

PROCEEDINGS  
of the  
NORTH DAKOTA  
ACADEMY OF SCIENCE

Founded December, 1908

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VOLUME VI  
1952

---

**PUBLICATION COMMITTEE**

Rae H. Harris (*Chairman*)  
Ralph E. Dunbar  
Ernest D. Coon  
J. Donald Henderson (*Ex Officio*)  
G. A. Abbott (*Ex Officio*)

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*Published jointly by the University of North Dakota  
and the State Agricultural College*

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July, 1952  
GRAND FORKS, NORTH DAKOTA

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1952

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**OFFICERS**

*President* - - - - - Wilson M. Laird, University  
*Vice President* - - - - Carl O. Clagett, Agricultural College  
*Secretary-Treasurer* - - J. Donald Henderson, University  
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*A.A.A.S. Representative* R. L. Post, Agricultural College  
Additional Members of Executive Committee:  
Harry Mason, Jamestown  
Julian J. Rolzinski, Devils Lake

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## SUGGESTIONS TO AUTHORS

**General.** Authors should submit to the secretary of the Academy at the time of the annual meeting following presentation of the paper a copy of the manuscript typed double space with wide margins on 8½" by 11" white paper.

**Titles and Footnotes.** Titles should be specific but should be kept short by deleting unnecessary words. The title should also show the name and address of the author's institution. Additional footnotes showing other pertinent information are desirable although not obligatory.

**Abstract.** A concise abstract of about 200 words must be supplied to the secretary of the Academy before the annual program is arranged. In case the complete manuscript is not published in the Proceedings the abstract as submitted will be used. This abstract should state the principal result and conclusions and should contain largely by inference, adequate information on the scope and design of the investigation. The abstract in general should conform to the suggestions outlined for complete manuscripts.

**Figures.** Drawings, graphs, or photographs may be published in the Proceedings at a cost to the author of approximately \$8.00 per cut. These cuts should be designed to fill a half page. The original drawing should be such that it will just fit in an area 8.25 inches wide and 7 inches high. Line drawings must be in india ink on white paper. The original lettering and symbols must be distinct and at least one-eighth inch high. Figure captions should be typed and included with the manuscript (not as a part of the figure). Figures should be numbered consecutively and their approximate position indicated in the running text. Each original drawing must be identified on its back with the figure number and the author's name.

(CONCLUDED ON FOLLOWING PAGE)

## SUGGESTIONS TO AUTHORS

If a graph is drawn on coordinate paper, the paper must be blue lined. The important coordinate lines should be ruled over with black ink and made narrower than the lines of the curves and those of the frame.

Photographs should have a gloss finish and should not exceed 10 inches wide by 8 inches high. For satisfactory reproduction the picture must be unblurred and must show sharp contrast between light and dark areas.

All drawings and photographs should be submitted to the Secretary of the Academy at the time of presentation of the paper. Payments must be made when galley proofs are approved.

**Literature.** In general only recent papers need be listed and these can often be cited more advantageously throughout the text than in the introduction. Long introductory reviews should be avoided especially when a recent review in another paper or in a monograph can be cited instead. References are arranged and numbered in alphabetical order of author's names and show author, title, journal, volume, first and last pages, and year. The list is given at the end of the paper. Reference numbers must invariably be cited in the text, but author's names and year may be cited also. Abbreviations for names of journals follow the list given in Chemical Abstracts 40, Pt. 4:1-CCIX, 1946.

**Organization.** The standard organization involves main sections for introduction, materials, methods, results, discussion, summary, and acknowledgements and literature cited. Alternately a group of related studies each made with different materials or methods may require a separate section for each study with sub-sections for materials and methods and for results under each section. Center headings are used for main sections and italicized, run-in headings for sub-sections. Headings should be restricted to these two types only.

**Tables.** Data should be arranged to facilitate the comparisons readers must make. Tables should be kept small by breaking up large ones if this is feasible. Only about eight columns of tabular matter can be printed across the page. Authors should omit all unessential data such as laboratory numbers, columns of data that show no significant variation, and any data not discussed in the text. A text reference can frequently be substituted for columns containing only a few data. The number of significant figures should be minimized. Box and side headings should be kept short by abbreviating freely; unorthodox abbreviations may be explained in footnotes, but unnecessary footnotes should be avoided. Leader tables without a number, main heading, or ruled lines are often useful for small groups of data.

Tables should be typed on separate pages at the end of the manuscript, and their position should be indicated to the printer by typing "(TABLE I)" in the appropriate place between lines of the text.

**Text.** Clarity and conciseness are the prime essentials of a good scientific style. Proper groupings of related information and thoughts within paragraphs, selection of logical sequences for paragraphs and for sentences within paragraphs, and a skillful use of headings and topic sentences are the greatest aids to clarity.

# NORTH DAKOTA ACADEMY OF SCIENCE

## ACTIVE MEMBERS — 1952

- Abbott, G. A. (Chemistry), University. Charter Member.
- Arnason, A. F. (Forestry), Commissioner, State Board of Higher Education, Bismarck. 1939.
- Banasik, Orville J. (Cereal Chemistry), Agricultural College. 1947.
- Bliss, Harald N. (Ornithology), Grafton. 1951.
- Bolin, Donald W. (Biochemistry), Agricultural College. 1946.
- Bolin, F. M. (Veterinary Science), Agricultural College. 1948.
- Bonneville, David C. (Chemistry), N. D. Research Foundation. 1951.
- Bosch, Wouter. (Chemistry), Agricultural College. 1948.
- Bosch, Mrs. Wouter. (Chemistry), Agricultural College. 1949.
- Brezden, William. (Chemistry), State Mill and Elevator, Grand Forks. 1945.
- Broberg, Joel W. (Chemistry), Agricultural College. 1948.
- Bryant, Reece L. (Poultry Genetics), Agricultural College. 1948.
- Buchanan, M. L. (Animal Husbandry), Agricultural College. 1950.
- Burr, Alex C. (Chemical Engineering), Bureau of Mines, Grand Forks. 1940.
- Cardy, James D. (Pathology), University. 1950.
- Carter, Jack F. (Agronomy), Agricultural College. 1950.
- Chetrick, M. H. (Chemical Engineering), University. 1947.
- Claggett, Carl O. (Biochemistry), Agricultural College. 1949.
- Conlon, Thomas J. (Agronomy), Agricultural College. 1950.
- Cooley, A. M. (Chemical Engineering), University. 1938.
- Coon, Ernest D. (Chemistry), University. 1923.
- Davis, Mildred L. (Nutrition), University. 1951.
- Dinusson, William E. (Animal Nutrition), Agricultural College. 1950.
- Doubly, Mrs. Elma K. (Bacteriology), Agricultural College. 1950.
- Doubly, John A. (Bacteriology), Agricultural College. 1950.
- Douglas, Raymond J. (Animal Husbandry), Agricultural College. 1950.
- Dunbar, Ralph E. (Chemistry), Agricultural College. 1938.
- Edwards, Lawrence J. (Chemistry), Agricultural College. 1950.
- Ellman, Robert. (Fuels), Bureau of Mines, University. 1949.
- Estensen, Ernest V. (Psychology), Agricultural College. 1951.
- Evans, Norman A. (Agricultural Engineering), Agricultural College. 1950.
- Eveleth, D. F. (Veterinary Science), Agricultural College. 1944.
- Facey, Vera. (Botany), University. 1948.
- Fischer, Robert G. (Bacteriology), University. 1948.
- Fleetwood, Charles W. (Chemistry), Agricultural College. 1948.
- Flor, Harold H. (Plant Pathology), Agricultural College. 1943.
- Fordyce, Ira V. (Chemistry), AGSCO, Grand Forks. 1947.
- Forster, Theodore L. (Dairy Technology), Agricultural College. 1950.
- Frank, Richard E. (Chemistry), University. 1949.

- Fredrickson, Ronald L. (Chemistry), Agricultural College. 1951.
- French, Harley E. (Anatomy), Dean Emeritus, University. 1911.
- Gault, Alta R. (Physiology), University. 1949.
- Geiszler, Gustav N. (Agronomy), Agricultural Experiment Station, Minot. 1950.
- Gohman, Walter J. (Physics), Minot. 1951.
- Goldsby, Alice. (Veterinary Science), Agricultural College. 1946.
- Gorz, Herman J. (Plant Breeding), Agricultural College. 1951.
- Graham, Charles M. (Internal Medicine), Grand Forks. 1951.
- Grimes, Ruby. (Mathematics), Agricultural College. 1946.
- Gustafson, A. A. (Bacteriology), Public Health Lab., University. 1950.
- Gustafson, Ben G. (Chemistry), University. 1939.
- Hagen, Irvan. (State Seed Dept.), Agricultural College. 1950.
- Hamre, Christopher J. (Anatomy), University. 1950.
- Harris, Rae H. (Agricultural Biochemistry), Agricultural College. 1938.
- Hart, Harry B. (Chemistry), Jamestown College.
- Hauenz, Edgar A. (Internal Medicine), Grand Forks. 1951.
- Hazen, Arlon. (Agricultural Engineering), Agricultural College. 1950.
- Heermann, Ruben M. (Agronomy), U. S. Dept. of Agriculture, Fargo. 1950.
- Helgeson, E. A. (Botany), Agricultural College. 1936.
- Henderson, J. Donald. (Physics), University. 1945.
- Higgins, Edith C. (State Seed Commission), Agricultural College. 1950.
- Hill, A. Glenn. (Mathematics), Agricultural College. 1946.
- Hoag, Donald G. (Botany), Agricultural College. 1950.
- Hoepfner, Jerome J. (Chemistry), Bureau of Mines, University. 1949.
- Hoffman, Glenn L. (Parasitology), University. 1951.
- Holland, Margaret Jean. (Pathology), University. 1951.
- Holm, Glenn C. (Veterinary Science), Agricultural College. 1950.
- Holtz, John C. (Chemical Engineering), Bureau of Mines, University. 1949.
- Hoyman, William G. (Phytopathology), Agricultural College. 1950.
- Hultz, Fred S. (Agriculture), President, Agricultural College. 1950.
- Hundley, John L. (Physics), University. 1930.
- Jensen, C. (Dairy Husbandry), Agricultural College. 1927.
- Kamps, Theodore. (Fuels), Bureau of Mines, University. 1949.
- Kaufman, Victor. (Physics), University. 1951.
- Kelly, Eunice. (Nutrition), Agricultural College. 1944.
- Kingsley, Allan F. (Agricultural Chemistry), Agricultural College. 1950.
- Kjerstad, C. L. (Philosophy and Psychology), University. 1937.
- Klosterman, Earle W. (Animal Nutrition), Agricultural College. 1948.
- Klosterman, Harold J. (Agricultural Chemistry), Agricultural College. 1948.
- Knoll, Clement. (Engineering), School of Forestry, Bottineau. 1949.

- Knudson, Walter L. (Biology), School of Forestry, Bottineau. 1950.
- Kchanowski, Nicholas. (Geology), University. 1949.
- Koons, Melvin E. (Bacteriology), Public Health Lab., University 1943.
- Koth, Arthur W. (Metallurgy), University. 1939.
- Kube, Wayne R. (Chemical Engineering), Bureau of Mines, University. 1949.
- Laird, Wilson M. (Geology), University. 1941.
- Langford, Larkin H. (Animal Husbandry), Agricultural College. 1950.
- Larson, Edith E. (Biology), University. 1947.
- Leraas, Marvin A. (Agronomy), Agricultural College. 1947.
- Loomis, Fred H. (Cereal Chemistry), Loomis Laboratories, Grand Forks. 1947.
- Lundy, John L. (Anesthesiology), Mayo Clinic, Rochester, Minn. 1940.
- Luper, Miltza (Medical Technology), Deaconess Hospital, Grand Forks. 1951.
- McMillan, William W. (Chemistry), N. D. Research Foundation, Fordville. 1947.
- MacDonald, John H. (Biology), Teachers College, Dickinson. 1951.
- Magnusson, Adelynn M. (Chemistry), University. 1951.
- Marwin, Richard M. (Bacteriology), University. 1949.
- Mason, Harry. (Physics), Jamestown College. 1951.
- Mattson, Harold. (Horticulture), Agricultural College. 1937.
- Milberg, Morton E. (Chemistry), University. 1951.
- Miller, Clifton E. (Pharmaceutical Chemistry), Agricultural College. 1947.
- Miller, Leonard E. (Chemistry), University. 1951.
- Milligan, Edward A. (Anthropology), School of Forestry, Bottineau. 1951.
- Moberg, Wenzel. (Geography), Agricultural College. 1943.
- Moore, Cyril C. (Chemistry), Teachers College, Minot. 1948.
- Moran, Walter H. (Chemistry), University. 1931.
- Munro, J. A. (Entomology), Agricultural College. 1927.
- Murphy, H. E. (Chemistry), Teachers College, Dickinson.
- Nelson, Casper I. (Bacteriology), Agricultural College. 1915.
- Norum, E. B. (Soils), Agricultural College. 1948.
- Oehler, Mrs. Alma. (Nutrition), State Mill and Elevator, Grand Forks. 1945.
- Ongstad, Orvin C. (Fuels), Bureau of Mines, University. 1949.
- Oppelt, Walter H. (Fuels), Bureau of Mines, University. 1949
- Opton, Edward M. (Zoology), Agricultural College. 1946.
- Ovrebo, Gerhard O. (Physics), Teachers College, Valley City. 1947.
- Owens, Paul R. (Floriculture), Owens Floral Co., Grand Forks. 1945.
- Parsons, Jesse L. (Bacteriology), Agricultural College. 1950.
- Pearson, Richard K. (Chemistry), University. 1950.
- Peterson, Robert H. (Chemistry), Agricultural College. 1951.
- Porter, Charles B. (Surgery), Grand Forks. 1951.



- Posin, Daniel Q. (Physics), Agricultural College. 1948.
- Post, R. L. (Entomology), Agricultural College. 1948.
- Potter, Loren. (Botany), Agricultural College. 1948.
- Reid, Russell. (Natural Science), State Museum, Bismarck. 1940.
- Riley, Kenneth W. (Chemistry), Marietta, Ohio.
- Robinson, Hugh M. (Botany), Teachers College Valley City.
- Robinson, Roy N. (Physics), Public Schools, Minot. 1951.
- Rognlie, Philip A. (Mathematics), University. 1946.
- Rolzinski, Julian J. (Biology), Junior College, Devils Lake. 1950.
- Ruth, Elbert B. (Anatomy), University. 1951.
- Ryan, Floyd T. (Forestry), School of Forestry, Bottineau. 1950.
- Saiki, Arthur K. (Pathology), University. 1949.
- Sands, F. H. (Chemistry), Agricultural College. 1946.
- Saugstad, Stanley. (Entomology), Wild Life Administration, Bismarck. 1939.
- Schultz, J. H. (Horticulture), Agricultural College. 1948.
- Sebens, William P. (Agriculture), Greater North Dakota Association, Fargo. 1948.
- Severson, Donald E. (Chemical Engineering), University. 1949.
- Severson, Roland G. (Chemistry), University. 1951.
- Shoesmith, Lloyd. (Soils), Agricultural College. 1950.
- Shrader, Ruth. (Anatomy), University. 1951.
- Sibbitt, L. D. (Cereal Technology), Agricultural College. 1946.
- Smith, Glenn S. (Plant Breeding), Agricultural College. 1930.
- Staley, Raymond C. (Mathematics), University. 1946.
- Stallings, H. Dean. (Library), Agricultural College. 1951.
- Stevens, O. A. (Botany), Agricultural College. 1910.
- Stewart, Donald L. (Chemistry), American Crystal Sugar Co., East Grand Forks, Minn. 1943.
- Stoa, Theodore E. (Agronomy), Agricultural College. 1950.
- Stokke, Orval R. (Bacteriology), State Health Laboratory, University. 1950.
- Sudro, W. F. (Pharmacy), Agricultural College. 1911.
- Summers, Lawrence. (Chemistry), University. 1951.
- Svore, Jerome H. (Sanitary Engineering), State Health Dept., Bismarck. 1943.
- Taintor, E. J. (Agriculture), Taintor Seed House, Grand Forks. 1945.
- Thompson, John C. (Mathematics), Teachers College, Dickinson. 1948.
- Thompson, Matilda. (Mathematics), Agricultural College. 1947.
- Treumann, William B. (Chemistry), Agricultural College. 1946.
- Tsumagari, Yukio. (Pathology), University. 1951.
- Tuneberg, Everett O. D. (Chemistry), School of Forestry, Bottineau. 1949.
- Van Heuvelen, W. (Chemistry), State Health Dept., Bismarck. 1945.
- Waldron, L. R. (Agronomy), Agricultural College. 1910.
- Walster, H. L. (Director of Experiment Station), Agricultural College. 1920.

- Wardner, Arthur K. (Agricultural Chemistry), Flaata Farms Co., Grand Forks. 1938.
- Wendland, Ray T. (Chemistry), Agricultural College. 1948.
- Whedon, Arthur D. (Zoology), Agricultural College. 1924.
- Wheeler, George C. (Biology), University. 1924.
- Whitman, Warren. (Botany), Agricultural College. 1950.
- Wiidakas, William. (Agronomy), Agricultural College. 1946.
- Wild, Robert L. (Physics), University. 1951.
- Wills, Bernt L. (Geography), University. 1949.
- Wischow, Russell P. (Cereal Chemistry), Agricultural College. 1950.
- Witmer, Robert B. (Physics), University. 1925.

## MEMBERS ELECTED IN 1952

- Bitzan, Edward F. (Chemistry), U. S. Bureau of Mines. 1952.
- Brown, Leonard W. (Chemistry), Armour and Company, Fargo. 1952.
- Chernick, Sidney S. (Pharmacology), Agricultural College. 1952.
- Christoferson, Lee A. (Neurological Surgery), Fargo. 1952.
- Corbus, Jr., Budd C. (Urological Surgery), Fargo. 1952.
- Cornatzer, William E. (Biochemistry), University. 1952.
- Davison, John P. (Biochemistry), University. 1952.
- De Boer, Benjamin. (Pharmacology), University. 1952.
- Downing, William L. (Biology), Jamestown College. 1952.
- Fisher, Stanley P., Jr. (Petroleum Geology), N. D. Geological Survey. 1952.
- Golob, Edward F. (Chemical Engineering), U. S. Bureau of Mines. 1952.
- Hansen, Miller. (Geology), N. D. Geological Survey. 1952.
- Haraldson, Harald C. (Geology), University. 1952.
- Henrickson, Russell M. (Chemistry), North Dakota Research Foundation. 1952.
- King, Richard P. (Animal Nutrition), Agricultural College. 1952.
- Kratochvil, Donald E. (Botany), Agricultural College. 1952.
- Schulenberg, Raymond F. (Anthropology), State Historical Society. 1952.
- Scott, George M. (Cereal Chemistry), Agricultural College. 1952.
- Sleeper, Bayard P. (Bacteriology), Agricultural College. 1952.
- Spier, Jack J. (Pathology), St. John's Hospital, Fargo. 1952.
- Towse, Donald F. (Geology), University. 1952.
- Traverse, Alfred. (Plant Paleontology), U. S. Bureau of Mines. 1952.

# NORTH DAKOTA ACADEMY OF SCIENCE

## *Minutes of the Forty-Fourth Annual Meeting*

**FRIDAY, MAY 2, 1952**

President Glenn S. Smith called the meeting to order at 9:10 a.m. in the First Floor Reading Room of the New Library Building at the North Dakota Agricultural College. After brief introductory remarks, Dr. Smith proceeded with the program as scheduled. The nine papers listed on the morning program were read and discussed.

The following committees were named and asked to report at the business session on Saturday morning. Committee on Resolutions: C. O. Clagett, Chairman; C. I. Nelson, G. A. Abbott, Alex Burr, and W. H. Moran. Committee on Nominations: W. C. Whitman, Chairman; E. W. Klosterman, A. M. Cooley, J. L. Hundley, and Matilda Thompson.

Noon Luncheon was served at 12:15 in Ceres Hall with the visiting members as guests of the Agricultural College.

The Academy reconvened at 1:30 p.m. in the New Library Building. The papers listed on the program for the afternoon were read and discussed with the exception of No. 22, Better Seed Potatoes for North Dakota Farmers. The author of this paper, Dr. Wm. G. Hoyman, was unable to attend the session. The meeting adjourned at 5:15 p.m.

The Academy Dinner, a joint meeting with the Red River Section of the American Chemical Society, was sponsored by the local Sigma Xi Club. One hundred thirty one members and guests were present at the dinner which was held in the main dining room of Ceres Hall. The program was in charge of Dr. Edward Opton, President of the local Sigma Xi Club. After welcoming the guests, he called on the Theta Chi Quartet who sang a group of numbers which were very well received. Next, he introduced Dr. R. T. Wendland, President of the Red River Section of the American Chemical Society, and Dr. Glenn Smith, President of the Academy. In Dr. Smith's response, the guests particularly enjoyed a poem, descriptive of Academy Sessions, which he had written while listening to papers during the afternoon.

