GEO EXPLORATION TECHNOLOGIES

Information

HYDROSCAN®

Airborne Seismo-Electromagnetics
for Detection and 3D-Imaging of Hydrocarbon Reservoirs

Case Example
Kazakhstan - Onshore Survey

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1 Introduction

HYDROSCAN® is an innovative helicopter-borne passive seismo-electromagnetic exploration technology for detection and 3D imaging of oil & gas reservoir potentiality up to depths of about 5,000m.

The development of the proprietary system is based on research results obtained over oil and gas fields, where it is found that specific low-frequency (LF) electromagnetic (EM) power spectra are largely raised as compared to dry and tight rock mass (Fig. 1).

Thus, a HYDROSCAN survey enables the discrimination between presence and absence of HC content in transmissible (productive) geological structures.

It opens a wide range of highly beneficial usage, from frontier exploration to field extensions, from prospect de-risking to seismic interpretation support, and from optimization of well placement to reservoir time-lapse monitoring.

For all tasks the HC reservoir identification capability includes conventional (anticlinal) traps as well as unconventional non-structural related traps, like occurrences in stratigraphic closures, fault zones, sub-salt and sub-basalt.

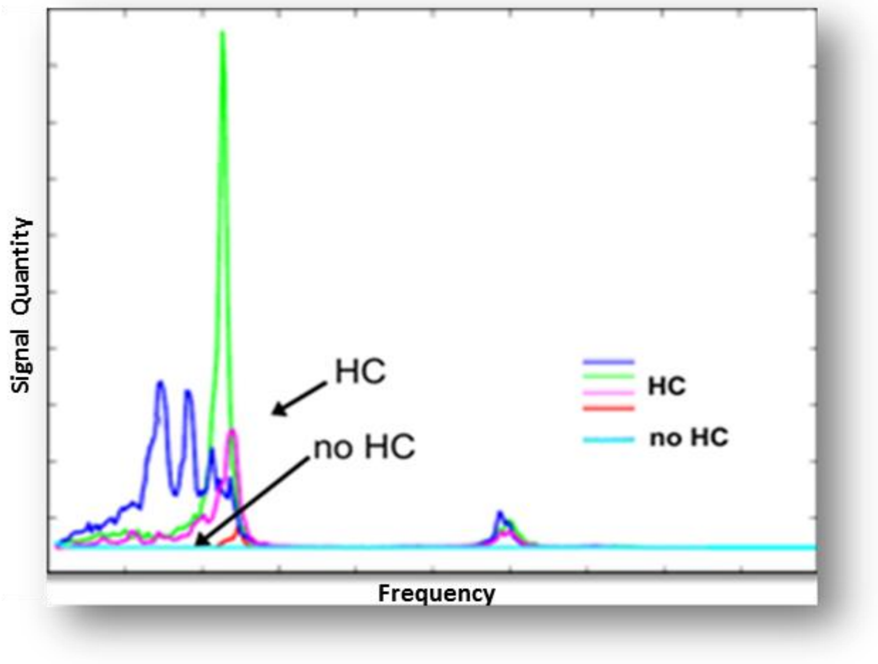

Fig. 1: Typical frequency spectra indicating no-HC and HC reservoir zones at different measuring sites

2 Petrophysical Principle

In general Seismo-Electromagnetics comprises the generation of electrical and magnetic fields in water-saturated porous (fractured and karstified) rocks as a response on seismic excitation.

In consistence with the observed diagnostic data, the following electro-kinetic model conclusively explains origin of the subsurface EM fields associated with HC/brine reservoirs and thereby pointing out the basic principles of the new method (Fig. 2 and Fig. 3):

