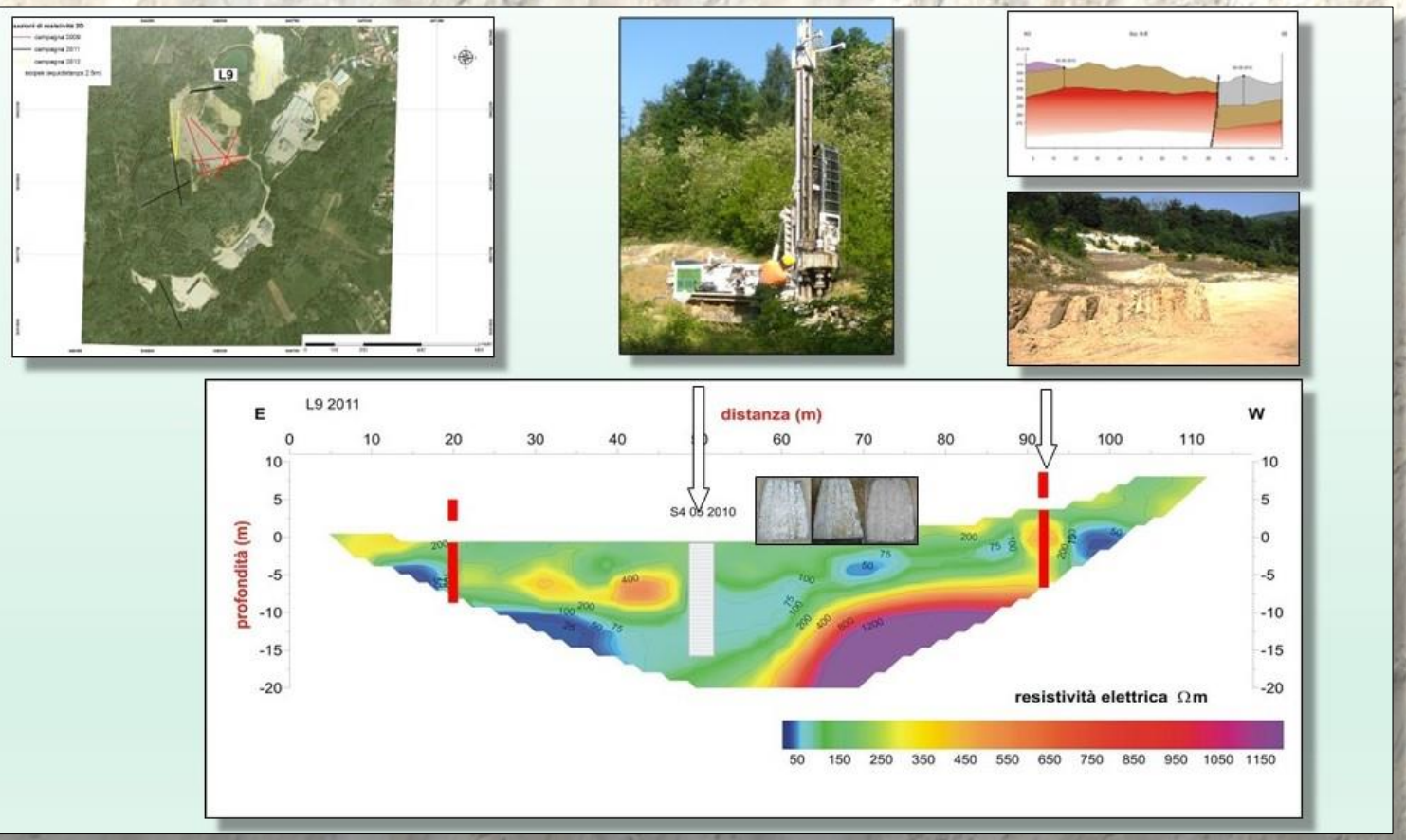
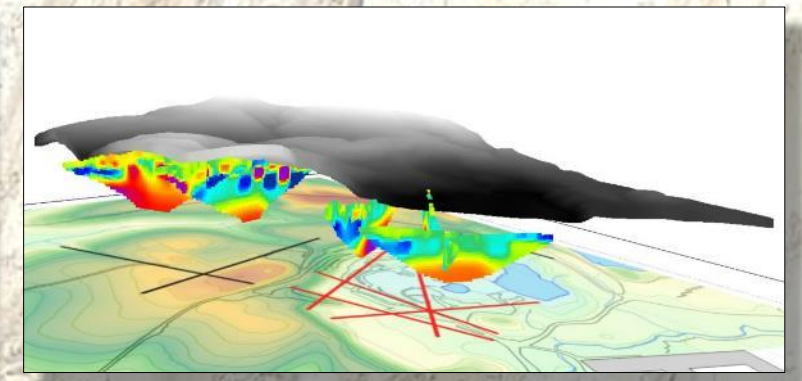
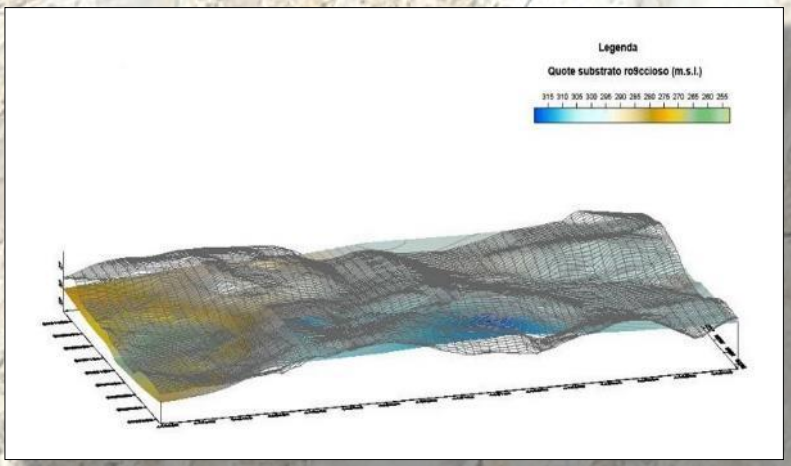
MULTIMETHODOLOGICAL APPROACH IN INDUSTRIAL MINERALS MINING

GIAN PAOLO BERTOLOTTI







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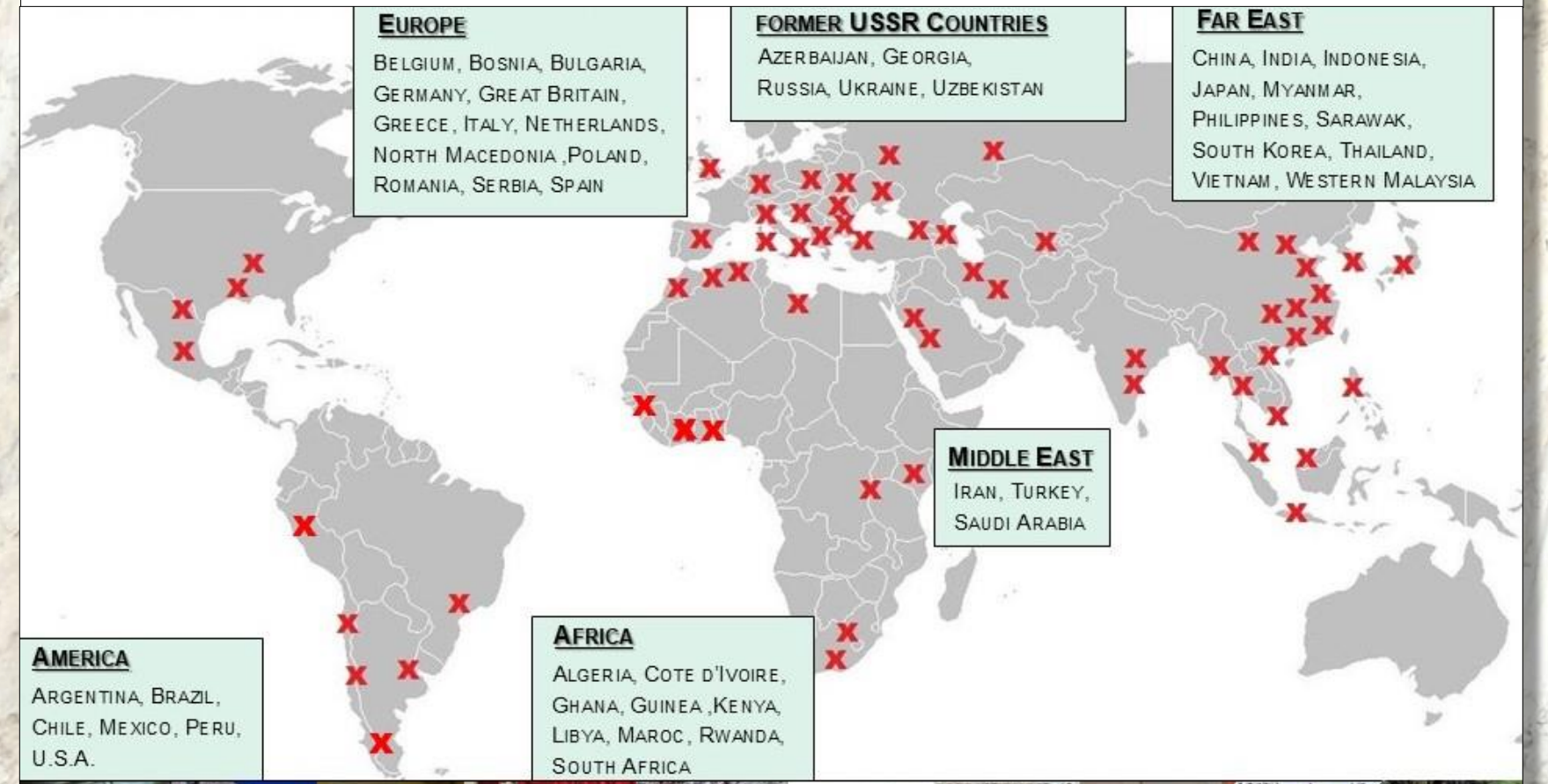
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1989-2026 : EXPERIENCES IN CERAMIC INDUSTRY

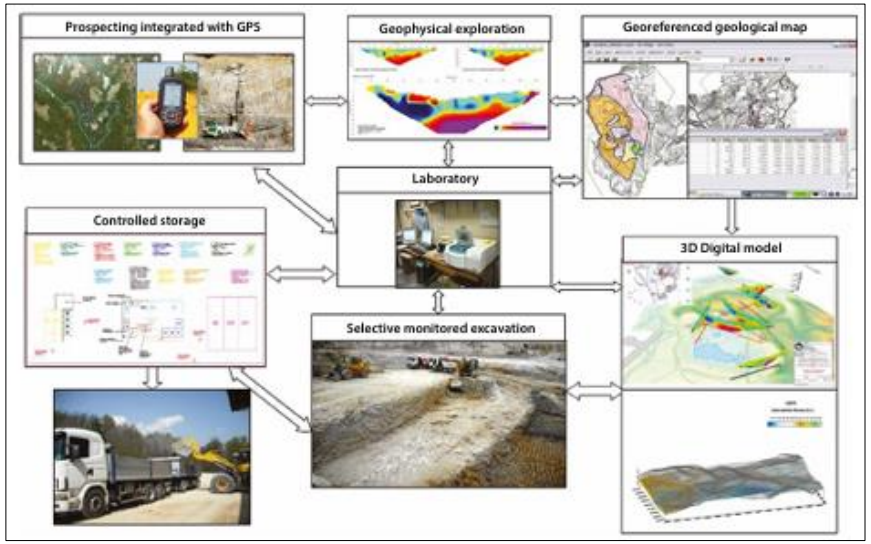




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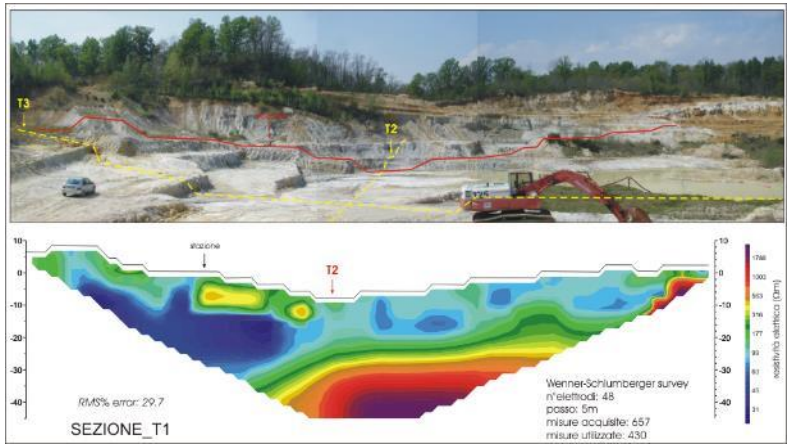
MULTIMETHODOLOGICAL APPROACH IN INDUSTRIAL MINERALS MINING



RAW MATERIALS FOR CERAMICS : CLAY MINERALS

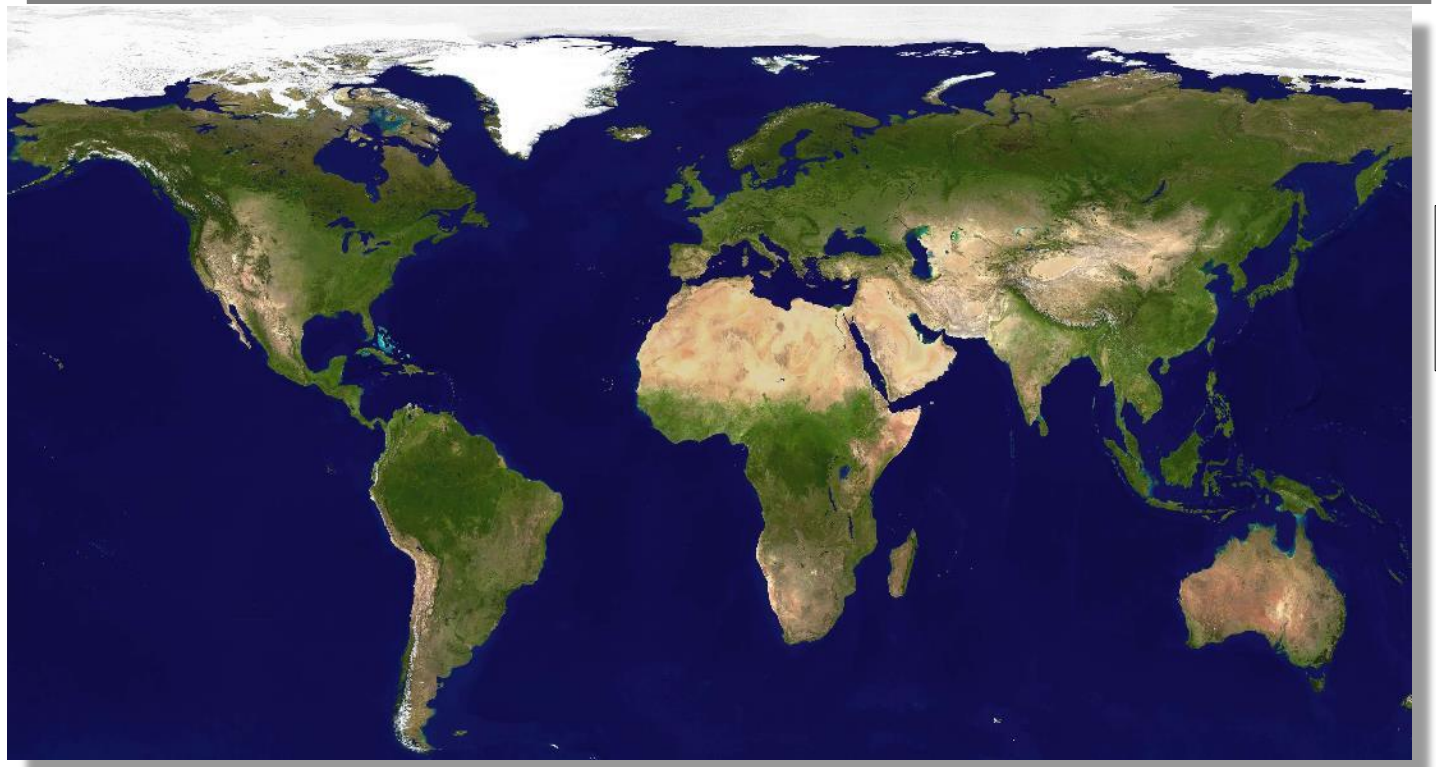


STUDY OF LOZZOLO CLAY DEPOSIT : A DIFFICULT CASE



RAW MATERIALS WORLD CONSUMPTION FOR CERAMICS

350-400 MILLION TONS



TILES

250-300 MILLION TONS/YEAR



REFRACTORIES

50 MILLION TONS/YEAR



SANITARYWARE

9-10 MILLION TONS/YEAR



TABLEWARE

7-9 MILLION TONS/YEAR



CERAMIC PIPES & LIGHT AGGREGATES

3-4 MILLION TONS/YEAR



Dondi,2013 modified

In **2024**, the world production of ceramic tiles reached **14.95 billion square meters** (in 2022 it was over 16 billion)
In preliminary figures **Italian tile production of 2025** is estimated around **388 millions m²** (+5% on 2024)
(data from Confindustria Ceramica)

TOP MANUFACTURING COUNTRIES

	COUNTRY	2020 (Sq.m Mil.)	2021 (Sq.m Mil.)	2022 (Sq.m Mil.)	2023 (Sq.m Mil.)	2024 (Sq.m Mil.)	% on 2024 world production	% var. 24/23
1.	CHINA	8,474	8,863	7,312	6,730	5,910	39.5%	-12.2%
2.	INDIA	2,318	2,550	2,300	2,450	2,400	16.1%	-2.0%
3.	BRAZIL	840	1,049	927	793	825	5.5%	4.0%
4.	VIETNAM	559	554	579	397	504	3.4%	27.0%
5.	IRAN	449	458	480	450	450	3.0%	0.0%
6.	SPAIN	488	587	500	394	416	2.8%	5.6%
7.	INDONESIA	304	410	430	413	407	2.7%	-1.5%
8.	ITALY	344	435	431	374	370	2.5%	-1.1%
9.	TURKEY	370	438	385	372	318	2.1%	-14.5%
10.	MEXICO	235	290	289	264	251	1.7%	-4.9%
	TOTAL	14,381	15,634	13,633	12,637	11,851	79.3%	-6.2%
	TOTAL WORLD	17,139	18,602	16,862	15,937	14,950	100.0%	-6.2%

Source / Fonte: Mecs / Acimac Research dept. "World production and consumption of ceramic tiles", 13th edition 2025

More than 90 % of tile production is represented by **Glazed and Unglazed Porcelain tiles** (W.A.< 0,5 % ISO 13006).
about 2/3 glazed and 1/3 unglazed tiles.
Export amount is around **80 %** of the total production.
(data from Confindustria Ceramica)

World production of ceramic tiles (2024) = 14950 km²

Province	km²
Milano	1580
Monza e Brianza	405
Bergamo	2761
Brescia	4786
Pavia	2970
Como	1279
Varese	1198
Totale	14979



Country	km²
TIMOR EAST	14874
BAHAMAS	13880
MONTENEGRO	13812
VANUATU	12189
QATAR	11586
JAMAICA	10991
KOSOVO	10887

Municipal area			
Surface	km²	Surface	km²
Milano	181,76	Cernusco sul Naviglio	13,31
Abbiategrasso	47,78	San Donato Milanese	12,81
Rho	22,24	Sesto San Giovanni	11,74
Magenta	21,99	Trezzano sul Naviglio	10,77
Legnano	17,70	Cologno Monzese	8,37
Segrate	17,41	Assago	8,05
Total surface = 373,93 km²			





