80 Meter HF Radio Experiments

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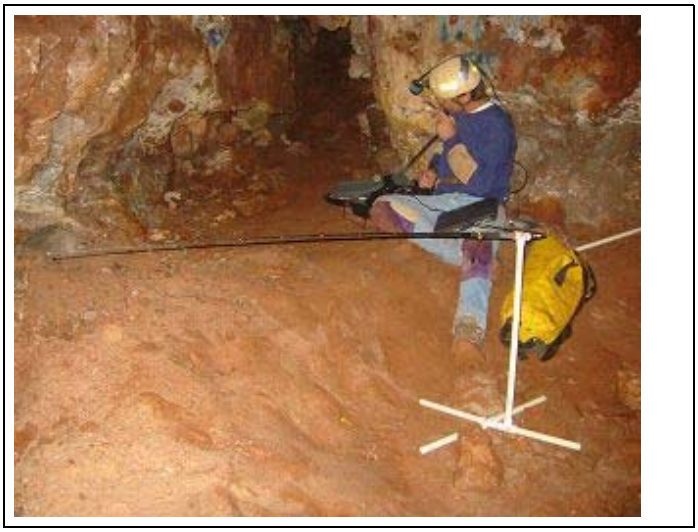
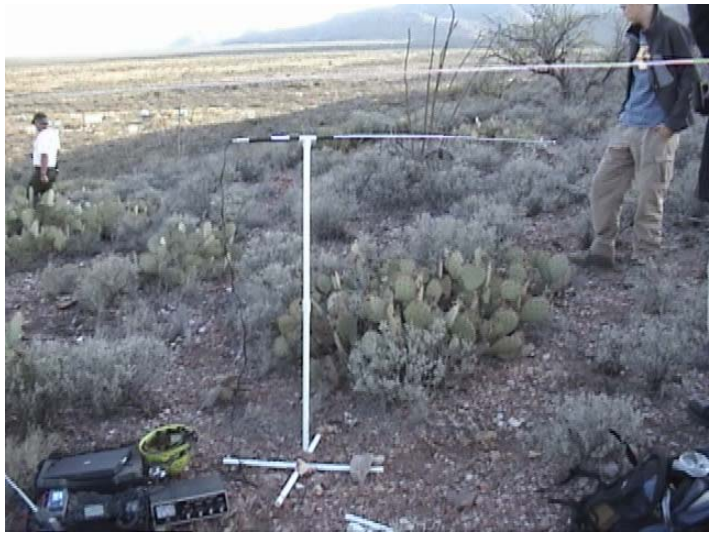


With the success of other reported HF radio use underground (most recently by Bonnie Crystal in SPELEONICS 24), some experiments were undertaken to see what was possible at 80 meters in the US ham bands using commercial off the shelf equipment. Both voice and data, using PSK31, were tried with success. Various antennas were tried with varying rates of success.

The first problem was to get caver ham radio operators willing to work on the experiment. This was solved by 'new blood' coming to the local Grotto with ham licenses and another long time caver getting his license.

The second problem is finding adequate testing for the underground station in an area with limited caves. We do have a lot of mines in Arizona, however. One abandoned kyanite (aluminum oxide) mine is inside a city mountain preserve. It is a straight tunnel that runs back over 200 feet (65 meters) into the mountain. At the back of the tunnel there is about 95 feet (29 meters) of overburden, sloping to nearly nothing at the entrance. This seemed to be an adequate testing area for the first try. The second test was in a small limestone cave that was about 300 feet (91 meters) long and ran within about 50 feet (15 meters) of the surface. The third test was in an abandoned chrysocolla mine (copper-bearing silicate) that ran horizontally into the mountain for about 600 feet (180 meters) and had about 200 feet (60 meters) of overburden at the test site. The fourth test was in a limestone tourist cave with two tour routes that were about 150 feet (45 meters) below the surface on average. These sites offered varying degrees of conductivity (hopefully to be tested later) and rock type for the tests.

