Drilling completion report - Koutavos lagoon, Kefalonia Island (Greece)

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RAPPORT

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Sinaps project

RT/PRP-DGE/2015-00022

Pôle radioprotection, environnement, déchets et crise

Service de caractérisation des sites et des aléas naturels

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Drilling completion report

Koutavos lagoon, Kefalonia Island (Greece)

D. Moiriat, N. Theodoulidis and E. Cushing

Rapport PRP-DGE n° 2015-00022

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SUMMARY

FIGURES

ANNEXS

1 INTRODUCTION

In this report, the realization of boreholes from 8 June 2015 to 25 June 2015 on Kefalonia Island (Greece) in the lagoon Koutavos close to the town Argostoli (Figure 1) is presented. It is the first step to be followed by laboratory geotechnical and geophysical in situ tests. The latter investigations will subject to more detailed reports regarding characterization of the geological series.

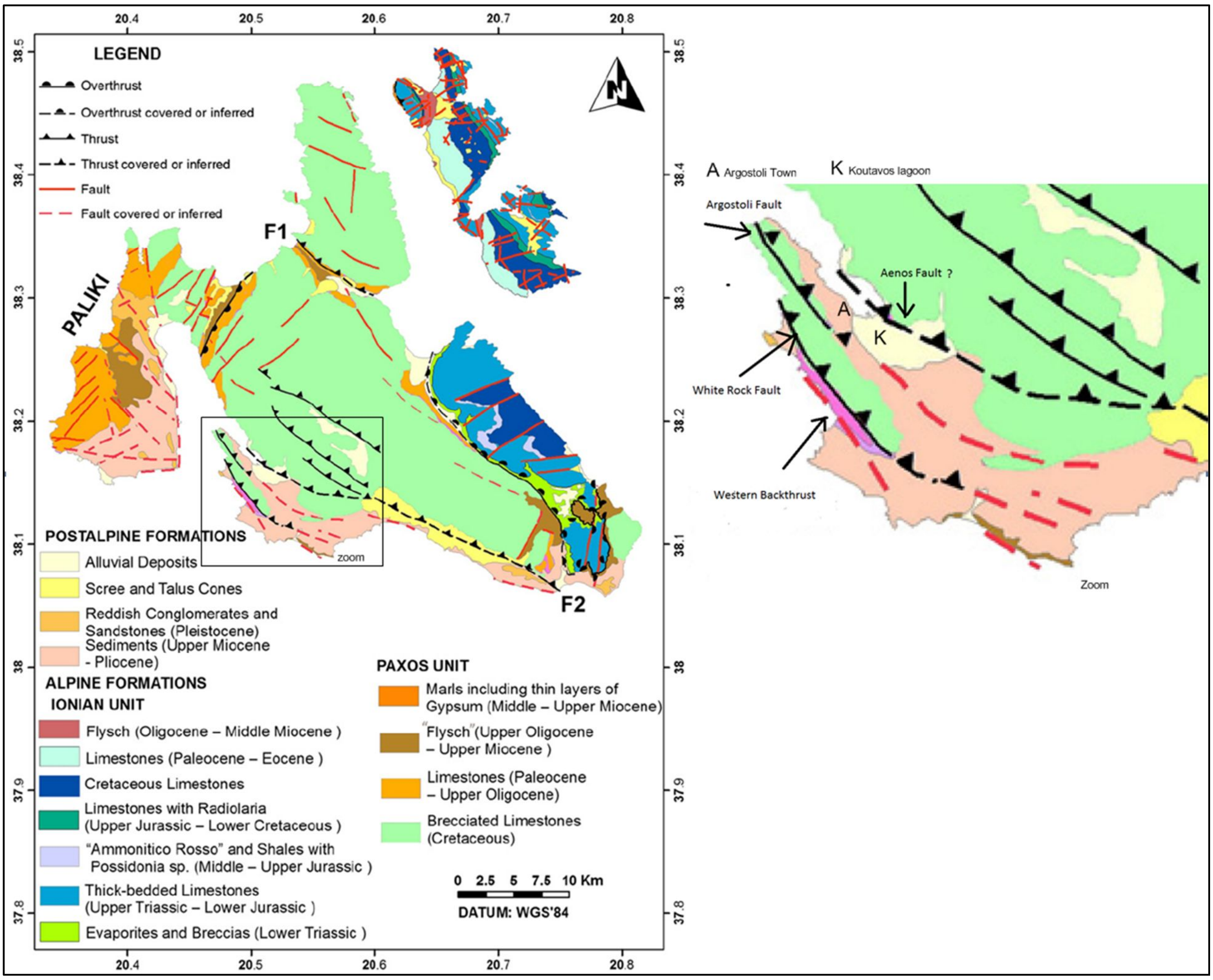

Figure 1 : Simplified geological map of Cephalonia and Ithaca (from Lagios et al, 2012)

This drilling campaign fits into the SINAPS@ project (funded by ANR) aiming at the study of site effects and seismic non-linearity imposed by strong ground motion of local earthquakes. The first objective is to install borehole and surface accelerometers of high resolution. Cephalonia Island has been chosen because of its high seismic activity (the highest in Europe) while the lagoon of Koutavos in addition to its geological interest, offers an easy access to perform drilling since it is located very close to the town of Argostoli.

The initial plan of drilling was:

- One borehole cored to a depth originally planned between 60m to 100m in order to install an accelerometer in the 'healthy' rock below the sedimentary layers (soft to hard soils). During the realization of this borehole, SPT tests were also planned in the soils to evaluate their stiffness and to provide an idea on their dynamic behavior and in particular their liquefaction potential.

- Two destructive boreholes at depths of 20m and 40m for cross hole (CH) and down hole (DH) measurements before installation of sensors at their bottoms. The exact location of those 3 expected boreholes is presented in in Figure 2.

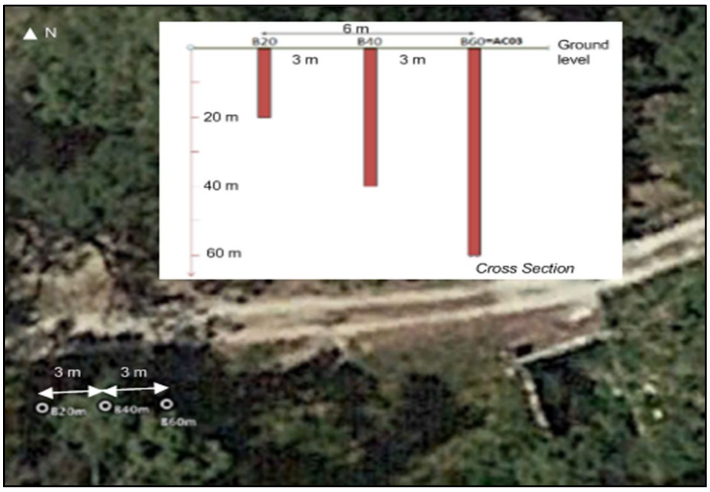

Figure 2 : Location of expected boreholes

Drilling and in situ geotechnical investigations were performed by GEOTER[1] company (project sub-contractor) and supervised by ITSAK[2] and IRSN[3]. The CH and DH measurements have been be made by a GEOTER geophysical team by the end of June, while sensors were installed early in July 2015.

