

# **Noise Survey at Newmont Gold's Mines North of Carlin, Nevada**

by  
Richard D. Miller  
Jeffrey Erickson

of the  
Kansas Geological Survey  
1930 Constant Avenue  
Lawrence, KS 66046

report to  
Newmont Exploration Limited  
Geology Trailer  
6 miles north of Carlin  
Carlin, Nevada 89822

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## **Introduction**

Noise associated with mining operations can inhibit the use of seismic reflections techniques in areas with low attenuation and in close proximity to routine activities such as milling, heavy transport, drilling, and excavation. At distances of a couple hundred meters, acoustic energy propagating from most heavy equipment and commercial operations discernible on seismograms is one of two types: 1) air coupled waves (audible sound to the human ear, travel through the air coupling to the ground in very close proximity to ground coupled receivers), or 2) surface waves (acoustic energy generally in the lower portion of the recordable frequency spectrum traveling in the very near surface in a retrograde elliptical fashion, also known as ground roll). Both air coupled waves and surface waves, regardless of their source, have unique characteristic frequency ranges that normally overlap the signal spectra of most reflection surveys. Seismic reflection surveys are usually tuned or sensitive to acoustic energy within a limited frequency band. For conventional petroleum reflection surveys, frequencies from about 10 to 100 Hz are of particular interest. For high resolution surveys, such as the one to be performed near the Post mine, critical frequencies fall within a band from about 50 to 250 Hz. Filtering is an effective method (both frequency and velocity) of attenuation as long as the amplitude of the noise is not large enough to saturate the recording system's analog-to-digital conversion.

A noise source generally present to some degree at most industrial sites is 60 Hz (or some higher mode) powerline noise or hum. Narrow band noise such as powerline noise can usually be notch filtered (frequency) assuming the amplitude is not too great. In situations where the amplitudes are too large to filter, little can be done to remove powerline noise. Velocity filtering is not effective on powerline noise due to its flat arrival pattern on a time series trace and the flat reflection arrivals at near offsets of reflection energy. The more conductive the soils, the more prominent 60 Hz will appear on seismograms recorded in close proximity to a source. Powerline noise is generally very attenuative and normally data acquired at distances greater than a couple hundred meters will not have an appreciable amount of 60 Hz recorded. The higher the moisture content of the upper few centimeters of soil, the more pronounced the 60 Hz noise problem.

The recording of high quality seismic signal requires the controlled production of acoustic energy. A noise source that can at best be minimized but never eliminated is the seismic

source itself. In association with the production of body wave energy necessary for producing reflection signal, noise of various kinds are generated. This noise can include air coupled waves, surface waves, direct waves, refractions, diffractions, and multiple reflections. Every recorded acoustic arrival that is not a primary reflection is noise. The ratio of signal to noise is influenced by site activities (in this case the mining operations) as well as the near-surface conditions and the seismic source.

Noise tests were performed on March 10 and 11, 1995 in preparation for a high resolution seismic reflection survey near Newmont Gold's Post mine located north of Carlin, Nevada. The tests were designed to measure the noise levels on seismic recording equipment in this active mining area in hopes of evaluating the impact of mine noise on high resolution seismic reflection data. The measurements were primarily focused on frequency content and amplitude of background noise near the proposed lines in comparison to quiet areas where seismic data has been successfully recorded on previous surveys. A total of 56 noise shots were recorded at eight different sites near Mike (Troll) and Post.

### **Data Acquisition**

Data for this test were recorded on a Geometrics 48-channel 2401X seismograph with 40 Hz Mark Products L28E geophones. The seismograph was set up to record 1 second of data at a sampling interval of 1/2 msec. Only three of the seismograph's 48 channels were actively recording data. The three-channel configuration was for speed. The quality of the noise test was not compromised by the small number of receivers. The data had sufficient redundancy to make confident determinations of frequency and amplitude of various identified noise sources.

The environmental conditions provided the best scenario possible for enhancing noise on a seismogram. The continuous drizzle, sleet, and freezing rain reported during the recording of the data would have not only maximized the impact of powerline noise, it would have also increased the cable to earth leakage and chatter from ground and geophone case impacts. To determine if any directionality was evident in the propagation patterns of the noise, the three station geophone arrays were oriented both east-west and north-south at each site.

