Verification science

‘Geological’ phenomenology of nuclear test explosions from an OSI perspective

By Dr Yosef Bartov, Director of the Earth Science Research Administration, Israel

The International Monitoring System (IMS) and the International Data Centre were designed to be fully capable of monitoring compliance with the Treaty. New research and improved communication technologies continuously refine the detection capabilities of the IMS. This column introduces some of the latest developments in verification science.

The on-site inspection (OSI) within the framework of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) has been recognized as a scientific enterprise (see Figure 1) and a multidisciplinary challenge. It will have to be conducted “in the least intrusive manner possible, consistent with the efficient and timely accomplishment of the inspection mandate”. The inspection team will have to recognize the geological phenomena related to underground nuclear explosions (UNEs) and translate them into targets for

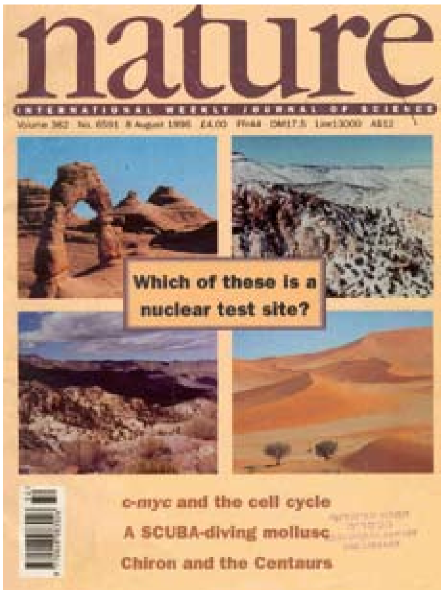

FIGURE 1 NATURE JOURNAL COVER PAGE (1996), REFERRING TO THE SCIENTIFIC ENIGMA OF OSI.

geophysical techniques as certified by the CTBTO Preparatory Commission.

At the initial period of the inspection, geological features, to be identified by visual inspection methods, are extremely important in the decision making process of the inspection team, and in evaluating the successful conduct of the inspection. Among those features that have been recognized at UNE sites, the most important ones are: craters (throw-out), collapse sinks, other subsidence structures, pressure ridges, domes, disturbed ground fractures, cracks, faults, ground slumps, landslides, fragmented rocks and man-made artifacts.

All these elements might be detected also by initial overflight observations, so that they might serve as direct indicators for events related to the purpose of the inspection. Some other physical parameters might also be observed or even measured. However, their recognition is dependent not only on the inspectors’ experience but also on their integration into other geo-scientific findings and their overall interpretation. The following phenomena have been monitored and observed over time: plant stress, water table rise, aftershocks, cavity collapse and chimney formation.

Still other anomalies have been reported as possible indicators for a UNE, but as to the present, no agreed phenomenology has been established concerning anomalous radon, geochemistry, heat and high temperature mineralogy, including rock melt.

Since much of the UNE phenomenology has well known natural equivalents (e.g. ‘geologic’ circular elements), measures have

AUTHOR (RIGHT OF HELICOPTER DOOR) AS PARTICIPANT IN INITIAL OVERFLIGHT OF FE02 EXPERIMENT, KAZAKHSTAN, 2002

to be taken to eliminate or minimize the on-site background noise in the natural or man-made realm.

Minimizing the natural background noise depends mainly on the experience of the inspection team, which includes their close observations and their ability to differentiate by secondary features (e.g. craters showing radial jointing, typical for UNEs, see Figure 2; in contrast to circular features typical for gravitational processes such as the formation of sinkholes, see Figure 3). Other interpretational methods rely on the comparison of existing data, e.g. from public domain sources or on data provided by the Inspected State Party. Except for the passive seismologic monitoring (aftershock measurements), the inspection team is only allowed to apply geophysical methods in a later phase of the inspection mandate..

Geophysical methods can be of an intrusive nature (e.g. active seismic surveys, borehole logging,) as well as of a non-destructive, non-invasive nature (e.g. natural electrical currents, observation of the natural magnetic field of the earth, gravity). With today’s instrumentation, operating costs for geophysical surveys became quite low. However, the

size and the geometry as well as the geological properties of the inspection area have to be taken into account.

