# SECONDARY RESOURCES DATABASE: THE DEMISE OF THE CONCEPT “RESIDUE”

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## Introduction

The return of residual fractions of metal production into the value chain enhances the circularity of our economy. Additionally, the use of these residues instead of virgin materials often results in lower $CO_2$ emissions. These streams, for instance, can contain a higher amount of interesting metals than ores that are currently excavated or can be used as reactive or non-reactive fraction in construction materials (*e.g.* the substitution of Portland cement by copper slag[1]). Digitalisation boosts the efficiency of progress and therefore Europe’s and Flanders’ research agenda also push towards this aspect in the fields of sustainable development and circular economy. A first step towards this direction is the construction of a database, a central “one-stop” point in the collection of characterisation data and in the behaviour of such materials when used in other processes.

Efforts towards digitalisation have been seen in other fields. Databases with the characterisation of materials are for instance available for pure minerals (rruff.info[2]) and proteins (www.rcsb.org[3]). Most of these arise from the efforts of one research team, which constructed and curates the database. Other initiatives are top-down, where a strategic choice has been made at a political level. An example of such an initiative is the Materials Genome Initiative[4], launched during the Obama presidency and maintained by the National Institute of Standards and Technology (NIST). A multitude of other initiatives are taking place, *e.g.* the region of Flanders invested in setting up a platform for big data gathering.[5]

This paper communicates the progress on the earlier presented software tool[6] to collect data on materials that are currently seen as residues: The Secondary Resources Database (SReDat). The details of the categorisation are provided as well as some examples of datasets. The broader picture is given, the Secondary Resource galaxy (SReWay), where the data is valorised and calculation tools are available. Future developments include coupling the residues to processing routes with an estimation of the outcome, for instance, the compressive strength evolution after adding sodium silicate solution to lead slag.

## SReWay environment

The SReWay is an online platform which is free and can be accessed through sreway.info. The SReWay galaxy contains different modules, including the Secondary Resource Database (SReDat), high temperature treatment tools, low temperature treatment tools and calculation tools. The SReDat categorises residues, acts as a central pool of characterisation data and provides an identity for the residue. This module is discussed in more detail in the next sections, as this is currently fully functional. The high temperature treatment tools will take a residue from the database and transform its characteristics. This can consider the calculation of the viscosity of a melt and resulting glass fraction, mineralogy or connectivity of the resulting glass network. The low temperature modules digitally synthesise a paste or concrete from a residue in the SReDat or a residue that underwent treatment in the high temperature module and estimates its properties. These calculations are empirical, based on input from users. Support calculations that do not need the database for providing accurate results are also included in the SReWay. The environmental impact or $CO_2$ footprint can be calculated based on previous work[1] and similar algorithms are provided to estimate the cost of a certain mixture. On top of these, calculations can be made to transform wt% in molar ratio of a mixture, from wanted molar ratios to the amount of g to mix and other easy, but usually time-consuming computations. These can be performed on a smartphone in the lab to lose even less time doing trivial calculations.

## SReDat data handling strategy

When uploading a resource, the user has to provide some information in order to be able to find the relevant data when doing a search. The type of resource (slag/sludge/ore…), industry of origin (copper/steel/lead…) and chemical composition for instance have to be filled in before a residue can be uploaded. Other sections encompass location, history and experimental results, such as X-ray diffraction, infrared/Raman/Mössbauer spectroscopy (a full overview can be retrieved in the example residue discussed in the next section).

Every person can upload data after registering online. Efforts will be performed to curate the database; low quality data can be deleted and low quality uploaders blocked. As such, a more critically assessed database is composed from the high quality data.

## Case study: Synthetic non-ferrous metallurgy slag

The SReDat functionality is demonstrated by the example of a synthetic slag, which was made to replicate a secondary non-ferrous metallurgy slag (the reader can follow the procedure on https://www.sreway.info/sredat). The search is started in a window as in Figure 1. The resource type can be defined in a drop-down menu (slag, ore, sludge…), a specific name or location can be search, or a search can be made for a residue with a certain chemistry. For the example, search for a "Resource Type", "Slag" and indicate that Fe and Si have to be included in the material.

