NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

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MEETING ANNOUNCEMENT

DATE: Wednesday, April 27, 2005

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: *Dr. Michael Manga*, Dept. Earth and Planetary Science, University of California, Berkeley

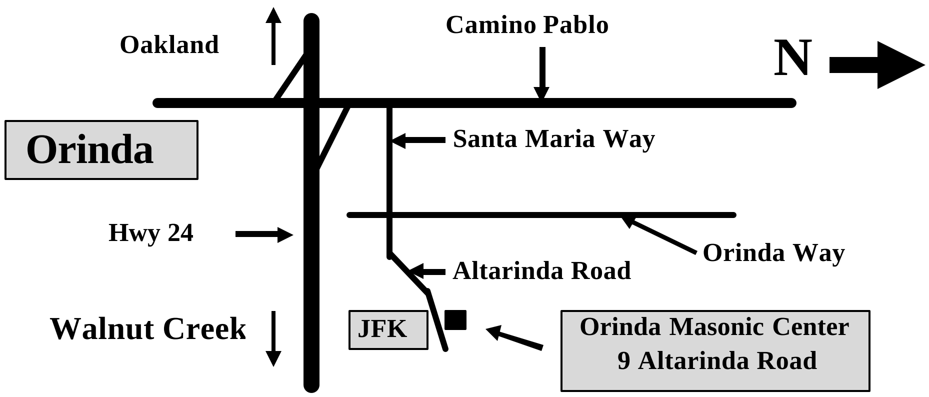
Why do Volcanoes (Only Sometimes) Erupt Explosively?

The fragmentation of ascending magma is generally thought to be the key physical process that leads to explosive eruptions. Fragmentation occurs when stresses associated with bubble growth or decompression exceed the strength of the melt, allowing the magma to break into disconnected fragments suspended within an expanding gas phase. Although repeated effusive and explosive eruptions are common at individual volcanoes, the dynamics controlling the transition between explosive and effusive eruptions are unclear. One important constraint on the dynamics is that effusive lavas generally erupt considerably more degassed than their explosive counterparts, even if they erupt from sources with similar volatile contents. One mechanism for degassing during magma ascent is the formation of intermittent permeable fracture networks generated by non-explosive fragmentation adjacent to conduit walls. We will show that such fragmentation, which occurs when shear stresses exceed the strength of the magma, are expected to occur in both explosive and effusive eruptions.

The presence of fracture networks allows for rapid magma degassing and hence can inhibit explosive behaviour. In order to test this hypothesis we will present a quantitative analysis of bands in obsidian from Big Glass Mountain, CA. We show that these bands can be created by the repeated breaking, reorientation, reannealing and stretching of fragments created at conduit walls. We thus conclude that, contrary to conventional views, explosive volcanism is not the inevitable consequence of magma fragmentation.

Explosive eruptions can also be triggered by rapid decompression caused, for example, by dome collapse or landslides. We show, using a series of analog lab experiments, that whether or not rapid decompression leads to explosive eruptions depends on the initial vesicularity of the stored magma and the overpressure P in the bubbles. The product P is proportional to the potential energy of the bubbly magma. If the decompression rate is fast compared to the relaxation time of the magma, as it is when a surface load is suddenly removed, the potential energy is converted to kinetic energy and the speed of expansion v can be calculated. If v is large enough, the magma will fragment and the eruption will be explosive. In summary, whether or not a given

Meeting Location



eruption will be explosive depends not only on the ability of the magma to fragment, but also whether it is able to lose the volatiles that provide the driving force for eruption.

Biography: Stealing directly from Dr. Manga's website (http://seismo.berkeley.edu/~manga/rsch.html), Dr. Manga has principally studied geological processes involving fluids, including problems in physical volcanology, geodynamics, hydrogeology, and geomorphology. The common theme running between these disciplines is an attempt to develop a better quantitative understanding of physical processes operating *in* the Earth. Depending on the nature of the problem, combinations of theoretical, numerical, and experimental approaches have been used. Because the intent is to understand natural systems, integration of both active processes and those recorded in the geologic record, with theoretical and model results is an essential component of the research. Often the fluid mechanics that need to be understood have not yet been studied. Consequently, his research typically involves new contributions in applied mechanics. Recent contributions include studies of convection, the properties and dynamics of suspensions, flow and transport in porous materials, percolation theory, and high pressure mineral physics. This work is currently funded by the National Science Foundation, the Petroleum Research Fund, the Sloan Foundation, and Lawrence Berkeley National Lab. Dr. Manga received his BSc, from McGill University (1990; Geophysics) and his PhD from Harvard (1994). He has been as Associate Professor at Cal since 2001.

