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Rendering Useless South Africa's Nuclear Test Shafts in the Kalahari Desert

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In 1973, South Africa surveyed the Kalahari desert as to its suitability as a nuclear test site for its nuclear weapons program, which had started to focus secretly on developing a nuclear weapon device in 1971.¹ In March 1974, the government approved the development of a test site (coordinates about 27-46S, 021-28E) in the Kalahari desert near Vastrap, north of Upington. The first vertical test shaft, 385 meters deep, was completed in November 1976 and a second one, 216 meters deep, was finished in 1977, less than one kilometer from the first one.

With its uranium enrichment plant only just starting to produce highly enriched uranium, South Africa's Atomic Energy Board decided to conduct a "cold test" of its gun-type fission system—a test of a complete nuclear explosive device without a fissile core. However, as preparations for the test proceeded, a Soviet intelligence satellite detected the site in the summer of 1977. It provided the information to the United States, which conducted a low-level aerial flight over the location, confirming that South Africa was preparing to conduct a nuclear test.² The United States then confronted South Africa, which hurriedly sealed the shafts and abandoned the site.

In 1987, the government of President P.W. Botha ordered the Armaments Corporation of South Africa (ARMSCOR)³ experts to inspect the shafts and ensure they could be used rapidly, in case the government ordered a test.⁴ ARMSCOR, which had taken over the nuclear weapons program in 1979 from the Atomic Energy Board, visited the Vastrap site and emptied water from the vertical shafts. They determined that the shafts were intact. To hide its activities at the first test shaft from overhead surveillance, ARMSCOR constructed a galvanized corrugated iron hangar on a concrete foundation over the shaft. South Africa refers to this building as the "shade." The site was kept on standby until the end of the nuclear weapons program in 1989, at which time the shafts were sealed.

¹ D. Albright, *South Africa's Secret Nuclear Weapons*, ISIS report, 1994

² The United States did not know that South Africa planned only a cold test.

³ ARMSCOR is the state run arms corporation which ran South Africa's secret nuclear weapons effort from 1979 until 1989.

⁴ Waldo Stumpf, "Birth and Death of the South African Nuclear Weapons Programme," Presentation given at the conference "50 Year After Hiroshima," organised by USPID (Unione Scienziati per il Disarmo) and held in Castiglioncello, Italy, September 28 to October 2, 1995.

After signing the Nuclear Non-Proliferation Treaty (NPT) in 1991, the International Atomic Energy Agency (IAEA) declared many South African nuclear sites, but it did not declare the Kalahari test site. South Africa had decided to deny it ever had a nuclear weapons program and had taken steps to hide the buildings in its dismantled nuclear weapons program, including the Kalahari site. Nonetheless, based on information from member states, the IAEA asked to visit this site, in particular the shade.⁵ The South Africans told the inspectors that Vastrap area was owned by the South African Defense Force and was used as a military target range. They said the shade was used by the air force for storage and as a workshop, providing no indication that the shade covered a nuclear test shaft.⁶ The IAEA uncovered no evidence that the building had been used or was then being used for the testing of nuclear explosive devices, although it did not ask to excavate the shade's floor.

Under intense international pressure, South African President F.W. De Klerk finally admitted in March 1993 that the country had developed nuclear weapons but had dismantled them. At this time, South Africa declared to the IAEA that the Kalahari facility was a nuclear test site and agreed to render it useless.⁷ The IAEA and South Africa agreed that the test shafts would be considered rendered useless when, as a direct result of the measures taken, their reconstitution would be more difficult or expensive than the construction of new facilities.⁸ However, this task proved harder to accomplish than expected. The South African experience provides lessons for other countries interested in the verifiable dismantlement of a nuclear test program. For example, should negotiations with North Korea bear fruit, the experience of South Africa could assist in the verifiable dismantlement of its nuclear test tunnels and shafts.

IAEA Survey Team Visit⁹

On April 29, 1993, an IAEA inspection team surveyed the Vastrap area to identify all the test shafts, to assess the condition of the first test hole, and to identify the "nature of activities and structures in the area of the Kalahari test site." As discussed above, the Vastrap area had been used for military target practice. In addition to the nuclear test site, it contained simulated enemy targets such as an enemy bridge, dummy missiles, sandbags, and old vehicles. Based on this visit, the IAEA developed a rough map of the Vastrap area (see Figure 1 below).

