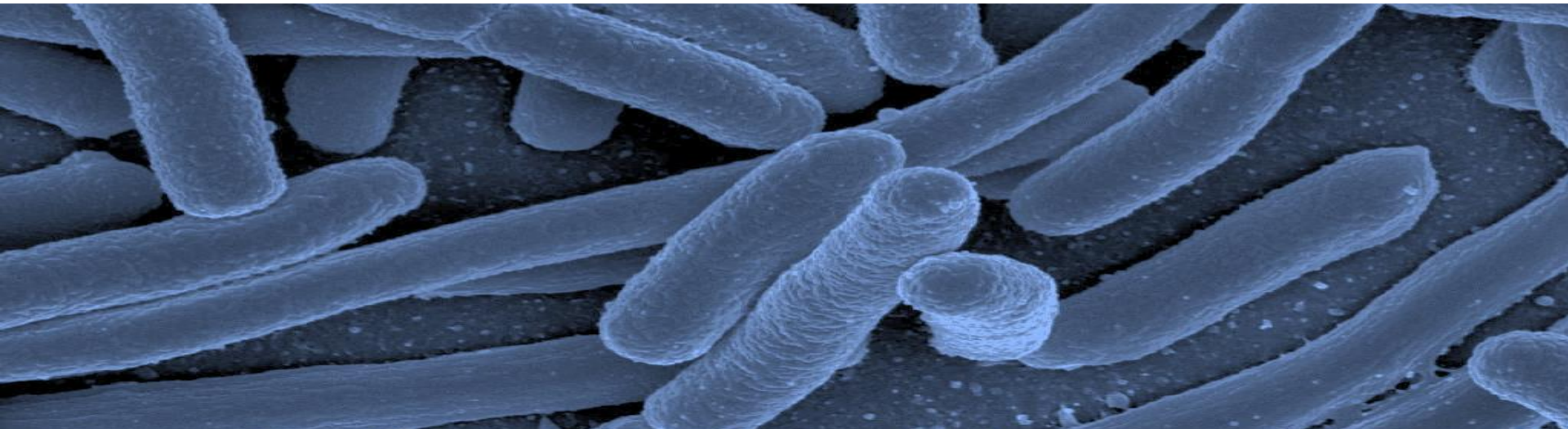
Dutch Exploration Day 2019

Using bacterial DNA from well cuttings to predict oil and gas with surface samples

Chris te Stroet, Jonathan Zwaan, Mart Zijp

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION



Principle

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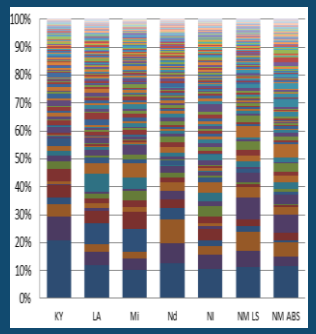
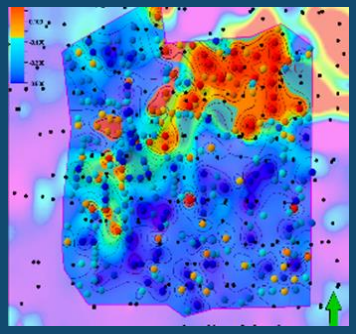
HYDROCARBON SWEET SPOT IDENTIFICATION

Using shallow soil samples (1 foot below surface or seabed)

To correlate DNA fingerprints with productivity





Causality is buoyancy of microbubbles

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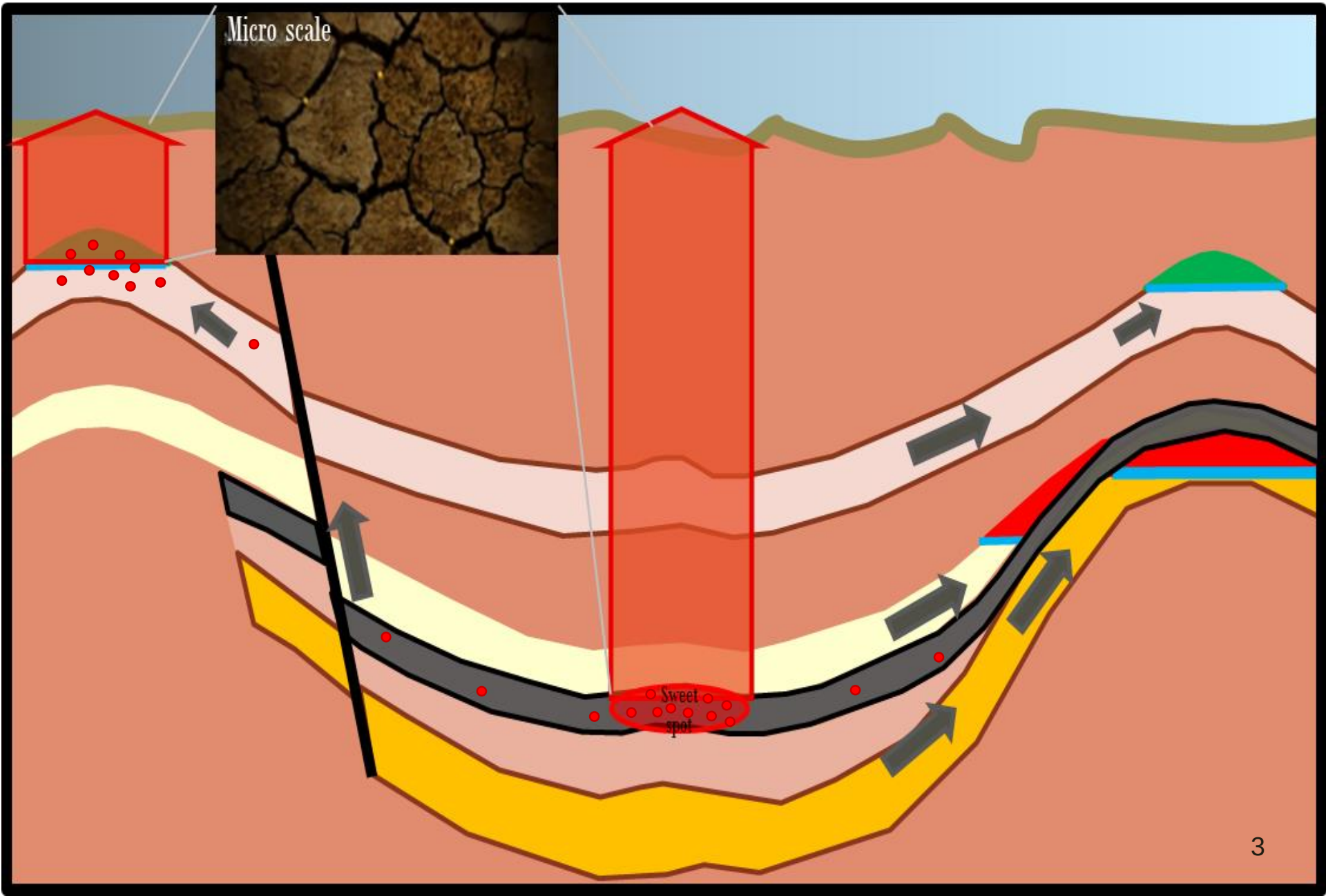
HYDROCARBON SWEET SPOT IDENTIFICATION



Proposition

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HYDROCARBON SWEET SPOT IDENTIFICATION

