FACULTY OF ARTS AND PHILOSOPHY

DEPARTMENT OF ARCHAEOLOGY

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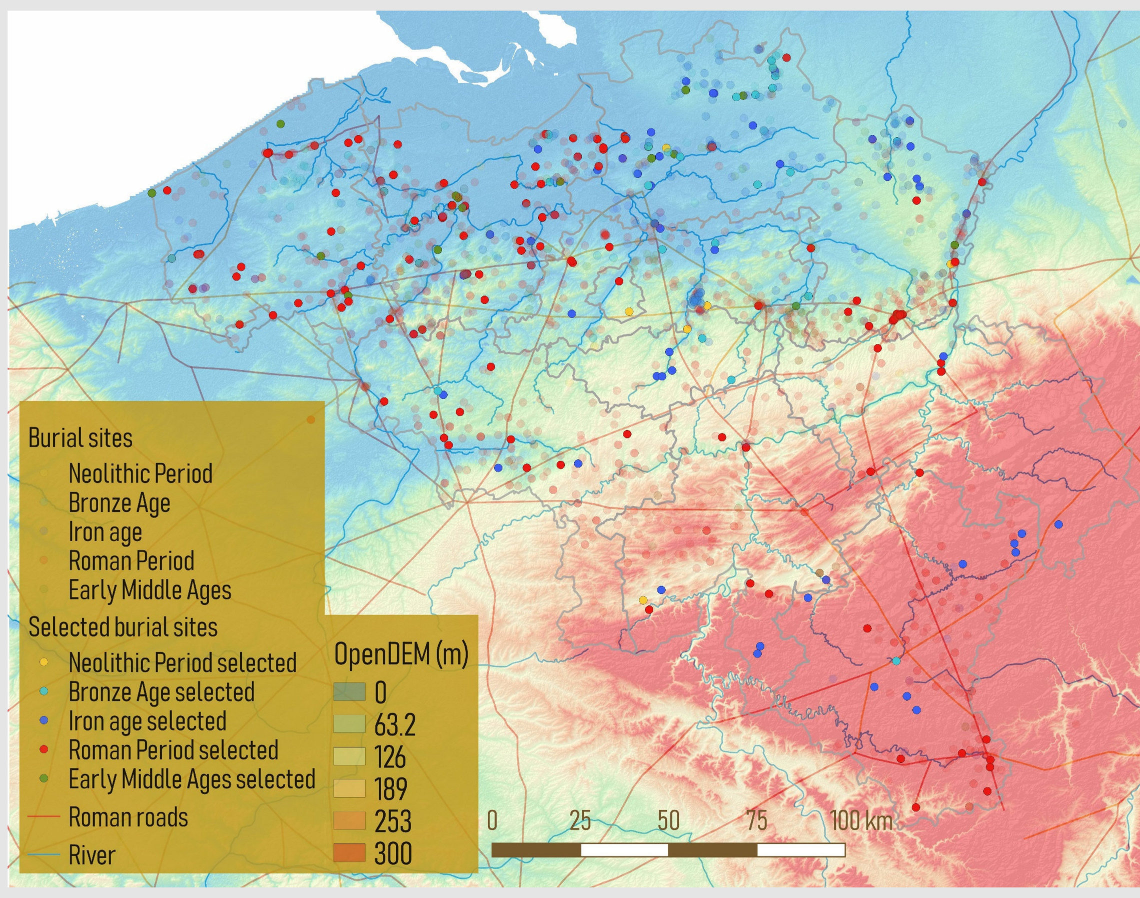
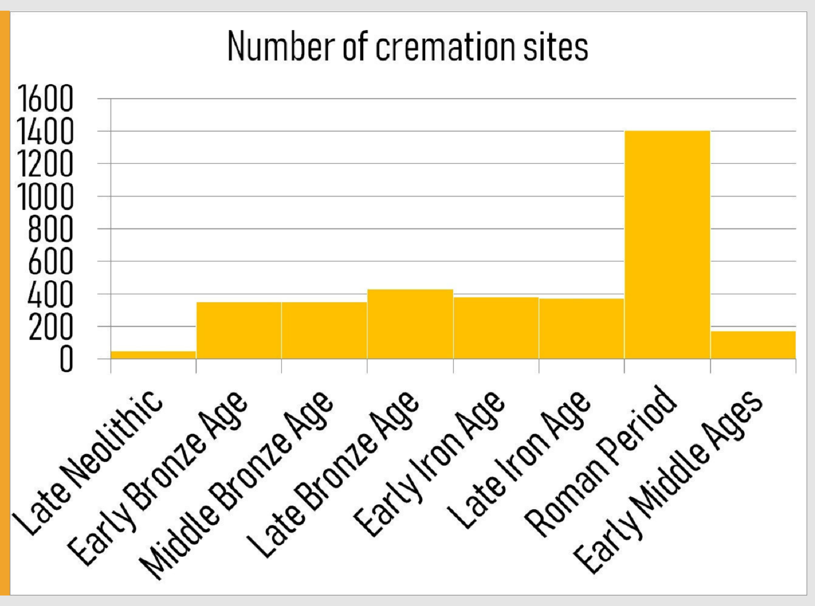
CREMATIONS, STRONTIUM AND RADIOCARBON: COMPUTATIONAL APPROACHES TO ANALYSE HUMAN MOBILITY IN PREHISTORIC BELGIUM

