

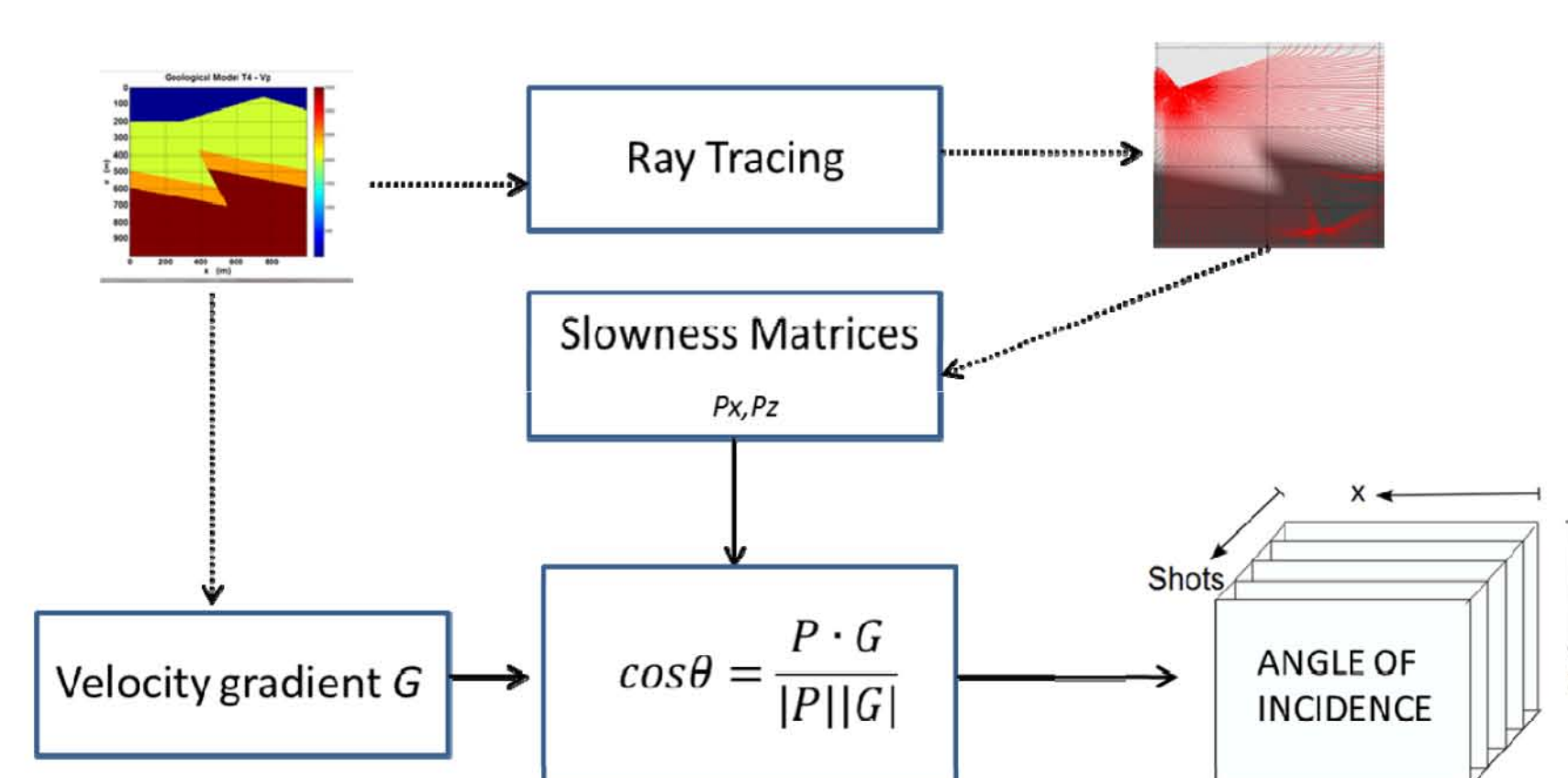
# Angle gathers with PP and PS depth migration: some experiments

