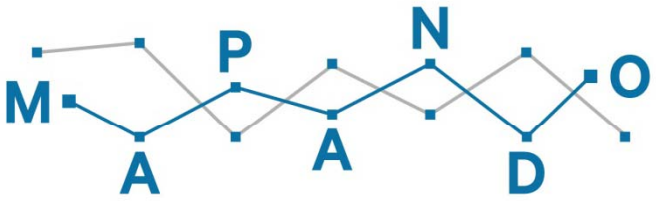


Laser Scanner and tool application for geomechanics on rock slope engineering

MAPANDO® **by Gaspari Alfredo**
www.mapando.it

THE METHOD

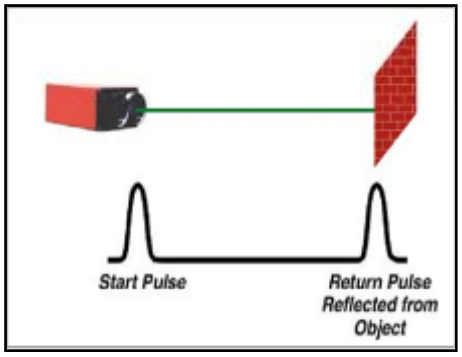
-Laser scanner with high range >1km, drone UAV, total station, GPS

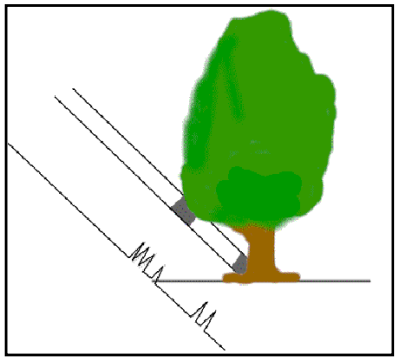
<u>Vertical angles and horrizontal</u>

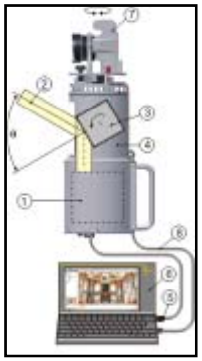
From the angular measurement of a mirror which directs the laser beam

<u>Distance</u>

From the measurement of the laser time to travel distance up to the target and return







TECHNICAL SPECIFICATION OF LASER SCANNER

Model: RIEGL LMS-Z420i

Eye safety class according to EC60825-1:2001: Laser Class 1

Measurement range: for natural targets, r ³ 80% up to 800 m
for natural targets, r ³ 10% up to 250 m

Minimum range: 2 m

Measurement accuracy: typ. ± 10 mm (single shot)
typ. ± 5 mm (averaged) Measurement resolution5 mm

Measurement rateup: to 12000 pts/sec @ low scanning rate (oscillating mirror)
up to 8000 pts/sec @ high scanning rate (rotating mirror)

Laser wavelengthnear infraredBeam divergence: 0.25 mrad

<u>Scanner Performance</u>:

Vertical (line) scan: Scanning range 0° to 80°Scanning mechanism rotating / oscillating

Minimum angle stepwidth 0.01°

Horizontal (frame) scan:Scanning range 0° to 360°Scanning mechanism rotating

Minimum angle stepwidth 0.01°

Max resolutions: 20400 punti/m2 @ 100 m

Main dimensions: 463 x 210 mm (Length x Diameter)Weightapprox. 14,5

SERVICES

DATA PROCESSING SERVICES AND SUPPORT OF THE ANALYSIS OF ROCKY SLOPES

- Cloud points, Georeferencing, DTM, DSM

- Planimetric view, sections, elevations

- Identification of discontinuity systems

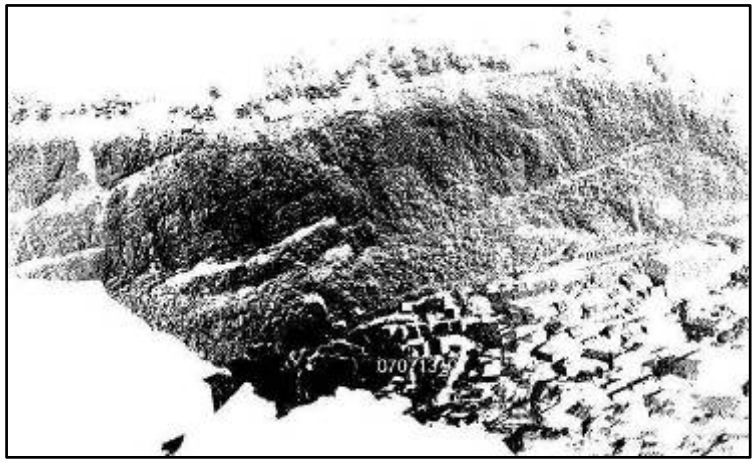
- Mapping of unstable conditions (Markland test)

