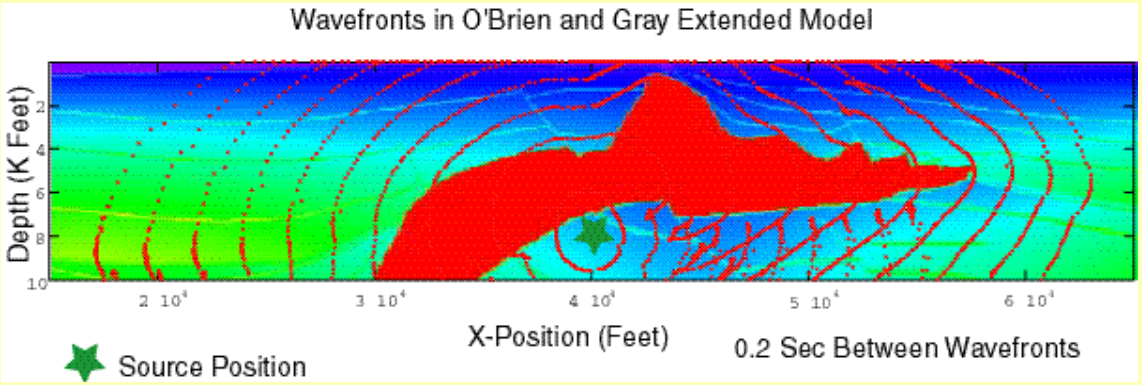
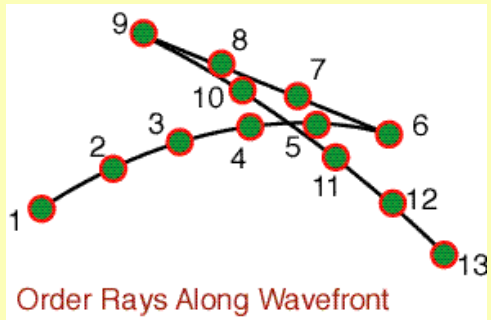
Improved Prestack Kirchhoff Migration for Complex Structures

- Provide algorithm improvements to Kirchhoff migration
- Allow improvements to current Kirchhoff implementations
- Maintain computational advantage of Kirchhoff



KIRCHHOFF MIGRATION

- 3D prestack migration important to image complex structures
- Kirchhoff most commonly used method today
  - » Kirchhoff computational requirement much less than alternatives
  - » Provides option for target oriented imaging
  - » Allows 3d prestack migration on computers available today
  - » In use at many companies



KIRCHHOFF MIGRATION (Cont.)

- Kirchhoff has problems in complex geologies
  - » Alternatives are more computationally intensive and benefits are not demonstrated
- Many groups are trying to improve Kirchhoff
  - » Technology for amplitude and phase is questionable
  - » Still problems with reliable traveltime calculation
  - » Uncertainties in using multi-valued traveltimes

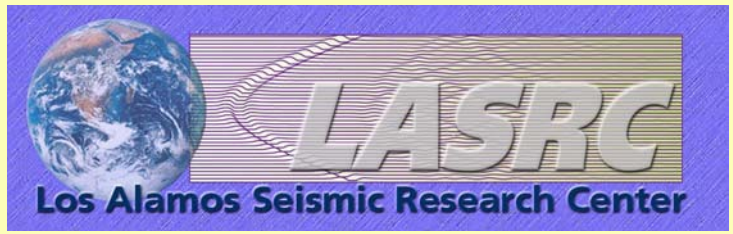
Advantages of the Kirchhoff Migration Method

- Rich history in industry so it is well understood and trusted
- Can do target-oriented imaging at a fraction of the cost of imaging an entire volume.
- Inexpensive generation of migrations for various offsets
- Computer memory requirements are less severe than some methods
- Ease of dealing with irregular source and trace spacing

What is Unique about this Project?

