THE SAN ALBERTO ANTICLINE OF SOUTHERN BOLIVIA
A DEPTH IMAGING CHALLENGE

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SUMMARY

The San Alberto anticline in southern Bolivia gives us a particularly good example of pre-stack depth migration used in an overthrust environment. This structure has dips up to 90 degrees with large lateral velocity variations. The target horizon is the Huamampampa, under the crest of the anticline and 4000-5000 meters deep. Time processing has never given a clear image of this objective, so it was decided to test PSDM. Initial testing used a top-down , time intensive approach to velocity determination in which many small migrations were run and compared to find the best velocity field. This work gave very encouraging results. Subsequent work using tomography for velocity determination is resulting in a much clearer image, and a better understanding of velocity behavior in this complex structure.

INTRODUCTION

Historically, much of Bolivia's hydrocarbon potential is found in the south of the country, in a series of anticlinal structures, of which the San Alberto anticline is a prime example. These structures are very steep, with dips up to 90 degrees. The topography in the area is also very rugged, with cliffs up to 1000 meters high, making for difficult access and expensive seismic acquisition. Nevertheless, in early 1997, 2D seismic data was recorded over the San Alberto anticline. Acquisition parameters are listed at the end of this abstract.

Conventional processing was performed on the San Alberto data with mixed results. As is often the case, results were very good in the synclines, but terrible over the anticline, which is the area of interest.

The data over the anticline suffered from various problems. Among these common overthrust problems were low signal/noise ratio, statics problems, high levels of coherent noise, and non-hyperbolic reflections caused by steep dips and rapid velocity variations. Statics and noise problems were ameliorated using refraction statics and pre-stack noise attenuation, but the non-hyperbolic reflections remained.

Testing of Prestack Depth Migration to solve this imaging problem began in April 1997. Over a period of three months a reasonable velocity model was arrived at using a very machine and labor intensive approach in which many migrations were run and compared. This approach was largely successful. The PSDM result gave a much clearer image of the structure than conventional processing. However, it was never possible to define an accurate velocity model with any confidence.

Currently testing continues on this line and others, using a new tomography routine for velocity determination. This program depth-migrates picked horizons while perturbing an initial velocity model. Over several iterations, the program arrives at an optimum velocity distribution to focus the picked events. The advantage of this approach is that the results are accurate for very steep dips, so it is well suited for overthrust situations like San Alberto.

CONVENTIONAL SEISMIC DATA PROCESSING

Conventional time processing was performed on the San Alberto data during the first part of 1997. The processing sequence that was used is listed below. Processing parameters were not unusual. Refraction statics using a single weathering layer was used, which solved most of the statics problems. 3D random noise attenuation run in cmp and offset planes helped to improve the signal/noise ratio. FK filtering applied on cdp's and offset planes helped to remove the coherent noise while preserving the steepest real dips in the data. The final time migration can be seen in figure 1.

PRESTACK DEPTH MIGRATION

Prestack depth migration of offset planes was run using a Kirchhoff migration, allowing all dips. For velocity determination, many migrations over limited areas of the data were run. These migrations were compared to find the best velocity field. This procedure was carried out starting from the top. Velocities of the tertiary sediments flanking the anticline were first analyzed, which took the most time. The velocities in the Tertiary layers are quite variable, depending on depth of burial to a great degree.

Once the Tertiary velocities had been determined as best as possible, the deeper layers were analyzed by replacing with different constant velocities and migrating. The final depth migration arrived at using this methodology is seen in figure 2. Note the considerable improvement over the conventional time processing image.

TOMOGRAPHY

Many methods currently used to determine velocities for depth migration are compromised by steep dips, rapid lateral velocity variations and complex topography, as exemplified at San Alberto. Consequently velocities determined using these methods are often unsuitable when any of these attributes is present. The intensive approach originally used for this dataset takes too long, and more complex velocity fields are not easily defined using this approach. Some form of velocity determination that can handle the steep dips and rapid velocity changes must be performed.

Velocity determination for depth migration was performed on the San Alberto data using a 2D tomography program. The tomography used on this project successively depth-migrates picked horizons, modifying the velocity field for each migration. Analyzing the effects of the velocity changes on the coherency of the migrated picked horizons, the program determines the optimum velocity distribution to best focus the migrated horizons.

This program is very flexible, allowing short sections of horizons to be used. Any number of picked horizons can be analyzed, and definition of the input and output velocity models is also very flexible. The program can be run over small areas of the input data, which saves a great deal of time. Use of the tomographic approach to velocity determination has helped a great deal in the San Alberto area. The time needed to arrive at a good pre-stack depth migration has been significantly reduced, and there is less uncertainty in the result.

CONCLUSIONS

Prestack depth migration can help a great deal in imaging of overthrust seismic data. However, the complexity of these situations and poor data quality makes PSDM difficult, time-consuming, and expensive. The San Alberto PSDM work is a good example of overthrust depth imaging with a relatively successful result, though it was a struggle. New tomography technology promises to make PSDM in these difficult environments much easier. It is important that we develop depth-imaging and tomography technology to make depth imaging more feasible in difficult geological scenarios.

