McPHAR INTERNATIONAL

AIRBORNE GEOPHYSICAL SERVICES

CANADA • SINGAPORE • INDIA

A Neterwala Group Company

OIL & GAS EXPLORATION

DETECT AND CHARACTERIZE OFFSHORE OIL-SEEPS

LOCATE SEDIMENTARY BASINS

DELINEATE BASIN BOUNDARIES AND STRUCTURE

INFER LOCATION OF THICKEST SEDIMENTARY SECTION

DETECT INTRA-SEDIMENTARY "MICRO-MAGNETIC" ANOMALIES

DETECT CHARACTERISTIC RADIATION PATTERNS

COST EFFECTIVELY PLACE SEISMIC SURVEYS

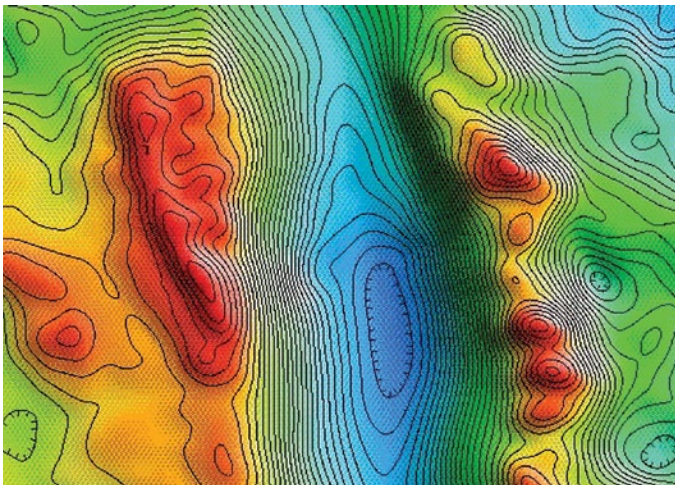
NEW DIMENSIONS IN EXPLORATION

GRAVEX Gravity & Gravity Gradiometry by OILSEARCH plc.

GRAVEX is a gravity sensing system delivering both gradient and gravity data, and comprises 4 temperature and attitude stabilized miniature gravimeters with a sensitivity of 0.3 mGal. The gravimeters are mounted on the aircraft at the wingtips, tail and Centre-of-Gravity. A laser compensation system relates movement of each wingtip gravimeter to the Centre-of-Gravity gravimeter, and undertakes the real-time aircraft movement compensation and synchronizes the operation of the individual gravimeters. The gravimeters' sample rate is 1 Khz and the delivered and recorded data rate is 100 Hz. The gradiometer base-line is >10 metres and the Hgg gradient minimum sensitivity is ± 0.1 mGal/metre, providing >200 times more accurate gradient than other AGG`s and at least a twofold improvement in sensitivity.

The **GRAVEX** system configuration for oil & gas exploration includes a high-sensitivity cesium magnetometer and, for offshore exploration, a **SEEPFINDER** system.

GRAVEX has been developed from a NASA Space Shuttle Columbia experiment by **Exact Group,** and is subject to world-wide patent protection.



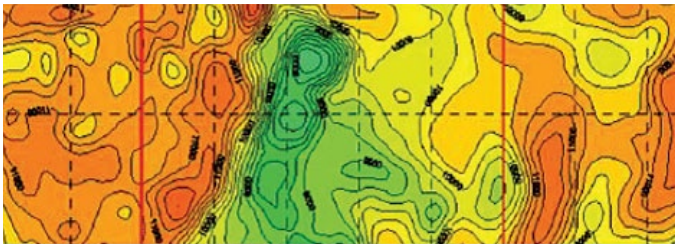
Caption needed.

SEEPFINDER Oil Detection System by OILSEARCH plc.

