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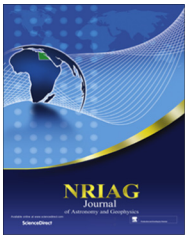

Tracing buried pipelines using multi frequency electromagnetic

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Abstract In this paper the application of multi frequency electromagnetic techniques to locate buried pipelines is described. The survey site has two pipelines of SUMED, one of the world choke-points. At desert or arid areas, regular geophysical surveys usually are difficult to carry out. EM techniques could be the best among geophysical techniques to be used for this target at these conditions. The EM survey was performed using a GEM-300 multi-frequency electromagnetic profiler. It is of handheld electromagnetic induction-type that measures in-phase and quadrature terrain conductivity without electrodes or direct soil contact. An area of 60×15 m was surveyed, that supposed SUMED pipeline existed. Six different frequencies, typically 2025, 2875, 4125, 5875, 8425, 12,025 Hz, have been used simultaneously. The slice maps for in-phase and conductivity distribution at each frequency could help to trace the extension of the pipeline. Two pipelines were traced successfully with 20 m spacing of each others.

1. Introduction

Oil is and will continue to be, for decades to come, the main source of energy for both the developed and developing countries all over the world. In 2011, total world oil production amounted to approximately 87.5 million barrels per day (bbl/d), moved by tankers on fixed maritime routes or via pipeline routes such as these chokepoints (Fig. 1) (IMO, 1982; Rodrigue, 2004;Swift, 2005; ITOPF, 2008).

Sea transport will continue to be the main transportation means to move oil and oil products from producing countries to consumers all over the world. Pipelines, on the other hand, are the mode of choice for transcontinental oil movements. Pipelines are critical for landlocked crudes and also complement tankers at certain key locations by relieving bottlenecks or providing shortcuts. Pipelines come into their own in intra-regional trade. They are the primary option for transcontinental transportation, because they are at least an order of magnitude cheaper than any alternative such as rail, barge, or road, and because political vulnerability is a small or

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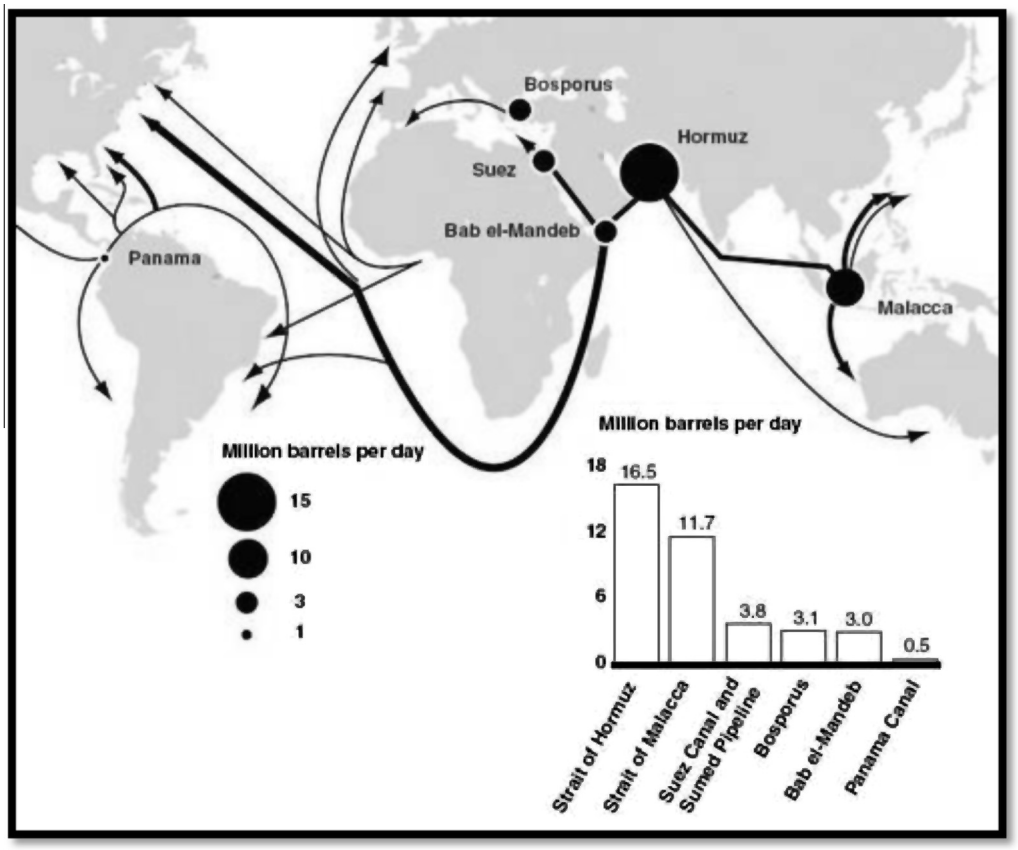

Figure 1 Oil flow and chokepoints, 2003.

non-existent issue within a nation's border or between neighbouring countries (Greene et al., 2003; TRB, 2004; Rodrigue et al., 2009).

One of the world chokepoints is the Suez-Mediterranean (SUMED) pipeline. The Arab Petroleum Pipelines Co., commonly known as SUMED, operates a 2.4-million barrel per day (bpd) crude oil pipeline in Egypt. The 200-mile long SUMED Pipeline provides a route between the Red and Mediterranean Seas by crossing the northern region of Egypt from the Ain Sukhna to the Sidi Kerir Terminal (Fig. 2). This provides a short-cut to the Mediterranean and northern European ports for cargoes that would otherwise have to circumnavigate Africa (Rodrigue, 2004).

Oil pipelines are made from steel or plastic tubes with inner diameter typically from 4 to 48 in. (100 to 1200 mm). Most pipelines are buried at a typical depth of about 3 to 6 feet (0.91 to 1.8 m). The oil is kept in motion by pump stations along the pipeline, and usually flows at a speed of about 1 to 6 m/(TRB, 2004). Considering these parameters, geophysics can play an important role in tracing and regular checking of such kinds of pipelines.

Several geophysical techniques had been used for a long time in mapping and locating superficial objects including pipelines but not limited to magnetics, VLF-EM, Very Low Frequency (VLF) electromagnetic, Time domain electromagnetic; electrical resistivity; Ground Penetrating Radar (GPR) and limited trials of using Frequency Domain electromagnetic (FDEM) (Gay, 1986; Won and Huang 2004; Bosch and Muller, 2005; Babu et al., 2007; Auken et al., 2006; Panissod

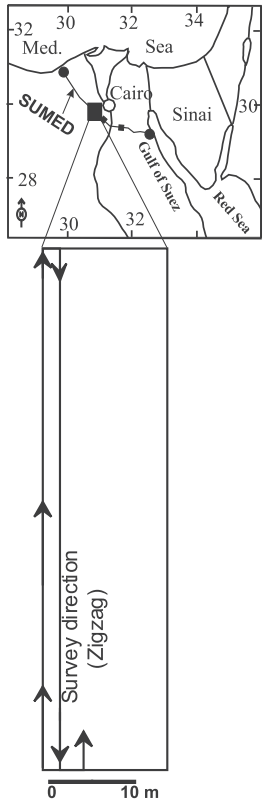

Figure 2 Sketch for SUMED pipeline and location of study area.