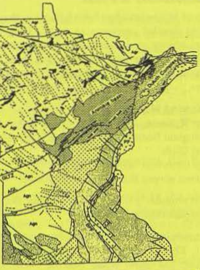

GEOLOGICAL SOCIETY OF MINNESOTA NEWS

WINTER 2000
VOLUME LIV NO. 4
http://www.geo.umn.edu/orgs/gsm/

The Chicxulub Impact Event- an artist's rendition
(See article on Page 4)

Where the Money Goes

In a recent conversation I had with another GSM member, the subject of GSM Membership came up. Since member dues are our primary source of income, and money is always tight, a continually expanding membership is what we strive for. As we discussed the recruitment of new members, and how best to get our message out, my colleague brought up an interesting point that I had not really thought about before: our lecture series is free and open to the public; field trips only cost an extra $5 for non-members; the only thing non-members don't get is our newsletter (and there are several opinions about how valuable that is...) and access to our video library. So where is the incentive to join and pay dues?

Hmmmm...I had to think about that one.

Well, obviously people join because they have an interest in geology. But, as was pointed out to me, the pursuit of things geological can be done without spending money on dues. So I got out my GSM Directory and looked through it for clues. And there, on the second page was my answer: The Mission Statement. This is what it is all about! The GSM provides free lectures and labs, conducts field trips, holds classroom presentations for schools, maintains a media library, helps maintain and expand a series of geological markers located throughout Minnesota, and Oh Yes, publishes a newsletter 4 times a year. And none of those things are free.

Those who love learning about geology enjoy being a sponsor for these endeavors. It is a good feeling to know that in some small way, I played a part in getting a geological marker set up along one of Minnesota's major highways; my dues helped to pay a university professor for the "free" lecture; because of me, a 3rd grader became enthralled with geology after seeing our rocks and fossil collection in her classroom, and now wants to be a geologist when she grows up; I had a hand in providing folks with the opportunity to learn about the geology of the state they live in and to have access to a real geologist to interpret the geological record and to answer questions during field trips; and all those printed newsletters and schedules were paid for—in part—by me.

That is my incentive to be a dues-paying member of our Geological Society of Minnesota. And yours too I hope. If you haven't renewed your membership yet for 2000-2001, don't wait any longer. And encourage a friend to join too!

—*Katy Paul*

Announcements

Dec 4, Last Lecture in 2000:

Plate Tectonics: Implications for Volcanism and Earthquakes

Lectures will continue to be held in Amundson Hall, Room B75 for the rest of the 2000-2001 series.

Visit Sue, the *T.rex* exhibit at the Science Museum in Saint Paul now through Jan. 21, 2001.

It's that time again! Have you remembered to renew your membership? Look at the label on this newsletter. If the date on the label does not say 10/01/01, you still need to send in your membership dues. Mail to: Gail Marshall, membership chair, address listed below.

Next Newsletter Deadline: February 1, 2001

GSM *NEWS*

Editor:
Katy Paul (952) 829-7807
e-mail: kpaul@fs.com

Reporters:
Patricia Hanauer
Tom Smalec

Production:
Charlie Brennecke 651-222-6985

The purpose of this newsletter is to inform the 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. It 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: Geological Society of Minnesota c/o Katy Paul, 6901 West 84th Street, Bloomington, MN 55438. Phone: as listed above, or e-mail: again, as listed above.

Officers: William Robbins, *President;* Bruce Goetteman *Vice President;* Steve Erickson, *Treasurer;* Judy Hamilton, *Secretary.*

Directors : In addition to the officers listed above; David Christianson; Paul Lemke; Sylvia Huppler; Gail Marshall; Jean Hosterman.

Send all GSM membership dues, change of address cards, and renewals to the GSM Membership Chair: c/o Gail Marshall, 12232 Allen Drive, Burnsville, MN 55337. Phone: (952) 894-2961. Membership levels are: $10 for full-time Students, $20 for Individuals, or $30 for Families.