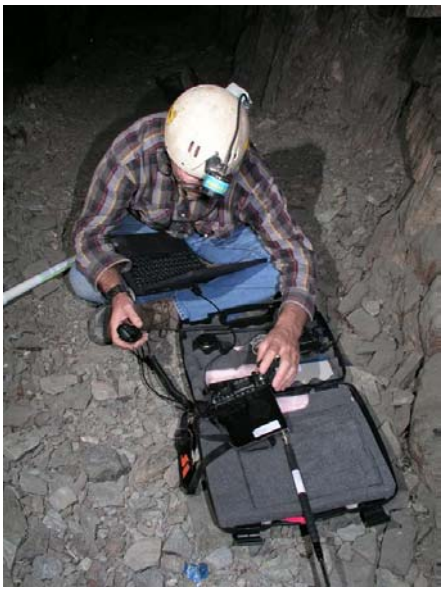
The last problem is what equipment to use. For both voice and data, standard QRP ham radios were used - Icom IC-703 and Yaesu FT-817ND. For some of the PSK31 experiments a kit-built PSK-80 data radio was used (PSK-80 kit from Small Wonder Labs http://www.smallwonderlabs.com/). For generating PSK31 signals otherwise, laptop computers were interfaced to the HF radios running Digipan soundcard software. The laptops used their own internal rechargeable batteries. Rechargeable sealed lead acid batteries provided the power for the transmitters.



A wide variety of antennas were tried on the surface including portable collapsible antennas, dipoles, mobile whips, and a full wave loop. Portable collapsible antennas (MFJ 1899T) were used exclusively underground. Direct connection of the small antenna to the radio was tried on the first test. It became obvious quickly that detuning effects and mechanical stability were not the best in this configuration. Subsequent tests used a portable stand made from PVC plumbing pipe and connectors. It allowed the antenna to be mounted vertically or horizontally and used a coax to the radio. This allowed physical separation and far increased the

mechanical and RF efficiency. The first test also did not use the recommended counterpoise of about 50 feet (15 meters) which was used on the later tests to help keep RF feedback from being a problem.

All of the tests produced excellent results. Two way SSB voice was achieved at power levels from 1 to 10 watts, often with very nice signal strengths. The small antenna performed very well and was, at the distances tested, equal to the full wave loop 3 to 6 feet (1 to 2 meters) above the ground. That was a surprising result, but the signal strength was so high during that test that what ever advantages the loop might have had were swamped by the strong signals. The most interesting result was that the dipoles, erected near the entrances in a nearly level plane with the underground station, lost the underground signal within a short distance from the entrance, while the small antenna continued to perform well.



Using the small antennas, the first test site yielded strong two way SSB signals at a horizontal distance of over 400 feet (122 meters). The underground station was 200 feet (61 meters) inside the mine. A one way SSB signal was received at slightly over 870 feet (265 meters) away on the other side of the ridge. The second test had good two way SSB communication at 300 feet (91 meters) from the entrance. Interestingly during the second test, a signal was received by the underground team from a ham that was about 40 miles (65 kilometers) distant using a horizontal dipole and 100 watts of power. That station was not able to hear (really was not listening for) the underground or surface stations which were running 10 watts. At the third test site, usable two way SSB communication was achieved at a distances of up to 500 feet (152 meters). At the fourth site, two way SSB communications from room to room in the cave were excellent at a distance of 500 feet (192 meters) which was just about as far apart as the stations could be on the cave tour route. The surface station was able to have very strong signals from anywhere in the cave using only 1 watt of power - distance up to 500 feet (192 meters) horizontally. This test was the only one done at night. The band was open and skywave QRM was running at S7 to S9. The underground stations were able to clearly copy stations from hundreds of miles away while they were 150 feet (45 meters) below the surface on average.

PSK31 signals were also copied down to the 1 watt level using the same antennas at all of the test sites. The main problem with the PSK set up was that the RFI from the laptop computer would nearly swamp the receiver in some cases, but the digital signal still prevailed. A different laptop using the same cables helped. While probably not the best digital mode for underground communications, it certainly was possible to pass text messages from one station to another with very limited power levels.