## **Processing**

The processing of the data was limited to scaling, frequency filtering, and spectral analysis. The sections are displayed in a fixed gain, trace by trace normalized, and automatic gain control (AGC) scaled format. Spectral analysis was performed on records with unique frequency characteristics. The resulting displays allow meaningful comparisons of noise levels and frequency characteristics of each of the identified noise sources.

## **Analysis**

Powerline noise is prominent on the three-channel seismograms with geophones deployed within 75 m of overhead lines (Figures 1-2). The spectra of traces with cyclic powerline noise evident have a 30 to 40 dB spike centered on about 60 Hz (Figure 4a). The cyclic nature of 60 Hz noise is evident on files that, based on field notes, were within 75 m of power lines (Appendix A). The very wet near-surface dramatically improved the electrical conductivity of the near-surface. Relative to the anticipated frequency band of high resolution seismic reflection data, the 60 Hz noise will be at the lower extreme of the recorded bandpass. Based on the QA/QC procedures to be followed during the acquisition of seismic reflection data at this site, data will not be collected while rain is falling and a high degree of earth-to-cable insulation will be maintained during the recording of the multi-fold reflection data. These two quality control measures will dramatically reduce the offset distance from powerlines necessary to record acceptable signal levels while keeping cyclic powerline noise below predetermined noise thresholds. Powerline noise at the amplitude levels evident on files 1 through 6 and 14 through 25 would be a major problem on production CDP data but would not, however, be sufficient to prohibit interpretation of final 24-fold stacked sections.

Frequency filtering of powerline noise with a digital notch was reasonably effective in attenuating much of the hum (Figure 3). A digital notch filter from 59 to 61 Hz dramatically reduced to overwhelming effects of the powerlines (Figure 4b). Acquisition notch or digital post-acquisition notch filters are designed to attenuate 60 Hz noise, but unfortunately have a detrimental effect on the richness of the frequency spectrum. If 60 Hz noise represents a significant portion of the digital word, a notch filter in association with vertical stacking would allow sufficient signal to be recorded to permit the enhancement of signal on CDP stacked sections.

Relative amplitude displays (Figure 1) allow comparisons of file to file noise types and levels. Powerline noise at both Mike (files 1 to 6) and Post (14 to 25) is more than 40 dB greater than any other noise source. Records away from powerlines have broadband noise with amplitudes that, based on qualitative analysis, are more than 60 dB down from signal levels recorded during previous seismic surveys at Mike in the late 1980s. The lack of industrial noise at the Mike site is evident when comparing files 7 through 13 with similar settings at Post as represented on files 32 to 56. Comparison of spectra from the quiet areas of Mike and Post have similar frequency properties (Figures 4c and 4f). The background noise at Post is obviously higher than at Mike. Based on qualitative comparisons the sporadic noise bursts evident on the Post records are about 50 percent (~3 dB) higher than similar bursts at Mike. With the dynamic range of the recording system being in excess of 110 dB, as much as a 6 to 9 dB increase in noise should not be a major factor in the success or failure of a well-executed reflection survey at this site. Analysis of frequency spectra indicate most spikes are extremely narrow band and as much as 6 dB greater than ambient. This suggests frequency filtering and broad band signal will combine to minimize the average noise as determined by these records.

Without prior knowledge of which records were recorded during Haulpack movement it is very difficult to distinguish which were recorded coincident with heavy equipment movement. Haulpack movement is not evident on files recorded with an east/west orientation (files 14 to 19). After careful examination, some higher levels of high frequency noise are evident on files recorded with Haulpack movement when the receivers were oriented north/south (files 20 to 25). Comparison of amplitude spectra clearly denote the subtle differences interpreted on the time series plots, especially a 10 Hz spike at about 40 Hz present on the spectra when the Haulpacks were in the area (Figures 4d and 4e). The apparent attenuation of noise based on geophone orientation is encouraging when considering that noise is reduced when recording is parallel to the proposed orientation of the production CDP lines. This apparent impact on recorded noise levels based on orientation is evident on many files from around the Post area.

Decreased noise levels are noted within several hundred meters of the water treatment facility. This decreased noise is probably related to distance from the active mine works. The frequency content of the noise has dropped, probably as a result of attenuation due to the increased travel path from the noise source. It is very unlikely that activities at the treatment

Figure 1. 56 field files plotted relative amplitude. Some display clipping of 60 Hz was necessary to allow any wiggle trace representations on files from quiet areas. This display clearly allows comparative analysis of the Mike site with Post.