2 GEOLOGICAL AND SEISMIC CONTEXT

2.1 GENERAL

Northwestern Greece is one of the main active tectonics area of the Mediterranean region and is has the highest seismic activity in Europe. Located at the boundary of the Eurasian/African plate, the convergence rate is up to few centimeters per year. In the Cephalonia area, this limit is constituted by the northwester most end of the Aeagean subduction frontal thrust (South of Cephalonia) linked to the dextral Cephalonia Transform Fault (CTF west of Cephalonia). This major fault plays the role of a transition zone between the African subducting plate and the continental Apulian plate. Since the mean slip rate and the CTF length are great, seismic hazard is high in term of frequency and magnitude. Cephalonia is located in the external part of Hellenides fold belt; encompassing the foreland (Pre-apulian –or Paxos zone) and the overthrusted Ionian zone to the East of the Island. Pre Apulian zone was characterized by an extensional regime until the lower Pliocene and some preexisting faults of Cephalonia acted as normal fault during the Neogene times. Since the lower Pliocene and up to now, the Preapulian zone has experienced strong shortening leading to the formation of active folds and strike slip to reverse faults. This tectonics is the cause of the relief of Cephalonia and also anticlines and synclines of Plio-Quaternary detritic beds.

The Koutavos lagoon is located in the Argostoli area characterized by sub-cylindrical structure of west verging thrust and folds with a strongly deformed and asymmetric anticline on the western part or the Minies area and a

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more gentle asymmetric NNW striking syncline to the east in the Argostoli-Katavothres area. Some important faults are mapped or suspected. From the West to the East (Underhill, 1989):

- Southwest dipping backthrusts located at Cape Lardhigos and on the west coast are described by Sorel (1976, 1985) – and Underhill (1989). This (these) fault(s) often overthrust the Paleomillazzien (1 to 0,5 Ma) raised beach and are located on the plane of the Paleogene-Calabrian unconformity.
- West verging White Rock Fault (Underhill, 1989)
- West verging Argostoli fault (Underhill, 1989)
- Aenos thrust located on the eastern part of the Argostoli syncline. This Fault is proposed by Underhill (1989), but has not been observed or mapped by Sorel (1976). This is located on the Aeanos mountain foothill which is interpreted by Sorel as being a Pliocene paleo-cliff. Previous field survey performed in 2013 with C. Guyonnet-Benaize for mapping this area dis not evidenced any fault trace.

2.2 UNCERTAINTIES REGARDING THE LOCAL GEOLOGY

Boreholes are located in the Koutavos lagoon filling with Quaternary sediments recovering Pliocene and Cretaceous formations. The best target for the sensor is the upper Cretaceous limestone which outcrops to the east of Koutavos lagoon (Annex 1) with distinct features: white color, well cemented (micritic cement) with rudistids pointed out a Cretaceous age. Its massive aspect provides an excellent choice like elastic middle for the wave propagation and as a result the reference of seismic signal without site effects.

- **Existence of fault crossing the Koutavos lagoon**

  The Aenos thrust mapped by Underhill (1989) under the Koutavos Lagoon remains questionable for us (Figure 1). The presence of this fault could impact the depth of the top of massive limestone which could be deeper than the predictions from previous boreholes in the neighborhood (Boreholes A1, A2 and A3 Annex 2 and located Annex 1).

- **Weathering and jointing in the massive limestone from Cretaceous**

  In addition and given the tectonic context, the limestone could be fractured and weathered with a thickness that may reach several meters. Moreover, deep karsts may develop along joints (stratigraphic and fracturing). However the limestone outcrops close to the drilling area to the East (Annex 1) point out limited karstic developments. The existing fracturation could impact also the cementation of PVC casing.

Taking into account these uncertainties, the expected depth target was fixed to 60 m and with a maximum excess around 40 m.

3 DRILLING OPERATION

3.1 PROGRESS OF DRILLING AND FINAL SKETCH

All the main works concerning the drilling and outfits of boreholes are listed in **Annex 3**.

During the first drilling (deeper borehole) from 8 June to 21 June, 2 serious problems occurred:

- At the depth 84.5 m, top of limestone was not yet identified, the water of drilling was completely lost in a fractured zone. Therefore, to avoid losing the borehole, the drilling was stopped at this depth below a soft rock (claystone) which is characterized without discontinuities or state of weathering and located between 82 and 83.5 m of depth.

- A failure occurred in the PVC casing and grout leakage came into the casing. Then, the re-drilling of borehole with destructive tool was also a failure and the borehole was abandoned.

A new destructive borehole was made at 1.5 m from the previous borehole with a new PVC which a better casing collapse strength.

The final location of all boreholes is presented in **Annex 4** and the characteristics of all boreholes are reminded in **Annex 5**. An additional destructive borehole B 5.5 m was made also.

Some observations could be noticed about all the boreholes

- All boreholes were wet drilling.
- No checking of the vertical deviation after the end of each borehole was performed. That could significantly impact the evaluation V_S and V_P measurements from CH Tests.
- No drilling parameters was monitored (drill speed, injection pressure) which could reveal geotechnical information about the geological layers.

3.2 OBSERVATIONS ON THE CORE SAMPLES

All observations are collected Annex 6, Annex 7 and Annex 8 (log and pictures). The log from Annex 6 is built from GEOTER log driller and IRSN observations.

3.2.1 SOILS

The total thickness of soils (geotechnical definition) layer is 68.4 m before encountering rocky materials. This sedimentary cover undertakes below 2 meters of artificial deposits 3 main geological units:

- From 2 to 8 m, soft sediments (grey silty-sands to silty-clay) with organic matter and shell remains distributed in 3 layers and associated with the present environment of lagoon in Koutavos. Those layers are aquiferous and this unconfined aquifer is connected with the adjacent sea.

  The values of SPT indicate a soft to firm material.
- From 8 to 19.2 m, 2 layers of brownish clayey to sandy silts show the increase of clay content with depth. The material is stiffer.
- From 19.2 to 47.2 m, a thick layer of red homogenous clay is found. Some silty to sandy interlayers could be observed. In the first ten meters, white calcareous concretions (may be groundwater calcretes) with a powdery aspect indicate a weathering. This material very stiff to hard is likely over consolidated. The one consolidation test should confirm this last observation.
- From 47.2 to 68.4 m, different levels of clayey marls from grayish to greenish then reddish to green and black at the bottom. Abundant calcareous concretions (calcrete ?) with a powdery aspect are founded between 48 and 58 m. Below 58 m, the content of shell remains grows up and from 60 m to 68 m depth abundant coral is mixed in the green marly clay. That last observation shows a past lagoon environment and shallow waters during the deposit. The values of SPT are a bit less high than above with values undertaken from 25 to 30.

