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Integrating deterministic geological model with multimodal machine learning to predict shale productivity

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Over the past ten years, diverse machine learning techniques have been extensively employed in forecasting output for non-traditional reservoirs. Nevertheless, these techniques primarily utilized discrete point data obtained from field databases, such as well drilling, completion, monitoring, experiments, and production data of horizontal wells. However, this data fails to capture the spatial heterogeneity of reservoir properties, which ultimately undermines the reliability of shale gas production. This study proposes a multimodal machine learning approach that utilizes a geological model restricted by well-logging and 3D seismic data. The deterministic geological model is constructed by utilizing the high vertical resolution of well logs and the planar resolution of reflection 3D seismic attributes. Subsequently, the detailed and precise data regarding geological properties such as porosity, permeability, gas saturation, TOC, brittleness, thickness, etc. in the vicinity of horizontal wells are acquired using the aforementioned geological model. These data are then combined with traditional tabular datasets to accurately represent the heterogeneity of the reservoir. Subsequently, a multimodal model is created that combines a convolutional neural network (CNN) module and an artificial neural network (ANN) module. The CNN module is designed to handle high-level information from the visual dataset, while the ANN module is used to evaluate the typical tabular datasets. A fusion module integrated and processed input from both modalities. The results demonstrate that the multimodal approach attained a coefficient of determination (R2) of 0.845 for the 12-month shale gas production prediction, which is greater than the R2 value of 0.721 obtained using simply the ANN model. In addition, this approach based on the multimodal of analysis can elucidate the varying levels of shale gas production between two horizontal wells that have similar average reservoir attributes. This is achieved by taking into account the lateral heterogeneity of the producing formations that the two horizontal wells have penetrated. Hence, the exceptional predictive accuracy of the multimodal machine learning technique offers valuable insights into forecasting shale gas production. This approach may be utilized to guide the selection of optimal locations for new horizontal wells and facilitate the efficient exploitation of shale gas reservoirs.

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References

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Primary authors: HUI, Gang (China University of Petroleum Beijing); Dr WANG, Muming (University of Calgary); Mr YAO, Fuyu (China University of Petroleum Beijing); Mr WANG, Hai (University of Calgary); Dr PI, Zhiyang (China University of Petroleum Beijing); Mr BAO, Penghu (China University of Petroleum Beijing)

Presenter: HUI, Gang (China University of Petroleum Beijing)

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