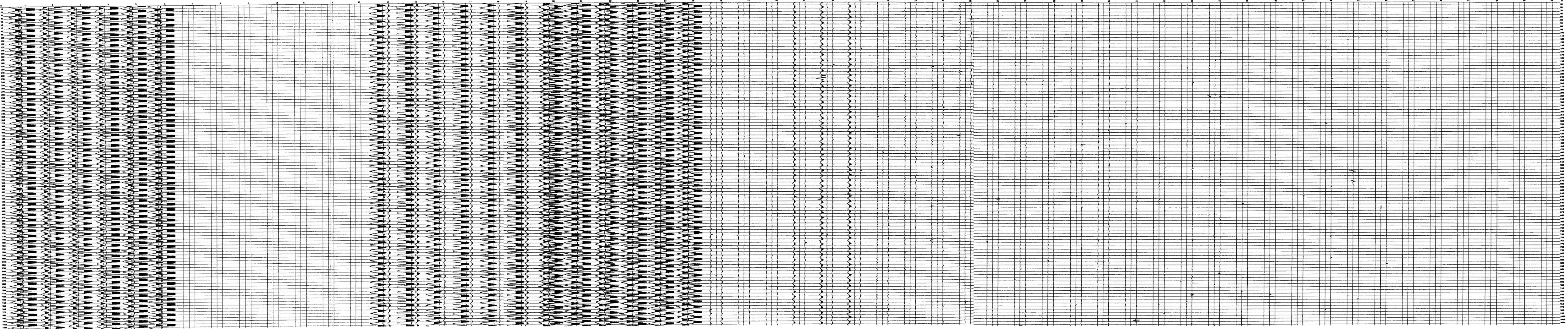


Figure 2. This AGC scaled plot of figure 1 provides a definitive look at the noise types and patterns.

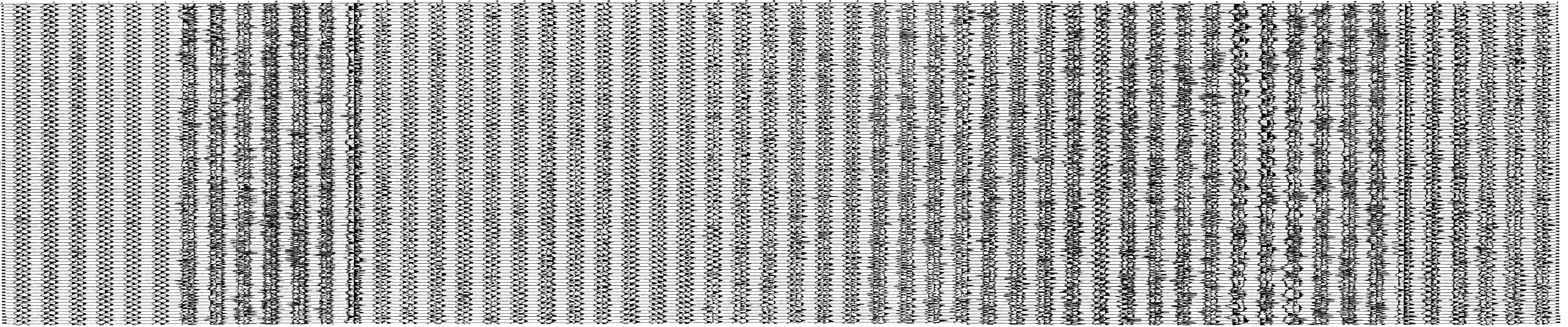
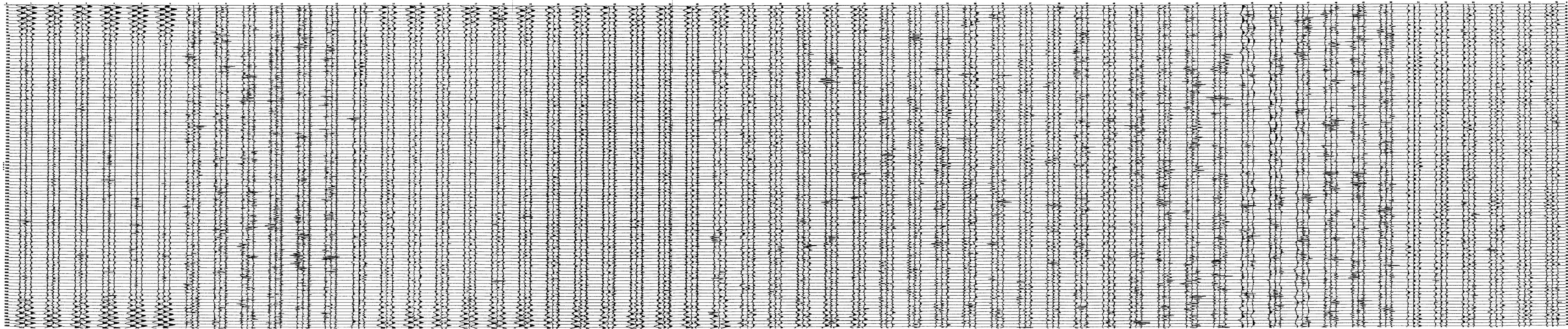