RAW MATERIALS REQUIRED FOR PORCELAIN TILE BODY COMPOSITION

A TYPICAL PORCELAIN TILE **BODY** COMPOSITION
IS MAINLY COMPOSED BY THE FOLLOWING ELEMENTS :

CLAYS AND KAOLINS **30-40 %**
PLASTIC PART
NECESSARY FOR A CORRECT SHAPING OF THE TILE



FELDSPARS **40-50 %**
FLUX PART
REQUIRED FOR THE MELTING OF THE PRODUCT DURING FIRING

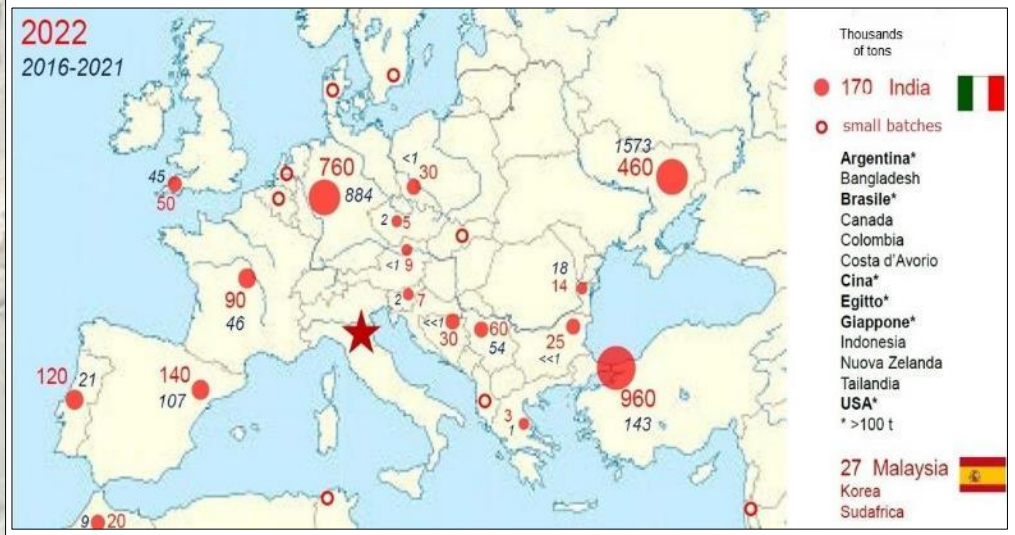


SANDS **10-20 %**
INERT PART
IMPORTANT TO HELP THE CORRECT COMBUSTION
AND GIVE STRUCTURE DURING FIRING



ITALIAN TILE PRODUCTION (2025) = 388 MILLIONS m² - WEIGHT PER m² = 20-25 KG

	BODY %		
CLAYS AND KAOLINS	30-40 % = 3-3,5 MILLION TONS/YEAR	(7,5-10 kg/m²)	
FELDSPARS	40-50 % = 3-4 MILLION TONS/YEAR	(10-12,5 kg/m²)	
SANDS	10-20 % = 1-2 MILLION TONS/YEAR	(2,5-5 kg/m²)	



(Dondi, 2023)

CLAY SUPPLIES FOR ITALIAN TILE BODY PRODUCTION : 2021-2023

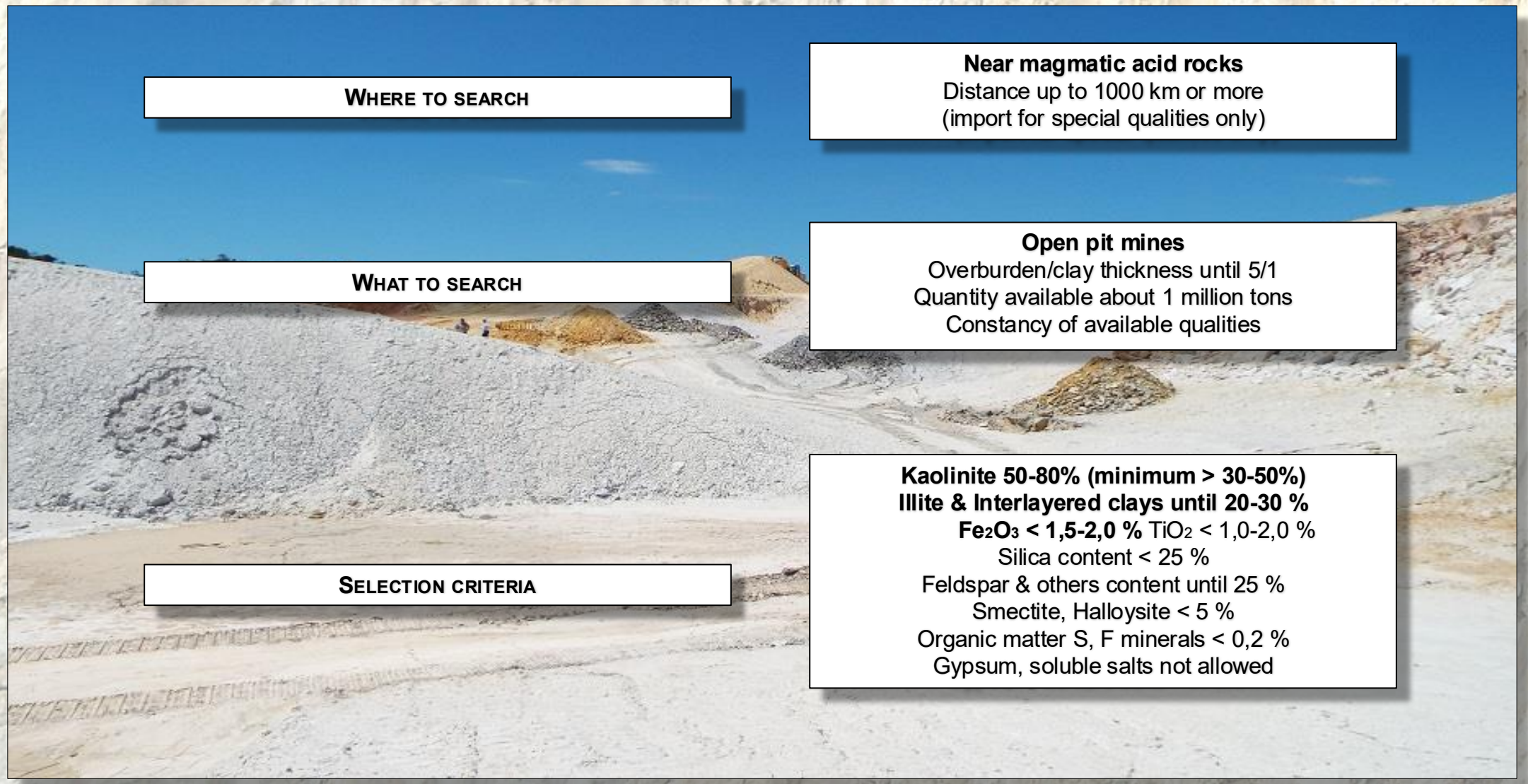
	2021 (ton)	2022/2023 (ton)	Δ (ton)
Ukraine	2,100,000	- (*)	-2,100,000
Germany	1,000,000	1,300,000	+300,000
Türkiye	250,000	600,000	+350,000
Portugal	30,000	300,000	+270,000
Romania	50,000	20,000	-30,000
France	50,000	100,000	+50,000
Sardegna / Sardinia (Italy)	150,000	300,000	+150,000
Piemonte / Piedmont (Italy)	10,000	200,000	+190,000
India	-	200,000	+200,000
Spain	50,000	100,000	+50,000
England	10,000	10,000	-
Brazil	10,000	10,000	-
Malaysia	-	100,000	+100,000
Argentina	-	100,000	+100,000
Total (ton)	*3,710,000*	*3,340,000*	*-370,000*

(*) In reality, official figures show imports of 505,000 tonnes in 2022 and 227,000 tonnes in 2023 /

(Di Primio, 2026)

CLAY SOURCES AVAILABLE IN ITALY FOR TILE BODY COMPOSITION (2023) 340,000 TONS AROUND 10 % OF THE TOTAL

CLAYS FOR PORCELAIN TILES (BRGM , 1983 MODIFIED)



WHERE TO SEARCH

Near magmatic acid rocks
Distance up to 1000 km or more
(import for special qualities only)

WHAT TO SEARCH

Open pit mines
Overburden/clay thickness until 5/1
Quantity available about 1 million tons
Constancy of available qualities

SELECTION CRITERIA

Kaolinite 50-80% (minimum > 30-50%)
Illite & Interlayered clays until 20-30 %
Fe_2O_3 < 1,5-2,0 % TiO_2 < 1,0-2,0 %
Silica content < 25 %
Feldspar & others content until 25 %
Smectite, Halloysite < 5 %
Organic matter S, F minerals < 0,2 %
Gypsum, soluble salts not allowed

CLAYS FOR PORCELAIN TILES

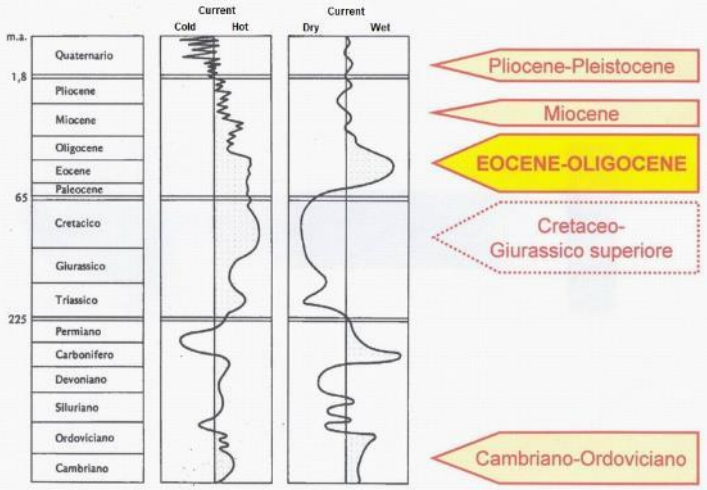
TYPICAL CHEMICAL AND MINERALOGICAL ANALYSES OF CLAYS USED IN EUROPE

Plastic clays (Illitic- kaolinitic clays)		Medium plasticity clays (Kaolinitic - illitic clays)		Low plasticity clays (Kaolinitic - illitic clays)	
Quantitative chemical analysis		Quantitative chemical analysis		Quantitative chemical analysis	
	%		%		%
SiO2	59 - 61	SiO2	65 - 67	SiO2	72 - 74
Al2O3	25 - 27	Al2O3	20 - 22	Al2O3	16 - 18
Fe2O3	1.0 - 1.5	Fe2O3	1.0 - 1.5	Fe2O3	1.0 - 1.5
TiO2	0.5 - 1.5	TiO2	0.5 - 1.5	TiO2	0.5 - 1.5
CaO	0.0 - 0.2	CaO	0.0 - 0.2	CaO	0.0 - 0.2
MgO	0.3 - 0.5	MgO	0.2 - 0.4	MgO	0,3 - 0.5
Na2O	0.1 - 0.5	Na2O	0.1 - 0.5	Na2O	0.1 - 0.5
K2O	1.5 - 3.0	K2O	1.5 - 3.0	K2O	1.5 - 3.0
SO3	< 0.1	SO3	< 0.1	SO3	< 0.1
C	< 0.2	C	< 0.1	C	< 0.2
L.o.I.	8.0 - 9.0	L.o.I.	6.0 - 7.0	L.o.I.	4.0 - 5.0
Qualitative mineralogical analysis		Qualitative mineralogical analysis		Qualitative mineralogical analysis	
Kaolinite - Illite - Quartz - Feldspar		Kaolinite - Quartz - Illite - Feldspar		Kaolinite - Quartz - Illite - Feldspar	

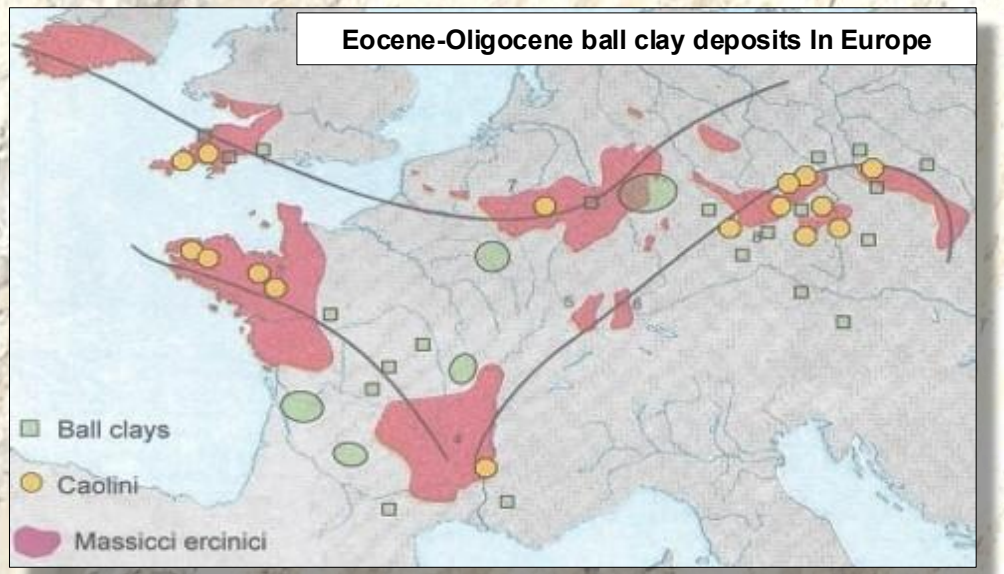
Ball clay deposits

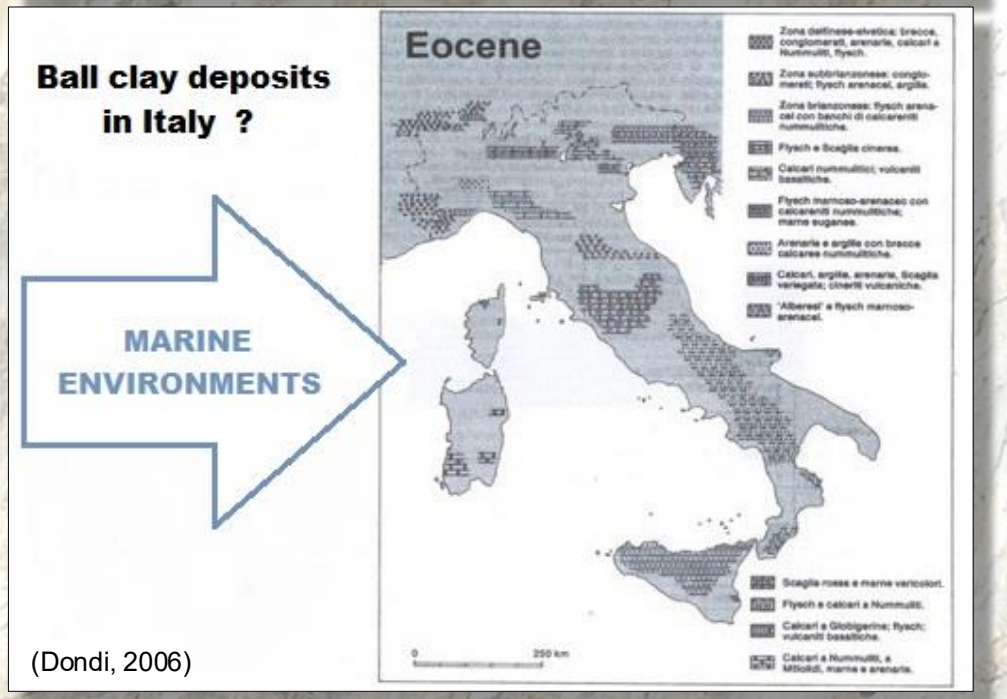
Geological Age	Location
Pliocene - Pleistocene	Turkey, Portugal, Italy, Serbia, Czechia
Miocene	Ukraine, Romania
Eocene -Oligocene	Germany, United Kingdom France, Austria, Czechia
Cretaceous	Spain, Romania, Czechia
Jurassic	Italy, Poland, Sweden

Kaolinization: climatic factors



(Dondi, 2021)

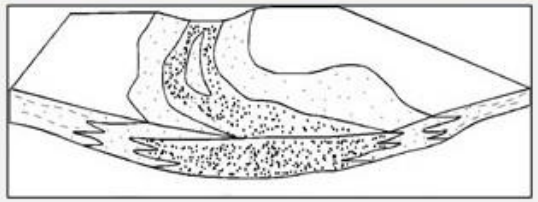


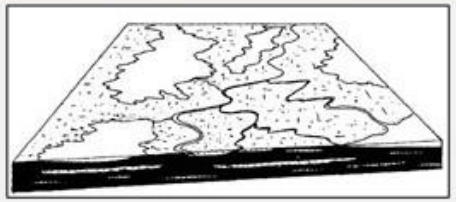


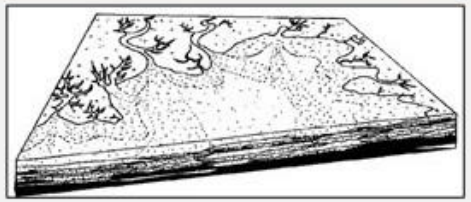
(Dondi, 2006)

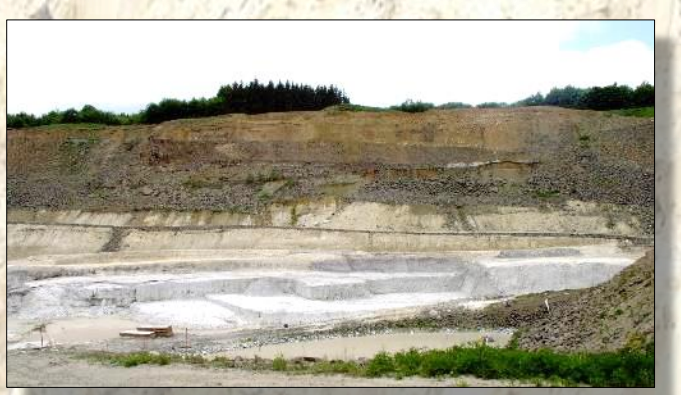
Provenance and geological features of ball clays (Dondi & others, 2003)

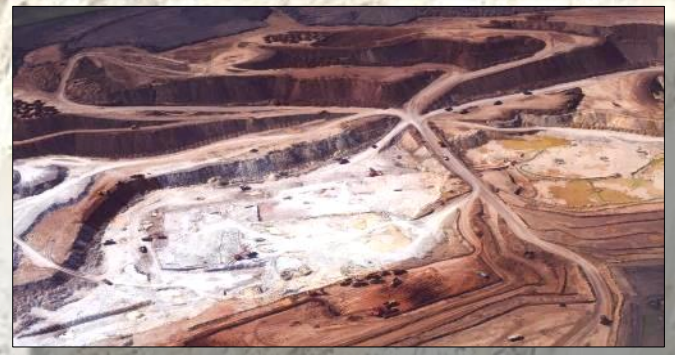
Country	Basin	Geological age	Genesis	t x 10^3
France	Provins	Eocene	Lacustrine	400
	Tournon St-Martin	Eocene	Lacustrine	100
	Nançay	Eocene	Lacustrine	100
Germany	Saxony	Eocene	Fluvio-lacustrine	100
	Westerwald	Eo-Oligocene	Fluvio-lacustrine	2000
Italy	Santa Severa	Pleistocene	Exhalative	60
	Sarcidano	Jurassic	Fluvio-lacustrine	200
Portugal	Barracão-Pombal	Plio-Pleistocene	Fluvio-lacustrine	500
Spain	Teruel-Ariño	Cretaceous	Fluvio-deltaic	300
Turkey	Silé-Istanbul	Plio-Pleistocene	Fluvio-lacustrine	600
Ukraine	Donbas	Eocene	Fluvio-lacustrine	1500
Great Britain	Devon	Eocene	Fluvio-lacustrine	600













