Benefits of in-situ and well-side geochemical monitoring at riser drilling

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Abstract
Recent achievement of scientific gas monitoring at the well side in ICDP projects shows the large potential of the real-time or in-situ geochemical monitoring at the scientific drillings. Schematic similarity to gas extraction method applying to the isotope measurements is also support this view. Within the several gas species, helium concentration well corresponds to the lithological changes of wall rock of drill holes and detects the fractured zone or faults. Hybrid analytical equipment that includes chromatography and mass spectrometry enables us to detect such lithology-related variations. Pre-selection of samples on-board to supply the samples to further isotope analysis is another important application of scientific gas monitoring so far performed. To obtain much reliable geochemical data, evaluations of fractionation, contamination and positioning are yet to be required with optimized arrangement of mud circulation line.

Developments of analytical equipment enable us to realize advanced geochemical monitoring at the well sides. The most popular application of the method is the safety monitoring to make an alert for the various drill hazards in industrial exploration. For example, hydrocarbons and hydrogen sulfide are monitored with gas chromatography to detect any sign of explosion or addiction.

Recently, scientific application has been tried by one Germany group (Wiersberg and Erzinger, 2008) and accomplished great achievements. Because mud gas derived from formation gases also contains hydrogen, nitrogen, oxygen, helium and other noble gases composition of these gases reflects origin of fluid or interaction in fluid channel. Although the previous trials were performed on-land drilling, e.g. KTB, SAFOD, and Unzen, the real-time monitoring profiles show the corresponding variation with lithological change. For example, helium profiles well corresponds to the lithological changes of wall rock of drill holes at SAFOD (see Figure 3 in Erzinger et al., 2006). Particularly, volatile inflows at the fractured zones or faults were well documented. Successive isotope analyses confirm increases of the contribution from deep origin component having excess ^{3}He at such changes. At Unzen drilling, helium concentration in monitored gases shows clear peaks at dikes. Online gas monitoring gives not only their temporal variation but also some suggestion for pre-analyze selection of samples for further on-board or shore-based analyses.

The potential of real time scientific monitoring is very large judging from above described their successful experiences. To realize these scientific achievements for IODP, they developed comprehensive gas extraction-analyze system, which is composed of three types of “hybrid” analytical equipments: mass spectrometer, gas chromatograph and α-detector. They also developed original gas extraction apparatus equipped for the mud circulation system. The serious problem on scientific mud gas monitoring is contamination, especially for noble gases: air or argon is sometimes used as carrier gas and they conceal noble gas signals from borehole. The GFZ equipment described in Erzinger et al. (2006) solved this problem by carrying gases by pumping and the equipment for integrated successive measurement has produced remarkable data on SAFOD or KTB or Unzen projects (Figures 1, 2, 3).

From different aspect, potential of mud-gas monitoring is also very large. The popular volatile extraction from rocks for gas mass spectrometry is “crushing” method. In this method, the sample specimens are stored into the ultra high vacuum apparatus and mechanically crushed for gas release (e.g. Ozima and Podosek, 2001). This situation is very similar to the riser drilling system if the mud circulation path is roughly closed system; the rocks at the bottom of the hole are crushed by drill bits and gases contained in the crushed rocks will be released in the circulated drill muds. Thus, drill mud is potential carrier of the volatiles released at the drilling. For example, sudden change of helium concentration found at the fracture zone of KTB drill hole (Erzinger et al., 2006).

However, following problems should be solved to obtain much reliable geochemical data. 1) Elemental and isotopic fractionation thorough the path of flow line; from gas release to measurement. 2) Contamination from mud or environment, 3) Accuracy of sampled position. Thus firstly, basic technical investigation by comparison between core, drill mud and extracted volatiles should be considered. Once such fundamental information is obtained, the reliability of real-time gas monitoring reaches in the region of quantitative measurement. Under such situation, scientific gas monitoring applying to drill mud should be regularly performed in riser drilling as any safety gas monitorings. Dense depth sampling should be available on the equipment for successful comparison of the results of further analyses to other borehole logging data.

In the above described context, German gas monitoring tool operated by Dr. Wiersberg and a suite of technical trials by Japanese ad-hoc gas monitoring task team were performed at the first scientific riser drilling expedition, Exp.319 of IODP, using D/V Chikyu (Figure 4). Although the German scientific monitoring shows some systematic variations of formation gases especially methane (Wiersberg, personal comm.), the assemblages of mud circulation line of D/V Chikyu prohibits us either an ideal sampling of gas dissolves in circulated drill mud or un-degassed drill mud. The sampled drill mud with gas aliquots from monitoring lines are ready to be measured. For future optimized real-time gas monitoring, rearrangement of mud circulation line is strongly recommended.

