

# Study the Effect of Temperature on Methane Desorption Based on Thermodynamics and Kinetics

Zheng Gao (✉ [gaozheng107@126.com](mailto:gaozheng107@126.com))

Xi'an University of Science and Technology <https://orcid.org/0000-0003-2298-0073>

**Dongmin Ma**

College of Geology and Environment, Xi'an University of Science and Technology, Xi'an 710054, China;  
2. Key Laboratory of Coal Resources Exploration and Comprehensive Utilization, MNR, Xi'an 710021,  
China; 3. Geological Research Institute for Coal Green

**Yue Chen**

College of Geology and Environment, Xi'an University of Science and Technology

**Chao Zheng**

College of Geology and Environment, Xi'an University of Science and Technology

**Jinxiang Teng**

College of Geology and Environment, Xi'an University of Science and Technology

---

## Research

**Keywords:** adsorption/desorption, coalbed methane, desorption hysteresis, adsorption heat

**Posted Date:** October 27th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-95370/v1>

**License:**   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

**Version of Record:** A version of this preprint was published at ACS Omega on December 29th, 2020. See the published version at <https://doi.org/10.1021/acsomega.0c05236>.

# Abstract

Desorption hysteresis is important for primary gas production. Temperature may cause serious change in the methane adsorption/desorption behaviors. In order to study the mechanism of methane desorption and desorption hysteresis, three sets of samples of long flame coal, coking coal, and anthracite were collected, and experiments such as microscopic composition determination, liquid nitrogen adsorption, and isothermal adsorption/desorption were performed. From the perspectives of desorption kinetics, desorption thermodynamics and methane occurrence state, the differences in methane and methane desorption characteristics and the desorption hysteresis mechanism are discussed. The results show that at the same temperature, anthracite (SH3#) has the largest saturated adsorption capacity and residual adsorption capacity, followed by coking coal (SGZ11#), and long -flame coal (DFS4#) is the smallest. As the temperature rises, the theoretical desorption rate and residual adsorption capacity of anthracite (SH3#) and coking coal (SGZ11#) will increase first and then decrease. Temperature and methane desorption are not completely positive effects, and temperature may have a threshold for promoting methane desorption. It is necessary to comprehensively consider the influence of temperature on the activation of gas molecules and the pore structure of coal. Under the premise of a certain temperature, as the pressure increases, the desorption hysteresis rate changes in a logarithmic downward trend, and the methane desorption hysteresis rate in the low pressure stage ( $P < 4\text{MPa}$ ) is large, and the methane desorption hysteresis rate in the high-pressure stage ( $P > 4\text{MPa}$ ) is lower; During the isobaric adsorption process, the adsorption capacity of anthracite (SH3#) increases the fastest, followed by SGZ11#, and DFS4# is the smallest. In the low-pressure stage ( $P < 4\text{MPa}$ ), the adsorption capacity increases significantly with the increase of pressure, but in the high pressure stage ( $P > 4\text{MPa}$ ), the adsorption capacity does not change significantly with pressure, but gradually stabilizes. Under the same pressure, the molecular free path of methane increases with temperature. Under the premise of constant temperature, in the low-pressure stage ( $0 < P < 4\text{MPa}$ ), when the pressure continues to decrease, the free path of methane molecules increases significantly, resulting in a decrease in the diffusion capacity. In the high-pressure stage ( $4 < P < 8\text{MPa}$ ), when the pressure continues to decrease, the free path of methane molecules does not change significantly; DFS4#, SGZ11#, SH3# sample desorption process of three sets of samples, the intermediate adsorption heat is greater than the isometric adsorption heat during the adsorption process, indicating that the desorption process needs to continuously absorb heat from outside the system. The energy difference produced in the process of adsorption and desorption causes the desorption hysteresis effect. The greater the difference in the isometric heat value of adsorption, the more significant the hysteresis.

