Drone Magnetic Site Surveys To Verify Wellhead Locations

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ISCWSA

Speaker Information

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  - Based in Denver, CO

David M. Velozzi

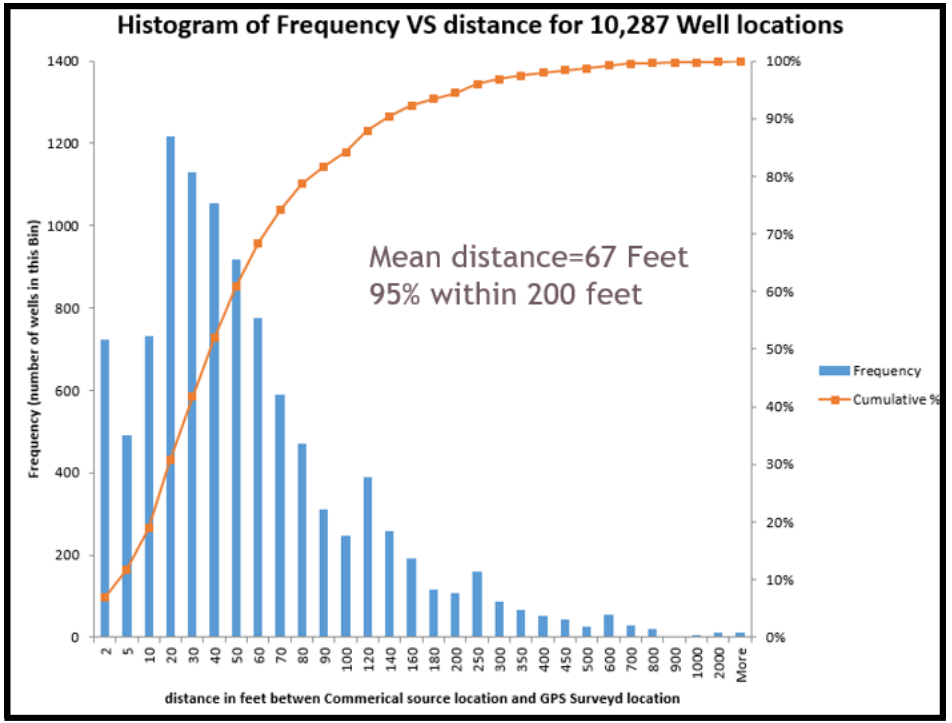
- Magnetic Variation Services LLC (MagVAR)
- B.S in Geological Sciences, M.S. in Earth Sciences
- Senior Geoscientist/Exploration Project Manager NEOS Geosolutions
- Geophysicist Schlumberger/WesternGeco
- Specialized in
  - E&P & Consulting Geoscience Services
    - Exploration Geology & Geophysics New Ventures- Regional and Prospect Scale
    - Well Log Correlation and Advanced Subsurface Mapping
    - Log Analysis & Petrophysical Modeling
    - 2D & 3D Structural & Stratigraphic Seismic Interpretation
    - Play and Prospect Identification, Generation and Evaluation
    - Geophysical Acquisition, Processing, Integrated Interpretations

Drone Magnetic Site Surveys
Outline

- Introduction
- Acquisition Platform
- Methodology
- Results and Discussion
- Summary and Way Forward

Drone Magnetic Site Surveys
Introduction- Verification of Existing Legacy Well Locations

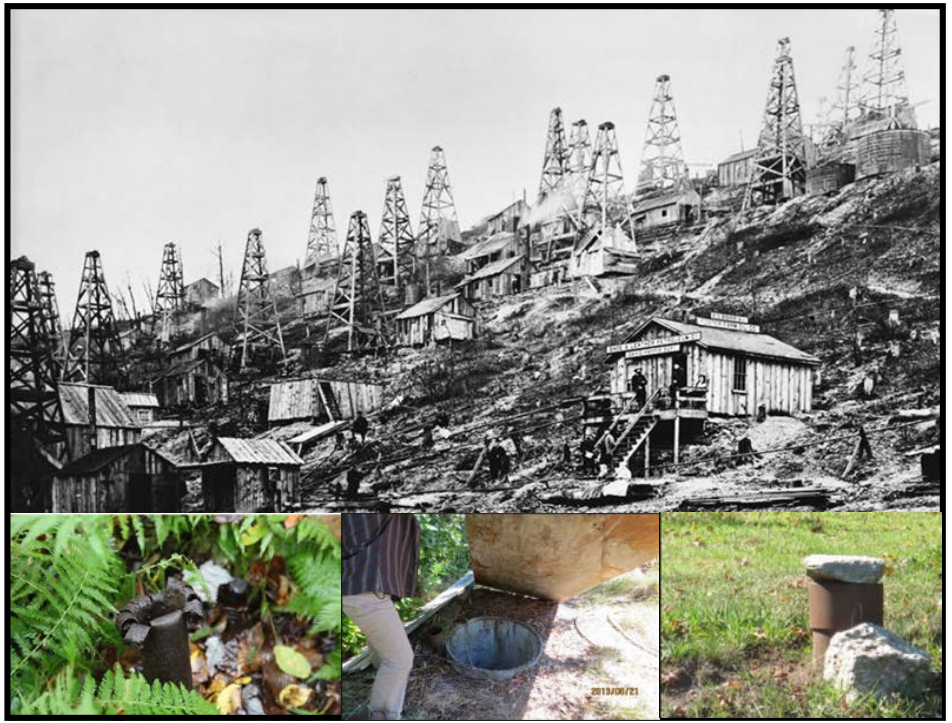
- Major study compared over 10,000 well locations from commercial vendor with surveys GPS locations
- 95% confidence is 200 feet
- Recommendaton:
  Assume 200 ft uncertainty for well locations that have not been verified



Source: Devon Energy

Drone Magnetic Site Surveys
Introduction – Identification of Unreported Wells for Collision Avoidance

- Lack of historical reporting of well locations
- Incomplete well database- state and/or commercial vendors
- Results in drilling hazard



Source: PA IRS

Drone Magnetic Site Surveys
Acquisition Platform – Specifications

- QuSpin Total Field Magnetometer
  - High Sensitivity rubidium vapor
  - Reading at 50 Hz and up to 400 Hz (3 readings per meter at 50 Hz)
- DJI Matrice 600 Pro
  - Flight speed of 15 m/s
  - Flight time around 20 minutes on one set of batteries
- Carbon Fiber Dragon Housing
  - Built in house at MagVAR