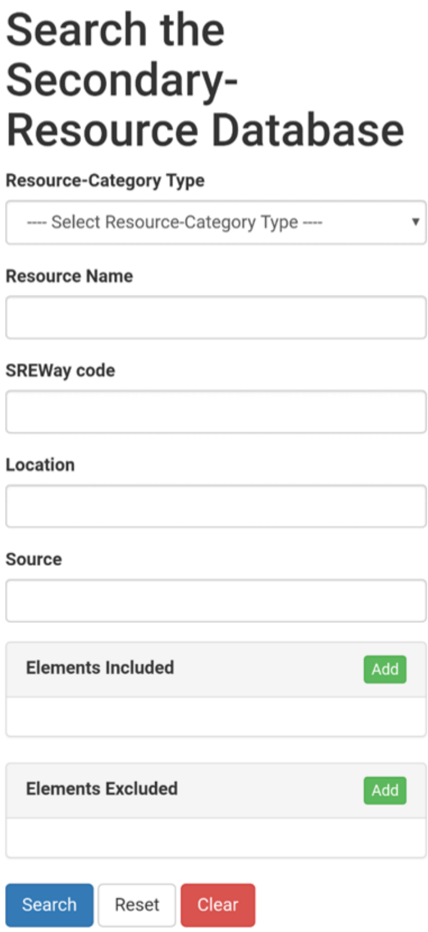


**Figure 1:** Search input window of the SReDat

When the "Search" button is clicked, the corresponding residues in the database are listed and the user can click on the name of her/his linking. The example follows the residue "Metamix 2016". In the database, all available information on this particular batch of non-ferrous metallurgy slag is listed. Figure 2 for instance shows the quantitative X-ray diffraction and Fourier transform infrared spectroscopy spectrum as shown online.

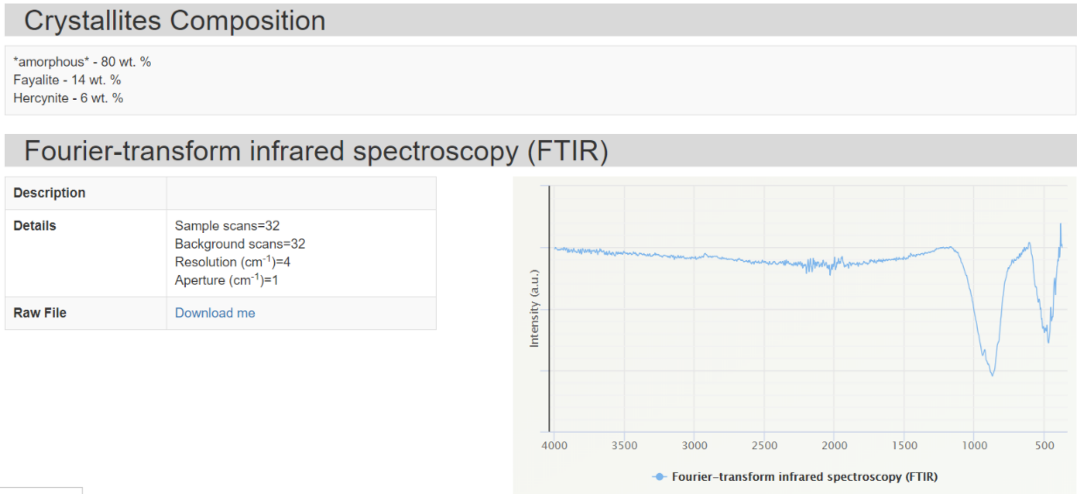


**Figure 2:** Example experimental data: The mineralogical composition ("Crystallites Composition") from X-ray diffraction and the Fourier transform infrared spectrum

## The way forward

The Secondary Resources Database is the starting point. The predictive power that will come from coupling the stored residues with processing steps and resulting products and properties is the final aim. While the environment is created to achieve this coupling and the tools described in this paper are developed, the search for partnerships to fill the database is essential for achieving our goals.

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