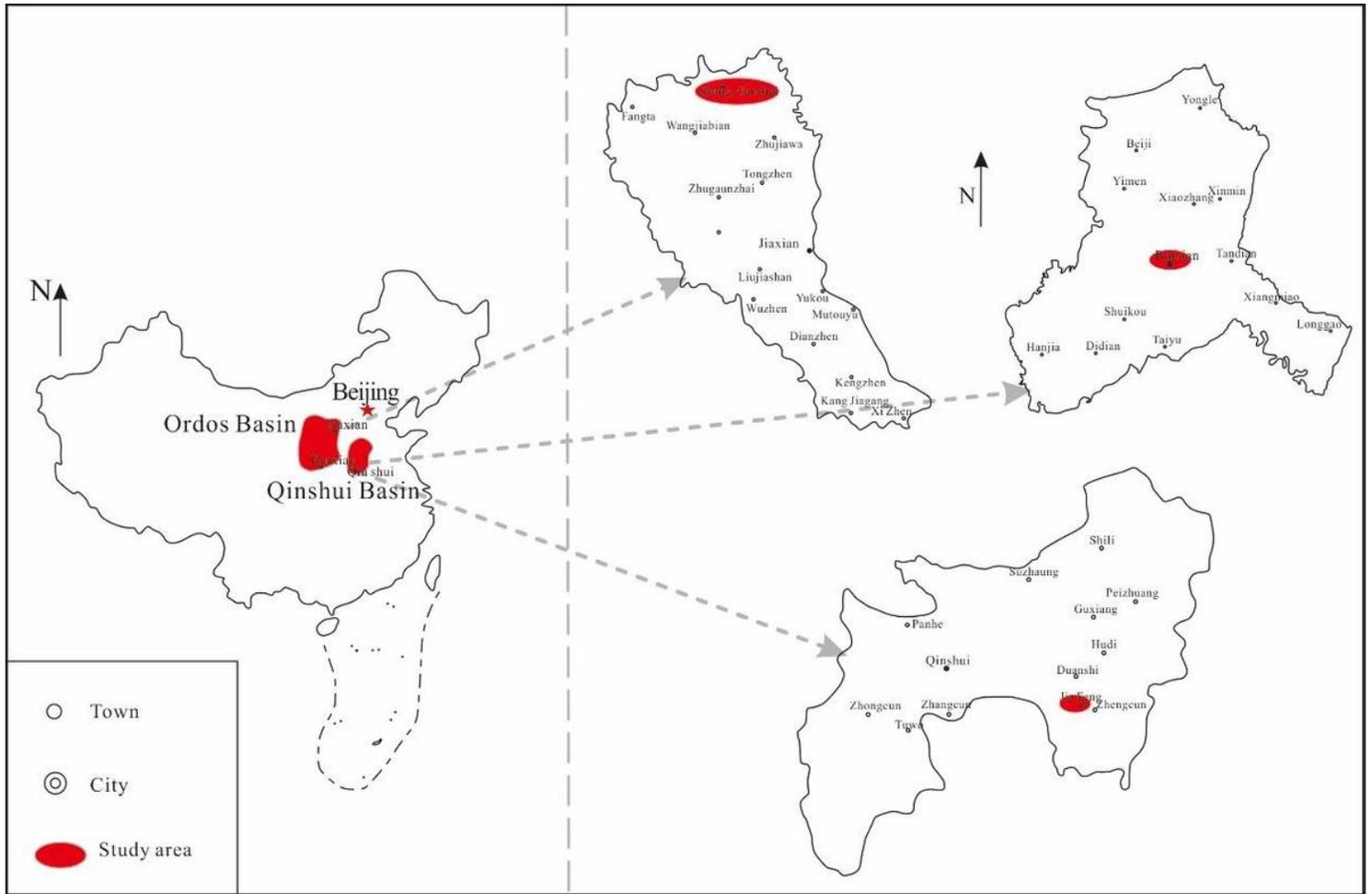
## Full Text

This preprint is available for [download as a PDF](#).

## Tables

Due to technical limitations, table 1-5 is only available as a download in the Supplemental Files section.

# Figures



**Figure 1**

Simplified location map of the study area Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