Colors and weathering's observations all along the series are clues of eustatic level variations:

- Reddish levels may show a emersion period or reworked pedogenic alteration under warm climate. Calcareous concretions are likely the witness of subaerial context (alteration of alluvial fan above sea level).
- Reduced level with corals, green to black, argillaceous, are representative of shallow marine water.

3.2.2 ROCKY MATERIALS

The rocky material is founded below 68.4 m. The transition between soil and rock is highlighted by decimeters fragments of limestones wrapped up into a marly greenish clay along roughly 50 cm. None weathering zone underlines this transition.

Four units can be defined up to 84 m:

- From around 68.4 m to 76.6 m, a white to yellowish marly limestone without jointing alternates with interlayers of marl.
- From 76.6 m to 81.2 m, the yellow limestone is very sandy without tectonic jointing. The low values of RQD in this material are caused by the drilling.
- From 81.2 m to 83.5 m, a brownish to greenish claystone with fragments of limestone presents a massive aspect. An oyster fossil witnesses a marine environment. This rock is very well indurated from 83 to 83.5 m and a soft level more marly is found around 83 m.
- Below 83.5 m, the last unit fits with a porous yellow sandy limestone well indurated without tectonic jointing.

The zone between 84 to 84.5 m is fractured and the drilling stopped here due to the total loose of water drill.

The top of Cretaceous is still deeper and the log of this borehole match with the description of boreholes A1 (Annex 2). The sensor has been installed in the new deep borehole at 83.5 m in the claystone[4] layer which presents the best RDQ value. In Annex 9 focuses on the rocky zone where the sensor in the deep borehole will be installed, is made.

3.3 ENGINEERING LAYERS (GEOTECHNICAL UNITS)

Those observations give indications on the geotechnical layers which will be useful to use with the geophysical in-situ measurements (CH, DH) and will be confirmed after the laboratory tests.

They match with the main geological units depicted above and are presented in Annex 6. Those units could be checked with the geophysical data (CH and DH measurements). In Annex 10, the laboratory tests program is given.

[4] For indication, the mean shear wave velocity in a massive claystone without discontinuities from Tournemire (France, French research underground laboratory managed by IRSN) is around 1 200 m/s. However, due to the presence of interlayers softer in this massive claystone, the shear wave velocity could be lower than the claystone from Tournemire.

4 CONSEQUENCES ON THE CROSS SECTION REVISION AT KOUTAVOS SITE

Knowing the geological section in the Koutavos "deep" borehole allows us to propose a modification of the preliminary cross section (see Annex 1, Figure 4 and Figure 4):

- The top of the Cretaceous is certainly near the depth of 90 m given its depth into boreholes A3 and A2 (Annex 2).
- The basal sandstones (marly to sandy limestones) formation match with the Pc : lower Pliocene Sandstones. The thickness of this formation in the borehole is about 17 m (from 68.4 to 84.5 m);
- The Lower Pliocene Pb (Sands-Sandstone) would be located between 47 and 67 m.
- The Lower Pliocene Pa (Sandy Shales) undertakes the thick layer of red clay and its thickness will be 30 m, between 17 and 47 m.
- Above, the total thickness regarding the Quaternary formations is around 15 m. This encompasses 7 m of brown to redish silty clay and 6 m of present soft material (lagoonal deposits).

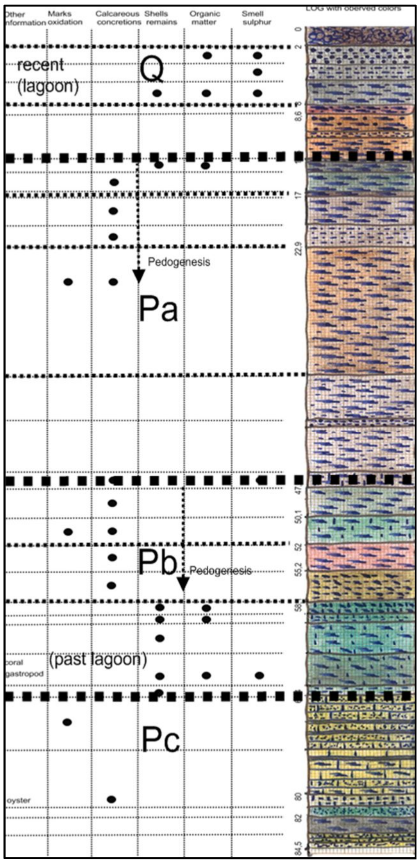

Figure 3 : Interpretation of geological series

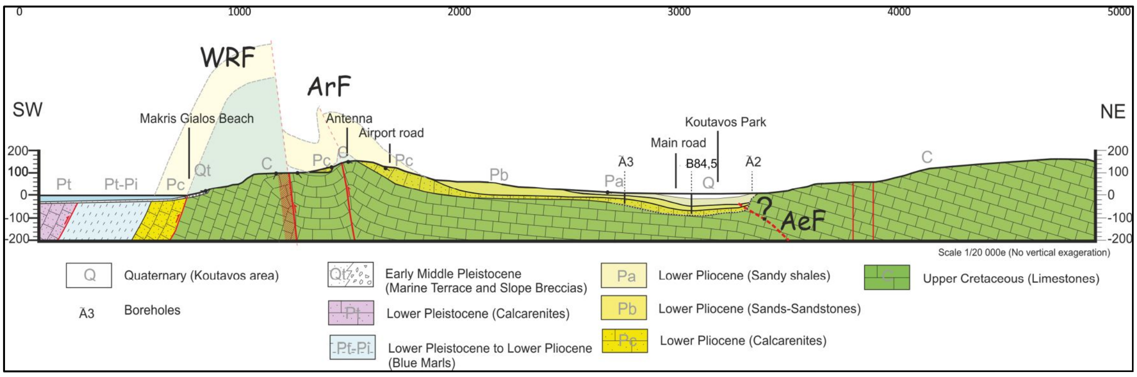

Figure 4 : Revised cross section

5 CONCLUSIONS AND PERSPECTIVE

This work has allowed defining the lithology for the installation of deep sensor which was the main objective of this drilling campaign.

Secondly, the log from core borehole has offered the opportunity to improve the geological cross-section into the Koutavos area. Nevertheless, the proposed modification needs to be checked with the already performed geophysical measurements (H/V and AVA measurements) and others data which will follow (geotechnical and geophysical results).

