Tracing Submarine hydrothermal Groundwater Discharge around Kueishantao off northeastern Taiwan using Radon

Chi-Yu, Lin, Chih-Chieh, Su, and Hsieh-Tang, Chiang
Institute of Oceangraphy, National Taiwan University, Taipei, Taiwan

CC BY

Abstract

The spatial distribution of radon in surface water was investigated in conjunction with chirp sonar and multi-beam bathymetric survey works on OR2-1792 cruise during May 25-28, 2010. Most of hydrothermal vents show good correlations with higher radon activities (0.004-0.006 Bq/L) in nearshore area. However, the highest radon activity (0.009 Bq/L) was located off eastern KST Islet where the water depth larger than 200 meters. From multi-beam bathymetric data, it also showed a clear depression which might related to the hydrothermal activity. A roughly evaluation from simply back-of-the-envelope calculation, reveals the activity of radon on the seafloor is at the same order of magnitude with the hot spring water in North Taiwan. Compared to the activity of radon at the hydrothermal vent in shallow waters near the KST Islet, it implies there are two different types of submarine hydrothermal systems in the study area. The hydrothermal SGD in the shallow waters which near the KST might be originated from the recirculated seawater and the system at deep waters might be derived from deeper sources.

Introduction

Submarine groundwater discharge (SGD) is studied widely in the past two decades. Burnett (2003) had defined it as any and all flow of water on continental margins from seabed to coastal ocean, regardless of fluid composition or driving forces.

Radon (^{222}Rn) is a member of ^{238}U decay chain. This inert gas is one of the most extensively used natural occurring tracers for SGD since it is enriched in groundwater, volcanoes and hydrothermal vents relative to seawater.

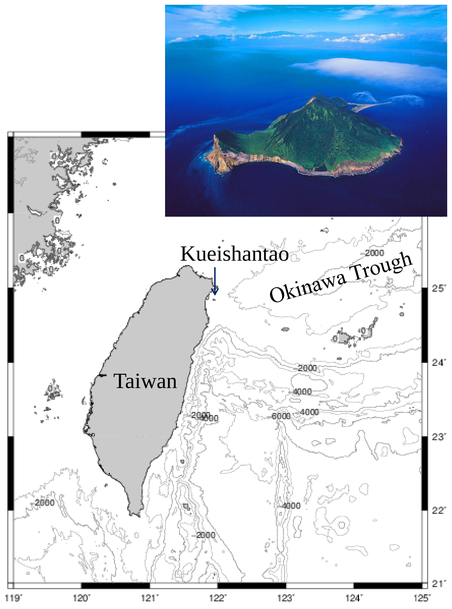

Fig. 1 Map showing locations of Okinawa Trough, Taiwan and Kueishantao islet and its aerial image.

Kueishantao (KST) is a young volcanic island located at the southernmost part of the Okinawa Trough off northeastern Taiwan (fig.1). Submarine hydrothermal systems are ubiquitous near the coast of KST islet and construct a special hydrothermal ecosystem (Chen et. al., 2005). In this study, we are trying to trace the location of the hydrothermal vents adjacent to the KST Islet from shallow (10 m) to deep (300 m) waters by using radon.

Methods

RAD7 is a radon-in-water monitor containing an internal air pump and α semiconductor detector that employs energy discrimination to count the daughters of ^{222}Rn. We detected the radon in seawater activity using multi-RAD-AQUA system method. The surface seawater is pumped with the vessel route, through a water-air exchanger accessory to separate the air in seawater, then dry the air through a passive drystick and a drying tube, and enter into 2 parallel connected RAD7s (fig.2). The flow rate of seawater and air were controlled between 4~6 LPM and 1 LPM, respectively.

In this study, besides the survey of surface seawater radon distribution, the chirp sonar and multi-beam investigations also conducted by using Ocean Researcher 2-1792 cruise in May 2010.

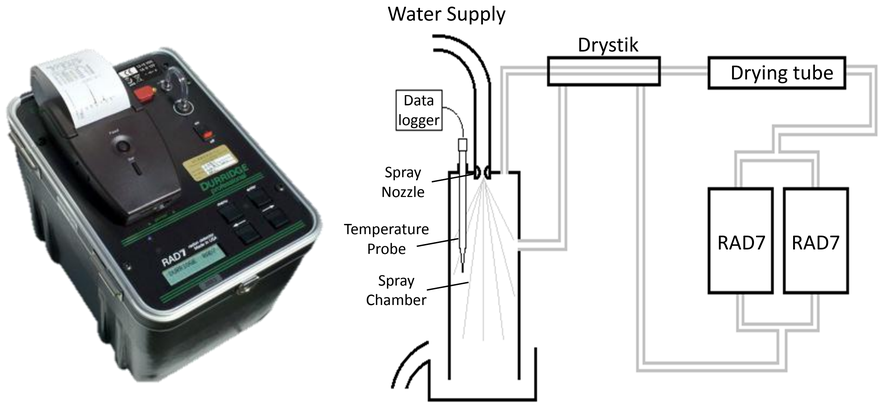

Fig. 2 RAD7 and Schematic diagram of the multi-RAD-AQUA system.

Results and Discussion

Numerous hydrothermal vents were identified via the chirp sonar profiles along the track lines which located at shallow waters in a water depth of around 20m (fig. 3), and most are concentrated in the east of KST Islet. Two types of hydrothermal vents can be classified through chirp sonar profiles. The intense type vents are located off east side of KST islet, and the tranquil type vents are adjacent to the fringes of the intense vents. Not only in chirp sonar data, the radon activity in surface seawater also revealed higher values (0.004-0.006 Bq/L) off the eastern KST islet (fig. 4).

