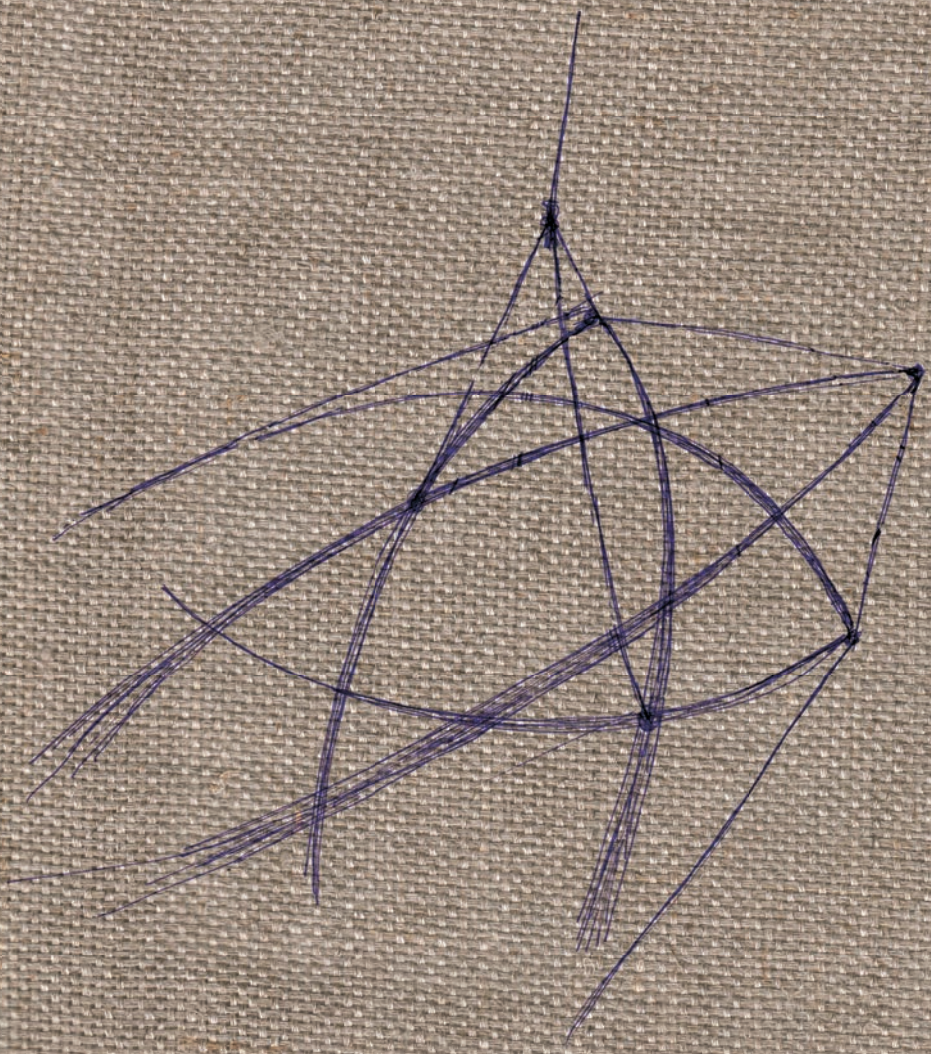
GEOTECHNOLOGIES 2013



DEAR FRIEND!

This notebook tells you about us - Russian company GEOTECHNOLOGIES We tried to make it interesting and, hope, we succeeded.

Hopefully, we'll have a chance to tell you more - just visit us.

Andrey Volkovitsky

Tatiana Vovenko

It's easy to find at PDAC, Trade Show: booth #444

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INTRODUCING OURSELVES

We are a young but already well established Russian company. Our name, GeoTechnologies speaks for itself. We specialize mainly in development of NEW geophysical technologies, we develop and manufacture

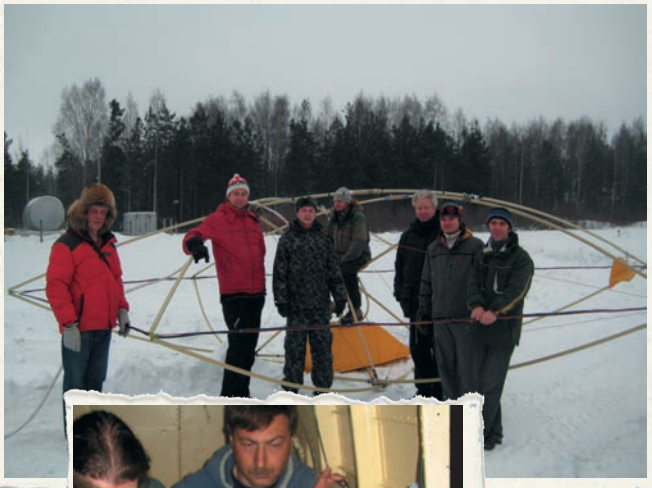
- complete airborne geophysical systems and equipment
- data acquisition systems
- on board and data processing software
- methods and instruments for navigation and positioning

We do not agree that "there is nothing new except what has been forgotten". Invention of new technology starting from theoretical research up to absolutely new complete turnkey system – that is what really interests and inspires us.

Our team is high qualified, professional specialists. All our engineers, geophysicists, mathematicians, and programmers have long term practical experience working with different airborne geophysical technologies.

We work together with leading scientific and business organizations in the industry. That's why we are always on the cutting edge.

During our eight years in business, we have developed many innovative and interesting ideas. Here we'll try to tell you about some of them. Please, have a look. You'll find something interesting, that's for sure.



PORTFOLIO OF OUR CAPABILITIES

RIGHT WAY is necessary for quality airborne survey. A pilot should follow given routes very accurately and not waste flying hours. Navigation segment of onboard system NavDat provides navigation solution automatically and advises the right way to a pilot.

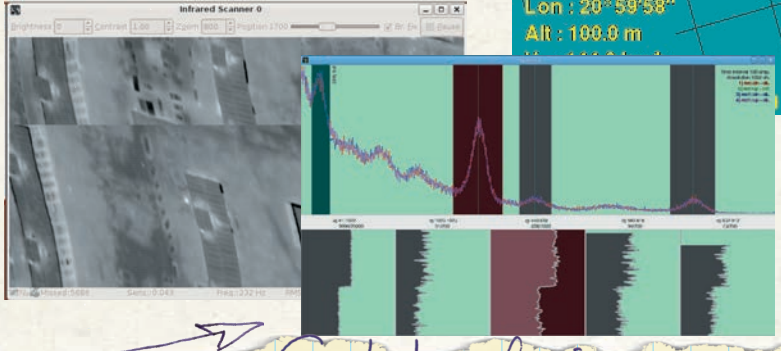
The experience has shown that a pilot fly an aircraft using NavDat advices even more accurately than flying along lines drawn on the ground.

At the picture you can see fragment of real flight paths. Note, route distance for this survey was only 50 m .

