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Microseismic Data: Then and Now

What is new and what has changed

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Microseismic Data Management

Microseismic Then

- Data stored on CD
- Data stored on paper
- Data stored on external drives
- Data stored in offices
- Data stored in digital folders
- Data stored in well files
- Data stored in physical libraries
- Data stored in online libraries
- Knowledge stored in people

Microseismic Now

- ~~Data stored on CD~~
- ~~Data stored on paper~~
- Data stored on external drives
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- Data stored in digital folders
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- Data stored in online libraries
- Knowledge stored in people
- Data stored in the cloud

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Data Management Practices

Poor practices lead to

- Data loss
- Confusion
- Lost employee time & company money
- Failure to adapt to new technology

We need to understand more about microseismic data to

- Develop good data management practices
- Preserve long term value of information
- Get what we pay for
- Retain value for sales, swaps & reprocessing opportunities
- Integrate past data with emerging technologies

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Outline

- Microseismic overview
- New technology and applications
- Data formats and standards
- Deliverables and interpretation products
- Looking forward

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What is Microseismic?

- Microseismic is a tool to make operations **BETTER** and/or **SAFER**

- Survey design
- Response Modeling
- Waveform Recording
- Processing flows

- Completions design evaluation
- Well placement and interaction
- Reservoir dynamics
- Cost savings

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Microseismic Methodologies

- Microseismic is a *passive* monitoring tool
- Instruments are placed in an array to *listen* for micro-earthquakes generated by rock breaking energetically

Downhole

- 1D string(s) of permanent or retrievable tools in a borehole
  - Geophones
  - Accelerometers
  - Fiber Optic Cable(s)

Surface

- Buried or surface network of sensors
  - Geophones
  - Accelerometers
  - Seismometers
  - Hybrid

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“New” Microseismic Technology

Surface

- Established technology, new to many people
- Subtle differences in monitoring inputs/outputs

Induced Seismicity Monitoring

- Data types, processing flows, and outputs can be similar to microseismic
- Monitoring involves different instrumentation, project scale, and end products
- Data formats and products may be dictated by regulatory bodies

Fibre Optic Distributed Acoustic Sensing (DAS)

- Flexible spatial sampling along length of wellbore (no geophones)
- May be coupled with strain measurements, temperature measurements (DTS)
- Rapidly evolving

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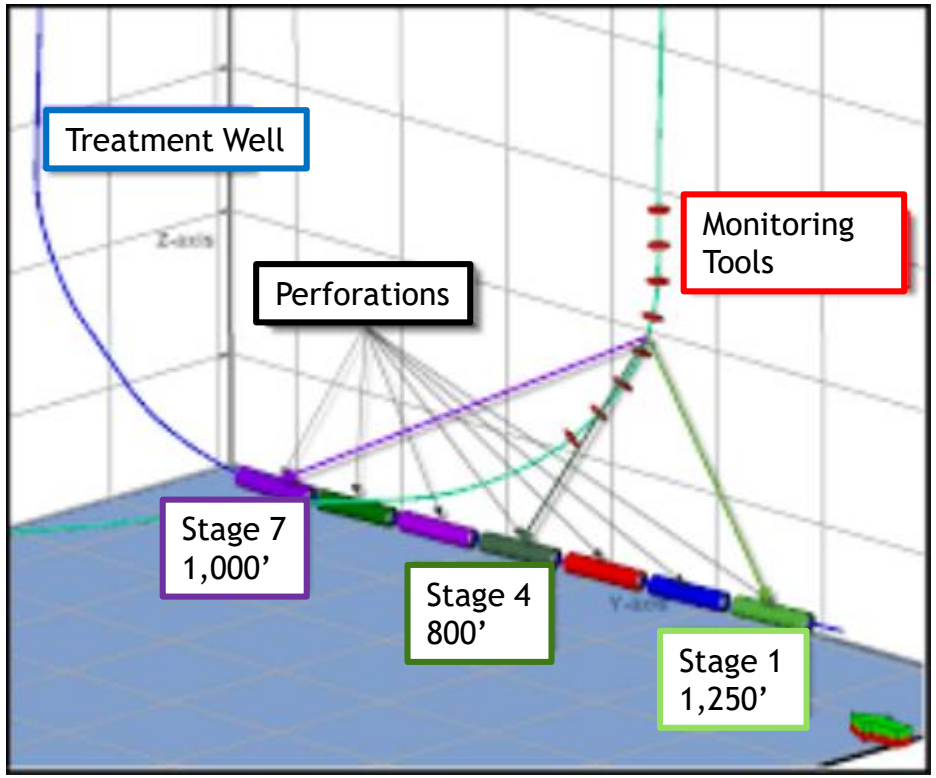
Acquisition