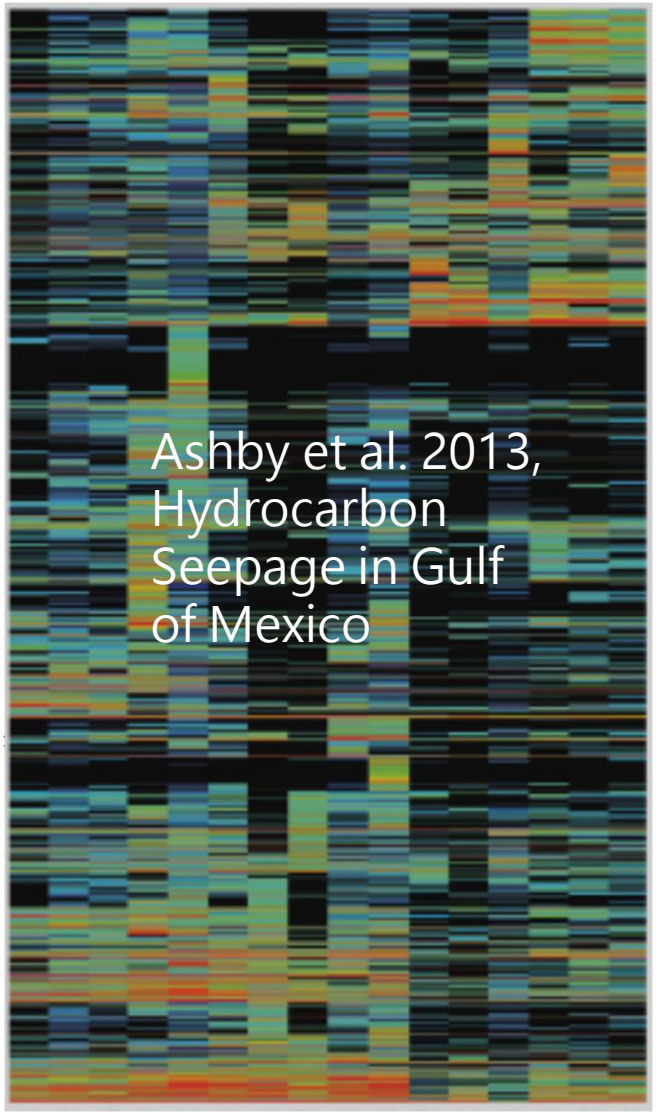
prioritized drilling in shale

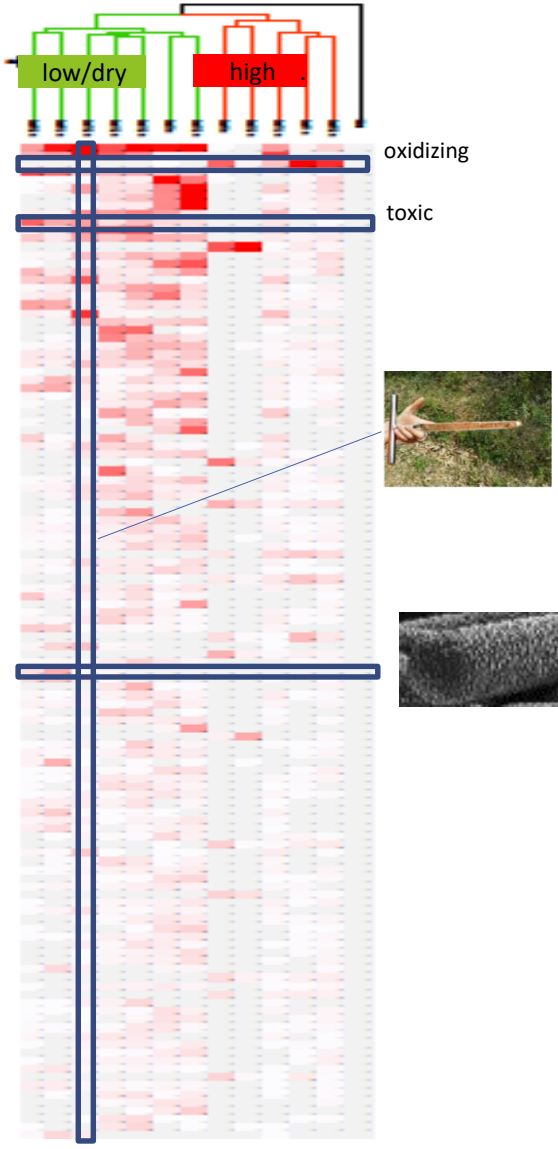
de-risking offshore wells

DNA Analysis and Machine Learning

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION

1. Soil sampling
2. DNA Extraction
3. Sequence microbes → DNA fingerprint
4. Compare fingerprints





The digital data (1): DNA fingerprints

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HYDROCARBON SWEET SPOT IDENTIFICATION

counts of species in samples by means of 16rS TACG info

nrsampl	nrcount	domain	class	order	family	genus
400	25759	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
544	19745	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
325	16108	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
424	12917	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
520	12658	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
625	12344	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
791	11896	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
665	11064	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
779	10931	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
847	10912	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
667	9372	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
474	8781	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
202	8072	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
245	7938	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
322	7511	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
254	7305	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
603	7143	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
555	7052	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
859	6570	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
606	6320	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella
619	6292	Bacteria	Actinobacteria	Gaiellales	Gaiellaceae	Gaiella

The digital data (1): DNA fingerprints

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION

counts of species in samples by means of 16rS TACG info

TACGTAGGGGGCAAGCGTTGTCCGGATTTATTGGGCGTAAAGA
GCGTGTAGGCGGCCAGGTAGGTCAGCTGTGAAAACTCGAGGC
TCAACCTCGAGATGTCGGCTGAAACCATCTGGCTAGAGTCCGG
AAGAGGAGAATGGAATTCCCGGTGTAGCGGTGAAATGCGCAG
ATATCGGGAAGAACACCCGTGGCGAAGGCGGTTCTCTGGGAC
GGTACTGACGCTGAGACGCGAAAGCGTGGGGAGCGAACAGG

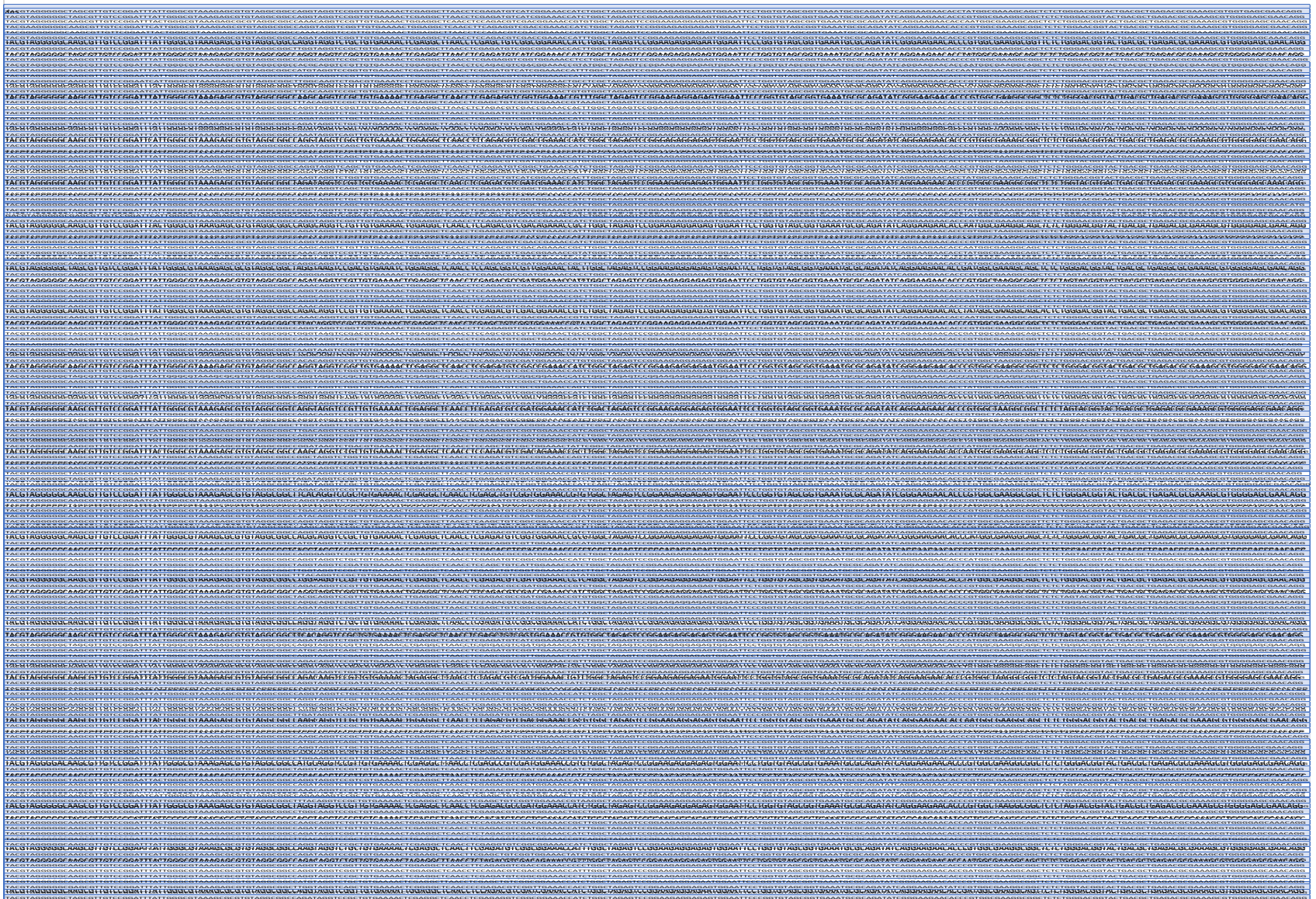
TACGTAGGGGGCAAGCGTTGTCCGGATTTATTGGGCGTAAAGA
GCGTGTAGGCGGCCAGGTAGGTCTGCTGTGAAAACTCGAGGC
TTAACCTCGAGCTGTCGGCGGAAACCATCTGGCTAGAGTCCGG
AAGAGGAGAATGGAATTCCCGGTGTAGCGGTGAAATGCGCAG
ATATCGGGAAGAACACCCGTGGCGAAGGCGGTTCTCTGGGAC
GGTACTGACGCTGAGACGCGAAAGCGTGGGGAGCGAACAGG

TACGTAGGGGGCTAGCGTTGTCCGGATTTATTGGGCGTAAAGA
GCGTGTAGGCGGCCAGGTAGGTCCGGTGTGAAAACTCGAGGC
TTAACCTCGAGATGTCATCGGAAACCATCTGGCTAGAGTCCGGA
AGAGGAGAGTGGAATTCCTGGTGTAGCGGTGAAATGCGCAGA
TATCAGGAAGAACACCTATGGCGAAAGCAGCTCTCTGGGACGG
TACTGACGCTGAGACGCGAAAGCGTGGGGAGCGAACAGGTTC

The digital data (1): DNA fingerprints

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION

Terabytes in size



Modeling prospectivity

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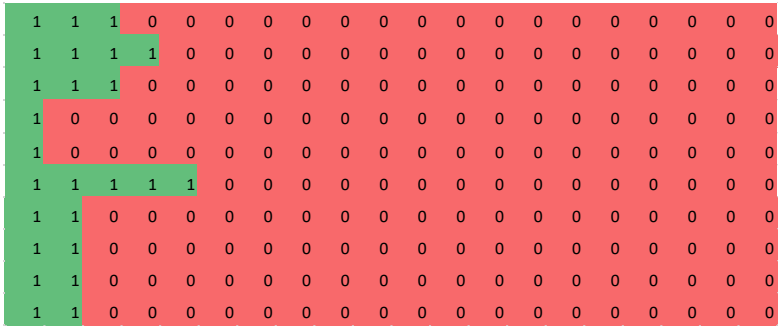

1 prospective area

0 non prospective area

1 biomarker

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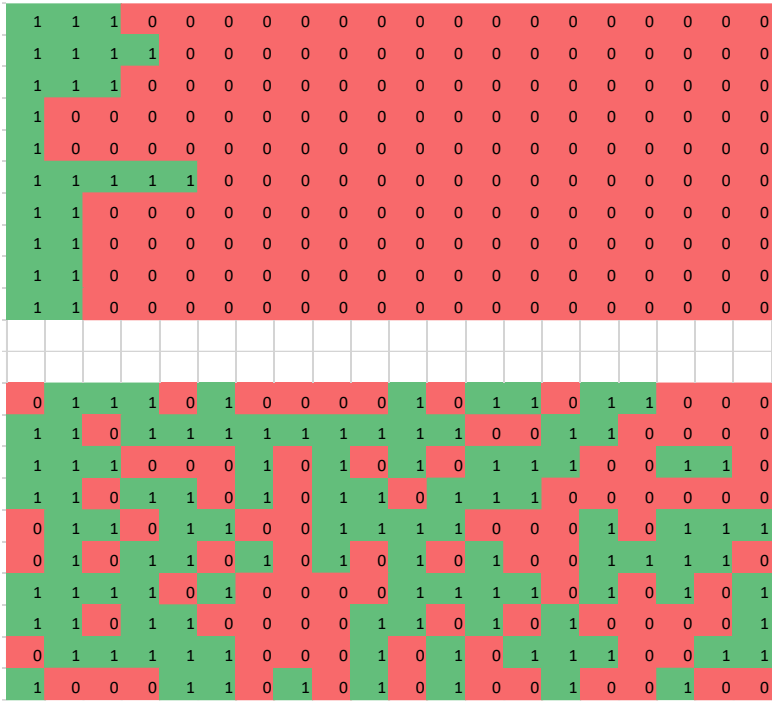
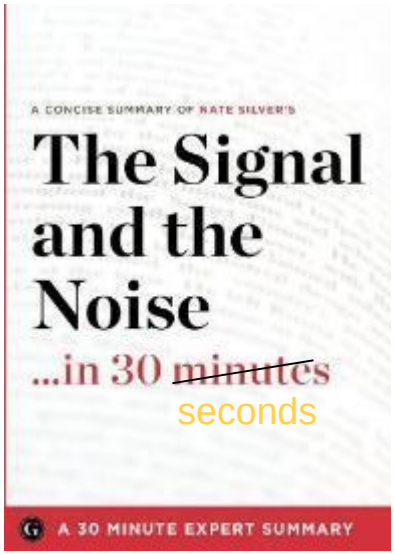
HYDROCARBON SWEET SPOT IDENTIFICATION

