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Acquisition Report

Explosive Source Tests and VSP Survey

Rosebery Mine, Tasmania

Nov 2011

For

MMG Corporation

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Executive Summary

Explosive source testing demonstrated that small explosive charges in fairly shallow holes should deliver reasonable energy to geophone sensors about 1 km or more away. The charge sizes were generally 60-90g of PETN in a 1200 mm hole. In these tests a well coupled geophone could clearly detect first arrival seismic waves approximately 100-700m from the shot. All test shots, some with up to 120g of explosive, were well contained in a 1200-1500 mm hole, with no fly-rock or craters.

The coupling of energy to the ground while adequate was not as good as hoped. Most test holes did not reach fresh rock and insufficient water was contained in the hole to couple the energy efficiently to the rock-mass. Thus, holes should try to reach very competent rock and charge sizes to 150g can be used without significant fly-rock. A single cast booster/explosive of 100-150g in a deeper hole of 1500 mm is recommended.

The geophones should be planted in the weathered rock where possible. Soil, moss and humus cover should be avoided as the geophones planted in this material are clearly less sensitive. Also, the wet and rainy weather of the area near Rosebery means that raindrop noise may be problematic. Thus, the geophones should have some loose soil humus cover where possible to attenuate these noisy events.

A zero-offset vertical seismic profile (VSP) survey failed to provide the velocity with depth profile to the target depth because the direct waves were either too weak to be detected, or the sources of noise too strong. The hydrophone string appeared to be fully functional and was deployed with no significant issues, but the relative strength of direct arrivals vs ambient noise is too low to pick the early, direct arrivals. Noise from a nearby drill rig and the mine appear to be significant problems. Tube waves in the hole were found to propagate without much loss; thus, the trapped noise energy masks the relatively weak direct waves. Another aspect that may have lowered signal-to-noise is the possibility that a nearby fault or dyke close to the shot-holes may have scattered the energy away from the borehole. Velocities in the top two hundred metres averaged 4700m/sec.

The experimental VSP survey should be re-trialed ideally with tube-wave baffles to significantly extend the velocity depth profile obtained with this first test.

Survey Aims

The principal aim was to test the viability of a small explosive source for imaging the Rosebery area geology. This would be achieved by recording the post-blast ground waves with geophones on the ground and a hydrophone array in a newly drilled borehole. Good signal-to-noise on the geophone array would indicate the source will perform acceptably. A secondary aim would be to gather time-depth conversion. Such data is useful for processing and interpretation later. Also, the hydrophone array data will also further indicate how much energy reaches the target.

Acquisition

The data was collected in a single day, Thursday 10 Nov 2011, starting at approximately 11am after equipment set-up and testing. Detonator and trigger tests were performed the previous day. Firstly, tests with a detonator and several nearby geophones verified the trigger was operating correctly. Then noise, with a surface impact, of the VSP array was analysed to verify that it was electrically correct. The VSP tool was lowered by 200m increments with 4 elements of overlap between “drops” of the array. The array was allowed time, about 5-10m, to settle with respect to hydrostatic pressure.

The first record was taken with the hydrophone array at 50m (top sensor element position), then deployed at 250, 450, 650, 850, 1050, and lastly 1230 to avoid hole bottom at about 1470 for the lowest sensor. At a depth of 850m extra channels were added (30ch) of surface geophones that headed up-hill with 10m spacing between geophones. As the VSP hydrophones and surface geophones were combined into a single record with the recording system there are 5 unconnected channels (1-3 and 28-29) due to link to computer and a small cliff face at the start of the geophone line.