Figure 3. This AGC and 60 Hz notch filtered section displays the effectiveness of digital filters in removing 60 Hz. Artifacts of digital filter manifest themselves as edge effects in the upper and lower 100 msec of each record.



plant proper are the source of this noise since records from within 300 m (files 45 to 50) possess lower background noise than those from almost 400 m (51 to 56). Noise levels on files from the western extreme of the proposed reflection lines are equivalent to or maybe even a little less than levels observed at Mike (files 7 through 12 as compared to files 51 to 56).

Slightly more low frequency (50 to 150 Hz) noise is present on records from Post than from Mike. The Mike remote site records (records 7-13) and spectra (Figure 4c) are very similar to Post records from site 5 (records 45-50) and spectra (Figure 4f). Noise from various activities are evident, but clearly these noise sources are intermittent and would therefore allow some degree of selectivity during recording to reduce their impact. Long duration and/or stacking sources will greatly reduce the effects of intermittent acoustic energy bursts.

Wind and rain are likely sources of the apparent noise spikes or bursts evident on records without heavy 60 Hz. Spectra from these records suggest narrow band frequency spikes randomly located between 0 and 500 Hz (Figure 4). Excluding the amplitude levels of the spikes, the background noise is very representative of wind and rain frequency bands. The noise between 100 and 400 Hz is less than 5% greater than electronic/system noise at higher frequencies. There is no clear indication that seismic reflection data recorded at this site would suffer from increased noise interference as a direct result of mining activities. Noise within the reflection band at the levels observed here is not dramatically different than would be experienced under mild, gusty wind conditions.

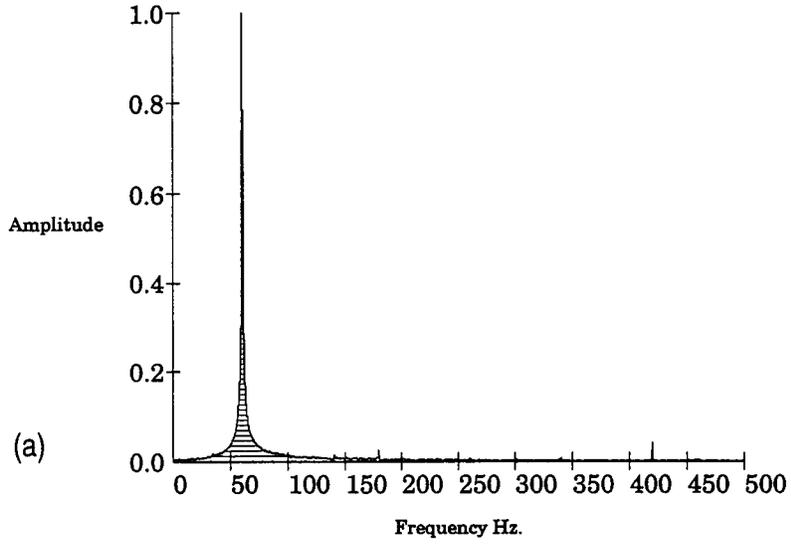
## **Conclusion**

It is very unlikely that seismic reflection data recorded along the proposed seismic lines would substantially suffer as a direct result of noise associated with the mining operations in the north area. If the noise levels and types at the time production seismic data are recorded near Post are consistent with those present in this report, reflection sections should be only mildly affected.

## **Acknowledgment**

Thanks to Todd Grant from Newmont Exploration his assistance during the acquisition of this data set.

