FIRST BREAK

fb VOLUME 37 | ISSUE 4 | APRIL 2019

SPECIAL TOPIC

Passive Seismic & Unconventionals

TECHNICAL ARTICLES ATTRIBUTE ANALYSIS IMPROVEMENT

UNRAVELLING AN ANOMALOUS SEISMIC RESPONSE

INDUSTRY NEWS BP PREDICTS BIG RISE IN RENEWABLE ENERGY

EAGE
EUROPEAN ASSOCIATION OF GEOSCIENTISTS & ENGINEERS

FIRST BREAK®
An EAGE Publication

EAGE EUROPE OFFICE
PO Box 59
3990 DB Houten
The Netherlands
- +31 88 995 5055
- eage@eage.org
- www.eage.org

EAGE RUSSIA & CIS OFFICE
EAGE Russia & CIS Office
EAGE Geomodel LLC
19 Leninsky Prospekt
119071, Moscow, Russia
- +7 495 640 2008
- moscow@eage.org
- www.eage.ru

EAGE MIDDLE EAST OFFICE
EAGE Middle East FZ LLC
Dubai Knowledge Village
Block 13 Office F-25
PO Box 501711
Dubai, United Arab Emirates
- +971 4 369 3897
- middle_east@eage.org
- www.eage.org

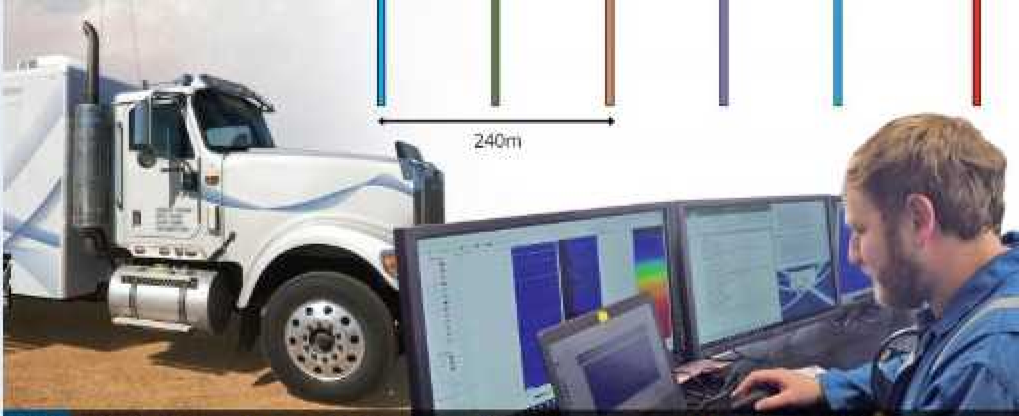
EAGE ASIA PACIFIC OFFICE
UOA Centre
Office Suite 19-15-3A
No. 19, Jalan Pinang
50450 Kuala Lumpur
Malaysia
- +60 3 272 201 40
- asiapacific@eage.org
- www.eage.org

EAGE LATIN AMERICA OFFICE
Carrera 14 No 97-63 Piso 5
Bogotá, Colombia
- +57 1 4232948
- americas@eage.org
- www.eage.org

EAGE MEMBERS CHANGE OF ADDRESS NOTIFICATION
Send to: EAGE Membership Dept at
EAGE Office (address above)

FIRST BREAK ON THE WEB
www.firstbreak.org

ISSN 0263-5046 (print) / ISSN 1365-2397 (online)



Editorial Contents

cover: An aerial view of the Rocky Mountains with an interplay of light and cloud causing the red band. This month Stephen Sonneberg demonstrates the unconventional potential of the Mowry Shale near the Rockies (photo courtesy of U.S. Geological Survey).

Preventing frac hits and well interferences with fast marching simulation using embedded discrete fracture models constrained by poroelastic geomechanical modelling of enhanced permeability

A., Ouenes[1,2*], A., Bachir[1,2], R. Smaoui[1], C. Hammerquist[1], M. Paryani[1] present a practical application of Embedded Discrete Fracture Models in a Fast-Marching Simulator where poroelastic geomechanical simulation provides the necessary enhanced permeability of the fractures that cause frac hits and well interferences.

Introduction

Investors are not happy. A recent article by a major newspaper (Olson et al., 2019) again highlighted the issue of 'underperforming' unconventional wells' production targets. It notes that financial executives from the oil industry state that predicting well performance is an art rather than a science. Others involved in the management of billions of shale assets offer their opinion by noticing that 'Geology doesn't line up with Excel spreadsheets too well, unfortunately.' These sentiments reflect the perceived state of unconventionals' technology which is reduced to 'an art and relying on Excel spreadsheets'. Such comments have dramatic consequences on all stakeholders in the unconventional business. A serious consequence came about shortly after the newspaper article was published: a law firm started an investigation targeting executives of an oil company accused of misleading their investors by providing them with false well performance forecasts. Lawyers and financiers quarreling about such highly technical matters put the burden on scientists and engineers to bring practical solutions to this complex problem. During this decade, great efforts have been made to better understand the performance of unconventional wells, but the challenges are overwhelming, and they evolve as our understanding of hydraulic fracturing progresses. Chief among these challenges, we find the issue of frac hits and well interferences.

