INVESTIGATION OF THE INFLUENCE OF DIP ON VELOCITY ANALYSES
(This chapter is based on the work of LEVIN, 1971)

1. PRESENTATION OF THE MODEL OF THE SUBSURFACE UNDER CONSIDERATION

This is shown in diagrammatic form in Figure 9.1. Since we are considering only one homogeneous layer, of constant velocity $V$, between the surface and the inclined reflecting surface, the usual distinctions between average velocity, root mean square velocity and interval velocity do not arise in this case.

\[
x \cos \alpha + y \cos \beta + z \cos \phi = d \tag{9.1}
\]

in a system of rectangular axes whose origin is the seismic source, with co-ordinates $(0, 0, 0)$; the $x$ axis is taken along the seismic profile, so that the co-ordinates of the geophones are of form $(x, 0, 0)$. $d$ is the length of the perpendicular dropped from the origin onto the reflecting plane; $\alpha$, $\beta$ and $\phi$ are the angles made by this perpendicular with the axes $Ox$, $Oy$ and $Oz$.

We shall define $D$ as the length of the perpendicular drawn from the mid-point of a segment $[OX]$ of the $x$ axis onto the reflecting plane, where $X$ is the abscissa of the geophone which we will consider in the
course of these calculations.

It is to be noted that the foot of the perpendicular along which D is measured does not cut the reflecting surface at the point of reflection of the seismic ray, which starts from the source (0, 0, 0) and re-emerges at (X, 0, 0).

2. CALCULATION OF TRAVEL TIME FROM SEISMIC SOURCE TO REFLECTING PLANE AND THEN TO GEOPHONE

For this calculation we will consider the plane defined by the axis Ox and the straight line d (the plane in which the seismic ray under consideration is propagated) Figure 9.2. Ox can have any direction with respect to the line of greatest slope of the reflecting plane.

In triangle SGG', the equation connecting the lengths of the sides is:

\[ SG'{}^2 = SG^2 + GG'{}^2 - 2\cdot SG \cdot GG' \cos (SGG') \]

and if \( t \) is the time taken for the seismic energy to travel along the path SRG:

\[ V^2 t^2 = x^2 + 4(d - x \cos \alpha)^2 - 2[x \cdot 2(d - x \cos \alpha)] \cos(\pi - \alpha) \]

which gives

\[ V^2 t^2 = x^2 + 4d^2 - 4d \cdot x \cos \alpha \quad (9.2) \]

But

\[ d = D + \frac{x}{2} \cos \alpha \]

and on replacing \( d \) in (9.2) by this value, we have:

\[ t^2 = \left( \frac{2D}{V} \right)^2 + x^2 \left( \frac{\sin \alpha}{V} \right)^2 \quad (9.3) \]

If we define \( V_a \) as

\[ V_a = \frac{V}{\sin \alpha} \quad (9.4) \]

we have finally:

\[ t^2 = \left( \frac{2D}{V} \right)^2 + \frac{x^2}{V_a^2} \quad (9.5) \]