Northern California Geological Society
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Would you like to receive the NCGS newsletter by e-mail? If you are not already doing so, and would like to, please contact **Dan Day** at danday94@pacbell.net to sign up for this service.

NCGS 2004-2005 Calendar

Wednesday March 30, 2005
Dr. Barbara Bekins, U. S. Geological Survey
Hydrogeology and the Weak nature of Plate Boundary Faults
7:00 pm at Orinda Masonic Center

Wednesday April 27, 2005
Dr. Michael Manga, University of California, Berkeley
An Explosive Theory About Volcanoes
7:00 pm at Orinda Masonic Center

Wednesday May 25, 2005
TBA
7:00 pm at Orinda Masonic Center

Wednesday June 29, 2005
Dr. Monty Hampton, Emeritus, U. S. Geological Survey
Formation and Evolution of Coastal Cliffs (or the All-Time Shortest Coastal Cliffs Short Course)
7:00 pm at Orinda Masonic Center

Upcoming NCGS Field Trips

May 21, 2005	***Robert Sibley Volcanic Regional Preserve in Berkeley Hills*** **Stephen Edwards,** Director, Tilden Regional Botanic Garden
June 25 - 26, 2005	***Blueschists and Breweries (BrewschistsII)*** **John Wakabayashi**, Consultant

(Tridib reported in March that 14 members have already reserved a place on the "Brewschists II" field trip. Not all details for this field trip are known; however, as planned, transportation will be by bus, thus eliminating the need for individual driving. For currently available stop by stop details please refer to the February 2005 newsletter. **Please contact Tridib Guha at** aars@netscape.com **for reservations.**)

Upcoming Meetings of Interest – Bay Area Geophysical Society

Thursday April 21st, 2005
Deep-Tow Marine Electromagnetic Sounding
Mike Hoversten, Energy Resources Program Head, Lawrence Livermore National Lab
Location: ChevronTexaco Park, 6001 Bollinger Canyon Road, San Ramon, CA 94583
Lunch: 11:30 a.m., ChevronTexaco Cafeteria
Talk: 12:30 p.m. Building D, Room D2193
In order to get visitor access to ChevronTexaco campus we ask that you contact either Warren King at (Warren.King@chevrontexaco.com) or Peeter Akerberg at (peeter@chevrontexaco.com), preferably a day or more ahead of the talk. One of us will request a visitors badge for you which can be picked up at the front desk in the main lobby the day of the talk.
Directions: Please follow these directions!
Map: Map of ChevronTexaco Campus
Abstracts, biographies, directions, and maps can be found at: http://sepwww.stanford.edu/bags/

$750 Northern California Geological Society Teacher of the Year Award

The Northern California Geological Society is pleased to announce that Mr. Chaiwat Neokul has been awarded the $750 Teacher of the Year Award. The award was presented to Mr. Neokul at the Society's March 30 meeting. Mr. Neokul came highly recommended, not only by his school, but also by his students. He teaches sixth grade earth science and ninth grade physical science at the Chinese Christian School in San Leandro. His curriculum includes units on mineral and mineral resources. He has also been a teacher of physics. Mr. Neokul earned his B.S. in 2001 from Pensacola Christian College.

The NCGS award, offered annually, is preliminary to the Pacific Section - AAPG competition for Teacher of the Year. His application has been forwarded.

San Francisco Bay Area Science Fair Award

The Northern California Geological Society is pleased to announce that it has awarded $100 to Rachael O'Riordan in recognition of her entry entitled **WAVES OF FURY** at the 52nd annual ***San Francisco Bay Area Science Fair.*** Using an ingenious model, Rachael compared the capacity of strike-slip and thrust faults to generate tsunamis. Her entry was selected from among *fourteen* geoscience related projects. Rachael is in the Seventh Grade at St. Charles School in San Carlos.

