

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY



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Recently Updated!

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MEETING ANNOUNCEMENT

DATE: Wednesday, April 28, 2004

LOCATION: Orinda Masonic Center, 9 Altarinda Rd., Orinda

TIME: 6:30 p.m. Social; 7:00 p.m. talk (no dinner) Cost:
\$5 per regular member; \$1 per student member

RESERVATIONS: Leave your name and phone number at
925-424-3669 or at danday94@pacbell.net before the meeting.

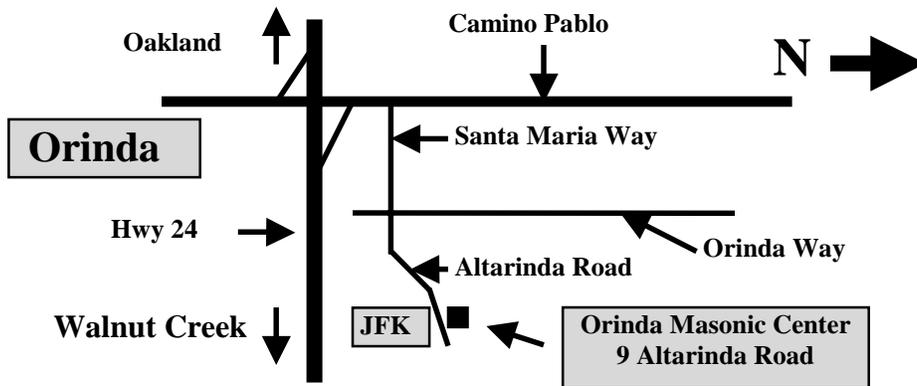
Speaker: John Stockwell, K-12 Program Chair
Northern California Geological Society

The Formation of Thundereggs

Reflecting a widespread bias toward "Rockhounds" and, in contrast to the situation in Europe, toward agate and other "cryptocrystalline" quartz as minerals, few geologists in the United States have taken an interest in the origin and formation of Thundereggs. Yet these objects, by other names, were being commented upon in this country as early as 1893, and in Europe in the 18th century. In addition, the nomenclature of "geodes" has been confused. The development of Thundereggs is a complex process, distinctly different from the process that forms amygdaloidal nodules. Thundereggs occur, presumably worldwide, in acid volcanics and often display great beauty in cross section. Much work on their formation has been done in recent decades in Germany. Some experimental results have been achieved. A good paper by Daniel Kile, a USGS geologist in Denver, was published in 2002. Perhaps of most interest is a 385 plus page study by the "Geode Kid" based on his very extensive observations while mining Thundereggs in a variety of localities throughout the western US. A worldwide gallery of specimens is presented.

John Stockwell received his B. S. in geology *magna cum laude* at Yale in 1957. He was employed as an exploration geologist by BP Alaska and later Sohio from 1974 – 1981, working mainly on and in Alaska. After 1981 he remained in the Bay Area and eventually retired in 2002 from teaching high school earth science and chemistry. He now considers himself an amateur geologist who happens to have had some formal training and professional experience. He is a member of the board (K-12 programs) of the Northern California Geological Society, past president of North Bay Field Trips, and is currently Field Trips North chairperson for the California Federation of Mineralogical Societies. The past 10 years he has taken a considerable interest in Thundereggs, collecting extensively and reviewing problems of their formation. These studies have led to a developing interest in acid volcanics. Mr. Stockwell resides in Berkeley and is a member of the San Pablo Bay Gem and Mineral Society.

Meeting Location



LAST CALL FOR MISSING MEMBERS

Should for some reason your name appear on the following list, please contact us. For whatever reason, our records show that we have not received dues for the current year (2003 – 2004). Please help us straighten out any misinformation. Otherwise, this will be your last newsletter. If you recognize the name of some one here, please let us, or that person, know. Your help is appreciated.

Pierre Armand, Denise Armstrong, Timothy Ault, Kermit Bandt, Greg Bartow, Bruce J. Bilodeau, Kenneth J. Bird, Richard Blake, Arthur Bonwell, Michael Carey, Clifton Davenport, Donald Downey, Richard Ely, Karen Emery, Elizabeth A. Gordon, Deborah O. Hagan, Alan R. Haight, Duncan R. Hickmott, William L. Hiss, Rod Huppi, Carla Kuhn, Jim Lehrman, Gloria Linder, Monzell R. Louke, David W. Lunn, Les Magoon, Frank McEnaney, Tim McHargue, Susan Olig, Roi Peers, Ray Pestrong, Art Poirier, Sarah Raker, Michael Rochette, Joseph M. Sabel, George Saucedo, Ed Simonis, L. Maile Smith, Linda Spencer, Corinne Stewart, James V. Vantine, Maureen Wan, Brian Wright

