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EMPIRICAL ESTIMATION OF THE UNIAXIAL COMPRESSIVE STRENGTH FROM THE POINT LOAD TEST ON ANISOTROPIC ROCKS (SCHISTS AND SHALES)

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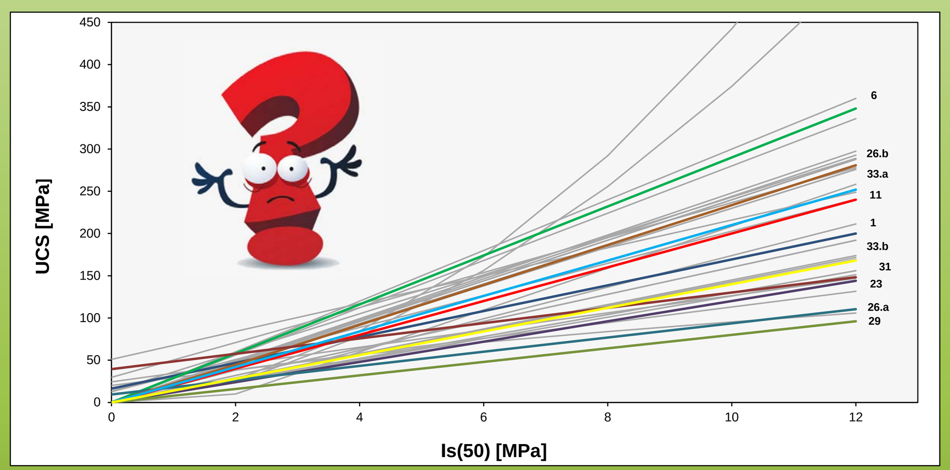
INTRODUCTION

The International Society of Rock Mechanics indicates that there is a direct linear relationship between the uniaxial compressive strength (UCS) and the point load index Is(50), which varies between 20 and 25. The results of these estimates are relatively acceptable in isotropic rocks. However, there are many works that have obtained a wider range of this RCS/Is(50) ratio, between 8 and 50, in tests with different types of rocks, mainly in rocks with moderate and high anisotropy. Therefore, the use of a single conversion factor for different types of rocks could provide wrong results.



