SUMMARY AND CONCLUSIONS

Borehole-radar reflection logging using 60-MHz omni-directional and directional antennas was conducted at the Project Shoal Area, Churchill County, Nevada. The overall quality of the radar data is marginal, ranging from very poor to good. Six boreholes were logged (HC-1, HC-2, HC-5, HC-6, HC-7, and HC-8), but the data from one borehole (HC-1) were uninterpretable. Of the five boreholes interpreted, four (HC-5, HC-6, HC-7, and HC-8) were logged using a directional receiving antenna capable of providing the information to determine the reflector orientation.

Twenty-seven reflectors were interpreted from the directional radar reflection logs. Histograms summarizing the range of interpreted azimuths (strike) and dips are shown in figures 11 and 12. Azimuths are concentrated in two orientations — northeast-southwest and east-west to slightly northwest - southeast. Reflectors are moderate to steeply dipping. The mean reflector dip is 72.6°; the median is 73° with a standard deviation of 10.1°. Reflector length was estimated for each reflector using a straight-ray reflection path approximation. Reflector length ranged from less than 7 to more than 133 m, with a mean of 47 m, median of 34.5 m, and standard deviation of 37.3 m.

Reflector quality scores from 1 (best) to 5 (worst) were assigned to each reflector to provide a sense of the spatial continuity of the reflectors and the comparison of the field data relative to an ideal planar reflector. The average reflector continuity score is 3.6 (fair to poor range, fig. 13), consistent with fractures or fracture zones that contain localized to moderate discontinuities but which are still relatively continuous over a scale of tens of meters.

The orientation confidence scores are low, generally about 4.0 (fig. 14). The low scores reflect the general data quality, but also indicate that the behavior of most reflectors departs from the ideal planar case. The low scores are consistent with reflections from fracture zones containing numerous, closely spaced, sub-parallel fractures.

An equal-area stereo-net that summarizes interpretations from all of the boreholes logged at the PSA is shown in figure 15. In general, the most continuous reflectors are those having the steepest dips, and either north-south or east-west strikes.

Direct-wave analysis performed on the radar reflection logs was used to generate logs of radar velocity and amplitude. Zones of low radar velocity correlate with decreases in direct-wave amplitude, most likely indicating the presence of saturated fracture zones. In boreholes HC-5, HC-6, and HC-7, direct-wave amplitudes increase with depth; this suggests an overall increase in electrical resistivity, possibly due to changes in mineral assemblage and (or) to a decrease in the specific conductance of ground water. In boreholes HC-6 and HC-7, at depths below 300 m, the direct-wave amplitudes increase over the same interval where direct-wave velocities are decreasing. This observation is consistent with an increase in primary or secondary porosity coupled with a decrease in specific conductance of ground water, and (or) a change in mineral assemblage. Another observation is the similarity between the direct-wave logs from HC-6 and HC-7 when the HC-7 log is shifted upward about 50 m. The similarities suggest that HC-6 and HC-7 are connected by structural features with a down-dip component in the direction of HC-7. The results of the borehole-radar reflection logging indicate that even where data quality is marginal, these data can provide useful information for ground-water characterization studies in fractured rock, and provide insights into the nature and extent of fractures and fracture zones in and near boreholes.

