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摘要：

构造煤是在构造应力作用下,煤体发生变形或破坏的一类煤,在世界主要产煤国家皆有分布。构造变形不同程度的改变着煤的大分子结构和化学成分,而且也影响到构造煤的纳米级孔隙结构(<10 0 nm) ,它是煤层气的主要吸附空间。通过构造煤显微组分和镜质组油浸最大反射率的测定,采用液氮吸附法对不同变质变形环境、不同变形系列构造煤的纳米级孔隙分类、孔隙结构特征进行了深入系统的研究,并结合高分辨透射电子显微镜和X射线衍射对大分子结构和孔隙结构的分析,结果表明:不同类型构造煤纳米级孔径结构自然分类,可将孔径结构划分为过渡孔(15～10 0 nm)、微孔(5～15 nm)、亚微孔(2 .5～5 nm)和极微孔(<2 .5 nm) 4类。低煤级变形变质环境中随着构造变形的增强,不同类型构造煤过渡孔孔容明显降低,微孔及其下孔径段孔容明显增多,可见亚微孔和极微孔,过渡孔的比表面积大幅度降低,而亚微孔的却增加得较快。从脆韧性变形煤至韧性变形煤,总孔体积、累积比表面积、N2 吸附量随着构造变形的增强,这些结构参数均迅速增加,但中值半径进一步下降。非均质结构煤孔隙参数与弱脆性变形煤相当。中、高煤级变形变质环境形成的各种类型构造煤与低煤级变质变形环境相比,孔隙参数的变化基本一致。但不同类型构造煤的变化又有所区别

关键词：构造煤 纳米级孔隙结构 连通性 煤大分子结构 构造应力

Structural Evolution of Nano-scale Pores of Tectonic Coals in Southern North China and Its Mechanism

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Abstract:

Tectonic coals, formed under the action of tectonic stress, easily deformed and broken up, were found in many countries that produce coals. Tectonic deformation changes the macromolecular structure and the chemical compositions of coals in a certain degree, and at the same time it can influence deeply the nano-scale pore structure of tectonic coals (<100 nm). It is the main adsorption space of coalbed methane. By means of measurement of the maceral compositions and reflectance of vitrinite, systematic researches were performed on the classification system of nano-scale pores structure suitable for tectonic coals and the structural evolution of nano-scale pores of fifteen sets of tectonic coal samples which belong to different deformation series formed by three metamorphic and deformed environments from 11 coal mines and theirs formation mechanism in the Huaibei-Huainan mine area, southern North China. Using the low-temperature nitrogen adsorption method, the images of coal macromolecular pore structure obtained in the high-resolution transmission electron microscope show a natural classification system of nano-scale pore structure of different kinds of tectonic coals. In Accordance with the pore diameter, there are four types, mesopores (15~100 nm), micropores (5~15 nm), sub-micropores (2.5~5 nm), and ultra-micropores <2.5 nm). In metamorphic and deformation environments of low-rank coal, as the deformation becomes stronger, the volume of mesopores of tectonic coals reduces rapidly, while the volume of micropores and pore diameter lower than micropore increase obviously, and sub-micropores and ultra-micropores can be found, and the specific surface area of mesopores reduces rapidly and the amount of micropores and sub-micropores increase. From brittle coal to ductile deformation coal, the parameters such as total volume of pores, the pore specific surface area (include BET method and BJH method) and the adsorption of nitrogen change with the deformation. If the deformation becomes more intense, these parameters will increase rapidly, and at the same time the medium semi-diameter reduces further. Inhomogeneous coal has a similar change of pore parameter as weak brittle deformation coal. In metamorphic and deformation environments of the middle- and high-rank coal, tectonic coals have a similar parameter changing with low-rank coal. But, there are differences in pore structural evolution of tectonic coals formed in different metamorphic and deformation environments. In short, the increase of temperature has not much influence on the structure of nano-scale pores, while structural stress has an important influence on the parameters of pore structure of tectonic coals. Under the thermal condition, orientation of structural units appears in certain parts, the pore structure are mainly micropore and sub-micropores, and the ultra-micropores are also exist, but the connection becomes worse. In the local orientation process of aromatic structure units, special thin-neck-bottle-shaped pores developed, and the pores are mainly built up by pores between the oriented and un-oriented units.

Keywords: tectonic coals nano-scale pore structure connection coal macromolecular structure structural stress