Strengthening International Partnerships in Nuclear Forensics through the Virtual Laboratory on Age Dating for Investigation Support (VLADIS)

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Abstract

The Virtual Laboratory on Age Dating for Investigation Support (VLADIS) is a consortium of nuclear forensics practitioners from Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), the Australian Nuclear Science and Technology Organisation (ANSTO) and the National Atomic Energy Commission of Argentina (CNEA). Launched in October 2020, VLADIS aims to create an online platform and discussion forum where age dating practitioners can learn from one another via presentations, sharing questions about radiochronometry (age dating) for nuclear forensics and building a network of cooperating practicing analysts. VLADIS is led and facilitated by nuclear forensics technical analysts from all participating laboratories, including experts in chemistry, mass spectrometry, data analysis and nuclear forensic signature evaluation. The project uses virtual platforms to provide organized, interactive, and collaborative content to enable a dialogue with the goal of an improved understanding of radiochronometric analyses of nuclear materials at ANSTO, CNEA, LANL, and LLNL. This forum aims to create an atmosphere where early career staff in particular can network and ask questions in an informal setting. This initiative is not meant to replace in-person visits and technical exchanges between laboratories. However, VLADIS will complement overall engagement between in-person meetings and is expected to continue after international travel resumes following the COVID-19 pandemic. The VLADIS initiative is being used as a pilot project for virtual information sharing, which could be redesigned for use with other partner countries to cover other topics beyond radiochronometry.

Introduction

The Virtual Laboratory on Age Dating for Investigation Support (VLADIS) is an online consortium of nuclear forensics practitioners. The goal for this initiative is to bring together nuclear forensic subject matter experts (SMEs) and new staff to discuss the latest developments in radiochronometry – or age dating – within the nuclear forensic community. This initiative was born out of LLNL and LANL's successful and long-running collaboration with ANSTO through the U.S. Department of Energy's Office of Nuclear Smuggling Detection and Deterrence (NSDD).

The Nuclear Forensics International Technical Working Group (ITWG) provides a set of guidelines that outline how to prepare nuclear materials, measure their model production ages, and interpret these ages in the context of a nuclear forensic investigation (ITWG (nf-itwg.org)). VLADIS seeks to build on this by bringing together age dating practitioners for in-depth discussions on the technical aspects of age dating analysis, thereby establishing best practices for age dating in the community. As well as a forum for discussing the technical details of an age dating evaluation, VLADIS created a space where practitioners can experience a community with open communication and collaboration as the ideal model.

This project utilizes virtual platforms to provide organized, interactive, and collaborative content to enable a dialogue that will lead to (i) an improved understanding of radiochronometric analyses of nuclear materials at ANSTO, CNEA, LLNL, and LANL; (ii) a forum for early career staff to network and ask questions in an informal setting; and (iii) create the relationship framework to make progress on our mutual age dating collaborations.

Motivation

VLADIS was launched in October 2020 to meet the need for ongoing communication and collaboration while travel was restricted due to the COVID-19 pandemic. This initiative stemmed from LLNL and LANL's collaboration with ANSTO and the collaboration between LLNL and CNEA based on the nuclear forensic evaluation of a uranium certified reference material through the NSDD. To date, relationship development to maintain these collaborations over the past decade has consisted of in-person meetings, group conference calls, participation in international meetings, and email communication. VLADIS aims to create a platform and discussion forum where age dating practitioners can learn from one another using web-based platforms to give presentations, share questions about radiochronometry (age dating), and build a network of practicing analysts. This initiative is not meant to replace in-person visits and technical exchanges between laboratories, as that is still the preferred method for building long-term partnerships. However, VLADIS will complement overall engagement between in-person meetings and is expected to continue even when travel resumes following the COVID-19 pandemic.

Additionally, due to savings in travel costs larger groups can participate in VLADIS, whereas traditional travel is often limited to one or two people per participating laboratory. Therefore, starting this group to virtually meet and collaborate with new staff in the face of international travel restrictions has allowed our collaborations to stay active and produce outcomes within reasonable timelines and on budget.

Project description

VLADIS meets monthly and is led and facilitated by nuclear forensics technical analysts from all participating laboratories, including experts in chemistry, mass spectrometry, data analysis, and nuclear forensic signature evaluation. Each virtual meeting is approximately one hour long, depending on the content.

VLADIS meetings are held via 'Webex' at a time convenient for all international participants, which allows all participants to join for real-time discussions. We also organized the use of the virtual platform 'Slack' to facilitate and increase informal communication between the SMEs and users to simplify document sharing and archiving. Using these two platforms allows participants to communicate in a variety of ways, such as more formal presentations on Webex, as well as the ability to post questions and receive answers from SMEs or share relevant materials on Slack.

The content of VLADIS is participant-led based on individual laboratories' capabilities and specific needs. Depending on the participants, the meeting schedules are updated to reflect current challenges, needs, or interests of the group. Each meeting has a planned topic with an expert leading the discussion and content. Relevant literature, externally releasable materials including white papers, or technical reports are distributed via our Slack channel to foster communication. To date, VLADIS presentation topics have included nuclear forensics outreach, measurement uncertainty and propagation and the use of TIMS (thermal ionizing mass spectrometry) and multicollector mass spectrometry in radiochronometry.

