DAVID FISCHER[1,2], GERHARD BOHRMANN[1], THOMAS PAPE[1], STEPHAN A. KLAPP[1,3], FRIEDER ENZMANN[3], WERNER F. KUHS[4], THOMAS HUTHWELKER[5]

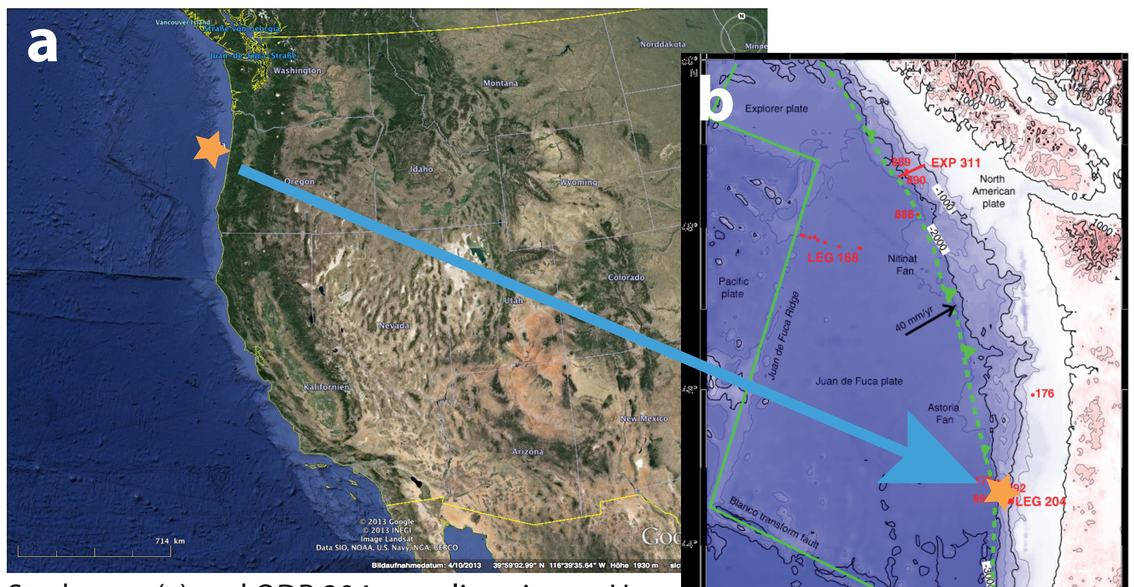
Sub-millimeter structure and internal architecture of ODP 204 (Hydrate Ridge) gas hydrates revealed by Synchroton Radiation X-Ray Cryo-Tomographic Microscopy (SRXCTM)

Introduction

Although recognized worldwide in different environmental settings including the seafloor, natural hydrocarbon-gas hydrates (GH) remain rather exotic materials whose interplay between chemical and physical parameters is still not fully understood. We radiographed gas hydrate specimen obtained during ODP Leg 204 to the renowned Hydrate Ridge offshore Oregon with Synchroton radiation provided by the Swiss Light Source in Villingen, Switzerland, in order to gain insight into their sub-millimeter scale internal structure. The project was conducted in the frame of the DFG-Schwerpunktprogramm "IODP". In contrast to earlier studies focussing on shape parameters of hydrocarbon gas hydrates, our approach enabled us to investigate specific areas of interest within small samples and to identify internal, architectural particularities of single gas hydrate grains, grain boundaries and matrix materials in the micometer to several hundreds of micrometers range.

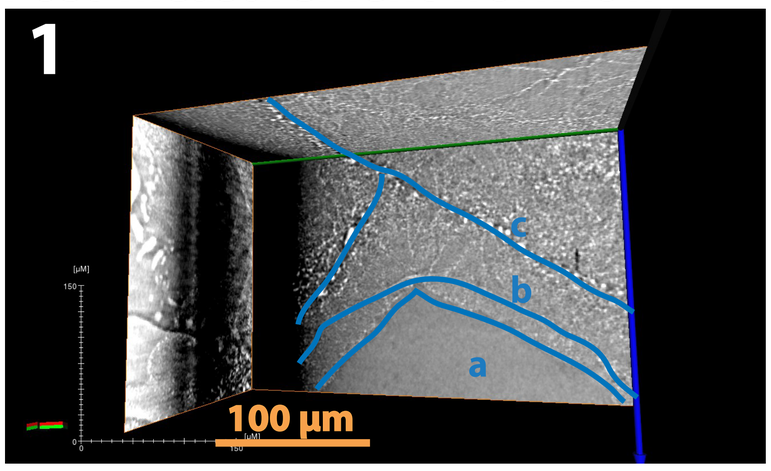
With this study we provide a new and unique dataset of the sub-millimeter scale internal structure of gas hydrates from Hydrate Ridge and show that Synchroton radiation is very helpful in investigating the architecture of natural hydrocarbon gas hydrates. Future investigations are needed to 1) adapt, establish and refine the used method for examining gas hydrates and 2) compare samples from different environmental settings and samples of different crystallographic compositions (e.g., sI and sII hydrates).