CHEMICAL AND MINERALOGICAL DIFFERENCES BETWEEN A MARINE AND CONTINENTAL CLAY WITH THE SAME GEOLOGICAL AGE IN THE SAME AREA (PLIOCENE , NORTHERN ITALY)

WHITE FIRING CLAY (CONTINENTAL DEPOSIT)

Chemical analysis

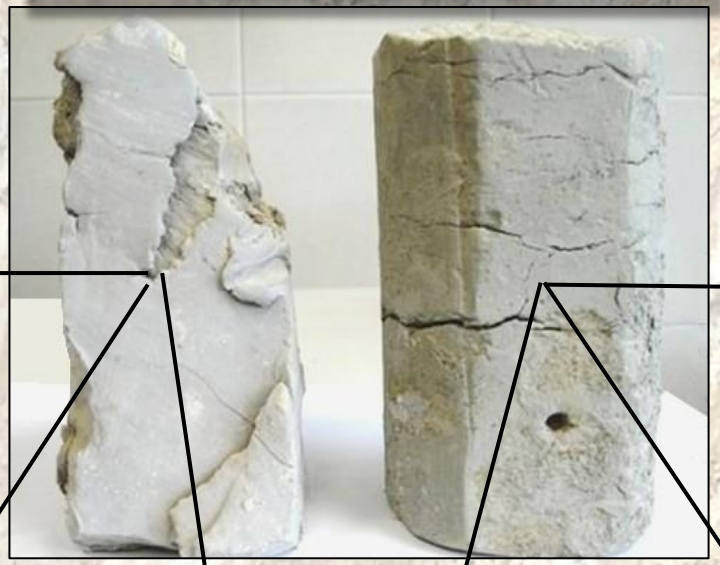
Oxide	%
SiO_2	74,0
Al_2O_3	15,0
Fe_2O_3	1,3
TiO_2	0,6
CaO	0,2
MgO	0,3
Na_2O	0,2
K_2O	2,5
SO_3	< 0,1
L.o.i. (1050 °C)	5,5

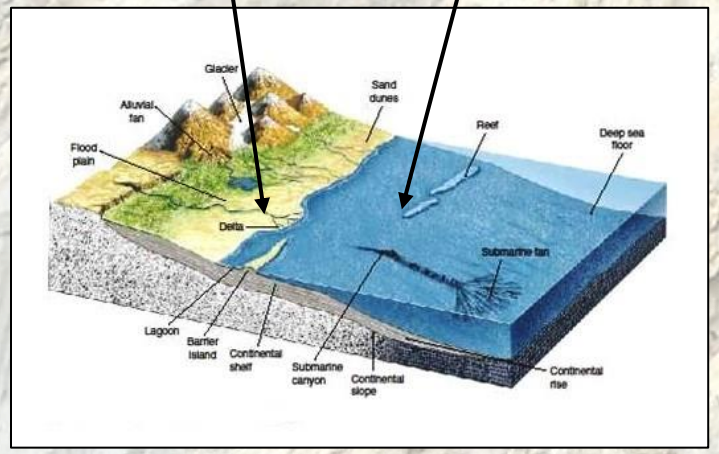
Mineralogical analysys

Mineral	%
Quartz	45
Kaolinite	25
Illite / Muscovite	20
Montmorillonite / Chlorite	-
Feldspars	10
Carbonates	-

After firing test at 1200 °C







RED FIRING CLAY (MARINE DEPOSIT)

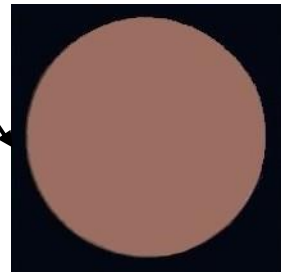
Chemical analysis

Oxide	%
SiO_2	58,5
Al_2O_3	16,5
Fe_2O_3	6,5
TiO_2	0,5
CaO	3,5
MgO	3,0
Na_2O	1,0
K_2O	3,0
SO_3	0,5
L.o.i. (1050 °C)	6,5

Mineralogical analysys

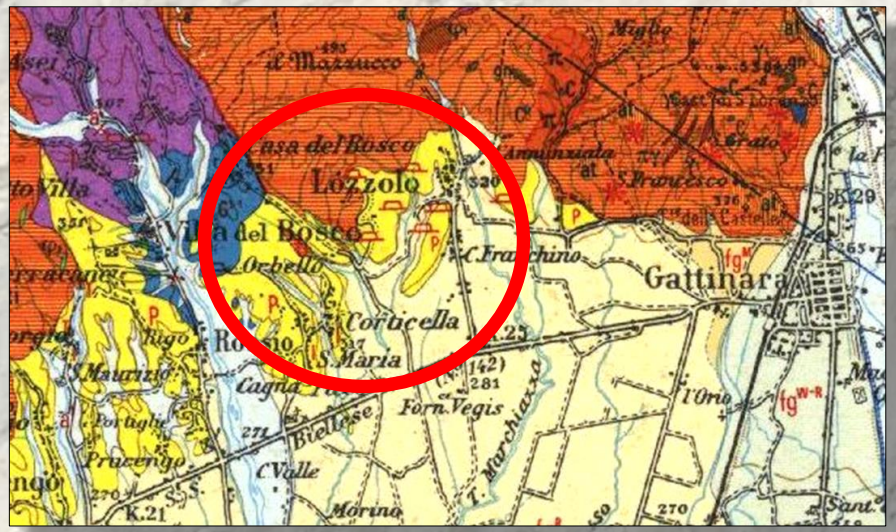
Mineral	%
Quartz	25
Kaolinite	-
Illite / Muscovite	25
Montmorillonite / Chlorite	10
Feldspars	30
Carbonates	10

After firing test at 1200 °C



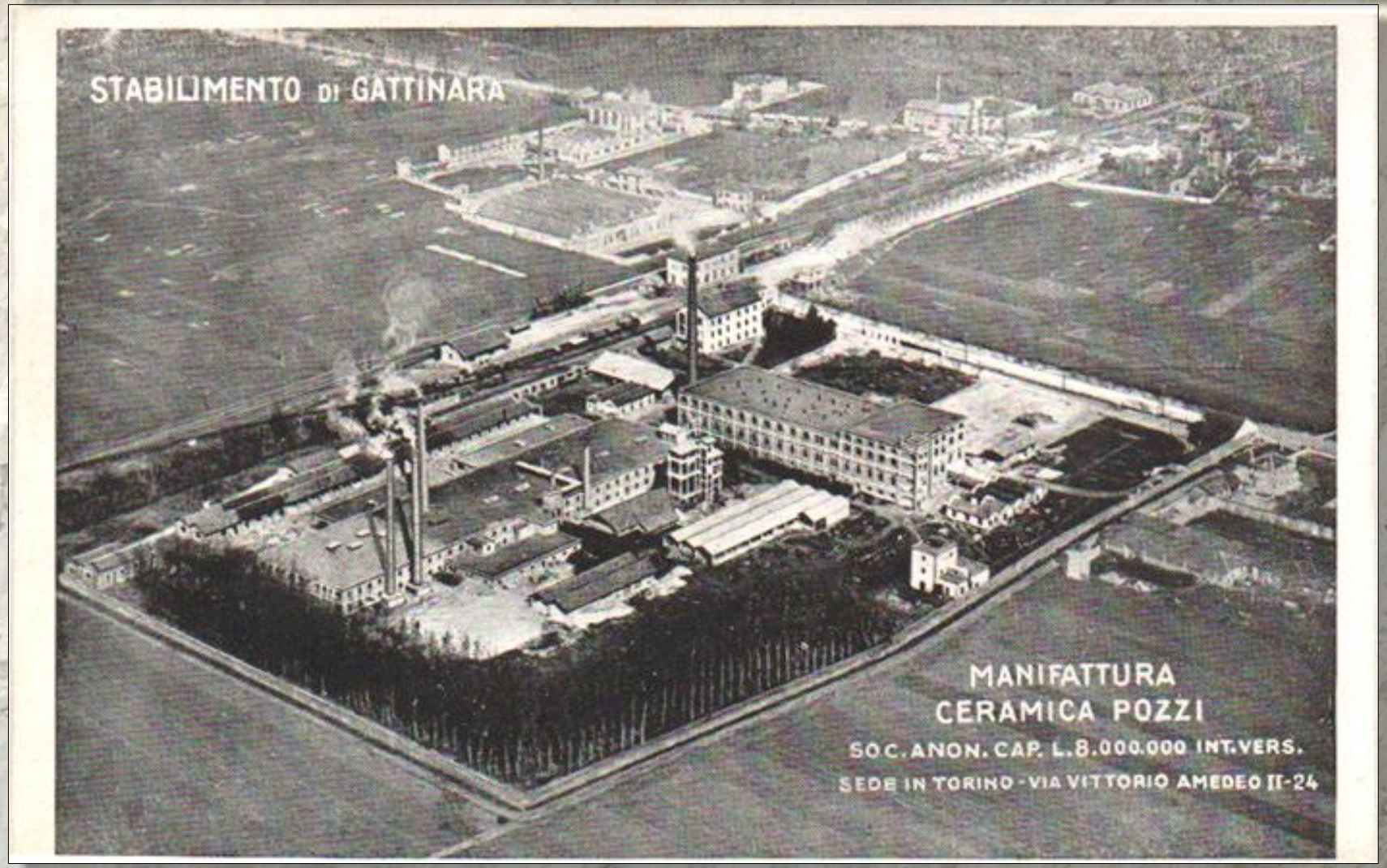
LOZZOLO CLAY MINES, VERCELLI PROVINCE NORTHERN ITALY







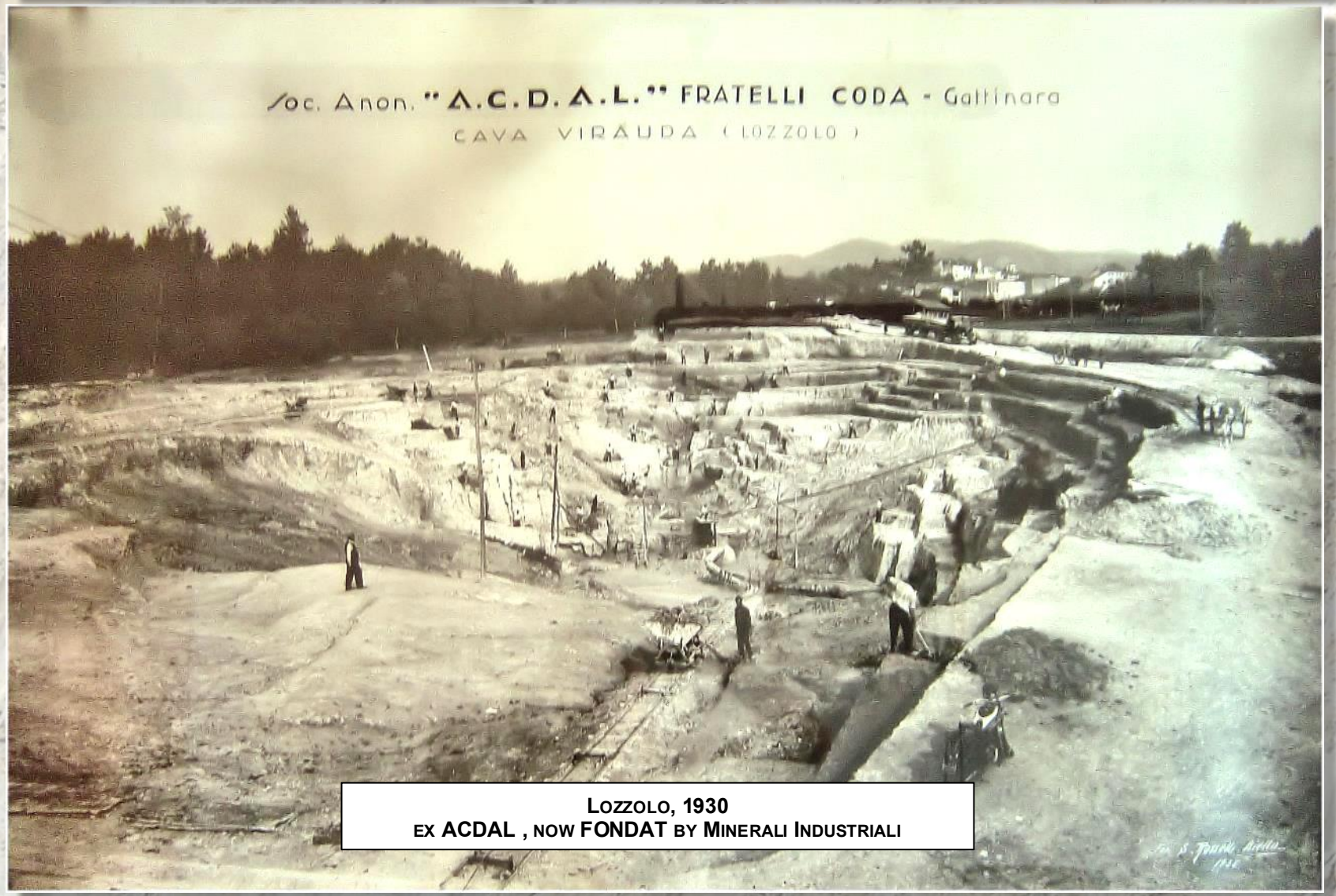
MANIFATTURA CERAMICA POZZI, GATTINARA FACTORY







LOZZOLO REFRACTORY CLAY MINES ARE EXPLOITED FROM THE BEGINNING OF ‘900



LOZZOLO, 1930
EX ACDAL , NOW FONDAT BY MINERALI INDUSTRIALI





PREVIOUS SITUATION OF THE CLAY MINE (YEAR 2000)

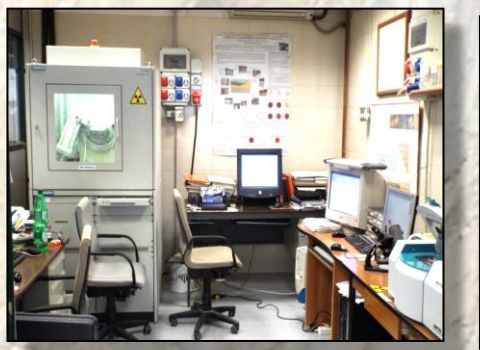
POSITVE ELEMENTS

- GOOD KNOWLEDGE ABOUT DIFFERENT LITHOTIPES AVAILABLE IN THE MINE
- LONG EXPERIENCE OF THE WORKERS IN MINE EXCAVATION

NEGATIVE ELEMENTS

- ABSENCE OF UPDATED GEOLOGICAL AND LITHOLOGICAL MAP OF THE MINE
- ABSENCE OF LOCAL LABORATORY FOR QUALITY CONTROL
- COMPLEX VARIABILITY OF THE CLAY QUALITY PRESENT IN THE MINE
- MINING FOCUSED ONLY ON RED PRODUCTS LESS REQUIRED BY INDUSTRY

SET UP OF A NEW LABORATORY NEAR THE MINE



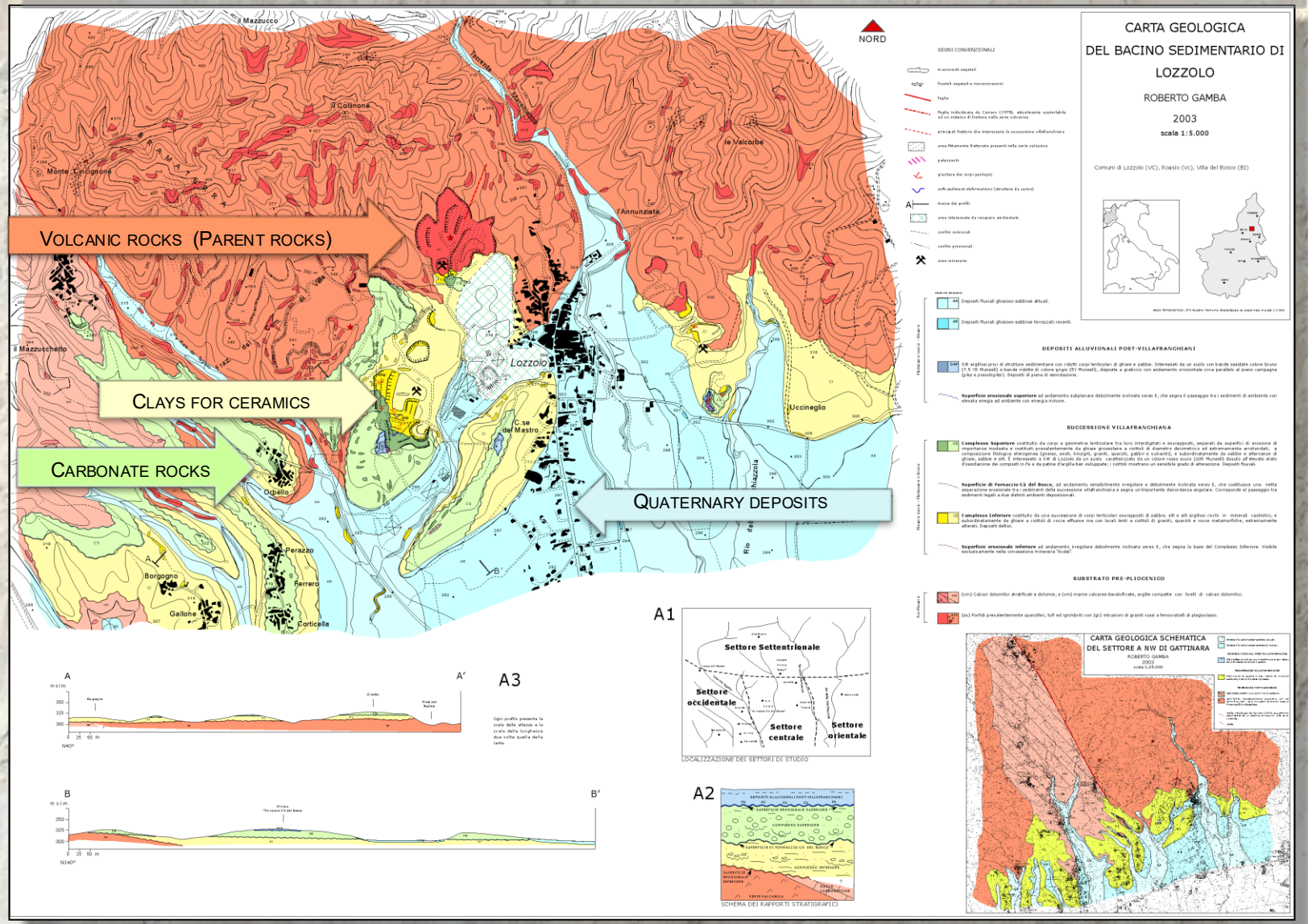





RICERCHE MINERARIE s.r.l.

