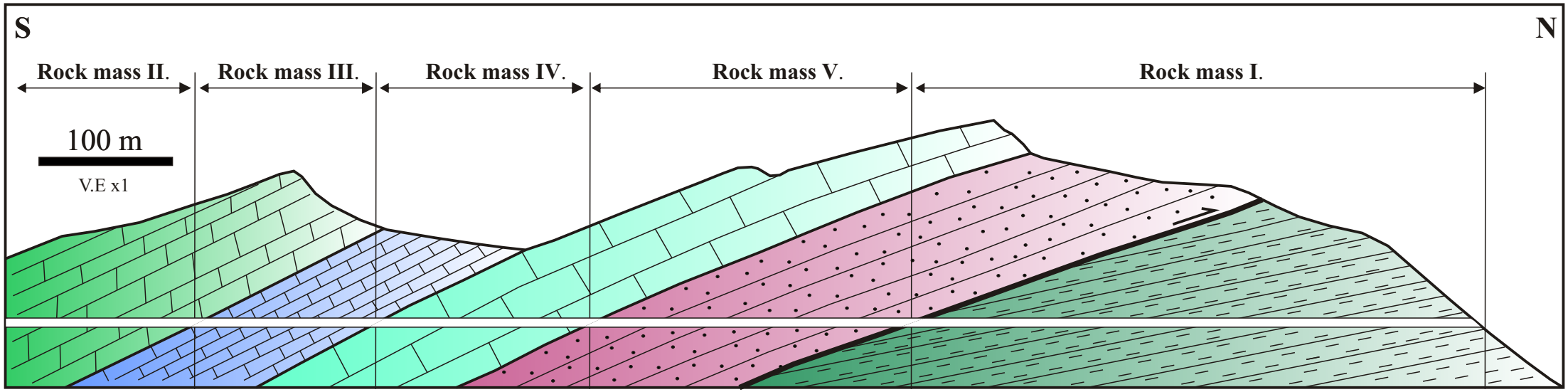


Legend

Rock mass I. Upper Cretaceous shales

Rock mass II. Lower Cretaceous limestones

Rock mass III. Upper Jurassic layered limestones

Rock mass IV. Lower Jurassic massive limestones

Rock mass V. Upper Triassic sandstones

Fault

Tunnel trace

GEO100 GEOTECHNICAL ENGINEERING LAB - SPRING 2019

Student No: Student Name:

Hand-in deadline: **24th April 2019** **GRADE:**

EXERCISE

In order to reduce the environmental impact of a region close to a national park located in the south of Italy, the construction of a 1100 m-long tunnel has been proposed. Based on a geological cross-section provided by the geologists (Figure above), the tunnel trace intersects five different rock masses, which dip towards the south. Your job as a geotechnical engineer is to provide the following information:

1) Provide a Geomechanic Rock Mass Classification for each rock mass using the SRC classification (Table 1). Some of the geomechanical properties of the rock mass (e.g. intact rock strength and state of stresses) have been provided to you based on field and lab tests. The rest of the properties such as spacing of discontinuities, roughness, aperture etc... can be estimated based on the outcrop photos of each rock mass (Pages 3, 4 and 5).

2) Based on rock mass classes previously defined and using **Table 2**, **give recommendations about the excavation procedures and type of support for each rock mass.**

3) Is there any special area along the tunnel trace that deserves special attention? What kind of tunnel support will you recommend during its excavation?