- Calculation of potentially unstable volumes on slope

DATA ACQUISITION ON SITE

Surveying area

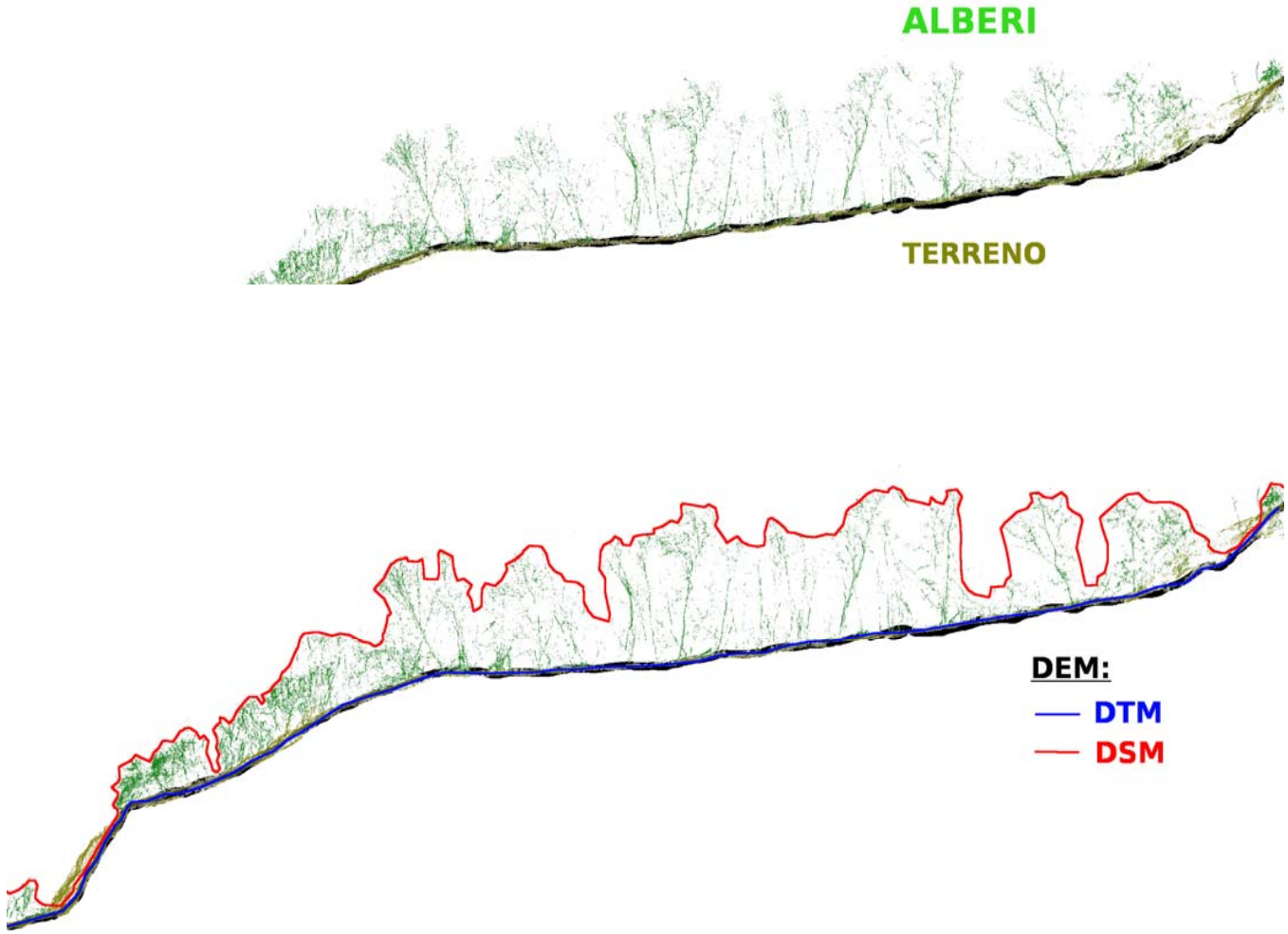
Laser-scanner working



Cloud of point

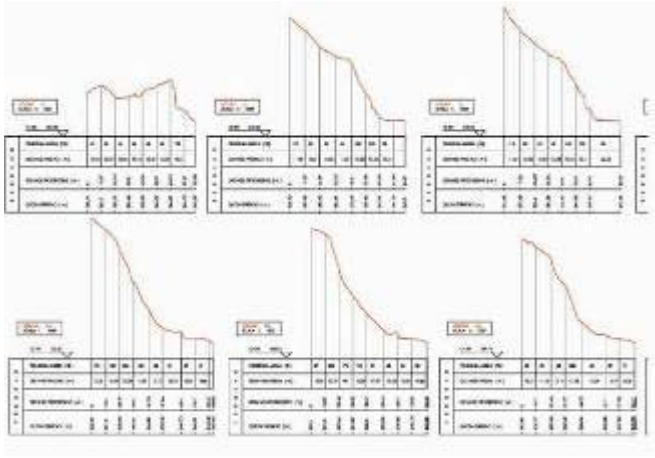
DATA ELABORATION:

Cloud points, Georeferencing, DTM, DSM

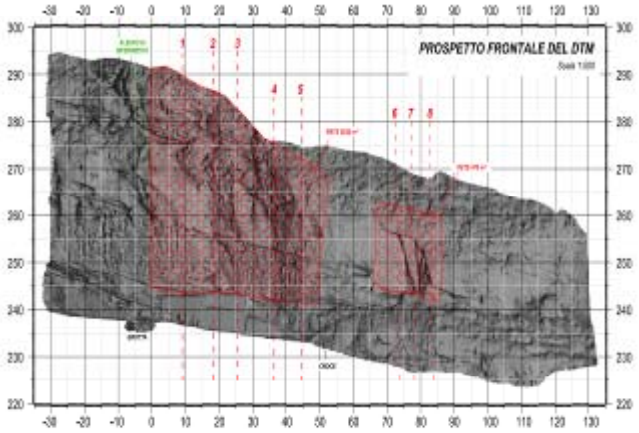


ELABORATION DATA: Planimetric view, sections, elevations

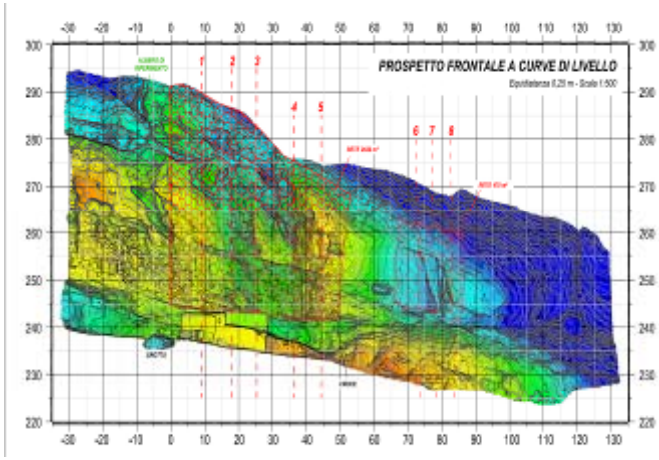
PLANIMETRIC VIEW OF ROCKFALL SLOPE



SECTION OF SLOPE

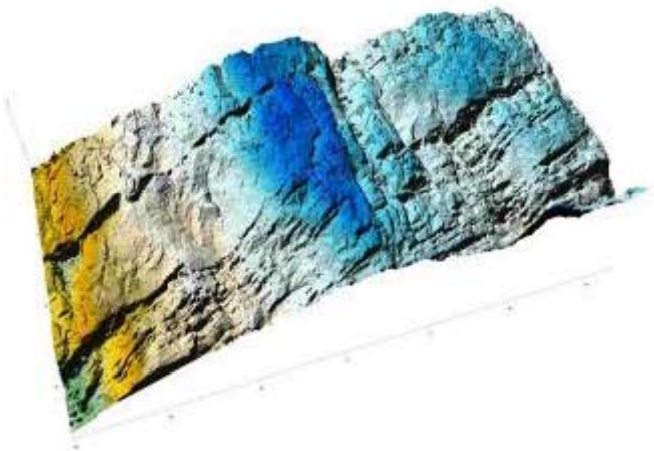


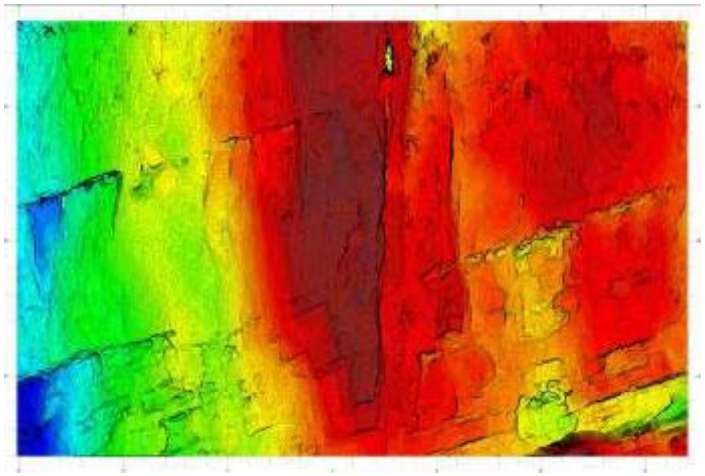
FRONTAL VIEW OF SLOPES (SHADY MODEL)



FRONTAL VIEW WITH LEVAL CURVES AND COLOURS GRADIENTS FROM A REFRENCES PLANE

DATA ELABORATION: Ortophoto and solid model





DATA ELABORATION: Identification of discontinuity systems

1. **Data collection >> position (x, y, z) + slope + immersion**

2. **Aggregation of data collected in areas with homogeneous geological features**

