Int. J. Econ. Environ. Geol. Vol. 8 (3) 51-55, 2017
Journal home page: www.econ-environ-geol.org
Open Access
ISSN: 2223-957X

Petrography of Jutana Dolomite: Implications for Geotechnical Utility

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***Received:** 7 December, 2016* ***Accepted:** 6 June, 2017*

Abstract: Present study has been carried out to know the reliance of mechanical properties on the petrographic parameters. The Jutana dolomite is comprised of dolomite, sandy dolomite and siliciclastic beds. In this study microfacies analysis and geotechnical utility of Jutana dolomite has been determined. Based on the microscopic study different microfacies were identified. The mechanical properties of Jutana dolomite were investigated with the help of the strength tests such as uniaxial compressive strength (UCS) and uniaxial tensile strength (UTS) and shear strength. The results of the strength tests show that the Jutana dolomite is a moderately strong, which is suitable for construction purpose. In addition, the interrelationships of petrographic and mechanical properties of Jutana dolomite were determined. The percent quartz (8-41%) grains play a positive impact on the uniaxial compressive strength of Jutana dolomite.

Key words: Petrography, dolomite, uniaxial compressive strength, Khewra gorge.

Introduction

Mechanical properties of rocks are generally very important from the engineering point of view and help in assessing the natural and artificial slopes and other engineering works (Bell, 2007). Mechanical characteristics of crushed rocks are of major importance for their utilization as construction aggregate, road aggregates and dimension stones (Ngerebara and Youdeowei, 2014). Mechanical properties of the rocks generally depend on texture and composition of rocks because they are reflected of their environments during sedimentation, diagenesis and erosion. Physical properties of construction materials are dependent on UCS, UTS, mineralogical and textural characteristics and the microstructures present within the rock. Uniaxial Compressive Strength (UCS) and Uniaxial Tensile Strength (UTS) are the most important parameters used in almost all engineering projects. They require very high quality core samples of regular geometry.

Jutana Dolomite is exposed along Salt Range Thrust (Kazmi and Jan, 1997; Fig. 1). The Salt Range area is regarded as "The Museum of Geology" having a large stratigraphic record from Precambrian to Recent alluvium (Asrarullah, 1967). This Thrust is placed along the southern part of the Salt Range in between the Jhelum River to the east and Indus River to the west and has the oldest strata over the Quaternary alluvium (Gee, 1989). The best part of Jutana dolomite is exposed within the eastern Salt Range near the Jutana village at 2 kilometers from the Khewra Gorge. The thickness of Jutana Dolomite is 80 meters at the type section. The persistence of Jutana Dolomite ranges up to the Khisor Range (Shah, 2009). Previous work on Jutana Dolomite is only related with petrographic studies. Whereas, in the present study the mechanical properties were carried out. Consequently, UCS and petrographic studies of Jutana Dolomite were carried out to determine the aggregate potential of dolostone. The main aim of this study is to examine the influence of petrographic features on the mechanical properties of Jutana Dolomite.

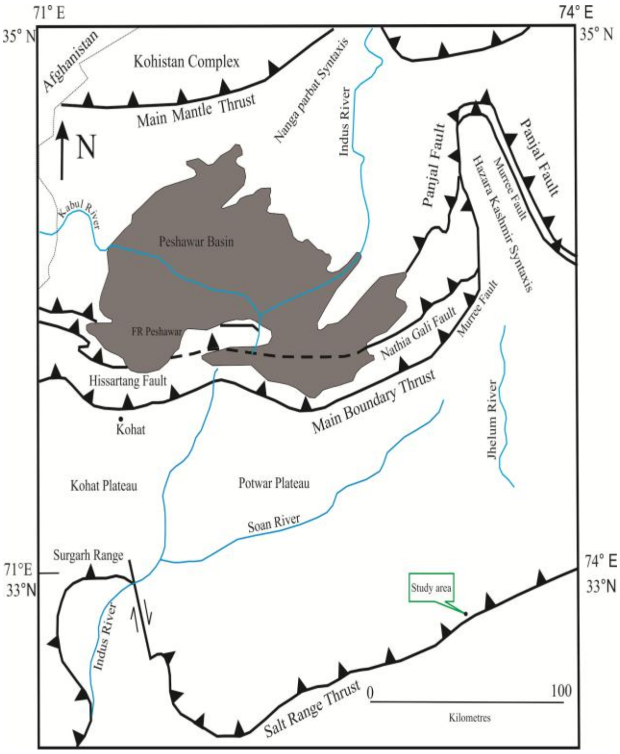


Fig. 1 Tectonic map showing the location of study area (after Kazmi and Rana, 1982).