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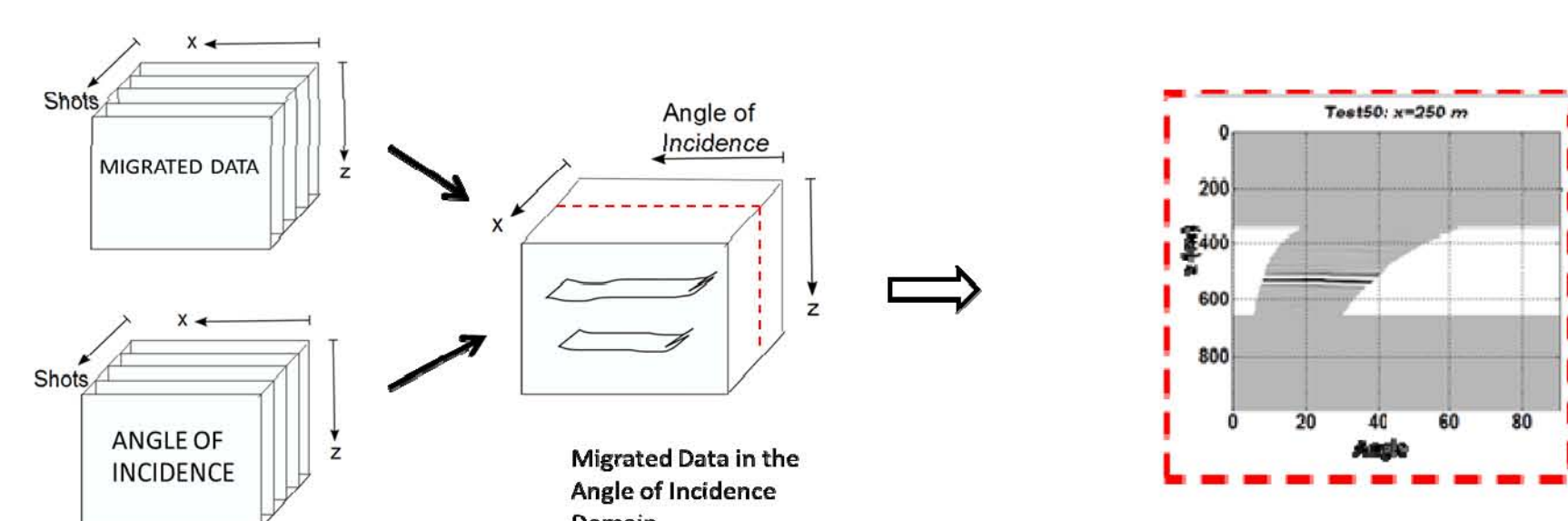
## SUMMARY

- Angle gathers have been identified as an appropriate domain for amplitude and velocity analysis with prestack migration, especially in complex geological settings. This report analyses angle gathers from depth migration of multicomponent data, PP and PS, using synthetic data and a shot-profile PSPI (wave-equation) migration.
- Two methods were applied. (1) A **ray tracing based method** assumes a known velocity model. The characteristics of the method and its application to P-wave and converted wave data and to horizontal and dipping reflectors are illustrated through two simple models, namely one with a flat interface and the other one with a dipping interface, with data calculated using Ray tracing (RT) and Finite Differences (FD). An analysis of amplitudes comparing with the results of Zoeppritz equations. (2) **The extended imaging condition method**: Due to Rickett and Sava (2002), this method obtain the angles from the data migrated in the offset domain. It showed reasonably good results with PP waves. However the results with PS-waves requires additional analysis.

