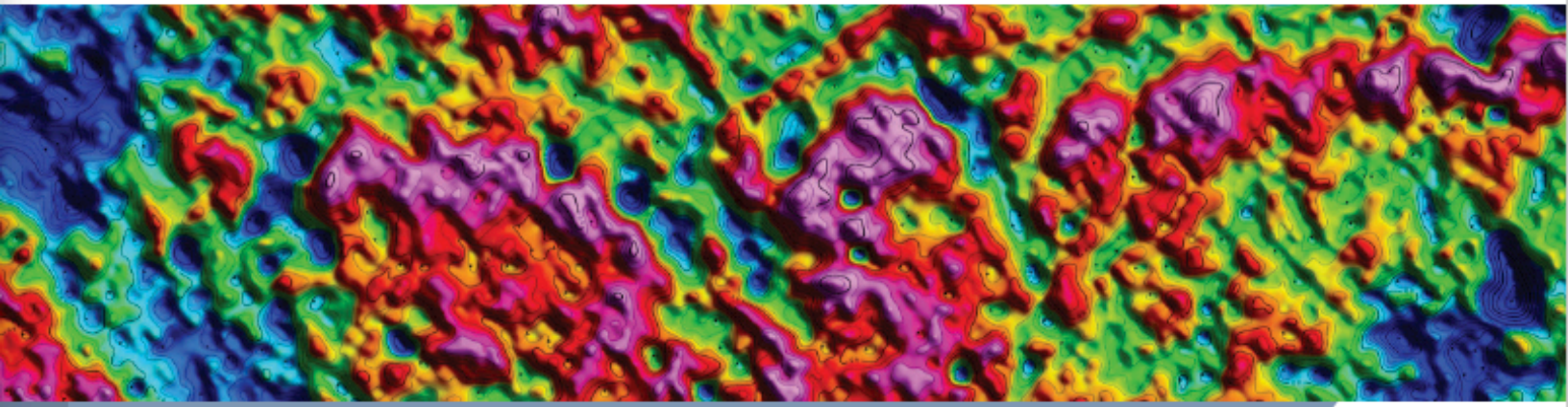
AIRBORNE RADIOMETRIC SURVEYS

GAMMA RAY SPECTROMETRY *for* HYDROCARBON EXPLORATION

- Data Acquisition
- Primary Processing
- Advanced Processing Techniques
- Integration with Magnetic Data



RESOLUTION...RELIABILITY...RESULTS!

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What Are Gamma Rays and How Can They Help Me Find Oil?

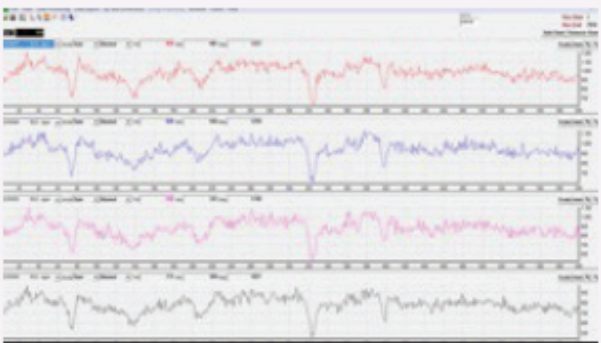
Gamma Rays are a naturally occurring product of radioactive decay in the crust of the Earth. Gamma Ray particles emanating from the surface of the Earth can be sampled and classified through spectrometric methods to reveal their individual source elements. Only three of these elements, Uranium, Potassium and Thorium, are abundant enough on Earth's surface to be measured by airborne Gamma-Ray Spectrometers. The relative concentrations of these three elements can provide a useful tool in identifying zones of hydrocarbon seepage over oil and gas reservoirs.