Thirdly, the drills gave indications on the different geotechnical units from the ground surface. This result still must be checked with the geotechnical laboratory tests. Moreover, those characterization and especially sieve analysis could provide information regarding possible tsunami deposits found in the first10 meters below artificial deposits and overlaying lagoonal deposits as proposed by Hadler (2013) (Figure 5).

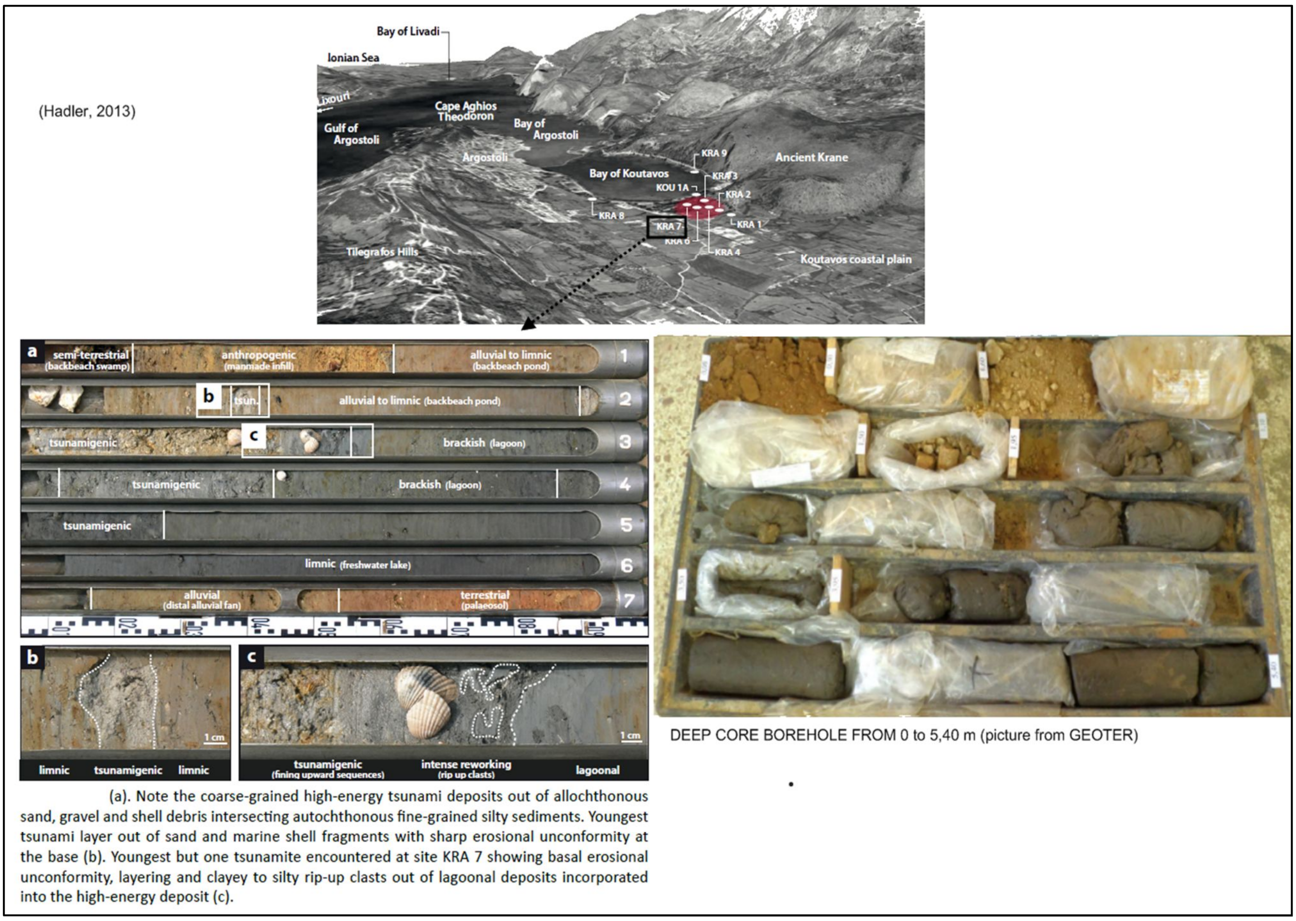

Figure 5 : Comparison of lithology between the core from KRA 7 (Hadler, 2013) and the deep core borehole in the first meters from the ground surface.

The evidence of tsunamigenic deposit is unclear on this core borehole picture.

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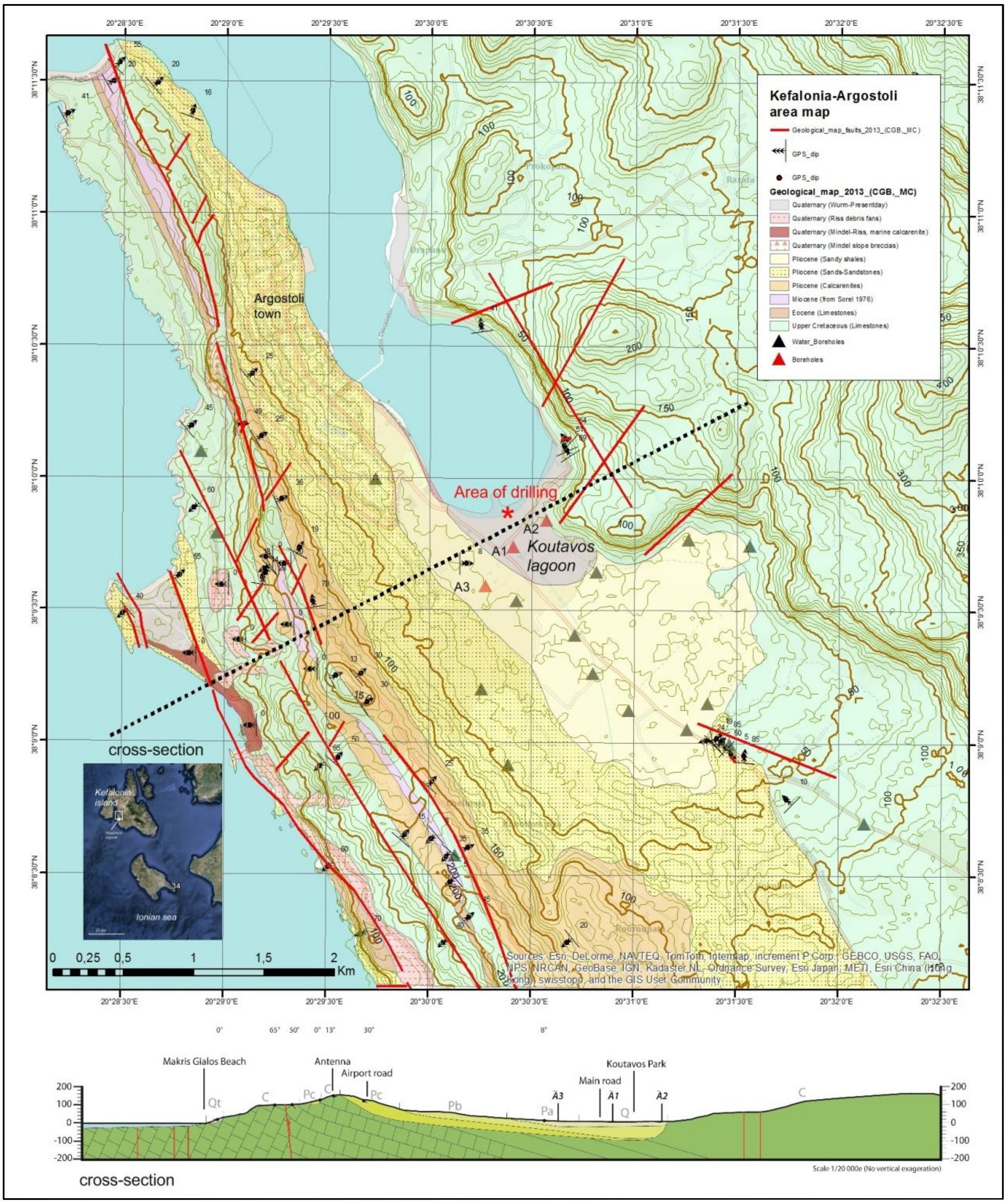
ANNEXS



