GEOLOGICAL SOCIETY OF MINNESOTA

NEWS

FALL 2001

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Synopsis: Utah Field Trip 2001

By Marj Gangl

WOW!! (not a geological term.) What a trip it was, thanks to our leaders, Rick Uthe and Walt Blowers. Eastern Utah on the Colorado Plateau is unique. The desert tends to "grow" on you. A descriptive term like "scenic" is an understatement. On any given day, there were about 28 trekkers. The thought crossed my mind that this trip could have been sponsored by Kodak, as cameras were clicking continuously. On the first two days we were around the Vernal, Utah area. One could easily see the south side of the tall, snowcapped Uinta Mountain Range, uplifted from the Colorado Plateau which moved northeast during the Laramide Orogeny. Driving through a series of flat floodplain terraces, we arrived at the Split Mountain area where the Green River cuts through the split. After waving at a group of rafters, we had an excellent view of the lofty Weber Sandstone Formation across the river.

Looking in the opposite direction, was our "old" favorite, the red Moenkopi Formation, among others. Our entire trip included many features such as anticlines, synclines, monoclines, etc. In short order, we viewed all the colorful formations in the Mesozoic Era. Some were viewed from our open air shuttle bus ride UP to the Dinosaur quarry, where the Morrison Formation (purple, grey, green and various shades thereof) of shales and siltstones, holds the Dinosaurs' fossilized skeletons.

On Day two, as we passed Blue Mountain, a huge anticline, we headed into rock formations of the Cretaceous Period. On a beautiful drive with stops along the way, we headed up to Harper's Corner. At about 8000 ft. elevation at the end of the road, we looked down and got a glimpse of the Green and Yampa rivers joining. This was such an interesting day. I cannot write about all the great things we observed. It would take many pages. Find someone who has a field trip guide and have that person copy pages 25 through 34, then read all about it, including Plug Hat Butte. The third day was a lovely drive from Vernal, to Price. Our altimeter registered 9000 ft. elevation at one point, in the pines.

Day 4: Off we went to to the San Rafael Swell area. We were treated with a view of the Coconino Formation while standing on the Kaibab, which was formed about 260 million years ago in the Permian Period. From here we looked "up the ladder" into rocks of the Triassic Period. At this point, we were at the western edge of the Colorado Plateau. On through San Rafael Canyon, driving in a linear valley, called Joe's Valley, we came to a Turquoise colored reservoir. Here we had a "test" which led to much discussion. We reviewed four options as to the piracy of Cottonwood Creek. I think we all flunked, as there doesn't seem to be a known answer. I was satisfied in my own mind that it is a "Niagara Falls " syndrome. *Continued on page 7*

Announcements

Aug. 23 - Sept. 3 State Fair, Saint Paul (which day will YOU be helping out at the GSM Fair Booth?)

Sept. 24: Fall Annual Meeting - 5 PM
Old Country Buffet - Maplewood

Sept. 30 Your GSM Membership Expires

Oct. 8 First Lecture of the 2001/2002 Lecture Series: **Forming and Finding Earth's Hidden Treasures**

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The purpose of this newsletter is to inform members and friends of the activities of the Geological Society of Minnesota. GSM*NEWS* is published four times a year: February 15, May 15, August 15, and November 15. GSM *NEWS* welcomes unsolicited Geology and Earth Science related articles and photographs. Deadline for article submission is three weeks before the date of publication. Send all material for GSM *NEWS to:* GSM c/o Katy Paul, 6901 West 84th St., #351, Bloomington, MN 55438, phone/e-mail listed above.

Officers: William Robbins, *President*; (Vacant) *Vice President*; Steve Erickson, *Treasurer*; Judy Hamilton, *Secretary*.

Directors: In addition to the officers listed above: David Christianson; Paul Lemke; Rose Mary O'Donovan; Gail Marshall; Katy Paul.

Send all GSM membership dues, change of address cards, and renewals to the GSM Membership Chair: Gail Marshall, 12232 Allen Drive, Burnsville, MN 55337 phone 952-894-2961. Membership levels are: $10 Full-Time Students; $20 Individuals, $30 Families

News from the Board...

Three of the four field trips scheduled for this summer will have already occurred by the time you read this. I would like to thank Rick Uthe and Walt Blowers for their very successful field trip to eastern Utah, the northern Colorado plateau, and the huge amount of effort that entailed. I would also like to thank Gail Marshall, Margaret Rodina and Rosie O'Donovan for their extensive work on the three short field trips.

