Potential Injection-Induced Seismicity Associated With Oil & Gas Development

A primer on technical & regulatory considerations informing risk management & mitigation

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An Initiative of the IOGCC & GWPC

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Dan Yates
Associate Executive Director
The Ground Water Protection Council

Introduction

- StatesFirst: Collaborative partnership between the Ground Water Protection Council and the Interstate Oil & Gas Compact Commission
- StatesFirst *Induced Seismicity Work Group* ("ISWG") chartered in 2014 and led by States
- The ISWG is focused on addressing public concerns associated with induced seismicity
- Work Group deliverable: a "Primer" document to summarize and share knowledge

GROUNDWATER PROTECTION COUNCIL

INTERSTATE Oil & Gas COMPACT COMMISSION

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Primer Overview

- Primary emphasis on potential induced seismicity associated with Class II disposal wells
- Document is solely informational and is not intended to offer recommended rules or regulations

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Primer Content

- 4 Chapters
  1. Understanding induced seismicity
  2. Assessing potentially induced seismicity
  3. Risk management & mitigation strategies
  4. External engagement & communication

- 9 Technical Appendices
  - Relevant earthquake science
  - Class II injection wells
  - Induced seismicity case studies
  - Design & installation of seismic monitoring networks
  - NRC Report on induced seismicity potential in energy technologies
  - Methods for estimating reservoir pressures changes associated with injection
  - Tools for risk management and mitigation
  - Data collection & interpretation
  - Considerations for hydraulic fracturing

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Primer Chapter 1

Understanding Induced Seismicity

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Focused on:

- Magnitude and depth of induced earthquakes
- Hazard and risk of induced seismicity
- Ground motion models for induced seismicity
- USGS hazard maps
- Estimated number of induced seismicity locations
- How fluid injection may induce seismic events
- Potential for seismicity related to hydraulic fracturing
- Future research opportunities

Key Observations

- Majority of earthquakes tectonic but seismicity can be triggered by human activities
  - Induced seismic activity has been documented since at least the 1920s underground injection, oil and gas extraction, impoundment of reservoirs behind dams, geothermal projects, mining extraction, construction, underground nuclear tests, and carbon capture and storage projects
- Most cases of felt injection-induced activity have been attributed to:
  - Direct injection into basement rocks
  - Injection into overlying formations with permeable avenues of communication with basement rocks

Primer Chapter 2

Assessing Potentially Induced Seismicity

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Primer Chapter 2 –Assessing Potentially Induced Seismicity

Focused on:

- Evaluating General Patterns of Seismicity
- Detection and Location
- Seismic Monitoring by States
- Evaluating Causation of Specific Seismic Events
- Methods Used in Causation Studies
- Further Analysis to Evaluate Causation

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Key Observations – Evaluating Seismicity

- Three components necessary for felt injection-induced seismicity:
  - Sufficient pore pressure buildup from disposal activities
  - Faults of concern
  - A pathway allowing increased pressure to communicate with fault

- State considerations:
  - Evaluate general patterns of seismicity to reveal areas of concern
  - Perform an investigation to evaluate possible causal factors of specific events; recognizing a detailed seismological and subsurface characterization and modeling effort may be needed.

Primer Chapter 3

Risk Management and Mitigation Strategies

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Key Observations

- States have developed diverse strategies for avoiding, mitigating and responding to risks of induced seismicity in siting, permitting & monitoring of Class II injection wells

- "One-Size Fits All" regulatory approach not appropriate
  - Differences in geology across US
  - Varying conditions across states

Key Observations – Risk Mitigation

- Risk mitigation options in siting and permitting new Class II disposal wells may include:
  - Avoiding injection into crystalline basement
  - Avoiding direct injection into known faults of concern
  - Locating faults in vicinity of proposed project area; place well outside “at-risk” area
- Considerations attached to permits may include:
  - Temporary seismic monitoring at sites
  - Procedure to monitor operations if ground motion event occurs
  - Procedure to suspend operations if seismicity levels increase above threshold
  - Metric to determine if operations could be re-started
- States may determine different response strategies “fit for purpose”

