

CLAIMS

1. A scientific method for transforming seismic data into a subsurface physical property model, comprising:

constructing the subsurface physical property model by performing tomographic inversion of the seismic data, using a computer, with residual depth errors reconstructed using property scanning;

wherein the physical property is one of velocity, a vector component of velocity, one or more anisotropy parameters, and any other property of a medium that affects a kinematic property of propagation of acoustic waves,

wherein the residual depth errors are reconstructed using the following relationship at each imaging point

$$DA(v_m - v_f)$$

where A is a matrix built from ray tracing, v_m is a base migration model of the property, v_f is a model of the property as picked from a property scan of migrated seismic data, and deviation operator D is defined by its operation on an arbitrary n -dimensional vector $a = \{a_j\}$:

$$(Da)_j = a_j - \sum_i \frac{a_i}{n}$$

where indices i and j denote different source-receiver offsets among a total of n offsets present in the migrated seismic data,

wherein the property model is constructed by computing an update to the base migration model, said update Δv being given by solving

$$(DA)\Delta v = Dz_m$$

where z_m is migrated depth, and

wherein the property scanning includes,

choosing a suite of property models,

generating tables of depth errors for each property model in the suite using the matrix

A ,

forming images by migrating the seismic data using each property model in the suite,

picking a focusing property at a plurality of image points, and

using the tables of depth errors, finding a depth error that corresponds to each focusing property.

2. The tomographic method of claim 1, wherein the migrated seismic data are formed into gathers of traces with a common image point but different offsets.

3. The tomographic method of claim 1, wherein matrix A comprises derivatives of imaged depths with respect to model parameters.
4. The method of claim 1, further comprising updating the base migration model with the update and repeating the method for at least one iteration.
5. The method of claim 1, wherein the suite of property models are generated based on the base migration model.
6. The method of claim 5, wherein the property models in the suite of property models do not differ from the base migration model by more than a pre-selected tolerance.
7. The method of claim 1, wherein the focusing property is picked based on flatness of the image points.
8. The method of claim 7, wherein the migrated data are formed into offset gathers generated by Kirchhoff or beam migration, or angle gathers generated by shot beam migration or wave equation based migration.
9. The method of claim 1, wherein the tables of depth errors are generated by multiplying the matrix A by the difference between the base migration model and a property model from the suite to simulate depth errors in the plurality of image points, and repeating for each property model in the suite, wherein each model is expressed as a vector.
10. The method of claim 1, wherein the tomographic inversion is ray-based tomographic inversion or wave-based tomographic inversion.
11. The method of claim 1, further comprising using the physical property model constructed from tomographic inversion for prospecting or producing hydrocarbons.

12. A non-transitory computer usable medium encoded with instructions, which when executed by a computer causes the computer to execute a scientific method for transforming seismic data into a subsurface physical property model comprising:

constructing the subsurface physical property model by performing tomographic inversion of the seismic data, with residual depth errors reconstructed using property scanning;

wherein the residual depth errors are reconstructed using the following relationship at each imaging point

$$DA(v_m - v_f)$$

where A is a matrix built from ray tracing, v_m is a base migration model of the property, v_f is a model of the property as picked from a property scan of migrated seismic data, and deviation operator D is defined by its operation on an arbitrary n -dimensional vector $a = \{a_j\}$:

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where indices i and j denote different source-receiver offsets among a total of n offsets present in the migrated seismic data,

wherein the property model is constructed by computing an update to the base migration model, said update Δv being given by solving

$$(DA)\Delta v = Dz_m$$

where z_m is migrated depth, and

wherein the property scanning includes,

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using the tables of depth errors, finding a depth error that corresponds to each focusing property.