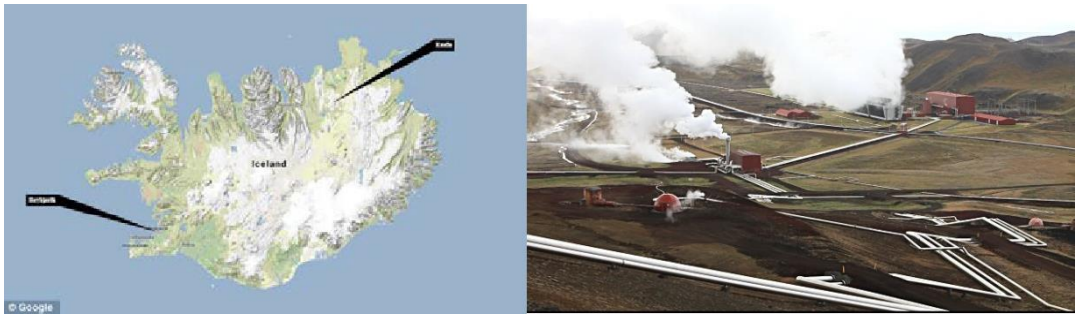
, con hamElectrical conductivity exercises

Exercise 1:



Krafla geothermal power station

Borehole KH5, has been drilled in Krafla, Iceland, in a high enthalpy geothermal reservoir. Electrical conductivity, porosity and density, have been measured on 12 samples fully saturated with seven different fluid conductivities.

(a) Determine the formation factor, surface conductivity, cementation index and tortuosity for the all the samples. (Data can be downloaded from the Moodle platform).

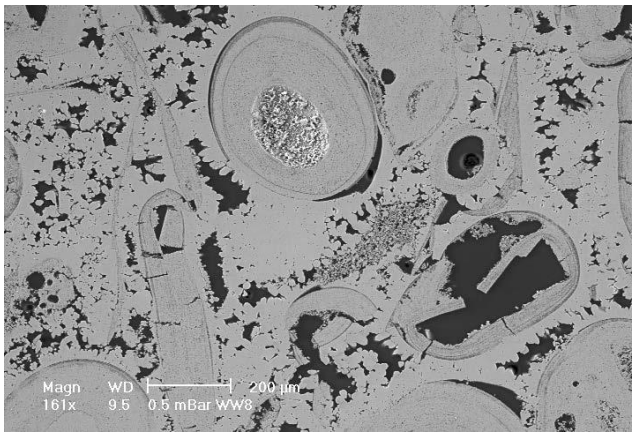
(b) Plot the formation factor as a function of porosity. Please comment on it.

(c) Determine which is the best formation for geothermal exploitation.

Lithology	ID	Length (mm)	Diameter (mm)	Density	Porosity
basalt breccia	KH5-07-1 a	21.71	25.4	1.85	35.83
basalt breccia	KH5-07-1 b	21.70	25.4	1.88	34.48
crystalline basalt	KH5-07-2	21.72	25.4	2.54	14.94
basalt breccia	KH5-07-3	21.69	25.4	2.06	33.85
fine grain basalt	KH5-07-4 a	21.77	25.4	2.74	6.58
fine grain basalt	KH5-07-4 b	21.75	25.4	2.73	8.09
tuff	KH5-07-5a	21.81	25.4	1.97	32.21
tuff	KH5-07-5b	21.81	25.4	1.99	31.08
crystalline basalt	KH5-07-6	21.75	25.4	2.17	27.52
breccia	KH5-07-7a	25.65	25.4	2.08	29.76
breccia	KH5-07-7b	25.55	25.4	2.12	27.30
basalt breccia	KH5-07-8	25.66	25.4	2.00	29.58

Water conductivity (mS/m)	Rock conductivity (mS/m)											
	KH5-07-1 a	KH5-07-1 b	KH5-07-2	KH5-07-3	KH5-07-4 a	KH5-07-4 b	KH5-07-5a	KH5-07-5b	KH5-07-6	KH5-07-7a	KH5-07-7b	KH5-07-8
20.08	9.40	8.61	1.38	18.21	0.90	1.46	5.95	6.49	2.81	5.85	4.59	6.48
92.76	13.14	12.67	2.29	23.41	1.50	1.72	8.44	8.73	4.13	7.43	5.82	8.09
330.30	31.28	29.55	3.27	48.76	1.60	2.52	15.88	17.01	8.91	15.53	11.95	17.17
828.82	69.55	64.91	6.26	93.88	2.62	4.13	19.57	27.77	20.45	34.19	24.02	34.23
1587.63	153.09	142.31	17.71	176.27	4.95	8.08	47.42	67.69	51.11	82.76	60.04	82.76
1998.20	154.78	130.19	24.53	185.30	5.39	8.94	54.60	82.27	46.76	99.48	39.41	88.85
5825.50	441.86	450.79	354.25	519.05	15.32	27.00	134.56	134.29	130.45	209.98	153.24	210.19

