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# Notes From the Underground

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## The Long History of Tunnel Warfare

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*Arthur Herman*

Perhaps the most surprising development of the recent war between Israel and Gaza was the discovery of the sophisticated network of tunnels that Hamas had quietly developed in the preceding years. The dark, low-tech tunnels running underneath Gaza offered a stark juxtaposition to the modern artillery Israel deployed on the surface.

But if the tunnels hinted at an older kind of warfare, that doesn't mean they should be dismissed as a military curiosity. Compared with the most sophisticated weapons systems in use today, tunnels have withstood the test of time: for centuries, they have allowed military units to approach their enemies undetected and helped weaker combatants turn the battlefield to their advantage. There's no way to know how long drones or lasers or anti-missile defense systems will last. But as long as there is warfare, tunnels will almost certainly be part of the fight.

### **From Antiquity to Modernity**

Tunnels and caves, tunnels' geologic predecessor, have a long history in warfare stretching back to biblical times. For at least 3,000 years, embattled populations have used them to hide from, and

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strike at, stronger enemies. Ironically, this has been especially so in the region where present-day Israel and Palestine are located. Archaeologists have found more than 450 ancient cave systems in the Holy Land, including many that were dug into mountainsides, which the Jews used to launch guerrilla-style attacks on Roman legionnaires during the Great Jewish Revolt from AD 66 to 70. The Romans faced the same tactic around that time in their fight along the Rhine and Danube frontiers in Europe, against Germanic tribes who would dig hidden trenches connected by tunnels and then spring out of the ground to ambush the Roman soldiers.

But the use of tunnels hasn't been limited to insurgencies. It wasn't long before the Roman Empire began using them as an offensive weapon in siege warfare. By digging a hidden trench right up to a city's walls, and then tunneling underneath to undermine the walls and force a breach, the Romans discovered that it was possible to end a siege long before the city's population was starved into submission by blockade.

Unsurprisingly, perhaps, the use of tunnels in this manner soon inspired the development of countertunnels. The ancient Roman historian Polybius described a siege in 189 BC at the Greek city of Ambracia, where the Romans began digging a tunnel parallel to the city wall:

For a considerable number of days the besieged did not discover [the Romans] carrying away the earth from the shaft; but when the heaps of earth became too high to be concealed from those inside the city, the commanders of the besieged garrison set to work vigorously digging a trench inside, parallel to the wall. . . . When the trench was made to the desired depth, they next placed in a row along the bottom of the trench nearest the wall a number of brazen vessels made very thin . . . [and] listened for the noise of the digging outside. Having marked the spot indicated by any of these brazen vessels, which were extraordinarily sensitive and vibrated to the sound outside, they began digging from within . . . so calculated as to exactly hit the enemy's tunnel.

This is a fine description of the use of countertunnels to intercept and disrupt a tunneling enemy's efforts. (It is also the first description of

using acoustics to detect tunnels, a strategy that has become ever more sophisticated, although not necessarily more effective, over time.) The Persian Empire's siege of the Roman city of Dura-Europos in AD 256 led to another new development: when Persian militaries tunneling under the walls of the city hit a Roman countertunnel, they filled it with a poisonous gas made from pitch and sulfur to asphyxiate the soldiers inside—the first known use of gas warfare. The art of tunneling and countertunneling continued throughout the Middle Ages, with militaries constantly looking for ways to gain the upper hand. At the Siege of Château Gaillard (1203–04), the castle built by English King Richard the Lion-Hearted, French soldiers encountered three stout defensive walls. They eventually managed to break through because they found an unguarded toilet chute that emptied into a chapel inside the castle.

