

**TRANSACTIONS OF  
THE MISSOURI ACADEMY  
OF SCIENCE**



**VOLUME 35, 2001**

# About the Academy

Scientists of the State of Missouri organized in 1934 to form the Missouri Academy of Science. By April 6, 1934, a Constitution and By-Laws were prepared and on August 14, 1934, the organization was incorporated.

The purposes of this Academy were presented in the fourth "article of agreement" as follows:

"This corporation is organized, not for profit but for the purposes of promoting the increase and the diffusion of scientific spirit, and of promoting cooperation between the scientific interests of Missouri. It proposes to accomplish these purposes:

- a. By holding meetings for the presentation of scientific papers embodying the results of original research, teaching experience, or other information of scientific interest.
- b. By fostering public interest in scientific matters, through open meetings, press releases and in such other ways as seem feasible.
- c. By encouraging local scientific organizations in every possible way.
- d. By promoting acquaintance in harmonious relationships between scientists in Missouri and among all who are interested in science.
- e. By supplying, so far as finances permit, a medium for the publication of results of original work, particularly those of special interest in this state.
- f. By concerning itself with legislation on scientific matters, and providing opportunity for discussion of such legislation.
- g. By working in any and all other ways which may prove feasible, for the advancement of science in Missouri."

The Academy held its organizational meeting on April 13-14, 1934, with 250 people attending. At the December, 1934, meeting, more than 400 people registered and by May, 1935, there were

approximately 750 members of the Academy. Statewide interest at a high level continued until activities made necessary by World War II caused disruption of Academy affairs except for some activity in the College Section.

Post-war revival of Academy activities started at a meeting on April 20, 1963, at Drury College. From the group of twelve persons who initiated the reactivation of the Academy in 1963, the membership has grown steadily to more than 800. Activities of the Academy have expanded to include the awarding of modest grants for projects proposed by high school and college students, and to sponsor the establishment of a Junior Academy of Science.

Since its reactivation in 1963, the Missouri Academy of Science has regularly held annual meetings at 16 different sites around the state. The refereed publications, the *Transactions of the Missouri Academy of Science*, has been published consistently since 1967. Six Occasional Papers have also been released.

Presently, 49 colleges and universities around the State of Missouri hold an Institutional Membership status. Many industries and other private businesses are supporting the Academy with Corporate Memberships.

Membership into the Academy is a year-round opportunity for everyone and runs from January 1 to December 31. Benefits include four quarterly *Bulletins*, one annual *Transactions*, and annual meeting lower pre-registration fee.

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**TRANSACTIONS  
OF THE  
MISSOURI  
ACADEMY  
OF  
SCIENCE**

**Volume 35  
2001**

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# Effect of $\text{CaSO}_4$ (Gypsum) on Cotton Lint Yields, Soil Fertility, and Physical Soil Properties of Heavy Clay Soils in Missouri

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**Abstract:** Cotton production on clay soils in Missouri is often limited by poor internal soil water drainage. A two year study was conducted at the University of Missouri Delta Center at Portageville, Missouri to determine whether gypsum ( $\text{CaSO}_4$ ) soil amendments may improve soil physical properties and increase cotton yields on a Sharkey clay soil (very fine, montmorillonite, thermic Vertic Haplaquept). Gypsum treatments were applied on small plots at 1.68 and 3.36  $\text{Mg ha}^{-1}$  rates. Gypsum improved soil drainage in the seedbeds as indicated by saturated conductivity measurements. Saturated hydrologic conductivity averaged  $6.0 \text{ E-}5 \text{ cm sec}^{-1}$  on untreated plots are compared to  $1.3 \text{ E-}4 \text{ cm sec}^{-1}$  on plots with 3.36  $\text{Mg ha}^{-1}$  gypsum. Gypsum additions decreased soil pH from 6.5 (untreated check) to 6.3 (both gypsum treatments). Soil compaction as measured by bulk density and penetrometer resistance was not significantly effected by gypsum. There was a slight trend towards increased yields from gypsum. However, cotton yields and fiber properties were not increased significantly by gypsum applications. Two year average cotton lint yields were 961  $\text{kg ha}^{-1}$  for the untreated check, 999  $\text{kg ha}^{-1}$  for 1.68  $\text{Mg ha}^{-1}$  gypsum, and 995  $\text{kg ha}^{-1}$  for 3.36  $\text{Mg ha}^{-1}$  gypsum.

## Introduction

Cotton (*Gossypium hirsutum*) is an important agronomic crop in Southeast Missouri. The Sharkey clay soil association, commonly referred to as "gumbo", comprises about one fourth of the six county area where cotton is grown in Southeast Missouri. It was formed on old slack-water areas along the former course of the Mississippi River (Scrivner et al., 1966). Compared to other soil associations the Sharkey has a limited potential for cotton production. Garrett et al. (1978) lists the average cotton lint yield under irrigated conditions for the Sharkey series as 560  $\text{kg ha}^{-1}$ , compared to the Malden series with 784  $\text{kg ha}^{-1}$ .

Excessive water is a limitation to the use of this soil because surface runoff is slow, and internal drainage is poor. Cotton requires good drainage as low soil oxygen levels limit root growth (Huck, 1970). Saturated hydraulic conductivity is generally less than  $4.2 \text{ E-}5 \text{ cm s}^{-1}$  compared to  $4.2 \text{ E-}3 \text{ cm s}^{-1}$  or more for the Malden soils (Garrett et al., 1978). The soil is firm and plastic and has a very high shrink-swell potential because of a high montmorillonite content. Consequentially, the soils are difficult to till and seedbeds are difficult to prepare. In most years cracks form as the soil is depleted of available water by the growing crops. Furrow irrigation is difficult to manage on Sharkey soils. These properties contribute to low productivity by limiting root growth and reducing plant available soil moisture.

Gypsum ( $\text{CaSO}_4$ ) has long been used as an amendment to condition clay soils (McCray et al., 1991). Benefits of gypsum applications can include increased water infiltration, increased root penetration, increased soil aeration, and decreasing the shrink-swell of clay rich soils (Walace, 1994). Gypsum works to decrease bulk soil density by allowing the calcium ion ( $\text{Ca}^{+2}$ ) to infiltrate between the structural layers that make up the clay mineral lattice. This allows montmorillonite to expand making room for additional water. The individual clay particles are not as tightly bound to each other (Ritchey et al., 1995). One potential problem with gypsum applications may be the soil acidification resulting from the sulfate it contains (Sumner et al., 1990).

The purpose of this investigation was to determine if applications of gypsum will increase cotton lint yields on heavy clay soils in Southeast Missouri. The secondary objective was to determine the effect of gypsum on the chemical and physical aspects of Sharkey soils.

## Materials and Methods

A cotton study was conducted at the University of Missouri-Delta Center Lee Farm (36°N, 89°W) in Pemiscot County, Missouri in 1999 and 2000. Cotton was planted on a Sharkey series (very fine, montmorillonitic, thermic Vertic Haplaquept) soil. The texture was determined by hydrometer and was found to be 68% clay, 36% sand and 2% silt. This classifies as clay on the USDA Textural Triangle. The clay mineralogy of the research area was identified using X ray diffraction and it was found to be composed of almost entirely montmorillonite with trace to minor amounts of kaolinite.

In 1998 the research area was limed with 3.32 Mg ha<sup>-1</sup> of calcitic lime. The experimental design was a randomized complete block with four replications. Three Gypsum treatments were applied to raised seedbeds with a spacing of 95-cm in early May of 1999. These gypsum applications were immediately incorporated and the cotton variety Stoneville 474 was planted the following day. In early May of 2000 the cotton variety Stoneville 474 was planted on the same raised seed beds used in 1999. Each plot was 3.8 m wide and 9.5 m long. Gypsum treatments were 0, 1.68, and 3.36 Mg ha<sup>-1</sup> pelletized gypsum was applied using a 3.8 m "Gandy box applicator". Soil samples of the study area were collected from the 0 to 15 cm depth before planting in 1999 and mid July 1999 and 2000. Soil fertility analysis consisted of pH (water), neutralizable acidity, exchangeable cations (Ca, Mg, K, Na), loss on ignition (LOI), Bray 1 extractable phosphorus, and SO<sub>4</sub>-S. Cation exchange capacity was calculated from measured values for Ca, Mg, K, and Na. Penetrometer readings were collected for the 7.5, 15 and 22.5 cm soil depth twice during 2000 on July 10 and August 28. These readings were collected from five positions relative to the beds and tractor wheel tracks. Following harvest in 2000 in situ bulk density and saturated hydraulic conductivity measurements were determined for each plot using the ring method for bulk density and enplaned cylinders having 7.5 cm of soil for the saturated hydraulic conductivity (Carter, 1993).

For both years nitrogen fertilization consisted of 45 kg ha<sup>-1</sup> N as urea ammonium nitrate 32% (UAN 32) pre-plant and 67 kg ha<sup>-1</sup> N as UAN 32 in mid June. The standard methods of weed and insect control were used for cultivating cotton in Southeast Missouri. The

crop was furrow irrigated five times during each growing season with approximately one inch of water each time.

In early October of each year the two middle rows of each strip were mechanically harvested and the seed cotton weighed and recorded. The seed cotton was ginned using a 20 saw Continental gin stand preceded by an inclined cleaner and feeder extractor. The gin stand was followed by one stage of lint cleaning. Lint samples from each plot were sent to the International Textile Research Center for fiber quality analysis using a high volume instrument.

Statistical analysis of the data were performed with SAS (1990) using General Linear Modeling procedures. Fisher's Protected Least Significant Difference (LSD) was calculated at the 0.05 probability level for making treatment mean comparisons.

## Results and Discussion

In 1999 and 2000 cotton lint yields for gypsum treatments were statistically equivalent to the control (Table 1). In 1999 the high rate of gypsum application numerically increased cotton lint yields (687 vs. 646 kg ha<sup>-1</sup>) while the low rate decreased yields (636 vs. 464 kg ha<sup>-1</sup>). The two-year mean lint yield was calculated for each treatment and the rate of 1.68 Mg ha<sup>-1</sup>. Gypsum was found to be the highest with 999 kg ha<sup>-1</sup> lint. In 2000 both rates of gypsum application raised cotton lint yields. Gypsum applications in 1999 or 2000 (Tables 2a and b) did not affect gin turnout. Lint quality was also not affected by gypsum applications in either year (Tables 2a and b). Gypsum applications lowered soil pH and raised the amount of neutralizable acidity (NA) in the soil. The amount of pH decrease was not related to rate of gypsum application. SO<sub>4</sub>-S and Ca levels were also increased by gypsum applications and the increase was related to the rate of gypsum application. Cation exchange capacity (CEC) was calculated from soil test values. The calculated CEC was greater for gypsum treatments; this is accounted for by the increases in Ca and NA levels for gypsum treatments. All other chemical soil fertility parameters were not affected by gypsum applications (Table 3).

Gypsum applications decreased in situ bulk density slightly in the seedbeds (1.1 vs. 1.2 g cm<sup>-3</sup>). The differences were found to be not significant at the alpha = .05 level (Table 4). These values are within the

range given as typical for the Sharkey series by Pettry and Switzer, 1996. Gypsum applications significantly increased the saturated hydrologic conductivity of the seedbeds. For the high gypsum rate this number was more than doubled ( $1.1\text{E-}4 \text{ cm sec}^{-1}$  vs.  $4.5\text{E-}5 \text{ cm sec}^{-1}$ ). This increase in hydraulic conductivity for the seedbeds is not great enough to cause a decrease in the time needed to drain the field.

When all five penetrometer readings from each treatment area were averaged for each date the application of gypsum decreased penetrometer resistance at the 7.5 cm depth. Average penetrometer readings for the 15 and 22.5 cm depths showed no consistent trend (Table 5). Gypsum applications decreased penetrometer resistance readings more in furrows than in seedbeds.

### Conclusions

Gypsum additions did not significantly increase cotton lint for the Sharkey series soils. There was however a numerical increase in the two year average lint yield for both rates of gypsum application. This increase was approximately  $34 \text{ kg ha}^{-1}$  for both years and both rates. Gypsum applications did increase exchangeable Ca and  $\text{SO}_4 \text{ S}$  levels in the soil. Currently pelletized gypsum sells for \$37.95 per Mg in Southeast Missouri. The cost to producers for the 1.68 and  $3.36 \text{ Mg ha}^{-1}$  rates are \$63.75 and \$127.50 respectively. At lint price of \$1.34 per kg lint gypsum application would not be a profitable practice for Missouri cotton producers. At times gypsum in the form of waste dry wall is available to cotton producers at lower prices. This waste product may be economical for cotton producers to use.

### Acknowledgements

This work was made possible by the generous support of Cotton Inc. and the Missouri State Support Committee.

### Literature Cited

- Carter, Martin R. 1993. Soil Sampling and Methods of Analysis. Lewis Publishers, Boca Raton, Florida.
- Garrett, J., F. Allgood, B. Brown, R. Grossman, and C. Scrivner. 1978. Soils of the Southeast Missouri Lowlands-major types, fertility, and yield information for soils found in the low lands of the Bootheel area. Univ. of Missouri - extension circular 922
- Huck, M.G. 1970. Variation in taproot elongation rate as influenced by composition of the soil air. *Agron. J.* 62:815-818.
- McCray, J.M., Sumner, M.E., Radcliffe, D.E., and Clark, R.L. 1991. Soil Ca, Al, acidity and penetration resistance with subsoiling, lime, and Gypsum treatments; Soil Use and Management. Vol. 7 p. 193-200.
- Pettry, D. E., and Switzer, R. E. 1996. Sharkey soils in Mississippi. *Miss. Agri. & Forestry Exp. Station Bull.* No 1057.
- Ritchey, K.D., Feldhake, C.M., Clark, R.B., Sousa, D.M.G. de, 1995. Improved water and nutrient uptake from subsurface layers of gypsum-amended soils; Agricultural utilization of urban and industrial by-products: Proceedings of a Symposium of Soil Science Society of America.
- SAS Institute. 1990. SAS/STAT guide for personal computers. Version 6.0. SAS Inst. Cary, N.C.

Scrivner, C.L., Baker, J.C. and Miller, B. J.,  
1966. "Soils of Missouri," Univ. of Missouri  
Agri. Expt. Station. Circular 823.  
Sumner, M. E. Radcliffe, D. E. McCray, Carter,  
M. E., and Clark, R. L. 1990. Gypsum as a  
ameliorate for subsoil hardpans. Soil  
Technology v 3 p. 253-258.

Walace, A. 1994. Use of gypsum on soil where  
needed can make agriculture more sustainable.  
Communications in Soil Science and  
Plant Analysis. Vol. 25 p. 109-116.

Table 1. Average cotton lint yields for gypsum treatments 1999 and 2000.

Treatment	Lint yield 1999 kg ha <sup>-1</sup>	Lint yield 2000 kg ha <sup>-1</sup>	2 year mean lint yield kg ha <sup>-1</sup>
Control	646 a	1275 a	961 a
1.68 Mg ha <sup>-1</sup> gypsum	636 a	1362 a	999 a
3.36 Mg ha <sup>-1</sup> gypsum	687 a	1302 a	995 a

Lint yields with the same letter indicate non-significance at the alpha = 0.05 level.

Table 2a. Average gin turnout and cotton fiber quality measurements for gypsum treatments 1999.

Treatment	% turnout	micronaire	length	uniformity	strength	elongation	leaf
Control	34	4.6	1.12	82.7	27.4	5.6	1.0
1.68 Mg ha <sup>-1</sup> Gypsum	34	4.5	1.11	82.5	27.3	5.2	1.0
3.36 Mg ha <sup>-1</sup> Gypsum	34	4.6	1.11	82.7	26.4	5.2	1.0

Table 2b. Average gin turnout and cotton fiber quality measurements for gypsum treatments 2000.

Treatment	% turnout	micronaire	length	uniformity	strength	elongation	leaf
Control	40	5.1	1.14	84.6	27.1	6.2	1.8
1.68 Mg ha <sup>-1</sup> Gypsum	41	5.2	1.13	84.8	27.3	6.1	2.0
3.36 Mg ha <sup>-1</sup> Gypsum	40	5.1	1.12	84.6	26.8	6.1	1.8

Table 3. Average soil fertility levels for gypsum treatments for soil samples collected June 27, 2000.

Treatment	pH Units	NA Meq/100gr	OM %	P	K	Ca	Mg	Na	SO <sub>4</sub> -S	CEC
				-----mg kg <sup>-1</sup> -----						
Control	6.5	0.8	2.3	62	260	3141	659	57	14.2	22.2
1.68 Mg ha <sup>-1</sup> Gypsum	6.3	2.3	2.3	63	272	3419	638	54	25.9	25.0
3.36 Mg ha <sup>-1</sup> Gypsum	6.3	1.8	2.4	60	261	3452	644	51	40.0	24.7

Table 4. Average bulk density and saturated hydraulic conductivity for 7.5-cm depth soil samples collected in seedbeds following harvest 2000.

Treatment	Bulk density gr. cm <sup>-3</sup>	Hydraulic conductivity cm sec <sup>-1</sup>
Control	1.2a	4.5 E-5a
1.68 Mg ha <sup>-1</sup> Gypsum	1.1a	9.1 E-5b
3.36 Mg ha <sup>-1</sup> Gypsum	1.1a	1.1 E-4b

Table 5. Average penetrometer readings for gypsum treatments 7-10-2000 and 8-24-2000.

Treatment	July 10 ,2000			August 28, 2000		
	6 inch	12 inch	18 inch	6 inch	12 inch	18 inch
	-----K Pa-----					
Control	152	313	383	219	400	418
1.68 Mg ha <sup>-1</sup> Gypsum	144	399	384	157	346	533
3.36 Mg ha <sup>-1</sup> Gypsum	154	261	418	208	368	418



# The First Distributional Record of the Least Weasel, *Mustela nivalis*, in Northeastern Missouri

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**Abstract:** This paper reports a significant range extension for the least weasel (*Mustela nivalis*). Failure to capture least weasels during the previous 50-year period in which the Adair County area has been intensely trapped for small mammals suggests that this species is a recent immigrant into northeastern Missouri. The location of the capture sites near the break between the Missouri and Mississippi drainage systems does not support a riparian mode of dispersal. We speculate that changes in agricultural policies and practices that have reduced row-crop farming and increased meadows and USDA Conservation Reserve Program land are factors in the recent movement of *M. nivalis* into northeastern Missouri.

**Key Words:** *Mustela nivalis*, weasel, shrew, Missouri, dispersal.

## Introduction

The least weasel (*Mustela nivalis*), the smallest carnivore, shows Holarctic distribution. Southern limits of its reported North American range extend from Montana through the upper Midwest to western Pennsylvania then south along the Appalachians into North Carolina (Hall, 1981; Sheffield and King, 1994). Extensive trapping programs failed to show the least weasel in northeastern Missouri (Beckert, 1968; Crawford, 1968; Ellis, 1984). The nearest confirmed distributional records are from Nodaway County, Missouri and Ringgold County, Iowa to the northwest (Easterla, 1970), Story County, Iowa to the north (Polderboer et al., 1941), and Henry County, Iowa and

McDonough County, Illinois to the northeast (Hall, 1951; Harty and Thom, 1978). Skeletal remains of *M. nivalis* found in a great horned owl (*Bubo virginianus*) pellet collected in Wapello County, Iowa, represent a tenuous closer record (Scott, 1939). Many papers describing marginal distributional records state or imply a recent southern movement for this species (Hatt, 1940; Easterla, 1970; Harty and Thom, 1978). Most peripheral records are from locations along waterways suggesting a riparian mode of dispersal (Sheffield and King, 1994). *Mustela nivalis* ranged farther to the south in prehistoric times. Parmalee and Munyer (1966) report a least weasel lower mandible and skull fragments from an excavation in a limestone bluff just south of St. Louis, Missouri (Columbia, Monroe County, Illinois).

Least weasels inhabit areas based on prey species abundance and the presence of adequate cover. They prefer intermediate-sized, inactive mammals such as microtine rodents, but will take more active cricetid species if microtines are not available. Occasionally they eat young rabbits, nestling birds, moles, insects, small reptiles and amphibians (Sheffield and King, 1994). Shrews are captured less frequently than expected based on their relative abundance and are seldom eaten when taken (Korpimäki and Norrdahl, 1987). Captive least weasels can survive for extended periods on diets of mice, rats and pigeons (Lewellyn, 1942; Easterla, 1970). Two mustelid species can coexist when rodent populations are high. The larger weasels have a selective advantage when prey species numbers are decreasing. *M. nivalis* has a competitive edge in its ability to rapidly recolonize when rodent populations increase (Sheffield and King, 1994).

While odor production serves for intraspecific communication, a mustelid odor can be detrimental to predators when prey populations are low. Stoddart (1976) states that rodents selectively avoid sites that smell of weasel. Some reports mention a mustelid odor associated with *M. nivalis* (Llewellyn, 1942), but others imply that its scent is mild in comparison to sympatric mustelid species (Stubbe, 1972; Brinck et al., 1983).

### Materials and Methods

We captured one *M. nivalis* at each of our trapping sites during a project to obtain shrews for laboratory use. Thirty kilometers separate the Schuyler County area located 5 km north-northwest of Greentop, Missouri, from the Adair County site situated 4 km east of Millard, Missouri. Each setting is typical old-field habitat, bordered by overgrown fencerows. Little row-crop agriculture occurs near either site. Most of the surrounding land is pasture, meadow or USDA Conservation Reserve Program (CRP) land. Highway US 63 generally follows the break between the Missouri and Mississippi drainage systems. Greentop and Millard lie along this highway. Thus, the site west of Greentop ultimately drains into the Missouri River and the site east of Millard is in the Mississippi drainage basin.

Standard (7.6 cm x 8.9 cm x 30.5 cm) Sherman traps (H.B. Sherman Traps, Inc., Tallahassee, FL, U.S.A.) with a fine treadle setting captured all animals described in this study. Traps baited with oatmeal soaked in peanut butter and corn oil were typically placed at alternate posts (8 m intervals) along bordering fence lines. Traps were set prior to dusk and checked every 2-4 h in the autumn and every 4-6 h in the spring and summer to assure shrew survival. Sampling occurred during the fall of 1996 at the Schuyler site and during the spring and summer of 1997 at both areas. Our animal use protocol required the release of all mammals captured other than shrews and vanguard species. Therefore, we did not routinely record rodent captures. The exception was the night of 17 April 1997 at the Adair site. We listed all species captured in 78 traps for that night. Animals were collected under Wildlife Collector's Permits issued by the Missouri Department of Conservation.

The captive weasels were maintained at the

Kirksville College of Osteopathic Medicine, a facility with animal care and use programs accredited by American Association for the Accreditation of Laboratory Animal Care, International. All aspects of the study received full Institutional Animal Care and Use Committee approval, and were conducted in accordance with the Animal Welfare Act, the Guide for the Care and Use of Laboratory Animals (National Research Council, 1996) and Acceptable Field Methods in Mammalogy (ad hoc Committee, American Society of Mammalogists, 1987). The captive weasels were maintained in an isolation room under standard environmental conditions (22 + 2°C, 12/12-h light dark cycles, 10 fresh air changes/h). Housing consisted of 49 cm x 34 cm x 30 cm polycarbonate cages with ventilated tops, aspen shaving bedding (Northeastern Products Corp., Warrensburg, NY), and an opaque, 22 cm plastic square for cover. Animals received tap water ad libitum and two or more of the following food items were always available: fresh CO<sub>2</sub> euthanized laboratory animal carcasses, prairie voles (*Microtus ochrogaster*) or least shrews (*Cryptotis parva*); mealworms (*Tenebrio* sp.); feline diet no. 5003 (Purina Mills Inc., St. Louis, MO); and a moistened shrew diet consisting of equal parts ground feline diet and Kozy Kitten Cat Food (Heinz Pet Products Co., Newport, KY).

Skins and skulls of the least weasels taken during this study were placed in the collection of the Truman State University museum. Carcasses were not preserved.

### Results

We captured two least weasels, a female at the Schuyler site on 10 October 1996, and a male at the Adair site on 23 August 1997. Both animals were collected along fence lines bordering state highways. Each site showed meadows of tall fescue (*Festuca arundinacea*); right-of-ways of smooth brome grass (*Bromus inermis*); and overgrown fencerows of lodged smooth brome grass, wild grape (*Vitis* sp.), poison ivy (*Rhus radicans*), and new growth trees. The saplings were black locust (*Robinia pseudoacacia*) at the Schuyler site and red cedar (*Juniperus virginiana*) at the Adair site. Students from the Truman State University mammalogy class concurrently trapped the Schuyler area during the autumn of 1996.

From our field observations and specimens classified by the students in the mammalogy class, the following species were listed for the Schuyler site: masked shrew (*Sorex cinereus*), southeastern shrew (*S. longirostris*), short-tailed shrew (*Blarina brevicauda*), western harvest mouse (*Reithrodontomys megalotis*), deer mouse (*Peromyscus maniculatus*), white-footed mouse (*P. leucopus*), meadow vole (*Microtus pennsylvanicus*), prairie vole (*M. ochrogaster*), woodland vole (*M. pinetorum*), southern bog lemming (*Synaptomys cooperi*), and house mouse (*Mus musculus*). On 17 April 1997 we listed all animals collected in 78 traps at the Adair site as follows: 50 *Peromyscus* (*P. maniculatus*, *P. leucopus*); 14 microtines (*M. ochrogaster*, *M. pennsylvanicus*, *M. pinetorum*, *S. cooperi*); and 6 *B. brevicauda*. These data are typical for mammalian abundance at each site. We routinely captured over twenty animals (80 to 100 traps) at each first post-dusk or post-dawn run; a total of 57 shrews (52 *Blarina* and 5 *Sorex*) were collected in 1054 trap-nights. The listed species for 17 April 1997, the weasels and one Norway rat (*Rattus norvegicus*) represent the species trapped at the Adair site. The female was taken near the highest point of the trapping area and the male was collected on a slope about 200 m from an extensive creek bottom. We were alerted to the capture of something other than a rodent or shrew by increased weight and activity within the trap. A faint musteline odor was noted upon sniffing the trap.

On 28 June 1997 we captured a long-tailed weasel (*Mustela frenata*) at the Adair site about 100 m down slope from the site where the male *M. nivalis* would be taken. The fence line was not overgrown in this area. Lodged brome grass provided the only cover. A strong musteline odor signaled the presence of a weasel as we approached the trap. We examined and then released the animal.

We reviewed the species lists at the Truman State University museum and from Missouri Department of Conservation's annual trapping reports. Higher vertebrate zoology or mammalogy classes at Truman State University have routinely collected mammals since 1948. Autumnal mammal census data have been gathered at selected northeastern Missouri riparian sites by the Missouri Department of Conservation since 1994. There were no reports of least weasel captures for either enterprise. Figure 1 shows the location of our trapping areas and previously

confirmed capture sites. The Adair site is 150 km from the nearest listed site.

Captive weasels were not immediately euthanized. The female died during her first night in captivity. She consumed a least shrew carcass and some mealworms before her death, but failed to eat the feline diet or shrew food mixture. More detailed food preference studies were conducted during the four days that the male was housed. He preferred prairie vole to least shrew, but ate both, and refused all other food items. A musteline odor was not obvious in the well-ventilated animal cubicle.

The nonpregnant female from Schuyler County measured: weight, 35.3 g; total body length, 189 mm; tail length, 29 mm; hind foot, 18 mm; ear 5 mm. The male from Adair County measured: body length, 210 mm; tail length, 38 mm; hind foot, 24 mm; ear 7 mm. Both animals showed the typical summer pelage.

## Discussion

It is said that mammalian distribution maps reflect the distribution of mammalogists rather than the distribution of mammals. The previous marginal records for *M. nivalis* fit that pattern. Most capture sites shown in Figure 1 are near a major university. This thesis also supports the argument that *M. nivalis* is a recent immigrant to the northeastern Missouri region. The area around Kirksville has been intensely trapped for the past 50 years with no previous captures of least weasels.

Our report does not support a riparian mode of dispersal. The capture sites are located near the break between the Missouri and Mississippi drainage systems, at a considerable distance from major rivers that extend into the previously reported range of *M. nivalis*. Changes in agricultural policies and practices are the probable reason for the recent immigration. The farms in the two northern tiers of Missouri counties averaged 26.5 percent of their land in the CRP (1992 Census of Agriculture). By any standards the numbers of mammals that we captured, particularly during the spring, are exceptional. These high small-mammal populations could support sympatric weasel species with minimal competition for prey. Most studies of *Mustela* sympatry have involved *M. nivalis* and *M. erminea*. It would be worthwhile to determine if least weasels interact with long-tailed weasels in manners similar to their described

interactions with ermines. The lack of the strong musteline odor in *M. nivalis* could give it a competitive advantage in prey capture over *M. frenata*. Certainly to the human nose, *M. nivalis* is stealthier. It is unfortunate that carcasses were not fixed. Much information concerning scent production, reproductive status and anal gland morphology could have been gathered.

Our captive weasels show no aversion to *Cryptotis* carcasses as a food source. Previous reports of food avoidance concerned *Sorex* sp. (Korpimäki and Norrdahl, 1987). One would expect a difference in odor and taste between the genera but there are no reports that indicate that *Cryptotis* is less repugnant. It is likely that *M. nivalis* prefers shrews to many of the items listed as occasional food items by Sheffield and King (1994).

#### Acknowledgments

This research was supported in part by EPA Grant CR823734010 awarded to OBM. We thank Steven Sheffield for his helpful suggestion on this project, and Brian Root for his review of the northeastern Missouri autumnal mammalian census data.

