









Ingegneria al servizio del monitoraggio conservativo nei Campi Flegrei

Castello di Baia, 21 febbraio 2025

Digitalizzazione e modellazione numerica della cavità di Cuma per il monitoraggio e l'analisi dei dati geospaziali

Leopoldo Repola, Domenico Calcaterra, Diego Di Martire, Vincenzo Morra, DISTAR-Università degli Studi di Napoli Federico II











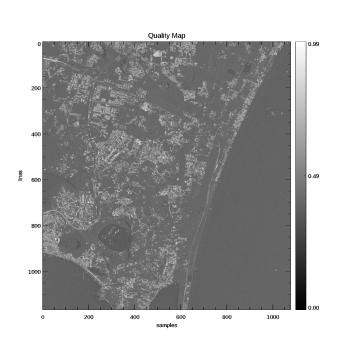


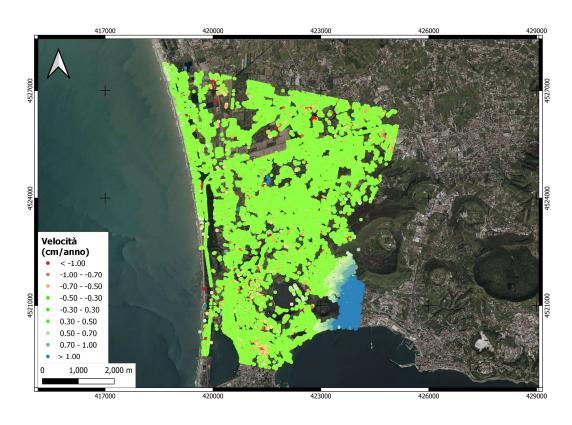






Monitoraggio SAR

















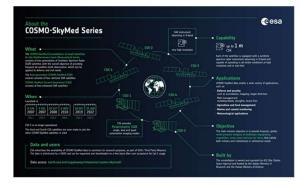




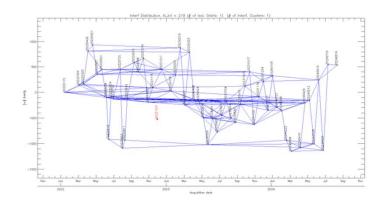


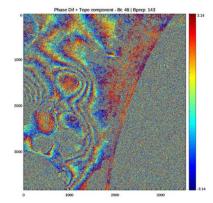
COSMO Second Generation - CSG

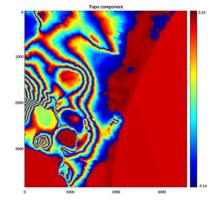
Sono state utilizzate 58 immagini acquisite in geometria descending nell'intervallo temporale 15/01/2022 – 16/08/2024, generando 219 interferogrammi

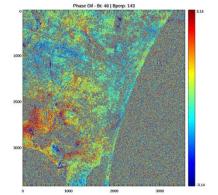


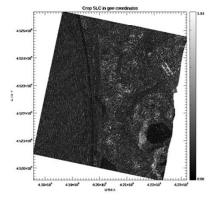




















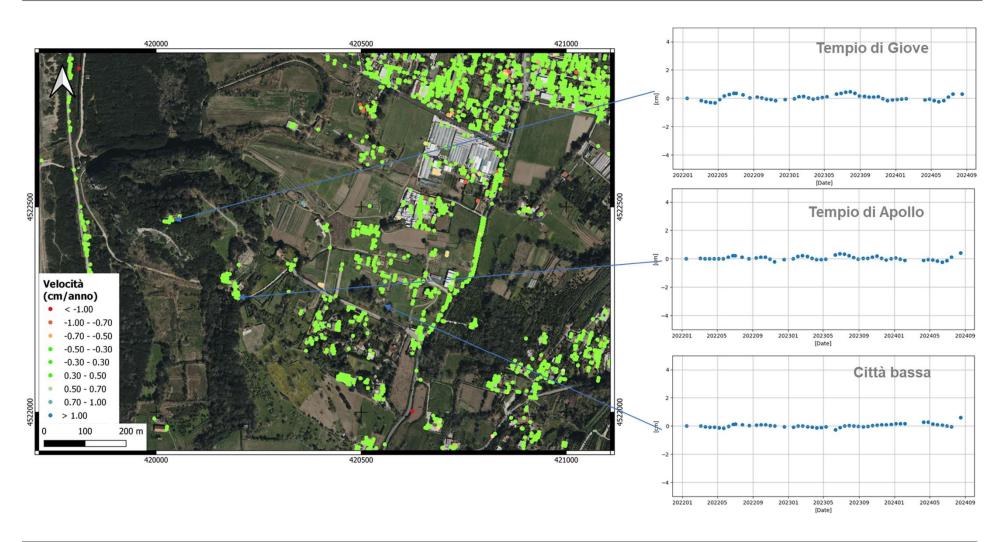






























Monitoraggio strumentale in situ

Antro della Sibilla:

No. 5 Stazioni di misura di spostamento (tipo A)

No. 2 Stazioni di misura ambientale

(termoigrometrica) (tipo B)

Crypta Romana:

No. 2 Stazioni di Tipo A

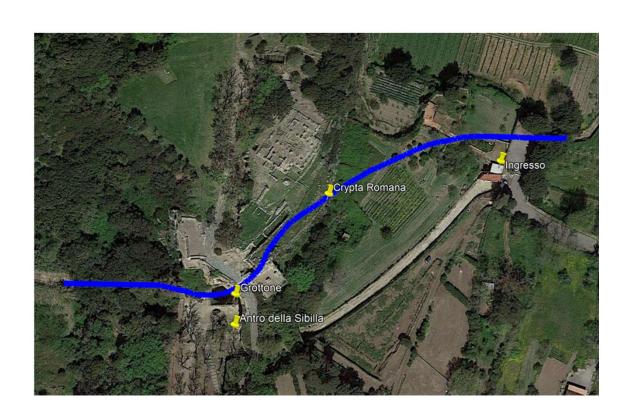
No. 1 Stazioni di Tipo B

No. 1 Stazione di misura accelerometrica

Grottone:

No. 9 Stazioni di Tipo A

No. 1 Stazione di Tipo B













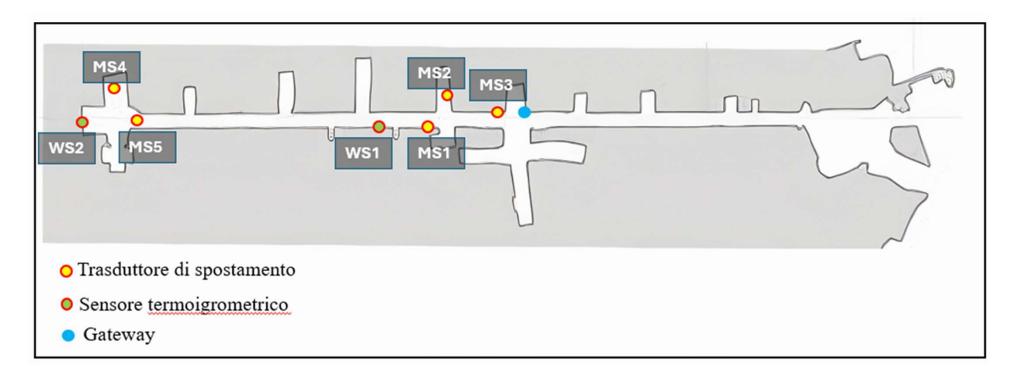








Antro della Sibilla













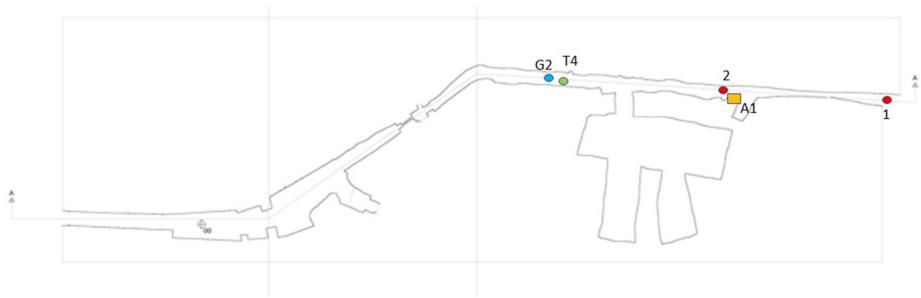








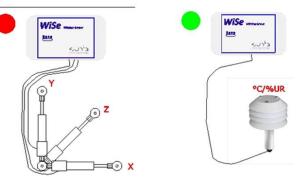
Crypta Romana



No. 2 Stazioni di Tipo A

No. 1 Stazioni di Tipo B

No. 1 Accelerometro















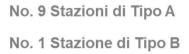






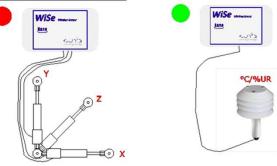
Grottone























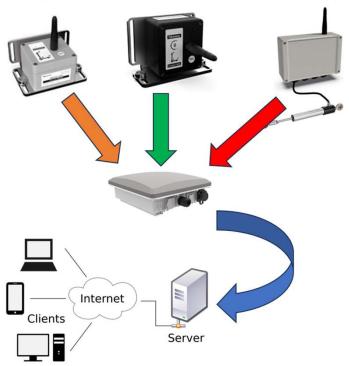






















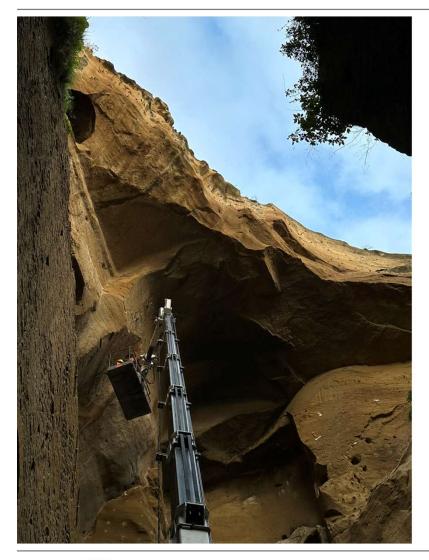






























































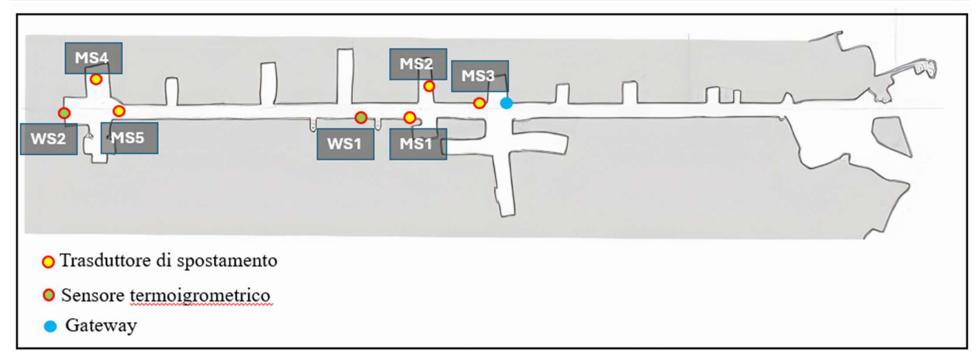












Trasduttore di spostamento	Denominazione in pianta
LOG-Wise_00050	MS3
LOG-Wise_00051	MS2
LOG-Wise_00052	MS1
LOG-Wise_00053	MS5
LOG-Wise_00054	MS4
Sensori Termoigrometrici	
LOG-Wise_00055	WS2
LOG-Wise_00056	WS1













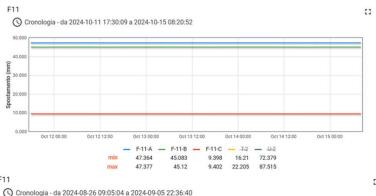


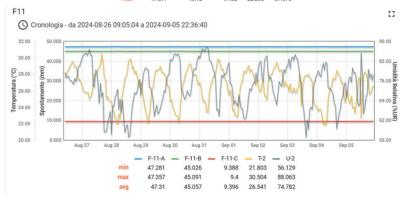




Sensore dinamico Risultati Velocimetro 3D :3 Oronologia - da 2024-10-19 07:16:00 a 2024-10-19 07:21:00 0.00020 © 0.00010 € 0.00000 M:.... 型 -0.00010 -0.00040 07:16:30 07:17:00 07:17:30 07:18:00 07:18:30 07:19:30 -0.0002 -0.00022 -0.00029 0.00026 0.00024 0.00026 0.00002 -0.00001 Velocimetro 3D :3 Ocronologia - da 2024-10-13 08:07:00 a 2024-10-13 08:10:00 0.0002 M:2.6 08:07:00 08:07:30 08:09:30 08:10:00 V3D-0308-X V3D-0308-Y V3D-0308-Z -0.0003 -0.00034 -0.00034 0.00045 0.00032 0.0003 -0.00001 Cronologia - da 2024-08-30 21:22:00 a 2024-08-30 21:26:00 0.0010 0.0000 M:3.7