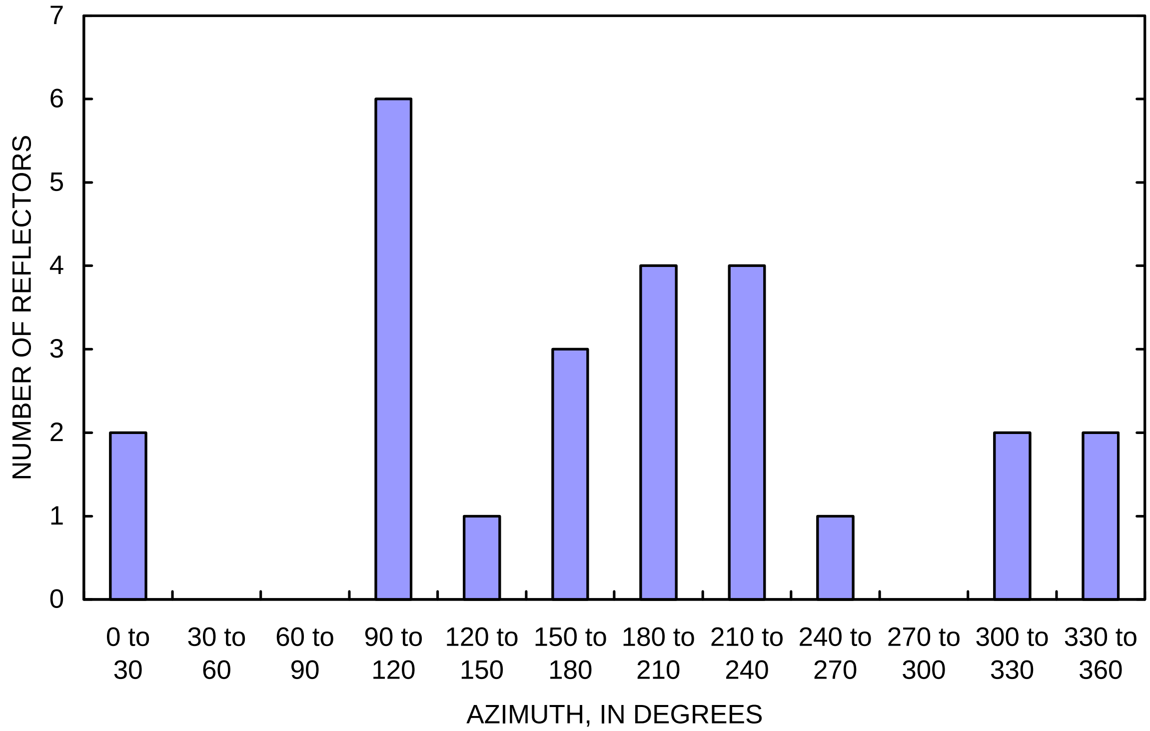

Figure 11. Distribution of interpreted borehole-radar reflectors sorted by azimuth, Project Shoal Area, Churchill County, Nevada.