#### Literature Cited

- ad hoc Committee for Acceptable Field Methods in Mammalogy. 1987. Acceptable field methods in mammalogy: preliminary guidelines approved by the American Society of Mammalogists. *Journal of Mammalogy*, 68(4), Supplement:1-18.
- Beckert, J.E. 1968. A field study of mammal distribution in Scotland County, Missouri. Masters Thesis No. 414. Truman State University, Kirksville, Missouri, 56pp.
- Brinck, C., S. Erlinge, and M. Sandell. 1983. Anal sac secretion in mustelids: a comparison. *Journal of Chemical Ecology*, 9:727-745.
- 1992 Census of Agriculture. 1994. Volume 1. Geographic Area Series, Part 25. Missouri State and County Data. Bureau of the Census, Washington, D.C., 593pp. + A-E app.
- Crawford, R.D. 1968. The distribution and abundance of mammals of Adair County, Missouri. Masters Thesis No. 435. Truman State University, Kirksville, Missouri, 64pp..
- Easterla, D.A. 1970. First records of least weasel, *Mustela nivalis*, from Missouri and southwestern Iowa. *Journal of Mammalogy*, 51:333-340.
- Ellis, L.S. 1984. Small mammal studies in northeast Missouri: use of railroad right-of-ways and survey of ten sites. Report submitted to Missouri Department of Conservation, Jefferson City, Missouri, 40pp.
- Hall, E.R. 1951. American weasels. University of Kansas Publications, Museum of Natural History, 4:1-466.
- Hall, E.R. 1981. The Mammals of North American. Second edition. John Wiley & Sons, New York, 2:601-1181 + 90.
- Harty, F.M., and R.H. Thom. 1978. Distribution of the least weasel (*Mustela nivalis*) in Illinois. *Transactions, Illinois State Academy of Science*, 71:81-87.
- Hatt, R.T. 1940. The least weasel in Michigan. *Journal of Mammalogy*, 21:412-416.
- Korpinmäki, E., and K. Norrdahl. 1987. Low proportion of shrews in the diets of small mustelids in western Finland. *Zeitschrift für Säugetierkunde*, 52:257-260.
- Lewellyn, L.M. 1942. Notes on the Alleghenian least weasel in Virginia. *Journal of Mammalogy*, 23:439-441.

- National Research Council, 1996. Guide for the care and use of laboratory animals. National Academy Press, Washington, D.C., 125pp.
- Parmalee, P.W., and E.A. Munyer. 1966. Range extension of the least weasel and pigmy shrew in Illinois. Transactions, Illinois State Academy of Science, 59:81-82.
- Polderboer, Emmett B., Kuhn, Lee W., and Henrickson, George O. 1941. Winter and spring habits of weasels in central Iowa. Journal of Wildlife Management, 5:115-119.
- Scott, Thomas G. 1939. Noteworthy additions to the collection of mammals from Iowa in 1938. Iowa State College Journal of Science, 13: 239-241.
- Sheffield, S.R. and C.M. King. 1994. *Mustela nivalis*. Mammalian Species, 454:1-10.
- Stoddart, D.M. 1976. Effect of the odour of weasels (*Mustela nivalis* L.) on trapped samples of their prey. Oecologia (Berlin), 22:439-441.
- Stubbe, M. 1972. Die analen markierungsorgane der *Mustela* arten. Zoologische Garten (Neue Folge), Leipzig, 42:176-188.

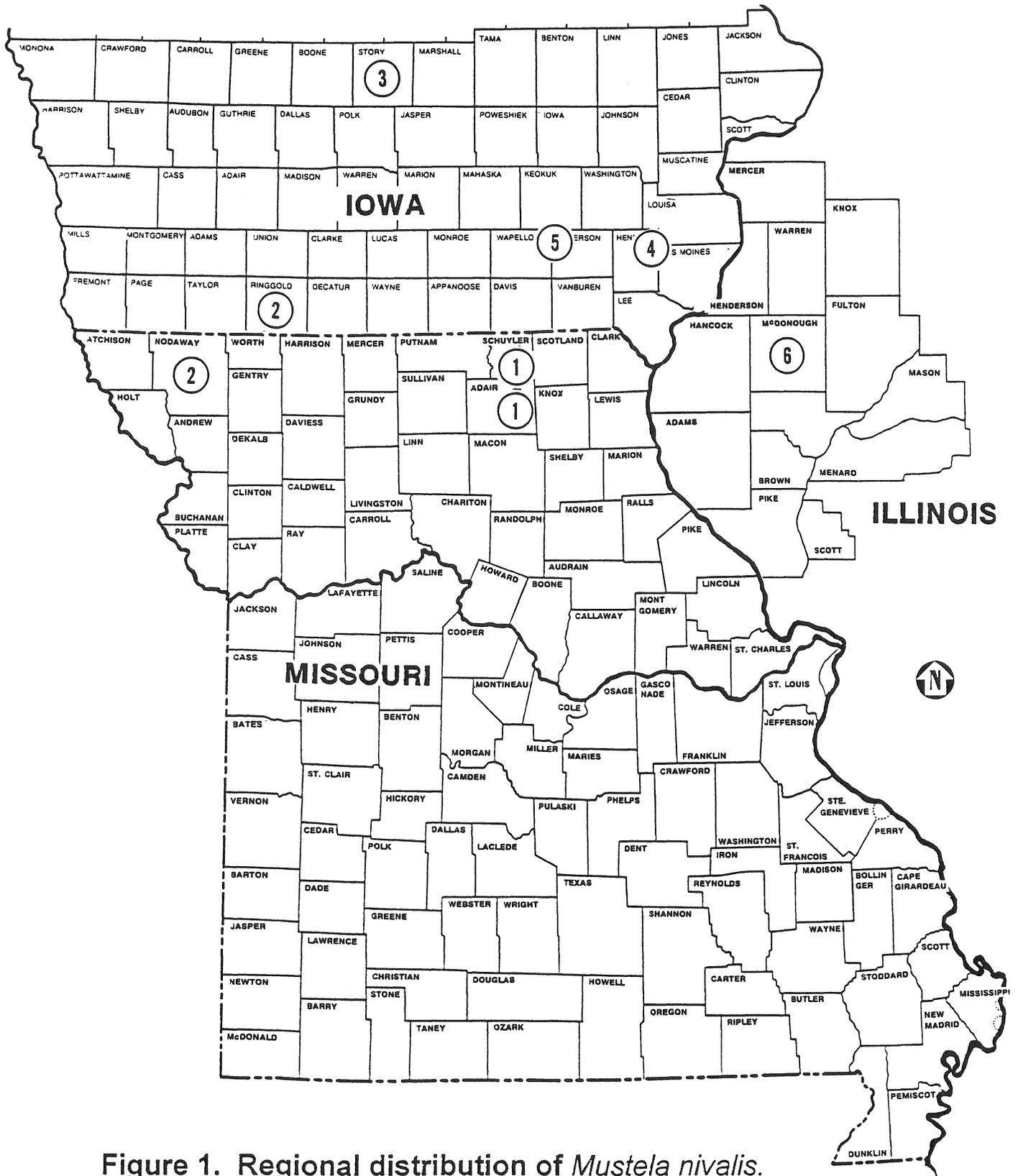


Figure 1. Regional distribution of *Mustela nivalis*.

- 1. Our capture sites, 2. Easterla, 1970, 3. Polderboer et. al., 1941
- 4. Hall, 1951, 5. Scott, 1939, 6. Harty and Thom, 1978.

# Reduction of 2- and 4-Alkylcyclohexanones with Sodium Borohydride in Alcohol Solvents: The Effect of the Solvent on the Stereochemistry.

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**Abstract:** A solvent effect has been demonstrated in the reduction of 2- and 4-alkylcyclohexanones with sodium borohydride in alcohol solvents. The proportion of *cis*-alcohol product decreases as the size and bulk of the solvent increases.

**Key Words:** Borohydride, reduction, alkylcyclohexanones, stereochemistry

## Introduction

Previously (Hathaway 1998), we have reported a solvent effect in the reduction of 2,6-dimethylcyclohexanone and 2-methylcyclohexanone with sodium borohydride in alcohol solvents. We now report that this solvent effect is general with reductions of other 2-alkylcyclohexanones, as well as with 4-alkylcyclohexanones. The reduction of ketones with sodium borohydride in an alcohol solvent is a common reaction to prepare an alcohol. Reduction of alkylcyclohexanones gives a mixture of *cis* and *trans* alcohol products.

## Experimental Procedures and GC Conditions

A solution of 0.50 grams of the ketone in the 10 mL alcohol solvent was stirred at room temperature. Sodium borohydride (0.10 grams) was added, and the reaction mixture was stirred for 30 minutes. The reaction mixture was diluted with water, and then extracted with two, 10 mL portions of hexane. The combined hexane layers were washed with 10 mL of distilled water, dried with magnesium sulfate, filtered, and the solvent was removed to yield the crude product. Proton NMR spectra of the products were recorded at 300 MHz in CDCl<sub>3</sub>. The C-1 methine protons were integrated to determine the relative amounts of each isomer. GC conditions: Carbowax column (30 m, 0.53

mm i.d.), column temperature at 110°C, injector and detector temperature at 200°C, flow rate at 5 mL/min, 0.4 µL of a dilute solution of the alcohols in hexane was injected.

## Results

Gas chromatography (GC) clearly separates the two isomers, but obviously doesn't tell which isomer is which. The earlier literature assigned the isomers by relative GC retention times (Wigfield and Phelps 1974). The order of elution of the isomers was found to be dependent on the type of GC column used. The C-1 methine hydrogens for the *cis* and *trans* isomers are clearly separated in the NMR spectra, and the chemical shifts of those hydrogens are known for many of the pure isomers (Pouchert and Campbell 1974). NMR spectra of the products for several of the experiments were recorded. In all cases, the chemical shift of the C-1 methine proton of the *cis* isomer is more deshielded (larger ppm value) than the methine proton of the *trans* isomer. The results of these analyses are shown in the following tables. The appearances of the peaks of each methane resonance also differs. The C-1 methine proton of the *cis* isomer appears as a broad singlet, while the methine proton of the *trans* isomer appears as a multiplet. This is consistent with the Karplus relationship. The C-1 methine proton of the *cis* isomer is gauche to the hydrogens on C-2 and C-6, which would give rise to very small coupling constants at best, while the C-1 methine proton of the *trans* isomer is anti to the C-2 hydrogen and the axial C-6 hydrogen, which produces large coupling constants.

## Discussion

As shown in Table 1, the proportion of *cis*-isomer decreases as the size and bulk of the alcohol solvent increases. Although the effect is not large, it is reproducible, as the results shown in Table 1 have been repeated many times. Table 2 shows very good agreement between the NMR and GC results. Since the proportion of *cis*-alcohol increases when a more bulky reducing agent is used (Carey and Sundberg 1990), the solvent must not be increasing the bulk of the reducing agent. Apparently, the bulkier solvents must be blocking the approach of the borohydride ion somewhat from the equatorial side of the ketone. This could be the result of hydrogen-bonding of the alcohol solvent to the carbonyl oxygen of the ketone.

## Acknowledgments

The authors acknowledge the support of the National Science Foundation ILI Grant 9650399. The authors thank Bjorn Olesen for helpful discussions.

## Literature Cited

- Carey, F. A. and Sundberg, R. J. 1990. Advanced Organic Chemistry, 3rd Edition; Plenum: New York, Part B, pages 241-244.
- Hathaway, B. A. 1998. J. Chem. Educ., 75: 1623-4.
- Pouchert, C. J. and Campbell, J. R. 1974. The Aldrich Library of NMR Spectra, Aldrich Chemical Company, Inc.: Milwaukee, WI, Volume 1, pages 114-116.
- Wigfield, D. C. and Phelps, D. J. 1974. J. Amer. Chem. Soc., 96: 543-549

Table 1: GC Analyses of Reductions of Alkylcyclohexanones: % *cis* Alcohol Formed

Alkyl Group	Methanol	95%Ethanol	Isopropyl alcohol	t-Butyl alcohol
2-Methyl	49.8	39.8	37.5	32.0
2-Ethyl	49.7	43.7	39.7	37.1
2-Propyl	49.9	43.9	41.7	39.0
2-Isopropyl	54.8	50.5	44.0	36.4
2-Butyl	51.4	44.4	42.8	40.4
2-t-Butyl	80.1	68.6	65.8	65.2
4-Methyl	26.9	22.7	20.6	15.3
4-t-Butyl	19.7	14.9	13.3	8.9

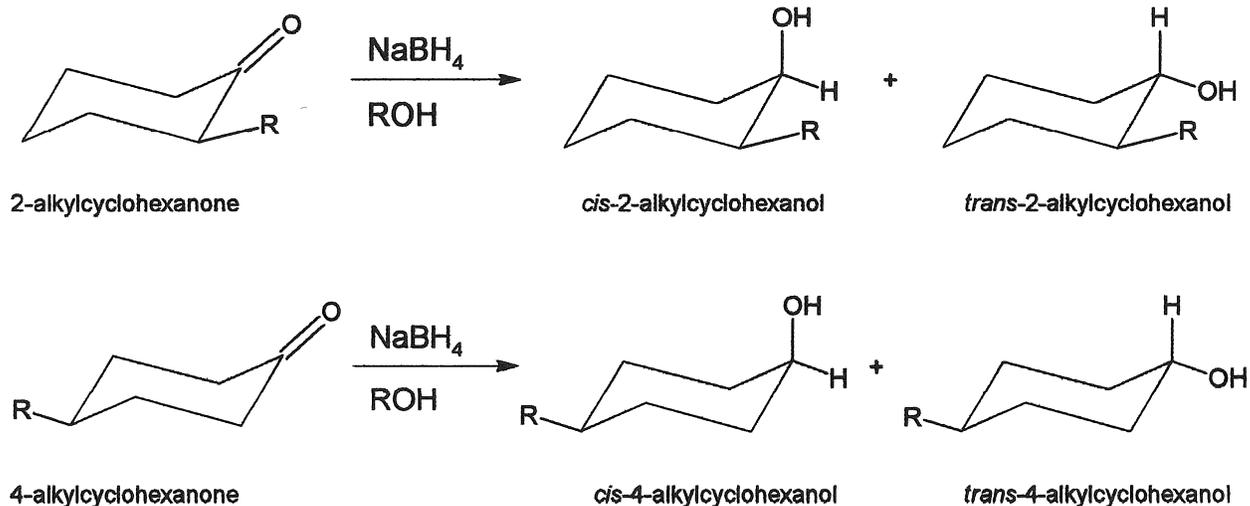
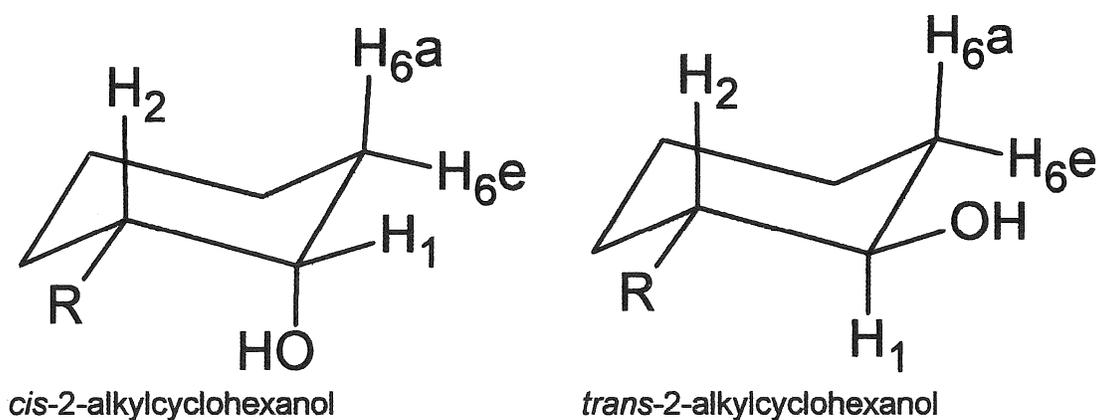
Table 2: Comparison of NMR and GC Analyses of Reduction of Alkylcyclohexanones: % *cis* Alcohol Formed

Alkyl Group	Solvent	% <i>cis</i> alcohol by NMR	% <i>cis</i> alcohol by GC
2-Methyl	95% ethanol	39.3	39.8
2-Ethyl	t-butanol	34.1	37.1
2-Propyl	t-butanol	37.6	39.0
2-Isobutyl	t-butanol	34.8	36.4
2-Butyl	t-butanol	39.5	40.4
2-t-Butyl	methanol	80.3	80.1
4-Methyl	95% ethanol	20.6	22.7
4-t-Butyl	t-butanol	5.4	8.9

Table 3: Proton NMR Chemical Shifts of C-1 Methine Hydrogens of Alkylcyclohexanols

Alkyl Group	<i>cis</i> -isomer (ppm)	<i>trans</i> -isomer (ppm)
2-Methyl	3.76	3.10
2-Ethyl	3.90	3.22
2-Propyl	3.86	3.19
2-Isopropyl	4.08	3.70
2-Butyl	3.86	3.19
2- <i>t</i> -Butyl	4.21	3.46
4-Methyl	3.91	3.51
4- <i>t</i> -Butyl	4.01	3.50

Figure 1: Reaction Schemes for Reduction of Alkylcyclohexanones

Figure 2: *cis* and *trans* isomers of 2-alkylcyclohexanols.



# The Influence of pH and Phosphorus on the Adsorption of Chromate On Smectites Having Synthetic Hydroxy-Al Interlayers

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**Abstract:** Chromium (Cr) is a transition metal commonly found in the environment because of human activity. In southeast Missouri, numerous Cr contaminated sites exist because of Aluminum (Al) metal fabrication and Cr plating of metals. Several of these areas are in populated regions and are registered as EPA superfund sites. The chromate species is of particular concern because of its appreciable migratory potential and the resultant threat to ground-water supplies. Recent research efforts have focused on describing chromate adsorption on a variety of absorbents, including soils, clay minerals and metal oxides. This investigation reports on efforts to describe the extent of chromate adsorption on smectite and synthetic hydroxy-Al interlayers associated with smectite (HIS) and to consider the influences of pH and phosphorus (P). The role of P is to act as a competing anion with Cr for surface adsorption sites and to assess the potential for Cr adsorption to be inhibited by P. Chromate adsorption is greater in acidic smectite suspensions, thus adsorption is pH dependent. Phosphorus only marginally displaced chromate from smectite and its synthetic hydroxy-Al interlayer analog, as revealed by marginal to slightly greater Cr concentrations in the suspension's aqueous phase in the presence of P. Based on previous research by the authors, chromate adsorption on similar substrates is outer-sphere; therefore the small differences in Cr adsorption in the presence of P is likely attributable to a surplus of surface bonding sites and incremental differences in the activity coefficients for these sites.

**Key Words:** Chromium, Adsorption, Phosphorus, Smectite

## Introduction

In the soil environment chromium is a transition metal capable of existing in two oxidation states: (i) the

chromic species (Cr<sup>3+</sup>), and (ii) the chromate species (Cr(VI)). The chromate species is considered to be the more mobile and toxic Cr species (Bartlett and Kimble, 1976). Appreciable research involving soil Cr has been conducted on soil Cr contamination because of its relatively common occurrence and its human health consequences (Ainsworth et al., 1989; Bartlett and Kimble, 1976; James and Bartlett, 1983; Zachara et al., 1988 and 1989). Aide and Tibbs (1987) reported on Cr contamination at Malden, Missouri, where sandy soils contained up to 5000 ppm Cr and was deemed a threat to the local community. Subsequently, Aide (1994), using XANES spectroscopy, showed that the Cr was almost completely composed as Cr(OH)<sub>3</sub> and its future migratory potential is low.

Employing kaolinite as a substrate, Zachara and others (1988) observed that CrO<sub>4</sub><sup>=</sup> protonation was an important reaction affecting chromate adsorption, especially at lower pH intervals where Cr adsorption was observed to be greater. Using Al-substituted Fe-oxides, Ainsworth and others (1989) proposed that chromate adsorption was influenced by background electrolyte surface reactions and surface ionization reactions. Subsequently, Zachara and others (1989) observed that chromate adsorption increased in acidic media, especially if kaolinite or crystalline Fe-oxides were present. Using a kinetic approach, Makami and others (1983) proposed two chromium complexation products at an Al-oxide interface: =AlOH<sub>2</sub>-HCrO<sub>4</sub> and =AlOH<sub>2</sub>-CrO<sub>4</sub>, where =AlOH is the surface site. Subsequently, Honeyman (1984), Zachara and others (1988, 1989) and Ainsworth and others (1989) each proposed =AlOH<sub>2</sub>-HCrO<sub>4</sub> and =AlOH<sub>2</sub>-CrO<sub>4</sub> as the surface complexation products for various Al oxide surfaces.

Interest is growing in quantitatively assessing competitive anion adsorption on phyllosilicate minerals and oxyhydroxides (Goldberg and Traina, 1987; Davis and Leckie, 1980; Zachara and others, 1988 and 1989).

Using kaolinite and goethite-hematite containing soils, Zachara and others (1988, 1989) confirmed that chromate adsorption was not affected because of competition with  $\text{SO}_4^{2-}$  adsorption, suggesting the chromate and  $\text{SO}_4^{2-}$  are competing for different surface sites. In their studies, chromate adsorption was dramatically reduced by an increase in the suspension's ionic strength, suggesting that the chromate - substrate bonding constituted an outer-sphere complex. Aide and Cummings (1997) showed that chromate adsorption on boehmite was outer-sphere and pH dependent, with Cr adsorption increasing in the order: pH 4.0 > pH 4.5 > pH 5.0 > pH 6.0. These authors showed that low P concentrations did not inhibit Cr adsorption; however, at higher P concentrations Cr adsorption was reduced, suggesting that a specific degree of surface saturation by the competing anion was necessary to effectively inhibit Cr adsorption.

Presently, a significant need exists for laboratory data involving chromate adsorption on a variety of mineral surfaces where the external conditions of pH, ionic strength, oxidation-reduction potential, and temperature are closely monitored. Such data can form the basis to describe the migratory potential of soil chromate and to predict if chromate contamination poses a health risk. The primary purpose of this investigation was to describe the effects of pH and P on chromate adsorption on a reference smectite and a smectite having hydroxy-Al interlayers (HIS).

## Materials and Methods

### Preparation of a Synthetic Smectite

A reference smectite was used because the smectite could be easily extracted and it was relatively free of iron oxide and organic matter coatings. Soil clays from Missouri are always mixtures of specific clay minerals and contain appreciable quantities of Fe oxide and organic matter. Thus, a reference clay was used to provide a "clean" system so that fewer assumptions would be involved in the data analysis. The smectite is a bentonite obtained from the Amory Mine operated by the American Colloid Company. The clay fraction (less than 2  $\mu\text{m}$ ) was separated by centrifuge fractionation after Na saturation and carbonate, organic matter and Fe-oxide removal (Kunze and Dixon, 1986). Smectite stock suspensions were prepared having exactly 5% smectite dispersed in distilled water. X-ray diffraction

was performed to authenticate the presence of smectite.

### Preparation of hydroxy-Al interlayered smectites (HIS)

Al-clay suspensions were prepared by the slow addition of 0.01 mole  $\text{NaOH} \cdot \text{l}^{-1}$  to  $\text{Al}(\text{NO}_3)_3$  in the presence of smectite. Specifically, known volumes of 0.01 mole  $\text{Al}(\text{NO}_3)_3 \cdot \text{l}^{-1}$  stock solution (pH 3.0) were slowly added to 2.5 g of smectite as a suspension. Total Al additions were equal to either 0 or 100% of the suspension's capacity for cation exchange. The pH levels were immediately adjusted to 4.0, 4.5, 5.0, 6.0 or 7.0 with additions of either 0.1 mole  $\text{HNO}_3 \cdot \text{l}^{-1}$  or 0.1 mole  $\text{KOH} \cdot \text{l}^{-1}$  at a rate of approximately  $5\mu\text{L s}^{-1}$ . Subsequent pH readjustments were at 40 and 100 hr. A few drops of Toluene were added as a microbial suppressant.

The aging period for the Al-treated smectite suspension was approximately 2 months. All suspensions were diluted to 1% (w/w) and the ionic strength adjusted to 0.05 mole  $\cdot \text{l}^{-1}$  using 1 mole  $\text{KNO}_3 \cdot \text{l}^{-1}$ . The Al-treated suspensions were routinely monitored for mole  $\text{KCl} \cdot \text{l}^{-1}$  exchangeable Al, Al solubility, pH, and cation exchange capacity by Mg saturation (Carter, 1993).

### Preparation of Chromate Adsorption Isotherms

Chromate equilibrating solutions were prepared, using reagent grade  $\text{K}_2\text{Cr}_2\text{O}_7$ , in concentrations of 0, 0.02, 0.04, 0.08, 0.12, 0.15, and 0.20 mmole chromate  $\cdot \text{l}^{-1}$  and buffered to the following pH levels: 4.0, 4.5, 5.0, 6.0, and 7.0 with either 0.01 mole  $\text{HCl}$  or  $\text{KOH} \cdot \text{l}^{-1}$ . To test the effect of phosphorus as a competing anion, a second set of Cr-bearing solutions were prepared having a concentration of 0 or 0.25 mmole  $\text{P} \cdot \text{l}^{-1}$  using  $\text{K}_2\text{HPO}_4$ . The ionic strength of all solutions was 0.05 mole  $\cdot \text{l}^{-1}$  using  $\text{KNO}_3$ .

Chromate isotherms were prepared using a batch technique. A predetermined amount of clay suspension was added to weighed screw-capped vials to provide 0.1 g smectite. The vials were centrifuged, decanted and re-weighed to determine the volume of residual solution. Chromate bearing solutions were transferred and the vials again weighed to determine the amount of

equilibrating solution, approximately 0.01 l. The equilibration period was three days. Separate samples were assessed at longer time intervals and no significant chromate concentration differences were observed. Chromate analysis was by the s-diphenylcarbazide method (Bartlett and Kimble, 1976) and the Cr adsorption was calculated using the initial and equilibrium solution concentrations and the total suspension volume. Phosphorus concentrations were analyzed using the Murphy and Riley molybdenum blue method (1962).

The Cr isotherms were described by linear regression after a natural logarithm transformation of the independent variable and assessed for significant difference (Neter and Wasserman, 1974). The U.S. Environmental Protection Agency's software package MINTEQA2 (Allison, 1991) was used to simulate Cr(VI) speciation.

## Results and Discussion

### Chromate isotherms

The adsorption isotherms (Fig. 1) show a dramatic pH dependency. For both untreated smectite and HIS, Cr adsorption is greatest at pH 4.0 and decreases steadily as the pH increases from 4.0 to 5.0 (Fig. 1 and 2). Chromate isotherms prepared at pH 6 and 7 are experimentally equivalent and show little to no Cr adsorption (Data not shown). Chromate adsorption in the presence of HIS was greater than equivalent comparisons to untreated smectite (Fig. 2). As an example, at a Cr concentration of  $60 \mu\text{mole} \cdot \text{l}^{-1}$ , Cr adsorption at pH 4.0 for untreated smectite has a Cr adsorption of approximately  $10 \text{ mmole Cr} \cdot \text{l}^{-1}$ , whereas HIS has a Cr adsorption of approximately  $12 \text{ mmole Cr} \cdot \text{l}^{-1}$ .

### MINTEQA2 Simulation of Cr(VI) Speciation.

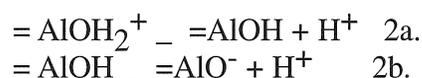
MINTEQA2 simulation of Cr(VI) speciation, with inclusion of the ion pair  $\text{KCrO}_4^-$  and adjusted to an ionic strength of  $0.05 \text{ mole} \cdot \text{l}^{-1}$ , reveals that  $\text{HCrO}_4^-$  is the dominant species in acidic media, with  $\text{HCrO}_4^-$  and  $\text{CrO}_4^{2-}$  having approximately equal concentrations at pH 6.5. A similar result may be obtained by using Baes and Mesmer's (1976) thermodynamic data, where the pH dependent concentration of  $\text{HCrO}_4^-$  in dilute solutions may be approximated as:

$$\text{Total Cr} = [\text{HCrO}_4^-] \left\{ 1 + 10^{-6.51}/[\text{H}] \right\} \quad 1.$$

Equation #1 predicts that the  $\text{HCrO}_4^-$  and  $\text{CrO}_4^{2-}$  species are present in equivalent concentrations at pH 6.5 and  $\text{HCrO}_4^-$  becomes increasingly abundant at lower pH levels. Chromate adsorption isotherms show an enhanced adsorptivity in acidic media, suggesting that the presence of the  $\text{HCrO}_4^-$  species favors the formation of the Cr - clay complex.

### The Charge Distribution of the Smectite and HIS

Protonation of Al sites may be described as:



where  $= \text{AlOH}_2^+$ ,  $= \text{AlOH}$  and  $= \text{AlO}^-$  are surface sites. Using a log  $K$  value of -6.3 (Table 1) for equation 2a shows that the majority of the surface sites should be extensively protonated at pH levels more acidic than pH 6. Thus the Al-sites of the smectite surface should be extensively protonated in the pH interval where significant Cr adsorption differences are evident. HIS has a greater reservoir of Al sites than the untreated smectite and should provide a greater Cr adsorptivity. Thus Cr(VI) adsorption on HIS involves the pH-dependent speciation of  $\text{HCrO}_4^-$  in the aqueous phase and the protonation of Al-sites on smectite and HIS.

### Chromate Isotherms in the Presence of Phosphorus

Chromate isotherms, prepared with phosphorus as a competing co-solute, demonstrated slightly decreased Cr adsorptivity (Fig. 3 and 4). Chromate isotherms, at each pH level, show that P suppresses Cr adsorption, with slightly greater Cr suppression at the highest phosphorus concentrations. Phosphorus is commonly recognized as having a strong affinity for oxyhydroxide surfaces (Aide and Cummings, 1997). Acid dissociation constants for P (Table 1) suggest that the  $\text{H}_2\text{PO}_4^-$  anion is the dominant species in the pH interval 4.0 to 6. Thus  $\text{H}_2\text{PO}_4^-$  and  $\text{HCrO}_4^-$  appear to compete for similar surface sites; however, the extent of anion competition between untreated smectite and HIS is insignificant. The lack of differential competitive differences suggests that Cr adsorption is not dramatically affected by the blocking of adsorption sites by P. Rather, the Cr adsorption differences are attributed more to incremental changes in the activity coefficients of the charged surface complexes or to a

surplus of available surface sites. These findings are similar to those of Zachara and others (1988 and 1989) and Aide and Cummings (1997).

### Conclusions

Chromate adsorption on untreated smectite and HIS is pH dependent, with more acidic pH levels being favorable for chromate adsorption. Phosphorus did not dramatically interfere with chromate adsorption, because the systems adsorptive capacity was not exceeded. It is proposed that  $\text{HCrO}_4^-$  interacts with  $=\text{AlOH}_2^+$  to form  $=\text{AlOH}_2\text{-HCrO}_4$  as the surface complex. The strength of the complex appears to be an outer-sphere complex because of the ease of Cr displacement when the system is swamped with a competing species.