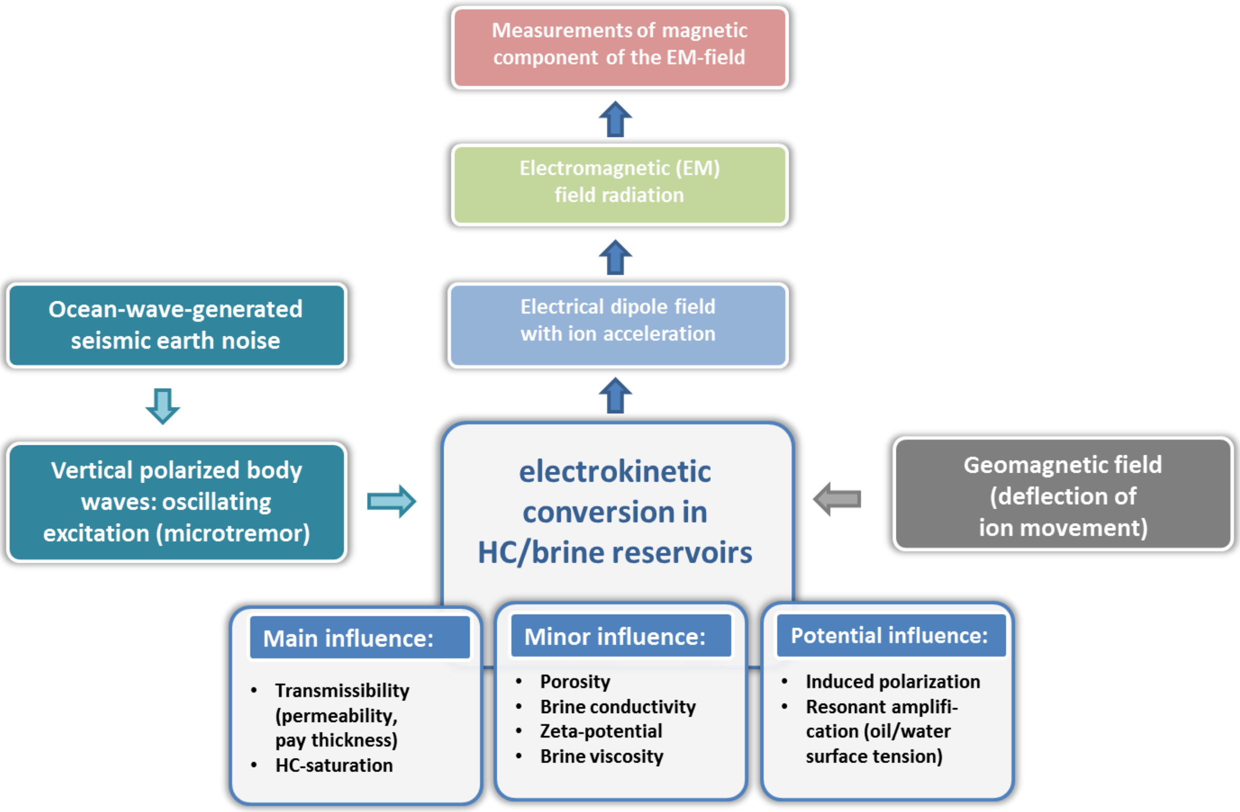

Fig. 2: Process chain and influencing factors of seismo-electromagnetic transformation in HC/brine reservoirs

The primary energy source and external driving force is the global omnipresent seismic background wavefield of the Earth which is generated by ocean waves interacting with the coast structure. At reservoir depths the seismic microtremor excitation results in sub-vertical pore fluid flow including convectional motion of the cations and anions within the brine electrolyte.

These charge carriers are deflected under the influence of the coexisting geomagnetic field into a sub-horizontal conduction current (Lorentz force), thereby provoking opposite path directions of cations and anions.

Driven by the established oscillating electrical dipole field, channelling and curving of the ions around the non-conductive oil droplets and gas bubbles are leading to additional charge acceleration with peeling off EM fields of specific frequency spectra. These are permanently radiating with high speed into the surrounding space and thus the magnetic component can be measured in the air above the earth´s surface.

The electro-kinetic conversion of the seismic wave field to the emitting EM field depends mainly on the HC transmissibility (productivity) of the reservoir formation, which integrates HC-saturation, permeability and net pay thickness.

3 Exploration

The HYDROSCAN airborne system consists of a special adapted high performance data acquisition instrumentation for seismo-EM onshore and offshore survey operations (Fig. 3).