PRESIDENT'S PAGE

The Geological Society of Minnesota has been helped in the past by organizations having similar purposes as ours. They have helped especially in publicity and literature distribution. I would like to recognize these various groups. I'm sure each would appreciate a thank you, and individualized visits to see what they have to offer.

- Bell Museum of Natural History
- Minnesota History Museum
- Minnesota Archeological Society
- Minnesota Mineral Club
- The Anoka County Gem and Mineral Club
- Many public libraries across the seven-county area.

Newspapers have been singularly unresponsive to our requests to publish meeting announcements.

So far, our plan to provide customized ride sharing to lectures has proved successful. This program matches riders with drivers from approximately the same areas, sharing parking and gasoline expenses, and saving gasoline. If you wish a ride to lectures, please call me. (Bill Robbins, 651-733-9894) This program could be particularly helpful to people on the fringes of the seven-county area.

GSM members present at the Annual Meeting held September 25, 2000 elected Rose Mary O'Donovan and Katy Paul to fill the two vacant spots on the Board. The nominating committee consisting of Judy Hamilton, Sylvia Huppler, Marlys Lowe and Dwight Robinson had selected these two candidates.

In GSM budgeting, currently underway, a significant expense is the cost of honoraria given to speakers and field trip leaders. The GSM board voted to increase these honoraria. This was, as events transpired, changed in a two-step process, first from $75 to $85, then to $100. The second step was in response to an offer by Don and Nora Mattsson to cover the cost of this second increase for a couple of years. GSM would like to thank them for this $500 donation.

—*Bill Robbins,*
President

2001 BOARD MEMBERS

OFFICERS:

Bill Robbins	President
Bruce Goetteman	Vice President
Judy Hamilton	Secretary
Steve Erickson	Treasurer

DIRECTORS:

Gail Marshall	Rose Mary O'Donovan
David Christianson	Katy Paul

STATE FAIR 2000

The State Fair Exhibit for 2000 went well. We generated some new members for GSM and definitely made many children happy as we answered their questions and allowed them to touch the rocks on display. We are always delighted to see their curiosity. Of course, we enjoy the parents too, and several were anxious to reach in their pocket or bag to show us their special find. Sometimes we could even identify it for them. My personal experience, however, has been that I can't always identify the sample so that leaves an opening to invite that person to our lectures.

This year we had 61 GSM members staff the booth, several working double shifts or a second time in the schedule. (See the list of names herewith. Those with a number in parenthesis after their name show the number of times worked.)

A special thanks goes to our President, Bill Robbins, for making more than half the phone calls for people to staff the booth.

Thanks and my personal gratitude to the set-up committee, Tom Schoenecker, Paul Lemke and Sylvia Huppler as well as the take-down committee Tom Schoenecker, Edna Schoenecker and Don Swensrud. All I had to do was pass out orders. Kudos to Sylvia Huppler for design, production and printing the brochure (and delivering it to my front porch). She also made the lecture poster for the booth.

Last, but not least, I have resigned from the Fair Committee. Next year is Retirement from full time office work, moving to another location, traveling, and all the other things retired folks do (except sitting in a rocking chair knitting — I might count and polish rocks, however.) So, we will need a new Chair for the State Fair Exhibit Committee. The job does mean a total commitment once a year, but since the booth and it's supplies are basically all stored at the Geological Survey, not a lot of planning for the booth is needed. That is, unless someone would like to redesign it—and that would be okay too.

I've enjoyed organizing the Fair Booth. But I'll be happy to turn over my big notebook (with photos of the booth) to someone else, take that someone on a tour of the Survey's storage room where we keep the supplies, and introduce you to a geologist or two who make it possible for us to use their space.

