Influence of sedimentary facies on rock hardness in limestone-marl alternations of the Jurassic Blue Lias Formation (Bristol Channel Basin, UK)

Filiz Afşar*, Hildegard Westphal#, Sonja L. Philipp*

* Department of Structural Geology and Geodynamics, Geoscience Centre (GZG), Georg-August-University of Göttingen
# Leibniz Center for Tropical Marine Ecology (ZMT), University of Bremen

Introduction

In coastal environments, the interaction between saline water and minerals within rocks influences the physical properties of rocks (e.g., hardness). Since physical rock properties in turn affect erosion, knowledge of these properties is important for coastal protection. The local tidal range at the Bristol Coast is the second largest in the world and determines the surface area influenced by erosion (WILLIAMS et al., 1997).
For this reason,we investigate the relationship between rock hardness and mineralogy in limestone-marl alternations of the Jurassic Blue Lias Formation (Fig. 1) at the Vale of Glamorgan Coast of the Bristol Channel (BC; Fig. 2).

SERIES	STAGE	GROUP	This report (based on PENN, 1987)	
Lower Jurassic	Toarcian	Lias Group	Upper Lias	
	Pliensbachian		Middle Lias	
	Sinemurian		Lower Lias Clay	Lower Lias
	Hettangian		Blue Lias	

Fig. 1: Stratigraphy in the study area (modifed after TAPPIN et al., 1994).

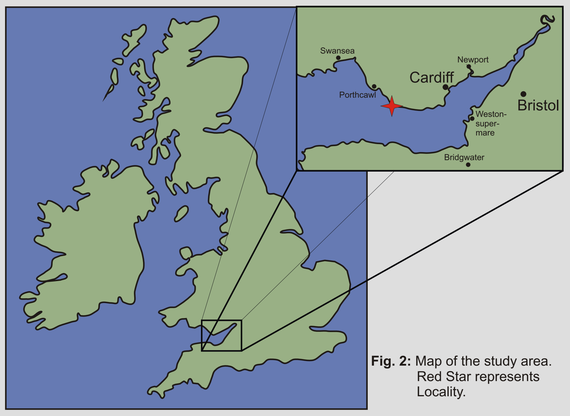


Fig. 2: Map of the study area. Red Star represents Locality.

Methods

Our study is based on two sedimentological sections and respective hardness measurements with a portable electronic rebound hardness testing device (Proceq EQUOTIP® 3). For statistical reasons, 30 measurements per sedimentary layer were taken in each section. Because of the difference between the hardness of limestones and marls, we used different sensors for each lithology (standard type D, impact energy: 11 N mm for marl layers and standard type C, impact energy: 3 N mm for limestone layers; VERWAAL and MULDER, 1993).

Results

1. Rock hardness- Average (RHA)

- The lithological contrast between limestones and marls in section 1 is stronger than in section 2, and the same for the RHA-values.
- In comparison with persistent limestones in section 1 (Fig. 4, Fig. 5), nodular limestones of section 2 are characterized by lower hardness values (Fig. 3, Fig. 6).
- Calcareous marls tend to have a higher hardness than pure marls (Fig. 6).

→ **This behavior is determined by differences in carbonate content.**

- The RHAs of marly lithologies (marls and calcareous marls) are generally ≤ 300, except the lower part of section 2 (< 95 cm, Fig. 6).

→ **Only this lower part is intermittently in contact with seawater.**

2. Rock hardness- Standard deviation (RHSD)

- The RHSDs in the lower part of section1 (< 30 cm, Fig. 5) are lower in marls and higher in limestone beds, while the pattern is vice versa in the lower part of section 2 (< 95 cm, Fig. 6).
- The RHSDs in the upper part of section1 (> 30 cm, Fig. 5) are higher in marls and lower in limestone beds, while the pattern is vice versa in the upper part of section 2 (> 95 cm, Fig. 6).

→ **These fundamental differences in the RHSD seem to be Systematic.**

Fig. 3: Outcrop of section 2.