Dean R. E. Dunbar announced the winners of the Annual Awards of the N. D. A. C. Chemistry Club.

Dr. Wendland introduced the guest speaker, Dr. D. L. Tabern of Abbott Laboratories, who spoke on the subject, "Radioactive Isotopes in Biology and Medicine". The audience seemed to capture some of Dr. Tabern's enthusiasm as he explained the methods of preparation and the current uses of radioactive isotopes. The fine illustrations that were projected on the screen as he presented his topic aided greatly in understanding some of the unusual problems encountered in working with radioactive materials.

**SATURDAY, MAY 3, 1952**

The meeting was called to order at 9:10 a.m. in the New Library Building with Dr. Glenn Smith presiding. The six papers listed on the morning program were read and discussed.

At 11:30 a.m. the Academy opened its Annual Business Session. The minutes of the 1951 meeting were approved as printed in the 1951 Proceedings. The report of the treasurer was read and approved as read.

Dr. Rae H. Harris, Chairman of the Publication Committee gave the report of his committee which was accepted. He pointed out the difficulty of operating under a limited budget when publishing costs continue to rise. It will be necessary to limit the length of the papers to be published and a maximum length of eight pages typed double-spaced was recommended. The Publication Committee appreciates the cooperation given by authors and wishes to emphasize the importance of following the Suggestions to Authors. When papers are submitted in proper form, the work of the committee is greatly reduced. It is planned to continue publishing the Proceedings in its present form and style.

The availability of a Research Grant of one hundred dollars from the A. A. A. S. was announced. Dr. Abbott moved that the Executive Committee consider applications for this Grant and select the winner. The motion was seconded. After some discussion, Dean Dunbar moved to amend the motion by setting September 1, 1952 as the deadline for applications. The amendment was seconded and carried. The motion was then voted on and it carried unanimously.

Dr. Carl Clagett presented the report of the Committee on Resolutions. After some discussion, the report was accepted as follows:

"The Committee on Resolutions consisting of Chairman C. O. Clagett, C. I. Nelson, G. A. Abbott, Alex Burr, and W. H. Moran presents the following resolutions:

1. We express our appreciation to the North Dakota Agricultural College for extending its facilities to the Academy, and for the luncheons provided; and to the Press for giving excellent publicity to our meetings.

2. We extend our sincere thanks to our distinguished guest speaker, Dr. D. L. Tabern, for his illustrated and most instructive address on "Radioactive Isotopes in Biology and Medicine".

3. We thank the Red River Valley Section of the American Chemical Society for its joint participation in our meetings, and assisting in securing the guest speaker.

4. Our thanks are extended to the local Sigma Xi Club for sponsoring the Academy Dinner.

5. We are especially grateful to the Administration of the Agricultural College and of the University for continuing the policy of financing the publication of the Proceedings of the Academy and to

the members of the Committee on Publication for the excellent work they have done.

6. We wish to urge the extension of that portion of the program of the National Science Foundation which aims to develop new manpower and personnel for research.

7. We respectfully wish to call attention of the legislature to the need for adequate support of the various research agencies in the State to the end that they may make maximum contribution to the development of the State of North Dakota.

8. The N. D. Academy of Science extends an invitation to the members of the State Geological Society as well as other learned societies to participate in our society.

9. To the Officers and Committees of the Academy, we express our thanks for providing the excellent program of papers, the comfortable arrangements, and for the successful conduct of this highly interesting and profitable meeting of the Academy.

10. We urge all members to encourage the participation in the Academy activities by other institutions of higher learning in the State that are not represented at this meeting."

It was suggested that our meeting be divided into sections so as to enable the presentation of a greater number of papers. There was considerable discussion of the various possibilities, but no conclusion was reached. Mr. Harold Klosterman moved that the Executive Committee give appropriate consideration to the possibility of dividing the program into different sections and use their best judgment in arranging future programs. The motion was seconded and carried.

Mr. Henderson gave a brief report on the North Dakota High School Science Fair that was held at Devils Lake. After various means for encouraging and aiding this worthy project were discussed, Dean Dunbar moved that the Executive Committee be allowed to spend up to twenty five dollars to promote the State Science Fair. The motion was seconded and carried.

The need of revising the Constitution of the Academy to make it more workable under present conditions was briefly explained by the secretary. Dr. Rae Harris moved that the Executive Committee appoint a Constitution Committee to investigate the problem of revising the constitution. The Secretary of the Academy should serve as one of the members of this committee. The motion was seconded and carried.

Twenty two candidates were properly nominated for membership and the secretary presented their names to the Academy. They were unanimously elected and their names may be found immediately following the list of Active Members in the first section of the Proceedings.

The Nominating Committee composed of Chairman W. C. Whit-

man, E. W. Klosterman, A. M. Cooley, J. L. Hundley, and Matilda Thompson submitted the following slate of candidates:

President - - - Wilson M. Laird, University  
 Vice President - - Carl O. Clagett, Agricultural College  
 Secretary-Treasurer - - J. Donald Henderson, University  
 A.A.A.S. Representative - R. L. Post, Agricultural College  
 Additional Members of the Executive Committee:  
 Harry Mason, Jamestown College  
 Julian Rolzinski, Devils Lake

There were no nominations from the floor and the above candidates were unanimously elected.

The Academy adjourned at 12:30 p.m. and following adjournment, luncheon was held at Ceres Hall complimentary to the visiting members.

J. Donald Henderson  
 Secretary-Treasurer

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## THE DOMESTIC CAT AND THE RABIES PROBLEM

*F. M. Bolin*

*Department of Veterinary Medicine  
 North Dakota Agricultural College, Fargo, North Dakota*

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Rabies is an acute, specific infection of the central nervous system caused by a filterable virus. All warm blooded animals including man are susceptible. It is commonly believed that the dog and related animals, such as the coyote, wolf and fox propagate the disease.

Rabies is a disease that has been known since ancient times. It has world wide distribution, having been reported from the tropic to the arctic regions. The old idea of dog days in the hot months of July and August causing rabies is not true. Rabies occurs during all months of the year.

The U. S. Department of Public Health and the U. S. Department of Agriculture are aware of the seriousness of rabies but our congress is reluctant to appropriate monies to study and control diseases in dogs, cats and wild animals (1).

In the period of 1940-44 there were 10 states that had reported 6 or less cases of rabies (2). During that period much of the rabies was along our eastern sea coast. The northern and western parts of the United States were comparatively free of the disease.

## CASES OF RABIES REPORTED IN VARIOUS STATES IN 1961

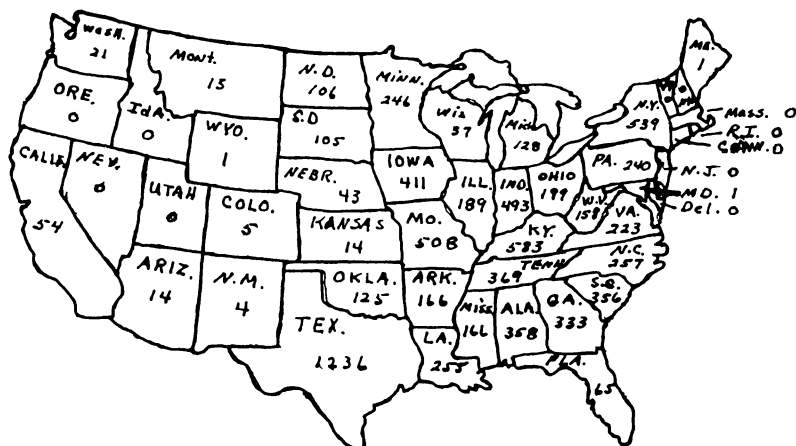


FIG. I

In Fig. I we have the 1961 distribution of rabies reported in the United States. The North Atlantic States had made excellent progress in keeping down and reducing the number of cases of rabies. An outbreak has, however, again struck this area. The North Central states have a serious problem with an increase in the disease and invasion of new territory such as North Dakota. In the Plain States such as North Dakota we have very little in the form of natural barriers on our boundaries.

Travel from state to state by car is an easy thing to do. There is little to stop animal migrations.

Iowa, Illinois, Missouri, Kansas and Oklahoma had very large numbers of cases of rabies reported in the 1940-44 period followed by an increase in the number of cases in Minnesota and South Dakota.

Our veterinarians in North Dakota were aware of rabies being present along the North Dakota, South Dakota border in the eastern half of the state in 1950.

In the introduction I stated that the dog and related species were believed to be propagators of the disease. A summary of the rabies examination from North Dakota and surrounding states is most revealing. In North Dakota the cat and the skunk were 32 each or 64 cases as compared with 13 for the dog and 1 for the fox. The cat and the skunk have much in common including their feeding and nocturnal habits. The part played by the preyed upon species, eg., mouse, rabbit, etc., in the propagation of rabies is not known. Repetition and volume of exposures are important in the production of disease.

TABLE I\*

## RABIES EXAMINATION FROM NORTH DAKOTA

ANIMAL	P.	N.	S.	S.G.F.	N.D.	A.I.P.	A.I.N.	S.H.O.
Raccoon	3		1					
Skunk	32	34	4	1	4			
Gopher	1	2						
Mouse	12	43	4	11	1			
Rat	4	9		2	2			
Mink	3	4		1				
Badger		2						
Squirrel	2	5		5				
Bobcat		2						
Muskrat	1	8		2	1			
Deer	1							
Rabbit		1						
Fox	1	1		2				
Bovine	8	9	3	3		3		
Dog	13	17	2	5		1	1	3
Cat	32	60	11	29		2		3
Sheep		1	4	1		1		
Pig		3						
<b>TOTAL</b>	<b>113</b>	<b>201</b>	<b>29</b>	<b>62</b>	<b>8</b>	<b>7</b>	<b>1</b>	<b>6</b>

TABLE II\*

## RABIES EXAMINATION FROM MINNESOTA

ANIMAL	P.	N.	S.	S.G.F.	N.D.	A.I.P.	S.H.O.
Raccoon	2	2					
Skunk	24	3	1		1		
Gopher	1	3	2				
Mouse	5	3	1	3			
Rat	1	2	1		2		
Mink	1						
Badger	1						
Squirrel			1	1			
Woodchuck	1						
Muskrat		2		3			
Weasel		1					
Hamster				1			
Cat	6	10		7		1	4
Dog	6	4		3			
Goat	1						
Bovine	7	1	2				1
<b>TOTAL</b>	<b>56</b>	<b>31</b>	<b>8</b>	<b>18</b>	<b>3</b>	<b>1</b>	<b>5</b>



TABLE III\*

## RABIES EXAMINATION FROM SOUTH DAKOTA

ANIMAL	P.	N.	S.	S.G.F.
Bovine	9	1	1	1
Dog	2	6	1	2
Cat				1
<b>TOTAL</b>	<b>11</b>	<b>7</b>	<b>2</b>	<b>4</b>

TABLE IV\*

## TOTAL RABIES EXAMINATION

Total from Minnesota:	122
Total from South Dakota:	24
Total from North Dakota:	428
	<b>574</b>

\* Key to Tables I, II, III, IV: P.-Positive; N.-Negative; S.-Suspicious; S.G.F.-Sent to Grand Forks Public Health Laboratory; N.D.-No diagnosis; A.I.P.-Animal Inoculation Positive; A.I.N.-Animal Inoculation Negative; S.H.O.-Sent Home for Observation.

## RABIES IN DOMESTIC ANIMALS

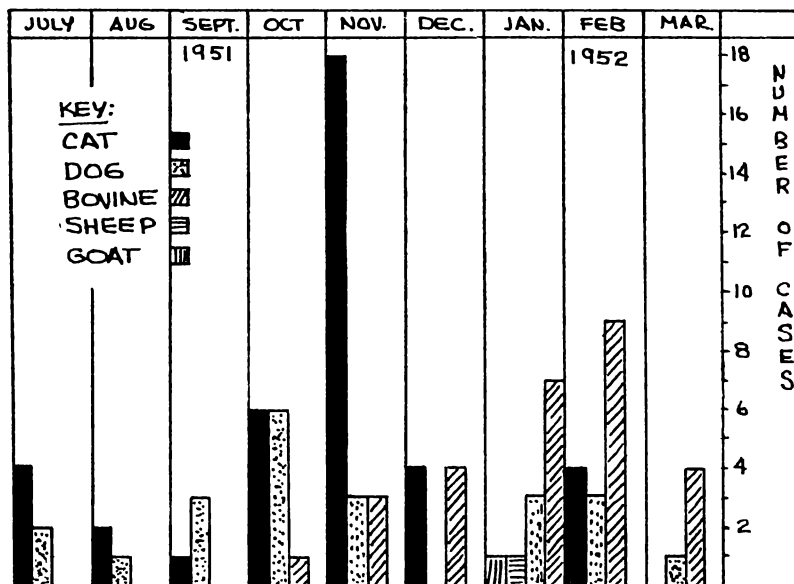


FIG. II

Those rabies examinations from Minnesota and South Dakota extend somewhat beyond the Fargo Moorhead trade area. We do have good communication by highway, rail and air in getting to the laboratory.

In Fig. II Rabies in Domestic Animals is shown. The disease occurred most frequently in the dog and cat in July, August and September, making its first appearance in cattle in October with an increasing number each month to February of this year when nine diagnoses of rabies in cattle were made. In March there were four cases of rabies found in cattle. The dairy barn cat and the stock-dogs are common farm accessories serving useful purposes. There have been no cases of rabies in animals vaccinated for at least 2 weeks. It would be inadvisable to reduce the number of useful cats and dogs in either the urban or rural areas. Stray dogs and cats should be eliminated. It is good insurance to vaccinate all dogs and cats each year in infected areas.

### RABIES IN WILD ANIMALS

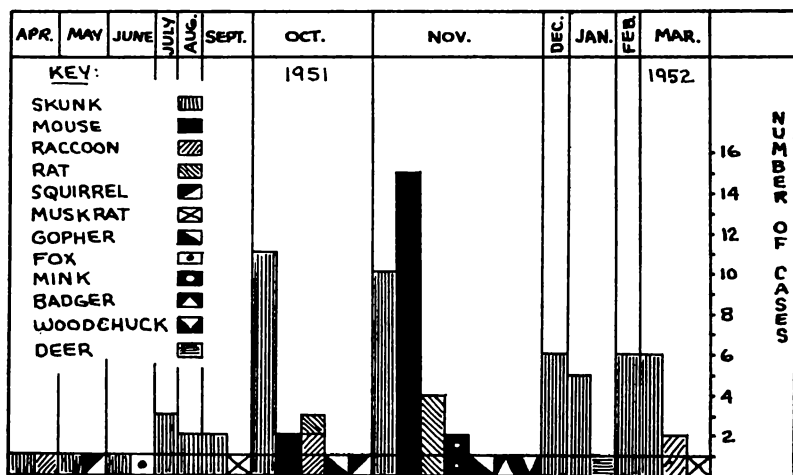


FIG. III

It appears that the introduction of rabies into southeastern North Dakota was by the skunk. In wild animals rabies was confined from April to October 1, 1951 to the skunk (10), raccoon (1), squirrel (1), fox (1) and muskrat (1).

During October and November there were nine different species of wild animals in which the Negri bodies were found. They were

all species which defend themselves at least to some extent by biting.

The mouse, rat, squirrel and gopher are preyed upon by the skunk, fox, mink, badger, dog and cat. There is a possibility of rabies being transmitted by eating the carcass of an animal dead of rabies. More likely transmission would be by the fighting that takes place over the carcass. Very little rabies would be transmitted from cow to cow, sheep to sheep or between cattle and sheep. It is quite natural for dogs to infect dogs; likewise for any species to transmit the disease within the species where fighting is accomplished by fighting—Canibalism is common in mice whenever crowding is present or when there is a shortage of food and water.

Surely the sequence from one species to another will change from one season to another or from one year to the next. The pattern in an area that has had rabies for many, many years will be different than that in North Dakota which is, however, currently having its first major prolonged outbreak of rabies.

In conclusion let me say that from the results of a study of the epizootology of the current outbreak of rabies we can expect to have more cases of rabies in wild animals and domestic livestock in 1952 than we had in 1951.

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2. A.V.M.A. Committee on Rabies. Rabies. Proceeding Book A.V.M.A. (1951): 402-403.

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## GEOLOGY OF EMMONS COUNTY, NORTH DAKOTA

*Stanley Parkins Fisher, Jr.*

*Geology Department*

*University of North Dakota, Grand Forks, North Dakota*

#### ABSTRACT

The Pierre, Fox Hills and Hell Creek formations of the Cretaceous period, and the Cannonball formation of the Paleocene series of the Tertiary period are exposed at the surface in Emmons County. All the formations are of marine origin with the exception of the Hell Creek. Contacts between the formations are conformable, except for channel scours in the top of the Fox Hills.

Present maps of this area show the bedrock in almost all of Emmons and the adjacent counties to the east as the "Lance" formation, the lowest unit of which is now known as the Hell Creek beds. Actually, the most extensive formation is the Fox Hills sandstone,

the upper beds of which may be followed for a score or more miles eastward into Logan County. The lower Fox Hills, which is divided into two sandstone members, is found to pinch out eastward.

The Breien marine member of the continental Hell Creek beds was not observed in Emmons County. This fact, together with the pattern of known outcrops of this member in Morton and Sioux counties, indicate a brief readvance of the Cretaceous sea from the south.

Field evidence is in agreement with the view that the older glacial till sheet is considerably younger than was once supposed. Several large, partly abandoned valleys in Emmons County were studied in conjunction with known channels in neighboring areas. The regional drainage pattern and other evidence suggests that: (1) Badger and Apple Creek valleys are the abandoned continuations of the pre-glacial Cannonball and Heart Rivers; (2) the old northwest-southeast valleys represent temporary ice-marginal courses of the Missouri River; and (3) the present course of the river in south central North Dakota may have been initiated during the retreat of an early ice sheet.

Elevations on various beds were obtained with a Paulin altimeter, and a surface structure contour map was constructed. The anticlines are small, and appear to be the result of successive periods of uplifting and folding. At least one, and possibly all, increase in folding with depth. These folds are of interest as sites for oil test-drilling. In addition, a few anticlinal noses may have closure at depth in spite of the fact that the structures are adversely affected by the regional thickening of the section. Below a depth of about 2000 feet, the subsurface section contains a number of potential source beds and reservoir beds. Regional unconformities and the possibility of eastward pinch outs of beds are briefly mentioned.

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## VALERIC ACID, ALPHA METHYL, 1-METHYL AMYL ESTER

*Clifton Eugene Miller*

*School of Pharmacy*

*North Dakota Agricultural College, Fargo, North Dakota*

As a part of an extensive study of the relationship between chemical structure and pharmacological action, we have been interested in the several isomeric caproic acids. Since a large quantity of one member of this series, alpha methyl valeric acid, was needed a study of its preparation was made. The literature survey (1, 2) disclosed that it had been prepared in fair yields by the acetoacetic ester re-

action, the malonic ester synthesis, and by the oxidation of the alcohol obtained by heating *n*-propyl alcohol with its sodium derivative.

### EXPERIMENTAL

The commercially available 2-methylpentanol-1 offered a convenient starting material for direct oxidation to the desired acid. The method (3) used is described herewith. A 2-liter three-necked flask, equipped with an efficient mechanical stirrer, separatory funnel, and thermometer was charged with a chilled solution of 240 cc. of concentrated sulfuric acid previously diluted with an equal volume of water. The stirrer was started and 306 g. of cold Eastman practical grade of 2-methylpentanol-1 added. An efficient ice-salt bath was placed around the flask and a solution of 320 g. of technical sodium dichromate in 200 cc. of water was added with stirring at such a rate that the temperature remained between 20 and 30°. This addition took about two hours, the ice bath was removed and stirring continued until the temperature remained constant. The contents of the flask were transferred to a 5-liter separatory funnel and diluted with an equal volume of water. The ester was separated and the aqueous layer extracted once with chloroform. The combined organic layers were washed with water until neutral and dried over anhydrous sodium sulfate.

The crude ester was stripped through a 30 cm. heated vigreux column to remove 1-methylvaleraldehyde, b.p. 115-116°, and unreacted 2-methylpentanol-1, b.p. 145-150°. Vacuum was then applied and the ester collected at 74-78°/4 mm. Yield, 166 g. of ester (67%);  $d_{25}^{25}$  0.8664;  $(n)_{D}^{25}$  1.4186; sap. equiv. calculated for  $C_{12}H_{22}O_2$  100.1; found 100.6.

Saponification of the ester was accomplished in the usual manner. A representative run is described. 171 g. (0.855 mol.) of ester were mixed with 56 g. of potassium hydroxide in 200 cc. of water and refluxed with stirring for three hours. The alcohol was separated by dilution with water. The aqueous layer was acidified with 0.6 mole of sulfuric acid in 200 cc. of water. The organic layer was separated and the aqueous residue extracted with chloroform. The combined organic layers were dried over anhydrous sodium sulfate. The chloroform was removed and the crude acid distilled to yield 94 g. (93%) of colorless liquid, b.p. 94-96°/15 mm. The literature (4) reports 96°/15 mm. Derivatives of this isomeric caproic acid will be reported elsewhere.