### Literature Cited

- Aide, M.T. 1994. Using XANES spectroscopy to determine the oxidation state of chromium in contaminated soil. *Trans. Missouri Acad. Sci.* 27:13-18.
- Aide, M.T., and M. Cummings. 1997. The influence of pH and phosphorus on the adsorption of chromium(VI) on boehmite. *Soil Sci.* 162:599-603.
- Aide, M.T., and N. Tibbs. 1987. Chromium in a sandy soil contaminated by aluminum etching waste fluids. *Trans. Missouri Acad. Sci.* 22:62-65.
- Ainsworth, C.C., D.C. Girvin, J.M. Zachara, and S.C. Smith. 1989. Chromate adsorption on goethite: Effects of aluminum substitution. *Soil Sci. Soc. Am. J.* 53:411-418.
- Allison, J.D., D.S. Brown, and K.J. Novo-Gradac. 1991. Miteqa2/Prodefa2, A geochemical assessment model for environmental systems: version 3.0. Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency. Athens, Georgia.
- Baes, C.F., and R.E. Mesmer. 1976. *The hydrolysis of cations.* John Wiley and Sons. NY.
- Bartlett, R. and J.M. Kimble. 1976. Behavior of chromium in soils: II. Hexavalent forms. *J. Environ. Qual.* 5:383-386.
- Carter, M.R. 1993. *Soil sampling and methods of analysis.* Canadian Soc. Soil Sci. Lewis Publ., Boca Raton, Fl.
- Cambier, P., and G. Sposito. 1991. Adsorption of citric acid by synthetic pseudoboehmite. *Clays Clay Mineral.* 39:369-374.
- Davis, J.A., and J.O. Leckie. 1980. Surface ionization and complexation at the oxide/water interface. 3. Adsorption of anions. *J. Colloid and Interface Sci.* 74:32-42.
- Goldberg, S., and S.J. Traina. 1987. Chemical modeling of anion competition on oxides using the constant capacitance model-mixed-ligand approach. *Soil Sci. Soc. Am J.* 51:929-932.
- Honeyman, B.D. 1984. Cation and anion adsorption at the oxide/solution interface in systems containing binary mixtures of adsorbents: An investigation of the concept of adsorptive additivity. Ph.D. diss. Stanford Univ., Stanford, CA (Diss. Abstr. 84-20552).
- James, B.R., and R.J. Bartlett. 1983. Behavior of chromium in soils: VII. Adsorption and reduction of hexavalent forms. *J. Environ. Qual.* 12:177-181.
- Kunze, G.W., and J.B. Dixon. 1986. Pretreatment for mineralogical analysis. In A. Klute (ed). *Methods of soil analysis. Part 1. Physical and mineralogical methods.* P. 91-100. *Soil Sci. Soc. Am Book Series, no 5.* Soil Sci. Soc. Am., Madison, WI.
- Mikami, N., M. Sasaki, T. Kikuchi, and T. Yasunaga. 1983. Kinetics of adsorption-desorption of chromate on  $\text{Al}_2\text{O}_3$  surfaces using the pressure-jump technique. *J. Phys. Chem.* 87:5245-5248.
- Murphy, J., and J.P. Riley. 1962. A modified single solution method for the determination of phosphate in natural waters. *Anal. Chim. Acta.* 27:31-36.
- Neter, J., and W. Wasserman. 1974. *Applied linear statistical models.* Richard D. Irwin, Inc., Homewood, Il.
- Stumm, W., R. Kummert, and L. Sigg. 1980. A ligand exchange model for the adsorption of inorganic and organic ligands at hydrous oxide interfaces. *Croat. Chem. Acta.* 53:291-312.

Stumm, W., and J.J. Morgan. 1981. Aquatic chemistry: An introduction emphasizing chemical equilibria. in natural waters. John Wiley and Sons. NY.

Zachara, J.M., C.E. Cowan, R.L. Schmidt, and C.D. Ainsworth. 1988. Chromate adsorption by Kaolinite. Clays and Clay Minerals 36:317-326.

Zachara, J.M., C.C. Ainsworth, C.E. Cowen , and C.T. Resch. 1989. Adsorption of chromate by subsurface soil horizons. Soil Sci. Soc. Am. J. 53:418-428.

**Table 1. Reported dissociation and surface complexation constants.**

<u>Reaction</u>	<u>log K</u>
$=\text{AlOH}_2^+ \rightleftharpoons \text{AlOH} + \text{H}^+$	-7.4 Stuum et al., 1980 -8.2 Cambier et al., 1991 -6.3 Ainsworth et al., 1989
$=\text{AlOH} \rightleftharpoons \text{AlO}^- + \text{H}^+$	-10.0 Stuum et al., 1980 -10.4 Cambier et al., 1991 -12.0 Ainsworth et al., 1989
$\text{H}_3\text{PO}_4 \rightleftharpoons \text{H}_2\text{PO}_4^- + \text{H}^+$	-2.2 Stuum et al., 1981
$\text{H}_2\text{PO}_4^- \rightleftharpoons \text{HPO}_4^{2-} + \text{H}^+$	-7.2 Stuum et al., 1981
$=\text{AlOH} + \text{CrO}_4^{2-} + \text{H}^+ \rightleftharpoons [\text{AlOH}_2^+ - \text{CrO}_4^{2-}]$	+11.3 Ainsworth et al., 1989
$=\text{AlOH} + \text{CrO}_4^{2-} + 2\text{H}^+ \rightleftharpoons [\text{AlOH}_2^+ - \text{HCrO}_4^-]^0$	+18.1 Ainsworth et al., 1989

where  $=\text{AlO}^-$ ,  $=\text{AlOH}$ , and  $=\text{AlOH}_2^+$  are surface sites

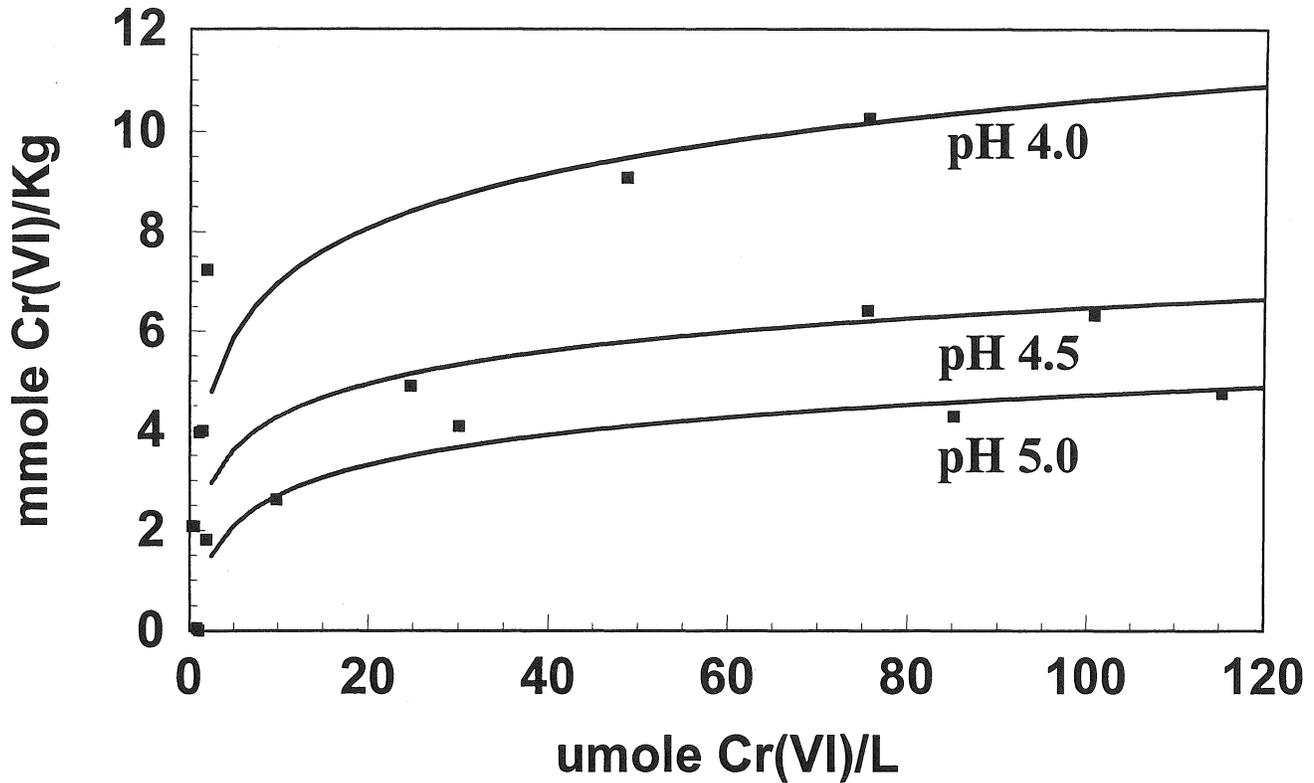


Figure 1. Cr(VI) Adsorption on 0% Hydroxy-Al Interlayered Smectites

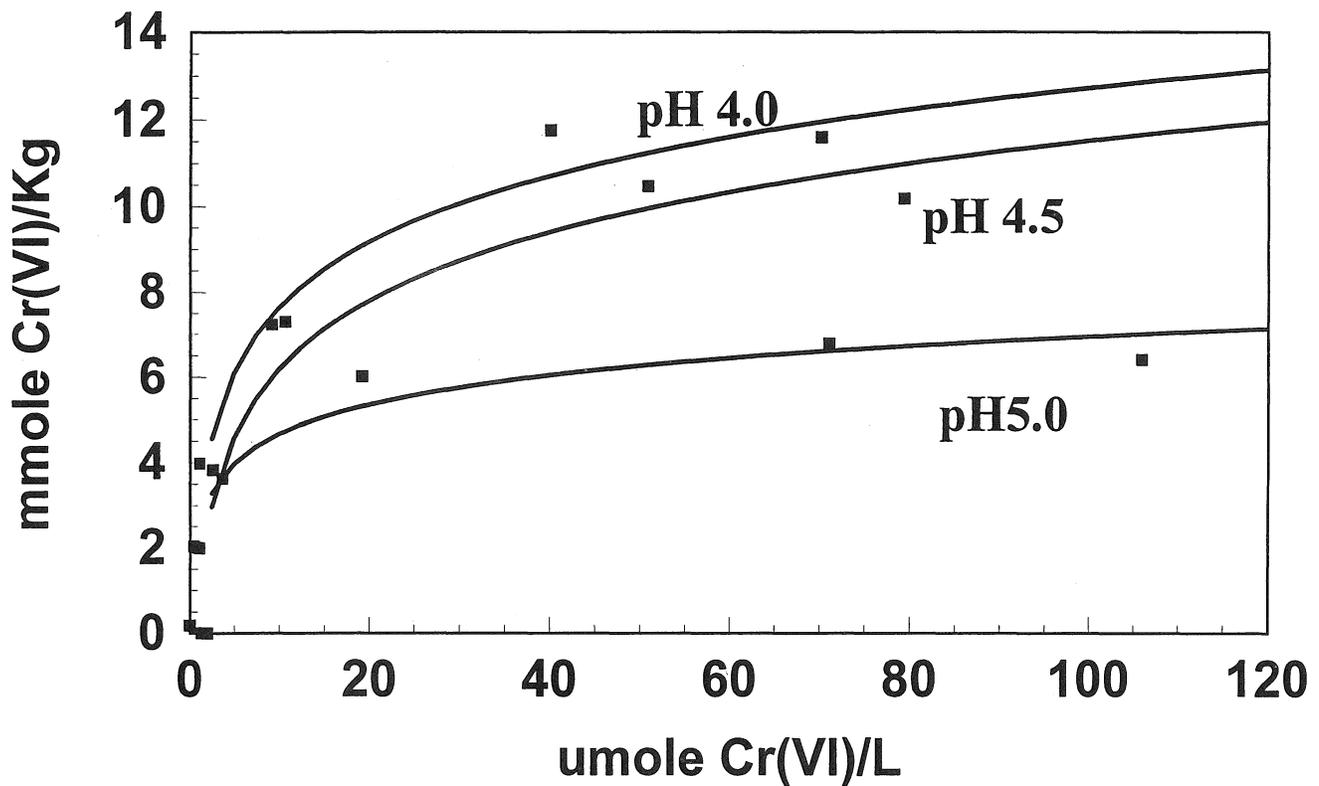


Figure 2. Cr(VI) Adsorption on 100% Hydroxy-Al Interlayered Smectites.

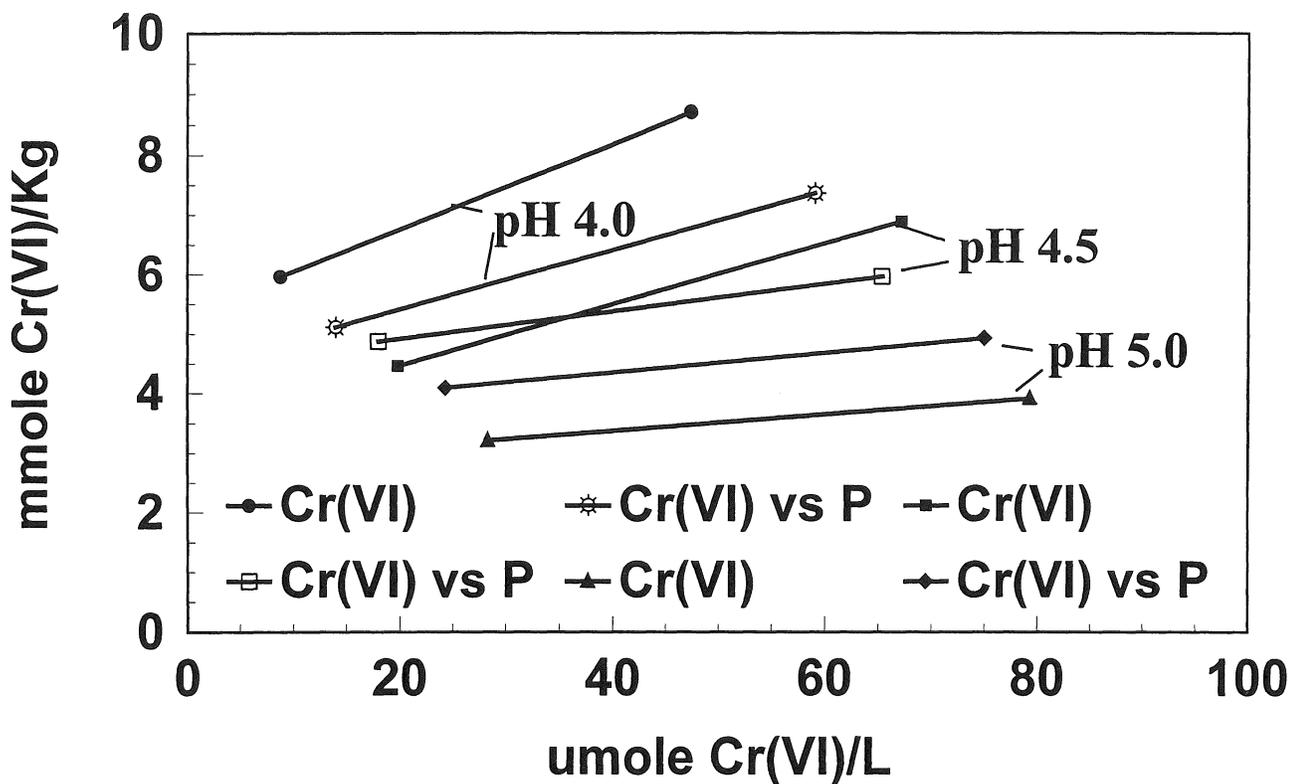


Figure 3. Adsorption on 0% Hydroxy-Aluminum Interlayered Smectites at pH Levels 4.0, 4.5, and 5.0 and the presence of P.

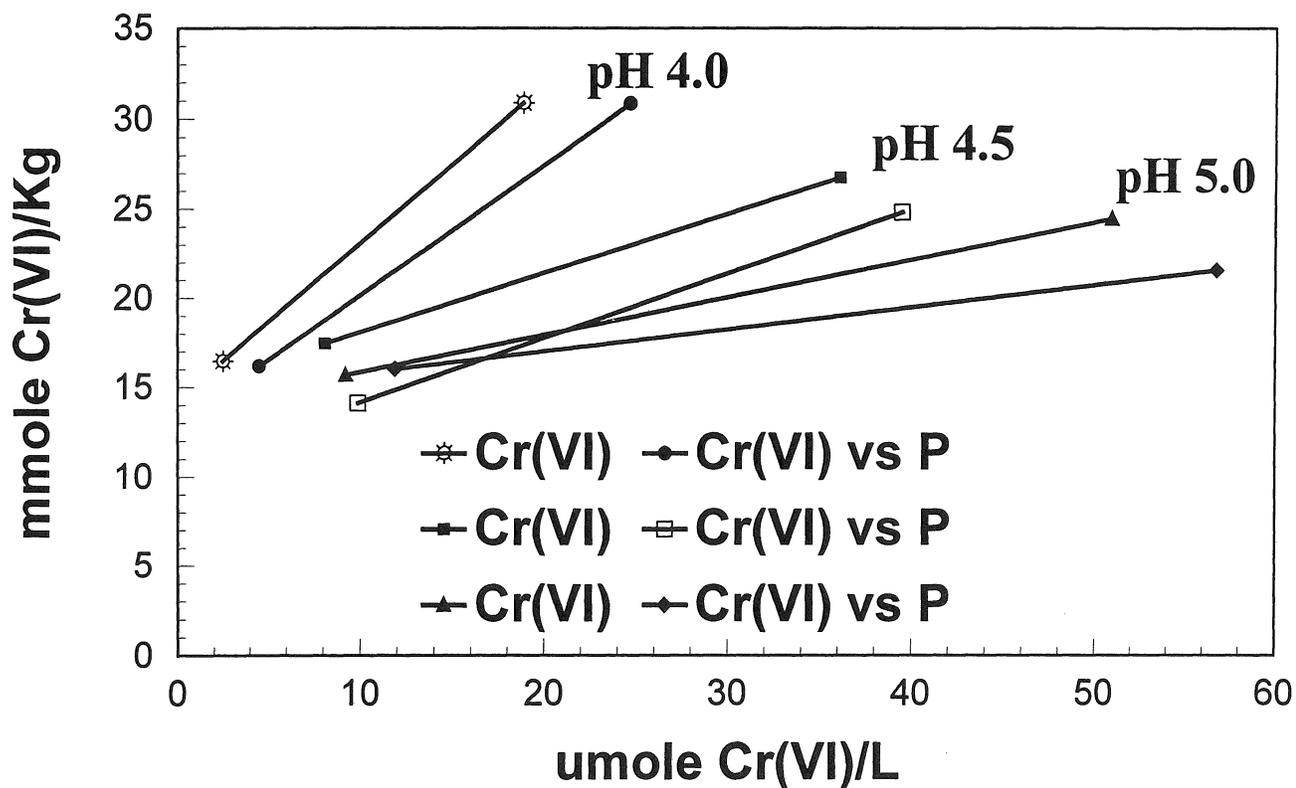


Figure 4. Adsorption on Hydroxy-Aluminum Interlayered Smectites at pH Levels 4.0, 4.5, and 5.0 and the presence of P



# Valley Anticline Associated with the Warrensburg Sandstone in Missouri

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**Abstract:** The Warrensburg Sandstone, a Pennsylvanian alluvial valley-fill in Johnson County, Missouri, lies with angular unconformity on Desmoinesian Pennsylvanian marine strata comprised mainly of shales and thin limestones. These Desmoinesian shales and limestones generally dip away from the valley center, creating a valley anticline beneath the unconformity. Structural relationships reveal that the valley anticline formed contemporaneously with the incision of the deep valley in which the Warrensburg Sandstone was deposited. The structure formed primarily by toward-the-valley slumping of the valley walls. In addition, flow of Desmoinesian shales toward the valley as pressure was relieved by valley incision may have also contributed to the development of the valley anticline.

**Key Words:** valley anticline, Warrensburg Sandstone, Pennsylvanian, Desmoinesian Series, Cherokee Group, slumping, channel sandstone, valley incision.

## Introduction

In the Warrensburg, MO area, U.S. Highway 50 exposes a two mile wide cross-section of the north-south trending Pennsylvanian Warrensburg Sandstone as well as dipping layers of the older Marmaton limestones and shales on both the east and west margins of the sandstone body. These Marmaton Group strata along both edges of the Warrensburg Sandstone dip about 25-30 degrees away from the sandstone body on both sides, giving the impression that the sandstone was deposited along the axis of an eroded anticline (Emerson, 1975; Beall, 1975; Emerson and Nold, 1981; Nold and Emerson, 1989). This relationship extends for at least 10 km to the north and 20 km to the south of Warrensburg (Figure 1). More importantly,

where Cenozoic erosion along the Blackwater River and its tributaries has cut through the bottom of the Warrensburg Sandstone, the same anticlinal dips are observed in the Desmoinesian rocks beneath the channel (Figures 2 and 3). Furthermore, where the Warrensburg Sandstone bifurcates south of Warrensburg, there is a valley anticline present along both branches (Figure 1). The coincidence between the branches of the Warrensburg Sandstone and the valley anticlines implies some relationship between the two.

In contrast, the regional structure in Johnson County is dominated by northwest and northeast trending faults and folds (McCracken, 1971). Structure contour maps of Ordovician and Mississippian rocks in the subsurface of Johnson County, based on dozens of well logs, show the northwest-southeast strike. The valley anticline in the Desmoinesian rocks beneath the Warrensburg Sandstone bears no relationship to regional structures.

## Stratigraphic Setting

The Warrensburg Sandstone is a north-south trending Pennsylvanian alluvial valley-fill which crops out for more than 80 kilometers in Lafayette, Johnson, and Henry Counties, Missouri (Figure 1 and Emerson, 1979). The present maximum thickness of the Warrensburg Sandstone is about 100 feet based on missile site cores. The original thickness is unknown as the Warrensburg is the youngest formation exposed in the outcrop area. The Warrensburg Sandstone has been assigned to the Pleasanton Group, Missourian Series, by the Missouri Geological Survey (Howe and Koenig, 1961; Thompson, 1995). The Warrensburg Sandstone lies with angular unconformity upon cyclothemic rock units belonging to the Desmoinesian Series (Figures 3 and 4). The lower portion of the

Desmoinesian, the Cherokee Group, consists mainly of shales, claystones, coals, and thin sandstones, the total thickness of the Group ranging from 200 to 300 feet thick within the region. The overlying Marmaton Group has a maximum thickness of 100 feet and is composed mainly of shales and thin limestones.

The above thickness of the Desmoinesian rocks is taken from water well logs and missile site cores. Both Groups are poorly exposed due to soil development and vegetative cover. Outcrops in Lafayette County and northern Johnson County are further obscured by a mantle of glacial deposits.

### **The Post Oak Creek Cross-section at Old Highway 13 North**

Figure 3 is a structural cross-section along Post Oak Creek showing the angular unconformity between the horizontal Warrensburg Sandstone and an excellent section of underlying dipping Desmoinesian Series sedimentary rocks. On Figure 1 the section is exposed about two miles north of Warrensburg where Post Oak Creek has downcut through the Warrensburg Sandstone. The section is 400 feet in length and, except for rocks covered by 44 feet of bridge abutment, has nearly continuous exposure. The section is shown with west on the right and east on the left because it is exposed on the south side of Post Oak Creek and is observed while facing toward the south. The dip angle of the tilted rocks averages about 30 degrees on the west end of the section and gradually changes to approximately 60 degrees on the east end of the section. The tilted Desmoinesian rocks are a series of shales, claystones, sandstones, coals, and limestones. No attempt has been made to divide these rocks into individual Formations because when the Pennsylvanian cyclothemic sedimentary rocks are structurally deformed and not in their normal stratigraphic order, identification is nearly impossible. We are certain that the tilted rocks are mostly Marmaton Group, with perhaps some underlying Cherokee Group rocks present as well.

Two normal faults are present within the tilted Desmoinesian Series rocks, the west fault being at 45 feet and the east fault at 300 feet on the 400 foot section (Figure 3). The west fault strikes north and dips about 60 degrees west and drag of beds on both sides definitely show it to be west side down, east side up.

The east fault strikes a little west of north and has a vertical dip; no dragged beds are observed and the fault is inferred to have the same type of displacement as the one on the west, that is west side down, east side up. Adjacent to the east fault is a small fault that displaces coal and shale (Figure 3). The two normal faults are inferred to divide this section into three slump blocks which are present in this portion of the east side of the valley anticline.

Inferences about the amount of displacement of the two normal faults are of considerable interest. First, the west fault. If the sequence coal, shale, sandstone that is exposed between zero and 30 feet is the same sequence, repeated by the west fault, as that exposed from 153-183 feet (Figure 3), then the stratigraphic separation and the slip of the fault would be approximately 80 feet. Estimating the amount of movement of the east fault is more tenuous. If we are correct in our inference that the fault is west side down, then a minimum of about 140 feet of stratigraphic separation would be required in order for the three limestones in the east fault block not to be exposed in the central fault block.

The three limestone units in the east block are in themselves a stratigraphic problem. We suspect them to be Marmaton Group limestones but three limestones should not be present so close together within the Group. Perhaps there is faulting which is not exposed that is present between some of the limestones.

### **Similar Midwestern Structures**

Hinds (1912), and Hinds and Greene (1915) mentioned several localities in east-central Missouri where the Moberly channel sandstone (Missourian Series) overlies dipping Cherokee Group and Marmaton Group rocks. Both Jackimovicz (1970) and Gentile (1976) found channel sandstones overlying tilted Marmaton limestones in Bates County, western Missouri. Unklesbay (1952) commented on a channel sandstone unconformable on a tilted Marmaton limestone in Boone County. The present authors did field work on the Moberly Sandstone and found that outcrops in that area, in comparison to the Warrensburg area, were extremely poor. In addition, several specific localities were visited that were described by Hinds (1912) and Hinds and Greene

(1915), and it was found that the outcrops no longer existed.

In nearby eastern Kansas, dipping strata have been noted along the margin of the valley-fill Ireland Sandstone (Pennsylvanian System, Virgilian Series). In Franklin County, steeply dipping Robbins Shale is found below the Ireland Sandstone (Ball et al., 1963). O'Connor (1960) found undisturbed beds of Ireland Sandstone overlying steeply dipping Weston Shale and Stranger Formation in Douglas County.

Simmons (1966) describes valley anticlines formed during the Recent within Ordovician limestones and shales in central Kentucky.

### **Utah Valley Anticlines**

Huntoon (1982) discussed anticlinal river valleys in Utah. The Meander anticline in Utah, has its axial trace along the Colorado River for 41 km and on the southeast side of the river, eight tributary canyons also contain valley anticlines. Dips on the limbs of these anticlines range from a few degrees to more than 30 degrees. The rims of the canyons are tilted away from the river as much as a mile from the axis. These canyons are eroded to a depth between 122 and 548 m into Permo-Pennsylvanian sedimentary rocks.

Harrison (1927), Shoemaker (1973), and Huntoon (1982) considered the Meander anticline an unloading feature and both Harrison (1927) and Huntoon (1982) believed that the Meander anticline is still growing. The mechanisms proposed for the origin of these features include salt flowage, salt solution, and brittle plate gliding.

### **Deformation Due to Valley Incision - Examples from Civil Engineering**

The terms stress release, rebound, unloading, shale flow, and bulging have all been used by civil engineers and engineering geologists to describe the formation of upraised valley floors and tilted valley margin rocks developed after stream incision or after excavation. One of the earlier references to the formation of valley margin anticlines and valley axis bulges is by Hollingworth et al. (1944). This study of the Middle Jurassic age Northampton Ironstone Field in England found that upward movement of valley floors, composed of Upper Lias clay, caused high dips on

rocks of the valley margin. Steep dips on valley side limestones are shown in cross sections (Figure 5), with dips from 10 degrees up to 80 degrees found in one valley for more than a kilometer. Contorted valley floor clays and marginal limestones which dip away from the axis are confined to valleys. Cross sections of Lias clay exposed in dam trench excavations for large reservoirs show highly contorted and thrust faulted layers.

Lydekker (1883) stated that broken, contorted, and steeply dipping strata adjacent to the valley bottom have been recognized in England.

Valley floor rebound due to stream incision in Tertiary and Cretaceous siltstones, clay shales, and sandstones of the Great Plains of Canada and the western United States is well documented in engineering literature concerning damsite investigations. These valley anticlines have been studied by several investigators (Crandell, 1958; Peterson, 1958; Matheson, 1972; Matheson and Thompson, 1973). Similar structures in Romania were described by Zaruba (1956). All described raised, tilted valley rims and contorted valley floor rocks. Ferguson (1967) found that in the Allegheny Plateau, that the valley bottoms were deformed by arching and thrust faulting, apparently caused by stress release during valley incision.

Nichols (1980) reviewed the literature concerning valley-floor expansion in terrains composed of clay, clay shale, and shales interbedded with limestones and dolomites. These studies from the United States, Canada, and western Europe indicated that unloading response begins at the time of incision and is continuous over long periods of time. Long-term valley floor uplift may be up to ten percent of valley depth. Rebound of .01 m (.04 ft) per year has been measured at Fort Peck Dam, Montana, since 1937 (Matheson and Thompson, 1973).

Unloading response can be rapid in both competent and incompetent rocks. Legett (1973) described a newly excavated limestone quarry floor in St. Louis County, Missouri, which overnight developed a ridge 60 cm high and 90 m long. Hollingworth et al. (1944) noted that Sir Malcolm Watson visited the Panama Canal in 1913 and observed bulging in the floor of the Culebra Cut. At one place a steam shovel working the Cut had been raised and tilted so that it fell over.

### **Incision of the Warrensburg Valley and Formation of the Valley Anticline**

The Warrensburg Sandstone has a maximum present day thickness of 100 feet as shown by missile site cores and by water well logs. The maximum thickness before surface erosion is unknown. The outcrop is 2-3 miles wide in the Warrensburg area (Figures 1 and 2). For comparison, a nearby reach of the Missouri River, with a channel of similar width, has incised its bedrock channel about 300 feet below the bluffs and presently contains more than 100 feet of Quaternary alluvium.

