# GlobaLID: A new database and interactive web tool for provenancing archaeological metals

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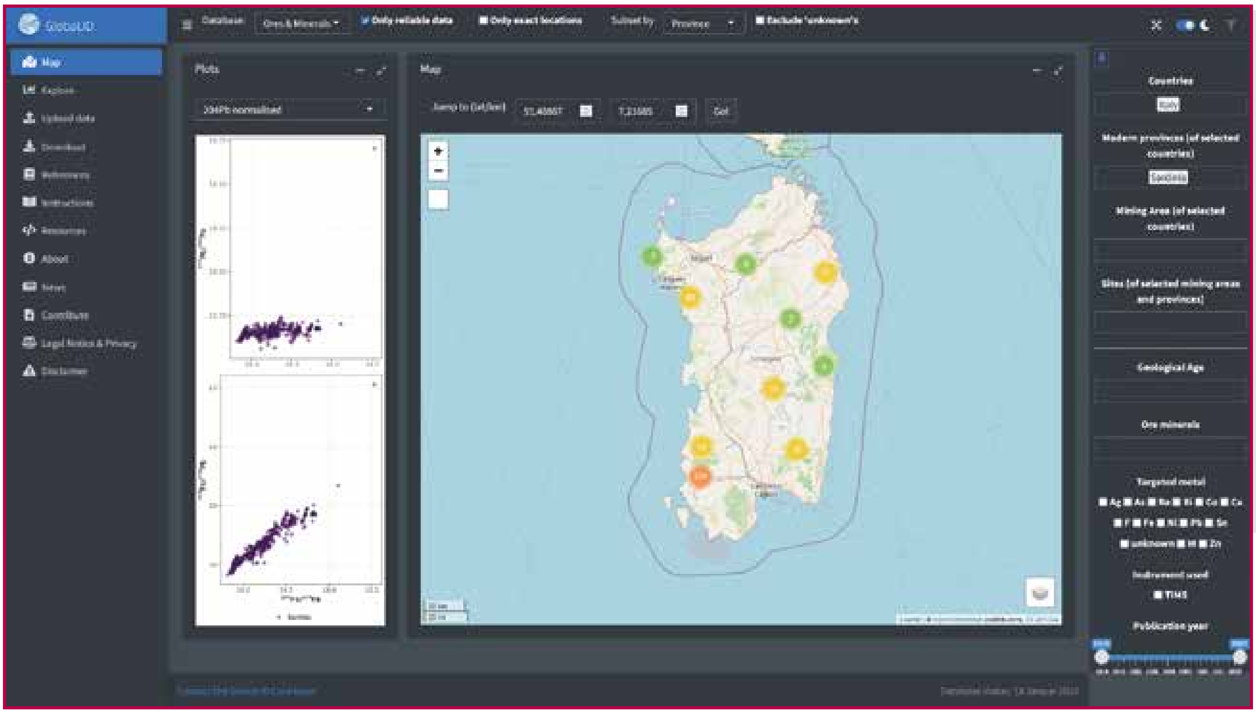


Lead isotopes are an everyday method to reconstruct the raw material origin of metal objects by comparison of sample data with reference data. Until this point, no global and open infrastructure exists that collects and provides access to such reference data. GlobaLID aims to provide such an infrastructure.

Reconstructing the raw material source of archaeological objects can provide valuable insights into past exchange networks. Usually a range of scientific methods like petrography, elemental analyses, and isotope analyses is used for this task. In most cases, the data of the archaeological materials are compared to reference data, i.e. data acquired from source materials than can be firmly linked to a geographic location, like metal ores of known deposits (Wilson and Pollard 2001).