Drone Magnetic Site Surveys
Acquisition Platform – Drone Flight Video

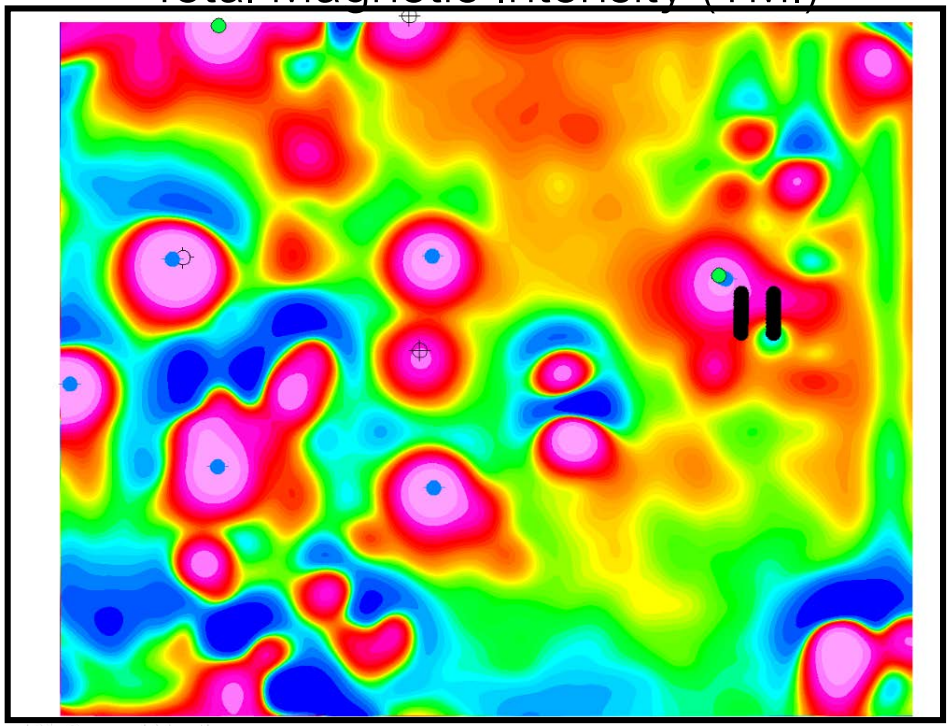
Drone Magnetic Site Surveys
Methodology – Survey Design Flight Specifications

- Drone altitude of 35 meters AGL
- Sensor altitude of 30 meters AGL
- Main Lines flown North-South at 15 meter spacing
- Tie Lines flown West-East at 75 meter spacing

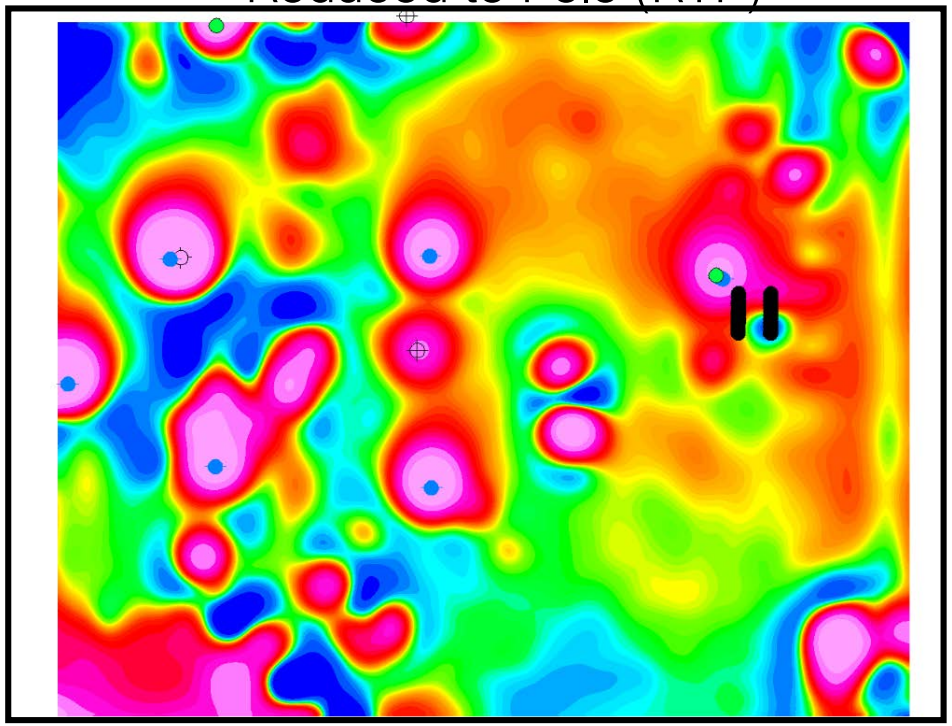
Drone Magnetic Site Surveys

Methodology – Placing Anomaly over the Causative Body- Reduced to Pole

Total Magnetic Intensity (TMI)

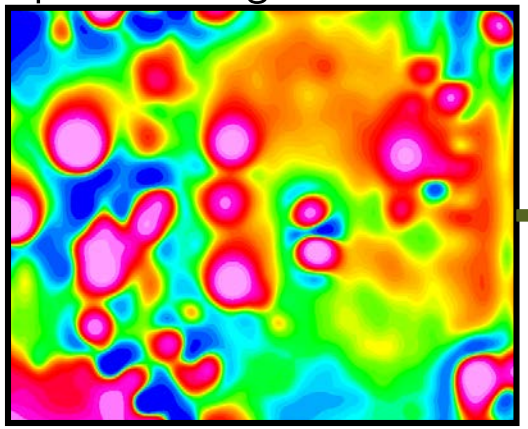


Reduced to Pole (RTP)