Table 1

Table 10.4 GEOMECHANIC ROCK MASS CLASSIFICATION SRC

Rock quality indices	Range of values				
1. INTACT ROCK STRENGTH					
Point-load test (MPa)	>8	8–4	4–2	2–1	Not applicable
Uniaxial compressive strength (MPa)	>250	250–100	100–50	50–25	25–5 5–1 <1
Rating	20	15	7	4	2 1 0
2. SPACING OR RQD					
Spacing (m)	>2	2–0.6	0.6–0–2	0.2–0.06	<0.06
RQD (%)	100–90	90–75	75–50	50–25	<25
Rating	25	20	15	8	5
3. CONDITIONS OF DISCONTINUITIES	Very rough surfaces. Not continuous joints. No separation. Hard joint wall	Slightly rough surfaces. Not continuous joints. Separation >1 mm. Hard joint wall	Slightly rough surfaces. Not continuous joints. Separation 1 mm. Soft or weathered joint walls	Slicken-sided surfaces. Continuous joints. Joints open 1–5 mm. Gouge materials	Slicken-sided surfaces. Continuous joints. Joints open <5 mm. Gouge materials
Rating	30	25	20	10	0
4. GROUNDWATER					
Inflow per 10 m tunnel length (l/min)	None	<10	10–25	25–125	>125
General conditions	Dry	Slightly moist	Occasional seepage	Frequent seepage	Abundant seepage
Rating	15	10	7	4	0
5. STATE OF STRESSES					
Competence factor[1]	>10	10–5	5–3	<3	–
Rating	10	5	–5	–10	
Tectonic structures	Zones near thrusts/faults of regional importance		Compression	Tension	
Rating	–5		–2	0	
Stress relief factor[2]	>200	200–80	80–10	<10	Slopes
Rating	0	–5	–8	–10	200–80 <10 / 79–10 –13 / <10 – 15
Neotectonic activity	None or unknown		Low	High	
Rating	0		–5	–10	
6. ROCK MASS CLASSES					
Class number	I	II	III	IV	V
Rock quality	Very good	Good	Fair	Poor	Very poor
Rating	100–81	80–61	60–41	40–21	≤20

[1] Uniaxial intact rock strength/vertical stress.
[2] Ratio between the age of the main orogenic deformation affecting the rock mass (in years × 10^{-3}) and maximum overburden thickness (in metres).

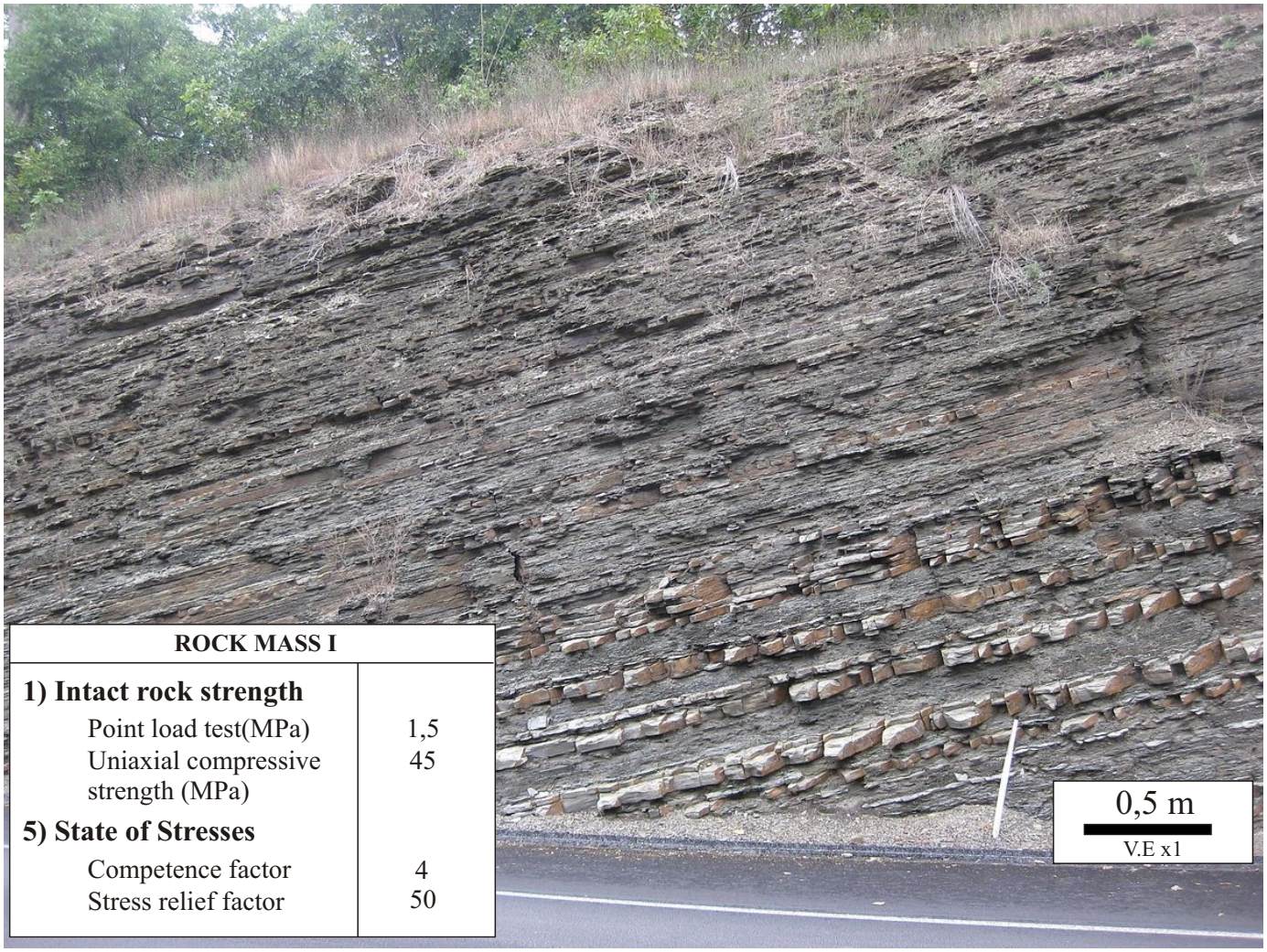
(Gonzalez de Vallejo and Ferrer, 2011)