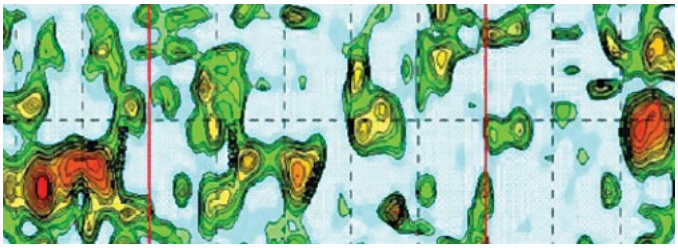
McPHAR offers **SEEPFINDER** surveys, courtesy of a strategic partnership with **Oilsearch plc** a subsidiary of the **Exact Group,** a UK based technology design group specializing in Remote Sensing for scientific, industrial and avionics applications. Oil Search have completed well over 300,000 line-km of **SEEPFINDER** surveys all over the world in the past few years.

SEEPFINDER is a computer controlled, airborne optical spectrometer capable of detecting fluorescence from minute concentrations of hydrocarbons on the surface of the water. The ultra-violet components of sunlight cause the polycyclic aromatic compounds in crude oil to fluoresce, and the composite signature of these emissions in the visible spectrum is detected and mapped by **SEEPFINDER.** Combined with accurate positional information provided by a GPS satellite receiver, the resulting data provides a high definition map of the oil seep.

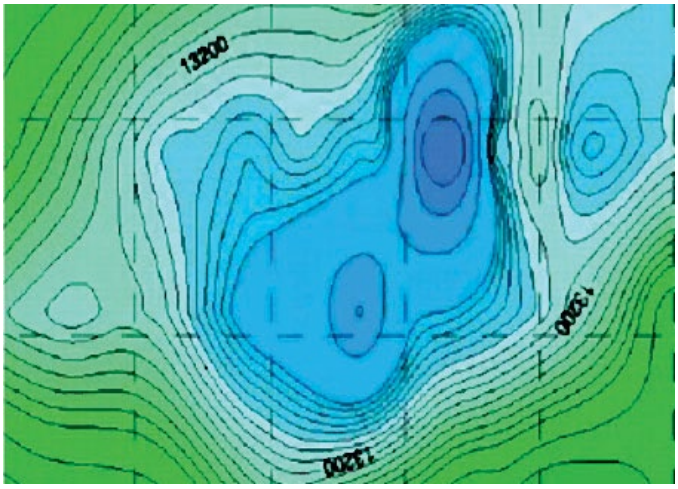
SEEPFINDER survey aircraft are also equipped with a high-sensitivity cesium magnetometer which records changes in the Earth's magnetic field, and often with an airborne gravimeter, providing information about the main structural trends including fault patterns and sedimentary basins that may contain a suitable suite of source, reservoir and seal rocks. Comparison of seep, aeromagnetic and gravity data sets will often reveal significant correlation.



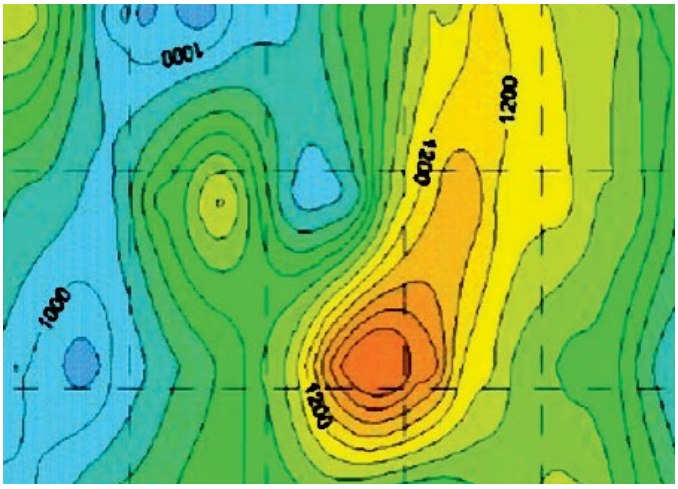
Caption needed.



Caption needed.