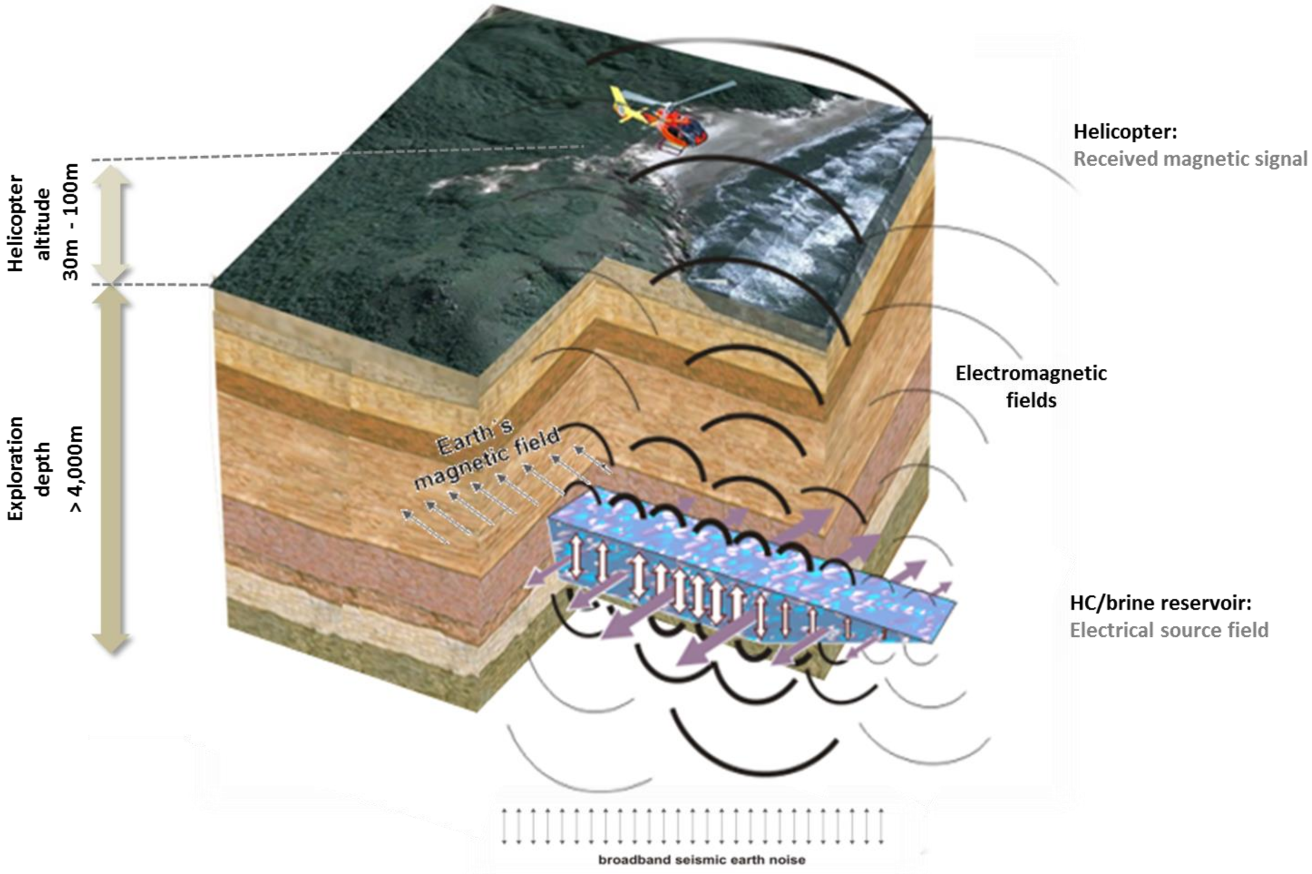

Fig. 3: Principle of helicopter-borne seismo-electromagnetic HYDROSCAN survey

The exploration procedure comprises

- continuous automatic measurement of the magnetic component of the EM field while slow and low flying along parallel survey lines of spacing 100m for detailed 3D surveys and spacings of about 400m for reconnaissance surveys,
- pre-processing leads to a distribution map of the received signal power which reflects the total sum emitted from all subsurface HC pays at different depths (Fig. 4),

