Onsite Automatic Geomagnetic Observatory: Proof-of-Concept for the Oil & Gas Drilling Industry

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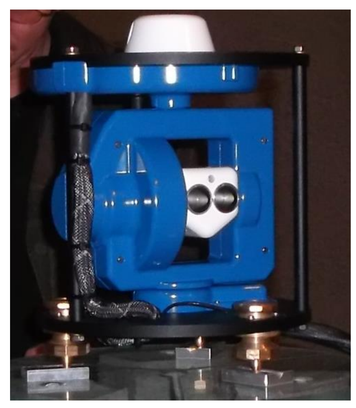
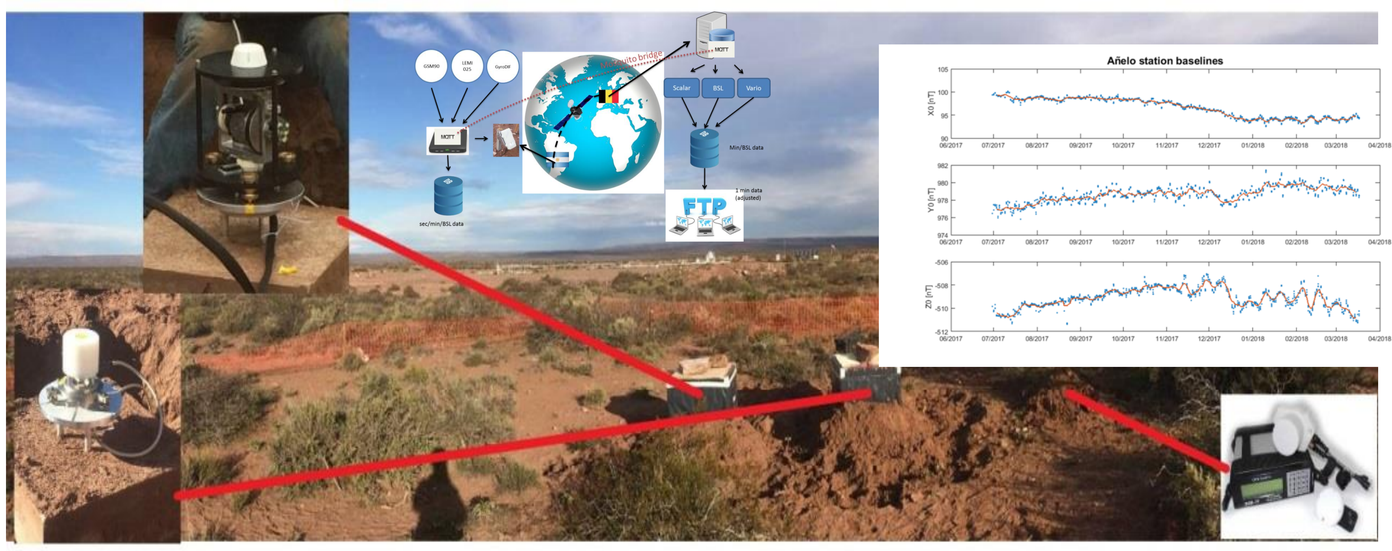
Left: conventional magnetic observatories require heavy facilities and manpower to perform daily DIflux measurements

Right: the Autodif is an Automated DIflux for magnetic observatories (azimuth reference is provided by an embedded laser pointing a reflector). The Gyrodif instrument is an Automated DIflux for remote applications (an embedded gyroscope provides the azimuth reference)