Russian scientists first recognized a correlation between decreased total gamma ray counts and petroleum deposits in the 1920's. Further exploration efforts using total gamma ray counts were utilized, but not prevalent, in the U.S. and elsewhere throughout the rest of the 20th Century. The use of total gamma ray counts without the ability to separate the relative constituent elements of Uranium, Potassium and Thorium, was often unreliable due to variations in surface geology and soil types. The advent of modern multi-channel spectrometers like the AGRS (Advanced Gamma Ray Spectrometer) system used by EDCON-PRJ has revolutionized the ability to detect and map geochemical signatures over zones of hydrocarbon seepage.

"Hydrocarbon accumulations at depth can result in measurable geochemical anomalies at the surface. Hydrocarbon microseepage is due to the vertical migration of gas above hydrocarbon deposits. Through a chemical reduction process, K and U concentrations can be reduced relative to Th. Alternatively, the signature of reduction-oxidation electrochemical cells above reduced bodies has been applied to both hydrocarbon and mineral exploration. Both types of alterations can be inferred from variations in radioelement concentrations." International Atomic Energy Agency, "Radioelement Mapping" IAEA Nuclear Energy Series No. NF-T-1.3, 2010

Data Acquisition

The AGRS System consists of four independently-processed detectors for a total of 16.8 liters of downward–looking NaI crystals. The 512 channel processors provide high-resolution and excellent signal to noise ratios throughout the gamma ray spectrum. We offer airborne radiometric surveys utilizing both helicopters and fixed-wing aircraft.

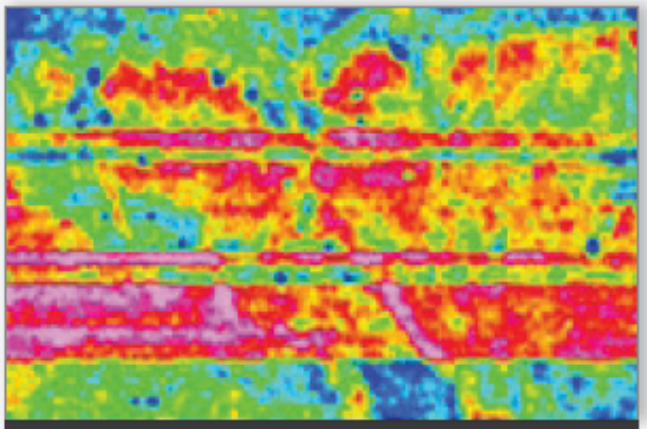


Real-Time Monitoring of Individual AGRS Detectors

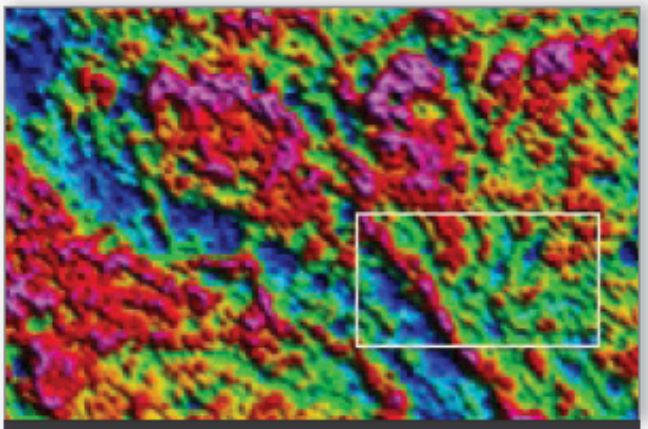
The Advanced Gamma Ray Spectrometer (AGRS System)

Pico Envirotec's Advanced Geophysical Information System enables our operators to monitor individual detector performance in real time. The 512-channel resolution of the AGRS along with the use of Geosoft Praga 4 processing software allows for removal of radon effects through 214 Pb photopeaks and eliminates the need for an upward-looking crystal.