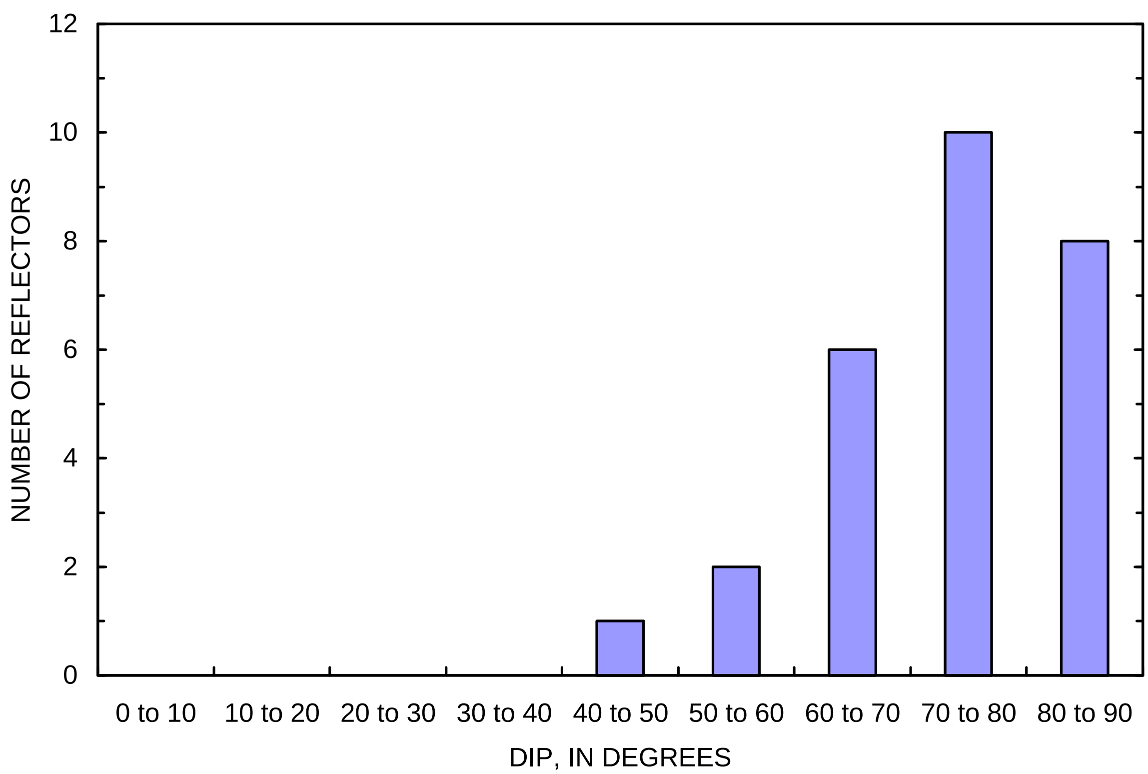

Figure 12. Distribution of interpreted borehole-radar reflectors sorted by dip, Project Shoal Area, Churchill County, Nevada.