Sensori statici







21:22:30

max

avg

-0.0010



V3D-0308-X - V3D-0308-Y - V3D-0308-Z

-0.00155

0.00167

0.00009

-0.00103

0.00146

0.00009

-0.00149

0.00188

0.00009







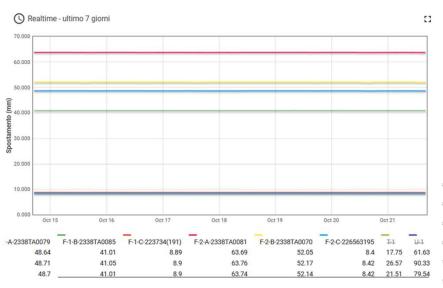


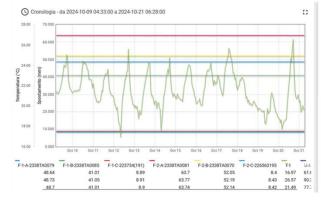




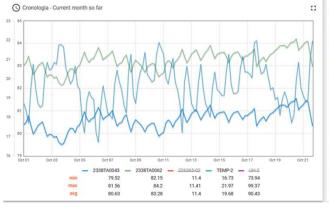


Risultati



















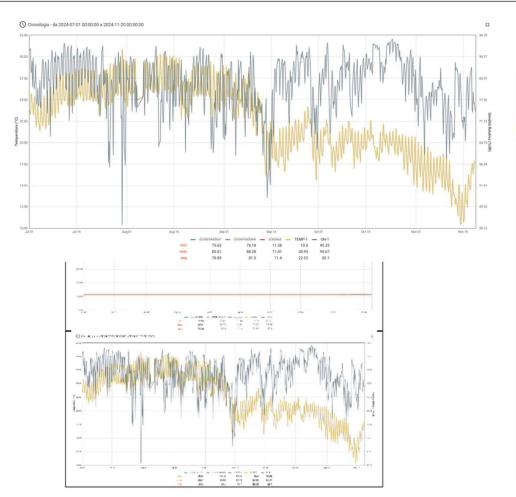


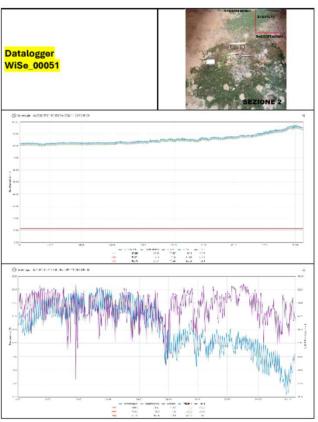






























Indagini mineralogiche e petrofisiche

L'approccio sperimentale alla caratterizzazione dei geomateriali del Parco Archeologico di Cuma ha previsto:

- analisi petrofisiche attraverso picnometria a Elio e porosimetria per intrusione di mercurio (MIP)
- analisi mineralogiche in diffrattometria a raggi X (XRPD)





















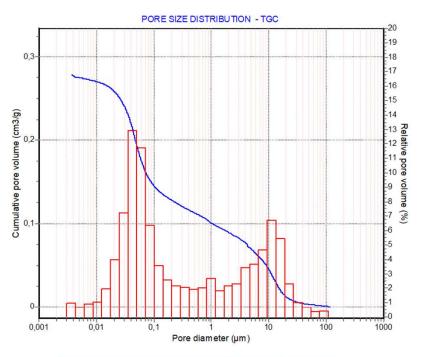








Indagini mineralogiche e petrofisiche



	TGC			
Total pore surface area (m²/g)	20.44			
Bulk density (g/cm³)	1.4406			
Apparent density (g/cm³)	2.4034			
Total pore volume (cm³/g)	0.27809			
Average pore diameter (μm)	0.0544			
Modal pore diameter (μm)	4.5512			
Porosity by Hg intrusion (%)	40.06			



Campione	Peso	Altezza	Diametro	Volume	Densità apparente	Volume reale	Densità reale	Porosità
				apparente				
	g	cm	cm	cm ³	g/cm3	cm ³	g/cm³	%
TGCP1	20,23	3,26	2,54	16,51	1,23	8,93	2,27	45,92
TGCP2	20,88	3,25	2,54	16,46	1,27	9,36	2,23	43,13
ТССРЗ	21,486	3,49	2,54	17,68	1,22	9,55	2,25	45,99
media						9,28	2,25	45,01











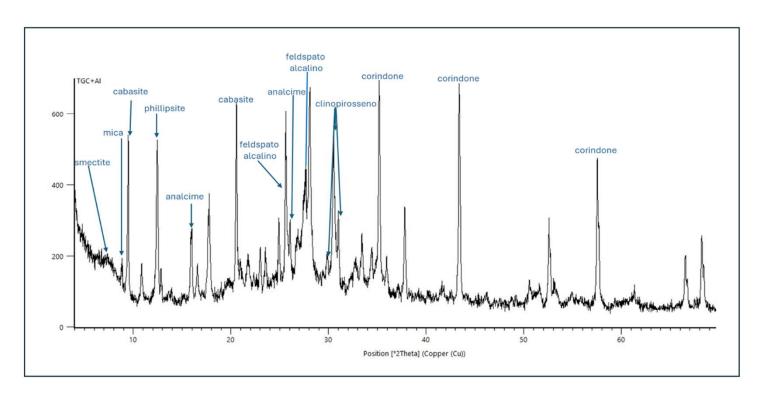








Diffrattometria



Il campione dall'analisi mineralogia risulta essere costituito da phillipsite, cabasite e analcime. tipica associazione di fasi zeolitiche, che generalmente caratterizza il Tufo Giallo Napoletano (TGN) (de Gennaro et al., 2000).













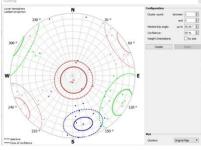


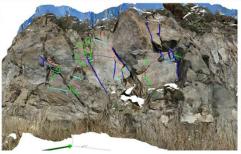


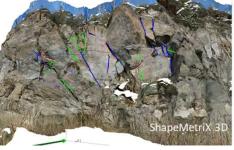




Caratterizzazione geomeccanica

























Caratterizzazione di sito



Caratterizzazione geo-strutturale e geomeccanica del settore SW del duomo lavico.