Exercise 2:



The Savonnieres Limestone is a carbonate rock aquifer. Its electrical resistivity (Formation factor) and sonic velocity have been measured at different confining pressure.

(a) Plot the sonic velocity, resistivity and formation factor as a function of the confining pressure.

(b) Describe how the acoustic properties are related (or not) to the electrical properties in rocks? (Data can be downloaded from the Moodle platform).

Pc (MPa)	VpDry (m/s)	VpSat (m/s)	Rt (OHM.m)	FF
0	3046.79	3578.27476	5.03457113	12.28
2.5	3194.52	3638.72645	6.33726663	15.46
5	3371.46	3701.25578	6.54244613	15.96
7.5	3444.03	3735.82388	6.53814347	15.95
10	3506.57	3771.04377	6.50891709	15.88
12.5	3551.05	3796.61017	6.46287662	15.77
15	3587.44	3814.7139	6.42054397	15.67

Exercise 3:

A shaly sandstone from the Eocene lower Wilcox sand, in Sheridan, Texas (US), is sampled in the context of a drilling campaign for hydrocarbon exploration. These sandstones are described as micaceous, shaly, fine grained to silty, with hard quartz sand, and the cementing material is quartz. In order to quantify the effect of the surface conductivity for an electrical geophysical survey, 15 samples were tested by measuring the electrical impedance in the laboratory (see next table):

				Water conductivities (mS/cm)							
Sample	Depth Sample	Porosity (%)	Qv (meq/cm^3)	160	94.5	52.49	28.22	14.92	7.802	4.049	2.085
1	3858	23.9	0.017	13.2	7.85	4.43	2.44	1.282	0.68	0.3625	0.1929
2	3746	21.2	0.052	11.41	6.84	3.87	2.14	1.169	0.6435	0.3609	0.2049
3	3800	23.1	0.052	-	8.59	4.86	2.68	1.451	0.7877	0.4345	0.2408
4	3766	8	0.26	-	2.01	1.14	0.643	0.3674	0.206	0.1198	0.07
5	3821	15.4	0.2	11.01	6.61	3.8	2.16	1.219	0.7105	0.4296	0.2677
6	3806	21.5	0.095	8.75	5.27	3.03	1.712	0.971	0.568	0.33	0.2073
7	3808	17.1	0.053	6.14	3.73	2.14	1.212	0.705	0.4135	0.2524	0.1599
8	3808	17.1	0.053	6.41	3.89	2.23	1.258	0.7154	0.414	0.2473	0.1515
9	3865	19.9	0.085	9.03	5.44	3.14	1.79	1.025	0.602	0.3698	0.2342
10	3809	12.5	0.253	1.06	0.671	0.402	0.239	0.1459	0.0924	0.0598	0.0391
11	3809	12.5	0.253	0.967	0.592	0.35	0.211	0.1265	0.0798	0.049	0.0323
12	3865	11	0.28	3.85	2.404	1.46	0.895	0.5737	0.3616	0.2461	0.1993
13	3865	11	0.28	3.8	2.39	1.48	0.602	0.6022	0.4155	0.2888	0.2246
14	3865	11	0.28	5.29	3.32	2	1.233	0.7965	0.5455	0.38	0.2949
15	3809	9.2	0.41	1.16	0.755	0.479	0.311	0.2052	0.1416	0.0948	0.0687

(a) Determine the formation factor, surface conductivity, cementation index and tortuosity for the all the samples. (Data can be downloaded from the Moodle platform).

(b) Considering the density of the samples equal to 2.2 gr/cm^3, obtain an estimation of the cation exchange capacity (CEC) for each sample. Use the following equation to calculate CEC from the volume concentration of clay exchange cations Qv:

$$Q_v = \rho_{solid} CEC \frac{1-\phi}{\phi}$$

Estimate, from the table of the class (p.48), what type of clay you expect to find in the Wilcox sand formation.