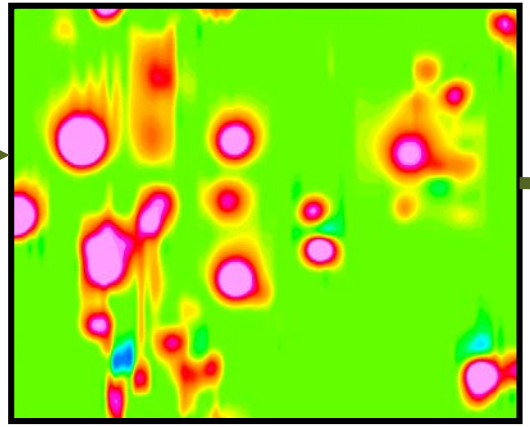


Drone Magnetic Site Surveys
Methodology – Cultural Separation from Geology

Acquired Magnetic Survey

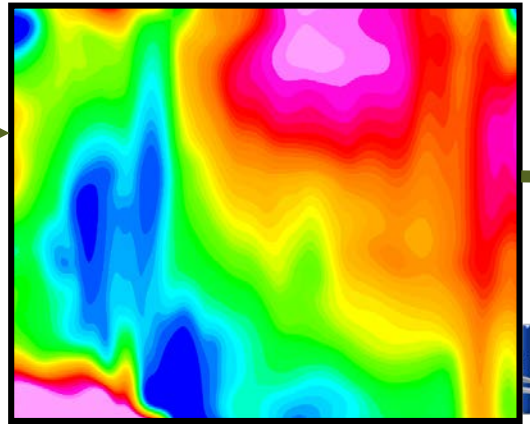


Culture Separation



Pre-Ground Verification Interpretation

Geology Separation

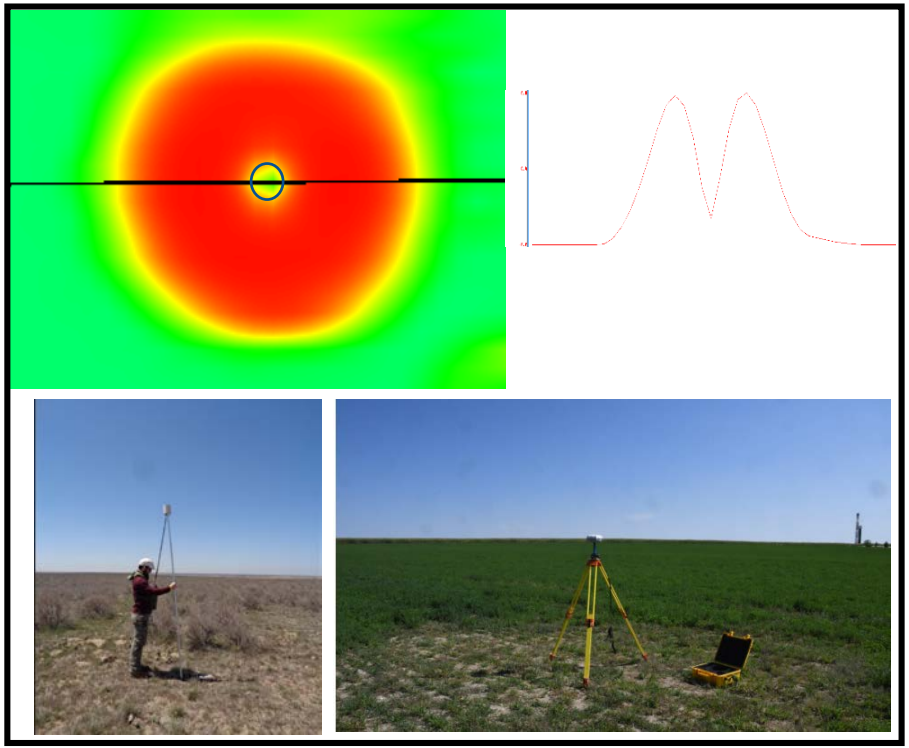


Basement Modeling & Geologic Integration

Drone Magnetic Site Surveys
Methodology – Pre-Ground Interpretation and Ground Verification

- Pre-Ground Interpretation locations from RTP Total Horizontal Gradient (THG) minima

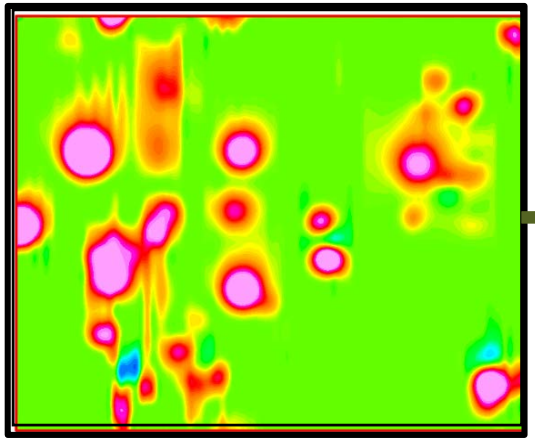
- Ground verify locations with Differential GPS and Overhauser magnetometer to record peak magnetic signature and get final surface location (X,Y) and elevation location (Z)



Drone Magnetic Site Surveys

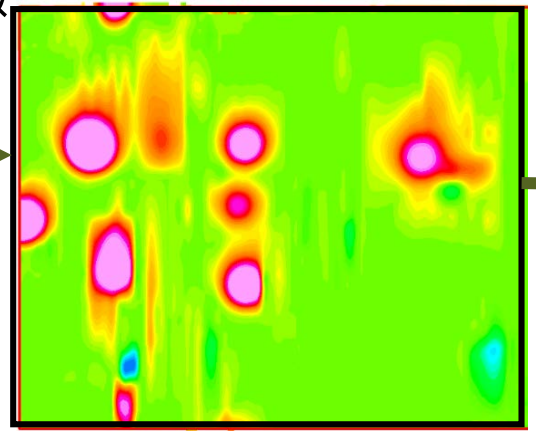
Methodology – Refined Cultural Separation – Final Interpretation