Primer Chapter 4

Considerations for External Communication and Engagement

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Focused on:

- Communications planning process
- Communications plan elements
- Responding to an event

Key Considerations

- Clear and direct communication with public important responsibility of states
- Many states choose proactive approach
- Earthquakes arrive without warning and are unpredictable
- Most of US has no public training on what to expect from earthquakes
- Public anxiety
- Determining cause is very difficult in most instances, and studies take time

In Conclusion

- Induced seismicity is a very complex issue where the base of knowledge is changing rapidly.
- State regulatory agencies that deal with potential injection induced seismicity should be prepared to use tools, knowledge, and expertise, many of which are offered in this document, to prepare for and respond to occurrences of induced seismicity.
- Risk management, risk mitigation, and response strategies are most effective when developed considering specific local conditions and situations

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Gerry Baker, Associate Executive Director, Interstate Oil and Gas Compact Commission

Ben Grunewald, Chief of Operations, Ground Water Protection Council

Joe Lee, Project Staff, Ground Water Protection Council

Steve Musick, Project Staff, Ground Water Protection Council

Mike Nickolaus, Special Projects Director, Ground Water Protection Council

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ISWG Editorial Committee

Tim Baker, Director, Oil & Gas Division, Oklahoma Corporation Commission

Rex Buchanan, Interim Director, Kansas Geological Survey (Co-chair)

Charles Lord, Oklahoma Corporation Commission

Hal Macartney, Geosciences Advisor, Pioneer Natural Resources

Herschel McDivitt, Director, Oil & Gas Division, Indiana Department of Natural Resources

Kris Nygaard, Senior Stimulation Consultant, ExxonMobil Upstream Research Company

Leslie Savage, Assistant Director for Technical Permitting, Oil & Gas Division, Railroad Commission of Texas

Rick Simmers, Chief, Division of Oil & Gas Resources, Ohio Department of Natural Resources (Co-chair)

Ed Steele, Oilfield Sciences & Water Technical Manager, GE Global Research Oil & Gas Tech. Center

Ivan Wong, Principal Seismologist, Seismic Hazards Group, URS Corporation

Bob Worstall, Deputy Chief, Ohio Dept. of Natural Resources, Div. Oil & Gas Resources Management

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ISWG Primer Independent Technical Review Panel

Nina Burkardt, Research Social Scientist, U.S. Geological Survey

Bill Ellsworth, Senior Research Geophysicist, U.S. Geological Survey

Ernest Majer, Senior Advisor, Lawrence Berkeley Lab

Sue Perry, Disaster Scientist, U.S. Geological Survey

Julie Shemeta, Founder and President, MEQ GEO, Microseismic Consulting and Services

Brian Stump, Albritton Chair in Geological Sciences, Southern Methodist University

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ISWG Technical Advisors

Andrew Adgate, Ohio Department of Natural Resources

Scott Anderson, Environmental Defense Fund

Dan Arthur, ALL Consulting

Brad Bacon, PDC Energy

Bill Bates, U.S. Environmental Protection Agency, HQ

Grant Bromhal, National Energy Technical Laboratory

Mike Brudzinski, Miami of Ohio University

Carlos Cabarcas, Hilcorp

Trenton Cladouhos, AltaRock

Jill Cooper, Anadarko Petroleum Corporation

Dustin Crandall, National Energy Technical Laboratory

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ISWG Technical Advisors (cont.)

Phil Dellinger, U.S. Environmental Protection Agency Region 6

Ted Dohmen, Hess

Nancy Dorsey, U.S. Environmental Protection Agency Region 6

Jeff Eshelman, Independent Petroleum Association of America

Cliff Frohlich, University of Texas

Lee Fuller, Independent Petroleum Association of America

Justin Furnance, Hilcorp

Shawn Maxwell, Itasca Microsiesmic & Geomechanical Evaluation

Bethany McCorkle, Ohio Department of Natural Resources

Linda McDonald, SandRidge Energy, Inc.

Stephanie Meadows, American Petroleum Institute

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ISWG Technical Advisors (cont.)