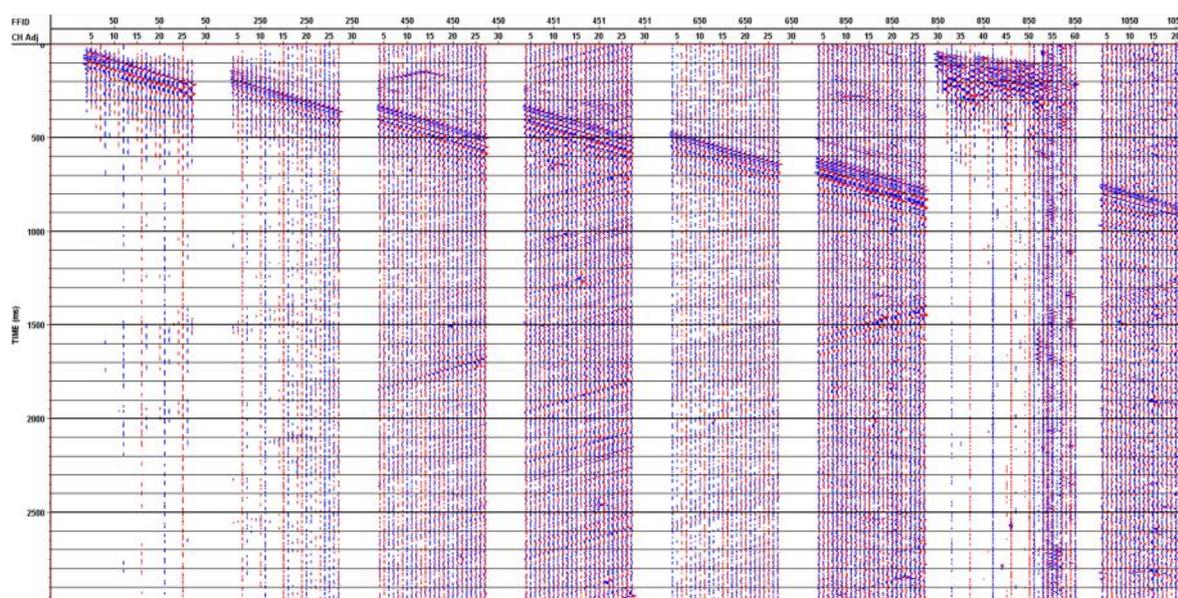


Figure 1 Examples of shot records with VSP string at various depths plus one panel with surface geophones (second last from right). Most of the energy is in tube waves, which appear as diagonal bands of signals.

After several shots it became apparent that there was insufficient signal-to-noise in the VSP hydrophone string to obtain good first break data. Firstly, it was discovered that a nearby drilling rig was the cause of most of the noise (see third panel in Figure 1)

Analysis of Surface Geophone Results

In general, the small explosive charges provided reasonable (refraction) signals except for a group of geophones that were planted in soil humus at the distant end of the geophone line (Figure 2). The signal vs background noise ratio is 10:1 to 5:1 for geophones up to 300m away on shots near the VSP area. Data from the single shot placed about 400m further down-slope were of similar quality. Thus, the fresh rock does not seem to attenuate the signals very much. It should be noted that “raindrop noise” is prevalent in many of the records (random noise spikes occurring during rain periods, see Figure 3).

