Mining Oil and Gas Well Integrity Data in Colorado and New Mexico



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Wattenberg Field



4th largest oil field 9th largest gas field

Stray gas contamination: Thermogenic CH₄ 42 water wells 32 cases 11 "culprit" oil and gas wells



Groundwater methane in relation to oil and gas development and shallow coal seams in the Denver-Julesburg Basin of Colorado

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Wattenberg Field



10

20

30

40

50 Km

4th largest oil field 9th largest gas field

Stray gas contamination: Thermogenic CH₄ 42 water wells 32 cases 11 "culprit" oil and gas wells

How did thermogenic stray gas migrate into the shallow subsurface through these culprit wells? Well Leakage

- 1. Casing leak
- 2. Unknown intermediate
- 3. Faulty cement seal or improper cement coverage



Sustained Casing Pressure (SCP)





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Sustained annular pressure (SAP), bradenhead pressure, surface casing vent flow (SCVF)



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Should be no SCP in a properly functioning well

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Sustained Casing Pressure (SCP)

Should be no SCP in a properly functioning well

Sustained casing pressure is an easily measured gauge of well integrity, but is poorly documented







As pressure builds annular liquid is displaced



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When SCP = formation fluid pressure at bottom of surface casing stray gas migration can be induced



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When SCP = formation fluid pressure at bottom of surface casing stray gas migration can be induced

Critical sustained casing pressure is a well-specific physically meaningful indicator of stray gas migration



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• Pressure measured as found on surface casing

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- Pressure measured as found on surface casing
- Instantaneous pressure measured at the end of the test

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- Pressure measured as found on surface casing
- Instantaneous pressure measured at the end of the test
- Filed as text-based PDFs that can be mined using Python

FORM 17 Rev 8/99 1120 Lincol Step 1. Record all Step 2. Sample rx Step 2. Conduct B	Dil and Ga n Street, Suite 801, BRA tuoing and casing pre w, if intermediate or a vicenhead test.	State of Co as Conserva Denver, Colorado 800 DENHEAD esures as found. urface casing pressure	blorado tion Comr 203 (303) 894-2 TEST RI >25 pt. In sense	nission 2100 Fax: (303 EPORT	894-2109	A CONSTRUCT	1	OR OGEC USE CALY	
Step 4. Conduct In Step 5. Send repo submitted	ntermediate casing test of to BLM within 30 day or if wellbore configuri	t ys and to OGCC within abon has changed sinc	10 days. Include a prior program. A	wellbore diagram mach gas and lig	if not previo uid analyses	usly if samples.			
1. OGCC Ope	rator Number:				-		11. Date of Te	est:	
2. Name of O	perator:			3. BLM Loa	se No:		12 Well Statu		Shutin
4. API Numbe	r		5. Multiple con	npletion?	Yes 📃	No	Gas Lift	Pumping	Injection
6. Well Name			Numb	er:			Clock/Inter	rmitter	
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found	-	-	Em				STEP 2: S	ee instructio	ns above.
	FM:	Pm.	rm.		_				
16.			STEP 3: B	RADENHEA	D TEST				
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no intermediat	e casing, monitor	only the production	on casing and te intervals	05:		-			
Define charact	eristics of flow in	"Bradenhead Flow	v" column						
using letter de	signations below:		V - Vener	10:					
U = No Flow; H = Water H2O:	M = Mud: W =	Whisper: S = Su	ros: G=Gas						
BRADENHEAD	SAMPLE TAKEN?		-	10:					
Yes	No	Gas	Liquid	20:		-			
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Other: /d	escribe)			30					
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First Well Integrity Study



2010 bradenhead testing policy establishes Wattenberg Test Zone (WTZ)

First Well Integrity Study



2010 bradenhead testing policy establishes Wattenberg Test Zone (WTZ) 3,923 readable bradenhead tests (after QA/QC)

First Well Integrity Study



2010 bradenhead testing policy establishes Wattenberg Test Zone (WTZ) 3,923 readable bradenhead tests (after QA/QC) Paired with QA/QC well construction data

How Many Wells Have SCP?



How Many Wells Have SCP?









