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Change in deformation modulus and strength of meta-siltstone depending on specimen size

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Abstract. The meta-siltstone samples of two scales are subjected to uniaxial compression and split tensile strength testing. The empirical relationships between the specimen size, deformation modulus and ultimate strength are determined. The strength behavior of the studied rock material was described using the Mohr–Coulomb envelopes.

It is important to account for geometrical dimensions of rock specimens when determining their strength properties with a view to prediction mechanical behavior of a geomedium under various type loading. Some researchers study, directly or indirectly, effect of dimension on mechanical characteristics of rock specimens [1–4].

This paper reports the research findings on the relationship between deformation moduli, compression and tension strength and dimensions of specimens of meta-siltstone detected in composition of rocks enclosing ore bodies.

The tests were carried out on cylindrical metal-siltstone specimens: 1—cross section diameters 1:30 mm; 2—cross section diameters 2:10 mm). The ratios of height to cross section diameter equaled 2 (for uniaxial compression testing) and 1 (for indirect tension strength testing—Brazilian test). Specimens from dimension group 1 were tested on Instron 8802 (Figure 1); specimens from dimension group 2—on Deben Microtest (Figure 2). The images of the specimens before and after the tests are given in Figure 1 and 2.

The test data were processed, and the resultant mechanical characteristics of different-dimension specimens were determined (see the table).

From the comparison of the averaged values in the table, dimension group 1 specimens have the deformation modulus E_d by 3.72 times higher and the compression strength σ_{com} by 2.37 times higher than the specimens from dimension group 2. The strength measured in the indirect tensile tests, σ_t, exhibit no significant dependence on the size of a specimen. These test results agree with the experimental data obtained on coal specimens in [4].

By the averaged values of σ_{com} and σ_t, the Mohr–Coulomb envelops were potted; here, thee are presented as the shear stress τ–normal stress σ:

$$\tau = 1.28\sigma + 15.19, \qquad \text{when} -10.47 \le \sigma \le 88.12, \tag{1}$$

$$\tau = 0.61\sigma + 10.48, \qquad \text{when} -11.81 \le \sigma \le 37.2, \tag{2}$$

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Where the formula (1) is for the specimens from dimension group 1 (diameter 30 mm) and the formula (2) is for the specimens from dimension group 2 (diameter 10 mm).

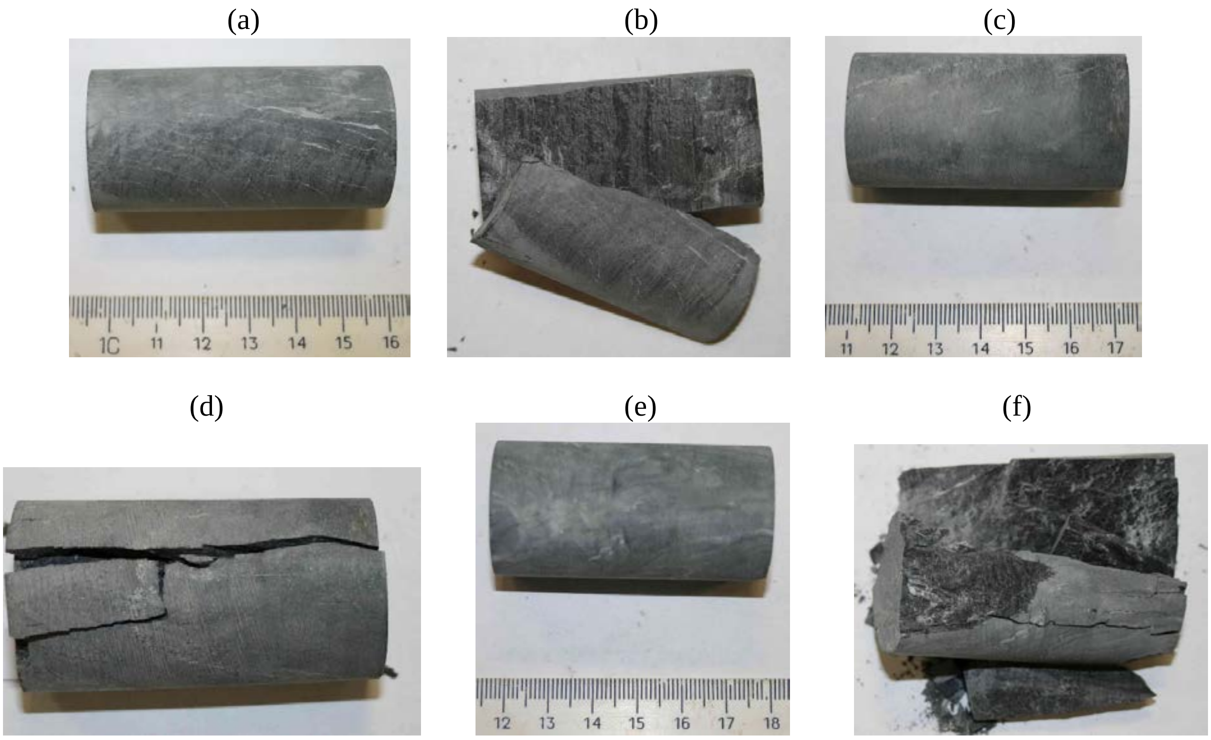

Figure 1. Meta-siltstone specimens (dimension group 1) before (a, c, e) and after (b, d, f) uniaxial compression tests.