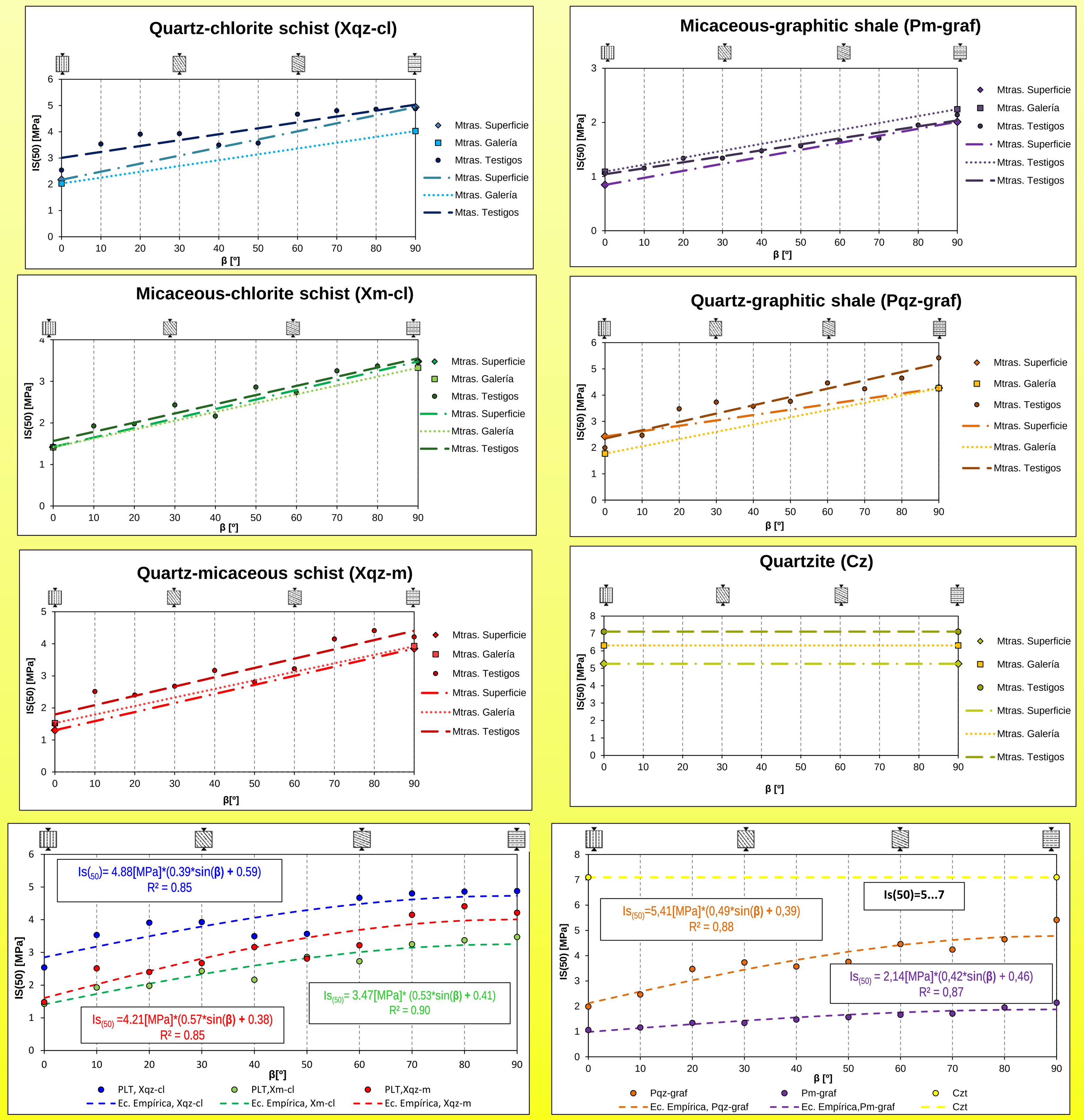
Examples of empirical relationships between the uniaxial compressive strength (UCS) and the point load index Is(50): 1. D'Andrea et al., (1964), 6. Hassani et al., (1980), 11. ISRM (1985) ,23. Chau y Wong (1996), 26.a 26.b. Kahraman (2001), 29. Palchik y Hazor (2004), 31. Fener et al., (2005), 33.a y 33.b Singh et al., (2011).

In this work, new empirical relationships are developed between uniaxial compressive strength and point load index Is(50) in anisotropic rocks, particularly in schists and shales. We have used data from 2015 point load tests (PLT) and 229 uniaxial compressive strength tests performed in anisotropic rocks obtained during various stages of study of Paute-Cardenillo hydroelectric project, located in the eastern slopes of the northern Andes Cordillera (SE Ecuador).

POINT LOAD TEST (PLT)