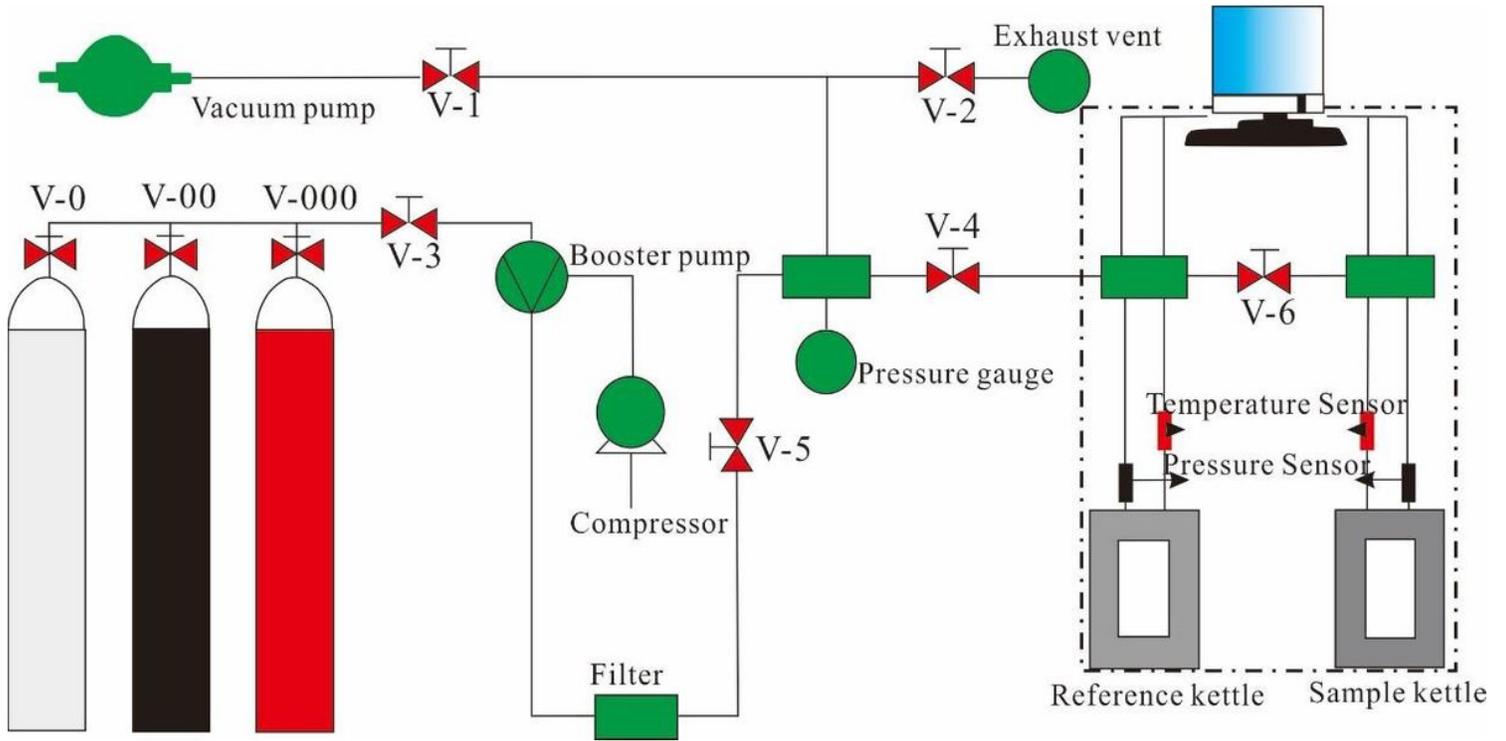


Figure 2

Experimental device of AST 2000 for methane adsorption/desorption

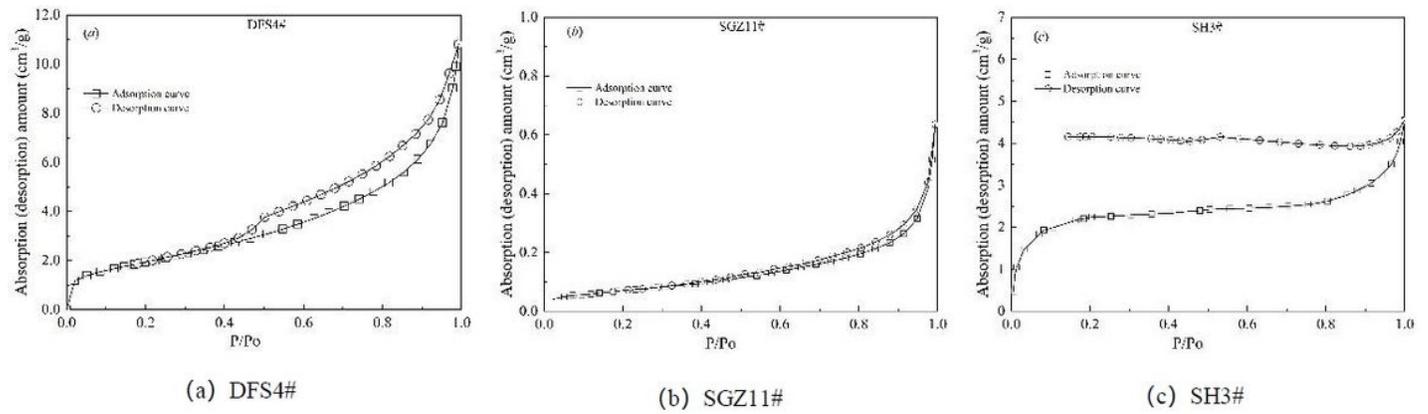