⁵ IAEA, *Report on the Completeness of the Inventory of South Africa's Nuclear Installations and Material*, GC(XXXVI)/1015, attachment, September 4, 1992, http://www.iaea.org/About/Policy/GC/GC36/GC36Documents/English/gc36-1015_en.pdf.

⁶ On the floor on one side of the shade, the inspectors saw a large concrete ramp which appeared to have been cast in situ. This structure may be visible in figure 13 and would have allowed a test device or other equipment to be wheeled over the test shaft.

⁷ Adolf von Baeckmann et al., "Nuclear Verification in South Africa," *IAEA Bulletin*, Vol. 37, Issue 1, 1995.

⁸ IAEA, *The Agency's Verification Activities in South Africa*, General Conference, GC(XXXVII)/1075, Attachment 1, September 9, 1993, http://www.iaea.org/About/Policy/GC/GC37/GC37Documents/English/gc37-1075_en.pdf. The equipment used in connection with the Kalahari test shafts was standard equipment, except for the cages for personnel and cameras, which the IAEA recommended South Africa should scrap.

⁹ IAEA, "A Visit to Vastrap," May 6, 1993.

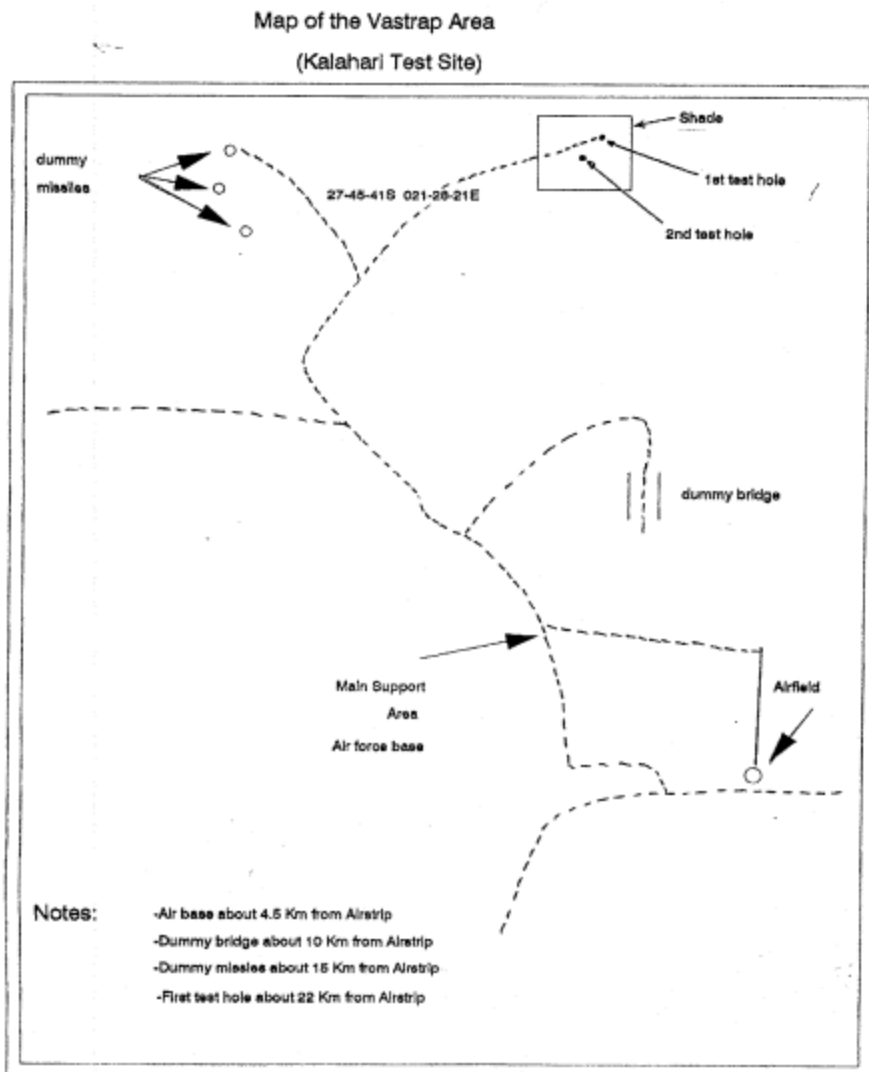


Figure 1: IAEA drawn map of the Vastrap area. The identification of the shade is difficult to understand. In addition, the identification of the first and second test hole appears reversed.