In the sixteenth century, when gunpowder was added to the tunneling battlefield, the results were literally explosive and increasingly lethal. European armies developed sophisticated techniques for planting barrels of gunpowder in concealed trenches in order to undermine or blow up enemy fortifications, also known as saps (hence the term “sapper” for engineers who did this kind of dangerous work). This technique reached a stupendous climax during the American Civil War at the Siege of Petersburg in July 1864, when Union troops surreptitiously dug a tunnel under Confederate lines, only to fill it with so many barrels of gunpowder that they weren't able to climb out from the resulting crater. In what became known as the Battle of the Crater, Confederate soldiers simply lined up around the edge of the tunnel and poured down deadly fire on their helpless foes.

By the beginning of World War I, tunnel engineers' main task was no longer to build tunnels to fortify cities, but to build trenches on the western front. The trenches were essentially a static system of tunnels that served as front lines for each side; it wasn't long before militaries began building tunnels in order to try to blow up the trenches belonging to the enemy. The British proved the most adept at this. At the Battle of the Somme in 1916, they successfully

exploded two enormous mines underneath the German trench. In 1917, at Messines Ridge, the British military devised an elaborate strategy to dig 22 separate tunnels or mine shafts underneath German lines over 18 months. The Germans discovered one of the shafts, which had to be abandoned, but the other 21 were finished undetected and stuffed with 450 tons of TNT. On May 30, shortly before the explosives were detonated, the British General Herbert Plumer told his staff, “Gentlemen, we may not make history tomorrow, but we shall certainly change the geography.” The explosion ripped the entire crest off the Messines-Wytschaete Ridge with a blast so enormous that British Prime Minister David Lloyd George claimed to hear it at 10 Downing Street in London. Ten thousand German soldiers were instantly killed or entombed. Plumer, however, was right. Although the British took what was left of the Messines Ridge, the war didn’t change course. Instead, it dragged on for another year and a half.

### **Underneath the Good War**

World War I brought three great innovations to the battlefield—the land tank, massed artillery firing high-explosive shells, and the airplane—that made armies feel increasingly vulnerable sitting out in the open. After the war, some military strategists responded by trying to put entire armies underground, in subterranean complexes connected by tunnels to supposedly impregnable casements and fortifications. The most famous (and the most futile) of these efforts was France’s so-called Maginot Line, an elaborate underground system of bunkers and supply depots supporting 22 large, aboveground forts and 36 smaller forts, all connected by a railway, pulled by diesel-powered locomotives, that passed through a network of tunnels. In 1940, however, Germany’s mobile blitzkrieg tactics completely bypassed the Maginot Line and France had all but lost the war before the thousands of soldiers in the fortresses could even fire a shot.

The U.S. Army built something similar, but on a much smaller scale, on the island of Corregidor in Manila Bay, with an 831-foot-long

tunnel, some 24 feet wide and 18 feet high, feeding ammunition and supplies to a complex of artillery positions chiseled out of solid rock. An additional 24 lateral tunnels provided storage and sleeping quarters for troops. This was where U.S. General Douglas MacArthur, his family and staff, and Philippine President Manuel Quezon took refuge during the Japanese invasion of the Philippine island of Luzon in December 1941. But like its Maginot Line counterpart, the Malinta Tunnel on Corregidor turned out to be more of a trap than an impregnable fortress, as the new mobile warfare techniques of World War II left it isolated and useless. Today, both are little more than tourist attractions and symbols of military folly.

But around the same time that these massive underground complexes were being built, tunnels also experienced a revival as a tool for insurgents. The pioneers in this revival of tunnel warfare were the Chinese during the Sino-Japanese War, especially during the fighting around the village of Ranzhuang in Hebei Province in 1937 and 1938. Chinese guerrillas dug nine miles of tunnels between houses in the village to foxholes on the battlefield, so that they could attack Japanese soldiers from the rear. The tunnel entrances and exits were usually located in a house or in a well, making it easier for guerrillas to enter and leave without being detected.

The Japanese soon caught on, however, and began filling the tunnels with water or even poison gas. The Chinese retaliated by installing filtering systems that drew off the water and the gas. This cat-and-mouse game—which is typical of tunnel warfare—continued until the Japanese finally withdrew. How important the tunnels of Ranzhuang were to the battle's outcome is a matter of debate. To the Chinese, however, they are a monument to defiant resistance to the Japanese invader and, like the Maginot Line, are a major tourist attraction.