Jeff Nunn, Chevron

Don Paul, University of Southern California Energy Institute

William Rish, Hull Risk Analysis Center

Brian Rovelli, GE Global Research

Justin Rubinstein, United States Geological Survey

Jim Rutledge, Schlumberger

Vanessa Totten Ryan, Chevron

Bob Sandilos, Chevron

Matt Skinner, Oklahoma Corporation Commission

Craig Sundstrom, Office of the Oklahoma Secretary of Energy & Environment

Laura Swafford, Chevron

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ISWG Technical Advisors (cont.)

Tom Tomastik, ALL Consulting

Tim Tyrrell, XTO Energy

Robert VanVoorhees, UITC

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Norm Warpinski, Pinnacle

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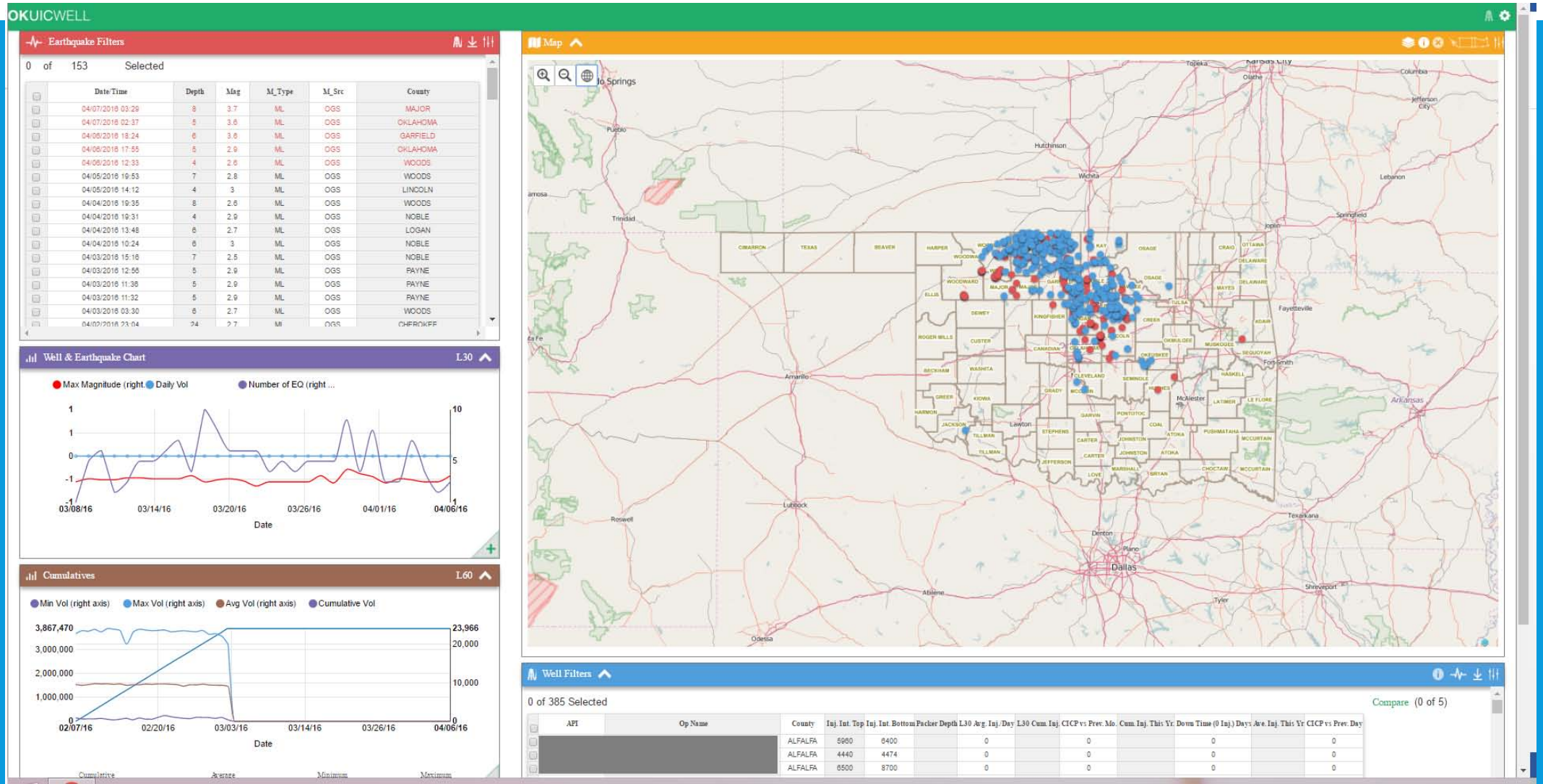