Methods and Materials

The main concern during the field was to observe the physical characteristics of Jutana Dolomite. On the basis of field observations, it is divided into three units i-e Lower dolostone unit, middle siliciclastic dolostone unit and upper micaceous dolostone unit. Sixteen chip samples were collected from Jutana Dolomite for making thin sections and were studied in detail under polarizing microscope. The petrographic studies included mineralogical composition, grain size and microfacies analysis.

In order to determine mechanical properties of studied rocks five suitable block samples were collected. Tests were performed on the cores extracted from collected block samples. UCS test is inevitably the most reliable means to determine the compressive strength of rocks (Liang et al., 2015). The specimens from drill cores are prepared by cutting them to the specific length and are thereafter grinded and measured. The UCS is calculated according to the procedure given by ISRM (2007) with length to diameter ratio of 2-2.5 of respective core samples.

The UTS is calculated by loadings disc in compression along diameter. Uniaxial tensile strength is used to verify tensile strength of rock samples or its resistance against fracturing. For this test the cylindrical cores are also extracted from the bulk samples with a specific length and diameter (ISRM, 2007). The loading causes a tensile deformation perpendicular to the loading direction, which yields a tensile failure. By recording the ultimate load and by knowing the dimensions of the specimen, the UTS of the material is calculated. The procedure used for UTS is ASTM (1986). In rock mechanics, tensile strength has the prime importance in analyzing rock strength and stability of hanging walls and surroundings of underground openings in the tensile zone of the rock, mining of minerals and in the preparation rock drilling and blasting programs. The apparent simplicity of these tests is illusive and results can vary with the specimen preparation, test procedure and equipment used (Hawkes and Mellor, 1970). In the present scenario, shear strength was not measured directly. Rather the shear strength parameters were found out indirectly by using the values of UCS and UTS (Fig. 2).

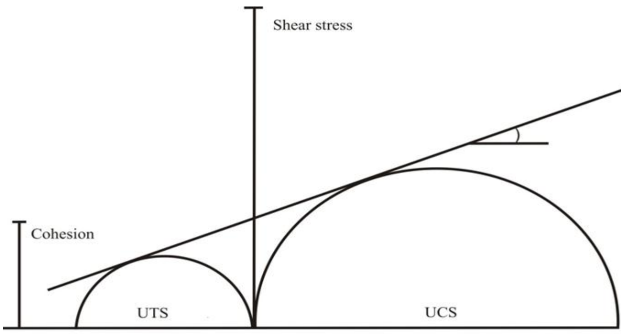
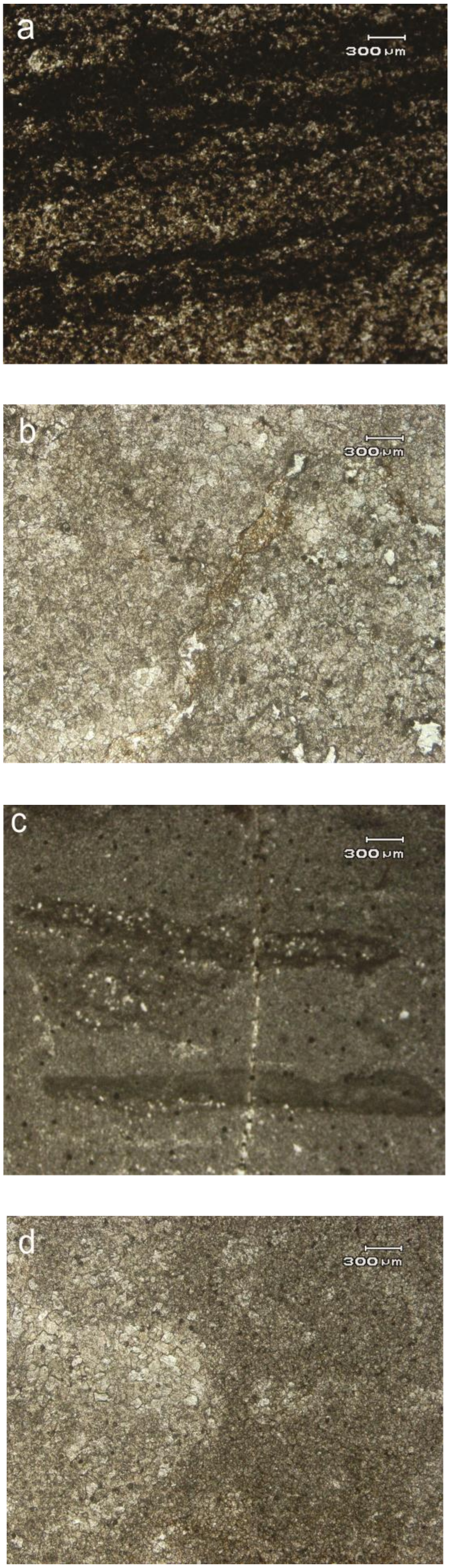