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FIELD RECORDING PARAMETERS

Source	Dynamite (4kg at 15m)
Number of channels	360
SP interval	25m
Group interval	25m
Fold	18000%
Far offset	4500m

PROCESSING SEQUENCE

Geometry and editing

Geometric spreading gain

Surface-consistent deconvolution

Trace equalization

CDP sort

Refraction statics

Velocity analysis

Residual statics

Velocity analysis

Fxy Decon over CDP and offset

FK filter on CDP's

FK filter on offsets

Pre-stack depth migration

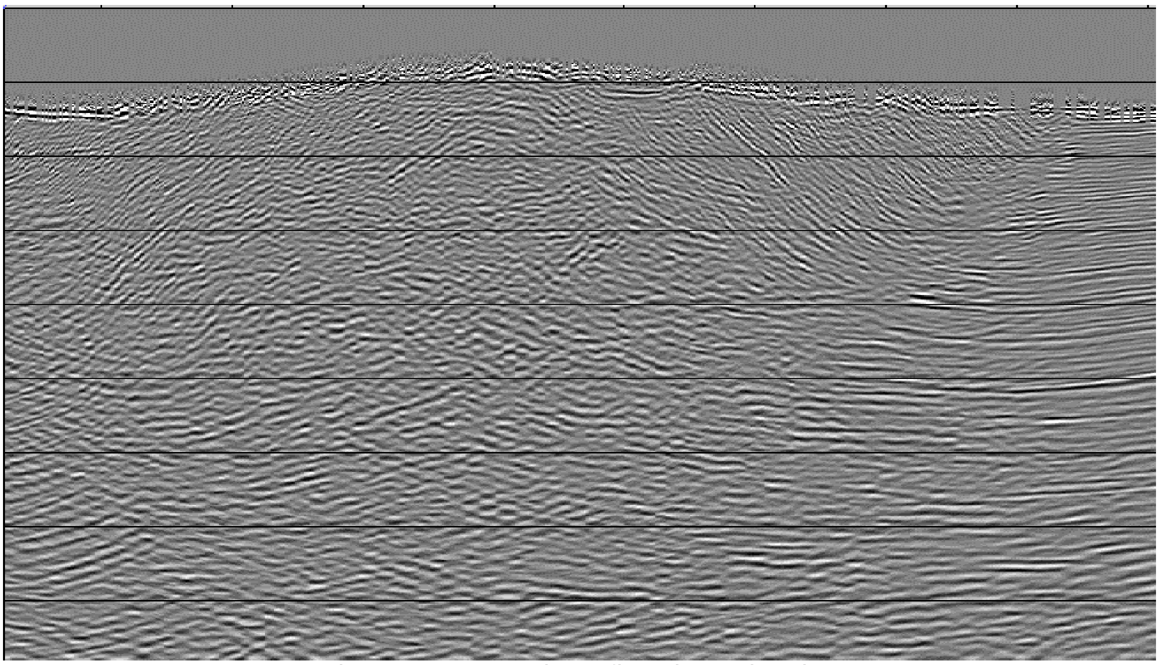

Figure 1: Conventional final time migration

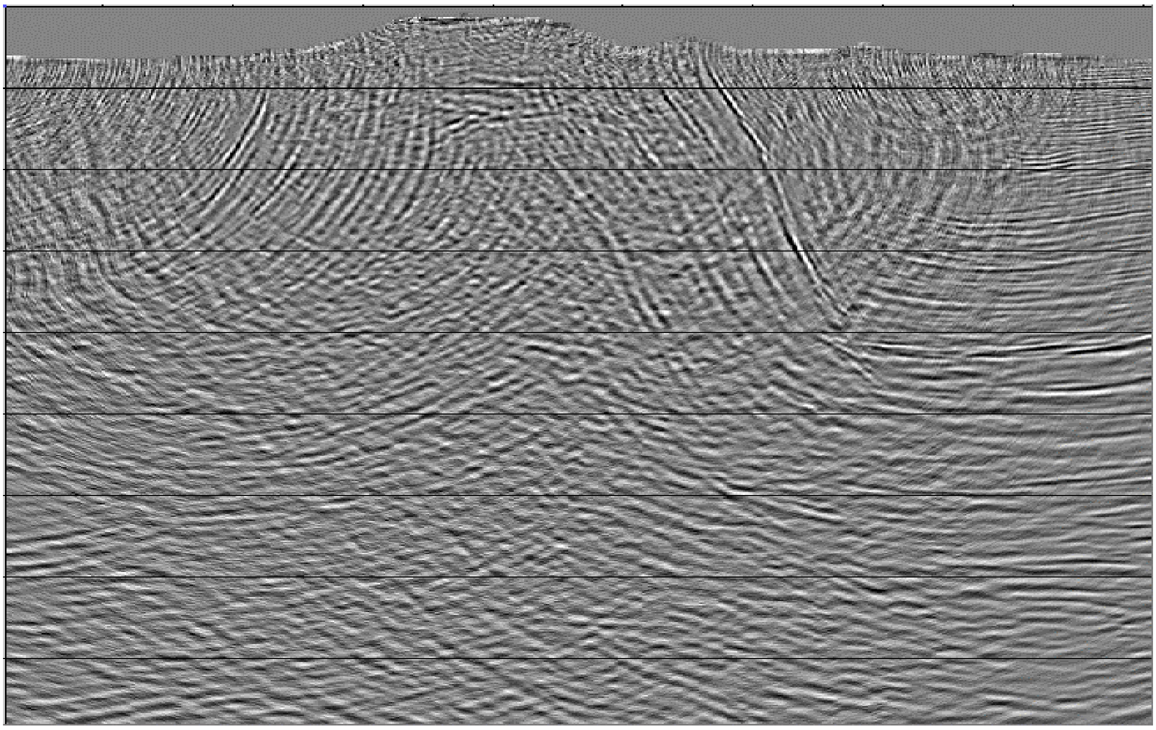

Figure 2: Pre-stack depth migration