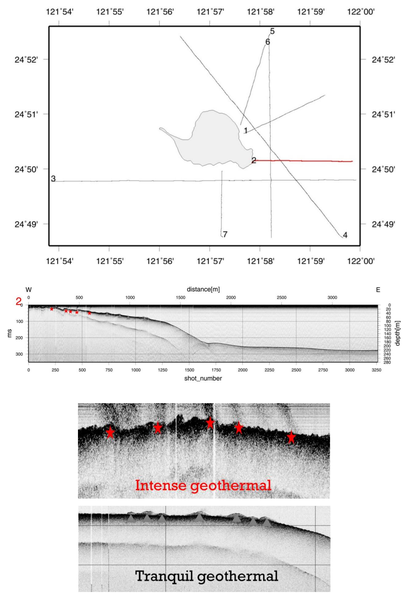

Fig. 3 Chirp sonar profile of track line 2 and two morphologies of hydrothermal vents.

However, the highest radon activity (0.009 Bq/L) in this study was found at deep waters with water depth larger than 200 meters offshore eastern KST islet. Although there's no chirp sonar data at this location, the feature of the sea bottom which derived from the multi-beam data showed a clear depression landform which might relate to the hydrothermal activity (fig. 5).

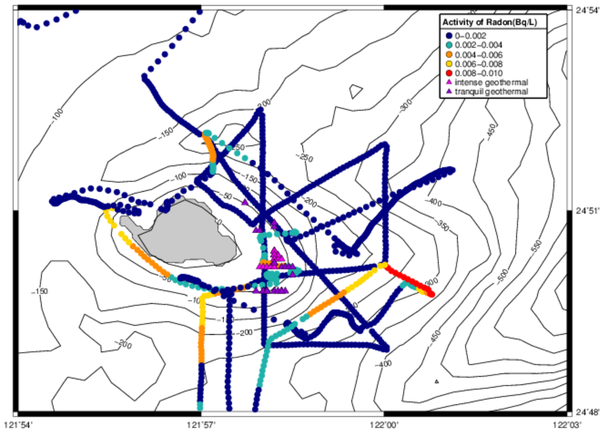

Fig.4 Distribution of radon-in-seawater activity and two types of hydrothermal vents.

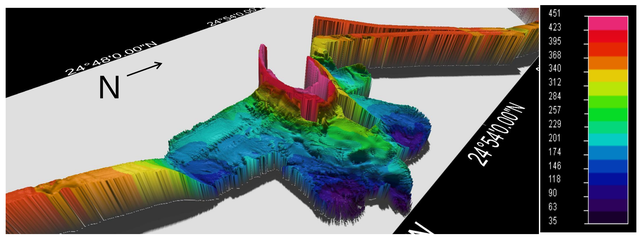

Fig. 5 Multi-beam bathymetric data show a clear depression.

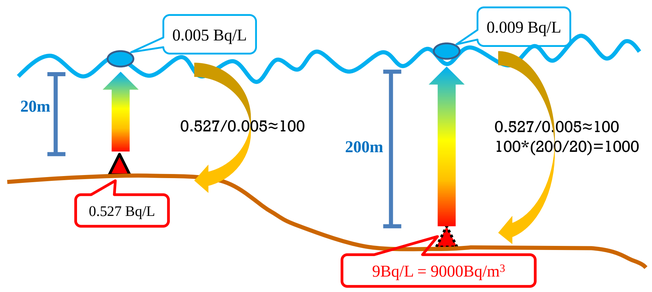

Fig. 6 A simply calculation of radon activity for the deeper hydrothermal vent.

On May 2005, a water sample was collected at the chimney of a large yellow smoker which is located at a water depth of 20 meters off south-eastern KST islet. Comparing with the average radon activity in surface water where the hydrothermal vents are highly concentrated at shallow waters, the radon activity at bottom water (0.527 Bq/L) is around 100 times higher than surface water (~0.005Bq/L). Considering the differences between water depth (20 vs. 200 m) and radon activity (0.005Bq/L vs. 0.009 Bq/L), a simply back-of-the-envelope calculation reveals the activity of radon on the sea bottom is at the same order of magnitude with the hot spring water in North Taiwan (fig. 6). It implies the hydrothermal SGD in shallow waters which near the KST Islet might originated from the recirculated seawater and the system at deep waters might derived from deeper sources.

Conclusion

1. Intense and tranquil submarine hydrothermal vents are identified by using chirp sonar profiles, and most of them are located at shallow waters in a water depth around 20 meters .
2. Radon activities in surface water reveal higher values (0.004-0.006 Bq/L) in the eastern Kueishantao Islet where cluster with many hydrothermal activities.
3. The highest radon activity is located offshore eastern KST Islet where the water depths larger 200 meters. The multi-beam bathymetric data show a clear depression which might be related to the hydrothermal activity.
4. From a simply back-of-the-envelope calculation, the activity of radon on the bottom is at the same order of magnitude with the hot spring water in North Taiwan.
5. The hydrothermal SGD in the shallow waters which near the KST might originated from the recirculated seawater and the system at deep waters might derived from deeper sources.

Reference

1. Burnett, W. C., Bokuniewicz, H., Huettel, M., Moore, W. S., Taniguchi, M., 2003. Groundwater and pore water inputs to the coastal zone. *Biogeochemistry* 66 , 3–33.
2. Chen, C. T. A., Wang, B. J., Huang, J. F., Lou, J. Y., Kuo, F. W., Tu, Y. Y., Tsai, H. S., 2005. Investigation into extremely acidic hydrothermal fluids off Kueishantao Islet, Taiwan. *Acta Oceanologica Sinica* 24, 125-133.