- XRF chemical analysis and L.o.I.
- XRD and Rietveld mineralogical analysis
- DTA/TG analysis
- Firing test on muffle kilns
- Technological tests for ceramics

DRAWING OF A NEW REGIONAL GEOLOGICAL MAP OF LOZZOLO AREA



MULTIMETHODOLOGICAL APPROACH IN INDUSTRIAL MINERALS MINING , MILANO 03 07 2026

CERAMIN CONSULTING

LABORATORY EVALUATION : XRF CHEMICAL MONITORING OF ALL THE CLAY QUALITIES AVAILABLE IN THE MINE

Nome	3 Super	Sabbione	K9	F2 Gialla	R5 Magro	Sabbione Bello	F2 Macch. Chiara	Sabbione Brutto	K10	R5 Grosso	Balmino Bianco Grasso	Balmino Verde
	01	02	03	04	05	06	07	08	09	10	11	12
	%	%	%	%	%	%	%	%	%	%	%	%
SiO_2	80,2	80,2	75,4	67,5	82,6	84,2	67,9	76,9	67,5	78,7	65,3	70,1
Al_2O_3	11,8	11,9	14,8	17,0	10,2	10,2	16,3	14,0	20,5	11,2	21,9	15,7
Fe_2O_3	0,99	0,77	1,17	6,10	2,21	0,65	5,34	1,48	2,17	1,99	2,30	4,05
TiO_2	0,64	0,28	1,06	1,09	2,06	0,57	0,53	0,21	0,94	0,26	0,94	0,84
CaO	0,15	0,07	0,24	0,24	0,06	0,09	0,23	0,11	0,34	0,05	0,15	0,26
MgO	0,23	0,19	0,35	0,40	0,12	0,12	0,42	0,28	0,49	0,20	0,66	0,73
Na2O	0,10	0,10	0,10	0,10	0,10	0,10	0,10	< 0,11	0,10	0,18	0,40	0,79
K2O	2,09	4,51	1,37	0,90	1,79	2,92	2,33	3,98	1,13	5,10	2,42	2,77
SO3	-	-	0,02		-	-	-	-	-	-	0,09	-
L.o.l.	3,48	2,22	6,19	6,14	1,46	2,16	7,13	3,58	7,74	2,36	6,55	5,04

Nome	Volpina R5	Balmino Giallo in AR5	Balmino Giallo mix R5	R5 Rosa	Volpina Gialla R5	Bianco Rosa Grasso	Bianco Rosa	Marangona Grassa	Marangona Grassa	Caolino	Caolino Ferroso
	13	14	15	16	17	18	19	20	21	22	23
	%	%	%	%	%	%	%	%	%	%	%
SiO_2	66,1	66,9	73,9	67,0	64,2	71,6	60,1	73,5	65,6	63,5	66,3
Al_2O_3	17,2	17,0	14,0	16,8	18,6	17,5	21,7	14,2	17,5	19,8	18,1
Fe_2O_3	4,79	4,22	2,80	5,52	5,04	1,94	4,93	2,83	7,77	2,80	2,95
TiO_2	1,53	1,04	0,80	1,06	1,03	0,73	1,22	0,83	1,08	1,05	1,05
CaO	0,25	0,14	0,06	0,12	0,13	0,25	0,22	0,14	0,16	0,15	0,16
MgO	0,95	0,76	0,33	0,64	0,86	0,45	0,40	0,52	0,56	0,78	0,54
Na2O	1,73	2,17	0,53	0,30	1,26	0,10	0,12	0,14	0,27	0,61	0,96
K2O	2,38	2,89	3,68	1,93	2,32	1,16	1,06	1,41	1,23	2,94	2,52
SO3	-	-	-	-	-	0,04	-	-	-	-	-
L.o.l.	5,30	5,42	4,27	6,69	6,41	6,76	9,68	6,77	6,73	7,62	6,40

Fe_2O_3	
	< 2 %
	2 - 4 %
	4 -5 %
	> 5 %

	%
Fe_2O_3	0,65 - 7, 77
TiO_2	0,21 - 2,06

	%
Al_2O_3	10,2 - 21,9
L.o.l.	2, 21 - 9,68

LABORATORY EVALUATION CLASSIFICATION OF CLAY QUALITIES ACCORDING TO CERAMIC BEHAVIOUR

LIGHT FIRING CLAYS

	AS3 SUPER (n° 1)	SABBIONE (n° 2)	K9 (n° 3)	SABBIONE BELLO (n° 6)
				
	%	%	%	%
Fe_2O_3	0,96	0,76	1,15	0,64
TiO_2	0,54	0,22	0,98	0,44
W.A.	10,76	9,09	9,71	14,5
	SABBIONE BRUTTO (n° 8)	K10 (n° 9)	BIANCO ROSA GRASSO (n° 18)	BIANCO ROSA (n° 19)
				
	%	%	%	%
Fe_2O_3	1,44	2,12	1,96	4,22
TiO2	0,17	0,97	0,70	1,52
W.A.	5,94	7,22	8,93	6,79
	CAOLINO (n° 22)	CAOLINO FERROSO (n° 23)		
				
	%	%		
Fe_2O_3	1,63	2,03		
TiO2	1,18	1,11		
W.A.	5,72	6,49		

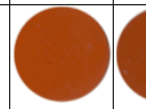
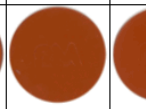
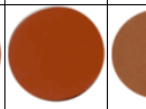
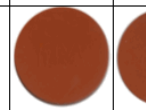
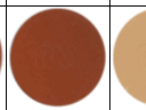
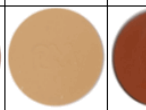
- ☐ LIGHT COLOUR AFTER FIRING
- ☐ GOOD CONTENT IN KAOLINITE
- ☐ REFRACTORY BEHAVIOUR

PLASTIC CLAYS

	BALMINO BIANCO (n° 11)	BALMINO VERDE (n° 12)	VOLPINA AR5 (n° 13)
			
	%	%	%
Fe_2O_3	2,17	4,15	4,95
TiO_2	0,94	0,80	1,51
W.A.	7,1	3,16	2,44
	BALMINO GIALLO AR5 (n° 14)	BALMINO GIALLO MIX AR5 (n° 15)	
			
	%	%	
Fe_2O_3	4,23	2,63	
TiO_2	1,08	0,78	
W.A.	0,93	4,94	

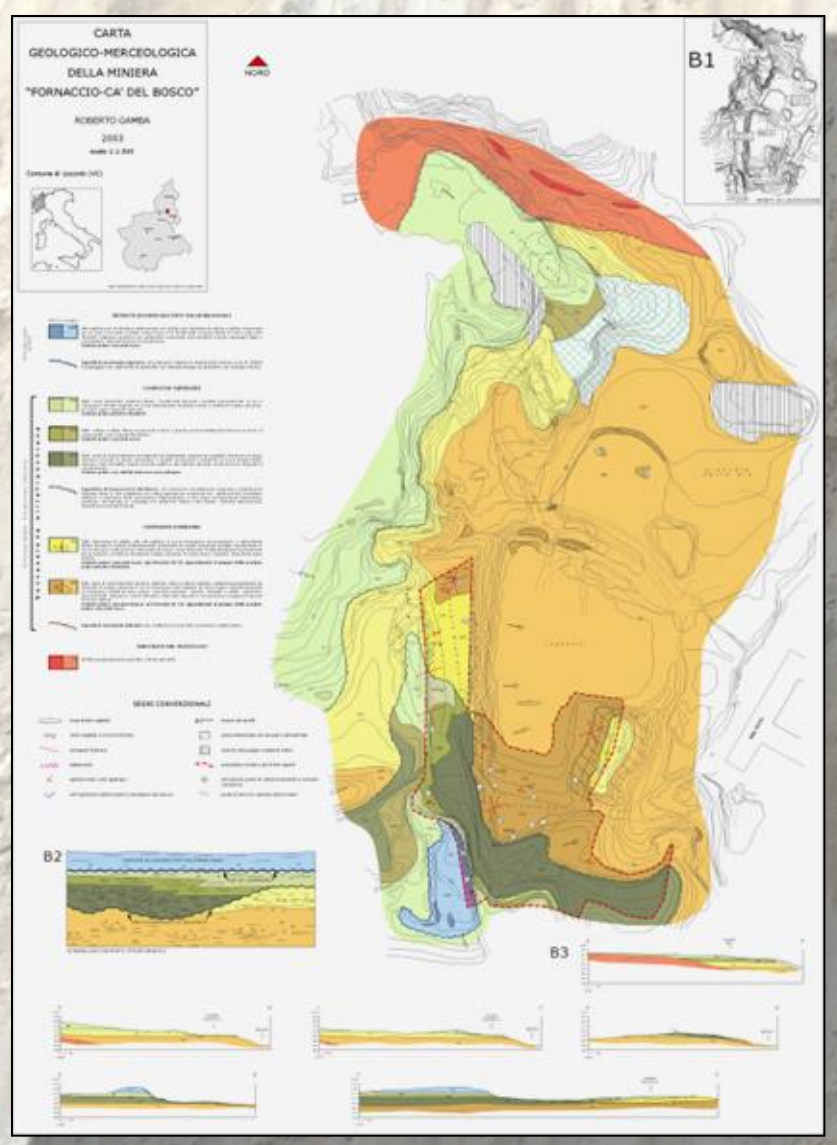
- ☐ GOOD CONTENT IN ILLITE/MICA
- ☐ GOOD PLASTICITY
- ☐ LESS REFRACTORY BEHAVIOUR

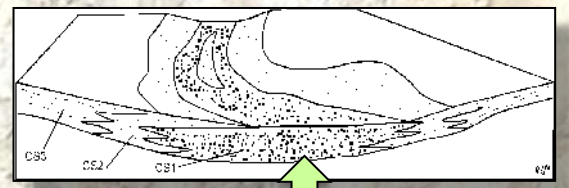
RED FIRING CLAYS

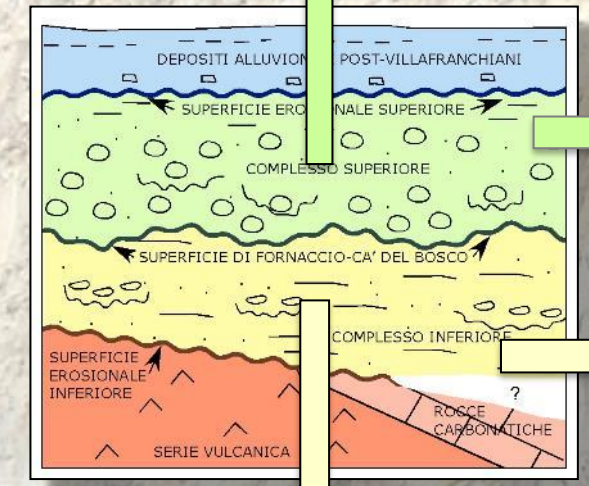
	F2 GIALLA (n° 4)	AR5 MAGRO (n° 5)	F2 MACCHIATA CHIARA (n° 7)	AR5 GROSSO (n° 10)
				
	%	%	%	%
Fe2O3	6,85	3,52	5,97	1,61
TiO2	1,11	1,48	0,55	0,21
W.A.	11,14	15,37	4,71	2,45
	AR5 ROSA (n° 16)	VOLPINA GIALLA AR5 (n° 17)	MARANGONA GRASSA (n° 20)	MARANGONA MAGRA (n° 21)
				
	%	%	%	%
Fe2O3	6,33	4,67	2,64	8,80
TiO2	0,99	0,93	0,75	1,01
W.A.	7,65	5,31	6,94	9,68

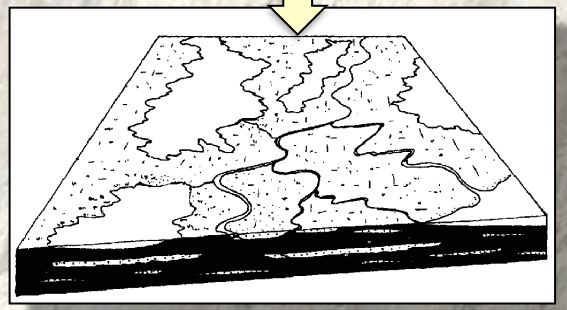
- ☐ DARK COLOUR AFTER FIRING
- ☐ HIGH CONTENT IN Fe Ti OX.
- ☐ REFRACTORY BEHAVIOUR

DRAWING OF A NEW DETAILED GEOLOGICAL MAP OF THE EXPLOITED AREA









	F2 GIALLA (n° 4)	ARS MAGRO (n° 5)	F2 MACCHIATA CHIARA (n° 7)	ARS GROSSO (n° 10)
	%	%	%	%
Fe2O3	6,85	3,52	5,97	1,61
TiO2	1,11	1,48	0,55	0,21
W.A.	11,14	15,37	4,71	2,45

	ARS ROSA (n° 16)	VOLPINA GIALLA ARS (n° 17)	MARANGONA GRASSA (n° 20)	MARANGONA MAGRA (n° 21)
	%	%	%	%
Fe2O3	6,33	4,67	2,64	8,80
TiO2	0,99	0,93	0,75	1,01
W.A.	7,65	5,31	6,94	9,68

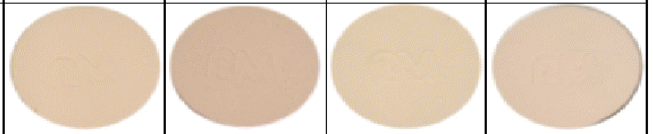
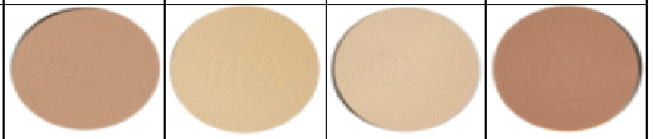
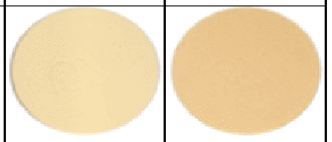
	ASS SUPER (n° 1)	SABBIONE (n° 2)	K9 (n° 3)	SABBIONE BELLO (n° 6)
	%	%	%	%
Fe_2O_3	0,96	0,76	1,15	0,64
TiO_2	0.54	0.22	0.99	0.44
W.A.	10.76	9.09	9.71	14.5

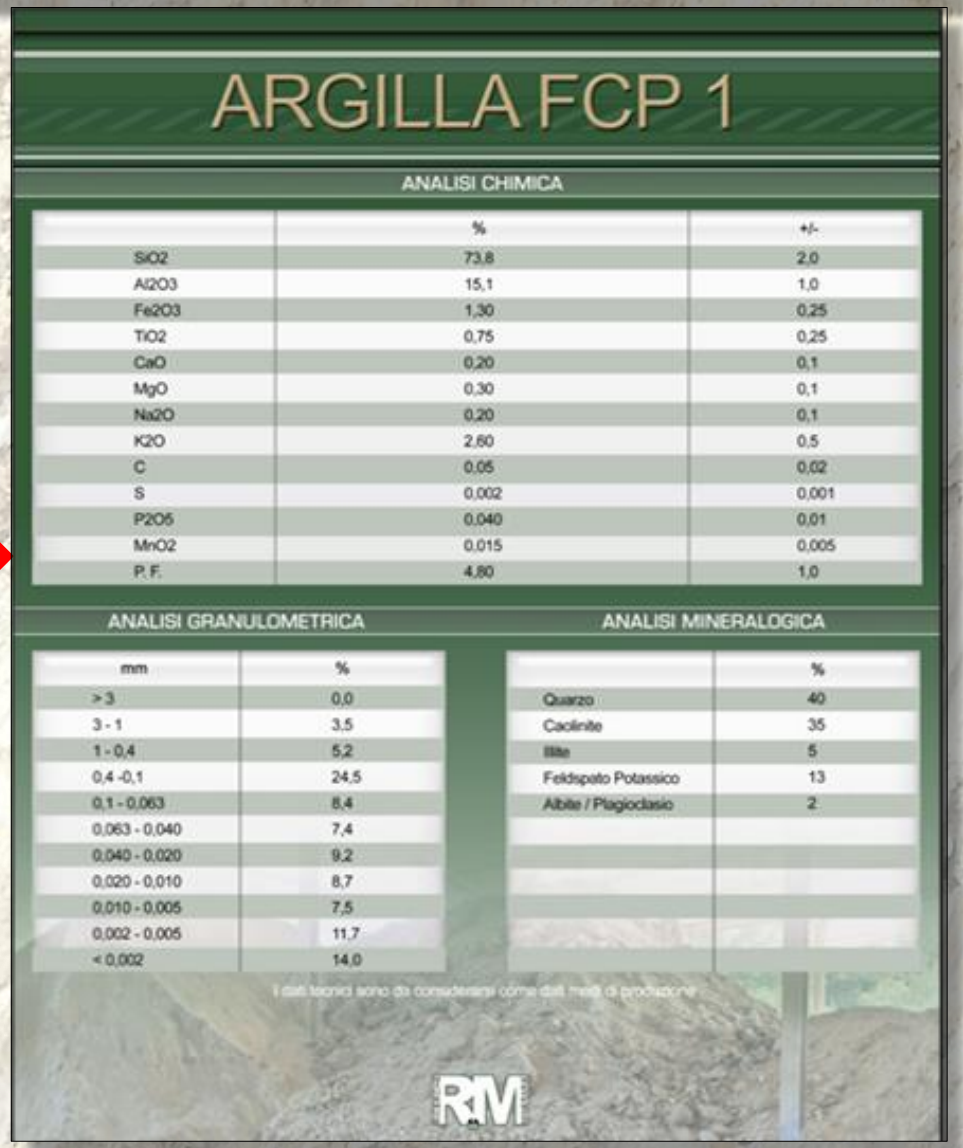
	SABBIONE BRUTTO (n° 8)	K10 (n° 9)	BIANCO ROSA GRASSO (n° 18)	BIANCO ROSA (n° 19)
	%	%	%	%
Fe_2O_3	1,44	2,12	1,96	4,22
TiO2	0,17	0,97	0,70	1,52
W.A.	5,94	7,22	8,93	6,79

	CAOLINO (n° 22)	CAOLINO FERROSO (n° 23)
	%	%
Fe_2O_3	1,63	2,03
TiO2	1,18	1,11
W.A.	5,72	6,49

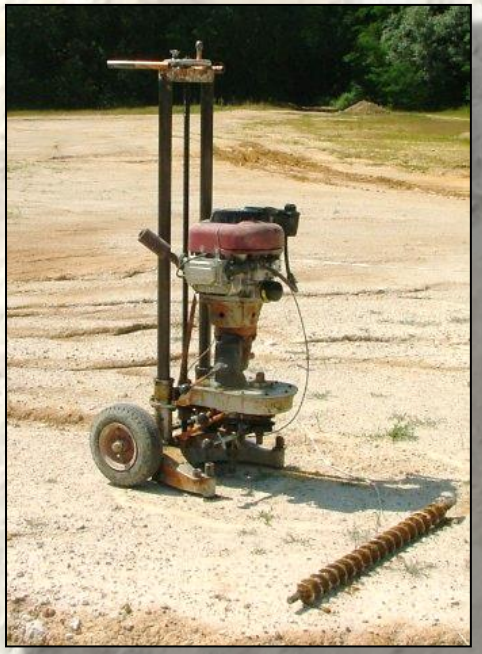
NEW CLAY PRODUCT FOR GLAZED PORCELAIN TILES

CREATED BLENDING LIGHT FIRING LITHOTYPES CONROLLED BY THE LOCAL LABORATORY

	AS3 SUPER (n° 1)	SABBIONE (n° 2)	K9 (n° 3)	SABBIONE BELLO (n° 6)
				
	%	%	%	%
Fe_2O_3	0,96	0,76	1,15	0,64
TiO_2	0,54	0,22	0,98	0,44
W.A.	10,76	9,09	9,71	14,5
	SABBIONE BRUTTO (n° 8)	K10 (n° 9)	BIANCO ROSA GRASSO (n° 18)	BIANCO ROSA (n° 19)
				
	%	%	%	%
Fe_2O_3	1,44	2,12	1,96	4,22
TiO2	0,17	0,97	0,70	1,52
W.A.	5,94	7,22	8,93	6,79
	CAOLINO (n° 22)	CAOLINO FERROSO (n° 23)		
				