We are investigating use of multiple arrivals in Kirchhoff Migration

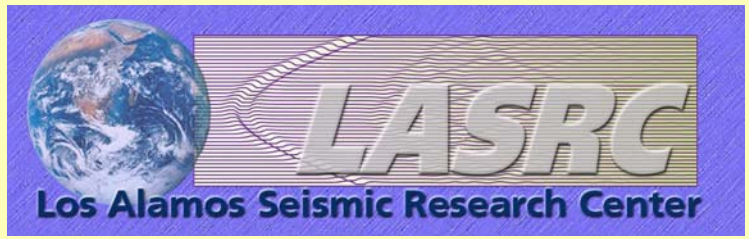
- efficient generation of traveltime tables
- use of amplitudes and phases
- currently doing target-oriented imaging for efficiency
- Investigating data contributions and raytracing influences on image



We have Developed a Numerical Testbench

Kirchhoff target oriented migration with wavefront construction

- Model multiple travel time arrivals
- Ray tracing using wavefront construction from image point
- Image seismic wavefield (no travel time table decimation, storage, or interpolation)



Numerical Testbench

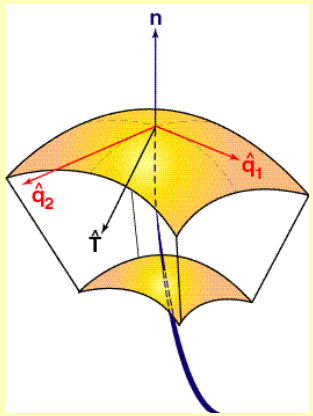
Study the impact on image due to

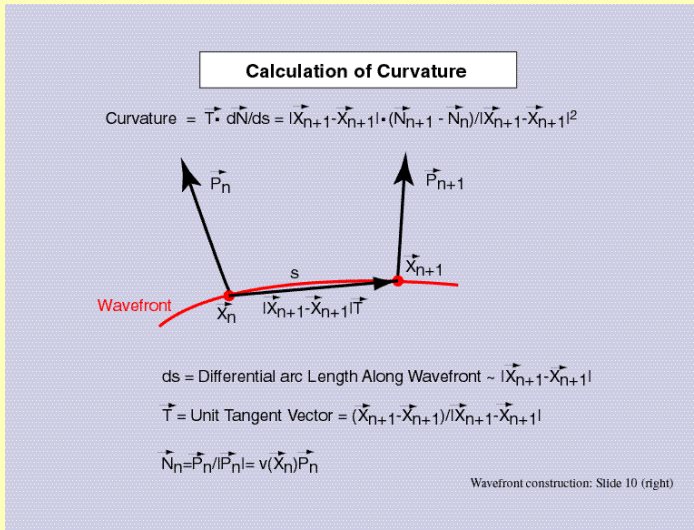
- amplitude
- phase
- coherence filtering
- minimum travel time
- maximum amplitude travel time
- different ray path legs

Use synthetic and real data sets

Accomplishments

- New wavefront construction ray addition criteria
  - » Based on physics of ray theory
- Wavefront curvature estimate without solving dynamic ray equations





Accomplishments

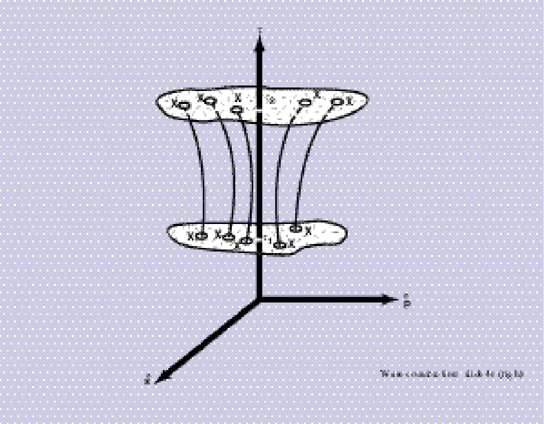
- Ray theory concepts
  - » wavefront entropy
  - » ray chaotic orbits (amplitude and phase unreliable)
  - » physical ray theory obtained via gauge transform of ray Hamitonlian