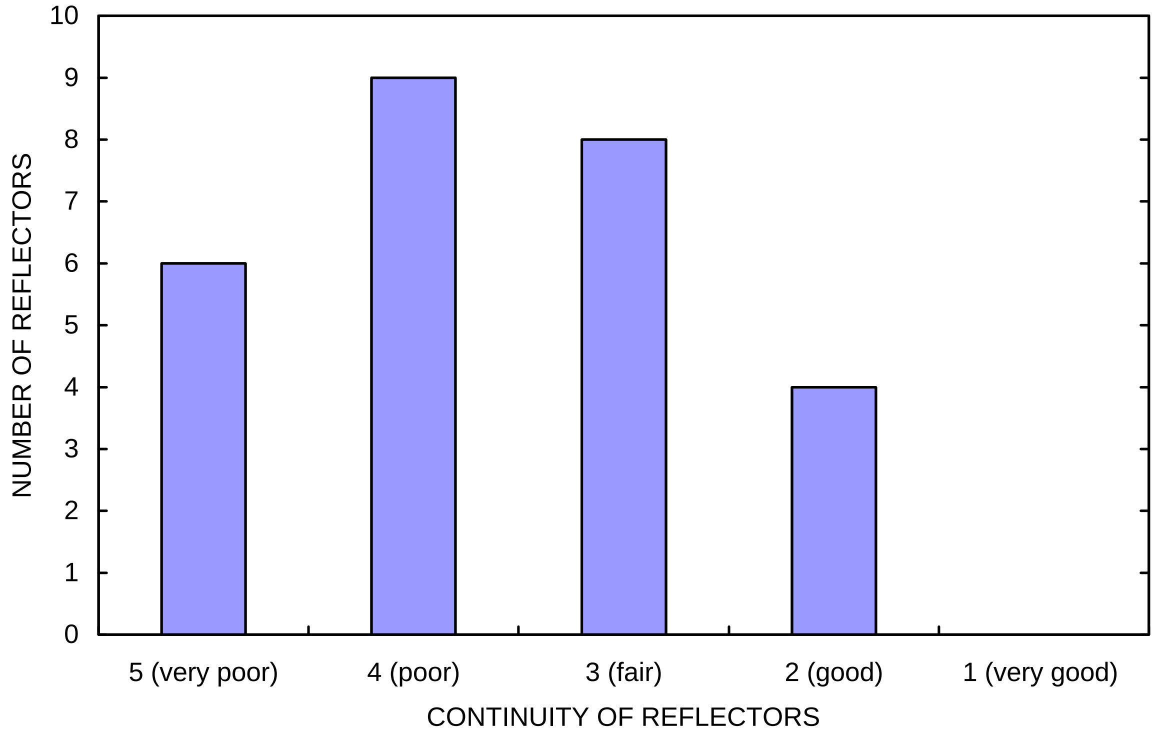

Figure 13. Distribution of interpreted borehole-radar reflectors sorted by the continuity of the reflectors, Project Shoal Area, Churchill County, Nevada.

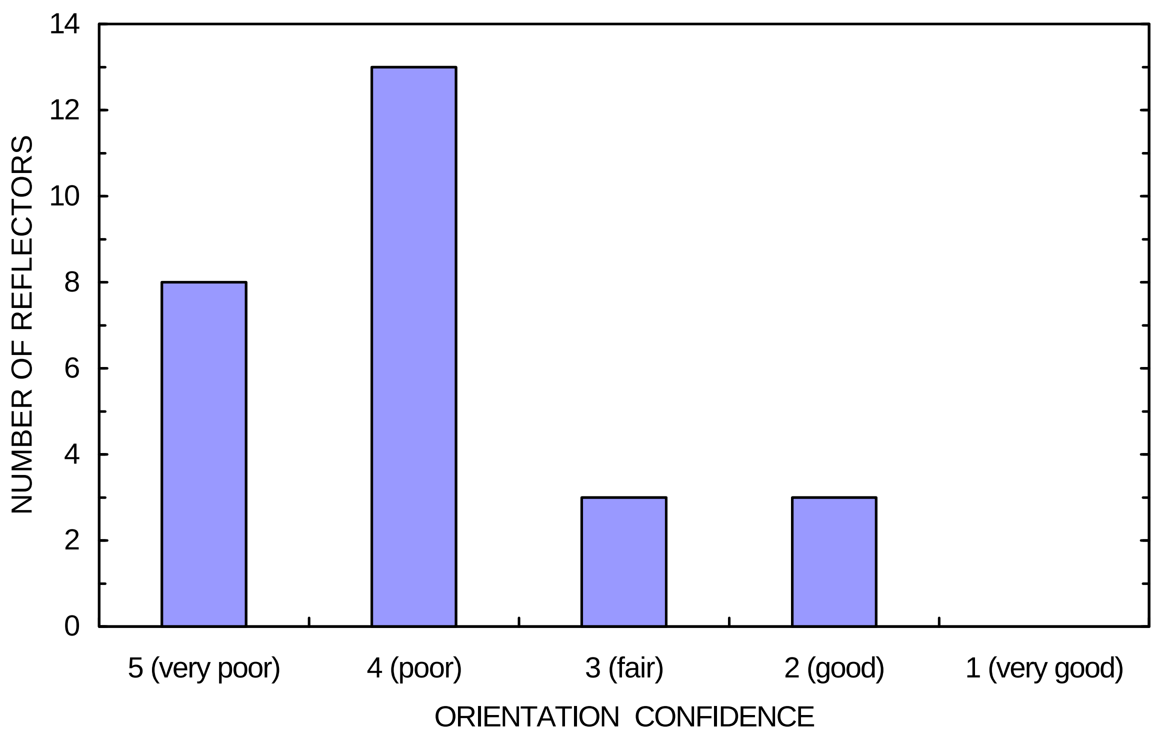

Figure 14. Distribution of interpreted borehole-radar reflectors sorted by orientation confidence, Project Shoal Area, Churchill County, Nevada.