	%	%		
Fe_2O_3	1,63	2,03		
TiO2	1,18	1,11		
W.A.	5,72	6,49		



PRELIMINARY DRILLING WITH MECHANICAL AUGER INSIDE THE CLAY MINE













HELP OF MECHANICAL AUGER DRILLING IN CLAY MINING

S1/S2 → LOWER RED FIRING CLAYS

NOT TOO INTERESTING FOR FUTURE MINING EXPLOITATION





1230 ° C

Fe_2O_3 = 4-5 %
TiO_2 > 1 %



S3/S4/S5 → LIGHT FIRING CLAYS

VERY INTERESTING FOR FUTURE MINING EXPLOITATION





1230 ° C

Fe_2O_3 = 1-1,5 %
TiO_2 < 1 %

CORE DRILLING PROSPECTING OPERATIONS AROUND THE MINING AREA







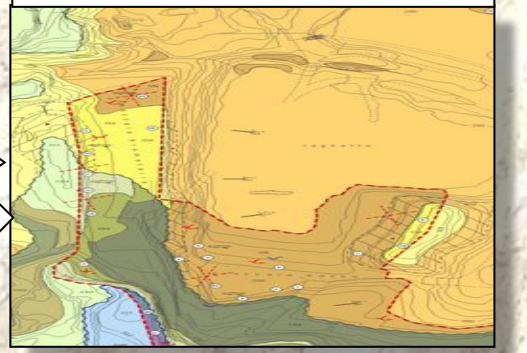
SUMMARY OF TRADITIONAL METHODS OF PROSPECTING OF CLAY DEPOSIT

PROSPECTING





GEOLOGICAL MAP



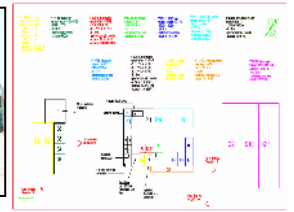
LABORATORY




SELECTIVE EXCAVATION



CONTROLLED STORAGE



PROBLEMS OF GEOLOGICAL INTERPRETATION STILL PRESENT AFTER FIRST PROSPECTING PHASE

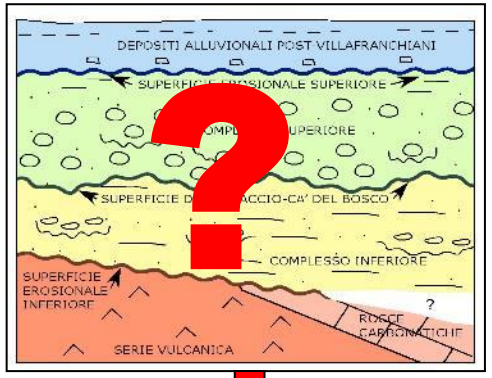






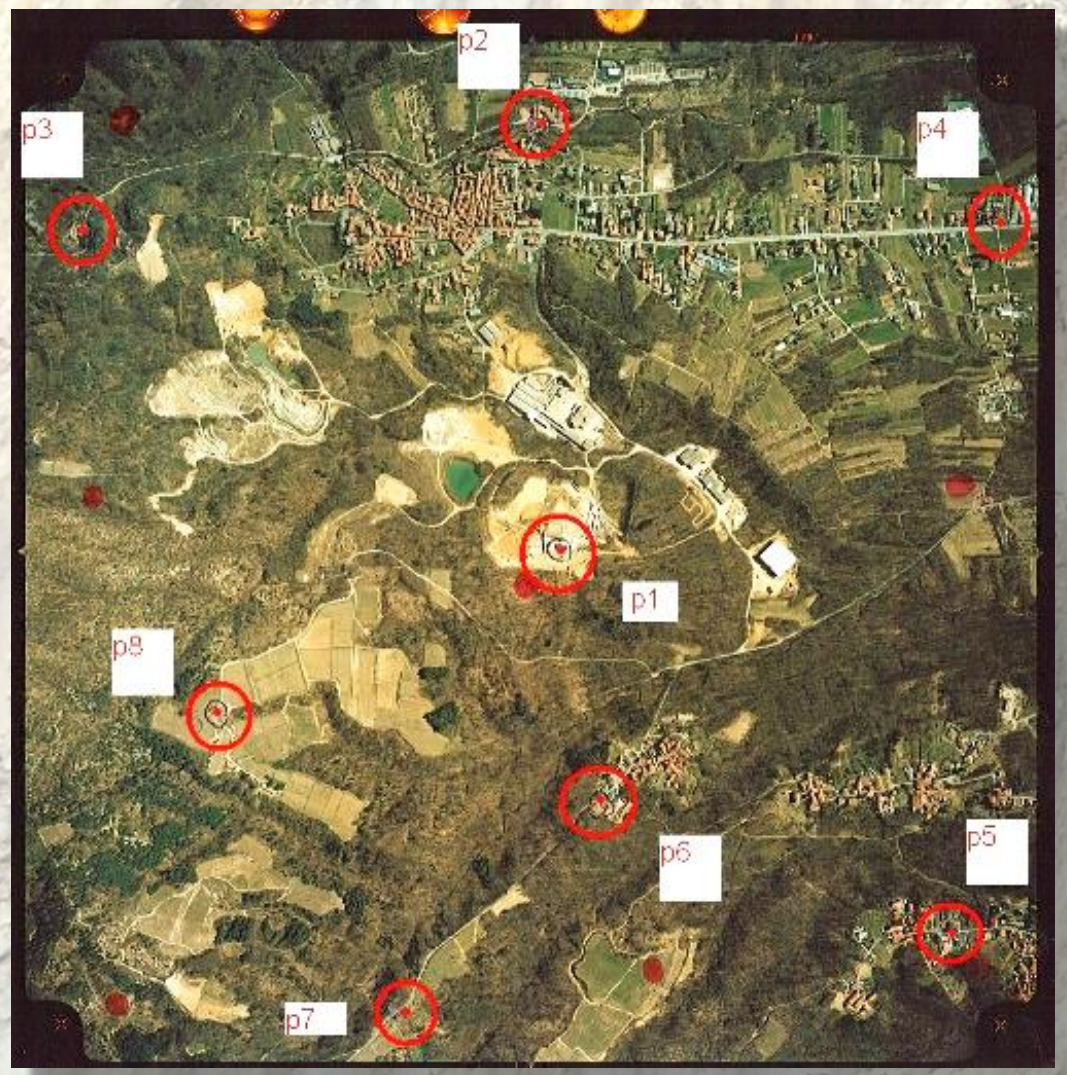


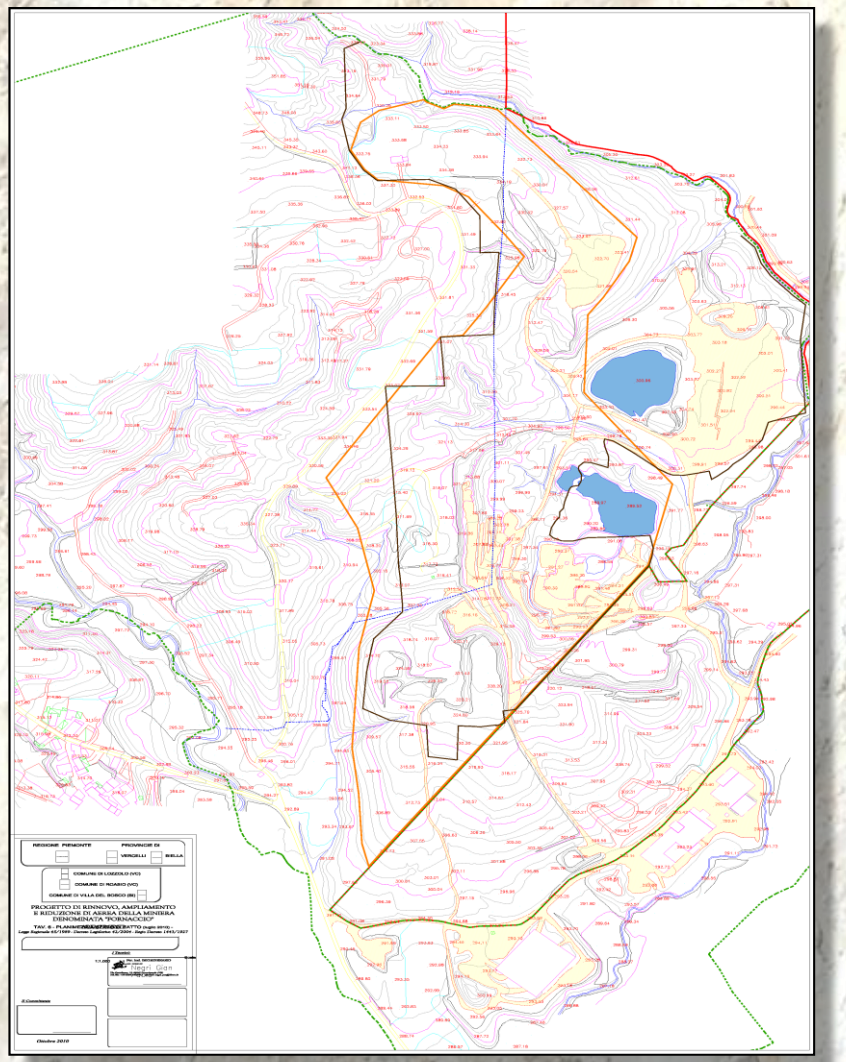
- INCLINED CLAY LAYERS > 40°
- SHARP LATERAL VARIATIONS
- SUDDEN DEEPENING OF CLAYS
- INVERSION OF STRATIGRAPHIC SERIES



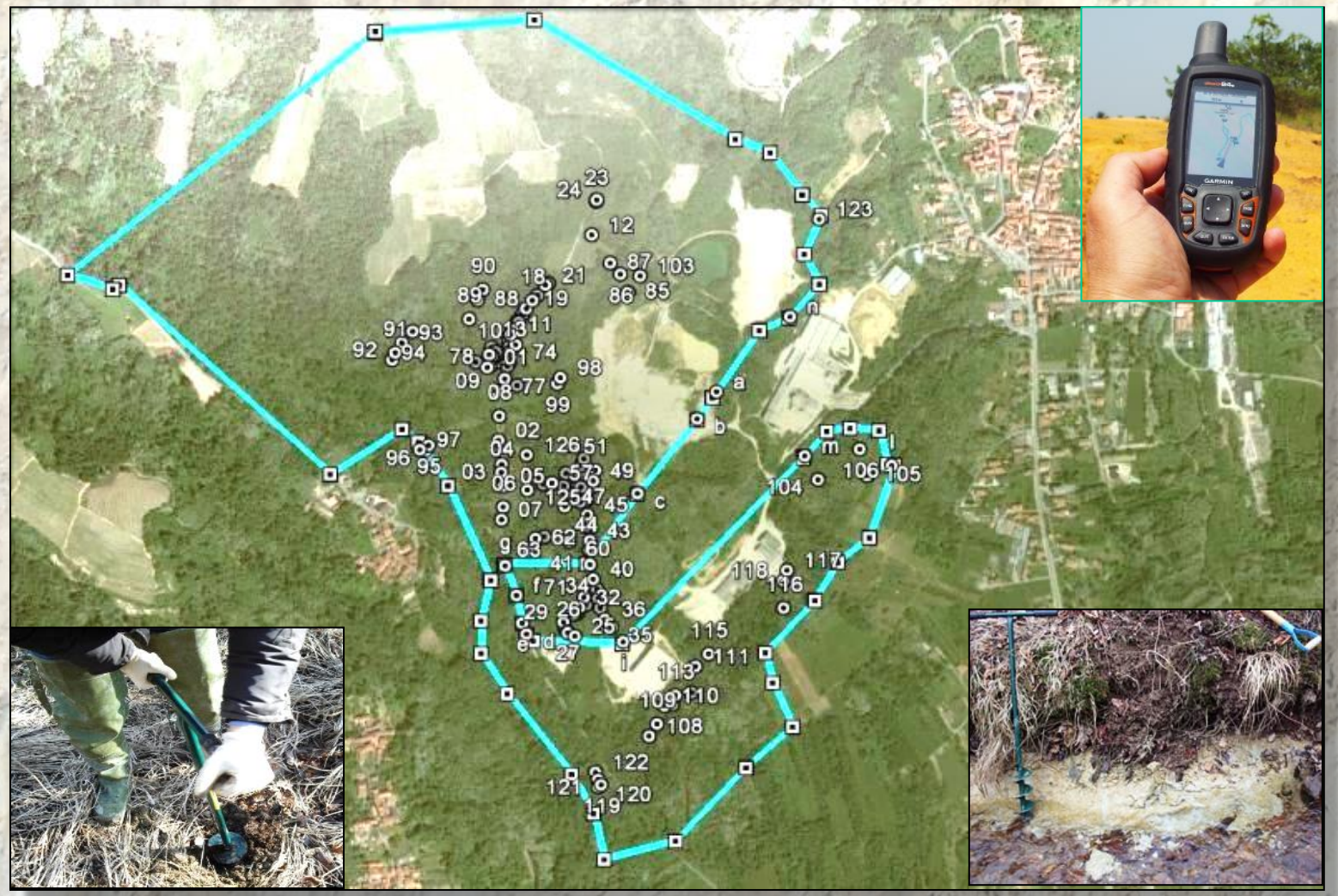
NEW PROSPECTING STUDIES REQUIRED
TO HELP A REVISION
OF PREVIOUS STRATIGRAPHIC
AND GEOLOGICAL INTERPRETATION

New prospecting techniques
I) Digital topographic model of the mining area with high precision GPS recording

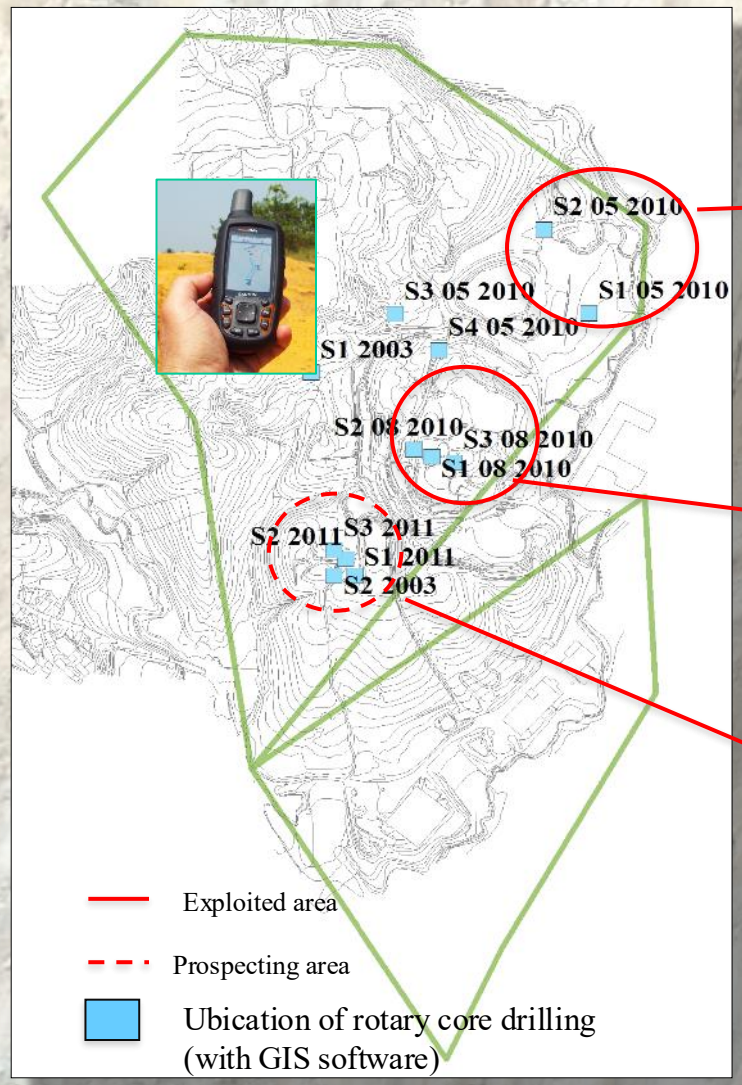


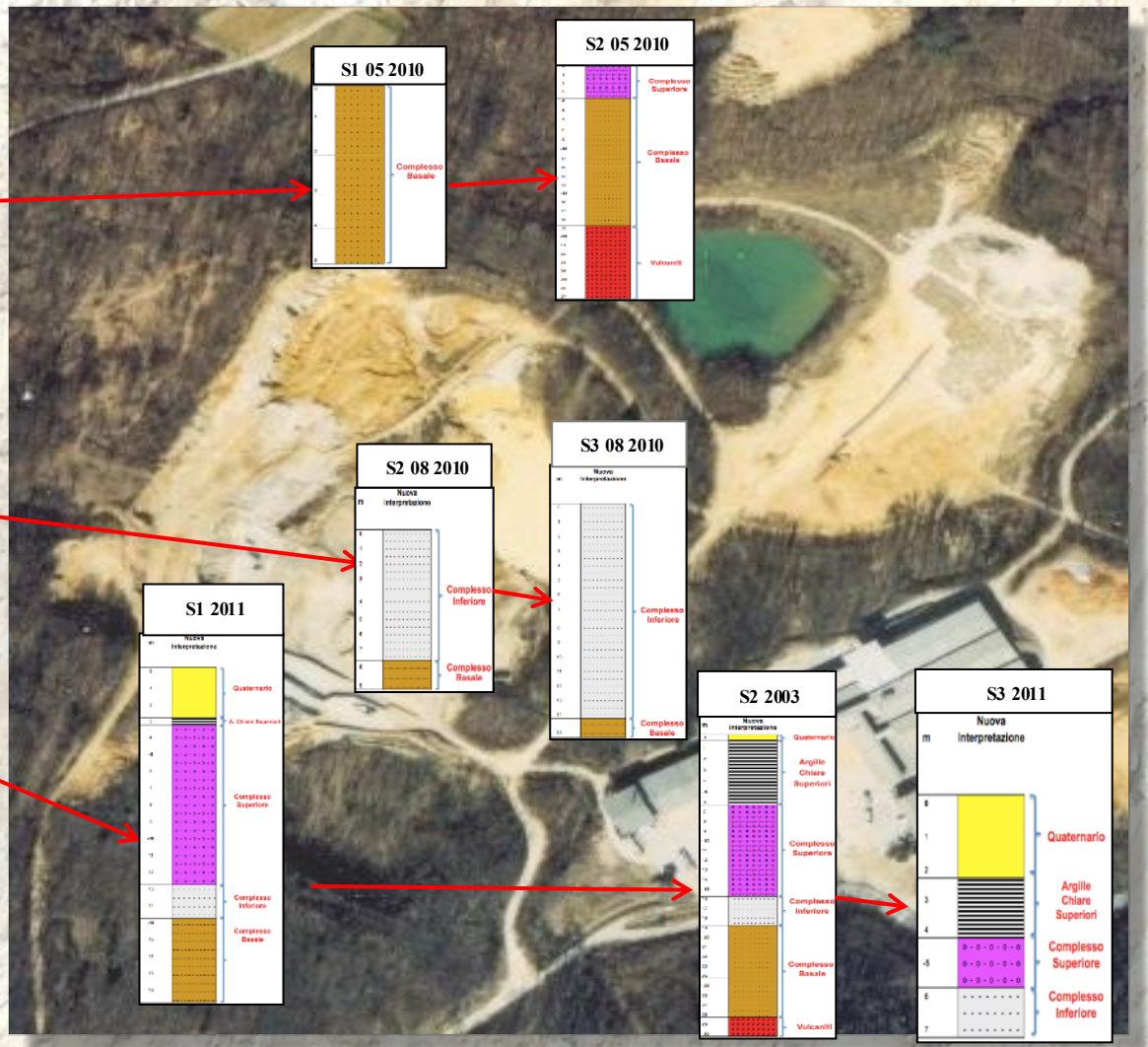


New prospecting techniques
II) Detailed surface sampling with GPS postioning around the mining area