Get the signal out of the noise





2 biomarkers

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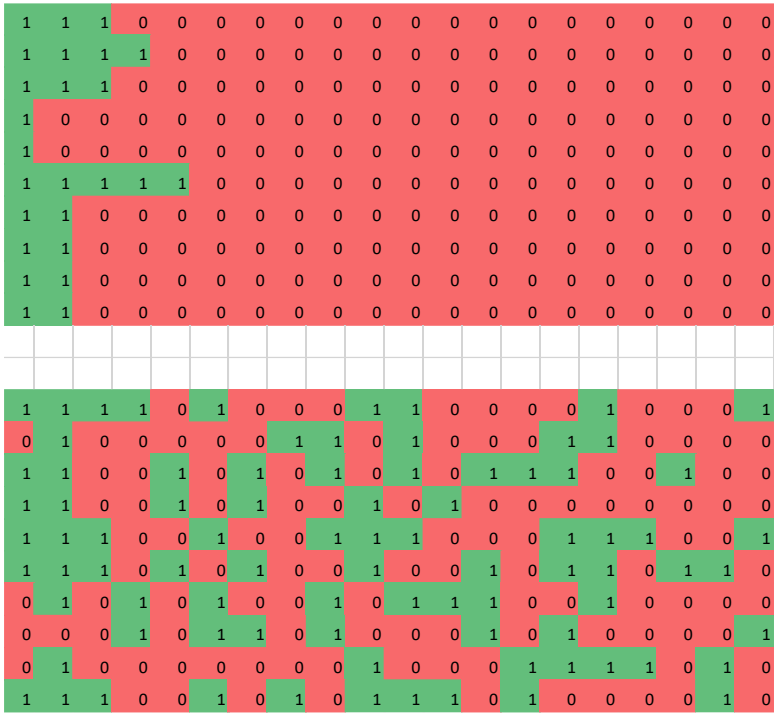
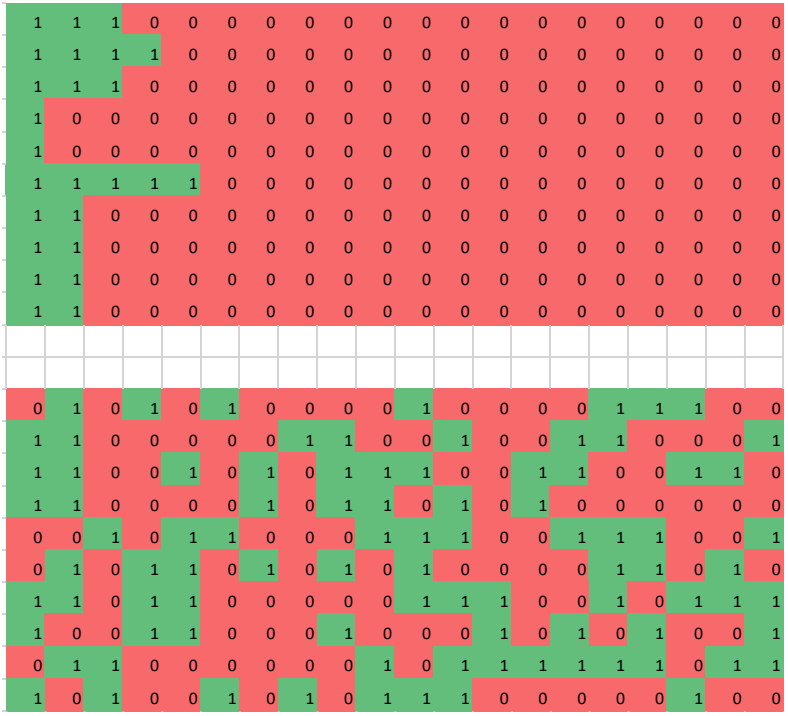


3 biomarkers

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION



4 biomarkers

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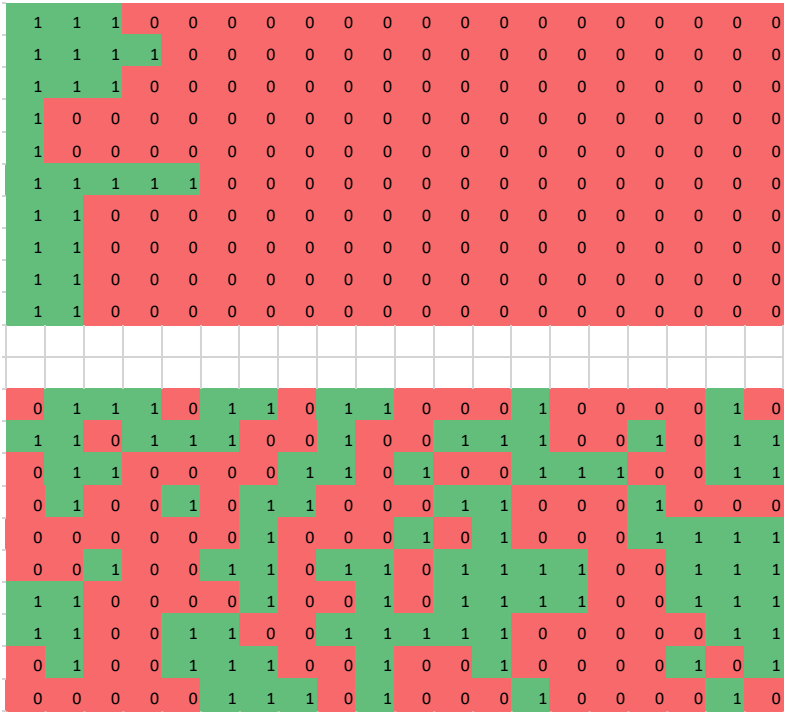
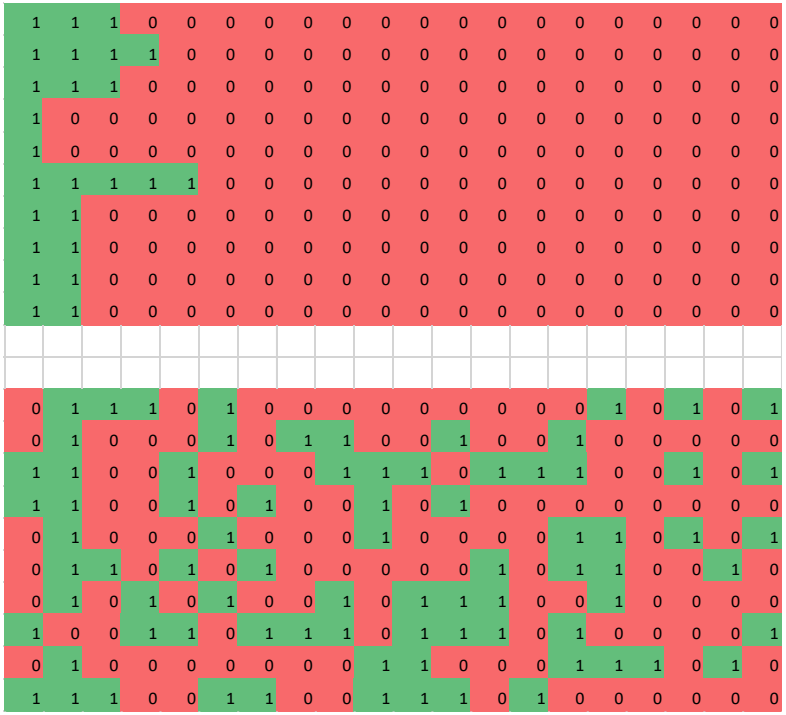
HYDROCARBON SWEET SPOT IDENTIFICATION