### SUMMARY

1. The oxidation of 2-methylpentanol-1 in acid media with sodium dichromate yields as the principal product valeric acid, alpha methyl, 1-methyl amyl ester.
2. Saponification yields the expected alpha methyl valeric acid in yields of 90 per cent.

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**THE DETERMINATION OF COBALT IN FEEDS**

*Richard P. King, Donald W. Bolin, Earle W. Klosterman, and  
W. E. Dinusson*

*Animal Nutrition, Department of Animal Husbandry  
North Dakota Agricultural College, Fargo, North Dakota*

**ABSTRACT**

Cobalt is one of the essential minor elements in the nutrition of ruminants. Cobalt deficient pastures and forages for the ruminant have been reported for Australia, Canada, and the United States.

Since cobalt has been found to be one of the constituents of vitamin B<sub>12</sub>, it can be definitely assumed that cobalt is necessary in the normal nutrition of all animals.

An easy, rapid and accurate method for cobalt determination in feeds is of prime importance. A large number of methods and modifications of previous methods have been published. In spite of these, there is a decided need for improvement in the determination of cobalt in feeds. A method for the determination of cobalt in feeds is being developed in this laboratory.

The method employs the nitroso R salt as a specific for cobalt by the use of the ion exchange technique on a perchloric acid-washed alumina column and colorimetric procedure with a 520 micron filter.

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**SOME OBSERVATIONS ON THE EFFECTS OF GRAIN  
"PRESERVATIVES"**

*R. H. Harris and L. D. Sibbitt*

*Department of Cereal Technology  
North Dakota Agricultural College, Fargo, North Dakota*

**ABSTRACT**

Conflicting reports have been circulated regarding the virtue of certain inorganic compounds for preventing deterioration in stored

wheat and other farm products. These "preservatives" consist principally of sodium bicarbonate, and their beneficial effects have been largely ascribed to the production of carbon dioxide in stored grain leading to the inhibition of the growth of micro-organisms which are chiefly responsible for heating in high moisture grain. It has been shown, however, on a theoretical basis that sufficient carbon dioxide is produced by the respiration of wheat containing 16.8% moisture to inhibit mold growth and suppress heating after a few days of storage.

Another benefit claimed by some from the use of these substances has been a reduction in moisture content of the grain because of the removal of moisture by the escape of carbon dioxide gas.

The laboratory experiments described here were made to determine whether these grain "preservatives" in any way justified their use in farm-stored wheat. A preliminary experiment with wheat at 21.0% moisture content held under approximately 88% relative humidity at room temperature, showed no detectible amount of heating; however, the sample containing 5 lbs of preservative per ton of wheat suffered less loss in germination, and had lower fat acidity than the control. Although both samples were badly damaged and unfit for other than feed uses, the treated wheat appeared slightly better.

Following these initial experiments, 17 lbs. of cleaned sound wheat were wetted with distilled water and thoroughly mixed in a MacLellan batch mixer to insure uniform distribution of moisture. After addition of the "preserving" compound with a second mixing, the damp wheat was placed in six inch glazed sewer tile, equipped with electrodes for temperature measurement. The tiles were wrapped with glass wool insulation, placed in large cans and packed with vermiculite.

For these insulated samples, heating was retarded by the compound, the degree of retardation corresponding to the amount of compound employed. However, all treated samples finally approached the highest temperature of the control and eventually became unfit for milling and baking purposes. Germination and fat acidity values showed generally the same picture as those for temperature. No consistent decrease in the moisture content of the treated wheat was noted.

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## THE SYNTHESIS OF SOME TETRALIN ANALOGS OF DDT'

*Leonard E. Miller, J. R. Willard and E. Leon*

*Department of Chemistry*

*University of North Dakota, Grand Forks, North Dakota*

Numerous analogs of DDT (1,1-bis-(p-chlorophenyl)-2,2,2-trich-

loroethane have been prepared, but to date no tetralin analogs are included among those which have been reported. Tetralin, 1-chloro-5,6,7,8-tetrahydronaphthalene and 1-methoxy-5,6,7,8-tetrahydronaphthalene have been caused to condense with chloral hydrate in the presence of sulfuric acid to form new compounds related to DDT.

Although, as in the preparation of DDT, a number of structural isomers may be formed from these reaction mixtures, only a single pure product was isolated in each case. Several attempts to characterize the tetralin analog itself by degradation experiments were unsuccessful. However, the infrared absorption spectrum of the tetralin analog resembles that of a 1,2,4-trisubstituted benzene. It is tentatively assumed from this evidence that condensation has taken place at the 2-position of tetralin.

Dr. C. W. Kearns of the Department of Entomology, University of Illinois conducted studies of the insecticidal activities of these analogs against house flies, milk weed bugs, German roaches and American roaches. 1,1-bis-(1-Chloro-5,6,7,8-tetrahydro-x-naphthyl)-2,2,2-trichloroethane was found to be one-tenth as effective as DDT against house flies. No other indications of insecticidal activity were found in these tests. However, results of food tests with black carpet beetles conducted by Dr. C. J. Weinman of the Natural History Survey, State of Illinois, indicated insecticidal activity in concentrations of greater than one-quarter of one per cent.

## EXPERIMENTAL

### 1,1-bis-(5,6,7,8-tetrahydro-x-naphthyl)-2,2,2-trichloroethane.

A mixture of 25 g. of chloral hydrate and 45 g. of tetralin was cooled in an ice-bath. Over a period of two hours, 250 ml. of conc. sulfuric acid was added to the mechanically stirred mixture. After an additional period of five hours of stirring, the reaction mixture was poured into 500 ml. of an ice-water mixture. The supernatant liquid was decanted from the solid mass which formed. The residual solid material was covered with boiling water and this mixture was boiled for ten minutes. The water was then decanted from the solid material. This washing process was repeated until the water washes were neutral to Congo red paper. The solid residue was then dissolved into benzene. The benzene was distilled from this solution until the distillate was no longer cloudy. The remaining benzene was removed by distillation under diminished pressure (12-14 mm.). The solid residue from this distillation was dissolved in absolute ethanol. After treatment of the ethanol solution with activated charcoal and cooling, 31.2 grams of colorless crystals separated; m.p. 114.5-115°. This represents a yield of 47 per cent of theory.

After two additional recrystallizations from absolute ethanol, the m.p. was 114.8-115°.

Anal. Calcd. for  $C_{22}H_{23}Cl_3$ : C, 67.06; H, 5.98; Cl, 27.08.

Found: C, 67.10; H, 5.89; Cl, 27.01.



The product was very soluble in chloroform, benzene, toluene, xylene, ethyl ether, and dioxane; it was soluble in ligroin, methyl acetate, ethyl acetate and ethylene chloride; it was slightly soluble in methanol and ethanol.

**Dehydrochlorination of 1,1-bis-(5,6,7,8-tetrahydro-x-naphthyl)-2,2,2-trichloroethane.** Ten grams of potassium hydroxide were dissolved in 100 ml. of absolute ethanol and 5 g. of 1,1-bis-(5,6,7,8-tetrahydro-x-naphthyl)-2,2,2-trichloroethane were added to the solution. After boiling under reflux for sixteen hours, the hot reaction mixture was poured into 100 ml. of cold water. After acidification with hydrochloric acid, the aqueous ethanol solution was extracted with four 50-ml. portions of ether. The ether was removed from the combined extracts by distillation. The solid residue was dissolved in absolute ethanol and treated with activated charcoal. On cooling, colorless crystals separated from the solution. After recrystallization from absolute ethanol, the product melted at 109-110°. The yield was 3.8 g. or 84.5 per cent of theory. A mixture of the product with the starting material melted at 94.5-96°.

Anal. Calcd. for  $C_{22}H_{22}Cl_2$ : C, 73.95; H, 6.21; Cl, 19.85

Found: C, 74.07; H, 6.05; Cl, 19.88

**1-Acetylamino-5,6,7,8-tetrahydronaphthalene.** Two hundred grams of 1-acetylamino-naphthalene were dissolved in 1000 ml. of absolute ethanol. Twenty grams of Raney nickel were added, and the mixture was treated with hydrogen under 50 atmospheres pressure at 100° for two hours. The Raney nickel was removed by filtration of the hot ethanol solution. On cooling, 1-acetylamino-5,6,7,8-tetrahydronaphthalene crystallized. The solid was collected on a filter, washed with a small volume of cold absolute ethanol, and was recrystallized from toluene. The ethanol filtrate was used as the solvent for the hydrogenation of a second 200 g. portion of 1-acetylamino-naphthalene. After drying the purified product in an oven at 60° for eighteen hours, the melting point was 154-156° (reported, 154°). The yield was 289 g. or 71 per cent of the theoretical amount.

**1-Chloro-5,6,7,8-tetrahydronaphthalene.** — Twenty-five grams of 1-acetylamino-5,6,7,8-tetrahydronaphthalene, 50 ml. of concentrated hydrochloric acid, and 75 ml. of water were boiled under reflux for one and one-half hours. At the end of this time, all of the acetylamino compound had dissolved. After cooling, the solution solidified. One hundred milliliters of water were added to the hydrolysis mixture, the solution was cooled to 0° in an ice-salt bath and a solution of 9 grams of sodium nitrite in 50 ml. of water was added slowly. The temperature was carefully maintained within one degree of 0° during the addition of the sodium nitrite solution, and the mixture was tested frequently with starch-iodide paper.

A solution of cuprous chloride was prepared in the following manner. Twenty-one grams of cupric chloride were dissolved in 150 ml. of water and the solution heated on a steam bath. To this hot

solution was added a solution of 9 grams of sodium bisulfite and 6 grams of sodium hydroxide in 75 ml. of water. The white precipitate which formed was washed by decantation and finally dissolved in a mixture of 60 ml. of concentrated hydrochloric acid and 20 ml. of water.

The solution of the diazonium salt was added to the cold cuprous chloride solution. The suspension of the diazonium-cuprous chloride complex was allowed to stand for fifteen minutes and then heated on the steam bath to induce decomposition of the complex. The hot solution was distilled with super-heated steam until the distillate was no longer cloudy. Approximately two and one-half liters of distillate were required. The distillate was extracted with 50-ml. portions of benzene until the benzene layer was no longer colored; a total of 450 ml. of benzene were required. The benzene extracts were washed repeatedly with 2 per cent sodium hydroxide solution until the wash solution remained clear when acidified with hydrochloric acid.

After removal of the phenolic components, the benzene was distilled from the extracts and the 1-chloro-5,6,7,8-tetrahydronaphthalene was distilled under 1-2 mm. pressure. The product was a yellow, slightly viscous liquid,  $n_D^{20}$  1.5635 (reported, 1.5642<sup>3</sup>). The yield was 7.2 grams or 30.1 per cent of the theoretical amount.

**1,1-bis-(1-Chloro-5,6,7,8-tetrahydro - x - naphthyl)-2,2,2-trichloroethane.**—Twenty milliliters of fuming sulfuric acid (20 per cent free sulfur trioxide) was added dropwise to a vigorously stirred mixture of 14.3 g. (0.086 moles) of 1-chloro-5,6,7,8-tetrahydronaphthalene and 7.1 g. (0.043 moles) of chloral hydrate over a period of two hours. After the reaction mixture was permitted to stand at room temperature for sixteen hours, it was poured into a beaker containing 100 g. of crushed ice. The yellow solid which formed was washed with water by decantation and was heated with a five per cent solution of sodium carbonate to remove the last traces of acidic compounds. The dried solid was dissolved in absolute ethanol and treated with activated charcoal. From the ethanol solution five crops of crystals were obtained by fractional crystallization. The total yield of this crude product was 9.7 g. or 49 per cent of the theoretical amount. After repeated recrystallization and treatment with activated charcoal, a small quantity of colorless crystals was obtained from each of the five fractions, m.p., 82.5-84°.

Anal. Calcd. for  $C_{22}H_{21}Cl_3$ : C, 57.11; H, 4.58

Found: C, 56.84; H, 4.72

**5,6,7,8-Tetrahydro-1-naphthol.**—A mixture of 76.5 g. (0.04 moles) of 1-acetylamino-5,6,7,8-tetrahydronaphthalene, 75 ml. of concentrated sulfuric acid, and 100 ml. of water were boiled under reflux for thirty minutes. After the acetylamino compound had hydrolyzed, the reaction mixture was steam-distilled to remove the major portion of the acetic acid. The reaction mixture was then placed in an ice-salt bath to cool.

To the cooled ( $0^{\circ}$ ) slurry of the amine salt, a solution of 28 g. of sodium nitrite in 80 ml. of water was added slowly with vigorous mechanical stirring during the course of one hour. The reaction mixture was constantly tested with starch-iodide paper to detect an excess of nitrous acid. A temperature of  $0-2^{\circ}$  was maintained throughout the diazotization.

The diazonium sulfate crystals and mother liquor were slowly added to a flask containing 300 ml. of concentrated sulfuric acid and 250 ml. of water heated to the boiling point. After allowing the solution to cool slowly, the solid material was collected on a filter and distilled under a pressure of 2-3 mm. The yellowish-white 5,6,7,8-tetrahydro-1-naphthol melted at  $68-69^{\circ}$  (reported  $68.5-69.0^{\circ}$ ). The yield was 14.9 g. or 25 per cent of the theoretical amount.

**1-Methoxy-5,6,7,8-tetrahydronaphthalene.**—Ten per cent sodium hydroxide was added to a beaker containing 14.9 g. (0.10 moles) of 5,6,7,8-tetrahydro-1-naphthol to form a slurry. The mixture was cooled to  $10^{\circ}$  in an ice-bath, and 25.2 g. (0.20 moles) of freshly distilled dimethyl sulfate were added dropwise to the well-stirred mixture during a period of fifteen minutes. After stirring for an additional fifteen minutes, the mixture was diluted with 50 ml. of water and extracted with ether. The absence of cloudiness in the water layer after acidification showed the reaction to be complete. The ether was removed by distillation, and the residue was distilled under pressure of 3-4 mm. at  $96-97^{\circ}$ . The distillate was a colorless oil,  $n_D^{20}$  1.5464 reported  $n_D^{25}$  1.5440). The yield of 1-methoxy-5,6,7,8-tetrahydronaphthalene was 16.0 g. or 98 per cent of the theoretical amount (based on 14.9 g. of 5,6,7,8-tetrahydro-1-naphthol).

**1,1-bis-(1-Methoxy-5, 6, 7, 8-tetrahydro-x-naphthyl)-2,2,2-trichloroethane.**—A mixture of 16.0 g. (0.10 moles) of 1-methoxy-5,6,7,8-tetrahydronaphthalene and 8.3 g. (0.05 moles) of chloral hydrate in a three-necked flask was placed in a water-bath at  $20^{\circ}$ . The mixture was stirred vigorously while 35 g. of fuming sulfuric acid were added over a period of two hours. After stirring for an additional two hours, the reaction mixture was allowed to stand for eighteen hours at room temperature.

The dark brown, semi-solid mass in the flask was warmed and poured into a beaker containing 100 g. of crushed ice. The product was extracted with diethyl ether, and, after drying the extract, the ether was removed by distillation. The residue was dissolved in absolute ethyl alcohol and treated with decolorizing charcoal. Two fractions were collected when the solution was subjected to fractional crystallization. Repeated recrystallization and treatment with decolorizing charcoal of each fraction gave a white solid, m.p.  $93.5-95^{\circ}$ . The total yield of 1,1-bis-(1-methoxy-5,6,7,8-tetrahydro-x-naph-

thyl)-2,2,2-trichloroethane was 1.1 g. or 4.9 per cent of the theoretical amount.

Anal. Calcd. for  $C_{21}H_{27}O_2Cl_3$ : C, 63.51; H, 6.00; Cl, 23.44.

Found: C, 63.71; H, 6.25.

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## COLLECTION AND IDENTIFICATION OF INTERNAL PARASITES IN NORTH DAKOTA ANTELOPE

*Alice I. Goldsby*

*Department of Veterinary Science*

*North Dakota Agricultural College, Fargo, North Dakota*

### ABSTRACT

Ninety-seven percent of the South Western North Dakota antelope were found to be parasitized when the intestines and abomasums were examined. The degree of parasitism ranged from 6 individual parasites to 6614.

The parasite load seemed to vary with the habitat of the antelope. Those in pastures grazed by sheep having the higher count in the abomasum parasites while those on pastures grazed by cattle had the higher count in the intestinal parasites. Nine genera in which were included 15 species were represented in the antelope parasites. Of the 15 species *O. ostertagia*, *O. bisonis*, *C. oncophoria*, *C. brevipes*, *M. expansia* and *M. benedeni* are reported for the first time as parasites infesting wild pronghorn antelope. *O. bullosa*, *O. bisonis*, *N. longispiculata*, *C. bisonis* and *C. brevipes* are reported for the first time in North Dakota.

## WOOL FIBER MEASUREMENTS

*M. L. Buchanan and D. W. Bolin*

*Department of Animal Husbandry*

*North Dakota Agricultural College, Fargo, North Dakota*

### ABSTRACT

A rapid, simple and accurate method has been developed for the determination of the wool fiber diameter. This method makes use of the audio oscillator and a vibroscope constructed from a 2 in. permanent magnet speaker. With this apparatus, the frequency is obtained at the maximum vibration of the wool fiber. The diameter of a vibrating wool fiber then can be calculated from the following equation:

$$D^2 = \frac{T \times 980 \times 10^4}{L^2 V^2 d \times 3.1416}$$

Where D is the diameter of the wool fiber in microns, T is the tension in grams, d is the density of the fiber, L is the length in centimeters, and V is the frequency in cycles per second.

This method has been found useful for evaluating the quality of individual fleeces in a selection program designed to reduce variability in fiber diameter.

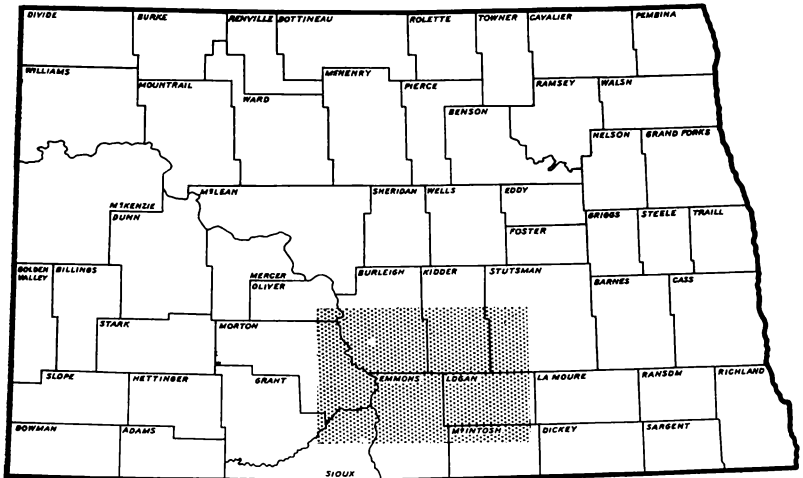
## SUBSURFACE GEOLOGY OF SOUTH-CENTRAL NORTH DAKOTA

*Donald Towse*

*Geology Department*

*University of North Dakota, Grand Forks, North Dakota*

**FIGURE I INDEX MAP**



SCALE - STATUTE MILES  
0 20 40 60 80

### INTRODUCTION

This paper is the result of studies of well records, cuttings, cores, and logs in the files of the North Dakota Geological Survey. The

work is part of the Survey's program of research into the subsurface geology and oil possibilities of the state.

General reports of the stratigraphy and structure of the state have recently been published <sup>1 2 3 4</sup>

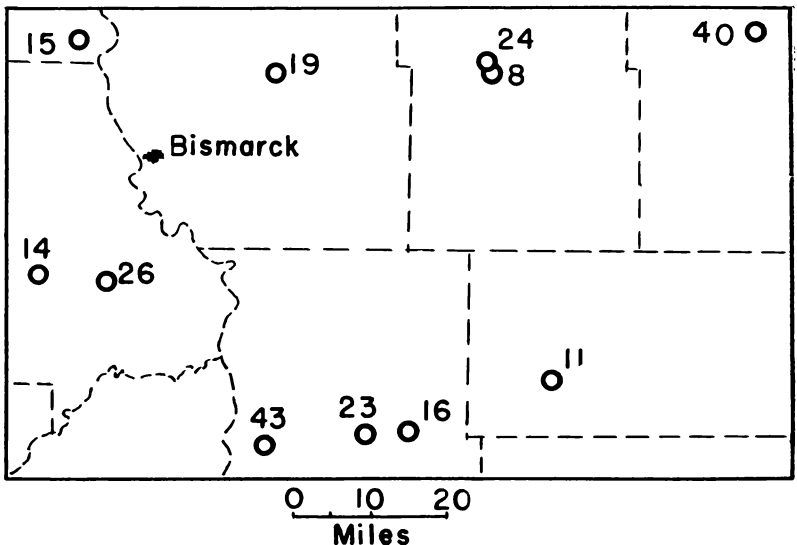
This is a brief report of the subsurface geology of the south-central part of North Dakota, an area that includes parts of Oliver, Morton, Burleigh, Emmons, Kidder, Logan and Stutsman Counties. The reader interested in the regional structure and stratigraphy is referred to the publications cited. The surface geology and stratigraphy of Emmons County<sup>5</sup> and the southern part of Morton County<sup>6</sup> have been described.