Table 2

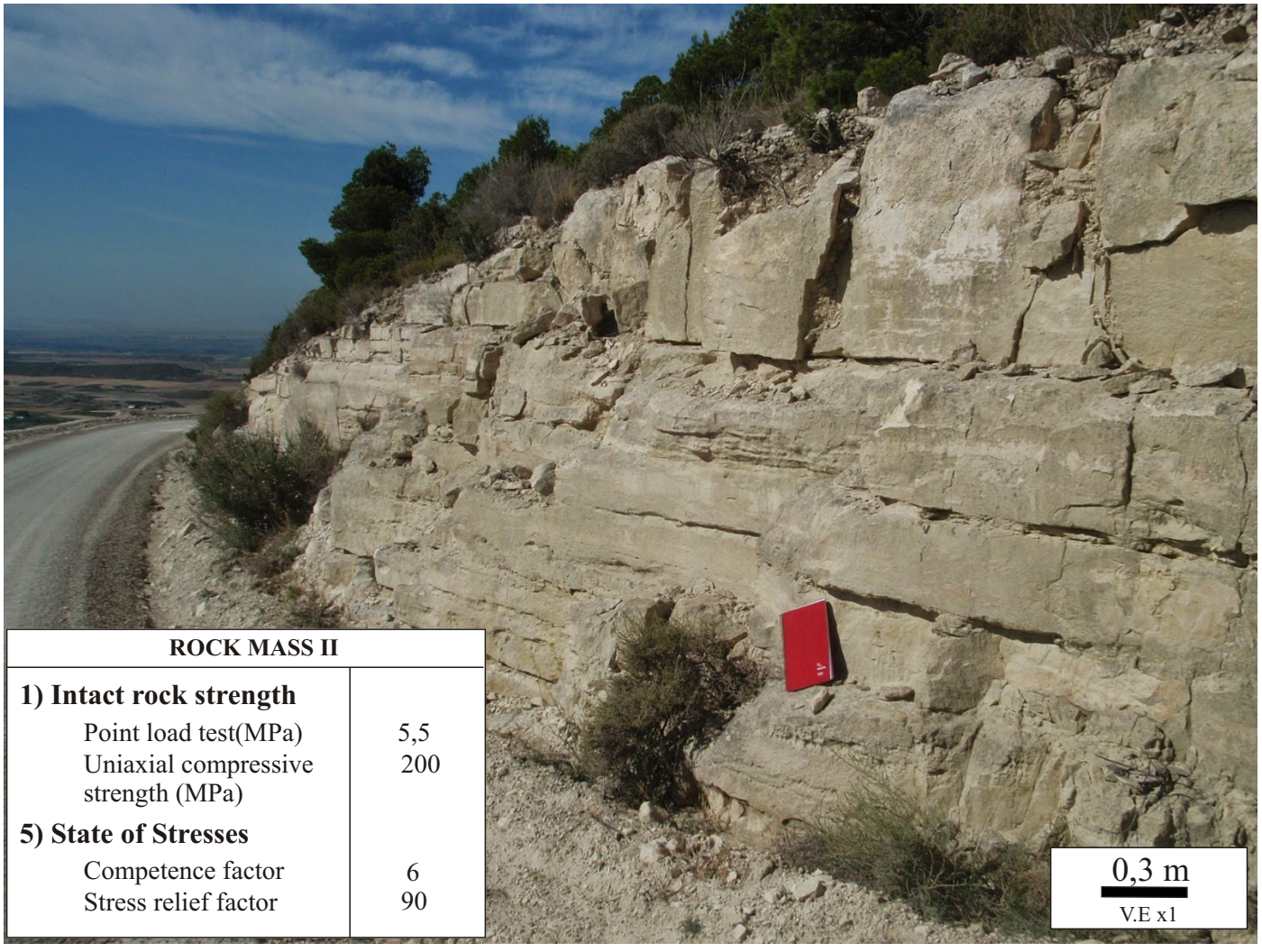
Table 10.7 GUIDELINES FOR EXCAVATION AND SUPPORT OF 10 M SPAN ROCK TUNNELS IN ACCORDANCE WITH THE RMR SYSTEM