Call Tom Schoenecker at 952-474-4600 to volunteer for staffing the Geological Society of Minnesota (GSM) booth in the education building at the state fair. He wishes to fill 72 stints, each 4 hours long, from Aug 23 through Sept 3. You do not need expertise in geology to do this. You simply refer fair visitors to our lecture season, where they can hear the experts.

GSM needs a new video library chair and possibly a new video library procedure. This procedure might use phoning and computers to allow selection of the specific tapes to bring to the lecture. If interested in volunteering in this capacity or discussing the library procedure, please call me.

Three spots need to be filled on the GSM board of directors. If you have an interest in becoming involved or in serving on the nominations committee, please call Sylvia Huppler, 651-483-4796, chair of the nominating committee.

Doug Zbikowski has guided another very successful outreach program this last school year. I commend Doug on his design and implementation of this program, which has now been taken to three other states by people who taught it here in Minnesota. I also thank him for all his work with this program.

The Budget Committee has completed its work for the year. Marlys Lowe chaired the committee, and Steve Erickson and Gail Marshall served on the committee. I would like to thank them for this effort.

If you would like to bring cookies to any one lecture during the lecture season, please call me.

~Bill Robbins, President
651-733-9894

THE DENHAM FORMATION-AN UNUSUAL ASSEMBLAGE OF VOLCANIC AND SEDIMENTARY ROCKS

Terrence J. Boerboom, Minnesota Geological Survey

The Denham Formation is the name assigned to a unique package of metamorphosed sedimentary and volcanic rocks that outcrop in northwestern Pine County, southeast of the town of Denham (Fig. 1, next page). In general, the glacial cover is quite thin in this area, and bedrock outcrops are fairly abundant, although scattered. The outcrops that define the Denham Formation are found in and near a small valley formed by glacial meltwater. This valley trends north-south, and cuts perpendicular to the strike of bedding in the Denham Formation, thus providing a good cross-section of the stratigraphy of the formation. The Denham Formation is Paleoproterozoic in age, or about 2 billion years old. It lies in depositional unconformity on top of the McGrath Gneiss, which is a metamorphosed porphyritic granite of Neoarchean age. The McGrath Gneiss has recently been dated at 2.55 billion years old (Van Schmus and others, 2001), which is when the rock originally cooled from a molten magma. Both the Denham Formation and the McGrath Gneiss were deformed and metamorphosed during the Penokean orogeny, a major collisional event that occurred about 1.8 billion years ago.

The Denham Formation contains an unusual assemblage of interbedded rock types that originally consisted of shale, siltstone, arkosic sandstone, conglomerate, dolomite, and pillowed to fragmental basaltic volcanic rocks. However, these rocks have been metamorphosed to the amphibolite grade as a result of crustal collision during the Penokean orogeny. The rocks that started out as fine-grained sediments, such as shale and siltstone, have retained the fewest primary bedding features and are now completely recrystallized into coarse-grained staurolite-garnet-muscovite schist and muscovite-biotite schist, respectively. Also, the beds of dolomite are completely recrystallized to tan or gray marble and retain no primary depositional features found elsewhere in similar rocks of this age, such as algal stromatolites. The primary sand grains in the arkosic rocks are well preserved because the rock contains a high proportion of dolomite in the matrix, which absorbed most of the strain associated with deformation.

The first of two deformation events that affected these rocks was synchronous with metamorphism. It produced an early foliation that typically is parallel to bedding, and a locally strong, shallowly plunging, lineation. The second deformation event folded both the early foliation and bedding along steeply dipping axial fold surfaces. In the Denham valley, the stratigraphic sequence dips variably to the north, except for local overturned south-dipping limbs on second generation folds. Both deformation events are the result of crustal compression associated with the Penokean orogeny.