3. **Identification of the main families of discontinuities >> Polar diagram**

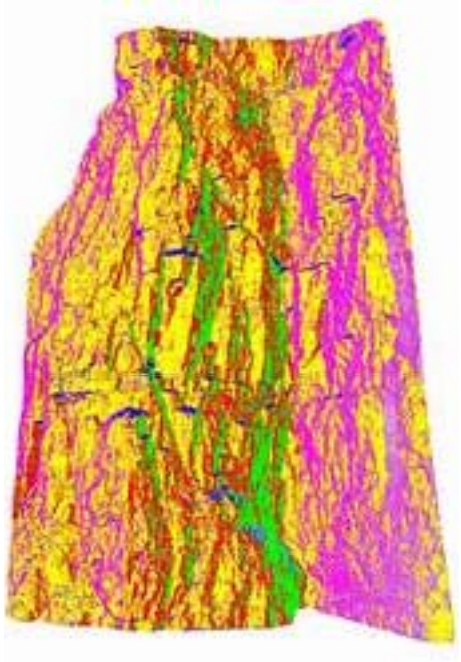
4. **Statistical calculation of the spacing of the main families >> VRU**

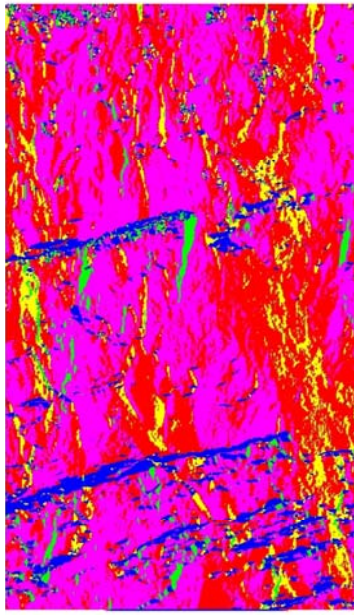
DATA ELABORATION: Identification of discontinuity systems

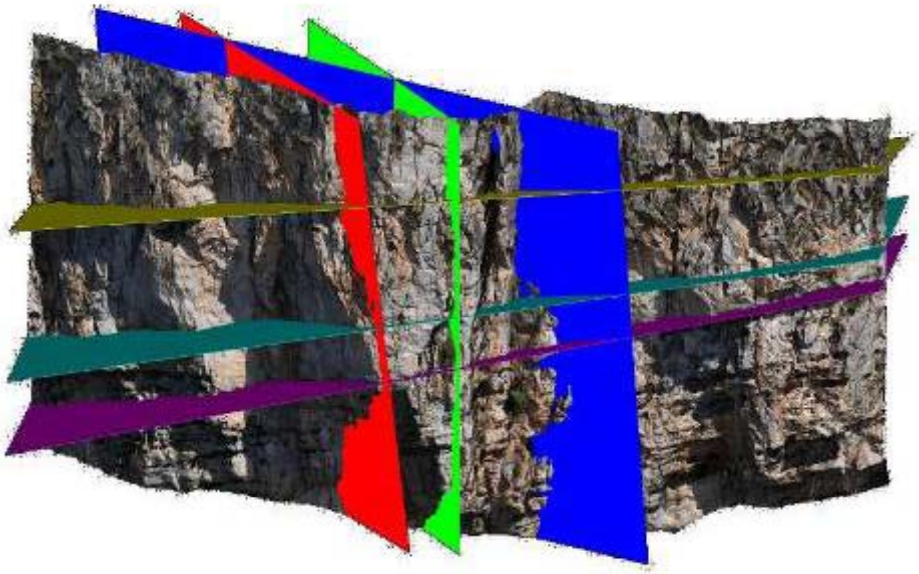
Data collection >> position (x, y, z) + slope + immersion

Automatic analysis of the entire population of plane

Triangulated model of noiseless detail (vegetation and steel mesh)