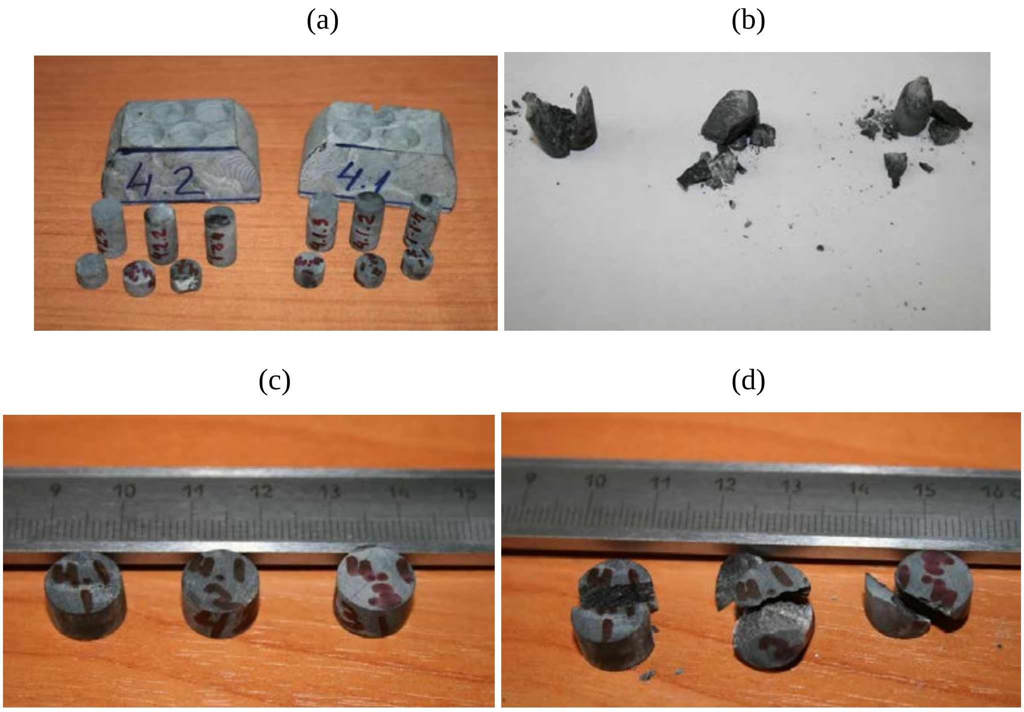

Figure 2. Meta-siltstone specimens (dimension group 2) before (a, c) and after (b) uniaxial compression and (d) indirect tension strength testing.

Table 1. Mechanical parameters of specimens in dimension groups 1 and 2

Specimen no.	Deformation modulus E_d, GPa	Compression strength σ_{com}, MPa	Indirectly tested tension strength σ_t, MPa
Dimension group 1			
1	22.73	90.8	10.1
2	20.01	85.9	9.7
3	21.65	87.7	11.6
Averaged value	21.46	88.13	10.47
Dimension group 2			
4-1-1	5.86	52.66	7.93
4-1-2	4.64	31.89	16.97
4-1-3	5.86	25.24	8.86
4-2-1	7.31	40.20	8.44
4-2-2	6.14	39.93	18.21
4-2-3	4.82	33.31	10.44
Averaged value	5.77	37.21	11.81

As is evident, the formula (1) covers a wider range of states (τ, σ) within the Mohr–Coulomb circles that the formula (2), i.e. the larger diameter specimens possess higher strength.

Conclusion

The mechanical experiments on uniaxial compression and indirect tensile strength testing (Brazilian test) have been carried out on solid cylindrical specimens made of meta-siltstone with the diameters of 10 and 30 mm and the height-to-diameter ratio 2 (compression) and 1 (tension).

It has been found that the meta-siltstone specimens with the diameter of 30 mm have 3.72 times higher deformation modulus and 2.37 times higher compression strength than the specimens with the diameter of 10 mm. The indirect tensile strength values exhibit no essential difference.

The tests have been carried out using the equipment of the Shared Access Center for Geomechanical, Geophysical and Geodynamic Measurements at the Siberian Branch of the Russian Academy of Sciences.

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