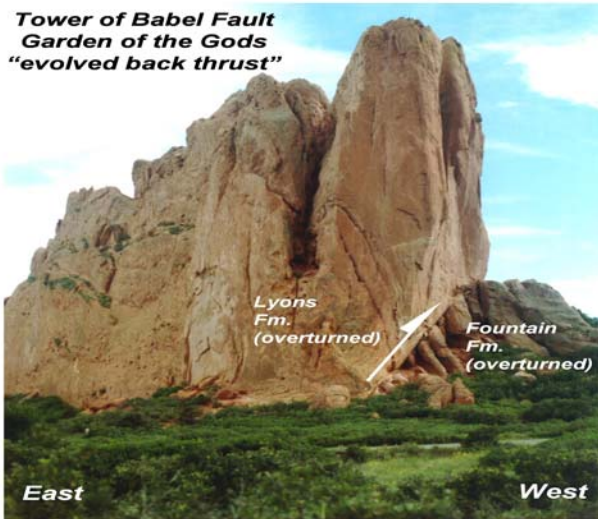




# Colorado Scientific Society

*The objective of the Society is to promote  
The knowledge and understanding of Earth science,  
And its application to human needs*



## “Evolved” Triangle Zones Along the Southeastern Flank of the Colorado Front Range

**Edward J. Sterne,  
*Petro-Hunt***



## Lake Alamosa and Middle Pleistocene Integration of the Rio Grande

**Michael Machette,  
*U.S. Geological Survey***

**Thursday, October 19, 2006**

**American Mountaineering Center**

**710 10<sup>th</sup> St. (NE corner with Washington), Golden**

**Social half-hour – 6:30 pm. Meeting time – 7:00 pm.**

## **Abstract**

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### **“Evolved” triangle zones along the southeastern flank of the Colorado Front Range**

By Edward J. (Ned) Sterne, Petro-Hunt LLC

Faults along the eastern flank of the Colorado Front Range display a diversity of attitudes and juxtaposed age relationships. This paper proposes a modified triangle zone model, one that allows back thrusts within the intercunaneous wedge, to explain the observed fault data. The “evolved” triangle zone model predicts a variety of characteristic fault types including: 1) foreland-dipping roof thrusts, which either show no stratigraphic separation or anomalous younger-over-older relationships; 2) foreland-dipping intercunaneous back thrusts which exhibit both

older-over-younger and younger-over-older bedding relationships; and 3) hinterland-dipping floor thrusts that show older-over-younger bedding relationships.

Evolved triangle zones are found at multiple stratigraphic and structural levels along the range. These stacked detachment levels accommodate displacement transfer along the range and give rise to some surprisingly complex but restorable structures. This model may be helpful in understanding apparently anomalous thrust relationships in a variety of tectonic settings.

## **Abstract**

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### **Lake Alamosa and Middle Pleistocene Integration of the Rio Grande**

By Michael Machette, U.S. Geological Survey

In 1910, Claude Siebenthal proposed the existence of a Pleistocene lake in the San Luis Basin of southern Colorado based on fossils and sediments exposed in Hansen Bluff, about 10 km southeast of Alamosa. Extensive studies of the bluff exposures in the 1980s by Karel Rogers and others revealed an early to middle Pleistocene section that has abundant plant and animal fossils, two volcanic ashes, and a paleomagnetic record that includes the Brunhes/Matuyama boundary. The depositional environments at Hansen Bluff and in nearby cores include shallow to perennial lakes, playas, and meandering streams. However, in the century since Siebenthal’s first work, no one had found morphological expression of the Lake Alamosa or documented its maximum altitude or lateral extent.

During geologic mapping of the Alamosa 1/2° x 1° sheet, I found several new exposures of shallow near-shore and lacustrine deposits. Beach gravels are preserved as bars, spits, and remnant deposits in saddles between bedrock-cored hills. Associated wave-eroded hills (bedrock) suggest that the ancient lake reached a maximum altitude of 2325-2330 m in the San Luis Basin. The most prominent features are well preserved south and east of Alamosa, along the northern margin of the San Luis Hills. Distinct spits at 2310-2330 m wrap around the southwestern side of Sierrro del Ojita and Saddleback Mountain and a kilometer-long spit is well preserved on the eastern side of the Rio Grande, just north of the basin’s outlet. None of these or the dozen other constructional lake features in the area is well exposed, but trenching shows they have well

developed, meter thick, stage III calcic soils (i.e., 300-500 ka of soil development).

In the middle Pleistocene, the upper Rio Grande had its headwaters in northern New Mexico. At that same time, the uppermost reach of the modern Rio Grande emptied into Lake Alamosa, which probably formed as a result of blockage by voluminous eruption of Servilleta flood basalt in the southern part of the San Luis Basin (SLB) between 3.7 and 4.8 Ma. Servilleta basalt covers most of the Taos Plateau northward to the Colorado/New Mexico border. On the western side of the SLB, basalt is at the surface north to Antonito, Colorado. New USGS aeromagnetic data suggest the subsurface basalt flows continue at least as far north as La Jara at depths of 30-100 m. Servilleta basalt is also preserved on the eastern side of the SLB beneath the Costilla Plain, on San Pedro Mesa, and in the Culebra graben north to Fort Garland, Colorado. Drill-hole data show that basalt extends northward to Blanca in the shallow subsurface.