Ray theory from a differential geometry perspective

Hierarchical ray theory

Theory	Integral	Physics	Symmetry
Ray Bundle	point	phase space manifold, Hamiltonian	quadratic
Art	path	Fermat's Principle, Hamilton ray equations, dH=0	geodesic
Dynamic	surface	Liouville Theorem, transport equation, d(dH)=0	symplectic
Physical	volume	Fresnel zone, coherent scattering, d(dH')=0	gauge

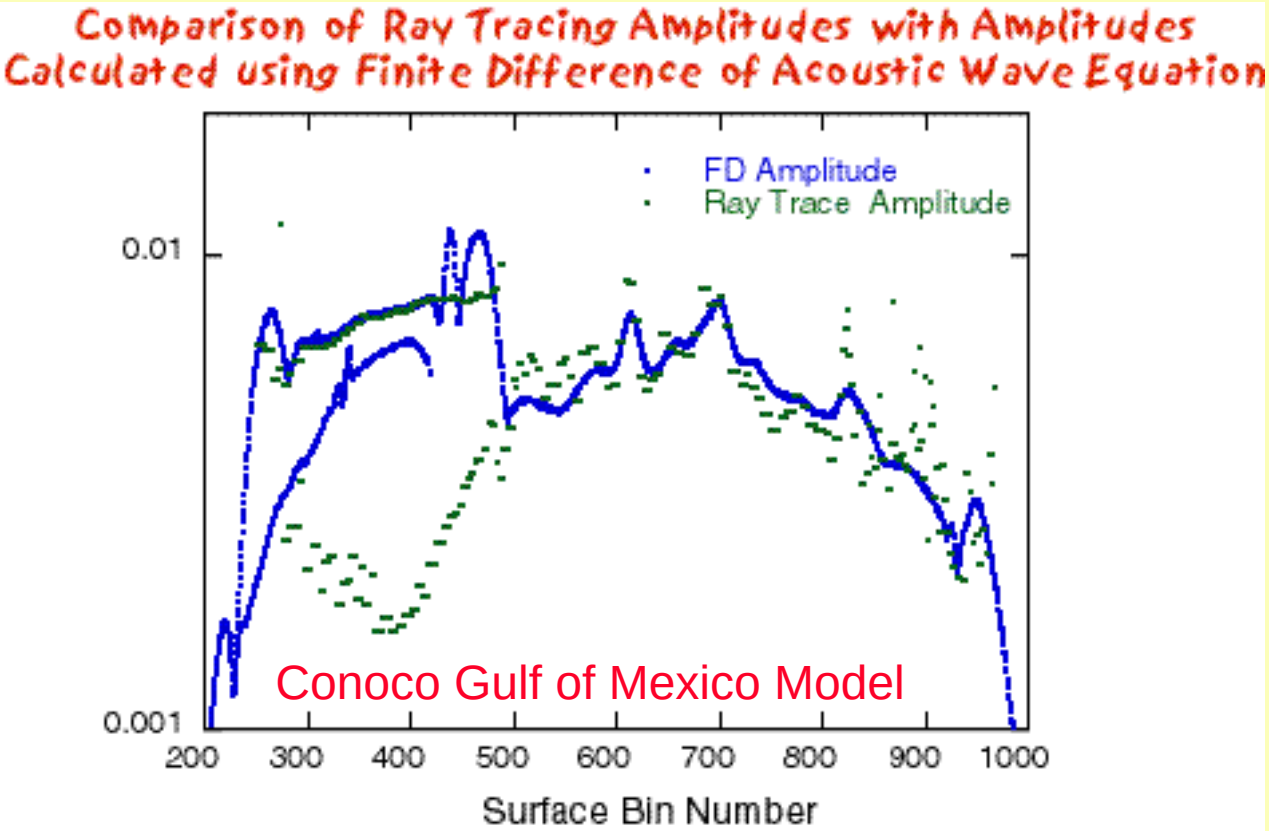
$H = 1/2\,[p_k p_k - u^2]$



Los Alamos

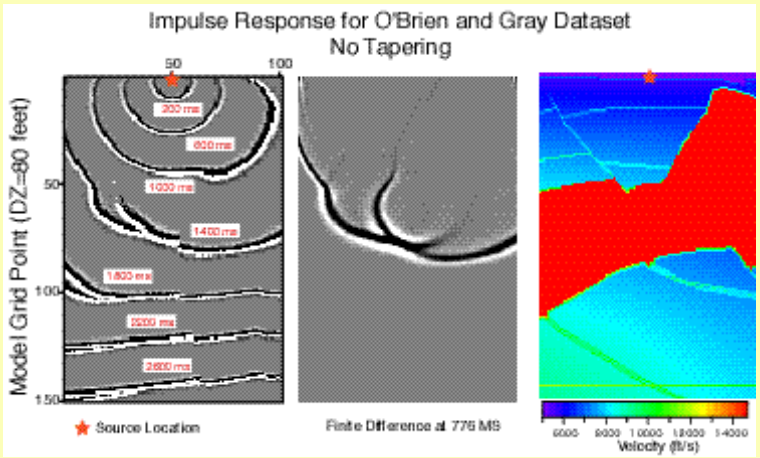
Accomplishments

- Ray Amplitudes Validated



Accomplishments

- Constant ray sigma step imaging
- Migration using wavefront construction
  - » Investigated impulse response
  - » Migrated real and synthetic data