Downhole

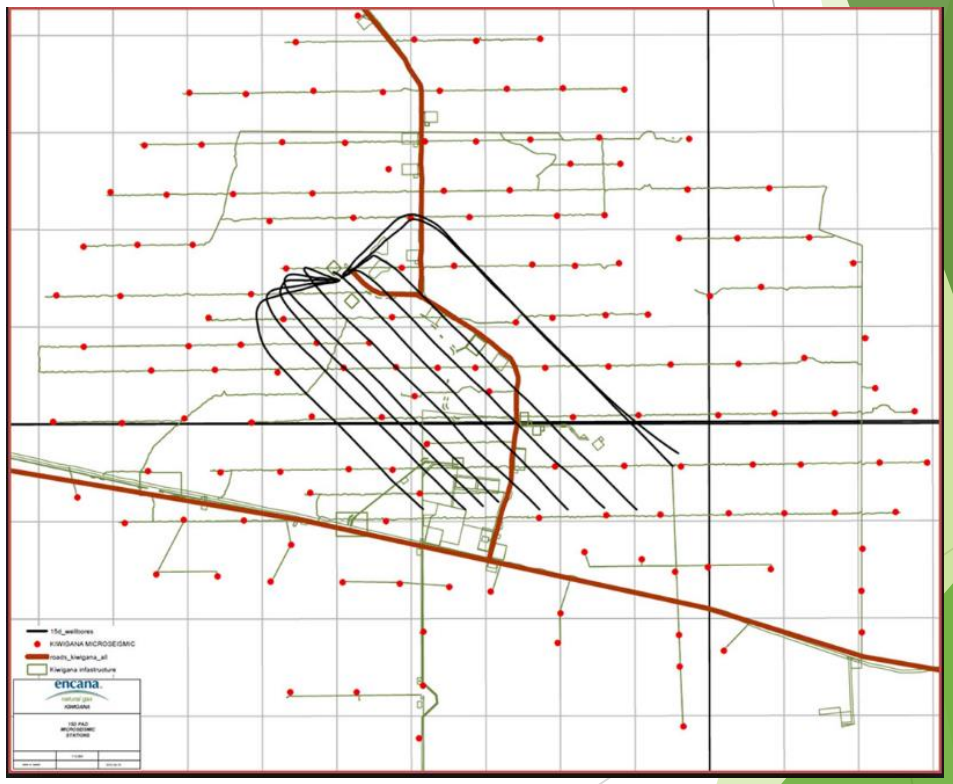
- 1D string of permanent or retrievable tools in a borehole