The Fair was held March 15-19 at the Hall of Flowers in Golden Gate Park, and the entries represent the best of many individual school or district based science fairs. The Fair, open to all Bay Area students in grades 7 to 12, "…is dedicated to encouraging original scientific research on the part of young people from all walks of life…" There are six categories for judging: Environmental Sciences, Engineering and Computer Applications, Behavioral Sciences, Biological Sciences, Physical Sciences, and Mathematics and Computers. More can be learned about the SFBASF at their website: http://home.pacbell.net/sfbasf/

It is expected that the Society will make this award annually.

2005 Annual Meeting
Cordilleran Section, GSA
Pacific Section, AAPG
Pacific Section SEPM

Bay, Basins, Basement, and Beyond

Fairmont Hotel, San José, California
April 29 – May 1, 2005

Did you know that 5 of the 15 pre- and post- field trips are being lead or co-lead by NCGS members? Are you going?! Time is running out!

The 2005 annual meetings of the Cordilleran Section GSA and the Pacific Sections AAPG and SEPM will be held jointly at the Fairmont Hotel in San José, hosted by the Department of Geology, San José State University. Up-to-date information about the meeting can be found at: www.geosociety.org/sectdiv/sections.htm

Hydrogeological Modeling of Subduction Zone Faults

Contributed by Dan Day

Dr. Barbara Bekins of the U.S. Geological Survey, Menlo Park, was guest speaker at the March 30, 2005, NCGS meeting. Her presentation ***Hydrogeology and the Weak Nature of Plate Boundary Faults*** introduced the audience to the application of hydrogeological modeling techniques to subduction zone faults. Her research in this area has been an interdisciplinary effort that involves Ocean Deep Sea Drilling projects, seismic imaging, chemical diagenesis, sedimentology, earthquake monitoring, and hydrogeological modeling. Her presentation was originally part of a one year GSA lecture tour during 2003-2004 supported by the USGS, the GSA Hydrogeology Division, and a Birdsall Internship at U.C. Santa Cruz under the guidance of her thesis advisor, the late Shirley Dreiss. Barbara is currently working at the USGS as a hydrogeologist modeling groundwater contaminant transport, biological groundwater remediation, and the influence of hydrogeological factors on fault movement.

The talk focused on subduction zone thrust faulting, which is considerably simpler to model than terrestrial strike-slip faults. During her lecture, Barbara wove fluid influences on fault mechanics, fluid sources, seismicity, and data from numerous seafloor drill holes into a workable theory for explaining the seismic behavior of several important subduction zone complexes.

Barbara began with a brief description of stress distribution on thrust (normal) fault planes. This theory has been well established in structural geology, but was examined from a fluid pressure perspective in the classic 1959 GSA paper by M. King Hubbert and Wiliam Rubey ***Role of Fluid Pressure in the Mechanics of Overthrust Faulting***. This treatise examined the effects that fluid pressure had on relieving the shear stress (force) component normal to the fault plane. Reducing this force by fluid pressure lubrication would also lower the coefficient of friction along the fault plane and allow substantial displacement to occur along the hanging wall. By similar analogy, Barbara felt that fluid pressure along submarine subduction zone faults would explain some of the aseismic to seismic transitions observed by geophysicists along major ocean trenches. If the shear stress is considered to be the maximum stress along a fault before failure (movement) can occur, one can classify faults as weak (stress is about 20 MPa at 10 km. depth and there is a complete stress drop during fault movement) or as strong (critical stress is about 100 MPa at 10 km. depth and a partial stress drop during movement). Basically, these criteria identify seismic from aseismic fault behavior. Barbara's challenge was to examine several well-studied subduction zone complexes and determine what characteristics distinguish seismic from aseismic fault activity.

Based on Hubbert and Rubey's pioneering work, fluid pressure provides a potential explanation. The latter can significantly lower the shear stress along the fault plane and facilitate motion. Similarly, fault gouge minerals, like clays, can lubricate the plane and accommodate displacement. A third hypothesis suggests that there is a dynamic weakening that occurs only during a seismic event that both lowers the coefficient of friction along the fault and increases the fluid pressure. Any or all of these mechanisms may be acting on various subduction zone complexes, but high fluid pressures are surely the most plausible culprit. How can fluid pressures be maintained over geologic time intervals of several million years? Barbara and her colleagues feel the process must have dynamic balance, it should be in constant disequilibrium, and there should be a geologic mechanism that continually drives the system towards producing fluids. The necessary fluid pressures are maintained by the sheer magnitude of the fluid sources, by low permeability, and by the length of the pathway that allows trapped fluids to escape.