—Judy Hamilton
State Fair Chair

Ken Barklind
Walt Blowers (2)
Charles Brennecke (2)
Tom Burt
John Bussard
David Christianson
Ted Chura
Marty Collier
Fran Corcoran
David Doty
Doug Earl
Steve Erickson
Warren Fieber
Bruce & Joan Goetteman (2)
Bob & Macy Gunville
Judy Hamilton (2)
Elaine Handleman
Dick Heglund (3)
John & Mrs. Howell
Sylvia Huppler
Jay Hutchinson
Dan Japunitch
Pat Johnson
John Jordan
Dean Kjerland
Paul Lemke
Diane Lentsch
Everett & Doris Luhmann
Anne & Mark Lukkarila
John Maronde
Gail Marshall
John Matlock
Conrad Nelson
Galen O'Connor
Val O'Malley
Clarence Ooten
Katy Paul
Gerald Paul
William Paule
Lisa Peters
Lee & Deb Preece
Bill Robbins (2)
Dwight Robinson
Margaret Rodina
Mark Ryan
Dee Schmaltz
Tom & Edna Schoenecker (2)
Bob Scruggs
Alan & Kay Smith
Don Swensrud (2)
Phillip Thompson
Nina Ward
David Wilson

Impact Events and Their Effect on the Or

By David A Kring, Un

It has become increasingly clear that impact cratering has affected both the geologic and biologic evolution of our planet, but it was not widely recognized until studies linked the mass extinction that defines the end of the Mesozoic Era with the Chicxulub impact event. That particular event also illustrates how a process that destroys some organisms can create opportunities for other organisms - in this case leading to distinctly different ecosystems during the Cenozoic Era. This dual pattern of disaster and opportunity has existed with impact events throughout Earth history, even during the earliest development of life.

The biologic consequences of impact cratering depend on many factors, including the energy of the impact event, the type of target materials, the type of projectile, and the ambient conditions on Earth at the time of impact. Consequences can range from the death of individual organisms to the complete extinction of species. While the former can be the direct result of an impact event, the more important biological effect, including extinction, will be through impact-generated environmental changes.

To be an effective extinction mechanism, the environmental changes need to extend throughout a habitat range and exceed an organism's ability to adapt. When the environmental effect is largely regional, the changes must overwhelm the migratory capacity of a species or last longer than its dormant capacity. When the effect transcends geographical boundaries and becomes global, the change must be rapid relative to the time scale of evolutionary adaptation or, again, last longer than the dormant capacity of a species.

The minimum types of impact events needed to exceed these extinction thresholds are not yet known. However, many of the environmental effects that could lead to extinction, particularly in the case of the Chicxulub impact event at the K-T boundary, have been identified.

Regional Effects

The Chicxulub impact occurred on a shallow carbonate shelf that is now part of the Yucatan Peninsula. In the immediate vicinity of the crater, the shock wave, air blast, and heat produced by the impact explosion killed many plants and animals. The air blast, for example, flattened forests within a 1000-2000 km diameter region, which would have included the highlands of Chiapas, central Mexico, and the Gulf states of the United States.

Tsunamis also radiated across the Gulf of Mexico basin, producing reworked or unusually high energy sediments along the latest Cretaceous coastline. Tsunamis were 100-300 m high as they crashed onto the gulf coast and ripped up seafloor sediments down to depths of 500 m. The backwash of these waves was tremendous, depositing forest debris in 400-500 m of water.

The abyssal portion of the Gulf of Mexico basin, the neighboring proto-Caribbean, and Atlantic Ocean were also affected by the splashdown of impact ejecta, density currents, and seismical!ly induced slumping of coastal margins following magnitude 10 earthquakes. Within a few hundred kilometers of the Chicxulub crater, the thick blanket of ejecta was sufficient to exterminate life.

Global Effects

While these effects devastated organisms in the Gulf of Mexico region, the most significant environmental perturbations were the direct and indirect result of ejected debris that rained through the atmosphere. This material was carried in a vapor-rich plume that rose through the atmosphere into space. Once above the atmosphere, it expanded on ballistic trajectories, enveloping the whole Earth as it fell back into the atmosphere. The impact ejecta was distributed globally in a pattern much different from that of volcanic plumes, which simply rise into the stratosphere and then spread into latitudinal bands.

Calculations indicate that most of this material re-accreted to the top of the atmosphere over a three-day period, where it then settled to the ground over a longer period of time, depending on grain size. If a substantial portion of this dust was sub-micron in size, model calculations suggest the dust may have made it too dark to see for one to six months, and too dark for photosynthesis for two months to one year. This would obviously disrupt marine and continental food chains and decrease continental surface temperatures.