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NCGS 2003-2004 Calendar

Wednesday April 28, 2004

John Stockwell, NCGS

The Formation of Thundereggs

7:00 PM at Orinda Masonic Center

Wednesday May 26, 2004

Jim Ellis, Ph.D.; Ellis GeoSpatial

Mapping with Remote Sensing & GIS

7:00 PM at Orinda Masonic Center

Upcoming NCGS Field Trips

May 1, 2004

*Geology of the Mt. Diablo
Structural Domain*

Ron Crane, Consultant

July 10 or 11, 2004

*The Merced Formation Along
the Beach*

Ed Clifton, Ralph Hunter
(Retired USGS), and Gregg
Bartow (Public Utilities
Commission)

Fall 2004

*East San Jose Landslide -
Tectonically Driven?*

Sands Figuers,
Norfleet Consultants

Fall 2004

Devil's Slide

Carl Wentworth, U.S.G.S. and
others

Upcoming Meetings of Interest – Association of Engineering Geologists

Thursday, May 13, 2004 (Please note: The date has changed)

Tanya Atwater, University of California, Santa Barbara

Tectonic Origin of the Western US

Old Spaghetti Factory, Oakland

*A Fund Raiser in Association with the California
Council of Geoscience Organizations (CCGO)*

Contact Chris Hundemer at 408-866-5436 for more
information (regular pricing: \$30/member; \$35/non-
member)

Upcoming Meetings of Interest – Bay Area Geophysical Society

May 20, 2004 BAGS Luncheon:

Eli Silver, University of California, Santa Cruz

[The Tectonic Enigma of the Middle America Trench:
Geophysical Studies](#)

Location: California State University, Hayward, 25800
Carlos Bee Blvd., Hayward, CA 94542

Talk: 12:00 p.m., Science North, Rm. 347

Lunch: 13:00 p.m., Bronco Billy's Pizza, 26775

Hayward Blvd., Suite J, Hayward, CA 94542 ([Map](#))

Directions: [CSU Hayward Campus](#)

Map: [CSU Hayward Campus](#)

An abstract and biography is at:

<http://sepwww.stanford.edu/bags/Talks>

Please check the BAGS website regularly for meeting
notices and updates.

www.ncgeolsoc.org

Please check our website for abstracts and biographies of
up coming talks under the “meetings” page. We’ve also
recently posted a number of photos from the November
2003 Mt. Burdell field trip lead by Rick Ford. We
continue to add content to the site in hopes that it
becomes more useful to you. Let us know what you
might find helpful.

2004 NCGS Graduate Scholarship Award!!

The Society is pleased to announce an award of \$1,000
to *Chad Pritchard* of Humboldt State University in
Arcata, California, for his Master of Science thesis
project on *Deciphering Recent Coseismic Subsidence
Events of Northern Humboldt Bay, California*. Mr.
Pritchard’s research program is aimed at refining
chronology and stratigraphic patterns of salt marsh
subsidence and regional synclinal and anticlinal uplift
episodes, in response to Cascadia Subduction Zone
earthquakes. The proposal was selected from a field of
nine well-designed and highly competitive applications,
on topics including paleoclimate pattern interpretation,
extensional crustal deformation, timing of regional fault
slip episodes, acid mine drainage contamination, fluvial
geomorphology and river habitat zonation, processes and
patterns of cavern weathering, and landslide hazard
mapping. We congratulate Mr. Pritchard on his award,
and look forward to a presentation of his research at a
future meeting of the Society in the year 2004.

Natural Gas in the Global Energy Future

The NCGS was extremely fortunate to have **Dr. Nahum Schneidermann** of ChevronTexaco, a recognized expert in global gas and oil reserves, discuss his impressions of world gas economics and its impact on the international energy market at the February 25, 2004, meeting. With the emphasis now on reducing greenhouse gases, the catalysts of global warming, natural gas has assumed a key role in the global energy picture. Dr. Schneidermann's lecture addressed these issues and focused on mankind's complex energy situation.