Rock mass class	Excavation	Rock bolts (20 mm diameter, fully grouted)	Shotcrete	Steel sets
I Very good rock RMR: 81–100	Full face, 3 m advance.	Generally, no support required except spot bolting.	–	–
II Good rock RMR: 61–80	Full face, 1–1.5 m advance. Complete support 20 m from face.	Locally, bolts in crown 3 m long, spaced 2.5 m with occasional wire mesh.	50 mm in crown where required.	None.
III Fair rock RMR: 41–60	Top heading and bench, 1.5–3 m advance in top heading. Commence support after each blast. Complete support 10 m from face.	Systematic bolts 4 m long, spaced 1.5–2 m in crown and walls with wire mesh in crown.	50–100 mm in crown and 30 mm in sides.	None.
IV Poor rock RMR: 21–40	Top heading and bench, 1.0–1.5 m advance in top heading. Install support concurrently with excavation, 10 m from face.	Systematic bolts 4–5 m long, spaced 1–1.5 m in crown and walls with wire mesh.	100–150 mm in crown and 100 mm in sides.	Light to medium ribs spaced 1.5 m where required.
V Very poor rock RMR: ≤20	Multiple drifts 0.5–1.5 m advance in top heading. Install support concurrently with excavation. Shotcrete as soon as possible after blasting.	Systematic bolts 5–6 m long, spaced 1–1.5 m in crown and walls with wire mesh. Bolt invert.	150–200 mm in crown, 150 mm in sides, and 50 mm on face.	Medium to heavy ribs spaced 0.75 m with steel lagging and forepoling if required. Close invert.
Horseshoe-shaped tunnels, maximum width 10 m, maximum vertical stress 250 kp/cm^2.				