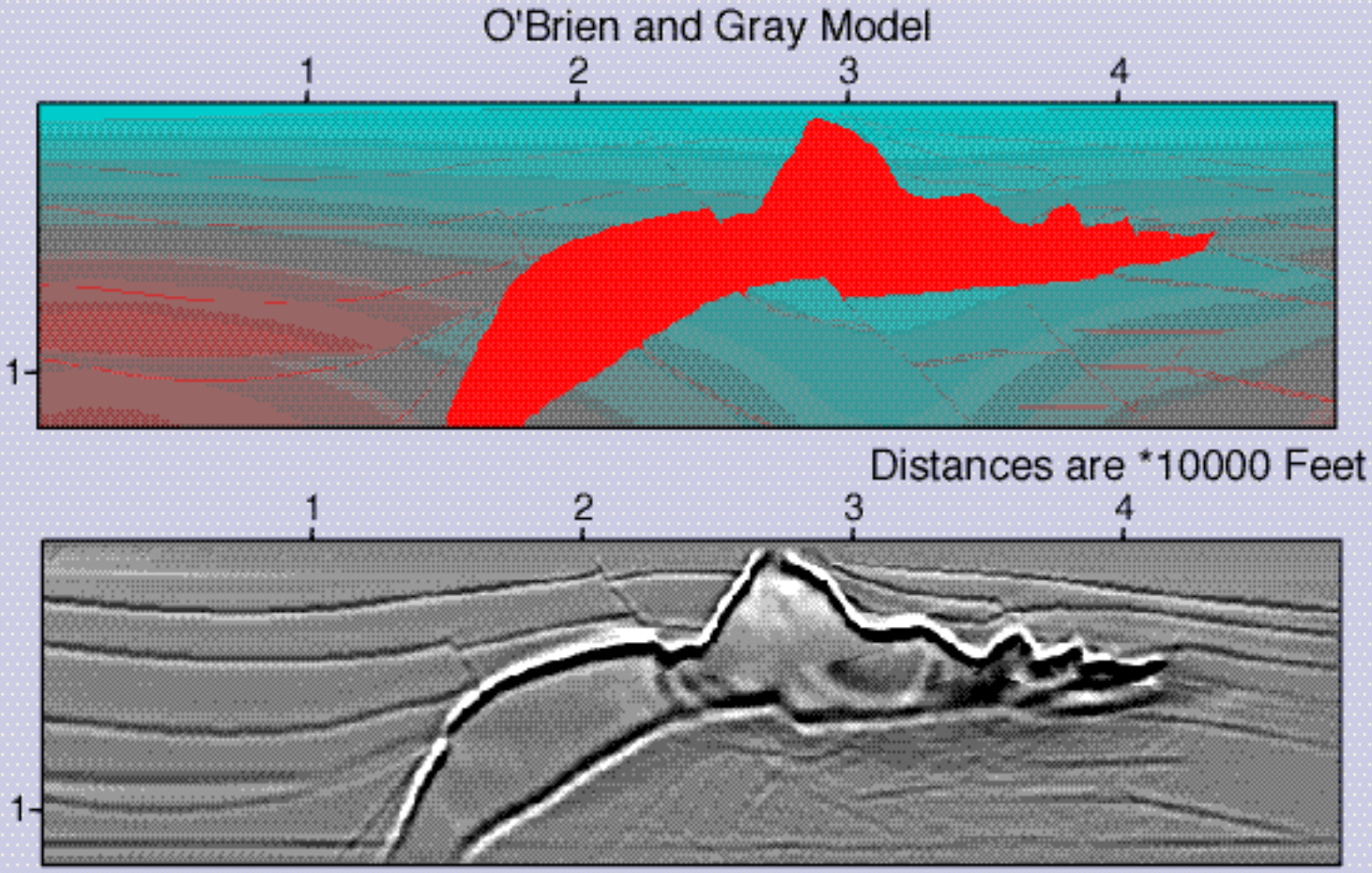


Image Obtained using Wavefront Construction

