IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 06, Issue 04 (April. 2016), ||V2|| PP 21-26

Mud volcano's formation mechanism and effects on fluid migration

Sun Lei[1], Zhang Xuerui[2]

[1]（*College of earth science of Northeast Petroleum University, Daqing, Hei Longjiang,China*）

[2]（*CNPC Chuanqing drilling engineering company limited,Geophysical company, Chengdu, Sichuan ,China*）

Abstract: This paper mainly in troduce mud volcano's distribution, classification, formation mechanism. Mud volcano erupts mud, water, sedimentary breccia and various gas, accumulation in the surface and the formation of cone shaped sedimentary body .There are 40 mud volcano development area in global, and more than 20 submarine mud volcano development zone. Mud volcano's formation mechanism is the high deposition rates on the deep water and passive continental margins and lateral tectonic compression at the edge of the active continental margin. Because of the mud volcano has important significance for the study of tectonic attribution, oil and gas exploration, geological disasters and global climate change, it has become a new research hotspot of the earth science gradually.

Keywords： - mud volcano；formation mechanism；fluid migration

I. DEFINITION AND RESEARCH SIGNIFICANCE OF MUD VOLCANO

Mud volcano is one of the seemingly volcano special geologic bodies by the muddy substance, the essential differences between a typical volcanic and mud volcano is the material basis， the formation of mud volcano by a Large set of thick fluid and organic-rich shales under compaction plastic material，Is not the magma of the deep crust mantle derived volcanic activity[1]. The mud volcano is not real volcano, because of there is not any relationship of underground magma activity. It is due to the formation of the eruption and deposits, somewhat similar in appearance to the volcano, so they give their name volcano, and the eruptible material is mainly mud, so called mud volcano. The top of the mud volcano often form crater, and often ejected mud and gas which can be ignited, or self-ignition[2]. Its shape has cone shape, shield shape, basin shape, pool shape etc(Fig. 1).

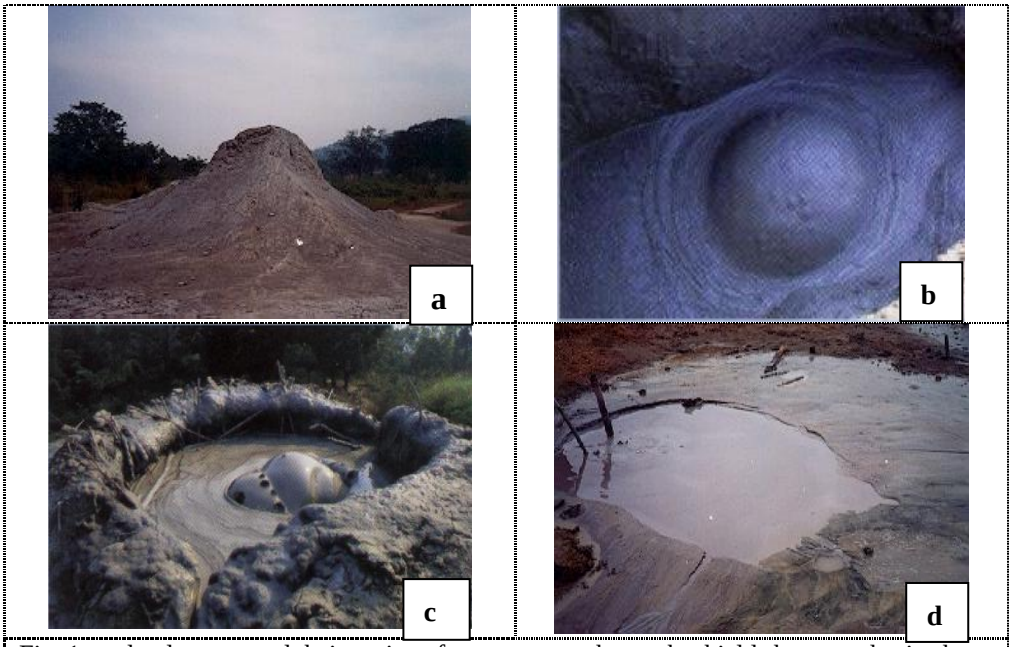


Fig. 1 mud volcanoes and their various forms a. cone shape b. shield shape c .basin shape d. pool shape

