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REPORT OF THE ISS OSI INVITED MEETING, VIENNA, 24-27 MARCH, 2009

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The International Scientific Studies project (ISS) was initiated in early 2008 with the objective of creating a series of activities aimed at application of modern scientific methods to improve the efficiency of analysis and the quality of verification of the Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO). The ISS On-Site Inspection (OSI) Invited Meeting convened on March 24, 2009 with the objectives of gaining a better understanding of the phenomenology of underground nuclear explosions (UNE) for OSI purposes and to identify areas of interest to OSI that could benefit significantly from contributions by the general scientific community. Fifteen invited experts from four countries, along with fifteen members of the OSI Division of the Provisional Technical Secretariat (PTS) met for four days at the Vienna International Center in an informal setting to discuss the application of observational methods, geophysical techniques, radionuclide measurement methods, environmental sampling methods, drilling techniques, and information management in the context UNE phenomena and OSI implementation.

The meeting began with the identification and description of two general OSI scenarios, a vertical borehole emplacement and a horizontal tunnel emplacement, that serve as general examples of past UNE testing activities that can be used as a reference to identify UNE phenomena relevant for OSI observations. A significant portion of the first day of the meeting was spent in the description of the details of these scenarios and their implications for OSI observables. This discussion then served as a foundation for the discussions of the following three days in which OSI methods and technologies were evaluated in the context of UNE phenomenology and signatures. The methods and technologies discussed included visual observation from air and ground, radiation detection from the air, ground, and subsurface, ground-based and airborne geophysical observations and analysis, collection strategies for air, water, and solid samples, drilling concepts, and aspects of data fusion, information management, and modeling and simulation. The informal setting of the meeting provided a “brainstorming” atmosphere and participation was excellent. One important aspect of this particular group was the very wide breadth of experience and expertise represented, ranging from those sharing their knowledge of UNE testing practice, radiological measurements and sampling, and knowledge of the underground effects of UNEs, to those with extensive experience in scientific and commercial geophysical measurements and surveys, to others with rich experience gained from several OSI field exercises, including the recent OSI Integrated Field Exercise in held in Kazakhstan in September 2008.

During the workshop a number of topic areas relevant to OSI, explained in the list below, were identified that will benefit from collaboration with the international scientific community. Most of the topics represent the potential for studies of long-term interest, but some topics were identified that could be addressed, either by workshop participants or others known to the participants, that could be included as abstracts for submission to the ISS meeting taking place in June 2009. Items with topics that could be covered in the June meeting are annotated in the list.

The meeting ended with the general understanding that ISS will not be completed with the June '09 Conference. Rather, the ISS is considered as a long term project sponsoring relevant ongoing international scientific initiatives to expand and improve the verification capabilities of the Comprehensive Nuclear Test-Ban Treaty.

List of topics of long-range interest for OSI development, including those selected for presentation during the June ISS meeting.

- Examples of statistical data concerning past UNE tests that resulted in release of radioactive material (gases, particulates) were presented at the workshop. Development of a more extensive collection of such data from countries with UNE testing experience would be very useful for assessing the overall probability of such releases by a possible violator of the CTBT. (long term study)
- Geophysical methods are called for in the CTBT to indentify buried artifacts or to detect and characterize the rock damage zone from an explosion. Geophysical surveys can also be used to obtain data to characterize and verify geologic information in the inspection area. Contributions to the overall application of geophysical methods for characterization of subsurface geology will be of great benefit to OSI. (2 abstracts identified for June -- also relevant for long term studies)
- Countries with UNE testing experience may have access to post-test observations in a variety of settings. Documentation of visual inspection observations and applied geophysical methods from past UNE tests into an atlas of phenomena would be of great benefit for the training of inspectors and development of OSI search logic. (long term study)
- Open source information (satellite imagery, maps, geologic data, etc.) can be used during an OSI to better characterize inspection area and provide tools for the inspection team. Contributions on how to exploit this resource and integrate it into the OSI regime would be of great benefit. (1 abstract identified for June – also relevant for long term studies)
- Participants of the workshop generally agreed that noble gas collection and analysis, especially for the short-lived isotopes of xenon and argon, is a key tool for OSI because it is one of the only ways to confirm the nuclear character of an explosion short of drilling. There is also the possibility that detection and measurement of ^{37}Ar could be at some time included as a component of the IMS. A number of science application areas related to noble gas collection and analysis were identified:
    - Better understanding of the source term for noble gas release is needed. One approach to this is to collect and analyze any data available on release from past UNE testing. (1 abstract identified for June – also relevant for the long term)
    - A common assumption made about noble gas release is that about 10% of the available inventory is released. This assumption needs to be examined, either via theoretical studies or from whatever data is available. (1 abstract identified for June – also relevant for long term study)
    - In order to better assign necessary equipment capabilities and measurement strategy for noble gases, "rule-of-thumb" noble gas release scenarios should be developed, which should include both the source term as well as release and transport mechanisms. (2 abstracts identified for June – also relevant for long term)

