Where: RP is the distance along the dipping horizon to the termination of the event

r is the depth of the geophone where the dipping horizon cuts the well

g is the depth of the shallowest geophone for which the reflector has an expression

α is the angle of dip

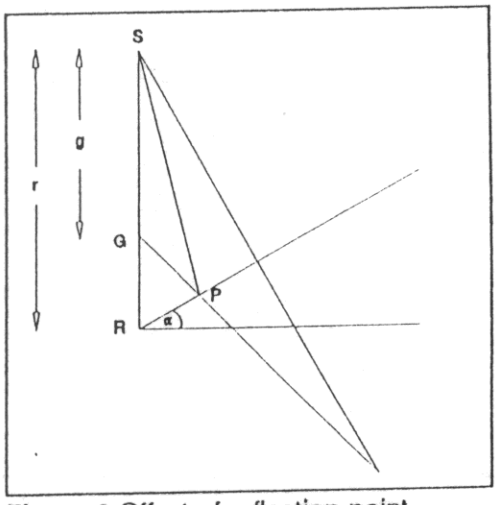

Figure 2 Offset of reflection point

Calculation of the offset of diffraction points from the well

Figure 3 shows a normal fault close to a vertical borehole with diffraction points associated with the upper and lower discontinuities of the inclined bed. The diffraction points will scatter energy in both the S- and P-wave modes and these events may be detected by the array of geophone stations. The right hand panel of this figure, illustrates the ray propagation paths for either of the wave modes assuming a constant velocity profile. Figure 4 illustrates the alignment of both P- and S-wave diffractions within the data. P-wave arrivals form event hyperbolae that are asymptotic to the first arrival curve in one direction and P-wave horizontal reflections in the other. S-wave diffractions display a sharper curvature and in fact are asymptotic to the equivalent S-wavefields.

It should be obvious from figures 3 and 4, that the shortest travel path for the energy is that of direct p-wave propagation to the diffracting point followed by horizontal travel back from here to the geophone array. This means that the geophone that records the shortest time of the diffraction is positioned at the same depth as the diffracting point; the depth of the discontinuity can therefore be inferred by observing the apex of the hyperbola. The offset of discontinuity can be calculated quite simply by considering the diagram shown at the bottom of figure 4.

If t_g is the one-way first arrival time to the geophone level at the depth of the apex of the diffraction hyperbola.

T is the travel time from source to diffraction point to geophone, i.e. the shortest travel time on the VSP display to the apex of the diffraction hyperbola.

t_o is the horizontal travel time from the diffraction point to the geophone (unknown).

v_a is the average velocity of the section between the source and the geophone.

v_i is the interval velocity (either P- or S-wave) between the diffraction point and the well.