The IAEA inspectors located the two nuclear test shafts. One was covered by dirt and the other by the shade. Figure 2 shows the depths and relative placement of the two shafts. Figure 3 shows some of the decoy military equipment that ARMSCOR had placed near the shade in the late 1980s as an attempt to show that the site was a conventional military facility.

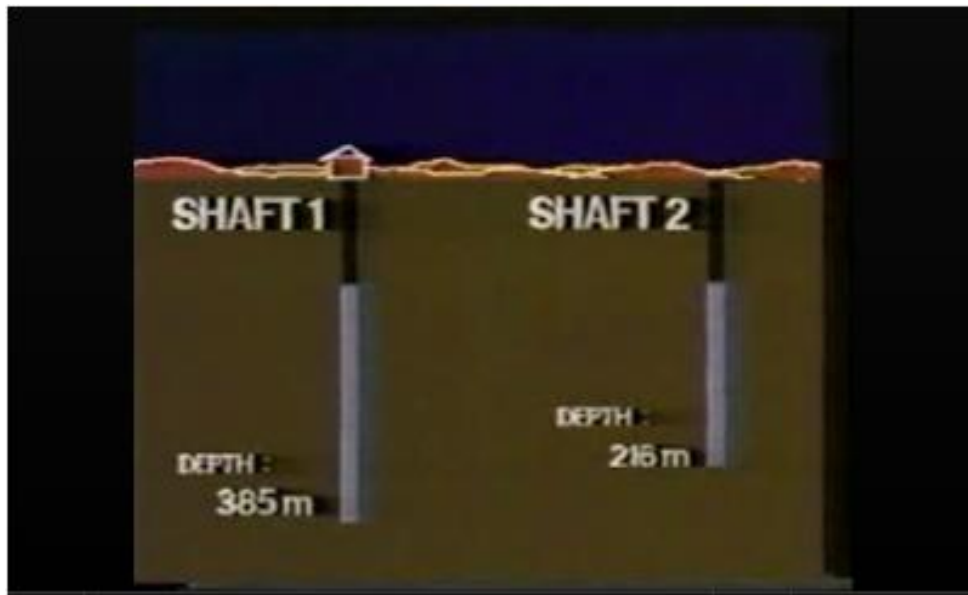
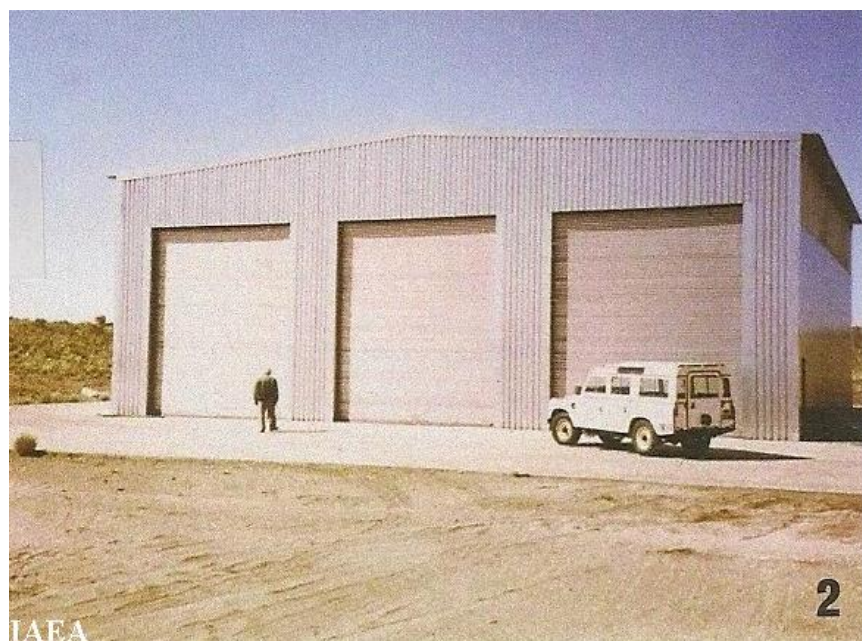


Figure 2: A schematic of the two test shafts prior to disablement, from ARMSCOR [video](#).



Figure 3: Decoy military equipment near the shade

An IAEA photograph shows the shade in the early 1990s (see Figure 4). The three bay doors seen in this photograph match the three big doors of the building described as covering the first test shaft in a schematic from the IAEA April 1993 survey visit (see Figure 5).



Vastrap military base test site in the Kalahari Desert.