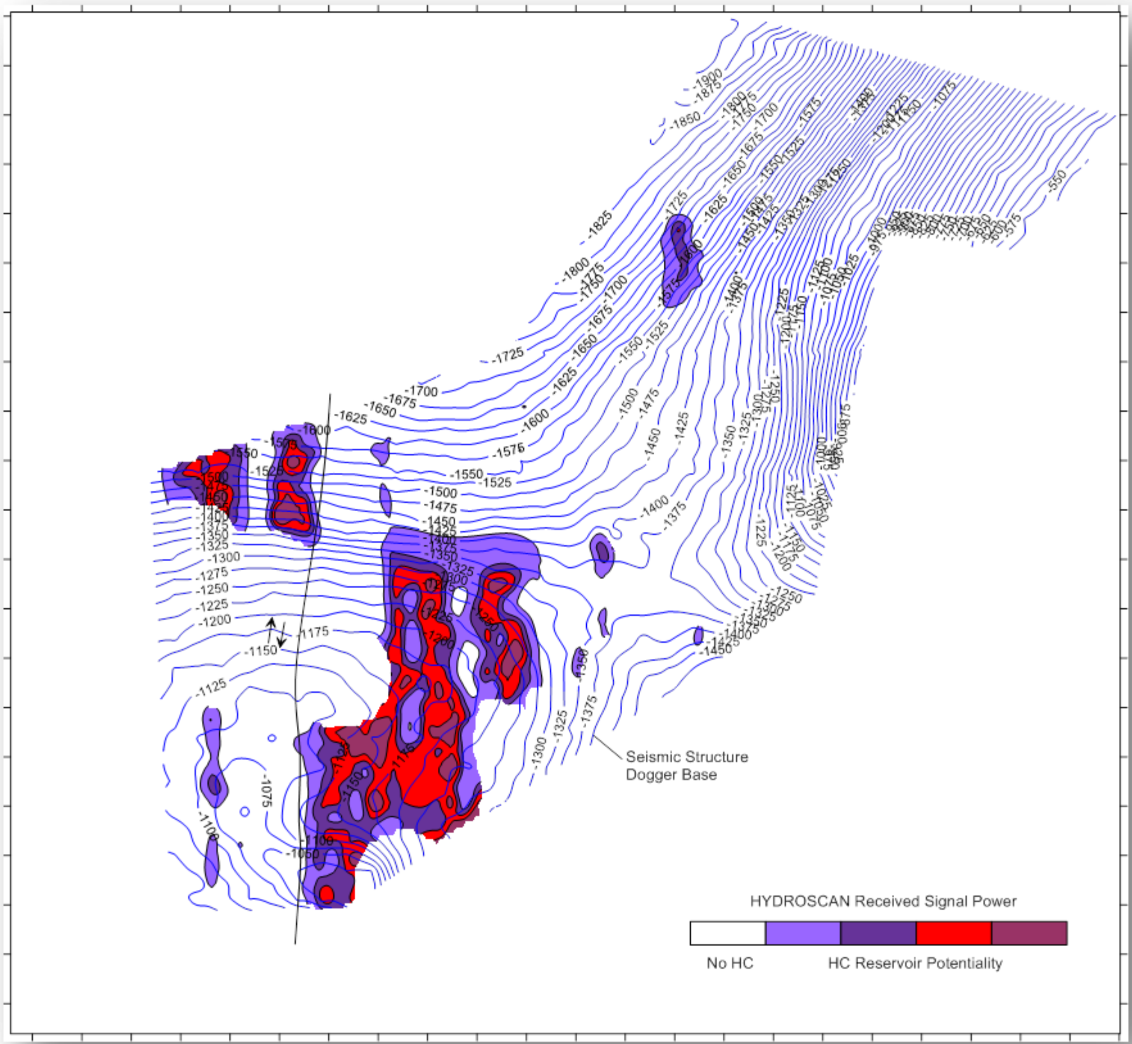

Fig. 4: Typical visualization of pre-processed receiving signal power of hydrocarbons based on HYDROSCAN method data combined with provided 2D reflection seismic data (Dogger base)

- 3D inverse modeling processing based on electromagnetic Maxwell equations, regularization techniques and finite element simulation (Fig.5a): providing reconstruction of the electrical source fields presented within depth slice contour plots for anomaly-indication, spatial distribution (anomaly depth center, multiple pays) and relative productivity interpretation of HC reservoir sources (Fig. 5b).

