On-site Elemental Analysis of Art and Artifacts

Art Conservation and Archaeometric Studies with Thermo Scientific Niton XL3t Series Handheld XRF Analyzers

Niton Analyzers – Lab-Quality Analysis in the Palm of Your Hand

With new advancements in technology, archaeometry is quickly becoming one of the most trusted methods in archaeological and museum studies. Whether your task is archaeological site survey, site mapping for excavation, conservation, or establishing provenance, quantitative chemical data has grown as the most sought after method to accomplish these project goals. Today, you have the ability to obtain quantitative elemental data in the field, in real time.

The ideal tool for these demanding jobs? The handheld Thermo Scientific Niton XL3t Series x-ray fluorescence (XRF) analyzer, now available with groundbreaking GOLDD technology. The low detection limits achievable with the new Niton® XL3t with GOLDD technology – plus light element analysis (Mg, Al, Si, P, S) without helium or vacuum purging – allow you to identify element concentrations at unprecedented low levels.

The Thermo Scientific Niton Solution

As the longtime industry leader in handheld XRF analysis, we have both the experience and expertise to provide you with handheld nondestructive testing solutions for art and artifacts in the field, in the lab, or on the museum wall. Combining advanced electronics, multiple primary filters for optimal sample excitation, and a 50kV x-ray tube – the most versatile x-ray tube ever used in a handheld XRF instrument – the Niton XL3t, the Niton XL3t GOLDD, and Niton XL3t 900 GOLDD with helium purge are in a class by themselves.

These essential tools have been engineered to take routine laboratory measurements into the field and change the fundamental way in which you do your research. With the ability to identify and quantify virtually any element from Mg through U in any sample, our analyzer is the ideal option for portable archaeometric analysis.

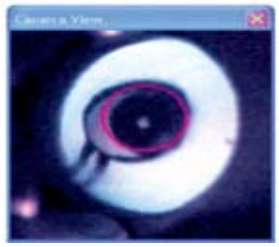


Figure 1: Eye feature on a painted object through the lens of the Niton analyzer CCD camera; 3 mm spot collimation allows you to isolate and analyze areas of interest.

Niton XL3t with GOLDD Technology Benefits At-a-Glance

- Integrated color CCD camera and sample imaging system to visually identify, locate, specify, and save the image of the analysis area together with XRF results (see Figure 1)
- Lower limits of detection – better trace element identification and quantification for better materials characterization, sourcing, and comparative studies
- Light element (Mg, Al, Si, P, and S) analysis without He or vacuum purge in alloys, lithic samples, and soils for the best characterization
- Numeric on-screen results with spectra for guidance in the field – spectra on screen and on PC
- Automatic parameter optimization – voltage and current adjust automatically based on sample and range of elements of interest for most accurate, repeatable results every time.
- Integrated Bluetooth™ and USB communications for direct data file transfer to your PC or networked storage device, or for connection to a GPS receiver for real-time archaeological site mapping

Archaeometry – A Field of Sample Types

- Clays and ceramics
- Soils
- Lithic materials
- Textiles
- Alloys
- Paintings/pigments/glazes
- Construction materials
- Clothing
- Bones, teeth
- Precious metals

Saving Time and Money with XRF

Cost/Sample:
- Lab: $600-$1200
- XRF: $0.5

Time:
- Lab, inside: 1 day
- Lab, outside: ~1 week
- XRF: 5 seconds to 6 minutes

The GOLDD Advantage

Where low detection limits and high precision are critical, our combination of hardware, software, and direct industry experience team up to provide you with a solution to your most difficult analytical requirements. GOLDD technology provides vast improvements in sensitivity and measurement times – as much as 10 times faster than conventional Si-PIN detectors, and up to 3 times more precise than conventional smaller silicon drift detectors (SDD). Our proprietary large area drift detector provides you with superior performance in the form of faster analysis and lower detection limits. The final product is the Niton XL3t with GOLDD technology – the most powerful and technologically advanced handheld XRF analyzer available today.

Unparalleled Improvement in LODs

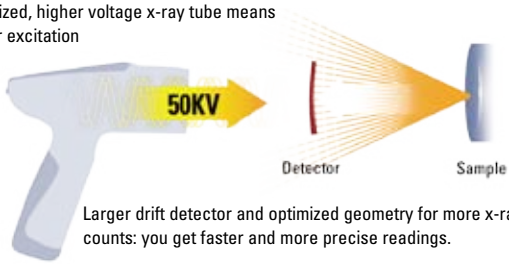
When it comes to performance testing, we decided to test against the best – ourselves. Figure 2 illustrates the across-the-board improvement in limits of detection[1] of the Niton XL3t 500 GOLDD in a head-to-head comparison against the Niton XLt 500 Series and the Niton XL3t 500.