Figure 4: The top picture shows the building over the first test shaft. The three bay doors on the building match with a schematic drawing of the building which covers the first test shaft (see Figure 5). The bottom low resolution photo may show the shade from another angle. It shows only two doors, in contrast to the IAEA schematic of the building which shows three doors on each side of the building (see Figure 5).

(Plan of the Shade)

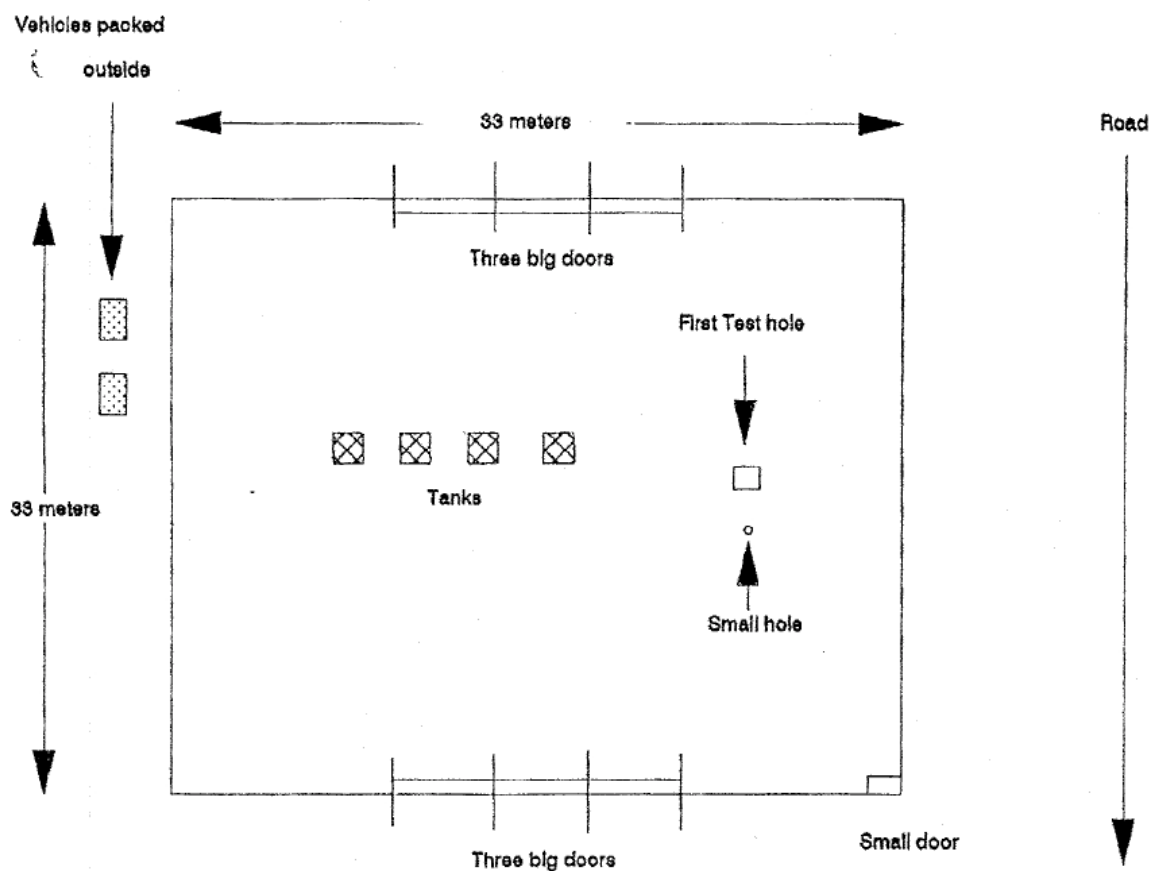


Figure 5: IAEA schematic of the plan of the shade. The three big doors match the three doors seen on one side of the building in Figure 4. The geographic orientation of the building is not provided.

Inside the shade, the IAEA survey team identified the location of the first test shaft. It had a plug of concrete on top and a steel casing underneath that was firmly bolted to the test shaft. The IAEA was unable to positively locate a small-diameter vertical shaft near the first test shaft and was cited for further inspection.¹⁰ At the time of the IAEA visit, the inspectors could not identify this hole because it had been covered by the concrete foundation of the shade in the late 1980s. The small shaft was possibly designed to hold diagnostic equipment to measure a nuclear explosive. However, ARMSCOR likely did not plan to use it in the event of a nuclear test. ARMSCOR was charged to maintain a capability to test a nuclear device on short notice and had little incentive to deploy scientific measuring equipment down a parallel shaft, which while potentially useful would have delayed the test.