South-central North Dakota lies on the southeast flank of the Williston Basin. The regional dip is west-northwest, and many of the Middle and Upper Paleozoic, Jurassic, and Triassic formations become thinner eastward and southeastward. Regional studies indicate that a gentle northwesterly plunging uplift was present in the area in Middle Paleozoic time<sup>7</sup>.

Similar deformation is apparent in maps drawn on the Dakota sandstone in Emmons County<sup>8</sup>, and several small surface structures are present in Morton<sup>9</sup> and Emmons County<sup>10</sup>.

Earlier reports of the subsurface geology of south central North Dakota<sup>11 12 13</sup> were based on one or two wells, and exploration in adjacent areas was inadequate to establish regional relationships. This part of North Dakota now has the greatest density of wildcat wells

**FIGURE II TESTS FOR OIL AND GAS**



in the state. The contributions of this paper are a restudy of the older wells and the correlation of the stratigraphy of the area with that established as the result of modern studies of recent wells.

### DEVELOPMENT

Eleven dry holes have been drilled in the area.

**Table 1. Tests for Oil and Gas**

Map. No.	Well	Location	Formation at Total Depth
8	Prairie O. and G. Armstrong	2-140N, 73W.	Madison
11	D. J. Carter No. 1	26-134N, 72W.	Cretaceous
14	Carter strat test	22-136N, 83W.	Big Snowy
15	Carter Semling	18-141N, 81W.	Pre Cambrian
16	Northern Ordnance Franklin Investment	35-133N, 75W.	Pre Cambrian
19	Continental-Pure Davidson	6-140N, 77W.	Pre Cambrian
23	Roeser-Pendleton Weber	35-133N, 76W.	Pre Cambrian
24	Magnolia State "A"	36-141N, 73W.	Pre Cambrian
26	Phillips-Carter Dakota	29-136N, 81W.	Pre Cambrian
40	Barnett Drlg. Gaier	11-141N, 67W.	Pre Cambrian
43	Peak Drlg. Olhauser	8-132N, 78W.	Pre Cambrian

No commercial oil has been found, but small shows have been reported.

**Table 2. Formation tests**

Well	Interval	Formation	Flow Pressure	Recovery
Prairie Oil and Gas Armstrong	2768	Piper	(cable tools)	Salt water
	3090	Charles	(cable tools)	Salt water
	3220	Charles	(cable tools)	Salt water
Carter strat test				No information
Carter Semling				No tests
Northern Ordnance	5062	Winnipeg sand	2150 PSI	4962' slightly brackish water. Loose sand.
Continental Davidson	4397-4422	Mission Canyon	400 PSI	2800' salt water and mud.
Roeser-Pendleton J. J. Weber	3374-3397	Charles	no DST	Core with dead bitumen
Magnolia State "A"	3357-3396	Lodgepole	zero	350' thin salty mud
Phillips-Carter Dakota	4912-4922	Charles-Mission Canyon	468 PSI	720' black sulfur water, ½ pint 30° oil.
Barnett Drilling Gaier	3395-4145	Red River	1710 PSI	900' mud and 2580' slightly salty water.
Peak Drilling Olhauser	3569-3599	Madison	zero	Salt water.

## Stratigraphy

Paleocene or Upper Cretaceous Montanan rocks form the surface of the area. Table 3 lists formation tops based on available sample and electric logs of the deep wells.

Table 3. Formation Tops

Map Number	15	16	19	23	24	26	40
Operator	Carter	No. Ordnance	Continental	Roeser-Pendleton	Magnolia	Phillips	Barnett
Location	18-141-81	35-133-75	6-140-77	35-133-76	36-141-73	29-136-81	11-141-67
<b>Cretaceous</b>							
Fox Hills	?	*	450	*		528	
Pierre	?	?	640	420	500	722	
Niobrara	2268	1268	1622	1275	1455	1838	1048
Greenhorn	2806	1815	2170	1855	1948	2400	1555
"Muddy"	?	2257	**	2288	2250	2880	?
Dakota	3465	2458	2810	2500	2500	3100	2052
<b>Jurassic</b>							
Morrison	3675	?	2925	2662	2706	3260	2224
Ellis	3828	2630	3060	2695	2740	3330	2290
Sawtooth (Piper)	4025	2844	3205	2845	2860	3650	?
<b>Triassic</b>							
Spearfish	4385	**	3548	**	3034	3870	**
<b>Mississippian</b>							
Amsden	4600	**	3588	**	3070	4000	**
Heath	4702	3105	3680	3105	**	4073	**
Otter	4760	?	3713	3175	**		**
Kibbey	4929	?	3773	?	**		**
Charles	5045	3132	3848	3250	3105	4410	**
Mission Canyon	5620	3310	4340	3428	**	4920	**
Lodgepole	5752	?	4468	?	3386	5032	2420
Englewood	6350	3875	4928	4010	3932	5582	2856
<b>Devonian</b>	6438	3920	5008	4060	4000	5650	2905
<b>Silurian</b>							
Stonewall	7118	4068	5455	4208	4290	6100	3062
<b>Ordovician</b>							
Stony Mountain	7550	4195	5750	4377	4495	6398	3125
Red River	7646	4290	5850	4470	4582	6495	3218
Winnipeg	8314	4872	6488	5050	5178	7135	3790
<b>Pre Cambrian</b>	8835	5345	6945	5543	5596	7764	4140

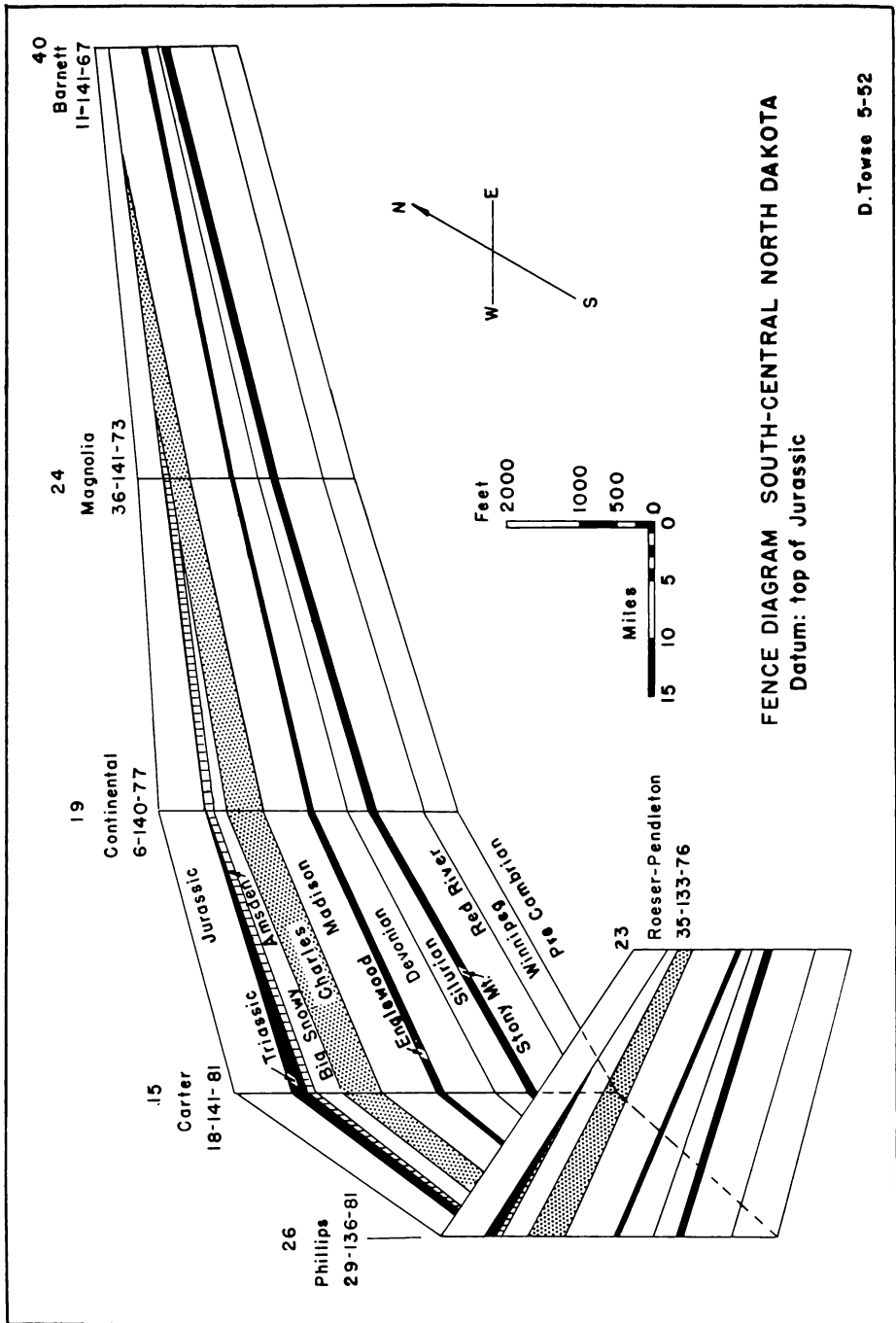
\* Surface

\*\* Missing

**Pre-Cambrian**—Most wells penetrating Pre Cambrian have found a pink orthoclase biotite granite, but the Phillips-Carter Dakota well (map No. 26) found hornblende schist. The geology of the Pre Cambrian is imperfectly known. Differences in basement lithology may affect its structural behavior.

**Cambrian**—Some geologists consider the basal glauconitic Winnipeg sandstones to be Cambrian. In the absence of faunal evidence to the contrary, the entire Winnipeg formation is considered to be Ordovician in this report.





FENCE DIAGRAM SOUTH-CENTRAL NORTH DAKOTA  
Datum: top of Jurassic

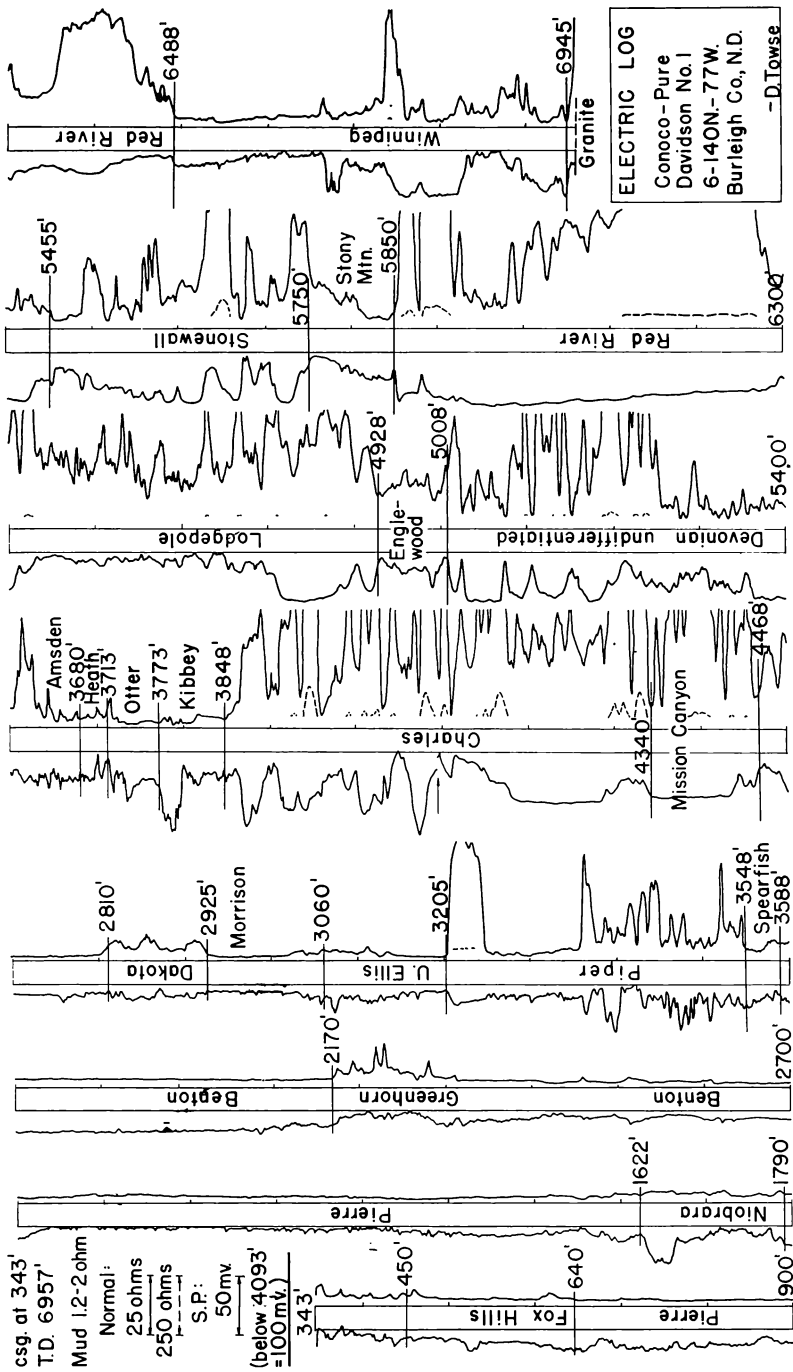


Figure 4. Electric Log. Continental-Pure Davidson No. 1

**Ordovician**—The Ordovician contains three formations, in ascending order, the Winnipeg, Red River, and Stony Mountain formations. The Winnipeg formation consist of green to gray shales and quartzose and glauconitic sandstones. The sandstones are porous, and the basal beds are arkosic in the Magnolia well. The light colored dense dolomites and limestones of the Red River have scattered porosity, but are generally tight. The Stony Mountain is gray shaly limestone containing many bryozoa fragments in well cuttings.

All three Ordovician formations are easily recognized in samples and electric logs. The Ordovician thins slightly from 1400 to 1000 feet in an easterly direction. The electric log characteristics of the Stony Mountain formation make it a useful unit for structural mapping throughout the state.

**Silurian**—The Stonewall formation is a distinctive very pale colored fine grained dolomite. It has good vugular porosity and contains quartzose sand at the top and base. The uppermost part may be red stained, and an unconformity is present at the top. The Silurian system thins from 800 to 60 feet in a southeasterly direction in south-central North Dakota.

**Devonian**—Correlation within the Devonian system must await more detailed study. The Devonian consists of pale and brownish crystalline dolomites, much shale, chert, and small amounts of limestone. Dead oil was present in the Phillips and Roeser-Pendleton wells. Porosity is fair to good. Devonian fossils were recovered in the basal part of the Continental Davidson well. The Devonian thins from 600 to 150 feet in a southeasterly direction. Data from the few wells to the north suggest a northwesterly trending area of thin Devonian rocks that includes most of the area of this report. Clastic content increases in a southeasterly direction, and it is suggested that slight warping in Devonian time caused erosion and non-deposition.

**Mississippian**—The shaly limestones and dark shale of the Englewood formation lie at the base of the Mississippian. The formation is a good marker in samples, electric logs, and radioactivity logs. A thick carbonate and evaporite unit lies above the Englewood. It is divided into, in ascending order, the Lodgepole, Mission Canyon, and Charles formations. The lower two formations have been included in the Madison group, and the Charles was originally included in the Big Snowy group<sup>1</sup>. The Charles sedimentation is more related to that of the Madison, however, and the most conspicuous lithologic change is at the top of the Charles. It is, therefore, here considered part of the Madison group.

The Lodgepole is a dense cherty, light gray, shaly limestone. The Mission Canyon is lighter in color, fragmental or oolitic, and quite porous. Slight oil shows were noted in the Roeser-Pendleton and

**Magnolia wells.** Exact delimitation of the formations is difficult, but the Mission Canyon is absent in the Barnett well and is missing or very thin in the Magnolia well.

The Charles formation is limestone or dolomite with much anhydrite. The base is taken at the base of the lowest thick anhydrite bed, but thin anhydrites are present in the upper part of the Mission Canyon formation. Post-Mississippian erosion has removed the Charles in the east. The total thickness of the Madison group and Englewood shale varies from 1400 to 500 feet in a southeasterly direction. Most of the thinning is due to erosion of Charles and Mission Canyon in post-Mississippian time.

The Big Snowy group lies between the Charles below and the Amsden above. The lowest formation, the Kibbey, has reddish quartz sandstone, shales and anhydrite. The middle formation, the Otter, has varicolored shales and dolomite. The Heath shale, at the top of the group, is a dark carbonaceous shale; some dolomite is interbedded. The Big Snowy group is 400 feet thick in the west and is missing in the Magnolia and Barnett wells. Local concentrations of sand, as in the Continental well, may be shoreline sandstones. The thinning of the group is in part due to erosion.

The Amsden formation is at the top of the Mississippian system in the area. It consists of pinkish dolomites, shale, and some sandstone. It overlaps Charles formation in the Magnolia wells. The Amsden formation is here more extensive than the Big Snowy group. It is believed that the present limit of the Amsden is near the original shoreline, and that local sandstone may be shore features. Sandstone is present in the Continental well.

**Triassic**—The Triassic Spearfish formation is 200 feet thick in the west and is missing in the Roeser-Pendleton, Northern Ordance, and Barnett wells. The Spearfish contains moderate brown shales and sandstone and gypsum. It is difficult to separate from the overlying Jurassic, but the top may be placed at the change in shale colors and the appearance of brown sandstones.

**Jurassic**—The Jurassic system overlaps the older formations and varies from 800 feet thick to 400 feet in the east and southeast. The system is divided into two units, the Morrison formation above and the Ellis group below. The Ellis is further divided into, in ascending order, the Sawtooth (Piper), the Rierdon, and the Swift formations.

The Piper has a persistent fragmental to dense light-colored limestone at the top. The basal part is brown shale and gypsum. The upper limestone has a characteristic resistance curve on electric logs. The Swift is a series of glauconitic sandstones with interbedded gray to greenish-gray shales lying below the vari-colored shales and the shaly sandstones of the Morrison formation. The Swift sandstones are porous and could be reservoirs. The Rierdon is difficult to sep-

arate exactly, but may be taken as the shaly interval between the Swift sandstones and the Piper limestone.

**Cretaceous**—The Cretaceous system is from 2500 to 3000 feet thick. Fox Hills and Hell Creek beds outcrop in the east. The Niobrara and Greenhorn limey shales are good electric log markers.

The Dakota group is a variable series of sandstones and shale at the base of the system. Some of the sandstones are quite porous. The "Muddy sand" is a sandy unit lying about 200 feet above the Dakota. The "Muddy" is apparently quite variable, and it is absent in the Continental well. There are several sand bodies above the Dakota in the Barnett well. The sandstones have variable porosity and may have oil possibilities on structure or where there are variations in porosity.

### OIL POSSIBILITIES

Some surface folds remain to be drilled in the area, and geophysics should find other structural possibilities.

Many of the Paleozoic rocks have suitable porosity, and small shows of oil have been found. Porosity variations in the carbonate rocks and in the sandstones of the Silurian, Big Snowy, Amsden, and Cretaceous sandstones may provide possibilities for stratigraphic or combination traps. Pinch-outs of Big Snowy, Charles, and Mission Canyon rocks below the Jurassic-Triassic unconformity offer additional possibilities, especially if some structure is also present.

The central part of the area has not been tested, and it should be evaluated by geophysics and the drill.

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# THE EFFECT OF FERTILIZATION UPON THE COMPOSITION OF NORTH DAKOTA SPRING WHEAT GRAIN<sup>1</sup>

*H. J. Klosterman and C. O. Clagett*

*Department of Agricultural Chemistry  
North Dakota Agricultural College, Fargo, North Dakota*

<sup>1</sup> Published with the permission of the Director, North Dakota Agricultural Experiment Station, Fargo, North Dakota.

The History of Agricultural Chemistry records an abundance of information illustrating the dependence of plant composition upon soil fertility. This relationship is demonstrated for example in the incidence of goiter in people who live in iodine deficient areas. A certain type of bone malformation found in animals from various parts of the world has been prevented by the application of phosphates to the soil. An analysis of plant material grown on these and other deficient soils has shown an extreme deficiency of the element in question.

The dependence of plant composition upon soil fertility may be demonstrated further with the case of the "alkalinity disease" which is quite common in many parts of the world including our neighboring state of South Dakota. In this instance, a relatively high selenium content in the soil has led to an incorporation of selenium in the plants growing there. The continuous ingestion of seleniferous material by animals leads to various ailments. We may consider this to be an infertile soil while actually it is the preferred soil for certain plants.

In the Miscellaneous Publication No. 369, Kenneth Beeson of the U. S. Dept. of Agriculture has reviewed the numerous studies of the mineral composition of various plants. He again points out that plant composition may be influenced by soil fertility.

During the past several years much attention has been focused on the use of commercial fertilizers on grain crops. In many cases phenomenal responses have been obtained. The question naturally arises as to the effect of these fertilizers on the mineral content of the grain. An increase in phosphorus and nitrogen would increase the nutritive value of the wheat.