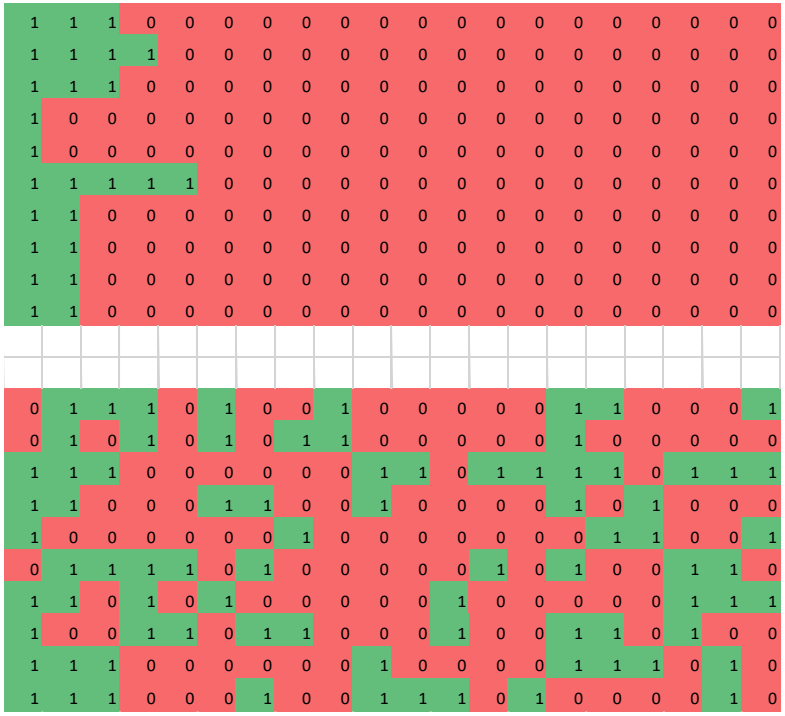
5 biomarkers

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION



10 biomarkers

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION



70 biomarkers

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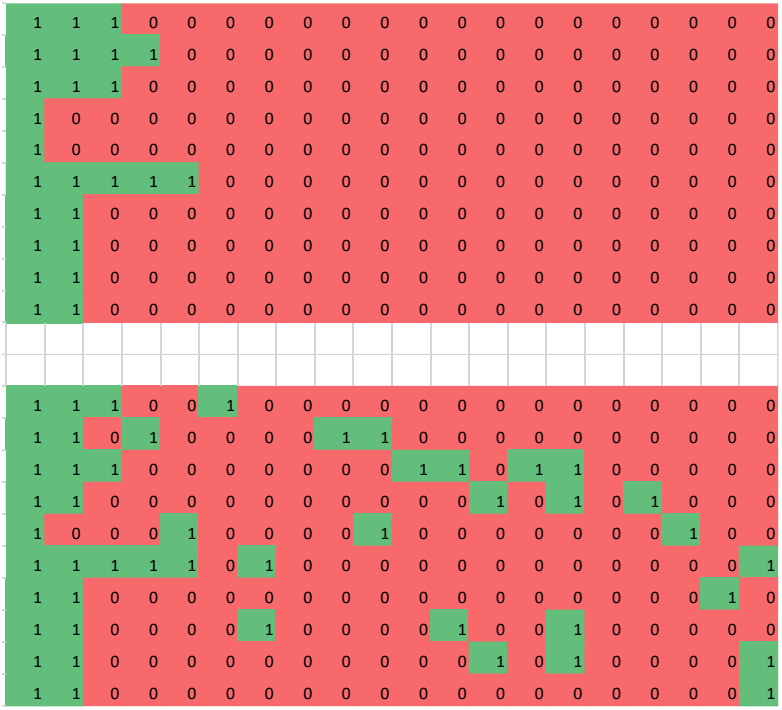
HYDROCARBON SWEET SPOT IDENTIFICATION



70 biomarkers

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION

Machine Learning

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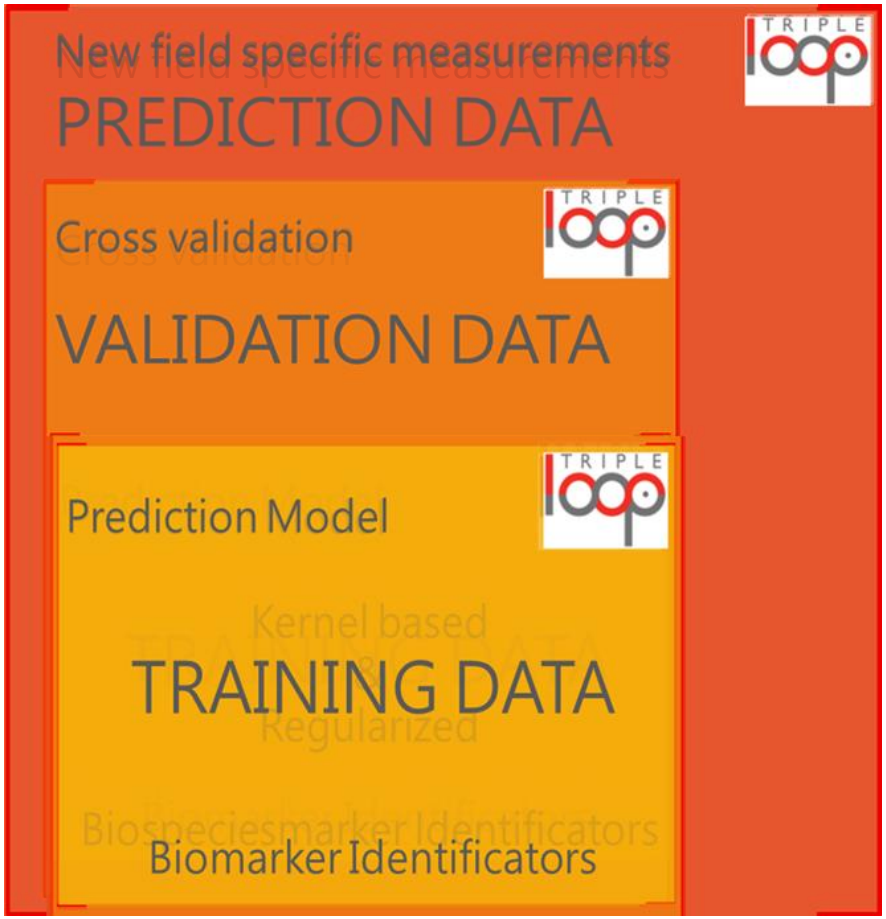

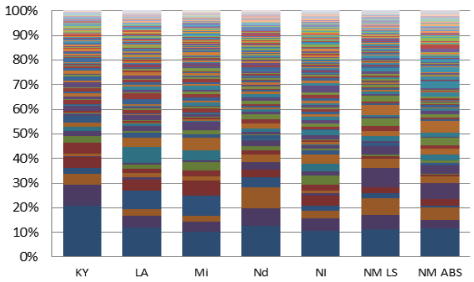

Huge number of biomarkers…

Best predictive model

- Minimize average misfit of N models → ω 's

Dutch North Sea case

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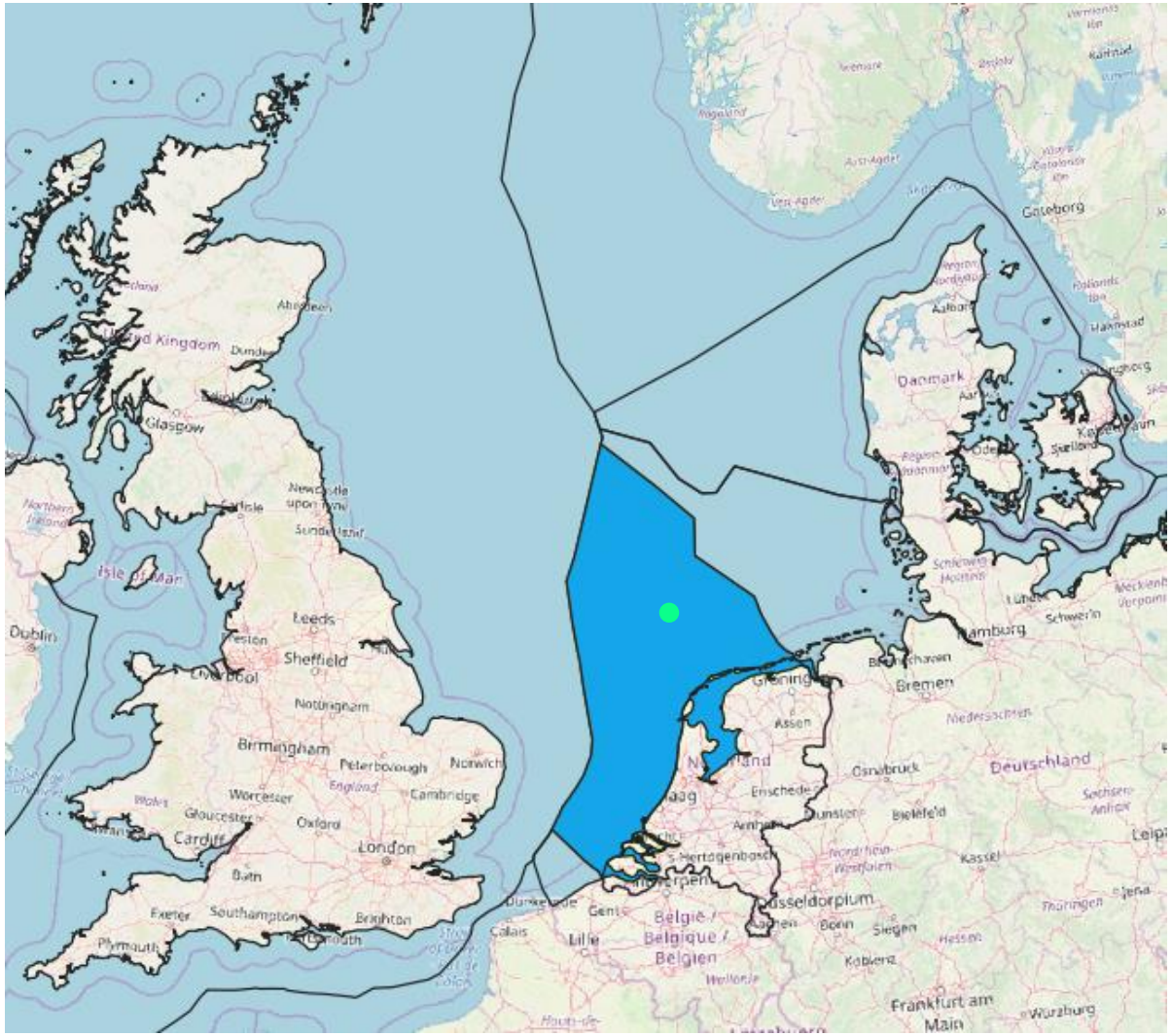
HYDROCARBON SWEET SPOT IDENTIFICATION