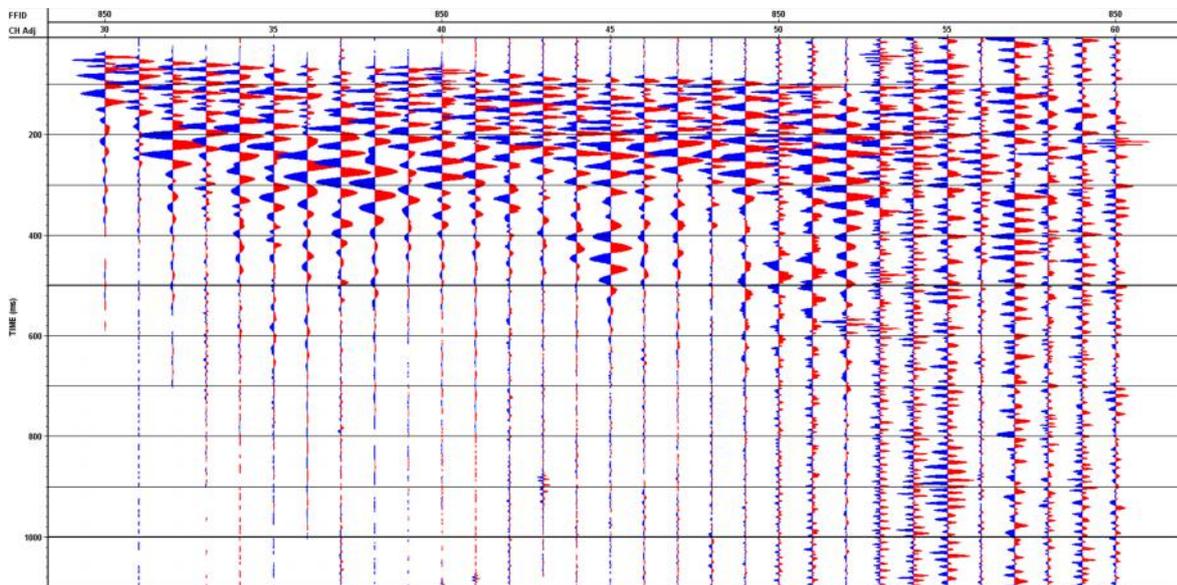


Figure 2 Surface geophone response to 60g of explosive 50-350m from shot-point. The refractions, a proxy measure of returned signal strength, are relatively strong; until the geophones that are placed into mossy and humus rich soil near the top of the hill ridge.

Many of the shots in the VSP tests were inconsistent in explosive coupling. This was noted in the relative strength of refractions and tube waves in the VSP data. Many holes did not allow water to remain with the explosive package because they were drilled slightly upward – a more comfortable position for the drillers (Figure 3 for example). Also, the use of multiple small boosters tied together did not seem to perform as well as expected. Single charges weight-for-weight performed better (Figure 4).

The greatest influences on received signal strengths are the coupling of explosive to rock (the quality of hole and water coupling) and the way the geophones are planted in the ground.

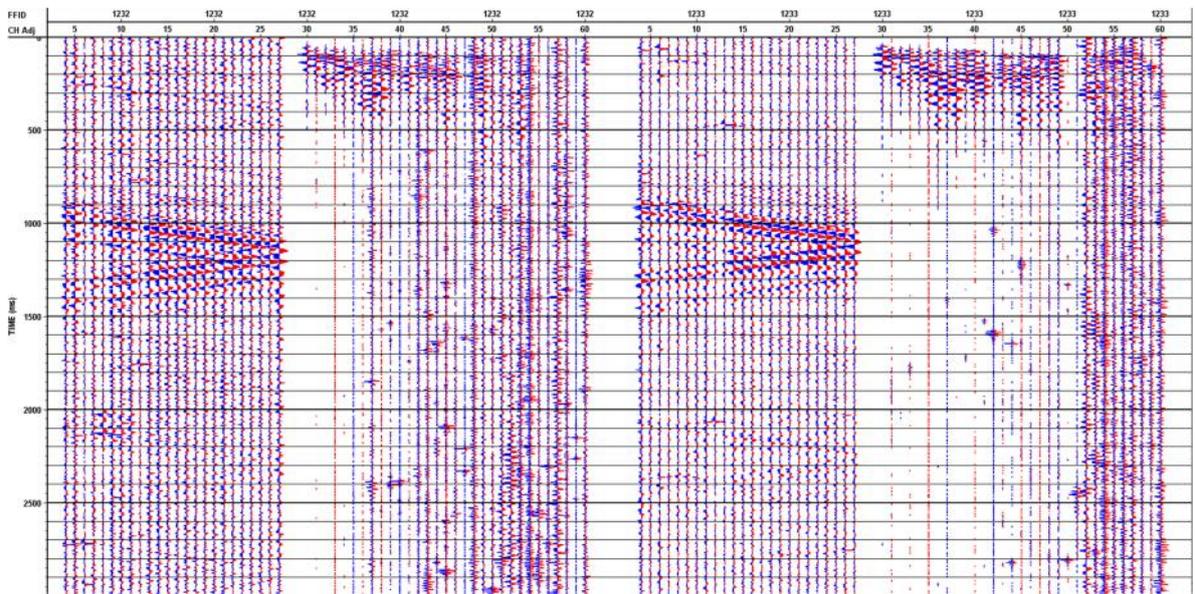


Figure 3 Combined VSP and surface records with VSP tool at maximum depth. The VSP data is the left portion of the panel (that has tube wave chevron patterns) and the surface geophones are the right portion. The record on the left (FFID=1232) used a “horizontal” hole and the record (FFID=1233) on the right used a “vertical” hole. Both used a single 75 g booster. Note the raindrop noise, random spikes, on the uncovered geophones.

