



Advance in the study of the weathering profile of sandstone on China Yungang Grottoes Based on Hyperspectral Imaging

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Yungang Grottoes were built in the mid-5th century A.D., and named as a UNESCO World Heritage site in 2001. Most of the grottoes were built on the feldspathic quartz sandstones. They were seriously damaged due to the environmental impact. The main form of the weathering is the powdered weathering. The weathering conditions are generally characterized by electrical sounding, penetration resistance, and molecular spectroscopy, etc. However, although these methods can give good results about the weathering conditions for a specified sample or site, they are not suitable to provide a global profile of the weathering conditions for the surface of stone relics in large size. The present paper provides a method for effectively and roundly assessing the weathering conditions of the Yungang Grottoes based on hyperspectral imaging. Powdered weathering could increase the porosities and change the spectral reflectance of the sandstone surface. The sandstone samples in different aging period were selected and the hyperspectral data from 400 nm to 1000 nm were collected. It has been found that there is a linear correlation between the weathering conditions and the spectral reflectance at 675 nm. Based on the powdered conditions, the sandstones of the grottoes have been classified into five levels. The classification is based on the spectral reflectance data, which have been previously normalized using Log Residuals method. The weathering profile has also been visualized in the Envi platform using IDL programming language. The visualization images have been verified using the measured hyperspectral data of the columns in front of the 9th and 10th grottoes as the examples. The visualization images are substantially fitted to the real observations, showing that hyperspectral imaging can be used to estimate the powdered weathering conditions of the sandstones.