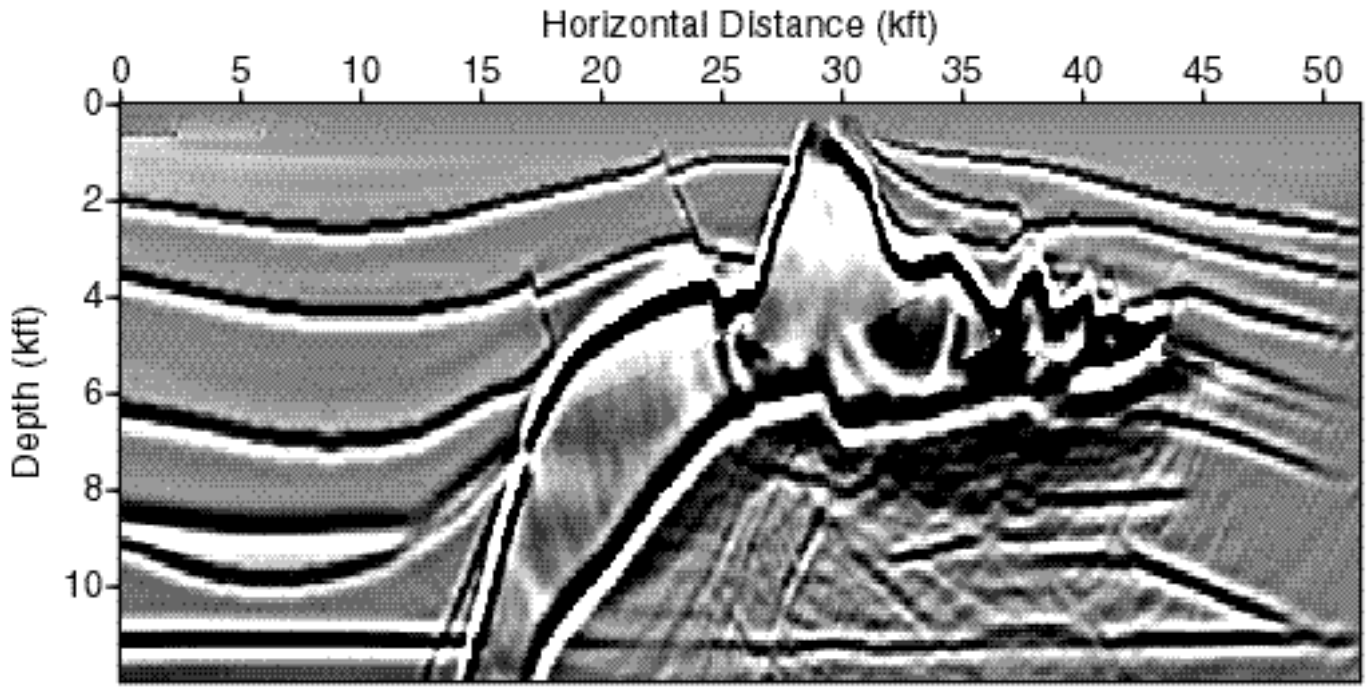
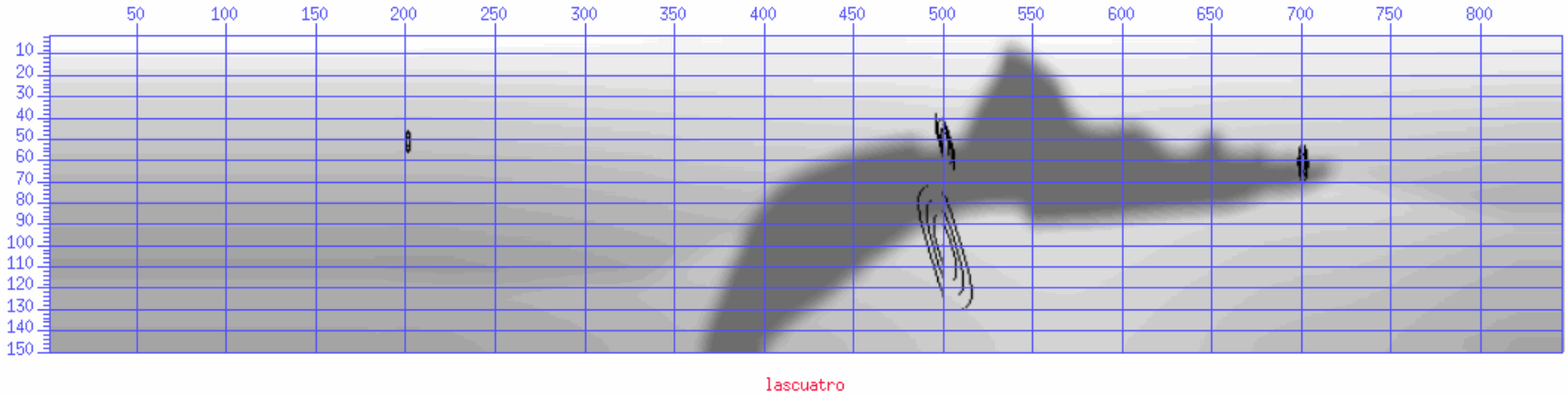