Despite deformation and metamorphism, many primary depositional features can still be recognized in the rocks, and the stratigraphy of the Denham Formation forms a coherent package that is shown schematically on Figures 1 and 2. The basal beds of the Denham Formation consist of siltstone that is locally interbedded with cross-stratified pebble conglomerate. This is overlain by coarse-grained and locally conglomeratic arkose that apparently pinches out laterally. The arkose is interbedded with amygdaloidal basalt flows that grade stratigraphically upward (northward) from massive, to pillowed, to fragmental. The volcanic rocks are thickest at the eastern limit of outcrop, where at least four flows of nearly 1,000 feet total thickness were recognized; the rocks thin westward to two flows of 300 feet total thickness. This distribution implies that the eastern exposures are nearest to the vent from which these volcanic flows emanated; however, there were likely several other eruptive centers located along this same horizon to the west. The volcanic rocks, in particular, have retained primary features such as pillows, amygdules, and fragmental textures in rocks erupted during explosive underwater volcanism. The overlying arkosic and pelitic strata (shale) apparently pinch out to the east where the volcanic package thickens, and are not present in drill holes to the north and east of the Denham valley. The northern-most outcrops in the valley consist of very pure dolomitic marble in which there are tightly folded quartz veins. Drill cores show that the marble unit is at least 500 feet thick, and is overlain by graywacke that is exposed discontinuously to the north for some distance. Drill cores indicate that the contact between marble and overlying graywacke is fairly sharp, and marked by a thin layer of graphitic schist.

Continued from page 3

Field and petrographic observations imply that clastic detritus (sand, silt, and clay) in the Denham Formation was derived mostly from a weathering residuum developed on the underlying McGrath Gneiss. Near the contact with the base of the Denham Formation, the McGrath Gneiss grades abruptly from granite gneiss containing quartz, orthoclase, plagioclase, and biotite, to strongly foliated, quartz- and sericite-rich schist that contains orthoclase, but no plagioclase. The arkosic parts of the Denham Formation similarly lack plagioclase and are composed of quartz and orthoclase grains, together with scattered cobbles of granitic gneiss.

Studies of weathered zones developed on Precambrian granitic rocks in southwestern Minnesota beneath Cretaceous sedimentary rocks may provide an analog (Setterholm and others, 1989). These studies demonstrate that plagioclase is one of the first minerals to alter to kaolinitic clay during the weathering process, and that orthoclase and quartz are the most resistant to weathering. The basal Cretaceous strata locally consist of reworked saprolite that includes beds of cross-stratified sandstone and nearly pure kaolinitic shale. Exposures of basal Cretaceous sediments locally contain

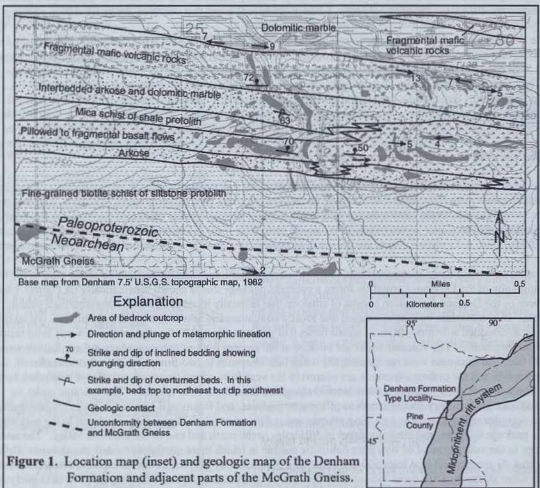

Figure 1. Location map (inset) and geologic map of the Denham Formation and adjacent parts of the McGrath Gneiss.

Continued from page 4

STRATIGRAPHIC COLUMN, DENHAM TYPE LOCALITY

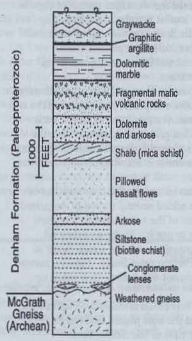

Figure 2. Schematic stratigraphic section of the Denham Formation.

coarse grains of orthoclase and quartz derived by slight reworking of grus-textured, weathered granite. The same process may have occurred in Paleoproterozoic time as clay and grus were eroded from the weathered McGrath Gneiss and reworked into beds of arkosic sandstone and kaolinitic shale. These sediments were subsequently metamorphosed to quartz- and orthoclase-bearing arkose and staurolite-garnet-sericite schist, respectively, and the weathered residuum on top of the McGrath Gneiss was metamorphosed to produce the muscovite-rich schist we see today.