One more important aspect for quality survey is trouble-free operation of geophysical instruments. Control of all instrumentation before and during a flight is a must. NavDat system provides integration of wide range of geophysical equipment and all necessary control tools

By now NavDat supports:

- airborne EM system EM4H
- helicopter EM system EQUATOR
- gamma-ray spectrometers RS-500, Exploranium GR-820, AGRS
- airborne magnetic systems GT-MAG-2, GT-MAG
- GPS-receivers Novatel, Javad, Topcon
- infrared scanner



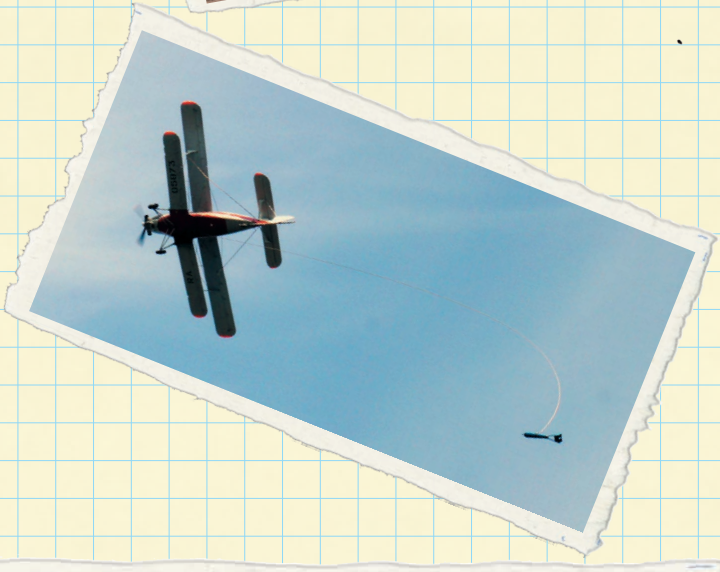
PORTFOLIO OF OUR CAPABILITIES
AIRBORNE ELECTROMAGNETICS

Our company offers two different proprietary airborne geophysical systems EM4H and EQUATOR. Both of them are systems for combined electromagnetic and high-precision magnetic survey. High reliability, efficiency and performance made them very popular.

EM4H

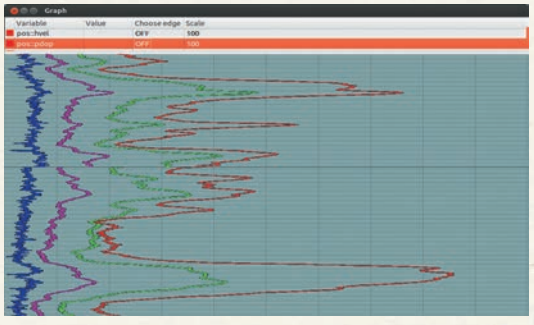
This is frequency domain system with separated receiver - transmitter geometry. GeoTechnologies produces EM4H since 2005. There are two different modification of the system:
-FIXED WING
-HELICOPTER-BORNE

For both modifications transmitter loop is mounted on an aircraft fuselage, receiver is towed in a bird, and magnetic sensor is placed in the same bird.
Special method of electromagnetic positioning was implemented in EM4H to provide continuous high accuracy monitoring of receiver position and orientation. The accuracy of positioning is enough to compensate influence of primary field and to measure both quadrature and in-phase response components.
EM4H is widely used in Russia: 13 systems were made since 2005.



TECHNICAL DETAILS

- Waveform (sine) frequencies: 130, 520, 2080, 8320 Hz
- Dipole moments (corresponding): 20000, 10000, 4000, 2000 A·m^2
- Transmitter loop area: 42 m^2 (for An-2, An-3 airplanes), 60 m^2 (for Mi-8 helicopter)
- Power requirements: 810 W (30 A for 27 VDC)
- Cable: 70 m two screened twisted pairs.
- Interface: RS232, Ethernet (TCP/IP)
- For navigation, data acquisition and control NavDat system is used



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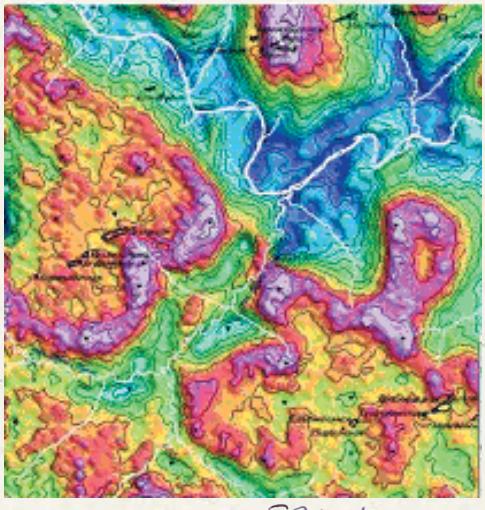
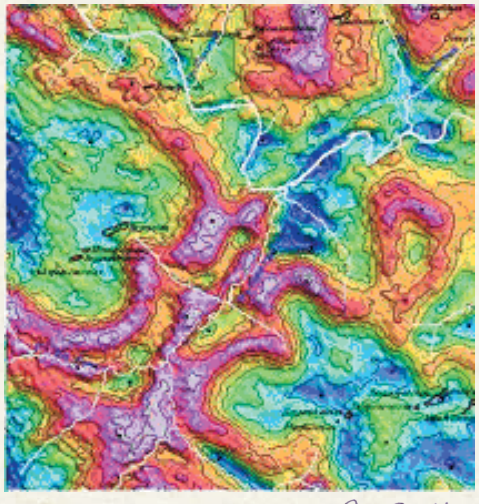
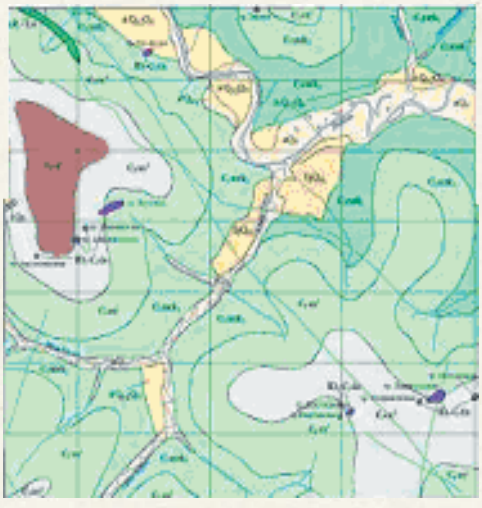
EM MAPPING
LOOKING AROUND

EM4H broad bandwidth provides high resolution resistivity mapping at different depth levels. These results can be profitably used in indirect search for potential mineral deposits.

Maps below illustrate EM4H benefits







Here are apparent resistivity maps for 520 Hz and 2080 Hz frequencies (Note, these maps are DIFFERENT!)
and detailed geologic map of the area.

It can be easily seen that resistivity maps conform to geological structure of the area.

To be more exact, resistivity maps show not only high conductive structures associated with hydrographic network (400 Ω · m) but boundaries of geological structures of different age (but not very different) as well.

They dates from Late Devonian-Early Carboniferous (900 Ω · m) up to Middle (1400 Ω · m) and Late Carboniferous (600 Ω · m). Note! Even structures with subtle resistivity difference are differentiated.

