CLAIMS

1. A method comprising: obtaining geophysical data for a subsurface region; generating, with a computer, at least two subsurface property models of the subsurface region for at least two subsurface properties by performing an inversion that minimizes a misfit between the geophysical data and forward simulated data subject to one or more constraints, the inversion including generating updates to the at least two subsurface property models for at least two different scenarios that both fit the geophysical data with a same likelihood but have different values for model materiality, with the model materiality being posed as an equality constraint in the inversion, thereby the inversion being constrained by a predetermined range of values for the model materiality, wherein the model materiality is a functional of model parameters that characterize hydrocarbon potential of the subsurface region, and further wherein the model materiality weighs porosity of a hydrocarbon reservoir in the subsurface region against shale content of the hydrocarbon reservoir; analyzing a geophysical data misfit curve or geophysical data misfit likelihood curve, wherein the geophysical data misfit likelihood curve is an inverse of the geophysical data misfit, plotting model likelihood as a function of model materiality over the predetermined range of values of the model materiality to identify the at least two subsurface property models that correspond to a high-side and low-side, respectively, for each of the at least two subsurface properties, with the high-side and low-side quantifying uncertainties in the subsurface properties, and further with the high-side and low-side each determined at a respective upper or lower bound for model materiality; and prospecting for hydrocarbons in the subsurface region with the at least two models that correspond to the high-side and the low-side for each of the at least two subsurface properties, wherein the at least two subsurface properties are the shale content and the porosity.

2. The method of claim 1, wherein the model materiality further weighs the porosity of the hydrocarbon reservoir against water saturation.

3. The method of claim 1, wherein the model materiality is a linear functional of model parameters that characterize hydrocarbon potential of the subsurface region.

4. The method of claim 2, wherein the porosity, the shale content, and the water saturation are determined for a predetermined depth range in the subsurface region.

5. The method of claim 1, wherein the geophysical data is at least one of seismic, electromagnetic, or gravity.

6. The method of claim 1, wherein the at least two subsurface properties are Vshale and porosity.

7. The method of claim 1, wherein the inversion is least squares inversion.

8. The method of claim 7, wherein the least squares inversion is bounded variable least squares inversion.

9. The method of claim 8, wherein the least squares inversion is non-negative least squares inversion.

10. The method of claim 1, wherein the geophysical data is one or more of P-wave velocity Vp, S-wave velocity Vs, Vp/Vs, impedance, density, or resistivity.

11. The method of claim 10, wherein the geophysical data is one or more of seismic stacks or gathers.

12. The method of claim 11, wherein the geophysical data is controlled source electromagnetic data.

13. The method of claim 1, further comprising obtaining probability density functions for rock properties from well-logs or cores, wherein the probability density functions are included as the one or

more constraints.

14. The method of claim 1, wherein three-dimensional information is included in the one or more constraints.

15. The method of claim 1, wherein a rock physics model, calibrated from well logs, is included in the one or more constraints.

16. The method of claim 1, wherein the geophysical data is synthetic data, and the prospecting for hydrocarbons includes planning a geophysical acquisition based on the high-side and low-side generated with the synthetic data.

17. The method of claim 1, wherein the model materiality is a functional that is a sum of an average for each of a plurality of model parameters that characterize hydrocarbon potential of the subsurface region.

18. The method of claim 1, further comprising generating subsurface images of the at least two subsurface property models that correspond to a high-side and low-side, and based at least in part on the subsurface images, estimating uncertainty for subsurface properties that indicate a presence or absence of hydrocarbon deposits in a subterranean geologic formation.

19. The method of claim 14, wherein the three-dimensional information included in one or more constraints is dip and azimuth derived from seismic data.