Aeromagnetic data.



Composite oil seep data.

ISMAP High-Resolution Airborne Magnetic Surveys

Intrasedimentary mapping **(ISMAP)** for hydrocarbon exploration involves the use of high-sensitivity, high-resolution aeromag-netics to resolve very low-amplitude anomalies (1nT to 5nT) originating from structures within the essentially non-magnetic sedimentary column, as well as high amplitude features from the crystalline basement.

Aircraft maneuver noise, of necessity, is very small. Using the "Figure-of-Merit" (FOM) technique to measure maneuver noise, all our aircraft are typically less than 1.0 nT. In addition, the use of differential GPS for navigation and positioning allows micro-magnetic anomalies to be determined to a positional accuracy of about +/- 2 meters.

The benefits of **ISMAP** are realized by the state-of-the-art data acquisition and processing techniques we use. These include 3-D drape flying, tie-line leveling, micro-leveling, equivalent source corrections where appropriate, and signal enhancement filtering.

ISMAP surveys are particularly useful in identifying linear or curvilinear features originating from sources within the sedimentary section. In addition, detailed comparisons of **ISMAP** data have been made to seismic data over the same area, and structures mapped within the sedimentary section from the magnetics can be correlated with those mapped by the seismics. It has also been found that the magnetic expression of the structure varies from basin to basin and within basins. In some cases it is consistent with juxtaposition by faulting of differently magnetized beds. In others the structure apparently corresponds to a zone where magnetic minerals have been deposited in parts of deltaic sediments; or have been uniformly destroyed or created, presumably by circulating fluids.

ISMAP surveys have demonstrated that structures can be mapped within the sediments enabling direct integration of seismic and magnetic interpretations. Without a doubt, the two techniques compliment each other.

An **ISMAP** survey generally produces magnetic signatures with an amplitude of 0.5 nT to 5 nT. Their spatial size is in the order of 50m to 100m. Therefore, it is required that the aeromagnetic information be able to resolve these anomalies to better than 0.5nT and 10m respectively. This requires the ultimate in dynamic magnetic field measurements, in navigation and positioning, and in final corrections for all the affects from diurnal variations to the "noise" created by the movement and orientation of the aircraft in the earth's ambient magnetic field.

Unfortunately, **ISMAP** mapping over mature areas is difficult because of the overwhelming presence of pipelines, wells, structures, fences, towers, etc., that have small magnetic signatures of an amplitude and size of the geologic features we are trying to map. However, in frontier exploration areas where the cultural features we see in mature areas are generally absent, the **ISMAP** technique is ideal and highly recommended as a mapping tool.

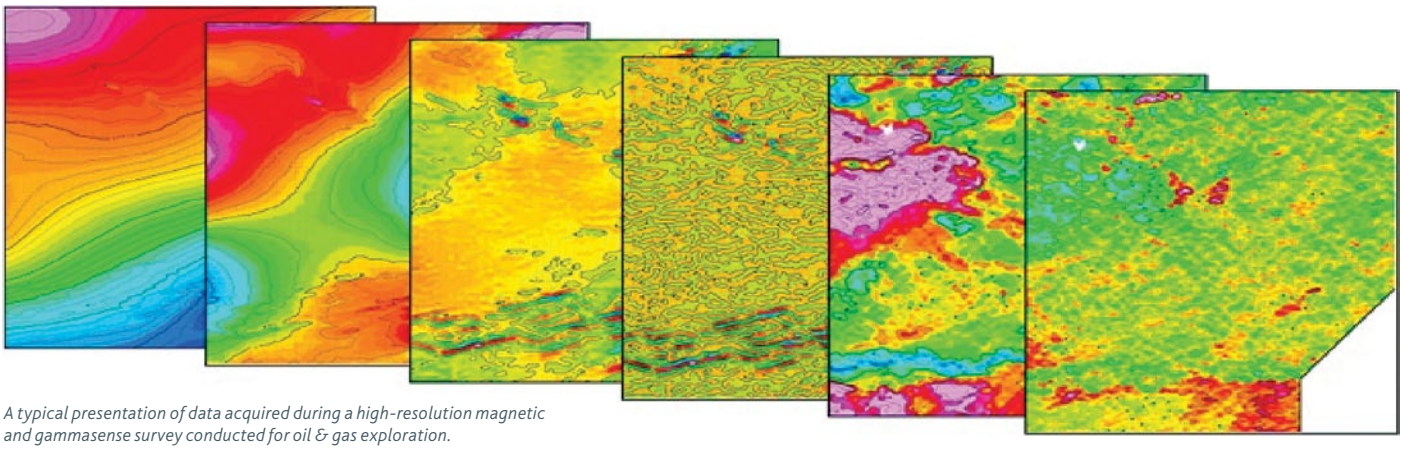
One of the most common exploration objectives of an **ISMAP** Survey Program is to gain an understanding of the regional geology so that more expensive seismic surveys can be economically limited to the most prospective areas of an oil concession. The interpretation resulting from an **ISMAP** survey program will greatly assist in making decisions where to site such seismic surveys.