The IAEA team found it more difficult to find the second test shaft, which was located about 780 meters from the first one and 80 meters from the road. It was covered by about a half meter of soil. After using a grader

¹⁰ Ibid.

and shovels, the South Africans and the IAEA team found the second shaft (see figure 6). The hole was sealed with a concrete plug about 2.5 meters by 2.5 meters.

On this survey, the IAEA took environmental samples around the concrete plugs at the first and second test shafts. It subsequently verified from these samples and other information that the site had not been used for nuclear testing.



Figure 6: Second test shaft at Vastrap. Visible is the concrete plug covering the shaft. Image taken from ARMSCOR video.

Satellite Imagery of the Kalahari Site

The sites of the first and second test shafts match the locations of two sites as seen in 2009 commercial satellite imagery (see Figure 7).

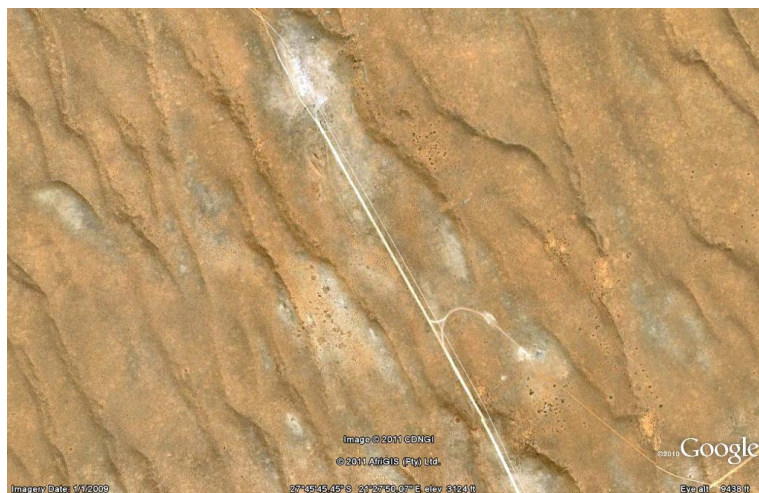
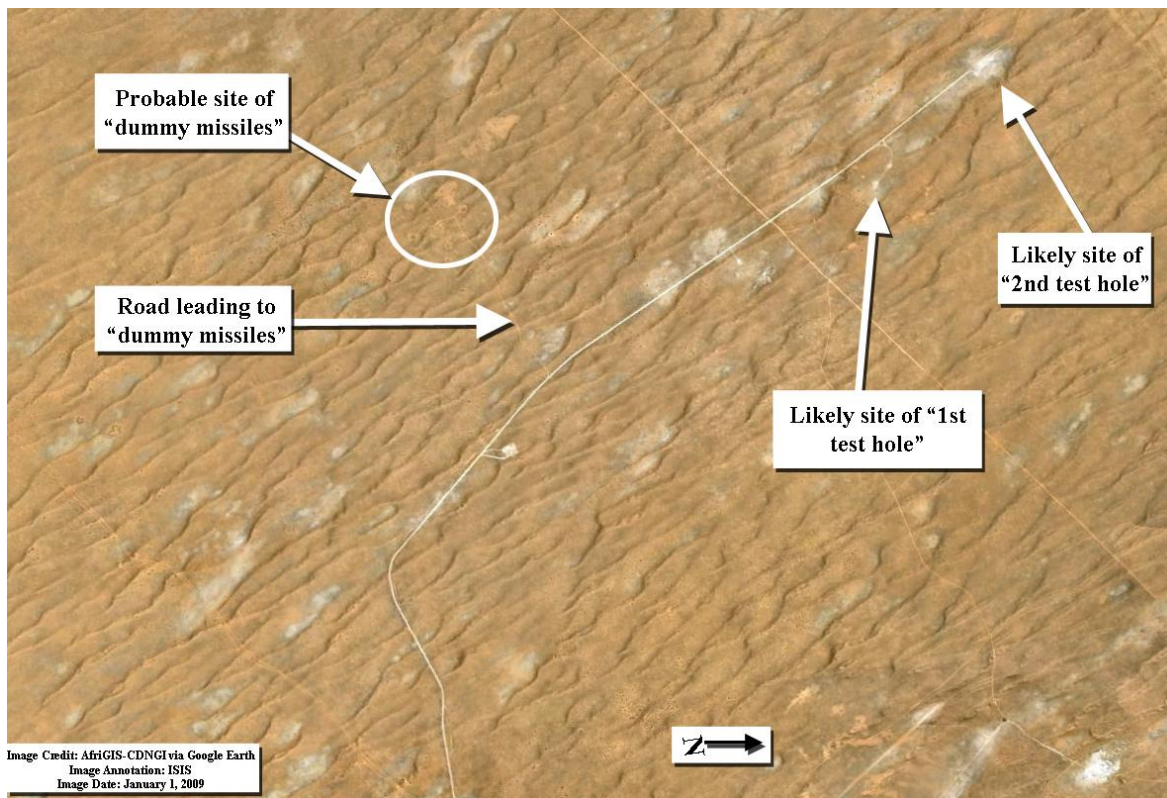