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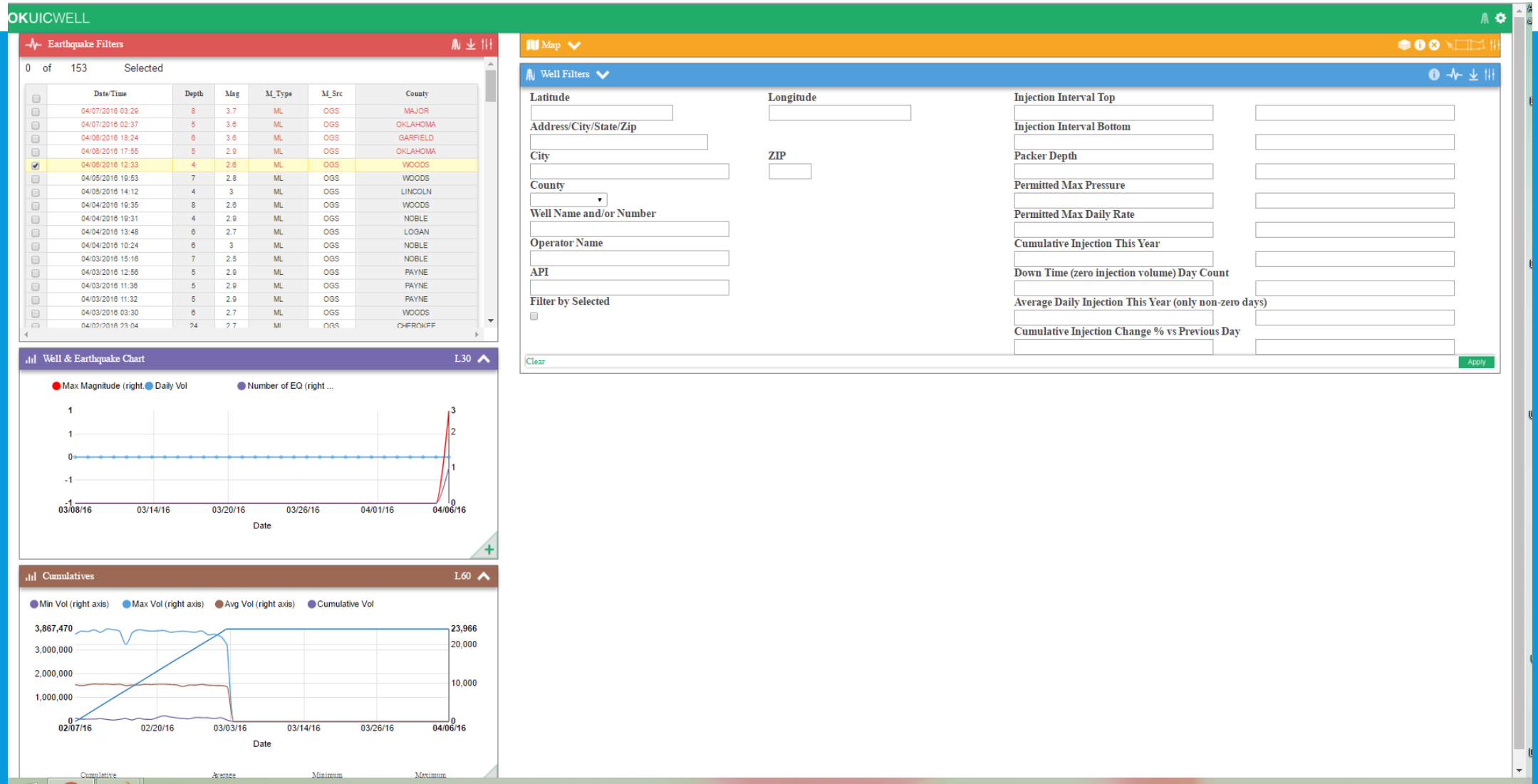