The deep incision of the Warrensburg valley was probably due to the rapid Carboniferous drops in sea level documented by Vail et al. (1977) and similar to valley incision caused by Early Cretaceous rapid lowering of sea level (Weimer, 1982). Heckel (1986) presented a Late Pennsylvanian glacial-eustatic sea level curve for the midcontinent. A major sea level drop at the Desmoinesian-Missourian boundary correlates well with the time of incision of the Warrensburg valley. The only known fossil age assignment was obtained from a thin coal in the basal conglomerate of the Warrensburg Sandstone collected by Emerson (1988). An age assignment of latest Desmoinesian by Palindex International for the basal Warrensburg fits well with the observed stratigraphy.

The very coarse boulder conglomerate derived from erosion of the Marmaton Group limestone beds and contained in the basal Warrensburg Sandstone in Johnson and Henry Counties is evidence of steep valley sides and of mass movement to introduce this material as channel lag deposits (Emerson, 1975, 1977).

The incision of the valley in which the Warrensburg Sandstone was deposited apparently allowed the development of the valley anticlinal structure. Two possible mechanisms for development of this structure are suggested. The first method is slumping of large blocks of steep valley sides. Bristol and Howard (1974) studied the sub-Pennsylvanian unconformity in the Illinois Basin. A Late Mississippian (Upper Chesterian Series) sea level drop (Vail et al., 1977) recognized in the Illinois Basin and southern Appalachians, caused entrenchment of a system of valleys in the Chesterian marine limestones and shales followed by alluvial valley-fill of Pennsylvanian Caseyville Formation clastics. Electric logs and

cross-sections from drill holes show great slump blocks of Chesterian strata arranged en echelon along the sides of the valley bottoms (Figure 6). Each block has rotated along the curved plane of a listric normal fault, so that the dip of the displaced strata is away from the valley axis. The slump blocks range from 10 to 125 feet in thickness and the maximum vertical displacement is 200 feet. Individual blocks are several hundred to 3000 feet long and up to several hundred feet wide. The northward advance of the Pennsylvanian sea across the area caused the streams that had been actively downcutting to begin aggrading and filling their valleys with the Caseyville alluvial sediments.

We believe that the rapid sea level drop (Heckel, 1986) at the end of Pennsylvanian Desmoinesian time caused the incision of the Warrensburg valley system and slumping of blocks of Marmaton (Upper Desmoinesian) limestones and shales along the valley sides. Subsequent sea level rise and alluviation during Missourian time deposited the Warrensburg Sandstone in this valley. Post-Paleozoic erosion of the land surface in this area has exposed the lower part of the Warrensburg valley fill sandstone underlain and flanked by the tilted slump blocks. The slump blocks tilted backwards as they moved downward into the valley giving the appearance of an anticline caused by structural deformation.

Figure 7 is an interpretive cross-section showing the Warrensburg river valley and the Warrensburg Sandstone during Pennsylvanian time. Also shown are the rotated slump blocks which have caused the tilting of the bedding away from the channel axis resulting in the valley anticlinal structure. This mechanism also explains the apparently excessive stratigraphic thickness for the tilted Desmoinesian strata beneath and adjacent to the Warrensburg Sandstone by repetition in individual slump blocks. The Marmaton Group is the only part of the Desmoinesian Series containing distinctive limestones more than 4 feet thick. These limestones are, in ascending order, the Blackjack Creek, the Higginsville, the Myrick Station, and the Coal City. Well logs and missile site cores from the area show that these four limestones occur in no more than 70 feet of stratigraphic section (Thompson, 1995, p.104). The north-south striking belts of tilted Marmaton strata (and perhaps some underlying Cherokee Group strata) beneath and adjacent to the

sandstone body make up at least several hundred feet of stratigraphic thickness. Repetition of the 70-100 foot thick Marmaton strata is the most logical explanation for this anomalous thickness. The Post Oak Creek cross-section at old Highway 13 north (Figure 3) shows two of the faults on the east side of the valley anticline which repeat the Marmaton strata within individual slump blocks. In general, relatively poor exposures within the area have allowed the inference of other faults between the slump blocks in only a few localities.

The alternative mechanism for the development of the valley anticline is that of tilting of the strata on the valley sides from bulging due to flow of the Cherokee Group shale and claystone toward the axis of the developing valley. This flow would be due to a pressure gradient caused by valley incision. This mechanism would be similar to that suggested by Hollingsworth et al. (1944) for Jurassic strata in England (Figure 5). Though exposures are poor in the area, exposures of shale beneath the Sandstone do not show the types of internal deformation that would be expected to be present if the structure was caused principally by shale-flow. Perhaps if this mechanism was operative, it was minor in importance compared to slumping.

### Summary and Conclusions

Detailed field mapping of the structures under and adjacent to the Warrensburg Sandstone shows that the Desmoinesian strata have been deformed into a valley anticlinal structure. Analysis of our field maps and structural cross-sections indicates that the tilted Desmoinesian strata adjacent to and beneath the Sandstone have an excessive thickness that is probably due to repetition. The valley anticlinal structure and the amount of repetition can best be explained by the breaking up of the valley walls into numerous slump blocks which moved toward the axis of the valley, the resulting tilt of the bedding being caused by rotation of the blocks. In addition, a pressure gradient within the underlying Cherokee Group shale and claystone may have caused flow toward the developing valley which resulted in thickening of the shales and tilting of the valley sides away from the center.

Lastly, examination of the literature leads us to believe that valley anticlines are a widespread

phenomenon but, with a few notable exceptions, they are not well known to a majority of the geologic profession other than those involved in dam construction.

### Acknowledgments

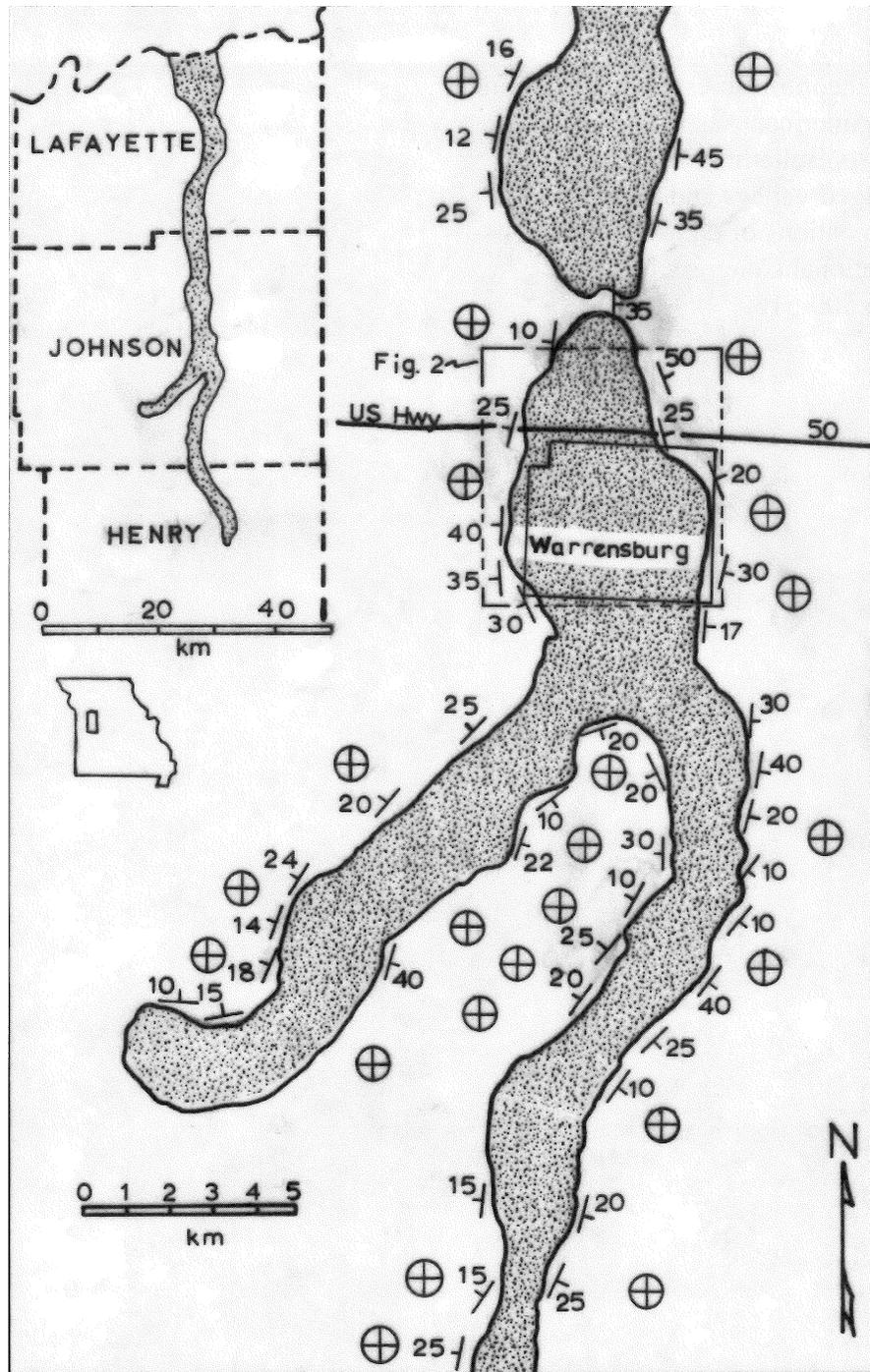
We acknowledge D. Barber and J. Beall for assistance in mapping. In addition, three anonymous reviewers made suggestions which were helpful in improving the manuscript.

### Literature Cited

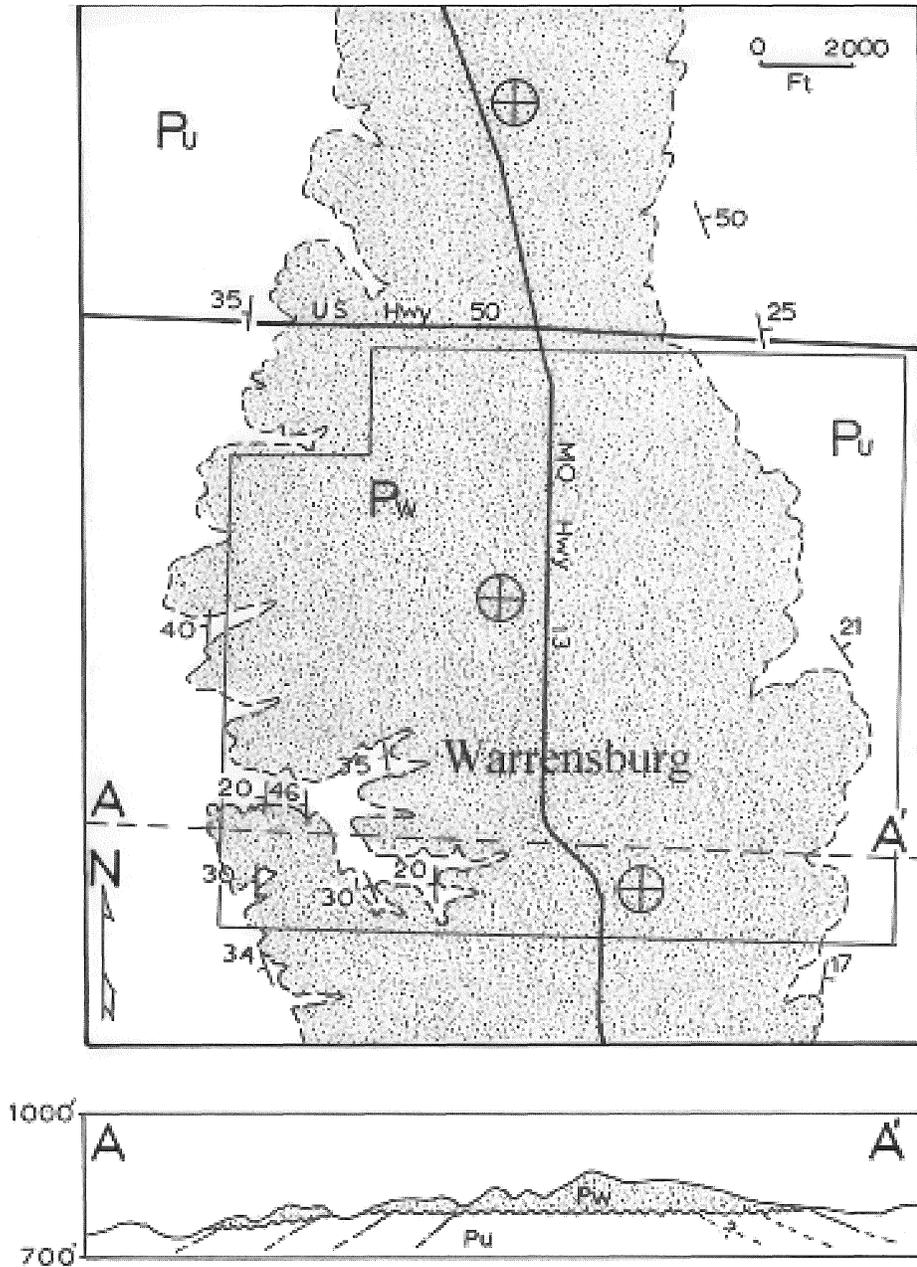
- Ball, S. M., Ball, M. M., Laughlin, D. J. 1963. Geology of Franklin County, Kansas: Kansas Geological Survey Bulletin 163, 57p.
- Beall, J. J. 1975. Deformation of Desmoinesian strata adjacent to the Warrensburg channel-fill sandstone: Association of Missouri Geologists, 22nd Annual Field Trip Guidebook, p.9-12.
- Bristol, H. M., and Howard, R. H. 1974. Sub-Pennsylvanian valleys in the Chesterian surface of the Illinois Basin and related Chesterian slump blocks, In Briggs, G., ed., Carboniferous of the Southeastern United States: Geological Society of America Special Paper 148, p.315-335.
- Crandell, D. R. 1958. Geology of the Pierre area, South Dakota: U.S. Geological Survey Professional Paper 307, 83p.
- Emerson, J. W. 1975. Warrensburg Sandstone revisited: Association of Missouri Geologists, 22nd Annual Field Trip Guidebook, p.13-25.
- \_\_\_\_\_.1977. Pennsylvanian channel sandstone nomenclature and correlation in Missouri: Abstracts with programs, Geological Society of America, v.9. p.591.
- \_\_\_\_\_.1979. Geologic Map of Missouri: Acknowledged contributor, channel sandstone mapping: Missouri Geological Survey.
- \_\_\_\_\_.1988. Unpublished data from Palindex International.
- Emerson, J. W., and Nold, J. L. 1981. The Warrensburg Sandstone: A structurally controlled channel-fill deposit: Abstracts with programs, Geological Society of America, v.13, p.277.

- Ferguson, H. F. 1967. Valley stress release in the Allegheny Plateau: *Bulletin of the Association of Engineering Geologists*, v.4, p.63-68.
- Gentile, R. J. 1976. The geology of Bates County, Missouri: Missouri Geological Survey Report of Investigations 59, 89p.
- Harrison, T. S. 1927. Colorado-Utah salt domes: *American Association of Petroleum Geologists Bulletin*, v.11, p.111-133.
- Heckel, P. H. 1986. Sea-level curve for Pennsylvanian eustatic marine transgressive-regressive depositional cycles along a midcontinent outcrop belt, North America: *Geology*, v.14, p.330-334.
- Hinds, H. 1912. The coal deposits of Missouri: *Missouri Bureau of Geology and Mines*, v.11, 2nd Series., 503p.
- Hinds, H., and Greene, F. C. 1915. The stratigraphy of the Pennsylvanian Series in Missouri: *Missouri Bureau of Geology and Mines*, v.13, 2nd Series., 407p.
- Hollingworth, S. E., Taylor, J. H., and Kellaway, G. A. 1944. Large scale superficial structures in the Northampton ironstone field: *Quarterly Journal, Geological Society of London*, v.C, p.1-44.
- Howe, W. B., and Koenig, J. W., eds. 1961. The stratigraphic succession in Missouri: *Missouri Geological Survey*, 2nd Series, v.15, 185p.
- Huntoon, P. W., 1982, The Meander anticline, Canyonlands, Utah: An unloading structure resulting from horizontal gliding on salt: *Geological Society of America Bulletin*, v.93, p.941-950.
- Jackimovicz, J. J. 1970. The petrology of two valley-fill sandstones in Western Missouri: M. A. thesis, University of Missouri, Columbia, 84p.
- Legett, R. F. 1973. *Cities and Geology*, McGraw-Hill, New York, 623p.
- Lydekker, R. 1883. *Geology of Kashmir and Chamba: Memoirs of the Geological Survey of India*, v.22.
- Matheson, D. S. 1972. Geotechnical implications of valley rebound: Ph.D. dissertation, University of Alberta, 424p.
- Matheson, D. S., and Thompson, S. 1973. Geological implications of valley rebound: *Canadian Journal of Earth Sciences*, v.10, p.961-978.
- McCracken, M. H. 1971. Structural features of Missouri: Missouri Geological Survey Report of Investigations 49, 99p.
- Nichols, T. C. 1980. Rebound--its nature and effect on engineering works: *Quarterly Journal of Engineering Geology*, v.13, p.133-152.
- Nold, J. L., and Emerson, J. W. 1989. The Warrensburg Sandstone and its subjacent anticline: A structurally-controlled deposit or a valley-controlled structure?: *Transactions of the Missouri Academy of Science*, v.23, p.90.
- O'Connor, H. G. 1960. Geology and ground-water resources of Douglas County, Kansas: *Kansas Geological Survey Bulletin* 148, 200p.
- Peterson, R. 1958. Rebound in the Bearpaw Shale, Western Canada: *Geological Society of America Bulletin*, v.69, p.1113-1122.
- Shoemaker, E. 1973. River anticlines of the Colorado: Symposium on northern Arizona geology, Museum of Northern Arizona, oral presentation.
- Simmons, G. 1966. Stream anticlines in Central Kentucky: U. S. Geological Survey Professional Paper 550-D, p.9-11.
- Thompson, T.L. 1995. The Stratigraphic Succession in Missouri: Dept. of Natural Resources, Missouri Division of Geology and Land Survey, v.40, 190p.
- Unklesbay, A. G. 1952. Geology of Boone County, Missouri: Missouri Geological Survey, 2nd Series, v.33, 139p.
- Vail, P. R., Mitchum, R. M., Jr., Thompson, S. 1977. Seismic stratigraphy and global changes of sea level, Part 4: Global cycles of relative changes of sea level: in Payton, C. E., ed., *Seismic stratigraphy -- applications to hydrocarbon exploration: American Association of Petroleum Geologists Memoir* 26, p.83-98.

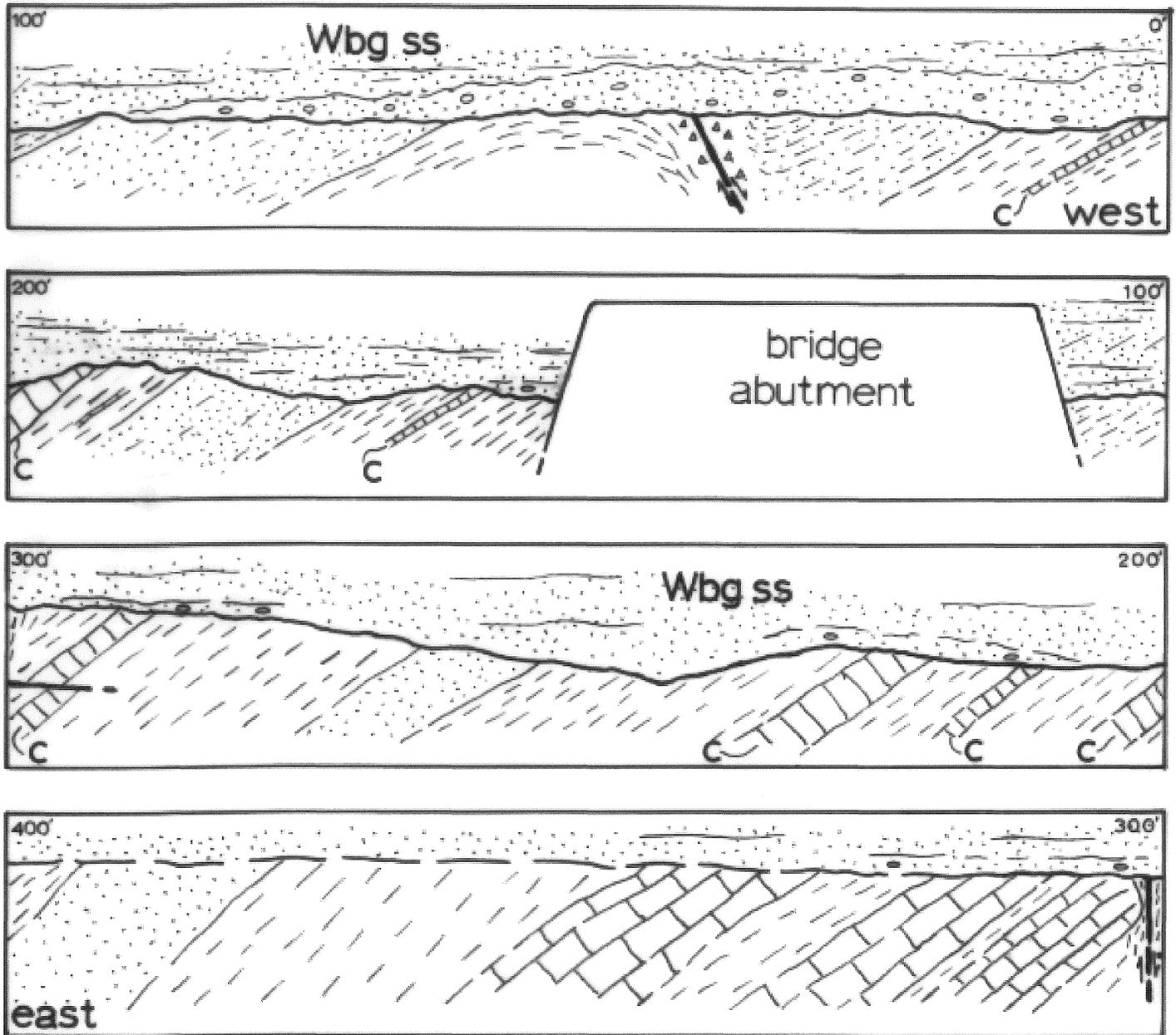
- Weimer, R. J. 1982. Sea-level changes and tectonic control of unconformities, western interior, U.S.A.: Abstracts, American Association of Petroleum Geologists Bulletin, v.66, p.642.
- Zaruba, Q. 1956. Bulged valleys and their importance for foundations of dams: Transactions of the Sixth International Congress for large dams, New York, p.509-515.



**Figure 1.** Map showing the location of the Warrensburg Sandstone in Missouri and showing the valley anticlinal structures in Desmoinesian Series cyclothemic strata adjacent to the Sandstone. The north-south trend of the valley anticline is at variance with the dominant northwest-southeast tectonic structural trend in the underlying Paleozoic carbonates.



**Figure 2.** Geologic Map showing dipping Pennsylvanian Desmoinesian rocks adjacent to and beneath the horizontal Warrensburg Sandstone (stipple). In the southwest part of the City of Warrensburg, Cenozoic erosion has cut through the Sandstone exposing dipping strata beneath. The cross-section shows the relationship of the Desmoinesian strata dipping away from the channel axis on both sides of the Sandstone. The depth to which the dipping layers extend is not known, but is not believed to be great.

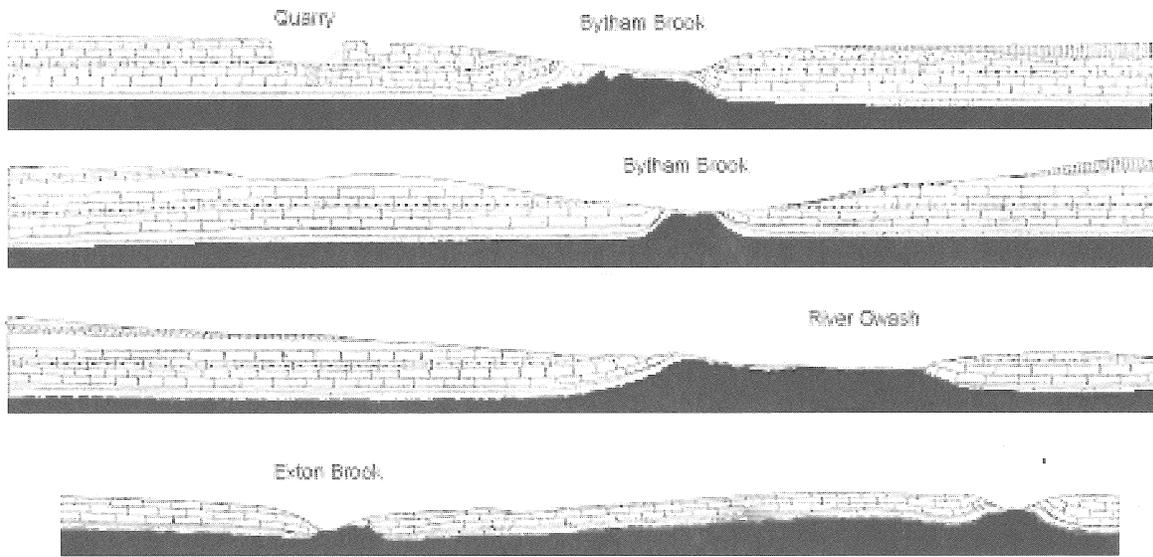


**Figure 3.** Cross-section along Post Oak Creek at the old Highway 13 bridge showing the angular unconformity between the horizontal Warrensburg Sandstone and the tilted undifferentiated Demoinesian Series rocks below. The location of this section is about two miles north of Warrensburg, MO, where Post Oak Creek has eroded through the base of the Warrensburg Sandstone and exposed the underlying rocks (see Figure 1). The cross-section is shown as four 100 foot long portions which combine to be 400 feet in length of nearly continuous exposure, with west on the right and east on the left because the rocks are exposed on the south side of Post Oak Creek. Standard geologic symbols are used, that is stipple for sandstone, dashes for shale and claystone, and "brick" symbol for limestones. Mixtures of stipple and dashes are used for sandy shale and shaley sandstone. Coal beds are marked with "C". The dip angle of the tilted rocks averages 30 degrees on the west end of the section and gradually changes to approximately 60 degrees on the east end of the section. Two faults are shown. The west fault has dragged beds on both sides and is definitely west side down, east side up. No dragged beds are observed on the east fault and it is inferred to have the same type of displacement, west side down, east side up. Adjacent to the east fault there is a minor fault which displaces coal and shale. These faults are believed by the authors to divide the exposed tilted rocks into three slump blocks on the east side of the valley anticline.

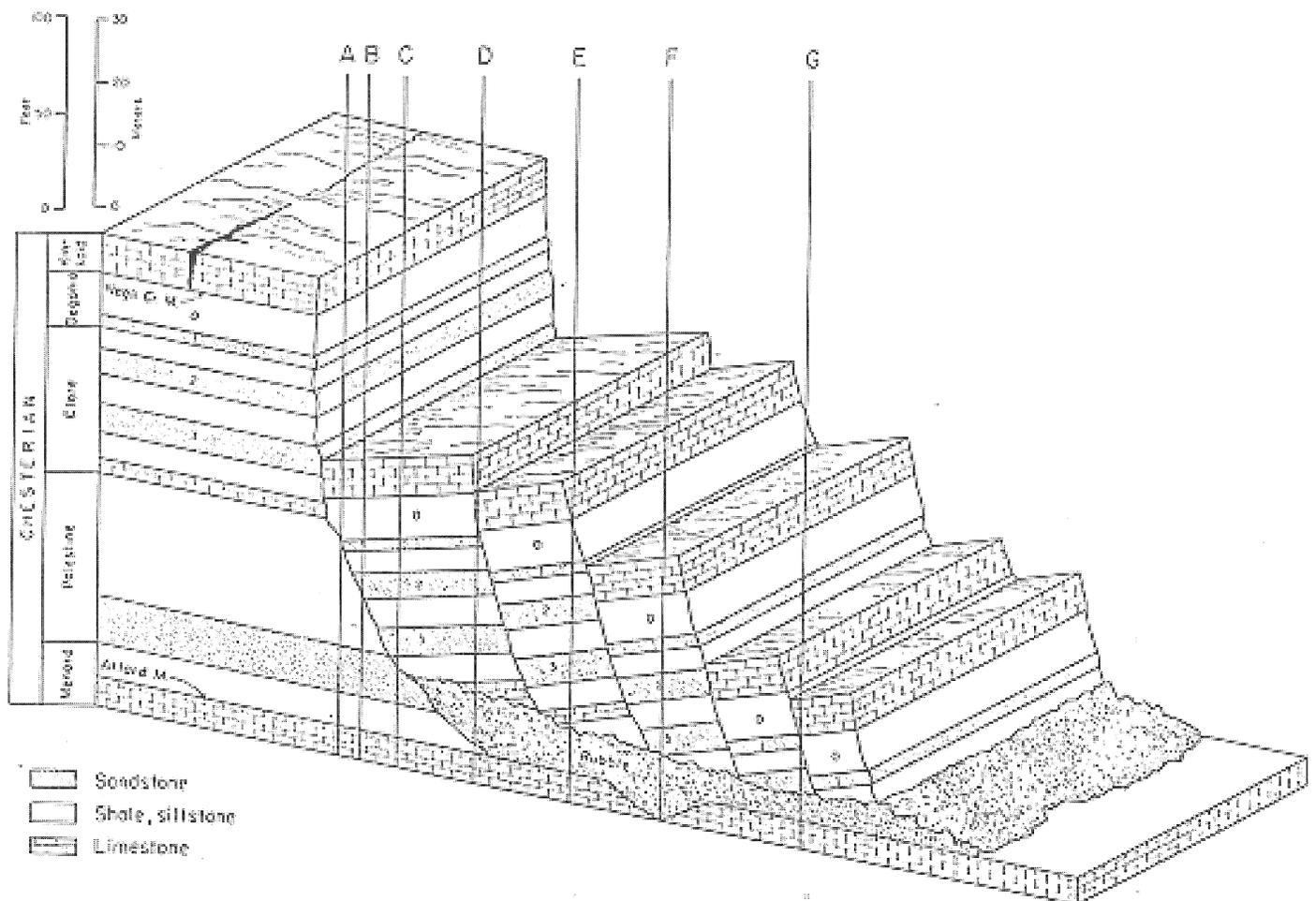


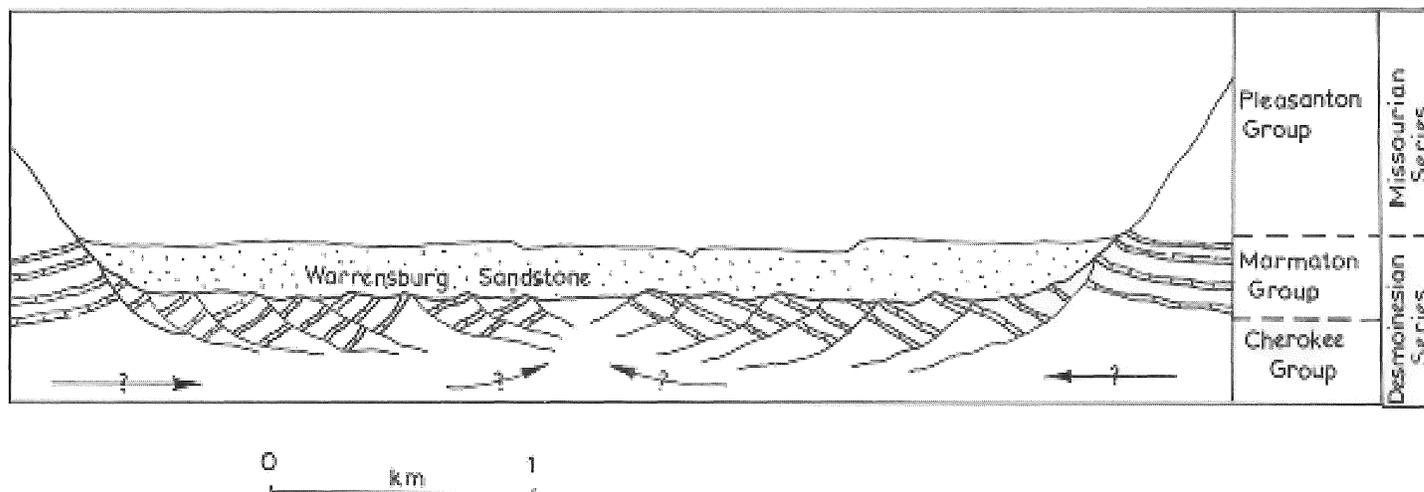
**Figure 4.** Photograph of the angular unconformity between the Warrensburg Sandstone, above, and the dipping Demoinesian Series rocks below. Located in Post Oak Creek north of Warrensburg at the old Highway 13 bridge. The dark bed in the center of this photograph is a coal bed located at 195 feet on the Figure 3 cross-section. The coal bed is underlain and overlain by shales and claystones.