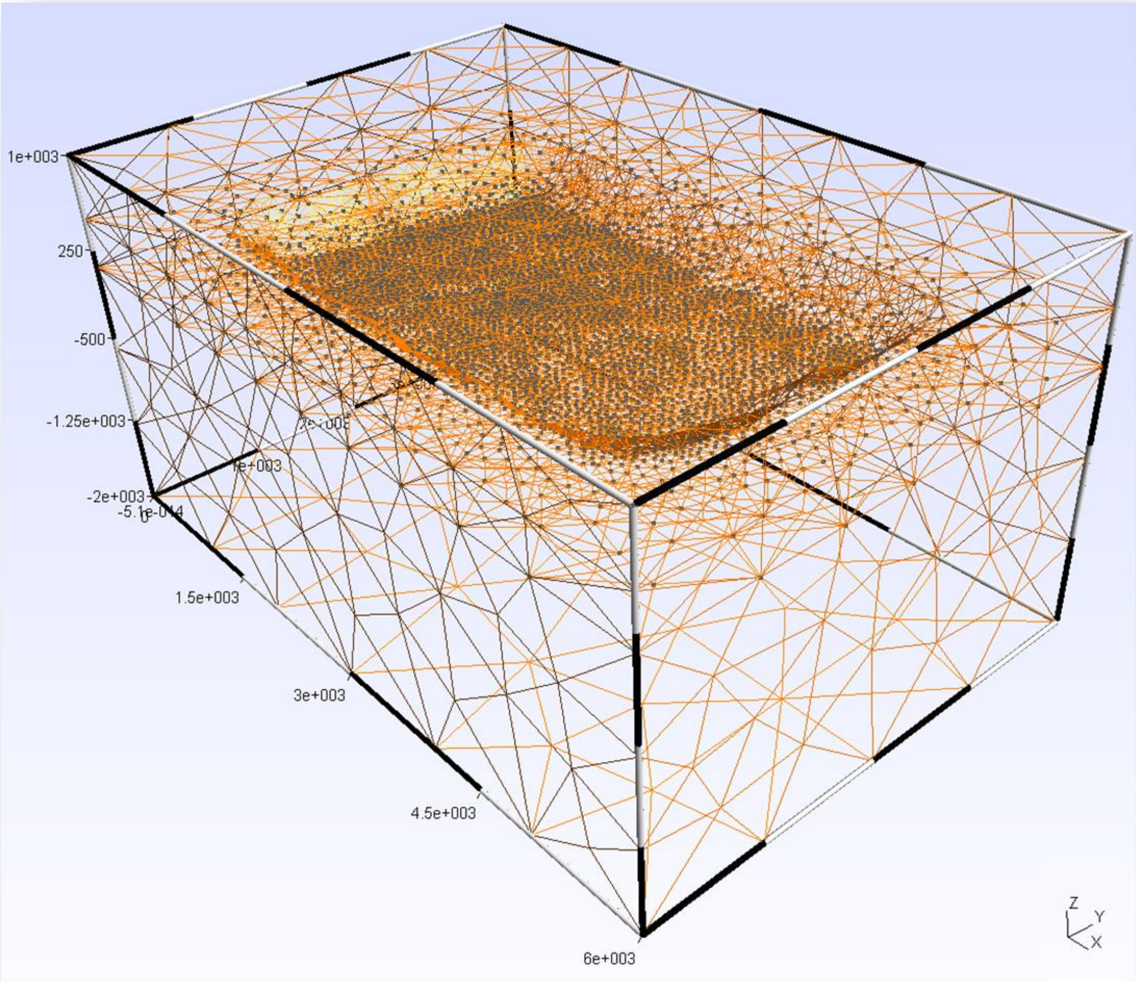

Fig. 5a: 3D FE mesh generation as basis for HYDROSCAN inverse modelling simulation