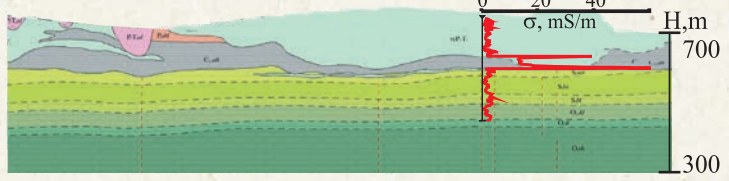
EM SOUNDING STUDYING IN DEPTH

Let's compare 1-D inversion results of EM4H data with geological section obtained from exploration drilling data.

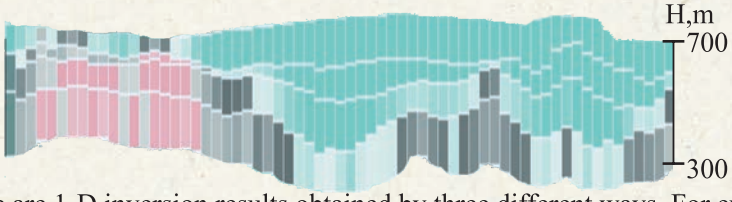
At the geological section we can see:

The subsurface is composed by igneous rocks (traps), their thickness varies from 70 to 170 m. Below there are coal measures. And at the basement there are Silurian and Ordovician limestones.

At the left part of the section thickness of carboniferous sediments increases and traps thickness decreases. Also there are Permian and Triassic sediments. Coal measures, Permian and Triassic sediments are highly conductive.

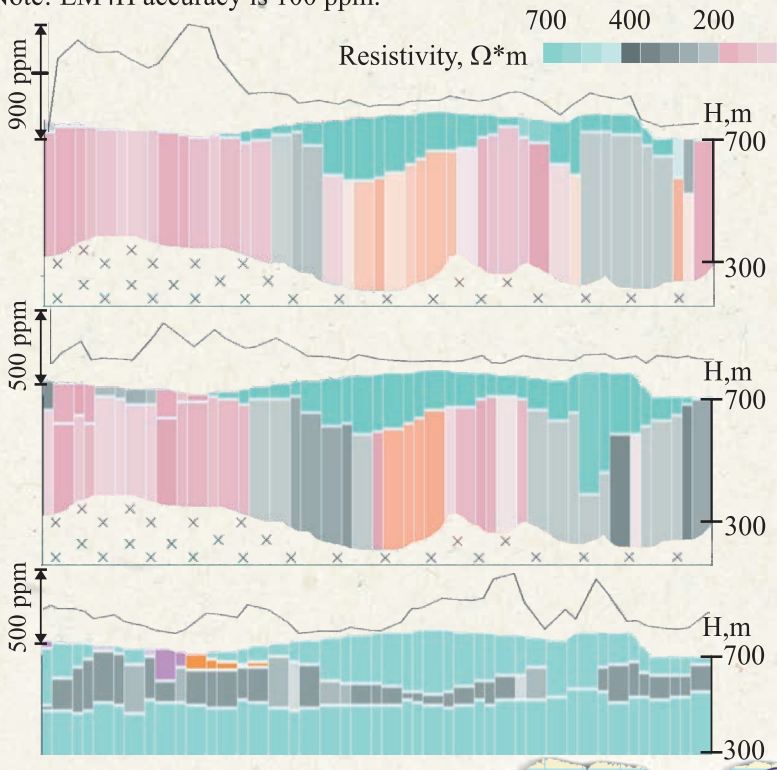


Conductivity log results (red chart on the section) demonstrate that conductivity of traps and limestones is 0.5-3 mS/m; and coal measures conductivity - 15-40 mS/m. Note that the thickness of cryotic soil is about 350 m.



Resistivity Depth Image. Automatically constructed from EM4H data for four frequencies.

Here are 1-D inversion results obtained by three different ways. For every cross-section approximation error chart is given. Note! EM4H accuracy is 100 ppm.



Two-layered inversion obtained with AIRBEO open source software, initial model is: 1000 Ohm*m, 50 m layer over halfspace of 200 Ohm*m.

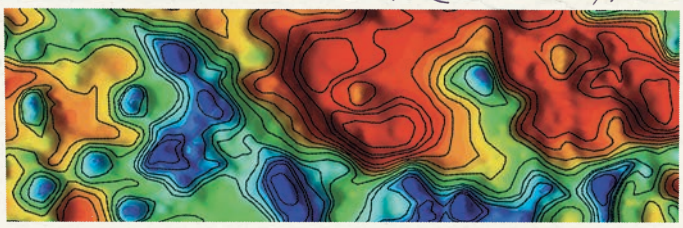
Two-layered inversion obtained with software developed by Geotechnologies in interactive mode. Model parameters were chosen to minimize the error.

1 D interpretation was completed with software developed by Geotechnologies in interactive mode. Geometry parameters of the model match geological cross-section.

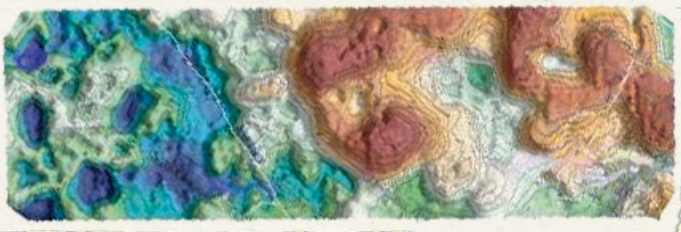
EM MAPPING
REALLY INFORMATIVE, ISN'T IT?

Let's compare EM4H apparent resistivity map and maps based on other geophysical methods.
Take a look at the pictures below.

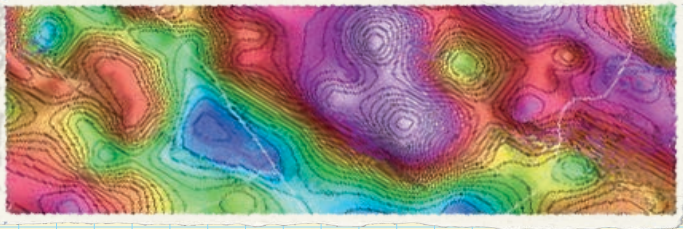
Apparent resistivity map (2080 Hz), EM4H data



Gravity field map, ground survey data



Trap isopach map, exploration drilling data



500 0 500 m

The comparison of these maps shows that resistivity map corresponds well to gravity map.

It can be easily seen that both gravity and electromagnetic maps correlate with trap thickness. Level of details of electromagnetic map is comparable to that of gravity map. Important remark: route distance for EM survey is 100m and distance between data points for ground gravity is 50m.

Note! Different physical properties allow trap detection by gravity method and by electromagnetic method: increased density and increased resistivity correspondingly.