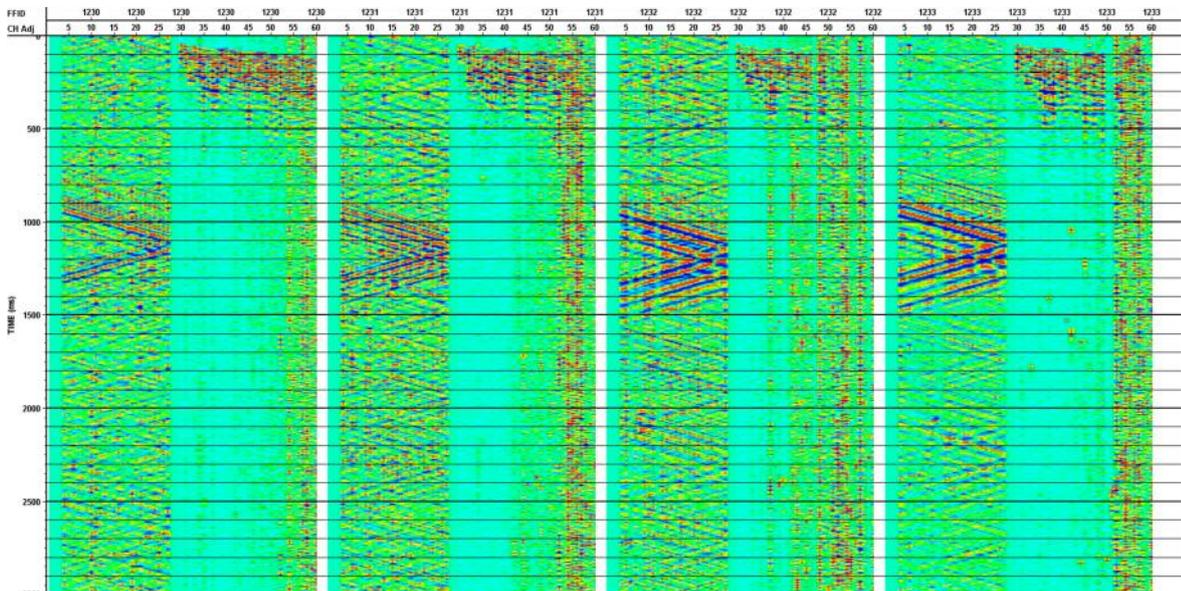


Figure 4 Four repeat shots with different holes and explosive strengths. From left to right the shots were with 3x30g, 4x30g hole re-used, 1x75g in reused hole, and 1x75g in new hole. The use of multiple boosters tied together does not perform as well as a single but smaller explosive in a good hole.

Analysis of VSP Results

The VSP data is relatively weak. The tube waves appear clearly at depths up to about 800m, and then become somewhat weak as well. These organ-pipe like modes have a characteristic slope and form diagonal bands in the data. Apart from the first 200m there is insufficient quality of data to prove velocity information. The velocities in the top 200 or so m appear to be of the order of 4500-5000m/s (4700 m/s average), which is typical for a crystalline rock environment.