Primary Processing



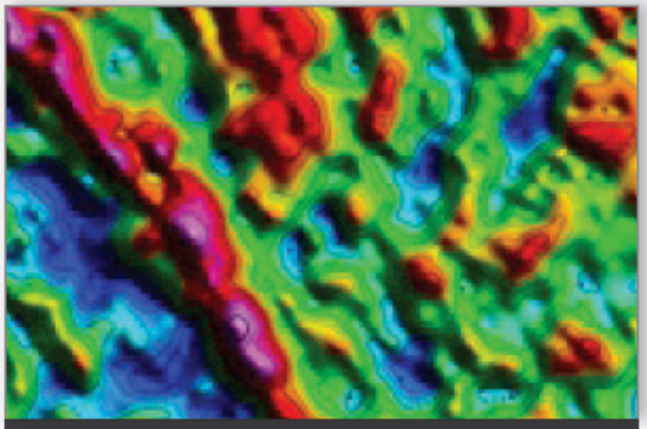
Raw Spectrometer Data



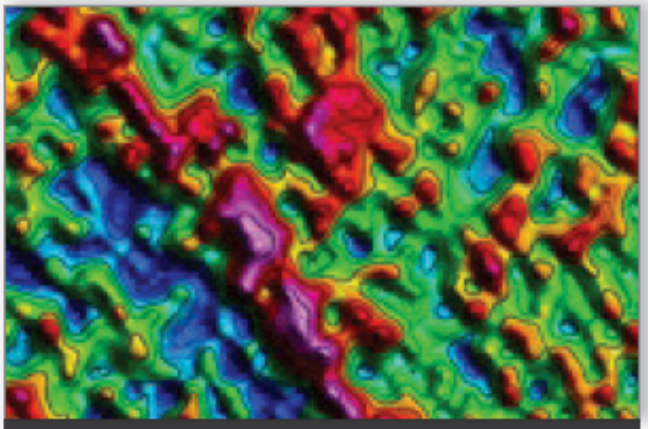
Primary Processed Data – Total Count

Raw data is low resolution and shows banding effects due to daily differences in temperature, humidity, radon, and soil moisture. Our primary processing methods include removal of radon and cosmic background, correcting for temperature and humidity, and normalizing to Thorium.

Advanced Processing



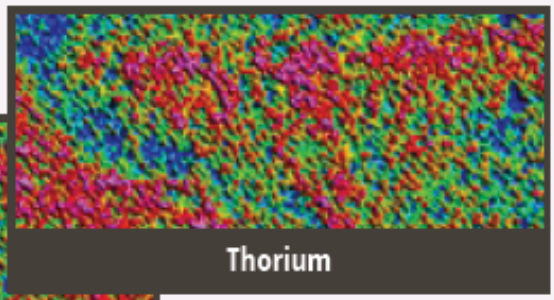
Close up of Total Count



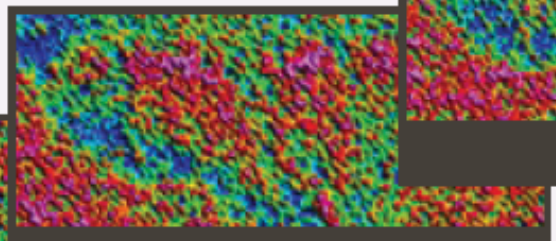
Total Count with KUTh Isolation

Our Advanced Processing techniques include isolating the Potassium, Uranium, and Thorium (KUTh) channels from the Total Count spectrum. The result is a much higher-resolution image than the standard Total Count Map. This data is then used to generate individual Potassium, Uranium and Thorium Concentrations.

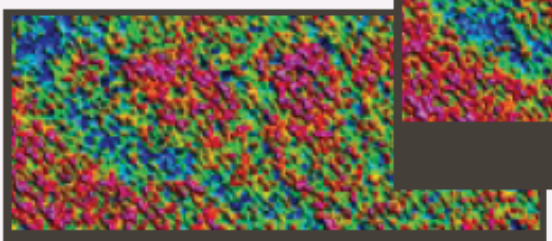
We also offer element ratio analyses and Soils Normalization Radiometrics in association with Thompson Solutions LLC, of Centennial, Colorado.



