Brittleness index is a very important parameter for horizontal well drilling, hydraulic fracturing and production prediction of gas shale. The evaluation methods for rock’s brittleness through testing are as follows: ① the characteristics of stress-strain curve, such as the ratio of reversible strain to total strain; ② the result of rock intensity testing, such as the function of compressive strength and tensile strength; ③ the ratio of brittle minerals to total minerals; ④ the characteristics of burial history of rock. However, Brittleness index that evaluates the rock’s brittleness is not always reliable which is concluded by Altindag (2002).

In this study, the relations between the brittleness and mechanical parameters for sand and shale are analyzed basing on the stress strain test. Rock can be classified into 4 categories, namely high brittle sand (I), low brittleness sand (II), high brittle shale (III) and high plastic shale (IV) (Fig1B). Comparing the mechanical characteristics of these 4 categories, high brittle sand is great different from high plastic shale with greater yield strength, greater compressive strength, greater Young’s modulus, greater ratio of reversible strain to total strain and lower Poisson’s ratio and so on. But some of these mechanical properties are similar between the high brittle shale (III) and the high plastic shale (IV).

By analyzing the correlations of the brittle categories and mechanical parameters, it can be assumed that the high brittle rock with high Young’s modulus, low Poisson’s ratio, high ratio of yield strength to compressive strength, high ratio of reversible strain to total strain, and the four brittleness factors are defined as follows:

\[ B_{Ym} = \frac{(Ym - Ym_{min})}{(Ym_{max} - Ym_{min})} \]  

\[ B_{\sigma} = \frac{(\mu_{max} - \mu_{min})}{(\mu_{max} - \mu_{min})} \]  

\[ B_{R} = \frac{(R_{\sigma} - R_{\sigma_{min}})}{(R_{\sigma_{max}} - R_{\sigma_{min}})} \]  

Where, \( R_{\sigma} \) is the ratio of yield strength to compressive strength; \( \sigma_{y} \) is yield strength; \( \sigma_{c} \) is compressive strength; \( Ym \) is Young’s modulus; \( \mu \) is Poisson’s ratio.

So a comprehensive brittleness index could be defined with the four brittleness factors above,

\[ B_n = (0.477 \times B_{Ym} + 0.622 \times B_{R}) \times 100\% \]  

Correlation analysis shows that the four brittleness factors are all good relations with the brittleness of rock. Multiple regression analysis show that \( B_{Ym} \) and \( B_{R} \) are significant compared with \( B_n \), while \( B_{\mu} \) and \( B_{R_\sigma} \) are not.

Based on analysis above, a new brittleness index is defined with Young’s modulus and the ratio of reversible strain to total strain, which shows that the higher Young’s modulus and the ratio of reversible strain to total strain are, the greater brittleness of rock is (equation 6). It is considered to be reliable and practical through the study of the relativity between mechanical characterizes, hydraulic fracturing effect with the new brittleness index.

\[ B_n = (0.477 \times B_{Ym} + 0.622 \times B_{R}) \times 100\% \]  


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Fig.1 The four categories of brittleness.