, and small circles for whole core MSCL samples.

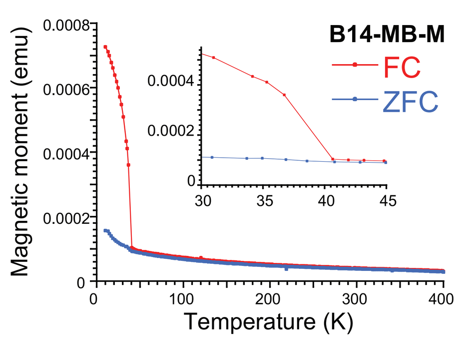


Grain size distributions in the glacial sediments 34-65 m have distinct peaks in medium and coarse silts (★), the size of wind-blown particles (Pye, 1995) previously used a wind intensity proxy in Southern Patagonia (Lise-Pronovost et al, 2015).

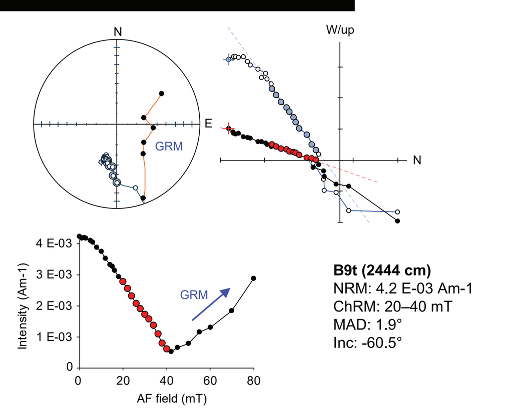
Reducing conditions



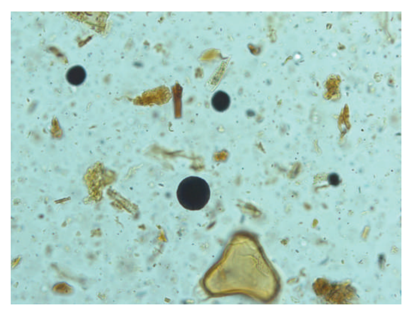
Cube samples TAS1803 Hole B. The blue minerals visible in cube 8b and 10 are changing color from white to blue upon contact with air (oxidation) and to bright yellow upon contact with a solution of ammonium molybdate and nitric acid. This indicates that it is a phosphate mineral that we tentatively identify as authigenic **vivianite** which can form in organic and iron-rich lake sediments under reducing conditions (Rothe et al, 2016).



This sample at 40 m depth has low temperature magnetic characteristics typical of well-crystaline **siderite** (Frederichs et al, 2003), an iron carbonate that can forms in reducing sediment conditions.



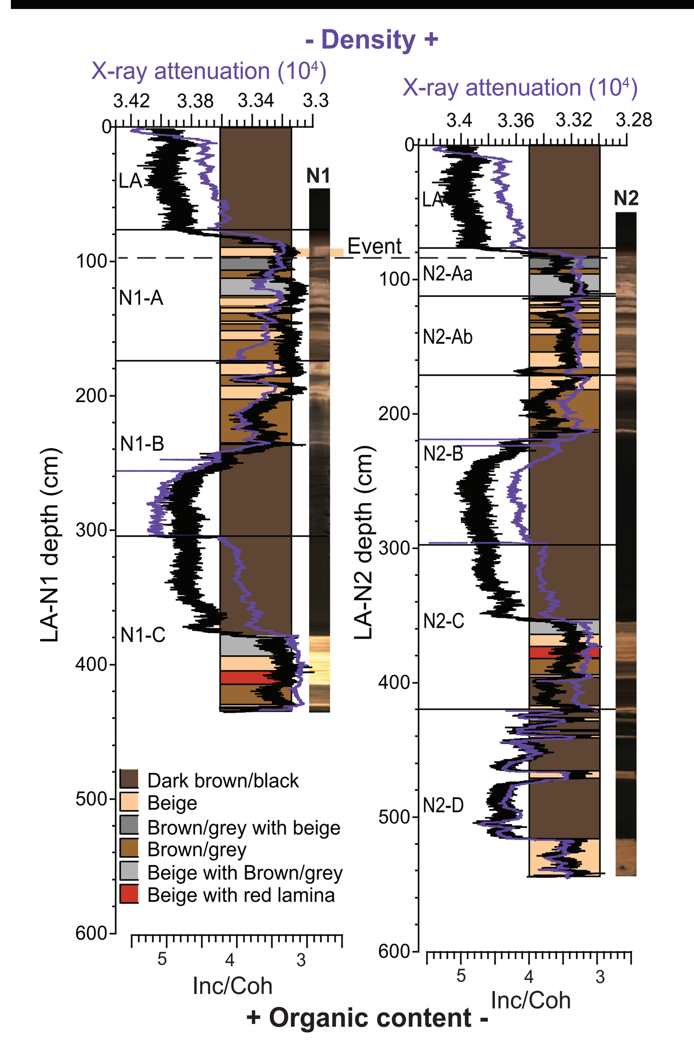
Acquisition of gyroremanent magnetisation (GRM) during alternating field demagnetisation is indicative of iron sulfide **greigite**, which can form as a by-product of pyritisation in reducing sediment conditions.