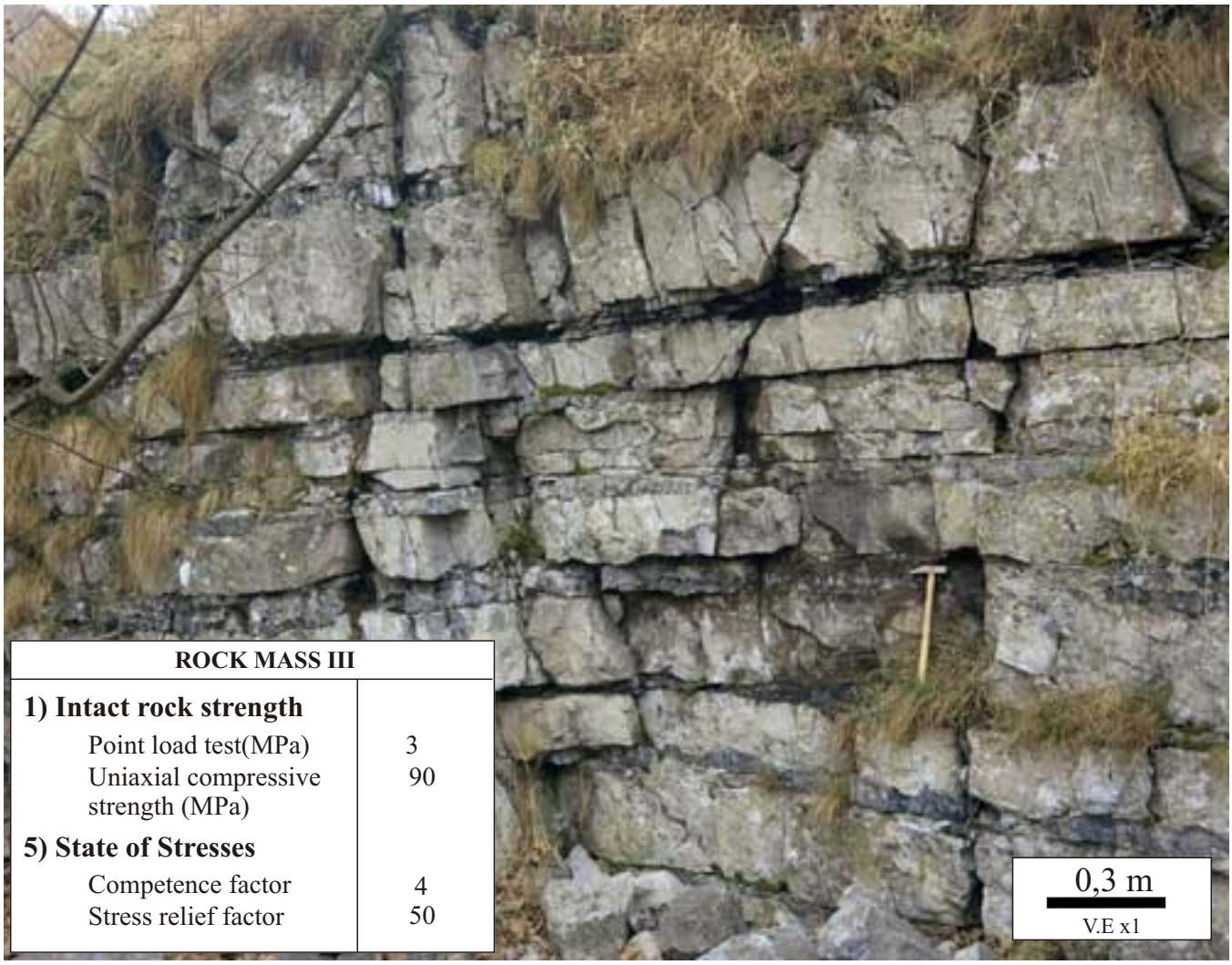
(Bienawski, 1989).



