

Rock Strength Measurement of Unconventional Shale– Comparison of Various Methods of Determining UCS

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Abstract

In this paper, resulting from our multi-year research work, we detail our comparison of three commonly used techniques for measuring the unconfined compressive strength (UCS) of source rock plugs. We analyze and discuss the cause of UCS variation among these methods. While many direct or indirect techniques have been developed and used, determination of UCS still remains challenging for unconventional shale: It is difficult to multiple plugs (especially vertical ones) with good quality from a whole core due to shale brittleness and complexity; and very often the limited available samples can't be used for UCS tests only. This only reinforces the need for considerable additional focused work needed to quantify the UCS accurately and better understand various techniques of measuring the UCS. A new method is introduced to determine more accurately the UCS of unconventional shale together with the multi-stage triaxial test.

We performed UCS measurements on shale plugs from various basins in the world using three different methods. The first method is to follow the procedure standardized by the American Society for Testing and Materials (ASTM) and the International Society for Rock Mechanics (ISRM), where a shale plug without any confining pressure is compressed until it fails. The second technique is similar to the previous one. However, a very small confining pressure (e.g. 100~200 psi) is applied on the plug. The last one is to derive the UCS from the Mohr-Coulomb failure envelope, which is obtained from single-stage triaxial tests on at least three similar plugs or multi-stage tests on one plug at various confining pressures. We introduced a new lab multi-stage triaxial test procedure that can accurately determine the failure envelope from one core plug. For comparison, multiple plugs from the same whole core or having similar properties are used in various tests.