Fig. 2 Determination of shear strength parameters based on Mohr coulomb failure.



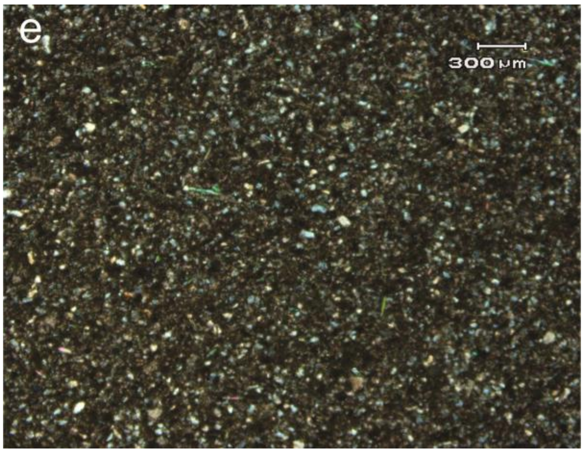


Fig. 3 Photomicrograph 3(a) showing algal lamination with in Jutana Dolomite, (b) Photomicrograph showing fine to medium size subhedral dolomite grains, (c) Photomicrograph showing micrite, broken algal filaments and silt size quartz grains, (d) Photomicrograph showing dolosparite at the left whereas micrite is at the right side, (e) Photomicrograph showing fine grained mica (muscovite) and silt size quartz grains.

Microfacies analysis

The microfacies of the Jutana Dolomite were determined from sixteen thin sections of the collected rock samples. Thin sections having same characteristics were regarded as a single microfacies. The standard classification was used for the description of the studied thin sections (Sibley and Gregg, 1987; Friedman, 1965). Such classifications include crystal size (aphanitic, very fine, fine, medium, coarse crystalline), crystal texture (equigranular, inequigranular, unimodal and polymodal), crystal fabric (peloidal, mosaic, porphyritic, poikilitic) and crystal shape (anhedral, euhedral or subhedral). The microfacies identified during the current study are, Siliciclastic algal laminated dolomite facies, sandy dolomite facies, dolomitic sandstone facies, siliciclastic dolomicrite facies, dolomicrite-dolosparite facies, micaceous siliciclastic dolomite facies. Photomicrographs of facies are given as 3a, 3b, 3c, 3d, 3e. The details of classification of these microfacies are given in Table 1. In the table only major minerals present within Jutana Dolomite are given. Calcite (mostly found in vein) and ore minerals are excluded from the Table 1.

Table 1 Showing the details of microfacies of Jutana dolomite.