Dr. Schneidermann, with assistance from his ChevronTexaco colleague Michael Spafford, has meticulously compiled information on global gas resources. Their database includes resource statistics, commodities pricing, and ethnographic information. The key to gas marketing lies in its consumer demographics. To illustrate this point he projected a nighttime satellite image of the earth onto the screen. Numerous pinpoints of light coalesced into eerily glowing metropolitan centers, and identified Middle Eastern petroleum producers via light from gas flare-offs at their major oil fields. The population centers, and hence the major energy consumer bases, formed large patches of light in eastern and southeast Asia (the Orient), Japan, India, Europe, North America, and scattered spots along the Atlantic coast of South America. These distinct geographical regions are the major global energy consumers. Successful energy resources must be able to penetrate these markets cost-effectively. This hinges precariously not only on resource location, but also on its exploration, production, and distribution costs. For petroleum and gas, these dynamics are markedly different. And it is the appeal of natural gas as an energy resource that has some oil giants, like ChevronTexaco, moving rapidly into this market. Ironically, these emerging global markets are juxtaposed in stark contrast to the 1.5 billion people who are still without commercially generated power, and must rely on primitive methods to heat and light their shelters.

Natural gas is often associated with oil, but is dramatically different in terms of its distribution and market pricing. Its spatial distribution is much broader than oil's, where only a few geographical areas control significant amounts of the world's supply. By contrast, at least a few natural gas deposits occur in most nations. This is due to the very narrow thermal window that generates petroleum. Gas, on the other hand, has a broader stability range and is often present as one of the by-products of petroleum cracking.

The economics of natural gas is also quite different than petroleum. The price of oil is globally controlled, whereas natural gas prices are established by local markets. These local distribution centers are called hubs. Prices can vary

dramatically between hubs, and temporarily at a given hub location. With the recent environmental focus on global warming, gas is now viewed as a viable substitute for coal, which creates significant undesirable emissions including greenhouse-effect gases. The economics become even more complex now that the Kyoto Protocol has allowed the trading of "pollution credits" among nations. Thus, a nation with a low pollution rating will be able to sell its credits to a nation with a high rating, which would diminish the need for polluters to develop a gas-based energy policy. Ultimately, however, heavily industrialized nations will be shifting from coal-fueled to methane-based economies.

The world has about 800 to 1000 basins that are potential hydrocarbon producers. Only 50 actually contain petroleum reservoirs, and 45 basins yield 85% of the world's oil. The bulk of the world's oil is produced by seventeen countries. In contrast, there are 1680 trillion cubic feet (tcf) of proven gas reserves. About 70 countries have significant gas reserves, and these are evenly distributed worldwide. There have been many new gas discoveries even in the last 2 years. The major challenges for energy producers are residential, commercial, and industrial markets. Currently, these markets are 37% supplied by oil, 25% by coal, 23% by natural gas, 7% by nuclear, 6% by hydroelectric, and 2% by other commodities. The major natural gas producers are Russia, the U.S., Canada, and the United Kingdom (U.K.). At current consumption rates, the world has about 50 years worth of proven oil and a 63-year supply of natural gas. However, most of the known natural gas reserves are not being exploited, so this is a very conservative estimate. In fact, on an equivalent energy release basis, annual gas discoveries are approximately equivalent to petroleum discoveries. Taking into account the untapped but known reserves of >16,000 tcf of gas extends current world supplies, at present consumption rates, to over 200 years. Today, North America and Europe account for 50% of the annual global gas consumption, Russia 22%, Asia 13%, the Middle East 8%, Central and South America 4%, and Africa 3%.

Another potential gas source is gas hydrates: methane stored in offshore marine sediments as a frozen clathrate compound 50 to 100 meters beneath the sediment-water interface. It is estimated that 24,000 tcf of gas is tied up in these hydrate complexes on continental margins, but the prohibitive cost of exploiting this resource currently renders it uneconomical.

Transportation is a key issue in gas economics. Pipelines are the cheapest mode of transportation, liquified natural gas (LNG) is also popular, and a third method is the gas-to-liquid (GTL) process. The LNG process converts the gas to a liquid phase and then back to a gas. This requires a substantial up front cost for these conversion facilities (\$3 billion per system) and ocean port access. The gas-to-liquids process involves converting the gas to other hydrocarbon products, which is likewise capital intensive.

Typical GTL end products are methanol, dimethyl ether, middle petroleum distillates, specialty chemicals, and waxes. LNG facilities are scattered throughout Japan, Korea, and Taiwan; Southeast Asia is their key gas supplier.

In today's energy market, 38% of electrical power is generated by coal, 18% by the hydroelectric processes, 17% by nuclear, 15% by natural gas, 9% by oil, and 3% other. In the next 20 years, Dr. Schneidermann feels that coal generation will remain at the same level, largely due its utilization in emerging industrial nations like the Peoples Republic of China. The PRC not only has large reserves of coal, but this industry employs a substantial sector of the population.