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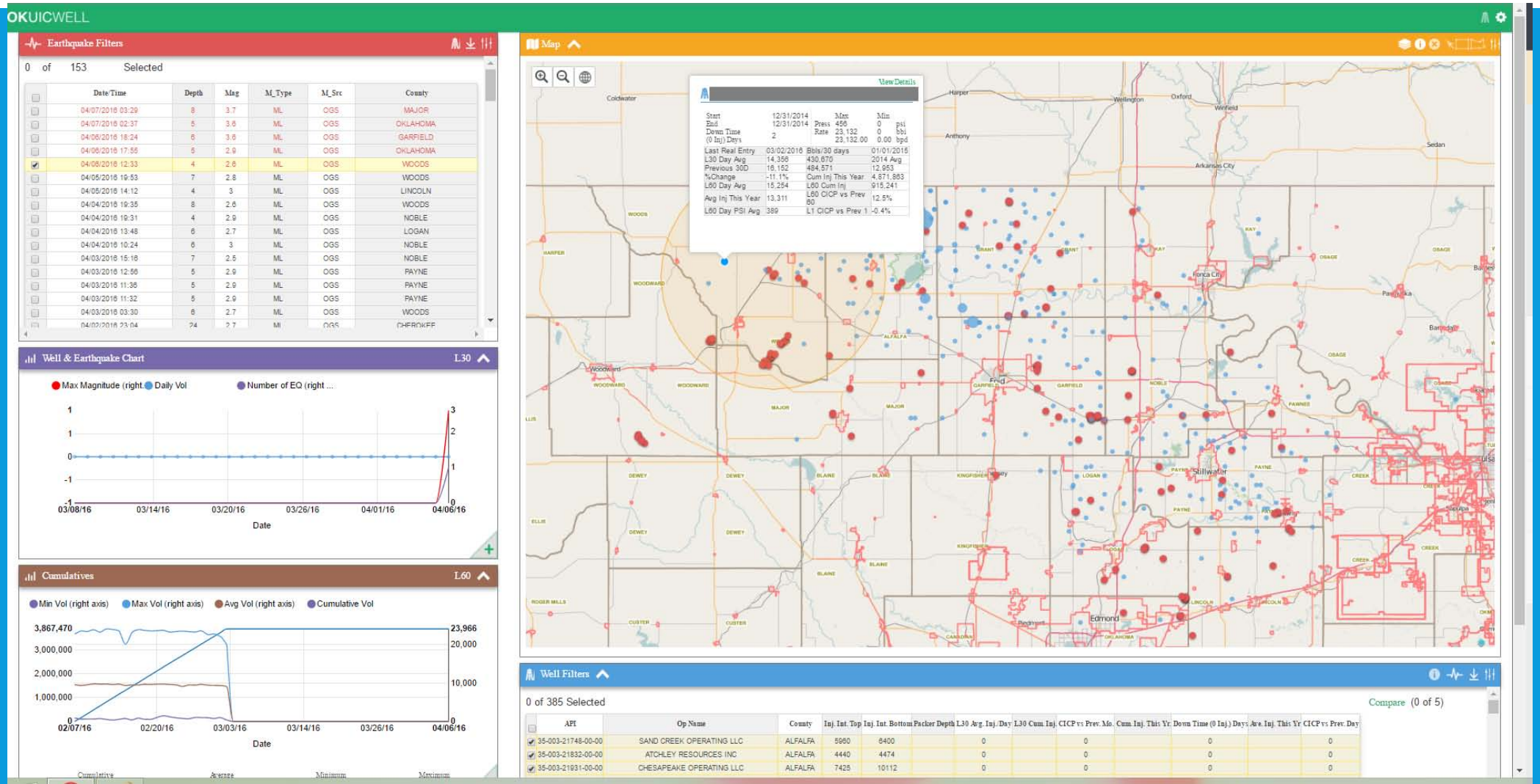