References

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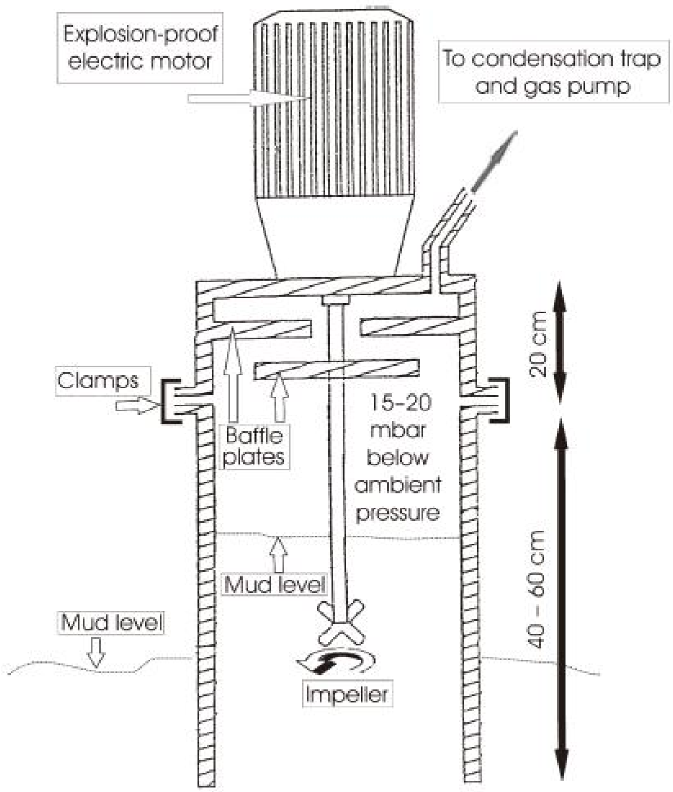

Figure 1: Gas extraction apparatus of GFZ (Erzinger et al. 2006)

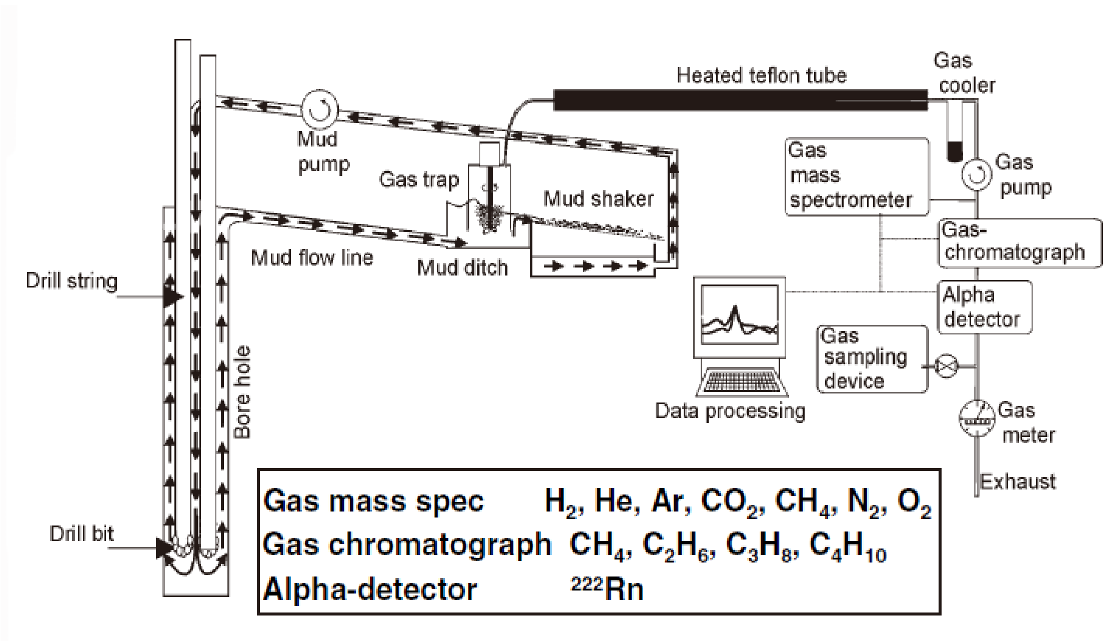

Figure 2: Overview of Mud gas monitoring equipment of GFZ (Erzinger et al., 2006)