The Right Tools for Your Analyzing Needs

Providing you with the right XRF tools for your analytical and budgetary requirements means offering you the widest range of options – powerful tools that will revolutionize the way you work.

By taking advantage of the standard Thermo Scientific Niton Data Transfer (NDT©) PC software suite to customize the instrument, you can set user permissions, create custom calibrations, or remotely monitor and operate the instrument hands-free from your PC. The NDT file format preserves and protects the data from each analysis, ensuring that it is not compromised.

Optimized, higher voltage x-ray tube means higher excitation



Larger drift detector and optimized geometry for more x-ray counts: you get faster and more precise readings.

Additionally, you can locate areas of interest on a sample using the integrated color CCD camera (standard on GOLDD models, optional on other models) and the optional integrated 3 mm small-spot collimation, and then store the test area image along with the analysis data. This helps you isolate small areas for analysis, providing valuable information about the chemical composition of a discrete section of the sample.

From the Field to the Museum Wall

Niton XL3t Series analyzers boast a broad variety of applications at the archaeological site, in the conservation lab, and even on the museum wall. Because our analyzers have been specifically engineered to provide superior archaeometric data, totally nondestructive analysis can be used for characterization of soil and in-situ site survey; paintings; pigments; ceramics; alloy objects such as statues, jewelry, silverware, and weaponry; NAGPRA compliance[2]; numismatics and other applications.

Further, when transporting samples is challenging or moving fragile objects is risky, you can bring the Niton XL3t analyzer to the site, the object, or the painting in question. By identifying elements without removing a painting from its frame or an object from its place of storage, you are reassured that your pieces can be examined safely, without the potential for physical damage.

Promise to Practice – XRF at Work

Archaeological Soils

By performing in-situ soil analysis at a site of suspected prehistoric or historic human activity, you can identify areas such as subsurface architectural features, hearth areas and fire pits, burial grounds, and much more based on trend analysis of the elemental composition of the soil[3]. This has been shown in certain buried architectural features by elevated (meaning above trend for the whole site) levels of calcium and strontium; in hearth areas and fire pits by elevated levels of K and Mg; and in burial grounds by elevated levels of P, Ca, and Sr, among other elements. Pairing a systematic sampling grid with a Bluetooth-equipped GPS device makes the reconnaissance survey and

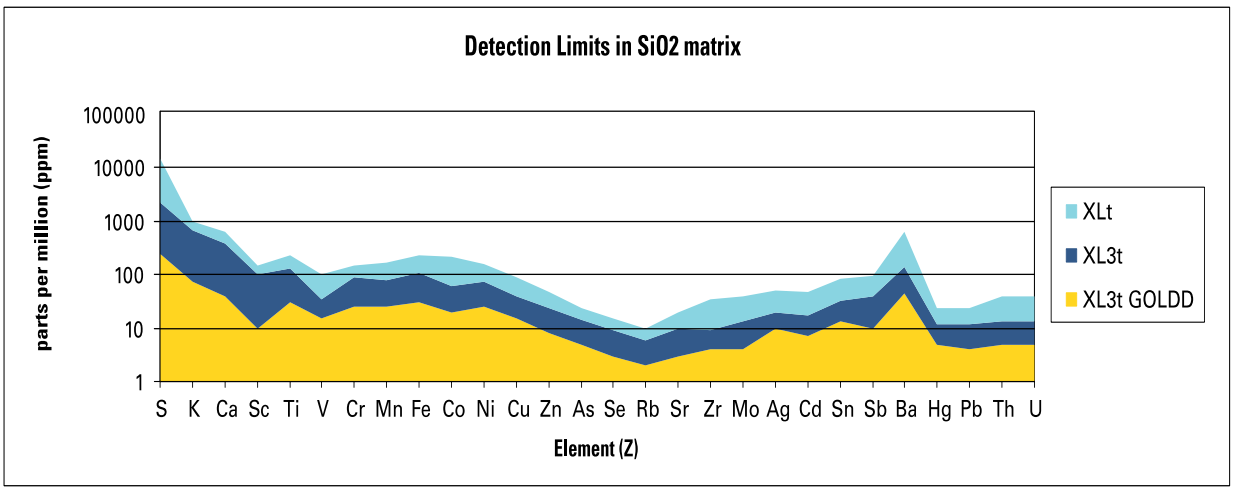


Figure 2. Instrument comparison data for LODs of various elements in an SiO_2 matrix. Note the greatly improved detection limits for the Niton XL3t GOLDD.

mapping process faster and easier than ever with direct storage of latitude, longitude, and altitude along with the reading results. Further, our optional telescoping Thermo Scientific Extend-a-Pole dramatically improves ergonomics and makes it possible for you to test the ground without ever bending down.