The Denham Formation is interpreted to represent an assemblage deposited on a developing rift-margin during Paleoproterozoic time. In this setting, the McGrath Gneiss was part of the continental margin that was weathered and eroded to provide detritus to an evolving rift basin undergoing simultaneous active, shallow water volcanism. The lower portion of the Denham Formation, including the siltstone, pillowed basalts, and arkose, was probably deposited into a shallow marine environment. Interbedded arkose and dolomite higher in the stratigraphic section represent rapid subsidence of the continental shelf and deepening water, possibly within localized fault-bounded grabens. The lack of arkose in the thick dolomite at the upper part of the sequence indicates that deposition of coarse detritus was restricted to the shallow, nearshore environment adjacent to the McGrath Gneiss. The abrupt upward change in sediment composition from dolomite to graywacke indicates rapid deepening of water and associated turbidite deposition. Most of the observed deformation of the Denham Formation is inferred to be the product of basin closure during the Penokean orogeny about 1.8 billion years ago. ■

References:

Setterholm, D.R., Morey, G.B., Boerboom, T.J., and Lamons, R.C., 1989, Minnesota kaolin clay deposits: A subsurface study in selected areas of southwestern and east-central Minnesota: Minnesota Geological Survey Information Circula 27, 99 p.

Van Schmus, W.R., MacNeill, L.C., Holm, D.K., and Boerboom, T.J., 2001, New U-Pb ages from Minnesota, Michigan, and Wisconsin: Implications for Late Paleoproterozoic crustal stabilization [abs.]: Institute on Lake Superior Geology 47th Annual Meeting, Madison, Wis., Program and Abstracts, v. 47, pt. 1, p. 100-101.

How Did Geology Get Started? - Part III

Chas Brennecke

Back in May we left the Earth in pretty shabby shape for a future home of the human race. I promised you that it would get worse, and here it is.

Another planet - this one about the size of Mars - was somehow nudged out of its regular orbit around the sun. Perhaps its orbit was chaotic, as Mercury's orbit is today, and some tiny influence or other bumped it into the path of the Earth. Now this is an asteroid impact to end all impacts: two full sized iron-cored planets in full collision. As a result, both planets were completely destroyed. No half measures - both mantles shattered and both crusts completely blown away by the impact, reduced to random rocks of various sizes.

There's only one comfort for the future. As a result of the "conservation of mass" there's no place for all this junk to go, except to reform a completely new composite planet around the center of mass. No doubt the two iron cores - being the most massive pieces of the loose ends flying around - settled down first, and the effect of their combined gravity helped assemble the lighter stuff into a new mantle. No one knows how long this re-assembly lasted. Experts' guesses range from a few days to several centuries, and the general consensus is that it's too bad there wasn't a video camera recording the whole she-bang.

But wait! We're not through yet - remember that we haven't given the conservation of momentum time enough to work yet. Such a massive collision added several orders of magnitude to the total momentum of the system (that is, the combined mass of the two planets). The new planet can't just eat all this extra energy, so it has to find a way to use it. As the smashed up rocks fall down to form the new mantle and crust, they find themselves moving much faster in their orbits than ever before; little by little the newly-forming Earth rotates faster. Finally, instead of rotating once for every orbit around the sun, it now rotates almost 400 times - that soaks up plenty of momentum.

Some of the lighter rocks in the outer portion of the debris cloud actually pick up enough momentum to permit them to set up a consolidated orbit around the new planet, and (more or less) suddenly the new planet has a satellite that requires about 10% of the momentum.
But the most remarkable thing about the changing planetary circumstances is this: as the new Earth forms and begins to rotate, it suddenly remembers that as a rotating mass it can't behave the way non-rotating masses do! Normally, you would expect a large mass, impacted by another high-speed mass, to tilt away from the impact. But at the same time this is happening, the New Earth is beginning to rotate at an increasing rate, and the old rules no longer apply. Instead of the axis of spin responding to the axis of the torque, it responds by moving at a right angle to both the axis of spin and axis of torque - physicists call this "precession." Why does it do this? I don't know.

In the case of the New Earth, the axis of spin finally settles down 23 degrees off the vertical. This means that the new planet will not only have days and nights in regular progression, but will also have seasons as it lopes around the Sun on its annual trip. And a new moon thrown in to boot! What a deal!