The Agronomy Department has been conducting fertilization experiments on Mida wheat in various parts of the state for the past few years. Since these experiments were conducted under controlled conditions, we secured and analyzed samples from each of the plots. We have data from Minot, Edgeley, Langdon and Fargo, for a total of eight crop years. Treatments ranged from 10 tons of manure per acre to 100 lbs. of 0-47-0 per acre, with lower levels of phosphate applications included. The data are summarized in Table I. Yield data were taken by the Agronomy Department and have been discussed elsewhere.

In addition to these samples we have analyzed a number of unfertilized samples grown under field conditions. The phosphorus and nitrogen of these samples are included in Table I. While it appears that fertilization raised the phosphorus level slightly, a statistical study showed that the change was significant in only one of eight trials, and that was barely significant at the 5% level. The slight differences observed lie within the standard errors usually encountered in studies of this type.

TABLE I

	Number of Samples		
	% N	% P	Yield Bu/A
Average of controls (31)	3.04	.41	28.3
Average of treatments (65)	3.01	.44	29.5
Average of highest treatments (31)	2.99	.43	31.9
Average of 36 samples (unfertilized)	2.99	.40	
Average 310 samples (from Beeson)		.40	

Note—data expressed on dry basis.

From these comparisons one must conclude: (1) that the average nitrogen and phosphorus content of these samples has not been significantly altered by fertilization; (2) phosphorus and nitrogen content of these samples is near that reported by others.

This study illustrates the relatively constant composition of plant seeds. Apparently an increase in soil fertility affects yield rather than composition. Nature will provide for the offspring if at all possible.

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## THERMAL TREATMENT OF NORTH DAKOTA LIGNITE AT CONTROLLED TEMPERATURES

*Walter H. Oppelt*

*Utilization Section, Charels R. Robertson Lignite Research Laboratory  
Bureau of Mines, Grand Forks, N. Dak.*

### ABSTRACT

The purpose of this paper is to report current results of an investigation of the thermal treatment of lignite, which has been carried out with funds made available by the Interior Missouri Basin Field Committee.

Lignite, classified as a low rank coal, is characterized by a high moisture content, averaging some 37%, and a high ratio of oxygen to carbon. While the ratio of oxygen to carbon is about 0.05 for

anthracite, it is as high as 1.02 for lignite. The ratio of the net heating value to the gross heating value is lower for lignite than for high rank coals. The lower the ratio of net heating value to gross heating value, the more heat is carried away in the stack gases with the water vapor as latent heat of vaporization and sensible heat.

The removal of moisture from the lignite would reduce the concentration of the water vapor in the products of combustion and thus increase the ratio of the net to the gross heating value, which, in turn, would result in a higher furnace efficiency.

The reduction of the oxygen content with a simultaneous increase of the carbon content over and above that obtained by the removal of the moisture would lead to a further decrease of the oxygen to carbon ratio and consequently to an increase of the heating value. It was experimentally shown that a thermal treatment of Kincaid lignite at controlled temperatures was able to improve both the ratio of oxygen to carbon and the ratio of net to gross heating value.

An electrically heated rotary drum, equipped with automatic temperature control, was used to carry out the investigation. Approximately 8.8 pounds of natural Kincaid lignite of  $\frac{1}{2}$  by  $\frac{3}{4}$  inch size were used in each experiment.

Material balances of experiments covering a temperature range between 250° and 950°F. were presented. These material balances showed the moisture of the lignite to be completely removed at temperatures of 300° to 400°F. With increasing temperatures, increasing quantities of additional water was obtained, originating from thermal decomposition of the carbonaceous substance. At a temperature of 950°F. as much as 6.9 pounds of water of decomposition per 100 pounds original lignite were recovered.

Condensable tar vapors began to form at approximately 700°F., increasing steadily with rising temperature. Noncondensable hydrocarbon gases were evident at 600°F. and increased with increasing temperatures. The release of carbon dioxide was noticeable at approximately 400°F., steadily increasing with higher temperatures. Hydrogen sulfide began to form at approximately 500°F.

Correlation of the ultimate analyses of the solid products showed that the carbon content increased steadily with increasing treating temperatures while the oxygen content decreased. The concentration of ash in the treated solid products increased with increase in treating temperatures owing to the steadily decreasing yield of treated material. The ratio of oxygen to carbon was lower than that of a subbituminous coal when the lignite had been treated at 250°F. A temperature of 950°F. produced a solid residue, the oxygen to carbon ratio of which was in the range of that of a bituminous coal. The ratio of the net to the gross heating value at a processing temperature of 250°F. was slightly better than that of a subbituminous coal,



and at temperatures of 500° to 600°F. it was equal to that of a bituminous coal.

Correlation of the data as a function of the processing temperature indicated that the removal of the moisture, which was completed at 300° to 400°F., had a more pronounced effect on both the ratio of oxygen to carbon and that of the net to the gross heating value than an additional treatment at higher temperatures, leading to thermal decomposition of the carbonaceous material.

Approximately 100% of the gross heating value of the original lignite was recovered in the solid product when processing temperatures up to 600°F. were employed. Caused by a rapid initial increase of the ratio of net heating value to gross heating value as a result of the removal of the moisture from the lignite, a maximum recovery based on the net heating value was obtained at approximately 300°F. Thermal decomposition of the lignite substance at temperatures above 600°F. reduced the recovery of the original heating value of the lignite in the obtained solid material progressively. Unless the recovery of by-products in form of tar would offset this loss, the application of processing temperatures above 600°F. is probably not advisable. It should be noted that these improvements in the lignite are at the expense of heat energy necessary to carry out the reactions, and nothing is implied at present as to commercial feasibility of any operations based upon the work reported here.

The major conclusions are:

1. That portion of the water content of Kincaid lignite which is usually called "moisture" was completely eliminated, under the prevailing conditions, at temperatures of 300° to 400°F.
2. Measurable quantities of carbon dioxide were evident at 400°F. and increased with increase of temperature.
3. Measurable quantities of hydrogen sulfide were evident at 500°F. but did not increase with temperature within the range studied.
4. Hydrocarbon gases were evident at 600°F. and increased with increasing temperature.
5. Beginning at approximately 700°F., increasing amounts of tar were produced as the temperature was raised.
6. Within the temperature range investigated, there was a continuous increase of the percentage of total carbon in the solid product with increase of temperature treatment. This increase was accompanied by a decrease in the oxygen to carbon ratio and by an increase in the ratio of the "net" to "gross" heating values.

# THE RELATIONSHIP BETWEEN COMB SIZE, BODY WEIGHT AND TESTIS WEIGHT OF MALE CHICKENS ADMINISTERED DIETHYLSTILBESTROL

*Robert E. Moreng and Reece L. Bryant*

*Poultry Husbandry Department*

*North Dakota Agricultural College, Fargo, North Dakota*

## ABSTRACT

Studies were carried out concerning the use of synthetic female hormones for fattening and finishing male chickens for market. The physical results of this treatment, widely known as "chemical caponizing," are quite evident at time of slaughter. The basic mode of action of the treatment is explainable, but the actual relationship between gain in body weight, shrinkage of comb area, and final testis size poses a question to be studied.

In order to gain information toward determining this relationship, a study was carried out on various breeds of male chickens approximately five to six months of age, and one year of age. These birds were implanted in the neck at the base of the skull with 12 milligram pellets of the synthetic female hormone agent, "diethylstilbestrol." Measurements were made on body weight and comb size at the time of implantation and again after a four week period of treatment. Data were collected on change in body weight, loss in comb area, and final testis weight at time of slaughter. The relationship between these factors was studied.

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## SECONDARY ENRICHMENT IN TIN DEPOSITS

*N. N. Kohanowski*

*Geology Department*

*University of North Dakota, Grand Forks, North Dakota*

The phenomenon of secondary enrichment involves leaching of valuable metals from the near surface of ore deposits, their transfer in solutions to lower depths, and their subsequent re-deposition. Thus, the percentage content of metals is increased in the remaining portion of a deposit as its surface is being eroded away.

Secondary enrichment processes in tin deposits have largely escaped their due recognition because end products of such processes do not differ greatly from minerals in primary ores. The more notable papers written in the past on the subject are by U. P. Greene (1) and by R. Herzenberg (2).

The present paper summarizes results of the writer's observations and laboratory experiments carried out during his 8 years of work in Bolivian tin deposits.

Topography, its stage of development, climate and humidity, height and fluctuations of ground water table, intensity of ultra-violet in solar radiation are some of the factors inducing secondary enrichment processes. Combined effect of some of these factors makes secondary enrichment both common and wide spread in tin deposits.

Such processes begin only when chemical action of surficial waters advanced ahead of mechanical abrasion. Should mechanical abrasion be more pronounced, valuable detrital placers would form down stream instead.

Hydration and peptization of rocks and minerals on surface are the initial stages of secondary enrichment. Intense ultra-violet in solar radiation at high altitudes speeds up the two. The role of solar radiation was first noted by Van Hise (3). The writer has studied it semi-quantitatively on formation of cornuite ( $m\text{CuO}\cdot n\text{SiO}_2\cdot \text{H}_2\text{O}$ ) in Corocoro. Two tin minerals are formed under the influence of ultra-violet radiation. Silesite ( $\text{SnO}_2\cdot n\text{SiO}_2$ ) forms on sun basked outcrops of quartz-cassiterite veins in arid climates. In humid climates, Arandisite ( $5\text{SnO}_2\cdot 3\text{SiO}_2\cdot 4\text{H}_2\text{O}$ ) forms instead. Their formation is thought to be due to diffusion of solids.

Leaching or removal of tin in solution follows hydration and peptization. Space does not permit a detailed description of reactions involved in hydration, peptization and leaching. However, various minerals possess different resistivities toward removing agents. A comparative study in 19 mining districts in Bolivia has permitted a compilation of the following table 1. This table shows the sequence in which minerals disappear as leaching progresses on outcrops and permits evaluation of the stage of development of secondary enrichment.

**Table 1. Minerals in Order of Increasing Stability.**

Bornite,  $\text{Cu}_3\text{FeS}_4$ ,  
 Sphalerite,  $\text{ZnS}$ ,  
 Siderite,  $\text{FeCO}_3$ ,  
 Molybdenite,  $\text{MoS}_2$ ,  
 Pyrite - Marcasite,  $\text{FeS}_2$ ,  
 Plagioclases,  
 Bismuthinite,  $\text{Bi}_2\text{S}_3$ ,  
 Stibnite,  $\text{Sb}_2\text{S}_3$ ,  
 Wolframite ( $\text{Fe},\text{Mn}$ ) $\text{WO}_4$ ,  
 Gold,  $\text{Au}$ ,  
 Galena,  $\text{PbS}$ ,  
 Tourmalines,  
 Cassiterite,  $\text{SnO}_2$ ,  
 Quartz,  $\text{SiO}_2$ ,  
 Diaspore,  $(\text{Al}(\text{OH}))\text{O}$ ,  
 Chalcedony,  $\text{SiO}_2$ .

Fluctuations in atmospheric humidity affect the rate of leaching by varying the volume of water available, direction of its motion and its velocity. A low atmospheric humidity draws ground waters toward the surface. Leaching is arrested and, in addition, chemical loads precipitated by such reversed waters seal effectively surficial openings.

The resulting surficial mineralization is known as a "desert varnish" in the language of our Southwestern miners. When the rocks exposed on the surface are porous, such a mineralization becomes disseminated throughout. It may pass unnoticed. However, a subsequent mechanical abrasion may re-concentrate it into a semblance of residual placers. When rocks exposed are more or less impermeable to escaping moisture, the latter finds its way through fissures which eventually become filled with brightly colored silicates, sulfates and sulfides. Any desert prospector remembers bitterly beautiful veins which sometimes are a thousand or more feet long, have attractive widths and "bonanza" values, but which lose all these characteristics within a few feet below the surface.

On the other hand when surface waters descend normally downward, they transfer their chemical loads to lower regions. Slowly percolating waters and creeping films of moisture are most active, while fast running waters effect largely a mechanical abrasion

Size of openings through which water passes also plays a significant role. Since most loads are transported in a colloidal state, colloidal micellae do not coagulate until waters have come to a standstill in fairly large openings.

Micellae containing tin may become very complex during the downward travel of descending waters. In Bolivian deposits notable for lack of calcium in host rocks, precipitation is not so much due to reactions of replacement as to breakdown of complex and unbalanced micellar structures and a subsequent coagulation of remnants.

Main factors conditioning such a breakdown and a subsequent coagulation are: 1) arrested motion, 2) evaporation or dehydration, 3) mixing with foreign electrolytes, 4) absence of suppressants of coagulation.

The effect of the arrested motion is too slow to be observed in case of tin carrying solutions. It is inferred from studies of waters carrying bismuth, in which case coagulation is rapid when motion is arrested.

Effect of evaporation was quantitatively established in actual mining operations in the Deseade mine (Tasna district) and in the Pepita mine (Caracoles district). The Caracoles case is the most illustrative and is described here.

A certain stope on the 186 level of the Pepita mine was abandoned immediately after its preparation in 1928, when sampling of it had averaged up to only 1.28% Sn. This stope was on a vein of cassiterite-tourmaline-wolframite-quartz, which varied from a few inches to

four feet in width and contained a central open fissure. Wherever this central fissure or fissures carried water as a strong flow, widths diminished. In stretches where the central fissure was partly closed or just moist, widths of vein filling increased. In 1940 the writer has resampled this stope to become acquainted with peculiarities of mineralization. Assays of his samples gave values three to four times higher than those of the map of 1928 for the stretches without running water. For the stretches carrying heavy water his assays coincided fairly closely with assays of 1928. Miners were put to slice overhand cuts on stretches now found to be workable. Ore breaking continued to a height of about 26 feet where sampling has shown values close to those of the map of 1928. The stope was then abandoned and remained so until 1947. In 1947, the writer returned to the district as its general superintendent and reopened the same stope. Sampling again showed workable values well exceeding those of maps of 1928 and 1940. Ore again was broken but this time to a height of only 11 feet, when assays again fell off to the original low.

This illustrates not poor engineering and mining practices of old miners, but an actual increment of ore due to secondary enrichment. Slowly moving descending waters have precipitated secondary cassiterite around old, ventilated workings which were large surfaces of evaporation. The writer estimates that during 8 years in tin-tungsten mines he reclaimed from \$100,000 to \$150,000 worth of tin and tungsten from just such sources.

Precipitation on mixing with foreign electrolytes was proven in laboratory in conditions that simulated those observable in mines. In nature this case arises when descending waters mix with ascending solutions from hypogene sources.

For his experiments the writer used natural crystals of cassiterite from Araca district selected for their perfect shape and absence of flaws. As "solvents" he used chemicals of "C.P." grade, which, however, were known to exist in deposits. An exception to that was the use of ammonium polysulfide instead of naturally occurring  $H_2S \cdot 6H_2O$ . It was found that application of heat was detrimental to leaching. Table 2 gives selected results of his experiments on leaching of cassiterite by cold solutions (40 to 70° F).

Each experiment lasted about a week depending on the rate of dissolution. Beakers were stirred periodically during this time. Periodically a drop of liquid would be drawn off for a semi-quantitative colorimetric determination of tin. Either cacotheline or mercuric chloride-aniline method of determination was used depending upon chemical involved in an experiment. At the end of experiments crystals of Araca cassiterite were removed, washed, dried and weighed to determine losses. Solutions were filtered through very porous filters to insure against any fragments that could have broken off. Concentrated phosphoric acid would then be added, a drop at a time and the liquid would then be gently stirred. It was found that slow

additions with several hours' intervening periods resulted in larger grains of precipitates. When sample drop of liquid no longer showed traces of tin, solutions would be filtered. Filtrates were discarded, while precipitates were washed, dried and transferred to a petrographic microscope. Larger crystals of these precipitates were then determined to be colorless cassiterite of Ahlfeld's type 2.

**Table 2. Solubility of Tin Oxide**

Reagents Used.	Weight of Crystal, grs.		% Weight Lost.
	Before.	After.	
Ammonium polysulfide.	0.416.	0.401.	3.61.
Ammonium polysulfide	0.512.	0.5165.	0.49*).
Same and MnO <sub>2</sub> .	0.251.	0.250.	0.4.
Sod. Thiosulfate & MnO <sub>2</sub> .	0.455.	0.375.	17.59.
H <sub>2</sub> O <sub>2</sub> and CuSO <sub>4</sub> .	0.250.	0.2455.	1.80.

\*) The contents of the beaker were momentarily brought to boiling at the start of the experiment, i. e. to 73° C. which corresponds to boiling point of water at that altitude.

Ahlfeld (4) distinguished 5 crystalline and 1 amorphous type of cassiterite in Bolivian deposits. He ascribed to each type a definite thermal range of formation. The writer's syntheses and observations, however, indicate that temperatures have little if any effect on selection of crystalline form of cassiterite. The following conclusions have been reached instead.

Cassiterites that are opaque or slightly translucent when in slivers of 2 millimeters or less thick were not found in crystalline form in deposits of 19 mining districts studied by the writer. These are amorphous "Wood Tins." Wood tins formed in sub-glacial or near-glacial conditions are most impure and may have specific gravities as low as 4.6. They often occlude semi-digested metamorphic or igneous rocks of the region. Wood tins of this origin differ widely in color and size of individual masses. The largest nugget ever found in pro-glacial placers of Chorolque district weighed around 1200 pounds, while the average size of vein cassiterite grains in the same district is about 1/16 th of an inch.

Amorphous wood tins of fluvial origin contain as a rule less identifiable occlusion, the matter held in suspension being ferric hydroxides, clay minerals and laterite.

Wood tins of either origin are often fractured and vuggy from corrosion. Surfaces of fractures and walls may be incrustated with cassiterite crystals of high translucency to a good transparency. Depending on this property, such crystals are of the type 1 and 2 respectively. This recrystallization is posterior to formation of amorphous wood tin and is actually due to a secondary enrichment.

Crystals of the type 1 are characterized by well developed pris-

matic zones terminated by pinacoids. Called "pegmatitic" by Ahlfeld these forms are actually found in any type of a tin deposit and are proper of a highly translucent to transparent cassiterite.

Type 2 is an equant form which may contain all possible crystalline faces and is proper of highly transparent cassiterite formed in sub-aqueous conditions. The writer has obtained this form in his syntheses.

Type 3, called by Ahlfeld "hydrothermal" is dipyramidal. Very highly translucent to transparent, it apparently substitutes for the type 2 in sub-aerial conditions. It has been found with silesite on arid outcrops and will stalactitic goethite at the bottom of oxidized open fissures.

Types 4 and 5 are generally known as "Needle Tins," the first of these being prismatic with pyramidal terminations, the second-acicular. Both types are highly transparent and colorless. Type 4 occurs in association with supergene marcasite and pyrite. Type 5 is mostly found in association with jarosites (ferric sulfates). The writer failed to obtain these form synthetically. Both types are very common in backfills of old workings and as wall incrustations. Owing to their minute size—often less than  $1/32$ nd of an inch long, these cassiterites have a tendency to slime during metallurgical treatment. Nevertheless, their economic importance should not be overlooked. Considerable tonnages of such cassiterite can be reclaimed in many of the Bolivian mines.

Finally, a few words must be said as to dimensional extent of secondary enrichment in tin deposits. It is difficult to give absolute figures based on observations in mines that have been operating for the past 40 to 60 years. Development of such mines has produced large evaporation surface and thus intensified and speeded up secondary enrichment. Nevertheless, secondary enrichment has been detected as far as 2400 feet from the surface. Zone of leaching above such enriched portions may range from 50 to 300 feet.

The writer has estimated, on basis of his studies of mine waters, that as much as 110 metric tons of metallic tins may be in solution in ground water of the Caracoles Proper District. The figure obtained for the Tasna district was 77 metric tons of metallic tin. Figures of this nature cannot be exact, but are illustrative of possibilities of secondary enrichment in tin deposits.

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### Acknowledgments.

The writer is indebted to Dr. S. P. Fisher and Dr. Donald Towse of this Department of Geology for proofreading of the manuscript and preparation of slides, respectively.

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## THE EPIZOOLOGY OF OVINE LISTERIOSIS

*D. F. Eveleth*

*Department of Veterinary Science  
North Dakota Agricultural College, Fargo, North Dakota*

### ABSTRACT

Listeriosis is an infectious disease caused by the organism **Listeria monocytogenes**. All animals and many birds are susceptible to natural or artificial infection. In sheep the disease is characterized by either abortion or encephalitis.

The disease has been diagnosed in all but a few states in the United States. All states not having listeriosis are in the southern part of the United States. Delaware and Nevada are the only two states north of the Mason-Dixon line in which listeriosis has not appeared. The spread of the disease within the United States has been in general from east to west. The same holds true for North Dakota. The disease is more prevalent in the Red River Valley than elsewhere in the state.

There are apparently non-clinical carriers among sheep. When these animals are introduced into new flocks the disease becomes established although it may be several months before symptoms of the disease occur.