# Spectrum of Trace 3, file 4



# Spectrum of Trace-3 file 4 notch

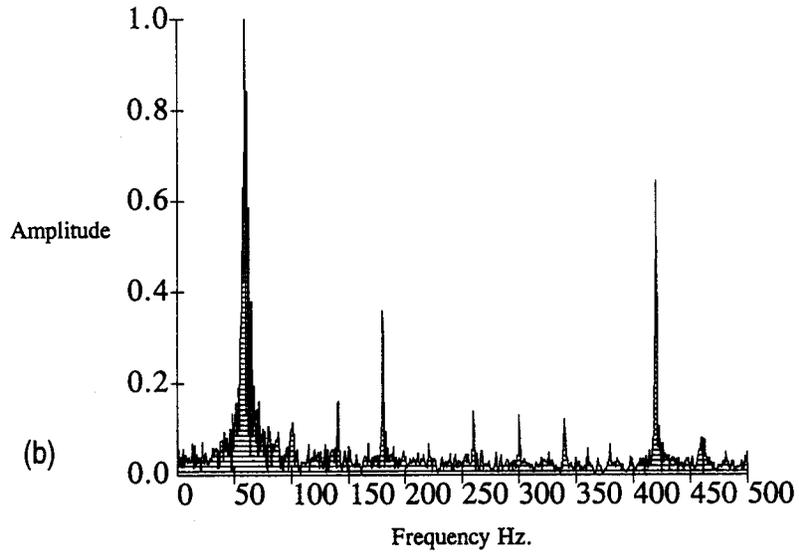
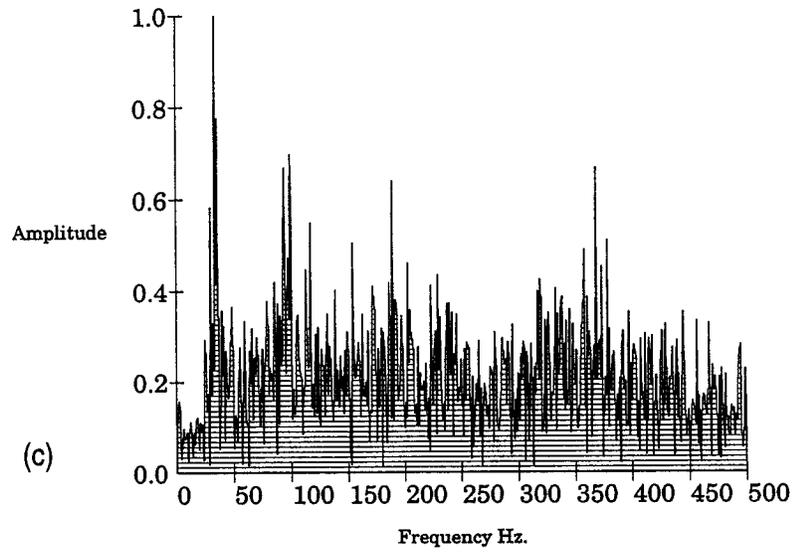


Figure 4a-b. Amplitude spectra a) 60 Hz noise is a well shaped spike;  
b) of (a) after 60 Hz notch filter, notice the relative decrease in 60 Hz;