From the GYRODIF instrument to a unique remote real-time magnetic observatory



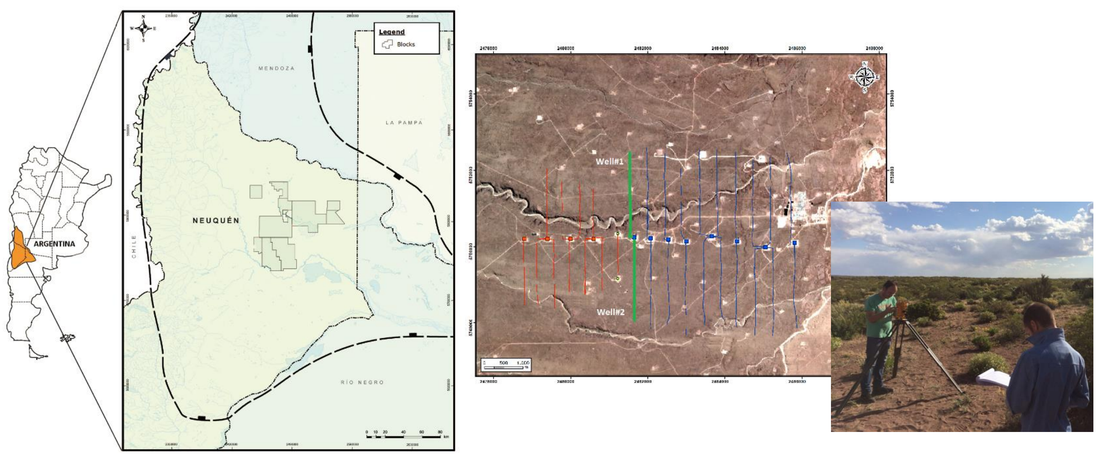
Date	Hour	Dec[deg]	Fcalc[nT]	Dip[deg]	Q[nT]
17/08/01	00:00	003.2577	24569.60	-39.3194	00.216
17/08/01	00:01	003.2580	24569.59	-39.3195	00.215
17/08/01	00:02	003.2585	24569.50	-39.3197	00.208
17/08/01	00:03	003.2587	24569.49	-39.3198	00.218
17/08/01	00:04	003.2585	24569.46	-39.3199	00.213
17/08/01	00:05	003.2581	24569.37	-39.3201	00.230
17/08/01	00:06	003.2575	24569.18	-39.3205	00.241
17/08/01	00:07	003.2570	24569.02	-39.3208	00.234
17/08/01	00:08	003.2566	24568.97	-39.3211	00.246
17/08/01	00:09	003.2564	24568.86	-39.3214	00.242
17/08/01	00:10	003.2565	24568.75	-39.3217	00.249
17/08/01	00:11	003.2568	24568.55	-39.3222	00.232
17/08/01	00:12	003.2574	24568.34	-39.3227	00.223
17/08/01	00:13	003.2577	24568.27	-39.3229	00.205
17/08/01	00:14	003.2577	24568.20	-39.3230	00.226
17/08/01	00:15	003.2577	24568.10	-39.3233	00.213
17/08/01	00:16	003.2578	24568.11	-39.3233	00.226
17/08/01	00:17	003.2579	24568.01	-39.3235	00.224
17/08/01	00:18	003.2579	24567.90	-39.3237	00.211
17/08/01	00:19	003.2577	24567.81	-39.3239	00.204
17/08/01	00:20	003.2575	24567.91	-39.3238	00.196
17/08/01	00:21	003.2572	24567.97	-39.3237	00.201
17/08/01	00:22	003.2572	24567.95	-39.3237	00.201
17/08/01	00:23	003.2572	24568.01	-39.3236	00.181
17/08/01	00:24	003.2572	24568.01	-39.3237	00.206
17/08/01	00:25	003.2571	24567.94	-39.3238	00.195

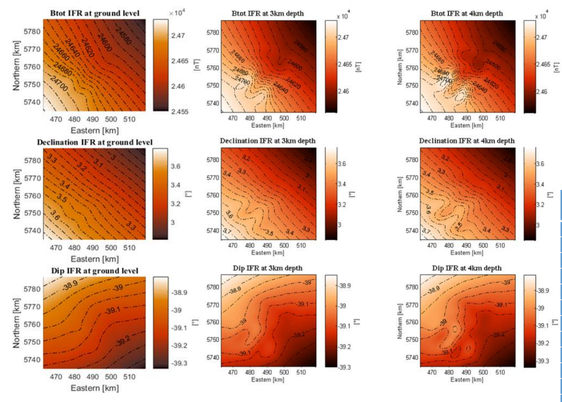
The Automatic Magnetic Observatory comprises a proton magnetometer (right) for Total Field monitoring (1hz data, 1nT absolute accuracy), a variometer (left) to monitor X,Y,Z variations (1hz data, 10pT resolution) and a Gyrodif (top) for calibration & QA/QC.

Real-time Magnetic Observatory minute data were uploaded on a ftp server continuously (every 15 minutes). In addition to Declination, Inclination and Total Field, a quality flag was added (Fcalc-Fmeasured) and a real-time e-mail alert system was set (in case of missing data or if D, I or F shows higher than expected time variations).

Providing local reference geomagnetic data to reduce the well positioning uncertainty

Every year, thousands of new wells are drilled throughout the world by the oil& gas drilling industry. Most of the wells trajectories are far more complex than simply vertical. Therefore, reaching the underground target truly is a navigational issue. The oil & gas drilling industry most widely used navigation tool is known as “Measurement while drilling (MWD)”. It relies on magnetometers and accelerometers located near the drill bit. The automatic geomagnetic observatory improves MWD technology by providing local reference geomagnetic data. It provides accurate temporal geomagnetic data, complementary to spatial geomagnetic data (obtained from a magnetic survey or a geomagnetic model).