Natural gas, or methane conversion to clean energy is feasible, but requires some infrastructure modifications. Currently, transportation systems must be established from Norwegian and Russian suppliers to the European market, from Trinidad to Central and South American consumers, from Nigeria to Europe, and from India and Australia to Asian markets. Much of this involves aggressive pipeline system design. The LNG process is feasible, but local permits are deterring domestic conversion plant construction, and current commercial markets are limited.

The future will see a decrease in solid fuel combustion and an increase in the cleaner methane-based energy technologies. The globalization of this resource, however, does require a significant investment in gas transportation infrastructure and a shift to methane-based power generation.

Our sincerest thanks to ChevronTexaco energy expert Dr. Nahum Schneidermann for his glimpse into the global natural gas market. His informative observations of the international energy scene, and predictions of future energy utilization, provided listeners with a fresh perspective on an important economic and environmental issue.

Hunting Dinosaurs on the Frozen Continent

Dr. Judd Case, Professor of Biology and Earth Science, and Dean of Science at St. Mary's College, Moraga, spoke on his exploits searching for dinosaur fossils in Antarctica at the March 31st NCGS meeting. *Discovering Dinosaurs in the Antarctic Peninsula* gave the audience a clear perspective of paleontologic research in arguably the harshest environment on earth – and on the benefits that can be reaped by meticulous scientific research.

Dr. Case has been involved in Antarctic paleontologic research for over a decade, having made trips to this frozen

continent down under to further his research on the origins and distribution of marsupials. His academic background in biology and paleontology has prepared him well for this task. Judd's principal collaborator on this Antarctic research has been James Martin, curator of vertebrate paleontology at the South Dakota School of Mines and Technology. Grant money has been provided largely by the National Science Foundation's Office of Polar Programs. Several colleges and universities have participated in the project, providing up to 14 scientists and graduate students to help with the fieldwork.

The initial interest in the Antarctic fauna was on marsupials and their global distribution over time. The first Antarctic mammals were marsupials, and Dr. Case felt that this fauna would provide clues to how these creatures had spread from North and South America to their current isolated stronghold in Australia. Floral evidence and paleomagnetic data show that Antarctica was not always at the South Pole, but occupied a position in temperate latitudes during late Mesozoic-early Cenozoic times. Currently, the continent is dominated by a thick ice cap pierced by the Transantarctic Mountains and ranges comprising the Antarctic Peninsula. The latter trends northward from the main continental land mass towards the southern tip of South America. Jim Martin's interest in this area involves pleisosaurs and mososaurs, the former a large, long-necked marine reptile with paddle-shaped limbs, and the latter resembling a fish-like crocodylian.

The appeal of the Antarctic Peninsula is its geographic location, the well-exposed lithologies in the back-arc James Ross Basin, and the excellent ammonite-dominated fossil control in these units. The peninsula linked Antarctica with South America at this time. The James Ross Basin contains a continuous sequence of marine sediments spanning the Cretaceous-Tertiary (K/T) boundary, with superb exposures on James Ross and Vega islands.

Judd's presentation mixed science with an overview of the logistics needed to establish an outpost, even for a short six-weeks' duration, in this barren land. Expedition scientists flew from North America to Terra del Fuego in early December, 2003, where the icebreaker Lawrence M. Gould took them to their destination off the coast of James Ross island. The group met with some minor adversity on the way—the sea had not thawed completely and the Gould was temporarily trapped in winter ice partly atop a small iceberg. It took some clever load redistribution to free the vessel, and eventually get supplies to shore. The same ice also prohibited access to some of the previously investigated sites on Vega Island immediately north of James Ross Island. The scientists slept in high-peaked Scott tents, and used a Canadian-designed Quonset hut for group dining, communications, computer stations, and cataloging specimens. Fresh meat, vegetables, and spices allowed the members to enjoy some exotic meals rather than the usual canned and dehydrated food sources. This expedition also enjoyed the company of three naval recruits

from nearby Palmer station. This American outpost on Anvers Island served as an emergency contact point should the expedition need help. Although the polar summer was near at hand, daily temperatures peaked in the mid 40°F's and snow flurries were not uncommon. Snow and overnight freezing conditions made footing treacherous, especially since the field sites were a 4 mile trek around a small cove. The expedition drew a following of curious animal on-lookers that included Wadell seals and several kinds of penguins.