Figure 3

Isothermal adsorption curve of liquid nitrogen

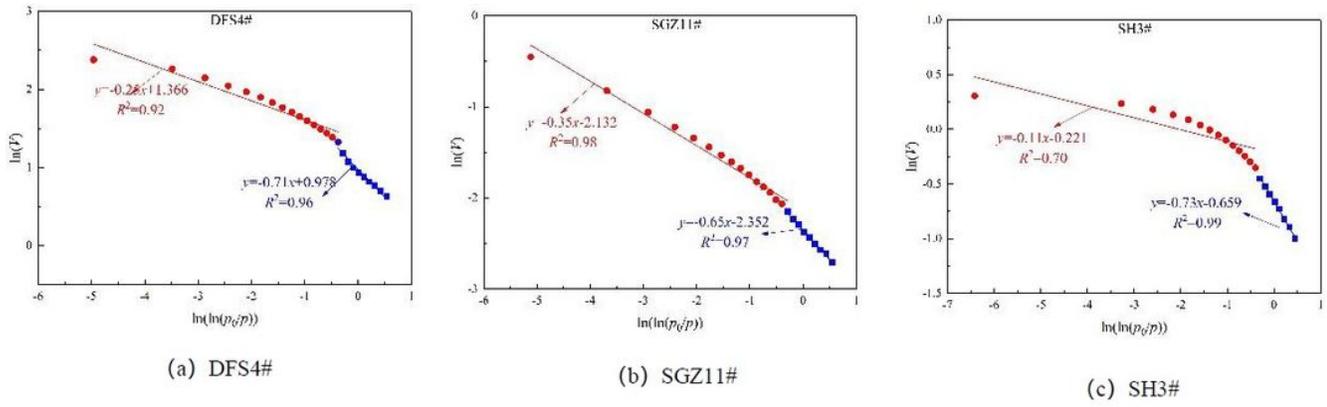
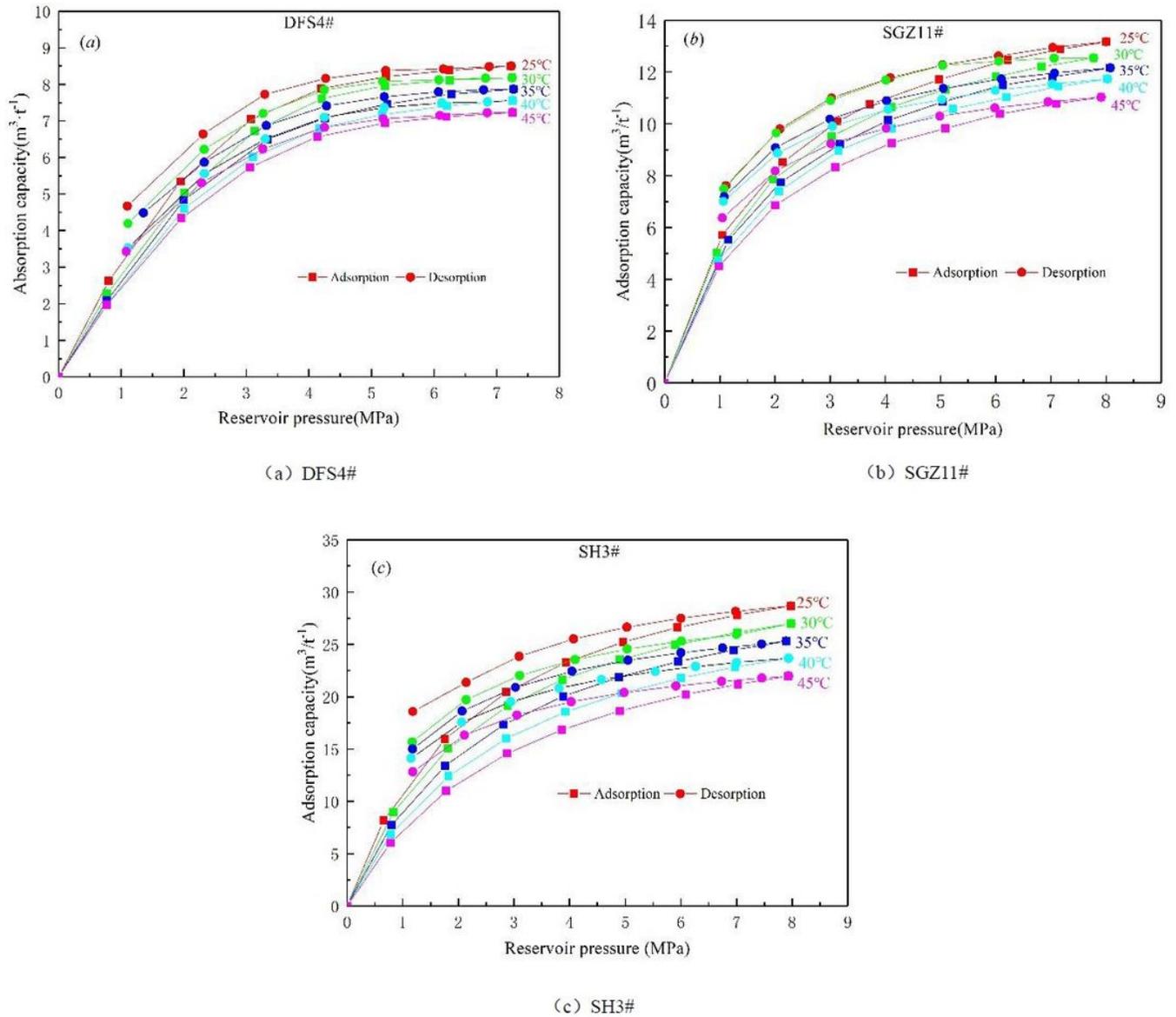