Mud volcano has a close relationship with mud diapir, it can be said that all mud volcanoes are related to mud diapir.The mud volcano on the bottom of the sea is a kind of submarine topography, which represents the flow and eruption of water, salt water, gas, oil, or sediment. Mud volcano developed in fast deposition rate and lateral extrusion tectonic basins, fluid of high pressure mud and gas in the deep subsurface through the fault and other high permeability channels transport to the surface. It erupts mud, water, sedimentary breccia and various gas , accumulation in the surface and the formation of cone shaped sedimentary body, eruption of material is sediment in the shallow part of the crust(Fig. 2)[3]. Sediments formed by different mud volcanoes on the surface of the earth, not only in the form, composition and age are different, and the depth of the material source is very different, the depth is about 2 ~ 15 km. In addition, the mud volcano release a large number of extremely strong greenhouse gas into the atmosphere resulting in a significant impact on global climate change[4]. Mud volcanoes in many sedimentary basins are distributed. The special geological body of the formation evolution and distribution characteristics are to the hydrocarbon migration and accumulation, clustered into reservoirs have close genetic relation and coupling relation. At the same time, the formation of mud and volcano and its activity, not only to be a window and observing of the deep earth tectonic movements and deep crustal fluid invasion excellent natural laboratory, but also is an excellent indication that the upward movement of the deep earth substance and obvious signs.

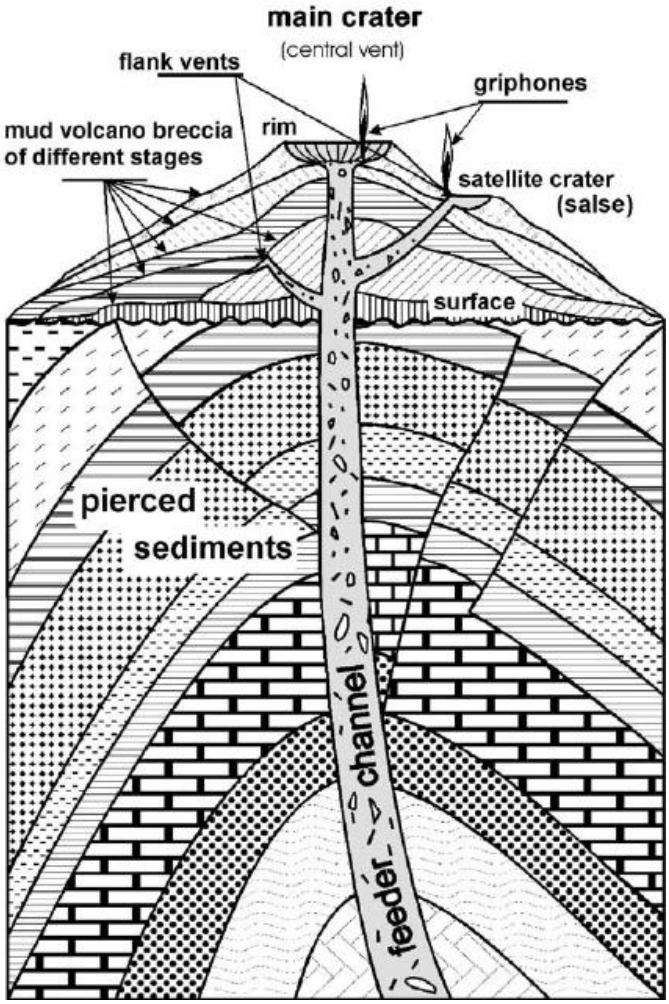


Fig. 2 Basic structure and main elements of mud volcano

Research on the mud volcano is very necessary, the importance is mainly reflected in the following aspects:(1)mud volcano is a ways of methane from the lithosphere into the atmosphere and hydrosphere;(2) it provides evidence whether sediment depth contains oil and gas; (3) by the study of the mud volcano clastic rocks can understand the deep earth information; (4) the mud volcano may affect drilling, pipeline design and installation; (5) the closely related gas hydrate is an important potential energy source[5]. Therefore, to study mud volcano has important significance in the research of tectonic, oil and gas exploration, geological disasters, biogeochemistry, global climate change and deep lithospheric problems.

