“Geopressured fluids-its distribution and formation mechanism”

Akira Ueda

Department of Civil and Earth Resources Engineering, Graduate School of Engineering, Kyoto University, C1-2-155, Katsura, Nishikyo-ku, Kyoto, 616-8540 Japan
E-mail: a-ueda@earth.kumst.kyoto-u.ac.jp

Abstract

Geopressured fluid is defined as groundwater in hydrostatic to lithostatic pressure conditions and distributes below ca. 2 km depth in sedimentary regions associated with oil and/or natural gas. The δD and $\delta^{18}O$ data show that most of the geopressured fluid can be explained as a mixture of fossil sea water and local meteoric water with oxygen isotope shift due to rock-water interaction. Recently, unusual high δD (-20 ‰) and low Cl concentration (ca. 6,000 mg/L) fluids are observed along faults in several localities (Niigata, Horonobe, Mobara and so on). This fluid might be also a mixture of sea water and local meteoric water in the early stage and changed the compositions during diagenesis. The mechanism of such enrichment of D and depletion of Cl in fluids are not clear so far. One possibility is a mixing of the essential fluid and water dehydrated from opal A to C and/or smectite to illite in deeper part with/without heating.

This proposal is; first, to research the distribution of geopressured fluid with highδD and low Cl concentration and to discuss the mechanism of the formation, second, to study the relation of earthquake and oil/natural gas formation.

Keyword; geopressure, fluid, isotope

Introduction

During digenesis, sea water trapped in deep marine sediments can be altered the chemical compositions owing to interactions with the surrounding rock and is called as “fossil sea water”. The isotopic composition of the fossil sea water can also differ from that of the original sea water. In several areas, fossil sea water was found to have $\delta^{18}O$ values of +5 to +8 ‰ due to the oxygen isotopic shift caused by these interaction, but to retain almost the same Cl concentration as fresh sea water (e.g. Sakai and Matsubaya, 1974; Mizukami et al., 1977; Shibata et el., 2005). Recently, unusual high δD (-20 ‰) and low Cl concentration (ca. 6,000 mg/L) fluids are observed along faults in several localities (Niigata, North Hokkaido, Mobara and so on). This fluid might be also a mixture of sea water and local meteoric water in the early stage and changed the compositions during digenesis (Ueda et al., 2009).

At depths below ca. 2 km in sedimentary regions associated with oil and/or natural gas, formation waters tend to be geopressured fluid with pressures between hydrostatic and lithostatic values (e.g. Mayers, 1968; Jones, 1970; Oki et al., 1999; Xu et al., 2006). The δD and $\delta^{18}O$ data show that most geopressured fluid can be explained as a mixture of fossil sea water and local meteoric water, with an oxygen isotope shift due to rock-water interaction.

In mud volcanoes, overpressured multiphase pore fluids (water and dissolved gases, mainly methane) are also recognized and are located mostly above strike-slip faults. The sediment is fluidized by rapid advection of pore fluids up through the sedimentary mass along a conduit fault (Brown, 1990). Although chemical and isotopic studies of the expelled fluids are very scarce, this type of fluid might be originate at least partly in dehydration in a subduction zone The main dehydration process is thought to be a transition from smectite to illite similar to that for geopressured fluids observed in sedimentary basins (e.g. Shih, 1967; Sokolov et al., 1968; Valyaev et al., 1985; Dia et al., 1995, 1999; Bechtel et al., 2000).

Primmer and Shaw (1990) analyzed the oxygen and hydrogen isotopic compositions of argillaceous rocks from a partly overpressured Tertiary sequence in an offshore well from the Texas Gulf Coast. They showed increasing illitization of illite-smectites with depth of burial and a general trend towards enrichment of D and depletion of ^{18}O with increasing illitization. The δD and $\delta^{18}O$ values of water in equilibrium with illite-smectite are calculated to be -15 to -40‰ and -1 to +8‰, respectively, similar to those of sample No.8 in the present study. Hyeong and Capuanod (2004) reported that δD values of water and clay in the normally pressured and geopressured sections are different. In the normally pressured section (<2.6 km), δD of water is constant (-15‰) while δD of clay increases linearly from -59 to -43‰ with increasing depth. In contrast, in the geopressured section δD of water is decreases linearly from -7 to -26‰ with increasing depth while δD of clay is nearly constant (-36‰). These results indicate that the observed chemical and isotopic characteristics of waters with unusually high δD and low Cl concentration may be explained by conversion (dehydration) of smectite to illite and isotopic equilibrium between water and smectite/illite during digenesis (e.g. Bechtel et al., 2000).

Research tasks

This proposal is; first, to research the distribution of geopressured fluid with high δD and low Cl concentration and to discuss the mechanism of the formation, second, to study the relation of earthquake and oil/natural gas formation.

1. Distribution survey of geopressured fluid with high δD and low Cl
   1.1 Collection of interstitial fluid in sedimentary rocks kept in site condition in accretionary prisms
   1.2 Analyses of isotopic (δD and $\delta^{18}O$) and chemical (pH, EC, Na, K, Ca, Mg, Fe, Al, Cl, SO_4, CO_2, SiO_2) compositions of fluids extracted from core samples
   1.3 Literature Investigation
   Survey of distribution and characteristics of geopressured fluid with high δD and low Cl in literature
   1.4 Theoretical consideration of history of the geopressured fluid with high δD and low Cl in the view point of rock-water interaction
2. Mechanism of formation of geopressured fluid with high δD and low Cl
   2.1 Coupled simulations of rock and fluid pressure distributions during formation of accretionary prisms
   2.2 Coupled simulation of fluid behavior including chemical change due to rock/water interaction
   2.3 Simulation of fault and fluid movements during earthquake in accretionary prisms

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