



Department of Energy



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Machine Learning:

# Going Beyond the Hype and Making it Work for Earth Science

Nina Marie Hernandez  
Managing Director

ePower Mo Conference  
Baguio City  
24 April 2018



**iraya**  
machine learning • geoscience

# Outline



AI – Is it Magic, or Math?

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Making AI Work for Earth Science

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Leveraging on AI for Energy Efficiency

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# Industrial Revolutions and Efficiency

1.0  
Mechanical

2.0  
Electrical

3.0  
Internet

4.0  
Digital

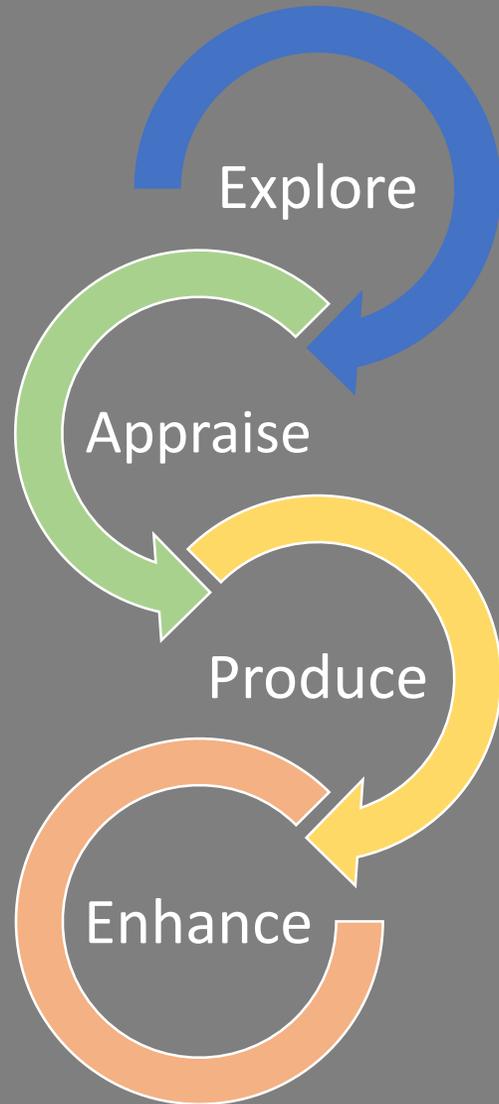
Source:  
World Economic Forum, 2016  
Samsung



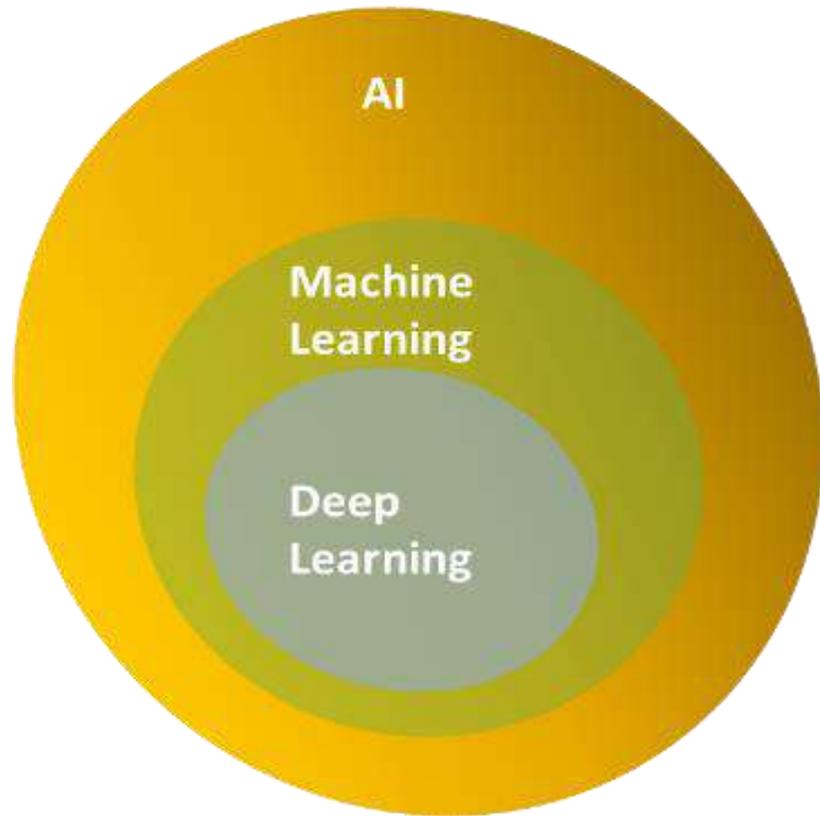
Department of Energy  
*Empowering the Filipino*



# Energy Exploration and Production Cycle



# AI & ML - What is it?

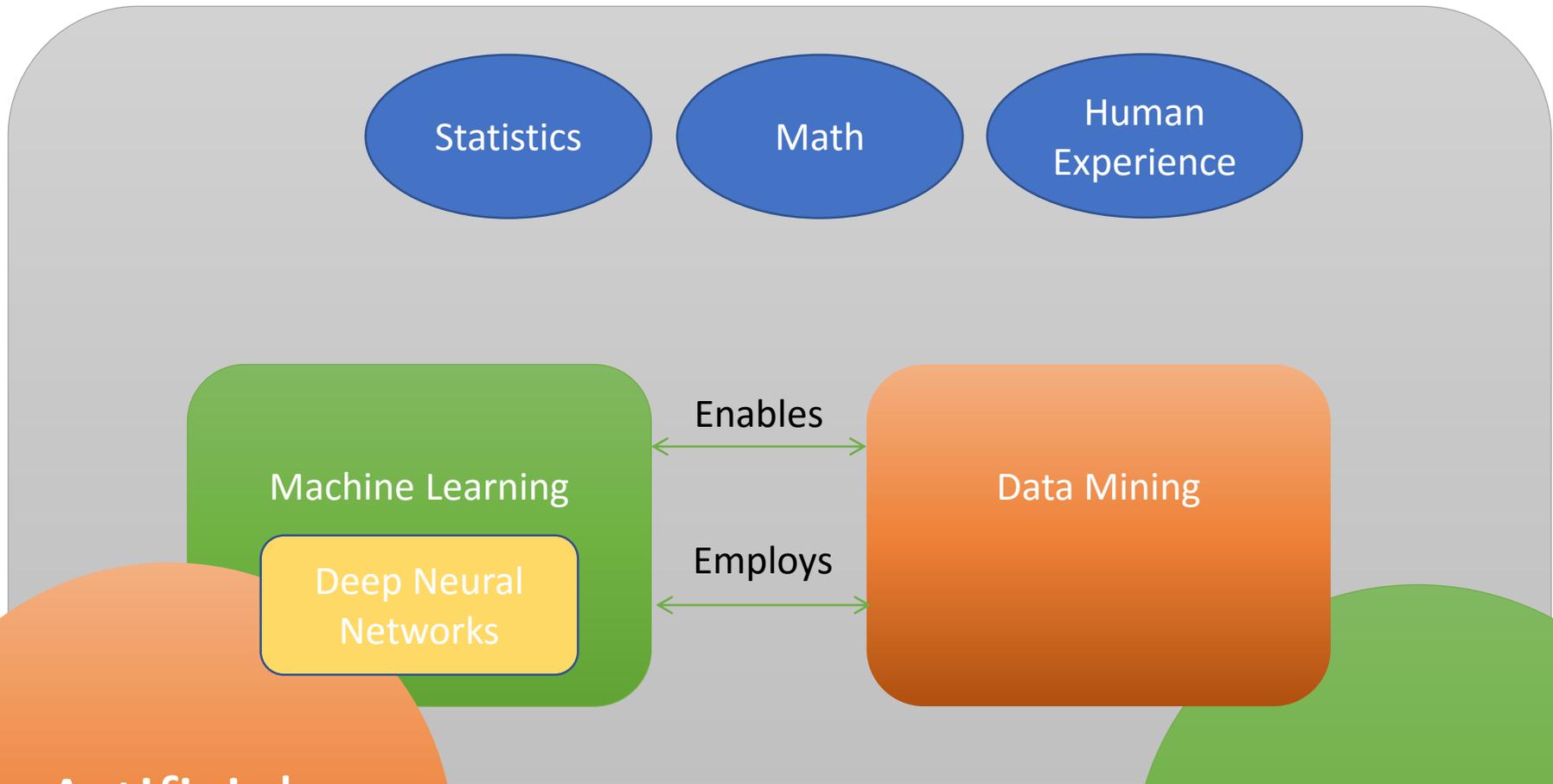


Arthur Samuel (1959) on  
**Machine Learning:**

*The field of study that gives computers the ability to learn without being explicitly programmed.*



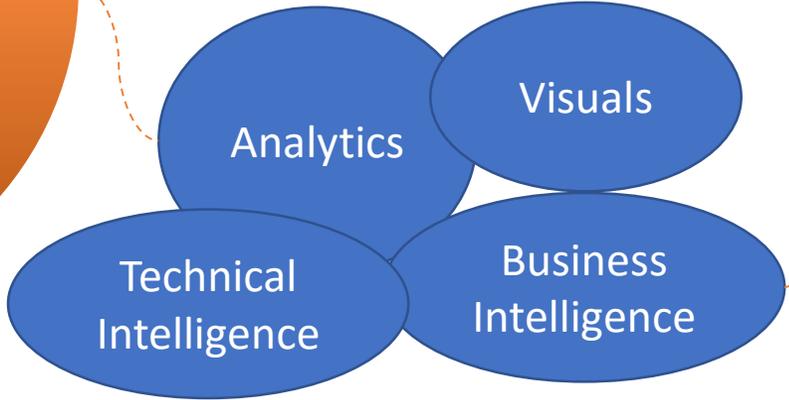
DATA



INSIGHTS

Artificial Intelligence

Big Data



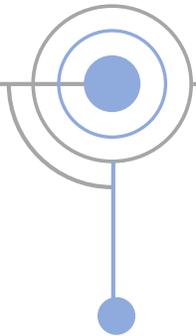
# History of Artificial Intelligence

1961 FIRST COMPUTER FOR SEISMIC DATA PROCESSING

1973- COMPUTER CHESS

1980- EXPERT SYSTEMS

1950



1950: TURING CAN MACHINE THINK?