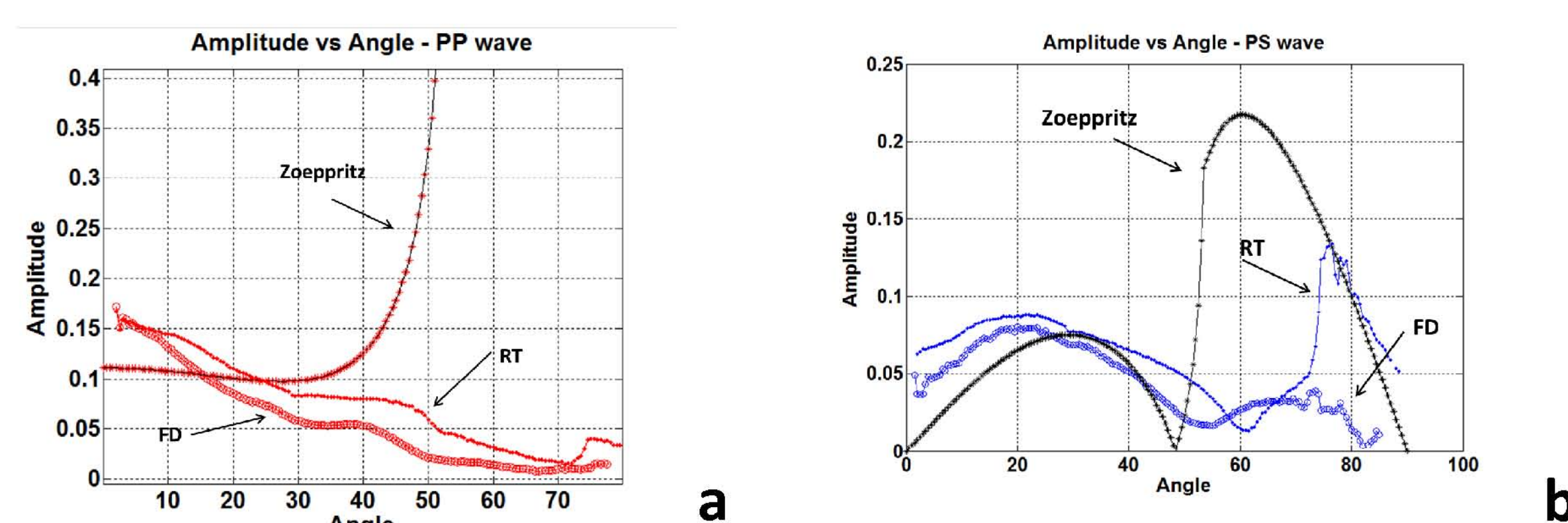
## The Ray tracing method



**Ray tracing method scheme** to obtain the angles of incidence from the velocity field.



**Angle gather generation:** angle of incidence and migrated data, are mapped to angle image gathers for each location.



**Amplitude vs. Angle of Incidence (a): PP, (b) PS**  
RT: migration of ray tracing data.  
FD: migration of Finite Difference data, and the theoretical Zoeppritz calculation.