Beech King Air survey aircraft.

Eurocopter AS-350B2 survey helicopter.

BASEMENT MAGNETIC MAPPING

It is generally assumed that the basement beneath the sediments of interest is generally of crystalline rock. These crystalline rocks have varying amounts of magnetite, generally in greater concentrations than the overlying sediments. This high concentration of magnetite allows the mapping of the basement topography with good accuracy using the magnetic method. Also, because the basement is generally of higher density than the sediments (limestones, marble, some shales and slates, particularly dolomite are an exception) it may be successfully mapped using the combined magnetics and gravity method (Elementary Gravity and Magnetics for Geologists and Seismologists, by L.L. Nettleton).



A typical presentation of data acquired during a high-resolution magnetic and gammasense survey conducted for oil & gas exploration.

AIRBORNE GAMMASENSE SURVEYS

The objective of surveying with a multi-channel, gamma-ray spectrometer system and a large volume gamma-ray sensor is to detect subtle characteristic radiation patterns as indicators of subsurface hydrocarbon accumulations over petroliferous terrane. **ISMAP** and **GAMMASENSE** techniques may be applied independently of each other, however, it is practical and cost effective to combine them in one multi-sensor, multi-method survey.

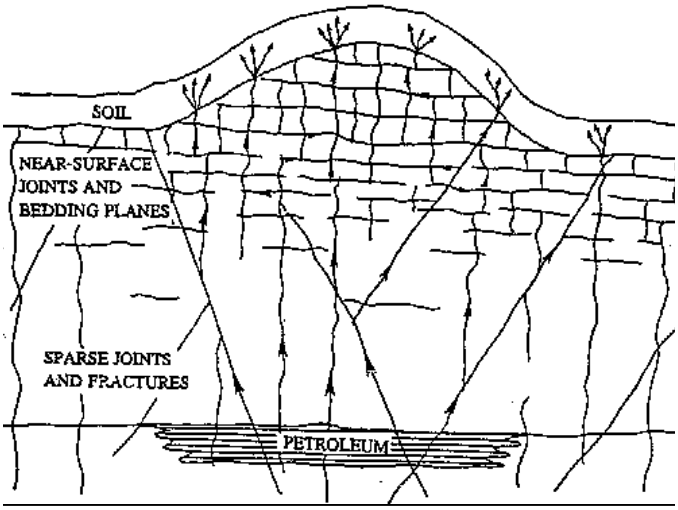
Hydrocarbon anomalies can be qualitatively and directly identified from airborne radiometric measurements. It has been repeatedly observed that the subtle anomalous patterns of radiation flux detected over petroleum basins exists over subsurface hydrocarbon accumulations.

HOW DOES GAMMASENSE WORK?