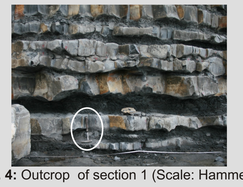
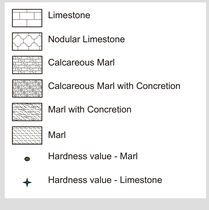


Fig. 4: Outcrop of section 1 (Scale: Hammer).



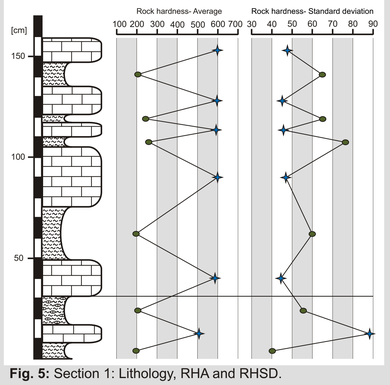


Fig. 5: Section 1: Lithology, RHA and RHSD.

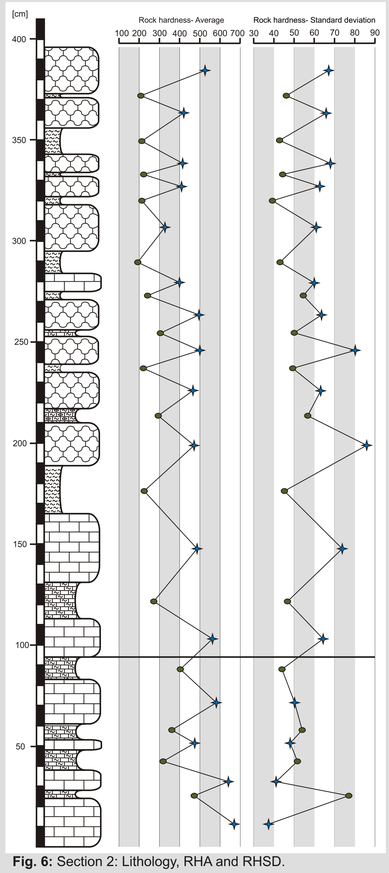


Fig. 6: Section 2: Lithology, RHA and RHSD.

Discussion

The different behavior of the RHAs in the lower part of section 2 can possibly be explained by seawater, since

- the lower part of section 2 is affected by seawater at every high-tide
- the lower part of section 1 is only occasionally in contact with seawater

Higher RHAs in marls of the lower part of section 2 could then be explained by the clay content; electrolytes within the seawater react with swellable varieties of clay, which in turn influence the mechanical properties and therefore the hardness of the rocks.
Therefore we hypothesize that the interaction of seawater electrolytes and swellable varieties of clay leads to a shift towards higher RHAs in marls of the lower part of section 2.

To test the hypothesis further we will gather more hardness measurments in further sections and analyse the content of swellable minerals of rocks.

References

PENN, I.E. (1987): Geophysical Logs in the stratigraphy of Wales and adjacent areas. Proceedings of the Geologists' Association, Vol. 98. 275-314.

TAPPIN, D.R.; CHADWICK, R.A.; JACKSON, A.A.; WINGFIELD, R.T.R.; SMITH, N.J.P. (1994): The geology of Cardigan Bay and the Bristol Channel. British Geological Survey, United Kindgom Offshore Regional Report, London HMSO.

VERWAAL W.; MULDER A. (1993): Estimating rock strength with the Equotip hardness tester. International Journal of Rock Mechanics and Mining Sciences 30: 659662.

WILLIAMS, A.; DAVIES, P.; CALDWELL, N. (1997): Coastal Processes and Landforms the Glamorgan Heritage Coast. WBC Book Manufactures Ltd. Bridgend.

Acknowledgements:

Jan-Peter Duda for help in the field, efficient discussions and for helping with drawings, **Meike Klischies** for help with drawings.
This project is funded by the **Deutsche Forschungsgemeinschaft (DFG)**.

If you have helpful suggestions or further questions, please contact us
filiz.afsar@geo.uni-goettingen.de

European Geosciences Union, General Assembly 2011, Vienna, Austria, 03-08 April 2011