Depending on the underlying geology, different isotopes of the chemical element strontium are taken up by plants that grow there. When humans consume local crops or cattle, they take up the local strontium signal in their bone. Migrants will exhibit a non-local signal. By measuring the $^{87}Sr/^{86}Sr$ ratio in cremated human bone, the CRUMBEL project studies human mobility in Belgium. To study long-term mobility fluctuations, ^{14}C dating of bone is indispensable to establish an accurate chronology.



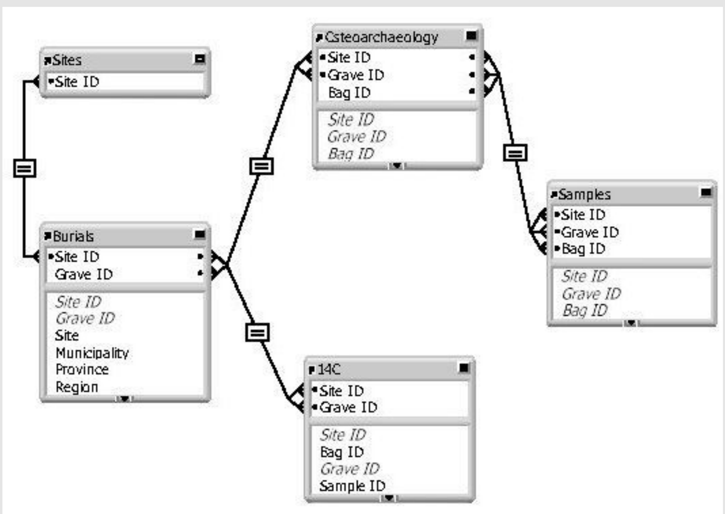
2200 burial sites are recorded in Belgium (transparent colours), of which the samples of 242 were found and selected to use in the project (highlighted colours).

The CRUMBEL project studies archaeological cremation sites in Belgium ranging from the Late Neolithic until the Early Medieval Period. Over 2200 burial sites are recorded. Of this, the finds collections of 465 sites proved to be accessible, of which the project selected over 200 cremation sites for sampling. Most available samples date from the Metal Ages and Roman Period.