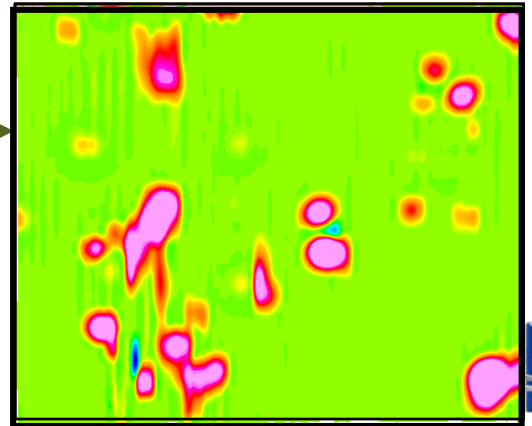
Pre-Ground Verified Culture



Reported& Unreported Wells

All Other Culture

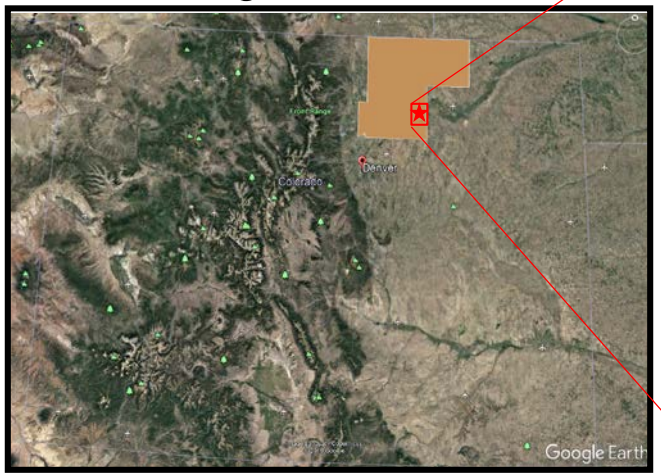


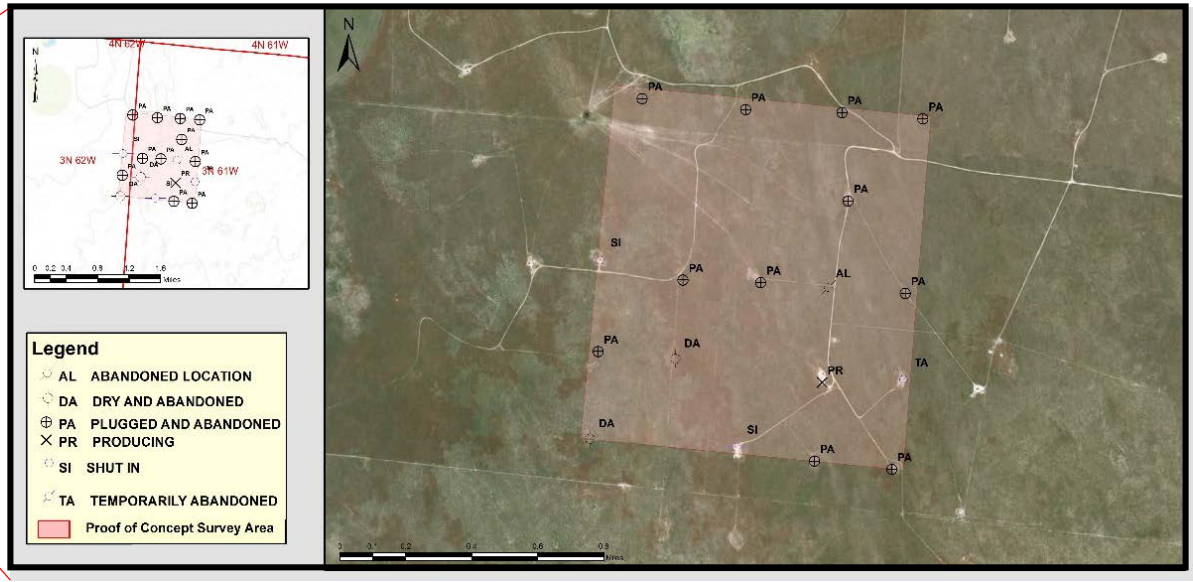


Final Interpretation of Existing Legacy Wells

Drone Magnetic Site Surveys
Results and Discussion – Case Study #1 Study Area

Regional View

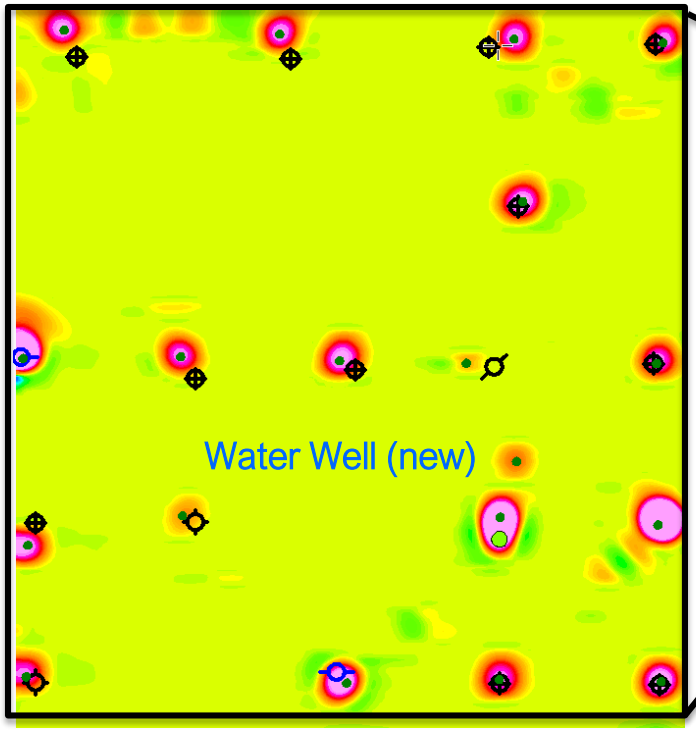


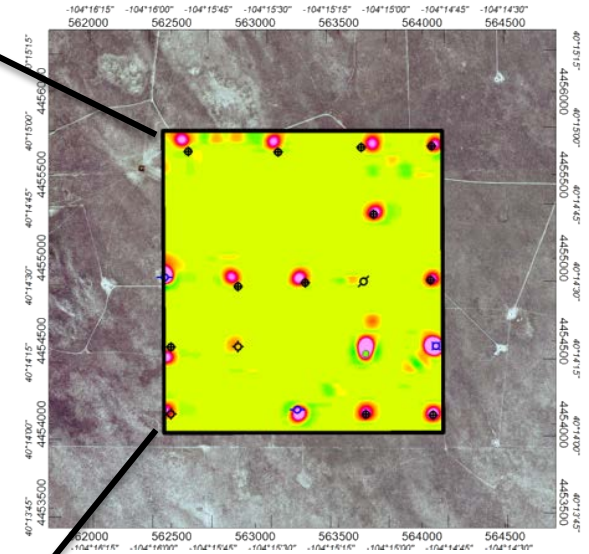


~ 1 sq. mile area

Drone Magnetic Site Surveys

Results and Discussion – Case Study #1 Post Ground Verification





Legend

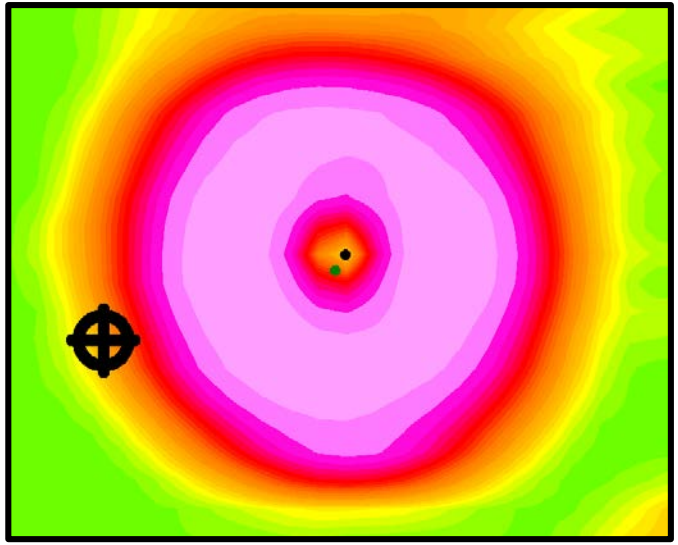
- Plugged and Abandoned
- Abandoned Location
- Shut In
- Dry and Abandoned
- Producing
- Temporarily Abandoned
- Survey Area

- Final Post Ground Verified Locations

- ✓ 18 point magnetic signatures identified
- ✓ 100% of 17 reported locations corrected
- ✓ 1 additional water well identified