## The extended imaging condition method

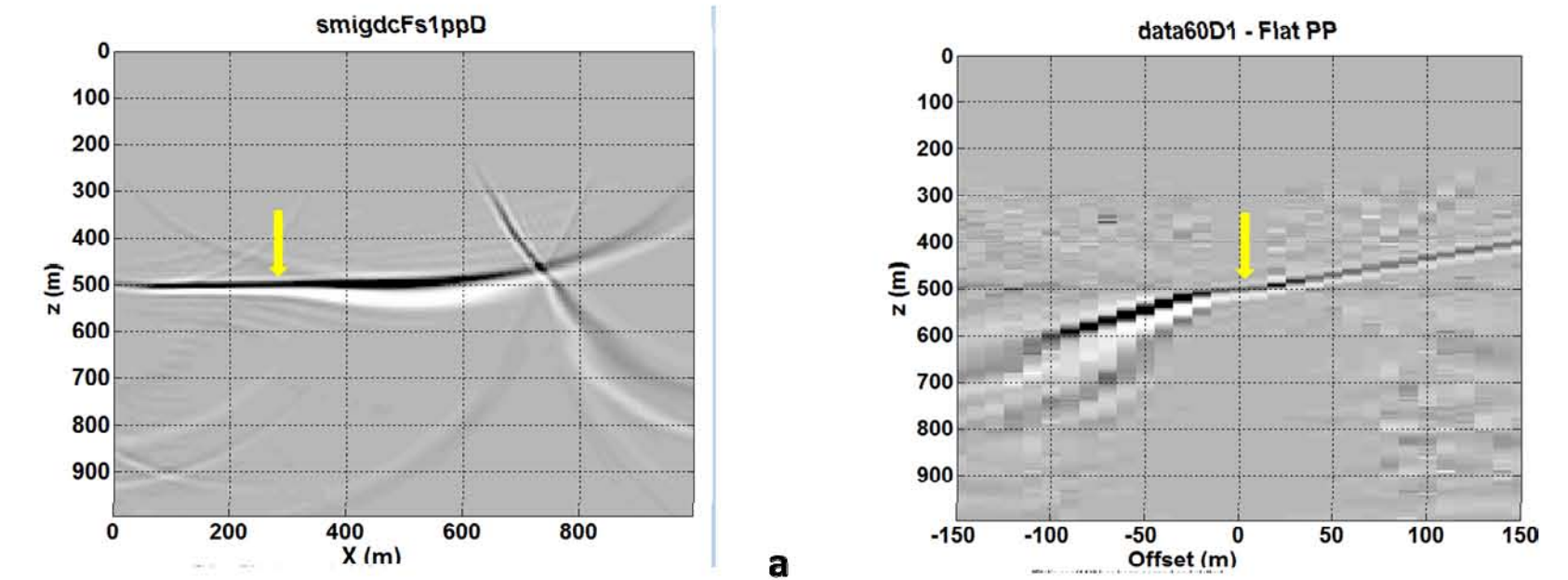
This method was proposed by Rickett and Sava (2002).

*Conventional imaging condition:*

$$Im(x, z) = \int U(x, z, \omega) D(x, z, \omega)^* d\omega$$

*Extended imaging condition:*

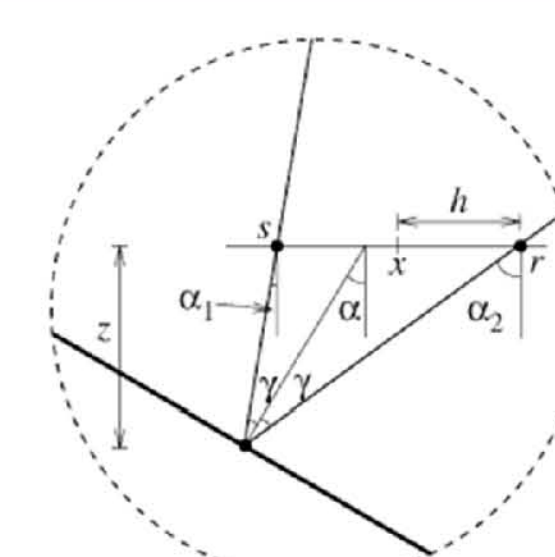
$$Im(x, z, h) = \int U(x + h, z, \omega) D(x - h, z, \omega)^* d\omega$$