Participating Laboratories

Each participating laboratory LLNL, LANL, ANSTO and CNEA, has its own age dating capability development history and motivation for joining VLADIS:

LLNL

LLNL has been at the forefront of radiochronometry method development for over 20 years. The application of age dating to nuclear materials has been integral to their nuclear forensic program since its inception. With early application of the uranium-thorium (U/Th) chronometer to ground-breaking work with the uranium-protactinium (U/Pa) chronometer, many experts from chemists to mass spectrometrists have brought the LLNL age dating capability to the forefront of the international communities' capabilities.

The motivation to initiate this virtual laboratory with participants from LLNL was driven by hiring new staff in the nuclear forensic group who needed mentoring in the area of age dating. During the pandemic, the ability to mentor new staff in the laboratory was not viable. Therefore, having the opportunity to discuss age dating concepts, literature, and tools was ideal.

LANL

Similar to LLNL, LANL has been involved in radiochronometry for over 20 years including some of the first work using ^{231}Pa and ^{230}Th chronometers applied to geologic systems in the early 1990s (Goldstein 1993). Both uranium and plutonium radiochronometry have been used by LANL for materials characterization for nuclear forensic programs and international partnerships including participation in recent Nuclear Forensics International Technical Working Group

Collaborative Materials Exercises (CMX-4, CMX-5, CMX-6). Expertise exists at LANL in both radiochemistry and mass spectrometry (TIMS and ICP-MS) fields that support precise radiochronometry measurements.

There are several challenges that are encountered in the field of radiochronometry including a paucity of certified reference materials for quality control and gaps in the general understanding of how the nuclides used for radiochronometry behave during uranium and plutonium processing. These challenges drive LANL's interest in continued international partnerships to advance the interpretation and quality of radiochronometry data. VLADIS provides a platform for newly hired staff at LANL as well as experts to engage with external SMEs and laboratory participants to address these challenges.

ANSTO

While ANSTO has long held the capability for U/Th dating of environmental samples using alpha spectrometry, our participation in the ITWG collaborative material exercise CMX-3 in 2010 identified the need to develop an age dating capability for nuclear materials for nuclear forensic purposes. ANSTO successfully conducted age dating of low enriched uranium materials during CMX-4 and CMX-5 using alpha spectrometry to measure the $^{234}U/^{230}Th$ chronometer, at the same time initiating a program of work to establish measurement protocols using mass spectrometry and also develop the $^{235}U/^{231}Pa$ chronometer. As ANSTO does not have a multicollector mass spectrometer on site, the work program aimed to verify protocols by single collector mass spectrometry – initially by q-ICP-MS and then by accelerator mass spectrometer (AMS). This program of work forms part of an agreement with LANL and LLNL.

VLADIS has given our small team access to SMEs, helping ANSTO to rapidly set up the procedure and quickly troubleshoot problems. Following verification of procedures using q-ICP-MS, ANSTO will then work to develop radiochronometry procedures by AMS. Due to its very high sensitivity, the AMS should permit dating of challenging materials, such as very young or isotopically depleted material. ANSTO can then report on this work to VLADIS as an additional method of radiochronometry. The ANSTO team, particularly a new staff member, has also appreciated VLADIS as a way to network with other scientists during a challenging time.

CNEA

Argentina has more than seven decades of history in nuclear technology. CNEA has conducted this evolution from research and human resources training and all other related activities. In recent years, CNEA was introduced to nuclear forensic analysis in support of a criminal investigation thanks to emerging bilateral and multilateral collaborations, concerned with improving nuclear security infrastructure in countries and regions around the world.

In this regard, Argentina started a joint project in nuclear forensics in 2017 with the United States through the Department of Energy to facilitate the exchange of new methodologies, results and experience with the goal of improving Argentina´s capacities developing an analytical plan for inspection of a nuclear sample. In 2018 the IAEA funded a Residential Assignment for human capacity building in age dating of a nuclear sample, with LLNL being the hosting and mentoring institution and the candidate for the training from the Mass Spectrometry Laboratory of CNEA.

This fruitful experience allowed CNEA to learn about this complex methodology and to start its development according to the installed laboratory capacities (instruments, materials) and also to create strong bonds with LLNL´s experts, participate in international technical meetings, conferences and joint publications in peer-reviewed international publications.

As new practitioners in this field, this virtual initiative will aid CNEA in dealing with the early stage development challenges of Isotopic Dilution Mass Spectrometry by having direct contact to SMEs in the active community. VLADIS is also a strategic tool to a more sustainable collaboration with US partners. This makes it possible to reach out to other expert colleagues with the goal of implementing a radiochronometry capacity in Argentina.

Conclusion

VLADIS has strengthened working relationships between participants and SMEs at LLNL, LANL, CNEA and ANSTO in the area of radiochronometry. These strengthened relationships will aid in the completion of the multi-instrument age dating study of certified reference materials using multiple chronometers, which is a current goal of the LLNL, LANL, and ANSTO engagement. Eventually, results from this age dating engagement will lead to a multi-lateral peer-reviewed publication for the broader radiochronometry community. The VLADIS initiative also serves as a pilot program to experiment with information sharing virtually that will lead to development of a framework and project plan that could be applied to additional partner countries, tailored to their specific capabilities and interests.

References

Goldstein, S., Murrell MT, Williams RW (1993). "231Pa and 230Th chronology of mid-ocean ridge basalts." Earth and Planetary Science Letters **115**: 151-159.