



# Arizona Geological Society Newsletter

OCTOBER 2011

## October 4, 2011 DINNER MEETING

**Stanley B. Keith** will be our featured speaker. See abstract below.

**Where:** Sheraton Four Points Hotel, Wild Cat Room, 1900 E. Speedway Blvd. in Tucson

**When:** Cash Bar at 6 p.m.—Dinner at 7 p.m.—Talk at 8 p.m.

**Cost:** With reservation, members \$24, guests \$27, Students \$10 (students free with online reservation).  
Without a reservation, a \$3 surcharge will be added (if the hotel is able to accommodate you).

**RESERVATIONS: CALL 520.663.5295 by 5 p.m. on September 30, 2011.**

Please indicate low-salt, vegetarian, or vegan meal preferences. A coffee/salad/roll/dessert option is also available for \$18.

Please cancel if you are unable to attend. The hotel cannot guarantee that meals will be available without a timely reservation.

## ON THE ORIGIN OF KEROGEN, OIL, AND EVERYTHING ELSE or HOW TO MAKE AN OIL FIELD BY THROWING HOT WATER ON A PERIDOTITE By Stanley B. Keith


Based on an extensive literature review and our own data, a new model is proposed for the origin of oil that is consistent with a well-known earth-scale process known as serpentinization. It is suggested that most kerogen (which is universally accepted as the starting material for oil formation) originally formed by hydrothermal metamorphism and hydrolysis of peridotite parents under greenschist facies conditions (Figure 1).

A relatively hydrogen-poor aromatic kerogen type is initially formed by polymerization and chelation of aromatic hydrocarbons around nickel porphyrin nuclei under highly reductive, non-ionic supercritical conditions that attend serpentinization (Figure 1) in 'kitchens' where the temperature ranges between about 300 and 550 °C. A buoyant coexisting kerogen and brine product is propelled upwards by expansional force associated with about a 40 percent volume increase during serpentinization. During migration, the kerogen is continuously hydrogenated by hydrogen donated from the co-migrating hydrothermal water component to the point where aliphatic hydrocarbon chains are cleaved off as alkane-rich liquid state hydrothermal oil in accord with abundant hydrothermal experimental data (equation 1). At cooler temperatures and pressures, more aromatic and condensed oils are produced in what are now cooler, ionic, and denser subcritical conditions for the coexisting water


### Serpentinite Reaction and Photograph of Serpentinite Hand Specimen

SIMPLIFIED SERPENTINIZATION REACTION WITH CARBON

<b>REACTANTS</b>	$6(\text{Mg}_{1.5}\text{Fe}_{0.5})\text{SiO}_3 + .04\text{C} + 8(\text{H}_2\text{O}) + .24\text{HCO}_3^-$										➔
	OLIVINE		IN OLIVINE		IN SEAWATER						
<b>PRODUCTS</b>											
	$3\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4 + \text{Fe}_3\text{O}_4 + .01\text{HC}$		$+ .455\text{H}_2 + .04\text{HC}$		$+ .09\text{CH}_4 + .04\text{CHOO}$		$+ 0.1\text{CO}_2 + 1.44\text{H}_2\text{O}$		$+ \text{HEAT}$		
	SERPENTINE	MAGNETITE	KEROGEN	KEROGEN	METHANE	FORMATE					
	IN ROCK				IN BRINE						
					HYDROCARBONS	LIFE	CLIMATE	CLIMATE			



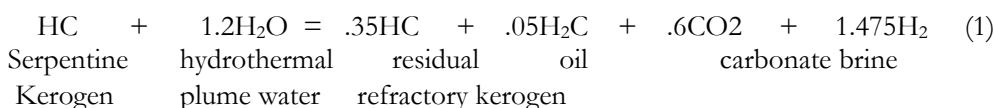
➔



Lizardite Serpentine  
Snarum, Norway

**Figure 1:** Hydrolysis reaction between unaltered peridotite and carbon-bearing hydrothermal water to produce magnetite and kerogen bearing serpentinite and a formate-carbonate bearing brine with abiogenic methane and a kerogen flocculate.

component. They also may be fractionated from the alkane-rich oil precursors.