Next, Barbara examined the generalized subduction zone model. Schematically, convergent plate boundary motion forces one plate to override the other. The down going (subducted) plate follows an inclined ramp-like thrust plane beneath the hanging wall (overriding) plate. Where this plane intersects the seafloor, an accretionary prism of sediment scraped off the down going plate is formed, typically laced with imbricate thrust faults as it grows. Arc volcanoes often form on the overriding plate some distance away from the plate boundary. To better understand subduction mechanics, structural geologists have defined a term called the taper angle, which is the angle between the seafloor surface of the accretionary prism tip and the fault plane separating it from the down going slab. This taper angle is usually only a few degrees and is stable over time. Where the accretionary prism taper tip intersects the seafloor, low temperature biological communities are supported by nutrient-rich fluids seeping upward along the subduction fault. On thicker parts of the prism away from the taper tip, oceanographers have discovered mound diapirism and mud volcano complexes formed by fluids escaping along imbricate faults. These seafloor features add credence to the fluid pressure theory and are the basis for accretionary prism hydrogeological models. Important data used in these models was acquired by the Integrated Ocean Drilling Program (IODP), which has methodically sampled many accretionary prism complexes around the globe.

Subduction zone areas referenced in Barbara's talk include Barbados, Nankai (near southern Japan), and Cascadia off the Oregon-Washington-British Columbia coast. Many of the drill holes in these prisms have been instrumented to measure temperature and pore fluid pressure. Dubbed "circulation obviation retrofit kits" (CORKs), these devices have provided vital information about accretionary prism fluid mechanics. Drill holes on the Cascadia accretionary prism off Oregon were fitted with CORKs. The Cascadia subduction zone is not very seismically active, having experienced its last major earthquake about 1700 and another minor temblor about 50 years ago. One of the CORKs was positioned across the subduction zone fault and was instrumented at, above, and below this plane. Seven months after it was installed, a thermistor located at the fault plane recorded a temperature excursion from 11ºC to 15ºC. This was interpreted as a fluid pulse moving up the fault plane from depth.

At Barbados, the Atlantic plate is being subducted under the Caribbean plate, forming the Lesser Antilles active volcanic chain to the west. The accretionary wedge here is particularly aseismic. It has a very shallow taper angle of 3 degrees. This results in a gently dipping subduction zone that lies only about 8 km. beneath the seafloor a distance of almost 120 km. from the tip. The accretionary wedge is Eocene age and the subduction rate is only about 2 cm. per year. Calculations based on this subduction rate show that subducted sediments take about 6 million years to travel 120 km. down the fault plane, but 40 million years to horizontally accrete a 120 km. long prism. This wedge was Barbara's doctoral thesis topic and was the basis for her first subduction zone hydrogeological models.

To hydrologically model an accretionary prism, the fluid sources must be specified. Barbara identified two: sediment burial compaction and clay mineral (water-rich smectite) dewatering. The initial sediments have water contents of 50 to 80%, which is not unusual for deep sea muds. The subduction process acts like a wringer, and compresses the clay-rich deposits to water contents of about 10%. A porosity-depth profile shows an exponential drop in pore volume as water is squeezed from the sediment. The clay mineral thermal dewatering process occurs at temperatures between 60 and 150ºC. Where it occurs is highly dependent on the local thermal gradient. At Barbados, the thermal gradient is 20ºC/km. and the clay mineral dehydration takes place significantly after the compaction dewatering. The sediment porosity values used in the model were derived from seismic velocity measurements and examination of deep sea cores. Pore pressures were measured in the instrumented bore holes. The results were in good agreement and showed an initial compaction dewatering overpressure of 0.36 near the prism toe and a deeper fluid overpressure of 0.50 lithostatic attributed to clay mineral thermal dehydration. Fluid pressures along the subduction fault plane were high enough to promote aseismic movement on this tectonic plate boundary.