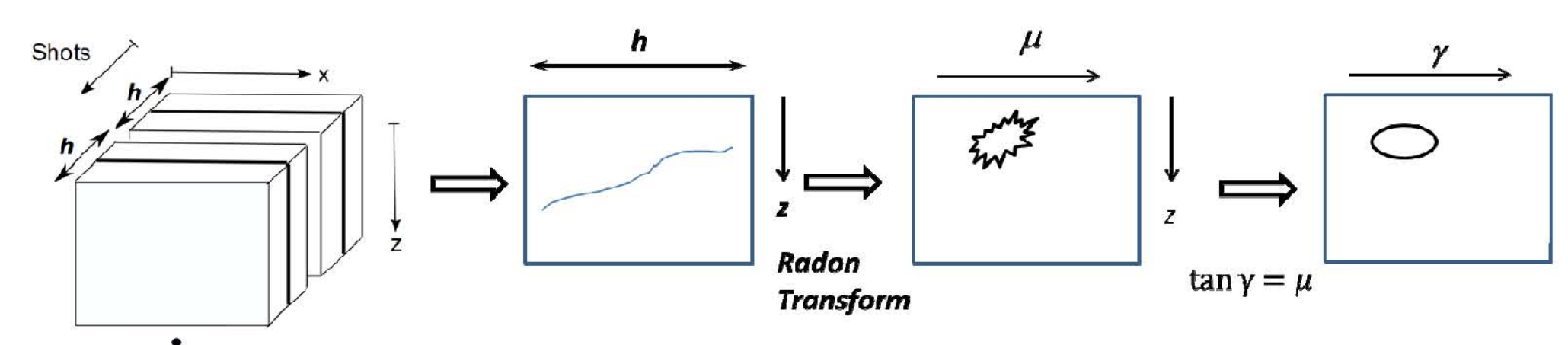
(a) The **conventional migration** section and (b) the **extended image**. The point shown by the arrows is the same one in both (offset zero and same x).

The equation that establishes the relationship between the extended image and the angle of incidence is

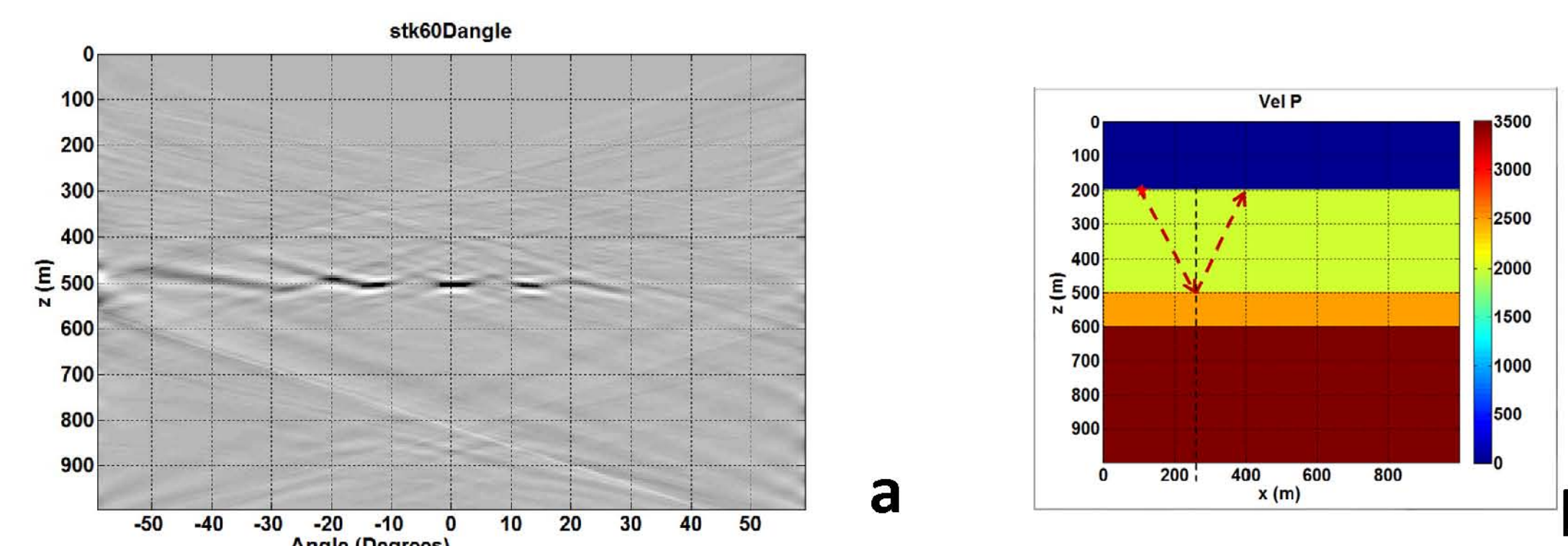
$$\tan \gamma = -\frac{\partial z}{\partial h}$$