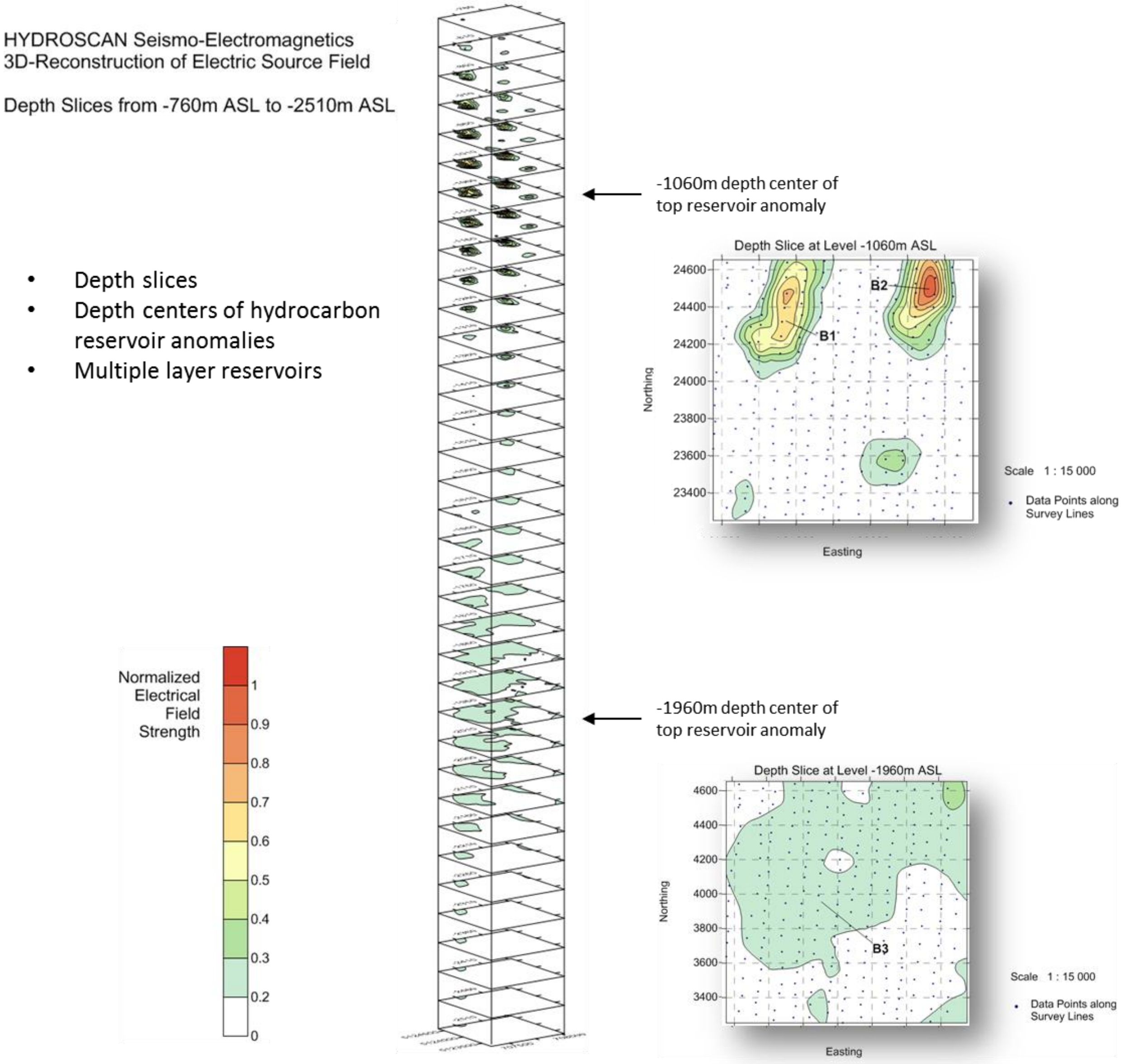

Fig. 5b: Proprietary HYDROSCAN 3D inverse modeling for spatial HC reservoir potentiality identification

4 Case Example: Onshore Survey - Kazakhstan

As part of an exploration campaign within an unproven area in Kazakhstan several HYDROSCAN surveys have been carried out.

Based on the obtained results most of these areas are lacking any HC potentiality. This is also true for most of the Z-area (Fig. 6) which is confirmed by the dry 2,100m deep well WZ1 (positioned before HYDROSCAN survey).

GEO EXPLORATION TECHNOLOGIES

But at the northwestern rim of the measured Z-area one main anomaly zone (Z1) of enhanced electrical source signal could be detected and reconstructed by 3D inverse modeling, providing anomaly depth centers at about 850m and 1,100m.

Thus concluding the presence of a HC reservoir which might be the eastern part (OWC) of a larger oil field.