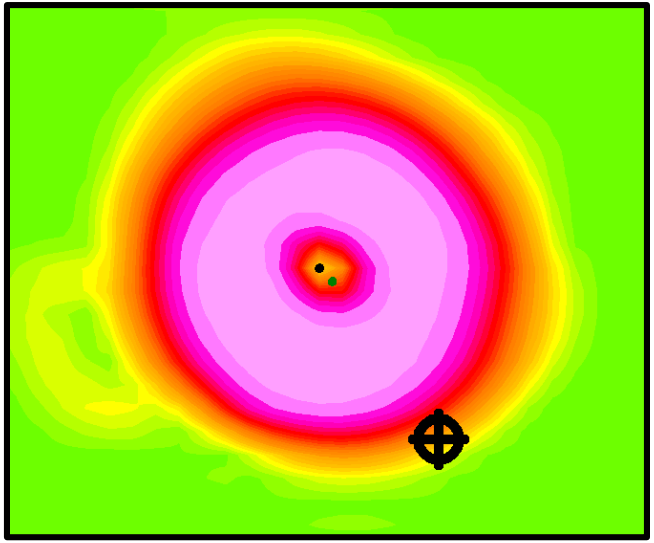
Drone Magnetic Site Surveys
Results and Discussion – Case Study #1 Inaccurate Well Location Reporting

Energy Minerals Corp
P&A 06/14/1989



100 meters

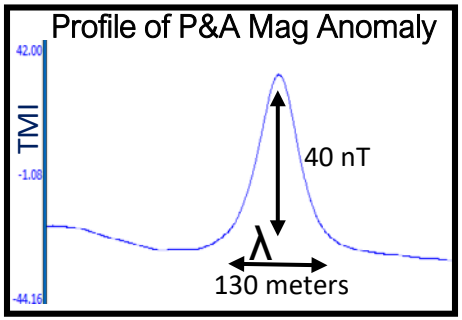
Energy Minerals Corp
P&A 04/06/1987



100 meters

Legend

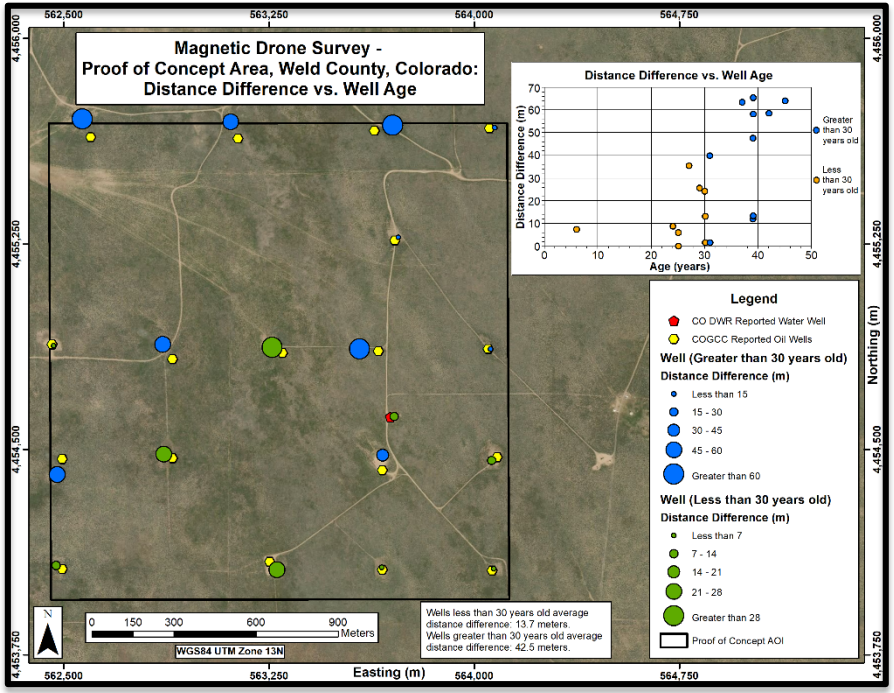
- Plugged and Abandoned
- Pre Ground Verified
- Ground Verified



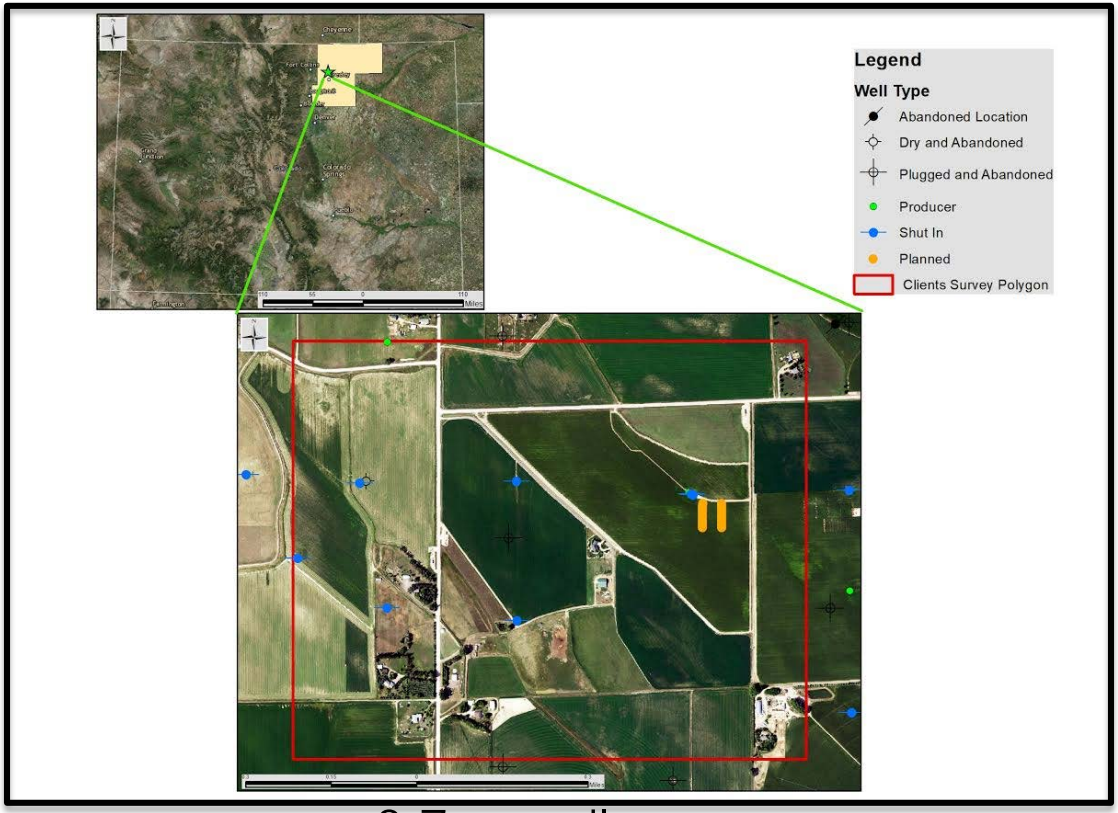
Drone Magnetic Site Surveys
Results and Discussion – Case Study #1 Reported vs. MagVAR Comparison

COGCC Reported v Actual Locations, for 17 recorded wells	
	Offsets (in meters)
Mean	38.73
Min	7.99
Max	73.13