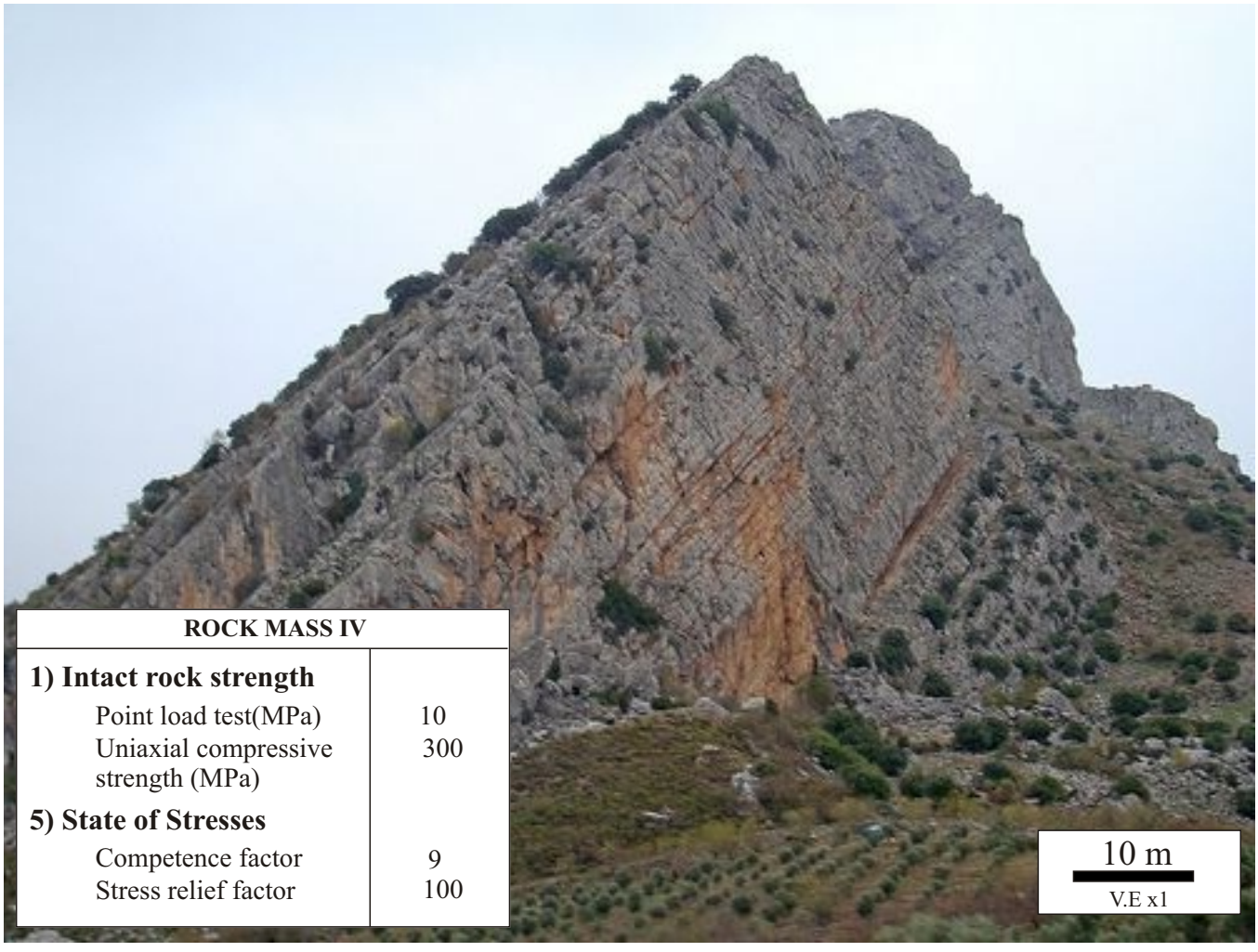
ROCK MASS I	
1) Intact rock strength	
Point load test(MPa)	1,5
Uniaxial compressive strength (MPa)	45
5) State of Stresses	
Competence factor	4
Stress relief factor	50