In an epizootological study of outbreaks of listeriosis on 44 farms it has been found that the transfer of sheep from farms where listeriosis existed onto other farms free of listeriosis has been followed by outbreaks of the disease in 30 cases. In the other 14 cases sheep from flocks of unknown history had been introduced during the year preceding the outbreaks studied.

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## PERMEABILITY AND ABSORPTION OF EPOXY FILMS<sup>1</sup>

*Roland J. Peffer and R. E. Dunbar*

*School of Chemical Technology  
North Dakota Agricultural College, Fargo, North Dakota*

<sup>1</sup> Research project sponsored by the Plastics Laboratory, Jerome Formo, Director; Minneapolis-Honeywell Regulator Co., Minneapolis, Minnesota.

Vapors are transmitted through thin polymeric films by one or more of the following mechanisms (2):



- (a) Uninhibited molecular streaming through preformed holes.
- (b) Molecular penetration followed by diffusion through holes and crevices formed by thermal agitation of the polymer segments.
- (c) Molecular absorption on the internal surfaces of the polymer and acquisition of sufficient activation energy from thermal vibration to move into preformed slits and crevices.

The mass of vapor transmitted through a film or membrane is proportional to surface area exposed, time of exposure, and vapor pressure differential across the membrane; and inversely proportional to the thickness of the film. From the aforementioned relationships a permeability constant can be calculated by application of Fick's diffusion law which is expressed as follows (5):

$$K = \frac{Nx}{At(p_1 - P_2)}$$

The permeability constant is more convenient in evaluating permeabilities of a variety of materials in that it expresses the mass of permeant which is transported per unit time through a specified volume of material under a certain vapor pressure differential.

Epoxy thermosetting resins are a comparatively recent development in the plastics industry. The epoxy resins are the condensation products of bisphenol and epichlorohydrin rendered thermosetting by the addition of a diamine (3). Many applications are being developed by the plastics industry for these resins, among the most important being the casting of hermetically sealed electronic units. Since the moisture tolerance of electronics equipment is comparatively low the permeability and absorption evaluation of these epoxy materials acquires considerable importance.

The thermosetting resins utilized in making the films used in this investigation were prepared by mixing four parts by weight of the commercial resin with one of the thermosetting agent. The mixture was then subjected to vacuum to remove air bubbles which would inhibit homogeneous film formation. Films were prepared by placing a quantity of the resin on pan glazed aluminum sheets and evenly applying the resin with a doctor blade. The films were then cured for two hours at 150 degrees Fahrenheit.

Permeability determinations were made by placing five milliliters of permeant; i.e. water or 95% ethyl alcohol, in each Payne Permeability Cup, sealing the exposed edges with high temperature silicone grease, and clamping the films into position. The cups were then placed in a controlled temperature oven in which air was constantly circulated over concentrated sulfuric acid to maintain a relative vapor pressure of permeant of less than two percent (4). All determinations were made at a temperature of 40 degrees Centigrade. The cups were weighed every 24 hours until transmission equilibria had been established and at less frequent regular intervals thereafter.

Absorption studies were conducted by suspending test specimens of 3 x 5 centimeters and weighing approximately 1.5 to 2.5 grams in the liquid whose absorption rate was being determined. The specimens were taken out, sponged off with absorbent tissue, and rapidly weighed at regular intervals. The absorption investigation was also performed at 40 degrees Centigrade.

**TABLE I. Water Permeability Constants for Epoxy Films.**

FILM	K - Permeability Constant <sup>+</sup>
Polyethylene	0.354
Epoxy C-8	0.380
RN-48	0.380
Epoxy C - 8, 65%	0.154
Zirconium Silicate	
Epoxy 6020A, 50%	0.161
Microsil	
Epoxy 6020A, 50%	0.254
CaCO <sub>3</sub>	
Epoxy 6020A, 30%	0.198
Clay	

+ Grams/24 hours per square meter — one millimeter thickness per centimeter of Hg.

The data in Table 1 indicates that the water vapor permeability of unfilled epoxy resin films is of the same order of magnitude as that for polyethylene which is considered to be second only to the phenol-formaldehyde resins in water vapor impermeability (1). The introduction of a filler in the resin reduces permeability from 40 to 60 percent. As is evident from Table 2 there appears to be no positive correlation between water absorption data and the permeability constants for the films.

**TABLE 2. Water Absorption of Epoxy Films.**

FILM	Percent Weight Gain <sup>+</sup>
Epoxy C - 8	3.2
Epoxy RN - 48	2.3
Epoxy C - 8, 65%	1.1
Zirconium Silicate	
Epoxy 6020A, 50%	2.0
Microsil	
Epoxy 6020A, 50%	3.2
CaCO <sub>3</sub>	
Epoxy 6020A, 30%	2.8
Clay	

+ After eleven days of immersion.

Preliminary studies of 95% ethyl alcohol permeability have resulted in rather erratic values. It has been impossible to obtain a

constant daily transmission rate. However from the data thus far acquired it can be stated that the permeability of 95% ethyl alcohol through the films under investigation will be considerably higher than that for water. The films being subjected to alcohol permeation swell rapidly and in some instances deteriorate within a short time.

**TABLE 3. 95% Ethyl Alcohol Absorption of Epoxy Films.**

FILM	Percent Weight Gain+
Epoxy C - 8	16.6
Epoxy RN - 48	17.5
Epoxy C - 8, 65%	5.4
Zirconium Silicate	
Epoxy 6020A, 50%	12.3
Microsil	
Epoxy 6020A, 50%	12.3
CaCO <sub>3</sub>	
Epoxy 6020A, 30%	13.1
Clay	

+ After eleven days of immersion.

As indicated by Table 3, 95% ethyl alcohol absorption is considerably higher than that for water absorption. All specimens became soft and swollen to a considerable degree and in the case of the filled films there was evidence of moderate cracking induced by the internal pressure of the liquid absorbed. There was also evidence of leeching in the unfilled C - 8 and filled 2020A series of films.

**TABLE 4. Benzene Absorption of Epoxy Films.**

FILM	Percent Weight Gain+
Epoxy C-8	26.3
Epoxy RN - 48	36.4
Epoxy C-8, 65%	0.4
Zirconium Silicate	
Epoxy 6020A, 50%	1.3
Microsil	
Epoxy 6020A, 50%	1.8
CaCO <sub>3</sub>	
Epoxy 6020A, 30%	3.1
Clay	

+ After eleven days of immersion.

The data for benzene absorption (Table 4) are interesting in that they indicate the unfilled films to have very great absorptive capacity but the inclusion of filler material diminishes absorption of benzene to values comparable to and in several instances less than that for water. The filled films exhibited excellent stability with no appre-

ciable indication of softening or swelling. There appears to be some evidence of leeching and film distortion in the unfilled film but not to the degree experienced in the alcohol absorption studies.

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### OXYGEN CONSUMPTION OF ADIPOSE TISSUE\*‡

*Sidney S. Chernick*

*Department of Pharmacology, School of Pharmacy  
North Dakota Agricultural College, Fargo, North Dakota*

\* The research reported here was done in the laboratories of Dr. I. L. Chaikoff, University of California, Berkeley, whose cooperation is gratefully acknowledged.

‡ This investigation was carried on in cooperation with the Quartermaster Food and Container Institute for the Armed Forces. The views and conclusions contained in this report are not to be construed as necessarily reflecting the views or endorsement of the Department of the Army.

Adipose tissues were once regarded as merely passive storehouses of fat, contributing but little to the metabolism of the animal as a whole. But in the past 25 years a considerable body of literature has emphasized the active participation of this interesting tissue in the metabolism of fats. (1) It has, for example, been repeatedly demonstrated that isolated adipose tissue consumes measurable amounts of oxygen and that the oxygen consumption is related to the metabolic status of the whole animal. The interplay between adipose tissue and the fat pools of the whole animal has been demonstrated by the classical experiments of Schoenheimer and Rittenberg (2) with deuterium-labeled fatty acids. Mobilization and deposition of fat were shown to be continuous processes regardless of the nutritional state of the animal. Saturation and desaturation of fatty acids occurred incessantly in adipose tissue.

Lipogenesis in adipose tissue has been studied by Wertheimer and his co-workers in Israel. They have found that under conditions that favor fat deposition, glycogen can be demonstrated in adipose tissue. (3) As fat accumulates, the glycogen content decreases. The suggestion was made that glycogen is directly concerned with fat synthesis in

adipose tissue. Recently, Shapiro and Wertheimer were able to demonstrate that adipose tissue incubated *in vitro* with serum enriched with deuterium oxide, contained fatty acids with stably bound deuterium. (4)

In the present study, comparisons have been made of the oxygen consumption of adipose tissues from various regions of the mouse and containing varying amounts of fat and nitrogenous materials. In addition to varying the fat content of adipose tissue, its degree of saturation also was altered.

### EXPERIMENTAL

Female albino mice were fed *ad libitum* a diet consisting of Purina chow with supplements of greens and milk twice weekly. The mice were killed by a blow on the head and samples of their depot fat rapidly excised. Adipose tissues from the following regions were studied: genital (large fat depots surrounding the vagina and uterus), perirenal (distinct fat depots about the kidneys), mesenteric (diffuse fat depots throughout the mesentery,) and inguinal subcutaneous (frequently included lymph nodes and non-fatty connective tissue). The excised fat depots were placed on moist filter paper and chilled on ice until firm (1-2 minutes). Slices were cut free hand with a thin razor blade. 300-359 mg of slices were blotted on moist paper, weighed and transferred to a Warburg vessel containing 3 cc of Ringer's phosphate solution (pH 7.4). Oxygen consumption was measured in an atmosphere of oxygen by the usual manometric technique of Warburg at 37.5°C. (5). In agreement with the suggestions of Ruska and Oesticher (6), it was felt that the usual method of relating oxygen consumption to the dry weight of the tissues was not appropriate for adipose tissue. The nitrogen content of the tissue, therefore, was determined on the total flask contents at the end of the run by the micro-Kjeldahl method. Separate aliquots of adipose tissue slices were extracted with alcohol-ether and the extract analyzed for total fat content by Bloor's oxidometric method. Iodine numbers were determined on the aliquots of the alcohol-ether extract.

### RESULTS

In Table 1 are compared the oxygen consumptions of the various adipose depots and of liver and diaphragm slices. The oxygen consumption expressed as  $\text{mm}^3$  of oxygen consumed per hour per mg tissue was 0.2 for genital adipose tissue and 2.1 for liver slices. In terms of  $\text{mm}^3$  of oxygen consumed per hour per mg tissue nitrogen the values were 55 and 73.

TABLE I

Comparison of the Respiration of Various Adipose Depots of Mice

Region Studied	Number of Mice	Total Fatty acid content of tissue per cent	Total Nitrogen content of tissue mg per gm	Oxygen consumed (cmm)	
				per mg fresh tissue per hour	per mg nitrogen per hour
Genital	21	77±1*	3.3±0.3*	0.17±0.01*	53±4*
Perirenal	10	74±2	4.0±0.3	0.20±0.01	50±4
Subcutaneous	11	58±5	8.2±0.9	0.24±0.01	28±3
Mesenteric	10	48±4	14.4±1.6	0.80±0.11	55±6
Scapular	10	52±3	11.5±1.0	0.65±0.05	56±4
liver	10	4.1	28±1	2.0±0.1	75±5
diaphragm	10	1.7	26±0.5	2.2±0.1	88±6

\*Mean and standard error

The data also reveal an interesting relationship between the nitrogenous constituents of the various depots and their O<sub>2</sub> consumption. For example, the cmm of O<sub>2</sub> consumed per mg fresh adipose tissue was practically identical for the genital, subcutaneous inguinal and perirenal tissues, but in terms of tissue nitrogen the O<sub>2</sub> consumption of the subcutaneous tissue was half that of the other regions. The dilution of tissue nitrogen in this case by small amounts of fibrous tissue accounts for this difference. Ruska, et al, (6) have found that "pure" connective tissues such as the central tendon of the diaphragm, fascia lumbodorsalis and sinew generally consume almost no oxygen. The contaminating fibrous tissue is reflected in the nitrogen values of the subcutaneous tissue.

The oxygen consumptions of mesenteric and intrascapular adipose tissues, on the other hand, were 3 to 4 times greater, when expressed in terms of fresh weight, than that of the 3 aforementioned depots, namely 0.8 and 0.7 versus 0.2 cmm of O<sub>2</sub> consumed per hour per mg fresh weight. But no great differences were found when the results were expressed in terms of tissue nitrogen (mesenteric 52, scapular 65, genital 55, and perirenal 46).

Table I also demonstrates an inverse relationship between the fat content of adipose tissue and its nitrogen content. From the foregoing it would appear that the metabolism of the fat cell does not suffer as fat fills the cell and compresses the cellular cytoplasm.

**The influence of degree of saturation of its fatty acids on oxygen consumption of adipose tissue**— In a second series of experiments, 2 groups of 16 mice each were fed diets that contained either linseed

oil or cocoanut oil as the main source of fat. The diets contained 40 percent casein, 10 percent sugar, 10 percent yeast, 5 percent sardine oil (for vitamins A and D) and 5 percent salt mix (7). In addition, 25 grams of cellu flour were mixed with each 100 gm of diet to provide bulk. The mice were fed the diet for 18 days and then killed. Oxygen consumption of genital fat only is reported since its behavior was representative of that of all the adipose tissues. The results are recorded in Table II.

**TABLE II**

Effect of Variation of Iodine Number on Oxygen Consumption of Genital Fat

Fat in diet	Analysis of genital fat			Oxygen consumption (cmm)	
	Per cent fatty acids	Nitrogen content	Iodine number	per mg fresh tissue per hour	per mg tissue nitrogen per hour
Linseed oil	77	3.6	120	0.20	56
Cocoanut oil	74	3.7	55	0.21	58

16 mice in each group.

The iodine number of a sample of the linseed oil diet was 168. Feeding this diet for 18 days raised the iodine number of genital adipose tissue from the normal value of 85 to 120. The iodine number of the cocoanut oil diet was 46 and that of genital fat 55 after 18 days on this diet. No difference was found in the nitrogen content of the adipose tissue of mice fed the two diets; in both groups the average values were about 3.6-3.7 mg of nitrogen per gm tissue. The oxygen consumption of the adipose tissue was in no way related to the degree of saturation of its fatty acids. In all three groups of genital adipose tissue studied, Purina chow diet, cocoanut oil diet and linseed oil diet, the  $Q_{O_2}$  (fresh tissue) was about 0.2 and the  $Q_{O_2}$  (tissue nitrogen) was about 56. The addition of glucose to the medium did not affect these values.

Iodine numbers were determined on some samples before and after incubation. There was no indication that the degree of saturation of adipose tissue fatty acids was altered in any of the groups studied during the period of incubation.

### SUMMARY

The rates of respiration of the adipose tissues from various re-

gions (genital, perirenal, subcutaneous, scapular and mesenteric) of the mouse were determined and found to be, in general, related to their nitrogen contents. The oxygen consumption of liver slices was 10 times as great as genital adipose tissue (compared on the basis of fresh tissue weights). However, when respirations of liver and adipose tissues were compared in terms of tissue nitrogen the oxygen consumption of the liver was only twice that of the genital depot fat. The accumulation of fat by the specialized cells of adipose tissue and the compression of their cytoplasm into the familiar "signet ring" does not seriously disturb the oxidative mechanisms of the cells.

Adipose tissues containing highly unsaturated fatty acids were obtained from mice fed diets rich in raw linseed oil; tissues with highly saturated fatty acids from mice fed coconut oil. The large differences in the degree of saturation did not influence the respiration of the adipose tissue.

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## PRELIMINARY REPORT OF RECENT WORK ON OLIGOCENE WHITE RIVER DEPOSITS OF NORTH DAKOTA

*Miller Hansen*

*North Dakota Geological Survey, Grand Forks, North Dakota*

### ABSTRACT

During the 1951 field season the program of the North Dakota State Geological Survey included an investigation of White River deposits of Oligocene age in the southwestern part of the state. Colgrove Butte and Bull Butte in Hettinger County, and the Lefor Buttes in Stark County are the areas of greatest interest.

These deposits contain limestone beds varying from four inches to four or five feet thick. The primary purpose of this survey was to determine available quantities and the quality of the limestone.



The problem involved sampling and measuring the thickness of beds so that additional information on the geology of the area was obtained as the work progressed.

Small gastropod shells of two varieties, widespread in the limestone, have not been identified at this writing. The channel conglomerate capping Black Butte, T. 135N, R. 95W in Hettinger County, yielded a fossil jawbone fragment which has been identified as a species of *Ancodon* by Mr. Morris F. Skinner, vertebrate paleontologist of the Frick Laboratory at the American Museum of Natural History. This faunal evidence extends the area of proven White River deposits in North Dakota.

Lithologically, the beds at Black Butte resemble exposures in the Little Badlands district about twenty miles to the northwest, and vary widely from the limestone capped School Butte only six miles north.

A persistent bed containing quartz sand, bentonitic clay, and volcanic ash found in every measured section is believed to represent the base of the White River formation in North Dakota.

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## THE DETERMINATION OF CHROMIC OXIDE WHEN USED AS AN INDEX SUBSTANCE IN DIGESTIBILITY EXPERIMENTS

*Donald W. Bolin, Richard P. King, and Earle W. Klosterman*

*Animal Nutrition, Department of Animal Husbandry  
North Dakota Agricultural College, Fargo, North Dakota*

### ABSTRACT

Chromic Oxide ( $\text{Cr}_2\text{O}_3$ ) has been used for measuring digestion coefficient. It is not absorbed by the digestive tract of the animal. The use of chromic oxide simplifies the experimental procedure by eliminating the necessity of weighing either the food intake or the feces output. With the chromic oxide technique the amount of food digested and absorbed in the different parts of the digestive tract can be determined.

A rapid simple micro method for the determination of chromic oxide has been developed by this laboratory. This method is essentially the oxidation of  $\text{Cr}_2\text{O}_3$  to  $\text{CrO}_3$  with perchloric-sulfuric acids using molybdenum as a catalyst. After the oxidation the amount of  $\text{CrO}_3$  in solution is determined colorimetrically using a 440 micron filter.

## SOME CHEMICAL PROPERTIES OF alpha-CHLOROANISOLE

*Lawrence Summers and W. D. Kelsch**Department of Chemistry**University of North Dakota, Grand Forks, North Dakota*

The alpha-haloalkyl ethers are organic compounds in which one carbon atom is bonded both to a halogen atom and to an ether oxygen. Chloromethyl methyl ether,  $\text{CH}_3\text{OCH}_2\text{Cl}$ , or alpha-chloroethyl methyl ether,  $\text{CH}_3\text{OCHClCH}_3$ , are examples of this type of structure. Although these compounds are named as derivatives of ethers, their chemical behavior is much better understood if they are regarded instead as halogen derivatives of hemiacetals. Thus chloromethyl methyl ether,  $\text{CH}_2(\text{OCH}_3)\text{Cl}$ , is closely related to the hemiacetal  $\text{CH}_2(\text{OCH}_3)\text{OH}$ . The chloro ether is prepared from formaldehyde, methanol, and hydrogen chloride. Its chlorine atom is much more reactive than chlorine in an alkyl halide, and the reactivity in fact approaches that of chlorine in an acyl chloride. For instance, the chloro ether is hydrolyzed readily by cold water, to give methanol and formaldehyde. The hydrolysis is acid-catalyzed, as it is in the case of a hemiacetal.

This general method of preparation of alpha-haloalkyl alkyl ethers (from an alcohol, an aldehyde, and hydrogen halide) cannot be applied for alpha-haloalkyl aryl ethers. In this case the ROH compound is a phenol, and does not react in this way. For this reason, alpha-haloalkyl aryl ethers have been little studied. One or two have been prepared from phenyl vinyl ether and a hydrogen halide, but this method obviously will not serve for chloromethyl ethers. From the vapor-phase chlorination of anisole,  $\text{C}_6\text{H}_5\text{OCH}_3$ , Weygand<sup>1</sup> obtained a product which analyzed for alpha-chloroanisole,  $\text{C}_6\text{H}_4\text{OCH}_2\text{Cl}$ , although this identity was not clearly established. Nothing was reported concerning the chemistry of the substance. In connection with some current studies<sup>2, 3</sup> pertaining to haloalkyl ethers, we have investigated more fully the preparation of this compound, and have determined some of its chemical properties.