73 Meters= Length of Boeing 747!



Drone Magnetic Site Surveys
Results and Discussion – Case Study #2 Study Area

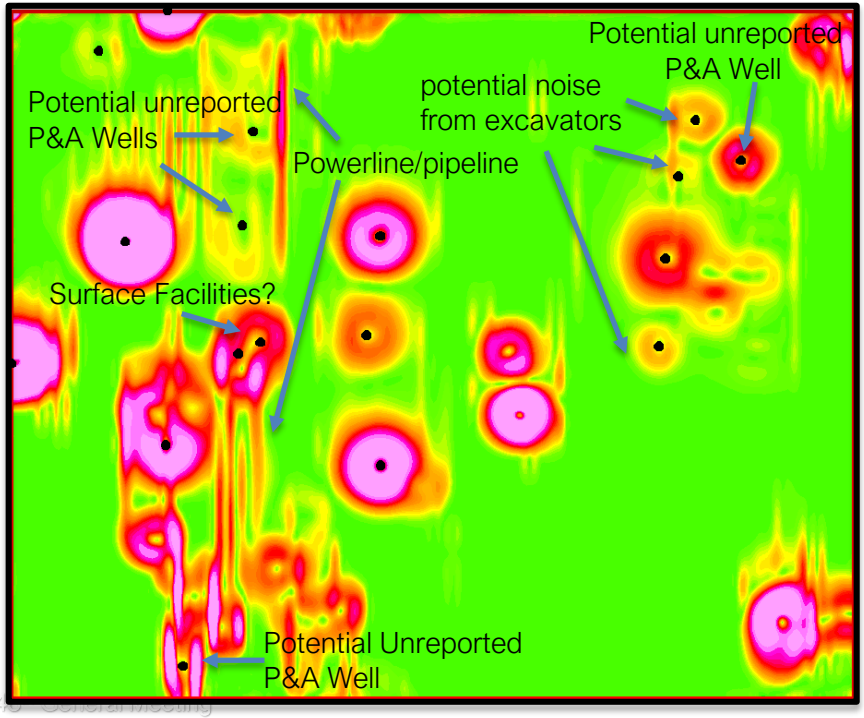


~ 0.7 sq. mile area

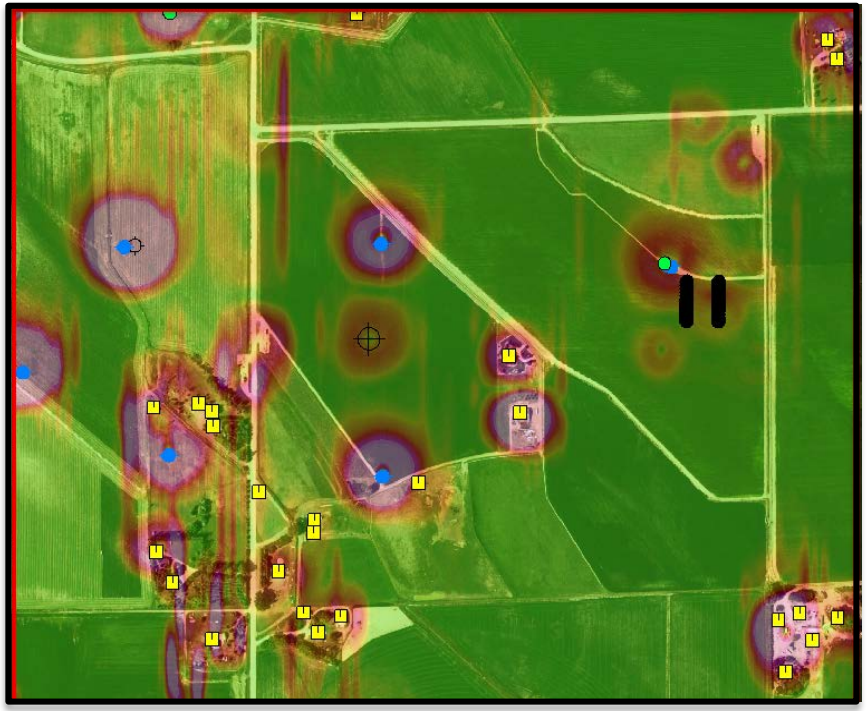
Drone Magnetic Site Surveys
Results and Discussion – Case Study #2 Airborne Interpretation

