Tracking down Soviet underground nuclear explosions.

WINNOWING WHEAT FROM CHAFF

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Every year hundreds of seismic events occur in the Soviet Union and are detected by sensors of the US Atomic Energy Detection System (USAEDS). Finding out which of these disturbances are earthquakes and which are the dozen or so underground nuclear events conducted each year by the Soviets is a major task for the intelligence community. This has been of particular importance since the signing of the Limited Nuclear Test Ban Treaty of 1963, which required the Soviets to conduct all their nuclear tests underground.

Prior to the signing of the Treaty the Soviets were known to have conducted only two underground nuclear tests, one in 1961 and one in 1962, although they may well have conducted some additional underground nuclear events at yields below the detection threshold. The Soviets probably did not, however, make major use of underground testing from 1949 to 1963; after all they had well-established atmospheric proving grounds at Semipalatinsk and Novaya Zemlya and conducting weapon development tests in the atmosphere was both easier, faster, and cheaper than to do them underground. This all changed in 1963, and our interest in underground test detection increased as a consequense.

A major factor spurring on improvements in seismic detection and identification techniques was the possibility that a treaty banning all nuclear testing, including that conducted underground, might be signed between the US and the USSR. Such a treaty has been discussed, off and on, for a number of years. An alternate proposal, to ban all underground testing above a certain size or magnitude, has also been discussed extensively, but no agreement has yet emerged. Both of these approaches keep raising the question—how can you tell if a distant seismic rumble from behind the borders of the USSR is a natural event or a nuclear explosion, and can you be confident enough in your identification to rely on national means of verification rather than on-site inspection of suspect nuclear tests?

When a seismic event is picked up on USAEDS sensors, it is recorded ultimately in Washington as a seismic wiggle which is then decoded by experts who decide, first, whether a seismic event has in fact occurred, and second, whether receipt of the signals by several separated seismographs enables an approximate location of the event to be determined, much in the same fashion that direction-finding is done to determine the source location for electromagnetic signals.

Once an event is established as Soviet in origin, various methods are employed to determine whether it was an earthquake or an explosion. For many events the "depth of focus" can be found (the depth beneath the earth's surface at which the disturbance occurred), and often this turns out to be so great that there is no question that the event was natural, simply because no one can drill shot emplacement holes to, e.g., depths of tens of kilometers. Other seismic analysis tools such as "complexity" (earthquakes normally produce more complicated seismic records than do nuclear tests) and "first motion" (shock direction at the focal point is normally outward, or compressive or an explosion and is compressive and rarefactive in opposing quadrants for an earthquake) also help identify some events. Shallow earthquakes put more energy into surface wave motion than do explosions. Although deep earthquakes have about the same surface wave motion as explosions they can be identified by their depth as earthquakes. This method of discrimination becomes ineffective for events of low magnitude because the seismic signal becomes too small.

The Soviets conduct a number of tests each year at known proving grounds, and these are the easiest of all to identify. The first Soviet underground test was detected in 1961 in an area some 40 nautical miles south of the normal atmospheric test area at Semipalatinsk. Prior to this event the area in question had not been recognized as a test site. After consideration of all the evidence, however, including the fact that the area in which the event occurred was not a seismic zone, was located close to a known test area, and contained sizable mountains suitable for underground testing (the Degelen chain), the community concluded that this was indeed a probable underground test site. Since then, of course, the Soviets have conducted many underground tests. The total detected from 1961 to 4 July 1969 now stands at 76. Most of these have been in the Degelen Mountains, but a number have been at other areas within the Semipalatinsk

Test Site. In general, a seismic event anywhere in the vicinity of Semipalatinsk is presumed to be a nuclear test unless shown otherwise. The same is also true of Novaya Zemlya, where the Soviets are known to have conducted five underground nuclear tests, the first in 1964. Although the Soviets used Novaya Zemlya for atmospheric testing up to 1962, there was by no means unanimous agreement that they had opened an underground test site when the first two seismic events were detected there in the fall of 1964. The events were, of course, brought under intensive intelligence scrutiny because of the past history of Novaya Zemlya in atmospheric testing, the relative lack of seismic activity in the area, and the presence of sizable mountain peaks suitable for underground testing. The Soviets confirmed for us that this was a test area by detonating there in the fall of 1966 their largest nuclear test—about 1 megaton. A clandestine report was also received describing rock slides from this event and providing evidence of tunnelling by the Soviets for emplacing their nuclear devices.