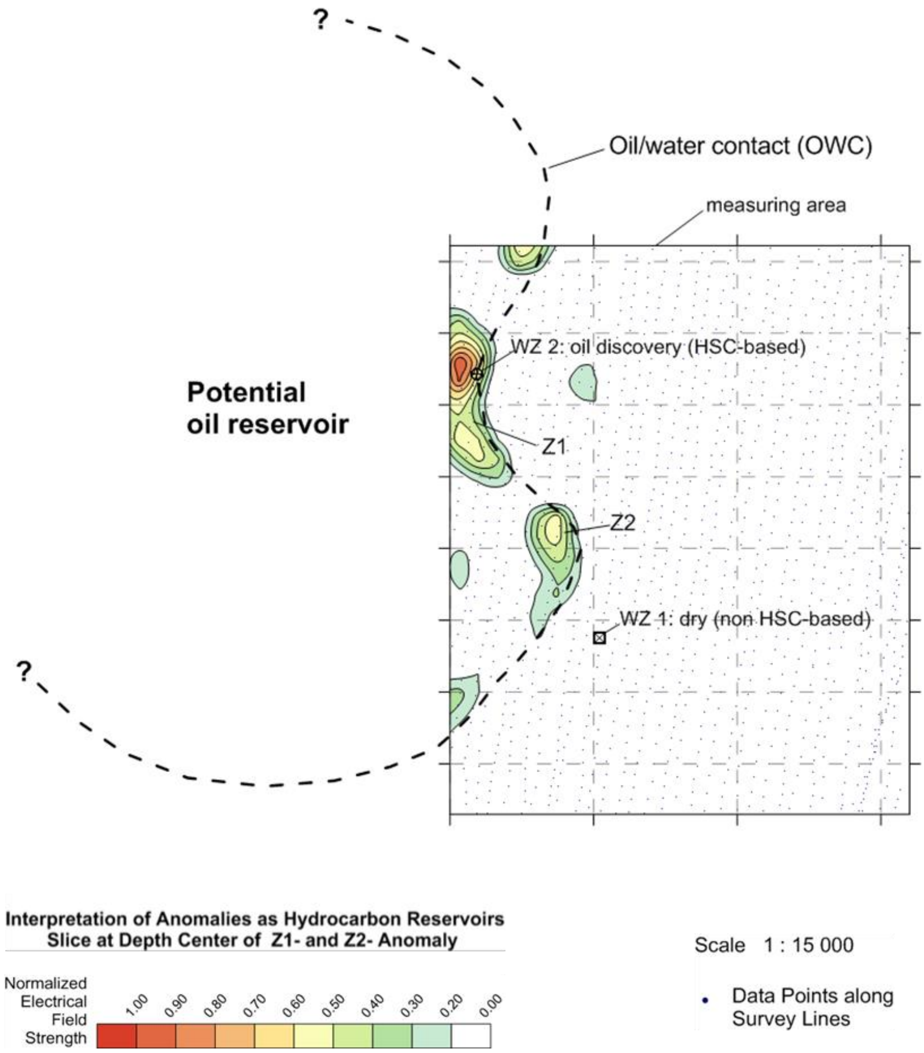

Fig. 6: Results of HYDROSCAN survey and Wild Cat drillings in Z-Area Kazakhstan

The prediction was confirmed by the second wild cat drilling WZ2 (on Z1-anomaly) which discovered several oil-bearing zones between 625m and 1,115m depth within a complete sandstone reservoir package exhibiting 25 – 30% effective porosity.

Another area was investigated as a blind test which means only the customer knows location and results of wells in this field (Fig. 7). The comparison between HYDROSCAN results and well data, subsequently provided by customer, confirms a 100% matching quote for the five productive wells as well as for the two dry wells.