18 Point Source Magnetic Signature Locations Identified

RTP Culture THG with Pre-Ground Verified Locations



RTP Culture THG with Known Culture

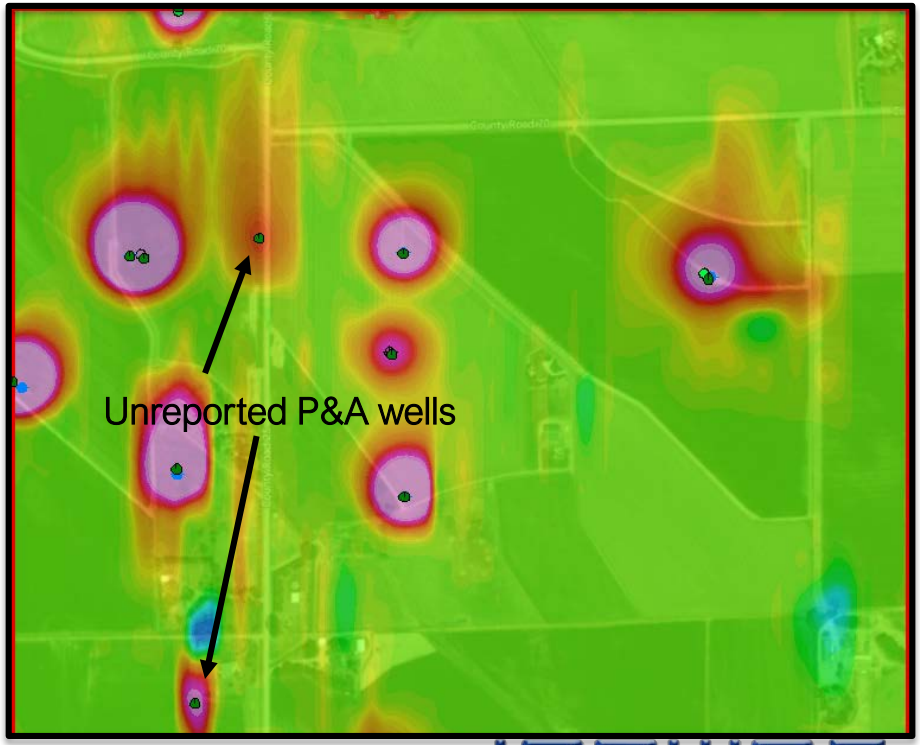


● Pre-Ground Verified Locations

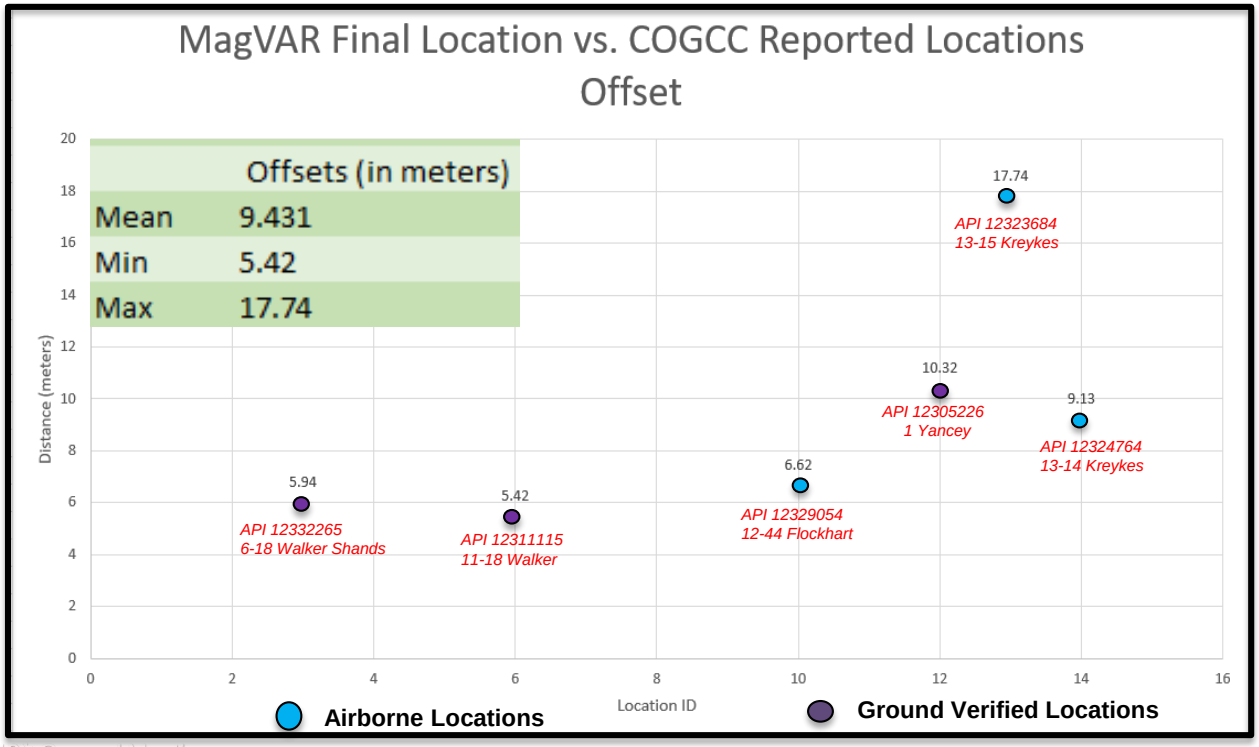
Drone Magnetic Site Surveys
Results and Discussion – Case Study #2 Post Ground Verification

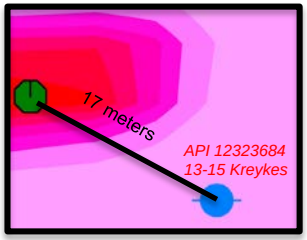
- 10 out of 18 point source aeromagnetic signature locations were identified as wellheads. Ground verification was further able to delineate the dry abandoned hole in western portion of study area as separate location giving 11 final locations
- 3 tightly spaced wells (producer and 2 shut-in) in eastern portion of study area had no surface expression of pre-existing wells and were ground verified with peak magnetic value as 1 location due to magnetic noise in area - signature tied to Shut In well 6-18 Walker-Shands
- Other 8 aeromagnetic signature locations were verified and interpreted as surface cultural noise
- Of the 11 locations 2 magnetic signatures were Identified and Interpreted as **Unreported P&A wells**
- Correctly identified 100% of 11 COGCC reported wells in study area (9 signature locations)

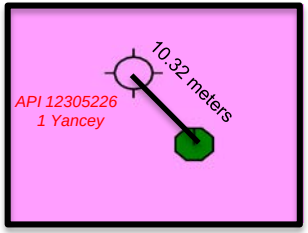
Final Interpreted Well Signatures with Reported COGCC Wells

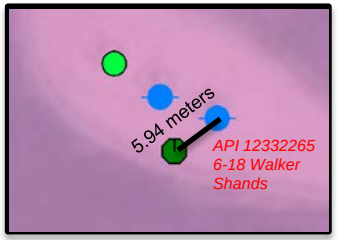


Drone Magnetic Site Surveys
Results and Discussion – Case Study #2 Reported Comparison









Drone Magnetic Site Surveys
Results and Discussion – Final Deliverables

- Final Geosoft Database: including Final Total Magnetic Intensity, RTP Culture, RTP Culture Wells Only
- Grids: in Geosoft .GRD and .DAT format – TMI, RTP, TMI_Geology, RTP_Culture, RTP_Culture_THG, RTP_Culture_Wells
- Public Domain Data: NAIP Imagery, SRTM 30 meter and Well Database used (COGCC)
- Final Powerpoint
- Final Packed ArcMap MXD inclusive of all data deliverables
- **Interpretation Products: Final Location Shapefile and CSV tied in with existing well header attributes (well spot data)**

