NEXT
New Exploration Technologies

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NEXT produces a novel software to process data obtained from handheld devices for mineral prospectivity mapping

In this article, we invited Jean Cauzid, Assistant Lecturer at the University of Lorraine to **explain about the purpose and functionality of a set of novel handheld devices for mineral prospectivity analysis** which have been developed in the EU funded Horizon2020 New Exploration Technologies (NEXT) project.

How would you describe the general purpose of handheld or portable devices in the domain of mineral prospectivity mapping?

Already for several years now, manufacturers have been designing tools for producing chemical analyses outside of the laboratory environment. In reality, these devices are equivalent to the tools that are typically used inside the laboratory. However, they are downsized, autonomous in energy and their use is simplified so that only a limited knowledge of the physics on which they rely is required on the part of the operator.

They often look like fat guns and are known as “handheld” or “portable” devices. Each device is capable of providing a limited amount of information for two reasons. To start with, their use is simplified to be fit-for-purpose to non-expert operators. As a consequence, no fine tuning of the analytical conditions nor extensive signal interpretation can be performed. The second reason is that a single tool cannot provide a full characterization of a sample. Even in the lab, one has to run several experiments on several devices to obtain a comprehensive set of data.

On the other hand, these handheld devices present several interesting features. They are cheap compared to their lab equivalents; they are designed to be run by non-specialists and are capable of producing data of an incredibly good quality. In fact, much more information can be extracted from the obtained data compared to what is usually arrived at in a laboratory set-up. This is not due to a lack of effort on the part of the manufacturers, it is due to the way these handheld devices are supposed to be used: by a non-expert, on a large range of possible applications and without input from other techniques.

Could you tell us more about the specific aims of your new software solution in the NEXT project?

Our aim is to extract the most from these tools by combining the data measured by the handheld devices in a new software solution with the following considerations: the software should remain fit-for-purpose use by non-experts, and we wish this software to become available as freely as possible. Beyond these considerations, there are two constraints which are necessarily faced and shape the development of the software: first, several analytical techniques must be used jointly and second, the application will be restricted to a limited geological context. The challenge is to make the change from one geological context to a different geological context as easy as possible.

Which analytical techniques have you been focusing on?

Because of the fact that several analytical techniques need to be used jointly to produce a duly comprehensive data set, we have been working with no less than six analytical techniques. Each of these are available as portable tools and are labelled XRF, LIBS, XRD, Raman, FTIR and VNIR-SWIR.

Photos of the handheld devices we are using together with a brief description of the sample preparation requirements for each device and of the data these provide, are shown below.

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Olympus TERRA portable XRD

The sample has to be powdered to a grain size smaller than 150µm and then inserted in the slit in the middle of the case. This technique provides data on the nature of the crystallized solids.
(Photo YongHwi KIM)

Spectral Evolution SR6500 VNIR-SWIR spectrometer

The sample can be unprepared, freshly cut or powdered. This device provides data on minerals, mainly the hydrated species through the cation-OH vibration, carbonates, and some sulfates.
(Photo YongHwi KIM)

Thermofisher Niton Xl3t GOLDD+ XRF spectrometer

The sample can be unprepared, freshly cut or powdered. This device provides quantitative data on elemental concentrations from Magnesium to Uranium.
(Photo Jean Cauzid)

EnSPectr RaPort Raman spectrometer

The sample can be unprepared, freshly cut or powdered. Most minerals can be measured with this device, however with some lower detection limits compared to FTIR and VNIR-SWIR for some mineral species.
(Photo Marie-Camille Caumon)

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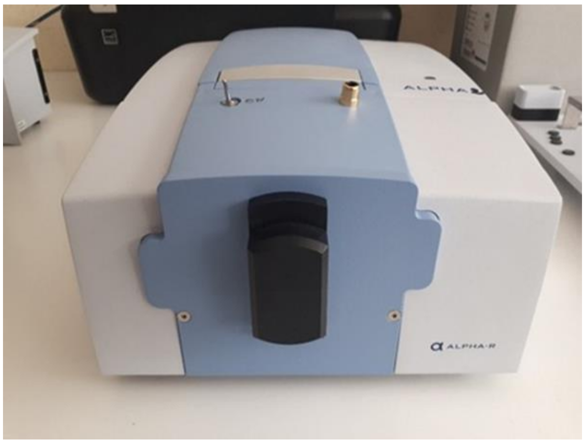
SciAps LIBS Z300 spectrometer