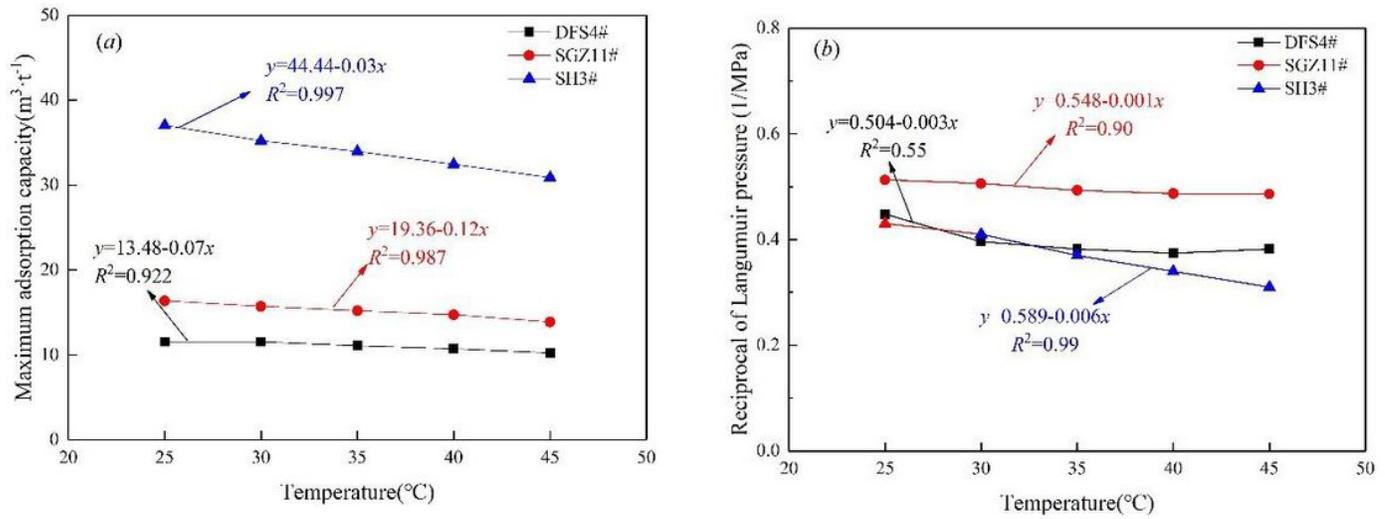
Figure 4

The FHH fractal model curves of different coal samples



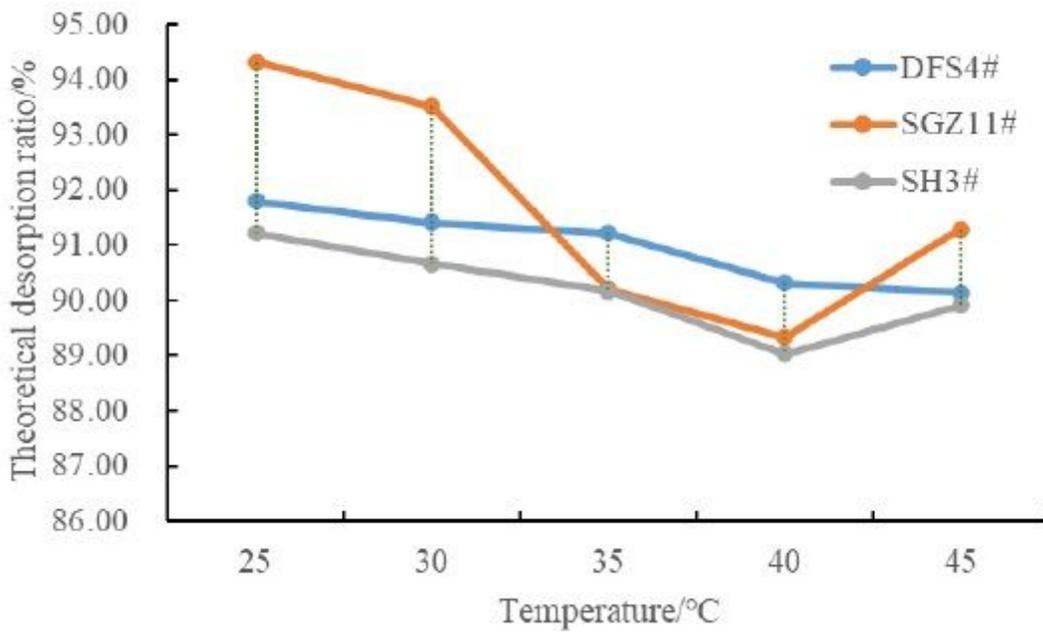
**Figure 5**

Isothermal adsorption / desorption curves at different temperatures



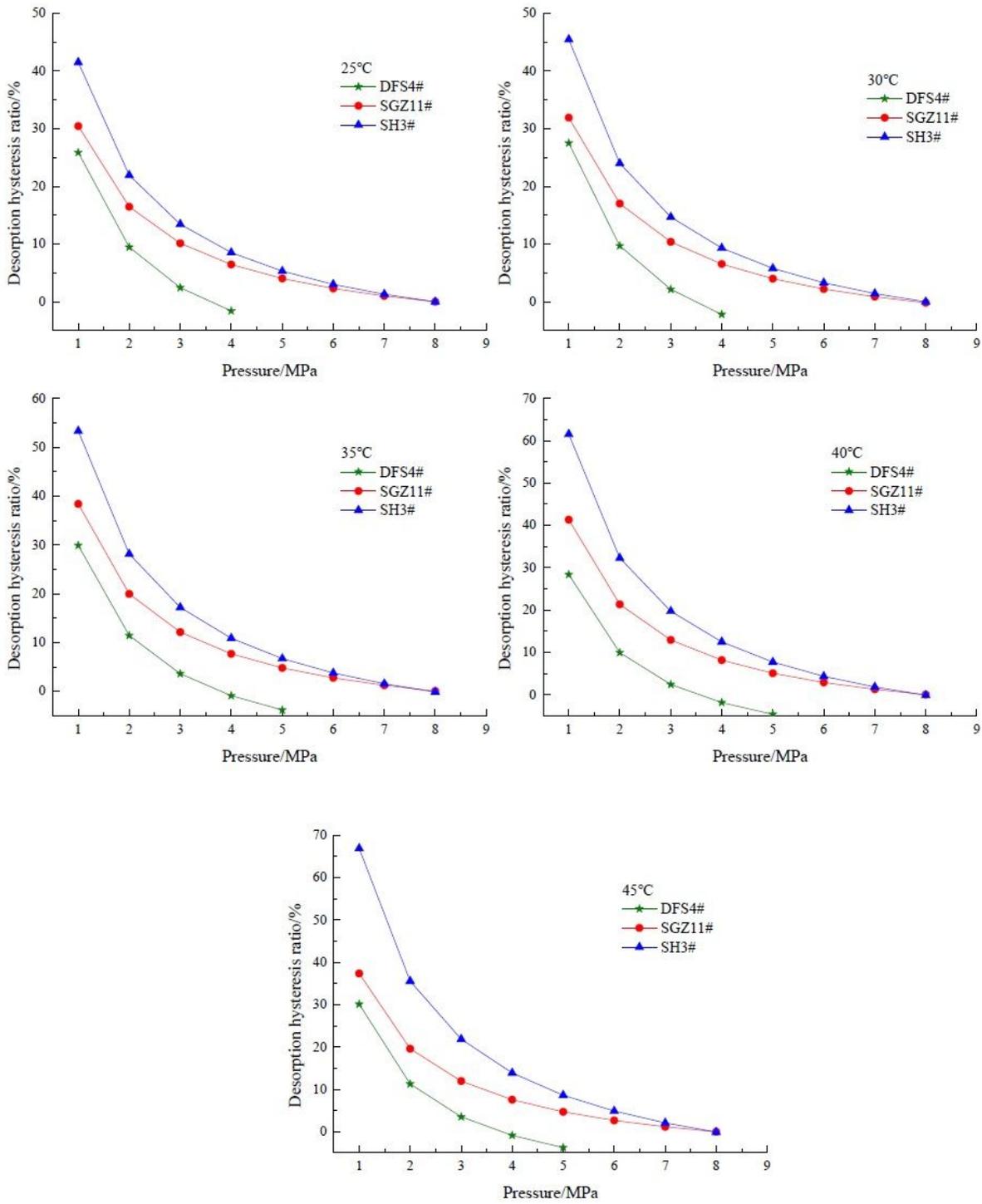
**Figure 6**

Relationship between temperature, saturation adsorption capacity, and adsorption constant