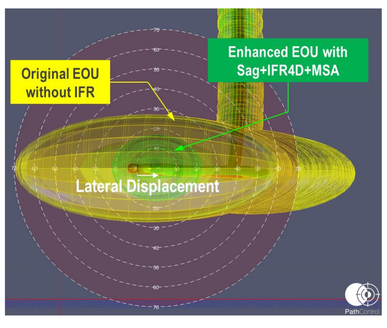


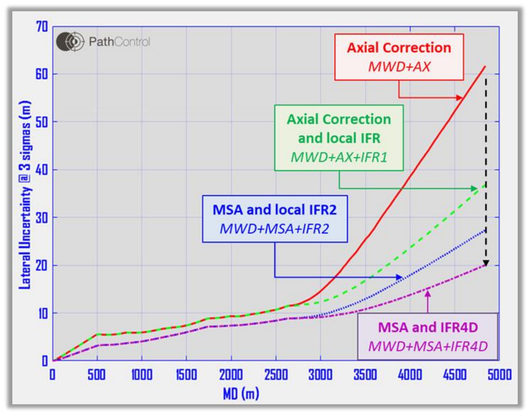
Units	Total Field Global nT	Declination Global deg	Dip Global deg
$\sigma_{instrument}$	1	0.01	0.005
$\sigma_{diurnal}$	0.1	0.01	0.01
$\sigma_{downward}$	3.2	0.015	0.02
σ_{total}	**3.4**	**0.021**	**0.023**

Units	Total Field Random nT	Declination Random deg	Dip Random deg
$\sigma_{temporal}$	1	0.01	0.005
σ_{noise}	2	0.005	0.005
σ_{total}	**2.2**	**0.011**	**0.007**

		Reference Error Model ISCWSA Rev4			Customized Error Model	
Geomagnetic Error Terms	Units	MWD	MWD+IFR	MWD+IFR2	MWD+IFR1	MWD+IFR4D
DECG	deg	0.36	0.15	0.15	0.1	0.1
DBHG	deg.nT	5000	1500	1250	400	400
DECR	deg	0.1	0.1	0.05	0.1	0.02
DBHR	deg.nT	3000	3000	750	400	200
DECG+DBHG*	deg	0.44	0.17	0.16	0.1	0.1
DECR+DBHR*	deg	0.18	0.18	0.06	0.1	0.02
MDIG	deg	0.2	0.1	0.08	0.1	0.08
MDIR	deg	0.08	0.08	0.02	0.08	0.02
MFIG	deg	130	50	45	50	45
MFIR	deg	60	60	15	60	15
* Local B_H value is about 20000 nT						

Above (from left to right): the two green lines show the pilot wells (about 4 800m meter depth, 2 000m length). RMI performed a ground based magnetic survey to provide a static 3D geomagnetic data reference grid (for Declination, Inclination and Total Field). The accuracy related to each geomagnetic parameter was established and a customized error model was adopted (conservatively, in order to avoid any operational disruption).





RESULTS

For this field test (non challenging wells), the most significant result is unsurprisingly due to the magnetic survey (called IFR1) leading to 40% reduction of the lateral uncertainty.
The combined effect of the magnetic observatory with non geomagnetic related corrections (SAG & MSA) leads to about 30% additional improvement.

CONCLUSIONS

- Successful field test demonstrating:
  - technology & equipment very high reliability
  - great added value in terms of wellbore positioning & collision avoidance
  - truly automated technology with no operational disruption
- Next steps:
  - Application to challenging wells (at high geomagnetic latitude or in areas with significant magnetic anomalies and / or high accuracy required)
  - Seafloor magnetic observatory under development

References

IPTC-19395-MS First Onsite Automatic Geomagnetic Observatory Improves Well-Bore Positioning, Momot F., Pathcontrol, Humbled F., RMI, Garbers M., TOTAL SA, Shabanov S., TOTAL SA, Gonsette A., RMI, Sikal A., Pathcontrol, Cousso O., TOTAL SA, Reynaud D., Pathcontrol

Magnetic Valley is an applied geophysics innovation project aiming at the development of operational products and services, based on the expertise of the RMI Geophysical Centre, in order to contribute to the socio-economic well being. For more than 50 years, the fields of expertise in which the Geophysical Centre is a world reference are: the Earth's magnetic field, the ionosphere and the environmental magnetism.

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