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Reservoir Characterization in Concession C97-I, Eastern Sirt Basin, Libya

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وصف صخور المكمن بعقد الامتياز (C97-I) شرق حوض سرت – ليبيا

لوكا دي فينسينزى وزياد أيوب

يمثل عدم تجانس جيولوجية المكمن بعقد الامتياز (C97-I) مفتاح التحدي فالحجر الرملي ذو النشأة النهرية التابع للجزء العلوي من تكوين السرير الرملي (الكريتاسي المبكر) والحاوي للنفط قد حلت محله وبشكل جزئي تتابعات بركانية مصمتة على هيئة تداخلات من رواهص الفتات البركاني أثناء وبعد فترة ترسيب هذه الصخور الرملية وهي الآن موجودة على عمق 12000قدم. تميزت المرحلة الأولى من الثوران البركاني الغني بالغازات بتوضع الفتات البركاني وتبعه في مرحلة ثانية نشاط ناري على هيئة طفوح بازلتية وقواطع ومتوافقات بركانية. وتأثرت رواسب الفتات البركاني بالطين البركاني والتي تمثل تدفقا حطاميا لرواسب أرضية وانهيارات وتدفقات طينية تكونت أثناء تلامس الحطام البركاني الساخن بمياه خارجية (بحيرة فوهة البركان، أمطار غزيرة) ثم انهالت إلى الأسفل تحت تأثير وزنها ولمسافة العشرات من الكيلومترات في بعض الأحيان.

وبالنظر إلى الأحداث البركانية سالفة الذكر بالمنطقة فقد وجد لدينا ثلاثة مناطق بركانية وهي: براكين مركبة وفتات بركاني وبازلت، وتفرعات من القواطع والمتوافقات البازلتية، ورواهص من الطين البركاني.

ولهذا الحد فقد مكن الحصول على المعلومات التقليدية وتحليلها (الموجة الأولية ومسح ثلاثي الأبعاد وتحويلات آثار تغيير الكتلة والسحنات السيزمية وتحليل المعلومات بالشبكة) من اكتشاف تواجد البازلت ولكنها لم تفلح في التمييز بين الفتات البركاني والحجر الرملي أي المكمن. تم اختيار سرعة الموجة القصيرة والمقاومة كخواص طبيعية تسمح بالتمييز بين الفتات البركاني وصخور الحجر الرملي. وتعتبر خاصية التمغنط ومساعدة الجاذبية والمغناطيسية التقنية المناسبة لدمج أفضل أثناء المعالجة والتفسير والسيزمية ثلاثية الأبعاد. أكدت الدراسات التمهيدية المحتملة إمكانية نجاح المشروع وعرّفت أفضل المعايير للحصول على المعلومات الجيوفيزيائية.

Abstract: *The key challenge in Concession C97-I is the heterogeneous geology of the reservoir: the oil-bearing fluvial sandstones of the Upper Sarir Sandstone Formation (Lower Cretaceous) being partly substituted by a tight volcanic sequence. Volcanism took place during and immediately after the deposition of these sandstones with intercalation of volcaniclastic conglomerates and basalt (volcanoes, sills, and dykes) currently at a depth of 12,000 ft. A first volcanic phase of gas-rich eruptions characterized by deposition of pyroclastics was followed by a second phase consisting of basaltic flows, sills, and dykes. The pyroclastic sediments were affected by lahars, which are matrix-rich debris flows, landslides and mud flows formed when hot pyroclastic debris comes into contact with external water (crater lake, very heavy rainfall) and then slides downward under its own weight at times for tens of kilometers.*

Due to the afore-mentioned volcanic events in the area we have the presence of three volcanic occurrences: volcanic complexes with volcanic-lastics and basalts, sills and dykes swarms of basalt and volcaniclastic laharic conglomerates.

So far, conventional seismic acquisition and processing (P-wave 3D survey, offset volumes trace inversions, seismic facies and neuronal network

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analyses) have managed to detect the presence of basalt, but have failed to discriminate volcanoclastic conglomerates from sandstones, i.e. the reservoir. S-wave velocity and resistivity wereselected as physical properties, which allow to differentiate between volcanoclastic and sandstone lithologies. Suitable techniques are magnetotelluric, in association with gravimetric and magnetic for a better integration during processing and interpretation, and 3-component seismic. Propaedeutic feasibility studies confirmed the potential success of the project and defined the most suitable parameters for the geophysical acquisitions.

