

Geothermal

Well Logging Services

Iceland GeoSurvey provides a wide range of open and cased hole logging services, using highly specialized equipment especially suited for the geothermal sector in accordance to the ISO 9001 standard. Iceland GeoSurvey has a long tradition and experience of working in geothermal fields all over the world, and well trained and experienced personnel in logging operations and consultancy.



www.isor.is



Iceland GeoSurvey's objectives are to provide geothermal logging services that enable a better understanding of subsurface conditions in geothermal systems, and provide information for field analysis in regards to:

- Geological subsurface structures of geothermal fields
- Extents and scale of the geothermal reservoirs
- Reservoir monitoring and production forecasting
- Chemical, physical and structural properties of reservoir rocks
- Chemical and physical properties of reservoir fluids
- Chemical and physical processes within geothermal field systems

Iceland GeoSurvey maintains three specially equipped trucks for real-time logging in open and cased wells, and another three units for slick-line logging with memory tools. The logging operations are divided into two main temperature categories:

▶ Well logging below 150°C

The measured data is transmitted through a 4-conductor standard GO cable head and a 6000 m long logging cable. Besides internally developed data acquisition applications, the Warrior Data Acquisition System, manufactured by Scientific Data Systems, is the primarily used data acquisition tool.

▶ Well logging above 150°C

Memory tools with slick-line cables, and cable lengths above 6000 m, are used for high temperature well logging and borehole monitoring. The instruments collect and store primarily temperature and pressure data as a function of time and depth.

386°C

is the highest measured temperature in a geothermal well in Iceland

20 geothermal well

on average have been drilled and logged annually in recent years in Iceland

Up to
3000 km
have been logged annually in recent years in Iceland



▶ Logging Applications

Temperature and differential temperature (400°C)

Used to estimate heat flow, find feed zones and to find out the fluid flow and the formation temperature in the geothermal system.

Pressure logs (400°C)

To estimate flow irrigate of the bedrock which is governed by the permeability of the rock, the viscosity of the liquid and a distribution of pressure. Production leads to a decline in pressure in the geothermal system.

Caliper logs

To measure the dimension of the well and show cavities where the well is drilled through soft formation, scaling in the well, etc. The tools have either 3 or 4 arms (two pairs). A caliper log is measured continuously from bottom to top and the device sends the data to the surface in real time.

Resistivity logs 16", 64" & SP

Measures the electric resistivity of the rock around wells. The resistivity depends on the porosity of the rock along with salinity and the temperature of the liquid in the porous medium.

Neutron logs (n-n)

A neutron source (Am-Be/Ra-Be), placed in the device, sends out high energy neutrons. The n-n logs are useful for estimation of the porosity.

Natural gamma ray logs

A natural gamma radiation of rock comes from radioactive isotopes, especially K, U's and Th. A correlation interposes silica content in Icelandic rock and its natural gamma radiation.

Televiwer

Emits acoustic pulses and detects their reflection from the surroundings, to detect shape, formation, fractures, casing damage, and other irregularities in the well and its surroundings.

Full-Waveform - Compensated Sonic Probe

To measure formation acoustic-velocity.

Fluid sampling in wells

To find the chemical composition of the fluid.

Fluid Flow

The continuous flow-meter spinner is logged to obtain an overall picture of inflow zones within the borehole.



Cement bound logs (CBL)

To estimate the quality of the cementing of the casings in the well. If casings are badly bounded to the formation it can collapse and cause serious damage to the well. The CBL-device emits an acoustic signal which propagates from the emitter in the probe along the casing to the two receivers higher up in the probe.

Collar Casing Locator (CCL)

Is used to detect variation in the amount of iron in the vicinity of the CCL tool. The recording of the CCL signal is used to locate casing joints and casing damages.

Downhole VideoCamera (80°C)

Motion pictures can be taken down to 600 m depth if the temperature is not higher than 80°C. The pictures can be shot either sideways or directly downwards. This equipment is used for studies of fractures, scaling, and casing damage.

Gyroscopic logging

Used in directional drilling to steer the drill bit along the planned track of the well. A real-time information about the inclination, the azimuth (true-north) and gyrotoolface of the well is recorded. The information is used to calculate the exact coordinates of the track. Two types of instruments are used, one type used for kick-off measures individual points, and the other type records continuously.



► Geothermal Logging Tools

Parameter	Parameter Name	Tool length [cm]	Tool diameter [mm]	Maximum Pressure [bar]	Maximum Temperature [°C]	Logging speed recommended [m/min]	Tool Combination Options
Temperature	T	61-86	28-47	1000-1034	<150	20-35	T-P, T-P-CCL
Temperature	T	<152	<45	340-1240	<400		T-P
Pressure	P	68-127	27-42	250-1100	90 - 140	20-35	P-T
Pressure	P	<152	<45	340-1034	<400		P-T
X-Y Caliper (4-arm)	CAL-XY	138	91,4	1034	<150	15-20	
Caliper (3-arm)	CAL	192-208	35-42	1000	<130	15-20	
Casing Collar Locator	CCL	60	40	1380	<150		CCL-GR
Cement Bond Log	CBL	277	70	800-1380	<150	10-25	
Resistivity logs 16" & 64"	RESISTIVITY	200-220	60-90	<350	<150		RES16-RES64
Salinity / Conductivity	SAL			<350	<150		
Neutron & Natural Gamma Ray	NN & GR	143-264	43-60	206-800	90 - 150	6-15	NN-GR
TeleViewer	TELEVIEWER	2000	43	800	135	5-8	
Sonic / Acoustic log	DT			207	70		
Deviation Survey (North Seeking, point every 25 m)	DEV	155	42	1030	200		
Gyroscopic Survey	DEV	98-213	42-44	800-1000	75-85	15-35	
Flowmeter	FLOW	65	43	1000	140		
Downhole Camera	DHI	48-56	53-89	172	75		
Downhole Fluid Sampling Tool	FS	247	50		90		
Renting of the Logging Truck					<150 or <400		
4 Conductor cable		< 5500m			<150		
Slick Line		< 6000m			<400		

New Tool Acquisitions : Project specific tool request are always considered and reviewed when requested by the customer. The geoSurvey is always open to alternative solutions and project requests.



Iceland GeoSurvey - ÍSOR
Grensásvegur 9
108 Reykjavík
Iceland

Tel.: +354 528 1500
Fax: +354 528 1699
Email: isor@isor.is
www.isor.is

Contact: Bjarni Richter
Marketing- and Project Manager, Senior Geologist
br@isor.is