Thus, by middle Pliocene time (ca. 3.5 Ma), Servilleta basalt probably blocked south-flowing drainages in the basin: the resulting closed basin was occupied (episodically) by Lake Alamosa in which the sediments of the Alamosa Formation were deposited. This formation is well known for thick "blue clays" that form confining layers within fluvial aquifers of the SLB.

Alluvial and lacustrine sediment nearly filled the upper SLB prior to the lake's overflow, sometime around 450 ka as estimated from a preliminary  $^3\text{He}$  exposure date of  $\sim 439 \pm 6$  ka on a boulder or the spit at Saddleback Mountain. When the lake rose during a middle Pleistocene glacial cycle (perhaps marine OIS 12), it overtopped a hydrologic sill on Oligocene Tertiary rock of the Fairy Hills and cut a deep gorge. The integration of the upper SLB into the upper Rio Grande drainage led to downstream incision of the river, especially north of the Red River and added about 18,000 km<sup>2</sup> to the river's drainage area.

## **Colorado Scientific Society Student Presentation Awards**

The Colorado Scientific Society invites entries for the Student Presentation Awards. The awards competition will be held in early November, with finalists invited to give a 15 minute talk (format like GSA or AAPG) on the evening of November 16, 2006, at the CSS monthly meeting at the Colorado Mountaineering Center in Golden Colorado. Topics for the talks can be any subject related to earth science. The abstract must include:

Title  
Name and University  
Abstract (maximum 250 words)

Please abstract, composed in 12pt. Times New Roman font, via email, by the **closing date of November 1, 2006**, to:

[ckluth@mines.edu](mailto:ckluth@mines.edu) or [kluths@comcast.net](mailto:kluths@comcast.net)

# CSS Fall Field Trip to the Paradox Basin led by Don Rasmussen

**Water Escape Structures**



**Upthrown block near Moab Fault**



**Oil-saturated Entrada ss at Rainbow Rocks**



**Thelma and Louise dropoff near Dead Horse Point**





# Earth Science Meetings and Talks

*Newsletter items must be received by the 25th of each month. Items may include special events, open houses, etc...thanks!*

**Colorado Scientific Society's** regular meetings are held the 3rd Thursday of the month at the American Mountaineering Center in Golden (unless otherwise advertised). Social time begins at 6:30 p.m. and talks start at 7:00 p.m. For more information contact Chuck Kluth at 303-273-3889 or [ckluth@mines.edu](mailto:ckluth@mines.edu)



**Denver Mining Club** meets every Monday (except when noted) at Country Buffet near Bowles and Wadsworth (at 8100 W. Crestline Ave.) 11:30-1:00. Oct 16, Joe Wojcik, consulting geologist, "The glamour of prospecting: life experiences of a famous South African prospector, 1902-1921. Oct 23, Diane Dudley, Star Mine Preservation, "History of the Star Ag-Pb-Zn mine, one of the longest operating mines in Colorado". Oct 30, Ed Raines, "The Leadville silver boom". <http://china-resources.net>.

**Denver International Petroleum Society** meets the second Friday of each month at the Wynkoop Brewing Co., 18th and Wynkoop Streets. Reception begins at 11:30, luncheon at noon, program at 12:30. Make reservations (required) by leaving message at (303) 623-5396. Reservations accepted after 8 a.m. on Friday until 10:30 a.m. on Wednesday prior to the meeting. Cancellations accepted until 11:00 am Wednesday prior to the meeting. Cost: \$15 for lunches; talk only is available for \$2 (make checks payable to "D.I.P.S."). Contact Keith Murray at (303) 986-8554 for information.

**Denver Region Exploration Geologists' Society (DREGS)** meets in the Mutual Consolidated Water Building, 12700 West 27th Avenue, Lakewood. Social hour 6:00-7:00 p.m. Technical presentation at 7:00 p.m. Meetings are normally scheduled for the first Monday of each month. For information contact Jim Piper, (303) 932-0137, or the website <http://www.dregs.org>.

**Denver Well Logging Society (DWLS)** meets on the third Tuesday of each month, Sept. through May. Lunch and a technical talk at the Wynkoop Brewery begins at 11:30 a.m., 18th and Wynkoop Sts. in Denver. Subject matter usually deals with the application of well logs to oil and gas exploration. Call Eleice Wickham at 303-573-2781 for reservations. Web page: <http://dwls.spwla.org>.