2012 Oil field discovery



> 10 Prospects below Salt Domes

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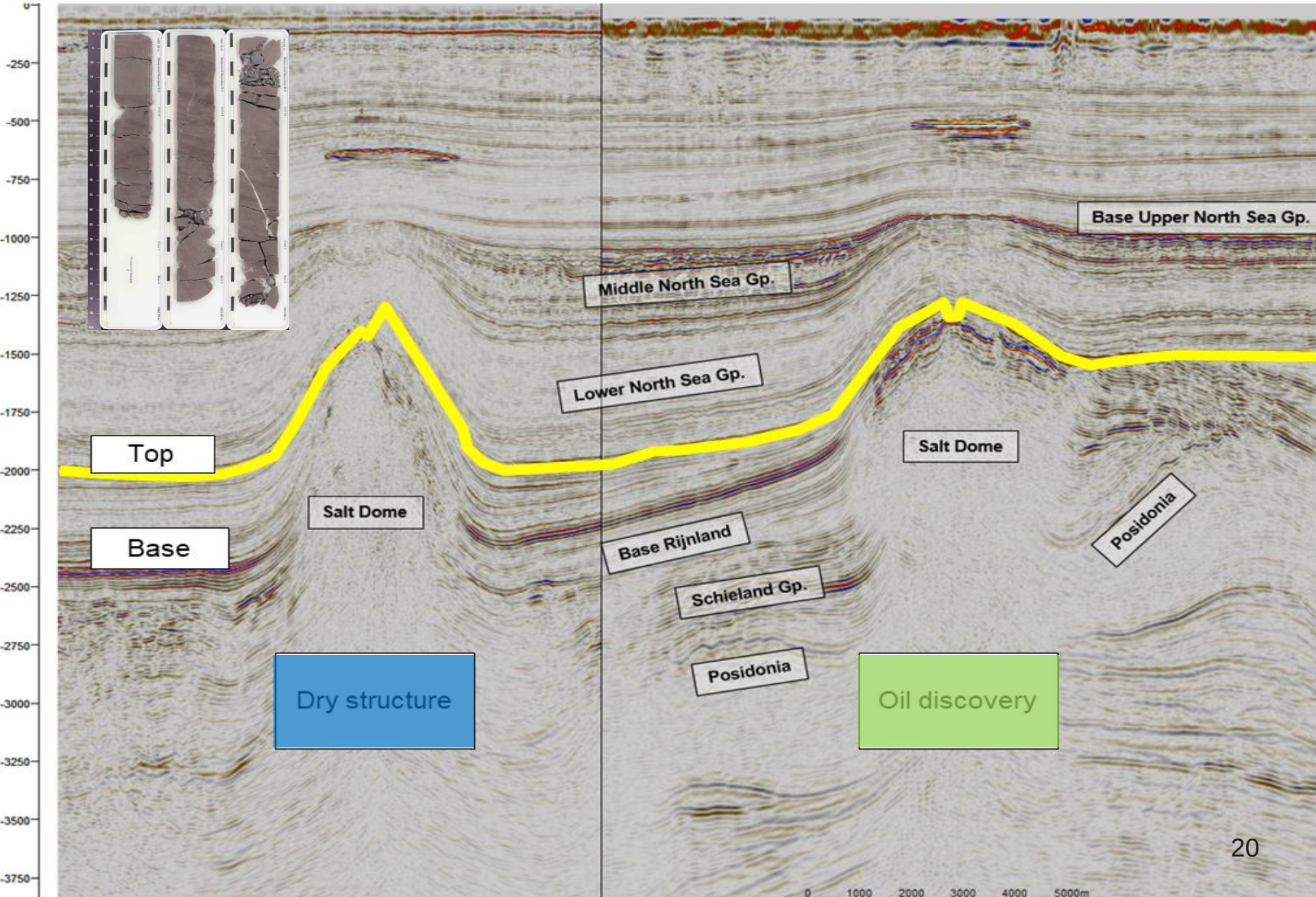

>2500 samples in database for training, but only 54 samples offshore with known prospectivity

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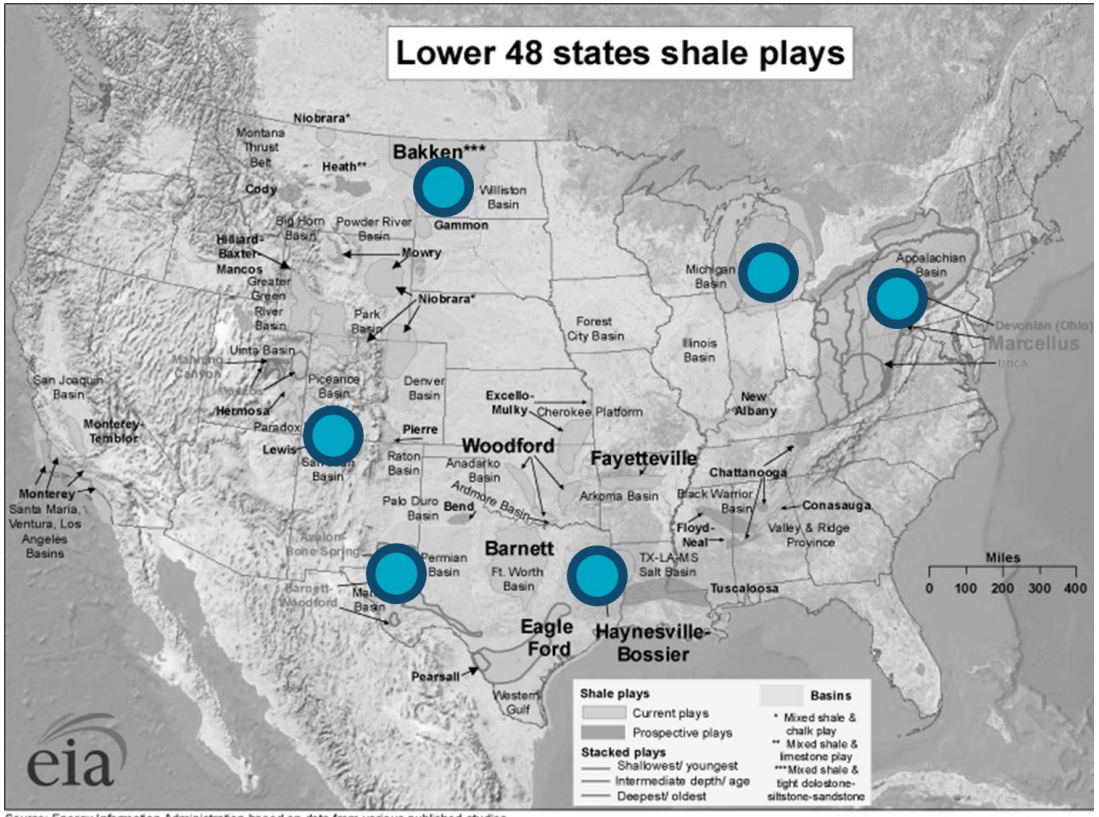
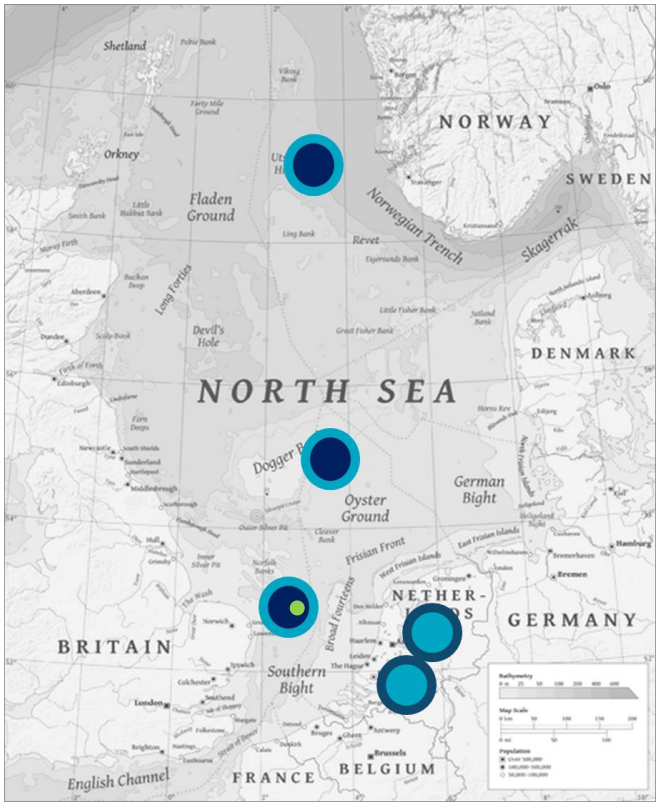
HYDROCARBON SWEET SPOT IDENTIFICATION