Riconoscimento di tre litofacies:

- A: molto fratturato e alterato;
- B: intensamente fratturato
- C : compatto e massivo









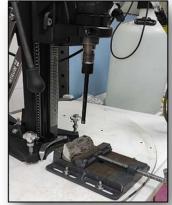








Microstruttura di campioni di roccia rappresentativi delle tre litofacies



Carotiere da banco

Tornio con fresa diamantata

Estrazione di provini cilindrici da campioni prelevati in campo

























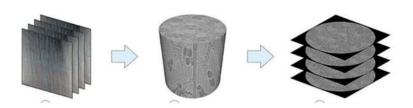
Micro-CT lab INGV - OV

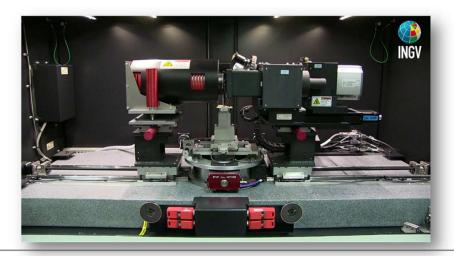
Microtomografia computerizzata ai raggi X INGV - Sezione Osservatorio Vesuviano

Tecnica di imaging 3D, non distruttiva, ad alta risoluzione spaziale (submicron), impiegata per visualizzare ed investigare qualitativamente e quantitativamente la microstruttura di un campione di roccia o materiale.

Zeiss Xradia 410 Versa Microtomographic

(Sorgente di microfocus di raggi X, detector innovativo, obiettivi con ingrandimento da 0.4 X a 20X - risoluzione fino a 0.9 µm)

















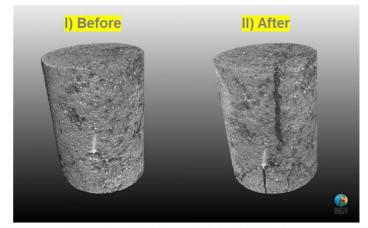




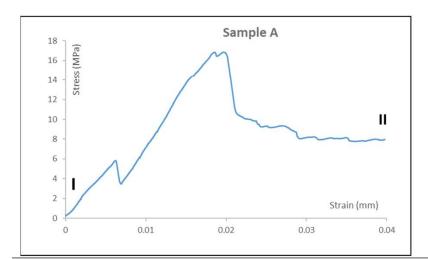


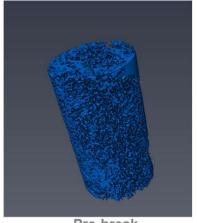
RISULTATI UCS micro-CT - SAMPLE A

MPa)



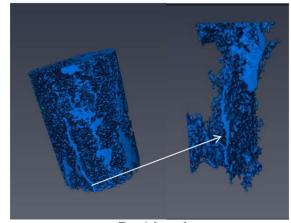
Diameter= 0,076 cm UCS=16.9 MPa



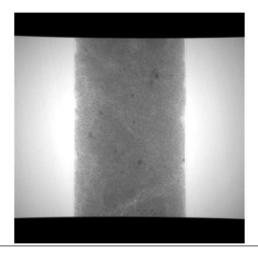


Pre-break Porosity=16,6 %

- Il campione raggiunge la condizione di rottura (UCS=16,9
- Formazione di un reticolo di fratture (piano sub-verticale).
- Differenza nel valore di porosità, prima e dopo la rottura.



Post-break Porosity= 18,7 %













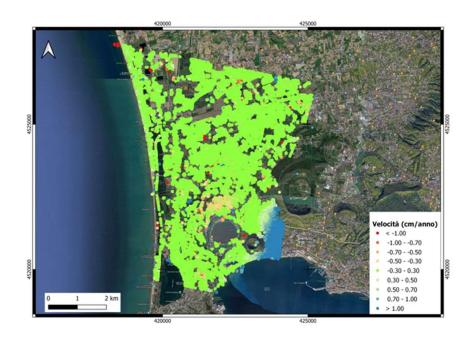








Livelli di approfondimento





Territorio Monitoraggio satellitare

Insediamento
LiDAR e fotogrammetria aerea













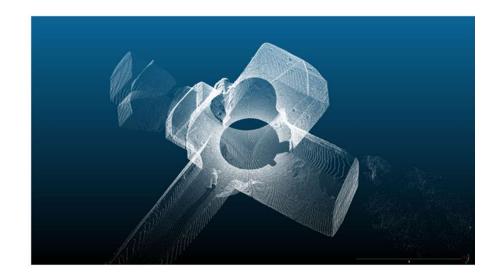






Livelli di approfondimento





Architettonico LiDAR, laser terrestre, fotografia aerea e terrestre Dettaglio architettonico
Laser Terrestre,
fotogrammetria terrestre,
scanner a luce strutturata



















Strumenti e indagini

Monitoraggio satellitare SAR

Monitoraggio strumentale terrestre attraverso sensori

Monitoraggio strumentale attraverso la digitalizzazione tridimensionale a diverse scale