SCHISTS | SHALES

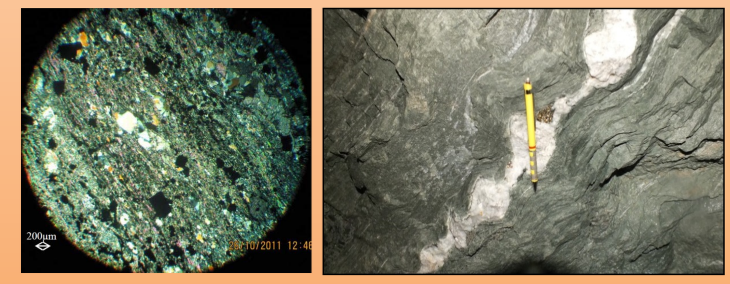
β = 0° 30° 60° 90° | β = 0° 30° 60° 90°



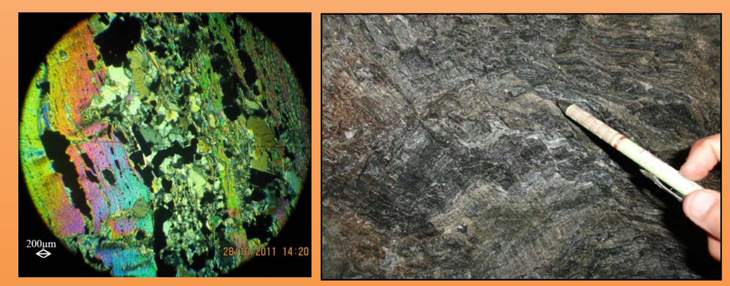
LITHOTYPES OF ANISOTROPIC ROCKS

JURASSIC SCHISTS

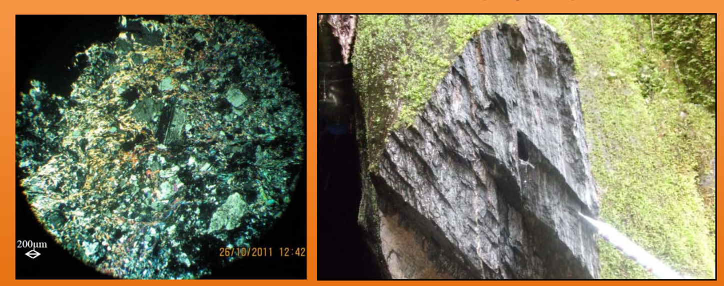
Quartz-chlorite schist (Xqz-cl)



Micaceous-chlorite schist (Xm-cl)

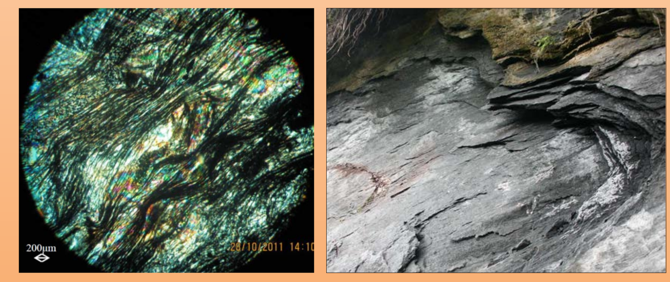


Quartz-micaceous schist (Xqz-m)



CRETACEOUS SHALES

Micaceous-graphitic shale (Pm-graf)



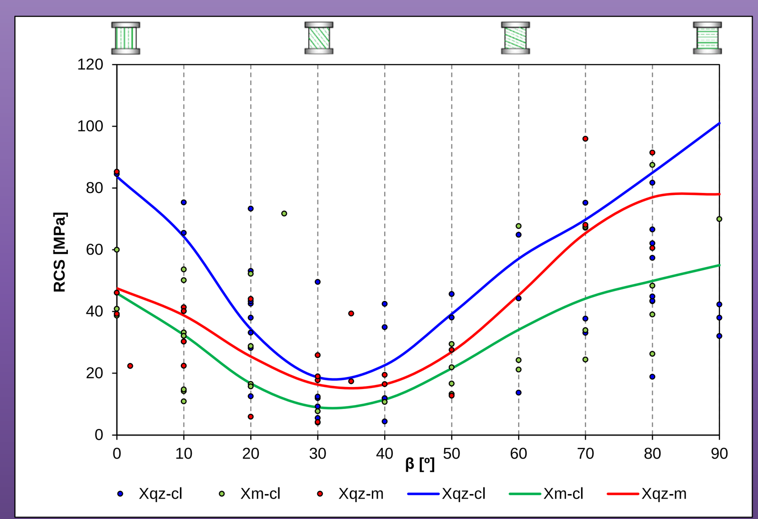
Quartz-graphitic shale (Pqz-graf)