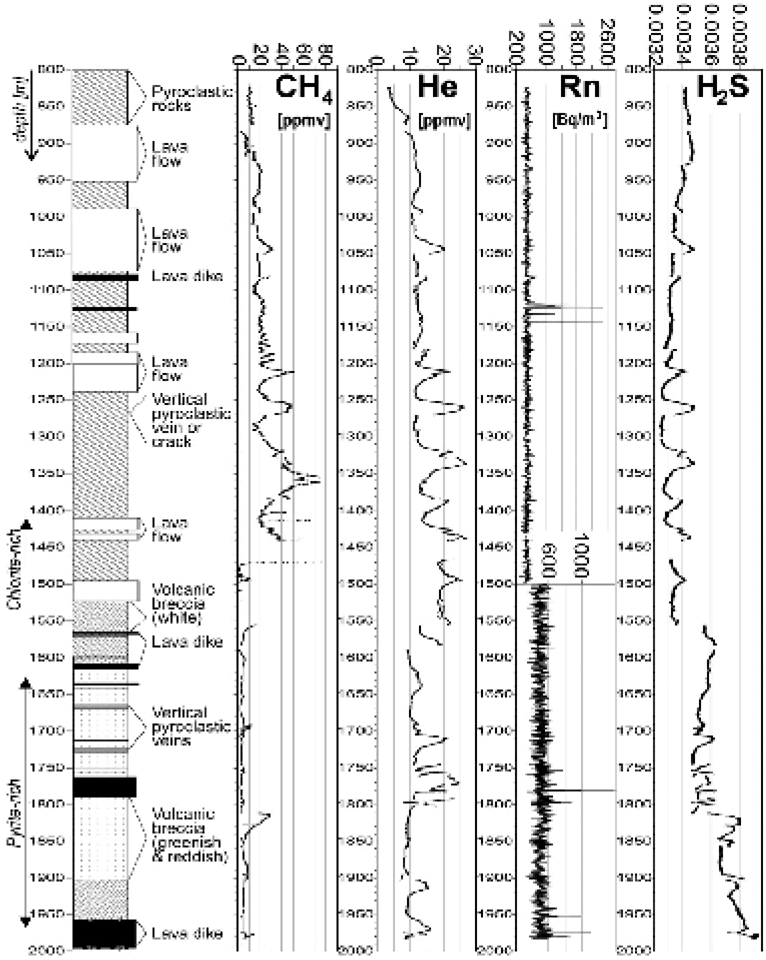

Figure 3: Gas monitoring profiles of USDP-4 driliing, Unzen, Japan (Tretner et al., 2008).

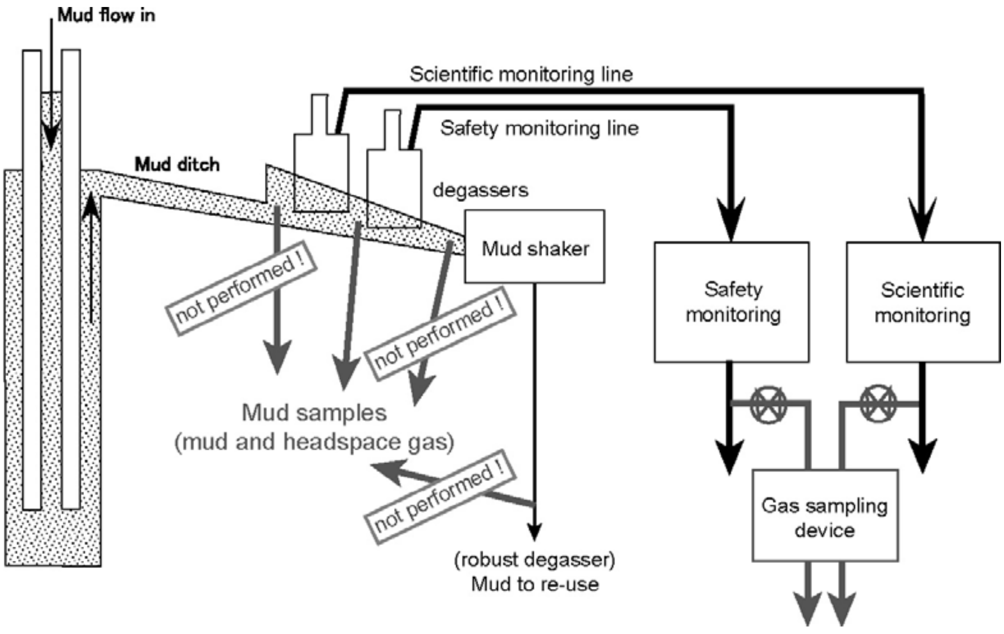

Figure 4: Gas-monitoring performed at Exp.319 of D/V Chikyu