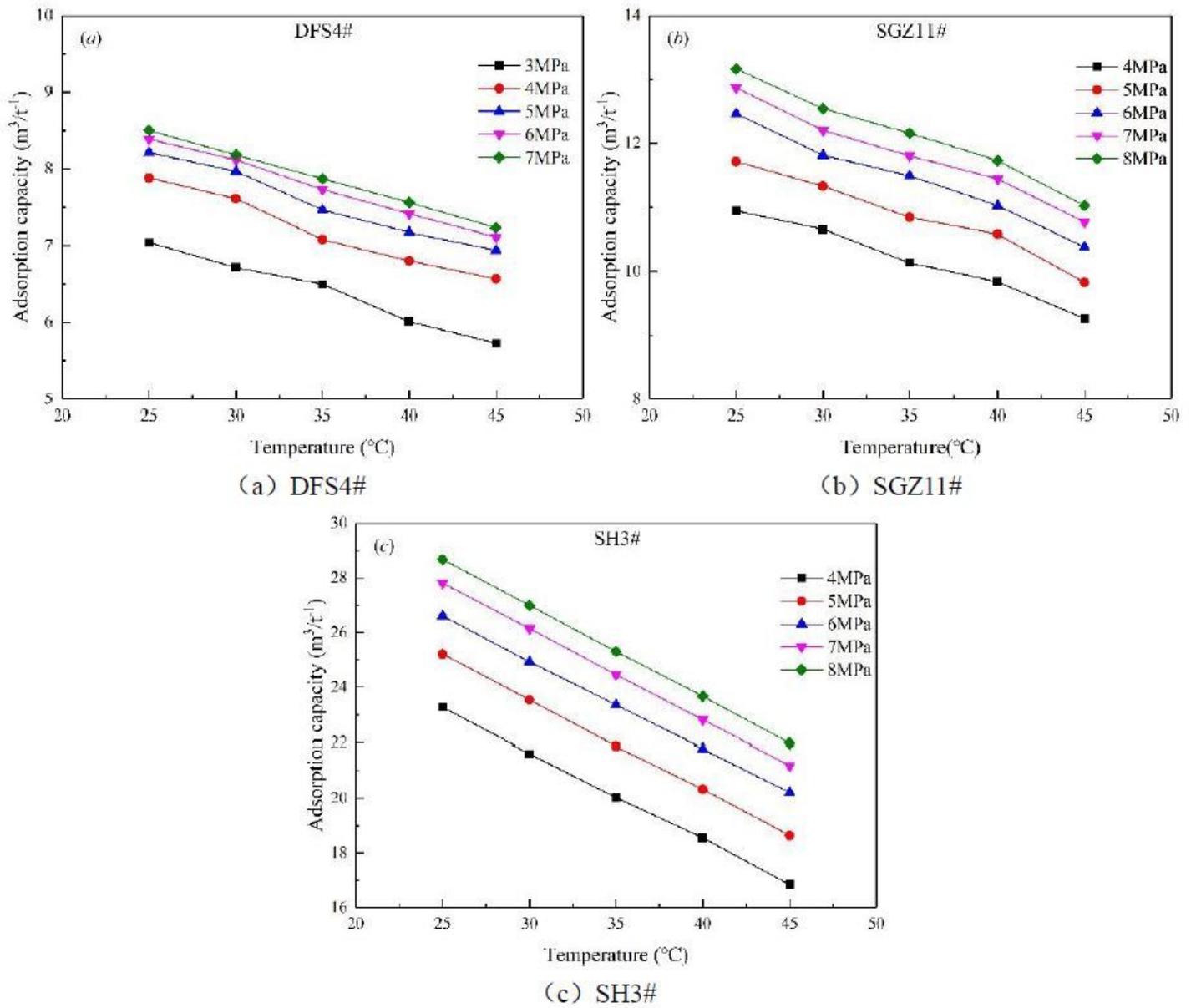
**Figure 7**

Theoretical desorption rate of coalbed methane



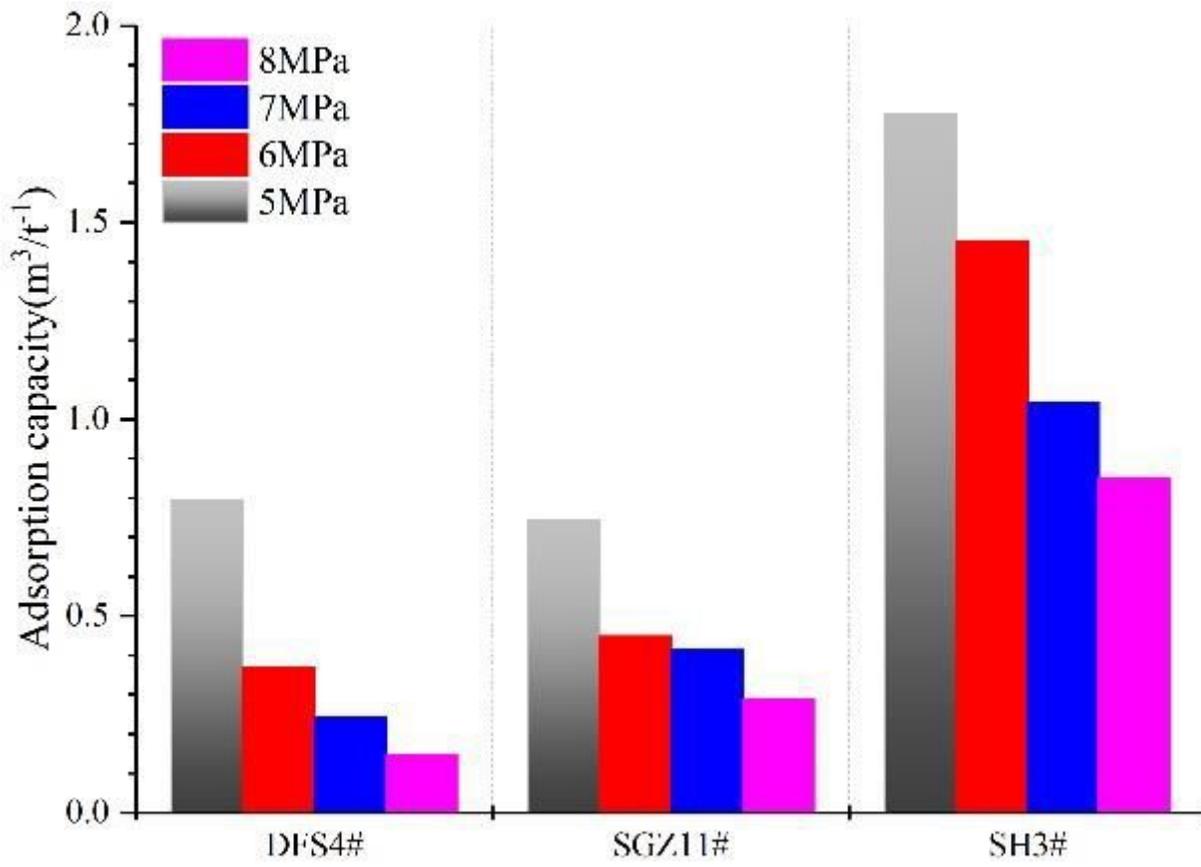
**Figure 8**

The change of desorption hysteresis rate under the same temperature and different pressure