Ispezione visive

Prelievi e indagini su campioni



















Monitoraggio terrestre Attraverso digitalizzazione tridimensionale













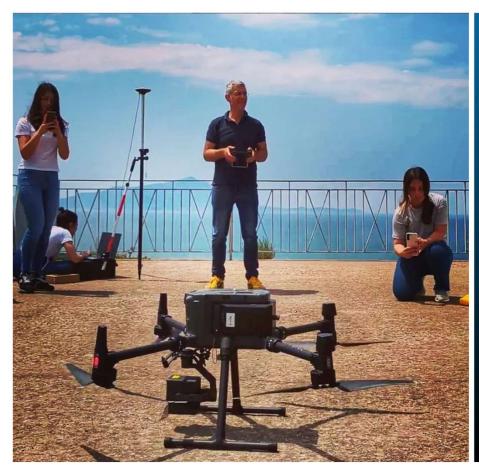


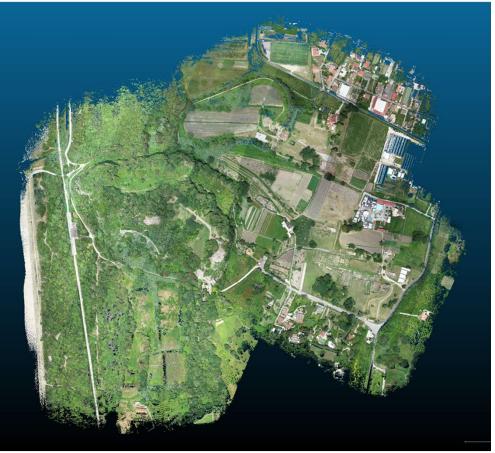






LiDAR e fotogrammetria da aerea con DJI Matrice 300 RTK















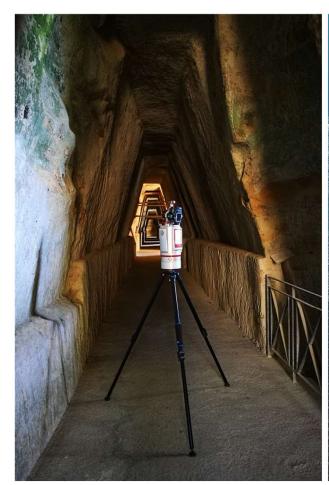


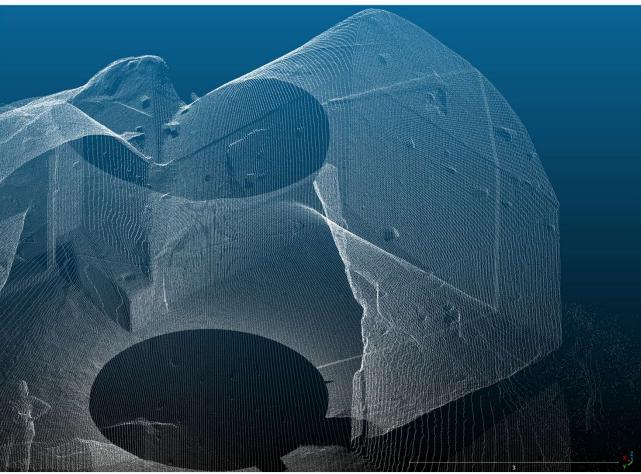






Laser scanner terrestre Riegl VZ400













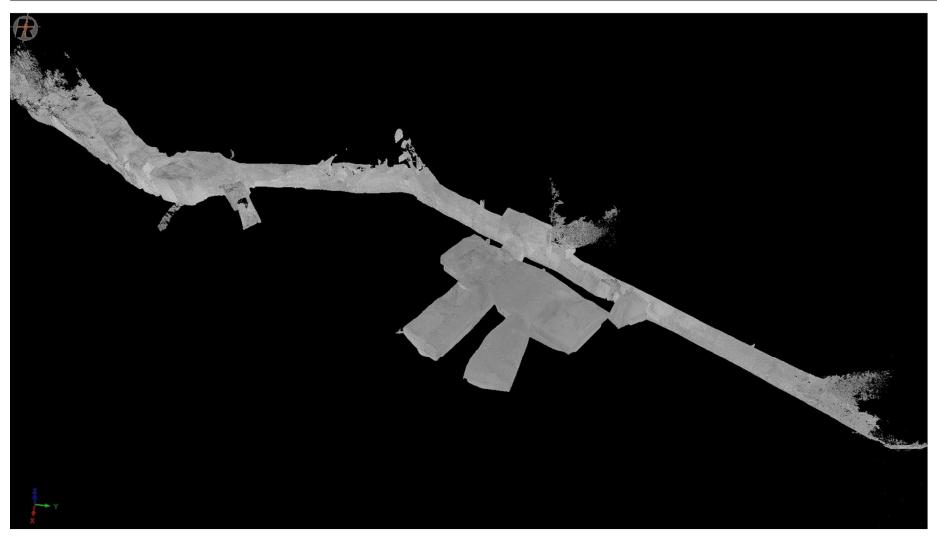
































































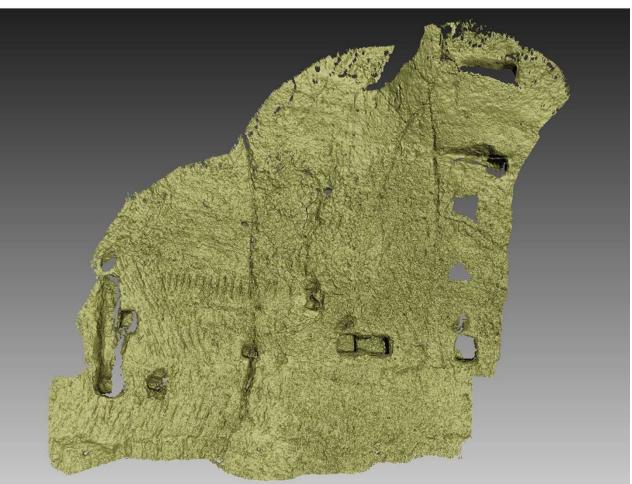






Scanner a luce strutturata Artec Eva















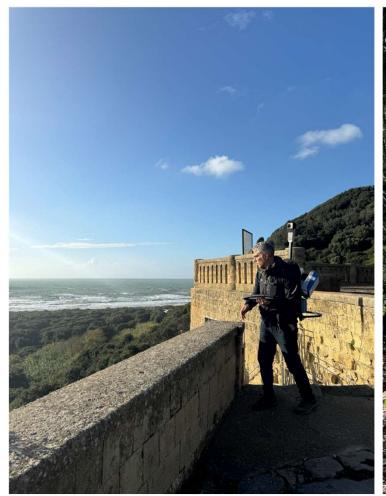








Laser scanner a differenza di fase statico e dinamico ZF 5016



































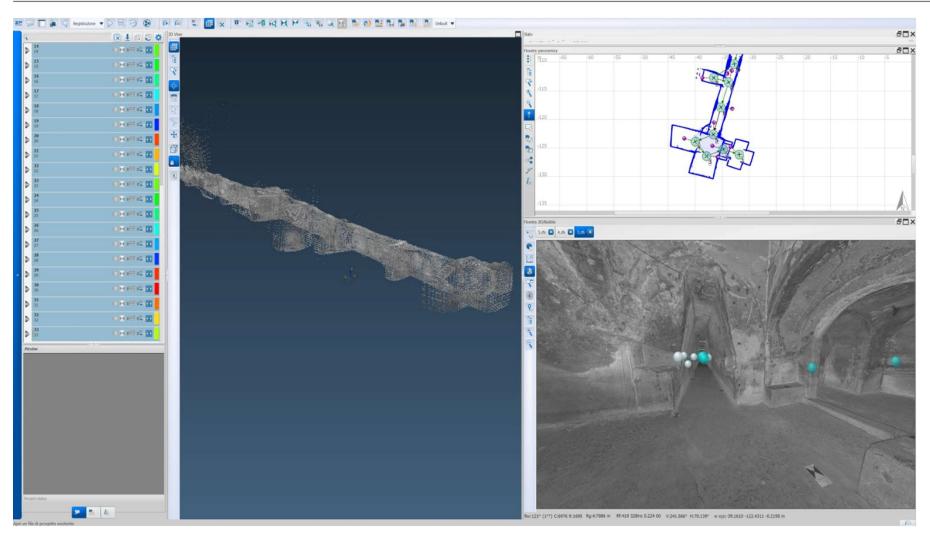






























Fotogrammetria Terrestre mediante videocamera Sony ILCE-7RM5 con ottiche 14mm – 16mm