Only about 20% of the original kerogen is reacted to hydrothermal oil; the remainder is carried as a refractory residuum in hydrothermal brines to surface seep sites where it is expelled as a chemical flocculate that mechanically accumulates in black shale chemically dominated sediments along with dolomite, calcite, alkali salts, and minor metal sulfides brought by the chemical brine component. The hydrocarbon petroleum and gas seepages are associated with extensive chemical and mud volcanism that is co-deposited in basin settings or mud volcanic edifices.

In addition to the surface exhalations, extensive hydrocarbons and brines are coevally deposited in more familiar reservoir settings such as porous sandstones during low temperature hydrothermal diagenesis. In such cases, the more buoyant oil component pushes the brine component to the sides where it precipitates its anomalous element component marginal to and above the petroleum reservoir. Clay, carbonate, and or anhydrite cement deposition above or lateral to the petroleum accumulation characteristically results in a self-sealing effect. Extensive deposits of hydrothermal dolomite typically form in higher temperature settings more proximal to the hydrocarbon deposit – especially the more alkane dominant, lower density (high gravity) hydrocarbon chemical facies. The entire process has much in common with Mississippi Valley Pb-Zn or Tennessee Valley Zn deposits.

#### About the Speaker

**Stanley B. Keith** has 30 years of exploration experience focusing on ideas, exploration and discovery of minerals and energy. His hands-on knowledge and extensive international travel include virtually all mineral deposit types and geologic settings. He began as a field and research geologist and his early career focused on mineralogy, geologic mapping, stratigraphy, tectonics, and isotopic age dating. While working for Kennecott and the Arizona Geological Survey in the mid-1970s he recognized an empirical relationship between mineral deposits and magma series. Later Exxon Research funded a research project to pursue this concept in the southwestern United States. In 1983 he co-founded MagmaChem Exploration and directed the development of the Magma-metal Series Classification while working on numerous exploration and research projects for both mineral and energy exploration companies. Stan is a prolific writer and speaker and has authored hundreds of technical reports and publications. His marathon, 3 day, magma-metal series workshops and field trips have been presented to the mineral industry, major companies in the oil and gas industry, and various government agencies. Beginning in 2000, Stan and colleagues began to apply the MagmaChem model to oil and gas, which led to the concept of the serpentosphere, the hydrothermal origin of kerogen, and this talk. This research was largely funded by Statoil of Norway. Throughout his career, he continually returns to the reality of the field, testing ideas through geologic mapping. He received a B.S. degree in Philosophy in 1971 from the University of Arizona and an M.S. degree in Geology from the University of Arizona in 1975.

If your company is interested in sponsoring an AGS dinner meeting, contact Ann Pattison, AGS VP of Marketing.

#### FIELD TRIPS

VP of Field Trips, Doug Shakel, has been very busy organizing two exciting field trips. Please check the AGS website for more details and to sign up.

**October 1, 2011 — Subsidence Cracks and Fissures in Cochise County**

**November 10-13, 2011 — Origin of the Salton Sea**

Alison Jones is soliciting interest from AGS members for an 8-day **Grand Canyon Geology raft trip**, starting on July 22, 2012. This year's trip was a huge success!! Our outfitter will be Hatch River Expeditions, and we have requested Stan Beus to be our geology guide again. Cost will be \$2875, which includes all camping gear, fabulous food, helicopter flight out, plane flight back to Marble Canyon or Las Vegas, and motel room at Cliffdwellers on July 21. Cost does not include transportation to Marble Canyon before the trip or boatmen's tips. A \$500 refundable deposit will hold your spot. Call Alison at 520-622-3222 or send her an email at [ajones@clearcreekassociates.com](mailto:ajones@clearcreekassociates.com) for more information.

## October Member Spotlight—Ken Hollett

**Ken Hollett** was born in Melrose, Massachusetts and moved with his family at age 6 to California and subsequently, at age 11, to Oregon. After graduation from Oregon State University and completing the NROTC Program in June 1969, Ken was commissioned an officer in the US Navy and sent to flight school in Pensacola, Florida. There he completed training as a Naval Aviator and helicopter pilot in 1970. He was assigned to the Helicopter Combat Support Squadron 3 (HC-3) at NAS Imperial Beach, California for the next 3 years. His tour with HC-3 included two deployments to the Viet Nam combat zone—serving aboard combat fleet support ships in the Tonkin Gulf. He left the Navy in 1973 and subsequently attended graduate school at the University of Hawaii, earning an MS in Geology and Geophysics from the Hawaii Institute of Geophysics in 1977.