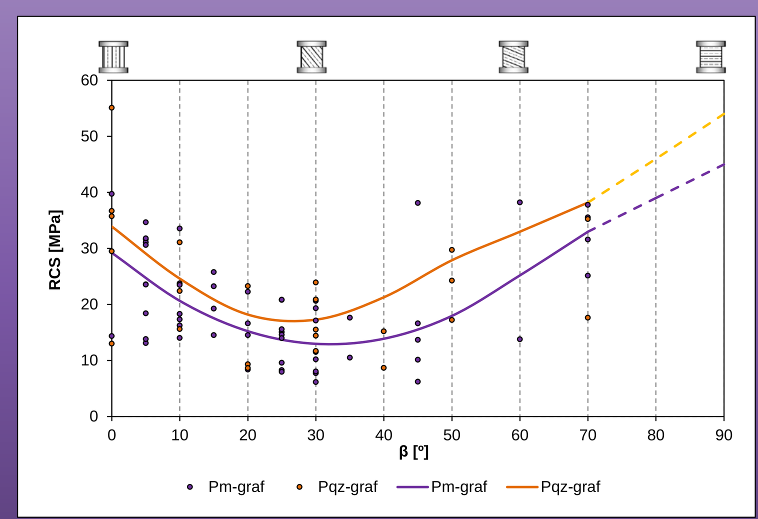
Quartzite (Cz)

UNIAXIAL COMPRESSIVE STRENGTH (UCS)