What the Japanese learned from the tunnel wars against the Chinese, however, would be invaluable in their fight against the U.S. Marines in World War II. They borrowed the techniques of hidden bunkers and emplacements connected by an elaborate network of tunnels, first on the island of Peleliu and then on Iwo Jima.

There, they turned an entire mountain, Mount Suribachi, into a honeycomb of tunnels and bunkers lined with concrete, with multiple exits so that Marines clearing one end of the tunnels would find themselves suddenly under attack from the other end.

Clearing the Japanese tunnels was a grim business. Facing Japanese soldiers determined to fight to the death, U.S. Marines favored flamethrowers, explosive charges, and hand grenades (according to U.S. rules of engagement, poison gas was not an option). Marines on Peleliu suffered twice as many casualties as Marines fighting on Tarawa, largely because of the tunnels; the Marines on Iwo Jima were still clearing tunnels two months after the island had fallen.

There was method to the Japanese soldiers' madness. They hoped that by inflicting as many U.S. casualties as possible—and making the United States' path to victory as slow, painful, and costly as possible—they would deter Washington from attempting a similar full-scale invasion of Japan's home islands. It worked, but not in the way the Japanese had hoped. In order to avoid an invasion, U.S. President Harry Truman chose to end the war by dropping atomic bombs on the Japanese cities of Hiroshima and Nagasaki.

### **Undermining the United States**

The dawn of the atomic age forced militaries to dig even deeper underground to protect the chains of command from nuclear attack. So the United States built supposedly nuclear-bomb-proof shelters, including a five-acre network of tunnels buried under 2,000 feet of solid granite built into Cheyenne Mountain, Colorado, to house the North American Aerospace Defense Command; and the Presidential Emergency Operations Center, located 120 feet under the East Wing of the White House. Fortunately, neither one has been put to that ultimate test, although the PEOC was used by Vice President Dick Cheney during the 9/11 crisis.

But the most adept students of tunnel warfare during the Cold War were the Communist forces in the Korean and Vietnam

conflicts. In Korea, underground warfare reached a new level of size and sophistication in the 1950s. To evade American air supremacy, North Korean and Chinese forces built underground fortifications so extensive that for every mile of military front on the surface, there were two miles of underground tunnels—more than 300 miles in total. The tunnels were built largely by prisoners, who ripped out more than two million cubic meters of rock for structures that hid not only tens of thousands of soldiers and supplies, but entire artillery batteries that could be wheeled out of mountain caves to fire on South Korean or UN forces (and then drawn back in to dodge subsequent airstrikes).

The tunnels dug by Communist forces in South Vietnam were nowhere near as massive as the North Korean version, but they enabled the Vietcong to maintain a guerrilla war for years against a more numerous and better-armed foe. The biggest underground complex was the tunnels at Cu Chi close to Saigon, initiated during Vietnam's Communist insurgency against the French colonial military in the 1950s. These tunnels extended some 200 miles toward the Cambodian border and came complete with ammunition storage, barracks, workshops, kitchens, hospitals, and even theaters for showing propaganda movies.

The U.S. military was so oblivious to the underground threat, at least at first, that in 1966 U.S. troops built a base camp—a 1,500-acre compound housing 4,500 troops—at Cu Chi, directly over the Vietcong tunnels. Black-clad guerrillas soon began organizing attacks on the base, popping out at night to blow up planes and steal weapons and equipment, including a tank, before disappearing into the darkness. The U.S. military responded by declaring the area around Cu Chi a “free fire” zone and pounded it with artillery, bombs, and even napalm in hopes of destroying the Vietcong. Yet the raids continued: from their tunnels, the Vietnamese guerrillas could wait out U.S. bombing raids and then prepare to strike again. The tunnels “were like a thorn stabbing the enemy in the eye,” a Vietcong officer later remembered, one that had become impossible for the U.S. military to remove. According to one historian, the

tunnels had allowed the Vietcong to so deeply infiltrate the U.S. military installation that at one point, all 13 of the base's barbers were members of the Vietcong.