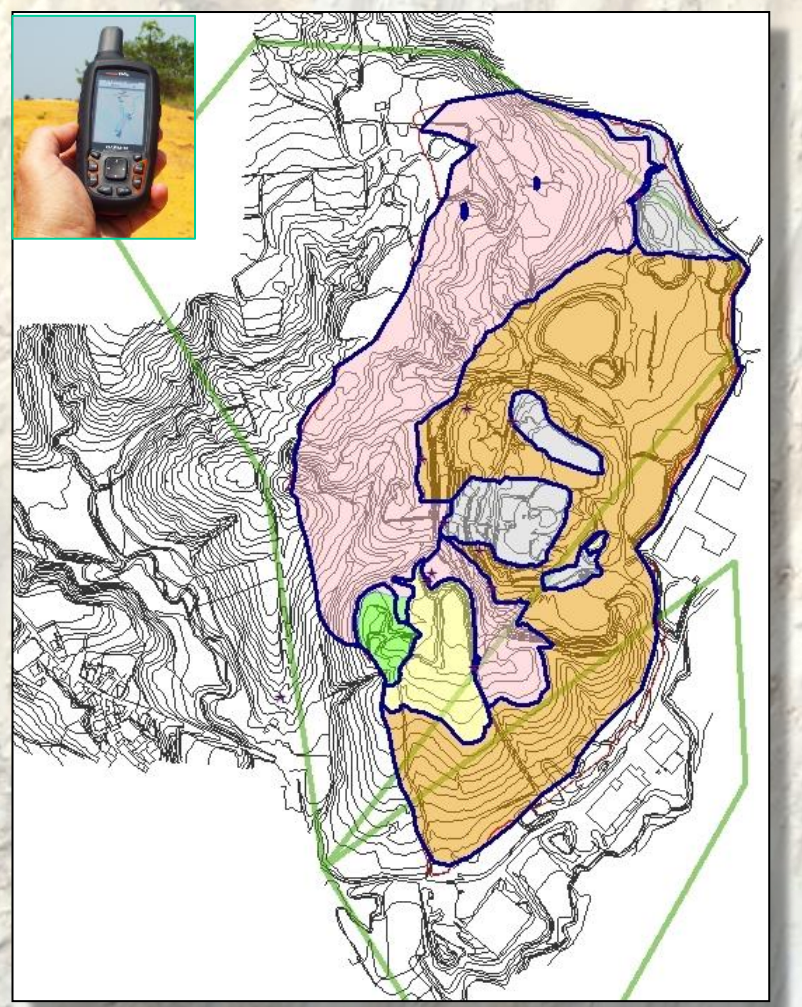


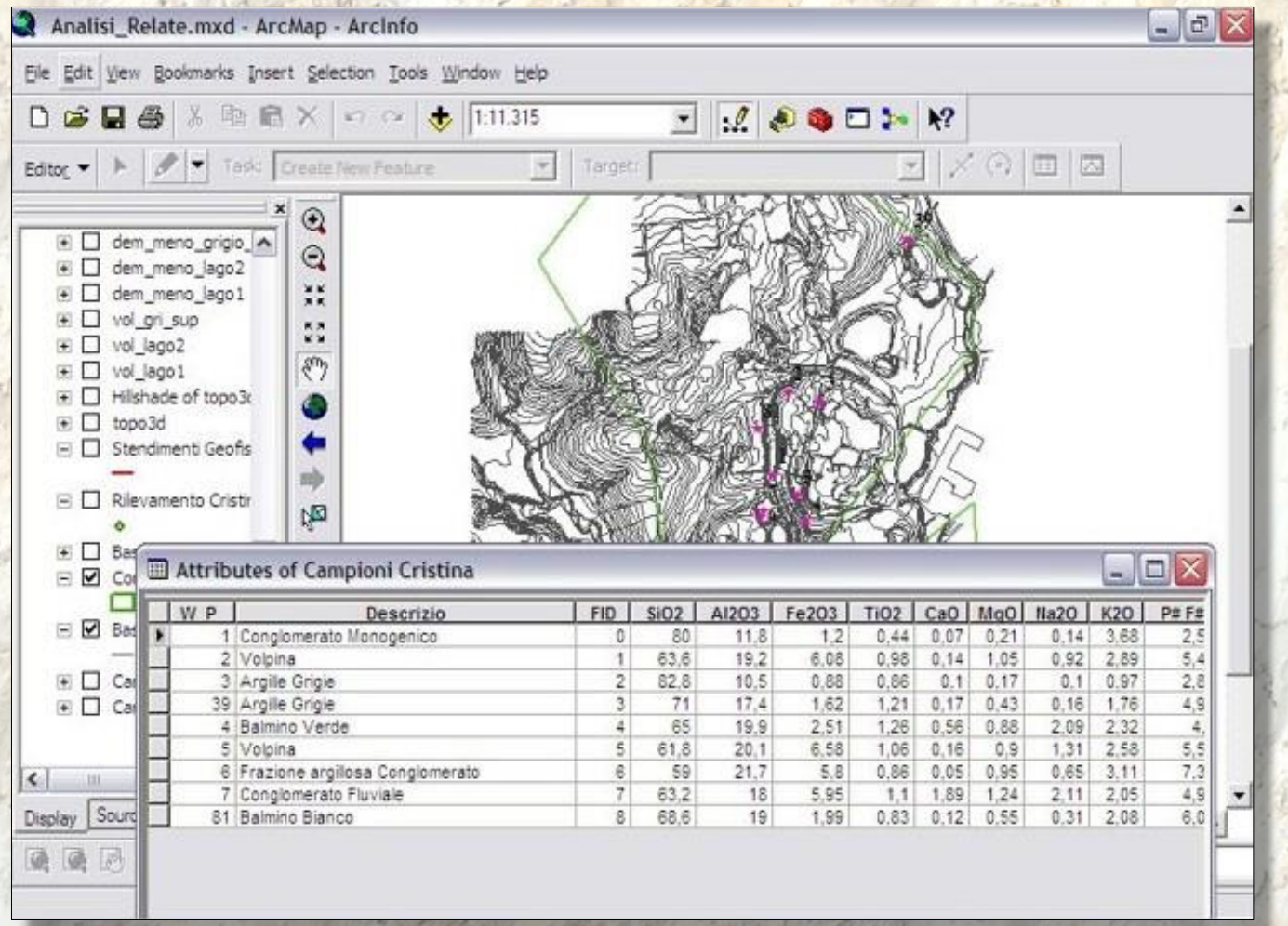
NEW PROSPECTING TECHNIQUES
III) GPS TOPOGRAPHIC POSITIONING OF ALL THE PREVIOUS CORE DRILLING WITH THE AID OF G.I.S. SOFTWARE





NEW PROSPECTING TECHNIQUES
IV) GEOLOGICAL INFORMATION AND ANALYTICAL DATA RECORDED ON G.I.S. PROJECT

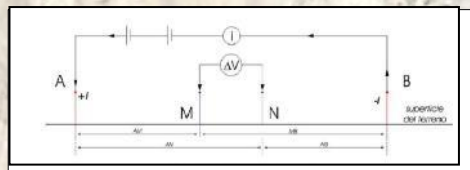


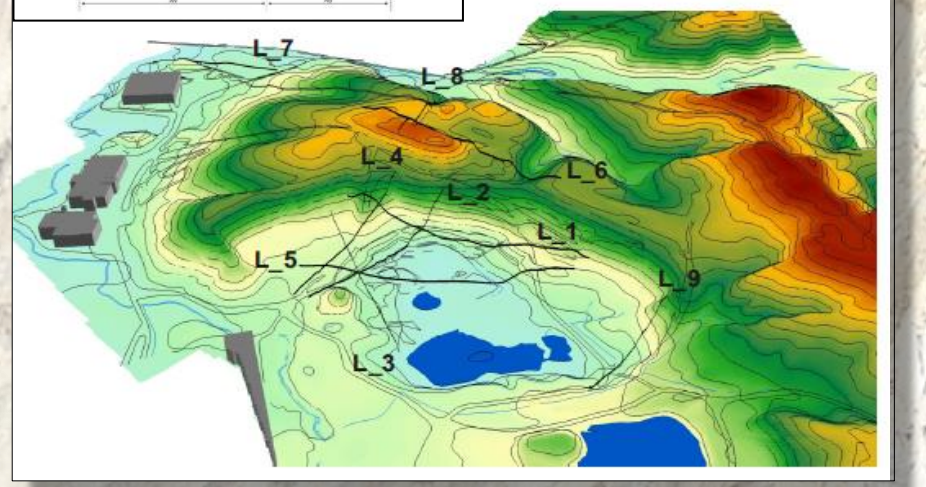


W_P	Descrizio	FID	SiO2	Al2O3	Fe2O3	TiO2	CaO	MgO	Na2O	K2O	P# F#
1	Conglomerato Monogenico	0	80	11,8	1,2	0,44	0,07	0,21	0,14	3,68	2,5
2	Volpina	1	63,6	19,2	6,08	0,98	0,14	1,05	0,92	2,89	5,4
3	Argille Grigie	2	82,8	10,5	0,88	0,86	0,1	0,17	0,1	0,97	2,8
39	Argille Grigie	3	71	17,4	1,62	1,21	0,17	0,43	0,16	1,76	4,9
4	Balmino Verde	4	65	19,9	2,51	1,26	0,56	0,88	2,09	2,32	4,
5	Volpina	5	61,8	20,1	6,58	1,06	0,16	0,9	1,31	2,58	5,5
6	Frazione argillosa Conglomerato	6	59	21,7	5,8	0,86	0,05	0,95	0,65	3,11	7,3
7	Conglomerato Fluviale	7	63,2	18	5,95	1,1	1,89	1,24	2,11	2,05	4,9
81	Balmino Bianco	8	68,6	19	1,99	0,83	0,12	0,55	0,31	2,08	6,0

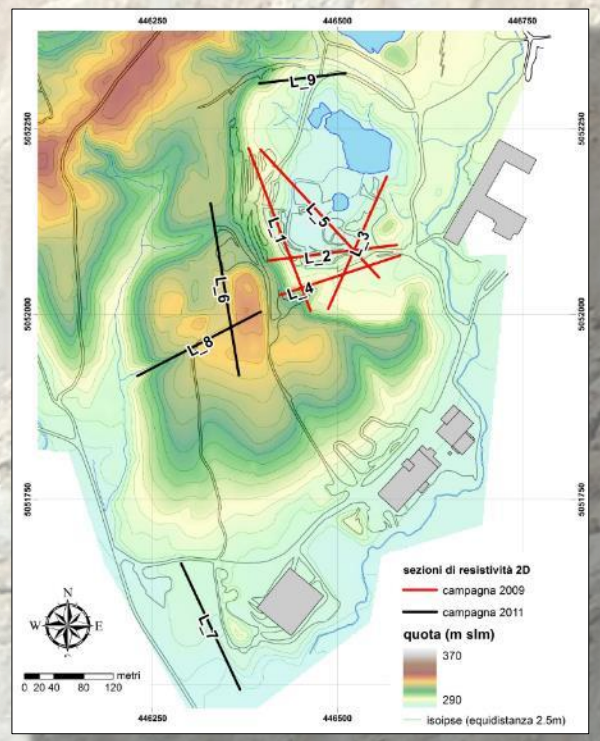
NEW PROSPECTING TECHNIQUES
V) GEOPHYSICAL SURVEY : GEO-ELECTRIC METHOD 2D (EARTH RESISTIVITY IMAGING)

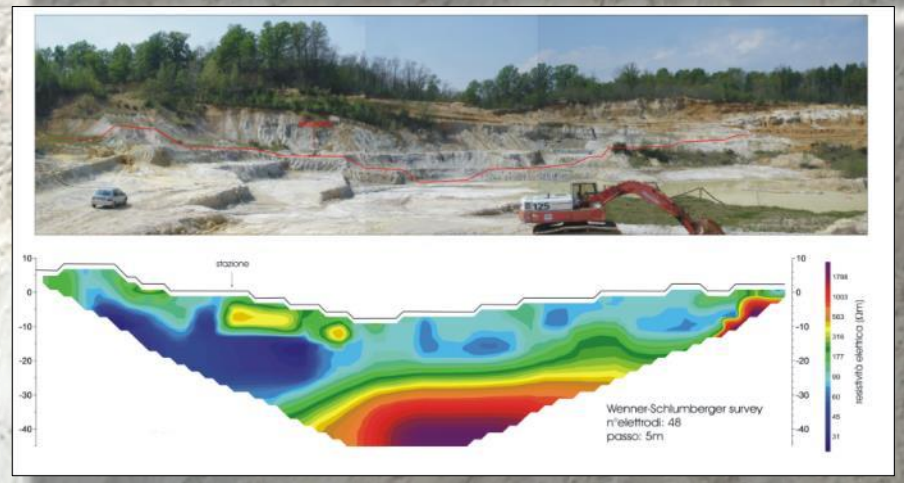






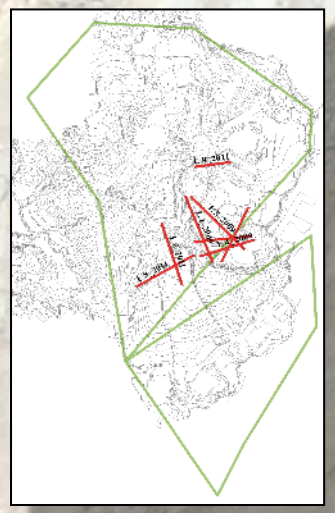


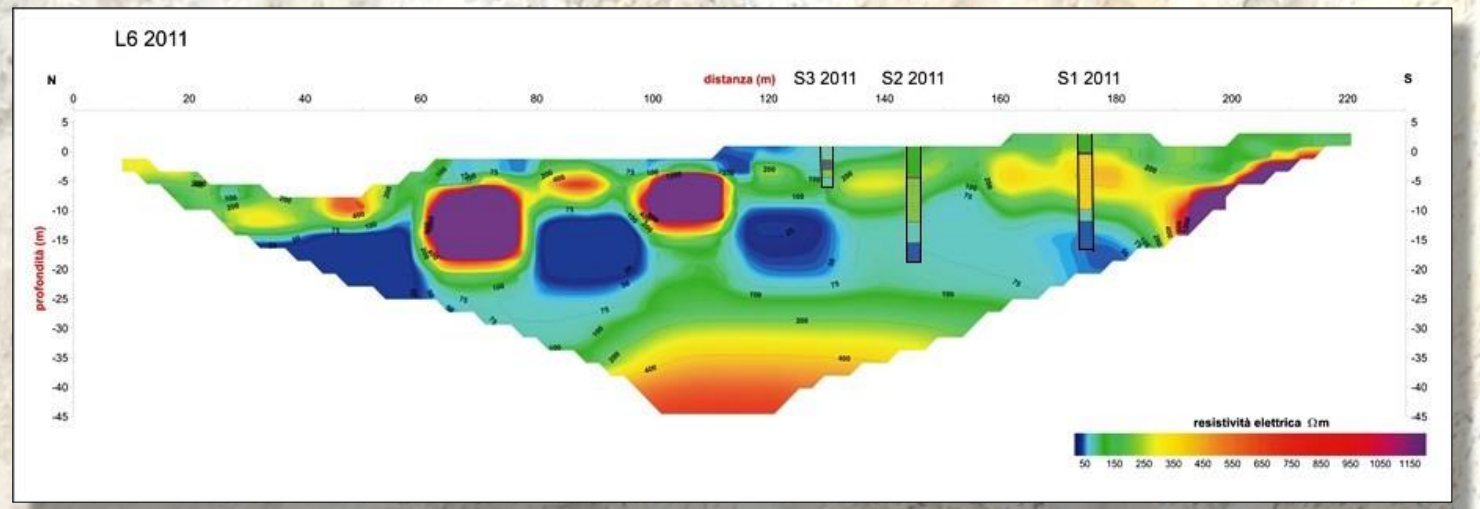






New prospecting techniques
VI) Calibration of geo-electrical data with stratigraphic information by core drilling

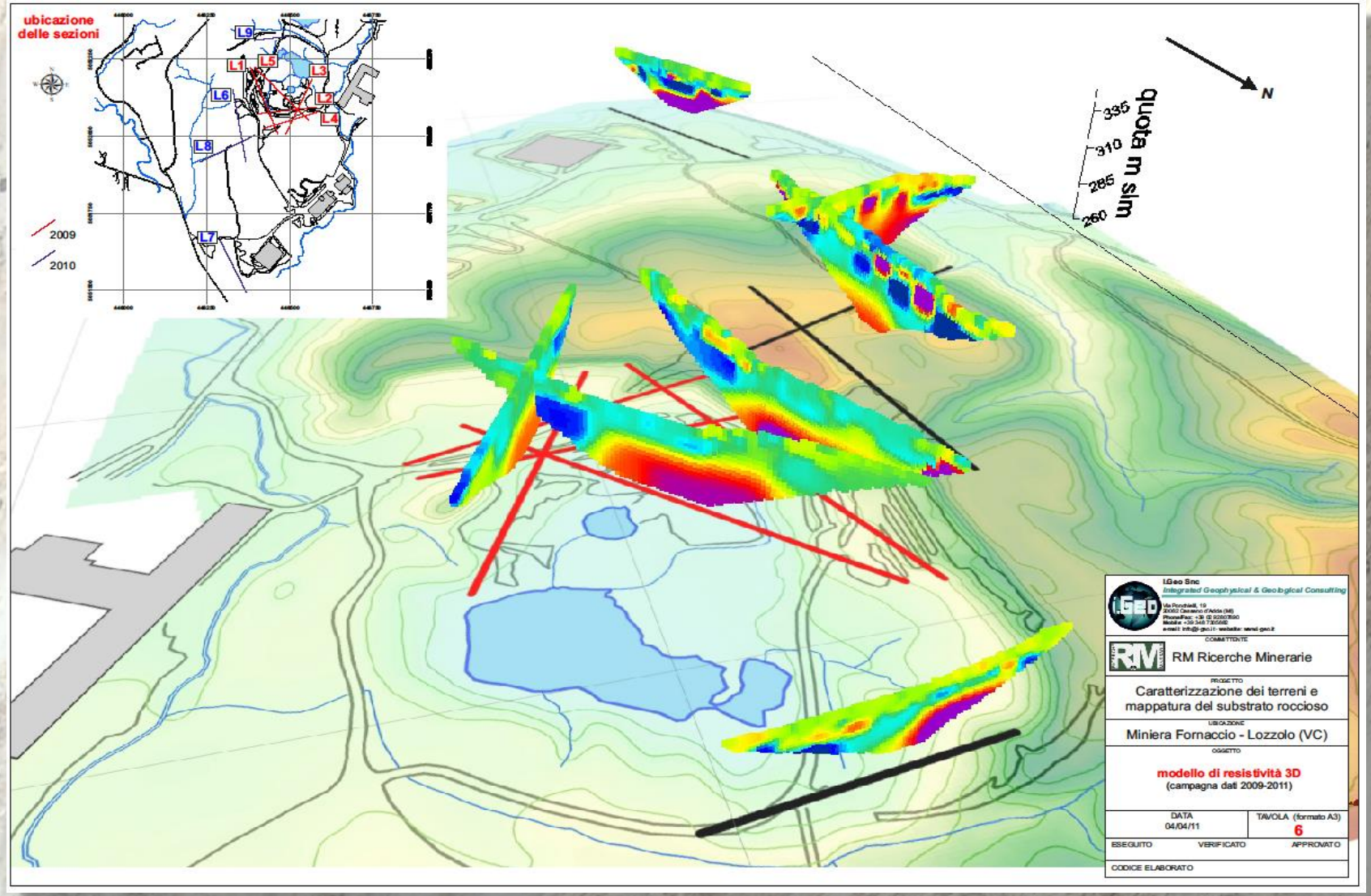




- Multicolored clay unit - 100-200 Ωm (surface unit with different shades of green)
- Reddish sandy unit + wheatered gravel - > 200 Ωm (from yellow to purple)
- Grey sandy/clay unit - 75-100 Ωm (green-light blue colours)
- Clayey sand - 75-100 Ωm (light blue with blue spots)
- Volcanic rocks - 400 Ωm (red colour lower levels)