1954: RUSSIAN TRANSLATION

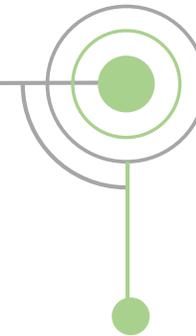
1956 FIRST USE OF WORD AI

1970



AI WINTER  
1980s-1990

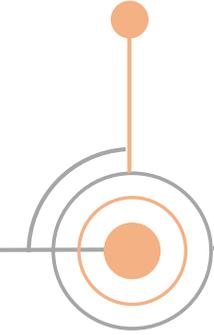
2000



1997 – IBM DEEP BLUE BEATS KASPAROV

2000 – ANN PREDICTION

2018



AUTONOMOUS CARS

ALPHA GO

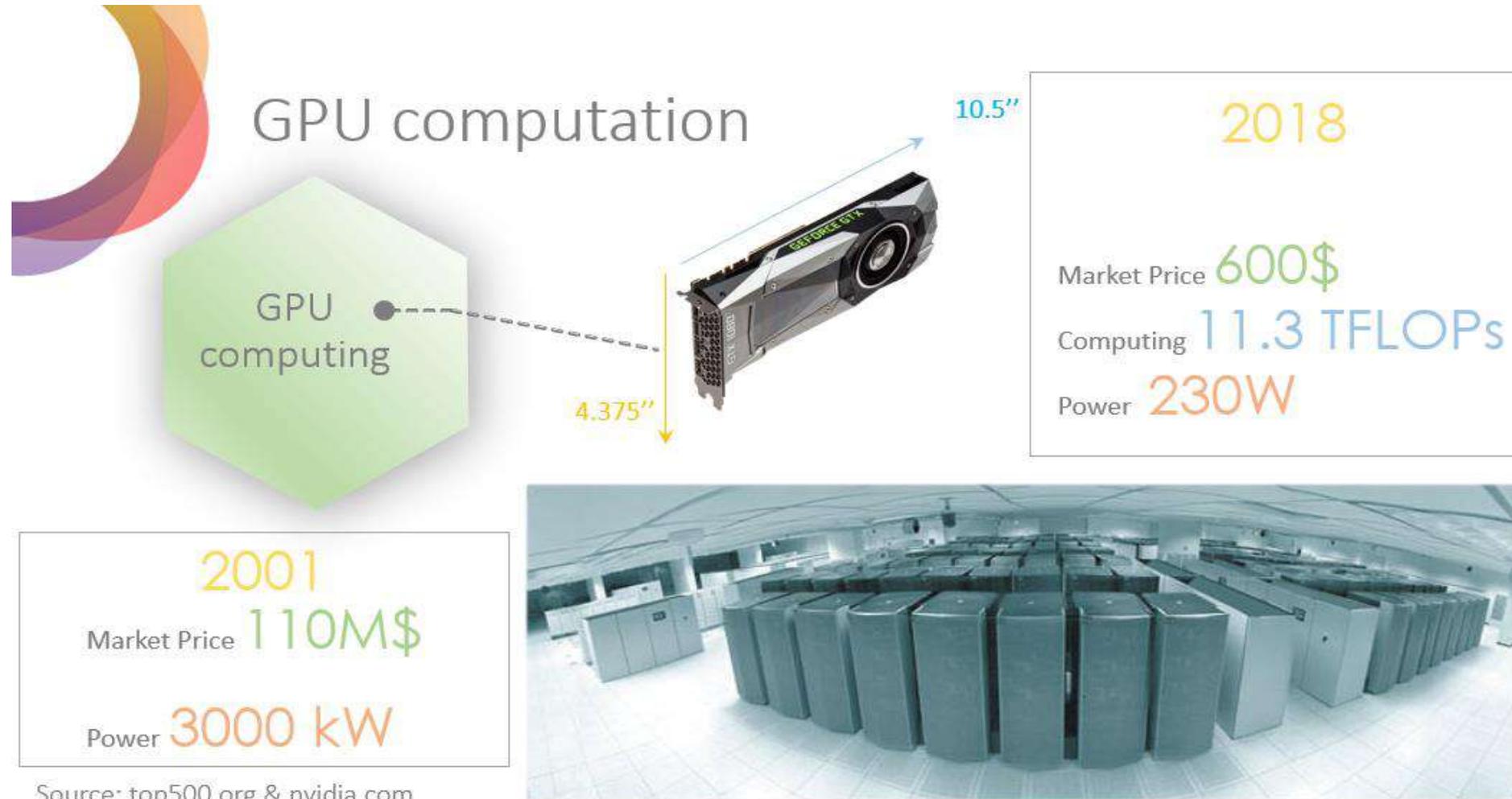
FACE RECOGNITION

EAGE PARIS 2017 ML



Figure 1. The Hype Cycle and AI winter [Menzi03]

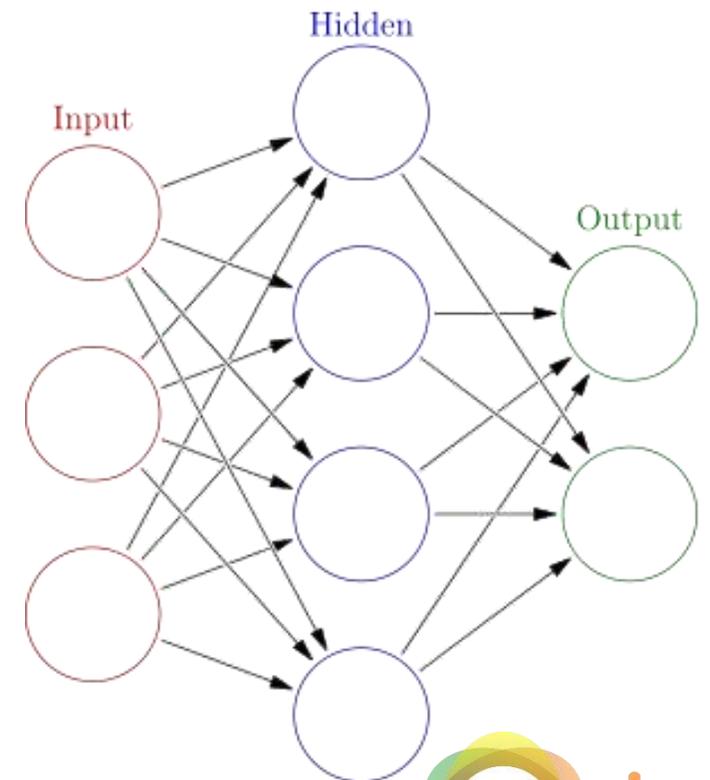
# AI explosion in 2018



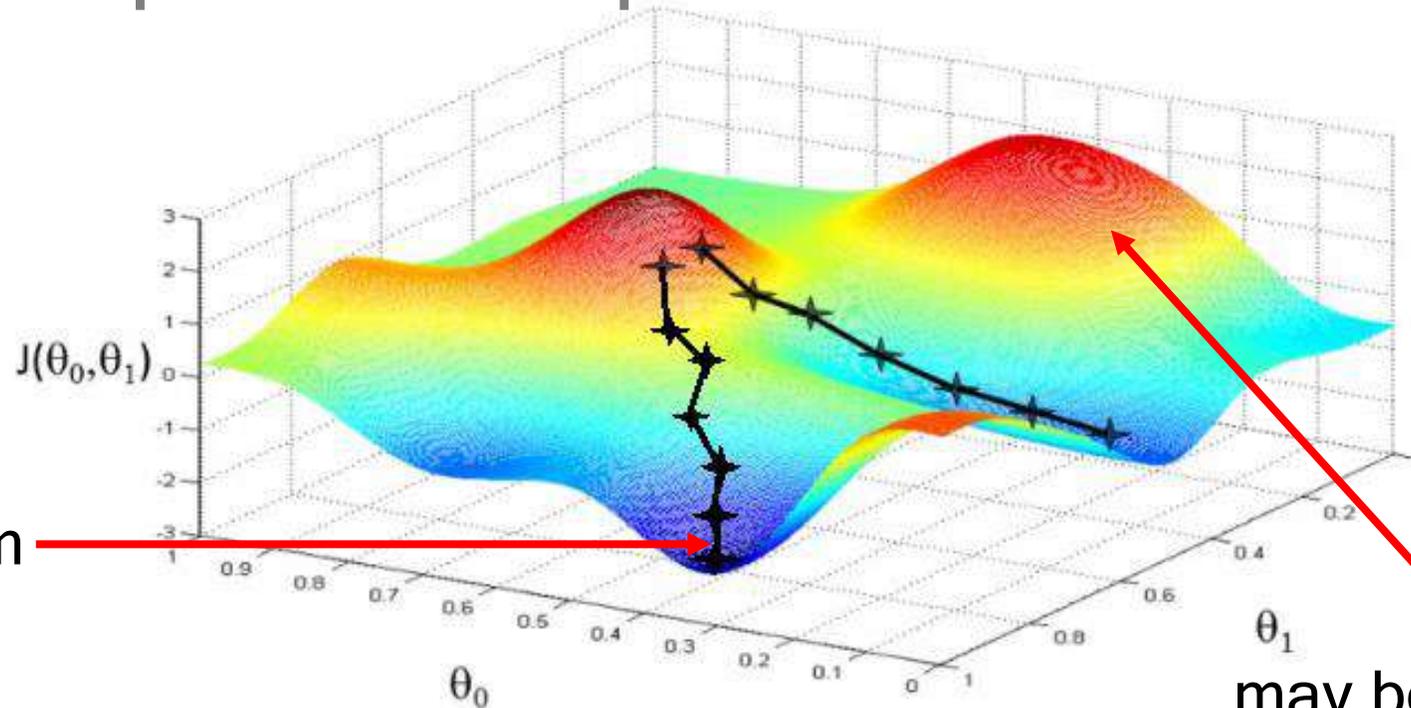
# Nature as an inspiration

Artificial neural networks (ANN) mimic neurons in a brain

- Layers of nodes with weighted connections between layers
- Information through network changes its structure - **it learns**