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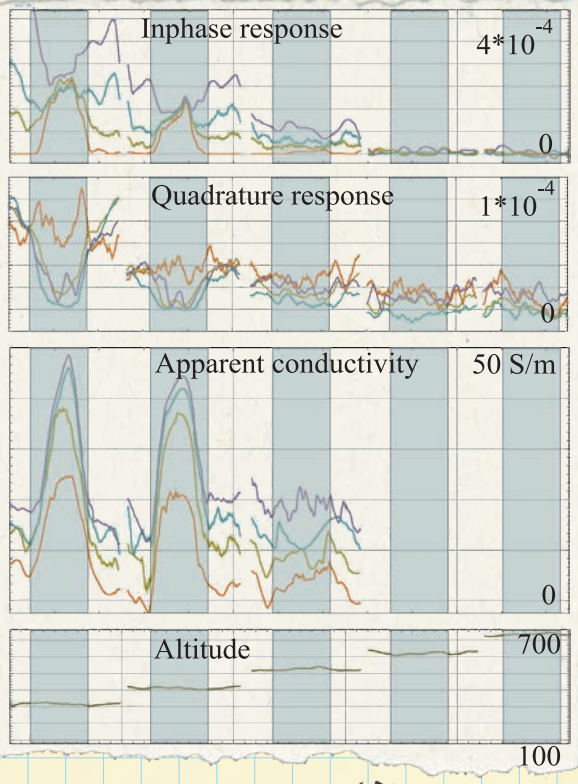
AIRBORNE EM

LET'S MEASURE SENSITIVITY

The maps on previous pages clearly prove high sensitivity of EM4H. But can we measure the sensitivity and how?



The main interest for geologists and geophysicists is sensitivity of a system to geoelectrical parameters of geological structures, in other words - ability of a system to detect an object. We decided to measure EM4H sensitivity experimentally.

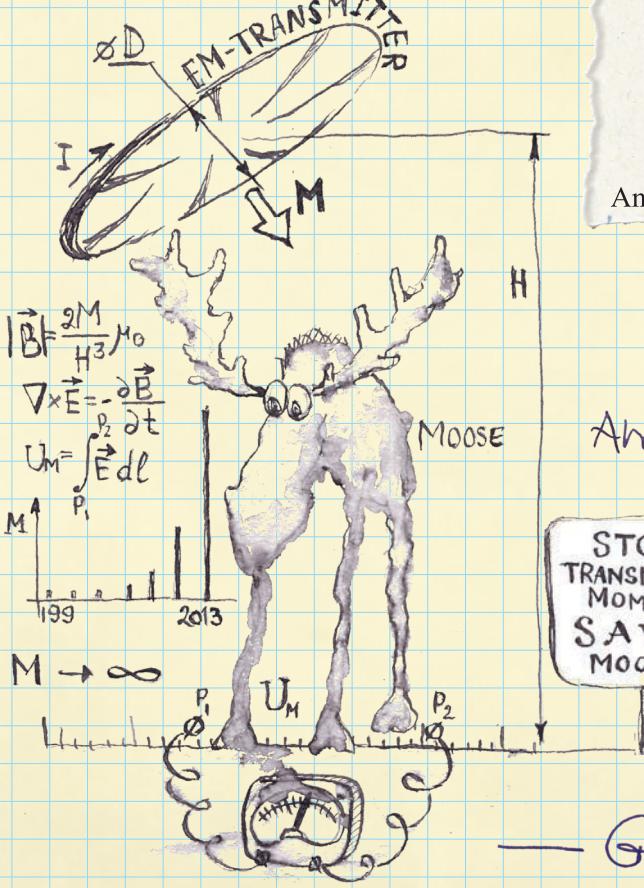
We found suitable test object. Salt lake! Mineral concentration in its water is really high - lake conductivity is about 50 S/m. This lake is very shallow: its depth is just 2-4 meters. Conductivity of environment is about 0,01 S/m.

We flew at different altitudes along the same flight line over the lake and its shore. And we found that:

1. From altitude less than 500 m the EM4H detects the lake and moreover, conductivity of salt water calculated from collected data is close to its real value.
2. At the altitude of 500 m response signal can be distinguished from noise but signal is so weak that calculated conductivity is not adequate.
3. From altitudes greater than 500 m we don't "see" ground.

And here is CDI based on collected data.

And this means that proved detection depth for conductive target in resistive environment is 500 m. From 400 m its conductivity is calculated correctly.



Note!

Transmitter moment of the system is rather small - just 2000 Am² for the highest frequency.

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PORTFOLIO OF OUR CAPABILITIES

EM SYSTEM EQUATOR

Helicopter-borne towed electromagnetic system with separated receiver-transmitter geometry was launched in 2010 and its non-standard technical features immediately aroused the interest.

ADVANTAGES

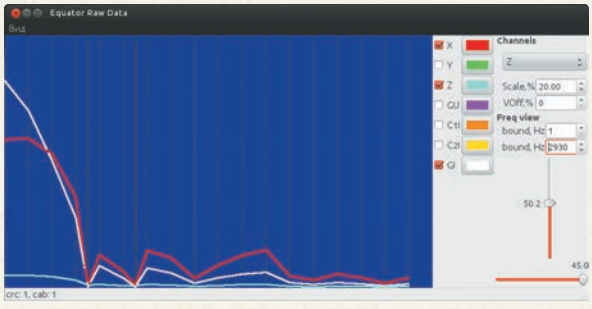
For this hybrid system (both Time-Domain and Frequency-Domain) the unique receiver that provides high-precision measurements in the presence of spherical and industrial noises was developed.

Light and delicate but rigid and durable design of towed transmitting system provides important advantages, such as high survey speed (up to 170 km/hour) and suitability for use in rough mountain terrain.

Wide frequency range makes the system very effective for detection of both contrast and low-contrast objects in conductive or resistive environments: “dielectric in dielectric” or “conductor in conductor”.

TECHNICAL DETAILS

- Dipole moment: 100 000 A*m2
- Base frequency: 77Hz
- Pulse shape: half sine
- Full-time measurements
- First off-time chanel: 5 μs
- Total weight: 250 kg
- Transmitter loop diameter: 7,5 m
- Survey speed: up to 170 km/hr
- For navigation, data acquisition and control NavDat system is used

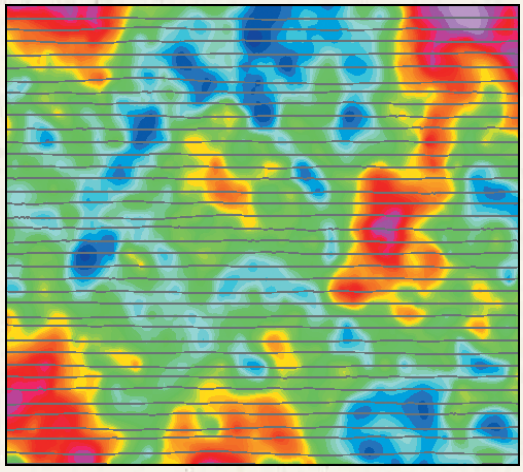


AIRBORNE EM

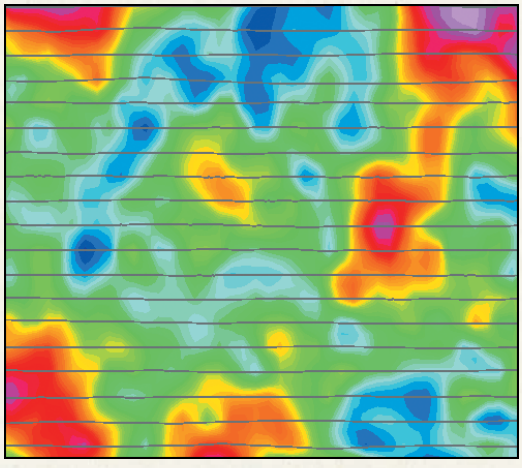
EVERY DETAIL IS IMPORTANT!