**EXPERIMENTAL**

The reaction vessel used for the vapor-phase chlorination was a three-neck Pyrex flask equipped with a gas-inlet tube extending into the center of the flask, a thermometer so placed that its bulb was close to the end of this tube, a dropping funnel, and a downward condenser attached to an ice-cooled receiver. All joints were ground glass. Irradiation was supplied by a 125-watt Hanovia sun lamp. A few ml. of anisole were placed in the reaction flask, the internal temperature was raised to  $225^\circ$ , and a stream of dry chlorine was then started. With the chlorine flowing, anisole was dropped

in at the rate of about 60-65 ml. per hour, while the temperature was maintained at 225-230°. At the end of the run, the receiver was disconnected and evacuated at a water pump to remove dissolved gases, and the remaining material was fractionated under reduced pressure. A typical run, using 125 ml. of anisole, gave 54.0 g. of recovered anisole, 75.7 g. of product fraction (b.p. 60-70°/4 mm., active Cl 23.6%), and 7.7 g. of more highly chlorinated material (b.p. 70-80°/4 mm., active Cl 34.4%). Active Cl was determined by treating a sample with sodium in 95% ethanol, and then titrating for chloride. Water alone did not hydrolyze the material completely. alpha-Chloroanisole,  $C_7H_7OCl$ , requires 24.9% Cl. On redistillation, the product fraction yielded 40.1 g. of material, b.p. 43-46°/1 mm., active Cl 23.0%. In general, distillation of the product fraction led to some loss in chlorine content and no obvious improvement in purity. From most runs the large middle fraction containing from 23.6 up to 24.4% Cl and estimated to be approximately 90% pure, was used as alpha-chloroanisole.

In this preparation, close control of the temperature was very important. From a run carried out at 220-225°, no fraction containing more than 11.9% active Cl could be isolated. On the other hand, a run in which the flask was allowed to become dry and the temperature to approach 240° resulted in a mild explosion.

Perhaps the most interesting chemical characteristic of alpha-chloroanisole was its relatively low reactivity as compared with chloromethyl methyl ether, for instance. It did not effect chloromethylation of benzene, under the conditions tried; nor could simple addition to ethylenic double bonds be demonstrated. Most noteworthy is the fact that alpha-chloroanisole could consistently be recovered from reaction mixtures after extractions and washings had been performed with water or with sodium bicarbonate solutions. alpha-Chloroalkyl alkyl ethers are very readily hydrolyzed by water.

The reaction with benzene was carried out by heating and stirring for two hours a mixture of 50 g. (0.64 mole) of dry benzene, 23 g. (0.17 mole) of alpha-chloroanisole, and 5.6 g. (0.04 mole) of fused, powdered zinc chloride. The mixture was poured on ice, and the benzene was separated, washed five times with water, and worked up. The main fraction obtained on distillation was mostly alpha-chloroanisole (b.p. 58-62°/3 mm., Cl 19.7%, weight 14 g.). There was 4.5 g. of high-boiling residue, not benzyl chloride.

The reaction with benzene was carried out by heating and stirring chloroanisole, plus powdered zinc chloride (10%) as catalyst, in a reaction flask and passing in the gaseous olefin, at 40°. In this way 19 g. of alpha-chloroanisole was treated with 10 g. of ethylene. There was no evidence of reaction. After hydrolysis followed by repeated washings with water and sodium bicarbonate solution, the product still yielded 9.4 g. of crude starting material, b.p. 36-40°/1 mm., which contained 18.3% Cl. The higher-boiling fraction, 7.5 g., was

insoluble in ethanol or petroleum ether. From these properties, plus its b.p., it could not have been the expected 1-phenoxy-3-chloropropane. It was conceivably a polymeric substance.

When the olefin was isobutylene, a reaction was indicated by a temperature rise and an increase in volume. Investigation showed, however, that simple addition had not occurred. The products were high-boiling materials, possibly polymers. In one case hydrolysis and washing were omitted, and after the reaction was finished the mixture was simply filtered through glass wool and distilled. Only a few grams of distillate passed over, at a high temperature, and the residue solidified to a black, hard brittle resin.

When alpha-chloroanisole was treated with zinc chloride in these experiments there was a reddish or pink coloration, evidence of complex formation. However, the material was not polymerized by zinc chloride alone, as a control experiment showed, and the starting material could be recovered after two hours at 40°.

The one clear-cut reaction of alpha-chloroanisole which was demonstrated was that with a Grignard reagent. Treated with phenylmagnesium bromide (10% excess) in the customary fashion, it reacted immediately. There was obtained benzyl phenyl ether,  $C_{12}H_{14}CH_2OC_6H_5$ , b.p. 96-104°/1 mm., in 54% yield. This product melted sharply at 39° after crystallization from ethanol, and did not depress the melting point of an authentic sample prepared from benzyl chloride and sodium phenoxide. Phenol and formaldehyde were also identified among the products of this reaction. Formation of benzyl phenyl ether offers a convenient means of identification of alpha-chloroanisole. In all the cases above where the latter material was recovered from reaction mixtures, its presence was confirmed by conversion to this derivative by means of phenylmagnesium bromide.

## DISCUSSION

alpha-Chloroanisole is apparently much more resistant to hydrolysis than was expected. Since this is the case, a number of possible technological applications of the material, for instance textile treatment or possible use as a preservative for wood or leather, suggest themselves. Our interest here, however, is in the chemistry of the substance. The alpha-chloroalkyl ethers form a class of compounds presumably capable of being attacked by an electrophilic catalyst at two sites, the oxygen atom or the chlorine atom. It is hoped that these and other studies may help to throw some light on the nature of the actual reaction process when these ethers react with aromatic compounds to give chloromethylation or with olefins to give addition.

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# MAMMUTHUS PRIMIGENIUS? A PROBOSCIDEAN FIND IN NORTH DAKOTA

*H. C. Haraldson*

*Geology Department*

*University of North Dakota, Grand Forks, North Dakota*

This is a preliminary report of the mammoth remains. The tooth listed 10-28-52 has been sent to Dr. C. B. Schultz, director of the museum at Lincoln, Nebraska for positive identification. As yet the identification has not been completed. Until a positive identification has been made my preliminary identification will have to suffice.

## **Discussion of nature of find, importance, description and Geology of the Area.**

The material is classified under order Proboscidea. It is further classified under suborder Elephantoidea. The family heading is Elephantidae which contains three genera, one of which is Mammuthus. The species Primigenius is one of the most interesting members. Mammuthus Primigenius is better known as the woolly Mammoth, and two specimens preserved by freezing have been uncovered in Siberia. They were in an excellent state of preservation, and therefore much is known of this extinct animal. Even the food which they ate was removed from their stomachs and analyzed.

The remains of species Primigenius are found quite often in other parts of the world, but very little has been recovered from North Dakota. The Mammoths disappeared at the end of Pleistocene time.

The specimens listed 10-27-51 were discovered by Mr. Norman Dahl in a gravel pit on his farm which is located four miles Northeast of Watford City in McKenzie County. The femur measured 3'9" in length. The other material included several sections of rib, a ball of a socket, a short length of bone, part of the shoulder blade and many smaller fragments. One of the tusks was found which measured 9'2" in length. Both ends were broken off, the outer end being flattened so that it looks thicker than it actually is. Considering the length of tusks found in other areas belonging to this same species it would be conservative estimate to say that this tusk was originally eleven feet long. This tusk was extremely fragile upon exposure to the atmosphere. A mold of plaster of paris reinforced by steel cables and angle irons was used to protect the tusk on the trip to the museum.

The mammoth tooth listed 10-28-52 was found and donated by Mr. R. E. Serrahn. This find was made in a gravel pit on his farm Northeast of Watford City and near the farm of Mr. Norman Dahl. The tooth is very complex consisting of some twenty odd plates of dentine covered with enamel, and the spaces between the enamel ridges are filled with cement. It is 12½" long and weighs 11 pounds.

This tooth is much more complex than the earlier Mammoth teeth and can be readily distinguished from those of the Mastodon. Study of the teeth offer the best means of identifying a group of mammoth bones and for this reason the tooth was sent to Dr. C. B. Schultz.

The geology of the area of discovery has not as yet been determined other than that it is in a glaciated area of Pleistocene age.

### SUMMARY

The finds were of particular interest in that we now know elephant material exists in the Watford City area, and in the future much more of it is likely to be recovered.

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## AN INVESTIGATION OF THE ORGANIC SULFUR-CONTAINING COMPOUNDS OF ALFALFA

*Kenneth C. Anderson and A. F. Kingsley*

*North Dakota Agricultural College, Fargo, North Dakota*

Published with permission of the Director of the North Dakota Agricultural Experiment Station as a progress report on Purnell Project 150, "Distribution of sulfur in North Dakota forage crops."

### ABSTRACT

Sulfur occurs in plants as inorganic sulfates and in organic combinations. It is a constituent of many compounds of importance in nutrition and metabolism. These include cystine or its reduced form cysteine, and methionine, amino acids which are present in most proteins, thiamin and biotin which are vitamins of the B-complex and possibly other compounds which may affect the general metabolism of the plant. With the exception of cystine and methionine, these compounds are present in minute amounts or are not present at all.

Investigations have shown that about 55 per cent of the total sulfur in alfalfa is organic in nature. If the organic sulfur content represented only cystine and methionine, alfalfa would be nutritionally complete as a protein feed. However, microbiological and chemical analyses have indicated that cystine and methionine account for less than half of the total organic sulfur.

In attempts to isolate the unidentified organic sulfur fraction alfalfa was fractionated into protein and residue by alkali dispersion. Methionine and cystine essentially accounted for all the organic sulfur in the protein and residue, indicating that the filtrate from the protein precipitation contained the unidentified organic sulfur fraction.

It is assumed that the accepted value for cystine and methionine are valid. However, further investigation of these values are being carried out.

## ANALYTICAL CHARACTERISTICS OF GASOLINE DERIVED FROM TIOGA PETROLEUM

*Ray Wendland, Robert Ripley, Robert Ryan,  
Rudolph Schroeder and Edward Walsh*

*School of Chemical Technology  
North Dakota Agricultural College, Fargo, North Dakota*

The acquisition of petroleum is the business of the exploration teams made up of the wildcatter, the geologist, the drilling engineers and their colleagues who build the pipelines, gas transmission systems and the like. But petroleum, once acquired, becomes mainly the business of the chemist and the chemical engineer who must make the most of this natural resource, which like nearly all the rest of natural products, is in a crude state. Intelligent utilization requires first that the chemist must learn about the composition of the oil in terms of the compounds present. Since hydrocarbons make up about 99% of the petroleum, the problem is to ascertain the types of hydrocarbons present, and if possible to detect the presence of a few characteristic individuals. Oils from various areas differ considerably in the ratio of distribution of alkanes (paraffins) to cyclanes (naphthenes) to aromatics. Refining and by-product utilization, especially in the important field of petrochemical synthesis, depend much on knowledge of this composition.

Since practically all petroleum is driven to the surface by gas pressure, one assumes that the crude contains dissolved gas, the composition of which can be determined without difficulty because of the small number of possible compounds present, these being methane, ethane, propane, two butanes and one or two of the pentanes. Thereafter, the composition of the liquid becomes more complex to a point of almost infinite variety. For instance, in the boiling range from 50 to 195°C. there are 315 possible alkanes alone, the distribution of which is given in Table I.

**TABLE I    DISTRIBUTION OF ALKANES IN GASOLINE**

Boiling Range °C	Types of Compounds	Number of Isomers
30-69	Hexanes	5
79-98	Heptanes	9
99-125	Octanes	18
122-150	Nonanes	49
137-165	Decanes	75
160-195	Undecanes	159

In addition to the alkanes are the cyclanes with four, five, and six carbon rings. Research has demonstrated the presence of but a few pure individuals of these groups of compounds, although the total number present is probably very large because of geometric isomerism that is common to the structures. In a special category among

the petroleum hydrocarbons are the aromatics: in the medium boiling range for gasoline (80-150°C.) the number of aromatics that may be present fortunately is small, six in all, and furthermore their optical characteristics are such that detection is easy. The aromatics are of great practical importance, since as fuels their critical compressions are very high.

For the characterization of compounds in the Tioga gasoline, the mode of operation adopted in this study was essentially a conventional one, embracing (1) Stripping out the gasoline and kerosene from the crude oil by distillation under partial vacuum; (2) redistillation of the volatile material through a heated four-foot helix packed column equipped for total reflux and partial takeoff; (3) evaluation of selected cuts by way of refractive index, density, specific dispersion, and specific refraction. These properties were correlated with constitution by reference to the system of identifying hydrocarbon types developed earlier by Wendland (1). Since we were dealing with complex mixtures, an additional aid was necessary in the form of composite charts against which the measured properties of the unknown fractions could be compared. This gave rise to what may be called "profile" analysis. For the purpose one tabulates first the known properties of the common hydrocarbons types (alkanes, cyclanes, aromatics) and then plots these against boiling points. Results are shown in Table II and Figures 1 and 2.\* Properties of the fractions derived from the gasoline are given in Table III and these in turn are superimposed on the Figures 1 and 2 as shown by the vertical lines (solid) on which the horizontal marks indicate the value of the measured property (Figure 1 plots **refractive index** vs. boiling point,, Figure 2 **density** vs. boiling point).

\* Figures 1 and 2 not included for technical reasons; available from author's files on request.

TABLE II

**PROPERTIES OF HYDROCARBONS REPRESENTING THE COMPONENTS OF NATURAL GASOLINE**

		(Lower boiling members up to 150° C.)			(2)
	ALKANES	B.P. 760 mm.	$n_D^{20}$	$D^{20}$	Specific Dispersion
C <sub>5</sub>	2-methyl butane	27.8	1.3537	0.6197	S. D. values for all the alkanes are in the range 96-101
(3)	n-pentane	36	1.3575	0.6262	
C <sub>6</sub>	2,2-dimethyl butane	49.7	1.3687	0.6492	
(5)	2,3-dimethyl butane	58	1.3750	0.6616	Note that alkanes are absent from a natural gasoline. Their S. D. values are always above 100 and range up to 135
	2-methyl pentane	60.2	1.3714	0.6531	
	3-methyl pentane	63.3	1.3765	0.6643	
	n-hexane	68.7	1.3748	0.6594	

- (2) Data are taken from "Selected Values of the Properties of Hydrocarbons" American Petroleum Research Institute Project No. 44 (Tables of the "a" series)



TABLE II (Continued)

C <sub>7</sub>	2,2-dimethyl pentane	79	1.3821	0.6738 (+)	
(9)	2,2,3-trimethyl butane	80.9	1.3894	0.6901	
	3,3-dimethyl pentane	86	1.391	0.6932	
	2-methyl hexane	90	1.3848	0.6786	
	n-hexane	98	1.3876	0.6837	
C <sub>8</sub>	2,2,4-trimethyl pentane	99	1.3914	0.6919	
(18)	2,2-dimethyl hexane	107	1.3935	0.6953	
	2,3,4-trimethyl pentane	113	1.4042	0.7190	
	2,3-dimethyl hexane	116	1.4012	0.7122	
	3-ethyl hexane	118	1.4016	0.7135	
	n-octane	125	1.3974	0.7025	
C <sub>9</sub>	2,2,4,4-tetramethyl pentane	122	1.4069	0.7194	
(49)	2,3,5-trimethyl hexane	131	1.406	0.7219	
	3-methyl-4-ethyl hexane	140	1.416	0.742	
	3-methyl octane	144	1.406	0.7207	
	3,3-diethyl pentane	146	1.4205	0.7539	
	n-nonane	150	1.4054	0.7176	
C <sub>10</sub>	2,2,5,5-tetramethyl hexane	137	1.4055	0.7187	
(75)	2,2,4,4-tetramethyl hexane	142	1.410	0.730	
	2,2,3,5-tetramethyl hexane	148	1.4142	0.7378	
	CYCLOBUTANES	B.P. 760 mm.	n <sub>D</sub> <sup>20</sup>	D <sub>D</sub> <sup>20</sup>	Specific Dispersion
C <sub>4</sub>	Methyl cyclobutane	39	1.3837	0.6931	
	1,2-dimethyl cyclobutane	70	1.3988	0.7122	
	Ethyl cyclobutane	71.5	1.402	0.7450	
	CYCLOPENTANES				
C <sub>5</sub>	Cyclopentane	49	1.4064	0.7454	
C <sub>6</sub>	Methyl cyclopentane	71.8	1.4097	0.7486	
C <sub>7</sub>	Dimethyl cyclopentanes	87-99	1.408	0.7448	
			to 1.422 to	0.7726	
	Ethyl cyclopentane	103	1.4198	0.7664	
C <sub>8</sub>	iso-propyl cyclopentane	126	1.4258	0.7765	
	Propyl cyclopentane	131	1.4262	0.7763	
C <sub>9</sub>	tert. butyl cyclopentane	145	1.4342	0.7753	
	sec. butyl cyclopentane	154	1.4362	0.7944	
	n-butyl cyclopentane	156	1.4316	0.7846	
	CYCLOHEXANES				
C <sub>6</sub>	Cyclohexane	80	1.4262	0.7785	
C <sub>7</sub>	Methyl cyclohexane	100	1.4231	0.7693	
C <sub>8</sub>	1,1-dimethyl cyclohexane	119	1.429	0.781	
	1,2-(trans) dimethyl "	123	1.427	0.776	
	1,4-(trans) dimethyl "	124	1.429	0.782	
	1,2-cis dimethyl "	129	1.436	0.796	
	Ethyl cyclohexane	131	1.433	0.788	

(+) Individual compounds within the groups are so chosen as to include those exhibiting maximum and minimum values of B.P., n<sub>D</sub><sup>20</sup> and D<sub>D</sub><sup>20</sup>

TABLE II (Continued)

C <sub>6</sub>	1-methyl-3-ethyl	148	1.4344	0.791	
	1-methyl-5-ethyl	150	1.4342	0.791	
	1-methyl-2-ethyl	152	1.4400	0.805	
	iso-propyl cyclohexane	153	1.4408	0.8022	
	n-propyl cyclohexane	156	1.4370	0.7936	
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	ALKYL BENZENES				Spec. Disp.
C <sub>6</sub>	Benzene	80	1.5011	0.8790	189.6
C <sub>7</sub>	Toluene	110	1.4969	0.8669	184.7
C <sub>8</sub>	Ethyl benzene	136	1.4959	0.8670	174.7
	1,4-dimethyl benzene	138	1.4958	0.8610	182.1
	1,3-dimethyl benzene	139	1.4972	0.8642	180.9
	1,2-dimethyl benzene	144	1.5054	0.8802	180.4
C <sub>9</sub>	iso-propyl benzene	152	1.4914	0.8618	166
	n-propyl benzene	159	1.4920	0.8620	167

Remainder of C<sub>6</sub> benzenes boil up to 176 °C.

Inspection of Fig. 1 and Table III shows that the refractive index values for the various gasoline fractions lie uniformly above the average values of strictly alkane hydrocarbons, thus implying the presence of the cyclanes. Specific dispersion values remain very close to 100 through the boiling range which should include benzene (70 to 82 C) hence benzene can be present only as a trace. Cyclohexane (or methyl cyclopentane) is very probably present because of the marked increase in  $n_D$  at the 80° point. Between 80 and 110° the high  $n_D$  and low specific dispersion argue for a mixture of heptanes and cyclanes present in about equal amounts. In the toluene range the high  $n_D$  and high specific dispersion values unquestionably prove the presence of toluene. Proceeding beyond 112 to 132 (where aromatics are normally absent in a good distillation)  $n_D$  and specific dispersion drop again but the former is such as to indicate nonanes present mixed with the C<sub>8</sub> cyclanes. In the xylene range (132-145°) the significant increase in  $n_D$  and dispersion proves the presence of the xylenes, possibly mixed with ethyl benzene. Between the C<sub>8</sub> and C<sub>9</sub> benzenes there is a boiling point spread of 8° C. and in this gap again the  $n_D$  and dispersion drop significantly, only to rise again (from 1.425 to 1.438 for index and 107 to 116 for dispersion) in the boiling range 150 to 176 in which occur numerous C<sub>6</sub> benzenes. Hence one must include that they are present. Beyond this point it becomes extremely difficult to ascertain composition without resort to much more extensive analytical methods, such as those developed by Van Nes and Van Westen (3).

TABLE III

## DISTILLATION AND CHARACTERIZATION OF TIOGA GASOLINE

Fraction	Boiling Range °C.	Weight g.	$n_D^{20}$	Density <sup>20</sup>	Spec. Disp.	$r$	Wt. Percent of total gas.
1	20- 40	13.9	1.3617	0.6352	96	.349	3.2
2	40- 55	5.5	1.3700	0.6785	99.9	.333	1.2
3	55- 70	41.2	1.3884	0.6899	101.3	.342	9.0
4	70- 79	15.4	1.4098	0.7384	102.5	.335	3.3
5	79- 82	5.1	1.4098	0.7388	102.6	.334	1.1
6	82-100	67.5	1.4084	0.7345	106.9	.336	14.7
7	100-107	25.2	1.4305	0.7691	120.6	.336	5.8
8	107-112	10.4	1.4208	0.7522	115	.337	2.2
9	112-132	60.0	1.4199	0.7502	112.9	.337	13.1
10	132-145	36.4	1.4362	0.7775	120.2	.336	7.9
11	145-150	11.7	1.4252	0.7631	107	.335	2.5
12	150-176	88	1.4380	0.7825	115.9	.335	19.1
13	176-200	80.4	1.442	0.7928	113.1	.333	17.5

Total distilled 460 g.

## Properties of Original Oil and Derived Fractions

(Source: Iverson Well No. 1, depth 8530 feet, by Amerada Petroleum Co.)

