Application note

Uranium and thorium exploration with handheld XRF

An Example from Nopal Project, northeast Mexico

Introduction

Uranium (U) is a rare element with an average concentration of 2.7 ppm on the earth's crust. In nature, it occurs mainly as U-238 (>99%) whereas U-235 (fissionable) makes up only about 0.7%. U-234 comprises less than 0.1% of natural uranium. The large size of the uranium atom tends to prevent it from entering into the early-crystallizing minerals in magmas. Hence, it is commonly concentrated in the final products of magma crystallization in silica-rich rocks such as granites (specifically, in the minerals found within granites such as zircon, sphene, and apatite). In such rocks, uranium may reach up to tens or even hundreds of ppm and form a mineral called uraninite or pitchblende (UO_2).

Uranium ore is mined in several ways: by open pit, underground, in-situ leaching, and borehole mining (using high pressure water jets). Low-grade uranium ore typically contains 0.01 to 0.25% uranium oxides (commonly reported as U_3O_8); however, some deposits have high concentrations of uranium—up to several percent. In nature, uranium occurs in a few deposit types, including unconformity-related deposits, Olympic Dam type deposits, sandstone deposits, quartz-pebble conglomerate deposits, surficial deposits (calcrete deposits), vein deposits, volcanic and caldera-related deposits, intrusive deposits, and metasomatite deposits.

Thorium (Th) is another naturally-occurring radioactive chemical element that is fissionable. It is about three to four times more abundant than uranium in the earth's crust (9.6 ppm), and it is chiefly refined from monazite sands as a by-product of extracting rare earth metals.

Handheld XRF Analyzers in Mining

Handheld XRF (HHXRF) analysis can deliver fast and accurate results with little or no sample preparation in various stages of mining activity, from grass roots exploration to exploitation, ore grade control, and even environmental investigations. A broad range of elements from magnesium (Mg) to uranium (U) can be analyzed using Thermo Scientific™ Niton™ Handheld XRF Analyzers. The high-power X-ray tube with dynamic current adjustment and silicon drift detectors in Niton XRF analyzers enable users to obtain low detection limits, high accuracy, and fast data acquisition times. When combined with a test stand, the analyzers can also be used in the lab on prepared samples. The analyzer results can be verified using certified reference materials, as shown in Figure 1.

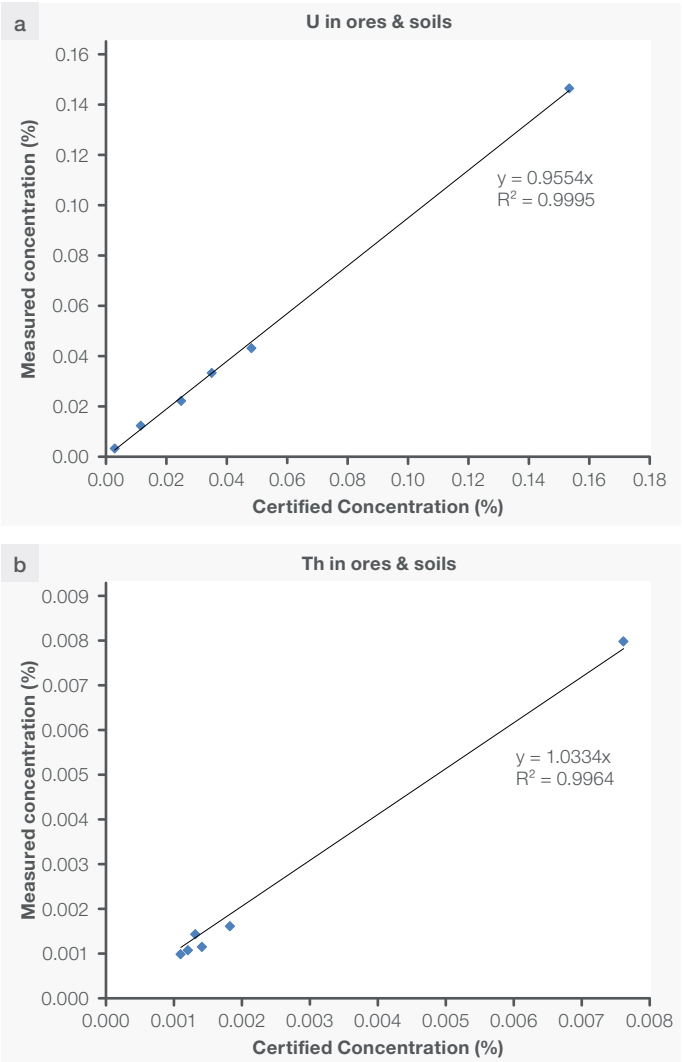

Figure 1. Verification of U and Th measurement accuracy on powdered ores and soil certified reference materials.

Method

This investigation was carried out in the Nopal area, northeast Mexico, by geologists from Servicio Geologico Mexicano (SGM). A total of 1,334 samples were analyzed systematically in 31 stations on 40 linear sections with 100 m spacing. The uranium content of each sample was measured by the radiometric method, by laboratory analysis, and by handheld XRF analysis on prepared samples. For the radiometric method, scintillometers were used. These instruments are commonly used for U-Th exploration, and some models can provide semi-quantitative data. The geochemical maps of uranium, based on these three methods, are shown in Figure 2.

Results

Figure 2 shows that there is significant overlap between the geochemical anomalies of uranium identified by lab analysis and HHXRF analysis. HHXRF analysis shows the same anomalies for Th as for U; laboratory data was not available for comparison. Although scintillometers are very effective tools for fast identification of radioactive samples, their data may not be as reliable as lab or HHXRF analyses because their U and Th anomalies do not overlap with those from lab or HHXRF analyses. Scintillometers can be more effective if used in conjunction with HHXRF in the field.

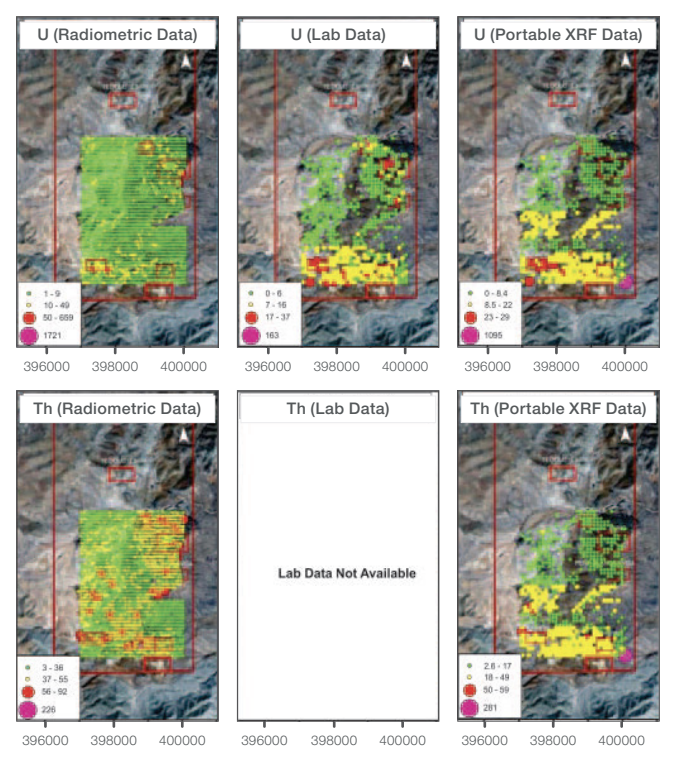

Figure 2. Geochemical map of U and Th measured by radiometry, lab, and field portable XRF.

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