You are searching for small objects?
Through away all doubts!
For our airborne EM system EQUATOR there are no minor details.

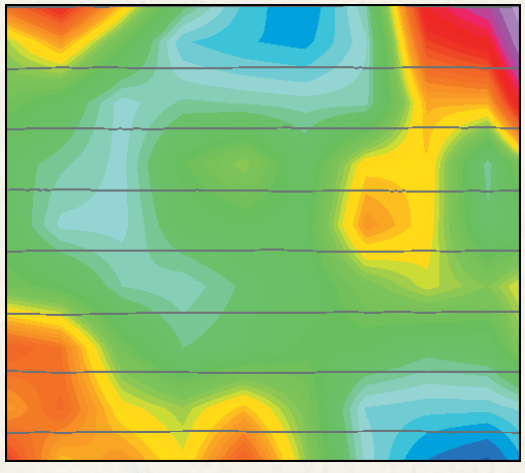
These conductivity maps are based on EQUATOR data of high detailed survey. We imitated survey of lower detail level by taking part of full data set.



All Routes



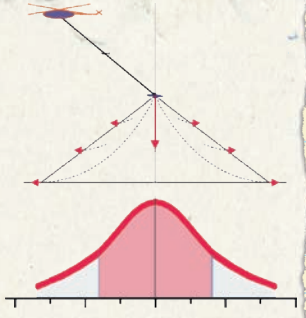
Every Second Route



Every fifth Route

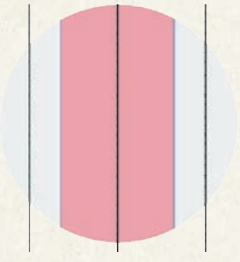
250 0 250 m 7 σ mS/m 11

This picture helps you to choose appropriate route distance. Transmitter magnetic field lines that intersect cone surface above ground level won't reach the ground. Even when transmitter is only 50 m above the ground footprint radius will be less than 70 meters.



Inside the footprint (grey) we highlighted (pink) the area where ¾ of field energy is concentrated.

Solid lines show the routes at 50 meters distance.



It's absolutely clear that increasing route distance we loose many details.

Note, even very small objects are easily seen at the detailed map. Besides, their isometric shape confirms high measurement rate and high lateral resolution.

Make the right choice and rely on EQUATOR!

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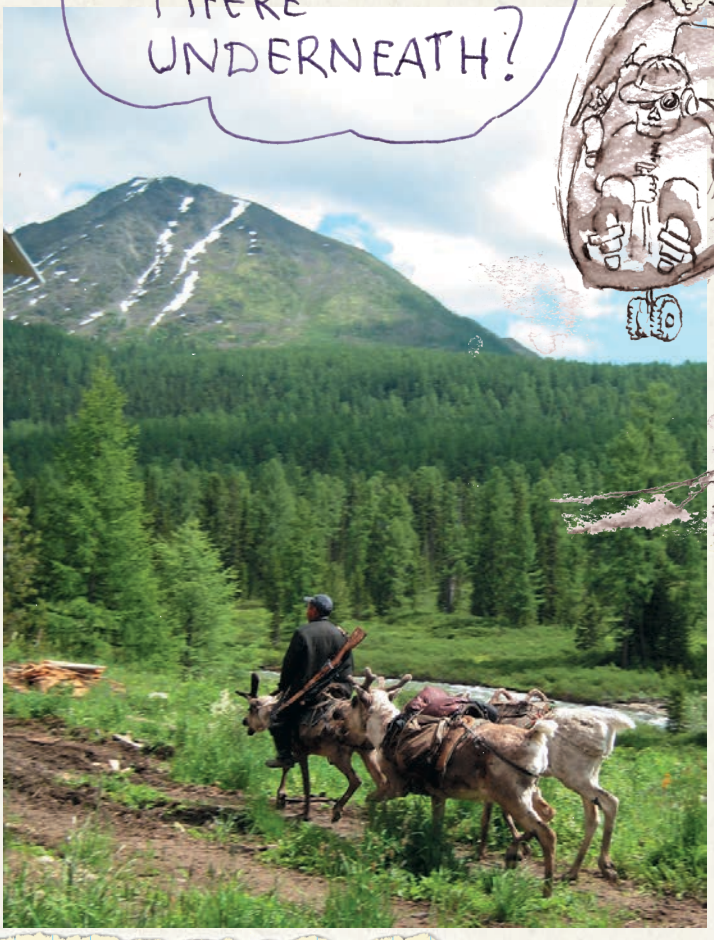
AIRBORNE EM

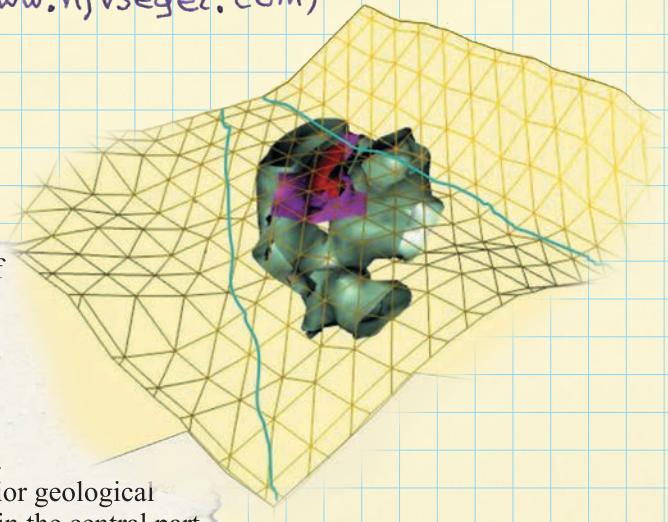


But is it possible to be more specific?

As it turns out YES it is!
If look more carefully.

AND WE DO!

This EQUATOR survey was flown in the Eastern Sayan over known porphyry copper deposit in 2010 for NF VSEGEI (www.nfvsegei.com)



One of the survey purposes was to specify the location and geometry of the ore body. Here you can see the results of interpretation: 3-D model of conductivity distribution.

Apparent resistivity at different depths was calculated within limited area that certainly includes the ore body .

Using these data iso surfaces for fixed resistivity values were modeled. By geologists opinion 700 Ohm*m surface corresponds very well to prior geological information. The area with higher resistivity values can be easily seen in the central part of the model, it corresponds to quartz core and is confirmed by drilling data.