- Detection of ^{37}Ar is a key component of noble gas analysis. Several studies could be carried out relevant to this aspect of OSI (generally relevant for long term):
  - Investigation and assessment of current status of ^{37}Ar detection.
  - Development of ^{37}Ar sample preparation and detection capabilities.
  - Investigation of ^{37}Ar background in soils around the world.
  - Assessment of lessons learned from various types of gas sampling experiments.
  - Carry out a comparative study of atmospheric ^{37}Ar measurements. (1 abstract identified for June)
- Development of alternative ^{37}Ar measurement schemes, such as proportional counting. (1 abstract identified for June – also relevant for long term)
- One study is known for which the concept of barometric pumping was modeled and tested. This general concept needs to be studied further to better understand how the process works in different geological settings and different UNE testing scenarios. (1 abstract identified for June – also relevant for long term)
- Sampling strategies for noble gas collection need to be further developed, especially to better understand the effect of ingress of atmospheric gas into the sample for various rates of pumping and for different types of sampling methods, such as the uses of tarps or vertical sampling tubes. (1 abstract identified for June – also relevant for long term)

- One scenario for OSI involves the direct venting of gas and particulate debris from a surface leakage site; this would be a major containment failure. A better understanding is needed of the source term for such a scenario – what are the likely levels of radiation available as a function of time and how might these best be detected during an OSI. (1 abstract identified for June – also relevant for long term)
- Scientific review of the relevant radionuclide list for OSI is needed which considers the volatility and refractory nature of each radionuclide as well as its half life. (1 abstract identified for June – also relevant for long term)
- Cooling technology for HPGe detectors needs to be reviewed. This detector technology is constantly being improved with respect to size and weight and reliability. (1 abstract identified for June – also relevant for long term)
- Alternatives to HPGe detectors for OSI field laboratory use, which are more rugged, reliable, and easier to use would help to improve the sample throughput process during an OSI. Gamma-gamma coincidence detection is one such alternative that needs to be examined. (1 abstract identified for June – also relevant for long term)
- Continuation phase geophysics is called for in an OSI to detect and characterize the underground damage zone from an UNE and provide the target zone for possible drilling for radiological samples. This specific application for deep exploration geophysics over a relatively small surface footprint is unique. The scientific community needs to be engaged to assess such applications. This can be

done via careful computer modeling experiments and with focused surveys at former UNE testing sites or at carefully chosen analogous sites. (long term)

- A list of physical factors needs to be developed for UNE phenomenology. The primary focus would be in the damage zone surrounding an underground explosion and concern such parameters as density, conductivity, permeability, thermal conductivity, fracture density, etc. as a function of distance from the detonation point. (long term)
- Modeling of fate and transport of subsurface fluid and heat, including post-explosion alteration of materials and generation of secondary sources of gas and fluid would be useful for describing UNE environment for the time period of days to months after an explosion. (long term)
- A critical tool for an OSI inspection team is the ability to rapidly collect and archive data in the field and incorporate other sources of data (e.g. from the IDC) available from open sources. Exploration of data fusion and display/visualization concepts would be important for this with the possible inclusion of data mining. (long term)
- Application of Bayesian analysis into OSI search logic could provide a powerful tool for the inspection team. Such approaches need to be developed and tested for the OSI application. (1 abstract for June – also relevant for the long term)
- It would be desirable to apply operational analysis methods to the overall process of development of the OSI regime and separately to the overall OSI process. (one abstract for June – also relevant for long term)
- Information technology methods could provide valuable mechanisms for the rapid transfer of information from the IDC to the OSI inspection team in the field. Possible applications of IT to this application could be examined. (long term)
- Applications of airborne and ground-based multispectral and infrared methods were not discussed during this workshop, but it was generally recognized that there is rich experience in the general scientific community in this area. The key is to link such applications to the specific interests of OSI. (long term)