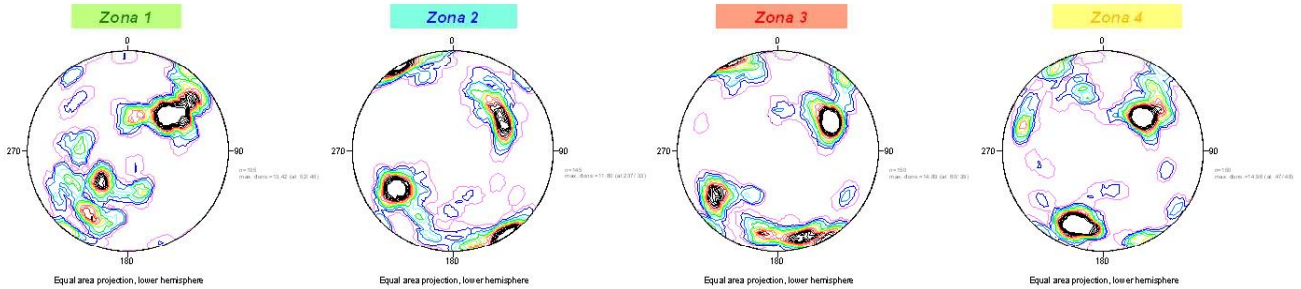






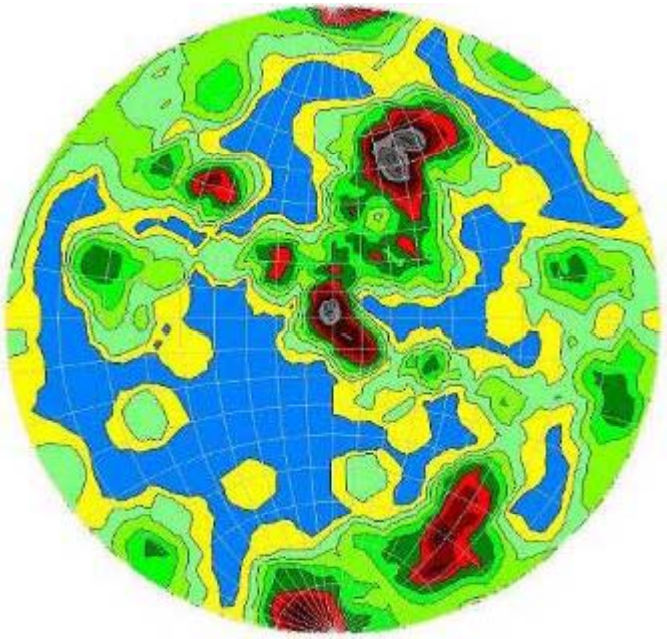
DATA ELABORATION: Identification of discontinuity systems

Aggregation of data collected in areas with homogeneous geological features



DATA ELABORATION: Identification of discontinuity systems

Polar Diagram



Statistical calculation of the spacing of the main families >> VRU

SPAZIATURA FAMIGLIA 56 / 63 - SOGLIA PARALLELISMO 90 %

PIANO	EST	NORD	QUOTA	IMMERSIONE	INCLINAZIONE	Plane014	Plane015	Plane025	Plane035	Plane052	Plane057	Plane079	Plane082	Pla
Plane014	57355.51	-17172.48	1289.14	59.7	51.7	0	1.22	1.89	28.41	15.63	26.43	19.15	35.86	57.
Plane015	57347.82	-17166.83	1291.94	56.8	55.9	1.22	0	1.18	26.97	15.91	25.32	18.71	34.31	53.
Plane025	57326.61	-17144.99	1300.14	55.1	45.8	1.89	1.18	0	29.42	23.35	29.17	24.14	37.41	50.
Plane035	57290.16	-17132.7	1276.56	43.6	59.4	28.41	26.97	29.42	0	5.72	2.02	1.11	6.9	14.
Plane052	57337.91	-17167.69	1275.23	30.2	49.6	15.63	15.91	23.35	5.72	0	2.62	8.29	2.93	25.
Plane057	57279.77	-17126.11	1275.01	35.1	65.2	26.43	25.32	29.17	2.02	2.62	0	2.08	1.66	8.6
Plane079	57285.04	-17128.64	1278.37	28.8	61.7	19.15	18.71	24.14	1.11	8.29	2.08	0	2.07	11.
Plane082	57238.96	-17097.96	1271.03	33.7	61.7	35.86	34.31	37.41	6.9	2.93	1.66	2.07	0	3.7
Plane083	57242.48	-17098.07	1274.82	58.3	70	57.32	53.81	50.37	14.64	25.49	8.64	11.99	3.75	0
Plane084	57245.41	-17101.25	1276.11	66.5	71.4	63.8	59.76	54.21	17.22	31.93	10.55	14.04	4.57	1.4
Plane085	57243.9	-17103.44	1271.57	51	76.5	52.74	49.63	47.68	15.02	18.2	8.71	9.25	0.92	2.7
Plane087	57245.2	-17107.22	1267.44	71.7	56.8	72.47	68.63	64	24.78	31.51	16.95	18.81	3	4.5
Plane090	57245.66	-17107.94	1269.04	70.8	58.7	71.25	67.44	62.66	23.89	30.57	16.21	18.02	3.28	3.7
Plane091	57244.26	-17106.31	1269.36	29.4	60.3	34.39	33.32	37.62	8.85	2.05	4.61	4.67	4.59	6.3
Plane092	57244	-17106.09	1270.37	36.1	59.9	40.47	38.96	41.69	11.05	4.33	6.2	6.52	3.62	5.6
Plane108	57337.1	-17042.64	1424.14	67.4	60.6	108.64	110.3	118.94	149.6	146.27	150.74	149.78	166.78	16
Plane116	57355.18	-17050.41	1425.67	54.8	48.4	137.78	138.05	142.23	169.91	171.04	168.69	167.1	179.56	17
Plane121	57330.13	-17045.1												
Plane134	57368.13	-17061.4												
Plane135	57374.03	-17059.97												
Plane137	57374.87	-17061.6												
Plane149	57364.78	-17050.2												
Plane152	57346.98	-17051.3												
Plane153	57429.72	-17018.1												
Plane154	57430.86	-17020.0												
Plane155	57433.6	-17021.1												
Plane156	57424.82	-17020.4												
Plane157	57426.14	-17021.17												