Annex 1 : Geological map around the area of drilling (previous gelogical cross-section)

Previous boreholes	Depth_start	Depth_end	Facies	Detail	Color	Re-interpreted facies (deduced from new geological map of Argostoli 2013 CGB & MC)
A1	0	1	Sand	muddy - with limestone gravels and pebbles	brown	Pliocene (Sandy shales)
	1	2,2	Sand	muddy	brown-reddish	Pliocene (Sandy shales)
	2,2	4,3	Sand	muddy - with fossils	ashgray-greengray	Pliocene (Sandy shales)
	4,3	9,7	Clays	muddy to sandy - locally with gravels of limestone origin	reddish-brown	Pliocene (Sandy shales)
	9,7	11,5	Mud	sandy	gray-yellowish	Pliocene (Sandy shales)
	11,5	29,9	Clays	muddy - with locally gravels of sandstone-limestone origin	reddish-brown	Pliocene (Sands-Sandstones)
	29,9	40	Clays	sandy to muddy - with gravels of limestone	reddish-brown	Pliocene (Sands-Sandstones)
	40	41,2	Clays	muddy - with fossils	ashgray-greengray	Pliocene (Sands-Sandstones)
	41,2	45,9	Sandstones	muddy - with gravels	reddish-brown	Pliocene (Calcarenites)
	45,9	48	Marl	clayey	yellowish	
	48	58,3	Marls	with fossils	blue	
	58,3	70	Marls	marls alternation with thin layers of cohesive clayey marls	blue, yellowish	
A2	0	1	Clay	sandy	reddish-brown	Pliocene (Sandy shales)
	1	5,1	Sand-Mud	with shells and few limestone boulders	ashgray	Pliocene (Sands-Sandstones)
	5,1	7,2	Clay	sandy	brown	Pliocene (Sands-Sandstones)
	7,2	11	Clay	sandy - with cobbles and gravels of limestone origin	reddish-brown	Pliocene (Sands-Sandstones)
	11	13,5	Limestones	boulders and fragments with marly material	whitish to brown maarly material	
	13,5	26	Limestones	compact microcrystalline	whitish-whitegray	Upper Cretaceous
A3	0	1	Backfiling mate	-		Anthropic
	1	3,5	Clay	sandy	brown-brownyellow	Pliocene (Sandy shales)
	3,5	13,6	Clay	sandy	brown-reddishbrown	Pliocene (Sandy shales)
	13,6	17,8	Marl	clayey	white-yellow	Pliocene (Sands-Sandstones)
	17,8	22	Marl	muddy - with alternations of coarse-medium muddy sand with sh	gray and white-gray muddy sand	Pliocene (Sands-Sandstones)
	22	24,5	Marl	clayey	white-yellow	Pliocene (Sands-Sandstones)
	24,5	34	Limestone	marly - with intercaltions of marl	whitish	Pliocene (Calcarenites)
	34	34,7	Marl	muddy - with shells	white-gray	Pliocene (Calcarenites)
	34,7	36,2	Marl	-	white to yellow	Pliocene (Calcarenites)
	36,2	41,7	Limestone	marly - with intercaltions of cohesive marl	white	
	41,7	47,2	Limestone	dolomitized - with shells	white	Upper Cretaceous

Annex 2 : Lithology in the previous boreholes A1, A2 and A3

A1, A2 and A3 are located Annex 1.

Annex 3 : Daily report of main earthworks

06 9 2015

- Drilling core of deep borehole (DB) up to 17,45 m of depth
- 7 tests SPT

06 10 2015

- Drilling core of DB from 17,45 m to 35,55 m
- 4 tests SPT

06 11 2015

- Drilling core of DB from 35,55 m à 49,45 m
- 4 tests SPT

06 12 2015

- Drilling core of DB from 49,45 m à 63,45 m
- 4 tests SPT
- Trench with an excavator to look for a water pipe close to deep borehole (direction noted on **Annex 5.**)

06 13 2015

- Drilling core of DB from 63,45 m à 75,50 m
- 3 tests SPT

06 14 2015

- Drilling core of DB from 75,5 m to 84,5 m
- Total loose of water at 84,5 m

06 15 2015

- Cement injection in the zone with total loose water in DB with cement Portland CEM I/B(W-P) 52,5 R, composition: 2 parts of cement for 1 part of water. Cement between from 69 m to 84, 5 m

06 16 2015

- Beginning destructive drilling B15 (location **Annex 5**)
- Checking of the cementation of the bottom DB by wash-out (observations of the clarity of water).
- Destructive drilling in the DB from 69 m to 83, 5 m.

06 17 2015

- End of destructive drilling B15, final depth is 15,6 m
- Installation of PVC casing with inner diameter 101 mm and bottom cap (large 10 cm, diameter 75 mm)
- Afternoon :
  - Grout injection with mix cement – bentonite and water with cement Portland CEM IV/B (W-P) 32,5N. Ratio: 1 part cement/ 4 part of water and 0, 2 parts of bentonite.

    Strenght of 400 KPa after 28 days
  - At 14.30 problems: PVC contraction of PVC during the injection (observations with the level of water in a tube).
  - At 15.15: During a wash-out, incomings of grey water meaning leakages of grout in the PVC.