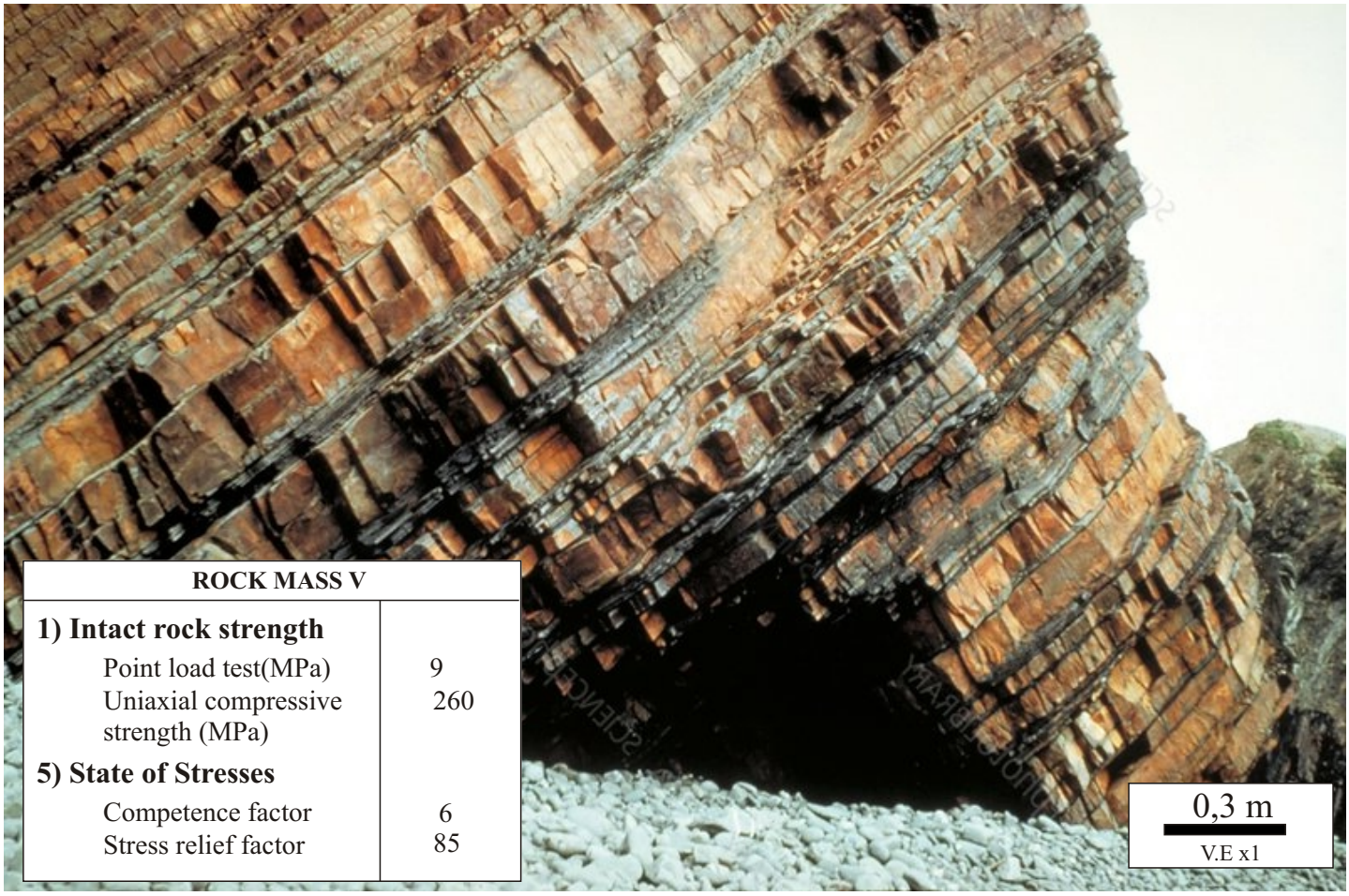
ROCK MASS II	
1) Intact rock strength	
Point load test(MPa)	5,5
Uniaxial compressive strength (MPa)	200
5) State of Stresses	
Competence factor	6
Stress relief factor	90



ROCK MASS III	
1) Intact rock strength	
Point load test(MPa)	3
Uniaxial compressive strength (MPa)	90
5) State of Stresses	
Competence factor	4
Stress relief factor	50



ROCK MASS IV	
1) Intact rock strength	
Point load test(MPa)	10
Uniaxial compressive strength (MPa)	300
5) State of Stresses	
Competence factor	9
Stress relief factor	100



ROCK MASS V	
1) Intact rock strength	
Point load test(MPa)	9
Uniaxial compressive strength (MPa)	260
5) State of Stresses	
Competence factor	6
Stress relief factor	85