Ken joined the US Geological Survey in October 1977 as a hydrologist and subsequently served in Tucson, Arizona; Sacramento, California; and Reston, Virginia —He retired in 2003 after 31 years of government service. During his career with USGS, he had the opportunity to serve on assignments all over the U.S. and abroad—serving with U.S. AID, U.S. State Department, and other U.S. government organizations. Particularly notable was his 3 year assignment with the Central Intelligence Agency (1999-2002) at Langley, VA as a senior scientist and intelligence officer—assessing global water-resource issues affecting U.S. foreign policy and national security. After retirement, he accepted an eight-month consulting assignment with the International Atomic Energy Agency (IAEA) in Vienna, Austria in their Isotope Hydrology Branch.

In addition to his new position as an AGS Councilor beginning in 2012, Ken is an officer and judge for the Southern Arizona Region of the Porsche Club of America and is Commanding Officer of Squadron 60 of the Association of Naval Aviators. Ken lives with his wife, Claudia Stone (a very active AGS member), and their Corgi, Sally, in Tucson.

**How did you first become interested in geology?** From Dr. Olds, a professor of geology at Oregon State University. He taught Geology 101 and many other great classes. He used many of his field slides to illustrate important discussion points.

**What was your first job?** My first job was at age 11 changing irrigation for a dairy. I moved up to plowing fields, spreading manure and eventually to helping harvest rye grass crops in the Willamette Valley of Oregon. In college, I worked as a houseboy at a sorority to earn food. I worked at a Piper aircraft dealership during the summer. Later I became a bartender and short-order cook at a pub just before graduating and heading off to flight school as a young ensign in the Navy.

**What was your first job as a geologist?** My first job was funded by the Army Corps of Engineers. I was a grad student researching the dredging history and sedimentation of Kaneohe Bay, Hawaii. My first job after my formal education was with Heinrichs Geoexploration using IP and DC resistivity to explore for and map buried disseminated copper. Shortly after Heinrichs, I was hired by the USGS in October 1977 as

(Continued on page 4)



## October Member Spotlight—Ken Hollett—continued

a hydrogeologist. My first project was mapping the water resources of the Papago Indian reservation, which took me three years and produced a Water-Supply Paper, Hydrologic Atlas and other reports.

**What is your most memorable field experience?** Salvaging a nuclear borehole geophysics tool wedged down hole in a newly drilled water well. Essentially we had to invent a fishing tool after we had a camera company take some videos of the wedged tool.

