

COMMENTS ON "ANGLE OF INCIDENCE AS A FUNCTION OF SOURCE-RECEIVER OFFSET OVER A DIPPING REFLECTOR; AN EXACT EXPRESSION FOR USP APPLICATIONS"

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In this Short Note, the convention established for the dip of the reflector, α , is that the dip angle is positive when measured counter-clockwise from the horizontal. However, with the source placed at the right-hand side of Figure 1, the angle of incidence, θ , of the downgoing ray at the reflector is measured from the normal to the reflector in a clockwise direction. It is nevertheless treated in the theory as being a positive angle.

If the same convention were applied to θ as was established for α , Equation (10) (Slawinski 1997) would become:

$$\theta = \arctan \frac{X \cos \alpha - Z \sin \alpha}{(2H - Z) \cos \alpha + X \sin \alpha} \quad (H-1)$$

in which the terms involving $\langle \sin \alpha \rangle$ have been reversed in sign compared to those in Equation (10) (Slawinski 1997).

Either of the following approaches will result in Equation (H-1):

- 1) For the derivation of the equations leading to an expression for θ , use a diagram with the source plotted on the left, thus allowing the downgoing incident angle, θ , to be positive when measured in a counter-clockwise direction, or:
- 2) Reverse the sign of α so that α and θ are both positive when measured in a clockwise direction.

Either approach would remove the necessity for separate discussions for the source updip and downdip from the