New Mexico



http://www.emnrd.state.nm.us/ocd/)

New Mexico



NEW MEXICO ENERGY, MINERALS & NATURAL RESOURCES DEPARTMENT

OIL CLASSEON TOX DESIGN Actual contract of real 2001 R of R0A205 R0AC CONTRACTOR FUELD

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BRADEN (ordenit Date of Test	HEAD TEST REPORT 1 copy to strays, address) an (MACD + All (hg) 5 API #30-0, 4:5 - 7.374:5 34.E. Lacation: Unit_Section <u>36</u> Township <u>32</u> Range <u>12</u>
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New Mexico Challenges

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NEW MEXICO ENERGY, MINERALS & NATURAL SESCURCES DEPARTMENT

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BRADENU (scienit 1	LEAD TEST	address)			
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OPE	NBRAI	DENHEAD AN	DINTERMEDIATE	TO ATMOSPHERE INDIVID	UALLY FOR 15 MINUTES FACH
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25 min_				Gas	
_ 30 min_				Gas & Water	
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2.25 million documents labeled only by API# and all are scanned images (~600,000 of interest)

New Mexico Challenges



2.25 million documents labeled only by API# and all are scanned images (~600,000 of interest)

TensorFlow



Open source machine learning framework developed by Google

TensorFlow



Open source machine learning framework developed by Google

Can be used for broad range of machine learning tasks but was developed for deep neural network modeling

TensorFlow



Open source machine learning framework developed by Google

Can be used for broad range of machine learning tasks but was developed for deep neural network modeling

Commonly used for categorization tasks

Roughly How it Works

"MobileNet" convolutional neural network

https://arxiv.org/pdf/1704.04861.pdf

Already trained using ImageNet (>14 million images)

Roughly How it Works



(https://codelabs.developers.google.com/codelabs/tensorflow-for-poets/#)

Roughly How it Works



Document Sorting



Document Sorting



New Mexico Challenges



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Protectly Names 2(4) (Cost/d Well No. 5245, Locations Unit Section 36 Invendin 32 Renew 17 Initial Bradenhead Pressure			
Well Status(Strat-In or Declucing) Initial PSI: Tubing/15 Intermediate 1// Casing/16 Bradenhead 135			
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190 hours of work





Well construction records for 232,645 wells in Colorado (114,843) and New Mexico (117,802).



Well construction records for 232,645 wells in Colorado (114,843) and New Mexico (117,802).

Well integrity test records for 34,727 wells. 19,540 in Colorado and 15,187 in New Mexico.



Well construction records for 232,645 wells in Colorado (114,843) and New Mexico (117,802).

Well integrity test records for 34,727 wells. 19,540 in Colorado and 15,187 in New Mexico.

After release of PA DEP well integrity data this will be the second largest dataset of well integrity information in the United States.

Conclusions

- Sustained casing pressure is an easily measure, but poorly documented, gauge of oil and gas well integrity.
- Bradenhead testing in Colorado and New Mexico provides insight into the development of SCP in oil and gas wells and can be used to identify wells that pose a high risk of inducing stray gas migration.
- Image based documents of interest can be identified and sorted from databases that contain seemingly unmanageable numbers of files using TensorFlow.
- Data from these documents can be easily obtained using a simple document scraping web application.

Acknowledgements

• National Science Foundation Sustainability Research Network Program (Grant CBET-1240584).

AirWaterGas 🖗 Sustainability Network

- Harihar Rajaram, Owen Sherwood, Joe Ryan, Troy Burke, Devansh Chauhan
- Summer scrapers: Natalie Guinan, Steven Wilder, Lewis Schiebel, Marcus Knipp, Valerie Constien, Benjamin Willows, Ludvig Zwilgmeyer

Extra Slides



Four major oil and gas basins: DJ, Piceance, San Juan, and Raton



> 300,000 Water wells



Total: 64,289; Vert: 42,279; Dev: 18,761; Horiz: 3,249





Total: 64,289; Vert: 42,279; Dev: 18,761; Horiz: 3,249



Total: 64,289; Vert: 42,279; Dev: 18,761; Horiz: 3,249

COGCC Data



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COGCC Data



cogcc.state.co.us



Python web scraping application