Frac hits are not a novelty and engineers started trying to understand and model these issues years ago (Lawal et al., 2013; Guindon, 2015; Ouenes et al., 2017; Paryani et al., 2017; Vargas-Silva et al., 2018). Now that these well interferences are affecting the bottom line and Permian shale players see a reduction of 30% to 50% in their child and/or parent well productions (Xu et al., 2019), even plenary sessions in conferences are devoted to this topic (Jacobs, 2019). These gatherings provide a good opportunity to reiterate the need for acquiring data to help improve our understanding of the stated problems while recognizing the need for an interdisciplinary approach to develop solutions (Jacobs, 2019). Unfortunately, the first boom in development of unconventional reservoirs created these myths that are increasingly hard to dislodge from the minds of many stakeholders who convinced themselves that we do not need to collect data, or model earth heterogeneities to improve our engineering designs, that there is a magical number of wells per section, and that it is OK to exchange debt among private equity-backed shale players who buy and sell billions of dollars of shale assets using decline curve analysis (DCA) and type curves. Unfortunately, the tools commonly used by the industry to design their hydraulic fracturing were invented in the 1980s and 1990s and lack the basic components needed to model and optimize the well spacing and hydraulic fracturing of the unconventional wells that will reduce or avoid the impact of frac hits and well interferences. New tools and technologies are needed to form the basis of the practical implementation of new science in unconventional reservoir development.

The science of unconventionals

To properly model the behaviour of unconventional wells one needs to capture the first order physics that have a major impact on the well performance. This must account for geologic factors such as rock mechanical property variation, reservoir pressures, natural fractures and weak interfaces and their impact on the stress field which controls the resulting fracture geometry. To capture all these multi-disciplinary components, we have built a software platform able to provide the necessary tools needed for any unconventional problem using a single grid in a single project. As a result, we created a preventative workflow deployable at field-development time scales to reduce frac-hit risk and optimize well interference potential. To address the unconventional production modeling challenges, the requirement of multidisciplinary tools and rapid execution of the workflow is critical. A typical industry workflow to study an interference problem in a pad is an R&D project that could last 3 to 6 months and use tools that frequently lack the right physics or do not accurately represent geologic reality. These inadequate tools perpetuate the idea that the unconventional business is an art and will keep engineers using only spreadsheets because nobody has time for a three-month study to understand a

[1] FracGeo | [2] GO GeoEngineering
[*] Corresponding author, E-mail: aouenes@fracgeo.com

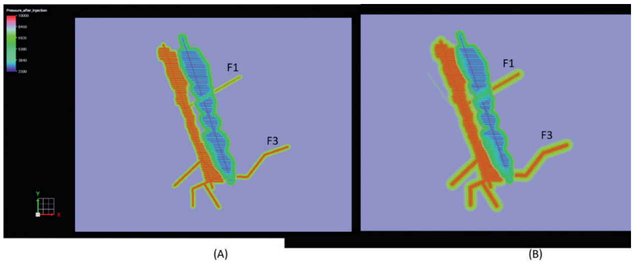


Figure 6 (A) Pressure around child and parent wells estimated using FMM and EDFM at the end of the hydraulic fracture injection period when using a constant fault permeability. Notice the higher pressure in green along F1 and F3 and inside the parent pressure field indicating the frac hit (B) pressure estimated using FMM and EDFM at the end of the hydraulic fracture injection period when using a variable and higher fault permeability derived from the strain simulation shown in Figure 4.

ask then what preventative measures can be taken to avoid this strong interference?

Jacobs (2018) described the latest 'active well defence' approaches where water is injected in parent wells to reduce the effect of the depletion when fracking the child well. The idea is proven to be effective in multiple basins but again the devil is in the detail and the presence of geologic discontinuities could greatly reduce the efficiency of this strategy. Figure 7 shows the pressure distribution after the parent well was pressurized first then followed by child injection. It appears that the presence of the faults could be a problem. Thus, the need to carefully design these water injection defences to avoid injecting in faults which could create the opposite effect and harm the child injection rather than help it.

These designs require data and rapid workflows able to provide quick answers. The use of surface drilling data provides the necessary information needed to capture the geologic and geomechanical variability at each well. The workflow described in this study is extremely fast and allows any engineer to employ the science of unconventionals and develop predictive models even for issues involving complex physics such as frac hits and well interferences which cannot be predicted with Excel spreadsheets.