06 18 2015

- The descent of a probe indicated a max depth in the PVC at 74, 5 m.
- Destructive drilling in the deep borehole before installing a new PVC casing.
- At the end of the day, metallic casing are clamped at 50 m.

- Choice of new PVC with a strenght up to 16 ba, outer and inner diameters 90/76, 4 mm.

6 19 2015 and 06 20 2015

- Extraction of metallic casing
- Re-drilling
- In the afternoon of saturday, new blocking in the borehole 80 m de metallic pipes, 12 m de metallic casing 143 mm.

06 21 2015

- all tubes are extracted

06 22 2105

- Destructive drilling of a new deep borehole far from 1,5 m of old borehole up to 83,4 m (location **Annex 5**).

06 23 2015

- Installation of PVC and grouting in the new deep borehole
- Destructive drilling B40 (location **Annex 5**) up to 12 m
- Undisturbed samples in the B40 at 3,60-4,3 m, 6-6,70 m and 10-10,70 m

06 24 2015

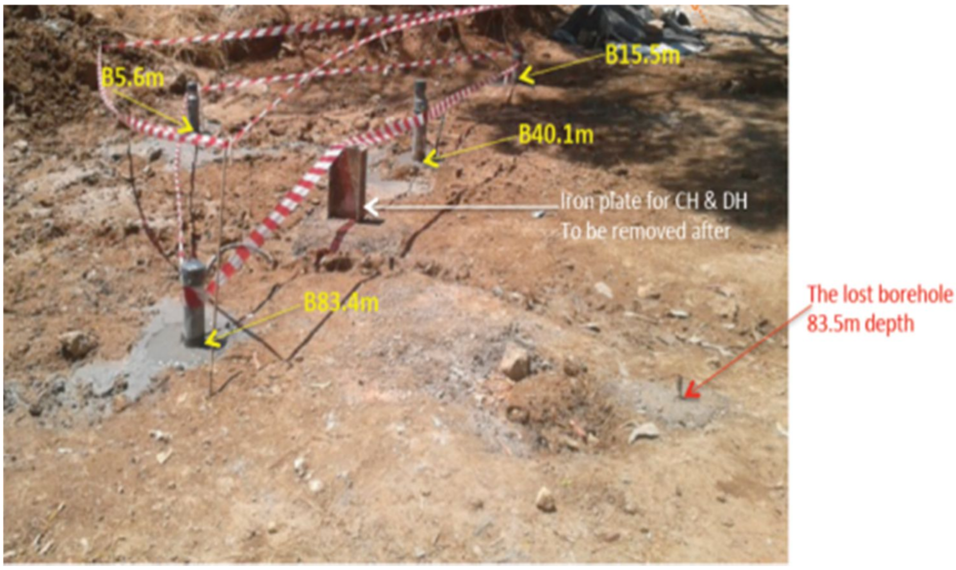
- Checking of grout of deep borehole
- End of drilling B40, the final depth is 40,1 m
- Destructive Drilling B40 and B5,5 m (location **Annex 5**)
- Installation of PVC and end of grouting B40 and B5,5 m
- Undisturbed sample in the B40 at 13,90 – 14,60 m