II. DISTRIBUTION OF MUD VOLCANO

Mud volcanoes are mostly distributed in the oil and gas zone, which is widely distributed in the world. Mud volcano has a characteristic, always appear in groups, they are often have hundreds in a region,the released gas is mainly CH_4[6]. So far, there are 27 marine areas exist mud volcano in the global. In some areas mud volcanoes are found have very high probability. The number of mud volcanoes in the world is still unknown, especially in the bottom of the sea[7]. There are more than 40 areas on the land, and more than 20 sea area development mud volcanoes, Each region has more than 200 mud volcanoes, the land and shallow sea area has been found more than 2000 mud volcanoes, continental slope and deep sea areas may have 5000 to 10000 mud volcanoes[8]. From the structure said global mud volcanoes are mainly distributed in the alpine Tethys suture belt and the circum Pacific belt[9]. World famous mud volcano cantain Yellowstone Park in the United States and Iran Makran, Romanian bouza, Azerbaijan, Baku has most numbers mud volcanoes in the global the number is about 220. In China, there are more than a dozen mud volcanic activity areas in Taiwan area, and many different shapes and sizes of mud volcanoes in the Xinjiang area.Submarine mud volcanoes are also found in the Caspian Sea, the Black Sea, the Norwegian Sea ,Mediterranean and Barbados offshore, Nigeria offshore and the Gulf of Mexico.

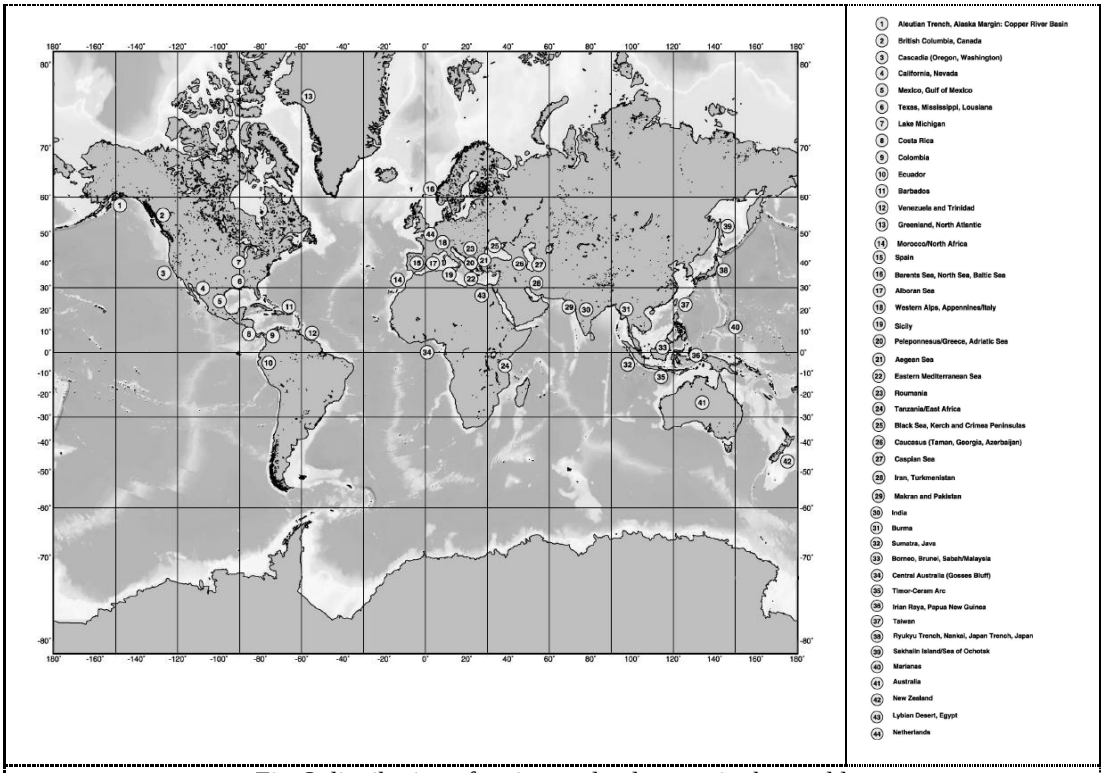


Fig. 3 distribution of major mud volcanoes in the world

III. MUD VOLCANO FORMATION MECHANISM

The causes and mechanism of the formation of mud volcano has 4 main categories:

3.1 Geological reasons

(1) the thick sedimentary cover (8 ~ 22km), mainly terrigenous detrital sediments;
(2) the subsurface of sediment layer exsit mud plastic layer;
(3) rock density reverse;
(4) gas accumulation in the deep sediment;
(5) high pressure anomaly.

3.2 Structural conditions

(1) due to the high deposition rate or thrust block overlap caused deposition cover rapidly sag;
(2) appear the diapiric or anticline;
(3) the fault occurs;
(4) the lateral tectonic extrusion;
(5) earthquake activity;
(6) the process of crustal equilibrium.