**Figure 9**

Relationship between temperature and saturated adsorption capacity under isobaric conditions



**Figure 10**

Relationship between pressure and adsorption capacity of different coal samples

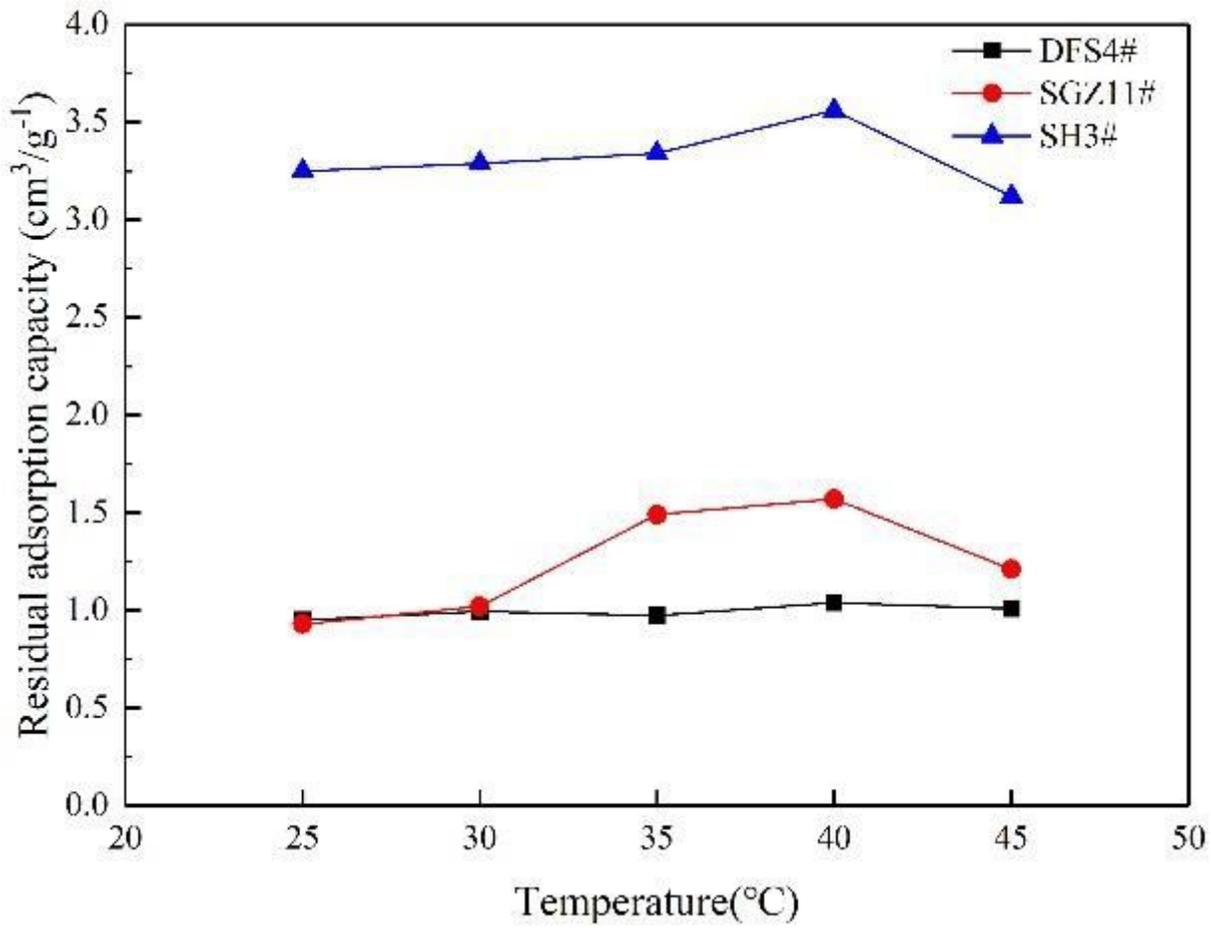


Figure 11

Relationship between residual adsorption and temperature