In addition to the dust in the vapor-rich plume of ejecta, several important gas species were entrained. The Yucatán Peninsula, near the Chicxulub impact site, consists of carbonate and anhydrite deposits that overlie a crystalline silicate basement, so the impact produced several climatically active gas components, including aerosol-producing SO2 and SO3, greenhouse-warming CO2 and H2O, and ozone-depleting Cl and Br.

The worst appears to have been the S species, which enhanced stratospheric S on the order of 105-106 times relative to modern abundances. Sulfate aerosols were converted to sulfuric acid rain, whose effects compounded those produced by nitric acid rain. Nitric acid rain was produced from nitrous oxides that were created when the atmosphere was shock-heated by the impact event. Acid rain could have defoliated continental vegetation and even aquatic plants in shallow, inadequately buffered lakes or seas whose entire water columns became acidic.

Asphyxiation of animals by nitrous oxides and toxic poisoning by metals acid-leached from the ground have also been suggested, possibly compounding the toxic effects of metals from the projectile. Sulfate aerosols significantly reduced the amount of sunlight reaching Earth's surface and would have thus, enhanced the effects of ejected dust particles and soot produced by fires.

Darkness and cooler temperatures produced by these particles were relatively short-term, lasting only a few years. On the other hand, there may have been a longer-term increase in temperatures becau! se a large quantity of greenhouse gases were produced from vaporizing sediments, the projectile, shock heating of the atmosphere, carbonates dissolved by acidic waters, and wildfires. However, the magnitude of greenhouse warming is still uncertain.

On the ground it is clear there were postimpact fires. Charcoal and soot, which are produced when vegetation or fossil carbon are burned, have been found in K-T boundary sediments around the world. Theoretical calculations suggest these fires were ignited by intense thermal radiation produced by ejecta reentering the atmosphere on ballistic trajectories. Fires consumed large quantities of vegetation, burned many animals, and robbed herbivores of their food. Fires would have produced several secondary effects too, absorbing sunlight, possibly inhibiting photosynthesis, lowering atmospheric temperatures, and producing organic pyrotoxins.

Several impact-caused perturbations on the ground and in the atmosphere could have contributed to the K-T boundary extinctions. However, it was likely the combination of primary and secondary effects that was so deleterious. Different parts of the global environment would have been perturbed over diverse time scales (e.g., days for reentering impact ejecta, months for dust in the stratosphere, and years for sulfate acid aerosols). The initial effects would be added to and amplified by secondary effects and the ensuing collateral damage.

The biological consequence of the Chicxulub impact was the collapse of entire ecosystems; cascading effects destroyed the infrastructure of the biosphere (e.g., collapse of food chains, loss of habitat), compounding the initial direct environmental effects. Thus, while the physical effects of the impact event may have been relatively short-lived, the time needed to reestablish chemical gradients, repair food chains, and rebuild integrated ecosy! stems was much greater. The details of the biologic crisis and its recovery are difficult to tease from the geologic record, but some progress is being made.

Impact cratering theory suggests the crisis was global and, indeed, marine bivalve extinction intensities are global without any latitudinal or geographic variations. In both marine and continental settings, organisms with dormant or resting states faired better through the crisis. For example, planktonic diatoms that produce resting spores specialized to persist in benthic or deep-pelagic environments of low- to no-light conditions, and, during periods of stress, had a high survival rate. It has also been suggested that the loss of primary productivity and the subsequent collapse of food chains had much less an effect on organisms that were detritus feeders or starvation resistant. The recovery of these survival species, however, did not represent the full recovery of the ecosystem with robust food chains and attendant biochemical gradients. It appears that while marine production may have recovered relatively quickly (albeit with a completely different population of organisms), the flux of organics to the deep sea took approximately three million years to recover.