La Hacienda y Presidio de Bobocomari and U.S. Army Fort Wallen[4] – Our analyzer can be an invaluable tool for archaeological site survey, such as its use in helping to establish the location of the sites of Fort Wallen – dated from post-U.S. Civil War – and the Hacienda y Presidio de Bobocamari – dated from the Spanish Colonial period – near Sierra Vista, Arizona. Because of incomplete and conflicting documentation, the exact position of these sites was uncertain, though historic literature reported their locations as being the same.

Aerial imagery of the area and field inspection confirmed that the Fort and the Hacienda/Presidio were two separate sites located 14 miles west of the reported location(s) and were remarkably well preserved.

However, chemical evidence was required to establish the identity and uniqueness of each location. Historical evidence implied that there should be a significant difference between the archaeochemical and archaeogeophysical signatures of these sites.

For Phase I of the investigation, a series of Class I handheld Niton XRF surveys were made of each site. The surveys showed elevated P levels in an area of Fort Wallen, while P, Ca, and various metal concentration data at the Hacienda/Presidio site suggested living and activity areas within that site.

Phase II consisted of three investigation methods: resistivity, radiometrics, and XRF, collectively called the Combined Survey Format. The radiometrics showed a strong correlation with the soil chemical analysis done using our analyzer. Low values around the 5 meter mark correspond to an adobe wall. Higher values around the 11 meter mark correspond to a proposed plaza area. The Niton XRF instrument made it possible to simultaneously assay and analyze many elements at one time, facilitating correlative studies.

As shown in Figure 3, peaks or depressions in the abundance of elements of interest were interpreted for possible archaeological significance. The graph indicates a concentration peak of K at the 4 meter sample location; elevated levels of K have been associated with hearths and other features. The reading is suspected to indicate a buried feature, which is also suggested by the Combined Survey Format. Surface concentration of artifacts further supports this interpretation. Although excavation must confirm the activities at this location, possible areas of buried features were indicated without disturbing the site.

Museum Health and Safety, NAGPRA, Toxins

Until relatively recently, materials that we now know to be toxic – such as As and Hg – were used in museum conservation. These preservatives were used to preserve taxidermy specimens, cloth and leather artifacts, and others. Our analyzers allow you to test for such toxic elements quickly and nondestructively so that appropriate personal protective equipment can be used or an effort to clean the object of the toxic substances can be made.

Further, when repatriating items for NAGPRA compliance, our instruments are well-suited to measuring the residual Pb, As, and Hg, thereby allowing you to take suitable precautions for responsible repatriation.

Ceramics

XRF analysis of ceramic artifacts also boasts a variety of applications. Ceramic artifacts can be subjected to comparative study for sourcing and grouping based on elemental composition of the ceramic substrate; pigments and paints on ceramics can be analyzed for composition; inorganic residues found inside ceramic vessels can be analyzed to help determine how the object was used; and more.

El Hibeh Project[5] **–** As part of its geoarchaeological research program, the El Hibeh Project of the University of California, Berkeley, conducted field tests at the site of El Hibeh, northern Middle Egypt. The tests were done to assess the utility of using a handheld XRF unit, specifically a Thermo Scientific Niton analyzer, for obtaining geochemical analyses of pottery suitable for provenance and other ceramic classification studies. When the geochemical ceramic data from the field test were combined with basic petrographic analysis for the pottery sample set, compelling results were generated. In particular, a triangular scattergram

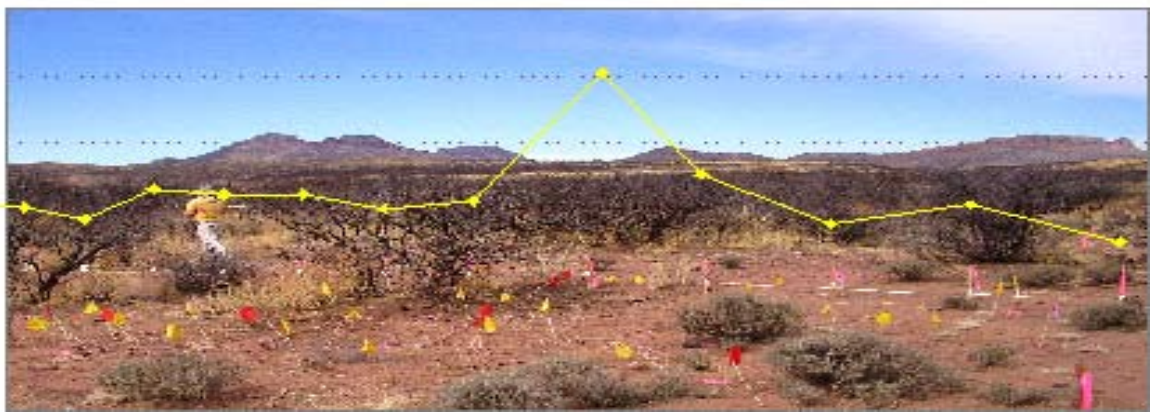


Figure 3: The XRF data were correlated to the survey lines. Here, the ppm values of K are visualized over the north survey line.