# Mathematically, training a neural network is an optimization problem



global minimum

may be N dimensional

- Show different input values and compute error
- Adjust weights in direction where error is minimized (along gradient)
- Eventually reach minimum value



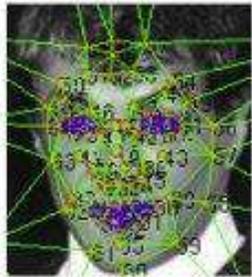
# Deep learning has found many applications in image processing



(a)



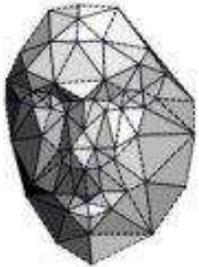
(b)



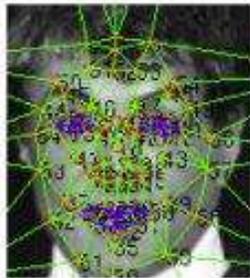
(c)



(d)



(e)



(f)



(g)



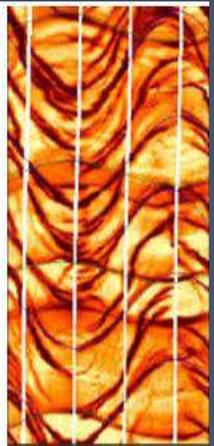
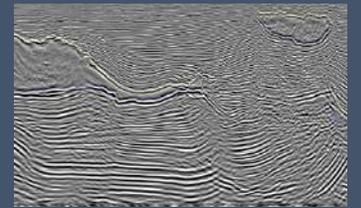
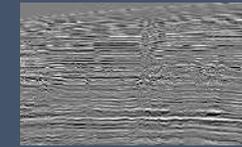
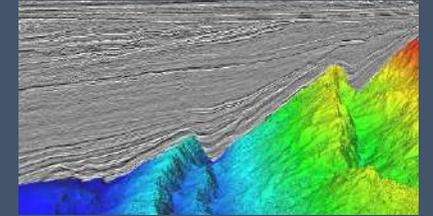
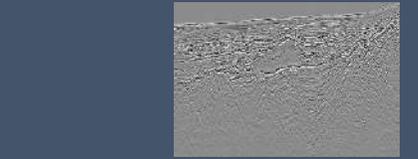
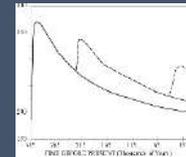
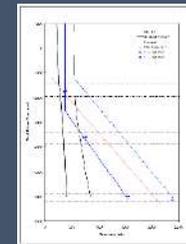
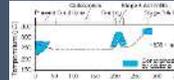
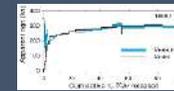
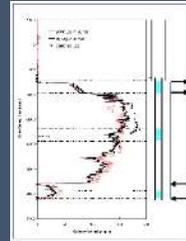
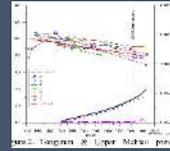
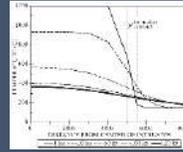
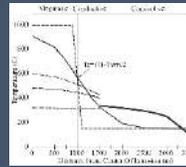
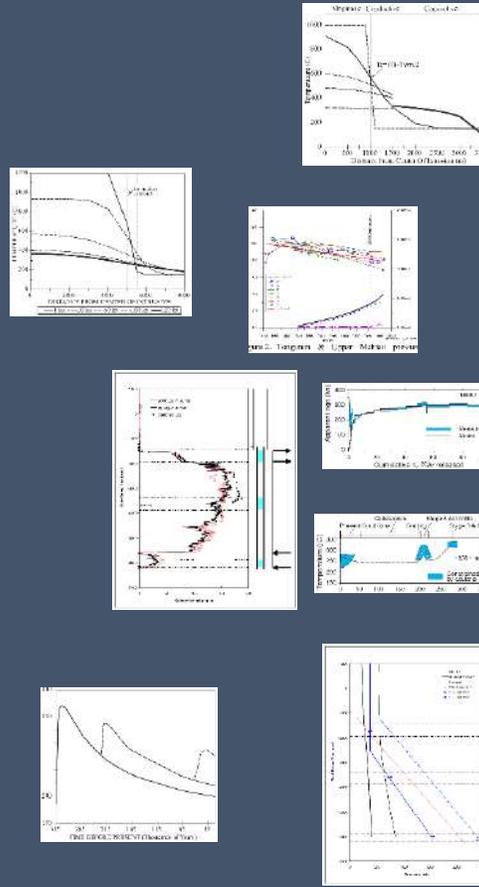
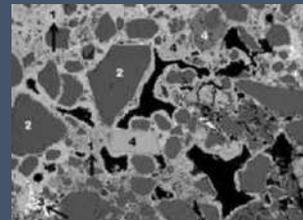
(h)

Facebook

- Facebook's DeepFace for facial verification
- DNN with 9 layers
- Trained using millions of images uploaded by users
- Accuracy reaching 97.35%

What do geoscientists do on a daily basis?  
We make (image) files

# EARTH PROBLEMS



# Making AI work for Earth Science

Use AI to (classify, predict, learn from) **archived, historical megadata**



New Data Acquisition  
is very **costly**

Learn Effectively



10 vs 1,000 wells

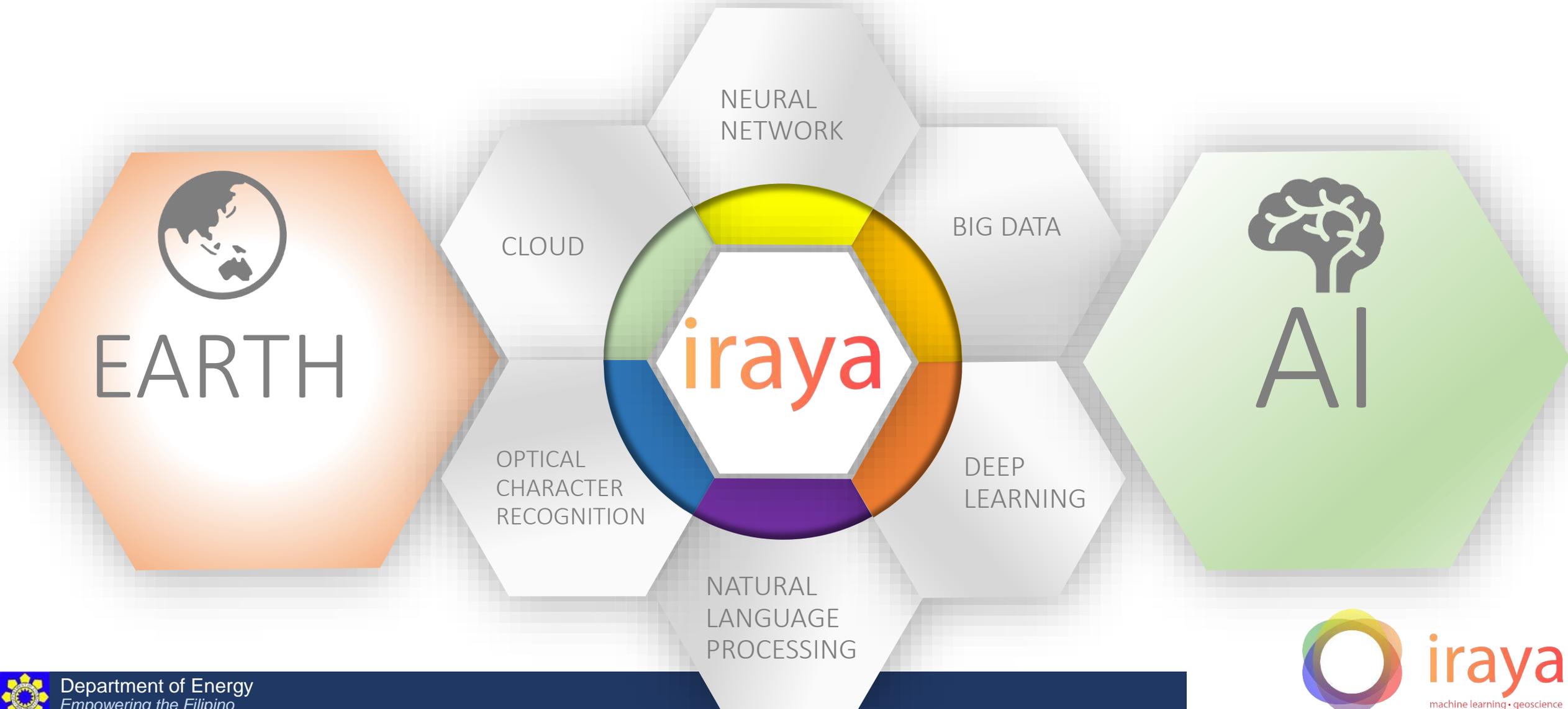
20 vs 2,000 seismic  
lines

Optimize efficiency during exploration and early  
development phase

Yet-to-Find becomes Easy-to-Find



# Making AI work for Earth Science



# Iraya Use Cases of AI

- Use Case # 1 : Data Mining
- Use Case # 2: Well Twinning
- Use Case # 3 : Clustering
- Use Case # 4: Deep Resolution

Actual AI examples in geoscience  
performed by Filipino scientists



# Use Case #1: Data Mining

- **Problem Definition:**

Extract information from a unstructured dataset

- **Standard Solution:**

Download data, manually read metadata and load in a spreadsheet

- **Machine Learning Solution:**

Apply mining robots, elastic search, natural language processing, optical character recognition to reduce timeframe by a factor of 100.