[Excerpted from GSA Today, August 2000]

MARKERS THROUGH TIME - Part One

by *Doug Zbikowski*

Humankind has recorded its thoughts in written form since about 5,400 years ago, when clay tablets were first used to record trade and business transactions in the Sumerian city of Uruk in southern Mesopotamia. Mesopotamia is the alluvial plain between and around the Tigris and Euphrates rivers just northwest of the Persian Gulf. Simple pictographs were first inscribed into small, wet clay tablets. Then about 4,900 years ago, wedge-shaped cuneiform signs were made with reeds or wood instruments pressed into the soft, moist clay to create the first characters. These characters came to represent not only things or ideas, but also sounds. This multiplicity of values makes the translation of early Sumerian a tedious and sometimes daunting task.

The first standalone public monuments with written text were erected some 4,500 years ago, again in Mesopotamia. The content of these early steles (upright stone slabs or pillars bearing an inscription or design and serving as a monument or marker) typically commemorated victories in war and gave conditions of peace and warnings about the consequences of further transgressions. They also marked territories and spelled out the fate of those who removed the markers. All brutal messages, but such were the times.

These early Mesopotamian steles were made of various rocks types available in the region. One of the oldest called "the stele of the vultures" is of limestone and commemorated a victory over another city state, showing vultures carrying off the severed heads of the enemy. Surely, an image you can't easily forget. Limestone was a common stele material, but sandstone was also easy to carve and use. However, a real masterpiece of artistic achievement came about 4,300 years ago in the form of a black diorite obelisk (a tapering, four-sided shaft of stone, usually monolithic and having a pyramidal apex). It records the purchases of land in northern Mesopotamia by King Manishtushu. Its inscriptions are finely cut with an elegance and precision not easily accomplished in the hard diorite (an intrusive igneous rock of composition intermediate between acidic and basic).

How long did these markers last? As steles were all direct or indirect claims to ownership of the territory, when conquering armies eventually ravaged the countryside, they were sure to be smashed. Today, we are fortunate if we find the pieces. Those we have discovered probably represent only a fraction of the stele that once existed. The messages thus far recovered, we owe to the considerable durability of buried rock.

As the Chair of our Public Service committee, Doug Zbikowski is actively involved in the Geologic Marker program throughout the state of Minnesota. These markers are placed along roadsides to bring attention to interesting geologic features, and to explain the history or formation of those features. As you can tell by this article, Doug's involvement in the marker program has piqued his curiousity about markers through the ages. In our next edition of GSM News, Doug will continue this discussion to include an historic review of the GSM markers, the status of our holdings, and the construction planned for next spring.

Don't miss Part Two of MARKERS THROUGH TIME in the February edition of GSM News.

—EDITOR

Hot Spots and Mantle Plumes (continued from Page 7)

of Caltech has spent his career studying Earth's interior and he notes that the assumptions upon which Wilson and Morgan based their original hot spot theories have been shown to be just that - assumptions. Much of the foundation of their theories have been disproved over recent decades, including the idea that the mantle is isothermal and that all hot material must come from the deepest Earth.

"These assumptions were made a long time ago and most never read the original papers," Anderson says. The basic assumptions behind the plume hypothesis have disappeared and new research is beginning to confirm Anderson's belief that volcanic activity is controlled by lithospheric motion and extension, not by deep mantle convection or plumes.

[From American Geological Institute's GEOTIMES, November 2000]

HOT SPOTS AND MANTLE PLUMES

by *Laura Wright*

In 1963, J. Tuzo Wilson came up with the idea that volcanic chains like the Hawaiian Islands arise when plates migrate over hot spots deep within Earth. Ten years later, W. Jason Morgan took Wilson's theory a step further when he proposed that hot material rises up from the core-mantle boundary in chimney-like plumes to feed hot spots on the surface. Only now, these theories may crumble under the weight of a few seismometers.

At three of the world's most famous hot spots, researchers are independently finding that the heat fueling regional activity is not rising up like a chimney from the deepest mantle. Instead, it may be a shallow phenomenon closely related to lithospheric activity. Scientists working in Iceland found the base of the hot spot feeding Icelandic volcanism extends only about 400 kilometers down into the mantle.