06 25 2015

- End of earthworks

Annex 4 : Location of all realized boreholes

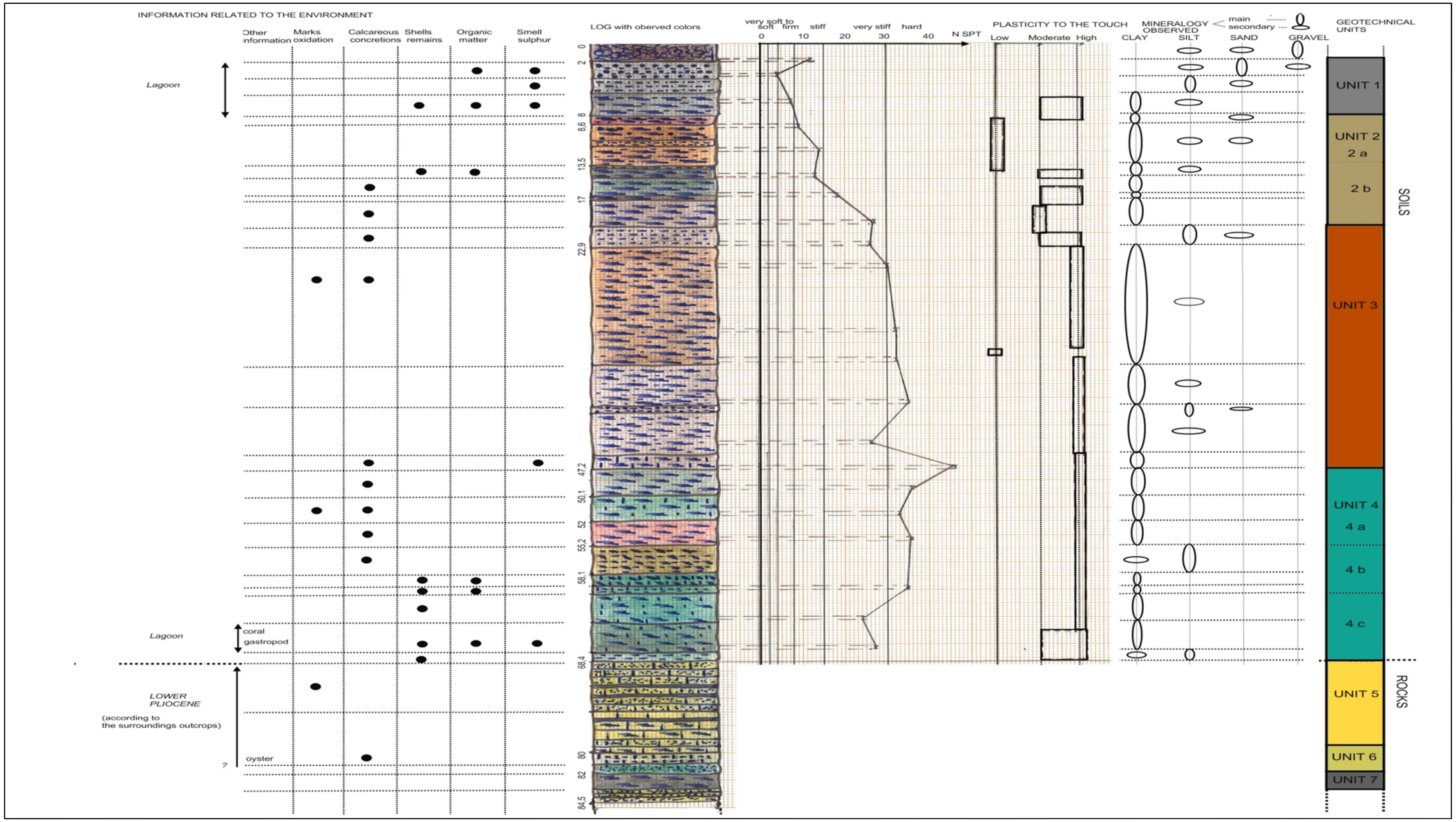
Top view



End of earthworks on 25 June 2015

	Borehole			PVC Casing						Grouting			
Name	Total depth	diameter	diameter core sample	outer diameter	inner diameter	thickness	casing collapse strength	final depth	depths	cement Portland	composition grout	injected volume	comments
	m	mm	mm	mm	mm	mm	ba	m					
Core deep borehole DB (or B83,5)	84,5	143	86	113	101	5	< 10	83,5	between 83,5 to 84,5 m	Portland CEM I/B(W-P) 52,5 R	2 parts of cement for one part of water		Before destructive re-drilling, reached height after grouting between 69 and 84,5 m
									between 0 to 83,5 m	Portland CEM IV/B (W-P) 32,5N	1 part cement/ 4 part of water and 0, 2 parts of bentonite.	around 1500 l >> volume of borehole (≈ 800 l)	Choice of GEOTER: grout more liquid than the grout from ASTM recommendation
B83,4	83,4	143	destructive	90	76,4	4	< 16	83,4	all the lenght	Portland CEM IV/B (W-P) 32,5N	1 part cement/ 4 part of water and 0, 2 parts of bentonite.		Different phase of injection of grout in the two first meters (lot of loose of grout in the permeable artificial deposits)
B40	40,1	143	destructive	90	76,4	5	< 10	40,1	all the lenght	Portland CEM IV/B (W-P) 32,5N	1 part cement/ 4 part of water and 0, 2 parts of bentonite.		
B15	15,6	143	destructive	113	101	5	< 10	15,5	all the lenght	Portland CEM IV/B (W-P) 32,5N	1 part cement/ 4 part of water and 0, 2 parts of bentonite.		
B5	5,5	143	destructive	90	76,4	5	< 10	5,5	all the lenght	Portland CEM IV/B (W-P) 32,5N	1 part cement/ 4 part of water and 0, 2 parts of bentonite.		

Annex 5 : Characteristics of realized boreholes

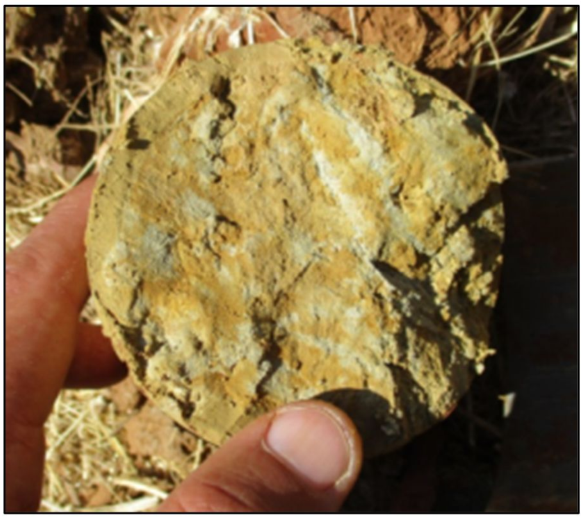


Annex 6 : Geological and geotechnical observations along the core borehole

Annex 7 : Soils pictures

Artificial deposits from 0 to 2 m

CLAY with organic matter and shell remains around to 64 m



Clayey SILT around to 56 m

Marly CLAY with coral around 66 m

Red CLAY around 40 m

Clayey SILT around to 19,8 m

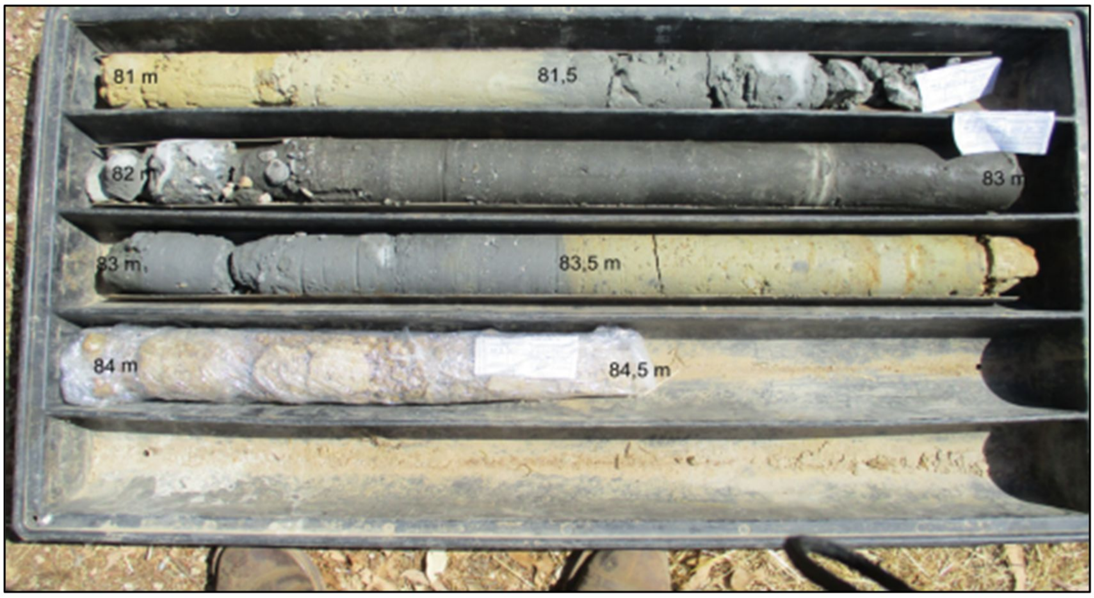
Annex 8 : Rocks pictures

Transition between soils and rock around 68,4 m

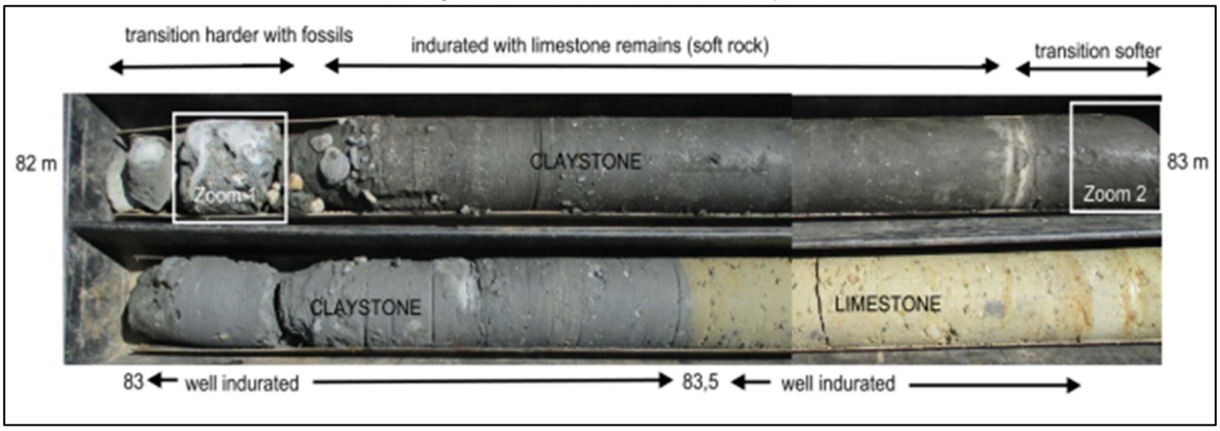
Sandy to marly LIMESTONE from 69,6 m to 71 m