When at last an Australian engineer revealed that the tunnels under the base were more extensive than anyone imagined, the U.S. Army realized what a hornets' nest it was sitting on. The effort to clear the tunnels included teams of Australians, Americans, and New Zealanders dubbed "Tunnel Rats" who entered small surface access holes barely two feet wide, usually armed with nothing more than a flashlight, a few grenades, and a small pistol. What they found was a vast labyrinth of communication tunnels leading to caves and caverns built at four separate levels. With nerve and courage, the Tunnel Rats defied the claustrophobic and cramped conditions—as well as booby traps, snakes, scorpions, hordes of bats, and angry Vietcong fighters—to clear the Cu Chi complex from the inside. At the same time, B-52 airstrikes pounded the tunnels from above, causing many to collapse. Some 12,000 Vietcong fighters were killed in the Cu Chi operation, but the United States had barely started securing the tunnel complex when the country withdrew from the war. Today, even the Vietnamese honor the Tunnel Rats as the toughest, deadliest foe they ever faced. (The Israeli military has a similar unit, the Samoorim ["Weasels"], as part of the elite Yahalom combat engineers.) Although the Tunnel Rats could not save the U.S. mission in Vietnam, they did write one of the grittiest, if largely forgotten, chapters in the history of the U.S. Army.

In Vietnam, the tunnel digging stopped with the end of the war (although the Vietnamese revived their use during the Chinese invasion in 1978). Not so in North Korea. After the Korean War, Pyongyang's appetite for tunnels increased. In preparation for a fresh invasion of South Korea, North Korea designed tunnel complexes across the demilitarized zone between the two countries. Between 1974 and 1990, South Korean authorities discovered four massive tunnels extending from North Korea under the border, each buried more than 100 meters under the surface and

measuring two meters high and two meters wide—wide enough for three North Korean soldiers to march through shoulder to shoulder (sufficient for a full division of North Korean troops, roughly 10,000 soldiers, to march through every hour). One of the tunnels emptied out just 30 miles from the South Korean capital of Seoul. South Korean authorities closed down the tunnels as they found them, but no one knows how many more may remain undiscovered.

### **The Invisible Threat**

The Israel Defense Forces face similar problems in Gaza today. In the IDF's recent incursion into Hamas-governed territory, it has claimed that it destroyed no fewer than 31 military tunnels leading into Israel. But there is no doubt that a large maze of tunnels still exists in Gaza.

These tunnels were clearly not the product of improvisation. Indeed, their size and sophistication suggest that, in recent years, North Korea has been providing Hamas both weapons and expertise in digging tunnels. The construction of Hamas' tunnels involved the removal of massive quantities of earth almost entirely with electric jackhammers operating some 60 feet underground, in order not to alert the Israelis. Then the surfaces of the tunnel were lined with concrete, and iron rails were installed down the middle to facilitate the transportation of soldiers, missiles, and weapons in—and kidnapped Israeli victims out. Some of Hamas' tunnels were large enough to drive a truck through, and nearly all were booby-trapped. They were also positioned so that detecting and clearing the tunnels would cause massive civilian casualties on the surface. Hamas' main underground command center, for example, is situated under a hospital.

What the IDF discovered, to its dismay, was that Hamas' tunnels weren't simply extensive—they were also jam-packed with weapons in preparation for an all-out offensive into Israel that Israeli authorities say was planned to coincide with the Rosh Hashanah holiday on September 24. If Hamas' rocket attacks hadn't

triggered a bold Israeli reaction, including ground operations in Gaza, the tunnels might have gone undetected—and the coming Hamas offensive would have been as much a psychological blow to Israel as the 9/11 attacks were to the United States.