Conclusions

The introduction of the EDFM in a FMM simulator allows the rapid quantification of frac hits and well interferences. The use of validated reservoir geomechanics allows the estimation of the fracture and fault permeability required by the EDFM. The results derived from this new approach match field observations. The workflow also allows the examination of preventive measures involving water injection and their impact on the fracking of a child well. This entire analysis could be carried out on any well and can be completed in a timeframe counted in hours or days not weeks or months.

Acknowledgements

The authors would like to thank Nick Umholtz and Peter O'Conor for editorial suggestions

References

Aimene, Y. and Ouenes, A. [2015]. Geomechanical modeling of hydraulic fractures interacting with natural fractures - Validation with microseismic and tracer data from the Marcellus and Eagle Ford.

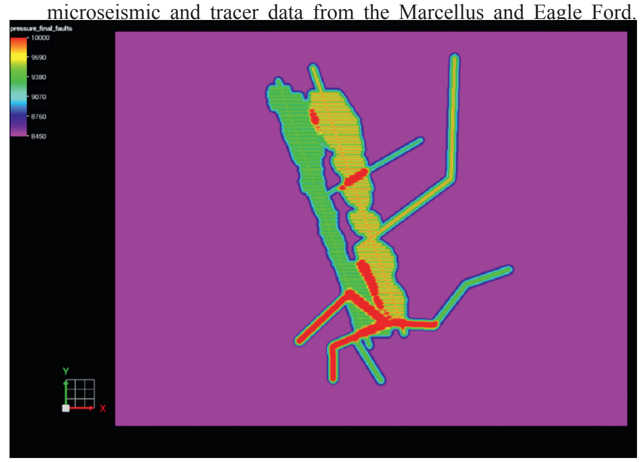


Figure 7 After injecting in the parent well and over pressuring it, injection starts in the child well. Resulting pressure around child and parent wells estimated using FMM and EDFM at the end of the child hydraulic fracture injection period.

Interpretation, **3** (3) SU71-SU88. doi: 10.1190/INT-2014-0274.1.

Aimene, Y., Hammerquist, C., Nairn, J. and Ouenes, A. [2018]. 3D anisotropic damage mechanics for modeling interaction between hydraulic and natural fractures planes in a layered rock- application to Eagle Ford and Wolfcamp. *URTeC,* 2902985.

Daves, D., Thomas, D., Lewis, B., Umholtz, N. and Ouenes, A., [2018]. Surface drilling data improve fracture modeling and reservoir simulation, Midland basin. *World Oil*, **11**, 80-83.

Guindon, L. [2015]. Determining Interwell Connectivity and Reservoir Complexity Through Fracturing Pressure Hits and Production-Interference Analysis. *Society of Petroleum Engineers*. doi:10.2118/0315-088-JCPT.

Hickey, M., Vasquez, O., Trevino, S., Oberle, J. and Jones, D. [2019]. Using Land Controlled Source Electromagnetics to Identify the Effects of Geologic Controls During a Zipper Frac Operation - A Case Study from the Anadarko Basin. *Society of Petroleum Engineers.* doi:10.2118/194313-MS.

Jacobs, T. [2018]. Fighting Water With Water: How Engineers Are Turning the Tides on Frac Hits. *Journal Petroleum Technology*, December.

Jacobs, T. [2019]. To Solve Frac Hits, Unconventional Engineering Must Revolve Around Them. *Journal Petroleum Technology*, February.

Jacques, A., Ouenes, A., Dirksen, R., Paryani, M., Rehman, S. and Bari, M. [2017]. Completion optimization while drilling – Geomechanical steering towards fracable rock using corrected mechanical specific energy. *URTeC,* 2693870.

Jenkins, C., Ouenes, A. Zellou, A. and Wingard, J. [2009]. Quantifying and predicting naturally fractured reservoir behavior with continuous fracture models. *AAPG Bulletin*, **93** (11), 1597-1608.

Khodabakhshnejad, A., Aimene, Y., Mistry, N., Bachir, A. and Ouenes, A. [2017]. A Fast Method to Forecast Shale Pressure Depletion and Well Performance Using Geomechanical Constraints - Application to Poro-Elasticity Modeling to Predict Mid and Far Field Frac Hits at an Eagle Ford and Wolfcamp Well. *Society of Petroleum Engineers*. doi:10.2118/187535-MS.

Lawal, H., Jackson, G., Abolo, N. and Flores, C. [2013]. A Novel Approach To Modeling and Forecasting Frac Hits In Shale Gas Wells. *Society of Petroleum Engineers*. doi:10.2118/164898-MS.

Moinfar, A., Varavei, A., Sepehrnoori, K. and Johns, R.T. [2013]. Development of a Coupled Dual Continuum and Discrete Fracture