Distribution of Regional Pressure in the Onshore and Offshore Gulf of Mexico Basin, USA

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INTRODUCTION

The U.S. Geological Survey (USGS) has created a comprehensive geopressure-gradient model of the regional pressure system spanning the onshore and offshore portions of the Gulf of Mexico, USA. The model was used to generate ten maps: five contour maps (Maps 1A - 5A) characterize the depth to the surface defined by the first occurrence of isopressure-gradients ranging from 0.60 psi/ft to 1.00 psi/ft, in 0.10-psi/ft increments, and five supporting maps (Maps 1B - 5B) display the spatial density of the data used to construct the isopressure-gradient maps. The boundary of the geopressure-gradient model represents the maximum extent of the calculated pressure-gradient data. The regional investigation, however, encompassed an area defined by the Upper Jurassic-Cretaceous-Tertiary Composite Total Petroleum System Boundary (Dubiel et al., 2010), and the availability of offshore data. Mathematical derivations, data-quality control methodology, linear pressure interpolation calculations, and contouring algorithms (Burke et al., in press [a]; in press [b]) define the geopressure-gradient model. A summary of previous isopressure-gradient mapping efforts of the Gulf Coast region are also provided by Burke et al., (in press [b]) and references therein.

Note that the isopressure-gradient surfaces depicted are regional in scope and are not intended for small-scale, detailed interpretation at specific locations.

PURPOSE

A comprehensive geopressure-gradient model was developed to characterize the regional pressure system of the Gulf of Mexico basin, which is one of the most important petroleum producing provinces in the United States. This geopressure-gradient model was used to generate a series of maps that depict the surfaces defined by the first occurrence of select isopressure-gradients spanning the Gulf of Mexico basin. The use and application of these geopressure-gradient modeling results are multi-disciplinary.

These isopressure-gradient maps enable the identification and quantification of the occurrence, magnitude, location, and depth of overpressured and underpressured regions, as well as zones of normal pressure. These maps broadly define overpressured areas, which is critical to recognize when exploring for deep oil and gas resources with distinct pressure signatures, for the evaluation of reservoir-seal integrity, and for assessing potential undiscovered hydrocarbon accumulations. These maps provide insight into potential pressure-related challenges associated with oil and gas production, which is critical for the safety and mitigation of pressure-induced geohazards related to new and ongoing exploration as well as to the development of the Nation's petroleum energy endowments. In addition, the identification of underpressured regions is a critical parameter for evaluating the feasibility of geological sequestration and long-term containment of fluids (Burke, 2011), such as supercritical carbon dioxide for alternative disposal methods of waste greenhouse gases.

DESCRIPTION

The data set available to the USGS for this Gulf Coast regional investigation consists of 336,681 mud-weight measurements from 863,340 wells; of these, over 202,060 pressure measurements from 69,381 wells were incorporated into the geopressure-gradient model. The data are from the proprietary industry IHS database (IHS Energy Group, 2011), as well as measurements from several folios which were digitally archived by (Burke et al., 2011).

Maps 1A – 5A show contours representing depths to surfaces defined by the first occurrence of isopressure gradients at magnitudes of 0.60, 0.70. 0.80. 0.90, and 1.00 psi/ft, respectively. The contours are given in 1,000-ft (300-m) increments. Figure A provides a graphical explanation of the first occurrence of an isopressure-gradient. Warmer colors represent areas of deeper surfaces; cooler colors represent areas of shallower surfaces. The datum is with respect to land surface or sea floor, as appropriate.

The data density maps (Maps 1B – 5B) quantify the data distribution that was used to generate the isopressure-gradient contour maps (Map 1A – 5A). The number of wells within a six-square mile grid block yields the data density. Cooler colors represent areas with less well control; warmer colors represent areas with greater well control.

METHODOLOGY

The methodology for building the geopressure-gradient model, as well as details of the linear interpolation and contouring algorithms used to generate the contours of the isopressure-gradient surfaces, is described by Burke et al. (in press [a]; in press [b]). In summary, only vertical wells were used for this investigation. Data were systematically removed from the pressure-gradient model based on the following criteria: (1) mud-weight measurement was null; (2) depth measurement was null; (3) mud-weight measurement equaled depth measurement, which is likely a data transcription error but would ultimately result in an erroneous pressure gradient approaching the lithostatic pressure; (4) pressure gradient was less than 35% of the hydrostatic pressure gradient, i.e. 5.8 ppg (0.30 psi/ft); and (5) pressure gradient was greater than 35% of the lithostatic pressure gradient, i.e. 30.0 ppg (1.56 psi/ft).

Pressure gradients were determined on a well-by-well basis using the equations described by Burke et al. (in press [a]; in press [b]). As a result, several pressure gradients were obtained at successive depths within a single well. In order to maintain the accuracy of the pressure-gradient surface, no extrapolations of pressure measurements were conducted to supplement the existing dataset; linear interpolation was the only method employed. In the case of a pressure reversal in a well, the depth corresponding to the first occurrence of the pressure gradient, which is the shallowest depth, was used in the calculations.

The isopressure-gradient surfaces were contoured using deterministic interpolation methods which allow for calculating values between known data points. These calculated values were weighted by proximity using a two-dimensional moving ellipse. The contouring algorithm was augmented by geologic interpretation to rectify aberrant contours as necessary.

