A geoforensic comparison of physical and chemical analysis of soils from the Plateau region of Switzerland

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Introduction

The aim of this study was to discuss the physical and chemical properties and differences of soils collected in the Western Swiss lowland.
To link that geological problem to a forensic question, it was decided to sample the soils as if they were part of a criminal investigation.

Methods

Dr. P. Bull and his team use in the University of Oxford a method based on the observation with SEM (Scanning Electron Microscope) of the features of the quartz grains present in the soil to differentiate between various geographical locations in England. This method was proven to work at a national and even at a regional scale.
Moreover, geochemical techniques, such as XRF and LA-ICP-MS (X-ray Fluorescence and Laser-Ablation Inductive-Coupled Plasma Mass Spectrometry, respectively) were also performed on the soil samples for the same reasons. Both methods will be evaluated in such a complex and homogeneous geological context.

Western Swiss Geology

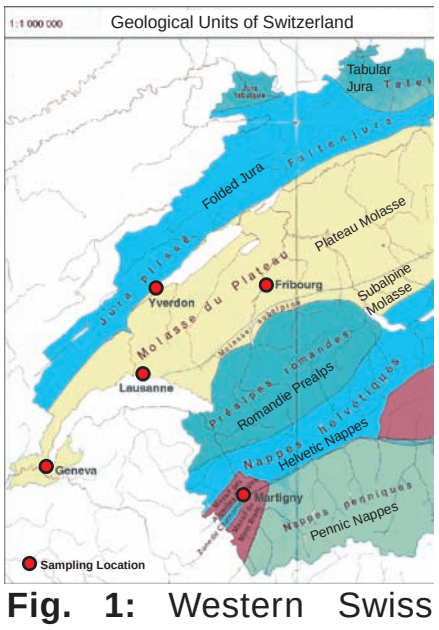

Fig. 1: Western Swiss Geology

The main geological units of Western Switzerland are presented on figure 1. The main part of the country is on the Swiss lowland, which is very homogeneous geologically and composed of various sandstones resulting from the erosion of the Early Alps. The soils of this homogeneous region were chosen to be sampled to evaluate physical and chemical methods.

Sampling procedure

Five different locations (Martigny, Geneva, Lausanne, Yverdon and Fribourg; Fig 1) were first defined as sites in which a dead body could be dropped discretely, which implied: 1. proximity of an important city (in which the fake crime would have been committed); 2. absence of built area, absence of lights; 3. proximity of a road; and 4. proximity of water (river, lake, pond).

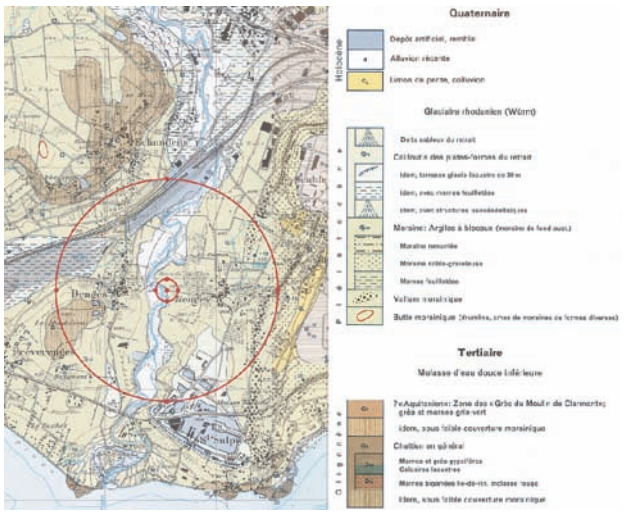

Fig. 2: Example of sampling procedure for Lausanne. 0, 1 and 10 m are represented by the single central point

The sampling if the soils was made on the field as follows: after having defined a fake "dropping" site, the soil of that site was collected and defined as the "source". Then, one soil sample was taken at 1 m North from the "source". Moreover, three times four samples were collected North, East, South, and West, respectively at 10m, 100m and 1km from the "source" (Fig. 2). Such a sampling procedure was reproduced on each site, hence preventing any preferential relation with the geology or the geography in presence.

Results

The SEM results are very interesting and the different provenance of the Swiss lowland soils are distinguishable with the help of statistical programs (SPSS). The groups resulting from a discriminant analysis are shown on figure 3A. Even if the geology of the Swiss lowland was very homogeneous between the four cities of the Molassic Plateau a description of the features of the quartz sand grains present in the samples induced a good separation.

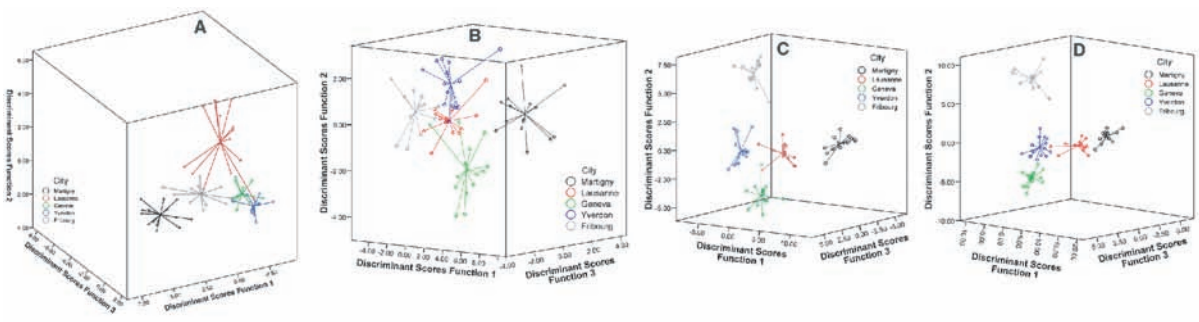

Fig. 3: 3D representations of the soil samples from each locations resulting from a discriminant analysis. **A:** SEM, **B:** XRF; **C:** LA-ICP-MS; **D:** both chemical methods (XRF and LA-ICP-MS)

The chemical analyses were first done with XRF to measure the major chemical elements, which do not show much variation in such an homogeneous environment. However, a partial separation resulted of this method (Fig. 3B). All the minor elements and traces were then analysed with LA-ICP-MS. This method induced a good separation of the different sites (Fig. 3C). Finally, the best separation between the different sampling locations is shown on figure 3D, which groups all the chemical data obtained by XRF and LA-ICP-MS; this separation is obviously amazing.

Conclusions

It is now proved than, even in the worse geological environment - a very homogeneous sandstone lowland - it is possible to distinguish between several soil traces provenance with physical and/or chemical analyses. These results now have to be used by the Police Forces because they can be used to exclude suspects from a crime they did not commit.