The local geology played a large role in the expedition's success. The target units were Senonian (late Cretaceous) age, covering the Santonian, Campanian, and Maastrichtian stages (listed in decreasing chronological order). The exposed sedimentary sequence represents an eastward migrating shoreline. The key formation is the Marambio Group (Campanian-Maastrichtian) capped by a protective volcanic layer. The Cape Lamb member of this group has been biostratigraphically well-characterized and well-dated at 71.0 million years old. The overlying volcanics include volcanoclastic breccias and basalt flows. The volcanics, which provided a protective cap to the underlying near shore and mid-continental shelf marine sediments, unfortunately often obscured them with thick talus slopes. Another complication was the pervasive permafrost, which fortunately thawed out in near surface exposures, permitting the friable sediments to be sampled. The basal Santonian units yielded dinosaur fossils—meat eaters akin to the tyrannosaurs and allosaurs, spiny armored ankylosaurs, iguanids, hypsodontids, and a newcomer, the hadrosaur, that sported a banana-shaped protuberance from the back of its skull. The major fossil discovery on this expedition, however, was completely unexpected.

On December 12, 2003, Dr. Case strayed from the other scientists and was wandering over James Ross Island exposures near landmarks Dagger Peak and adjacent Cone Ridge, when he spied some gastroliths, smooth rounded cobbles ingested by dinosaurs to help digest their meals. These stones were lithologically out of place in this terrain, and caught Judd's eye. He followed the trail upslope and soon came upon terrestrial vertebrate bone fragments. Summoning the others in the party, the group excitedly began screening fragments out of the rubble, revealing leg joint pieces, foot bones, toes, vertebrae, skull fragments, and teeth. Subsequent examination produced a composite profile of a small fleet-footed meat-eater about 6 to 8 feet tall and closely resembling the sinister theropod velociraptors depicted in the *Jurassic Park* film series. Coincidentally, this creature fills a height gap in this carnivore class that previously had jumped abruptly from 12 foot-high to 3 foot individuals. These findings were featured in a February 26th press release that included another Antarctic dinosaur discovery, a primitive sauropod (brontosaurus-type creature) found at 13,000 feet in the Transantarctic range, within one week of Dr. Case's find.

Overall, the late Cretaceous Antarctic dinosaur fauna survived longer than elsewhere in the world. The theropod discovery is unique because the carcass was obviously transported from shallow to moderately deep waters, where it was disarticulated by scavengers. The inclement weather conditions also played a role in the find by forcing the research team to abandon their intended digs on Vega Island in favor of accessible sites on the north shore of James Ross Island. As an addendum, Dr. Case pointed out that the overlying Cretaceous-Tertiary boundary spans a 30 foot-thick sedimentary interval that provides a detailed chronology of faunal extinctions across this time line. An iridium-rich glauconite clay horizon is also included in the sequence, currently associated worldwide with a cataclysmic meteorite impact that doomed the dinosaurs and ushered in the Age of Mammals.

It is our pleasure to thank St. Mary's College Dean of Science Judd Case for a pleasurable recap of his exciting trip to Antarctica. This unique fossil discovery literally saved the expedition and added a missing piece to the theropod evolutionary tree. And it provides a fitting boost to the growing Earth Science program Dr. Case is assembling at St. Mary's.

The Marvelous Monterey Formation

Anyone familiar with California Coast Range geology can readily recognize outcrops of the classic Miocene Monterey Formation. It crops out from the San Francisco Bay Area to Santa Barbara, and is present in the offshore subsurface. Its unique mineralogic, lithologic, structural, and petrochemical characteristics were detailed in **Dr. Richard J. Behl's** April 5th AAPG Distinguished Lecture *The Miocene Monterey Formation of California: Plankton to Petroleum, Source to Reservoir*. Dr. Behl has spent much of his 25-year career as a well site geologist, stratigrapher, and sedimentary petrologist studying the Neogene continental margin sediments off the California coast. His extensive experience in this pursuit qualifies him as an expert spokesman on the genesis and tectonic evolution of the Monterey Formation.

The Monterey Formation is a unique phenomenon in the Neogene stratigraphic section of the California Central Coast Range. It is a ubiquitous, often thick unit that crops out throughout the central coast, particularly in the Santa Maria basin and surrounding areas in the Salinas Valley-San Luis Obispo-Santa Barbara region. Trapped within these siliceous sediments are not only the organic precursors of petrochemicals, but also a wealth of paleoclimatological information.