NON-ENDORSEMENTS

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REFERENCES

Burke, L.A., 2011, Carbon dioxide fluid-flow modeling and injectivity calculations: U.S. Geological Survey Scientific Investigative Report 2011-5083, 16 p. http://pubs.usgs.gov/sir/2011/5083/sir2011-5083.pdf

Burke, L.A., Kinney, S.A., and Kola-Kehinde, T.B., 2011, Digital archive of drilling mud weight pressures and wellbore temperatures from 49 regional cross-sections of 967 well logs in Louisiana and Texas, onshore Gulf of Mexico basin: U.S. Geological Survey Open-File Report 2011-1266, 14 p. http://pubs.usgs.gov/of/2011/1266/

Burke, L.A., Kinney, S.A., Dubiel, R.F., and Pitman, J.K., in press [a] October 2012, Characterization of regional pressure of the onshore and offshore Gulf of Mexico basin: Gulf Coast Association of Geological Societies Transactions, v. 62, 1 p.

Burke, L.A., Kinney, S.A., Dubiel, R.F., and Pitman, J.K., in press [b], Regional Map of the 0.70 psi/ft Pressure Gradient and Development of the Regional Geopressure-Gradient Model for the Onshore and Offshore Gulf of Mexico Basin, USA: Gulf Coast Association of Geological Societies, Memoir Series v. 1, 19 p.

Dubiel, R.F., Warwick, P.D., Swanson, S., Burke, L.A., Biewick, L.R., Charpentier, R.R., Coleman, J.L., Cook, T.A., Dennen, K., Doolan, C., Enomoto, C., Hackley, P.C., Karlsen, A.W., Klett, T.R., Kinney, S.A., Lewan, M.D., Merrill, M., Pearson, K.M., Pearson, O.N., Pitman, J.K., Pollastro, R.M., Rowan, E.L., Schenk, C.J., and Valentine, B., 2010, Assessment of undiscovered oil and gas resources in Jurassic and Cretaceous strata of the Gulf Coast, 2010: U.S. Geological Survey Fact Sheet 2011-3020, 4 p.

IHS Energy Group, 2011, PI/Dwights PLUS U.S. well data: Englewood, Colo., IHS Energy Group, 15 Inverness Way East, D205, Englewood, CO 80112, USA.

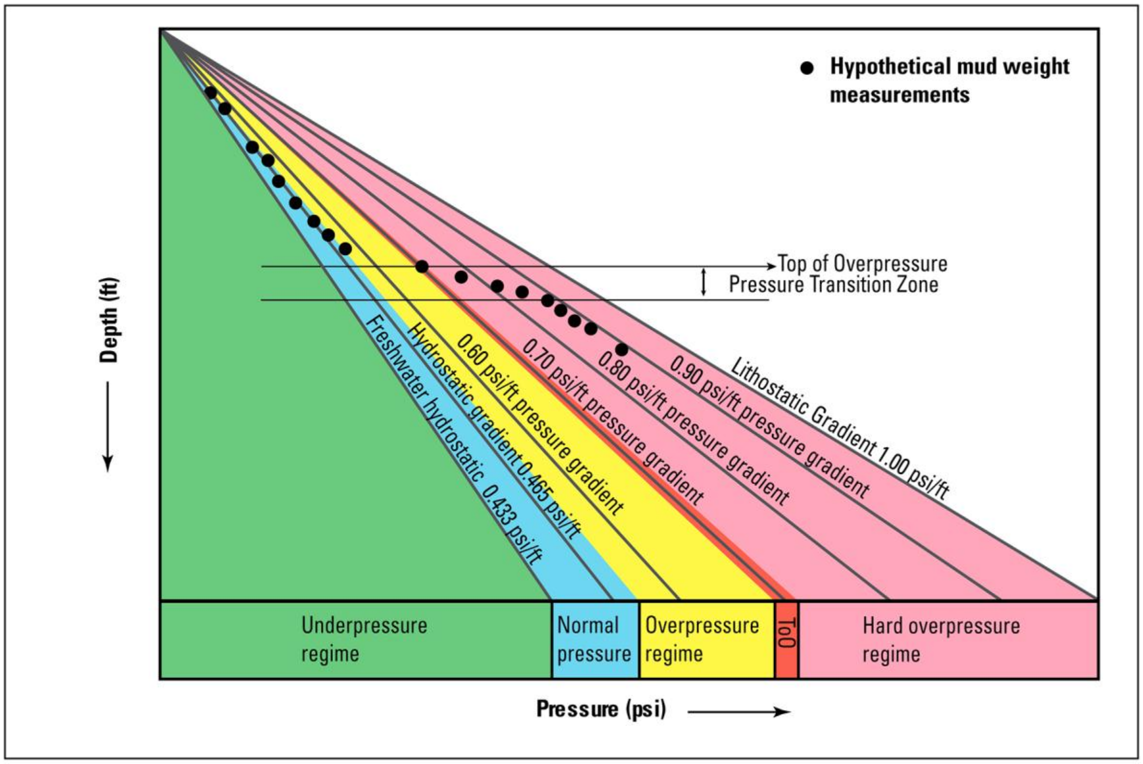

Figure A. Graphical explanation of pressure gradients. The top of overpressure is denoted by ToO.