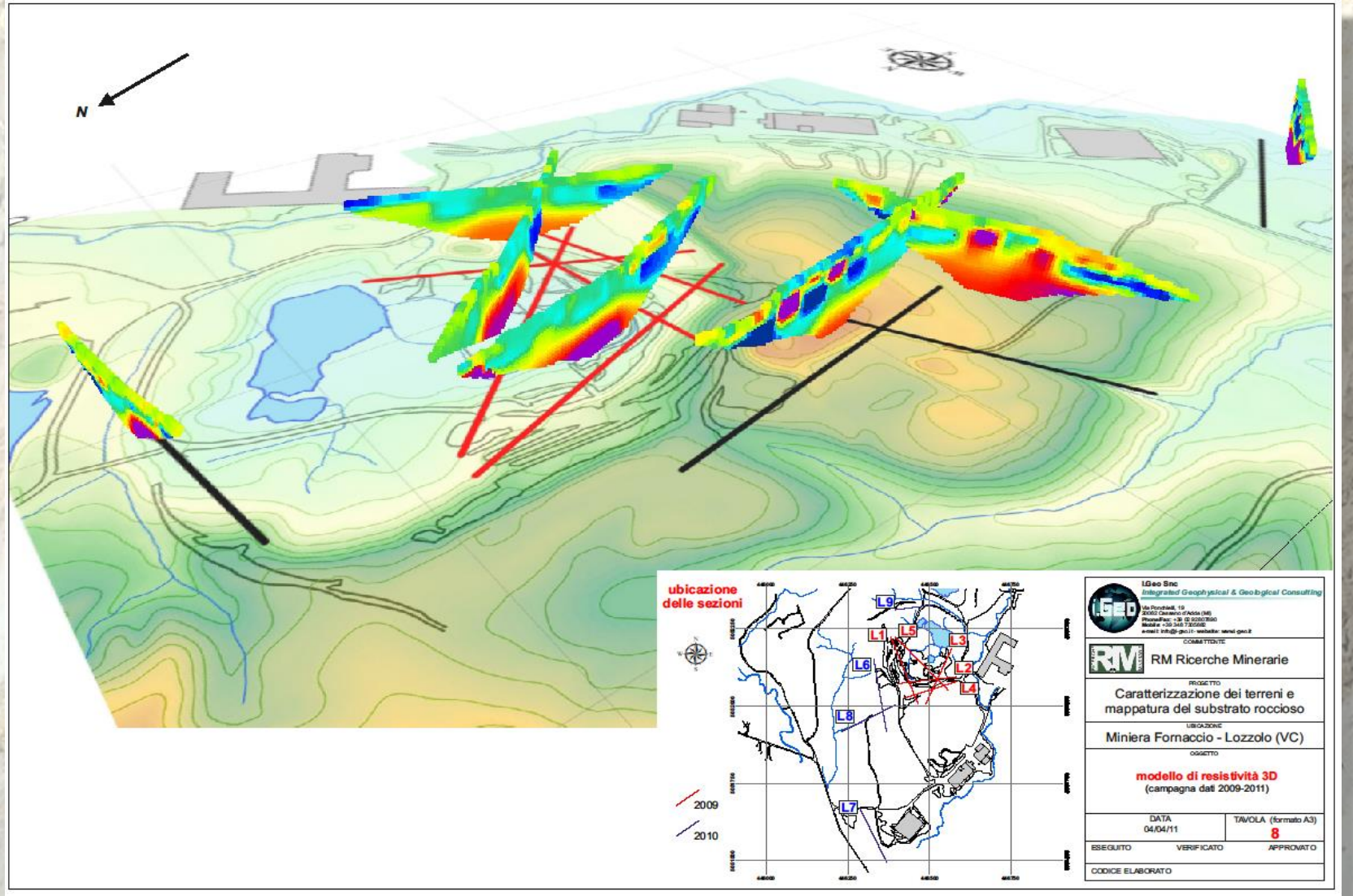
NEW PROSPECTING TECHNIQUES

VII) DIGITAL MAPPING PROJECT WITH LOCATION OF ELECTRO-STRATIGRAPHIC SECTIONS RESULTING FROM GEO-ELECTRICAL PROSPECTING



NEW PROSPECTING TECHNIQUES

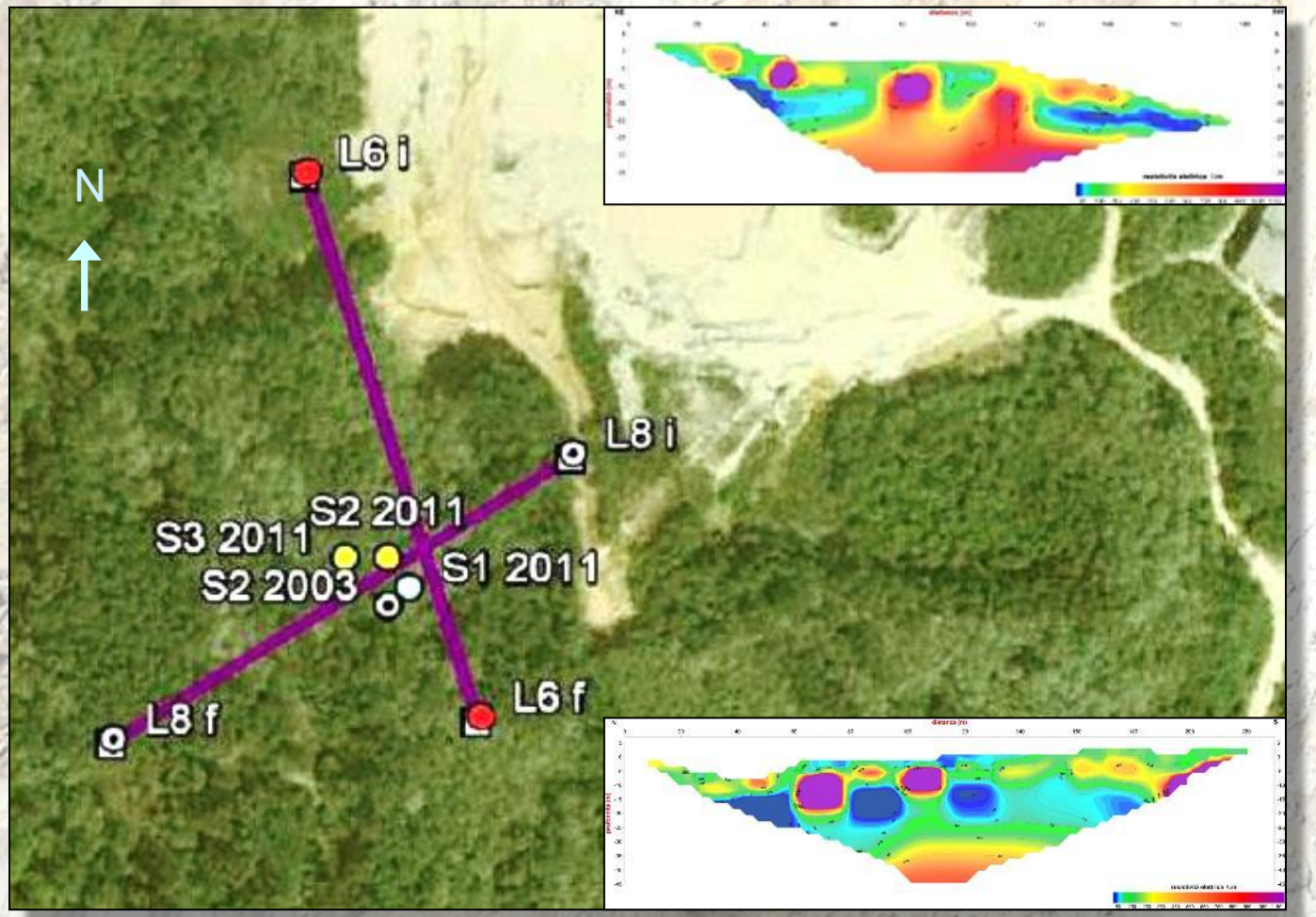
VII) DIGITAL MAPPING PROJECT WITH LOCATION OF ELECTRO-STRATIGRAPHIC SECTIONS RESULTING FROM GEO-ELECTRICAL PROSPECTING



NEW PROSPECTING TECHNIQUES
VI) CORRELATION BETWEEN GEOPHYSICAL SURVEY AND CORE DRILLING IN THE SAME AREA

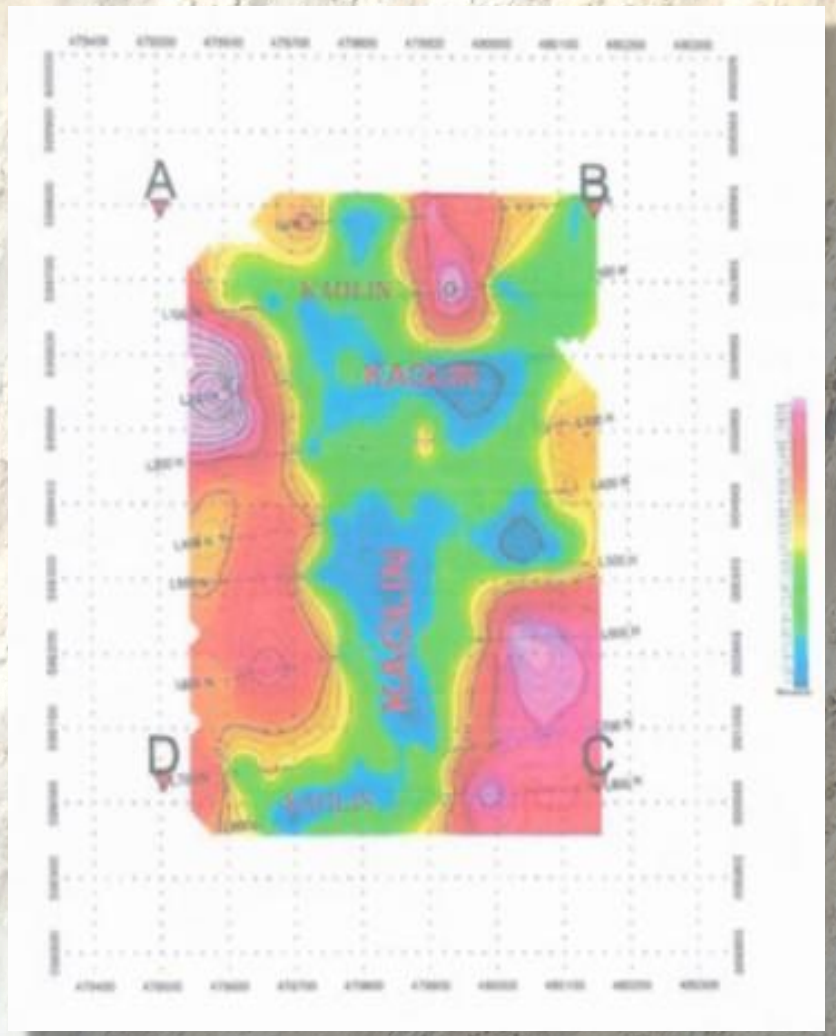


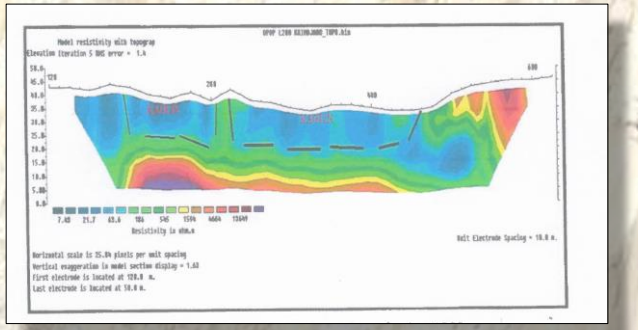


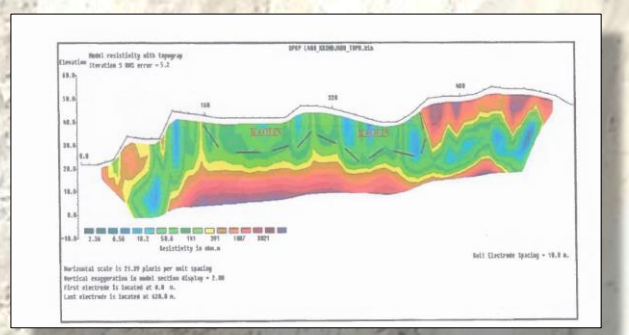


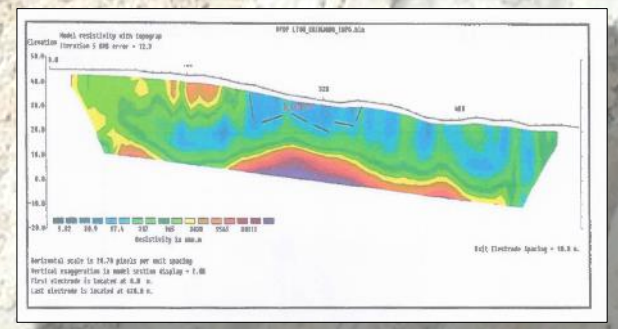
NEW PROSPECTING TECHNIQUES
LIMITS OF GEO-ELECTRIC METHODS IN CLAY DEPOSITS EVALUATION (IVORY COAST EXPERIENCE)





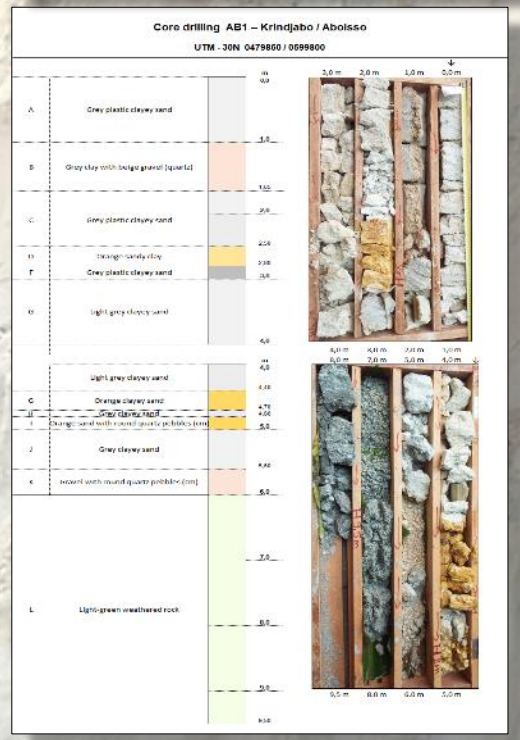


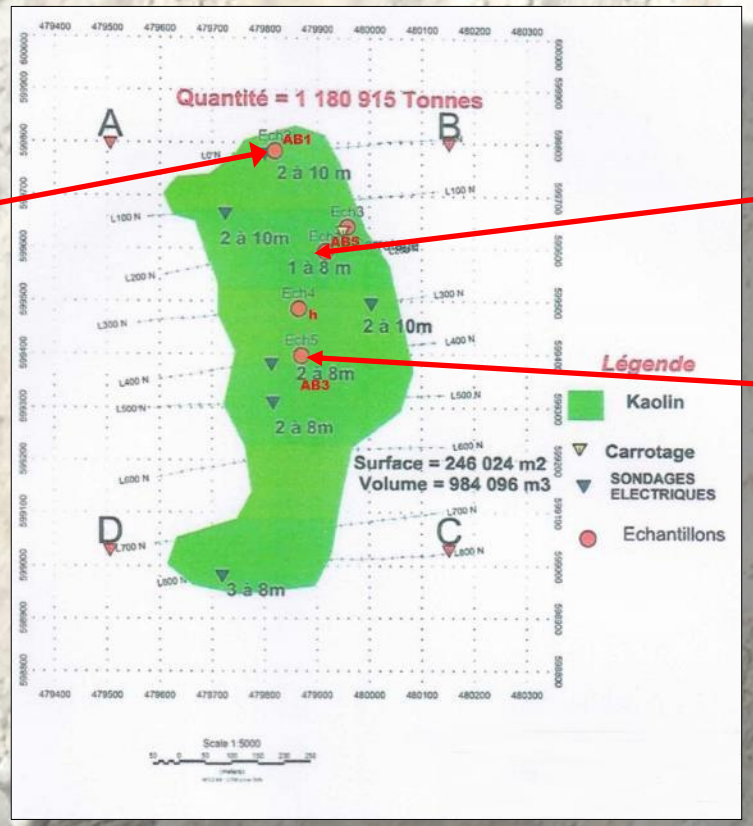




New prospecting techniques
Limits of Geo-electric methods in clay deposits evaluation (Ivory Coast experience)

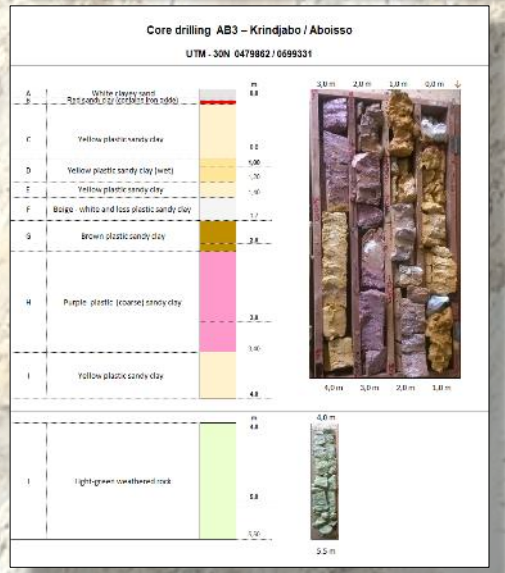




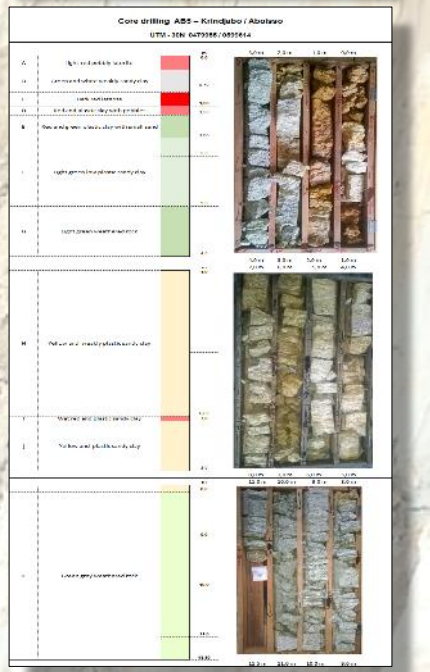


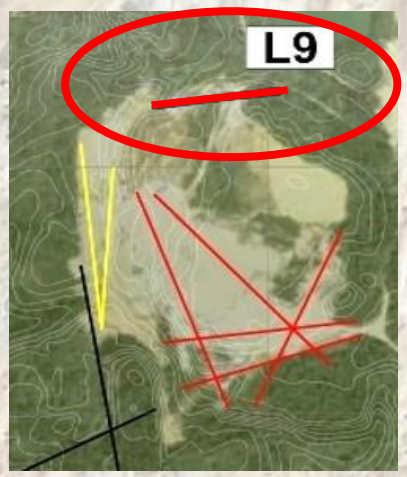
Error in estimating of kaolin quantity caused by alternating sands and clays with different electrical resistivities And with widespread presence of water for geophysical exploration made in wet season