**Figure 6 - bottom next page.** Cross-section from Bristol and Howard (1974) showing the development of valley-side slump blocks within an Illinois valley incised into Mississippian Chester strata. The incision was caused by a Late Mississippian sea level drop (Vail et al., 1977). Later alluviation filled the valley with Caseyville Formation clastic sediment during Early Pennsylvanian time.



**Figure 5 - above.** Cross-sections from Hollingsworth et al. (1944) showing the deformation caused by flow of Upper Lias clays toward the axes of valleys in the Northampton Ironstone Field, England. Bulging of the valley floor is apparently due to flow caused by pressure relief resulting from valley incision. The bulging caused the valley walls to be tilted away from the axis, resulting in an anticlinal structure. Length of the longer cross-sections is approximately 5000 feet.





**Figure 7.** Interpretive cross-section showing the Warrensburg river valley as it was filling with the Warrensburg Sandstone during Pennsylvanian time. Shown also are Desmoinesian limestones and shales within the rotated slump blocks responsible for tilting the bedding away from the center of the valley on both sides creating the valley anticline. This mechanism explains the excessive apparent stratigraphic thickness for the tilted Desmoinesian strata beneath and adjacent to the Warrensburg Sandstone by repetition in individual slump blocks. Arrows in the Cherokee Group indicate the possibility of shale flow from pressure release due to valley incision.



# Materials Science: Internet and WebCT<sup>®</sup> Enhanced Laboratory in General Chemistry.

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**Abstract:** A laboratory was designed and implemented covering the area of materials science. Along with the usual demonstration oriented introduction to these topics, a classroom technology integrated approach was used to introduce topics such as superconductivity, organomagnetic materials, ferromagnetic behavior, polymers, and fullerenes into the general chemistry (chemistry for science majors) curriculum at Central Missouri State University. Demonstrations of the Meisner effect and well-known polymerizations were performed for the students. Students researched information from the Internet to relate physical properties to the elements and materials. A short paper was written using web-based references concerning superconductivity, organomagnetic materials, polymers, molectronics, or fullerene nanotechnology. The students discussed their findings using the WebCT<sup>®</sup> electronic forum. Assessment surveys indicated the students had a positive response to the materials laboratory and an increased understanding of interesting research directions chemists may choose.

**Keywords:** Chemical Education, Materials Science, Laboratory.

## Introduction

Several papers in the chemical literature have discussed advanced materials or materials science in recent years [1,2,3]. Materials have emerged in the last decade to become a very active research area. Molectronics, or nanotechnology, may provide the key to computers with hereto unimagined speed and requiring significantly less energy. Supramolecular chemistry and crystal engineering utilize intermolecular interactions to design materials or supramolecular constructs with magnetic and non-linear properties. These tremendous advances in materials science necessitate a more thorough introduction of these topics into the general chemistry curriculum.

It is often the case in general chemistry (chemistry for science majors) that time only allows for teaching the tools of chemistry and the arithmetic of chemistry. The purpose of this new laboratory is to expose students to a wide scope of topics that fall into the materials category. Superconductivity [4,5], organomagnetic materials [6], ferromagnetic behavior [7], piezoelectric materials [8], polymers [9,10], and fullerene based nanotechnology [11,12] topics are discussed in a historical perspective. Demonstrations of the superconductivity Meisner effect [13] and common polymerizations such as the syntheses of Nylon and polyurethane were performed. This lab requires the student to search and cite the Internet for information on one of these topics and discuss their findings in an open electronic forum in the WebCT<sup>®</sup> environment [14].

Specific goals (Table 1) were generated with the assistance of the FLAG website [15]. The intended goals were to increase the basic knowledge of the student in the area of materials science, to help the student analyze data from differing sources and points of view, to encourage effective communication skills through writing and discussion forums, to use the Internet as a citable source of scientific information, and to educate students on the role of scientists in society.

## Methods

A three-hour laboratory introduced students to the areas of polymers, molectronics (nanotechnology) and superconducting materials. The demonstrations and lecture were completed in one laboratory period. The students had one week to complete their assignments out of class.

Common polymerizations demonstrations [16,17] such as the preparation of Nylon and polyurethanes were performed. The magnetic field phenomenon known as the Meisner effect found in superconducting

materials was demonstrated with a small pellet of  $\text{YBa}_2\text{Cu}_3\text{O}_6$  at 77K.

The topics were discussed with some historical perspective to chronicle the technological leaps in materials science and its effects on society and industry. Dr. Richard Smalley's work in the area of fullerenes [18,19] which earned him the 1996 Nobel Prize in chemistry was used to initiate discussion on the history of nanotechnology, the present utility of molelectronics and the most probable uses of nanotechnology in the near future.

The students were then directed to do several tasks. First, the students were to write a short paper on any of the advanced material categories such as high performance polymers, organomagnetic materials, ferromagnetic behavior, superconducting materials or nanotechnology; the papers were written and cited from Internet resources. The understanding of structure, intermolecular forces, and solid-state chemistry is essential in the understanding of the principles behind materials science. The students were given an assignment to plot chemical and physical properties with respect to periodicity (see periodic table assignment). Finally the students posted electronic communications of their findings on a bulletin board. The electronic bulletin board was provided by the use of the electronic course management program WebCT®.

Periodic Table Assignment: Find a suitable site on the web that includes physical (density, radius, etc.) and chemical (ionization energy, reactivity, etc.) properties of the representative elements. Choose a period or a family of representative elements and graph the physical property (e.g. mp) versus the group number (for a period) or atomic number (for a family). Then, prepare a second graph as the first, except substitute a chemical property for the physical property. What do these graphs illustrate? Make a hypothesis based on prior knowledge that would explain the trend(s). There are many web sites that include periodic tables and properties. A short list of useful URLs is presented for the periodic property assignment.

1. [http://chemserv.bc.edu/web\\_elements/web\\_elements-home.html](http://chemserv.bc.edu/web_elements/web_elements-home.html)
2. <http://www.uky.edu/projects/chemcomics/>
3. <http://pearl1.lanl.gov/periodic/>
4. <http://www.cs.ubc.ca/cgi-bin/nph-pertab/tab/periodic-table>

## Results

Students were surveyed (Table 2) upon completion of written assignments, Internet assignments and ample online discussions. The survey was used to help identify if the intended goals and objectives of the materials lab were met.

Analyses of the results (presented in tables 3-9) were broken down by major to verify if students' perception of the laboratory was major dependent. The survey questions, based on a Likert scale, were rated as strongly agree, agree, neutral, disagree or strongly disagree with numerical values of 5,4,3,2,1, respectively. The average overall rating of the questions varied between 3.5-4.1 for the spring 2001 class. The number of students responding to a survey is enclosed in parentheses. Several of the tables were combined by year. In these cases brackets specify one of the years. The overall ratings suggest the students agreed that they were more informed about the role of science in society, the contributions made by materials science on society, chemists' contributions to the field of materials science, and that the electronic discussion forums allow the students to discuss a multitude of topics. The understanding of the specific science related to materials and the relative enjoyment of the materials lab rated just slightly lower. The biology and health science students appeared to have a more favorable response to the discussion forums and in the enjoyment of the lab than did the chemistry students. As a whole, there were many more strongly agree responses than strongly disagree responses, which would indicate the constructive utility of the laboratory.

The fall 2000 class responses were generally much less agreeable than the spring 2001 class. The overall average range (Table 3) was from 2.7-3.0. The only difference in instruction between the two classes was that the fall class did not perform the WebCT® open forum discussions. A favorable rating of the WebCT® forum by the spring class would appear to indicate the effectiveness of the forum in this laboratory.

Table 10 provides useful web sites that may be very helpful in the development of the materials activity at other institutions.

## Conclusion

The results of the survey would suggest that the lab, to some extent, met many of the intended goals and that this activity should be further refined to better

meet those goals. Students' participation in an electronic forum increased the effectiveness of this activity.

## References

1. Schaeffer, R.W. *J. Chem. Educ.* 2000 77 833.
2. Gulden, T.D.; Norton, K.P. Steckert, H.H.; Woolf, L.D.; Baron, J.A.; Brammer, S.C.; Ezell, D.L.; Wynn, R.D. *J. Chem. Educ.* 1997 74 785.
3. Campanion A.; Schug, K. *J. Chem. Educ.* 1973 50 618.
4. Cogdell, C.D.; Wayment, D.G.; Casadonte, D.J., Jr.; Kubat, M., Kim A. *J. Chem. Educ.* 1995 72 840.
5. Butera, R.A.; Waldeck, D.H. *J. Chem. Educ.* 1997 74 1090.
6. Lahti, P. M. In *Magnetic Properties of Organic Materials*; Lahti, P. M., Eds.; Marcel Dekker, Inc.: New York, NY, 1999; pp 661-701.
7. Sugawara, T.; Nakazaki, J. In *Magnetic Properties of Organic Materials*; Lahti, P. M., Eds.; Marcel Dekker, Inc.: New York, NY, 1999; pp 535-552.
8. Seymour, R.B.; Kauffman, G.B. *J. Chem. Educ.* 1990 67 763.
9. Dust, J.M. *J. Chem. Educ.* 1995 72 956.
10. Meister, J.J. *J. Chem. Educ.* 1995 72 593.
11. Heinhorst, S. *J. Chem. Educ.* 1999 76 1472.
12. Ong, E.W.; Razdan, A.; Garcia, A.A.; Pizziconi, V.; Ramakrishna, B.L.; Glaunsinger, W.S. *J. Chem. Educ.* 2000 77 1114.
13. McHale, J.; Schaeffer, R.; Salomon, R. E. *J. Chem. Educ.* 1992 69 1031.
14. WebCT Version 3.13  
<http://www.webct.com/company>  
accessed on 4/11/01
15. [www.wcer.wisc.edu/nise/cl1/flag/goals/doggoal\\_search.asp](http://www.wcer.wisc.edu/nise/cl1/flag/goals/doggoal_search.asp) accessed on 4/2/01
16. Flynn, B.R. *J. Chem. Educ.* 1991 68 685.
17. Ihde, J. *J. Chem. Educ.* 1990 67 264.
18. Thess, A.; Lee, R.; Nikolaev, P.; Dai, H.; Petit, P.; Robert, J.; Xu, C.; Lee, Y-H.; Kim, S-G.; Rinzler, A.G.; Colbert, D.T.; Scuseria, G.; Tománek, D.; Fischer, J.E.; Smalley, R.E. *Science* 1996 273 483.
19. Dai, H.; Hafner, J.H.; Rinzler, A.G.; Colbert, D.T.; Smalley, R.E. *Nature* 1996 384 147.



TABLE 3: Average Response for Each Major and Overall Average Fall 2000			
5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree			
Q#		Major (Responses)	Ave.
1	I am more informed about the role science and technology has made to society and our economy.	Biology (2) Geology (2) Other (5) Overall Average (9)	3.0 2.5 2.8 2.8
2	I have a better appreciation of the important contributions materials science has made to society.	Biology (2) Geology (2) Other (5) Overall Average (9)	3.0 2.5 3.2 3.0
3	I have a better understanding of the basic knowledge of the concepts and theories behind the materials science revolution.	Biology (2) Geology (2) Other (5) Overall Average (9)	2.5 3.0 3.0 2.9
4	The materials laboratory gave me a better understanding of chemists' contributions to the field of materials science.	Biology (2) Geology (2) Other (5) Overall Average (9)	2.5 3.0 3.2 3.0
5	These activities gave me a better understanding of the interdisciplinary nature of research (chemistry, engineering, physics, etc.)	Biology (2) Geology (2) Other (5) Overall Average (9)	1.5 2.5 3.4 2.8
6	I am more aware or better prepared to understand specific materials science related topics such as polymers, superconductivity, non-linear optics and organomagnetism from mass media resources.	Biology (2) Geology (2) Other (5) Overall Average (9)	2.0 1.5 3.4 2.7
7	I am more aware of the vast amount of resources concerning materials science and other topics on the internet due to the internet (written) assignment associated with this laboratory.	Biology (2) Geology (2) Other (5) Overall Average (9)	2.0 2.0 3.2 2.7
8	The WebCT® student discussions provided an opportunity to discuss a multitude of materials science topics.	Biology (2) Geology (2) Other (5) Overall Average (9)	N/A N/A N/A N/A
9	I enjoyed this lab more than most of the traditional laboratories we have performed this semester.	Biology (2) Geology (2) Other (5) Overall Average (9)	3.0 2.0 3.0 2.8

TABLE 4: Average Response for Each Major and Overall Average Spring 2001

5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree

Q#		Major (Responses)	Ave.
1	I am more informed about the role science and technology has made to society and our economy.	Biology (10) Health Prof. (3) Other (6) Chemistry (5) Overall Ave. (24)	4.3 4.3 3.5 3.8 4.0
2	I have a better appreciation of the important contributions materials science has made to society.	Biology (10) Health Prof. (3) Other (6) Chemistry (5) Overall Ave. (24)	4.1 4.3 3.6 4.0 4.0
3	I have a better understanding of the basic knowledge of the concepts and theories behind the materials science revolution.	Biology (10) Health Prof. (3) Other (6) Chemistry (5) Overall Ave. (24)	4.0 4.0 3.8 3.8 3.9
4	The materials laboratory gave me a better understanding of chemists' contributions to the field of materials science.	Biology (10) Health Prof. (3) Other (6) Chemistry (5) Overall Ave. (24)	3.9 4.6 4.0 4.2 4.1
5	These activities gave me a better understanding of the interdisciplinary nature of research (chemistry, engineering, physics, etc.)	Biology (10) Health Prof. (3) Other (6) Chemistry (5) Overall Ave. (24)	3.8 3.3 3.6 4.2 3.8
6	I am more aware or better prepared to understand specific materials science related topics such as polymers, superconductivity, non-linear optics and organomagnetism from mass media resources.	Biology (10) Health Prof. (3) Other (6) Chemistry (5) Overall Ave. (24)	3.4 4.0 3.3 3.8 3.5
7	I am more aware of the vast amount of resources concerning materials science and other topics on the internet due to the internet (written) assignment associated with this laboratory.	Biology (10) Health Prof. (3) Other (6) Chemistry (5) Overall Ave. (24)	4.0 3.6 3.3 3.6 3.7
8	The WebCT® student discussions provided an opportunity to discuss a multitude of materials science topics.	Biology (10) Health Prof. (3) Other (6) Chemistry (5) Overall Ave. (24)	4.3 4.6 4.0 3.2 4.0
9	I enjoyed this lab more than most of the traditional laboratories we have performed this semester.	Biology (10) Health Prof. (3) Other (6) Chemistry (5) Overall Ave. (24)	3.5 4.5 4.0 2.8 3.6

Question	<u>5</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
1	[4]	1[5]	[1]	1	
2	[3]	1[5]	[2]	1	
3	[2]	[6]	1[2]	1	
4	[2]	1[5]	[3]		1
5	[1]	[7]	[1]	1[1]	1
6	[1]	[4]	1[3]	[2]	1
7	[2]	[6]	[2]	1	
8	[4]	[5]	[1]		
9	1[3]	[3]	[1]	[2]	1[1]

Question	<u>5</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
1		4	1		
2	1	3	1		
3	2		3		
4	2	2	1		
5	2	2	1		
6	1	2	2		
7	2		2	1	
8		3		2	
9		1	2	2	

Question	<u>5</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
1	1	2			
2	1	2			
3	1	1	1		
4	2	1			
5		1	2		
6	1	1	1		
7	1		2		
8	2	1			
9	1	1			

Question	<u>5</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
1		1[4]	2[1]	2[1]	
2		1[4]	4[2]		
3	[2]	1[2]	3[1]	1[1]	
4	[1]	1[4]	4[1]		
5	[1]	2[2]	3[3]		
6	[1]	2[1]	3[3]	[1]	
7		1[3]	4[2]	[1]	
8	[1]	[4]	[1]		
9	1[1]	[4]	1[1]	2	1

Question	<u>5</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
1			1	1	
2			1	1	
3		1		1	
4		1		1	
5			1	1	
6				1	1
7				2	
8					
9				1	

High Performance Polymers	<a href="http://www.technology-catalysts.com/strtegic_Analysis/srvhighp.htm">www.technology-catalysts.com/strtegic_Analysis/srvhighp.htm</a> <a href="http://www.iop.org/journals/hp">www.iop.org/journals/hp</a> <a href="http://www.netaccess.on.ca/~dbc/cic_hamilton/poly.html">www.netaccess.on.ca/~dbc/cic_hamilton/poly.html</a> <a href="http://www.omega23.com/reference/k23j28_polymers.html">www.omega23.com/reference/k23j28_polymers.html</a>
Nanotechnology	<a href="http://www.zyvex.com/nano.com">www.zyvex.com/nano.com</a> <a href="http://www.nanozine.com">www.nanozine.com</a> <a href="http://www.rand.org/publications/MR/MR615/mr615.html">www.rand.org/publications/MR/MR615/mr615.html</a>
Superconducting Materials	<a href="http://www.aub.edu.lb/alumni/ssc/supcond3.thm?clka=lwm">www.aub.edu.lb/alumni/ssc/supcond3.thm?clka=lwm</a> <a href="http://www.soton.ac.uk/~newrep/vol12/nxdk003.htm">www.soton.ac.uk/~newrep/vol12/nxdk003.htm</a>
Non-Linear Optical Materials	<a href="http://www.msi.com/materials/sstate/nlo.html">www.msi.com/materials/sstate/nlo.html</a>
Composite Materials	<a href="http://www.composite.about.com/industry/composite/mlibrary.html">www.composite.about.com/industry/composite/mlibrary.html</a>

# Senior Division

## 2001

### Agriculture Section

**Aide, M. Department of Geosciences, Southeast Missouri State University.** FRAGIPAN FORMATION AND THE ROLE OF SILICON. Fragipans are subsurface soil horizons typically described as having silt loam textures, acid pH values, high bulk densities, and a consistence that is brittle when wet and hard when dry. In the Midwestern USA, these soil features are frequently associated with loess deposition, typically forming when the loess is less than two meters. The Hildebrecht soil, located in St. Francois County, Missouri, has a thick fragipan and its solution chemistry suggest that silica overgrowths contribute to its strength. The source of the silica appears related to the overlying loess. The fragipan appears to represent a paleo-surface involving loess deposition onto weathered limestone residuum. The Fe-oxide content is strongly correlated with clay content, suggesting that Fe is not a cementing agent responsible for the fragipan's properties.

**\*Cobb, K.R., T.M. Moore, F.D. Worman, and R.L. Tabor. Department of Agriculture, Central Missouri State University.** THE EFFECTS OF HYDROGEN PEROXIDE ON THE EARLY GERMINATION OF SWEET CORN, *ZEA MAYS*. Previous studies have indicated that low doses of hydrogen peroxide have a positive influence on the early germination of sweet corn. The study used petri dishes with 1.5%, 3%, 6%, and 12% solutions of hydrogen peroxide for the treatments and distilled water for the control. The sweet corn used was weighed to the nearest one-hundredths of a gram, so that all seeds were approximately the same weight throughout the study. Seeds were maintained at approximately 28 degrees Celsius and were checked for germination every 24 hours for three days. Trends indicated that after the first 24 hours, 5% of the seeds germinated in the distilled water, 15% of the seeds germinated in the 1.5% and the 3% solution, and there were no seeds germinated in the 6% or the 12% solutions. After 48 hours, 30% of the seeds germinated in

the distilled water, 65% of the seeds germinated in the 1.5% solution, 50% of the seeds germinated in the 3% and the 6% solution, and 0 seeds germinated in the 12% solution. The final examination of the seeds after 72 hours indicated that 55% of the seeds germinated in the distilled water, 70% of the seeds germinated in the 3% and the 6% solutions, and 5% of the seeds germinated in the 12% solution. There was a positive influence on early germination of sweet corn using low doses of hydrogen peroxide.

**\*Helling, M., and G.L. Gille. Department of Agriculture, Northwest Missouri State University.** VARIATION IN GRID SOIL SAMPLING. Precision farming is increasingly becoming a common fixture in agriculture today. New technology is enabling agriculturalists to discover relationships that would have otherwise been difficult to comprehend or would have even gone unseen. The use of GPS (Global Positioning System) and related software has provided agriculturalists the opportunity to see the spatial variability within a given field. Two fields, corn and pasture, located on the Northwest Missouri State University North Farm were intensively soil sampled by grid. Grid and soil sampling locations were determined with the aid of GPS navigation hardware and software. Each 40-acre field was divided into 15 smaller blocks, which were divided into 9 sub-blocks. A total of 135 samples were taken, in a composite manner, from the center of each sub-block within both fields. Each composite sample was composed of 6 sampled soil cores, taken at a depth of 6 inches. After collection, samples were ground and then tested for pH, phosphorus, and potassium content. Results, from pH, P, and K, indicated significant variation at the block level. The resulting significance was found to support soil property variation across the entire field at the block level. Contrary to blocks, sub-block variation was insignificant, although variation was observed.

**\*Wilson, M.A., V.A. Khan and C. Stevens. Department of Agriculture, Southeast Missouri State University and Department of Agriculture Sciences, Tuskegee University.** EFFECT OF AGRI-GRO FERTILIZER ON YIELD POTATOES. Our studies were conducted with a split-split plot design where 'Atlantic' potato variety was the main plot and rates of Agri-Gro fertilizer was the subplots. Agri-Gro fertilizer was applied at three different growth stages. Total yield showed no significant differences between levels of Agri-Gro fertilizer. Marketable numbers and yield showed no significant differences between fertilizer levels, however, there was a significant difference from the control. Again, as the levels increased, so did the yield, indicating the maximum level had not yet been reached, and that the levels need to start at 48 ozs/ac and increase from there. The objectives of this study were to evaluate the effect of three rates of foliar applied Agri-Gro fertilizer on yield of 'Atlantic' potatoes in Missouri.

### Atmospheric Science Section

**\*Akyüz, F.A., P. Guinan, and W.L. Decker. Department of Soil and Atmospheric Sciences, University of Missouri-Columbia.** A QUALITY CHECKING PROCEDURE FOR THE AUTOMATED WEATHER MONITORING NETWORK IN MISSOURI. High quality weather data is a valuable resource used by all facets of the community. Scientists, educators, engineers, etc. use weather data as part of their decision making process and therefore it is critical the data they receive be of high integrity. Automated weather station networks collect an enormous amount of weather information where visual inspection of the data could not keep up with the real-time user access. The process of developing an automated quality checking procedure has been developed in order to offer high quality weather data in real-time to the end-user. The procedure will be implemented for quality checking among the existing network of 25 automated weather stations throughout the state. The automated quality checking procedure consists of 4 components: range, step, persistence, and spatial checks. All variables measured hourly are checked against those 4 components before made available for the end-user in a timely fashion. The real-time and archived research quality network data will improve

Missouri's natural resources management practice in agriculture, emergency management, energy saving, transportation and research.

**Buonanno, C.C. National Weather Service Forecast Office, Fort Worth, TX.** AN OVERVIEW OF THE INTERACTIVE FORECAST PREPARATION SYSTEM. The National Weather Service (NWS) "provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy" (from NWS mission statement). To support this mission, The National Weather Service recognizes a requirement to provide innovative, valuable and useful weather services to respond to the nation's threat of experiencing significant weather events. The current NWS modernization allows for a continual upgrading of computer resources to support this goal. The Interactive Forecast Preparation System (IFPS) is a software system that utilizes an interactive, graphical method of relating a forecast from the forecaster(s) to their client base. Through IFPS, a forecast is rendered through a manipulation of a digital database of forecast parameters, creating a flexible, integrated, coherent package of forecast products. Use of the IFPS will present a shift in forecast methodology from that of more antiquated methods. A review of this software will be presented, along with the change in forecast methodologies it offers, and aspects for future training of meteorologists.

**Chambers, M.D. and A.R. Lupo. Department of Soil and Atmospheric Sciences, 109 Gentry Hall, University of Missouri-Columbia.** THE SHORT- AND LONG-TERM VARIABILITY OF SELECTED MIDWESTERN TORNADOES. Predicting the occurrence of tornadoes has proven to be one of the most difficult aspects of severe weather forecasting. The isolated nature and short duration of these destructive events not only makes forecasting them difficult, but also makes studying them a challenge. Despite these challenges, recent studies have shown that certain weather events across the Midwest exhibit impressive interannual variability that can be related at least in part to the El Nino and Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) phenomena. Thorough knowledge of the characteristics of

this variability, and other relationships like it, can be extremely useful for long-term forecasting applications. In the hopes of furthering the general understanding of interannual variability and its importance in forecasting severe weather, this study focuses on selected Midwestern U.S. tornadoes. This climatological study considers all tornadoes of intensity F2 (according to the Fujita Scale) or greater that occurred in Iowa, Kansas, Missouri, and Nebraska from 1950 through 1999. Once all applicable tornadic events were collected and organized, statistical calculations were examined to find trends in the data and to investigate the interannual variability and its relation to ENSO and PDO. Several flow regimes conducive to tornadic activity in the Midwest were also determined. Results thus far have shown an increase in tornadic activity during the La Nina phase and during PDO2. Downward trends in tornadic activity were also evident over the 50-year period in all four states.

**Lupo, A.R. Department of Soil and Atmospheric Sciences, 109 Gentry Hall, University of Missouri - Columbia.** THE VERIFICATION OF COLUMBIA AREA WEATHER FORECASTS: SEASONAL VARIATIONS. This study has examined the performance of forecasts issued by the National Weather Service (NWS) Office in Saint Charles, MO for Columbia, MO using a subjective point rating system for over one year (416 days). The parameters included were temperatures, wind speed and direction, sky coverage, and precipitation. Skill scores have been calculated and statistical tests applied to determine the accuracy of these forecasts and the degree to which they represent an improvement over baselines such as persistence and climatology. Results have shown that forecasts issued by the NWS were a significant improvement over persistence or climatology. NWS forecasts were also slightly better than model guidance for both the early (0-12 hr) forecasts and the forecasts 12 to 24 hours out. In examining the forecasts more closely, the NWS forecasts were even more accurate than the model guidance when comparing just temperature and precipitation, which are the two variables the general public is most concerned with in a weather forecast. When examining the seasonal variation of forecast accuracy, it was found that overall the winter season forecasts issued by the NWS and model guidance were better than forecasts issued

during the summer season. Also, during the summer, model guidance forecasts were better than NWS forecasts, while the opposite result is found during the cold season. The summertime decrease in forecast accuracy can be attributable to the scoring method used and the fact that summer precipitation is more localized, resulting in lower precipitation forecast scores in that season.

**Lupo, A.R., P.S. Market, F.A. Akyuz, A. Oehl, C. Maune, and J. Lam. Department of Soil and Atmospheric Sciences, 109 Gentry Hall, University of Missouri - Columbia.** THE COLUMBIA (MO) HEAT ISLAND EXPERIMENT OR "COHIX". The Heat Island effect (HIE) is a well known feature in the microclimate of urban areas and many studies have examined this effect for large cities. Few studies have addressed the HIE for medium-sized urban areas. This study examines the combined impact of Columbia, MO and the University of Missouri campus on the microclimate of central Missouri. Temperature and precipitation were the primary variables examined. Several students, staff, and faculty at the University of Missouri volunteered to provide readings over a one-year period of study. Twenty Radio Shack® digital Max/Min thermometers were purchased and given to participants who were chosen for their reliability to provide data and to site the instrument, and their location (in order to provide reasonable coverage locally). Also included in the data set was information provided by area automated weather stations, a cooperative weather station, and the weather station at the Columbia Regional Airport located 7 miles southeast of Columbia. Initial results indicate that the City of Columbia, MO has no discernable effect on the distribution of monthly precipitation totals. However, when examining the monthly mean temperatures, there is a distinct urban influence on the local surface temperatures. In particular, the inner city region and the built up area of south Columbia tend to be 2-3°F warmer than the surrounding environment. This difference grows to 3-6°F when comparing the warmest station in the city to the coolest station outside Columbia. There is also a seasonal influence evident as the HIE is more evident in the mean monthly maximum (minimum) temperatures during the warmest (coldest) months.