Facies (Name)	Dolomite (sparite /micrite) (%)	Quartz (%)	Mica (%)	Classification			
				Size	Texture	Fabric	Shape
Siliciclastic Algal Laminated Dolomite Facies	80-85	5-6	5	Fine grain	Equigranular	Mosaic	Anhedral
Sandy Dolomite Facies	60-65	10-12		Medium to coarse	Inequigranular	Mosaic	Euhedral
Dolomitic Sandstone Facies	70-75	18-20	2-3	Fine grain	Inequigranular	Mosaic	Anhedral
Siliciclastic Dolomicrite Facies	50-55	3-4		Fine to very fine	Inequigranular	Mosaic	Subhedral
Dolomicrite-Dolosparite Facies	85	3-4		Fine	Inequigranular	Porph-yrotopic	Subhedral
Micaceous Siliciclastic Dolomite Facies	75	5	15	Fine to very fine	Inequigranular	Mosaic	Anhedral

Results and Discussion

Five block samples were collected for geotechnical testing. Block samples were collected in order to extract the cores from them. Uniaxial compressive strength of the Jutana Dolomite ranges from 34.94 MPa to 50.27 MPa (Table 2). Uniaxial tensile strength of the Jutana Dolomite ranges from 7.87 MPa to 13.13 MPa (Table 3). Cohesion value is 20.3 Mpa and angle of internal friction is 30º. Brady and Brown (2004) revealed that cohesion is two times UTS. In this research, it is in accordance with the identified relationship. The uniaxial compression strength values are many times greater than the uniaxial tensile strength values. The values of uniaxial compressive strength indicate that the Jutana dolomite is moderately strong according to the proposed scheme of Anon (1979) and ISO (2003). The mechanical strength (UCS) of any rock greater than 35 MPa is suitable to be used in engineering and construction works (Bell, 2007).

Table 2 Laboratory results of UCS tests.

Sample No.	Load (KN)	Diameter (m)	Strength (MPa)
1	90	0.0478	50.27
2	65	0.0487	34.94
3	85	0.0481	47.77
4	72	0.0483	39.34

Table 3 Laboratory results of UTS tests.

Sample No.	Load (KN)	Diameter (m)	Strength (MPa)
1	15	0.0485	8.33
2	13	0.0462	7.87
3	24	0.0484	13.33
4	20	0.0472	11.46

Table 4 Showing the values of UCS and Quartz percentage.

Sample No.	Quartz (%)	UCS (MPa)
1	8	34.94
2	19	39.34
3	23	47.77
4	41	50.27

By applying regression analysis of UCS with quartz percentage, regression coefficient (R^2) value was determined for the best fit line in the form of linear equation (Fig. 4). Their mutual relationship indicates that strength of the rock increases with quartz content. Fahy and Guccione (1979), Shakoor and Bonelli (1991) obtained inverse correlations between the uniaxial compressive strength and percent quartz grains, but positive relationship between these two parameters was found by Gunsallus and Kulhawy (1984) and Zorlu et al., (2004). Physically a positive correlation between the uniaxial compressive strength and quartz content is expected (Zorlu et al., 2008). In this study a positive correlation between UCS and quartz percent has been obtained.

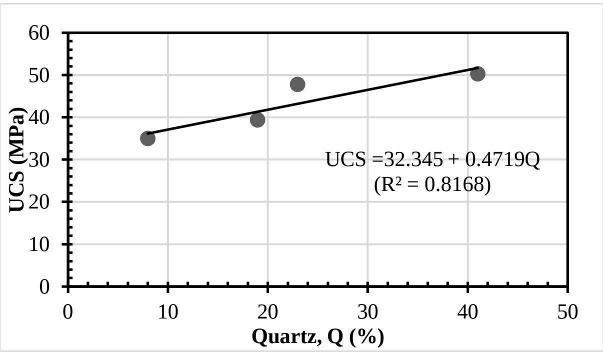


Fig. 4 The relationship between quartz (%) and the UCS of Jutana Dolomite.

Conclusion

Jutana Dolomite is divided into three parts in this study, upper micaceous dolostone, middle siliciclastic dolostone and lower dolostone unit. Microfacies have been named on the basis of minerals percentages i-e quartz, dolomite and mica. The names of the microfacies are siliciclastic algal laminated dolomite facies, sandy dolomite facies, dolomitic sandstone facies, siliciclastic dolomicrite facies, dolomicrite dolosparite facies and micaceous sandy dolomite facies. The UCS results show that this rock is moderately strong, hence suitable for using in small construction industries. Regression analysis indicates significant positive correlation between UCS and quartz percentage of Jutana dolomite.