Figure 7: January 2009 Google Earth image of Vastrap with the likely site of two test shafts with close up below.

Figures 8 and 9 show the two test shaft areas. As can be seen in the satellite image in figure 8, the building seen in the photograph (see Figure 4) no longer exists. The building was removed at some point after the IAEA visits in 1993, although the foundation appears to remain. The dimensions of the foundation correspond to the foundation visible in Figure 4. The two small sheds can be seen over the area where the building once stood. It is unclear if the sheds cover the test holes.



Figure 8: April 18, 2009 commercial satellite image of what is likely the site of the first test shaft with the shade removed. Two small sheds can be seen on the square pad.

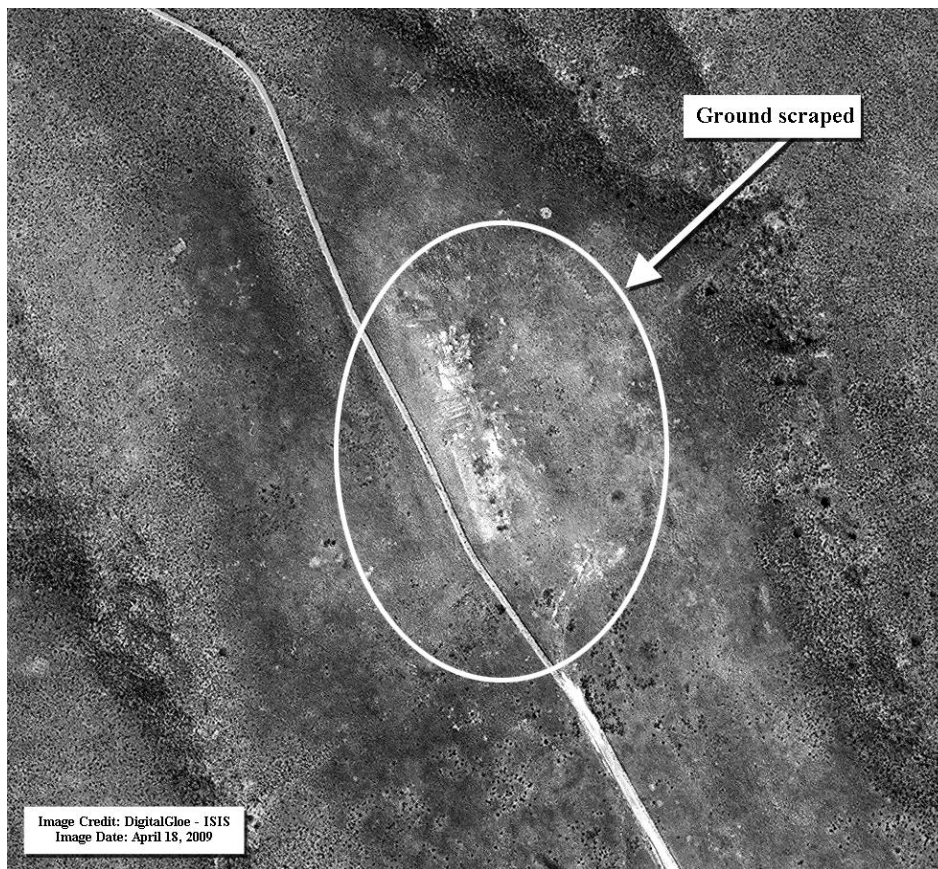


Figure 9: April 18, 2009 commercial satellite image of what is likely the area of the second test shaft. Scrapes in the ground are consistent with the extensive grading operations conducted in 1993.