**Ratley, C.W., A.R. Lupo, and M.A. Baxter.** Department of Soil and Atmospheric Sciences, 109 Gentry Hall, University of Missouri. SPRING-TO-SUMMER TRANSITIONS IN THE MISSOURI OZARKS REGION. It has been observed in central Missouri that the sultry, oppressive days of the summer season frequently make an abrupt entrance, often in mid-June. The mild and frequently wet pattern of the mid-western spring evolves into a prolonged period of intense heat and humidity. This transition is examined relative to the large-scale circulation shifts, which also lead to the onset of the southwest summer monsoon. Daily temperature data (for 1 April through 1 September) were acquired from the Midwest climate center, while 500 hPa heights were obtained from the Missouri Climate Center and the National Climatic Data Center (Asheville, NC) webpage archives. A subjective criterion was developed using these parameters in order to determine the onset date or period. The frequency of significant precipitation (0.25 inches or more) was also examined over the period above before and after summer onset. Initial results demonstrate that the criterion identify the 10 - 20 June period as the annual changeover from the spring-to-summer flow regime in a typical year. The 500 hPa height anomaly fields also demonstrate this change in upper air flow character. After the 10 - 20 June period there was a significant decrease in the frequency of heavy precipitation. In addition, there is a correlation between the date of summer onset in Mid-Missouri and the onset of the southwest monsoon, with the former leading the latter by 7 - 21 days. Finally, there was significant interannual variability found in the summer transition dates. Summers characterized as El Nino summer seasons typically were accompanied by an early summer onset and a smaller decrease in the post-onset precipitation frequency. La Nina years were characterized by a later onset period and a larger decrease in the precipitation frequency after onset.

**Zacher, C.A. AERO Research.** SOME UNCOMMON LIGHTNING ASPECTS AND SPECTRAL FEATURES DOCUMENTED USING SPECIAL PHOTO TECHNIQUES.

Good lightning photos usually evoke a lively interest. Obtaining significant photographs of value for scientific purposes presents a number of difficulties. Simple obstacles include: daylight, fogging of film,

the field-of-view problem, randomness to a degree, and timing interval between flashes. These are dealt with, and largely remedied through means of using electronically triggered cameras. But analysis and interpretation of finer points include resolving problems of exposure, color balance, overexposure, true-color and contrast phenomena, normalizing, and diagnostics of ambient and internal lights, as well as image capture. Often, because of the non-linear response of the photographic medium, to lightning flash observations it is difficult. Systematic problems of image sensitivity can be dealt with using a variety of developmental techniques for capturing "true" (i.e. understood or normalized) image values, alternatively time-resolving, or even "rebuilding" inadequate over- or under- exposures. Examples of the results of using the special techniques will be shown and displaying some unusual or anomalous lightning also.

## Biology Section

**Jilk, R., and L. Huntington.** Department of Biology, Rockhurst University. A NOVEL *ARABIDOPSIS THALIANA* MUTATION CAUSES DEFECTS IN CELLULAR DEVELOPMENT. A mutant strain of *Arabidopsis thaliana* was created by T-DNA insertional mutagenesis. The characterization of this mutation shows a recessive mutation with several apparently unrelated phenotypes. This mutation was originally isolated for the fact that the trichomes do not show the branching patterns seen in wild type strains, earning the mutant allele the name SINGLE TRICHOME VARIANT 1. Scanning electron microscopy of the developing leaves also shows incompletely differentiated epidermal pavement cells. The mutation also leads to a high degree of lethality, where 90% of plants wilt and die within two days of being transferred to soil. Studies done to determine optimal growth conditions demonstrate that the mutant plants are highly sensitive to microbial infection, and do best when raised in sterile conditions. Even so, the surviving plants leave only sterile seeds. The site of the T-DNA insertion has been mapped and sequenced to a region of chromosome 5 with no previously reported function. The results of the characterization of the mutation indicate that the affected protein plays a key role in proper cellular differentiation and morphogenesis.

**Rachel Nygaard-Baker and Noorullah Babrakzai. Department of Biology, Central Missouri State University.** A PRELIMINARY INVESTIGATION ON THE MUTAGENICITY OF PARSNIP ROOT. Crude methanol extract of 242.5 g of parsnip root was prepared by blenderizing it in 485 ml of methanol, followed by filtration and evaporation. Green onions with growing roots were incubated in 7, 15, 31, 62, 125, 250, 500 and 1000 ppm of the extract for 24 hours in tap water. The onion root tips were fixed and lactic-acetic orcein squashes on microscope slides were made for cytogenetic study. The mitotic indices (expressed as percentages of dividing vs. non-dividing cells) generally exhibited a decrease of 0.37%-12.9% from controls (16.47%), except in 500 and 1000 ppm treated lots, which were higher, 28.24% and 26.52% respectively. Anaphase bridges, sticky and knotted chromosomes, multipolar spindles, polyploidy and C-metaphases were encountered in 31-1000 ppm treated lots as qualitative mutations. The observed range of mutations was 11.7%-22.6% vs. 2.7% in the controls. These results lead us to conclude the parsnip does have bioactive principles that interfere with the cell division cycle (CDC) of the onion roots, resulting in its acceleration, and inhibition in different doses as evidenced by the mitotic indices and chromosomal mutations. Supported in part by grants from the CMSU Research Council and the McCAP program.

**Oller, A.R. Department of Biology, Central Missouri State University.** TRANSFORMATION AND EXPRESSION OF A PULLULAN GENE IN *SACCHAROMYCES CEREVISIAE*. Pullulan is a polysaccharide of great economic importance in pharmaceutical and industrial products. Previous studies identified a pullulan gene through Random Amplified Polymorphic DNAs (RAPD) Polymerase Chain Reaction (PCR) techniques, and the gene was transformed into pullulan deficient mutants created by gamma irradiation. Once restored pullulan synthesis was determined, the gene was sequenced. The present study was to determine whether ligation of the gene into the pYES2 yeast expression vector caused pullulan elaboration in *S. cerevisiae*, which is much easier to culture than the native fungus, *Aureobasidium pullulans*. The pullulan DNA was ligated both forward (sense) and backward (antisense) into the pYES2

through the use of several restriction endonucleases. The plasmid vector was then cloned into competent *Escherichia coli* cells. The presence of the desired DNA was confirmed through plasmid isolation and use of restriction endonucleases. The plasmid DNA was then electroporated into competent *Saccharomyces cerevisiae* cells. The *Saccharomyces* transformants were then plated on Synthetic Media (SM) and Ueda media. Pullulan synthesis was visualized on Ueda plates. Transformants were visualized microscopically to confirm pullulan elaboration from the cell. Further, pullulan elaboration was determined by alcohol precipitation and filter weights. Reverse Transcriptase (RT)-PCR was performed on the transformants to confirm gene expression. The organisms containing the sense DNA were found to produce pullulan visually and microscopically, whereas the organisms containing the antisense DNA did not. The *S. cerevisiae* transformants were found to produce even greater quantities of the polysaccharide than *Aureobasidium pullulans* in the wild. RT-PCR further indicated gene expression of the sense DNA, but not the anti-sense DNA.

**Raveill, J. A. Department of Biology, Central Missouri State University.** HYBRIDIZATION IN THE FLORA OF NORTH AMERICA. Hybridization in the flora of the North American continent was examined using published volumes of The Flora of North America. This publication will eventually include all vascular plants with volumes published to date covering all ferns, fern allies, gymnosperms, and some angiosperms including two subclasses of dicots, Magnoliidae and Hamamelidae, and four subclasses of monocots, Alismatidae, Arecidae, Commelinidae (in part), and Zingiberidae. All monotypic genera were eliminated leaving a total of 1600 species in the study. Due to various degrees of consideration by contributing authors, specific criteria were used to judge if the species was implicated in hybridizing with at least one other species. Hybridization was noted in all subclasses with variation among groups. Higher percentages of species considered to hybridize were seen in non-angiosperms, including 49% among fern allies, 42% among ferns, and 43% among gymnosperms. All angiosperm subclasses had similar values around 20% except for the Arecidae with 10% and Hamamelidae with 60%. The latter value was largely determined by

the genus *Quercus* which comprised nearly half of the species in the subclass and where nearly all species are thought to hybridize.

**Reichard, L.A. Division of Math and Sciences, Department of Biology, Maple Woods Community College.** A SURVEY OF THE NUTRITIONAL MAKE UP OF AN AVERAGE COMMUNITY COLLEGE STUDENT IN THE MIDWEST. Students attending community colleges are often living very busy lives attempting to balance time for family, school, work, and social endeavors. With such hectic demands on their time it is no wonder that nutritional needs often suffer and are not one of their highest priorities. By looking at a one-week self-reporting survey of student's dietary intakes, trends in their dietary habits begin to emerge. This survey looks at the student's caloric intake of protein, carbohydrate, lipid profile, and fiber. The survey gathered additional information on vitamins A, B1, B2, niacin, B6, B12, folate, C, D, and E as well as the minerals calcium, iron, magnesium, phosphorus, potassium, sodium, and zinc. Also, caffeine and alcohol levels are recorded. Since dietary choices over time do add up and often establish patterns that may affect a person's later health status by increasing one's risk factors for such common conditions as obesity, arteriosclerosis, diabetes, heart disease, stroke, high blood pressure, and certain forms of cancer. It is imperative that attention is given to a person's dietary habits and if found to be unhealthy in some nutritional area(s), the person will be in a position to correct the condition(s). The goal is not only a longer life, but also a healthy one.

**\*Snell, K.L., and H.W. Keller. Department of Biology, Central Missouri State University.** BIO-DIVERSITY OF TREE CANOPY CRYPTOGRAMS IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK. Cryptogams (myxomycetes, macrofungi, mosses, liverworts and lichens) that live on the bark surface of living trees are often overlooked by conventional biodiversity studies. Density and assemblages of cryptogams in tree canopies represent important baseline data needed to assess environmental changes over time through human encroachment and physical factors that impact the forest ecosystem. The Great Smoky Mountains National Park (GSMNP), home to the largest remaining old growth

forest in the Eastern United States, was targeted for sampling by a team of student climbers using the double rope technique to reach the upper canopy. Bark samples with cryptogams were collected from over 160 trees at varying heights up to 115 feet. Cryptogam specimens were divided among various expert team members. Expected outcomes of this study include; discovery of new species and park records, correlation of species to vertical height, and the possible relationships between different taxonomic groups in their observed tree canopy assemblages. Students at CMSU will focus on the myxomycetes (true slime molds) collected in situ from the canopy. Myxomycetes found in treetops differ in number and species diversity when compared to those found on ground sites. Bark samples will be scanned microscopically and cultured in moist chambers to detect small myxomycetes that have gone undetected in the field. Compiling our data of species richness and comparing this with the other taxonomic groups will shed new light on tree canopy biodiversity and any changes over time in this unexplored habitat. Supported by the National Science Foundation, Division of Environmental Biology, Biotic Surveys and Inventories Program Award #0079058.

## Chemistry Section

**Bosch, E. Department of Chemistry, Southwest Missouri State University.** DESIGN, SYNTHESIS AND COMPLEXATION CHARACTERISTICS OF A SIMPLE DIPYRIDYL LIGAND. This paper will first describe the design and molecular modeling of a simple dipyridyl compound that was predicted to bind metal cations as a trans chelating ligand. Secondly I will describe the synthesis and characterization of the dipyridyl ligand, 1,2-bis-(2-pyridylethynyl)benzene. The X-ray structural characterization of the (1:1) complexes of this ligand with silver (I) cation and palladium (II) dichloride will be presented. Finally the structures of the unexpected coordination polymer and oligomer formed between this ligand and copper (I) iodide and copper (I) bromide, respectively, will be described.

**Sorrells, J.T. and K.G. High\*, Drury University.** HOMONUCLEAR DECOUPLING AND 2-D NMR IN UNDERGRADUATE RESEARCH AND TEACHING. NMR 2-D techniques such as COSY and HETCOR are ever increasing in importance and use in chemistry. Most modern spectrometers are capable of performing these techniques on a large number of chemical systems ranging from rather simple organic molecules to more complex proteins. The use of homonuclear decoupling is not as frequent. However, the principles involved in homonuclear decoupling are frequently easier for undergraduate students to understand. Given this, students in the Instrumental Analysis course at Drury University have studied a number of molecules the usefulness of COSY as compared to homonuclear decoupling. Some molecules of interest include ethyl hydrocinnamate, dibutyl phthalate, and 1,3-dinitrobenzene. In addition to this, COSY and HETCOR has been utilized in undergraduate research related to the hydrolysis of carnosine, a dipeptide like molecule.

### Computer Science Section

**\*Naugler, D.R. Department of Computer Science, Southeast Missouri State University.** WHO IS TEACHING YOUR CHILDREN COMPUTER SCIENCE? The discipline of Computer Science has matured so recently that, often in the same department, the faculty are from several intellectual generations and several disciplines. Experienced teachers are often "retreads" having PhDs in "related" areas (too flexible a term) or in clearly unrelated areas. Given the rapid development of the discipline how valuable is a PhD earned twenty-five or thirty years ago? The relative dearth of new Computer Science doctorates who consider academic careers means that most departments will not achieve the ideal of a full-time faculty of all (or mostly) Computer Science PhDs in the near future. Some departments face an uncertain future as the faculty approached retirement with no replacements in sight. Very few undergraduate Computer Science degrees are CSAB accredited and one of the major barriers is the requirement that some of the faculty have PhDs in Computer Science. So who should teach undergraduate Computer Science? Computer Science should be taught, predominantly, by Computer Scientists. So who is a Computer

Scientist? Tentative answers to the above questions are presented from the perspective of a PhD in a "related" area who has been teaching Computer Science for twenty years.

**\*Shade, E. Computer Science Department, Southwest Missouri State University.** SCRIPTING IN C++. By redesigning the core classes and libraries of C++ it is possible to achieve almost all of the benefits of scripting languages while retaining the efficiency of a compiler and the interoperability of C. Scripting languages such as Perl, Python, Ruby, and Tcl differ from traditional languages in several ways. They are interpreted, dynamically typed, and garbage-collected. They provide convenient libraries for lists, associative arrays, strings, regular expressions, and I/O. Their primary advantage to the programmer is rapid application development. Their disadvantages include slow execution time and lack of easy interoperability with other languages. The essence of scripting in C++ is to provide a dynamically-typed 'val' class that is compatible with all the primitive C++ types, and then define lists, associative arrays, and other container classes to operate on val's. Since there is no convenient syntax in C++ for expressing user-defined aggregates such as lists, it is also necessary to provide a generic function that can read them from a character string. The only part of the standard C++ libraries that is preserved is the iostream interface.

**\*Vollmar, K.R. Department of Computer Science, Southwest Missouri State University.** NUMBER SEQUENCES FOR COMPUTER SCIENCE. By far the most popular number sequences in computer science are the cardinals, the integers, and powers of two. However, other sequences are sometimes encountered, especially in combinatorics and number theory, which have application to several areas of computer science, and which often have an intriguing physical analogy. This paper describes some of the more likely sequences that students may encounter and the classic reference materials for research.

**Wang, Y. Department of Computer Science, Southwest Missouri State University.** HOW TO BALANCE THEORETIC FOUNDATIONS AND PRACTICAL SKILLS IN COMPUTER SCIENCE UNDERGRADUATE COURSES? Both theoretic foundations and practical skills are critical factors for students in the computer science area to be successful in their careers. However, many students are interested in only the courses or the parts of courses that emphasize practical skills. This tendency leads some instructors to remove some necessary theoretic foundations from course contents, and some schools to reduce the number of well-needed theoretic courses from their curricula. In this paper the author observes teachings with different emphases, compares students' performance under the different teaching styles, and intends to stir up a discussion on this issue among peer educators.

### Conservation Section

**Ashley, D.C., J. Casey, and H. Billups. Department of Biology, Missouri Western State College.** IMPACT OF DROUGHT CONDITIONS ON POPULATIONS OF THE WHITE-FRINGED PRAIRIE ORCHID (*Platanthera praeclara*) AT THREE NORTHWEST MISSOURI PRAIRIES. *Platanthera praeclara* populations at three prairies (Helton Prairie, Tarkio Prairie, and Little Tark Prairie) in northwest Missouri have been monitored during the last five years. Individual plants (flowering and vegetative) have been located, counted, measured, and permanently marked during the summer growing seasons. In addition, seedpod maturation and number has been determined for each population. The dry conditions of the summer of 2000 severely impacted all three populations of the orchid. No plants were seen at Helton Prairie (compared to 61 in 1999), only two were located at Tarkio Prairie (compared to 5 in 1999), and only 60 were seen at Little Tark Prairie (compared to 208 in 1999). In addition, most of the plants seen at Little Tark early in the spring were no longer evident by early summer and only four plants (compared to 189 in 1999) produced flowers.

**Brewer, S. Department of Biology, Missouri Western State College.** PRELIMINARY INSIGHTS TO THE GROWTH, REPRODUCTION, AND POLLUTION TOLERANCE OF THE NORTHERN CRAYFISH, *ORCONECTES VIRILIS*, IN THE BLUE RIVER.

Little is known about the effects of pollution on *Orconectes virilis*. This study investigates how water quality may influence length-frequencies, sex and reproductive status of the northern crayfish. Using backpack electrofishing and seining, 496 crayfish were collected at four sites along the Blue River. Five water samples were taken randomly at each site and analyzed using a spectrophotometer (DR/2010). Length-frequency analysis revealed significant difference ( $\alpha < 0.05$ ) between the lengths of crayfish collected at different sites. Significant differences were also found between the mean lengths of males and females at all locations. Fifty-five percent of males collected were in the F2 reproductive form but this did not prove significant. Water quality analysis revealed significant differences ( $\alpha < 0.05$ ) for all parameters excluding chromium. This preliminary study reveals that *O. virilis* favors areas of higher nitrates, phosphates, oxygen, and ammonia. However, levels of these pollutants may be affecting the molting cycle in males thereby affecting reproduction. Multiple samplings through different seasons will be required to obtain more conclusive evidence concerning the effects of the pollutants identified in this study.

**Madzura, T. University of Missouri Outreach and Extension, Columbia.** WATERSHED INFORMATION & EDUCATION FOR NATURAL RESOURCES CONSERVATION. There are approximately 174 water bodies listed on the 303 (d) list for Missouri due to diverse water quality impairments that include: pesticides in drinking waters, wastewater treatment plant problems, channelized streams and nutrient enriched water bodies. These impairments need immediate attention to restore water bodies to their approved uses. There is a critical need to better coordinate and target programs and activities where water quality is impaired by nonpoint and point sources of pollution. Easier access to existing related information and data is a major key. Anticipated impacts include: a) More Missourians taking action to protect, conserve and enhance shared natural

resources, b) Greater acceptance of the watershed stewardship concept of natural resources conservation, c) Healthy watersheds with sustainable soil, water, plant, animal and air resources as indicated by improved water quality, and d) Impaired waters removed from the 303 (d) list. MoWIN a University of Missouri Outreach & Extension project collaborates with state and federal agencies and non-governmental organizations to help landowners and natural resource interest groups find the information they need for improved natural resources conservation. Natural resource conservation is not an isolated issue, neither is it a government only responsibility. Rather, it is an important component of complex human-environment system interactions that may together bring the world to the edge of catastrophe or create improvements in welfare and equity for all. Hence, it's everyone's responsibility. As such, " Clear, accurate, and timely information is the foundation of a sound and accountable water quality program. Informed citizens and officials make better decisions about their watersheds." (Clean Water Action Plan, 1998). For more information please visit our web site at: <http://outreach.missouri.edu/mowin/>.

**McCauley, J.R. and J.A. Raveill. Biology Department, Central Missouri State University.** EFFECTS OF PRESCRIBED FIRE AND CANOPY THINNING ON THE HERBACEOUS VEGETATION OF AN OAK-HICKORY SAVANNA RESTORATION. Oak-hickory savanna covered much of Missouri in pre-settlement times but has largely disappeared due to conversion to other land uses and succession to closed-canopy forest. Only a few scattered, degraded fragments remain including Clearfork Savannah in Knob Noster State Park. In 1983, the Missouri Department of Natural Resources initiated management efforts to restore the original vegetation of scattered oaks and hickories with an understory of prairie grasses and forbs. The restoration methods employed were thinning of the upper canopy and periodic burning. Efficacy of restoration strategies was evaluated by comparative studies in 1992 and 2000 of burned, thinned and burned, and control areas. Variables examined included species richness, species evenness, total herbaceous cover, herbaceous-layer biomass and conservation coefficients for each species sampled. Comparisons were made among treatment

areas and between years using analysis of variance, and paired t-tests. With successful management techniques, the expectations were for the treatment areas and samples from 2000 to show more diversity, greater herbaceous-layer biomass, and higher sums for conservation coefficients at each scale sampled.

**\*Morey, B., A. Scott, J. Peters, B. Davidson and J. Rushin. Biology Department, Missouri Western State College.** A TWO-YEAR STUDY OF TRANSIENT AND NESTING BIRD SPECIES IN FIVE HABITAT CATEGORIES WITH AN ANALYSIS OF THE EFFECTIVENESS OF 15-MINUTE VS. 8-MINUTE SAMPLING COUNT DURATIONS IN A POINT COUNT SURVEY. Ninety (90) species of birds were observed in old field/prairie, old field/prairie/forest edge/pond, agricultural field, forest/forest edge and forest/forest edge/pond habitat categories at the Pony Express Conservation Area near Osborn, MO during five, 10-day sampling intervals from May 1 to June 20 in 1999 and 2000. The highest bird abundance (30/plot) found was in the forest/forest edge pond habitat and the lowest abundance (22/plot) was found in the forest/forest edge habitat category for the 15-minute count duration. These results demonstrate the positive effect of a pond on bird abundance for the forest/forest edge habitat category. A pond and forest edge were shown to have a positive effect on abundance in the old field/prairie habitat category. The 8-minute count was shown to cover 59% of the bird abundance surveyed during the 15-minute count. Also, increases in diversity indices were shown for the 15-minute count over the 8-minute count. These results seem to suggest that the extra seven minutes used in the 15-minute count over the 8-minute count may produce a more representative picture of birds occurring in each plot in a point count survey of this type. Supported by the Missouri Department of Conservation.

## Geography Section

**Dodds, C. Department of Geography/Geology, Northwest Missouri State University.** THE CHANGING LANDSCAPE OF MEXICO'S POPULATION GEOGRAPHY, 1900-2000. Major changes in location of population in Mexico occurred during the 20th century. Some were the results of traditional forces, such as: nature of the physical environment; culture and interaction between key cultures; changing attitudes by government planners, and their view of national development issues; plus changing market forces in the economy. For Mexico the long border shared with the 20th century's major economic power is a critical, and unique force affecting the movement and location of population. Use of data from 1900 to the recently available 2000 census information makes possible a description of changing distribution, as well as some preliminary analysis of the forces that have shaped the current demographic landscape.

**Falke, T.M., T.L. Peterson. Department of Geography, University of Missouri - Columbia.** AN ANALYSIS OF CENSUS GEOGRAPHY. This presentation examines the US census geographies between the 1980, 1990, and 2000 censuses in order to assess the accuracy and validity of past census procedures and to evaluate present redistricting practices. The 1980 census enumeration district boundaries of the counties in Missouri were digitized into ESRI's ArcEdit off a mylar analog map series called, "1980 Census Map." This spatial coverage of the 1980 census was then compared in ESRI's ArcInfo to digital coverages of the 1990 census and the 2000 census files. The results of this study will show the spatial differentiation of the past 3 decennial census counts using ArcEdit and ArcInfo. Utilizing this GIS technology prompted a comparison of census enumeration districts that can contribute to techniques for improving the spatial analysis of such areas. Keywords: census, Arc, Missouri

**Fredrick, B. and R.T. Pavlowsky. Department of Geography, Geology, and Planning, Southwest Missouri State University.** USING BED SEDIMENT TO MONITOR PHOSPHORUS TRANSPORT AND DISTRIBUTION IN THE JAMES RIVER BASIN, SW MISSOURI. Eutrophication in

Table Rock Lake, southwest Missouri over the past decade has raised concerns about sources and transport of nutrients, especially phosphorus, in the James River Basin. Understanding the cycling, storage, and transport of phosphorus in the James River is necessary to evaluate the effectiveness of management efforts to reduce phosphorus inputs to the lake. This study used bed sediments as a medium to identify the concentrations and spatial patterns of phosphorus in the James River Basin. Fine-grained sediments were collected from eighty sites located by GPS (Global Positioning System) during a two-week period in the summer of 1999. These samples were dried and put through a 2 mm sieve, evaluated for sand and organic matter, and analyzed for "acid extractable" total phosphorus and metals. A GIS (Geographic Information System)-based approach was used to delineate the drainage area above each site and determine the land use characteristics of the sub-watershed. Sediment-phosphorus concentrations in the James River Basin average 366 ug/g and range from 100 ug/g to 1960 ug/g. The highest concentrations are found immediately below wastewater treatment plant outfalls. The spatial distribution of phosphorus is described in a multivariate regression equation ( $r^2=0.87$ ) consisting of three predictors: (1) dilution factor related to the loading of wastewater treatment plant effluents; (2) organic matter content of the sediment; and (3) percent forested land cover in the drainage area of the sampling site. There is a strong positive relationship between phosphorus in bed sediments and phosphorus in overlying water column data in the basin. The results of this study will be used to guide phosphorus management activities in the James River Basin.

**Johnson, A. Department of Geography, University of Missouri-Columbia.** COMPARISON OF SCALES: EVALUATION OF STATSGO AND SSURGO SOIL SURVEY DATA WITHIN THE DRASTIC MODEL. The purpose of this research is to compare the results of two DRASTIC models using different soil data sources. The DRASTIC model, created in 1985 by the Environmental Protection Agency and the National Well Water Association, was developed to assist planners, managers, and administrators in the task of evaluating the relative vulnerability of different geographies to groundwater contamination from various sources of pollution. As an overlay/index

model, the DRASTIC model uses seven environmental variables (one being soils) to derive its results. The two models will be run identically with the exception of 1:250,000 STATSGO and 1:24,000 SSURGO soil survey data. The DRASTIC model has almost always used 1:250,000 soil survey data. Lately, however, 1:24,000 soil survey data has become available digitally. It appears quite attractive for use in the DRASTIC model. This research will compare the results to see if the larger scale soil data affects the output of the DRASTIC model. The results of the comparisons will be a series of maps and a written description of geographic factors that may influence the results.

**McCray, T.R. Department of Political Science and Geography, Central Missouri State University.** THE LONG BALL AND CHAIN ON RUSSIAN ECONOMIC REFORM. Russia's economy shows recent signs of life, on the strength of oil and natural gas exports to Europe. But day-to-day living for the average Russian remains a greater challenge than it was in the Soviet era. Russia's GDP, the value of its currency and its social safety net have degenerated over the past decade and entrenched corruption has disheartened foreign-direct investors. Today, fundamental physiographic and historic social realities continue to hobble Russia's deliverance into the world marketplace. Redressing these fundamentals is a task beyond calibrating by the International Monetary Fund or coaxing by the Paris Club of creditors. Russia is in for a long-term struggle to make its economy more responsive to the talents and needs of its people.

**Meserve, P. Department of Science. Columbia College.** THE PLACE OF OLD GEOGRAPHY. Primary and secondary education in North America has included geography since the end of the 18th century, commonly as background to national and world history. Geographic education at this time was primarily rote memorization of locations, but included basic 'data' on political, economic, and physical geography. The majority of (male) Americans had limited educational opportunities beyond grade and high school even in the late 19th and early 20th centuries; textbooks used for human geography then were therefore major sources of public information about societies, places, and interactions around the globe. An examination of these textbooks reveals societal (and profes-

sional) biases, errors, and misconceptions about societal relations, colonialism, ethnicity, processes of development, and numerous other topics. The factual and conceptual misinformation of these textbooks helped frame (and mislead) the world-views and perspectives of generations of students/adults. Examples of writings from these textbooks provide useful lessons in how early education (and academic disciplines) are used in societal reproduction and in how paradigms shift within a discipline.

**White, J. and R.T. Pavlowsky. Department of Geography, Geology, and Planning Southwest Missouri State University.** SPATIAL ASSESSMENT OF NONPOINT POLLUTION USING BED SEDIMENT SURVEYS IN THE KINGS RIVER, NW ARKANSAS. This study of the Kings River Basin provides a spatial assessment of nonpoint pollution sources (NPS) and sediment phosphorus (P) concentration in a predominately agricultural watershed with numerous sites of land-applied animal waste. Past water column studies have targeted total phosphorus (TP) issuing from diffuse land use practices, however, few studies have used streambed sediment surveys to detect TP levels at a watershed scale. Sediment surveys may be preferred over water column surveys due to their ability to concentrate a range of pollution constituents, to be less affected by fieldwork error, and to incur fewer processing costs. Ninety-two streambed sediment samples were collected from the main stem of the river, its tributaries, and the Table Rock Lake arm near the Missouri-Arkansas border. For each site, sediment geochemistry, upstream drainage area, land use, geology, quantity of poultry operations, and sediment particle size were quantified and entered into a Geographical Information System (GIS) to create a spatial model of source geography. The median TP concentration was 130 ug/g, ranging from 40 ug/g near a pristine forested area to between 560 ug/g and 1280 ug/g adjacent to a dense area of poultry operations that reapply manure as fertilizer. Regression statistics reveal a positive relationship between TP and sediment organic matter (OM), Al, and Fe content, and a negative relationship with the percent sand of the samples (mean sand % = 85%). This study gives credibility to streambed sediment surveying in Ozarks watersheds. The quantitative results will aid natural resource managers in their ongoing attempt to under-

stand the overall dynamics of NPS pollution issuing from agricultural watersheds and how this pollution affects the local tourism industry as a result of eutrophication and declining aesthetics in Ozarks waterways.