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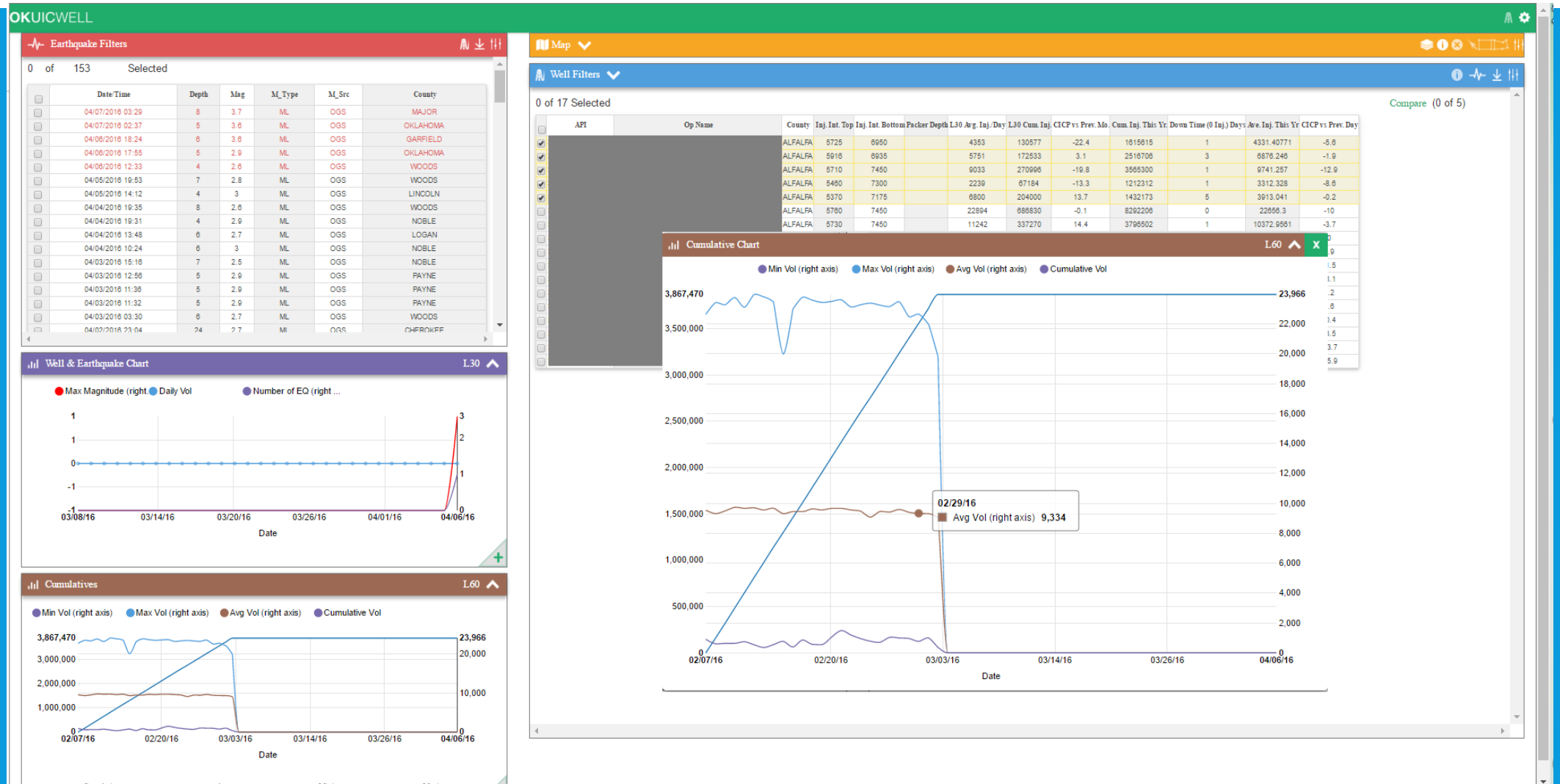