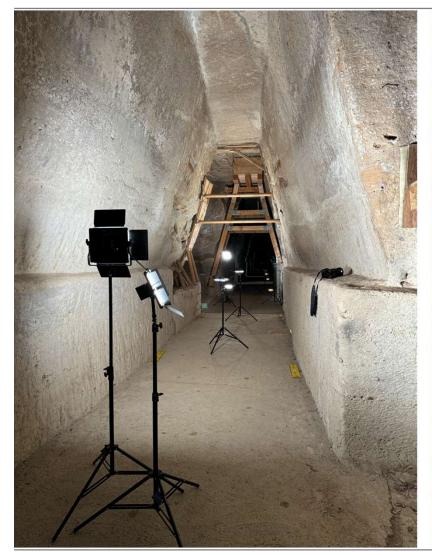


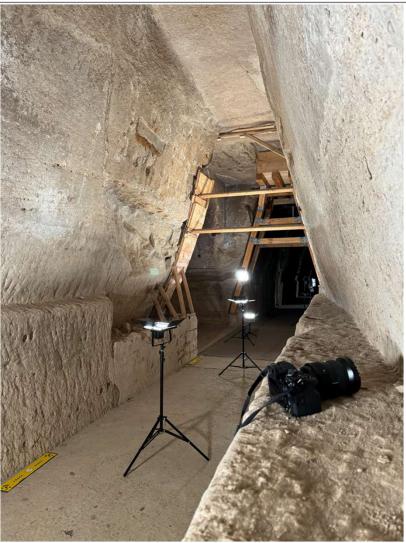






















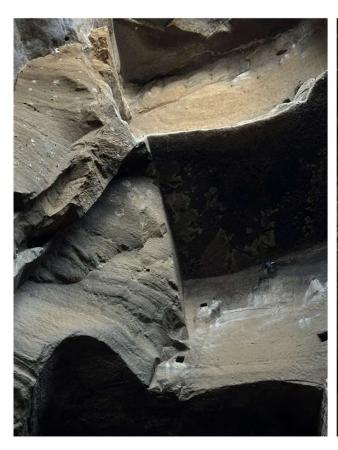








Ispezioni visive e saggi in situ























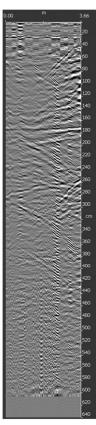


Volta Intradosso antenna 900 MHz



















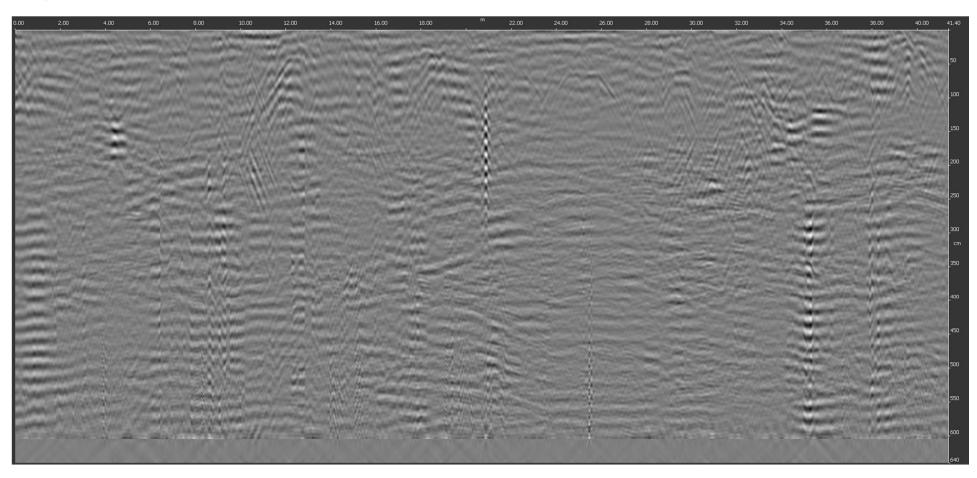








Copertura esterna – dati Chaser antenna 200 MHz











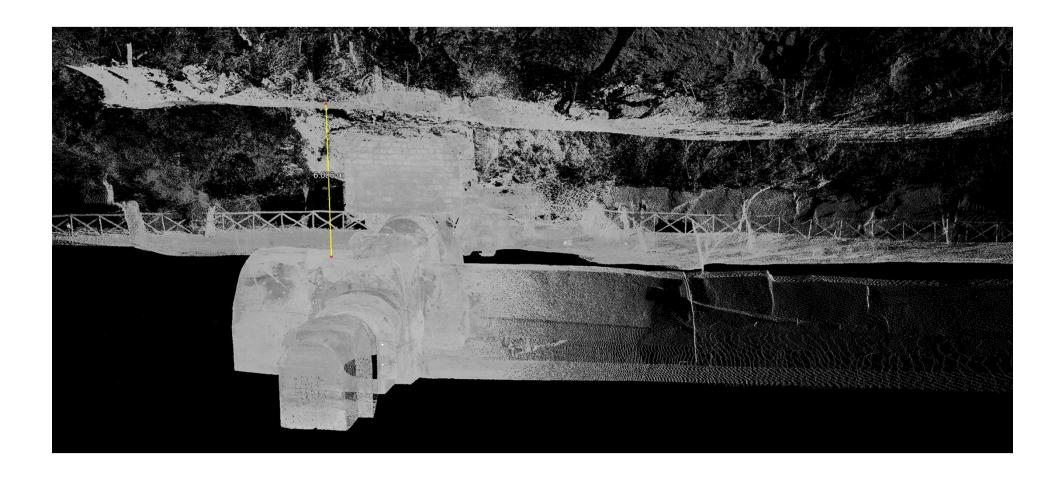




















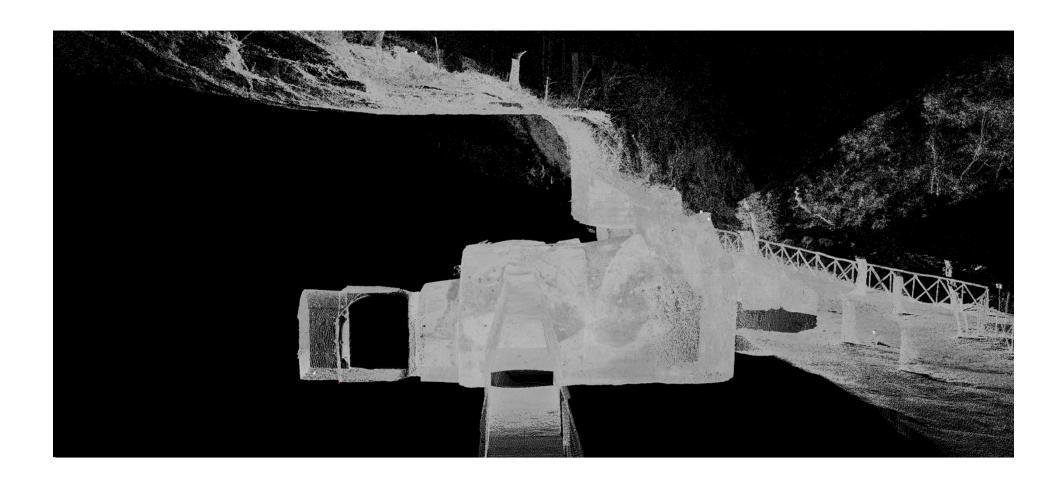




















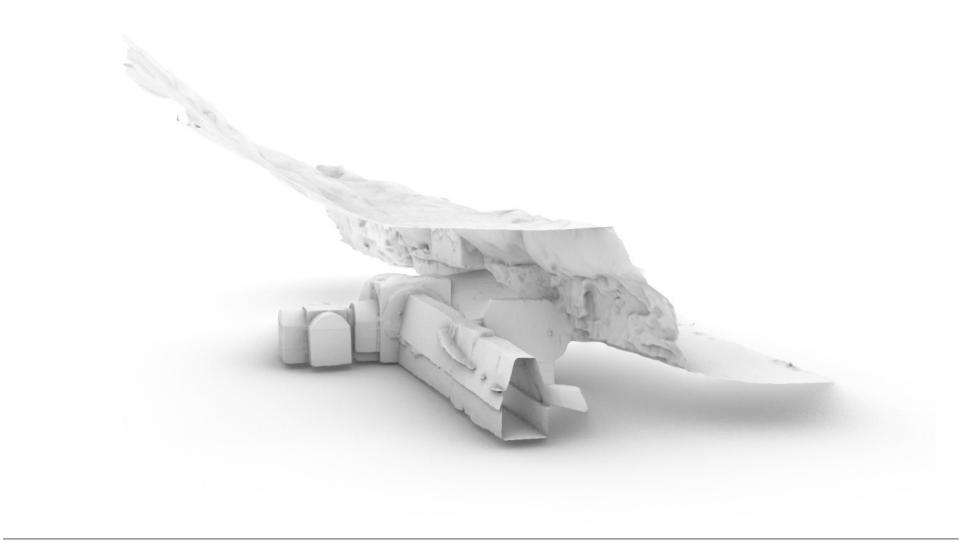






















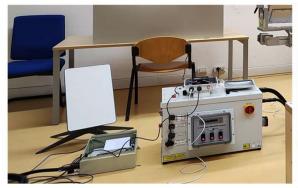