**Rocky Mountain Association of Geologists (RMAG)** Reception at 11:30, lunch at noon, talk at 12:30. Reservations by recording at 303-623-5396 until 10:30 a.m., Wed. before the luncheon. Cancellations until 11:00 a.m. on Wed. at 303-573-8621. Luncheon is \$20 payable to RMAG at the door. Talk only (no res)—cost is \$3. Location: Denver Marriott, 17<sup>th</sup> & California. Oct 20, Sven Egenhoff, "Beyond the Milankovich paradigm, What we've learned from the lateral variability in the carbonate cycle stacking patterns". Nov 3, Bruce Kelso, "Niobrara natural gas in the eastern DJ Basin, Co, Kan, Neb ". Web page: <http://www.rmag.org>.

**Rocky Mountain SEPM** Reception at 11:30, lunch at noon, speaker at 12:30. Reservations, Dave Uhl: 303-389-5092 before noon of preceding Friday. \$15.00 lunch, \$3 talk only. Wynkoop Brewing Company, 1634 18<sup>th</sup> St., Denver. [David.uhl@EnCana.com](mailto:David.uhl@EnCana.com).

**University of Colorado at Boulder, Geological Sciences Colloquium** Wednesdays, 4:00-5:30, Rm. 180. Refreshments at 3:30 on the 3rd floor. Oct 11, Mark Clementz, "From hooves to flippers: new insights into the ecology of Eocene Cetaceans from stable isotopes". Oct 18, Raymond Jeanloz, "From Earth to stars: Toward gigabar pressures and kilovolt chemistry". 303-492-8141. Web page: <http://www.colorado.edu/GeolSci>.

**Colorado State University, Dept of Geosciences**, Rm 320 Natural Resources Bldg, 4:10 pm. Oct 16, Florian Schwander, "Active volcanism: new avenues toward monitoring, hazard assessment, and mitigation". Oct 30, Robert Jarrett, "Reflections on the Big Thompson Canyon flood, 1976". 970-491-5661. <http://www.cnr.colostate.edu/geo/seminars>

**Friends of Dinosaur Ridge**. Morrison Town Hall, 7:00p.m. Web page: <http://www.dinoridge.org>. Admission is free, but donations are welcome. Oct 14, 9 a.m.-2 p.m., Hike with Harald Drewes on S. Table Mountain. (meet at east end of 19<sup>th</sup> St in Golden.) For more information contact the FODR Visitor Center at (303) 697-3466.

**Colorado School of Mines, Van Tuyl Lectures** Thursdays from 4-5 p.m. in Berthoud Hall room 108. Oct 12, Ron Johnso, "The history of Eocene Lake Uinta". Oct 19, Durell Scott, "Riverine carbon fluxes from the landscape to the sea: A New Zealand perspective". <http://www.mines.edu/academic/geology.html>

**USGS Geologic Division Colloquium**. Thursdays, 1:30, Foord Room, Building 20, Denver Federal Center. For more information contact: Peter J. Modreski, U.S. Geological Survey, Denver, Colorado tel. 303-202-4766, fax 303-202-4767 email [pmodreski@usgs.gov](mailto:pmodreski@usgs.gov).

**For a constantly updated, online geo-calendar, visit the Colorado Geological Survey at**  
<http://geosurvey.state.co.us>

Colorado Scientific Society  
P.O. Box 150495  
Lakewood, CO 80215-0495

<http://www.coloscisoc.org>



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2006-2009: Matt Morgan, CGS, 303-866-2066, [matt.morgan@state.co.us](mailto:matt.morgan@state.co.us)  
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2004-2007: Lee Shropshire, UNC, 970-352-8778, [leeshrop@att.net](mailto:leeshrop@att.net)

## COMMITTEE CHAIRPERSONS

Best Paper Award: Matt Morgan, 303-866-2066, [matt.morgan@state.co.us](mailto:matt.morgan@state.co.us)  
Database Manager: Cory Conrad, 303-629-8788, [cconrad@knightpiesold.com](mailto:cconrad@knightpiesold.com)  
Field Trips:  
Graphics: Karen Morgan, CGS, 303-866-3529, [karen.morgan@state.co.us](mailto:karen.morgan@state.co.us)  
History: Marjorie E. MacLachlan, USGS-retired, 303-986-7192, [jcmemachlan@aol.com](mailto:jcmemachlan@aol.com)  
Membership:  
Memorial Funds: Emmett Evanoff, 303-444-2644, [emmettevanoff@earthlink.net](mailto:emmettevanoff@earthlink.net)  
Newsletter Editor: Celia Greenman, CGS, 303- 866-2811, [celia.greenman@state.co.us](mailto:celia.greenman@state.co.us)  
Outreach: Sue Hirschfeld, 720-565-9302, [eqdoc@ix.netcom.com](mailto:eqdoc@ix.netcom.com)  
Program: Vince Matthews, CGS, 303-866-3028, [vince.matthews@state.co.us](mailto:vince.matthews@state.co.us)  
Publicity: Mearl Webb, 303-810-1296, [mf\\_webb@msn.com](mailto:mf_webb@msn.com)  
Science Fair: Chuck Weisenberg, 303-238-8806, [cweisnbrg@aol.com](mailto:cweisnbrg@aol.com)  
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