Modified from SPE 134772

Surface

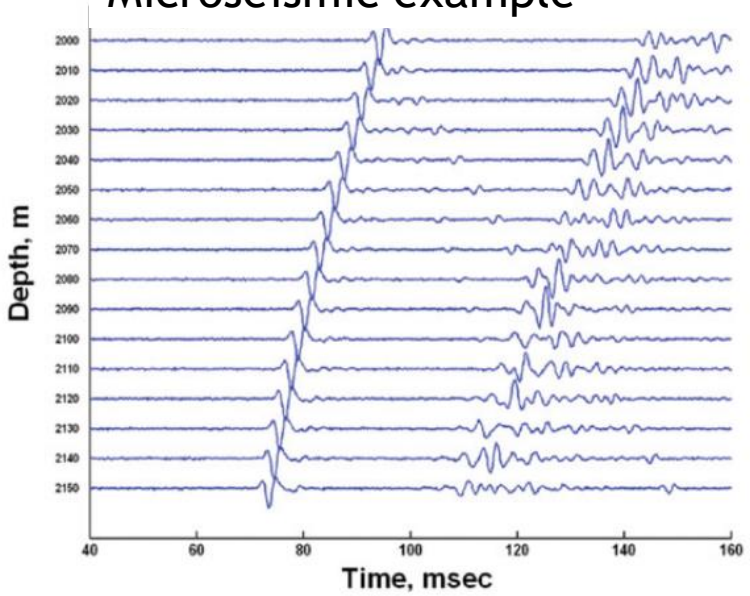
- Buried or surface network of sensors



Snelling & Taylor, 2013

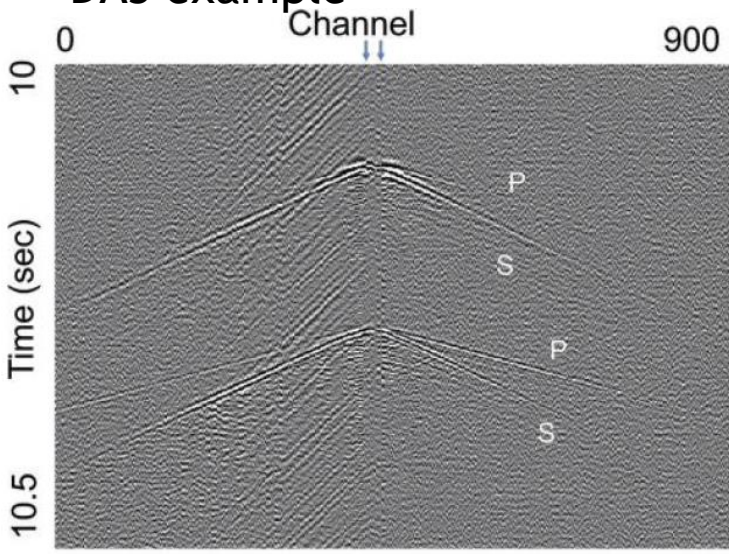
Microseismic Data

Microseismic example



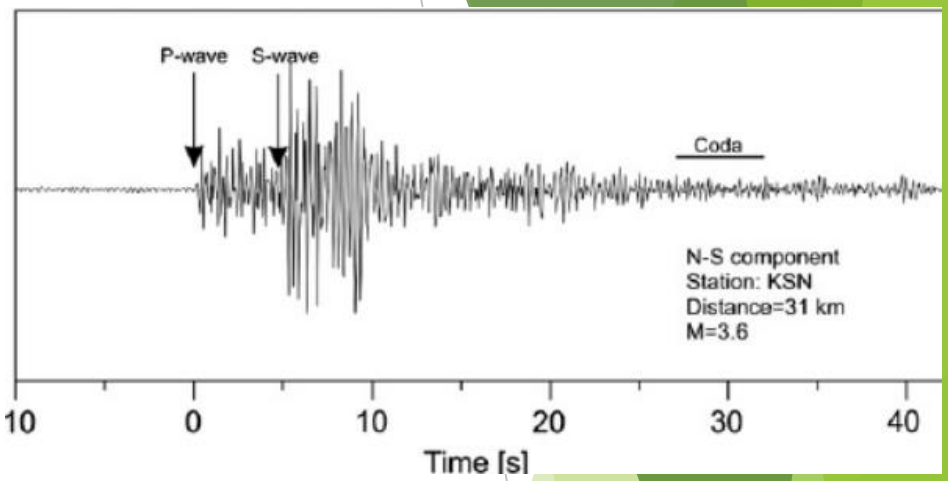
Wong et al., 2011

DAS example



Karrenbach et al., 2017

Earthquake example



Singh et al., 2012

- microSEISMIC!
- Time series with amplitude values for each station
- Data are processed to obtain a catalogue of events