INTRODUCTION

Concession C97-I is located in the Eastern Sirt Basin at 250 km to the southeast of the town of Al Burayqah. There are two main areas of interest: the Nakhla oil field in the central part and the NPT-high oil fields and prospects in the southeastern part.

Methods

On behalf of Wintershall-Libya, in the third quarter of 2004 the contractor Bureau of Geophysical Prospecting (BGP) acquired a 1kmX1km grid of magnetotelluric stations and a 500mX500m grid of magnetic and gravimetric stations over 400 sq. km on the Nakhla oil field and the NPT high. In the fourth quarter of 2004 the contractors Arab Geophysical Exploration Services Company (AGESCO) and Compagnie Générale de Géophysique (CGG) acquired the first 2D 3-component survey ever recorded in Libya, consisting of 140 full-fold km in the NPT high, where several wells are planned to be drilled in the near future. Figure 1 shows the outlines

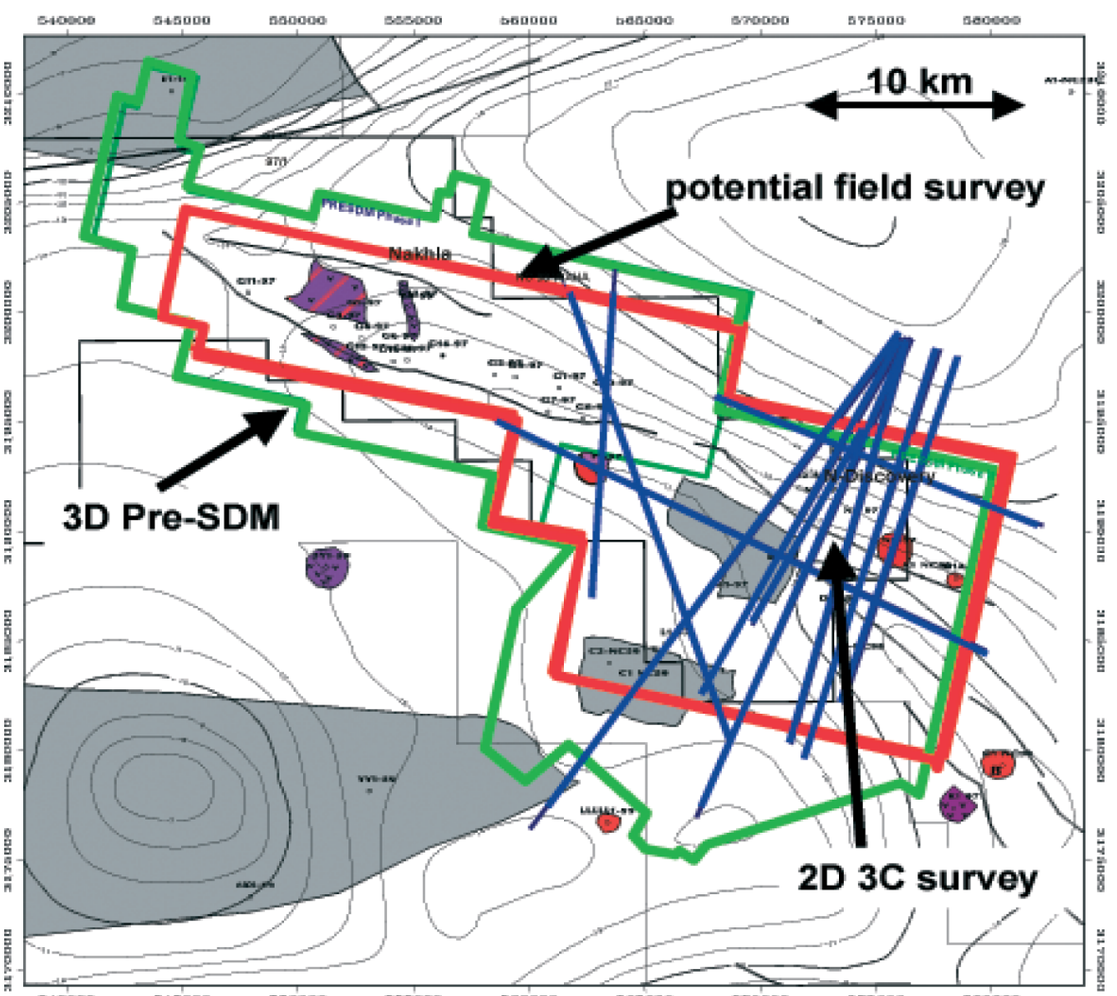

Fig. 1. Geophysical programs and existing data. Curves are Bouguer anomaly (in milligal), red indicates sills and dykes, purple indicates volcanoclastic conglomerates, red and purple indicate volcanic complex, grey indicates basement; the distribution of the lithologies in this picture is based on wells and 3D seismic.

and the location of the geophysical programs and previous existing data, *i.e.* 3D Pre-Stack Depth Migration set.