For tracing sources of metal in copper, lead, and silver artifacts, the analysis of their lead isotope ratios is a standard method nowadays. Lead isotopes are a radiogenic isotope system and hence their ratios change with time. Formation of an ore deposit stops this clock because the radioactive parent isotopes are separated from the lead. Consequently no further radiogenic growth of lead can occur. Lead isotopes are thus an indicator for the formation ages of the ore deposits. Ores for archaeological metal artifacts usually contain traces of lead, which are incorporated into the finished products during the metalworking processes. The isotopic signature is not altered during smelting, allowing to directly link the metal to its ore. The latter is what makes lead isotopes particu-

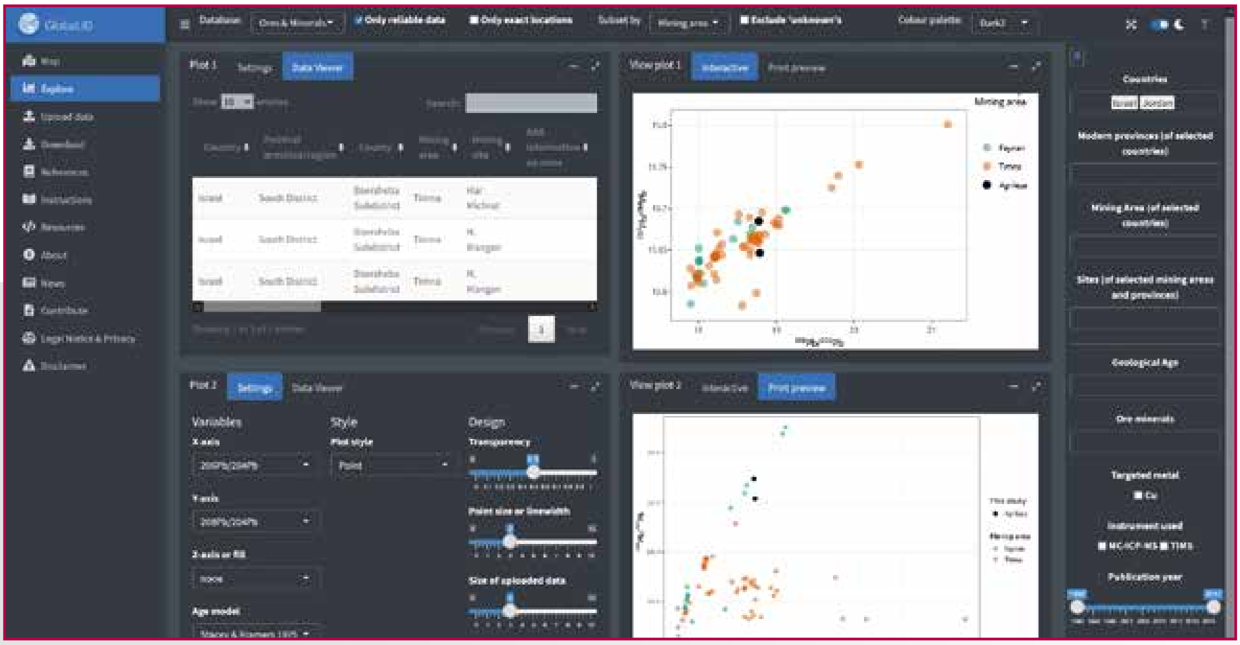

Fig. 2 - The plot area to create and customize plots and inspect data from the database more closely.

larly well suited for the raw material reconstruction (Killick et al. 2020).

An extensive reference database is indispensable for a successful reconstruction of the raw material origin using lead isotopes. If ore deposits are not represented in the database, either because they were not sampled, all ore was mined in the past or the mine is not recognised as such anymore, it will be impossible to link the metal object to this deposit. Another problem is that ore deposits can form at the same time and hence will have widely overlapping isotope signatures. Conversely, multiple ore-forming stages can occur in the same deposit and result in different lead isotope signatures for each stage. Hence, it is often necessary to include additional information in the database like the geology and mineralogy of the deposits or for which metal(s) it was exploited in the past (Baron et al. 2014).

Lead isotope reference data are currently scattered across publications of all kinds and vary in their quality and amount of additional information. Consequently, each group has to build its own reference database, facing in one way or another the same problems: (1) findability and accessibility of the respective publications, (2) comparability of the data and especially their meta-information, (3) and language barriers. Moreover, the published lists are necessarily static and therefore quickly become outdated.