Site_ID	Verification Method	MagVar_lat	MagVar_long	MagVar_Z (m)	MagVar_Z (ft)	MagVar_X_NAD83	MagVar_Y_NAD83	FID_1	API	API_Label	Operator	Well_Title	Facil_Stat	Section	Township	Range	COGCC_Latitude	COGCC_Longitude	Ground Ele	Spud Date	COGCC_NAD83 X	COGCC_NAD83 Y
5	Reported	40.49260922060	-104.82974602300	1459.5230000000	4788.46143932000	3186415.89132000000	1423002.51861000000	5	12326747	05-123-26747	SRC ENERGY INC	11-18 KOCHERT	SI	18	6N	66W	40.49262000000	-104.82976000000	4869	8/2/2008	3186415.89132000000	1423002.51861000000
10	Airborne	40.49620648680	-104.83403113700	4896	0.00000000000	3185214.26463000000	1424304.00380000000	10	12329054	05-123-29054	SRC ENERGY INC	12-44 FLOCKHART	PR	12	6N	67W	40.49615500000	-104.83404000000	4887	9/26/2008	3185214.01087000000	1424282.32742000000
13	Airborne	40.49074202770	-104.83721483700	4874	0.00000000000	3184343.73364000000	1422306.69675000000	3	12323684	05-123-23684	NOBLE ENERGY INC	13-15 KREYKES	SI	13	6N	67W	40.49067000000	-104.83704000000	4873	5/10/2006	3184394.92313000000	1422278.93118000000
3a	Ground Verified	40.49222197470	-104.82391635100	1460.9870000000	4793.26458908000	3188038.32611000000	1422873.75586000000	7	12332264	05-123-32264	SRC ENERGY INC	3-18 Walker-Shands	PR	18	6N	66W	40.49231500000	-104.82405000000	4853	3/1/2011	3188014.80312000000	1422906.49234000000
6	Ground Verified	40.49112987170	-104.82996901300	1463.0080000000	4799.89516672000	3186357.94492000000	1422463.13156000000	1	12311115	05-123-11115	PETRO-CANADA RESOURCES (USA) INC	11-18 WALKER	PA	18	6N	66W	40.49117300000	-104.83001400000	4854		3186346.64386000000	1422476.99653000000
9	Ground Verified	40.49283551460	-104.83249185800	1465.4750000000	4807.98899900000	3185651.59365000000	1423079.19565000000	0									0.00000000000	0.00000000000	0		0.00000000000	0.00000000000
12a	Ground Verified	40.49254296510	-104.83470367200	1465.7710000000	4808.96012764000	3185037.24107000000	1422967.99845000000	0	12305227	05-123-05227	CHANDLER & ASSOCIATES LLC	1 YANCEY	DA	13	6N	67W	40.49260300000	-104.83476400000	4864		3185024.37167000000	1422988.12126000000
7	Reported	40.48905964170	-104.82973139300	1459.5230000000	4788.46143932000	3186429.73432000000	1421709.45841000000	6	12326748	05-123-26748	SRC ENERGY INC	12-18 KOCHERT	SI	18	6N	66W	40.48907000000	-104.82974000000	4846	7/30/2008	3186429.73432000000	1421709.45841000000
15	Airborne	40.48604908750	-104.83374050100	4849	0.00000000000	3185322.89529000000	1420604.32804000000	0									0.00000000000	0.00000000000	0		0.00000000000	0.00000000000
14	Airborne	40.48947171200	-104.83408466400	4857	0.00000000000	3185217.80330000000	1421850.45065000000	4	12324764	05-123-24764	NOBLE ENERGY INC	13-14 KREYKES	SI	13	6N	67W	40.48940000000	-104.83408000000	4856	3/17/2007	3185221.30342000000	1421820.81048000000
12b	Reported	40.49257175810	-104.83497367100	1466.1150000000	4810.08873660000	3184962.06960000000	1422977.92430000000	2	12323683	05-123-23683	NOBLE ENERGY INC	13-11 KREYKES	SI	13	6N	67W	40.49258000000	-104.83498000000	4868	5/2/2006	3184962.06960000000	1422977.92430000000
3b	Ground Verified	40.49222197470	-104.82391635100	1460.9870000000	4793.26458908000	3188038.32611000000	1422873.75586000000	8	12332265	05-123-32265	SRC ENERGY INC	6-18 Walker-Shands	SI	18	6N	66W	40.49226100000	-104.82387000000	4852	3/12/2011	3188054.29763000000	1422887.02219000000
3c	Ground Verified	40.49222197470	-104.82391635100	1460.9870000000	4793.26458908000	3188038.32611000000	1422873.75586000000	9	12332267	05-123-32267	SRC ENERGY INC	18-18 Walker-Shands	SI	18	6N	66W	40.49228200000	-104.82394500000	4852	3/7/2011	3188034.56885000000	1422893.47529000000

Airborne MagVar Z (ft) from SRTM sampled to the well location

Drone Magnetic Site Surveys
Conclusions and Way Forward

Magnetic Site Surveys help:

- Avoid collisions with existing wellbores
- Avoid frac hits of legacy wellbores
- Identify hazardous objects before planning a new pad

Magnetic Site Surveys enable:

- Verification of the location of existing wellheads
- Identification of wellheads missing in the database
- Discovery of buried objects: storage tanks, pipelines, etc

Drone Magnetic Site Surveys
Conclusions and Way Forward

Drone Services

Enhanced Collision Avoidance

Tools: Magnetic Data
Public Domain NAIP and DEM Imagery
Public/Commercial Vendor Well header Databases

Analysis/Offerings:

- Identification of orphaned wells and location of inaccurate legacy reported well locations
- Final Ground Verified location and elevation of surface location

Environmental Baseline Studies

Tools: Magnetic Data
Hyperspectral Data (FTIR)
and/or Lidar with Methane Detector
Public Domain Data

Analysis/Offerings:

- Allows baseline for monitoring-Time lapse
- Identify problematic wells/wells of concern
- Surface seepage and leak detection
- Trace gas
- Surface fault identification/lineaments
- High resolution Imagery
- Predrill Environmental Baseline
- Environmental Surveillance

Drilling Geohazard Studies

Tools: Magnetic Data
Active Source EM
Hyperspectral Data (FTIR)
and/or Lidar with Methane Detector

Analysis/Offerings:

- Integrated study to detect leaky wells via Hyperspectral surface seepage/gas detection with Magnetic identification of P&A wells
- Integrated study to map shallow gas charged zones usingActive source EM with migration pathways (faults/well conduits)mapped from magnetic data and linked with surface seepage and Lineaments from Hyperspectral and/or Lidar

Exploration Prospecting Studies (hydrocarbon and Mining)

Tools: Magnetic Data
VLF EM
Hyperspectral Data (FTIR)
Integration with Seismic & Well Data

Analysis/Offerings:

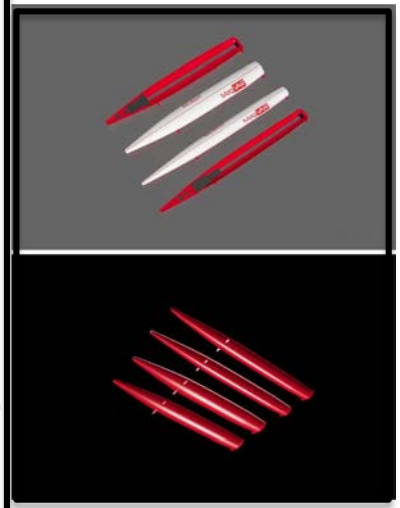
- Integrated exploration study to identify key Exploration Insights including magnetic basement depth, resistive basement,mapped intrusions, salt bodies, fault identification,integration with geology and key hydrocarbon systems screeningincluding hydrocarbon trap identification, structures, Source presence through surface seepage
- Integration with 2D & 3D seismic mapping/ interpretationand well data
- Surface Mining Prospectivity and target delineation

Water Resources Targeting

Tools: Magnetic Data
Active Source EM-Frequency Domain
Lidar

Analysis/Offerings:

- Aquifer Detection
- Surface water Ground Water Interaction
- Mapping Shallow Stratigraphy
- Water well Targeting



Acknowledgments
MagVAR Geoscience Team

- Noah Hagen, Ryan Paynter, Alec Berarducci, Alexander Mitkus, Rohith Sali, Stefan Maus, Sara Constantine, Andrew Genco

Thank You

Questions?

ISCWSA