# Data Mining Analogy



Harvesting



Transform

Sort



Enhance

# Sentiment Analysis Beyond Twitter

Search: philippines|

SCIENCE-DIRECT

Microearthquakes at the puhagan geothermal field, Philippines – A case of induced seismicity

C.J. Bromley. Author links open the author workspace.1. Numbers and letters correspond to the affiliation list. Click to expose these in author workspace

Relevance 2 Year 1987

Patigimon Negros Oriental

PANCEA-STANFORD

Geothermal Developments in the Philippines -- 1980

Finn, Donald F.X.

Relevance 2 Year 1980

Mak-Ban Laguna

PANCEA-STANFORD

Hydrology of the Greater Tongonan Geothermal System, Philippines and its Implications to Field Exploitation

Seastres, Jose S., Jr.; Salonga, Noel D.; Saw, Virgilio S.; Clotworthy, Allan W.

Relevance 0 Year 1996

PANCEA-STANFORD

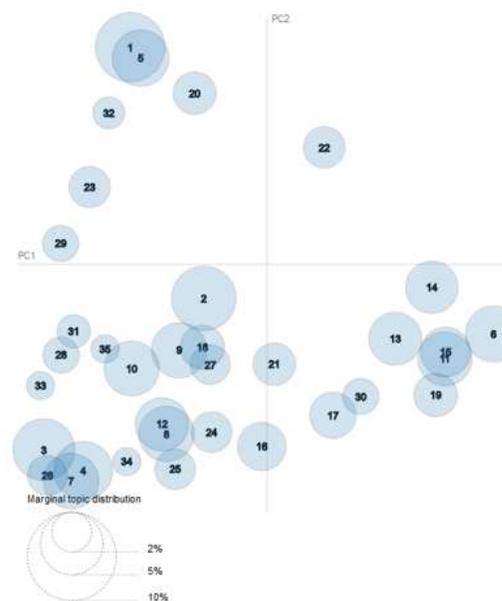
Stratigraphic Correlation in Mt. Labo, Mt. Canlaon and Mt. Cabalian Geothermal Areas, Philippines Using Fission-Track, Thermoluminescence and Zircon Morphology

Ramos, S. G.; Zaidie-Delfin, M. C.; Hayashi, M.

Relevance 0 Year 1998

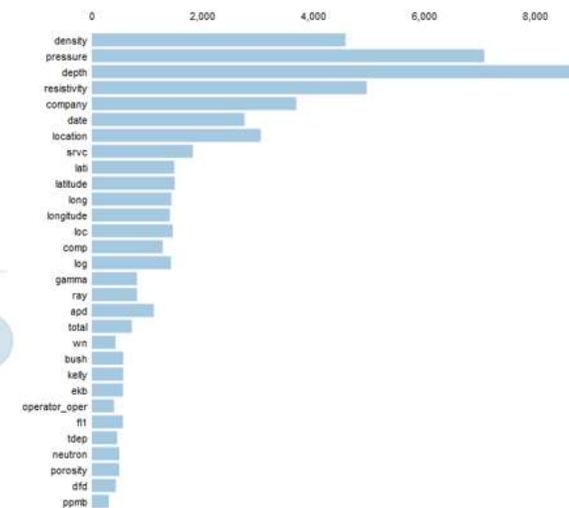
Selected Topic: 0 Previous Topic Next Topic Clear Topic

Intertopic Distance Map (via multidimensional scaling)



Slide to adjust relevance metric (α)  
α = 1

Top-30 Most Salient Terms 1



Overall term frequency

Estimated term frequency within the selected topic

1. saliency(term, w) = frequency(w) \* [sum\_i p(i, w) \* log(p(i, w)/p(i))] for topics i. see Chuang et al. (2012)  
2. relevance(term, w, i, topic t) = λ \* p(w, i, t) + (1 - λ) \* p(w, i, w). see Silvert & Shirley (2014)



# Elastic Docs beyond Google

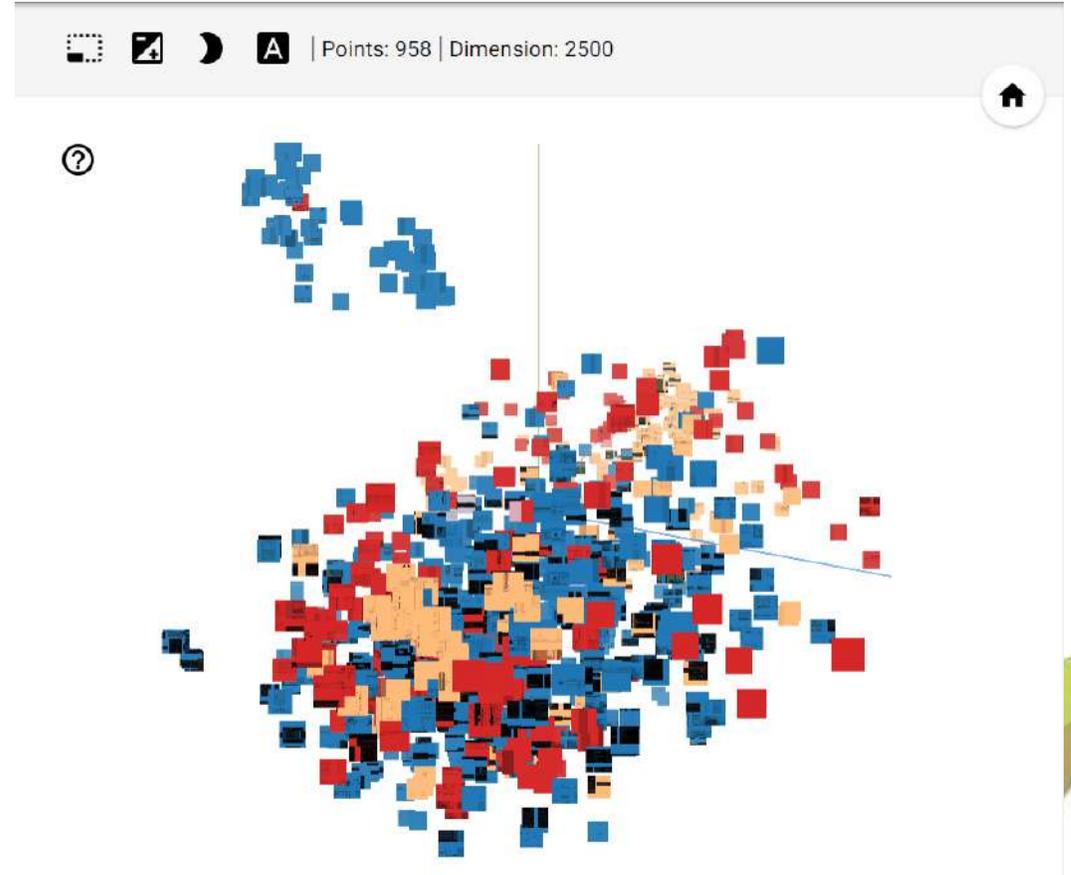
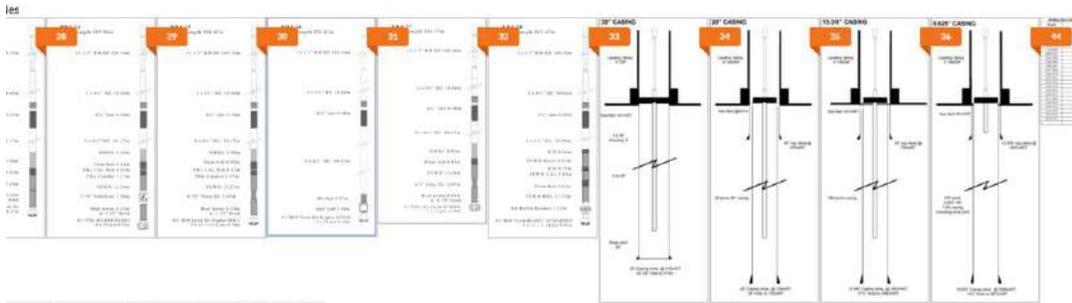
2.1 Bit Run Summaries  
2.2 Casing and Cementing Summaries  
Section 3 Geology and Shows  
3.1 Geology and Shows  
3.2 Sample Distribution, Petrology

**12 1/4" Phase: 01 - 14 October 2000**

**Bit Run 15 Summary**

|                |                  |
|----------------|------------------|
| Bit Number     | NB 7             |
| Bit Size       | 12 1/4"          |
| Bit Type       | Hycalog DS34HFGN |
| S/N            | 23351            |
| Jets           | 7 x 18           |
| Depth In, mRT  | 2560m            |
| Depth Out, mRT | 3004m            |