3.3 Geochemical reasons
(1) sediment deep oil generating process;
(2) clay dehydration.
3.4Fluid migration along the fracture zone
(1) high deposition rates on the deep water and passive continental margins;
(2) lateral tectonic compression at the edge of the active continental margin.

By analyzing seismic profiles and morphological characteristics of mud volcano can determine, all mud volcanoes have two forming mechanisms.1: Mud volcanoes are formed on the diapir directly, The diapir is likely to reach the bottom of the sea[10]. This type of mud volcano is usually relatively large scale.2: Liquefaction of sediments along the fault upward migration. In this case, sediment with high fluid content reaches the bottom surface of the sea floor, forming mud volcanoes. n this case,high fluid sediment reaching the seafloor surface, forming mud volcano(Fig. 4).

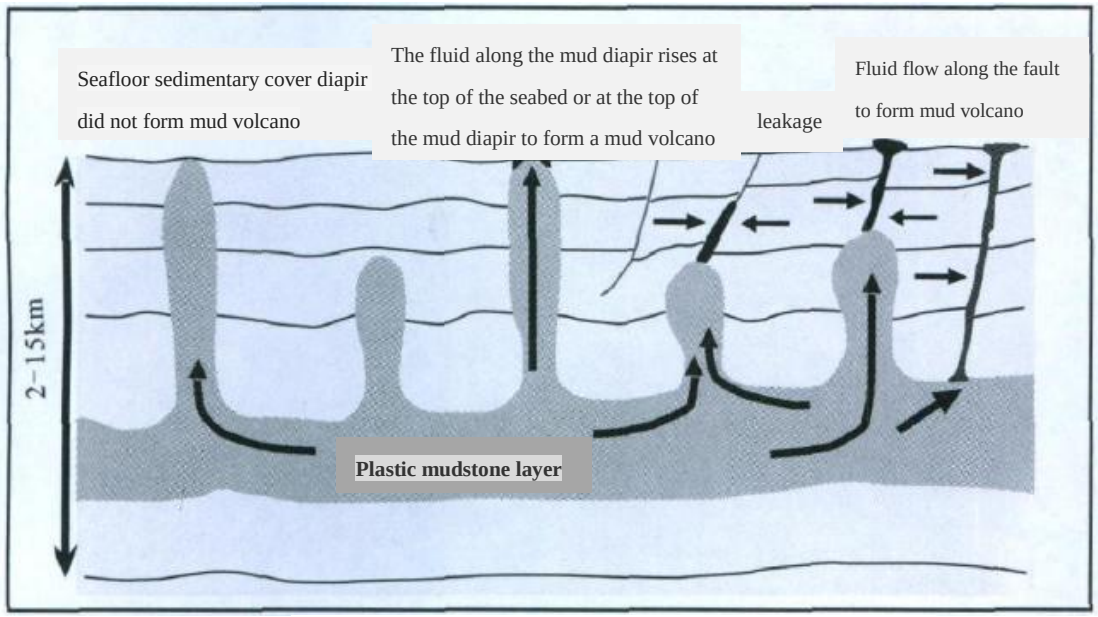


Fig. 4 two basic formation mechanisms of submarine mud volcano

Due to the formation of mud volcano require mud have high formation pressure, In the studing of mud volcano, significance of pore fluid pressure increase in deep of shale layer in forming the mud volcano have been discussed[11]. Induced factors, tectonic activities (including seismic) and human disturbance (such as drilling) are considered to be the main cause of the eruption of mud volcanoes.

IV. EFFECT OF MUD VOLCANO ON FLUID MIGRATION

Mud volcano is on the basis of rock burst cracking of large volumes of fluid along the fracture surface of the rapid migration, even late plastic mudstone along the fluid channel invading a rupture structural disturbance, but centralized distribution also have a certain relationship with tectonic setting.