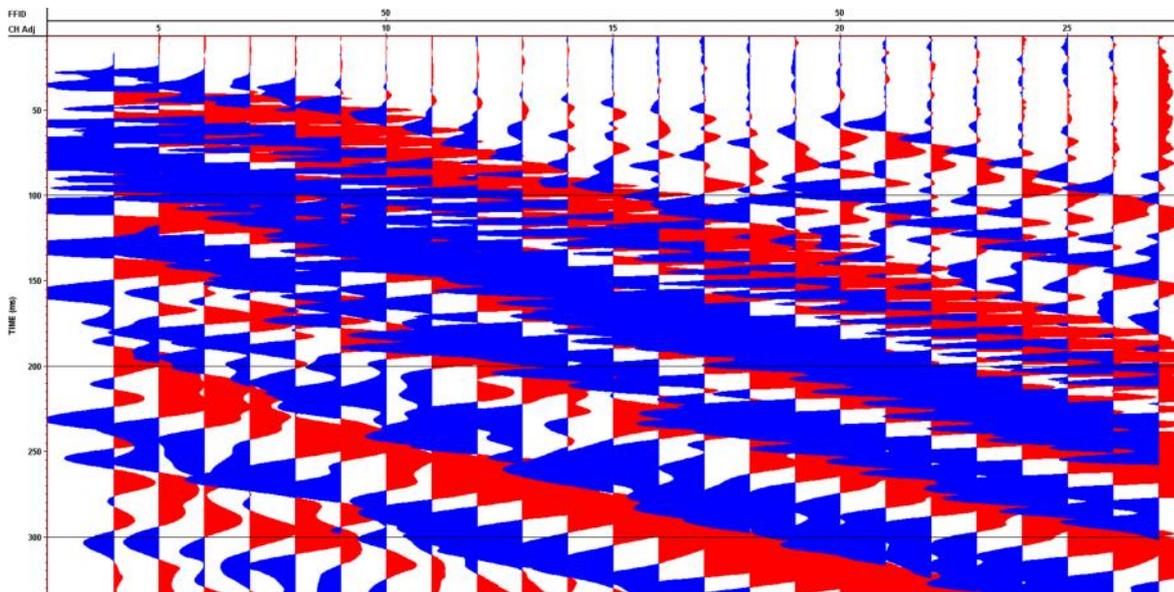


Figure 5 Zero offset VSP with string top set at 50m, lowest sensor at 280m (rightmost). The first energy is relatively clear in the high gain presentation of the data, the first blue pulse. Also, there is a major fracture at approximately 210-220m in the hole. Such fractures are sources of tube wave emission when the p-wave arrives at the fracture location.

The data appears to have low signal-to noise. It is not clear whether the hydrophone array was in some way not providing good signal because of electric malfunction – unlikely as the tube wave signals have good fidelity, but not great S/N either. P wave energy from the explosives were not strong. However, the surface geophones have reasonable signal-to-noise when well coupled. Thus, there appears to be trapped tube-wave energy from nearby drilling or mine activity. This energy can be seen in the bands of tube arrivals which are often stronger going upwards (downwards – a line of energy trending downwards from left to right vs upwards – trending upwards from left to right). This can be seen in figures 6 and 7, where there are upward moving bands throughout the data. Tube-wave reflections from the top and bottom of hole are apparent (and seen from the explosion generated band of energy which bounces back and forth too). Despite turning off the nearby drill the later shots are also full of these un-damped wave-modes.

The background noise can be better handled if the tube-wave noise were better damped in the hole. Signal processing is unlikely by itself to remove these noise patterns in the data.