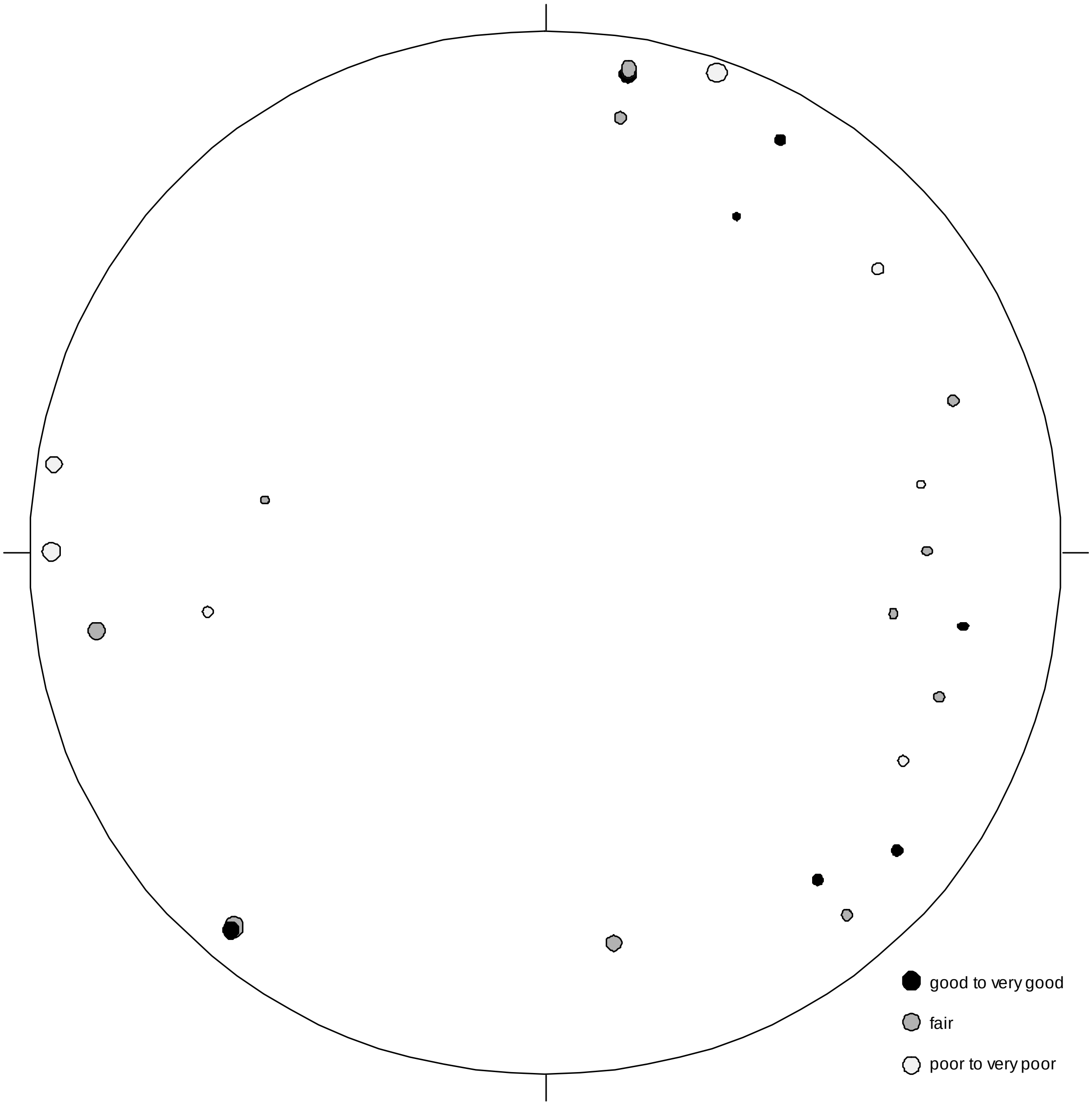

Figure 15. Lower hemisphere equal-area stereo-net showing poles of all interpreted radar reflectors, weighted by reflector length and combined reflector quality, Project Shoal Area, Churchill County, Nevada.

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