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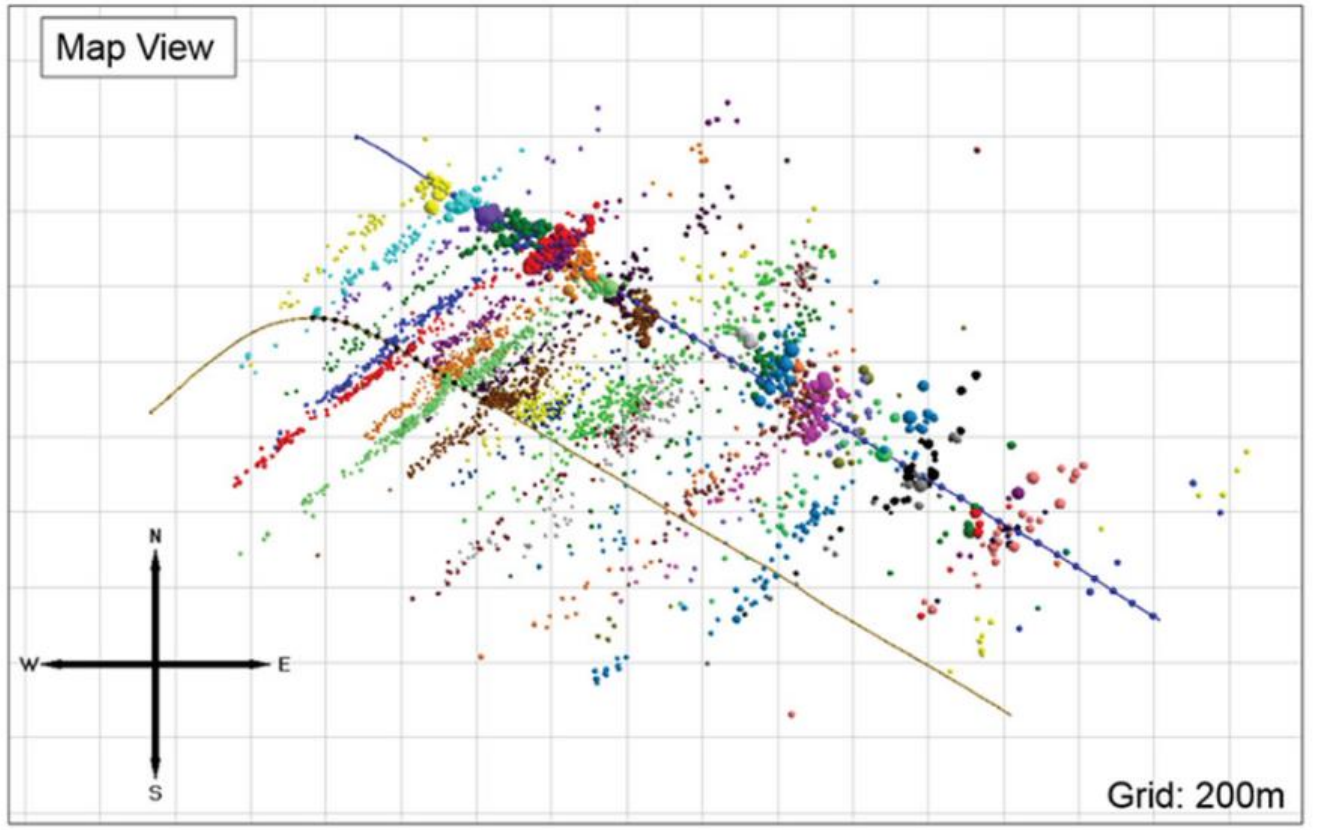
Microseismic Data

Processing → Catalogue → Interpretation Products

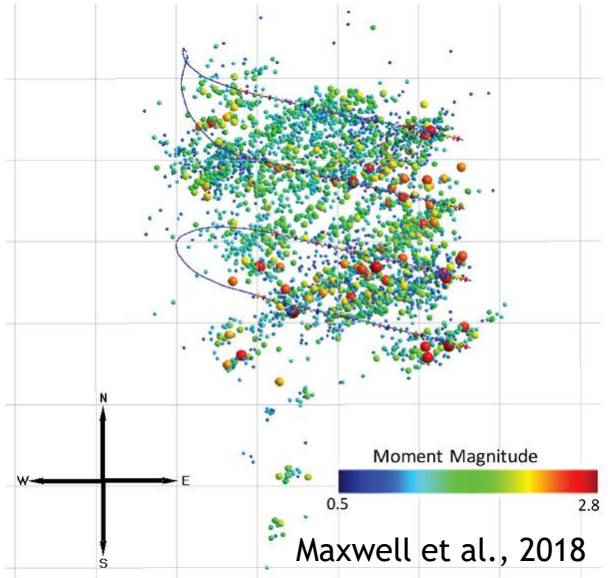
Date	Time (UTC)	Northing (UTM)	Easting (UTM)	Magnitude (Mw)	…