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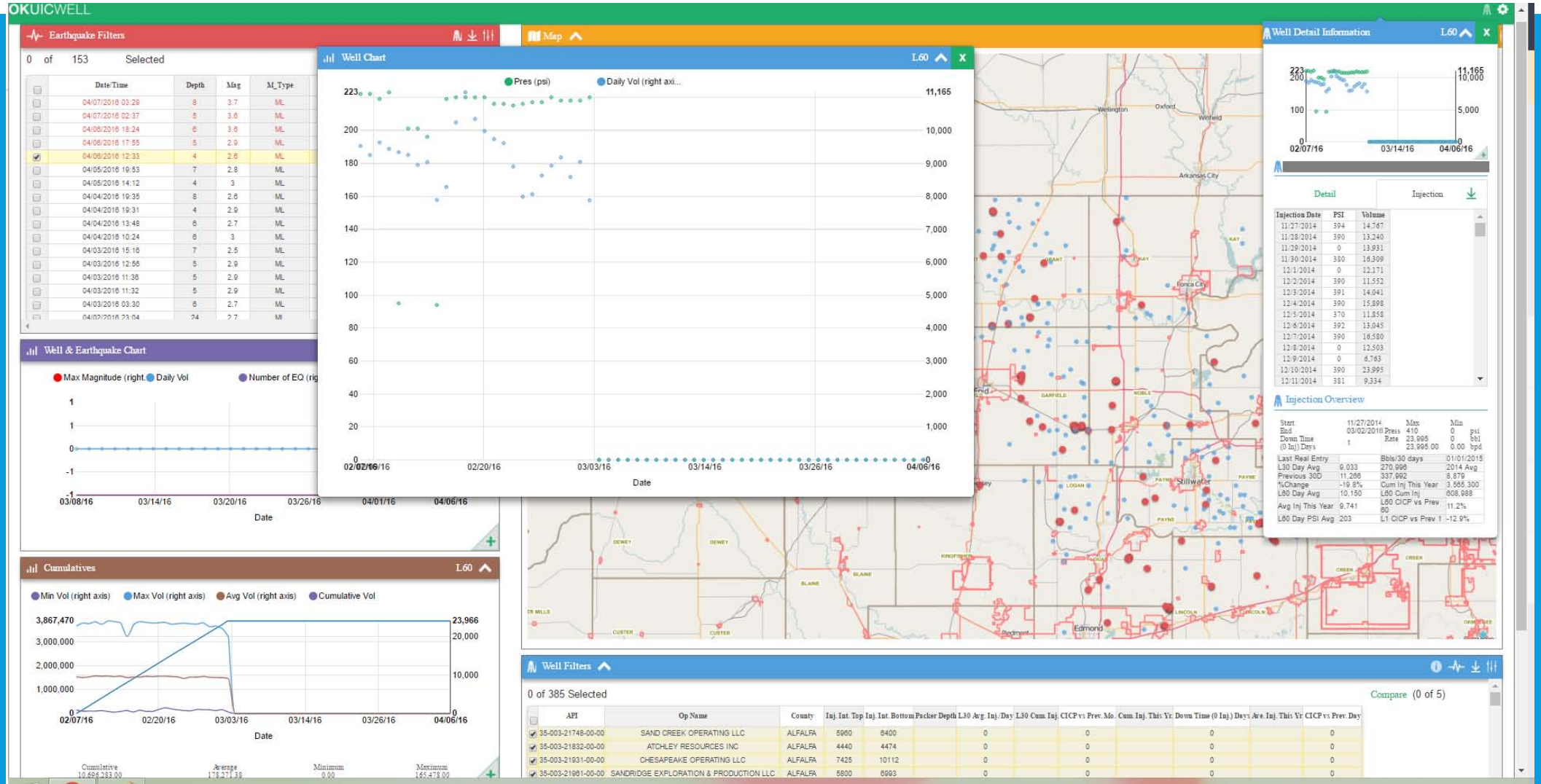

