Directed Study: Brine Water Origins and Geochemical Analysis
GEOL: 5362 CRN: 30637

Title: Brine Geochemistry
Student: Stephanie Ray
Instructor: Dr. Benjamin Brunner
Credit hours: 3 (8 weeks summer June 8, 2015-August 4, 2014)
Meetings: weekly 30 minutes with advisor, tentative Wednesday 12:00

Objective

The purpose of this directed study is to develop an understanding of the origin and fate of salts in naturally-occurring brine waters as well as an understanding of the sources of the water. Specific tasks include completing a literature review covering the origin of brine salinity and the composition of formational waters, and the development of a reference table of major water-rock reactions which control the composition of formational brines. After completion of this directed study, the student will understand how brines form and know what controls their chemistry with emphasis on how water-rock reactions affect the chemical evolutions of brines.

<u>Sections and Timeline</u>

Section 1: The literature review will focus on the origins of brine salinity and composition, along with isotopic composition of formation waters.

A) Origins of chemical composition and overall salinity of brines
- Origin of elevated salinities
- Controls on salinity and chemical composition

B) Deuterium isotope composition (δD) and oxygen isotope composition ($\delta^{18}O$) of Formation Waters
- Holocene Meteoric Water
- "Old" Meteoric Water
- Bittern Water from Evaporites
- Brines from Mixing

Deliverable: Due June 30, 2015

A literature summary report of brine waters origination and how basin formation influences the salinity and affects the geochemistry. In addition to the report, an open discussion over the findings with the faculty advisor will follow.

Section 2: The purpose of this section is to develop a reference table of the major water-rock reactions, which control the composition of formation brines.

A) Water-Rock Reactions
- Major Cations
- Major Anions
- Reactive Organic Species

Deliverable: Due August 4, 2015

Develop a table that serves as a reference chart for the geochemical reactions in basinal brines. In conjunction with observed concentrations of ions and elements, this chart can be used to rapidly assess what reactions were involved in the formation and evolution of a certain brine. The table will show complete geochemical reactions that list all the involved constituents, give information on the conditions under which the reactions occur and provide citations for literature that contains further details for each reaction. In addition to the reference table, an open discussion over the findings will follow.

<u>Section 3:</u> If time permits, section 3 will include an example application of:

Diagnostic tools to determine the source of brines using δD and $\delta^{18}O$ and Na-Cl-Br systematics

Deliverable: Due date is August 4, 2015 (last day of summer classes)

The deliverable is an interpretation of example data set from the USGS Produced Waters Geochemical Database using δD and $\delta^{18}O$ and Na-Cl-Br systematics.

<u>The literature review</u> includes but is not limited to source papers from the following original summary review book chapter: *Kharaka and Hanor, (2014) Deep Fluids in Sedimentary Basins, Chapter 7.14.1. In: Holland, H and Turekian, K (eds.) Surface and Groundwater Weathering, volume 7: Treatise on Geochemistry 2nd Edition, pp. 471-515.*

Potential References:

Bennett S and Hanor JS (1987) Dynamics of subsurface salt dissolution at the Welsh Dome, Louisiana Gulf Coast. In: Lerche I and O'Brien JJ (eds.) Dynamical Geology of Salt and Related Structures, pp. 653–677. New York: Academic Press.

Birkle P, Rosillo AJJ, Portugal E, and Fong AJL (2002) Evolution and origin of deep reservoir water at the Activo Luna oil field Gulf of Mexico, Mexico. American Association of Petroleum Geologists Bulletin 86: 457–484.

Bray RB and Hanor JS (1990) Spatial variations in subsurface pore fluid properties in a portion of southeast Louisiana: Implications for regional fluid flow and solute transport. Transactions Gulf Coast Association of Geological Societies 40: 53–64.

Bryant EA (1997) Climate Processes and Change. Cambridge: Cambridge University Press.

Case LC (1945) Exceptional Silurian brine near Bay City, Michigan. American Association of Petroleum Geologists Bulletin 29: 567–570

Connolly CA, Walter LM, Baadsgaard H, and Longstaff F (1990) Origin and evolution of formation fluids, Alberta Basin, western Canada sedimentary basin. II: Isotope systematics and fluid mixing. Applied Geochemistry 5: 375–395.

Drever JI (1997) The Geochemistry of Natural Waters: Surface and Groundwater Environments. Upper Saddle River, NJ: Prentice-Hall.

Frank TD and Gui Z (2010) Cryogenic origin for brine in the subsurface of southern McMurdo Sound. Antarctica Geology 38: 587–590.

Fournier RO, White DE, and Truesdell AH (1974) Geochemical indicators of subsurface temperature. I: Basic assumptions. Journal of Research of the US Geological Survey 2: 259–262.

Jones BF, Hanor JS, and Evans WR (1994) Sources of dissolved salts in the central Murray Basin, Australia. Chemical Geology 111: 135–154.

Kharaka YK, Maest AS, Carothers WW, Law LM, and Fries TL (1987) Geochemistry of metal-rich brines from central Mississippi Salt Dome Basin, USA. Applied Geochemistry 2: 543–561.

Kharaka YK, Cole DR, Thordsen JJ, Kakouros E, and Nance HS (2006b) Gas–water–rock interactions in sedimentary basins: CO2 sequestration in the Frio Formation, Texas, USA. Journal of Geochemical Exploration 89: 183–186.

Land LS (1995) The role of saline formation water in crustal cycling. Aquatic Geochemistry 1: 137–145.

Mazor E (1997) Chemical and Isotopic Groundwater Hydrology: The Applied Approach. New York: Dekker.

Moran JE, Fehn U, and Hanor JS (1995) Determination of source ages and migration patterns of brines from the US Gulf Coast using 129I. Geochimica et Cosmochimica Acta 59: 5055–5069.

Moldovanyi EP and Walter LM (1992) Regional trends in water chemistry, Smackover Formation, Southwest Arkansas: Geochemical and physical controls. American Association of Petroleum Geologists Bulletin 76: 864–894.

Muramatsu Y, Fehn U, and Yoshida S (2001) Recycling of iodide in fore-arc areas: Evidence from the iodide brines in Chiba, Japan. Earth and Planetary Science Letters 192: 583–593.

Pang Z and Reed M (1998) Theoretical chemical thermometry on geothermal waters: Problems and methods. Geochimica et Cosmochimica Acta 62: 1083–1091.

Posey HH and Kyle JR (1988) Fluid–rock interactions in the salt dome environment: An introduction and review. Chemical Geology 74: 1–24.

Siemann MG and Schramm M (2000) Thermodynamic modeling of the Br partition between aqueous solutions and halite. Geochimica et Cosmochimica Acta 64: 1681–1693.

Starinsky A and Katz A (2003) The formation of natural cryogenic brines. Geochimica et Cosmochimica Acta 67: 1475–1484.

Grade

The grade for this directed study will be based on the following three components: i) deliverables (50%), ii) ad hoc assessments during weekly meetings (25%), and iii) open discussion of findings after handing in the deliverables (25%).

Accomodations

Accommodations are possible for active duty military and others, but arrangements must be made in a timely manner. If you are in the military with the potential of being called to military service and /or training during the course of the semester, you are encouraged to contact the instructor as soon as possible. If you have a disability and need classroom accommodations, please contact The Center for Accommodations and Support Services (CASS) at 747-5148, or by email to cass@utep.edu, or visit their office located in UTEP Union East, Room 106. For additional information, please visit the CASS website at www.sa.utep.edu/cass.