## Geology/Geophysics Section

**\*Baugaard, W.D., and J.M. Gregg, Department of Geology and Geophysics, University of Missouri-Rolla.** STRATIGRAPHY AND FLUID EVOLUTION OF THE BUSHY PARK DEPOSIT, SOUTH AFRICA. The Bushy Park zinc-lead deposit is hosted by karst related breccias which were formed in intertidal, marginal marine, carbonate self-deposits of the Gaap plateau (Campbellrand Subgroup) after sub-areal exposure. These Paleoproterozoic age (~2.5 Ga) rocks are completely dolomitized and partly silicified but have not undergone major metamorphism. The study area transects three major formations in descending order: the Koggelbeen Formation (columnar stromatolites and oolites), the Klippan Formation (brecciated and silicified unit), and the Papkuil (algal laminates). The deposit hosts significant amounts of zinc ore (several million tons at 4%). Samples were taken from logged cores from Bushy Park drilling project. Preliminary petrographic, cathodoluminescence, and reflected light studies on carbonate cements and associated gangue and ore minerals have revealed a complex fluid chemistry associated with mineralization, characteristic of many Paleozoic Mississippi Valley-type deposits. Planned fluid inclusion microthermometry will further characterize the fluid chemistries and lead to a better understanding of the deposit.

**Dudley, M.A. and J.L. Nold. Department of Earth Science, Central Missouri State University.** MINERALOGY AND ORE TEXTURES OF THE SHEPARD MTN IRON DEPOSIT, IRON CO., MISSOURI The St. Francois Terrane of southeastern Missouri hosts 6 major iron occurrences and over 30 minor occurrences. The Shepard Mountain Deposit represents one of the largest minor iron deposits and occurs about a mile SW of the Pilot Knob underground magnetite deposit. The ores are exposed as two northeast-trending, near vertically dipping veins, hosted by Middle Proterozoic rhyolites. Ore mineralization is characterized by abundant magnetite and lesser

amounts of hematite with minor quartz, pyrite, chalcopyrite, maghemite?, chlorite, goethite, and sericite. Textures indicate a complex history of oxidation and reduction. Magnetite commonly forms euhedral aggregates and is present less commonly with colloform habit. Hematite is present as specular laths and as martitic replacement textures in magnetite. One of the unusual features of the deposit is the partial reduction of specular hematite to magnetite. Although the primary mineralization suggests similarities to the Pilot Knob underground and Iron Mountain deposits, the gangue mineralization in the Shepard Mountain deposit shows none of the diversity observed in these nearby larger deposits. Mineralogical and textural evidence indicates probable deposition of Fe-oxides from Si-poor hydrothermal solutions.

**\*Dunn-Norman, S., L.F. Koederitz, R.C. Laudon, D. Numbere, and A. Gupta. School of Mines & Metallurgy, University of Missouri-Rolla.** FEASIBILITY OF APPLYING HORIZONTAL WELL TECHNOLOGY TO THE HEAVY OIL SANDS OF WESTERN MISSOURI.

It has been known for well over 100 years that heavy oil deposits occur in Pennsylvanian aged sandstones in the shallow subsurface of west-central Missouri. In-place reserve estimates have varied widely, but an inventory in 1977 places them at 1.8 to 1.9 billion barrels. Recoverable reserves are very difficult to estimate because of uncertain geologic conditions and sensitivity of reserves to economic conditions. A number of companies, including Phillips, Shell, Esso and Carmel Energies, have attempted to produce this oil using a number of different enhanced oil recovery (EOR) techniques. Carmel Energies operated a successful Vapor Therm recovery process (cyclic steam injection enhanced by fuel gas) into the 1980s, but the operation was discontinued when the price of oil fell below \$20/barrel. In October, 2000, a well was drilled in Section 32 of T36N, R33W to evaluate the potential for applying horizontal well technology to these sands. Two sands having a total thickness of 41 net feet, porosity of 17% and water saturation of 38% were identified. Projected drainage areas associated with horizontal well lengths drilled parallel to point bar lateral accretion growth directions (across clay drapes) suggest that horizontal well technology could significantly enhance production from these sands.

**Hagni, A. Eagle-Picher Industries, LLC., Quapaw, OK.** AN OVERVIEW OF MINERALOGICAL CHARACTERIZATION TECHNIQUES EMPHASIZING APPLIED MICROSCOPY. As processing of geological and recycled materials becomes more complex due to environmental and economic limitations, resolving mineralogical interactions during and after processing becomes more critical. Several traditionally economic geology tools are applicable to characterizing materials mineralogically. These include X-ray diffraction, transmitted light microscopy, reflected light microscopy, scanning electron microscopy, transmission electron microscopy, and electron microprobe. Non-traditional techniques, including Auger electron spectroscopy, X-ray photoelectron spectroscopy, Mossbauer spectroscopy, and cathodoluminescence microscopy, are also beneficial in determining mineralogical interactions of processed materials. Each of these techniques is summarized with an industrial application example of its usefulness, and how these techniques are best utilized when used in conjunction with one another.

**\*Hagni, R.D. and P. Shivdasan. Department of Geology and Geophysics, University of Missouri-Rolla.** SEQUENTIAL ALTERATION OF LARGE PYRRHOTITE CRYSTALS TO MARCASITE, SKELETAL PYRITE, AND GOETHITE IN PEGMATITIC CARBONATITES AND FLUORITE ORES AT OKORUSU, NORTH CENTRAL NAMIBIA. Large pyrrhotite crystals in very coarse-grained pegmatitic carbonatites in the late Cretaceous alkaline igneous-carbonatite complex at Okorusu in North-Central Namibia show an interesting sequence of alteration stages. The initial alteration of the hexagonal pyrrhotite crystals is to elongate marcasite crystals oriented parallel to the (0001) face of the host pyrrhotite. Pyrrhotite and marcasite are subsequently altered to a mosaic of skeletal pyrite, initially fine-grained and subsequently coarser grained, and with intimately intergrown secondary magnetite and hematite. Those stages of alteration are interpreted to have formed during late magmatic time, and they can be observed in pyrrhotites from carbonatites elsewhere, e.g., Jacupiranga, Brazil; carbonatites in Russia. Further alteration of the pyrrhotite, marcasite, pyrite, magnetite, and hematite to goethite occurred during the replacement of the host pegmatitic carbon-

atite by the fluorite ores. Locally, the platy crystals have been dissolved to form platy leach casts. The presence of platy goethite pseudomorphs and platy leach casts after pyrrhotite provide important evidence for the origin of Okorusu fluorite orebodies by the replacement of pegmatitic carbonatite. Supported by two National Science Foundation international travel grants and two Society of Economic Geologists research grants.

**\*Hagni, R.D. Department of Geology and Geophysics, University of Missouri-Rolla.** THE SIGNIFICANCE OF CARROLLITE REPLACEMENT TEXTURES IN BORNITE PODS AT THE SWEETWATER MINE, VIBURNUM TREND, SOUTHEAST MISSOURI. Ore microscopic examination shows that carrollite is present as a persistent minor ore mineral in most bornite pods in the Viburnum Trend in southeast Missouri. Carrollite is especially abundant in bornite pods in the Sweetwater mine at the south end of the Trend, where it forms rather large crystals about 600-2000  $\mu\text{m}$  across. Carrollite was deposited early in the paragenetic sequence of the varied ore minerals present in the bornite pods, and it exhibits an especially interesting variety of replacement textures with respect to the subsequently deposited chalcopyrite and bornite. Internal chemical zoning within the carrollite crystals commonly has led to the preferential replacement of their interior portions, whereas the thin outer portions of those crystals may remain as unreplaced remnants that exhibit isometric crystal form. Many partially replaced carrollite crystals, however, exhibit interior unreplaced remnants that are spheroidal. The spheroidal shapes of these carrollite replacement remnants have some similarities, with respect to shape and size, to the spheroidal textures that are typical for the main portions of the bornite pods represented by abundant chalcopyrite and bornite. These observations raise the interesting question as to whether the spheroidal textures shown by chalcopyrite and bornite in most of the bornite pods could have resulted from the replacement of abundant earlier deposited spheroidal carrollite.

**\*Shivdasan, P. and R.D. Hagni. Department of Geology and Geophysics, University of Missouri-Rolla.** OCCURRENCE OF MAGNETITE AND ITS RELATIONSHIP TO PEGMATITIC CARBONATITE, PYROXENE CARBONATITES AT THE ALKALINE IGNEOUS-CARBONATITE COMPLEX, OKORUSU, NAMIBIA. Previously unrecognized carbonatites at Okorusu in North-Central Namibia, pyroxene carbonatite and pegmatitic carbonatite, have been found to be comparable in mineralogical composition during the field mapping, and the modal percentages of magnetites are unusually high. The magnetites in the pyroxene carbonatites are medium grained embayed crystals whereas in pegmatitic carbonatite they are very coarse and euhedral crystals that tend to form at the margins of their contacts especially with the Na-fenite host rocks. Magnetite rims of thickness up to 2 feet and magnetite disseminations occur within the pegmatitic carbonatite. Magnetite contains inclusions of calcite, apatite, phlogopite, and pyroxenes. Electron microprobe analysis of magnetites indicate that they are not zoned with regard to their Ti contents, in contrast to magnetite associated with carbonatites at Jacupiranga, Brazil. Okorusu magnetites exhibit abundant exsolutions of ilvospinel in a characteristic cloth texture, and oxidation exsolution occurred subsequently. Supported by two National Science Foundation International Travel grants and two Society of Economic Geologists research grants.

**Trimble, J.C. Geography, Geology, and Planning, Southwest Missouri State University.** UTILIZING DIGITAL ORTHOPHOTOS TO ASSESS STREAM CHANNEL MIGRATION PATTERNS. Assessing lateral migration patterns of streams that have not been previously surveyed is problematic. The current study utilizes digital orthophotos to assess floodplain erosion patterns for Chat Creek in southwest Missouri. Chat Creek is listed on the EPA's 303d list for zinc contamination; eroding floodplain deposits are a potential non-point source of zinc. Aerial photographs from 1939, 1975, and 1992 were ortho rectified using a 1997 USGS digital orthophoto quarter quad (DOQQ), a digital elevation model (DEM), and camera calibration data. The orthophotos were evaluated for accuracy and channel centerlines were digitized for each year. The centerlines were overlain and divided into 317, 20 meter

segments for assessment. Three types of reaches were identified within Chat Creek. Channelized sections were identified as separate reaches because lateral movement is the result of anthropogenic activities. Two other types of reaches were identified; "stable" reaches averaged less than 5 meters of change per segment and "disturbance" reaches averaged 5 - 10 meters of change per segment for the study period (1939-1997). Combining this data with floodplain zinc concentrations will provide estimates of non-point source zinc loading into Chat Creek from lateral channel migration.

## Physics Section

**\*Geilker, C.D. and D.B. Baker. Department of Physics, William Jewell College.** INSTANT FEEDBACK IN THE CLASSROOM USING PRS INFRARED REMOTES. Techniques for registering immediate student feedback in the classroom have evolved from hard-wired keypads on desks, through radio-frequency transmitter-receivers, to the present infrared devices, which resemble TV remote controls. With a remote assigned to each student, the instructor may interpolate questions via the blackboard, overhead projector, or computer screen. Student responses are displayed in real time as they occur, visible to the instructor and also to the students, if desired. The responses for each question can be sent to the computer's hard disk and accessed later for review or grading. We have used this technology in our algebra- and calculus-based physics classes and also introduced it into the core-curriculum general education courses taught in the physics department. While it can be used spontaneously as a two-minute interlude in any lecture, it seems to work best with "concept tests" prepared as suggested by Mazur (Peer Instruction, Prentice Hall, 1997). We are considering incorporating the scores into the students' grades, as suggested by Burnstein and Lederman (The Physics Teacher, Jan., 2001, p.8).

**\*Kapoor, Y.M. Division of Agriculture, Natural Sciences and Mathematics, Lincoln University.** STUDY OF THE SMALL ANGLE X-RAY SCATTERING DATA OF SOLIDS WITH TWO LENGTH SCALE STRUCTURE. A technique has been developed for using small angle x-ray and neutron scattering to study solids that are composed of systems of interacting scatterers. These solids have structure on two length scales that normally differ by a factor of at least 100; average diameters of the systems and the scatterers. The diameter is defined to be the longest distance separating two points in a scatterer. The new method makes use of an equation for analyzing the intensity of the small angle scattering from systems of interacting scatterers. The equation for the intensity takes account of the shapes and the diameter distributions of both the systems and the scatterers. With this technique, structure on length scales from 5 to 10,000Å can be investigated.

**\*Manivannan, K. and C.P. Schaefer.\* Southwest Missouri State University, and Meltzer, D. E., Iowa State University.** PROMOTING ACTIVE LEARNING IN PHYSICS LECTURE CLASSES USING INTERACTIVE DEMONSTRATIONS. Physics teachers consider in-class demonstrations to be a very important part of instruction. Demonstrations make physics classes fun and entertaining, and can help to stimulate students' interest and curiosity. However, it has become increasingly clear that some form of interactive engagement is essential to maximize the effectiveness of classroom demonstrations.(1,2) Only a handful of interactive curricular materials (2) are currently available for in-class demonstrations. We will describe several interactive physics demonstrations suitable for any classroom setting that can easily be implemented without additional resources. The central feature is the use of the "problem-dissection" technique (3) to break a concept into several linked "mini"-demos. These are presented to the class in a sequence while utilizing techniques (3) for acquiring immediate feedback from all the students in the class. We present some preliminary findings on the effectiveness of these interactive demos. Work supported in part by a FFR grant and a ST3 grant. (1) P. A. Kraus, 1997. (2) D. R. Sokoloff and R. K. Thornton, 1997. (3) D. E. Meltzer and K. Manivannan, 1996.

## Science Education Section

**Carden-Jessen, M. Department of Geography, Geology, and Planning, Southwest Missouri State University.** THE EFFECTIVENESS OF USING ENVIRONMENTAL EDUCATION TO CONTENT. When the scores of the 1999 and 2000 MAP test were reported to a rural school district in Southwest Missouri, there was an indication that more formal study of environmental education as a method to teach content was needed. The scores of Conway Junior High School increased in the Advanced and Proficient categories by 37% in just two years. There was a reduction in the Step One category from 23% to 5%. The change that took place from the 1997-1998 school year to the 1998-1999 school year was small. The textbook was no longer used. The primary method of instruction was provided by the Missouri Projects (Project Learning Tree, Project Wild, and Project WET) along with information and materials gained from attending Missouri Department of Conservation workshops. Supplemental materials are needed to cover space and simple machines but all other content knowledge was covered through environmental education methods. Not only were the test scores greatly improved, no students were pulled out of science for special classes. The types of activities were such that all students, no matter the level, were able to participate and achieve some measures of success.

**\*Eckdahl, T., D. Ash, and N. Reece. Department of Biology, Missouri Western State College.** FUNCTIONAL GENOMICS IN THE UNDERGRADUATE CURRICULUM. Microarray technology promises to revolutionize the investigation of gene expression at the genomic level, but it has been inaccessible to undergraduates because of limitations in funding and faculty expertise. To address these issues, the Genome Consortium for Active Teaching (GCAT) was organized in December 1999 to bring functional genomics methods into undergraduate courses and independent student research. Its goals are to make microarray experiments affordable through cost sharing, to provide a clearinghouse of information, raw data and analyzed results for use in teaching genomics, and to develop a network of teachers using functional genomics. In September of 2000, the first GCAT members (23 faculty from the US and Canada)

obtained 135 yeast DNA microarrays (provided by Dr. Pat Brown of Stanford University) which consist of every open reading frame from the budding yeast *S. cerevisiae*. As part of GCAT, Missouri Western students conducted functional genomics experiments to address the effects of DNA binding drugs on global patterns of gene expression in yeast. They gained experience in experimental design, yeast culturing, RNA isolation, preparation of fluorescent cDNA probes, hybridization, and microarray data analysis. The in-class experiments have also lead to exciting independent research projects for several students. These outcomes at Missouri Western validate the GCAT approach and support the view that it will have an important impact on undergraduate education.

**Forawi, S.A. Department of Curriculum and Instruction, Central Missouri State University.** CRITICAL THINKING AND THE NATIONAL SCIENCE STANDARDS. Reform initiatives of science curriculum development have stressed the importance of fostering students' ability to think critically. The National Institute of Education recommended in 1984 that critical thinking be included in curriculum development to make it possible for students to develop critical thinking skills and use them effectively in changing society. This was aimed to identify and assess critical thinking attributes of the National Science Education Standards. Participant educators will identify and assess those proposed activities of the National Science Education Standards using a critical thinking rubric (Paul, 1995). Participants will work as a professional reference group to validate similar results of 120 preservice teachers who responded to the critical thinking rubric. Implications and results discussion were provided.

**Frazier, R. and S.A. Forawi. Department of Curriculum and Instruction, Central Missouri State University.** PRESERVICE TEACHERS' PERCEPTIONS OF SCIENCE FIELD EXPERIENCE. The purpose of this study was to identify variables of success related to science field experience. A sample of 50 preservice teachers participated in an elementary science field experience as part of a science methods course. Students' journals, field experience grades, and observations (interviews) were analyzed. Major results indicated a positive response to the field

experience by the preservice teachers. The data analysis also showed predictable patterns of variables related to students' successful science field experience that included an early planning for lessons, science resources, teacher support, and student' cooperation. Implications of the study will contribute important practice and information for preservice teacher education reform.

**Hall, T. R., D. Ashley, and J. Rushin. Department of Biology, Missouri Western State College.** ACADEMIC ACHIEVEMENT IN INTRODUCTORY BIOLOGY: THE RELATIONSHIP OF STUDENT VARIABLES. The purpose of the current investigation is to identify student variables affecting achievement in an introductory biology course designed for biology majors. 53 students from four separate semesters responded to an instrument assessing entry-level background, interest in biological emphasis, and confidence of successfully completing activities that relate to understanding biology as a process. The confidence measures were subcategorized according to ability to write research manuscripts, ability to relate and understand scientific concepts in the real world, ability to understand scientific literature, ability to perform experimental tasks within the laboratory, and confidence in succeeding with a college education. Data analysis revealed that confidence significantly increased in each subcategory except success in college ( $p < .002$ ). Additionally, those with high cumulative confidence coming into the course had significantly better grades than students with low cumulative confidence ( $F(3, 242) = 3.635, p < .014$ ). Male students had significantly higher confidence in performing laboratory techniques than females ( $p < .023$ ), and no difference in the other four subcategories ( $p < .05$ ). The data presented in this study can assist biology professors determine what parts of the curriculum are facilitating confidence, and what modifications need to be made to enhance student learning to a greater degree.

**Mantei, E.J. Department of Geography, Geology and Planning, Southwest Missouri State University.** SUCCESS IN THE CLASSROOM WITH INTERNET NOTES AND POWERPOINT LECTURE SLIDES. A multi-year study of student exam scores in classes, which used computer-related

activities in presenting class material, was compared to the same in classes, which used the chalkboard and overhead transparencies format. Seven hundred and forty three students represented the control group. Class material had been presented to these students using the traditional method. These materials were converted into detailed Internet notes. A condensed version of the Internet notes was prepared in PowerPoint and used for lecture presentations. Two hundred and sixty eight different students represented the test group. These students used Internet notes and were exposed to PowerPoint slides. The test group rated the presentation of class materials in the Internet-notes and PowerPoint formats as much more desirable than the traditional format used in other classes they attended. Students in the test group scored a half-letter grade higher on exams than those in the control group. The use of Internet Notes and PowerPoint slides was more efficient. The same subject material was presented in 15-20% less time compared to the traditional method. Appropriate controls in the testing were used.

**Roy, P., J. Wagner, and J. Carl. Education Department, Drury University, Springfield, MO 65802.** USING PARTNER SCHOOLS TO TEACH THE SHOW-ME AND NATIONAL SCIENCE EDUCATION STANDARDS. A number of Missouri Show-Me Standards, as well as National Science Education Standards, were successfully implemented in collaboration with the middle and high school science teachers. Pre-service teachers at Drury University were actively involved in facilitating activities and providing individual tutoring to students in partner schools. The constructivist model was implemented in teaching the following science concepts: the periodic table, classification, DNA, and the scientific method. Strategies used were: cooperative learning, hands-on inquiry, computer-aided instruction, and lecture. Students in the partner schools demonstrated meaningful understanding through active participation, higher-level questioning, and achievement. A positive classroom climate was observable through students' excitement and motivation to learn, thus creating an atmosphere conducive to learning.

**Sarkar, S. Department of Chemistry and Physics, Central Missouri State University.** RESULTS AND REFLECTIONS FROM THE EISENHOWER WORKSHOPS FOR HIGH SCHOOL TEACHERS, "SHOW-ME" CHEMISTRY IN THE MARKETPLACE. "Show-Me" Chemistry in the Marketplace, a professional development activity for high school teachers, was funded by the Eisenhower grant cycle XVII. It was conducted at Central Missouri State University for five consecutive weekends in Fall 2000. The workshop focused on the properties and principles of matter and energy, and tied abstract concepts in relevant and engaging contexts of marketplace chemistry. Through several safe and short investigative activities, teachers learned interdisciplinary approaches of teaching natural sciences to meet the Show-Me and National Science Standards. The paper will briefly discuss the activities covered, implementation of these activities in the respective classrooms, and pre and post survey results from more than a thousand high school students.

**Schaefer, C.P. and K. Manivannan. Department of Physics, Astronomy & Materials Science Southwest Missouri State University.** ACTIVELY ENGAGING STUDENTS IN LEARNING PHYSICS USING THE KWL METHOD. Research has shown that active learning improves comprehension and conceptual understanding of physics, but active learning is not always easy to apply to what you are teaching. Even if the students are actively engaged in learning they may leave the classroom not realizing what they have learned. The KWL method, familiar to teachers of reading, can be used also in teaching physics.(1,2) The KWL initials stand for recording what the students know, what they want to know and what they have learned. This method offers a general system of approaching new material that can be used by teachers to actively engage students in the learning process. Preliminary results show that students easily learn and like this method. Four semesters of data show that students taught with the KWL method do as good or better than the students taught by the traditional method. (1 Donna Ogle, 1986. 2 Eileen Carr and Donna Ogle, 1987.)

**Shaw, J.E. Department of Chemistry and Physics, Northwest Missouri State University.** INCREASING ACTIVE LEARNING ACTIVITIES IN INTRODUCTORY PHYSICS. By scheduling the calculus based introductory physics course to meet in three two-hour blocks each week with the laboratory reserved for the same time, laboratories and other active learning activities can be increased and better integrated to the presentation of material in the course. This has been done at Northwest Missouri State University for the past 4.5 years. The first 20 to 30 minutes of class is devoted to a discussion of homework problems followed by a 20 to 30 minute lecture. The students then perform a laboratory or other active learning activity for the last hour of the class. The success of this approach has been measured by means of attendance, retention, performance on a conceptual pre-test/post-test, performance on regular course examinations, and special course evaluations given to the students. All of these measures have shown that this approach has been very successful. Attendance has ranged between 75% and 85% over the past 4.5 years as compared to 50% to 75% for the eight years prior to this. Overall retention has been 80% over the past 4.5 years as compared to 70% for the eight years prior to this. Course evaluations show that the students definitely prefer that the lecturer "get to the point" in concise lectures and allow the students to gain knowledge of the details within the framework of some active learning activity following the lecture.

### Speleology Section

**\*Adams, G. L., and B.M. Burr. Department of Zoology, Southern Illinois University Carbondale.** TROGLOMORPHIC BANDED SCULPIN (*COTTUS CAROLINAE*) IN PERRY COUNTY, MISSOURI: MORPHOLOGICAL VARIATION AND CONSERVATION STATUS. Banded sculpin (*Cottus carolinae*) occur in surface streams and springs in the eastern United States. Occasionally, *C. carolinae* have been reported in cave systems but these populations do not appear to be more than troglaphiles, exhibiting no cave adaptations. However, populations of *C. carolinae* have been found from caves in Perry County, Missouri, that display characteristics similar to other cave-adapted fish species and are here referred to as grotto sculpin. Significant external morphological dif-

ferences were found among all populations using discriminant function analysis ( $P < 0.05$ ). Canonical analysis provided separation based on alterations in eye size, head shape, and caudal peduncle region. *Cottus carolinae* collected from caves and resurgence streams in Perry County exhibit reduced pigmentation and pelvic fin ray counts compared to other surface streams in Missouri and to the literature. Differences among populations were also detected using variables associated with brain morphology and cephalic lateralis pore size. Caverniculous populations of sculpin may be jeopardized from a conservation standpoint due to their limited distribution, decline in range, and the impact of human activity. Because grotto sculpin hold the unique position as the only representative of cottids showing cave adaptation we argue for recognition, if not as a distinct taxonomic species, then at least as a distinct population segment or a biologically isolated unit. We recommend U.S. Fish and Wildlife Service and Missouri Department of Conservation consider providing protection for the grotto sculpin under state and federal laws. Supported by National Speleological Society, Missouri Speleological Survey, Raney Award, and Explorer's Club.

**\*Adams G.L., S.R. Adams, and B.M. Burr. Southern Illinois University at Carbondale.** STATUS OF SPRING CAVEFISH IN MISSOURI: A STUDY IN PROGRESS. Spring cavefish (*Forbesichthys agassizi*) were first discovered in Missouri at Benton Hills in 1976 and subsequently listed as State Endangered. In May, 1999, we initiated the first comprehensive study of spring cavefish in Missouri. The objectives of this study were to: 1) document abundance and distribution of spring cavefish on a spatial and temporal scale and 2) examine life history characteristics of this poorly-studied species. Five springs at Benton Hills were examined, but only two (West Spring and East Spring) were found to support cavefish populations. East Spring generally had higher fish abundance compared to West Spring. Seasonal variation was detected in abundance and distribution at both springs, with highest numbers observed in spring (95 total) and lowest numbers in summer (18 total) and fall (7 total). During spring, cavefish were found throughout East Spring, but were concentrated at the spring head in West Spring. A size-frequency histogram revealed at least two size classes

were present, the smaller size class representing young-of-the-year. Many fish (>80%) in the summer and fall samples exhibited signs of stress, including damaged fins and fungus. In winter, 2001, fish abundance was higher (23 total) compared to summer and fall, and fish appeared to be in better condition. We will continue monitoring over the next two years to further elucidate factors affecting abundance and life history patterns of spring cavefish in Missouri. Supported by Missouri Department of Conservation.

**Aley, T.<sup>1</sup>, C. Aley<sup>1</sup> and D. Ashley<sup>2</sup>.** <sup>1</sup>**The Ozark Underground Laboratory and** <sup>2</sup>**Department of Biology, Missouri Western State College.** THE OZARK UNDERGROUND LABORATORY: 35 YEARS AS AN EDUCATIONAL RESOURCE IN SPELEOLOGY. The Ozark Underground Laboratory (OUL) consists of 600 acres of Ozark upland overlying Tumbling Creek Cave, a unique resource designated a National Natural Landmark. The purposes of the OUL are to encourage education, resource use, and research in the cave regions of the United States. The Laboratory conducts educational field trips, is available for extended field studies, provides research facilities and assistance and does consulting work and contract investigations on water and land use problems in cave regions. A variety of typical Ozark habitats are easily accessible from the OUL. These include caves and other karst features, Ozark upland forests and glades, and clear Ozark streams. Personnel of the OUL provide educational field trips relating to karst resources and also present technical training workshops in karst hydrology.

**Ashley, D.C.** Department of Biology, Missouri Western State College. A DESCRIPTION OF TWO BIOSPELEOLOGY COURSES AVAILABLE TO MISSOURI STUDENTS. BIO355 (Cave Ecology) is a three credit course available to students enrolled at MWSC. The course deals with the ecology of cave habitats and includes information on biotic and abiotic factors affecting cave organisms, cave microhabitats, trophic interactions, and evolutionary adaptations. Students are required to participate in two caving trips during the semester. Field activities emphasize miniprojects that relate to cave ecology. BLA432-1N (Ozark Cave Biology) is a four credit course offered during a three week summer session at Saint Louis

University's Reis Biological Field Station near Steelville, MO. It is an introduction to the study of caves including geological processes involved in cave formation and the biology of cave organisms. Field work involves studying numerous cave systems in the Ozarks of Missouri.

**Ashley, D.C.** Department of Biology, Missouri Western State College. SPELEOLOGICAL FOCUS OF A BEGINNING CAVE EXPLORING CLASS IN THE CURRICULUM OF MISSOURI WESTERN STATE COLLEGE. PED171 (Beginning Cave Exploring) is a "life time activity" course offered through the Department of Health, Physical Education and Recreation at MWSC. The course description indicates it is an introduction to the sport of spelunking with an emphasis upon safety aspects and appreciation of cave ecology. Students enrolled in PED171 receive nine hours of class instruction before participating in a caving trip. Topics covered before the caving trip include: cave formation, geographical distribution of caves, speleothems, equipment, techniques and rules of caving, caving organizations, cave conservation and cave ecology. Student grades are based on a final exam, completion of a "cave journal," participation in the caving trip and equipment maintenance and preparation. Although most students do not continue caving after the course, some alumni from this course have become active participants in a number of caving organizations.

**Ashley, D.C.<sup>1</sup>, P. McKenzie<sup>2</sup>, P. Haverland<sup>3</sup>, and T. Aley<sup>4</sup>.** <sup>1</sup>Department of Biology, Missouri Western State College, <sup>2</sup>Ecological Services, U.S. Fish and Wildlife Service, <sup>3</sup>Midwest Science Center, National Biological Service, and <sup>4</sup>Ozark Underground Laboratory. EVALUATION OF THE POPULATION STATUS OF THE TUMBLING CREEK CAVESNAIL (HYDROBIIDAE: *Antrobia culveri*). The Tumbling Creek Cavesnail was described in 1971 based on specimens recovered from Tumbling Creek Cave in Taney County, Missouri. A stratified sampling scheme was developed in 1996 to monitor the population of this endemic snail. The snail population has been censused thirteen times in the last five years. This monitoring project provides evidence that snail populations have decreased substantially. Data on snail size class distributions suggest a

decrease in recruitment of young individuals into the population has occurred. We were unable to find a single specimen of *A. culveri* during the last cave visit. This project was funded in part by a grant from the U.S. Fish and Wildlife Service

**\*Elliott, W.R. Missouri Department of Conservation, Natural History Division.** THE MISSOURI DEPARTMENT OF CONSERVATION'S CAVE PROGRAM. The Missouri Department of Conservation (MDC) began a concerted effort to conserve caves and cave life in the late 1970s. The initial focus primarily was on endangered species, such as Indiana bats, Gray bats, and Ozark cavefish. Of the 5,700 caves in Missouri, MDC owns about 210. The Natural History Division spearheaded efforts to inventory and evaluate caves, and certain caves were protected for wildlife and other values. MDC provides assistance to other agencies and private landowners to evaluate and protect their cave resources. MDC provides magazine articles, television programs, public lectures, teacher workshops, and grants to research karst wildlife and hydrology. With the addition of a full-time cave biologist in 1998, our program has grown to include databases on caves and their wildlife, symposia and workshops on cave ecology and management, publications, videos, and increased support of research, management, education, proper cave signage, and cave gating. We are sponsoring cave restoration and bioinventory projects with cooperating grottoes (chapters) of the National Speleological Society. In 2001 MDC will sponsor a cave gating workshop, an interstate publication on karsts, small grants, a new video, and perhaps a traveling, educational "Cave Caravan."