**BHA 15**  
BHA Length 294.54m  
12 x 5" HWDP 109.34m



# Data Mining

LAS DATA IN DIFFERENT FORMAT

1,595 files

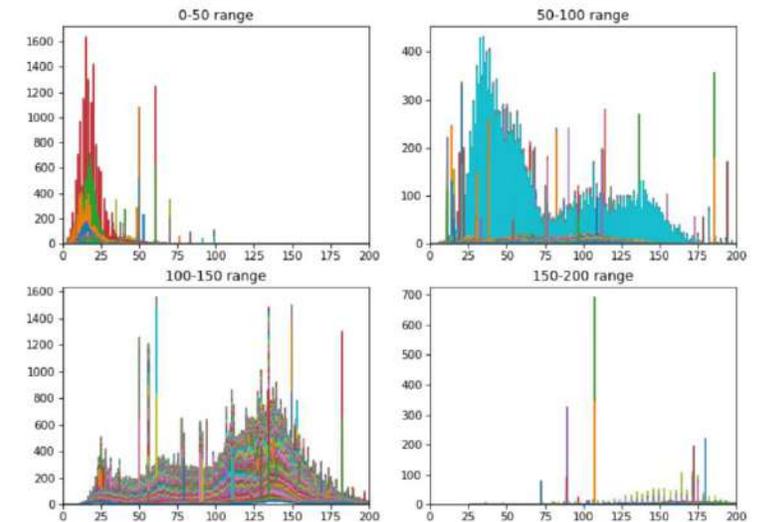
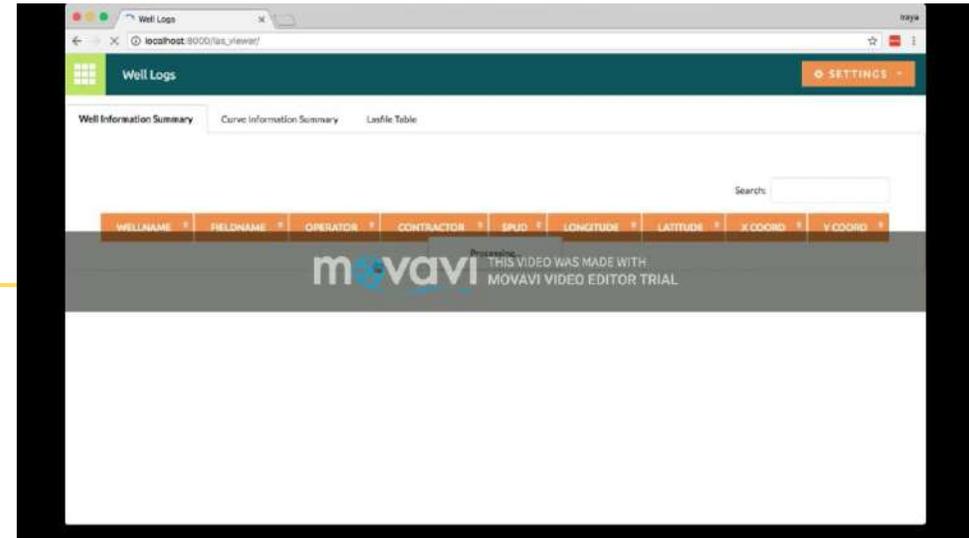
2 hrs 33.66 mins of Data Mining

Identified:

66,515 curves

5,681 most used (10% of data)

90% of DATA REMAINS TO BE TAPPED



# Use Case #2: Well Twinning

- **Problem Definition:**

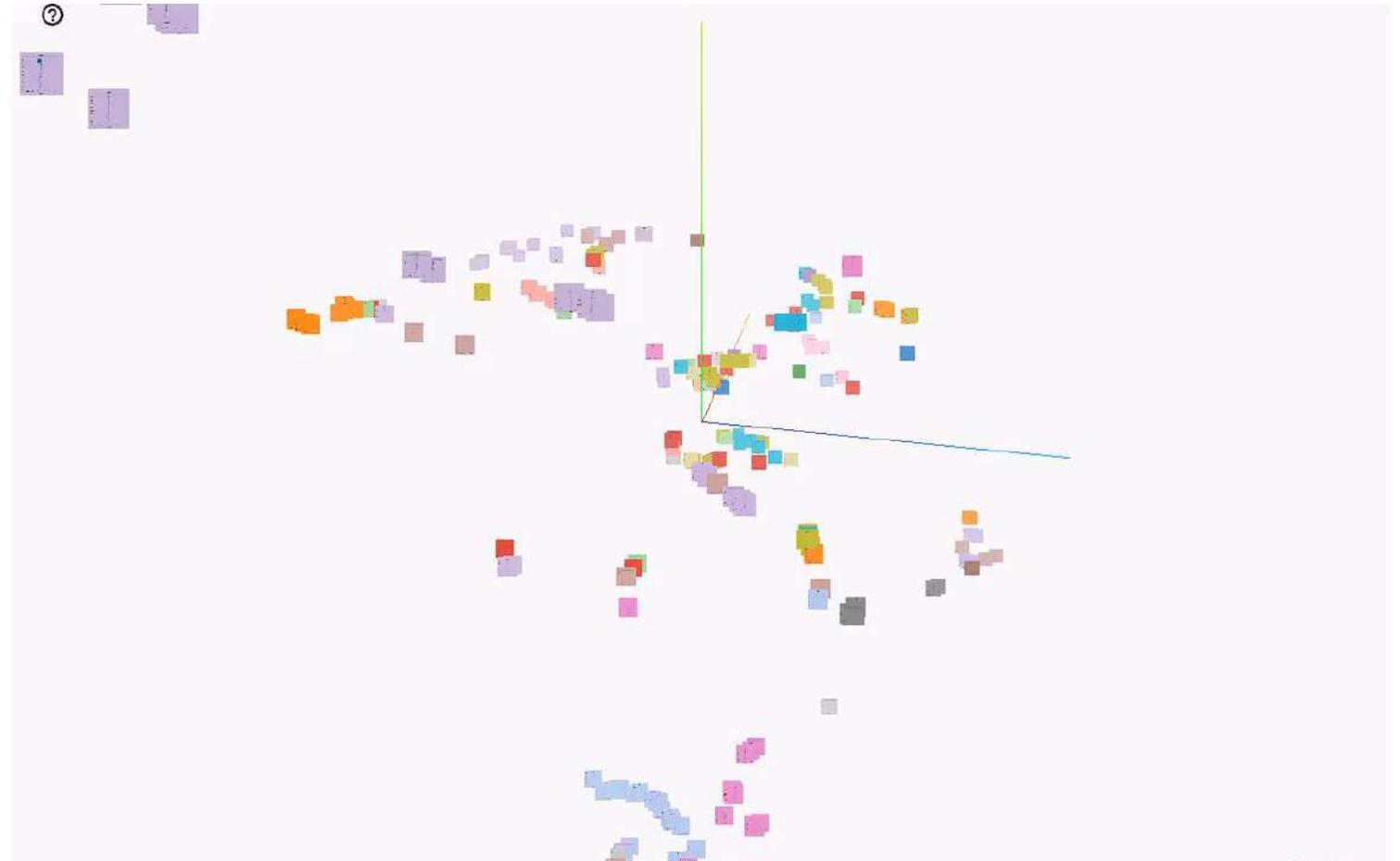
Find analog wells of a wildcat exploration area

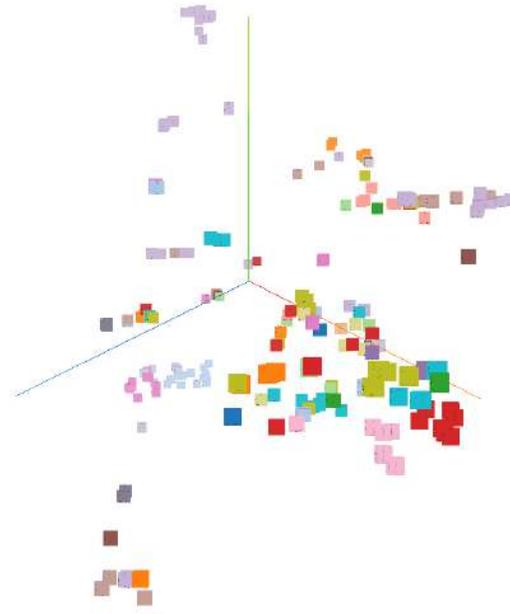
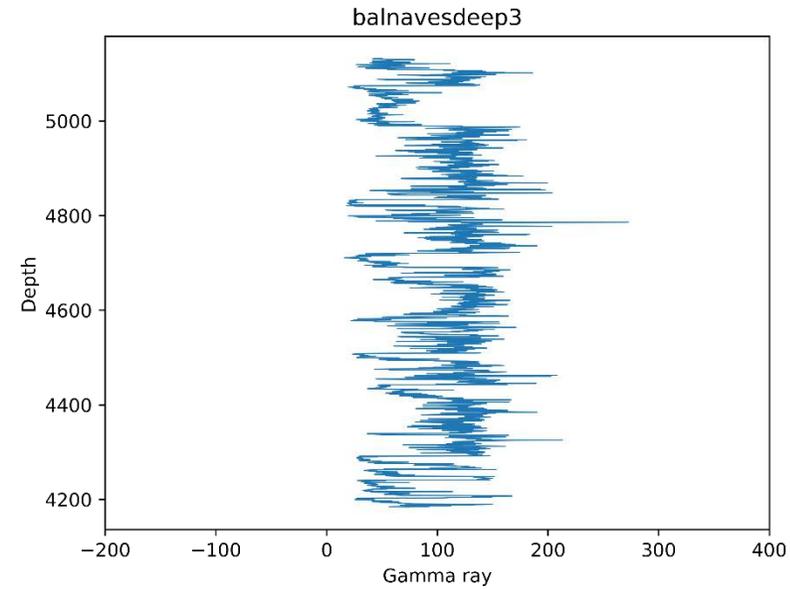
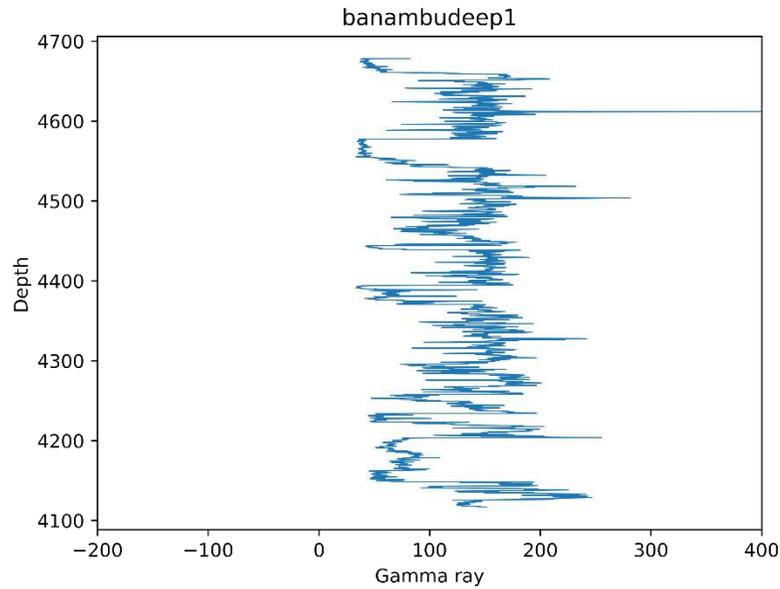
- **Standard Solution:**