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011



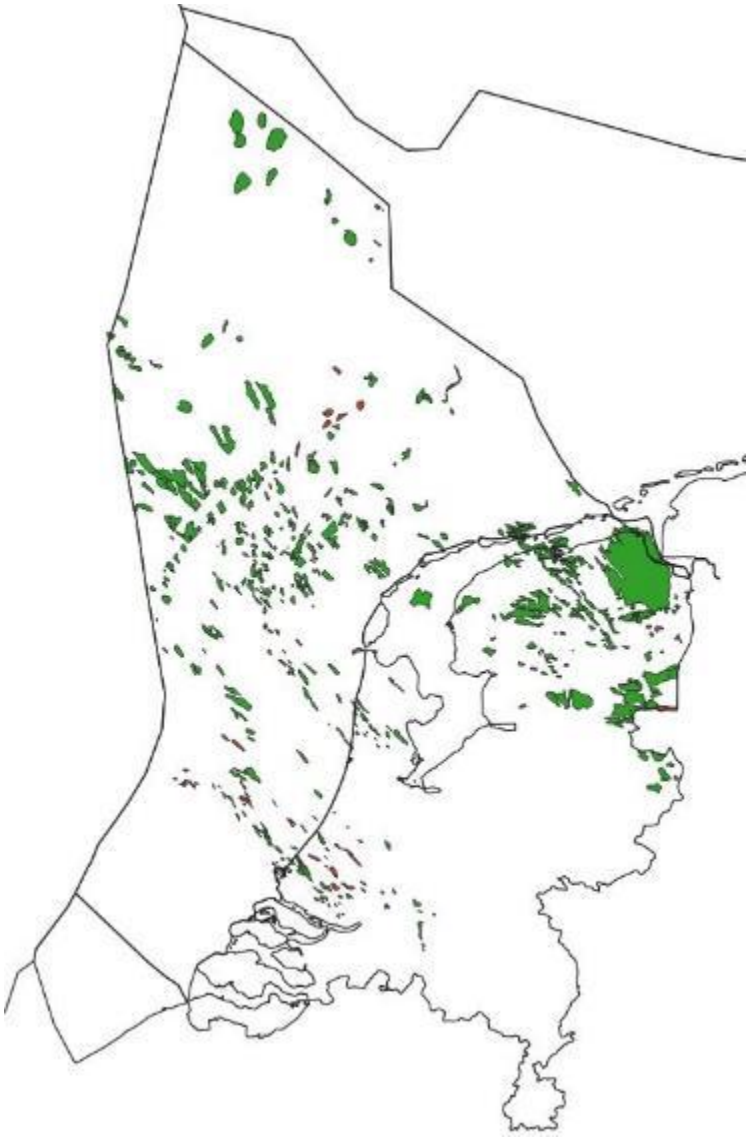
Correlation predictive model

Solution: Use Cuttings of drilled wells

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION

Core shed in Zeist NL

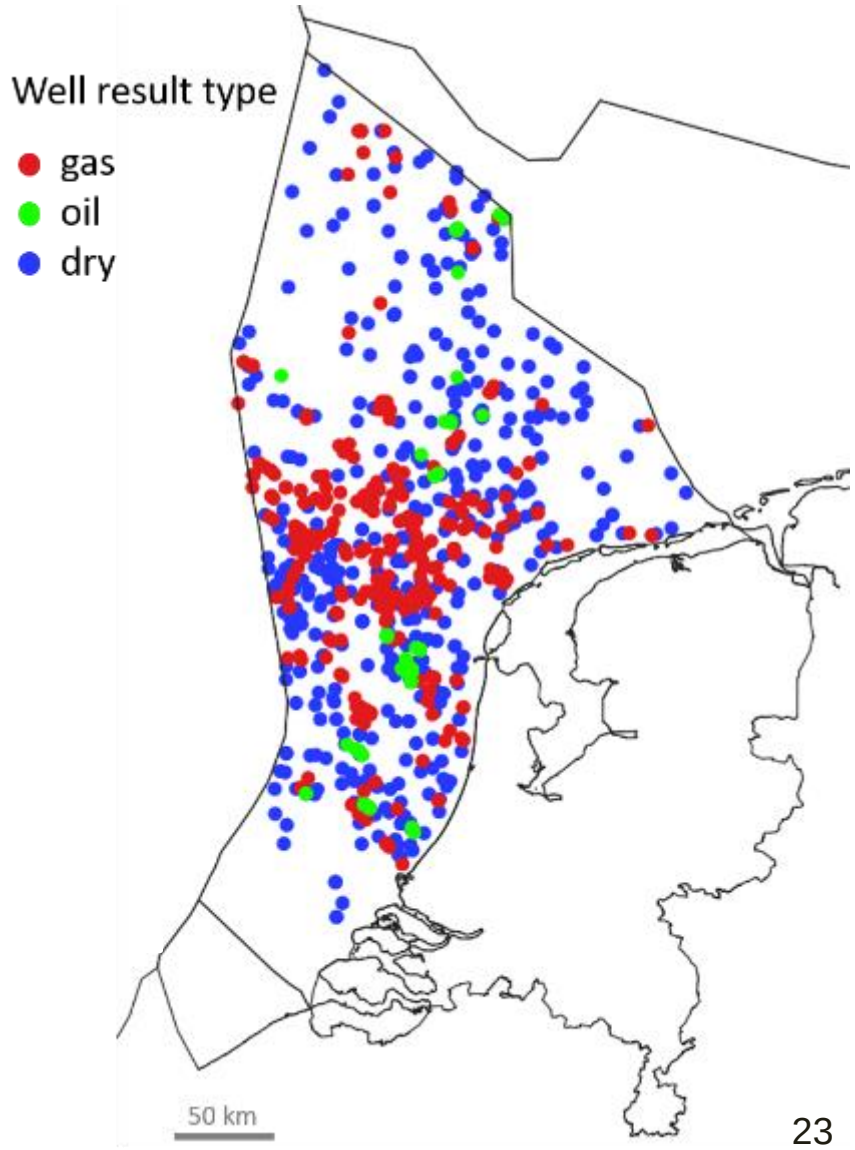
Gas and oil fields



The digital data (2): 1080 locations with known prospectivity from DINO database used for training

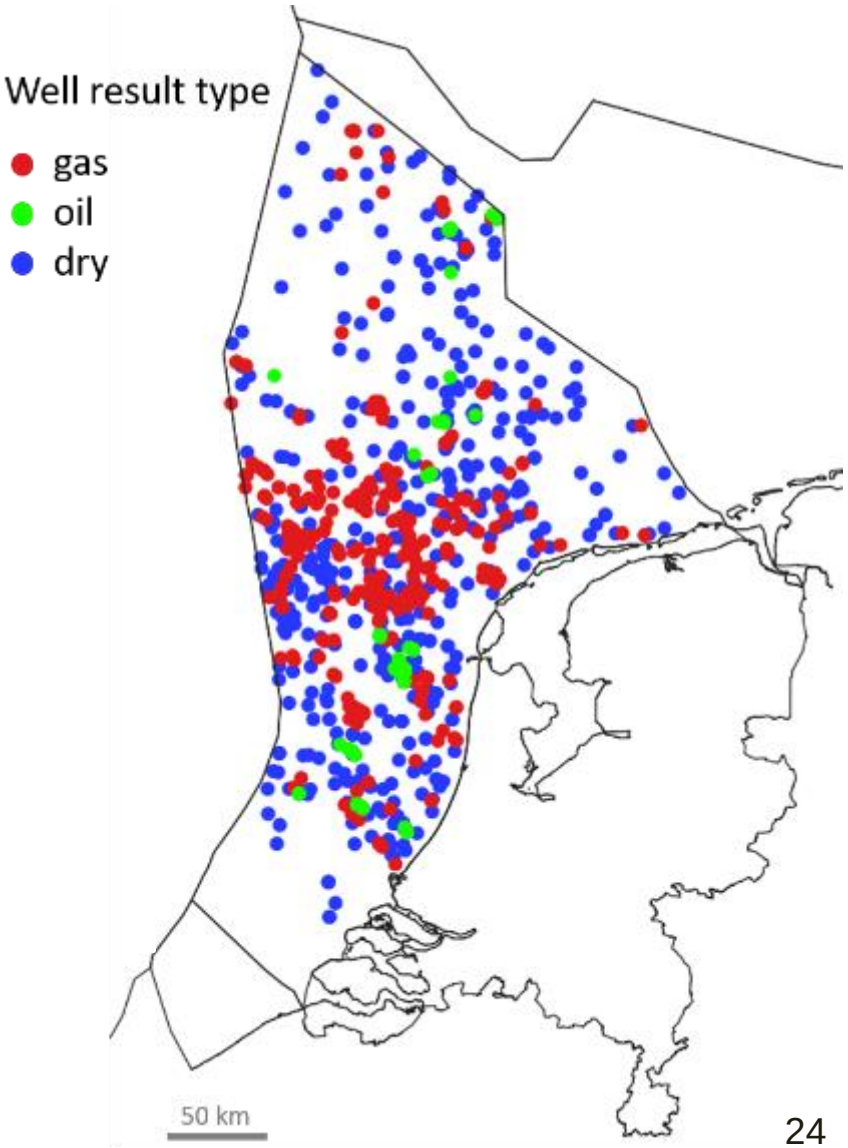
BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION

SHORT_NM	DESCRIPTION	LABEL	x utm	y utm	SET_NI	SAMPL	PRESE
F12-01	Droog	-1	619415	6037565	1A	CUTTINGS	UNWASHE
F12-03	Droog	-1	613385	6027120	1A	CUTTINGS	UNKNOWI
F13-01	Droog	-1	576529	6014269	1A	CUTTINGS	WASHED
F13-01	Droog	-1	576529	6014269	1B	CUTTINGS	UNKNOWI
F14-01	Droog	-1	598453	6006318	1A	CUTTINGS	UNKNOWI
F14-02	Droog	-1	606349	6019471	1A	CUTTINGS	UNKNOWI
F14-03	Droog	-1	605023	6007283	1A	CUTTINGS	UNWASHE
F14-04	Droog	-1	591092	6011154	1A	CUTTINGS	UNKNOWI
F14-05	Olie	2	600615	6014023	1A	CUTTINGS	UNWASHE
F14-06	Olie shows	-1	599798	6006768	1A	CUTTINGS	UNKNOWI
F14-07	Droog	-1	603716	6009457	1A	CUTTINGS	UNKNOWI
F15-01	Droog	-1	626477	6020894	1A	CUTTINGS	UNKNOWI
F15-03	Droog	-1	610865	6011551	1A	CUTTINGS	UNKNOWI
F15-05	Gas	1	618009	6006127	1A	CUTTINGS	UNWASHE
F15-06	Droog	-1	626253	6005234	1A	CUTTINGS	UNWASHE
F15-07	Gas	1	616925	6006356	1A	CUTTINGS	WASHED
F15-08	Droog	-1	622312	6008419	1A	CUTTINGS	UNKNOWI
F15-08	Droog	-1	622312	6008419	1A	CUTTINGS	UNKNOWI
F15-A-01	Gas	1	619231	6009257	1A	CUTTINGS	UNKNOWI
F15-A-03	Gas	1	619235	6009257	1A	CUTTINGS	WASHED
F16-01	Droog	-1	579152	5998768	1A	CUTTINGS	UNKNOWI
F16-02	Droog	-1	587179	5991218	1A	CUTTINGS	UNKNOWI
F16-04	Droog	-1	570680	5991173	1D	CUTTINGS	UNWASHE
F16-05	Gas	1	566050	5992581	1D	CUTTINGS	UNWASHE
F16-A-05	Gas	1	566174	5997104	1D	CUTTINGS	UNWASHE
F16-A-07	Gas	1	566174	5997106	1D	CUTTINGS	UNWASHE
F17-01	Droog	-1	599831	6000912	1A	CUTTINGS	UNWASHE
F17-03	Olie	2	597324	5991546	1A	CUTTINGS	UNWASHE
F17-04	Olie	2	594058	5991405	1A	CUTTINGS	UNWASHE
F17-05	Droog	-1	599207	5991079	1A	CUTTINGS	UNWASHE
F17-06	Droog	-1	598802	5994116	1A	CUTTINGS	UNWASHE
F17-07	Olie	2	595931	5991152	1A	CUTTINGS	UNWASHE
F17-09	Olie	2	597502	5990546	1C	CUTTINGS	WASHED
F18-02	Olie en gas	-1	613213	5993234	1A	CUTTINGS	UNKNOWI
F18-03	Droog	-1	627672	5992754	1A	CUTTINGS	UNKNOWI
F18-04	Gas en olie shows	-1	613368	5997171	1A	CUTTINGS	UNKNOWI
F18-05	Olie	2	613418	5994541	1A	CUTTINGS	UNKNOWI
F18-06	Olie shows	-1	611985	5995501	1B	CUTTINGS	UNKNOWI
F18-07	Olie shows	-1	612881	5995304	1B	CUTTINGS	UNKNOWI
F18-10	Droog	-1	613815	5994071	1A	CUTTINGS	UNKNOWI
F18-11	Droog	-1	625378	5985850	1C	CUTTINGS	WASHED
G10-01	Gas shows	-1	648167	6031271	1A	CUTTINGS	UNKNOWI
G10-02	Droog	-1	651018	6028952	1A	CUTTINGS	UNWASHE
G10-03	Droog	-1	639368	6036109	1A	CUTTINGS	UNKNOWI
G13-01	Droog	-1	646676	6011696	1A	CUTTINGS	UNKNOWI
G13-02	Droog	-1	639442	6005888	1A	CUTTINGS	UNKNOWI
G13-03	Droog	-1	637273	6019564	1A	CUTTINGS	UNWASHE
G14-01	Droog	-1	664756	6008541	1B	CUTTINGS	UNWASHE
G14-02	Droog	-1	661820	6006370	1A	CUTTINGS	UNWASHE
G14-06	Droog	-1	665265	6019260	1A	CUTTINGS	UNWASHE
G16-01	Gas	1	644090	5999997	1A	CUTTINGS	UNKNOWI
G16-02	Droog	-1	637908	5993588	1B	CUTTINGS	UNWASHE
G16-04	Droog	-1	641720	5993261	1A	CUTTINGS	UNWASHE
G16-05	Droog	-1	636626	5986275	1A	CUTTINGS	UNWASHE
G16-06	Droog	-1	643390	5996583	1B	CUTTINGS	UNWASHE