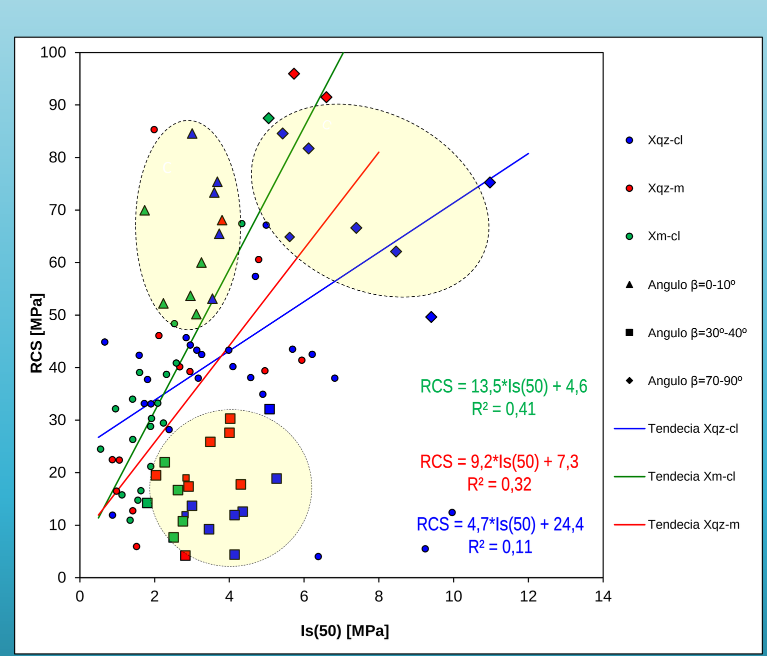
SCHISTS | SHALES

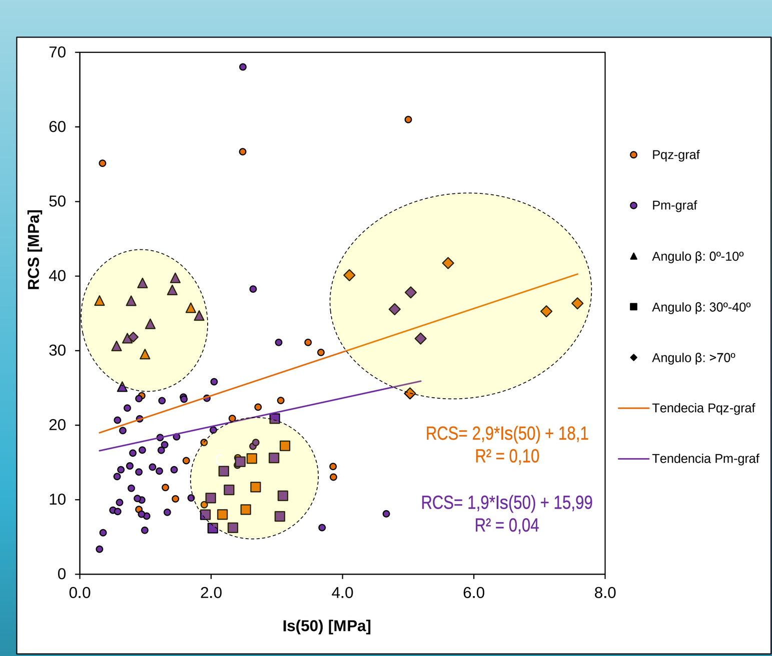
β = 0° 30° 60° 90° | β = 0° 30° 60° 90°





PLT vs UCS





NEW EMPIRICAL EQUATIONS

Coefficient of lineal regression (K_L)

$$K_L = RCS/Is_{(50)}$$

	SCHISTS			SHALES	
β (°)	Xqz-cl	Xm-cl	Xqz-m	Pqz-graf	Pm-graf
0	29	32	30	16	30
10	20	19	19	10	18
20	10	8	10	6	12
30	5	4	6	5	9
40	6	4	5	6	9
50	9	8	8	7	11
60	13	11	12	7	14
70	15	14	17	8	18
80	18	15	19	10	21
90	21	17	19	11	24

Coefficient of non lineal regression (K_{NL})

$$K_{NL}\ (\beta = i^\circ) = A \cdot \sin(\beta + B)$$

(Khanlari et al., 2014)

Lithology	0º ≤ β ≤ 30º		30º < β ≤ 90º	
	A	B	A	B
Xqz-cl	-46,9	27,6	37,3	-18,8
Xm-cl	-58,1	30,6	34,3	-18,1
Xqz-m	-48,1	28,4	42,8	-23,6
SCHISTS	**-52**	**29**	**39**	**-21**
Pqz-graf	-22,0	14,7	13,7	-3,7
Pm-graf	-40,9	27,6	40,2	-18,6
SHALES	**-28**	**19**	**21**	**-8**

Coefficient of non lineal regression based on a lineal regression (K_{VHF})

$$RCS_{90^\circ} = K_{L,\,90^\circ} \cdot Is_{(50),\,90^\circ}$$

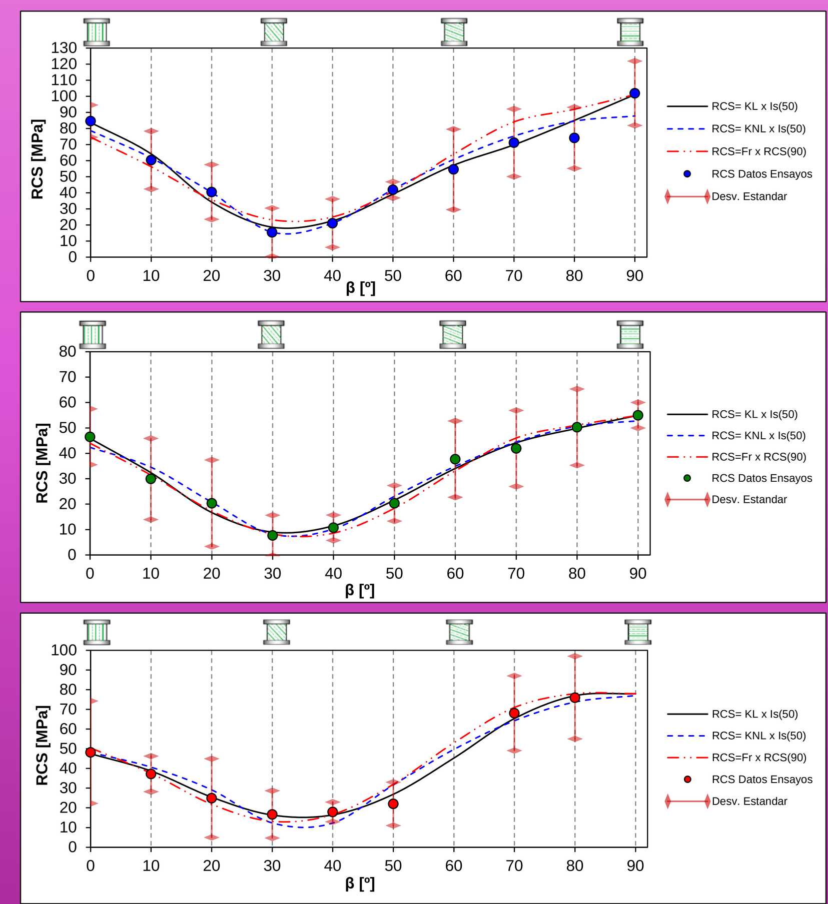
$$Fr = RCS\ (\beta = i^\circ) / RCS_{90^\circ}$$