Geographical and geological setting

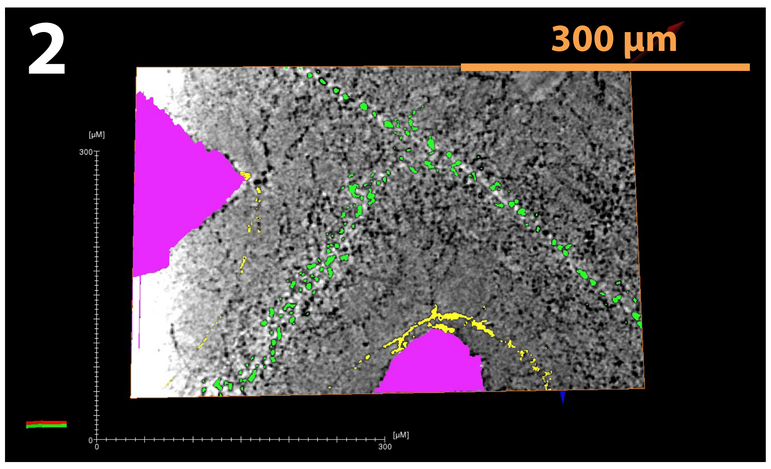


Study area (a) and ODP 204 sampling sites at Hydrate Ridge (b). Figure (a) is from Goolge Earth (Inc.) and (b) originally appeared in Tréhu et al. (2006).

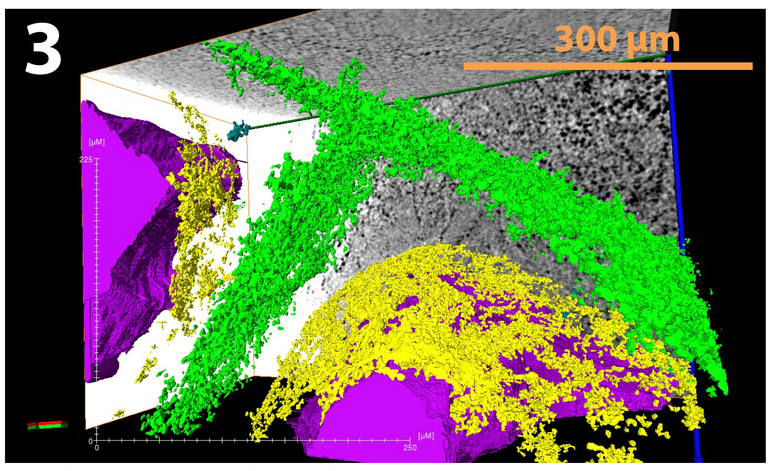
Post-measurement workflow



Initial step in sample analysis: 3-D arrangement of grey-value tomographic slices produced using Synchroton radiation X-ray cryo-tomographic microscopy. Certain features are visible based on density differences. a) gas hydrate, b) small boundary pore network, c) boundary pore network.

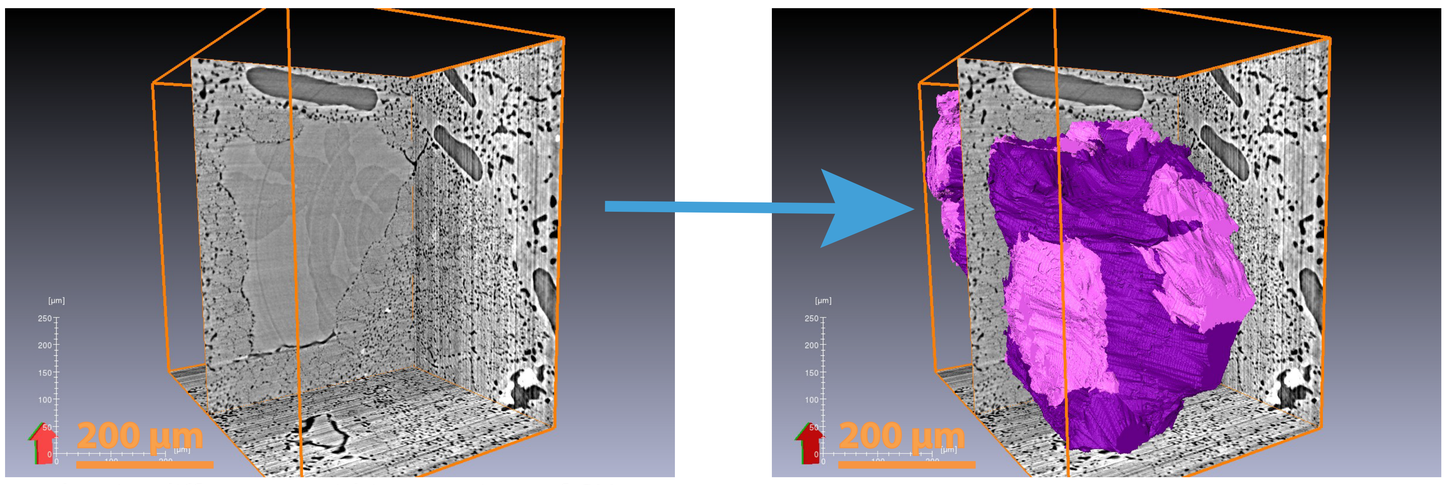


Second step in sample analysis: Use 3-D visualization software to identify and mark segments of same/similar composition or structure (purple: GH, green/yellow: pores).