Thorium



Uranium



Potassium

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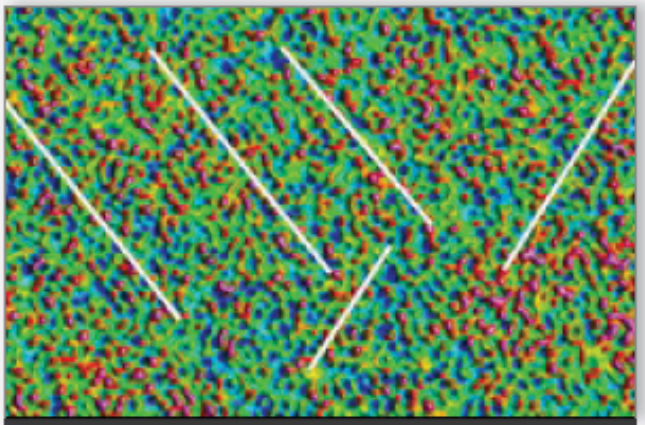
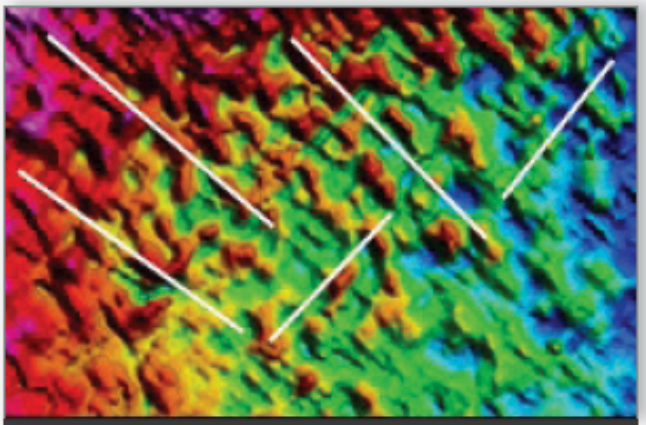
Integration with Magnetic Data



Uranium to Potassium Ratio



Vertical Gradient of RTP Magnetics

We typically acquire magnetic data at the same time as radiometric data. The benefit of integrating these two sets of data is shown here. On the left is a map of Uranium to Potassium Ratio, one of the tools used to target areas of hydrocarbon seepage. On the right is the vertical gradient of the reduced-to-pole magnetic data over the same area. Subtle northwest and northeast trending lineations are apparent in both images. These lineations reveal the fault and fracture patterns present in the sedimentary strata which can be interpreted as pathways for seepage and targets for oil and gas production.

Suggested Reading

International Atomic Energy Agency, "Guidelines for Radioelement Mapping Using Gamma Ray Spectrometry Data" IAEA TECDOC 1363, Vienna, 2003.

International Atomic Energy Agency, "Radioelement Mapping" IAEA Nuclear Energy Series NF-T-13, 2010.

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Olson, R. "The Relationship of Radiometric Surface Anomalies and Hydrocarbon Microseepage" Bulletin of the South Texas Geological Society Vol. 51.7, 2011.

Saunders, D.F., Burson, K.R., Thompson, C.K., "Model for Hydrocarbon Seepage and Related Near-surface Alterations" AAPG Bulletin 831 1999.

Saunders, D.F., Burson, K.R. Branch, J.F., Thompson, C.K., "Relation of Thorium-normalized Surface and Aerial Radiometric Data to Subsurface Petroleum Accumulations" Geophysics Vol. 58 No. 10 Oct. 1993.

Tompkins, R., Clark, J.R., Siegler, D., "Enzyme Leach Geochemistry: A Significant Advancement in Hydrocarbon Exploration" AAPG Bulletin 84 No. 13, 2000.

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