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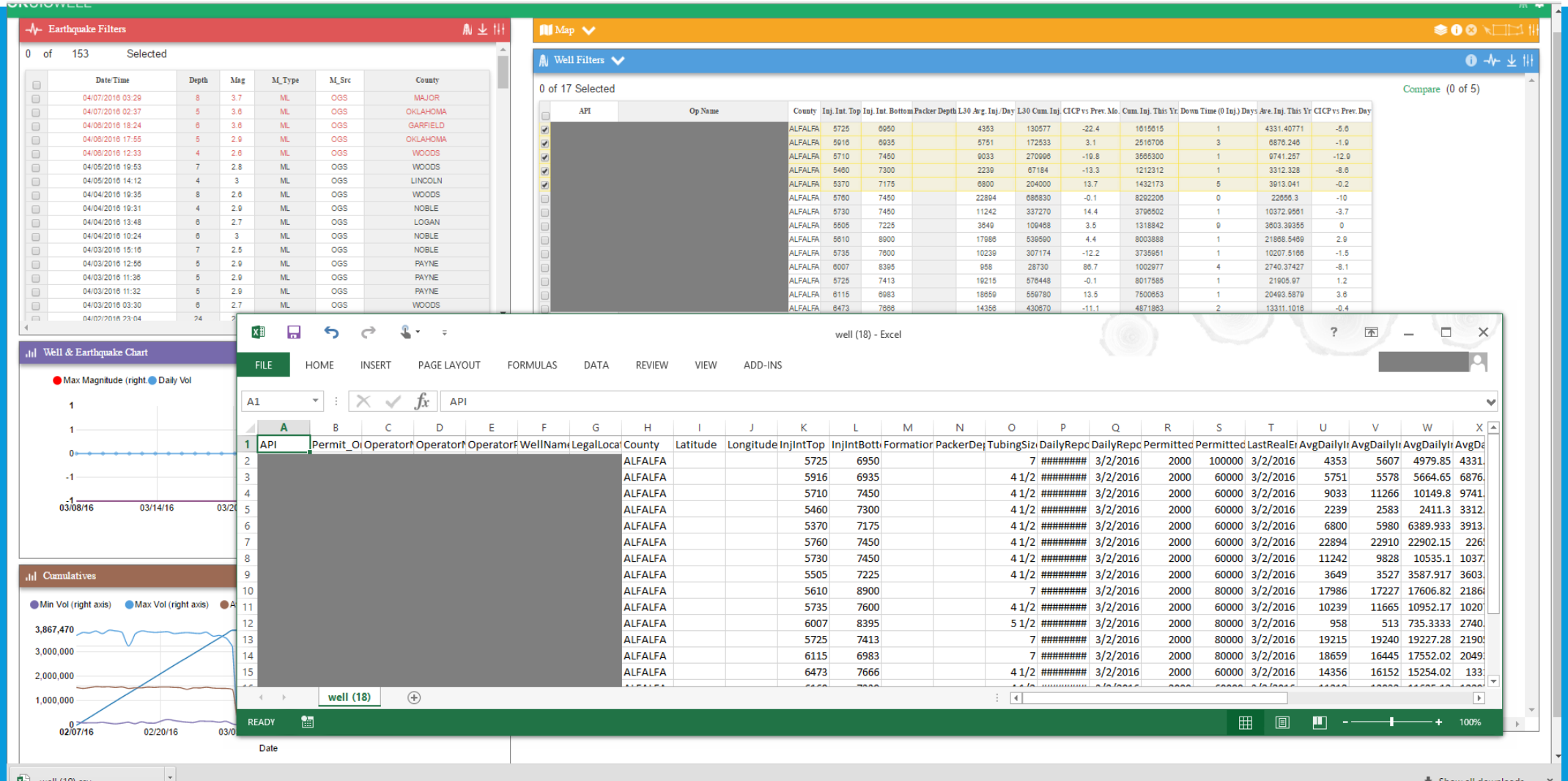


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