1. Database, GIS and R as basic tools

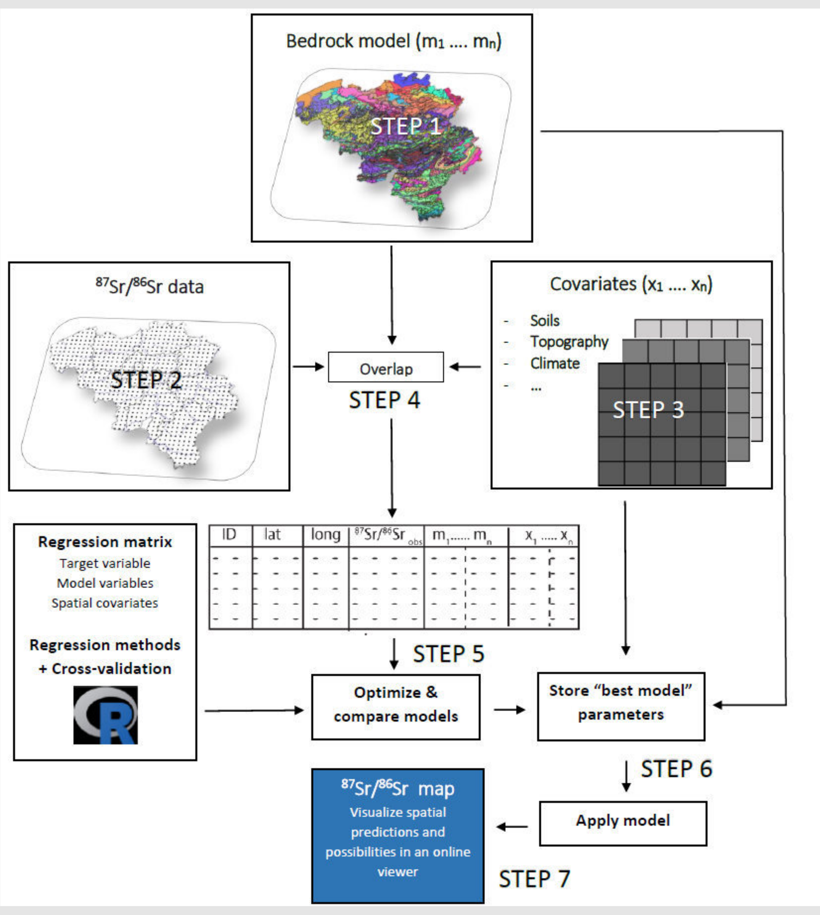
The database holds a large, layered dataset of 465 accessible burial sites containing 1 to 1100 individual cremation burials each. Multiple types of analysis and samples are linked to the individual burials (osteological, 14C-dating, Sr isotopes, light stable isotopes). Geographical coordinates linked to the sites make it possible to visualise the data in a GIS environment.



Simplified relational structure of the CRUMBEL database.

2. Geostatistics to create a Belgian strontium map

One main goal of the CRUMBEL project is to create a bioavailable strontium map of Belgium. This map will form the basis to interpret and to link the analysed individuals to certain locations. Different vegetation (grass, shrubs, and trees) of ca. 300 points in Belgium will be sampled to estimate the local $^{87}Sr/^{86}Sr$ signature of each area. In addition, different variables will be taken into account (geology, soil type, elevation, climate, etc.), which could influence the local $^{87}Sr/^{86}Sr$ signature. By combining all data using statistical analyses, a strontium map of Belgium will be generated.



Flowchart summarizing the workflow (after Bataille et al. 2018, 7).

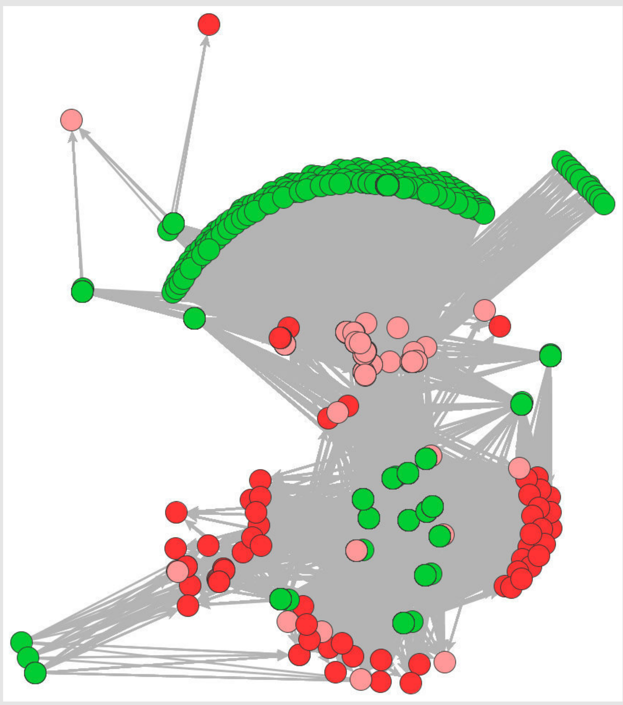
BATAILLE, C. P., VON HOLSTEIN, I. C., LAFFOON, J. E., WILLMES, M., LIU, X. M., & DAVIES, G. R. (2018). A bioavailable strontium isoscape for Western Europe: A machine learning approach. PloS one, 13(5), e0197386

3. Computational interpretation of the strontium results

During the project, several 1000's of individual strontium values will be produced. These near-big data make it impossible to analyse them in a qualitative way. Network analysis is being tested to process and interpret the data quantitatively. The methodology can prove valuable to:

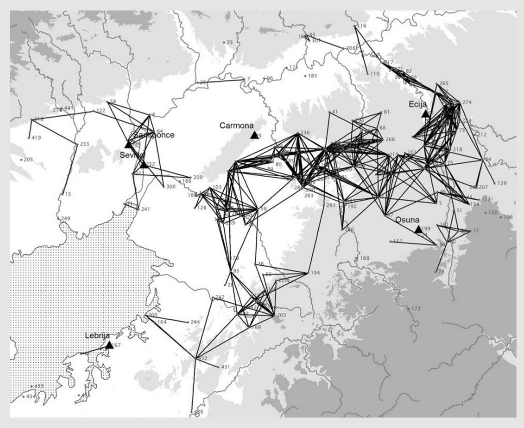
-automatically decide the most likely region of origin when multiple regions fall within the range

-look for patterns and clusters of connection in certain directions, shifts in certain periods (e.g.: are river-bound sites better connected than non-river-bound sites? Does this shift over time?)



First testing on a similar (British) Sr dataset. The regions with different Sr values are shown in green, red are the measured human Sr values.

BRETTELL ET AL. 2012; BUDD ET AL. 2001/2003/2004; CARVER ET AL. 2009; CHENERY ET AL. 2010/2011; ECKARDT ET AL. 2009/2015; EVANS ET AL. 2006; HEMER ET AL. 2013; JAY ET AL. 2013; LEACH ET AL. 2009; MÜLDNER ET AL. 2011/2013; MONTGOMERY ET AL. 2005/2009; POLLARD ET AL. 2011; POWELL ET AL. 2014; REDFERN ET AL. 2016; SHAW ET AL. 2016; SIMMONDS ET AL. 2008;
Published data derived from IsoArch.eu, May 6th, 2019.



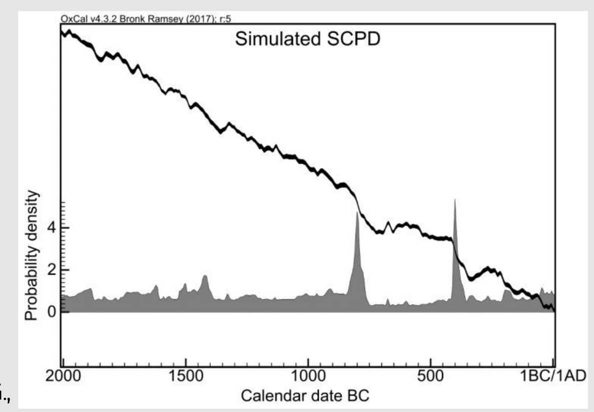
Example of a visibility network.

BRUGHMANS T., KEAY S., EARL G. (2015). Understanding Inter-settlement visibility in iron age and Roman Southern Spain with exponential random graph models for visibility networks, Archaeol Method Theory 22, p. 82, fig. 13.

4. Bayesian modelling of radiocarbon results

Radiocarbon dating helps in establishing the precise age of a cremation burial, especially in cases where typochronological dating is not possible. An existing 755 published Belgian ^{14}C dates will be supplemented by 600 more dates of selected burials. In order to visualize the temporal distribution of ^{14}C-dated cremations (i.e. the frequency), the summed calibrated probability distributions (SCPD) method is adopted.

Simulated SCPD (dark grey, same number of dates at each temporal bin) compared with the IntCal13 calibration curve (black). The peaks visible at the graph are a consequence of the calibration. Specifically, two main sharp peaks are visible at ca. 800 BC and at ca. 400 BC and do not reflect increased human activity (Reimer et al. 2013).



REIMER, P.J., BARD, E., BAYLISS, A., BECK, J.W., BLACKWELL, P.G., BRONK RAMSEY, C., BUCK, C.E., CHENG, H., EDWARDS, R.L., FRIEDRICH, M., GROOTES, P.M., GUILDERSON, T.P., HAFLIDASON, H., HAJDAS, I., HATTÉ, C., HEATON, T.J., HOFFMANN, D.L., HOGG, A.G., HUGHEN, K.A., KAISER, K.F., KROMER, B., MANNING, S.W., NIU, M., REIMER, R.W., RICHARDS, D.A., SCOTT, M.E., SOUTHON, J.R., STAFF, R.A., TURNEY, C.S.M. & VAN DER PLICHT, J. (2013). IntCal13 and Marine13 radiocarbon age calibration curves, 0–50,000 years cal BP. Radiocarbon, 55(4), pp. 1869-1887.

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