In the late 1970's, the Monterey was of major interest to petroleum exploration firms. Dr. Behl began his geological career as a well site geologist, and developed a keen interest in the Monterey Formation that has spanned over two decades. The Monterey is in many ways a unique formation that chronicles a significant portion of the late Neogene history of the California continental margin. It is Miocene age, but transgresses time from about 17 to 5 million years ago, and can locally be Pliocene. It consists of thin bedded, laminated siliceous pelagic sediments a few centimeters to about a meter thick, often rich in organic material. The dominant constituent is diatoms, tiny planktonic creatures with complex skeletons or "tests" composed of opaline silica, a hydrous amorphous form of silica. These tiny skeletons settle to the ocean bottom once the animals died and form an ultra fine-grained siliceous ooze with an interconnected microporosity up to 65%. A minor fraction is composed of coccolithophorids and calcareous foraminifera, along with some interbedded smectitic clays and siltstones, and occasional volcanogenic components. Neogene Monterey equivalents can be found around the Pacific rim margins in South America, Alaska, and Japan. Beautiful exposures of laminated Monterey sediments, of course, crop out along the central California coast. The Monterey and its equivalents were laid down in mid-Miocene time when ocean currents and upwelling brought nutrients to surface waters that allowed abundant plankton communities to flourish. Prior to the Miocene, the siliceous sediments accumulated on the North Atlantic margins. As seafloor spreading continued to modify ocean basins, the conditions necessary to support large planktonic populations developed in the Pacific, while those in the North Atlantic eventually subsided.

The plankton blooms reflect climatic changes associated with the nutrient-rich current upwellings. Global conditions were warmer in the Paleocene (early Tertiary) and then gradually cooled. The Monterey formed during these cooler times as polar ice sheets began to expand. Scientists hypothesize that the cool climate and higher winds drove the current upwelling process, bringing nutrients to the surface, and allowing organic-rich sediments to accumulate. The east Pacific boundary currents were particularly active, and created an intense upwelling along the California coast. Diatoms were the quickest to react to these favorable conditions, and thus dominated the planktonic community. Under certain conditions, the Monterey sediments can contain calcareous or phosphate-rich layers, although these are very minor components. The Monterey also contains detrital sedimentary layers comprised of clay and silt from terrestrial sources, often as down slope-transported turbidite muds.

Much of the Monterey Formation was laid down in marginal basins formed when the plate tectonic boundary on the west coast of America transitioned from subduction to a strike-slip transpressional regime. This tensional stress configuration generated "pull apart" basins on the

continental margin that slowly filled in with planktonic debris from near surface waters. Hence, the nonmarine fluvial Paleocene sediments gave way to deepwater basin deposits as crustal thinning occurred along the continental margin.

Diatoms have very intricate, porous skeletal structures. The sediments formed from these skeletal remains therefore have initial porosities up to 70%. Burial compresses the sediments and drives diagenetic processes that recrystallize the opaline silica diatom tests, initiate hydrocarbon cracking reactions, and flush pore fluids out of the pore spaces. This gradual lithification process converts the parental diatomite first to a cemented and partially crystalline porcelanite (reminiscent of porcelain china) stage, and eventually to dense, cryptocrystalline chert. Pore fluid migration can also mobilize silica, and precipitate it elsewhere as cherty nodules and lenses.

The Monterey Formation displays a wide range of bedding thickness, from tenths of a millimeter to tens of centimeters thick. These bedding laminations are cyclic in nature and can be recognized in subsurface well logs as well as in outcrop exposures. The finer layering represents rapid sedimentation rates, whereas slower sedimentation tends to obscure discrete annual events and results in thicker bedding units. The fine laminations and thicker bedding sequences represent cycles ranging from annual repetitions to periods of over a hundred thousand years. Careful examination has linked these cyclic sedimentation features to the earth's orbital or Milankovitch cyclicity. The earth is inclined on its rotational axis with respect to its orbital plane, and precesses like a gyroscope or top as it revolves around the sun. Its orbital characteristics can be broken up into eccentricity, precession, and obliquity, with the associated sedimentary cycle durations decreasing in this order. The Milankovitch cycles control climate fluctuations and have been correlated with Pleistocene glacial cycles. Gamma ray well logs have been examined by Fourier analysis to extract various cycle frequencies, and the cores have been studied to tie in the biostratigraphy with these cycles. This procedure was applied to the Santa Maria basin between San Luis Obispo and Santa Barbara to determine the sedimentation / in-filling rate. The sedimentation rates calculated from these studies ranged from 8.5 cm. to 80 cm. per 1000 years, and showed a relationship to climatological effects on plankton productivity. The same technique has also been applied to offshore drilling cores using oxygen isotope analysis and paleomagnetic data to correlate paleotemperatures with absolute age.