Caitlin O'Grady analyzes ceramic artifacts at the Arizona State Museum[6] conservation laboratory.

using elemental Fe, Sr, and Rb data (in parts per million) provided excellent temporal and spatial separation of ceramic fabrics type, origin, and date

Paintings

Our analyzers are the premier handheld XRF tools for paintings conservation. With the integrated CCD camera to see the exact area you are analyzing, the greatest precision, the unique capability of detecting and quantifying Ba, as well as the lowest published limits of detection for all elements, Niton XL3t analyzers excel in a variety of applications, including pre-treatment studies, authentication and forgery identification, and materials characterization. From characterizing the artist's palette to identifying previous conservation efforts before beginning treatment, Niton XL3t Series analyzers provide you with valuable information every step of the way.

Eastern Poland (Bieszczady Region) – An icon typical for the time period of the late 17th century was analyzed. The points marked by the numbers shown in Figure 4 indicate where spectra (Figure 5) were collected with a collimated system.

The Right Tools for Your Analyzing Needs

Thermo Scientific Niton XL3t analyzers are the most accurate and robust handheld XRF instruments we have ever offered for art conservation and archaeometric analysis. Our breakthrough instruments can be found serving the needs of some of the world's most important museums and most significant archaeological sites. We work closely with you, our customer, to create new solutions, or enhance existing ones, to ensure that we continue to deliver the groundbreaking technology you need to transform the way you conduct research. Thermo Scientific Niton XL3t analyzers, now with models featuring GOLDD technology – the ideal tools for in-situ chemical analysis of art and artifacts.

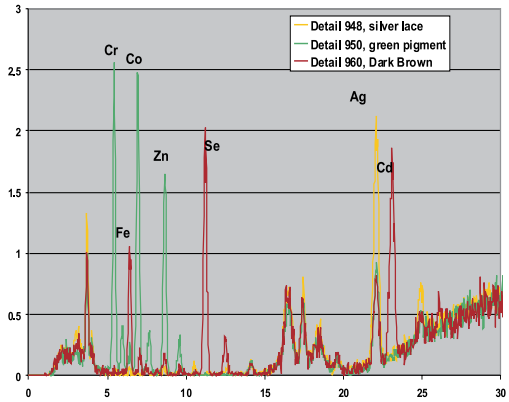


Figure 4 and 5: Spectra of three of the pigment colors on the icon. Composition of the green pigment (Cr, Co, and Zn), brown pigment (Fe and Se), and silver leaf (Ag), are clearly visible.

Notes

1. Limits of detection (LODs) are dependent on testing time, interferences/matrix, and level of statistical confidence. Ongoing research and advancements in our Niton XL3t, XLi, XLp, and XLt Series analyzers will lead to continual refinement of many of the values detailed in the tables. Contact a Thermo Fisher Scientific office, or your local Niton Analyzers representative for the latest performance or for specifications related to your application.

2. Native American Graves Protection and Repatriation Act, 25 U.S.C. 3001 et seq. [Nov. 16, 1990] (Final Regulations, 43 CFR 10 as amended and published in the Code of Federal Regulations October 1, 2003).

3. Dhaliwal, Muninder and Brackett, Claudia. The Use of X-ray Fluorescence (XRF) Technology to Aide Archaeological Investigations to Locate Evidence of Human Occupancy of Prehistoric Sites in Arizona.

4. We would like to thank Richard J. Lundin, director, Wondjina Reseach Institute, Sonora, Calif., and Claudia Brackett, associate professor, chemistry, and Muninder Dhaliwal, student, California State University - Stanislaus.

5. Morgenstein, Maury and Redmount, Carol A. "Using Portable Energy Dispersive X-ray Fluorescence (EDXRF) Analysis for On-site Study of Ceramic Sherds at El Hibeh, Egypt" Journal of Archaeological Science, 32 (2005), pp. 1613-1623.

6. We would like to thank Caitlin O'Grady, National Science Foundation Fellow in Archaeological Science; Teresa Moreno, assistant conservator; Nancy Odegaard, conservator and head of the Preservation Division, Arizona State museum, Univeristy of Arizona, Tucson, Ariz.

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All competitive references are based on an internal direct comparison of commercially available handheld XRF analyzers, July 2007.

N3 4-304 11/2008