## Spectrum of Traces-1,2,3 files 8 & 9



## Spectrum of Traces-1,2,3 files 14,15,16

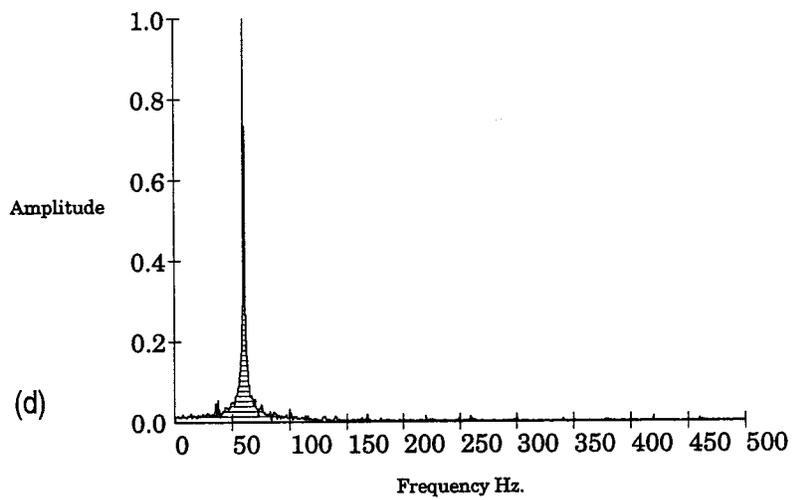
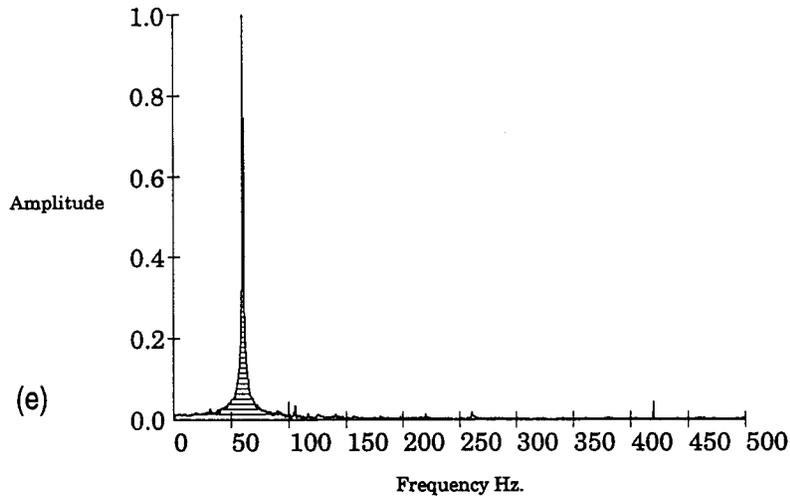


Figure 4c-d. Amplitude spectra c) of two files from Mike, this can be referred to as background; d) of summation when Haulpacks were moving nearby;

## Spectrum of Traces-1,2,3 files 17,18,19



## Spectrum of Traces-1,2,3 files 42,43,44

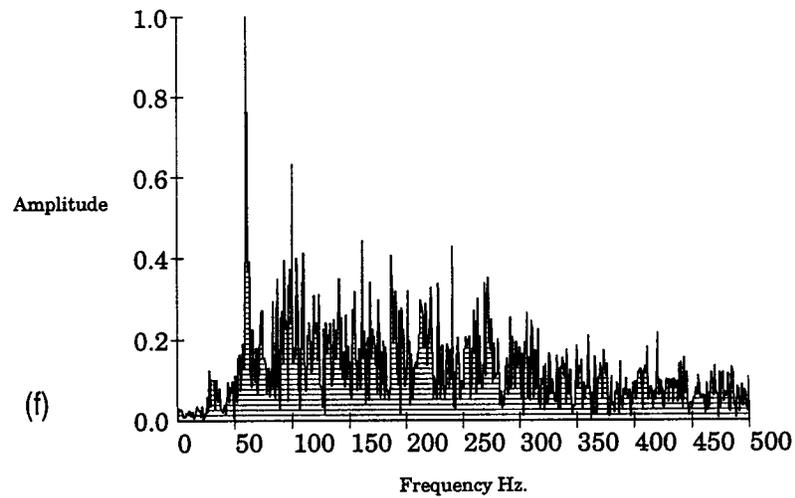


Figure 4e-f. Amplitude spectra e) of summation when no Haulpacks were in the area;  
f) from the central part of the proposed reflection profiles.

**Appendix A**  
**FIELD NOTES**  
**NEWMONT GOLD COMPANY, 10 - 11 MARCH 1995**  
**AMBIENT BACKGROUND NOISE SURVEY**

Conducted by Jeff Erickson (KGS Exploration) and Todd Grant (Newmont Exploration)  
 See maps #1 (US Geological Survey) Troll Area and #2 (Newmont Gold Co.) North Area

The survey was conducted 10 - 11 March on Newmont Gold Company property. Commonalities were that the weather was overcast, with precipitation ranging from a light drizzle to heavy sleet and freezing rain throughout the time data was taken. The soil was wet to soaked, and was frequently muddy. Trafficability problems prevented the survey team from following the proposed shot lines exactly. Instead, selected points with representative noise levels were chosen. Generally, we took 3 samples N-S and 3 samples E-W at each site.

