Seismic Shooting at Permanente

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This article has been reintroduced to honor the memory of the late Ed Criley, a member of the GW Chapter and employee of the U. S. Geological Survey. Photographs in this article appear courtesy of Gordon Coleman.

Sometimes a blaster or blasting engineer encounters situations where the limitations of blasting technology or the capabilities of the explosive products are being pushed to the limit. Such a situation developed quite a few years ago when the U. S. Geological Survey was selected to conduct some research that involved detonating fairly large charges in deep holes.

Ed Criley of the USGS was in charge of determining what explosives to use and how to load them. Ed's problem involved the detonation of a 1000 lb charge of high velocity explosive in a partially cased hole drilled 1000 ft deep in (then) Kaiser Cement's quarry at Permanente, CA. The depth involved and the need for reliable detonation, coupled with safety considerations (if the charges didn't fire, they would have to be retrieved) all contributed to Ed's problem.

I had worked with Ed and Jack Van Shaack, branch field operations manager, on several USGS projects and had been doing the blaster training for their shooting crews. Ed contacted me to see if a satisfactory product was readily available, both for the explosive and for the detonating system, and to pick my brain regarding a process whereby the charge(s) could be retrieved if necessary. The explosive product and the need to have the capability for retrieval were fairly straight forward. We selected Hercules' Gas Well Explosive in 5" x 100 lb 23G cartridges with internal stainless steel aircraft lowering cables. The cables had a swaged loop top and bottom. The cartridges were to be coupled together and lowered to the bottom of the hole with a small truck-mounted crane. Ten cartridges would give us a 1000 lb column approximately 100 feet long. I was somewhat concerned about the ability of the internal cables in the upper cartridges handling the full 1000 lb weight, so we made the decision to fill the hole with water. The specific gravity of the explosives was 1.35 grams/cc, so the effective weight of each 100 lb cartridge when submerged would be reduced to about 26 lbs, for a total weight for the column of approximately 260 lbs. This eased the strain on the cables sufficiently.

Flooding the hole, however, brought about another problem: Finding a detonator that would function properly under a pressure of approximately 435 psi under 1000 ft of water at the bottom of the hole. None of the manufacturers in those days rated their seismic detonators to shoot reliably above about 250 psi. I contacted an inside source at Hercules who told me (unofficially) that they regularly tested their Vibrodets to 1000 psi, thus I felt comfortable that they would function satisfactorily at about half that.

Enough explosives and detonators for at least three shots were ordered and Ed arranged for the necessary crane, cable, firing lines and other accessories. Ed and I got together at Permanente the day before the scheduled blast and made up the detonator assemblies. My plan was to put three caps in one circuit for the bottom cartridge and another three on a separate circuit for the top cartridge. (Yeah, I'm a belt and suspenders kind of guy.) If there was ever a situation that begged for double-priming, this was it. I didn't want splices in the firing lines, but couldn't avoid the underwater splices required to tie the detonators to the two firing lines. These were made up carefully, with the splices crimped and sealed with silicone sealer which was overlaid by heat-shrink tubing. After the silicone sealer took a partial set, we shrunk the tubing tightly around each splice.

On the morning of the shot, we inserted the cap assemblies into the cartridges (see photos 1 and 2), taped them securely and started the loading process. The crane picked up the first cartridge (with detonators inserted) and the second cartridge and lowered them into the hole until the upper cable loop was at the top of the casing. A rod was installed to hold it (see photo 4) while the next cartridge was hoisted and coupled to the first with a screw-pin anchor shackle. The rod was removed and the assembly lowered to the next loop. This process was repeated until the top cartridge with its detonators was attached to the column and the whole lot lowered carefully down the hole.

Photo 1 – Ed making the initial cut.

Photo 2 – Ed and Wes inserting caps.

Both firing circuits were monitored continuously with galvanometers as the column was lowered. Unfortunately, at some point near halfway, one circuit opened. The reason was unknown, but we suspected that the wire probably caught on slag or a burr on the inside of the casing. A discussion ensued as to whether or not we should retrieve the column and either repair the wire break or re-prime, or to just continue the lowering process. Time was a consideration as the scheduled firing time was rapidly approaching. Numerous seismic lines had been laid out with recording devices that were programmed to wake up and record at a specific time.

I was reasonably confident that one set of detonators would do the job so we elected to continue the lowering (with fingers crossed that we wouldn't snag the remaining circuit).

Photo 3 – Loading the first cartridges.

Photo 4 – Jack waiting for the next cartridge.

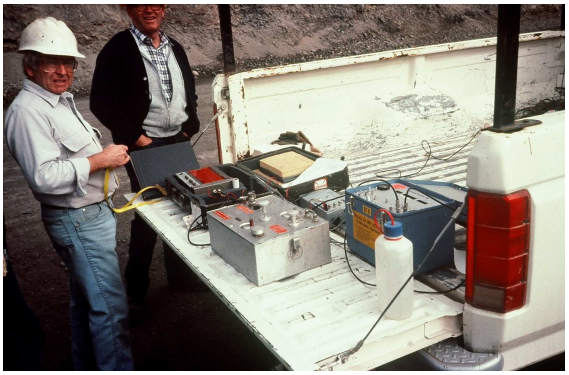

Photo 5 – Ed and Jack with their shooting box and recording gear.

Photo 6 – Conventional blasting seismographs

The shot went off successfully and on schedule and resulted in a geyser of water a couple of hundred feet high. Most of the lowering cable was ejected with the water (photos 7 and 8).

Photo 7 - Water ejection shortly after detonation.

Photo 8 - Water still raining down with mostly steam coming out of the hole.

I captured the results on videotape and a couple of blasting seismographs and Jack's people recorded the results with their seismic lines. The next day we loaded a second shot in the same hole. It took nearly a tanker truck of water to fill the cavity from the previous shot and we lowered the charge to only 900 feet to keep it in competent rock. A third shot was also loaded and detonated. After that, the cavity volume had become so large that further shots in this hole were not attempted.

One has to wonder what future mining people will think when they encounter that huge void down there. It's unlikely that anyone will see it though. Mining to that depth would require a considerable expansion of the pit and that isn't likely to happen at Permanente due to the proximity of the surrounding communities.