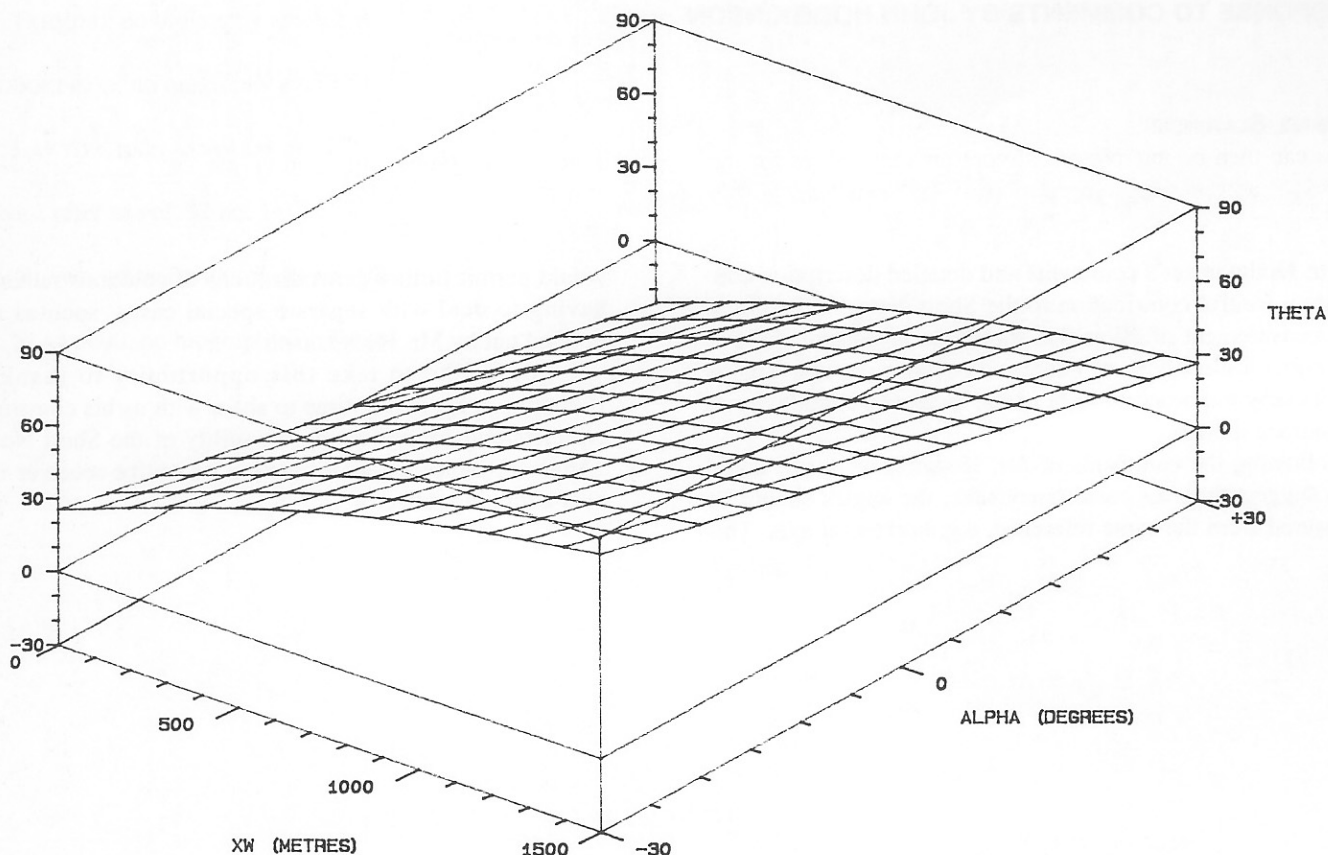


Fig. 1. Same as for Fig. 4 except that values of θ are computed using Equation (H-1) instead of Equation (10) (Slawinski 1997)

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receiver, but the first is to be preferred since it retains the convention of positive angles being measured in a counter-clockwise direction. It is evident that basing theory on a diagram in which all angles conform to a common convention is not a trivial consideration.

It is to be noted that the results from Equation (10) (Slawinski, 1997) and from Equation (H-1) differ significantly. For example, using the values specified in the caption for Figure 4 (Slawinski, 1997), with $\alpha = 30^\circ$ and $X = 1000$, Equation (10) yields $\theta = 71.02$ degrees, whereas Equation (H-1) yields $\theta = 15.98$ degrees.

Referring to Figure 4 (Slawinski, 1997), the 3-D plot shows that for $\alpha = -30^\circ$, θ reduces from a positive value at $X = 1500$ to zero at $X = 500$, and then becomes greater than zero again as X approaches zero. However, based upon Equation (10) (Slawinski, 1997), θ continues to reduce to negative values from $X = 500$ to $X = 0$ and beyond.

Figure 4 (Slawinski, 1997), may be taken to represent absolute values of θ , but since negative values of θ are significant, it would seem preferable to plot the actual values of

θ . When shooting updip towards the well, (source located downdip from the receiver), negative values of θ occur when the downgoing ray from the source passes through the well-bore above the receiver, before being reflected back to the receiver in the well. Modelling such negative values of θ might be useful in positioning a second well-receiver at an appropriate distance above the first receiver in order to examine the downgoing wavelet prior to reflection.

The revised 3-D plot of Figure 4 (Slawinski, 1997) would take the form shown in Figure H-1, which uses the same input values as given in the caption for Figure 4 (Slawinski, 1997), but for which the values for θ were derived from Equation (H-1).

It is believed that these changes would enhance the utility of what is already a valuable contribution by Dr. Slawinski.

REFERENCES

- Slawinski, M.A., 1997, Angle of Incidence as a function of Source-Receiver Offset over a Dipping Reflector; an exact expression for VSP applications: *Can. J. Expl. Geophys.* 33, 66-69.

RESPONSE TO COMMENTS BY JOHN HODGKINSON

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Mr. Hodgkinson's comments and detailed description constitute a fruitful contribution to the Short Note. As he notes, the measurement of all angles should be consistent, following either a clockwise or counter-clockwise pattern. This is particularly important in light of the increased complexity of subsurface models.

Following the comments of Mr. Hodgkinson's, one could also suggest that, for consistency sake, the angles should be measured from the same reference, e.g. horizontal axis. This

would permit further generalizations of solutions rather than having to deal with separate special cases, such as those pointed out by Mr. Hodgkinson.

I would like to take this opportunity to thank Mr. Hodgkinson for taking time to share with us his constructive criticism and for enhancing the utility of the Short Note on "Angle of incidence as a function of source-receiver offset over a dipping reflector".

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