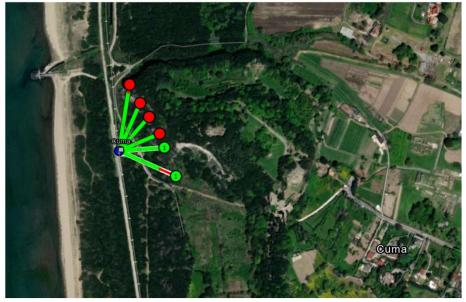




Ground-Based SAR



















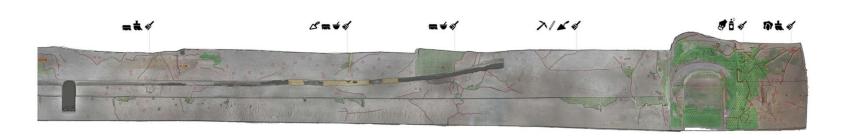


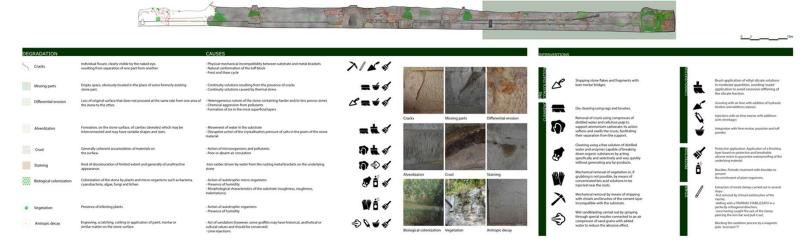




















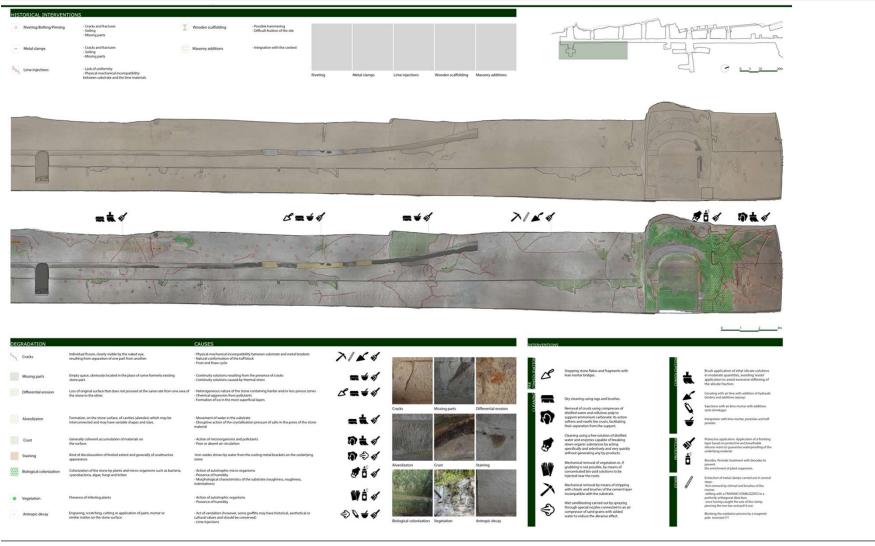
























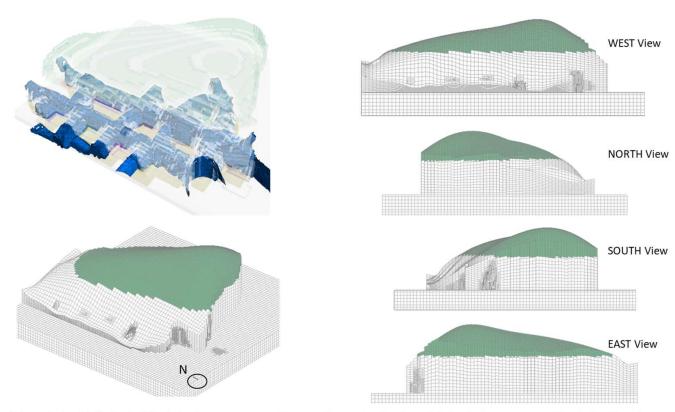






Caso studio per applicazione analoga - Fontanelle Cemetery

Advanced geometric model



de Silva F., Scotto di Santolo A., 2018. Probabilistic Performance-based Approaches to the Static and Seismic Assessment of Rock Cavities. International Journal of Rock Mechanics and Mining Sciences. Dicembre 2018, 112, 354-368. https://doi.org/10.1016/j.ijrmms.2018.10.028