The East Nankai Trough at the intersection of the subducting Philippines plate and the Asian plate off southern Japan offers a different scenario. Here the accretionary prism taper angle is 4.1 degrees, and varies slightly with depth. The fault plane is aseismic near the accretionary prism tip, and becomes seismically active at depth. The 100ºC/km. thermal gradient at Nankai is much higher than at Barbados. Barbara noted that the thermal gradient-controlled clay mineral dehydration process at Nankai occurs much closer to the prism tip than at Barbados. Thus, the sediments are dewatered more rapidly and the fluid pressure plummets not far down dip from the prism toe. These calculations agree quite well with the observed transition from aseismic to seismic behavior where Barbara's model calculated the fault plane fluid pressure should suddenly drop off.

By comparing the Barbados and Nankai accretionary prism architectures, it also appears that the taper angle at the prism tip is controlled by fluid pore pressure. Low pore pressure yields a steep taper angle, and high pore pressure a shallow angle. Provenance (sediment source) plays an important role in sediment porosity and permeability, and indirectly, on the fluid pressure. Ultimately, the permeability appears to be more important than the subduction rate for controlling fluid pressure and subduction zone seismicity.

Barbara left the audience with some thoughts on fault mechanics in subducting plate boundaries. There is a growing body of evidence that hydrogeology is an important tool for modeling and understanding subduction zone seismicity. Subduction zone seismicity is favored by low fluid (pore) pressure, and aseismic behavior by high fluid pressure. The accretionary prism leading edge taper angle is controlled by the sediment permeability and pore pressure, which are associated with the prism lithology. Low taper angles indicate clay-rich sediments, as are seen off Barbados. Granular turbidite deposits, such as those feeding the Cascadia prism, form permeable, low fluid pressure sediments with larger taper angles. Compaction and clay thermal dehydration are two processes for generating and maintaining sediment pore pressure and lubricating the subduction fault plane. Sediment mineralogy may not only affect the pore pressure, but also the location of subduction zone faults—and this is a function of the source lithology. Future research will focus on sediment porosity ahead of the accretionary prism to determine how this is related to the onset of subduction. Hydrogeological applications to terrestrial strike-slip faults, noted Barbara, will require metamorphic petrologists' input to determine fluid source reactions as a function of depth. The terrestrial strike-slip fault model will be significantly more complex than for submarine subduction zones due to lithological variability along strike.

The NCGS sincerely thanks Barbara Bekins for a fascinating new look at subduction zone seismic behavior. The hydrogeological approach to fault mechanics is not new, and its relationship to fault seismicity has been suggested for many years. Barbara's modeling approach, supported by both geophysical and drill hole data, helps to better understand the full range of seismic response that occurs along plate boundary faults.

Geologist initiates helicopter rescue of injured cyclist on Mt. Diablo

This article was prepared by Linda Lucchetti and Past NCGS President John Karachewski for a Lawrence Livermore National Laboratory employee newsletter. This is not John's first encounter with a helicopter *rescue. During the 1998 NCGS field trip to Sutter Buttes the NCGS witnessed a helicopter retrieval of a fallen climber, with a less fortunate ending.*

When John Karachewski left his home for a hike in Mt. Diablo State Park on Sunday April 10, he was looking forward to an enjoyable day taking landscape photos, looking at the Franciscan ultramafic rocks, and getting some exercise. But, that plan was soon to change dramatically.

John was halfway up the steep Burma Fire Trail off the Northgate Road when he stopped to take some photos and noticed a solo mountain biker lying in the middle of the dirt road. "From a distance I thought he might be napping in the sun, because it was a warm afternoon and his bike helmet was covering his face and shading his eyes. But then I heard some faint cries for help." John said. He rushed to the injured man who was scraped with several bloody abrasions, semi-conscious, and laying on his back.