Probably the most interesting of the Soviet seismic events are the so-called "out-of-area" tests they have conducted in the past few years primarily for peaceful purposes. Here the assets of intelligence were brought fully to bear on identifying what were presumed from the start to have been probable explosions because of their occurrence in non-seismic areas of the Soviet Union distant from the normal test sites. All told there have been six such events since 1965, one each near the towns of Ufa and Tyumen (slightly west and east of the Urals, respectively), two near Karshi (just north of the Afghanistan border), and two near Azgir at a site north of the Caspian Sea. In some cases it took months of analysis to establish that the events actually were nuclear explosions. Although they were for peaceful purposes, the Soviets maintained press silence about the events, making the job of tracking them down much more difficult. We were aided in the case of the first Karshi event in 1966 by Soviet articles about the great difficulties they had had in shutting off a wild gas well in the Urtabulak deposit, which was quite close to the location of this event. They had tried a number of different techniques to seal off the well, but all had failed, and it was at least conceivable that they might resort to a nuclear explosion to stop the runaway well. The matter was thrown into doubt when the Soviets listed this seismic event on their published earthquake list, contrary to their previous practice. We finally

received good information indicating that this was indeed a Soviet nuclear explosion to put out a runaway gas well. Because of its proximity to this event, a seismic disturbance near Karshi in 1968 was also considered to be probably an explosion to seal off a wild well. Other out-of-area events have generally been harder to pin down as to identity and purpose, but information from intelligence sources has provided a valuable supplement to that provided by the USAEDS seismic net.

There remains the problem of the "unidentifieds," the much larger number of events that are detected, but for which there is no ready or probable explanation. Seismic means alone are unable to distinguish, for example, between chemical and nuclear explosions. The Joint Atomic Energy Intelligence Committee regularly examines small seismic events that often later turn out to be Soviet high explosive detonations (sometimes with yields as high as several kilotons) for canal and dam construction. If the yields are large enough, tens of kilotons or more, there is no question of their nuclear nature, but at low or modest yields collateral evidence has to be brought to bear to sort out the wheat from the chaff.

When all the foregoing techniques have been applied, the usual result is that there are perhaps 20-30 seismic events per month of magnitude 3.8 (equivalent to a nuclear explosion yield of about 1 kiloton if fully coupled in hard rock) or greater that are not identified. We usually can in time identify the largest events. Those that remain unidentified are for the most part rather small events. As a result of progressive improvements in seismic detection method, events of smaller and smaller magnitude are being detected.

This raises another question: at what point on the scale do these small events become insignificant to us? If the Soviets are conducting a few tests annually in the fractional to low kiloton range without detection, is our knowledge of their nuclear progress, which has already been severely hampered by lack of debris from their underground tests, seriously reduced? The answer to this question is of utmost importance in defining the seismic level below which underground nuclear tests would not be allowed under a threshold test ban treaty. A decision about such a definition would also be affected by the possibility that underground shots could be "decoupled," that is, conducted in an underground cavity in such a way that the seismic signals from the explosion would be weakened by the time

they reach the cavity wall. This would result in distant readings of seismic signals suggesting a substantially smaller shot than was actually fired. Indeed, such a decoupled shot might not be detected at all. Such a technique could permit the Soviets to experiment with larger yields, and therefore possibly make more progress in the development of nuclear weapons, than they would legitimately be entitled to under a threshold test ban treaty.

As matters stand at present, most of the unidentified events have occurred in seismically active areas of the USSR, i.e., areas in which earthquakes are relatively frequent. These events in seismic areas are therefore presumed to have been earthquakes. An attempt is made to develop collateral evidence that would indicate whether any of these were nuclear tests, but because of limitations on intelligence capabilities and resources, normally no firm conclusions about them are possible. As a result, it is possible that the Soviets have "gotten away with" some nuclear tests in seismic areas in recent years without our knowing about it.

It is, however, fair to conclude that a combination of seismic record analysis and intelligence analysis has been reasonably successful in identifying seismic events occuring in the USSR, particularly those in seismic areas. For events in seismic areas our capabilities are less good when the yields are small, but fortunately, our concern about missing a limited number of small yield tests is least in this area. Any improvements in present intelligence capabilities to identify small events in seismic areas probably will be limited and costly to achieve.