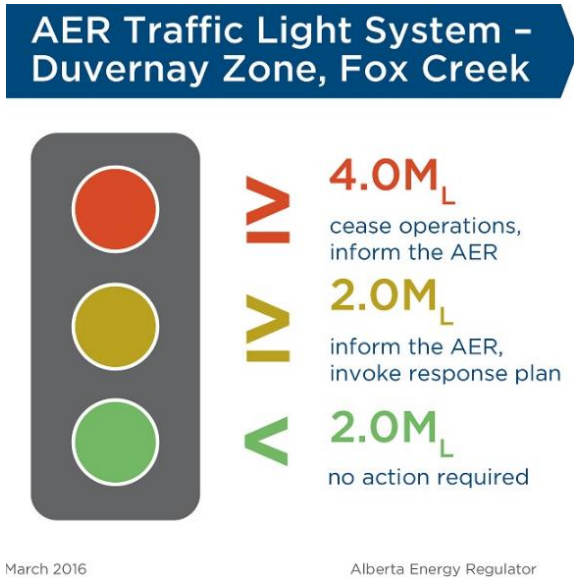
Chorney et al., 2016

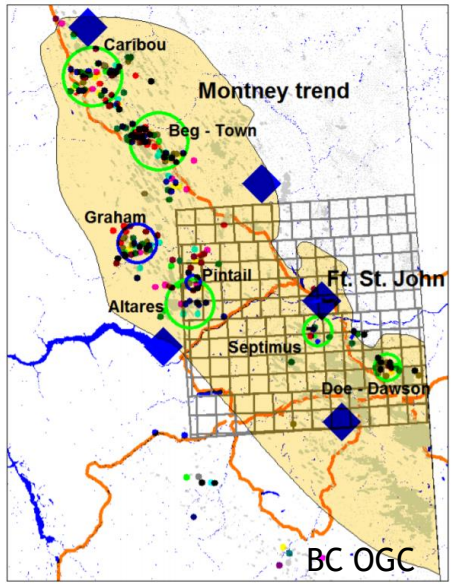
Induced Seismicity

- Can be monitored concurrently with microseismic
- A result of hydraulic fracturing and disposal activity
- Evolving provincial & geographic regulations and data standards
- Regulatory solutions may differ from larger corporate datasets



Maxwell et al., 2018





BC OGC

Data Standards

- No standards for data format or deliverables
  - Confusion over data classification – well or seismic?
  - Data formats and deliverables are specific to service companies
- Standards exist for regulatory situations
  - Special well applications
  - Induced seismicity
  - Special circumstances
- Standardization Efforts
  - SEG-2M
  - Energistics – 2012 forum for development of a microseismic XML format
  - G. Eynon study (2015?) consulted with operators and service companies

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Data Formats

Microseismic

- Raw data in continuous data (or trigger files) as SEGY, SEGD, SEG2, SEG2M
- CSV catalogue and PPT Reports
- Supporting information (surveys, field reports, tool specs, array moves, etc.)
- Lack of standard presents difficulties for reprocessing, lookbacks

Induced Seismic Events

- CSV data catalogue with specific attributes
- Raw data usually in SEED or miniSEED format
- Sensor information (location, sensitivities)
- Data format and file length specified by local regulations