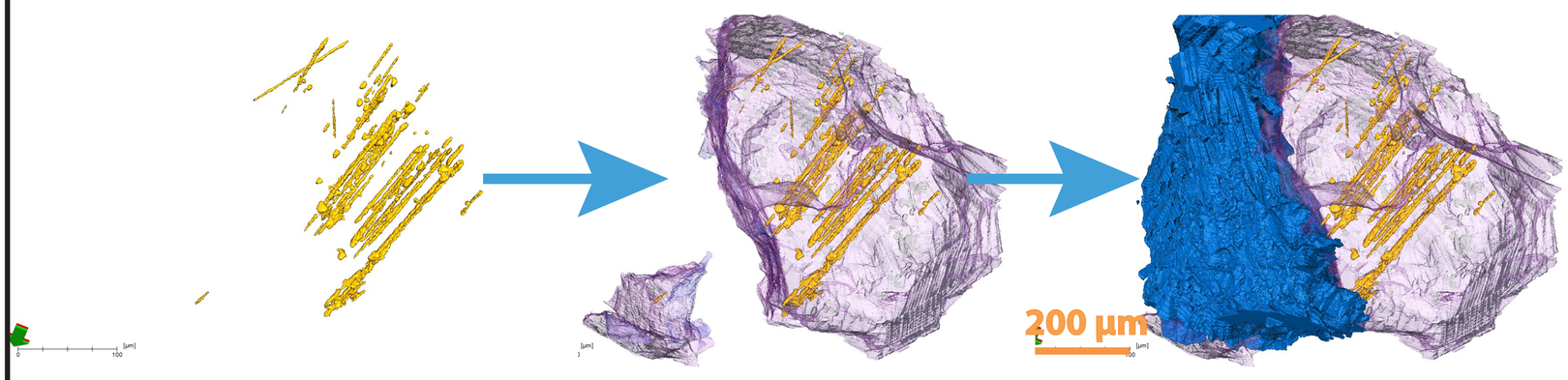


Final step in sample analysis: Create and interpret 3-D visualizations and understand the internal architecture of specimens.

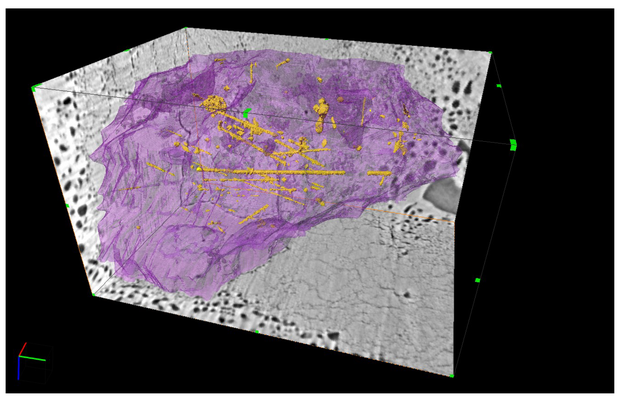
Preliminary results



Distinct density differences within one piece of GH appear as different shades of grey: structures I and II?



Tubes (yellow), GH (purple translucent and blue). What are these tubes and is there a structural control on their distribution?



Conclusions

1) SRXTCM provides essential insights into internal architecture of sub-millimeter scale gas hydrate samples

2) Many samples contain gas-filled tubular structures of unknown origin
--> perhaps pressure release features?

3) Although not proven, we suggest that density differences between sI and sII gas hydrates might be visible in SRXTM images

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1MARUM – Center for Marine Environmental Sciences and Department of Geosciences at the University of Bremen, Leobener Straße, D-28359 Bremen, Germany
2 Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Am Handelshafen 12, D-27570 Bremerhaven, Germany
3 Springer, Tiergartenstraße 17 | 69121 D-Heidelberg, Germany
4 GZG, Abt.Kristallographie, Georg-August-Universität Göttingen, Goldschmidtstr.1, D-37077 Göttingen, Germany
5 Swiss Light Source, Paul Scherrer Institute, CH-5232 Villigen, Switzerland

Cited literature: Tréhu, A.M., Torres, M.E., Bohrmann, G., and Colwell, F.S., 2006. Leg 204 synthesis: gas hydrate distribution and dynamics in the central Cascadia accretionary complex. In Tréhu, A.M., Bohrmann, G., Torres, M.E., and Colwell, F.S. (Eds.), Proc. ODP, Sci. Results, 204: College Station, TX (Ocean Drilling Program), 1–40. doi:10.2973/odp.proc.sr.204.101.2006

ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG
HELMHOLTZ GEMEINSCHAFT
BREMERHAVEN
Am Handelshafen 12
27570 Bremerhaven
Telefon 0471 4831-0
www.awi.de

Contact: David Fischer
david.fischer@awi.de
0049-471-48312389