Origin of gases and water in mud volcanoes of Andaman accretionary prism: implications for fluid migration in forearcs

Jyotiranjan S. Ray a,⁎, Alok Kumar a, A.K. Sudheer a, R.D. Deshpande a, D.K. Rao a, D.J. Patil b, Neeraj Awasthi a, Rajneesh Bhutanic c, Ravi Bhushana a, A.M. Dayal b

a Physical Research Laboratory, Navrangpura, Ahmedabad 380009, India
b National Geophysical Research Institute, Uppal Road, Hyderabad 500007, India
c Department of Earth Sciences, Pondicherry University, Puducherry 605014, India

⁎ Corresponding author.
E-mail address: jsray@prl.res.in (J.S. Ray).

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Abstract
Extensive mud volcanism on the Andaman accretionary prism occurs above a complex network of faults and is caused by the convergence of the Indian plate and the Burmese microplate. Mud volcanoes of the Andaman forearc have received little attention in spite of the fact that they are one of the important features of this tectonic setting, located within an ocean basin that has one of the highest sedimentation rates in the world, and that the materials emitted by them present a unique opportunity to study the chemistry of the detachable parts of the subducting slab. In this study we present mineralogical, chemical and isotopic data for argillaceous matter (mud matrix), gases and water emitted by these mud volcanoes and attempt to understand the variations in terms of their sources and processes within the forearc. The mud matrix is composed of smectite–illite–kaolinite–chlorite–plagioclase–quartz–calcite assemblage derived both from sediments and altered oceanic crust and originates from a deep-burial diagenetic environment. The modes of fluid migration in forearcs and the evidences we conclude that the sampled mud volcano ejecta originate at the plate-boundary décollement zone, from the sediments and altered oceanic crust of the subducting slab. In this study we present mineralogical, chemical and isotopic data for argillaceous matter (mud matrix), gases and water emitted by these mud volcanoes and attempt to understand the variations in terms of their sources and processes within the forearc. The mud matrix is composed of smectite–illite–kaolinite–chlorite–plagioclase–quartz–calcite assemblage derived both from sediments and altered oceanic crust and originates from a deep-burial diagenetic environment. The modes of fluid migration in forearcs and the evidences we conclude that the sampled mud volcano ejecta originate at the plate-boundary décollement zone, from the sediments and altered oceanic crust of the subducting slab.

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1. Introduction

Mud volcanoes (MVs) are subaerial and submarine sedimentary structures whose surface morphology resembles that of a real volcano, but on a much smaller scale. They form as a result of emission of depressurized pore water, gases and argillaceous material from deep seated sources and occur either on top of surface-piercing shale dikes or along faults/fractures (Dimitrov, 2002; Kopf, 2002). The latter is more common in convergent margins, where lateral tectonic compression leads to rise of fluidized mud, derived from subducting materials, along the basal décollement (Hensen et al., 2004; Saffer and Tobin, 2011). The gases emitted by the mud volcanoes are generally hydrocarbon rich, with methane being the main component (Dia et al., 1999; Dimitrov, 2002; Milkov et al., 2003; Etiope et al., 2004). Molecular and stable isotopic compositions of gases suggest that majority of these MVs (>76% globally) emit thermogenic hydrocarbons, whereas the rest emit either pure microbial methane or gases of mixed origin (e.g., Etiope et al., 2008, 2009). Predominantly carbon dioxide emitting MVs are also not uncommon (Shakirov et al., 2004; Yang et al., 2004). Thermogenic hydrocarbon emitting MVs are believed to suggest the presence of petroleum source rocks beneath these structures (e.g., Milkov, 2005). A large number of MVs are indeed observed in actively producing petroleum basins, e.g., Azerbaijan, Mexico and Columbia. Recent estimates suggest that MVs are one of the significant contributors of methane to the atmospheric budget of greenhouse gases, and hence require appropriate consideration in climate models (Dimitrov, 2003; Etiope and Ciccioli, 2009). These estimates also require regular modifications, keeping track of new discoveries of MVs and the amount of methane emitted by them (Etiope et al., 2008).