This is, of course, the great advantage of tunnels in warfare. They are an invisible and silent threat, unless you know what to look for and where to look. More often than not, countertunnelers have had to rely on luck, instinct, and human intelligence (that is to say, an informer) to find their whereabouts—and, as history has shown in Cu Chi and Messines Ridge, by the time they find out, it's often too late. Meanwhile, the factor of the unknown can gnaw at an antagonist's imagination, filling an entire community with fear and adding a dimension of psychological warfare to the other challenges tunnel warfare poses.

No one in Israel can be sure that the IDF has taken out all of the tunnels Hamas has built, any more than they know how many tunnels Hamas' Shiite counterpart, Hezbollah, has dug into Israel from Lebanon. Reports suggest that the Hezbollah tunnels may be, if anything, even more sophisticated. Likewise, South Koreans cannot be sure they've found every tunnel that their Communist neighbor has burrowed under the demilitarized zone, although no new tunnel has been found since 1991.

### **Technology versus Tunnels**

Even the United States can't rest easy. The recent uncovering of more than 200 tunnels dug across the Mexican-U.S. border—95 in Nogales, Arizona, alone—has spurred fears of an underground assault. Most of these cross-border tunnels are used for smuggling illegal immigrants or drugs; but they could also become conduits for terrorists. That danger has prompted the Pentagon and the Department of Homeland Security (DHS) to develop new ways of detecting tunnels that are more systematic than relying on dumb luck or the occasional informant. In January 2011, the U.S. government even set up a Joint Tunnel Test Range at the Yuma Proving Ground in Yuma, Arizona, to sample the latest anti-tunneling technologies.

High-tech tunnel detection is an inexact science, to say the least. One underground detection expert, Paul Berman, has told the *Times of Israel* newspaper that electrical resistivity tomography, which measures levels of resistance in the earth under a given patch of ground, can find anomalies that would point to the existence of tunnels—or again might not. So far, no one has found the magic high-tech formula for finding hidden tunnels. “Tunnels have only been, so far, successfully located by intelligence, not by technology,” according to John Verrico of the DHS Science and Technology Directorate. Seismic testing technologies that help oil and gas exploration or the construction trade find the geophysical character of a piece of land aren’t designed to look for the distinctive features of tunnels. Sensors that work well in finding gaps or crevasses in one environment may miss significant features of another, including the presence of a man-made tunnel.

Ground-penetrating radar has been one promising area of research, using pulses of radio frequency energy to find voids or gaps beneath ground surface. GPR works fine for locating utility lines and minesweeping operations and finding buried historical sites. But looking deeper, to the 10- to 20-meter depths where terrorists like to lay their tunnels, is more difficult. Lockheed Martin is working with the DHS on a lower-frequency version of GPR, using electromagnetic waves to plot tunnels deep underground, but until now the results have been indeterminate.

Another promising approach is the prototype Active Acoustic Tunnel Detector, being developed at Idaho National Laboratory, which transmits up to 200 hertz of acoustic waves into the ground. An onboard motion detector measures how the waves move the dirt and rock that those sound waves pass through. If the ground is solid, the resulting graph shows a rapidly rising line. If there’s a gap or void, the graph line will appear as a hump or dip. A third approach uses microgravity analysis, measuring minute changes in the planet’s gravitational field to locate a tunnel. That requires a higher level of precision than current testing can show and will require a heavy investment in research to get any reliable results.

In any case, once a tunnel is found, there still remains the problem of how to clear or secure it safely, especially if it's booby-trapped. The use of robotic vehicles to explore and neutralize a tunnel structure may eventually replace the volunteer "Tunnel Rat." But for now, the old techniques of clearing them with explosives and a handgun remain the standard—as do the dangers of that approach.

In fact, if there's any certain bet to come out of the fighting in Gaza, it's that tunnel warfare in the hands of future insurgencies and militant groups will pose a persistent problem in spite of all the high-tech weaponry and gadgets of traditional militaries. Which side ultimately prevails depends on many factors. But anyone who thinks there's clear light at the end of this tunnel had better think again.