During the various OSI workshops and field exercises, it was found that more research must be geared towards a well-considered methodology selection. This research may be conducted by State Signatories as well as the Provisional Technical Secretariat (PTS) and would heavily rely on the access to public domain data sources. It can be implemented and quality-checked either in former nuclear test sites or on new chemical explosions test-beds.

A number of issues in OSI earth sciences are unresolved: there is no agreement yet on geological and geophysical phenomenology; there is no-existing standard methodology for geological mapping or for sampling; and there is no procedure for using background data bases (e.g. authentication and storage). In order to improve visual inspection and geophysical surveys, the professional staff of the inspection team, which must include well-trained geologists and geophysicists with access to UNE phenomenology from test areas, should go through repeated training sessions.

State parties should be encouraged to establish relevant voluntary databases, aimed to supply needed information to OSI staff. The database should be prepared in accordance with up-to-date UNE knowledge concerning phenomenology. These data-bases will enable the inclusion of a consultation phase within the initial stages of an OSI, in which local experts could help the inspection team to eliminate natural geological anomalies from the investigation. The same procedures proposed for the visual inspection are suggested for the application of the geophysical methods during the final phase of the inspection mandate. ■

Biographical note

Dr Yosef Bartov is Director of the Earth Science Research Administration and Chief Scientist at the Ministry of the National Infrastructure, Israel. He has a PhD in Geology from Hebrew University in Jerusalem. Between 1984 and 1987, he served as Director of the Geological Survey of Israel.

He participated in all OSI workshops, in two of the field experiments in Kazakhstan (1999 and 2002), and as a lecturer in three of the Experimental Advanced Courses organized by the Provisional Technical Secretariat. ■

FIGURE 2: AREAL PHOTO FROM NEVADA TEST SITE, UNITED STATES (COURTESY DEPARTMENT OF ENERGY). CIRCULAR STRUCTURES RELATE TO UNEs CONDUCTED SINCE 1963.

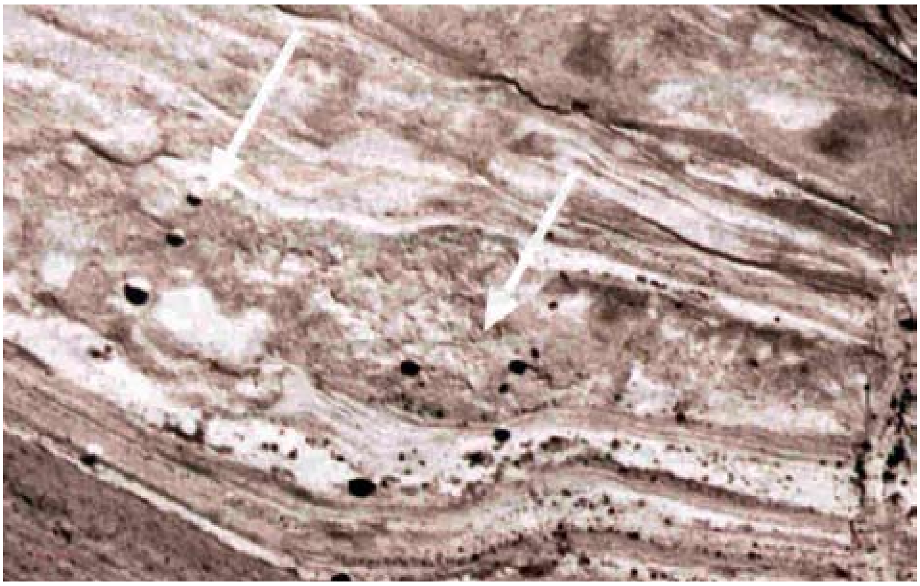

FIGURE 3: AREAL PHOTOGRAPH FROM DEAD SEA VALLEY, ISRAEL. CIRCULAR FEATURES ARE SINKHOLES FORMED DUE TO RECENT DEAD SEA LEVEL DROP. NOTICE RESEMBLANCE WITH CIRCULAR FEATURES IN FIG.2 (COURTESY GEOLOGICAL SURVEY, ISRAEL)