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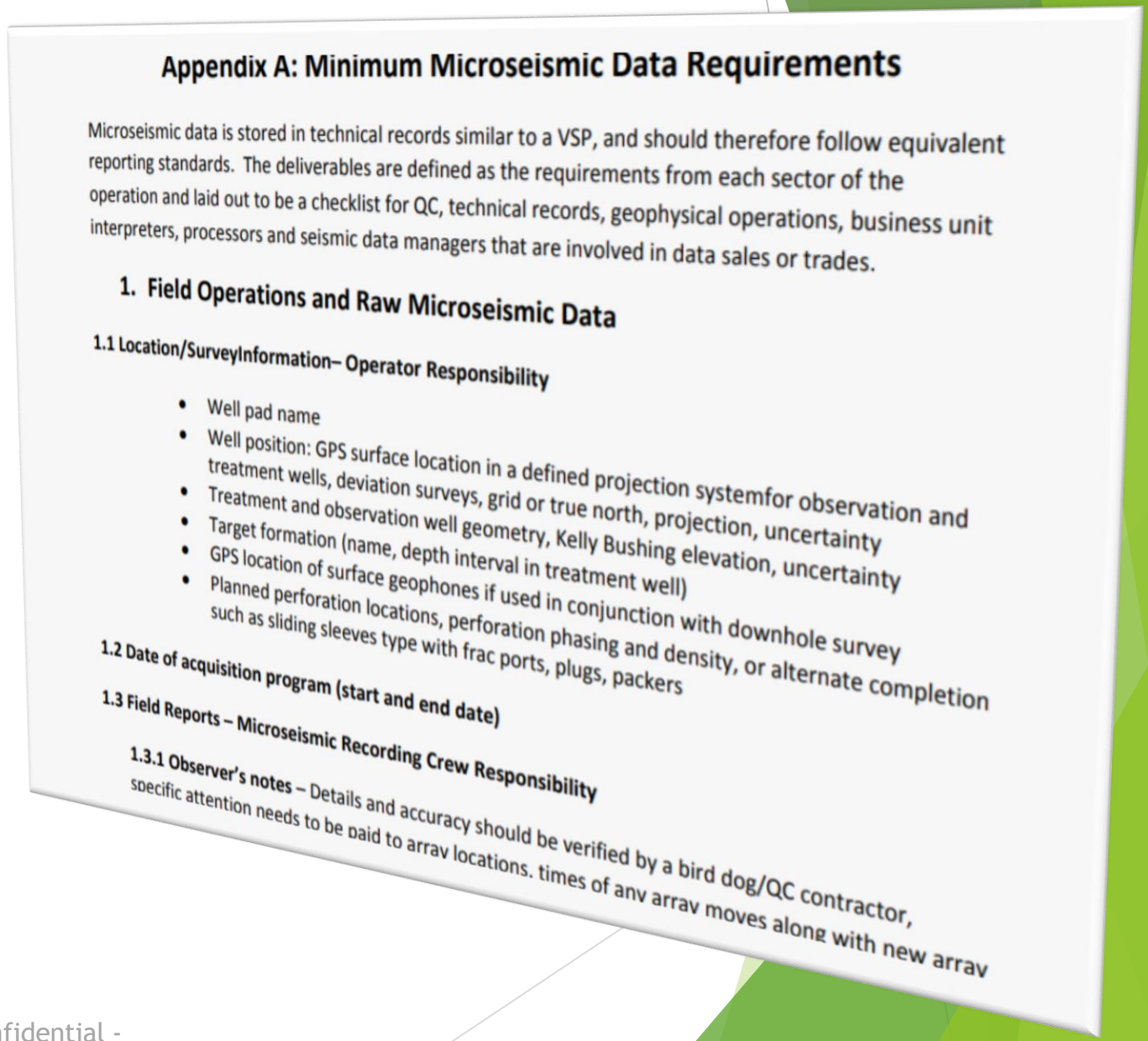
Data Guidelines

Guidelines for microseismic data deliverables and formats

- Minimum data requirements
- Expected deliverables
- Advanced processing options

- Available through the CSEG
- 2012 - Specific to downhole hydraulic fracturing
- Comprehensive document but not standard deliverables
  - You get what you ask for



Appendix A: Minimum Microseismic Data Requirements

Microseismic data is stored in technical records similar to a VSP, and should therefore follow equivalent reporting standards. The deliverables are defined as the requirements from each sector of the operation and laid out to be a checklist for QC, technical records, geophysical operations, business unit interpreters, processors and seismic data managers that are involved in data sales or trades.

1. Field Operations and Raw Microseismic Data

1.1 Location/SurveyInformation– Operator Responsibility

- Well pad name
- Well position: GPS surface location in a defined projection systemfor observation and treatment wells, deviation surveys, grid or true north, projection, uncertainty
- Treatment and observation well geometry, Kelly Bushing elevation, uncertainty
- Target formation (name, depth interval in treatment well)
- GPS location of surface geophones if used in conjunction with downhole survey
- Planned perforation locations, perforation phasing and density, or alternate completion such as sliding sleeves type with frac ports, plugs, packers

1.2 Date of acquisition program (start and end date)

1.3 Field Reports – Microseismic Recording Crew Responsibility

1.3.1 Observer's notes – Details and accuracy should be verified by a bird dog/QC contractor, specific attention needs to be paid to array locations. times of any array moves along with new array

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End Use

Data catalogues are now routinely integrated into data analysis and geoscience software packages

Visualization & Analysis

- Import into Petrel, Transform, Spotfire, etc.
- Integration with seismic, geological models & interpretations
- Spatial analysis of drilling and completions design
- Temporal fracture development and assessment of pumping parameters
- Statistical analysis & machine learning for local and regional trends

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Microseismic Standard Development

- Service companies continue to output variable and proprietary data products
- Up to consumers of data to push for complete information
- Demands force standards and push development and innovation
- Software companies well-positioned to guide data formats for some files

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Summary

- Data management practices have evolved as microseismic has become mainstream
- Progress has stalled and has not kept up with technology
- Guidelines are freely available
  - Specific to downhole microseismic
  - Not always followed
- Continued practice refinement is required for surface microseismic, IS, and fiber data

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