1080 locations with known prospectivity from DINO database used for training

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION



Train with 70% of the data

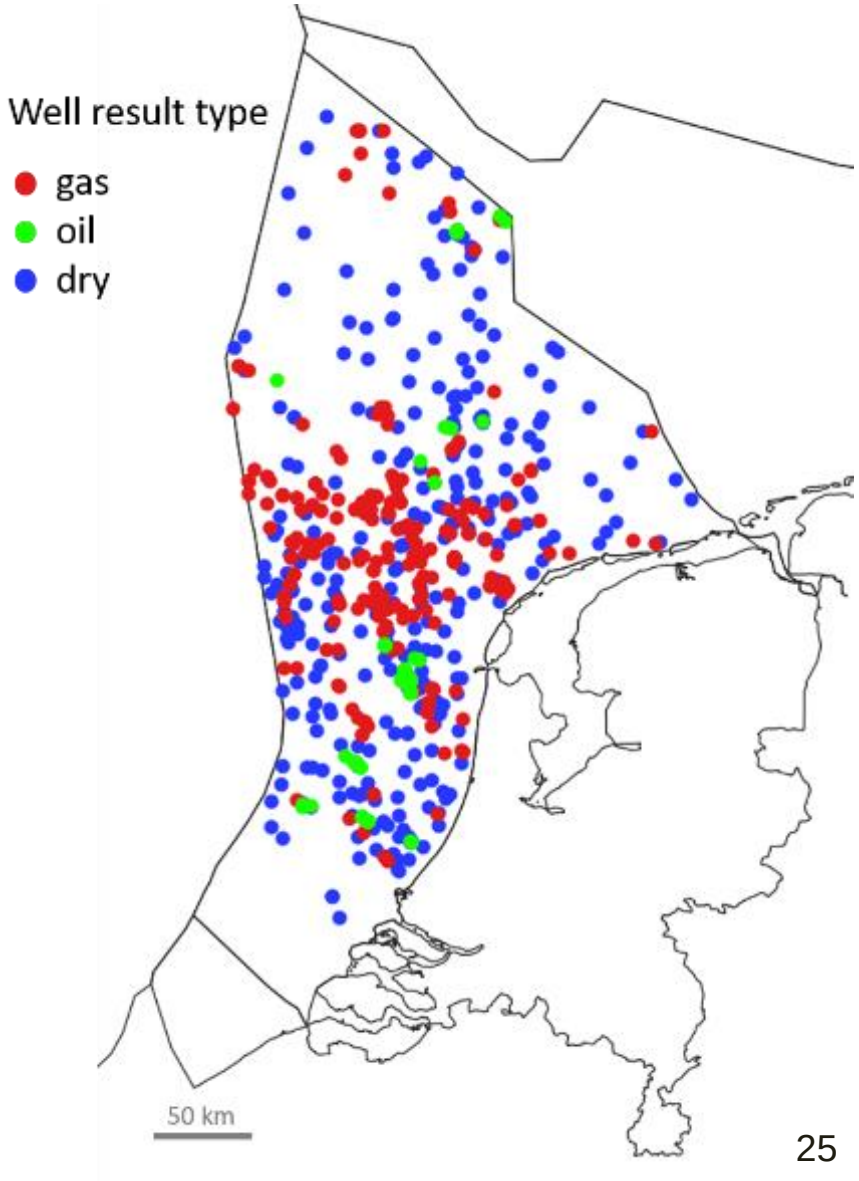
BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION

New field specific measurements
PREDICTION DATA

Cross validation
VALIDATION DATA

Prediction Model
Kernel based
&
Regularized
TRAINING DATA

Biospeciesmarker Identificators
Biomarker Identificators



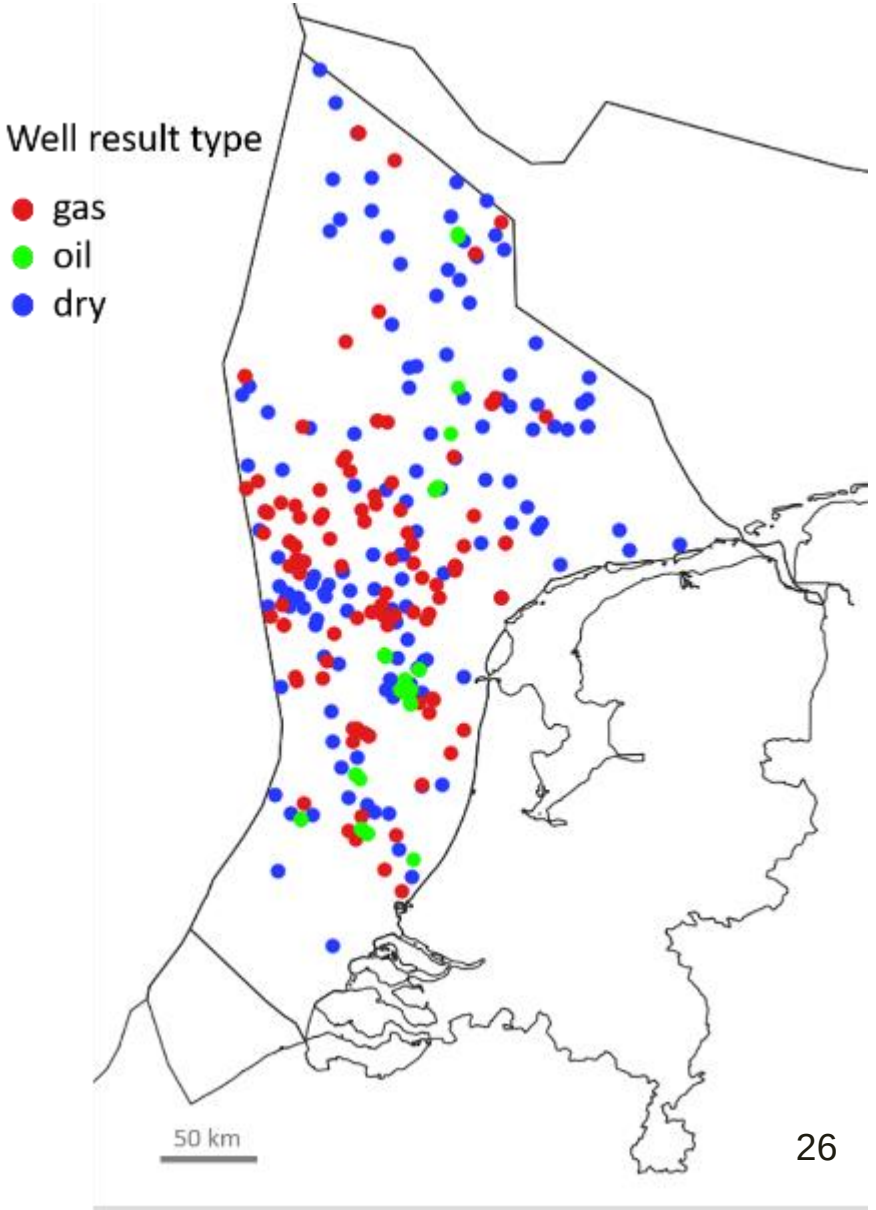
Validate on 30% of the left outs

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION

New field specific measurements
PREDICTION DATA

Cross validation
VALIDATION DATA

Prediction Model
Kernel based
TRAINING DATA
Regularized
Biospeciesmarker Identificators
Biomarker Identificators



Estimated prospectivity of predictions is 83% accurate (non-optimal data)