Dr. Behl also presented data tying mineralogical paragenesis in the Monterey sediments to petroleum genesis and reservoir formation. He and his research colleagues feel that the typical fractured Monterey hydrocarbon reservoir develops in response to mineralogical paragenesis associated with burial diagenesis of diatomite opaline silica. The opal goes through a two

stage recrystallization process, first converting from amorphous hydrous opal to poorly crystalline cristobalite and tridymite silica phases, then to crystalline quartz as the burial temperature increases. Laboratory studies show that cherts form from diatomaceous sediments at relatively low temperatures, creating thin brittle layers in a relatively ductile sedimentary matrix. The cherty layers are deposition points of silica mobilized during diagenesis from shaley interbeds (which are silica-depleted). These brittle layers are severely fractured during subsequent tectonic deformation of the sediments.

Uniquely, the Monterey acts as both a hydrocarbon source rock and a reservoir rock. Its trapped organic matter, derived from deceased planktonic algae, is a type II kerogen. The total organic content of the sediments can range up to 23% in phosphatic layers. It is overall a fairly organic rich formation, often rich in sulfur. Dr. Behl used the Santa Maria basin, located between the Santa Ynez Mountains and the Central Coast Range south of San Luis Obispo, as an example of petroleum reservoir evolution in the Monterey Formation. The Santa Maria basin is bounded by NW to SE-trending faults. It formed 17 to 18 m.y. ago as a rapidly subsiding basin during a transtensional to transpressional tectonic regime, and shallowed as it gradually filled in with sediments. It was uplifted during the last 6 to 7 million years and underwent ramp style thrusting deformation that trapped oil in up-dip pinch outs sealed by impermeable sedimentary on-lap sequences. The early-formed brittle chert layers buckled, fragmented, and rotated in the ductile matrix, and shortened by up to 40%. The shale interlayers were able to accommodate this intense deformation by bedding-parallel ductile flow. As the opaline sediments recrystallized, water was released from the amorphous silica. Pore fluids flushed out of the system as porosity decreased from about 60% to 30% during diagenetic recrystallization. These fluids were driven out of the source sediments along with the petroleum hydrocarbons, which had been generated by breakdown of kerogen-rich organic matter in the sediments. The petroleum-bearing fluids followed tectonic fault zones in the formation that drained large portions of the sediments. Pressurized fluids fractured brittle cherty and calcareous layers in multiple migration episodes punctuated by carbonate cementation of the fracture conduits. Dolomitic and porcelanite layers show slightly different fracturing behavior, and hence have different reservoir characteristics. The cherty layers exhibit finer brecciation and a more abundant, open interparticle porosity that readily accepts hydrocarbon fluids. These shattered zones frequently form in anticline hinges and create extensive petroleum reservoirs. Some of these petroliferous fluid conduits and fracture zones have been exposed in outcrops along the coast near Vandenburg Air Force Base.

The NCGS gives its sincere thanks to Dr. Richard Behl of California State University, Long Beach, for his comprehensive sedimentologic, structural, and stratigraphic tour of one of California's most recognizable formations. His lecture emphasized the important role this unit plays in interpreting Neogene paleoclimate cycles, and the effects that diagenetic phenomena can have on the mobilization and emplacement of petroleum in subsurface reservoirs. We also acknowledge the continuing support of **ChevronTexaco** Corporation, which provides a generous grant to the NCGS to help underwrite the cost of hosting the annual AAPG Distinguished Lecture series. ChevronTexaco kindly provided one of its San Ramon Park lecture rooms, with refreshments, for Dr. Behl's presentation.

Visiting Brazilian Professionals Enjoy a Day on Mount Diablo

Two members of a team of business professionals from the southern Brazilian state of Parana enjoyed the company of **Ron Crane**, consultant, and **Dan Day** on April 13th to see geological highlights of the San Ramon Valley and Mount Diablo. Dan's wife, Laura, is a member of the San Ramon Valley Rotary Club and Rotary International District 5160, which is hosting a one month visit by a five-member Brazilian Group Study Exchange (GSE) team. The purpose of this exchange is to expose team participants to some of the techniques used in their vocations here in America. The foreign exchange members also share their professional and business experiences with their American colleagues. This year's GSE team was led by Rotarian Eliane Junquiera Massaretto, a Court Justice Administrator.

Ron Crane, who will be leading the May 1st NCGS field trip to Mount Diablo, showed Brazilian Geography teacher **Marcos Roberto Marin** and aspiring English teacher **Marcia de Marchi** some of the basic geological features of the San Ramon Valley before taking them on a tour of Mount Diablo. Ron also related important historical facts of the region to the two young Brazilians, and explained some of the recent cultural changes, particularly infrastructure development, that have impacted the area.

The local San Ramon Valley Rotary Clubs hosting these exchange students, and Rotarians of District 5160, would like to express their deepest thanks to Ron for taking time from his busy day to show Marcos and Marcia the local geology. This trip will long be remembered by these bright young Brazilian schoolteachers!