Decommissioning the Test Shafts

Rendering the test shafts unusable for nuclear tests was more complicated than expected. The physical decommissioning of the test shafts took a number of months. The IAEA judged the shafts as rendered useless in August 1993 after ARMSCOR and the IAEA addressed the technical insufficiencies in the initial steps taken to disable the shafts in June.¹¹

The first plan for the rendering useless of the test shafts, incorporating specific suggestions made by the Agency team, was prepared by ARMSCOR and initiated on June 2, 1993. This effort was recorded by ARMSCOR in a [video](#). The video contains a schematic of the dismantlement plan (see Figure 10), which essentially alternated layers of sand with reinforced concrete plugs. Figures 11-22 are also from the ARMSCOR video.

¹¹ See GC(XXXVII)/1075, Attachment 1 (1993).

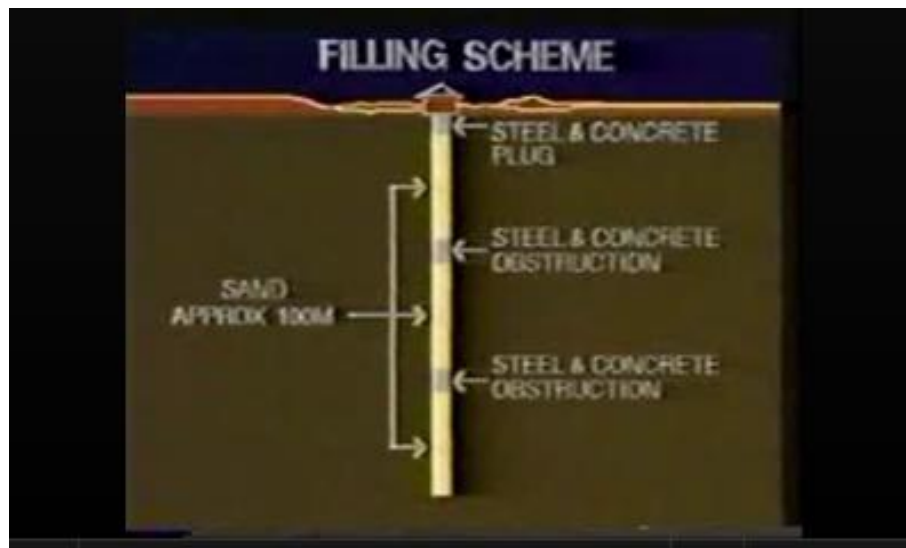


Figure 10: Filling scheme of shaft 1.

The video shows ARMSCOR taking a number of steps to remove the concrete plugs and steel casing from the first test shaft and the concrete plug from the second test shaft.



Figure 11: ARMSCOR uses a jackhammer to remove concrete above test shaft 1.



Figure 12: ARMSCOR drills holes to hold conventional explosives in the concrete cap at the first test shaft.