(From Rickett, and Sava, 2002)

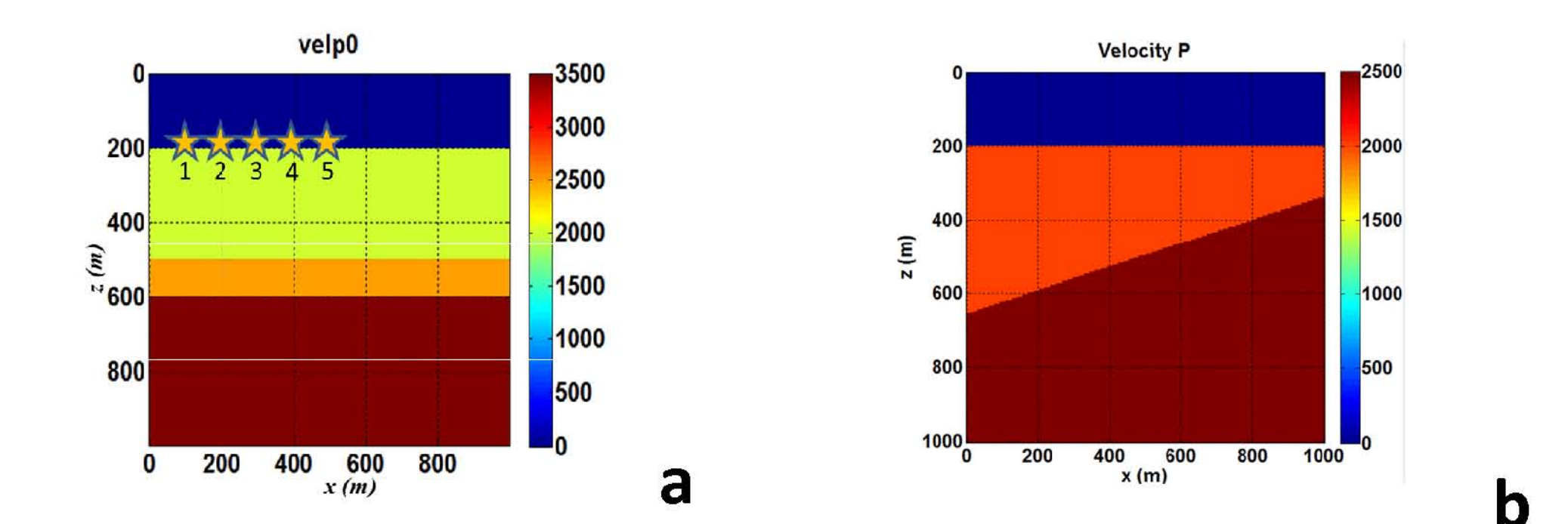


**Extended imaging angle gather technique:** It was applied the Radon Transform in the h-z (offset-depth) domain.

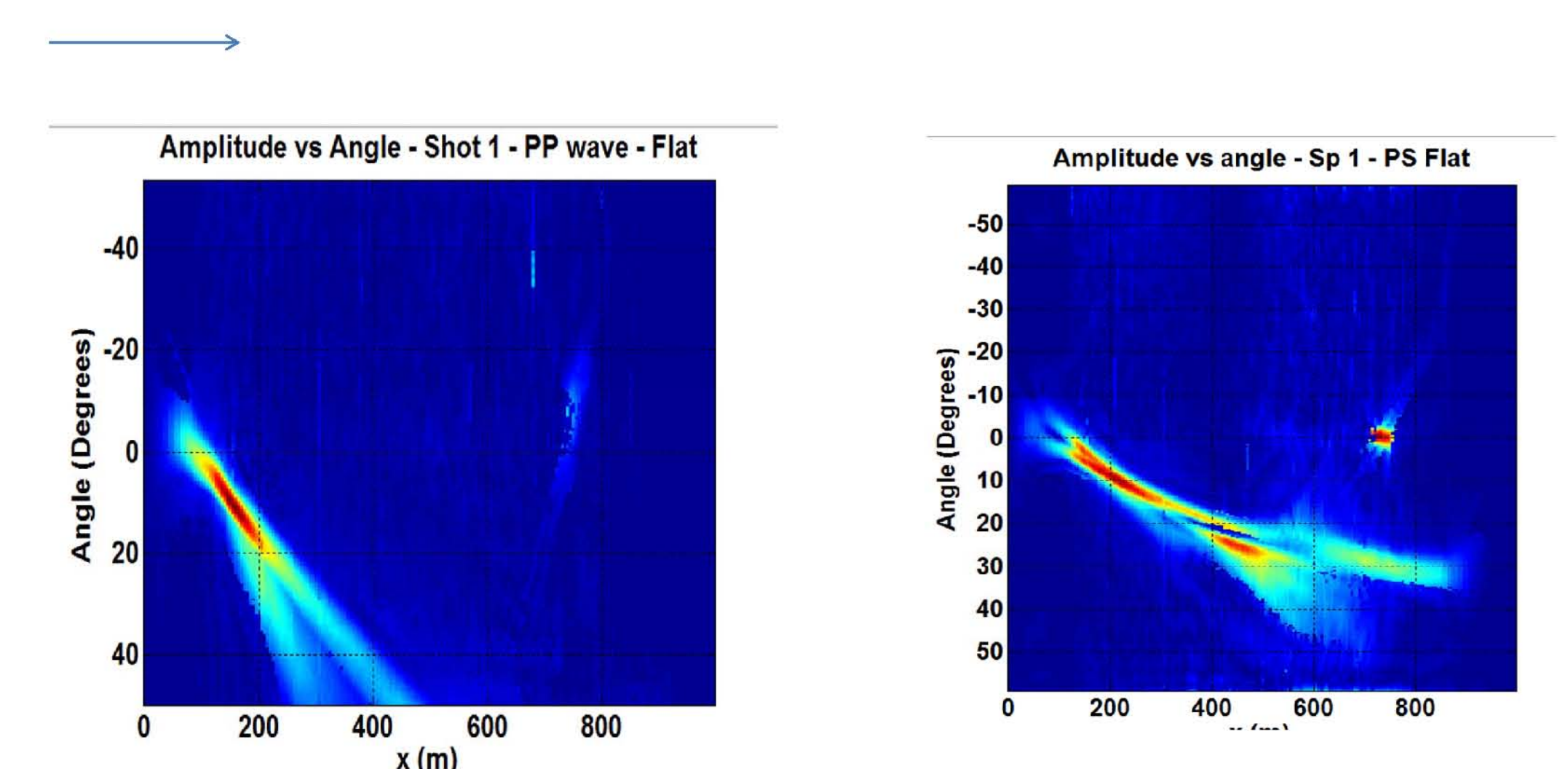


(a) Angle gather at x=300 m from five shots. Each shot corresponds to a "burst of energy". (b) Angle of incidence for shot 1.

## Models



(a) Model 1: Flat layers with free surface. Five shots, identified with stars, are located on the surface. (b) Model 2: dipping interface. The same shot distribution was used for both.



Amplitude as a function of the angle for all locations in the line. The source in shot 1. (a) PP wave. (b) PS wave. Notice the differences on the energy distribution and the smaller angles for PS.

## Conclusions

- From the RT method Amplitude vs angle (PP and PS) corresponds closely to the theoretical (Zoeppritz).
- The angles for PP data with method 2 agree closely with the expected.
- The angles of incidence for converted waves require further analysis.
- Methods to obtain the angles of incidence for PS waves and for velocity analysis using this data gathers require further investigation.

**Reference:** Rickett, J. E. and Sava, P. C., 2002, Offset and angle-domain common image-point gathers for shot-profile migration. Geophysics, Vol. 67, No. 3, 883-889.