The earth's crust contains uranium, thorium, and potassium. These primordial radionuclides were randomly laid down during the planet's formation. They and their progeny emit highly energetic gammarays in the course of radioactive decay. As their half-lives approximate the age of the earth, it is to be expected that all three elements contribute measurably to our natural radiation background. Hundreds of millions of years after the laying down of the radionuclides, hydrocarbon deposits were formed. Uranium is the most mobile of the three radionuclides. Subsurface hydrocarbons, however, through recognized geochemical processes, alter uranium's mobility above hydrocarbon deposits (in its fully oxidized state, the uranium ion is water-soluble, highly mobile, and easily transported by ground water, however, on entering an environment containing organic matter, the ion is reduced becoming insoluble and immobile).

Potassium also shows similar characteristic mobility changes. As a consequence, the gamma radiation flux detected over hydrocarbon deposits is noticeably altered by the contributions from uranium and potassium. In addition, the random radiation pattern normally observed has now changed into a characteristic radiation pattern, thereby creating a readily identifiable pathfinder in potentially productive basins.

If you wish to know more about the **GAMMASENSE** method, please contact us. A bibliography of Technical Papers and Case Histories is available (in some instances we can provide a copy of some papers).



Possible microseepage paths up through the network of fractures, joints and bedding planes

Large volume gammaray system installed in one of our aircraft.

DATA PROCESSING AND INTERPRETATION

DATA PROCESSING

McPHAR is dedicated to processing geophysical data in the field. For this purpose all our airborne systems are sent to the field with a geophysicist and a PC-based data processing system to support them. The Field Data Verification Workstation (FWS), as this system is known, can process airborne gravity, magnetic, radiometric and electromagnetic data, and produce plots and maps in full-colour of the survey data, often within hours of the survey flight ending.

The FWS software, which is the core of this system, permits our field geophysicists to differentially correct the GPS navigation data; carry out flight path recovery; perform QC of all data, undertake post-flight magnetic compensation and leveling; undertake radiometric corrections and preliminary processing; electromagnetic processing; and generally to perform filtering, gridding and contouring of data, imaging of selected data and plotting to any map scale and layout.

Final data processing is undertaken at our processing centre in India, which is staffed by very experienced geoscientists and equipped with a state-of-the-art network of computers, scanners, plotters and other hardware.

INTERPRETATION

The interpretation of geophysical results into meaningful geological parameters is the prime function of any of our interpreters. The many highly qualified geophysicists and technicians on our staff share a strong geological back-ground. The manipulation of geophysical data is only a means to an end, and the final product of the interpretation is the compilation of a series of maps showing interpreted geological parameters.

The data processing routines and mathematical operators applied to the data are not the end product of the interpretation; they help delineate geologic and economic targets to be discussed in the final report.

We bring many techniques to bear on an interpretation project in order to determine depths to causative sources, to delineate discontinuities and boundaries, and to draw conclusions regarding geological structure beneath the survey.

A wide variety of contour and interpretation maps, profiles, cross-sections and models, and a written report are the result of the interpretation.

CANADA - McPHAR INTERNATIONAL CANADA LTD.
36 Ash Street, Uxbridge, ON, Canada L9P 1E5
T. +1 905.852.2828 **F.** +1 905.852.2899

SINGAPORE - McPHAR INTERNATIONAL SERVICES PTE. LTD.
10, Jalan Besar, # 10 – 12 Sim Lim Tower, Singapore 208787
T. +65 629 380 89 / 629 383 70 **F.** +65 6293 5756

INDIA - McPHAR INTERNATIONAL PVT. LTD.
Liberty Building, 4th Floor, Sir Vithaldas Thackersey Marg, New Marine Lines (E), Mumbai 20
T. +91 22 2205 6823 / 2205 6866 / 2206 6231 / 2206 6261 / 2201 6527 **F.** +91 22 2208 2113

E. sales@mcpharinternational.com **W.** www.mcpharinternational.com