$$Fr = A - B \cdot \cos 2(\beta + \psi) + C \cdot \cos 4(\beta + \psi)$$

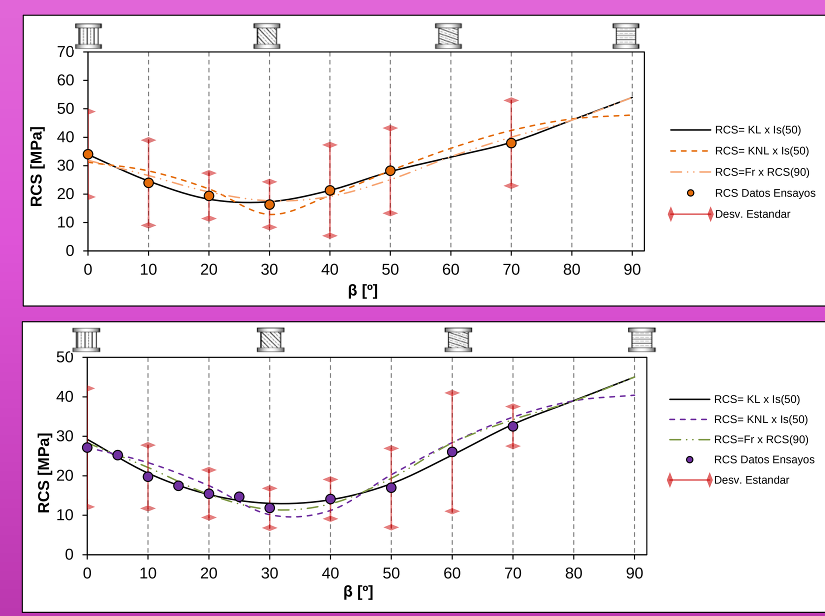
(Vutukuri et al., 1995)

Lithology	A	B	C
Xqz-cl	0,54	0,05	0,32
Xm-cl	0,52	0,02	0,39
Xqz-m	0,52	0,15	0,35
SCHISTS	0,55	0,04	0,35
Pqz-graf	0,52	0,08	0,19
Pm-graf	0,52	0,09	0,26
SHALES	0,50	0,06	0,23

SCHISTS



SHALES



CONCLUSIONS

Comparing the results of the three proposed empirical equations with the mean values of RCS for each angle of anisotropy, it is observed that the three proposed methods present a good fit, within the values of standard deviation for each angle of anisotropy.

Although the three methods show small variations with the experimental values (< 7 %), it is considered that the equation with the best fit in reference to the laboratory values is the linear correlation coefficient (K_L).

In practice, any proposed method can be used for the prediction of the uniaxial compressive strength according to the Is(50) index, taking into account that the constants deduced for each of the methods are exclusively for anisotropic rocks (schists and shales).

References

Khanlari,G.R., Heidari, M., Sepahigero, A.A., Fereidooni, D., (2014): Quantification of strength anisotropy of metamorphic rocks of the Hamedan province, Iran, as determined from cylindrical punch, point load and Brazilian tests. Engineering Geology, 169: 80-90.

Vutukuri, V.S., Hossaini, S.M.F. y Foroughi, M.H. (1995): A study of the effect of roughness and inclination of weakness planes on the strength of rock and coal. In: Proc. of Second International Conference on the Mechanics of Jointed and Faulted Rock (H.P. Rossmanith ed.). Taylor and Francis, Balkema, Rotterdam, 151-155.