Find the nearest 1 or 2 wells in the nearest field (highly risky, does not capture all variabilities)

- **Machine Learning Solution:**

Leverage on big volume dataset to find geological analogs and de-risk potential prospect





Banambu Deep

Index 27  
Label Banambu Deep

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Search

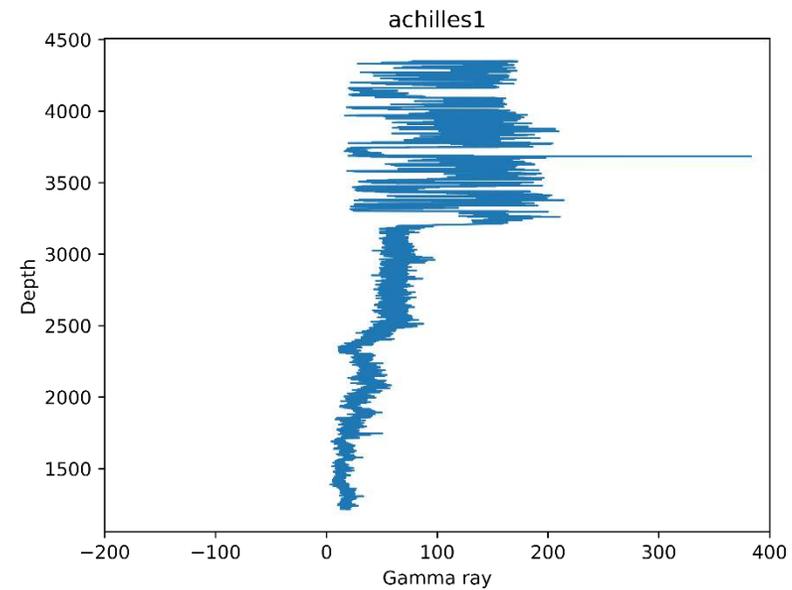
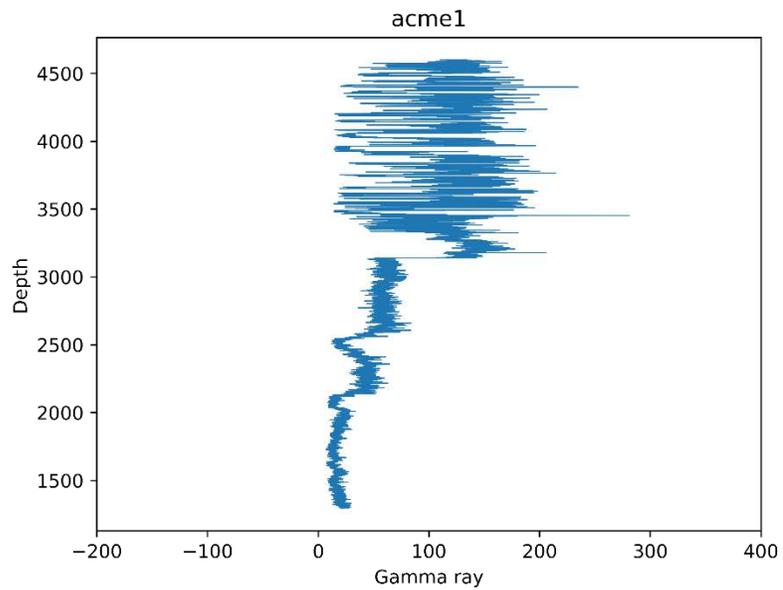
neighbors  20

distance  COSINE  EUCLIDEAN

Nearest points in the original space:

|               |       |
|---------------|-------|
| Banambu Deep  | 0.930 |
| Banambu Deep  | 0.974 |
| Banambu Deep  | 0.974 |
| Banambu Deep  | 1.009 |
| Banambu Deep  | 1.029 |
| Banambu Deep  | 1.035 |
| Banambu Deep  | 1.037 |
| Banambu Deep  | 1.044 |
| Banambu Deep  | 1.050 |
| Banambu Deep  | 1.058 |
| Banambu Deep  | 1.058 |
| Balnaves Deep | 1.061 |
| Balnaves Deep | 1.061 |
| Balnaves Deep | 1.066 |
| Balnaves Deep | 1.075 |
| Balnaves Deep | 1.077 |
| Balnaves Deep | 1.077 |
| Banambu Deep  | 1.081 |
| Banambu Deep  | 1.083 |
| Balnaves Deep | 1.088 |

- Automated identification of the closest well “twin”, without prior geological knowledge
- Applicable in ultra-wildcat area or cross-country analog search



- Effective in automated identification of the closest genetic “twin” of the well
- Twin can provide valuable information on lithology, production history, drilling risks, etc.



# Use Case #3: Clustering

- **Problem Definition:**

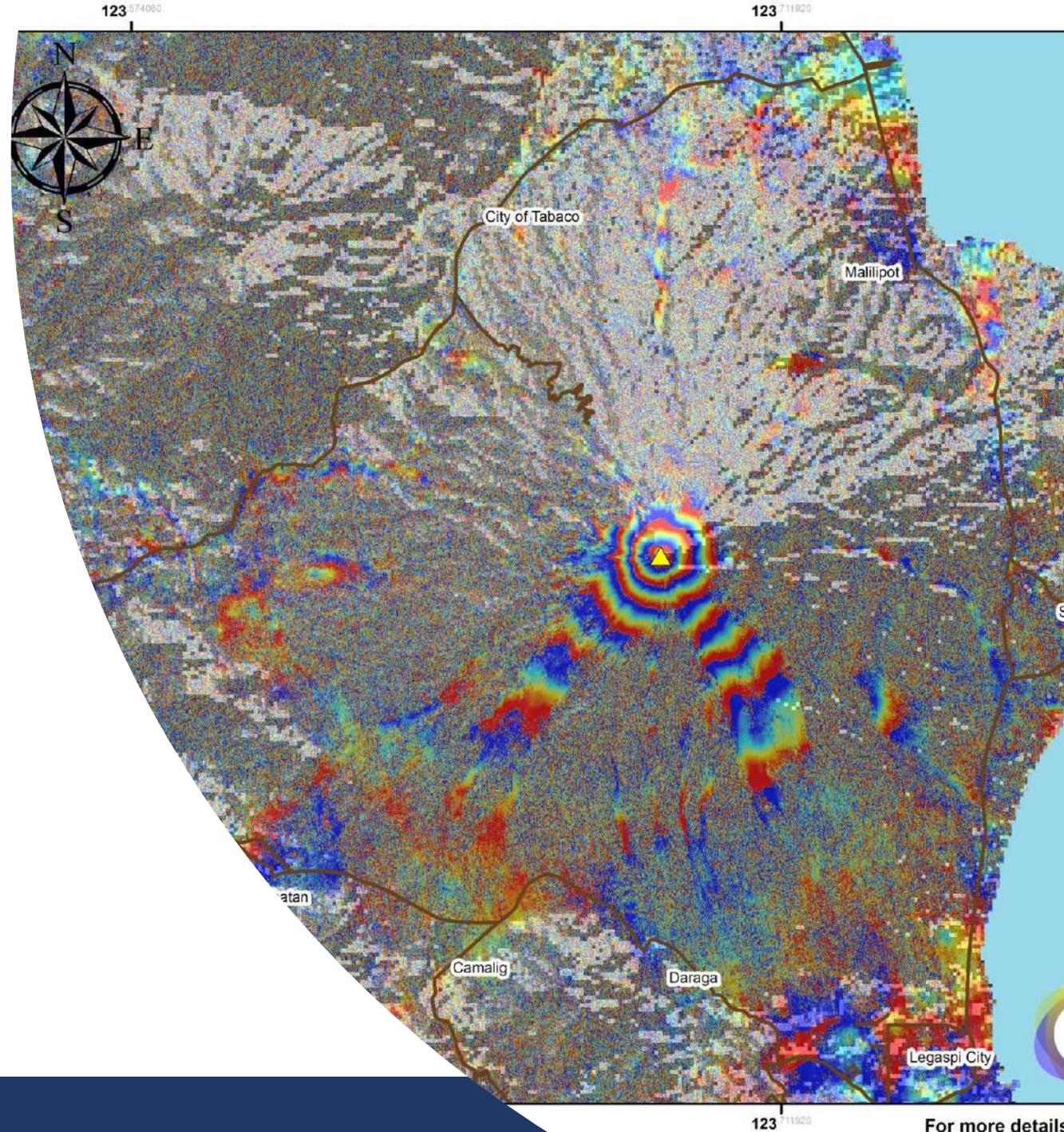
Identify surface features from satellite data