But we're still not through. Remember those two iron cores that came together to form the New Earth's consolidated iron core? Keep in mind that the term "iron" is a shortcut. Although iron is by all measures the largest component of the cores, the term also includes every other metal that is heavier than iron. It would surely be a remarkable coincidence if both these "iron" cores had exactly the same composition. This means that core today is subject to the same mixing and churning processes that the original was - with the added angular momentum thrown in, and the additional possibility that the two original cores had different magnetic signatures. Hm! I wonder if turmoil in the core could be responsible for the dramatic shifts in the New Earth's magnetic field down through the latest 3 billion years? What will the future bring?

Utah Field Trip, continued from page 1

Day 5 was a study of the Mid-Cretaceous Seaway. Incidentally, its eastern shoreline runs about north and south through the middle of Minnesota. Several coal seams were visible in the area of Price.

Day 6 involved a trip up the Colorado National Monument to view some ancestral Rockies near Grand Junction, Colorado. From there, we drove along the Colorado River to Moab, Utah. Here we learned about the Paradox Salt Basin. This basin was formed southwest of the Uncompahgre uplift which we viewed in western Colorado, one of the larger grabens of the ancestral Rockies (320 Kilometers--200 miles-- long). The average thickness of evaporite minerals in it is 4500 feet. Day 7 was spent viewing Salt anticlines and Canyonlands National Park. One spectacular view was at the Green River overlook. Day 8 we learned how the arches and fins were formed in Arches National Park. They are very complex and beautiful.

On Day 9, our first stop was at an enormous salmon-red Sandstone wall of the Comb Ridge. The whitish outer Comb Ridge, mostly Navajo Sandstone, looked like it could be Paul Bunyan's comb (that is if he ever combed his hair). From here we ventured on to Natural Bridges National Monument. We saw mature and younger bridges formed by the White River. At Owachomo Bridge, we could see the narrow span of about 9 feet in thickness. It is 180 feet wide but only 106 feet high. Its demise is inevitable. From here we drove "doowwwn" (Rick's word) a short distance, a drop of about 1100 ft., through a series of switchbacks. It was breathtaking...then on to Bluff, Utah. Day 10 was a half day study of the Monument upwarp and taking in the scenery of the monoliths and sand dunes in colorful Monument Valley. Then we headed back to MN.

This is an oversimplification of our trip. For those of you that did not go on the trip, plan ahead so you can go on the next one in two or three years (we hope). Then you can get the full explanation of what the rocks are made of, how old they are, and how they got there. See you then! ***~Marj Gangl***

MEMBERSHIP RENEWAL

Reminder... your GSM membership expires September 30th. With your support, GSM can continue to offer a fine lecture program, provide area schools with an invaluable resource through the Outreach Program, and introduce you to the pool of talented professionals in the field of geology. Fill in the form below, and mail it with your check, to Gail Marshall, Membership Chair.

Geological Society of Minnesota
c/o Gail Marshall, Membership
12232 Allen Drive
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A few weeks ago a friend of mine made an auto tour of the western Montana and central Idaho area, where he had served in the Navy over fifty years ago. Since he was covering essentially the same ground that we covered in our 1996 field trip, I gave him my copy of the tour guide and suggested he check out the Missoula Floods. To make a long story short, he was delighted with the suggestion; although he didn't cover the area as thoroughly as we did, he has a perceptive eye and enjoyed having a professional insight into the area. In return, he brought back a book, which he bought at one of the interpretive centers along the way, describing the Missoula Floods in great detail.

CATACLYSMS ON THE COLUMBIA

John E. Allen and Marjorie Burns, with Sam Sargent
Timber Press, Portland, Oregon
194 pages, Appendices, Index - $14.95

The book covers the entire Columbia River basin, from Missoulia to Astoria, and deals with many more sites of interest than we could possibly have covered. However, it does not have the detail that Dick Uthe's tour guide has, and it lacks his lively style. The language is pedestrian at best, and has an unfortunate tendency to fall into a rather stiff pattern of using the same descriptive terms to describe geological features. It has many aerial photos illustrating the effects of the floods, but I would love to get into them with a few labels and arrows to show which features are which and how the dynamics worked to get the results demonstrated.

Nevertheless, it's a book I should like to have in my geology collection and I'm going to write off to see what kind of a deal I can get. Their cover price is $14.95 - perhaps if there are ten members who would like to have a copy we can get them down to a flat $10. If you're interested, let me know and we'll see how they respond!

Cheers! - - Chas Brennecke (651) 222-6985

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