Sandy LIMESTONE around to 78 m

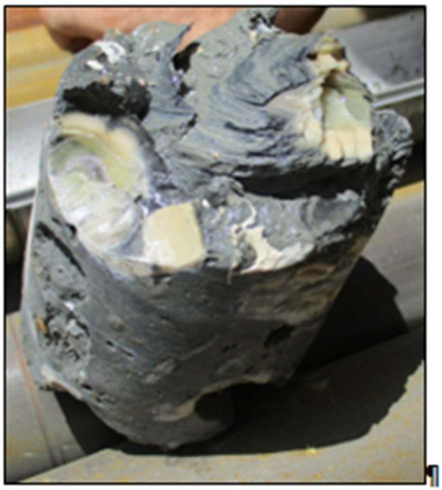
Annex 9 : Focus on the rocky zone where will be installed the sensor in the deep borehole



Rocky materials between 81 to 84,5 m



Focus between 82 to 84 m



Zoom·1·around·82,2·m¶

Zoom·2·around·to·83·m¶

Annex 10 : Program for laboratory testing

Type of test	z top	z bottom	N SPT	Log geological	Disturbed samples	From undisturbed samples of core borehole					From undisturbed samples of B40				
						Water content	Density measures	Atterberg limits	Sieve analysis dry method	Rock unconfined test	Exact depths of each sample	Material finer than sieve n0200 60 €/test	Triaxial Consolidated Undrained (CU)	Oedometric test (one dimensional consolidation test)	Resonant Column Test (RCT)
SOILS	0	1,5		Artificial deposits sandy/silty medium dense gravels											
	1,5	1,95	12												
	1,95	3,5		Dark greenish blue grey, very loose silty SANDS with many shells and organic mattter							3,60 to 4,3	1			
	3,5	3,95	4												
	3,95	5,5		Dark greenish soft sandy SILT with clay											
	5,5	6,4		Dark greenish GREY, CLAY with silt, some shells and organic matter							6 to 6,7	1			
	6,4	6,95	7												
	6,95	8													
	8	8,6		Dark brownish RED stiff sandy CLAY											
	8,6	8,9		Dark brownish RED medium silty SAND											
	9	9,45	9	Dark reddish BROWN sandy CLAY with interbeds of dense clay SAND							10 to 10,7	1			
	9,45	10,8													
	10,8	11,5		Dark reddish BROWN sandy SILT											
	11,5	11,7		Dark reddish brown silty CLAY with interlayers of silts											
	11,7	12,15	14												
	12,15	13,5													
	13,5	13,8		Dark greenhish blueish GREY, stiff sandy SILT											
	13,8	14,5		Dark greenhish blueish GREY, stiff CLAY							13,9 to 14,6	1			
	14,5	14,95	13												
	15	15,6		Green Calcareous CLAY (marls) with shell fossil											
	15,6	17		Dark Greenish CLAY											
	17	17,45	18												
	17,45	19,8		CLAY brown with concretions calcareous + thin layers of silty sand (30 cm total)											
	19,8	20,25	27												
	20,25	22,1		Dark brown sandy SILT to silty SAND											
	22,1	22,55	26												
	22,55	24,8		Dark reddish brown CLAY											
	24,8	25,25	30												
	31,6	32,05	31												
	32,05	34,1													
	35,1	35,55	32												
	35,55	37,1		Dark brown hard CLAY with interlayers of silty CLAY											
	37,1	39,4			around 37,5										
	39,4	39,95	35												
	39,95	40,8			39,85 - 42,6										
	40,8	44		Dark reddish BROWN very stiff silty CLAY											
	44	44,45	26												
	44,45	45,7													
	45,7	46,5		Dark reddish BROWN hard CLAY											
	46,5	46,95	46												
	46,95	47,2													
	47,2	49		Dark greenish to greyish BROWN CLAY + oxydes + smell sulphur											
	49	49,45	36												
	49,45	50,1													
	50,1	51,8		Green light blueish Hard MARL with calcareous clay											
	51,8	52,25	43												
	52,25	54,3		Dark brownish RED CLAY											
	54,3	54,75	36												
	54,75	55,2													
	55,2	57,2		brownish YELLOW hard clayey SILT with calcareous concretions											
	57,2	57,6													
	57,6	58,1													
	58,1	59,3		Dark greyish stiff clayey MARL with and organi matter											
	59,3	59,7		hard silty MARL with fossils shells and organic matter											
	59,7	60,15	35												
	60,15	63		Dark greyish BLUE very stiff clayey MARL with coral fossils											
	63	63,45	24												
	63,45	66,3													
	66,3	66,75	28												
	66,75	67,4													
	67,4	68,4		very stiff Clayey SILT											
ROCKS	68,4	69,6		Sandy to marly LIMESTONE with interlayers of very hard sandy MARL, slighty weathered. Porous Rock Mass.											
	69,6	71													
	71	72						in the interlayers of marl							
	72,4	73,9													
	73,9	75,5													
	75,5	76,9		Sandy LIMESTONE with one interlayer de stiff sandty MARL . Rock mass is weak slighty weathered. 1 joint set noted with rough undalating surfaces without filling, slight oxydization, close spacing, partly open											
	76,9	78,5													
	78,5	80													
	80	81,1		light yellow, hard silty MARL moderate plasticty											
	81,1	82		dark blueish GREEN hard sandy MARL. Weak marly SANDSTONE with oyster fossil remnant. Moderate plasticity						to 82 m					
	82	83,5		dark blueish GREEN hard sandy MARL. Weak marly CLAYSTONE with fossil remnant. Moderate plasticity to clayey hard MARL											
	83,5	83,9		light brownish yellow, hard silty MARL. Silty CLAYSTONE											
	83,9	84,5		light yellow, sandy LIMESTONE. Rock mass is weak, porous without joint. Total water losses while drilling the layer											