It was more than 20 years ago that the Oxford group made a first attempt to overcome at least the first obstacle by publishing their reference database OXALID in open access (Stos-Gale and Gale 2009). It gained wide popularity over the years because it was only until the last couple of years that similar databases became available (e. g. Artioli et al. 2016; García de Madinabeitia et al. 2021). Nevertheless, a central repository for lead isotope data that would overcome all the above-listed obstacles and provide a common interface to lead isotope reference data is still missing.

GlobaLID aims not only to provide such a repository but also to design an infrastructure that facilitates the interaction with lead isotope data (Klein et al. 2022). The Global Lead Isotope Database (https://globalid.dmt-lb.de/) consists of two parts: a database (Westner et al. 2021) and an interactive web application (GlobaLID Core Team 2021). The database is the core of GlobaLID. It stores all the reference data, their meta-information and the original reference of the publication it is taken from. A lot of effort is made to harmonise the additional information (e.g. reconstruction of geographical locations) and to ensure that all data are available in the highest possible quality. The second part is an interactive web application (Fig. 1) that allows an easy

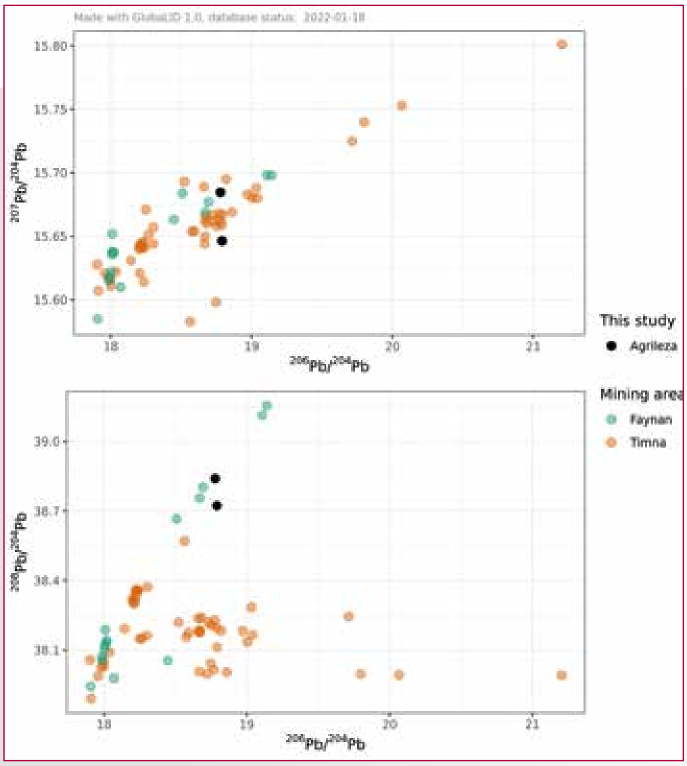


Fig. 3 - Example plots exported from the GlobaLID web application.

