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A preliminary bioavailable strontium isotope soil map of Europe.

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The GEMAS project collected samples from grazing land (n=2118, 0-20cm depth) and agricultural soil (n=2211, 0-10cm depth) at a scale of 1 site/2500km^2 in most of Europe[1]. Elemental analysis using different extractions (Aqua Regia and MMI), whole soil XRF data and Q-ICPMS lead isotope data have been published[1].

Here we report high-precision $^{87}Sr/^{86}Sr$ results for the first 1000+ samples. To best represent Sr in plants and animals an ammonium nitrate soil extraction was chosen[2]. Samples were measured in three laboratories and shared QC samples demonstrated the robustness of the complete extraction and measurement protocol. Observed $^{87}Sr/^{86}Sr$ values range from 0.7038 to 0.7597 with the majority of samples centring about the median of 0.7092.

Spatial interpolation of the data shows some major trends over Europe with high $^{87}Sr/^{86}Sr$ in known old intrusive terrains in Scandinavia, Iberia and the Alps. To improve the spatial resolution we investigated relations between measured $^{87}Sr/^{86}Sr$ values and other parameters for which higher spatial density (interpolated) data exists in geological and lithological databases like IGME5000[3] and GLiM[4]. For each sampling site matching geological age data and lithology were obtained by overlaying sampling locations on the IGME5000 and GLiM maps and extracting age and lithology information. All statistical and geospatial manipulations were performed using the R statistical package.

Overall the $^{87}Sr/^{86}Sr$ values show a moderate correlation (Pearson R=0.54) with age but demonstrate varying homogeneity in different lithological units. Within the GEMAS dataset the strontium isotope ratios correlate most strongly with the lead isotope results, $^{206}Pb/^{208}Pb$ (R=0.56) indicating a combined age and "crustalinity" effect. Whole soil Rb (XRF) is slightly higher correlated (R=0.26) with $^{87}Sr/^{86}Sr$ than extracted Rb (AR) at R=0.12 indicating some influence of the long term Rb signal in the soil parent material.

Sodium is the highest correlated whole soil (XRF) element (R=0.33), which initially might hint at the influence of seaspray as it is often hypothesized that seaspray is a major source of $^{87}Sr/^{86}Sr$ variation in coastal regions. To test this hypothesis the distances to the coast in the major north-westerly wind direction in Europe and the shortest distance to any coast were calculated. Neither distance measure provided any significant correlation with $^{87}Sr/^{86}Sr$ values, indicating that the cause of the Na-Sr correlation is not likely to be seaspray, which would agree with poor correlation with presumably mobile Na in the Aqua Regia extracts.

In concordance with observations of other authors[5] modeling accuracy is improved by creating separate models for contrasting lithologies; igneous, marine limestones and other types. Igneous parent material provided the most convincing model using parameters like age, Rb/Sr ratio and $^{206}Pb/^{208}Pb$. Attempts to model $^{87}Sr/^{86}Sr$ of soil on marine limestones with the LOWESS version 3[6] $^{87}Sr/^{86}Sr$ vs. age curve were not convincing although some pattern similarity could be observed. Uranium and sodium content combined with pH are reasonable predictors of $^{87}Sr/^{86}Sr$ in soils on marine limestone parent material. The $^{87}Sr/^{86}Sr$ dataset with coordinates and models will be available from the main author after publication later in 2017.

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