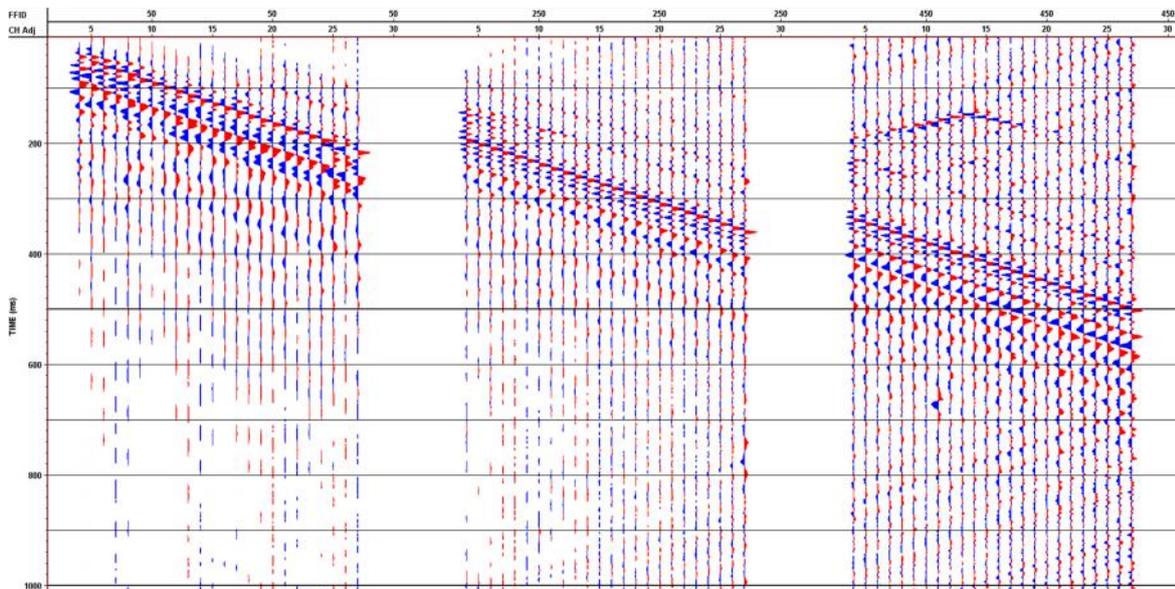


Figure 6 First two string positions, 50, 250, 450m to top sensor. Ideally there should be low noise prior to received energy (a white clear zone in the upper portion of the plots as in the left-most panel) The rightmost panel also has noise from a nearby drill starting up.

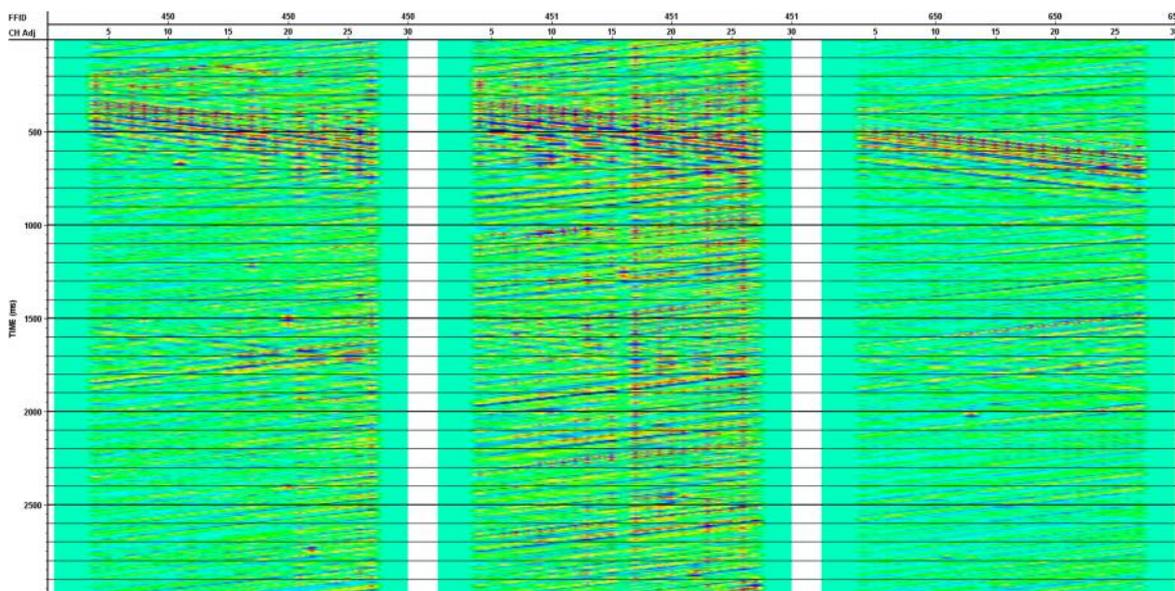


Figure 7 Examples of upward tube waves from external sources. The main down trending energy is from the explosive. However, there are many bands prior to the explosive energy arriving and much later, indicating various external noise sources.