Holocene-scale lake sediment Pb records, a database and review

John F. Boyle[1], M. Moyle[1] and N. Dubois[2]

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The Human Traces (pastglobalchanges.org/human-traces) working group (WG) focuses on the long legacy of pre-Anthropocene human impacts, and how they manifest themselves in different parts of the world and in different types of stratigraphic records. The activities of the WG aim to address the knowledge gap concerning spatial and temporal variations in early human impacts on ecosystems, with the overarching goal to create a global synthesis of human traces in geologic archives. Following a presentation on Greenland ice-core Pb records by Professor Joe McConnell at an earlier Human Traces workshop (see McConnell et al. 2018), a discussion identified the need to link environmental archives more fully to address some specific questions about regionality of long-transported atmospheric Pb pollution. A Pb records sub-group was established with the aims of: 1) assembling long (Holocene) lake and peat sediment Pb records from around the world, for comparison with these high-resolution ice-core records, and to produce a database that will be of wider use to the paleocommunity, and 2) reviewing methodological approaches to collecting Pb sediment records.

A hybrid workshop was held on 20–21 September 2023 at the Department of Geography & Planning, University of Liverpool. Twelve individuals attended in person, with a further seven online. The primary aims of the workshop were to: 1) review records assembled by the participants, and choose regions for a global synthesis paper; 2) identify: data gaps, common narratives, significant periods and their spatial footprints, and factors influencing Pb distribution, and 3) develop papers on methodologies and grand challenges.

Global synthesis paper
Having identified a number of existing and potential long Pb records in peat and lake sediment archives across the globe (Fig. 1a), we discussed approaches to identifying regions for a global synthesis paper. We concluded that the two ideal approaches of identifying regions based on 1) statistical analysis of pattern, or 2) analysis of metallurgical historical/archaeology, were impractical. The former lacks sufficient data points, and the latter is of a complexity beyond the scope of a single paper. Instead, we agreed on regions based on the collective experience of the workshop participants (Fig. 1b). These regions were not given strict definitions, and we have subsequently decided

to use the IPCC region polygons, slightly modified to meet our needs by some splitting and merging.

The records identified at the meeting (N=192) clearly do not include all existing datasets. We continue to add sites as we find them and welcome suggestions. We have deliberately included regions that contain no sites. For these we can predict what patterns are expected, and can predict areas where suitable sites may occur. Each region in the global synthesis will receive just one page of figures and text. The figures will show a small number of sites, selected to be representative of the regions, and the text will offer a chronological account of the major features of the records, with reference to known historical and archaeological narratives. A short global summary will compare and contrast the regions, identifying major trends, information gaps and new research questions.

Methodological issues
A productive discussion was held about methodological issues such as appropriate analytical techniques (is scanning XRF sufficiently precise?), source identification by isotopes or by enrichment factors, whether fluxes or concertation data should be preferred, and approaches to variable chronological confidence. We concluded that the body of published records could have been more usefully combined had there been some agreed community standards in methodology and reporting. In response, we have decided to write a methods paper aimed at research students and early-career

researchers (ECRs), and cover the full process from site selection, choice of methods, data processing, and reporting standards, and have sketched out a plan for this paper.

Other outputs
The initial objective of the WG was to generate a community database of long Pb records (to be hosted by Neotoma), with an associated published description and analysis of the records found. This remains the primary planned output. The "Global Synthesis" and the "Methods" papers described above will supplement this work and provide a contribution to the wider research community of exceptional value. In addition to this, we recognize that a number of research pathways may arise from the new dataset. To reflect this, we decided to write a "Grand Challenges" paper, covering topics such as: distinguishing the impacts of historical empires on the ancient global Pb pollution signal; distinguishing mining from metallurgical signals; and separating the signal of Pb due to silver mining from later direct Pb mining.

AFFILIATIONS
[1]Department of Geography & Planning, University of Liverpool, UK
[2]EAWAG – Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland

CONTACT
John F. Boyle: jfb@liverpool.ac.uk

REFERENCES
McConnell JR et al. (2018) Proc Natl Acad Sci USA 115: 5726-5731

Figure 1: (A) Long Pb records in peat and lake sediment identified at the workshop. **(B)** Provisional regions for global synthesis.

B
1 Britain & Ireland
2 Scandinavia
3 Central Europe
4 Southeast Europe
5 Southwest Europe
6 Russia
7 Mediterranean Africa
8 Sub Saharan Africa
9 South Asia
10 East Asia
11 Southeast Asia
12 Southwest Asia
13 Oceania & Australia
14 Arctic North America
15 Eastern North America
16 Western North America
17 Caribbean
18 Central America
19 Amazonia
20 Northern Andes
21 Southern Andes
22 Eastern South America
23 Antarctica