GEOLOGISTS ARE HAPPY

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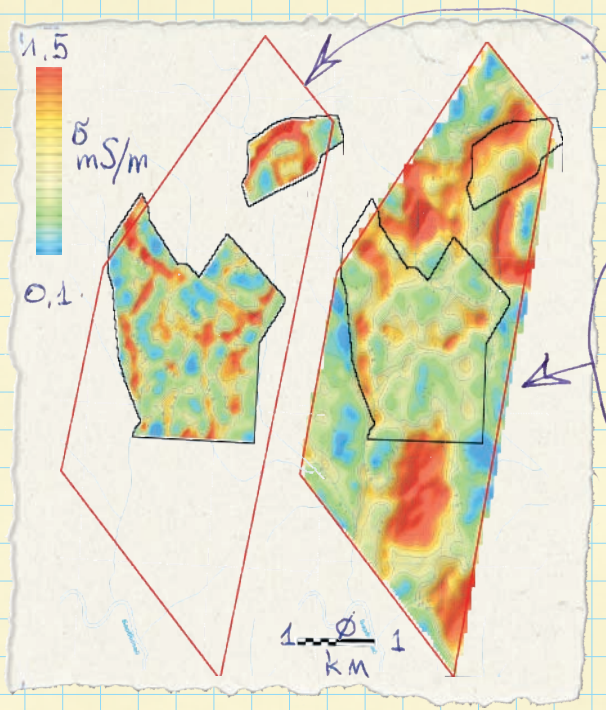
AIRBORNE EM VS GROUND EM
WHAT WILL YOU CHOOSE?



Ground geophysics spent the whole summer in the hard to reach area conducting electromagnetic survey and got perfect results. Here they are!

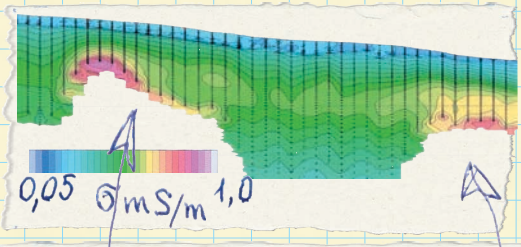
Airborne EQUATOR EM survey took half an hour to fly it and one day to process data. And here are the results!

These maps are so similar, almost like mirror images!

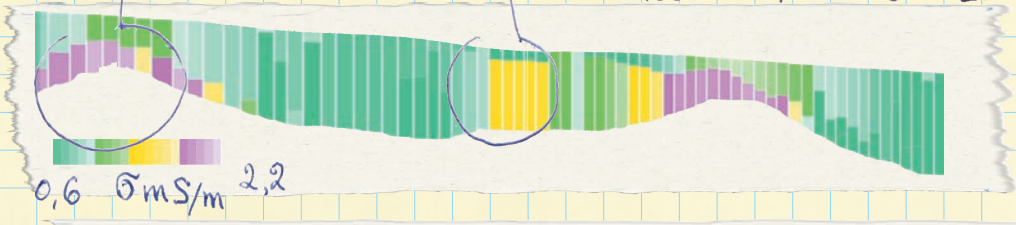
Still have any doubts?

Look, here are two cross-sections.

For this section ground data were used



And for this airborne data were used. Note! The route was flown ONCE.



Unbelievable?

But this is known deposit ERGOJU (http://grkdelta.narod.ru/mr_ergoju_1.htm) and the upper section was taken from this site. And, please, take into account that electrical properties of this area complicates EM survey greatly: "conductive" target is 100 meters deep, its resistivity is 300 Ohm*m and resistivity of host rock is 1000 Ohm*m.

ISOLATOR in ISOLATOR is detected!

So what will you choose next time?

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PORTFOLIO OF OUR CAPABILITIES

Give me MY OWN AIRBORNE MAGNETICS!

Complete solution: instrumentation, software, installation, personnel training and support. ALL together! And right now! Even genies only dream of that

The example. It took Geoken company less than six months not only to order and get, install and launch full airborne system but also to complete high quality 90 000 line km airborne survey. Now Geoken owns three aircrafts equipped with our magnetic systems.

We offer magnetic systems for different applications:

1. Traditional airborne magnetic system GT-MAGx2 for one or two-sensor survey - proven high-reliable system that is widely used in “stinger” or “towed bird” configurations.
2. Advanced system GT-MAG for complicated survey, the system of choice for gradiometry.
3. “Walking” magnetometer GT-MVS.
4. Base magnetic station GT-MVS-SB.

For data acquisition and control and for navigation (if necessary) NavDat is used in all these systems

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MAGNETICS

NEED GROUND OR AIRBORNE MAGNETICS?

This page helps you to make a choice. We'll do the rest.

	GT-MVS-SB (BASE STATION)	GT-MVS-SB (WALK)	GT-MAG-2	GT-MAG
Precise Sensor Type	high-sensitivity Self-oscillating split-beam (Cs, K, ...)	high-sensitivity Self-oscillating split-beam (Cs, K, ...)	high-sensitivity Self-oscillating split-beam (Cs, K, ...)	high-sensitivity Self-oscillating split-beam (Cs, K, ...)
Sensor Number	1	1	2	4
Sensitivity	0.0002 nT/√Hz	0.0002 nT/√Hz	0.0002 nT/√Hz	0.0002 nT/√Hz
Resolution	0.001 nT	0.001 nT	0.001 nT	0.001 nT
Sample Rate	1 Hz	up to 1000 Hz	up to 1000 Hz	1000 Hz
Fluxgate channels	-	-	1x3 components	up to 3x3 components
Fluxgate Sample Rate	-	-	same as for precise channel	same as for precise channel
Data Storage	USB-flash	USB-flash	-	-
Data Output Interface	Wi-Fi, USB	Wi-Fi, USB	USB	USB, Ethernet
Internal GPS	GlobalSat OEM GPS Receiver ET-332, 1 Hz	GlobalSat OEM GPS Receiver ET-332, 1 Hz	up to 2 Javad/Topcon or Novatel 1-100 Hz	up to 3 Javad/Topcon or Novatel 1-100 Hz
External GPS	Any with serial output	Any with serial output	-	-
Radar Altimeter	-	-	TRA 3000/3500	TRA 3000/3500
Standard Software	NavDat (ground module)	NavDat (ground module)	NavDat, Compensator Reinmag for “stinger”	NavDat, Compensator Reinmag for “stinger”
Power Supply	10-26 VDC / 15W (45W max)	10-26 VDC / 15W (45W max)	22-31VDC / 15W (60W max)	22-31VDC / 15W (120W max)
Console dimensions	170x215x35 mm	170x215x35 mm	325x290x70 mm	325x290x140 mm

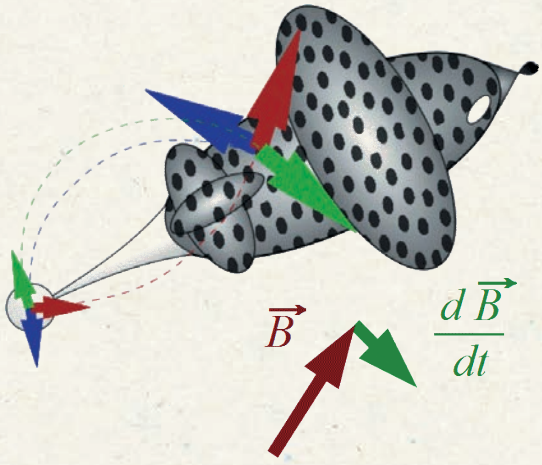
AIRBORNE MAGNETICS
NEW INSTRUMENTS, NEW QUALITY

Our specialists try to achieve maximum precision and sensitivity developing new technologies for airborne magnetic survey. In our opinion even traditional airborne magnetics can and should be more accurate.