DISTANZA MINIMA : 0.08 DISTANZA MASSIMA : 1.22 MEDIA : 0.78

Plane380	Plane382	Plane392	Plane397	Plane398	Plane401	Plane452	Plane485	Plane497	Plane514	Plane518	Plane528	Plane549
73.61	78.75	167.39	125.28	150.68	60.24	67.24	22.28	48.86	39.52	46.22	64.72	15.93
72.41	78.08	166.97	123.45	149.78	56.73	65.77	20.76	47.53	38.47	45.27	64.96	13.38
66.59	73.84	162.76	117.34	147.16	51.48	59.09	12.82	40.89	35.82	43.85	63.31	8.92
78.24	87.39	179.17	132.53	163.21	45.59	51.3	25.52	60.4	26.54	33.11	81.47	16.46
53.87	60.86	144.76	114.48	138.21	21.39	83.85	44.29	76.42	30.57	41.45	83	44.02
63.43	73.54	163.3	118.69	149.32	23.64	75.51	47.68	85.14	27.31	40.11	100.02	40.46
49.25	59.4	146.46	106.16	135.97	5.75	97.57	62.39	100.12	42.83	55.86	112.18	58.33

DATA ELABORATION: Mapping of unstable conditions (Markland test)

- **Input data:**
  - Friction angle
  - Dip direction and Dip of slope
  - Dip direction and Dip of discontinuity plane
  - Dip direction and Dip of intersection of discontinuity