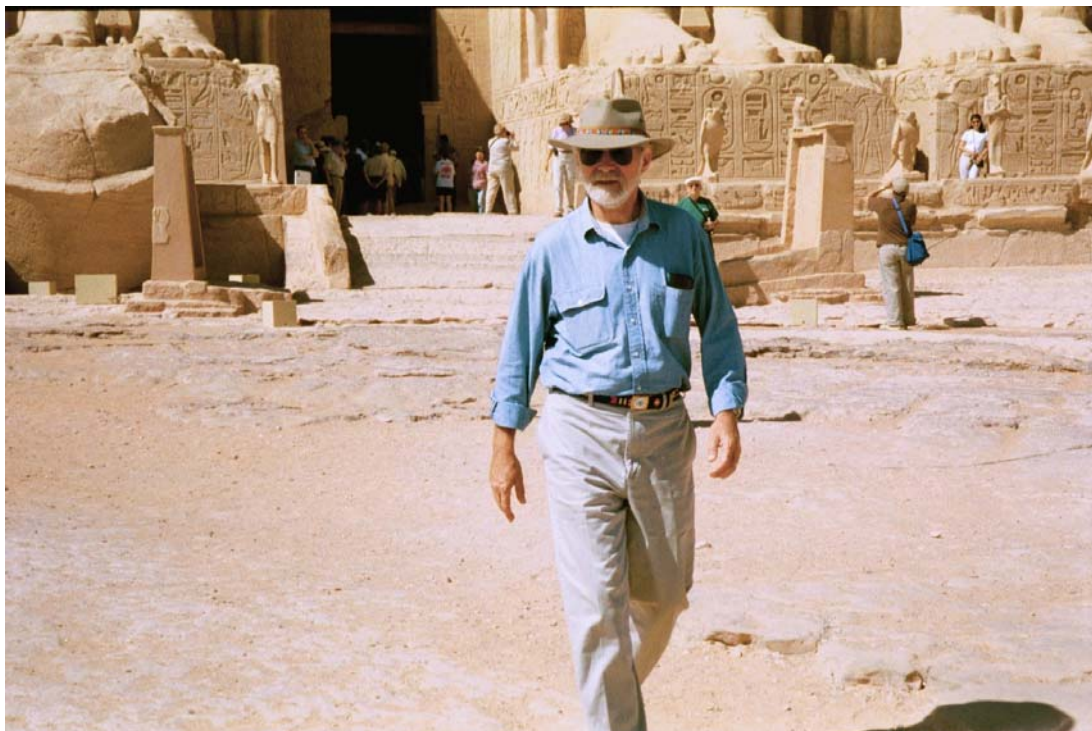
**What do you consider your greatest professional achievement?** Being the project chief of the highly charged and sensitive water-resource project in the Owens Valley CA. A series of very important USGS Water-Supply Papers were produced as a part of the study, which served to guide the California State Appellate court in resolving the water wars in the valley and appointing a competent Water Master to guide future water use in the valley. My senior-authored WSP 2370-B Geology and Water Resources of the Owens Valley, CA, was recognized by the Director and Chief Hydrologist for scientific excellence and won paper of the year in 1992 for the Western Region of WRD-USGS.

**Your greatest achievement EVER?** Being selected to serve first as the Assistant Chief of the USGS Office of Ground Water in Reston and later to be selected to go on assignment from the USGS to the Central Intelligence Agency as a Senior Water Scientist and Intelligence Officer and asked to develop a series of papers and positions that defined the US strategy on global water and how to recognize regional and local global waters issues that could escalate to regional and international tension and conflict. This project was the subject of a talk I gave to the AGS in 2010.

**What are your hobbies?** I am still struggling to learn the guitar. I lead tours at the Pima Air and Space Museum and I volunteer at the VA Hospital. Collecting and aging good cigars is also high on my list, as well as continuing to collect wine corks from bottles that I have sampled.

**Water, Whiskey or Wine?** 18 year-old MacCallan single-malt scotch, please!

**Ken touring  
Egyptian  
antiquities**



*Do you know someone who would be an interesting subject for a "Member Spotlight" column? Email his/her name and contact information to [ajones@clearcreekassociates.com](mailto:ajones@clearcreekassociates.com).*

## Announcements

**Conference:** Opportunities for Alternative Energy Development in Arizona and the Southwest—Geologic/Hydrologic Considerations

Tempe, Arizona, October 27-28, 2011

Sponsored by AEG and the Arizona Land Subsidence Group

More information about the presenters/topics, sponsorship, exhibits, and registration can be found at this link:

<http://www.aegweb.org/i4a/pages/index.cfm?pageID=5464>

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### From the State Geologist:

The statutory authorization for the Arizona Geological Survey ends June 30, 2012.

The Arizona Legislature is beginning a Sunset Review of AZGS to determine if the agency should be continued, revised, consolidated, or terminated at that time. This is standard procedure for all state agencies, commissions, and boards.



A Committee of Reference has been formed, co-chaired by Sen. John Nelson and Rep.

Kate Brophy McGee, that is reviewing AZGS goals, objectives, and accomplishments. The committee will make a recommendation to the full Legislature no later than December 1, 2011, on the future of AZGS. The Legislature will then take action when they convene in January 2012. The Survey could be extended for up to 10 years.

AZGS recently responded to a set of 17 questions from the Committee about efficiency, productivity, achievement of goals, and possible options to privatize Survey functions, or consolidate AZGS with other state bodies. The Committee of Reference will hold a public hearing on the future of AZGS on Monday, October 17 at 2:30 pm in Senate Hearing Room 109 at the State Capitol. We do not know at this time if the public will have an opportunity to voice opinions or recommendations about the Survey at this hearing.