BUT HOW?

Negoro, a well known specialist in magnetic measurements, put a piece of iron under marine compass, and he was successive enough and force young captain of schooner "Pilgrim" to round Cape Horn and come to Africa instead of South America! Such superior "correction" quality one can only envy!

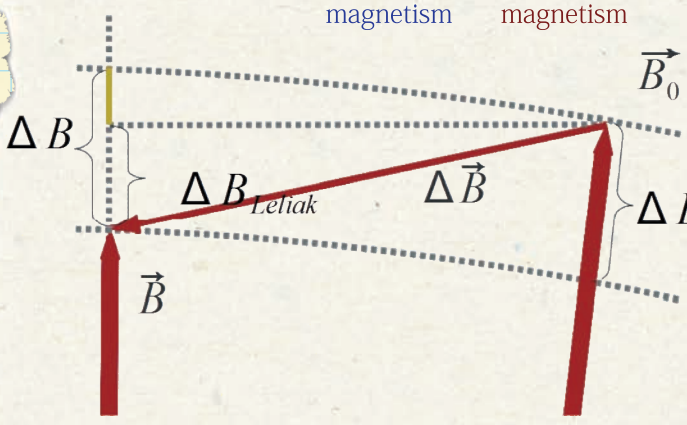
Something very similar we're faced when performing an airborne survey with magnetic sensor directly attached to aircraft's fuselage. Magnetic field associated with the airframe of the aircraft is added to the Earth magnetic field and affects measurements result.



But **data can be corrected!** All we need are three field vector projections (which include the interference of aircraft) and this correction rule:

$$\Delta B = \left(\Delta\vec{B}, \frac{\vec{B}}{B}\right) = \left(\vec{B}_P, \frac{\vec{B}}{|B|}\right) + \left(A_I\vec{B}, \frac{\vec{B}}{|B|}\right) + \left(A_E\frac{d\vec{B}}{dt}, \frac{\vec{B}}{|B|}\right)$$

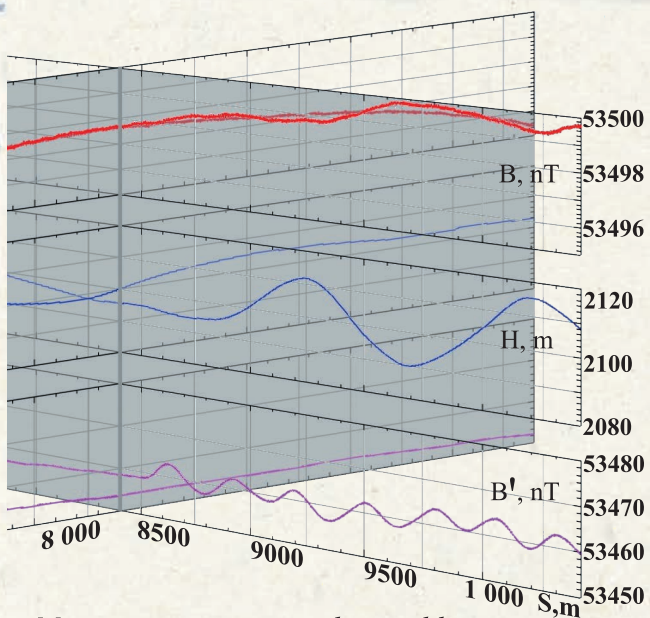
permanent magnetism — induced magnetism — eddy-current magnetic fields



This model of magnetic interference is known as Leliak model *(Leliak, P., (1961). Identification and evaluation of magnetic field sources of magnetic airborne detector equipped aircraft: IRE Transactions on Aerospace and Navigational Electronics, 8, no. 3, pp. 95-105)*.

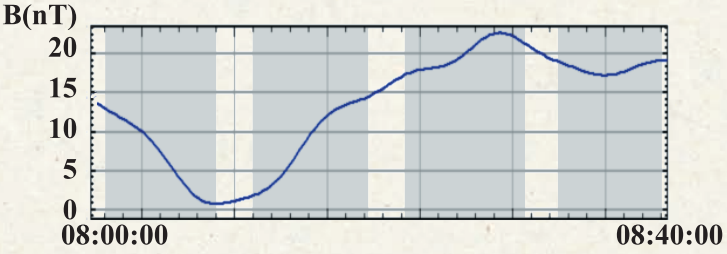
It can be shown that this correction is very accurate. Even interference of 100 nT is corrected as precise as 0.1 nT!

$\vec{B}_P$, A_I and A_E are all parameters we need. **But how to get them?** Let's perform a calibration. The first idea is to take high altitude, where Earth's field is smooth, and to "rotate" magnetometer together with aircraft supposing that field is homogeneous and constant. Then aircraft's magnetism will manifest itself.



Measurements on two orthogonal lines.
B — *compensation result (1 nT per cell),* H — *altitude,* B' — *measured field value (10 nT per cell).*

But there is no place on our planet with such ideal conditions! And it is impossible to "rotate" an aircraft in fixed point. It is supposed to move forward! In GRADIENT magnetic field. It means that the field IS CHANGING while maneuvers are flown during calibration!

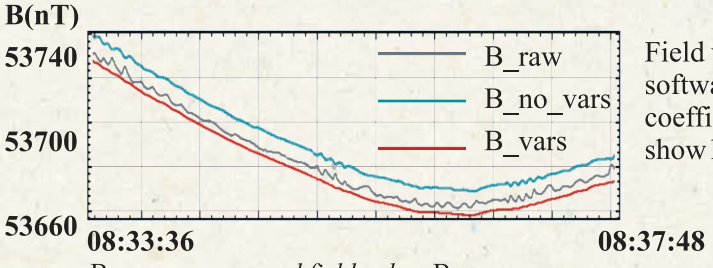


Field variations during calibration flight. Marked time zones correspond to time of calibration.

Our specialists came to conclusion that such idealization leads to obviously erroneous parameters calculation and results can be improved.

And for this purpose field gradient effects during calibration flight must be considered. But the gradient values are individual for each point and are a priori unknown!

Nevertheless, the ReinMag software developed by our specialists allows parameters estimation as accurate as possible. Gradient values on the lines of ordinary calibration flight are estimated as well as correction coefficients.