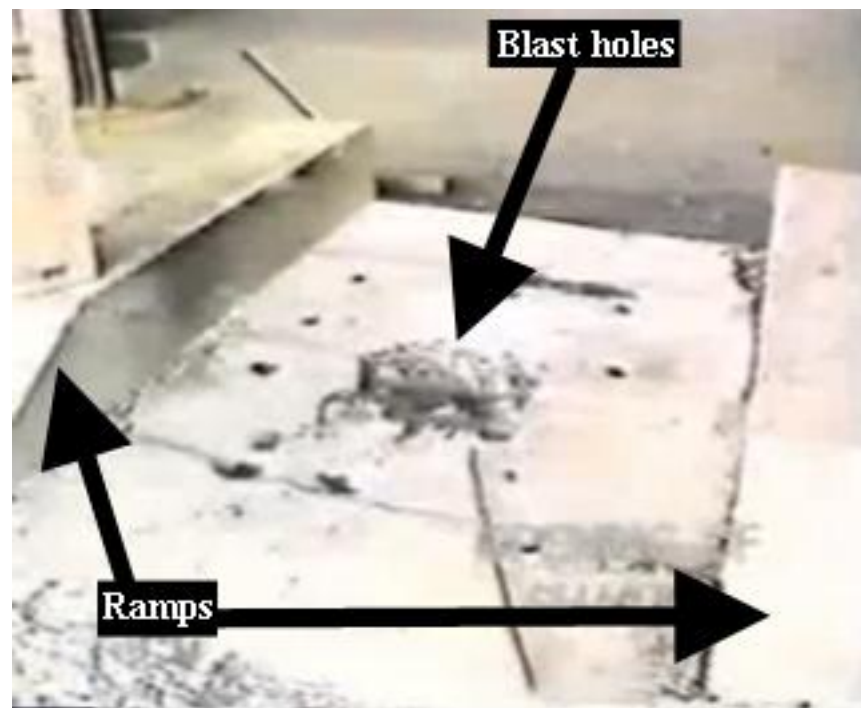


Figure 13: Blast holes to hold explosives visible on the cap of the first test shaft. On the left and the right are ramps. These could be the structure that inspectors noted inside the building (see footnote 6). The ramps would have allowed the test device or other equipment to be wheeled over the shaft.



Figure 14: The concrete cap on the first test shaft, post-blast.



Figure 15: Concrete cap being removed by bulldozer, post-blast.



Figure 16: Removing the steel cap of the first test shaft.



Figure 17: The opening of the first test shaft.



Figure 18: The opening of the second test shaft.

As shown, ARMSCOR attempted to disable the shafts using a layering approach to fill the shafts with sand and steel and concrete obstructions. This procedure did not work. The video shows ARMSCOR attempting to fill the shafts with sand using a large bulldozer. However, as can be seen, much of the sand is ejected from the shafts, undoubtedly a result of the over-compression of the air in the shafts (see Figure 19).





Figures 19 and 20: Sand shooting out of test shaft 2. Vastrap, June 2, 1993. The bulldozer can partially be seen in figure 20 for height reference.

To complicate redrilling, ARMSCOR had prepared steel and concrete obstructions to be inserted into the shafts. To do this, ARMSCOR filled steel drums with concrete and scrap metal. Figures 21 and 22 show concrete filled drums. The video does not show whether the barrels were placed in the shafts, although it implies that they were not put into the shafts in June but in July instead. Moreover, the shafts were not completely filled with the sand in June.



Figure 21: Barrels to be inserted into the test shafts at Vastrap by ARMSCOR.



Figure 22: Concrete-filled steel drum for use in the rendering useless of the test shafts at Vastrap.

With additional IAEA advice, South Africa developed a more effective procedure to render useless the test shafts. Figure 23 shows the suggested procedures provided by South Africa to the IAEA for test shaft 1. The second test shaft was rendered useless in a similar manner. However, because this shaft is less deep, instead of three concrete plugs, only one was planned to be inserted.

Figure 23: Procedure for rendering useless test shaft 1

<u>PROCEDURE</u>
Pump water out of test shafts
Insert first concrete plug
Backfill shaft with sand
Insert second concrete plug
Backfill shaft with sand
Insert third concrete plug
Backfill with sand
Cast concrete cap on first shaft. Remove equipment

The measures to render useless the test shafts were successfully completed from July 26 to 30, 1993 and were witnessed by the IAEA.¹² Figure 24 shows a reinforced concrete plug being lowered into shaft 1. Figure 25 shows concrete being poured into shaft 1.

¹² See GC(XXXVII)/1075, Attachment 1 (1993).

Members of the team visited the Kalahari site on 11 August 1993 and concluded that the measures taken had rendered useless the test shafts.¹³

Conclusion

The rendering useless of the Kalahari test shafts helped South Africa and the IAEA establish internationally that South Africa had indeed dismantled its nuclear weapons program. It was accomplished at little cost and relatively quickly, despite the unanticipated problems.

The South African experience is relevant to any future negotiated disablement or dismantlement of shafts or tunnels dedicated to underground nuclear tests. The IAEA can provide a useful role in designing an acceptable procedure of rendering the site and equipment useless and certifying the completion of that procedure. The Comprehensive Test Ban Treaty Organization (CTBTO) could also be tasked to play an important role in dismantling or disabling a test site.



Figure 24: Concrete and steel obstruction being lowered into the first test shaft in the shade (July 1993) *Source: IAEA, Against the Spread of Nuclear Weapons: IAEA Safeguards in the 1990s, <http://www.iaea.org/Publications/Booklets/Safeguards/pia38e14.html>*

¹³ See GC(XXXVII)/1075, Attachment 1 (1993); and Baeckmann et al., “Nuclear Verification in South Africa.”



Figure 25: Casting concrete in test shaft 1 inside the shade (July 1993) *Source: IAEA, Against the Spread of Nuclear Weapons: IAEA Safeguards in the 1990s,*
<http://www.iaea.org/Publications/Booklets/Safeguards/pia38e14.html>