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### Welcome New AGS Members!

**Brandon Bishop, Graduate Student, University of Arizona, Tucson, AZ.**

**Lora Chiehowsky, Commonwealth Silver and Gold, Tucson, AZ.**

**Steve Domingo, TSD & Associates, LLC., Tucson, AZ.**

**Rachel Feuerbach, Student, University of Arizona, Tucson, AZ.**

**Cin-Ty Lee, Professor, Rice University, Houston, TX.**

**Marie Light, Pima County Department of Environmental Quality, Tucson, AZ.**

**Callum (Cal) Mark, Clearwater Resources., Ltd., Blaine, WA.**

**Robert Peter, Anglo American Exploration, Vancouver, BC.**

**Rohini Sharma, Freeport McMoRan Copper & Gold, Tucson, AZ.**

In order to encourage interaction between students and working professionals, **BHP Billiton** is proud to sponsor student dinners at monthly Arizona Geological Society dinner meetings. **BHP Billiton** is a global mining, oil and gas company headquartered in Melbourne, Australia. The company mines copper, iron, gold, and coal, and has proven oil reserves. It is the world's largest mining company measured by revenue and, as of February 2011, the world's third-largest company measured by market capitalization. **AZGS is grateful to BHP Billiton for their generous support of our student members.** In order for students to receive dinner at our monthly meeting compliments of BHP, students must make an online dinner reservation.

## 2012 AGS Officers & Councilors

The following slate of officers was approved by online voting and voting at the September 6, 2012 dinner meeting.

President	Jeffrey Cornoyer, Rosemont Copper Company
VP Programs	Robert J. Kamilli, U. S. Geological Survey
VP Field Trips	Doug Shakel, Retired
VP Marketing	Ann D. Pattison, Independent
Treasurer	Coleen Brown, Retired
Vice Treasurer	Michael Conway, Arizona Geological Survey
Secretary	Alison H. Jones, Clear Creek Associates
Vice Secretary	David F. Briggs, Independent
Past President	Greta J. Orris, U.S. Geological Survey
Councilor 1 (12-14)	Michael Busby, Clear Creek Associates
Councilor 1 (12-14)	Kenneth J. Hollett, Retired, U.S. Geological Survey
Councilor 2 (11-13)	Kim Wilson, Independent
Councilor 2 (11-13)	Robert E. Powell, U.S. Geological Survey
Councilor 3 (10-12)	Corolla K Hoag, SRK Consulting
Councilor 3 (10-12)	Claudia Stone, SRK Consulting

AGS is always looking for new people to serve on the Executive Committee. Please let an Executive Committee member know if you wish to serve in 2013.

## 2011 AGS MEMBERSHIP APPLICATION OR RENEWAL FORM

Please mail check with membership form to: Arizona Geological Society, PO Box 40952, Tucson, AZ 85717

Dues (check box) ☐ 1 year: \$20; ☐ 2 years, \$35; ☐ 3 years: \$50; ☐ full-time student (membership is free)

NEW MEMBER or RENEWAL? (circle one) Date of submittal \_\_\_\_\_

Name: \_\_\_\_\_ Position: \_\_\_\_\_

Company: \_\_\_\_\_

Mailing Address: \_\_\_\_\_

Street: \_\_\_\_\_ City: \_\_\_\_\_ State: \_\_\_\_\_ Zip Code: \_\_\_\_\_

Work Phone: \_\_\_\_\_ Home Phone: \_\_\_\_\_

Fax Number: \_\_\_\_\_ Cellular Phone: \_\_\_\_\_

E-mail: \_\_\_\_\_ Check this box if you do not have an email address ☐

***Starting in 2011, all newsletters will be sent by email. If you do not have an email address, we will mail a hard copy to you, but we cannot guarantee timeliness.***

If registered geologist/engineer, indicate registration number and State: \_\_\_\_\_

Enclosed is a \_\_\_\_\_ tax-deductible contribution to the J. Harold Courtright Scholarship Fund.