B_raw — *measured field value,* B_no_vars — *calibration result ignoring variations,* B_vars — *calibration result taking variations into account*

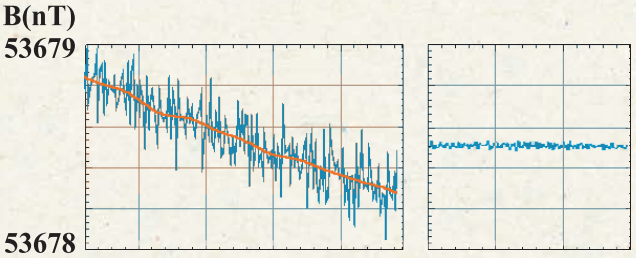
Field variations in time can be taken into account also because the software calculates everything in post processing. The obtained coefficients can be used in real-time during a survey. Given charts show high performance of compensation.

Heading (deg)	Altitude (m)	B (nT)
5	2100.5	53697.5
95	2100.0	53697.6
185	2095.5	53697.7
275	2093.0	53697.9

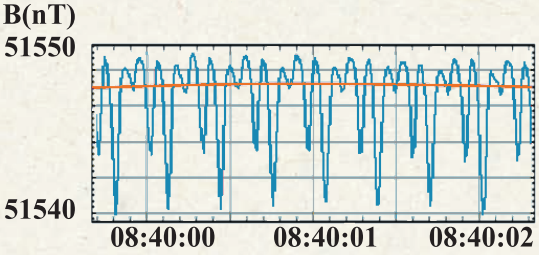
Moreover, the table on the right shows compensation results in the same point flown in four orthogonal headings at almost the same altitude. Such quality of correction of interference associated with heading is obtained automatically! You can find more detailed description of Geotechnologies' compensation method on our website:
http://www.gtcomp.ru/en/downloads_en.html

AIRBORNE MAGNETICS

But this is not the whole story ! Aircraft's vibrations, which are unavoidable in flight, also affects airborne magnetics quality. They are caused by engines and propellers functioning and their frequency band is 20-40 Hz usually. And in case of helicopter-borne magnetics we are frequently faced with magnetic interference associated with main and tail rotor and their blades. This noise frequency is of 10 Hz order. But if sample rate of magnetic field measurements is high enough all described noises may be filtered correctly.



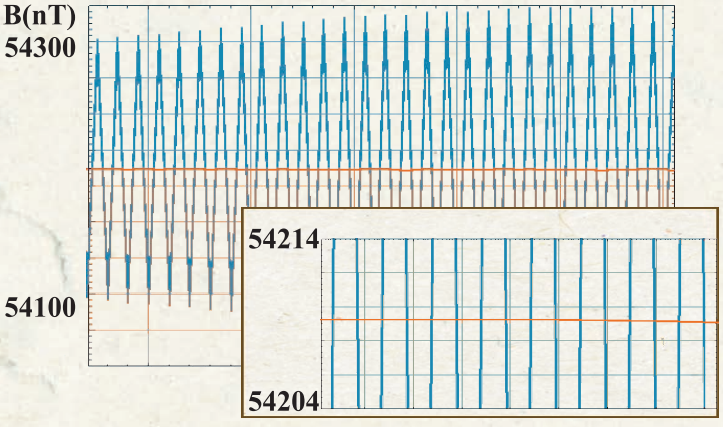
An-2: engine on (in flight); engine off



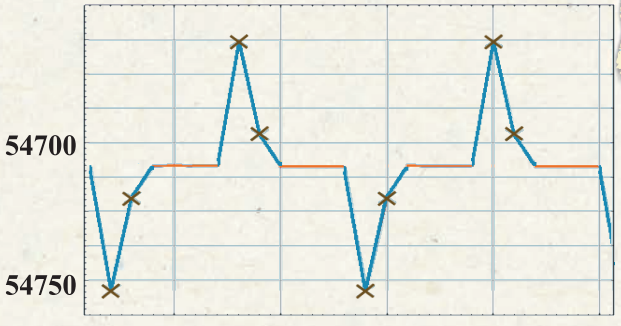
Mi-2 helicopter rotor field

And besides, high sample rate allows removing of powerline fields interference of 50/60 Hz. High-precision airborne magnetics is now possible near power lines, factories, plants, drilling equipment etc.

And of course, if magnetic and EM survey are combined, EM transmitter field, which often is HUGE, also affects magnetic measurements. But we are able to exclude EM-on-time samples if magnetics sample rate is high enough. No need to use special signals to transfer to magnetometer information about EM-transmitter current state – it can work independently!



Power line field and filtering result

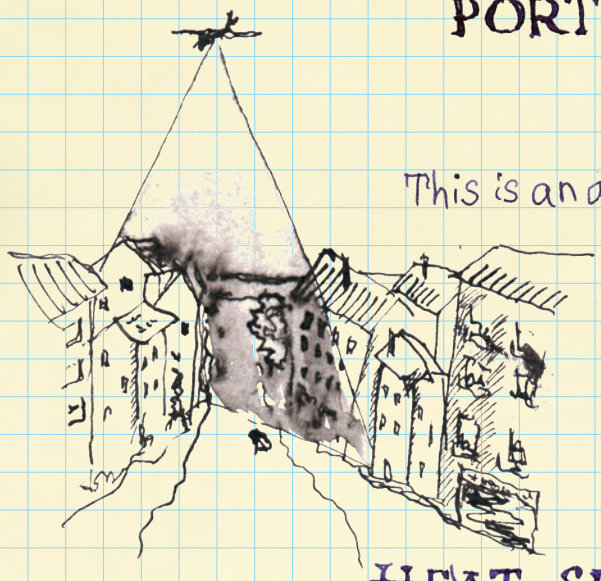


Elimination of EM- system field

Actually, magnetic field measurements sample rate should noticeably exceed frequencies of all possible noises or interferences to filter them correctly. Because even if measurements are synchronized to the interference source, helicopter main rotor, for example, there is a very poor chance to filter other noises, for instance, one of power lines. And they are so frequent nowadays.

PORTFOLIO OF OUR CAPABILITIES

AIRBORNE INFRARED IMAGING

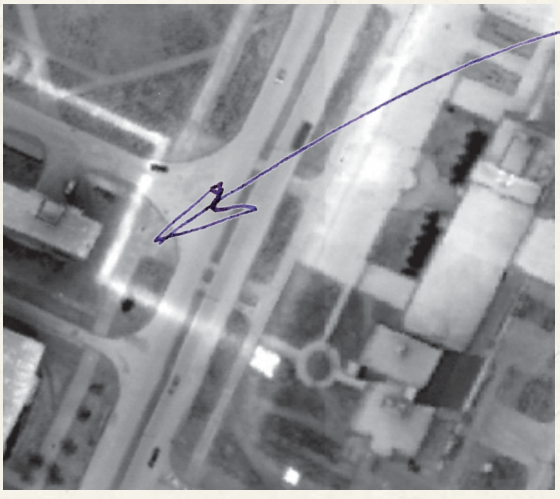


This is an airborne infrared scanner.

It can solve problems, for example

HEAT SUPPLY NETWORK MONITORING

Problem zones of underground network



In addition:

-Scan-T can be installed in light aircraft inside or outside fuselage with ease.

-We provide full software support including automatic georeferencing.

-Onboard system for navigation and data acquisition - NavDat

— Geotechnologies — gtcomp.ru —

TO BE CONTINUED

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