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From Neutron Imaging to Neutron Activation Analysis: Neutrons in Cultural Heritage Applications

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The McClellan Nuclear Research Center (MNRC) is owned and operated by the University of California, Davis (UC Davis). MNRC's mission is to advance research and applications in the nuclear sciences, including educational and training opportunities for the next generation of nuclear scientists. The MNRC operates a 2 MW TRIGATM reactor, which is currently the highest power TRIGATM reactor in the United States. The MNRC reactor can also be pulsed to approximately 400 MW for 30 milliseconds. The MNRC was originally developed by the US Air Force to detect hidden defects in aircraft structures using neutron radiography. UC Davis took ownership of the reactor in the year 2000, following the closure of the McClellan Air Force Base. Today, MNRC continues to provide and expand the use of its unique neutron radiography capabilities while expanding its applications to various research disciplines. An overview of research at the MNRC will be shown in this presentation.
The Center offers the largest neutron radiography capability in the World: samples as large as 10.00 m long, 3.65 m high, and weighing up to 2,270 kg can be accommodated. Two of the four radiography bays are laboratory-size rooms where smaller samples can be inspected using both radiography and tomography. The maximum usable neutron beam size is 22-50 cm in diameter with intensities of approximately 1x105 n/cm2·s to 1x107 n/cm2·s, depending on the bay used. The highly collimated (L/D up to 350) neutron beams provide high spatial resolution and quality. Dynamic radiography can be taken at 30 frames/second; the film neutron radiography system can produce images with spatial resolutions of 50 µm; and MNRC's neutron tomography systems have an overall spatial resolution of approximately 200 µm.
In addition to neutron imaging, Neutron Activation Analysis (NAA) can be performed at the center. NAA is an analytical method for the determination of elemental concentrations in a material; it has good sensitivity for over 60 elements. The method is based on gamma spectroscopy after sample irradiation with neutrons in a reactor. The detection limits depend on the specific element and the available neutron flux; at MNRC they range from a few micrograms to less than a nanogram independent of the total sample weight. Due to its high achievable accuracy, NAA has recently been identified as a primary method, i.e., a standard method for the certification of reference materials.
Neutron imaging and NAA have already been used extensively in archeology and cultural heritage. Both techniques are non-destructive. Imaging artifacts, such as metal cast sculptures, allows determining their inner structure and how they were manufactured, which may also reveal knowledge transfer between different cultures.
NAA can be used in archeology to source artifacts, pottery and pigments. NAA analysis of the elemental composition of artifacts made of clay, for example, can provide invaluable knowledge about the geographical origin of the clay and can therefore reveal migration and trading routes.

Summary

We will present neutron imaging and neutron activation analysis based research opportunities at the McClellan Nuclear Research Center (MNRC)in the field of cultural heritage.
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