Acknowledgement

Thin sections were prepared at the Department of Geology, University of Peshawar. Mechanical tests were performed at TEVTA, Taxila.

References

Anon, (1979). Classification of rocks and soils for engineering geological mapping. Part 1- Rock and Soil Materials. *Bull. Int. Assoc. Eng. Geol.*, **19**, 364-371.

Asrarullah, (1967). Geology of the Khewra dome. Pakistan Sci. Cong. 18th/19th. Jamshoro, Proc. Pt-III, Abs, 3-4.

ASTM, (1986). D-3976, Standard test method for splitting tensile strength of intact rock core. American society for testing material, Philadelphia, Pennsylvania, U.S.A.

Bell, F. G., Lindsay P. (2007). The petrographic and geomechanical properties of some sandstones from the Newspaper Member of the Natal Group near Durban, South Africa. *Eng. Geol.*, **53**, 57–81.

Brady, B. H. G., Brown, E. T. (2004). *Rock mechanics for underground Mining*, Third edition, Kluwer Academic Publishers, 1-576.

Fahy, M. P., Guccione, M. J. (1979). Estimating the strength of sandstone using petrographic thin section data. *Bull. Assoc. Eng. Geol.*, **16**, 467-485.

Friedman, G. M. (1965). Terminology of crystallization textures and fabrics in sedimentary rocks. *J. of Sedimentary and Petrology*, **35**, 643-655.

Gee, E. R. (1989). Overview of the geology and structure of the Salt Range with observation on related areas of Northern Pakistan, *Geol. Soc. Am. Spec. Pub.*, **232**, 95-112.

Gunsallus, K. L., Kulhawy, F. H. (1984). A comparative evaluation of rock strength measures. *Int. J. Rock Mech. Min.*, **21** (5), 233-248.

Hawkes, I., Mellor, M. (1970). Uniaxial testing in rock mechanics laboratories. *Eng. Geol.*, **4**, 179–284.

International Standard Organization (2003). 14689-1. Geotechnical investigation and testing. Identification and classification of rock. Part 1: identification and description. Geneva: International organization standardization 1-16.

ISRM, (2007). The complete ISRM suggested methods for rock characterization, testing and monitoring: 1974–2006. In *Suggested methods prepared by the Commission on Testing Methods*. R. Ulusay, J. A. Hudson (eds.), *International Society for Rock Mechanics.* ISRM Turkish National Group, Ankara

Kazmi, A. H., Rana, R. A. (1982). Tectonic map of Pakistan. *Geol. Surv. Pak.*, Quetta.

Kazmi, A. H., Jan, M. Q. (1997). *Geology and Tectonics of Pakistan*. Graphic Publishers, Karachi, 1-528.

Liang, M., Mohamad, E. T., Khun, M. C., Alel, M. N. A. (2015). Estimating uniaxial compressive strength of tropically weathered sedimentary rock using indirect tests. *J. Teknologi,* **72** (3), 49-58.

Ngerebara, O. D., Youdeowei, P. (2014). Correlation of mechanical properties of some rocks in south eastern Nigeria. *Int. Jr. Sci. Res., Publ.,* **4**, 1–6.

Shah, S. M. I. (2009). Stratigraphy of Pakistan, Ministry of Petroleum and natural Resources. *Geol. Surv. Pak*., Quetta. GSP Memoirs **22**, 400 pages.

Shakoor, A., Bonelli, R. E. (1991). Relationship between petrographic characteristics, engineering index properties and mechanical properties of selected sandstone. *Bull., Assoc., Eng., Geol.,* **28**, 55-71.

Sibley, D. F., Gregg, J. M. (1987). Classification of dolomite rock texture. *J. of Sedimentary and Petrology,* **57**, 967-975.

Zorlu, K., Ulusay, R., Ocakoglu, F., Gokceoglu, C., Sonmez, H. (2004). Predicting intact rock properties of selected sandstones using petrographic thin section data. *Int. J. Mech, Min. Sci*, **41**, 93-98.

Zorlu, K., Gokceoglu, C., Ocakoglu, F., Nefeslioglu, H. A., Acikalin, S. (2008). Prediction of uniaxial compressive strength of sandstones using petrography based models. *Engineering Geology,* **96**, 141-158.