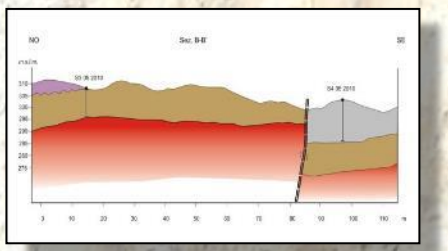




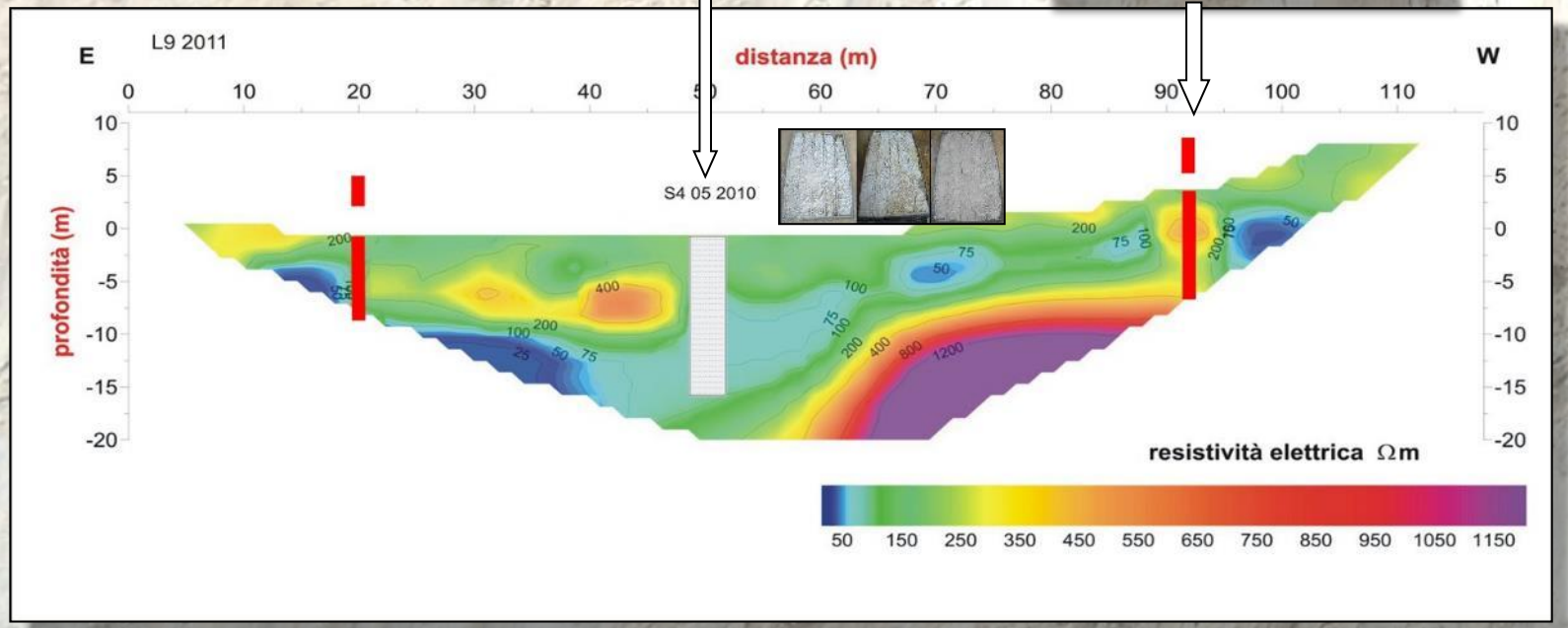



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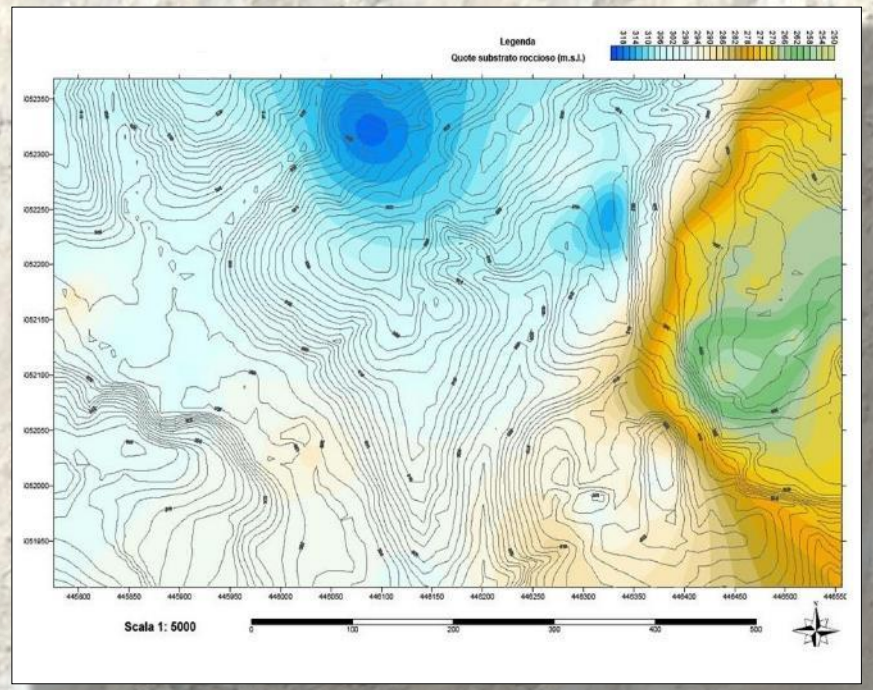


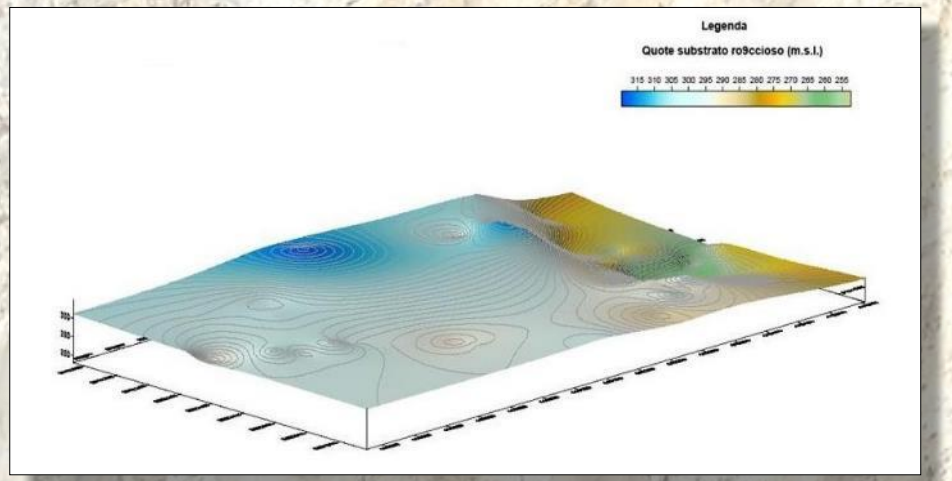


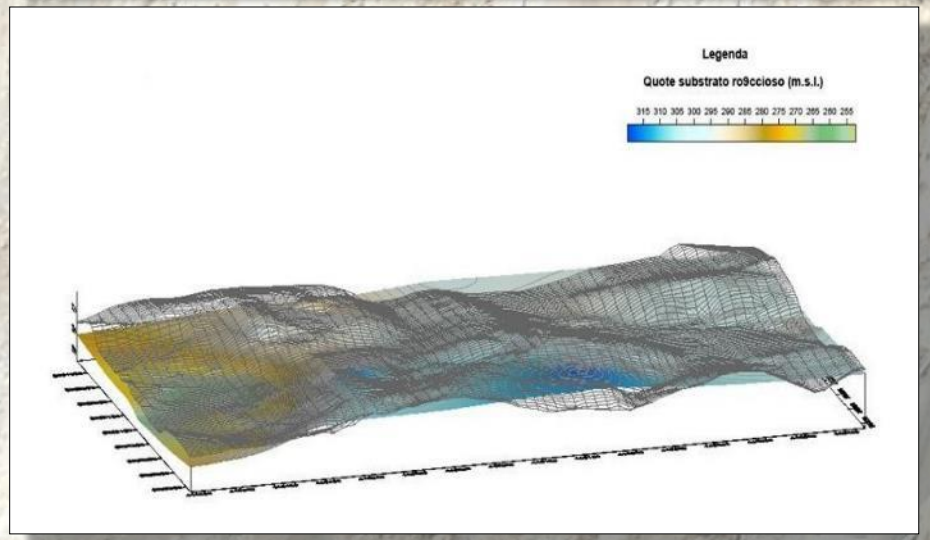



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resistività elettrica Ωm
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NEW PROSPECTING TECHNIQUES
VIII) PRELIMINARY 3D MODEL OF THE DEPOSIT (DEPTH OF LOWER VOLCANIC ROCKS TOP LEVEL)

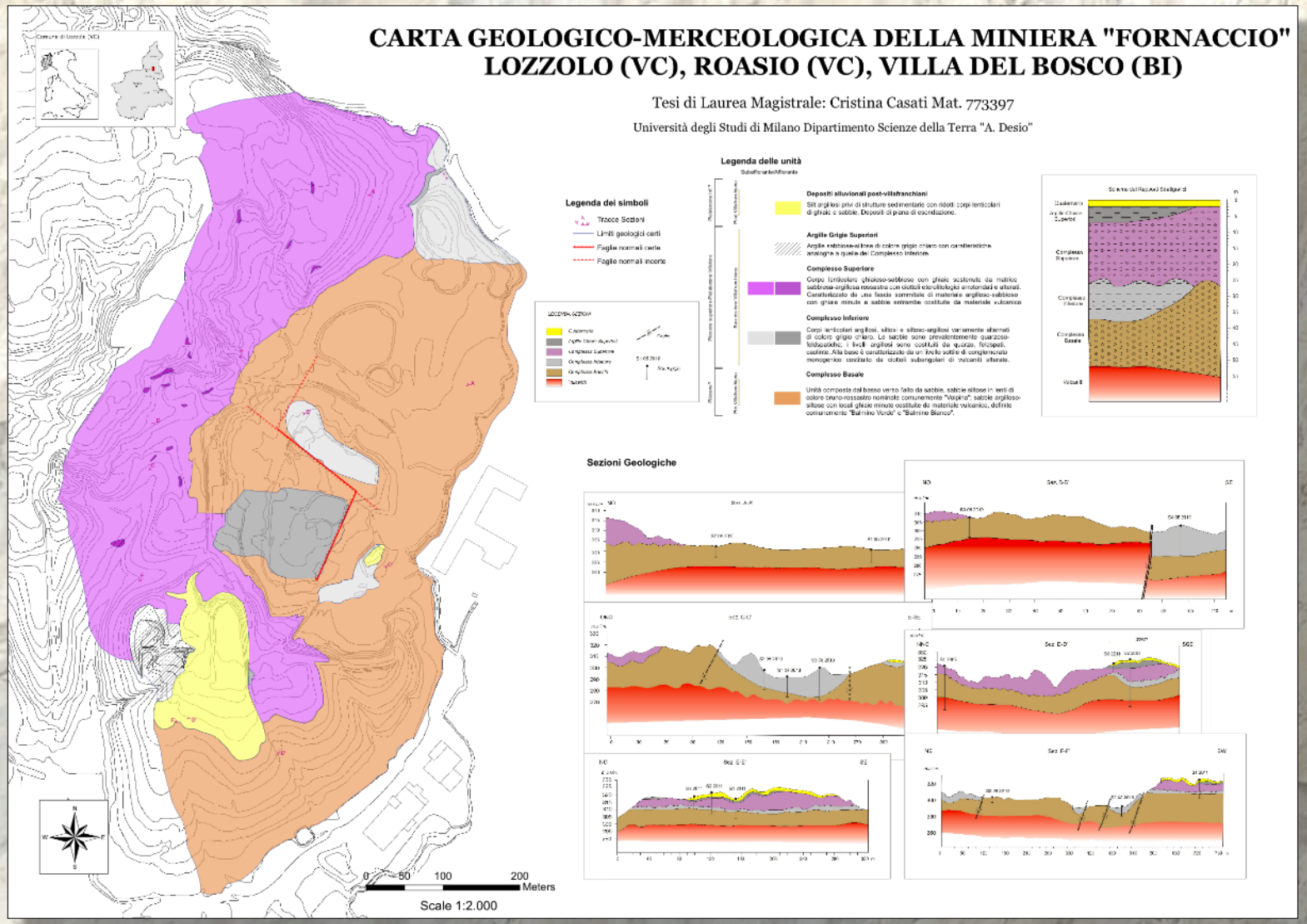


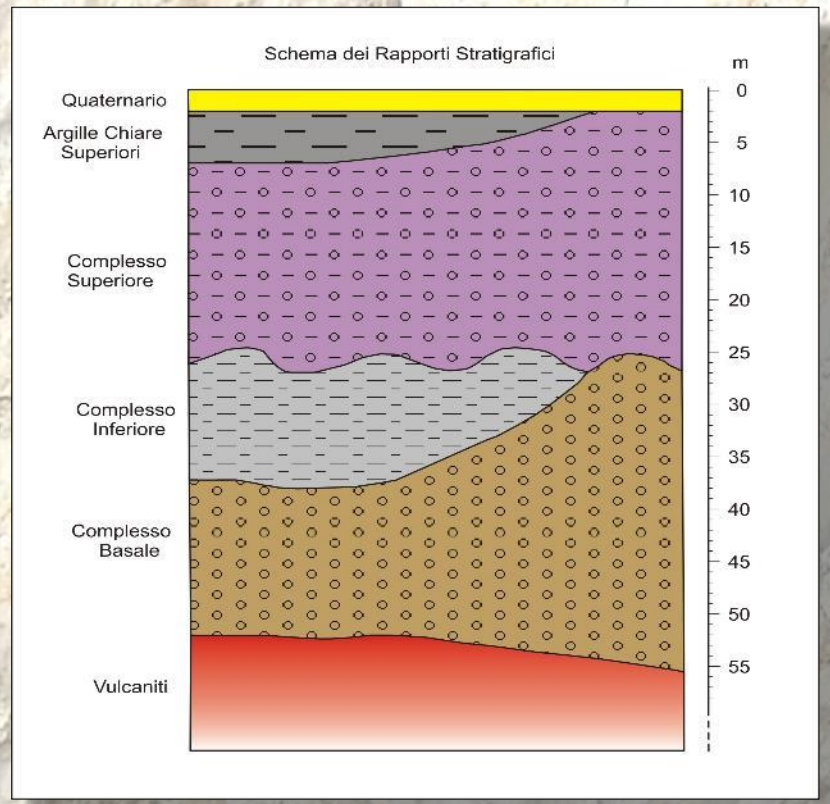




NEW PROSPECTING TECHNIQUES

IXI) NEW GEOLOGICAL MAP AND UPDATED STRATIGRAPHIC SCHEME OF THE CLAY MINE



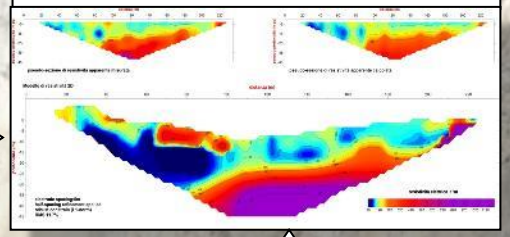


SUMMARY OF NEW METHODS OF PROSPECTING APPLIED IN THE STUDY OF LOZZOLO CLAY DEPOSIT

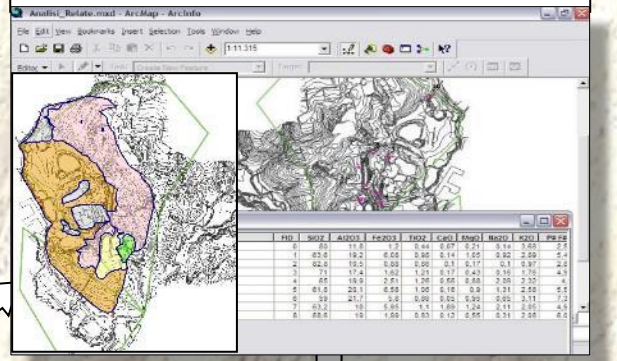
PROSPECTING INTEGRATED WITH GPS



GEOPHYSICAL EXPLORATION



GEOREFERENCED GEOLOGICAL MAP



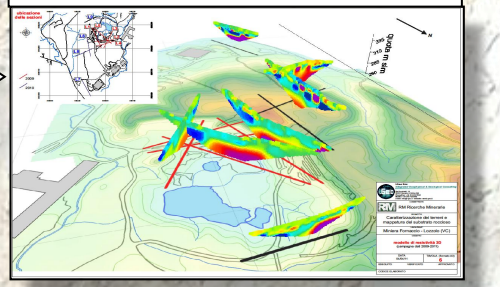
SELECTIVE MONITORED EXCAVATION



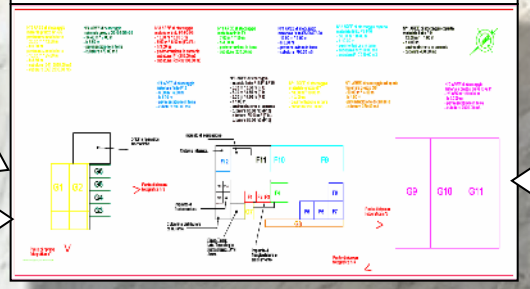
LABORATORY



DIGITAL MODEL OF THE DEPOSIT

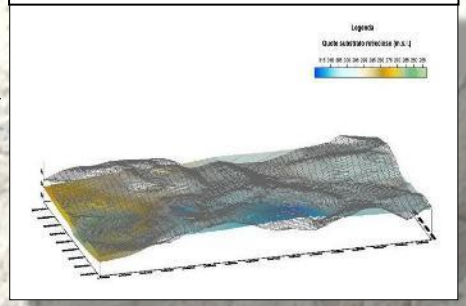


CONTROLLED STORAGE





3D DIGITAL MODEL OF THE DEPOSIT



CERAMIN CONSULTING

CONCLUSIONS

- IN RECENT YEARS CERAMIC INDUSTRY REQUIRE MORE AND MORE HIGH QUALITY CONTROLLED RAW MATERIALS

- WHITE FIRING CLAY MINERALS MUST BE CONSIDERED STRATEGIC RAW MATERIALS ESPECIALLY FOR THE CERAMIC PRODUCTION IN ITALY

- NEW PROSPECTING METHODS APPLIED IN LOZZOLO CLAY MINE HELPED TO BETTER UNDERSTANDING THE COMPLEX STRATIGRAPHY OF THAT DEPOSIT AND TO IDENTIFY QUALITIES DEMANDED BY THE MARKET

- GEOPHYSICAL STUDIES ASSOCIATED WITH CORE DRILLING PROSPECTING RESULTED VERY HELPFUL TO IDENTIFY THE PRESENCE OF TECTONIC STRUCTURES ASSOCIATED WITH THE MAJOR CONCENTRATIONS OF MORE VALUABLE KAOLINITIC CLAYS

- A MULTIMETHODOLOGICAL APPROACH IN INDUSTRIAL MINERAL MINING COULD BE VERY HELPFUL IF USED CORRECTLY TO EXPLORE AND FIND SIMILAR CLAY DEPOSITS ELSEWHERE

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