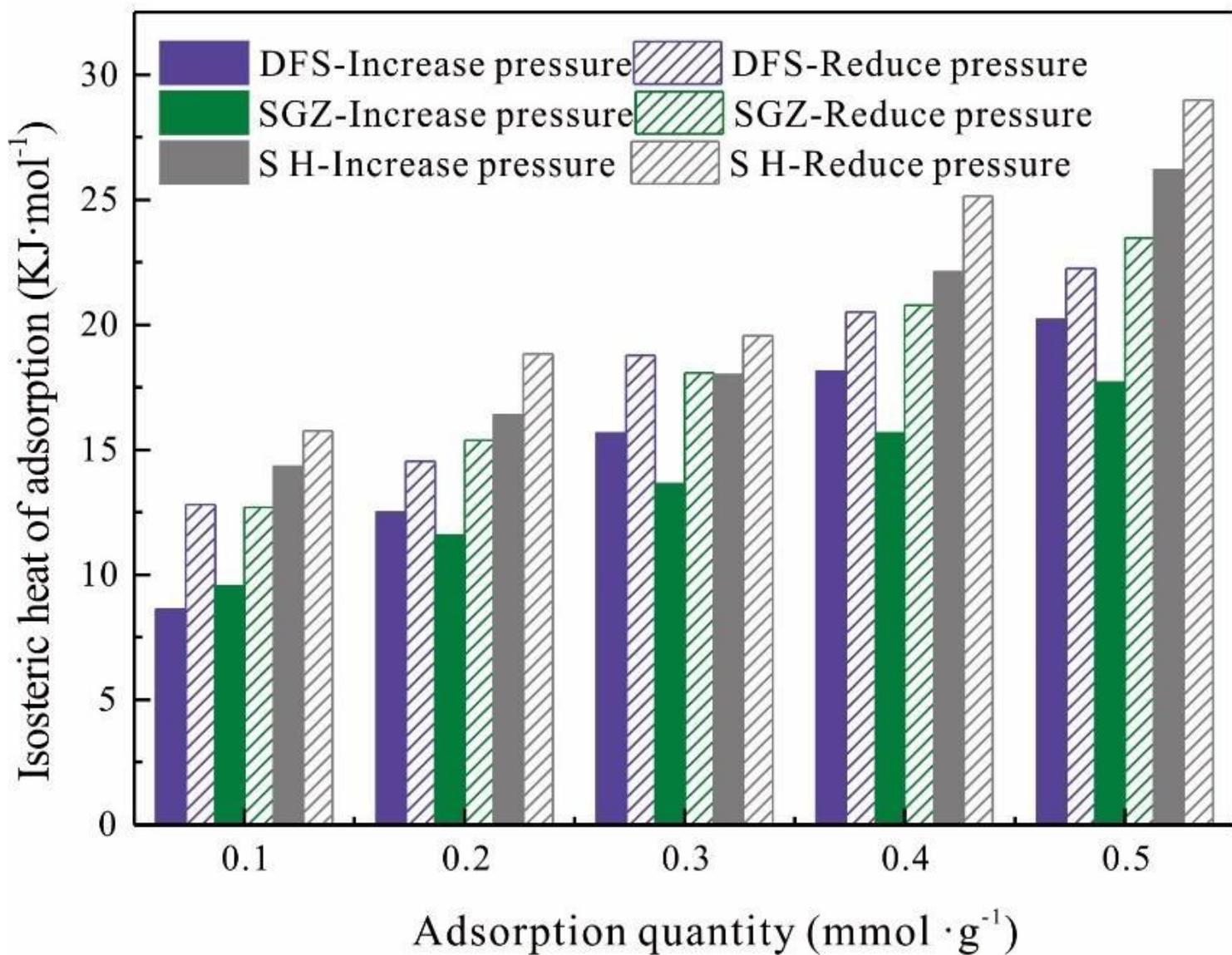
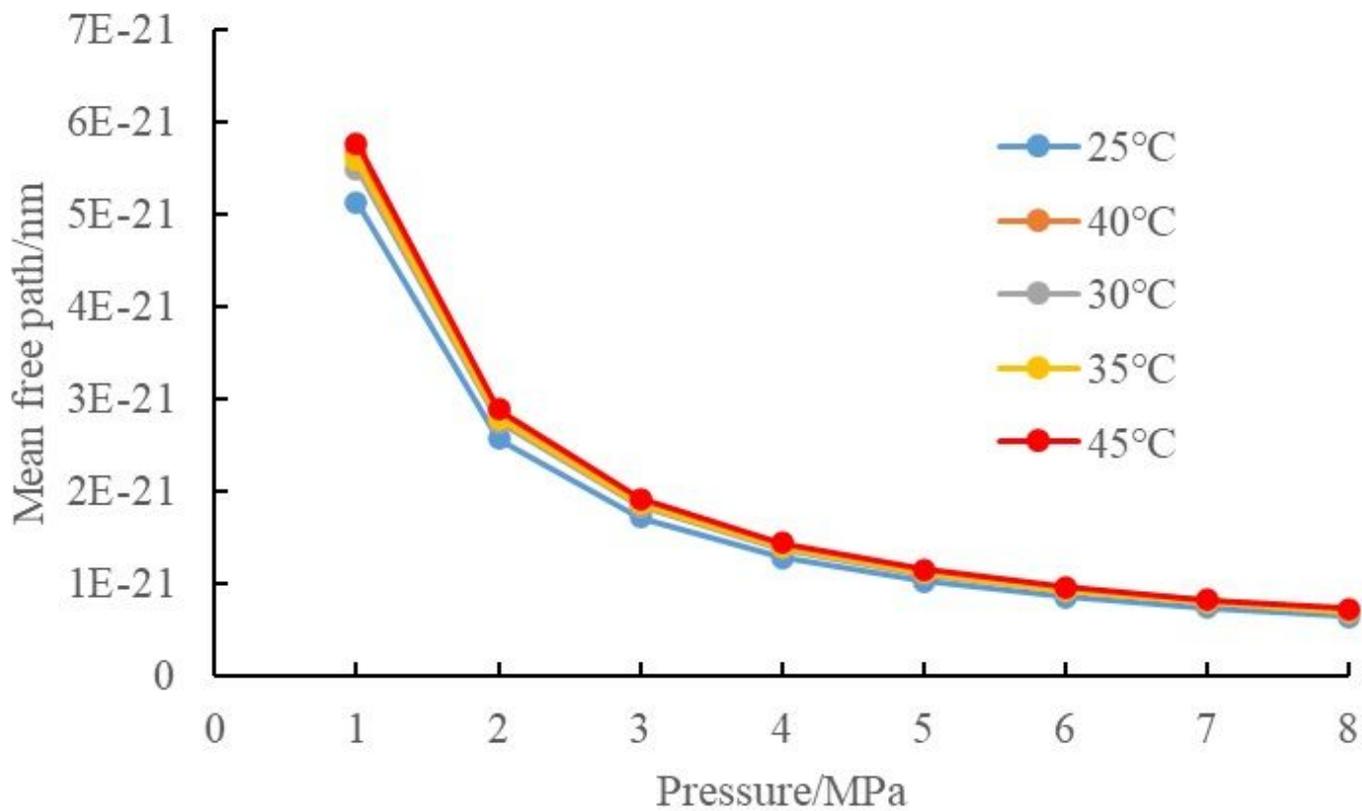


Figure 12

Relationship between adsorption capacity and adsorption heat



**Figure 13**

The relationship between the free path of methane molecules and pressure

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [table.pdf](#)