The sample can be unprepared or freshly cut. Powders are preferably pelletized before analysis. This device provides mainly qualitative data on all elements from Hydrogen to Uranium. Quantification can be attained via the measurement of standards and the building of calibration curves.
(Photo YongHwi KIM)

Bruker Bravo Raman spectrometer

The sample can be unprepared, freshly cut or powdered. Most minerals can be measured with this device, however with some lower detection limits compared to FTIR and VNIR-SWIR for some mineral species.
(Photo Marie-Camille CAUMON)



Bruker Alpha FTIR spectrometer

The sample can be unprepared, freshly cut or powdered. The front side of the device can be changed to access various modules of IR analyses. Most minerals can be measured with this device, which however remains sensitive to water content.
(Photo YongHwi KIM)

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This approach derives from the assumption that the strengths of one technique will address the weaknesses of the others. Errors and uncertainties from one analysis are reduced by the use of accurate values from another. In adopting this approach, it becomes clear that individual measurements complete, validate and sustain each other; which guides our entire efforts to be based on the concept of reconciliation.

With the first two techniques, we are analyzing the elements in the sample (silicon, iron, lead, etc.). With the other four techniques, we are analyzing the minerals (quartz, pyrite, dolomite…). Each mineral is made from a series of elements and rocks consist in assemblages of several minerals. Among these techniques, XRF only provides a quantitative analysis of a sample. Under some conditions, the other techniques can be made quantitative but the result from their portable version is not quantitative by default. Our approach is to obtain the list of the minerals in the sample from the four techniques and quantify the amount of each mineral from the XRF measurements. LIBS is there to address some constraints concerned with the elements which XRF cannot detect.

On which geological context have you been testing your new tools?

In NEXT, we focused on the Elvira deposit, a base polymetallic resource from the Iberian Pyrite Belt. A large portion of our work consisted in being sure that in Elvira, each mineral can be recognized without ambiguity with at least one of the four mineralogical techniques. This was done in parallel with the modeling of the Elvira deposit by colleague partners in the NEXT project. The latter enabled to obtain a listing of the minerals that can be found in Elvira which was not fully known at the beginning of the project. Consequently, we started working on automating the data extraction from the devices. It cannot be fully automated as all these devices are commercial and data extraction relies on a specific software, which is usually not open source. We also finalized the automatic identification of each mineral in a measurement point. Currently, we are working on the automation of the mineral quantification from the list of detected minerals and the XRF data.

How do you see the final product of your efforts and the commercialization prospects of the advances you have achieved?

The final product will be a software available as a free and open-source library that can be downloaded by the final users. However, in the process, we are creating a new space for commercial business as anybody skilled in analytical techniques will be able to advise final

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users, help them in choosing the best set of techniques and provide them with a software solution. All of this can be achieved without breaching manufacturer intellectual property.

Evidently, it should be borne in mind that the large knowledge gained and the advances achieved have been strictly in relation to the specific geological context of the Elvira deposit. Yet, we are highly confident that it will be possible to transfer the use of our new tools to additional geological contexts.

During a year of studies in Australia back in 1988, I decided to switch from environmental studies to mining. After helping local communities in Africa how to go about contracting new schools and wells for water supply as part of my National Service, I seized the opportunity to start a PhD. This involved getting myself into a synchrotron, a machine as big as a building. Surely not a coincidence that since then I have been lecturing on, and also searching for, ever smaller devices, trying to make analytical tools directly available to users who really need the data. I use all the skills I developed earlier: managing complexity as in environmental sciences, staying grounded as in mining, targeting the longer term as in a PhD and explaining things unusual to my audience as contracts in the bush."

Jean Cauzid is Assistant Lecturer at the University of Lorraine, France

More about NEXT: www.new-exploration.tech

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