**\*Elliott, W.R. Missouri Department of Conservation, Natural History Division.** CAVE VANDALISM: A PERVERSIVE PROBLEM. The vandalism of caves is a persistent, pervasive problem throughout the world. Prehistoric humans used caves for shelter and self-expression, which ranged from graffiti to sacred art. Presently, cave vandalism occurs in three overlapping categories: 1) Casual vandalism caused by recreators and untrained novices who may visit caves to sightsee, litter, smoke, drink, go to the restroom, disturb bats, build fires, and mark graffiti; 2) Malicious vandalism involves harassment or killing of

bats, breaking and stealing speleothems, breaking cave gates, and massive spray painting; and 3) Professional looting of archaeological artifacts is supported by selling the loot at flea markets, gem shows, and on the internet. The overuse of caves, even by well-meaning visitors, gradually degrades the largely nonrenewable cave environment. Missouri has weak cave and archaeological protection laws. The Missouri Cave Resources Act is rarely enforced on vandals, probably because it is poorly known among prosecutors and it provides only Class B misdemeanor penalties. Felony theft and strong penalties under the federal Archaeological Resources Protection Act and federal Cave Resources Protection Act may be effective, but may apply only to federal land. The real problem is in preventing vandalism and apprehending vandals. I will discuss alternatives for public education and technology for cave protection.

**Roman, L.L. and G.L Adams. Department of Zoology, Southern Illinois University Carbondale.** INFLUENCE OF FOOD AND PHOTOPERIOD ON THE METABOLIC RATE OF BANDED SCULPIN, *COTTUS CAROLINAE*. Metabolic rate of aquatic organisms is known to be influenced by environmental factors, including temperature, photoperiod, season, and food availability. Organisms adapted to cave habitats are thought to exhibit a reduction in metabolism as a result of this unique environment. In Fall 1999, metabolic rates of grotto sculpin, allocated to the *Cottus carolinae* species group, were studied in caves of Perry County, Missouri and found to be significantly lower than *C. carolinae* living in surface streams. Lower metabolism of grotto sculpin raised questions about environmental conditions in the cave that might influence physiology. As caves sustain a fairly constant temperature and season, we were particularly interested in ways photoperiod and food availability influence metabolic activity of *C. carolinae*. We conducted a laboratory experiment in which adult and juvenile *C. carolinae* from a surface stream were placed into one of the following four photoperiod and food treatments: (1) 24 hours dark/low food; (2) 24 hours dark/high food; (3) 12 hours light:12 hours dark photoperiod/low food; and (4) 12 hours light:12 hours dark/high food. The fourth treatment served as a control to account for the influence of laboratory acclimation on the sculpin. Initial metabolic rates,

weights, and lengths were measured after fish were collected and before being placed into their designated treatments. After a minimum of eight weeks of acclimation, final metabolic rates, weights, and lengths will be taken. Results of these analyses and their implications on metabolism as a result of photoperiod and availability of food will be presented. Supported by Cave Conservancy Foundation Undergraduate Fellowship.

**Smith, K. L. and G.L. Adams. Department of Zoology, Southern Illinois University Carbondale.** DIFFERENCES IN FEEDING BEHAVIOR, PREY SIZE AND DIETARY COMPOSITION AMONG BANDED SCULPIN POPULATIONS IN PERRY COUNTY, MISSOURI. In the early 1990s, unique populations of banded sculpin (*Cottus carolinae*) were discovered in Missouri, showing troglomorphic adaptations typical of many cave species. Banded sculpin are traditionally crepuscular feeders. We were interested in investigating the differences in feeding behavior of these unique cave sculpin populations from typical surface populations. Stomachs were removed from samples collected for a previous study

and analyzed for content. At the study sites, contents were flushed, using a non-lethal method, from the stomachs of fish found and taken to the laboratory for analysis. Initially, results indicated surface sculpin had an average stomach content weight approximately six times that of the cave populations, while there was not a significant difference in total body weights. Surface sculpin total body weight was only 1.1 times the weight of the cave sculpin. Surface sculpin stomachs contained an average of 76% fish including *Percina* and *Notropis*, and 16% invertebrates including Ephemeroptera, Trichoptera, Zygoptera and Gammaridae. Organic debris (1%) was also found in the surface sculpin stomachs. In the cave sculpin, the stomachs contained 55% partially digested invertebrate material, 32% Gammaridae and a higher percent (4%) of organic debris compared to surface sculpin. The cave sculpin stomachs also contained 9% acanthocephalon parasites, which were not found in the surface populations. Differences in diel rhythmicity will be discussed. This study is important because it will lead to conservation efforts on behalf of these unique cave populations of banded sculpin.



# Collegiate Division

## 2001

### Biological Science Section

**\*Billiard, K.N. and J.R. Penrod. Division of Agriculture, Natural Science and Mathematics, Lincoln University.** INFLUENCE OF FOOD QUALITY AND HABITAT DENSITY ON DEVELOPMENT OF *Aedes triseriatus*. Larval growth and development parameters play a significant role in size of adult female *Aedes triseriatus*. Adult size for female mosquitoes is critical to their ability to become infected with and to transmit specific diseases. This study examines the effect of food quality in concert with population density as a function of crowding. Food quality is presented as either natural leaf litter or a protein supplement (concentrated liver). Influences of density are examined by altering the volume of water while maintaining a constant number of larvae. The experimental design includes three volumes of water (25, 50 or 100 ml) scored against four food manipulations (no food, leaf litter, protein or both leaves and protein). Development time should be longest when no food resource is available and development times should decrease with protein supplementation, leaf litter and combined additions in that order. The restriction of habitat size should create crowding at small volumes extending development times, however because food resource remains constant for all volumes, the ratio of food/ml should increase. This would alternately cause a decrease in development time producing an interaction between the variable of food quality and habitat density. Supported by HAMP.

<sup>1</sup>Butcher, M.,\* <sup>2</sup>A.E. Marsh, <sup>1</sup>C.A. Schmidt. <sup>1</sup>Department of Biology, Central Missouri State University. <sup>2</sup> University of Missouri-Columbia, College of Veterinary Medicine. SURVEY FOR *SARCOCYSTIS NEURONA* IN TAXA OF SMALL MAMMALS FROM JOHNSON AND HENRY COUNTIES, MISSOURI. *Sarcocystis neurona* is a parasite responsible for Equine Protozoal Myeloencephalitis (EPM). EPM, the leading equine neurological disorder of the decade, is an attack on the central nervous system, where inflammatory lesions

form, caused by replicating parasites in the brain and/or spinal cord. The lifecycle of *S. neurona* is largely unknown; however, it has been shown by genetic analysis of *S. neurona* that the opossum (*Didelphis virginiana*) is a definitive host. The intermediate host species has not been identified, and there may be more than one species involved. An investigation was initiated to determine the natural life cycle of *S. neurona*. Tissue samples of the opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), hispid cotton rat (*Sigmodon hispidus*), deer mouse (*Peromyscus maniculatus*), and the prairie vole (*Microtus ochrogaster*) were examined microscopically for merozoites and/or sarcocysts. Twenty-one (35%) of the sixty samples surveyed, including samples from *D. virginiana*, *P. lotor*, *S. hispidus*, and *M. ochrogaster*, displayed *Sarcocystis* sp. merozoite and/or sarcocyst infection and were subjected to a digestion process to separate the parasite from the host mammalian tissue. Amplification of the parasite intertranscribed spacer region 1 gene and a gene sequencing protocol were utilized to distinguish between *S. neurona* and other similar sarcocystis species (*S. falcatula* and *S. kirkpatricki*).

Counts, J.W., L. Henley, M. Skrabal, and H.W. Keller. Department of Biology, Central Missouri State University. BIOLOGICAL JEWELS IN TREE CANOPIES. The Great Smoky Mountains National Park (GSMNP) is famous for its large remaining uncut forest, over 40,000 hectares, in the Tennessee-North Carolina region of eastern United States. The All Taxa Biodiversity Inventory (ATBI) program will attempt to complete a comprehensive inventory of all life forms in the Park. This will include the first comprehensive inventory of the cryptogams (myxomycetes, macrofungi, mosses, liverworts, and lichens) in the tree canopy. An undergraduate research team spent six weeks collecting bark samples from over 160 trees. Using the double rope climbing technique students scaled the tree canopy to heights of 35 meters. The data collected will help in determining the effects of humans and other physical factors on the environ-

ment. The tree canopy biodiversity research project has led undergraduates to pinpoint specific topics for further investigation such as the faunistics and taxonomy of tardigrades, the diversity and distribution of myxomycetes on oaks and the association of myxomycetes with mosses. Canopy bark samples were sorted, placed in moist chambers, and cultured for a minimum of two weeks. Moist chambers were then scanned for tardigrades and myxomycetes using a dissecting microscope. A digital camera system provided picture records of life cycle stages. Mature fruitings were preserved in specimen boxes. Tardigrades (water bears) are removed with an Irwin loop and then mounted in Hoyer's solution or polyvinyl lactophenol. Specimens collected from the tree canopy have produced 30 new myxomycete records, including a new species of *Diachea* for the Park. The National Science Foundation, Division of Environmental Biology, Biotic Surveys and Inventories Program Award #0079058 has supported this project.

**Fletcher, T.C. and M.G. Scott. Division of Agriculture, Natural Sciences and Mathematics, Lincoln University.** STRETCH RECEPTORS IN THE MAMMALIAN TYMPANIC MEMBRANE. Stretch receptors in the tympanic membrane are potential air pressure detection systems in mammals. Human ears with damaged tympanic membranes are less sensitive to air pressure changes than healthy ears. The pars flaccida may be the region of the tympanic membrane that is responsible for pressure detection in humans. It seems to minimize static air pressure differences between the ear canal and middle ear cavity by the passive movement of the membrane toward the side of lower air pressure. Encapsulated nerve corpuscles that are embedded in the pars flaccida may function as mechanoreceptors that sense the pressure difference. The objective of our current research is to extend these observations from humans to other mammalian species. We are currently examining the tympanic membrane of two bat species to determine whether they have similar sensory receptors. The bat species studied include *Pipistrellus subflavus* and *Eptesicus fuscus*. Supported by the Heartland Alliance for Minority Participation.

**Gallegos, A. and L. R. Ayyagari. Department of Biology, Lindenwood University.** ANTIBACTERIAL PROPERTIES OF TOAD SKIN SECRETIONS. Frogs and the closely related toads seem to have evolved and adapted to living in microbe-laden waters and mud because of a well-developed defense system. The defense system is elicited by environmental stimuli and chemical signals through the secretion of proteins from the animal's skin, which act as barriers against infection. These skin secretions were reported to contain Magainin-like proteins with inhibitory activity of both gram-negative and -positive bacteria, fungi and protozoa. In a study to investigate the composition of skin secretions, toad skin swabs were made after an injection of epinephrine at various times and after different amounts of epinephrine in frog Ringer's solution. Culture lawns of both gram-positive and -negative bacteria and fungi were tested with filter paper discs dipped in skin secretions at various dilutions. Inhibitory zones were observed in all culture plates as compared to the zones observed with control skin-swabs of the toad not given any epinephrine. Preliminary biochemical characterization of the skin secretions showed the presence of proteins. These proteins were eluted on a Sephadex G-25 column at a marker protein size of 45,000 Daltons. After elution through the column the peak fraction continued to show anti-microbial properties in the zone-inhibition assay. The homogeneity of this protein is presently being examined in gel-electrophoresis. A much more exhaustive study is also being conducted in *Xenopus* frogs.

**\*Hoecker, J. and M.G. Scott. Division of Agriculture, Natural Sciences and Mathematics, Lincoln University.** THE VERTEBRATE PARATYMPANIC ORGAN. Variation in atmospheric pressure is a potential source of information that might be used by animals as the basis of a pressure altimeter and/or meteorological forecasting. A putative atmospheric pressure receptor found in the avian middle ear, the paratympanic organ, has also been reported to occur in the middle ear of some bats and reptiles. In that report, the paratympanic organ was of variable occurrence in the bat *Pipistrellus pipistrellus* and was not observed in the five other bat species examined. The status of the reptile *Anolis carolinensis* was

unclear. We will report on our anatomical examination of the bats *P. pipistrellus*, *P. subflavus*, *Eptesicus fuscus*, *Myotis velifer*, *Tadarida brasiliensis*, *Rhinolophus rouxi*, *Pteronotus parnellii*, *Pteronotus quadridens*, *Natalus stramineus*, *Eumops perotis* and *Leptonycteris* sp. and the reptile *A. carolinensis*.

**\*Kirk, S.P., S. Meredith and J.R. Penrod. Division of Agriculture, Natural Science and Mathematics, Lincoln University.** MITOCHONDRIAL DNA DELETIONS AS INDICATORS OF OOCYTE AGING IN RATS. Ovarian follicular changes occur rapidly in the human female relative to the other organs of the body. This common change in function occurs in a dramatic fashion around the menopausal period. Not only does this result from an age-related phenomena, but evidence has shown oxygen accumulation in the mitochondria leads to mtDNA mutations that encourage cellular senescence. In this experiment we are examining the effects of aging on rat oocyte mtDNA. Vaginal smears were conducted between 08:00 and 10:00 hours daily on Holtzman rats. Rats exhibiting a minimum of two normal length (4-5 days) estrus cycles were killed with CO<sub>2</sub> at proestrus. Individual oocytes were removed from the ovaries and stored as either single or groups of oocytes. DNA was isolated from the oocytes and amplified using polymerase chain reaction (PCR). Primers developed to amplify a region containing a common 5kb deletion were used to compare oocytes from young and old rats as well as oocyte mtDNA and brain mtDNA. In undamaged (young) mtDNA these primers amplify a segment of nucleic acid 5,294 base pairs (bp) in length, while in aged rat tissues it has been shown to generate a fragment only 460 bp in size. Supported by HAMP.

**\*Marshall, M.E., L.C. Dunn, M.F. Haskins, Rockhurst University, and S. Vortriede, University of Missouri-Kansas City.** A SURVEY OF ARACHNIDS AND INSECTS, WITH AN EMPHASIS ON BLISTER BEETLES, INHABITING ALFALFA IN WESTERN MISSOURI AND EASTERN KANSAS. Eight alfalfa fields, representing approximately 80 acres, were scouted from June 1, 2000 through October 15, 2000. Fields were located in Franklin County, KS, Jackson County, MO, and Johnson

County, MO. Investigators used both visual inspections and sweep nets to survey each field on a weekly or bimonthly basis. Orders of arachnids and insects represented in the sampling included: Araneae, Coleoptera, Collembola, Diptera, Hemiptera, Homoptera, Hymenoptera, Neuroptera, Orthoptera, Thysanoptera, and Lepidoptera. Twenty swarms of blister beetles, *Epicauta* sp., were identified during the study, and many behavioral observations were made. Starting in mid-July beetles were routinely found on a weekly basis.

However, since frass and leaf damage were minimal in each of the fields, investigators could not determine a swarm's movement between sampling periods. Dispersal of the swarm may have also contributed to the investigators' inability to relocate individual swarms.

**\*Mong, T.W., J.J. Millsbaugh, B.E. Washburn, J.H. Schulz, and S.B. Jones. Department of Fisheries and Wildlife, University of Missouri (TWM, JJM, BEW), Missouri Department of Conservation (JHS), and USGS Columbia Environmental Research Center (SBJ).** ASSESSING STRESS IN MOURNING DOVES USING NONINVASIVE TECHNIQUES. Wildlife face a variety of potential stressors including inclement weather, food shortages, human disturbance, predators, and disease. However, assessing stress in free-ranging vertebrates is difficult because the measurement process (i.e., capture and blood collection) may be stressful itself, and thus confound the results. Fecal stress hormone measurements, however, are noninvasive and may be easily obtained without disturbing the animal. We will present results of fecal stress hormone validation studies in mourning doves (*Zenaidura macroura*), a species of management concern, to evaluate the effectiveness of these assays for assessing stress. Biological (i.e., stress protocol) and biochemical (i.e., ACTH injection) validation experiments, resulting in > 600 fecal samples, were conducted to determine if we could reliably detect stress hormones in dove feces. These initial validation studies are critical steps in developing a practical and noninvasive tool for assessing stress in free-ranging wildlife. In addition to validation results, we will describe uses of the technique and future research needs.

**\*Wagoner, K.<sup>1</sup>, S. Cook<sup>2</sup> and C. Cook<sup>2</sup>.** <sup>1</sup>Missouri Southern State College Department of Biology, <sup>2</sup>Harbor Branch Oceanographic Institute. THE EFFECT OF LOW SALINITY EXPOSURE ON THE SURVIVAL AND DEVELOPMENT OF *SIPHONARIA ALTERNATA*. Laboratory research, utilizing *Siphonaria alternata* from Lignumvitae Key and Big Pine Key, subjected larvae within the jelly mass and larvae without the jelly mass to low salinity for different lengths of time. Each egg mass was cut in half. One half remained in the jelly. The jelly in the other half was teased away with a razorblade. Each half underwent identical treatments. Groups of three egg masses were exposed to salinity of 1.0 ppt, 10.0 ppt, and the control at 39.0 ppt for 6.0 hours and 24.0 hours. Video taping was used in addition to visual observations to identify fifty random larvae as prev-eliger, veliger with dark shells, veliger with light shells, or abnormal. Veligers that hatched were recorded and then removed to avoid duplicate data. Overall activity and appearance were recorded. There was a recovery phase following each exposure. The egg masses were placed in full strength seawater for 6.0 hours. The data was subjected to chi-square analyses and the Yates corrected chi-square analysis. The results for the majority of the groups from these analyses showed that the number of active veligers decreased when the jelly was missing. A few groups, mainly two of the preveliger groups, showed no difference in activity with the jelly missing.

**Wing, B., J. Quinn\*, and K. Davidson\*. Biology Department, Drury University.** IN VITRO CORRELATES OF GLYCATED PROTEINS FOUND IN DIABETES MELLITUS. Patients with diabetes mellitus often suffer from chronic complications such as blindness, kidney failure, amputations, and enhanced risk of arteriosclerosis. Studies on these complications have been linked to the cross linking of certain proteins with the elevated levels of glucose in the bloodstream. Formulation of glycated proteins has been detected in solutions simulating in vitro conditions. In our current study, solutions of 100mM alpha-crystalline, lysozyme, fibrinogen and thrombin were added to 100mM solutions of glucose. The protein solutions were incubated in a 37°C incubator to simulate physiological conditions, and a 65°C incubator to speed up the nonenzymatic reaction. A control

solution of MOPS buffer and protein were used for each respective solution. In order to quantify the amount of glycation each week, the samples were tested on SDS-polyacrylamide gels. The lengths of the bands of alpha-crystalline, lysozyme and thrombin decreased in size by 56%, 69%, and 35% respectively, thus indicating that glycation was occurring. The results of fibrinogen were inadequate to yield any data.

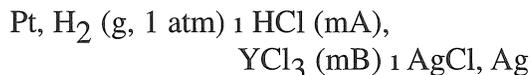
## Chemistry Section

**Cummins, M., S. Clark, E. Galinanes, R. N. Roy, and L. N. Roy. Hoffman Department of Chemistry, Drury University.** HARNED'S RULE FOR THE SYSTEM  $\text{HCl} + \text{HOCl}_3 + \text{H}_2\text{O}$  FROM 5 TO 55°C. Electromotive-force measurements of cells containing hydrochloric acid and Holmium chloride at constant total molality have been used to determine the variation of the logarithm of the activity coefficient of hydrochloric acid with change in the amount of Holmium chloride in the solution. The results will be interpreted in terms of Harned's rule (ion-ion interaction) for the ionic strength  $I = 0.05, 0.1, \text{ and } 0.25 \text{ mol kg}^{-1}$  in the temperature range 5°C to 55°C.

**\*Harman, S., K. Weiss\*, and J. Gordon. Central Methodist College, Fayette MO.** STUDENT-CONSTRUCTED SPECTROMETERS FOR DEMONSTRATING BEER'S LAW. Two simple spectrometers were constructed to demonstrate the basic principles of spectroscopy and applications of Beer's law. One spectrometer was constructed from a film canister using an interchangeable LED as the combined light source and monochromator and a photoresistor as the detector. The spectrometer was used to determine the molar absorptivity of permanganate. Good agreement was found when results were compared to those from two commercial spectrometers. The second spectrometer was constructed from a graduated cylinder. Many experiments show the linear dependence of absorbance on concentration. This system was designed to demonstrate the relationship between path length and absorbance. As expected from Beer's law, the relationship was found to be linear. Both spectrometers were easily and inexpensively constructed and could be used in any introductory chemistry course.

**Singh, R., J. Bacon, J. Ishaku, R.N. Roy, and L.N. Roy. Hoffman Department of Chemistry, Drury University.** ACTIVITY COEFFICIENTS FOR THE SYSTEM  $\text{HCl} + \text{YCl}_3 + \text{H}_2\text{O}$  AT  $5^\circ\text{C}$ ,  $25^\circ\text{C}$ , AND  $55^\circ\text{C}$ .

The emf of the cell



was used to investigate the  $\text{HCl} + \text{YCl}_3 + \text{H}_2\text{O}$  mixed electrolyte system at ionic strengths of 0.025, 0.05, 0.1, and 0.25 mol  $\text{kg}^{-1}$  and at temperatures of  $5^\circ\text{C}$ ,  $25^\circ\text{C}$ , and  $55^\circ\text{C}$ . Harned's rule as well as the Pitzer ion-interaction model will be applied to treat the experimental data. The results (thermodynamic quantities such as the activity coefficients, Harned interaction coefficients, etc.) of this original research will be compared with those of similar systems such as  $\text{HCl} + \text{GdCl}_3 + \text{H}_2\text{O}$ , and  $\text{HCl} + \text{EuCl}_3 + \text{H}_2\text{O}$ .

## Geology Section

**Dolde, J. Department of Geosciences, Southeast Missouri State University.** GEOLOGICAL RELATIONSHIPS IN NEW PRECAMBRIAN ROCK EXPOSURES NEAR MILLCREEK, MISSOURI . The study area lies between the NW-trending Sims Mountain Fault and Ironton Fault zones where re-routing of Highway 67, west of Millcreek, Missouri (lat  $37^\circ32'\text{N}$ , long  $90^\circ19'\text{W}$ ), exposes new relationships between igneous units and their contacts with Cambrian strata. The northernmost exposure shows rhyolite in contact with Bonnetterre Formation (el. 720') along a previously unmapped major fault ( $\text{N}5^\circ, 65^\circ\text{W}$ ) coincident with the SE wall of the Butler Hill Caldera. Lamotte Sandstone lies unconformably (el. 800') above an igneous intrusive 0.7 mi south of this fault. In the igneous sector, steeply foliated, crystal-poor ignimbrite is intruded by a dome of aphanophyric (roof facies?) rhyolite. A 20 m thick dike ( $\text{N}70^\circ\text{W}, 60^\circ\text{SW}$ ) emanating from the dome cuts the host ignimbrite and encloses a mega-xenolith of ignimbrite. The dome-related dike and ignimbrite are cut by a 3m thick dike ( $\text{N}52^\circ\text{E}, 75^\circ\text{SE}$ ) of crystal-rich lava. Veins and pockets of epidote-calcite-fluorite-pyrite-galena are common in all igneous units. Existing geological maps require revision in this area.

**Horrell, A. and I. El-Hussain. Department of Geosciences, Southeast Missouri State University.** GEOPHYSICAL INVESTIGATION OF A THIRD ORDER SPLAY OF THE SIMMS MOUNTAIN FAULT ZONE IN CAPE GIRARDEAU, MO. The study area is located at the intersection of Hopper and Kage streets in the northern portion of section 35, T31N, R13E of Cape Girardeau 7 fi" Quadrangle. Bedrock Geologic Map of Cape Girardeau-McClure MO-IL 7fi" Quadrangle (Satterfield, 1993) shows that the NW-SE trending Simms Mountain Fault Zone (SMFZ) transects the study area. The objective is to determine if a nearby NW-SE trending graben bounded by 2nd order splays and a NNW-SSE trending graben bounded by 3rd order splays are linked by an unmapped 3rd order splay of the SMFZ. Investigative methods include electrical resistivity and bore hole analysis. A geophysical traverse across the northern member of the 2nd order graben of the SMFZ in the study area proved that these methods are successful in detecting buried faults and should detect whether a buried 3rd order links the graben segments. Results will be provided to the city planner for use in the Hopper St. expansion project.

**Mathenia, C.M. and Plymate, T.G. Dept. of Geography, Geology, and Planning, Southwest Missouri State University.** STRUCTURAL STATE OF K-FELDSPAR IN GRANITES OF THE TAUM SAUK CALDERA, ST. FRANCOIS MOUNTAINS, SOUTHEAST MISSOURI. We have determined the structural state of the K-feldspar in six samples of Proterozoic granite from the Taum Sauk Caldera, St. Francois Mountains, southeastern Missouri. We separated K-feldspar from each sample by density and determined the structural state parameter Z (defined to vary from 0 for perfectly disordered sanidine to 1 for perfectly ordered microcline) from unit cell refinements based on an average of eight x-ray diffraction peaks per sample. We found the K-feldspar in all six samples to be highly ordered, nearly maximum microcline. The structural state parameter Z for three samples of the Graniteville Granite, the central pluton in the Taum Sauk Caldera, averaged 0.94 with a standard deviation of 0.07. The Z parameter for three samples of the Munger Granite Porphyry, a series of ring plutons exposed around the western and southern edge of the caldera, averaged 0.87 with a standard deviation of

0.06. The structural state of the K-feldspar in these rocks is similar to the structural state reported by other workers for the granites exposed in the Butler Hill Caldera to the east. We interpret the uniformly high structural state of the K-feldspar in the granites throughout the St. Francois Mountains as evidence for a major resetting event that occurred subsequent to crystallization of the youngest granitic rock unit exposed in the complex, the 1.36 Ga Graniteville Granite.

## Physics Section

**\*Bogart, T. and R.A. Mayanovic. Department of Physics, Astronomy and Materials Science, Southwest Missouri State University.** OPTICAL ABSORPTION MEASUREMENTS OF YTTERBIUM(III) IONS IN AQUEOUS AND IN ETHANOL SOLUTIONS. The 4f electrons of the lanthanide series of the elements (La - Lu), being well shielded by intervening electron shells, are largely unreactive with neighboring ligands. As a result, the lanthanide ions interact with ligands in the formation of complexes mainly through relatively weak electrostatic forces. This leads to rather weak absorption band features in optical spectra of lanthanide ions in solutions, making such measurements rather difficult. The optical transmission spectra of  $\text{YbCl}_3$  in ethanol solutions show band features associated with  $\text{Yb}^{3+}$  complexes having  $\text{Cl}^-$  ligands in the near-UV region ( $\sim 370$  nm) that do not appear in the spectra of  $\text{YbCl}_3$  in water. In addition, absorption features in the near infra-red region ( $\sim 1000$  nm) occurring due to excitation of the electrons within the 4f shell show fine modulations due to chloro ytterbium(III) complex formation in the ethanol solutions. The development of a high-temperature optical cell suitable for studies of lanthanide and other metal-based solutions under elevated temperature and pressure conditions will also be discussed.

**\*Brown, C., W.L. \*Crouse, B. \*Heavilin, and J. \*Russell. Department of Physics and Chemistry, Northwest Missouri State University.** MUSICAL ACOUSTICS OF THE GUITAR. This research focused on the differences between different manufacturers' guitar strings. The frequency spectrum was measured as well as the time for the amplitude of the string to decay. It was found to be very difficult to pick

the guitar string in such a manner as to reproduce the same frequency spectrum. An apparatus was constructed upon which the guitar strings could be mounted between the poles of a powerful magnet. By pulsing a current through the string it could be excited so as to generate reproducible frequency spectra. The apparatus did not have a sounding board so the frequency spectra could be studied separate from the influence of the guitar body. A computer interfaced multi-meter was used to measure the decay of sound from the vibrating string. Comparisons were made between different manufacturers' guitar strings with the strings being excited magnetically as well as with the usual guitar pick. They were also compared with the sound they produced on a guitar to examine the effects of the guitar body on the frequency spectrum. It was found that the guitar body produces the majority of the higher order harmonics. Substantial differences were seen between the different strings in both their frequency spectrum and decay times.

**Rice, J.D.\* and S. Guha. Physics, Astronomy and Materials Science Department, Southwest Missouri State University, Springfield, MO 65804.** OPTICAL SPECTROSCOPIC STUDIES OF CONJUGATED MOLECULES/POLYMERS. In recent years there has been a growing interest in the use of organic material for optoelectronic devices. This is due in large part to the potential low cost of the device applications and the ease of fabrication of these materials. Organic light emitting diodes (OLED) allow the possibility of high-resolution displays without the viewing angle problems associated with liquid crystal displays. One of the major breakthroughs in this field is the electrically pumped organic laser based on conjugated molecules. Organic materials such as parahexaphenyl (PHP), ladder type poly(paraphenylene), and polyfluorene (PFO) have a strong potential in the field of OLEDs due to their high blue luminescence, which allows the development of red, green and blue light emitting diodes from efficient color conversion techniques. We present optical spectroscopic studies of these materials, which give insight into their structural properties. These structural properties play a key role in understanding the electronic and optical properties of these materials.

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