Condition of instabilities

$\beta > \lambda > \Phi$

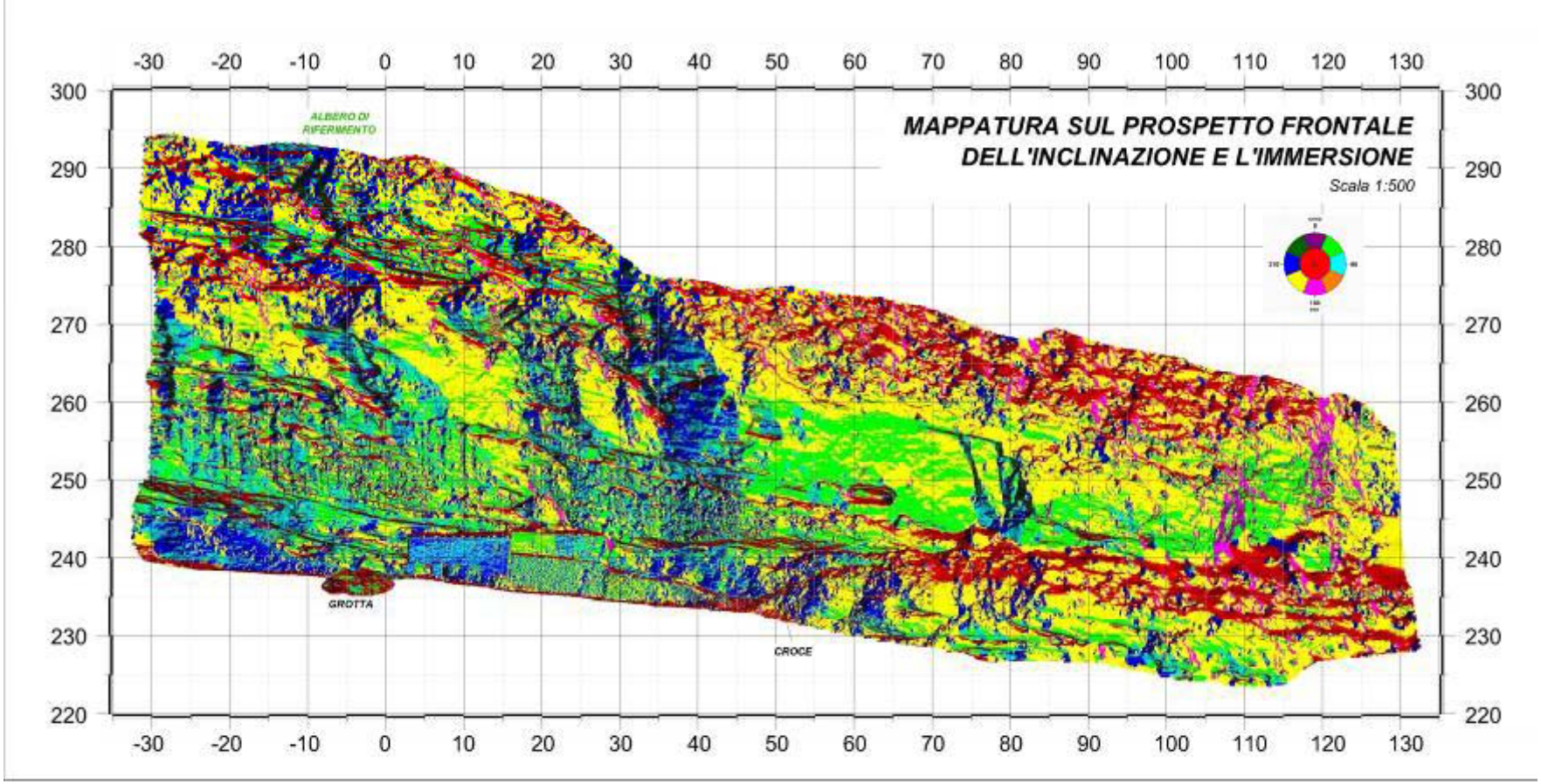
$\varepsilon = \pm 20° \alpha$

A+B+C

- **OUTPUT:**
  - -Mapping of plane and intersection that that meet the conditions of instability

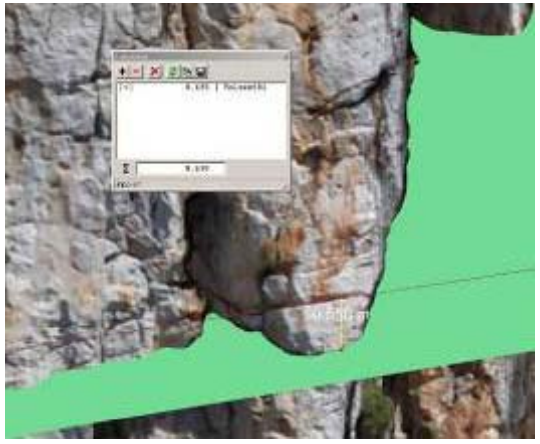
DATA ELABORATION: Mapping of unstable conditions (Markland test)

(frontal view of unstable condition)

