INDUCED SEISMICITY IN NORTHEAST BRITISH COLUMBIA

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BC Laws provide public access to the current laws of British Columbia.

The list of Acts and Regulations by which the Commission operates is available via www.bcofgc.ca.
### 2012 Reserves

- **40 TCF Gas**
- **120 MMSTB Oil**
- **102 MMSTB Condensate**
- **277 MMSTB NGL**

### Production

#### NEBC Daily Production Split (August 2013)
- **4.2 BCF/d**
  - **MONTNEY**: 2.0 BCF/d
  - **HORN RIVER**: 0.53 BCF/d
  - **DEEP BASIN CADOMIN**: 0.14 BCF/d
  - **JEAN MARIE**: 0.23 BCF/d
  - **CONVENTIONAL**: 1.29 BCF/d
Northeast British Columbia shale gas play areas

Fort St. John

829 miles

The other Washington
Shale gas play areas
Shale Gas Stratigraphy

Horn River Basin

Evie, Otter Park and Muskwa target zones

Upper and Lower Montney target zones
FORT ST JOHN GRABEN – SEPTIMUS BASIN

From: Barclay et al Bulletin of Canadian Petroleum Geology Vol 38A Dec 1990

From: Dr. Zeev Berger, CSPG Reservoir Issue 2, February 2009
INDUCED SEISMICITY IN NEBC

1985 – 2004

2004 – Present
Where are we at today?

- >1000 proven/possible induced events (mag 1 to 4.3)
- 6 events > magnitude 4.0, max event 4.3
- 20+ events reported ‘felt’
- Wellbore damage??
  - Deformed casing at Etsho (?)
  - Casing damage near Septimus (?)
  - Cement damage (?)

CNSN array coverage

Seismicity red dots

Sample of event ratios

Proposed CNSN station

Original CNSN seismograph stations

560 kilometres (348 miles)

270 kilometres (168 miles)
Caribou – frac IS?, disposal IS?

Beg – frac IS?, disposal IS?

Graham – disposal IS? 

Eagle/Eagle West – waterflood IS

Altares – Montney frac IS

Septimus – frac IS?, disposal IS?

Doe/Dawson frac IS?
Water-flood induced
• Events areally confined
• Pressure controlled
TATTOO
7 EVENTS
(MAG 2.4 TO 3.1)
DEC 2011

ETSHO
31 EVENTS
(MAG 2.2 TO 3.8)
APRIL 2009 TO JULY 2011
Frac-induced seismicity:
- occurs within 300m of injection point – injection point travels
- usually occurs within 15 hrs of injection
- stops with end of fracting
- confined to re-activation zones
- not triggered from distant injection points
- mostly in target zone

Mitigation:
- Pump rates
  - Etsho
  - Kiwigana
  - Tattoo
- bypassing stages
- exit re-activation zone
- Flowback

- **216 events** (1.0 to 3.0Mw)
  - 197 events (1.0 to 2.0Mw)
  - 19 events (2.0 to 3.0Mw)
Shale Gas Frac-Induced Events (Magnitude vs Time)
- 'fault driven events’ – b-values 1.1 to 1.2
- ‘fracture driven events’ – b-values 1.9
- events > 0.5ML were ‘fault driven’
Microseismic Activity October - January

- b-value = 0.7-1.0
- b-value = 1.0
- b-value = 0.7
122 events, mag 1.6-4.0, Mar 2001- Sept 2013

- Distant epicentres
- Spatially random
- Magnitudes increase w/volume

Water disposal well
Septimus Mag vs Time

122 events, Mag 0.2-4.2ML, Feb-Aug 2013

From: Dr. Zeev Berger, CSPG Reservoir Issue 10, November 2008

From: BCOGC Montney Formation Play Atlas, October 2012, Mark Hayes
Beg Mag vs Time

10 events
Mag 1.5 - 3.4
Aug 2013
Seven events
October 18 to 28th
Magnitude 1.4 – 2.7
Six felt events
CONCERNS

Surface Effects
- Ground motion
  - Public safety
  - Property damage

Wellbore Integrity
- Casing deformation
- Reservoir breakthrough
- Aquifer contamination
MONITORING

CNSN

Portable Dense Array

Dense arrays in place or planned
### NOTIFICATION AND CONSULTATION

#### Detection
- Recorded by CNSN or dense arrays
- Felt Reports

#### Notification
- Phone calls
- Info Collection Questionnaire
  - Area operations?
  - Microseismic?
  - Known faults?
  - Felt reports or wellbore damage?

#### Consultation - Information sharing phase & Monitoring Recommendations
- Describe known incidents and mitigation options to Operator
- Recommend installation of dense array to identify accurate hypocentres
- Recommend using dense array data to implement mitigation strategy
  - Bypass injection (stages) near re-activation zones
  - Avoid known problem faults – “we know which faults to look out for”
- Submit routine seismicity reports to OGC

#### Current requirements specific to Order or Permit
- Suspend operations if Magnitude 4.0 event detected
- Report all events > Magnitude 2.0
Formalize operational reporting requirements
- Actively fracturing wellbores – near real-time reports
- Dense array deployments – where, when, regular reports

Require microseismic monitoring when fracturing near disposal wells

Require enhanced monitoring in high-risk areas, disposal wells, ‘felt’ areas

Report magnitude 2.0 events and suspend operations at Magnitude 4.0

Submission of microseismic

Disposal Wells – ongoing Engineering review
Wellbore Integrity – post event testing
THANK YOU

Thanks

Lori Denys
Mark Hayes
Aron Bird
Jeff Johnson
Sara Li
Verna Kazakoff
Curtis Kitchen
Kelly Okuszko
OGC Field Inspectors

Dr. Honn Kao
Dr. Amanda Bustin

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