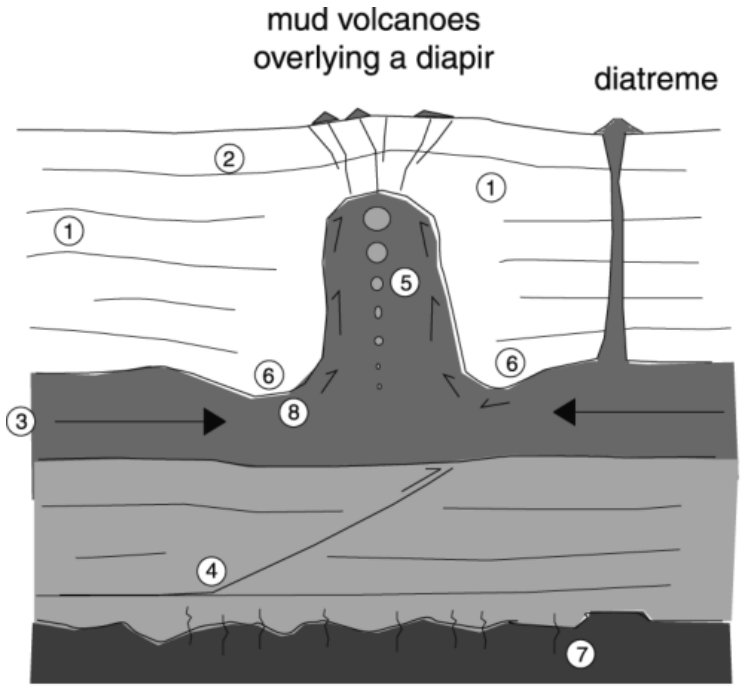
4.1 Flow stress rupture

Early scholars regarded the pore fluid in sedimentary basins as a kind of move material, only migrating in preexisting connected pores or cracks, many slow seepage of fluid motion unexplained phenomenon attributed to the fault of the transporting effect[12].Secor was first noticed pore fluid pressure anomaly effect form micro cracks, called aqueous fissure. And proposes uniaxial stress model that when the pore fluid pressure greater than the minimum to earth stress and rock strength rupture . Taking into account the conditions under triaxial stress, not all can keep underground fissures opening state as a fluid transport channel. Combined triaxial stress model, the relationship between geological observations and the overlying pore fluid pressure and the load pressure, summed up the "crack opening" to form and maintain the condition and experience judgment formula, and consider that cracks have a cyclical opening and closing, pore fluid also showed periodic squeeze. The study confirmed that the pore fluid is able to rely on its own energy to break through solid rock matrix outward migration, but mainly confined to

the overpressured layer and its vicinity, it has been widely used to explain the overpressure fluid release which in the overpressure mudstone and pressure storehouse[13]. In the course of the study of oil and gas migration, it is found that the micro fracture is not only the hydraulic effect, but also one of the important power of the oil and gas generation. Collectively known as the flow stress rupture ,Engelder according to fracture mechanics theory, taking into account the stress concentration phenomenon,fracture propagation model is proposed, Under the conditions of the original micro cracks, At the end of the crack, due to the stress concentration caused the crack propagation need less pressure of the pore fluid. And the micro cracks in the underground rock are widespread. Engelder's model indicates that the flow stress rupture is a common geological phenomenon.

4.2 Fluid diapireffect

In the rapid subsidence basin overpressure is a common phenomenon, the excess pore fluid in the overpressure system needs to be squeezed through a certain channel periodicity[14]. In the absence of early channel conditions, it can also produce a wide range of flow stress cracking. And even some develop into the through the sealing layer of normal fault systems within the dense layer of the release of the remainder of the pore fluid[15]. However, most of the basin is not a homogeneous body, the tectonic stress is not uniformly distributed in the basin, In weak tectonic belt and extensional fault zone is more conducive to the flow stress rupture generation,but also conducive to crack propagation. If there are plastic mudstone along the fluid channel invasion at the end of fluid activity， the fracture zone is a mixed fracture zone or a mixed rock zone， pierce the surface into mud volcano[16]. Therefore, the different types of fluid diapir structure can be regarded as fluid diapir effect products in different stages of development. Fluid diapirism can be divided for the flow stress rupture, crack propagation and large scale fluid migration, plastic mudstone mixed and a large number of mudstone mixed into the mud mound 4 process, the last 3 evolution stages respectively form different fluid diapir structure. If these 4 processes as a fluid diapir cycle, the fluid diapir activity also has multiple cycles, different stages product of evolution vertical stack,cause the fluid diapir continue to upward growth.



fluid sources for overpressuring and mud extrusion:

(1) pore fluid expulsion from compaction
(2) biogenic methane from degradation of organic matter
(3) lateral fluid flux through stratigraphic horizons or fault zones
(4) fluid migration along deep seated thrusts
(5) thermogenic methane and higher hydrocarbons
(6) fluids from mineral dehydration (opal, smectite)
(7) hydrothermal fluids, alteration of crustal rock
(8) fluid expulsion from internal deformation within the diapiric intrusion

Fig.5 Schematic diagram of a mud diapirconclusion

V. CONCLUSIONS

Because the mud volcano, mud diapir and oil and gas migration and accumulation exists certain origin relation and coupling relation，Therefore, in the analysis of oil and gas migration and accumulation and oil and gas distribution should be considered and emphasized volcanic mud, mud diapir development and evolution control and influence on the distribution of oil and gas accumulation law.