In Hawaii, preliminary research shows similar results. Plans are underway for the most extensive seismographic study of the Hawaiian-Emperor chain ever completed. At Yellowstone, seismologists, volcanologists and geologic mappers are coming up with the same conclusion - the long-held assumption that hot spots are fed by deeply-fixed mantle plumes may not be true. In the case of mantle hot spots, teleseismic tomography may end the debate over how hot spots develop.

Gillian Foulger of the University of Durham, UK, and Bruce Julian of the U.S. Geological Survey led the Iceland research team as they assembled a seismic monitoring system on the island. As earthquakes occur, seismometers on Iceland pick up acoustical waves traveling through Earth.

When a wave travels into an especially hot region, its velocity decreases. They were able to produce an image of the subsurface that revealed a temperature anomaly ending at a mere 400 kilometers into the mantle, ruling out the possibility that a deep mantle plume rising from the core-mantle boundary (2,000 kilometers) causes the volcanic activity in Iceland. "It seems important to me for people to go back and evaluate what we really do know and what is just an assumption," Julian says.

Because the distribution of seismometers was limited to Iceland's landmass, the only waves that the instruments are able to receive are those approaching Iceland within 30 to 40 degrees of vertical. The narrow range of waves that reach the seismometers impede scientists' ability to produce a high-resolution picture of what is going on beneath Iceland. More seismometers placed over a larger area broadens the range of seismic waves that can be measured. As more waves are collected over a broader region, the resolution of the 3-D image of the subsurface improves.

A continent away, John Orcutt of Scripps Institution of Oceanography has plans to overcome the problem the Iceland researchers faced. Orcutt and his team of researchers from Scripps, Woods Hole Oceanographic Institution, the Carnegie Institution of Washington and the University of Hawaii, hope to deploy a network of 70 seismometers on the sea floor surrounding the Hawaiian islands to finally visualize what fuels the enigmatic Hawaiian-Emperor chain. "We want to know if [the hot spot] is really coming from the core-mantle boundary and I think that this experiment will do that,"Orcutt says. By establishing a network of seismometers over a large area of sea floor that will collect data for 15 months, Orcutt believes he will be able to resolve with great accuracy what feeds Hawaiian volcanism.

Back on land, some of the folks at Yellowstone are thinking the same thing about what keeps the underground blaze burning. Bob Christiansen of the USGS thinks the Yellowstone hot spot is not related to a deeply fixed plume, but rather to upper-mantle convection related to the regional extension that pervades the northwestern United States. He points out that the hot spot track at Yellowstone runs along what is known to be a major structural boundary in the lithosphere. The Eastern Snake River Plain records the former track of the Yellowstone hot spot, which has been active only since the onset of basin and range extension in the region 15 to 17 million years ago; the hot-spot track marks the northern edge of large-scale regional extension.

"There does not appear to be evidence for a deep mantle source," Christiansen says.Don Anderson

Continued, bottom of Page 6

Predictions for the Future

What can scientists predict about some of the features of the Earth existing today? Quite a lot. The Atlantic Ocean will continue to expand, while the Pacific Ocean (originaly Panthalassa Ocean) will shrink. Eventually, the Mediterranean Sea (remnant from the Tethys Sea) will disappear, contecting Africa with Europe. India will continue to push into the southern Asian continent, pushing the Himalayas higher. Meanwhile the city of Los Angles will continue its journey north to join with the city of San Francisco. This will take serveral million years to occur. Maybe in another 200 million years there will be no need for a transoceanic trip from America to Asia. Will the GSM still be going strong at that time?

COMING IN FEBRUARY!

- NEWS ABOUT THE GSM GEOLOGIC MARKER PROGRAM!
- HISTORY!
- MAPS!
- NEW CONSTRUCTION! READ ALL ABOUT IT!

Geological Society of Minnesota
c/o Katy Paul
6901 West 84th Street
Bloomington MN 55438

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FIRST CLASS MAIL

10/1/01
Steve ERICKSON
9393 Turnberry Alcove
Woodbury, MN 55125

55125-7714 56