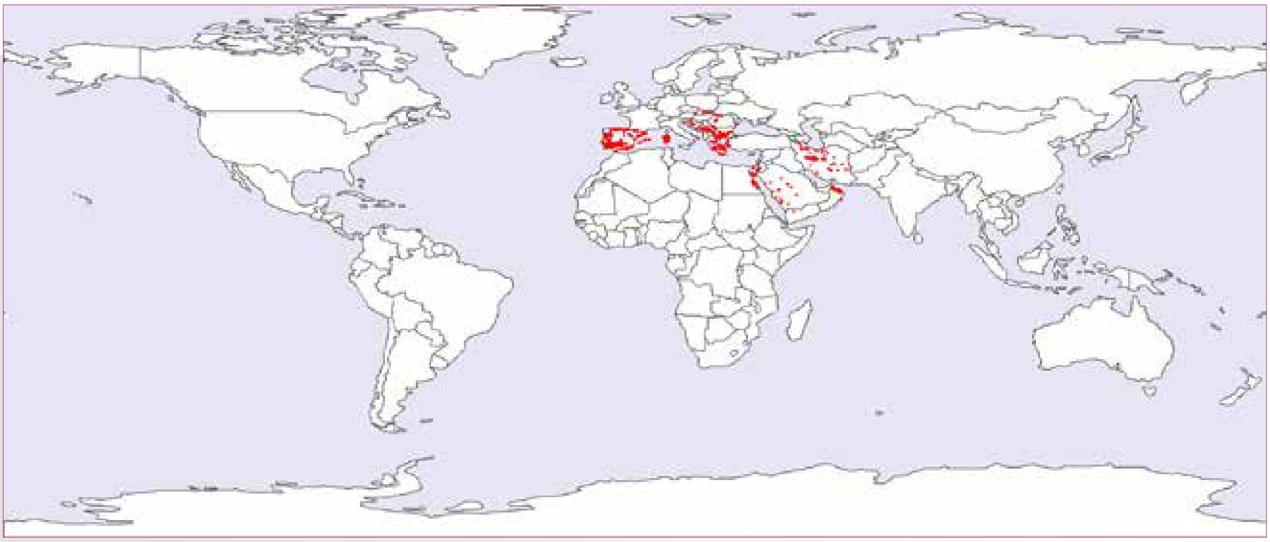

**Fig. 4 - The current coverage of the GlobaLID web application.**

access to the database through a web browser and to compare one's own data with the database (Fig. 2). The functionality of the web application includes the most common tasks in raw material reconstructions with lead isotope data: various filters to interact with the database; a map to inspect the geolocations; various plotting options (e. g. histograms, density estimates, scatter plots) with different axes (lead isotope ratios, parameters of different lead isotope age models); customisation of the plots; download of publication-ready plots (Fig. 3), the references from which the data in the respective plot is taken from, and of the reference data itself. The interface of the web application was kept intentionally simple to provide easy access for all users, including researchers without detailed knowledge in lead isotope geochemistry. The database can also be downloaded and used independently from the web application to e. g. carry out more advanced data analyses than currently possible with the web application.

Database and web application are published in open access and open source and are free to use without a registration. Both are under constant development to include more reference data (Fig. 4), to design them closer to the needs and expectations of the users, and to include additional features. Stable versions of the database (published with a DOI) are further available in a certified repository (Westner et al. 2021) while all working versions are available on the Github pages of the database (https://github.com/archmetalDBM/GlobaLID-database) and web application (https://github.com/archmetalDBM/GlobaLID-App).

The aim of GlobaLID cannot be reached without the support of the community (Klein et al. 2022). A high quality of the reference data can only be achieved with expertise in different scientific disciplines such as ore geology, mineralogy, and isotope geochemistry. Of particular importance is the contribution from local experts who specialize in ore deposit geologies of certain regions. Additionally, the core team neither has access to all lead isotope publication nor can it read all non-English publications. Hence, the web application also includes the option to upload data for the database. These data will be checked for their consistency by the core team and enriched with additional meta-information before being made available in the database. Each contributor is mentioned in the web application and wherever possible.

Similarly, everybody is invited to get involved in the development of the web application by providing feedback, suggesting features etc. on its GitHub page – the web application can only be as good as it meets the needs of its users and we are firmly committed to make it as good as possible.


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## Abstract

*Lead isotope signatures of non-ferrous metals are a well-established approach to tracing ore sources, which can provide important information to reconstruct past exchange networks. Like many other provenancing methods, the usefulness of lead isotopes in provenance studies relies heavily on a comprehensive reference database. GlobaLID aims to provide an infrastructure for a central storage of lead isotope data. It consists of a comprehensively evaluated database with extensive geological and contextual information and of a web application that provides an intuitive interface to interact with the database, options for comparison with own sample data, and to design and download publication-ready lead isotope plots.*



## Parole chiave

Lead isotopes; exchange networks; archaeometallurgy; provenance; open access



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