After a quick assessment, John used his cell phone to dial 911 and directed the operator to transfer him to the Mt. Diablo State Park dispatcher. He informed the dispatcher of the victim's condition and their exact location, Burma Fire Trail just north of Coffeeberry Springs. While waiting for the Ranger to arrive, John comforted the injured cyclist and was able to gather valuable information about his medical condition as well as his name, age, wife's name, phone number, and type of car he was driving. Interestingly, 32-year old Juan had lost his short-term memory and did not know where he was or what day it was. Juan also continued to repeat the same information over and over again. Because the accident occurred on a fire road, park ranger Ryen Goering was able to reach us in his four-wheel-drive vehicle. After evaluating Juan's vital signs and complaints about back pain, the rescuers assessed that they could not transport him down the steep dirt road and so a medical helicopter was summoned to retrieve him. The flight nurses and rangers rolled Juan on to a back stretcher, while I snapped a quick shot of the rescue effort and helicopter flying to a closer landing spot. Together we carried the stretcher and loaded Juan through the back of the CalStar helicopter. It was only a short one or two minute flight to John Muir Hospital in Walnut Creek.

John believes that having his cell phone played a critical role in the rescue effort, and oddly enough, something he left behind "I walked out of the house without my cell phone and was on my way to the park when I realized it was missing. Usually, if I am out hiking for a long time, I check back with my wife, so I thought I better have it and drove back to my house to get it.

Also, it was a good thing that this Good Samaritan has wilderness survival skills. "Luckily, being a geologist, I've had training in map reading and first aid. I knew what to do and more importantly what NOT to do, such as moving someone with a potential head, neck, or back injury or giving them food or water. I just tried to calm Juan and I kept talking to him," John said. After the helicopter evacuation, ranger Goering indicated that "John did a great job" and Juan was lucky that he found him because very few people use this trail.

On Monday afternoon, John had an emotional phone conversation with Juan's wife, Sonia. She thanked him and was very grateful to everyone involved with the rescue. Sonia indicated that Juan suffered a serious concussion, fractured a bone near the base his skull, and broke several vertebrae. She indicated that his condition was improving, but he will need to wear a neck brace and body cast for up to three months. Sonia was surprised to learn that Juan was evacuated from the mountain in a helicopter, the only thing she knew was that he went mountain biking and ended up in the hospital. Juan's parents also flew up from Mexico to be with him in the hospital.

John has extensive wilderness experience throughout the western US, often on solo trips, but this was his first backcountry emergency. His advice for future trips include carrying cell phone (but don't assume it will work everywhere), so take a good first aid/CPR class, know your location, and make sure to wear a properly fitted bike helmet.

NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

NCGS FIELD TRIP and PICNIC (BBQ)

ROBERT SIBLEY VOLCANIC REGIONAL PRESERVE IN THE BERKELEY HILLS

Saturday May 21, 2005

Leader: Dr. Stephen Edwards, Director Tilden Park Regional Botanical Garden

The volcanic rocks at Robert Sibley Volcanic Regional Preserve are all late Miocene Moraga Fm. Garnis Curtis has studied this formation and this site for decades and believes this is a piece of the Quien Sabe Volcanics that has been transported north on the East Bay fault system. In terms of accessibility and exposure, Sibley is the showcase site for this volcanic complex, which is also represented by the Tolay Volcanics in Sonoma and probably Burdell Mountain in Marin County. We will be looking primarily at basltic-andesitic rocks, but with considerable textural and structural variety. A basaltic volcano (Round Top) dominates the landscape. Kaiser quarrying and erosion have exposed its deep interior and underpinning like no other volcano in California.

Following the field trip, geoscience family & friends gathering with BBQ (vegi & non-veg) at Tilden Park

THIS FIELD TRIP WILL BE LIMITED TO 70 PEOPLE

*** Field Trip Logistics **

Time & Departure: Saturday May 21, 2005, 9:30 am (sharp), gathering place at the Visitor' Center.

Cost: $10/person for both members & non-members

******************************* REGISTRATION FORM (Sibley Volcanics Field Trip & Picnic) ***************************

Name:________________________________ E-mail:________________________________

Address:________________________ Phone (day):__________________ Phone (evening):_________________

Lunch: Regular:______ Vegetarian: _______ (Please check one) Check Amount: _______________

Please mail a check made out to **NCGS** to: **Tridib Guha**
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Martinez, CA 94553

Questions: e-mail: aars@netscape.com Phone: (925) 370-0685 (evening - PREFERRED) (925) 363-1999 (day – emergency)
People who are willing to drive their car or SUV please indicate.