Image with topw=0.5

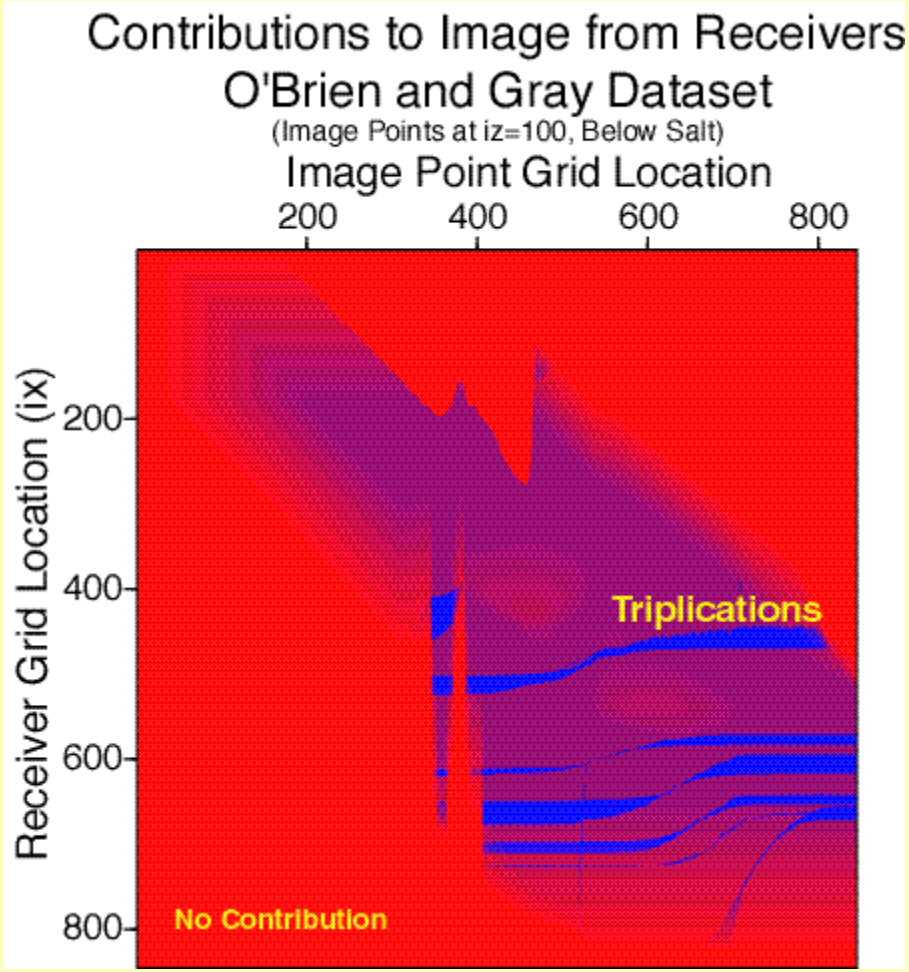
Investigation of Image Quality

- Image Resolution
  - » Gives information about position error and limits on reservoir size



Investigation of Image Quality

- Contribution of data to Image
  - » Help design data acquisition
  - » Want to maximize receiver aperture for best image



Schedule of FY00 Work

FY 00 means May 2000 - May 2001 (FE Fiscal year)

- Investigate what gives best images
  - First arrivals
  - Multiple arrivals
  - Maximum amplitude
  - Paths that avoid or travel through salt
  - Shortest path length

Scheduled FY00 Work

- Development of quantitative measures of image resolution and quality
  - » Resolution function
  - » Data contribution histograms
  - » Semblance measure of image quality

Cost for 3D Seismic Exploration

(Estimated by Bill French, costs per square km)

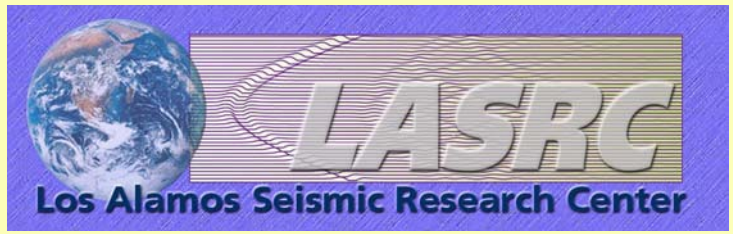
Acquisition: $7,000

Processing: $1,200

Prestack Migration: $2,000

Interpretation: $240

Our Goal is to maximize information from acquisition and migration while improving drilling success



Kirchhoff Migration is Important

- Many unresolved issues
  - » Improvements will lead to better imaging and better success in drilling
  - » Quantitative estimates of image quality willl be useful
- Our studies transcend scale and geometry
  - » Applicable to interwell regimes
- Industry has shown great interest in our work