Has been found or presumed exist submarine mud volcano is confined to the slope, slope and deep sea island area. Geological and structural characteristics of these regions show that the submarine mud volcano formation have two main reasons: high deposition rate, lateral tectonic compression, but also need plastic clay layer and mud volcano formation required other conditions also comes from these two main reasons.

A general model for gas hydrate formation in mud volcanoes: Gas hydrate of mud volcano center formation is a low temperature hydrothermal process driven by water and methane percolation, and the formation of the gas hydrate in the mud volcano is driven by the diffusion of methane and the mixing of formation water , the edge of mud volcano's gas hydrate formed by the methane diffusion and the mixing of formation water driven the replacement effect.

Mud volcano's formation and hydrocarbon generation,migration and accumulation and preservation have direct relationship,It is a product that the evolution of hydrocarbon accumulation after the Himalayan movement cause preservation condition damage. In the early stage of exploration, mud volcano can be used as a standard to evaluate the prospective of hydrocarbon bearing area. Nearly 40% of the known oil and gas fields are found on the oil and gas display zone of the earth. The most dense area of the mud volcano is closely related to the oil and gas reservoirs in the new - Paleozoic and Mesozoic strata. Therefore,mud volcano provide an important way to find better traps.

REFERENCES

[1]. He Jiaxiong,Zhu Youhai etc. Volcano, mud volcano, mud diapir and relationship with Gas bearing and hydrocarbon migration and accumulation[J].Geology in China,2010,37(6):1720~1732.

[2]. Fan Weiping; Zheng Leiqing; Gong Jianhua etc.The formation of mud volcano and their relationship with oil and gas[J].Tuha oil&gas,2007,12(1):43~47.

[3]. Aliyev A A,Guliyev I S,Belov I S. Catalogue of recorded eruptions of mud volcanoes of Azerbaijan[M]. Baku: NaftaPress,2002.

[4]. Milkov A V,Etiope G. Global methane emission through mud volcanoes and its past and present impact on the Earth's climate a comment[J]. Inter. J. Earth Sci.2005

[5]. Liang Jie, Gong Jianming, Chen Jianwen.Mud volcanoes and natural gas hydrate[J].Marine Geology Letters,2006,22(12):20~23.

[6]. Du Letian, Introduction of foreign natural gas scientific research and analysis of the Earth[J].Nature gas geoscience[J]. 2007,18(1):1~18

[7]. Dimitrov L I.2003. Mud volcanoes: A significant source of atmospheric methane[J].Geo-Marine Letters,23 (3-4) I :155~161.

[8]. Milkov A V. 2000. Worldwide distribution of submarine mud volcanoes and associated gas hydrates [J].Marine Geology，167: 29-42.

[9]. Kopf A . 2002. Significance of mud volcanism [J].Rev Geoph，40(2) : 1-52.

[10]. Ginsburg G D，Soloviev V A.Mud volcano gas hydrates in the Gaspian Sea [J].Bulletin of the Geological Society of Denmark，1994，41: 95抄100.

[11]. Mazzini A ，Sensen H，Akhmanov G G,et al . Triggering and dynamic evolution of t he LU S I mud volcano，Indonesia [J] .Earthand planetary Science Letters,2007,261:375～388.

[12]. Hooper E C D. Fluid migration along growth faults in compacting sediments.Journal of Petroleum Geology, 1991, 14(2): 181-196

[13]. Secor D T.Role of fluid pressure i n join ting.American Journal of Science, 1965, 263: 633- 646

[14]. Zhang Qiming, Hu Zhongliang. Yinggehai-Qiongdongnan Basin high temperature and high pressure environment and oil and gas migration mechanism [M] Seismological Press, 1993.

[15]. Catwright J A.Episodic basin-wide hydr of raturing of over pressured Early Cenozoic mud rock sequences in the North Sea basin.Marine and Petroleum Geolog y, 1994, 11(5): 587-607

[16]. Zhang Shulin,Tian Shichng.Genesis of diapir structures in Yinggehai Basin and petroleum geological significance [J] .China offshore oil and gas,1996,10(1):1~6.