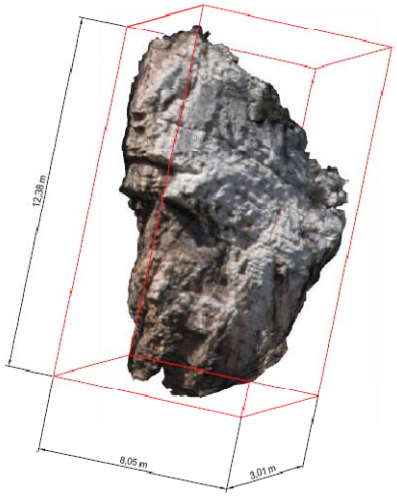


DATA ELABORATION: Calculation of potentially unstable volumes on slope

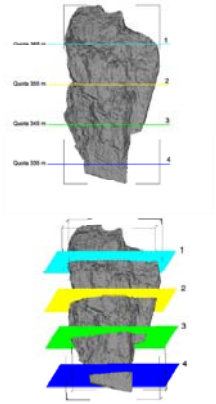
AREA TO BE STUDIED



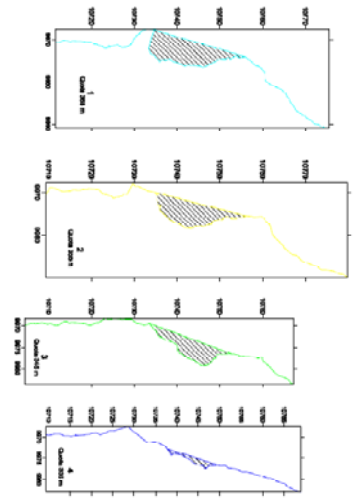
AUTOMATIC CALCULATION OF VOLUME



GEOMETRY OF BLOCK

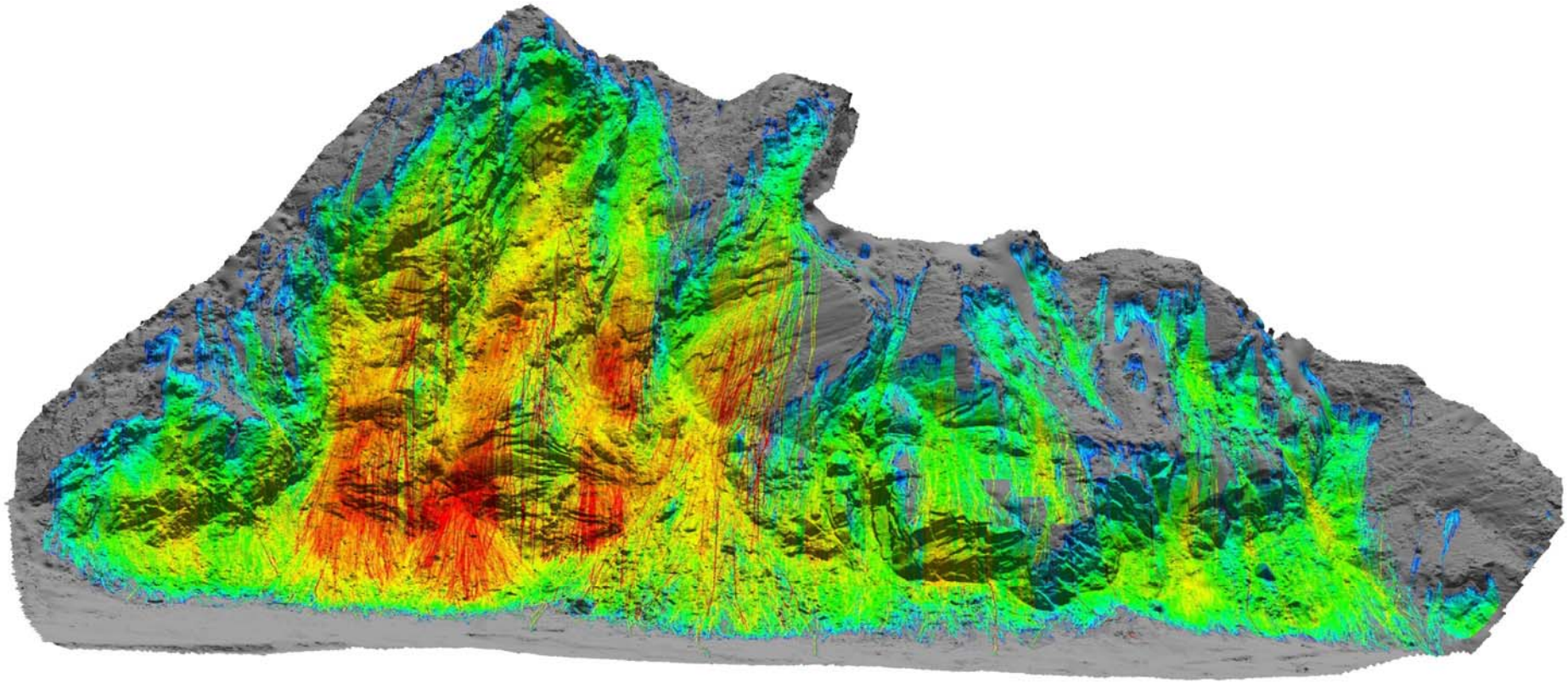


SECTION PLAN OF BLOCK



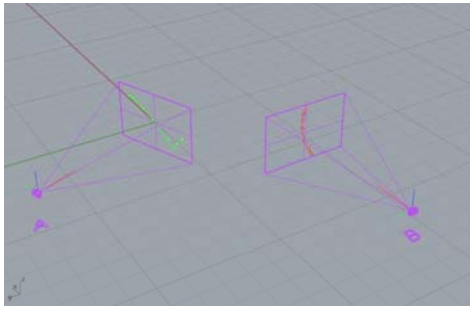
SECTION PLAN

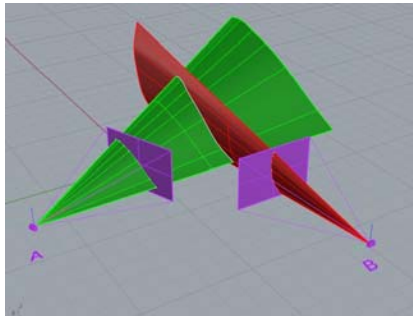
OTHER SERVICES: Rockfall trajectories analysis



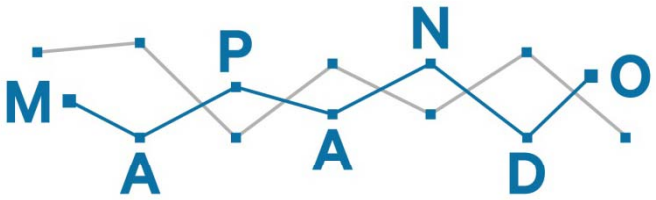
OTHER SERVICES: Reconstruction of real 3D trajectories on slopes during scaling phase

- **Instruments used on site:** Laser Scanner and minimum n°2 metric photocamera
- **Input data:** Survey of scene with laser scanner





- **OUTPUT:**
  - -3d point trajectories of objects (blocks and visible fragment)
  - - velocity vectors of centre of gravity of blocks
  - - acceleration of blocks



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