The processing and intepretation work has included the integration with the existing 3D Pre-SDM and trace-inverted volumes already covering the area of study as well as well logs and cores.

The absence of 3-component and magnetotelluric equipment in Libya was a further challenge for the projects.

RESULTS

After a three-month processing carried out by BGP in Tripoli with the support of Wintershall-Libya's geophysicists and geologists, the results of the potential field work have allowed us to draw a map with the most likely distribution of volcanic lithologies and associate a risk in the future drilling locations (see Figure 2), which was the main objective of the project, as well as to better define the tectonic and the depth of the basement.

According to the theory and the result of the feasibility study, during the 2D 3-component acquisition the P-waves generated by the vibrators have been both reflectedas P-waves by the top of the reservoir and converted and reflected as S-wave. The 3-component processing started at the beginning of January 2005 in CGG's offices in Massy (France) and was completed in October 2005. This included PP-sections and PS-sections and an acoustic and elastic inversion in order to generate Vp/Vs ratio sections, which were integrated with the afore-mentioned results for confirmation of the lithology prediction.

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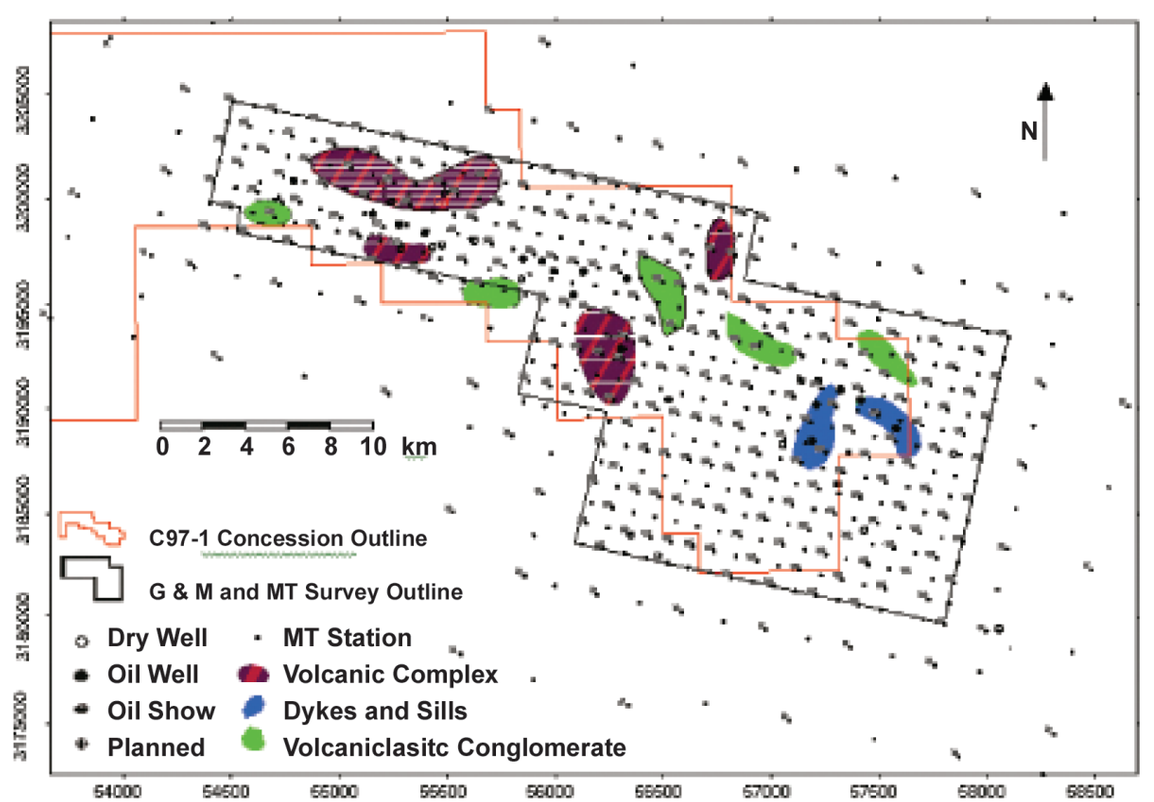

Fig. 2. Map of the most likely distribution of the igneous lithologies in the Sarir Formation.