- **Standard Solution:**

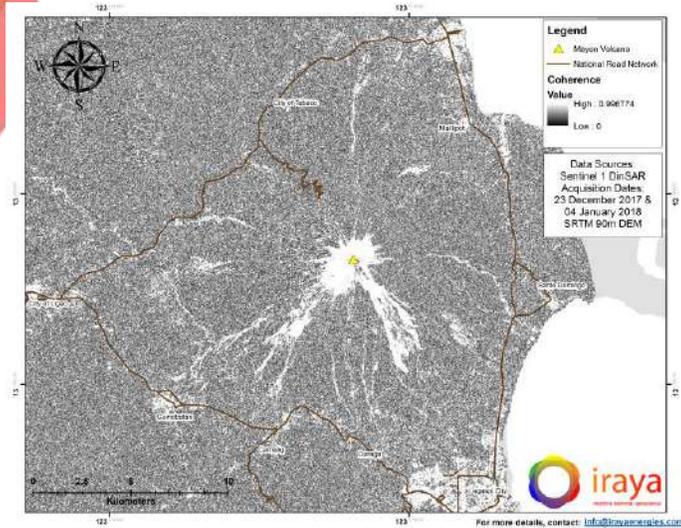
Manual Interpretation

- **Machine Learning Solution:**

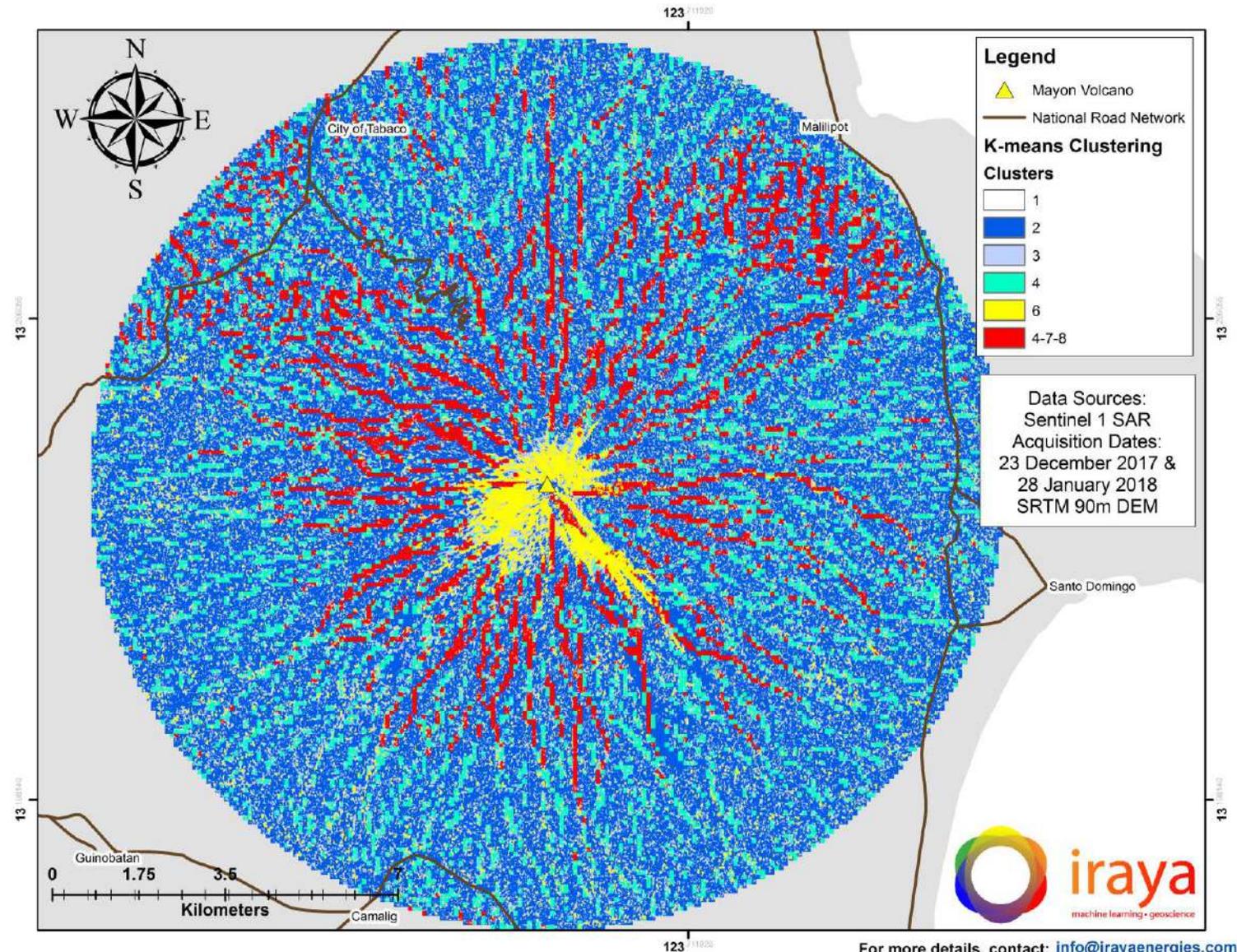
Unsupervised classification of multiple extracted features



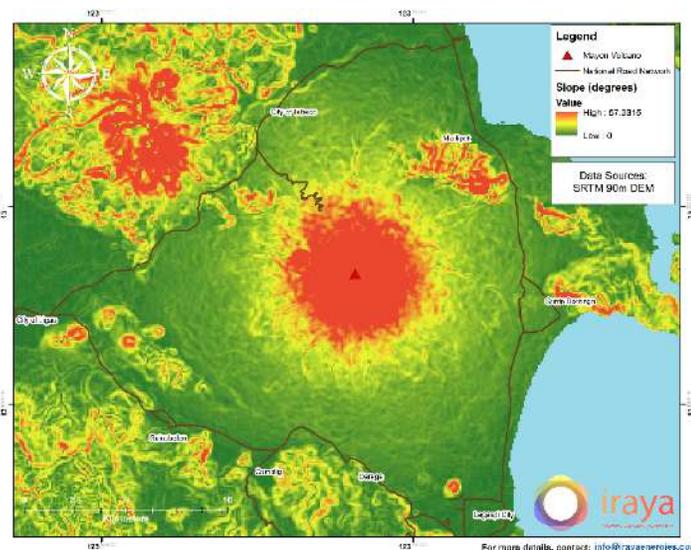
# Coherence



# K-means Cluster



# Slope



# Use Case #4: Resolution Enhancement

- **Problem Definition:**

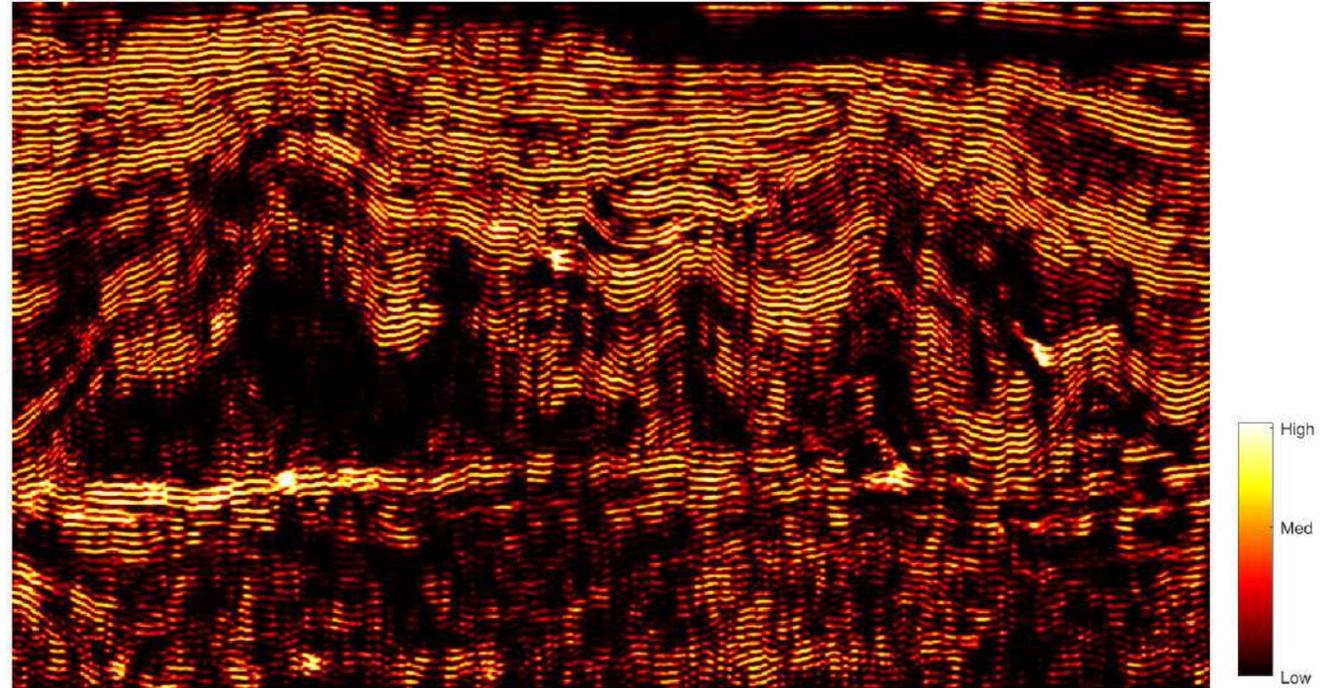
Increase seismic image Quality in Vintage Seismic acquisitions for better interpretation