Total data samples / files: 56 (Newmont 0001 - 0056). Data recorded on Newmont Gold Co. 3.5" disks and on hard drive of seismograph.

| FILE           | DESCRIPTION                                     | DIRECTION / ORIENTATION                        | NEARBY SOUND SOURCES   |
|----------------|---|--|--|
| 0001 -<br>0003 | NE end of Troll (Mike) seismic line, South Area | East-West<br>(on map as Site 1-6)              | Perpendicular to & under power lines<br>Highway appx. 1/4 mi. to east  |
| 0004 -<br>0006 | NE end of Troll (Mike) seismic line, South Area | North-South<br>(on map as Site 1-6)            | Parallel to & under power lines<br>Highway appx. 1/4 mi. to east   |
| 0007 -<br>0009 | Middle of Troll seismic line, South Area        | North-South (on map as Site 7-13)              | Unimproved dirt road intersection  |
| 0010 -<br>0013 | Middle of Troll seismic line, South Area        | East -West (on map as Site 7-13)               | Unimproved dirt road intersection  |
| 0014 -<br>0016 | North Area Site 2<br>Haulpack road inter.       | East - West<br>Parallel to proposed lines      | 200' from power lines, 300' from haulpack road<br><b>HAULPACKS PASSING CLOSE BY</b> , 50' from 2' diameter hot water pipe  |
| 0017 -<br>0019 | North Area Site 2<br>Haulpack road inter.       | East - West<br>Parallel to proposed lines      | 200' from power lines, 300' from haulpack road<br><b>NO HAULPACKS PASSING CLOSE BY</b> , but still fairly heavy traffic distant on road, 50' from 2' diameter hot water pipe |
| 0020 -<br>0022 | North Area Site 2<br>Haulpack road inter.       | North-South<br>Perpendicular to proposed lines | 200' from power lines, 300' from haulpack road<br><b>HAULPACKS PASSING CLOSE BY</b> , cables under 2' diameter hot water pipe  |
| 0023 -<br>0025 | North Area Site 2<br>Haulpack road inter.       | North-South<br>Perpendicular to proposed lines | 200' from power lines, 300' from haulpack road<br><b>NO HAULPACKS PASSING CLOSE BY</b> , but still fairly heavy traffic on road, cables under 2' diameter hot water pipe     |
| 0026 -<br>0028 | North Area Site 3<br>Valley basin               | East-West<br>Near east end of proposed lines   | Powerlines 1000' away; active drill rig 1000' away<br>Haulpack road appx. 1000' away   |
| 0029 -<br>0031 | North Area Site 3<br>Valley basin               | North-South<br>Near east end of proposed lines | Powerlines 1000' away; active drill rig 1000' away<br>Haulpack road appx. 1000' away   |

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NEWMONT GOLD CO. SEISMIC BACKGROUND NOISE STUDY

JEFF ERICKSON / TODD GRANT

10 - 11 MARCH 1995

| <b>FILE</b>    | <b>DESCRIPTION</b>                         | <b>DIRECTION /<br/>ORIENTATION</b>                            | <b>NEARBY SOUND SOURCES</b>  |
|----------------|--|---|--|
| 0032 -<br>0035 | North Area Site 1<br>Hilltop near Post Pit | North-South<br>South of proposed lines                        | Powerlines 200' & 400' away<br>Haulpack roads 1000' away to east & south       |
| 0036 -<br>0038 | North Area Site 1<br>Hilltop near Post Pit | East-West<br>South of proposed lines                          | Powerlines 200' & 400' away<br>Haulpack roads 1000' away to east & south       |
| 0039 -<br>0041 | North Area Site 4<br>Valley floor          | North-South<br>Between proposed lines                         | 100' from inactive hot water pipeline<br>Near dry creekbed                     |
| 0042 -<br>0044 | North Area Site 4<br>Valley floor          | East-West<br>Between proposed lines                           | 100' from inactive hot water pipeline<br>Near dry creekbed                     |
| 0045 -<br>0047 | North Area Site 5                          | East-West<br>South & appx. center of<br>both proposed lines   | 400' from active hot water pipeline<br>1000' from active water treatment ponds |
| 0048 -<br>0050 | North Area Site 5                          | North-South<br>South & appx. center of<br>both proposed lines | 400' from active hot water pipeline<br>1000' from active water treatment ponds |
| 0051 -<br>0053 | North Area Site 6                          | North - South<br>South of proposed lines                      | 1200' from active water treatment ponds  |
| 0054 -<br>0056 | North Area Site 6                          | East-West<br>South of proposed lines                          | 1200' from active water treatment ponds  |