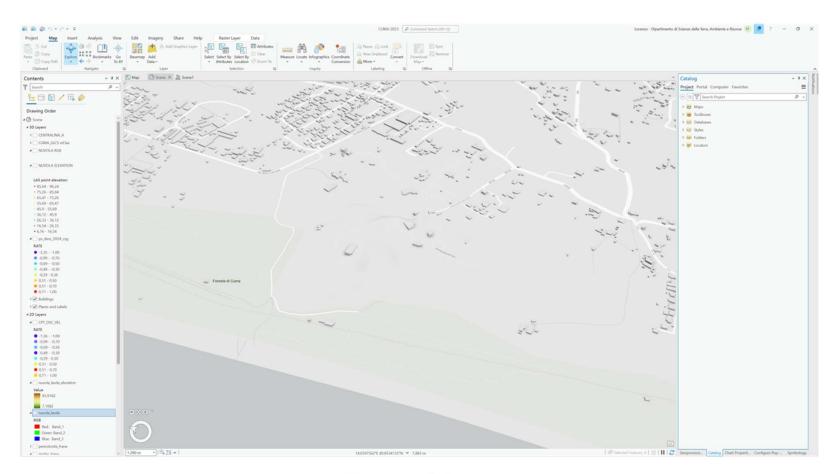












Mappa di base









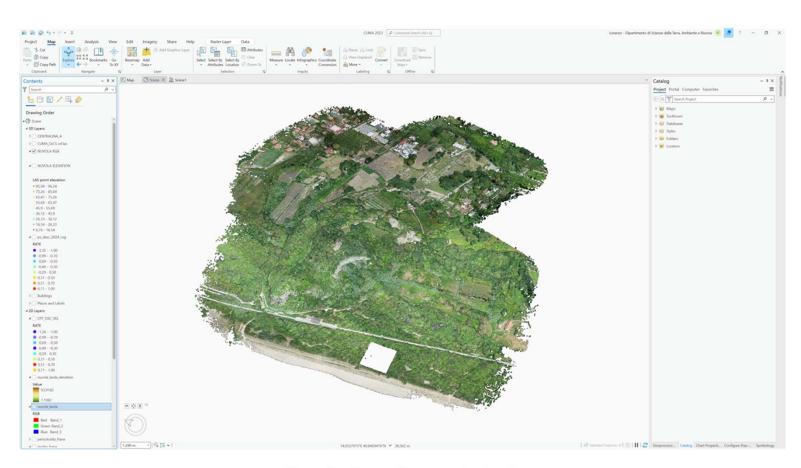












Nuvola di punti con valori rgb









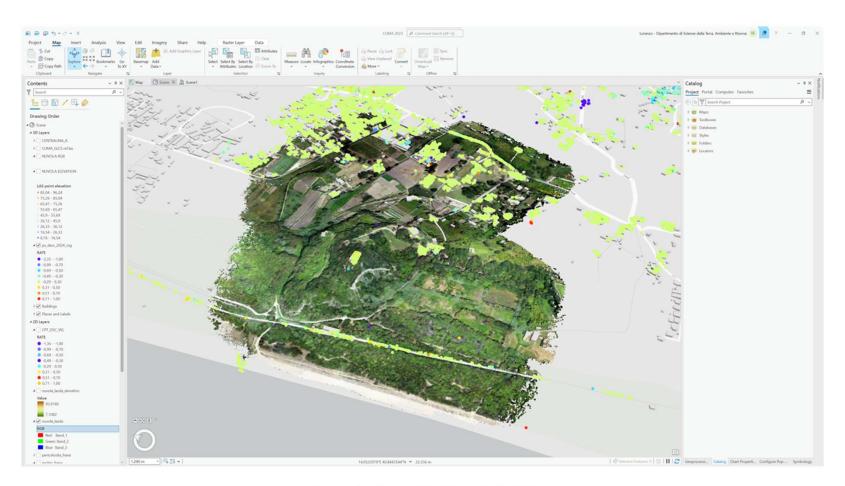












Interpolazione DEM e dati SAR









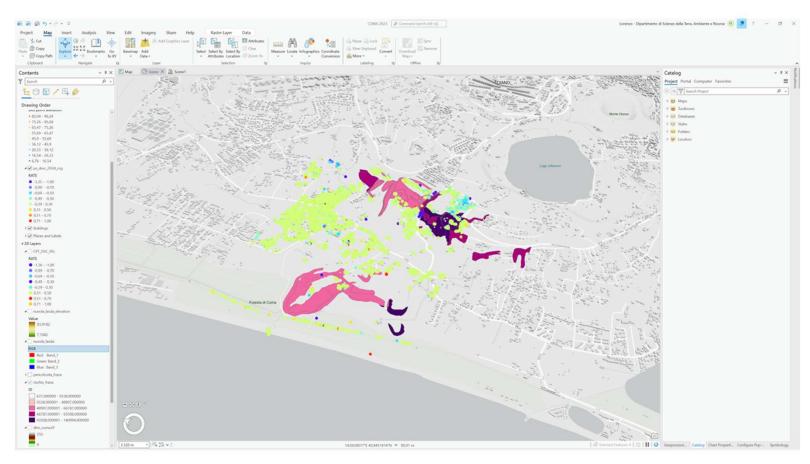












Interpolazione dati SAR e shape file di altra origine (esempio pericolosità frana)











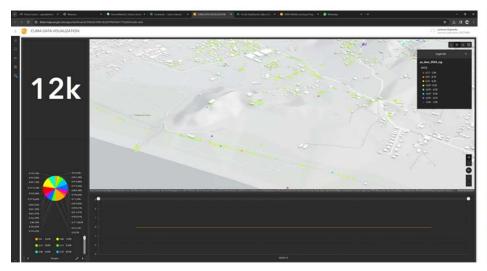


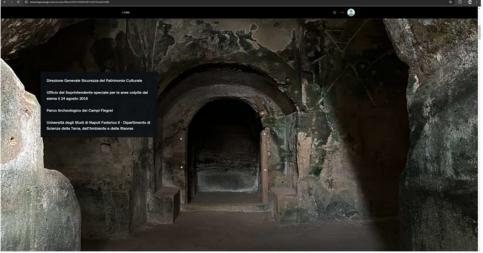






Visualizzione dati Dashboard e Storymap (WIP)





https://storymaps.arcgis.com/stories/84ec43093160409287c9d756edef3d8b

www.proximaterra .it





















Responsabile scientifico
Domenico Calcaterra
Coordinamento scientifico
Leopoldo Repola, Diego Di Martire



Alessandro Flora, Emilio Bilotta, Filomena de Silva



Andrea Prota, Marco di Ludovico, Gian Piero Lignola