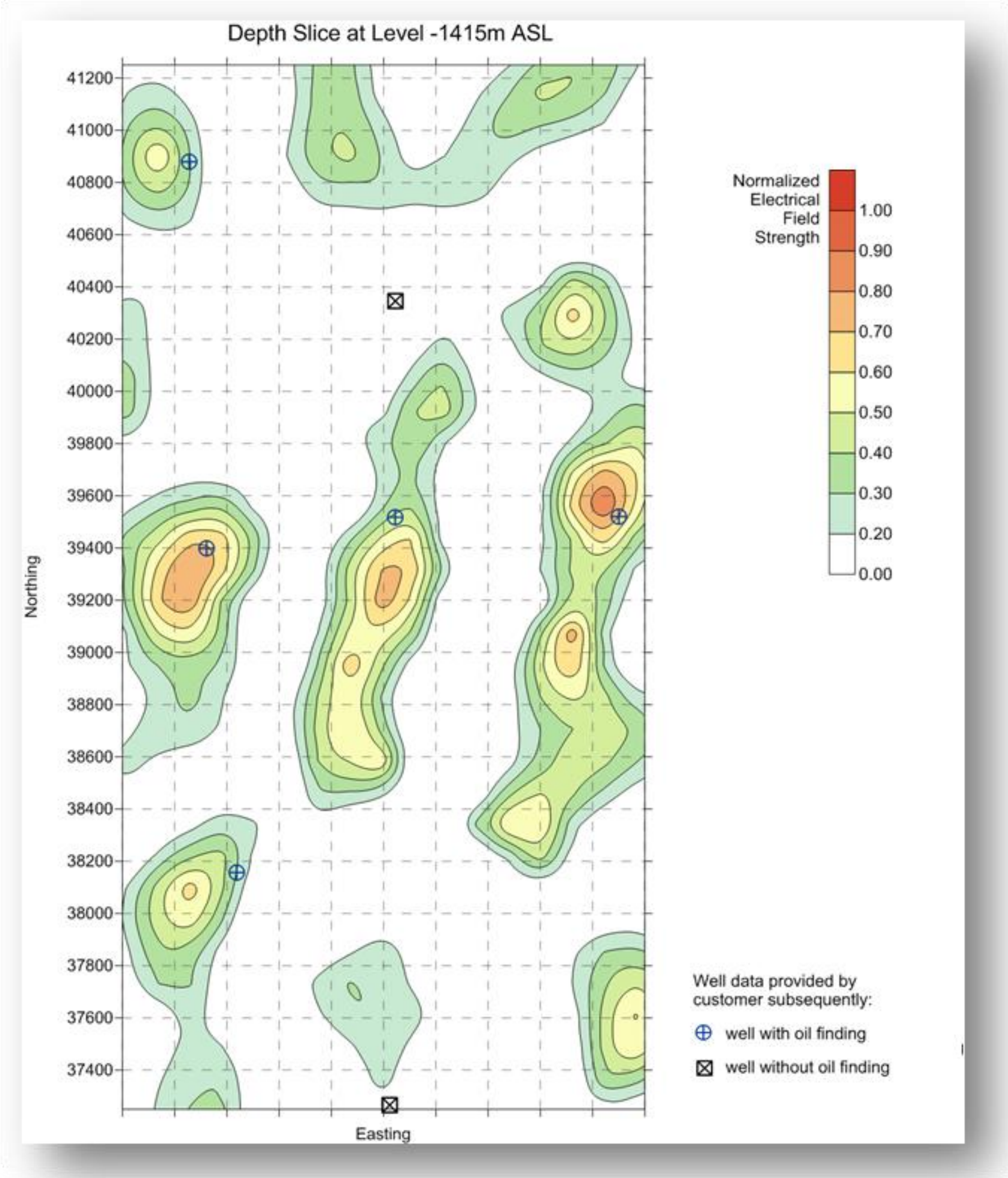

Fig. 7: Results of HYDROSCAN survey in proving ground K-Area Kazakhstan

5 Benefits

A HYDROSCAN survey provides considerably advantageous and efficient features, such as

- discrimination between presence and absence oil & gas reservoirs
- 3D Inverse Modeling for depth estimation and multiple pay layer indication
- efficient risk reduction, thus providing added-value information for geologists and geophysicists
- no geographical / surface / infrastructure related constraints,
- no environmental limitations,
- no need for ground permitting,
- no need for extensive time-consuming ground-based measurement setups including transportation of equipment and cables,
- quick turn-around from preparation through data acquisition and processing to result delivery with final report.

Accuracy of HYDROSCAN Exploration		
Dry well avoidance	> 80%	Indication of HC absence
HC detection ability	> 80%	Sensitivity for transmissible (productive) HC reservoir zones
Lateral HC location	> 80%	Resolution controlled by survey line spacing
Multiple reservoirs	+	Identification by spatial anomaly differentiation (3D inverse modeling)
Depth of HC reservoir	+/- 10%	Deviation between actual depth and model (anomaly) depth centre
Net pay thickness	Integration, diffuse	Vertical anomaly extension is larger than pay
Detection capability limits	> 0.3 Darcy-m/ > 0.003 Darcy-m	Oil transmissibility/ Gas transmissibility (Parameter comprising permeability, net pay thickness and HC-saturation)

All seismo-electromagnetic results acquired by GET´s helicopter-borne technology have been proven empirically by comparison to data of more than 50 productive and dry wells till May 2015, confirmed either by client or published by German Authority of Mining, Energy and Geology.