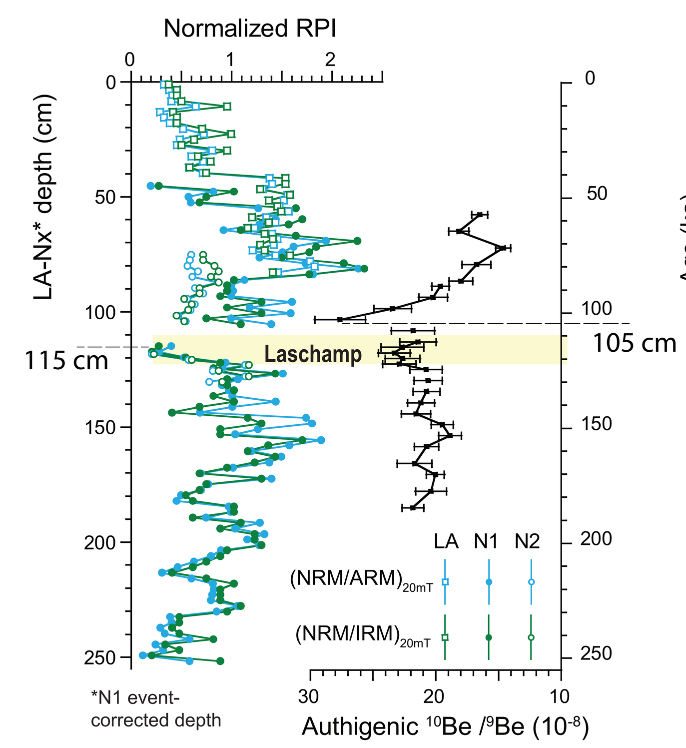
Framboidal **pyrite** 10-20 μm is observed under the microscope in the core end samples TAS1803 -B21 and -22.

- -Vivianite is a target for uranium series dating (Goetz and Hillaire-Marcel 1992; Nuttin et al, 2013)
- -Paleomagnetic record partly or entirely held by greigite (excellent recorder but unknown time of formation)
- -Opportunity to investigate lake sediment diagenesis

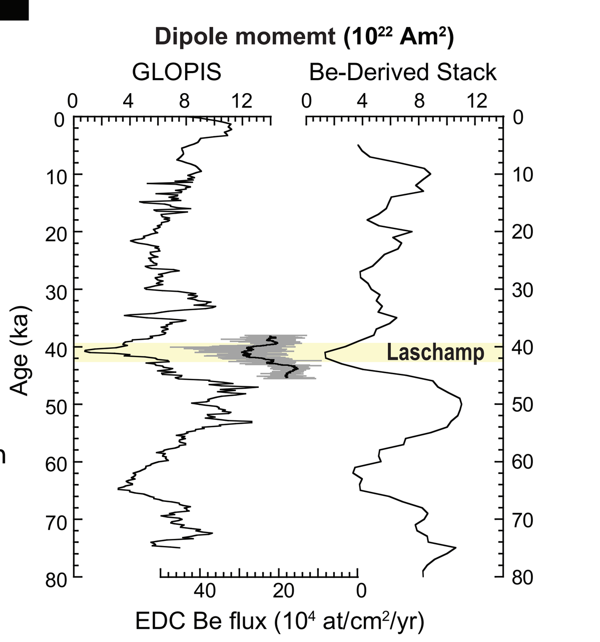
Chronostratigraphy and paleomagnetic field record