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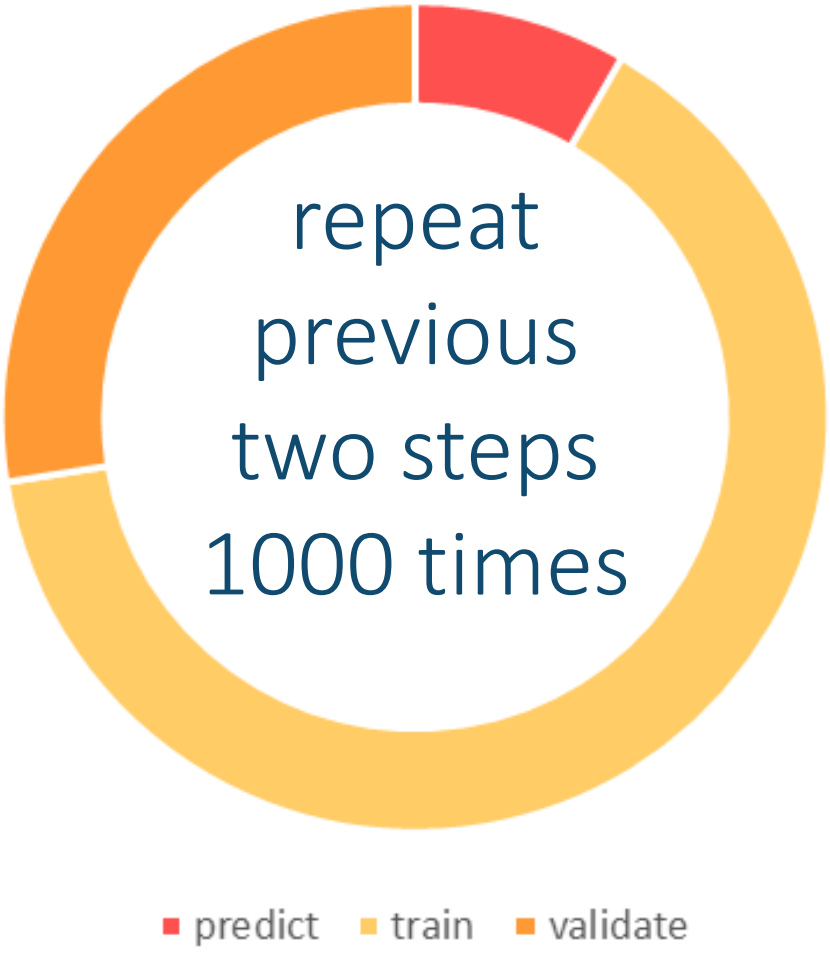
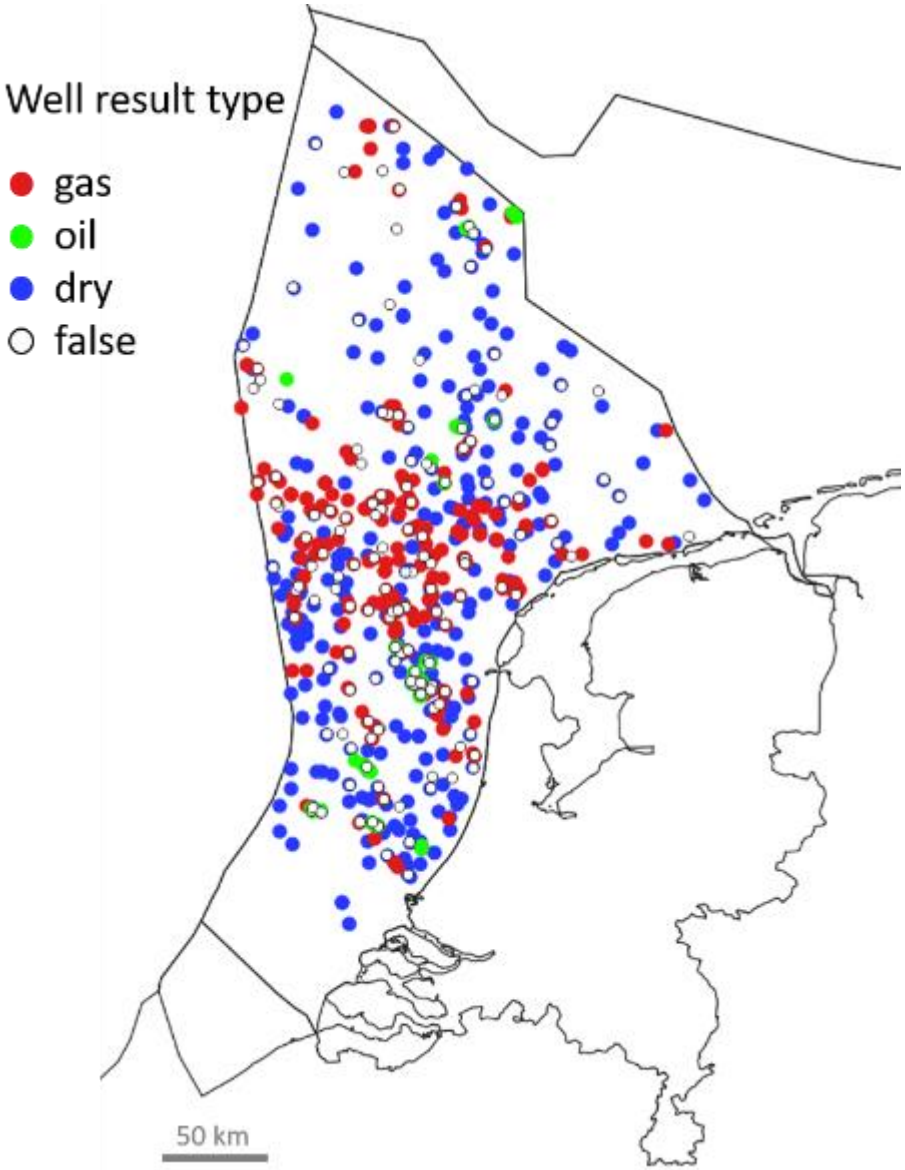
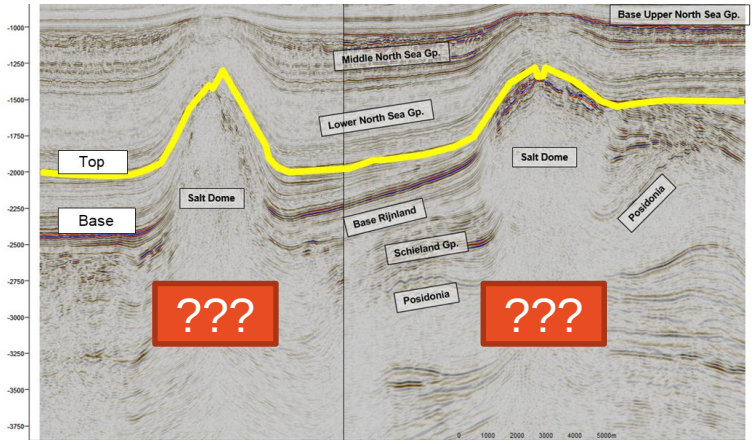
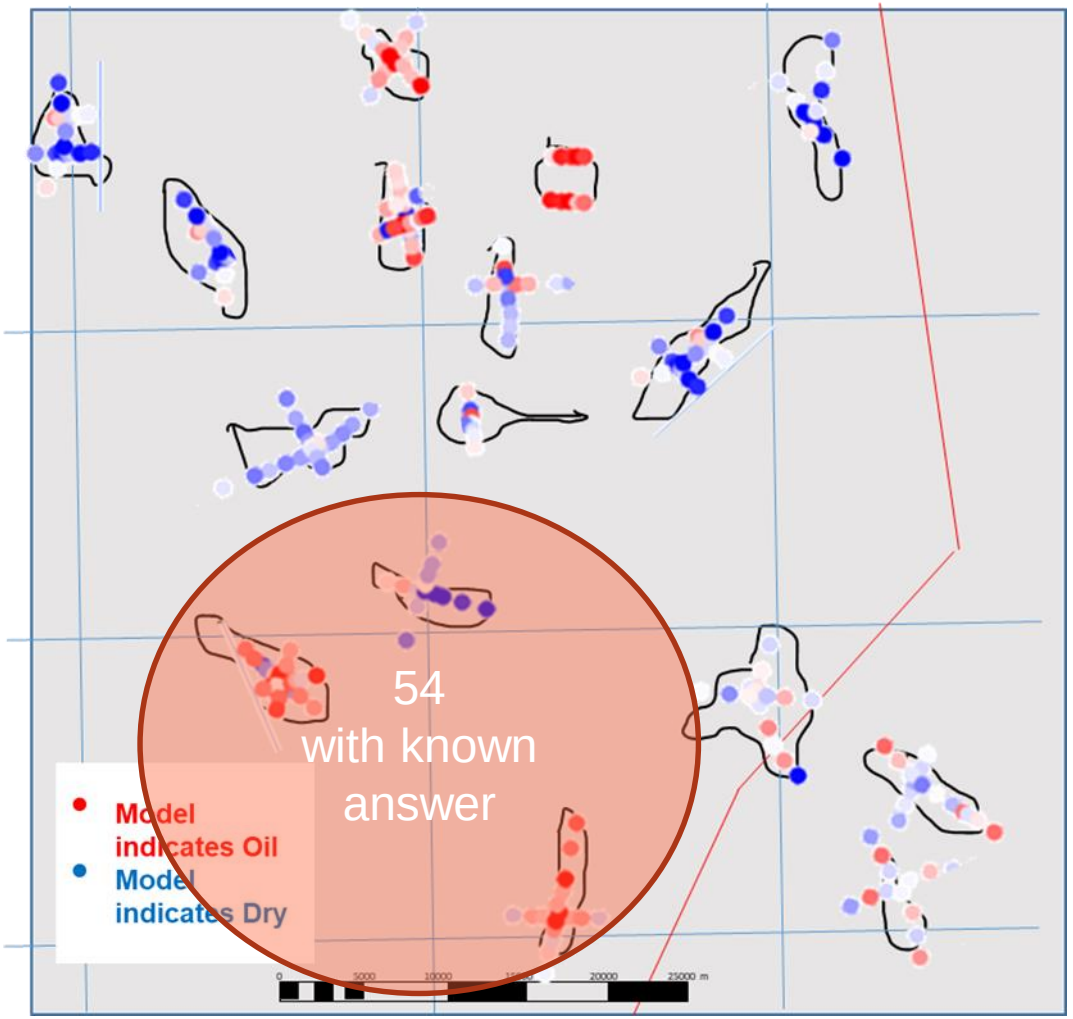




2020: Estimate prospectivity from seabed samples above prospects using 1000 trained models

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION





Estimate prospectivity from vibrocore samples

BIODENTIFY
HYDROCARBON SWEET SPOT IDENTIFICATION

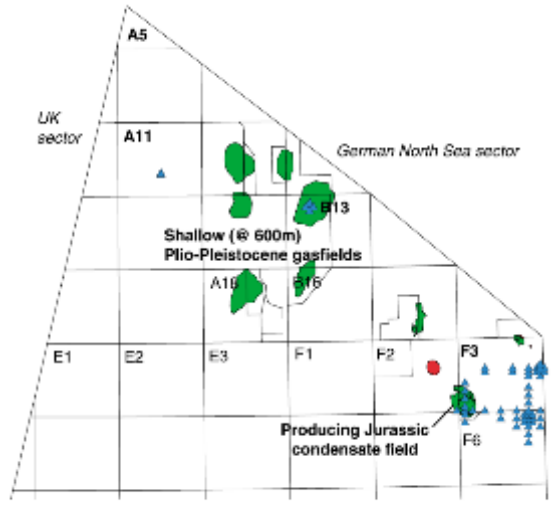


Fig. 2. Part of the study area with the locations of oil, gas and condensate fields; triangles show the positions of the 60 vibrocores taken in 2002.

questions 8-9

Thank you

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DNA fingerprinting and Machine Learning to predict well prospectivity

DNA fingerprints cuttings

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