- **Standard Solution:**

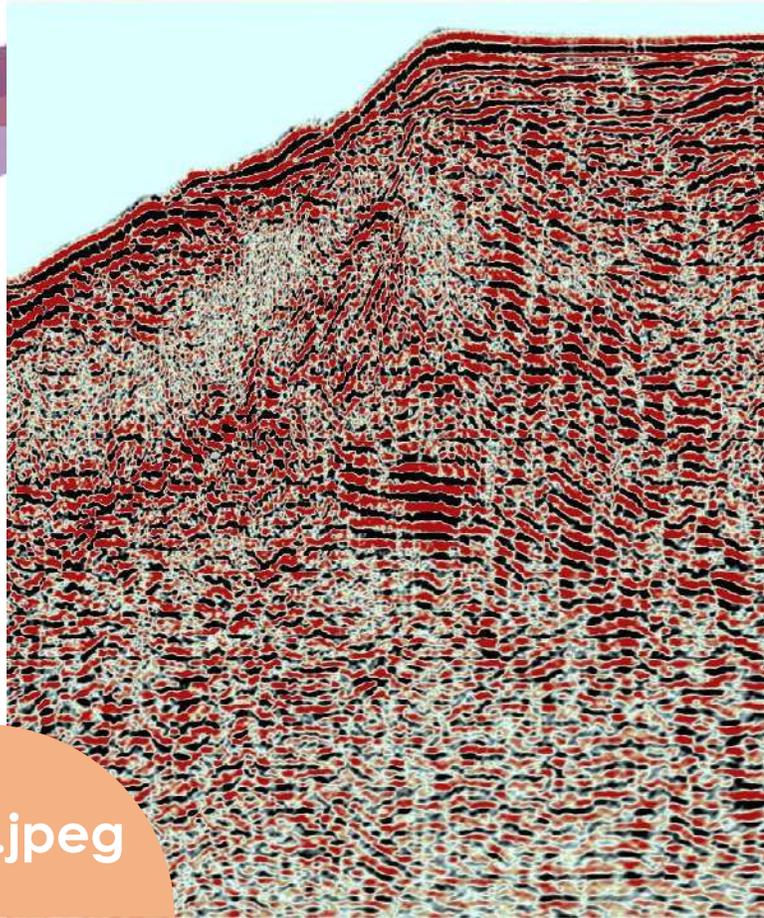
Traditional Seismic Processing + Stochastic Static Modeling

- **Machine Learning Solution:**

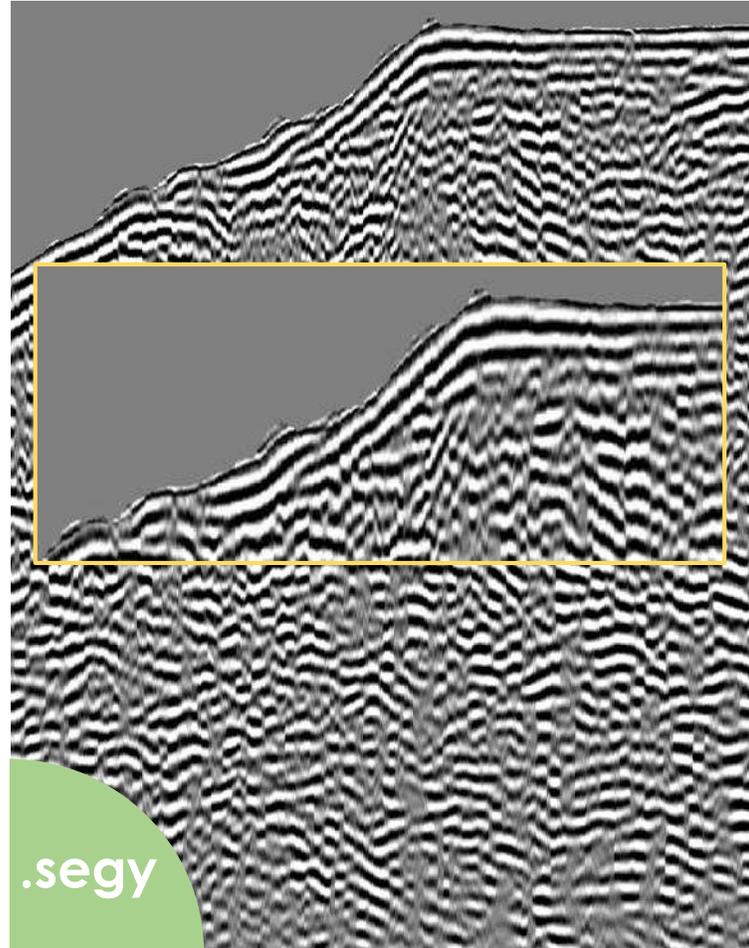
Model-based residual processing using deep convolutional neural network



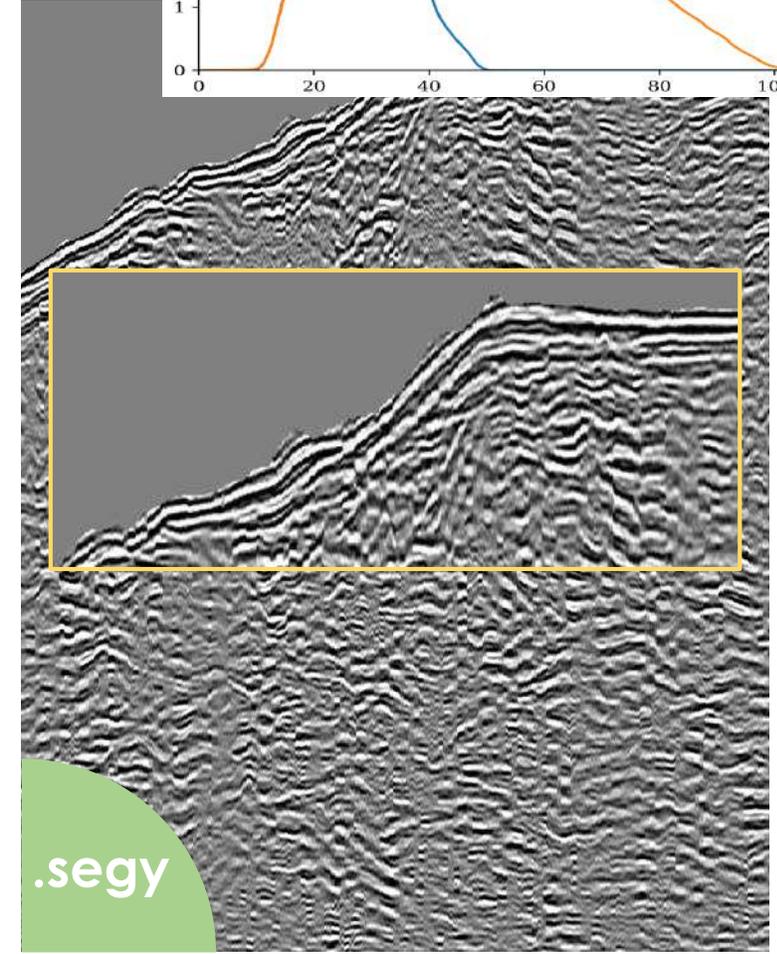
# Let's assume...



We have a powerpoint with somewhere a seismic image



We would like to find it, clean it and convert it into .segy



And why not enhance it at the same time

## Fully automatic - AI driven



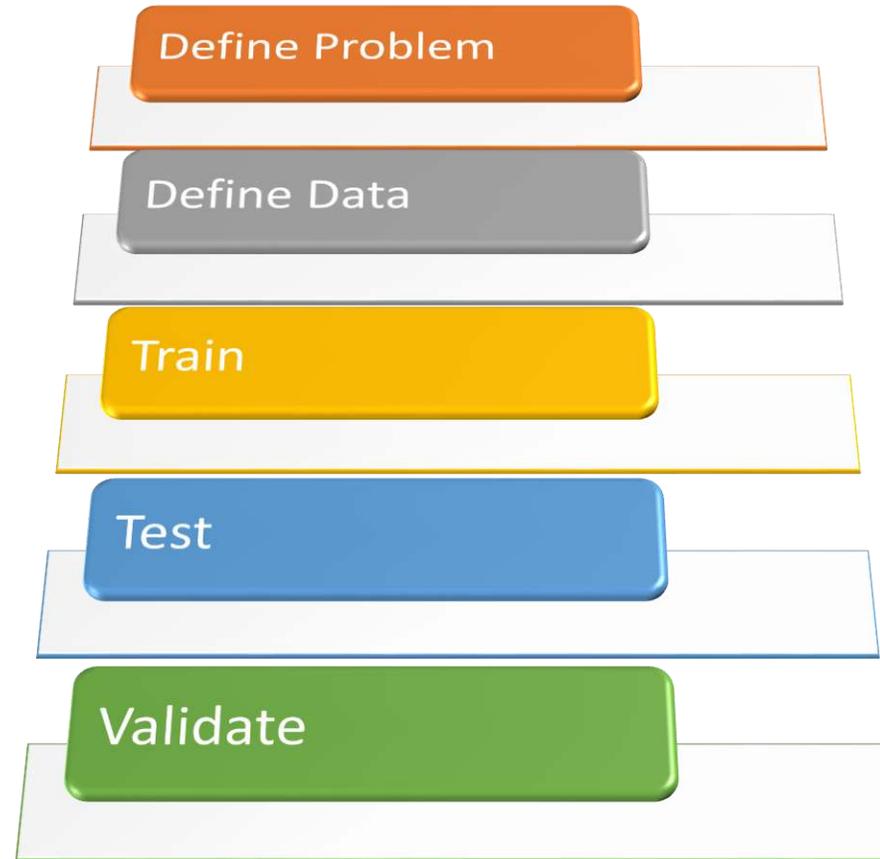
Conclusion:

Leveraging on AI for Energy  
Efficiency

# Conclusion

Leveraging on AI for  
Energy Efficiency:

Tap into our inner  
scientist



# Conclusion

Leveraging on AI for Energy Efficiency:

Public and Private Investment in People and Technology





# Thank you!

For discussions on how AI can help increase efficiency in your organization's processes, or AI investment opportunities pls contact:

[info@irayaenergies.com](mailto:info@irayaenergies.com) or [nmh@irayaenergies.com](mailto:nmh@irayaenergies.com)