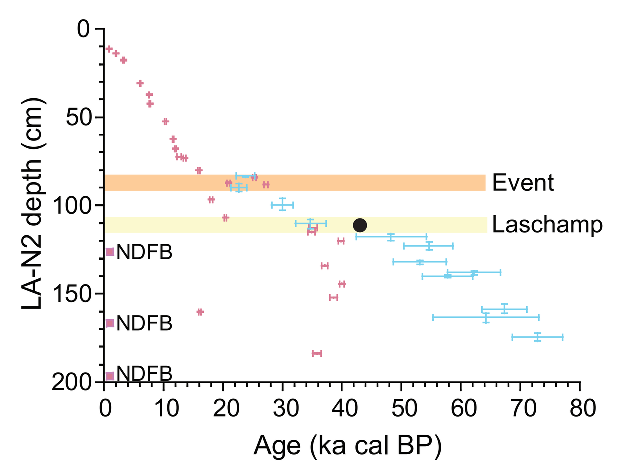
Lake Selina TAS1402 cores stratigraphy, photography, and proxies of density and organic matter from micro-XRF (Itrax) core scanning. An event deposit is identified in core N1.



Relative paleointensity (RPI) proxies derived from remanent magnetisation (NRM/ARM and NRM/ARM) and cosmogenic nuclide beryllium ($^{10}Be/^{9}Be$) display similar variability. Low magnetic remanence ratio (115 cm) and maximum production of cosmogenic Be (105 cm) are attributed to the Laschamp geomagnetic excursion and the 10 cm offset may be linked to the magnetic lock-in depth.

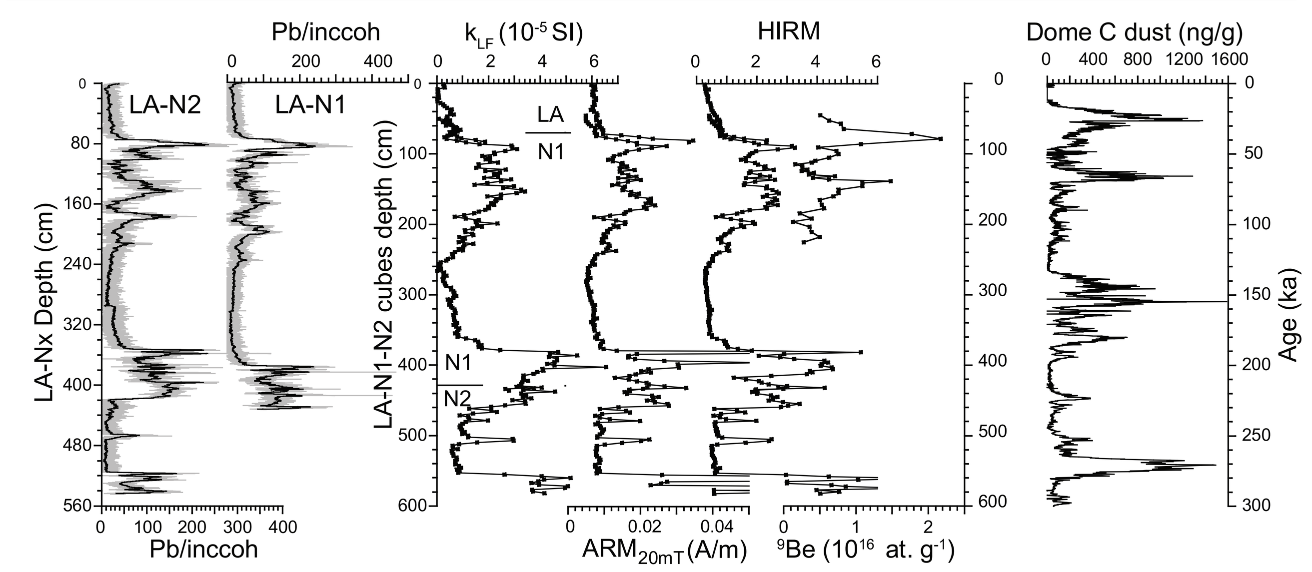


Dipole moment stack from marine sediments remanent magnetisation (GLOPIS; Laj et al, 2004) and beryllium (Simon et al, 2016), and Be flux at Antarctica EPICA Dome C (Raisbeck et al, 2007) can be used for paleomagnetic dating at the millennial-scale.



Radiocarbon (pink), optically-stimulated luminescence (OSL; blue) and Laschamp geomagnetic excursion (41 ka; black) contrain the chronology of the uppermost 2 m.

Detrital input and Southern Westerly winds



Selected proxies of detrital input in Lake Selina; Pb (local bedrock), magnetic susceptibility (k_{LF}) and anhysteretic remanent magnetisation (ARM) (ferrimagnetic content), mass proportion of high coercivity magnetic minerals (HIRM), and authigenic ^{9}Be (local runoff). Dust deposition at Antarctica EPICA Dome C (Lambert et al., 2008) is shown for comparison.

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