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY



NCGS FIELD TRIP

Geology and Groundwater Resources of the Merced Formation in the Westside Basin of the Coastal San Mateo and San Francisco Counties

Saturday July 10, 2004

Field Trip Leaders:

Ed Clifton, (Retired) United States Geological Survey
Ralph Hunter, (Retired) United States Geological Survey
Greg Bartow, San Francisco Public Utility Commission

The Merced Formation, in its sea cliff exposures between Lake Merced and Mussel Rock, displays a nearly continuous section of more than 1700 m of late Pliocene and Pleistocene strata. The section offers a unique opportunity to explore the late Neogene and quaternary history of coastal California in the San Francisco Bay Area. Focus will be on depositional facies that range from shelf depth to eolian dune and their implications relative to sea level history and tectonism in this area over the past 2+ million years. Discussions will include the applicability of sequence stratigraphic concepts in a rapidly subsiding basin. One stop along the way will be devoted to a discussion of Lake Merced and the Westside Groundwater Basin.

Exposure of the Merced Formation differs from year to year. Past trips have encountered a variety of fossil remains, including that of a mammoth or mastodon, fossil foot prints of diverse Pleistocene mammals, sedimentary structures produced by ancient earthquakes, and an ash fall that, today, would devastate the Bay Area. Part of the walk will be along the base of a giant landslide that is activated by contemporary earthquakes and El Niño winters.

THIS FIELD TRIP WILL BE LIMITED TO 50 PEOPLE. CARPOOL/VANPOOL IS A MUST

***** **Field Trip Logistics** *****

Time: **Saturday July 10, 2004, 7:30 am**

Departure: Gathering place will be announced in the next issue and notified to the registrants by e-mail. Gather (?) at 7:30 am for distribution of guidebook, coffee and doughnuts, and leave by 8:00 a.m.

Cost: \$30 for members; \$40 for non-members and \$20 for students. Cost includes refreshments, lunch, and field guides.

***** **REGISTRATION FORM (Merced Formation Field Trip)** *****

Name: _____ E-mail: _____

Address: _____

Phone (day): _____ Phone (evening) _____ Please indicate check amount:

Lunch (Sandwich) Regular _____ Vegetarian _____ (Please check one)

Please mail form and check made out to **NCGS to: Tridib Guha, 5016 Gloucester Lane, Martinez, CA 94553**

Questions: e-mail: aars@earthlink.net; Phone: (925) 370-0685 (evening - PREFERRED) (925) 363-1999 (day – emergency)

People who are willing to drive their car or SUV please indicate (NCGS will pay for the fuel cost)

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY



NCGS Field Trip

Geology of the Mt. Diablo Structural Domain

Saturday May 1, 2004

**Field Trip Leader:
Ron Crane, Consultant**

This trip will concentrate on the southern portion of the Mt. Diablo Structural Domain. We will investigate the general structure of the area and go up Mt. Diablo to the top with several view stops, with lunch at the top. In the afternoon we will go down the northern road and across the north plunge along Ygnacio Road, stopping at the Domengine Outcrop, and on to the Marsh Creek Road.

THIS FIELD TRIP WILL BE LIMITED TO 30 PEOPLE. CARPOOLING IS A MUST!!

***** **Field Trip Logistics** *****

Time: **Saturday May 1, 2004, 7:30 am** : I-680/ Sycamore Valley Road Park and Ride

Departure: We will gather at the Danville Park and Ride lot immediately east of the I-680 Freeway on the Sycamore Valley Road exit, at the end of the parking lot. Gather there at 7:30 am for distribution of guidebook, coffee and doughnuts, and leave by 8:00 a.m. The trip should be over by 4:30 pm.

Cost: \$30 for members; \$20 for students. Cost includes refreshments, lunch, and field guides.

***** **REGISTRATION FORM --- PLEASE RSVP by Thursday, April 29, 2004** *****

Name _____ E-mail or Fax No. _____

Address (Street/City/Zip) _____

Phone (day) _____ Phone (evening) _____ Please indicate if you are a nonmember (cost is \$40 – includes membership for the remainder of the year) _____

Regular Lunch _____ Vegetarian Lunch _____ (Please check one)

Please mail form and a check made out to NCGS to: **Tridib Guha, 5016 Gloucester Lane, Martinez, CA 94553**

If you have any questions or need additional information, e-mail Tridib at: aars@earthlink.net or call: (925) 370-0685 (evenings - PREFERRED) or (925) 363-1999 (day - emergency only)

People who are willing to drive their car or SUV please indicate and NCGS will pay your fuel costs.