A	Crude	Wt. distilled 1210 g.	1.4613	0.80.72	125		100%
B	Gasoline	Boiling range 20-200 Wt. 460 g.				See distillation data above Octane number ASTM 46.4 Research 48.6	38%
C						Sulfur 0.037% Corrosion: slight tarnish on Cu strip	
C	Kerosene and light fuel oil	Wt. 266 g.	1.4659	0.8303	124		22%
D	Heavy Residual Oil	Wt. 395 g.	—	0.8874		Deep color	32.6
E	Loss	90 g.				Presumed to mostly gas and liquids in the range 0 to 40°C.	

The residue from the gasoline distillation (Table III) comprises the kerosene and light fuel oil fraction. With  $n_D$  1.4659, density 0.8303 and specific dispersion 124 (all at 20°) there appears to be a significant content of aromatic material, poly-alkyl benzenes and naphthalenes.

The octane number, sulfur content and corrosion value of the gasoline fraction (20-200 °C.) were determined in the State Laboratory at Bismarck and the data are listed in Table III. Sulfur content and corrosive action are both quite low—a significant favor for quality. The octane number of 47 to 48 indicates the need for upgrading by chemical treatment. The amount of gasoline indicated by the distillation was 38 percent of the crude, but this figure could be revised upward by inclusion of the very light fractions in the forerun to a maximum of 46 percent.

### SUMMARY

Fractional distillation and characterization of the gasoline obtained from the Amerada Iverson well showed the following:

1. Practical absence of benzene in the 80° fraction.
2. The presence of considerable cyclohexane (or cyclopentanes) in the 80° range.
3. The presence of toluene (110°) and xylenes (132-145°) in significant amount.
4. The presence of cyclanes (naphthenic hydrocarbons) throughout the fractions intermediate to the aromatics.
5. The kerosene and light fuel oil fraction above the gasoline has a significant content of aromatics.
6. The octane rating of the natural gasoline, 46 to 48, shows the need of reforming to meet the demand of present day engines. At this level however the Iverson gasoline is better than certain varieties, some which rate zero on the octane scale, e. g. the Michigan gasolines.
7. Consideration of points 4 and 6 would indicate that reforming (upgrading) of the gasoline could be easily accomplished by "platforming", a relatively new and rather simple treatment which involves dehydrogenation.

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## MILLING AND BAKING STUDIES WITH HARD RED SPRING AND DURUM WHEATS

*R. H. Harris, L. D. Sibbitt, and G. M. Scott*

*Department of Cereal Technology  
North Dakota Agricultural College, Fargo, North Dakota*

### ABSTRACT

Three hard red spring wheat varieties: Rival, Mida, and Cadet; one soft white wheat, Golden of low protein content; and six durum varieties were employed in this investigation. All samples except Golden were grown at Langdon in 1950. The durum wheats were more difficult to mill than the hard red spring wheats and their flours had higher ash content. The durum flours required less water to form doughs and produced loaves of inferior volume, grain and

texture, and crumb color, than the hard red spring wheats. Kubanka was best for baking quality and was also superior to Golden except for crumb color. In dough mixing requirements, the durum flours were markedly different from the hard red spring flours with the exception of Kubanka. The doughs did not develop properly, and show lack of stability to mixing. Their mixing behavior was, however, generally superior to that of Golden. For sugar production during baking, the durum flours were greatly superior.

When the hard red spring and durum flours were blended by variety, the baking quality generally tended to decrease significantly above 20% durum concentration and the mixing pattern was impaired above 50% of durum. For the blends of Golden with Kubanka, the loaf volume increased with addition of Kubanka and exceeded that of the original flours. The mixing behavior of the soft wheat flour was generally strengthened even by a small addition of durum flour, especially Kubanka. The sugar producing ability of the blends increased directly with the proportion of durum flour present.

In conclusion, it appears that durum wheat may be used in blends with bread wheats for milling and baking purposes. Durum wheat flour will improve the baking quality of low protein wheat flour, particularly if Kubanka is the durum variety used. With stronger flours, concentrations of 20% durum did not materially impair loaf quality, while increasing the sugar producing activity of the dough.

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## A PRECISION ADIABATIC CALORIMETER

*Gilbert H. Reiling*

*Physics Department*

*University of North Dakota, Grand Forks, North Dakota*

### I. Introduction

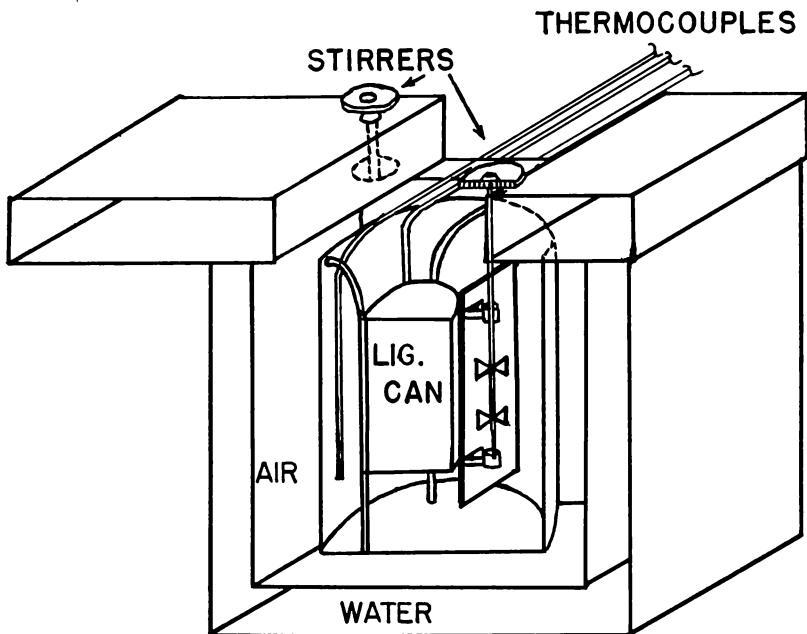
The design of a calorimeter is dependent upon the type of measurement made and the precision sought. In the specific heat measurement of lignite an adiabatic calorimeter is preferable since the conductivity of lignite is low. The adiabatic method requires that the calorimeter temperature and the jacket temperature be kept equal thereby eliminating thermal leakage. A precision adiabatic calorimeter must consist of the following features:<sup>1</sup>

1. A water jacket that completely surrounds the calorimeter.
2. Constant stirring of jacket and calorimeter liquid to equalize the temperature and to avoid error in the stirring constant.
3. Jacket heating control to maintain adiabatic condition.
4. Calorimeter closed so that there is a minimum evaporation error.
5. Heat conduction paths (i.e. stirring rods, support mounts,

thermocouples, etc.) must be maintained near calorimeter temperature so that the lag is a minimum, and so that heat flow through these parts is a minimum.

A calorimeter was constructed with these conditions in mind.

Fig. 1—Cross Sectional View of Calorimeter and Jacket



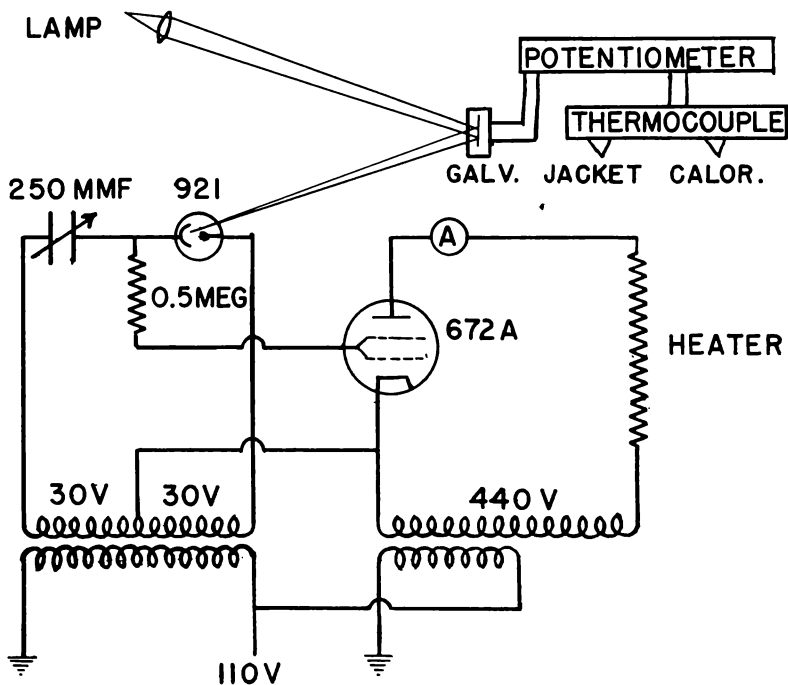
## II Apparatus

The environment (Fig. 1) consists of an 18 liter rectangular water jacket made of No. 26 gauge galvanized iron completely surrounding the calorimeter. The outside dimensions of the lower part are  $10\frac{1}{2}$  by  $11\frac{1}{2}$  by  $14\frac{1}{2}$  inches; the inside dimensions are 7 by 8 by 11 inches. A water cap which can be opened or closed is used on top and it is made in two rectangular sections through which water is circulated. One half of the water cap measures 12 by 9 by  $1\frac{1}{2}$  inches and the other measures 12 by 6 by  $1\frac{1}{2}$  inches. Each half of the water cap has a baffle through the center to distribute the circulating water. There are two  $1\frac{1}{4}$  inch diameter tubes extending 8 inches into the lower jacket from each water cap and through one of the tubes in each section the stirrers are mounted. The liquid in both sections is held up with atmospheric pressure. The jacket has 4 General Electric 650 watt, 110 volt flexible copper tube heaters connected in series and mounted in the top and along the bottom of the jacket.

The calorimeter is on 4 lucite mounts and separated from the

jacket by approximately 1 inch air space. The calorimeter stirrer, which is made in two easily disconnected sections, has a lucite partition in order to avoid heat transfer from the jacket to the calorimeter. The evaporation between the calorimeter and the jacket is minimized by constructing a rather tight fit between the jacket top and the calorimeter. In order to lessen the changes due to room temperature the whole container is insulated with glass wool and enclosed in a wooden container.

Fig. 2—Heating Control Circuit



The jacket heating (Fig. 2) is automatically controlled by a heating arrangement employing a phase shift thyatron tube circuit.<sup>2 3</sup> The control unit operates in the following way. A differential thermocouple system is made by connecting copper-constantan thermocouples in series and placing one part in the calorimeter and one part in the jacket. The leads are connected to a galvanometer with high sensitivity. From a lamp and lens system a wedge shaped beam of light falls on the galvanometer mirror. The galvanometer coil and mirror, which are rotated by a temperature difference between the calorimeter and the jacket, reflects the light to an RCA 921 photocell and changes its resistance proportionally. Thus the phase of the grid voltage with respect to the plate voltage can be shifted from 0 to

90 degrees—making the tube conducting over any desired part of the positive half cycle. The variable condenser may also be used to shift the phase of the grid voltage so that the tube will fire. The secondary of the power transformer places 440 volts on the plate of the RCA 672-A thyratron tube which has a maximum average current of 3 amperes. This arrangement produces from 0 to 850 watts of heat in the calorimeter jacket. Copper-constantan thermocouples and a potentiometer are used to record the temperature of the calorimeter.

#### Apparatus List\*

1. Jacket; No. 26 gauge galvanized iron (\$30—metalsmith).
2. Calorimeter; copper.
3. Potentiometer; Type K or low range student.
4. Motors; 2, .02 hp.
5. Power transformer; 440 v. 3 amp.
6. Filament transformers; 5 v. 5 amp.
7. Grid transformer; 60 v. centertapped.
8. Thyratron tube; 672-A RCA, 3 amp average (\$35.00)
9. Photocell; 921 RCA (\$2.00)
10. Condenser; 225 mmf. (radio receiver type)
11. Resistor; .5 megohm.
12. Switches; 3, spst.
13. Ammeter; AC or DC, 0 to 5 amp.
14. Light source and lenses
15. Miscellaneous metal (copper and brass)

\* Approximate cost of items not available in physics department is listed in parenthesis.

#### III Conclusion

In the adiabatic calorimeter described only a stirring correction is needed. If the stirring is relatively constant then it is only necessary to determine the stirring constant periodically. Errors can be determined and evaluated by following the procedure outlined in White.<sup>1</sup>

#### IV Acknowledgements

Appreciation is expressed to Professors J. L. Hundley and R. L. Wild of the physics department of the University for their cooperation and helpful suggestions in the construction of the calorimeter; and to Professor A. C. Burr of the Lignite Laboratory for helpful discussions on the technical aspects of lignite. To the North Dakota Research Foundation the author is indebted for partial support which made this work possible.

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## DEHYDRATION OF POTATO GRANULES

*A. M. Cooley, R. E. Fredrickson, and D. E. Severson*

*Department of Chemical Engineering  
University of North Dakota, Grand Forks, North Dakota*

The dehydration of potatoes is not a new idea. The Spanish conquerers found dried potato products being used by the aborigines of South America. Dehydrated potatoes were used extensively in military rations in both major world wars.

Dehydrated potatoes present two advantages from the military point of view; first, they are much less subject to deterioration and can be preserved for relatively long periods; and second, the removal of water permits much easier transport. The dehydrated product weighs about one-fifth as much as the original potato.

The dehydrated potatoes available during World War II for military use were largely in one or two forms, diced potatoes or potato shreds. Diced potatoes are first cut into dice, blanched (i.e. killed with steam but not cooked) and then dried. Potato shreds are pre-cooked, extruded and dried. The dice must be cooked at the time of reconstitution. Both of these products are high in bulk.

A later process, which was developed too late for extensive use during World War II, is the manufacture of dehydrated potato granules, in which mashed potatoes were dehydrated to granules which consist of single, unbroken potato cells. This product is completely precooked and can be reconstituted by merely adding hot water and/or milk and stirring with a fork. The bulk density for packing is from 0.7 to 1.0 gm./ml. as compared with about 0.25 gm./ml. for shreds.

The presently favored commercial process is based on the work of Rivoche, a Frenchman, who presented a sample of dehydrated mashed potato to the British government just before the late war. The German occupation of France prevented further knowledge of this process from reaching the British until after the war, although research was conducted on this process in England during the war. He was finally given a U. S. patent on the process in 1950, and most present production is carried out under license from this patent.

The essence of the process is that the whole cooked potato must be broken down to single cells and dried; without the breaking of more than a small proportion of the individual cells, and without scorching of the product. The off-flavors and lumpy or soupy consistency of dehydrated potatoes so well known to veterans of World War II are due in large measure to excessive cell breakage, incomplete breakdown to single cell size, scorching of material during drying, and oxidative changes occurring during storage of the material after dehydration.

If one attempts to dry whole cooked or mashed potatoes by ordi-

nary drying methods, the pieces become case-hardened and may scorch on the outside before drying on the inside. The critical operation is drying from the 80% moisture content of the original potato to below 50%. A properly comminuted potato of 45% moisture or below may be dried very readily in a stream of hot air at 250-350° F. On the other hand, if the initial drying phase does not leave the potato in a condition of uniform moisture content without case-hardening, further drying cannot result in a reconstitutable product.

Several schemes have been devised for carrying out this initial phase of the drying. These include mechanical dewatering after freezing and thawing by centrifuging or pressing between absorbent rollers, and drying under reduced pressure with application of moderate heat. The mixback process is the most successful commercially. In this process the initial phase of drying is accomplished by mixing whole cooked or mashed potatoes with previously dried granules, in such proportion that the over-all moisture content of the mix is 30-45 per cent. The mixing must be sufficiently intimate that the moisture can distribute itself uniformly throughout the mass in a reasonably short time, yet without excessive cell rupture. This mix is then dried, first in an air stream to a moisture content of 10-15%, and thence to a rotary drier in which the moisture is reduced to 4-6%.

The Chemical Engineering Department of the University of North Dakota is at present carrying out studies on the potato granule process under contract to the U. S. Army Quartermaster Corps. The object of this research is to obtain operating data on a pilot plant dehydration unit that can be used in the design of commercial equipment for this purpose, and to obtain fundamental data on the mixing and drying operations. One object has been the utilization of a wider number of varieties of potatoes, inasmuch as most varieties of Red River Valley potatoes are at a disadvantage in the present process.

In small scale experiments in the University of North Dakota pilot plant, batch mixing has been employed, although a continuous mixer has been built and tested. Potatoes are first peeled mechanically, cooked in steam, and then mixed with dry powder. This mix is dried in an air duct; the wet material is fed in with an auger, and enters an air stream with a velocity of about 80 feet per second. The material is dried during passage through 133 ft. of 8-inch duct, and passes into a cyclone separator, from which the dried product is removed through an airlock.

The most critical stage of the process is the initial mixing of freshly cooked potato with previously dried granules, and it is to this step that much of this investigation has been directed. If the mixing is too violent, cells will be ruptured; if not thorough enough, agglomerates of cooked potato will remain which will not dry properly. Ruptured cells give poor texture on reconstitution; and, in addition, the loose starch from the broken cells act to cement other cells into

agglomerates. These agglomerates will not dry properly and tend to scorch easily because of lowered surface for evaporation per unit volume.

It was found necessary to give first a mixing period of about 5 minutes to accomplish the initial comminution of the cooked potato. An aging period is then necessary to allow time for water to become equalized between the wet and the dry material. If too much mixing is done before aging, cell breakage will occur. The aging requires at least 20 to 30 minutes, and should be followed by a final mix of about 5 minutes, during which the remainder of the breakdown to single cells takes place.

A moisture content of wet mixback of about 40 per cent, necessitating a cooked potato to dry powder ratio of about 3:4, was found to be the optimum in the process carried out here. Higher moistures gave agglomerates which were difficult to dry, and low moistures gave excessive cell breakage because of too rapid moisture transfer. It should be borne in mind, also, that the above ratio means that the average potato cell is recycled about seven times before removal as product, and the higher the moisture that can be used, the lower will be the number of recycles, and therefore the less the deterioration from subjection to operating conditions.

Studies carried out here indicated that cell breakage occurs largely in the mixing step, very little in the drying step. Relative broken cell content of samples is obtained by shaking a sample with hot water and determining the starch content of the supernatant centrifuged liquor. It has also been noted that much more cell breakage occurs on reconstitution than during the dehydration process.

Except for one plant at present operating in the Red River Valley, all present production of dehydrated potato granules is located in Idaho. The Idaho varieties, grown under irrigation, have in general higher solids content and higher specific gravity than those grown in most other sections. For the processing herein described, high solids contents are much to be desired; and it has come to the attention of the authors that one plant has been moved from New York to Idaho because of the difficulty of obtaining potatoes suitable for processing in the New York area. Thus part of the current investigation has been centered on modifying the process to permit use of lower moisture varieties.

Experiments on North Dakota Pontiac potatoes were unsuccessful when the method described above was employed. The recycle powder kept building up in screen size until it could not be used for further processing. A modification of the standard procedure has been developed in this laboratory, however, on which North Dakota Russetts and North Dakota Pontiacs of low specific gravity could be processed without excessive build-up of screen size.

In this modification the potatoes are first cooked and mashed while hot. This can be done by use of a beater or by pressing between

rolls. The mashed potato is then cooled to about 100° F. before mixing with dry powder. The mix is then aged, mixed again, and dried as before. This procedure gives less cell breakage and a satisfactory product, possibly because the lower mixing temperature permits slower exchange of moisture and is less damaging to the cell walls.

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## NATIVE LEGUMES OF NORTH DAKOTA GRASSLAND

*Warren C. Whitman and O. A. Stevens*

*Botany Department*

*North Dakota Agricultural College, Fargo, North Dakota*

No careful study of the occurrence and distribution of native legumes in the natural grassland of the Northern Great Plains has been made. Stevens (2) has discussed in general some of the native legumes of North Dakota. Sarvis (1) has recorded observations of the influence of grazing on some native legumes in pastures at Mandan, N. Dak. The present study was begun in 1949 as North Dakota Agricultural Experiment Station Project Hatch No. 34 to characterize the native legume flora of North Dakota on a quantitative basis and to estimate the possibilities of cultivating some of the legume species as dryland forage crops. This paper deals with the abundance and distribution of native legumes in the natural grassland of our state.

### **Methods**

The occurrence and abundance of native legumes in natural grassland has been studied in three principal sections of the state. These are the western section, with most of the sample areas concentrated within a radius of 60 miles of Dickinson; the central section, with most of the sample areas in the region between Valley City, Harvey, and Devils Lake; and the eastern section, with the sample areas mainly in the Kindred-Leonard region southwest of Fargo. The sample areas in the western and central sections were taken in the mixed prairie type of vegetation, which is the principal natural grassland type in these sections. The sample areas in the eastern section were located in remaining fragments of the tall grass prairie type, largely on sandy soils.

Sample areas varied in size from about one to three acres. The presence and abundance of native legumes was determined by quadrat counts of the number of plants and stems of each species of legume found in the square-meter quadrats which were distributed at random along two, three, or four transect lines extending through the sample area. The number of quadrats and the number of transect lines used was determined by the size and shape of the sample areas. On the larger areas 50 quadrats were taken along four transect lines, while on the smaller areas 25 quadrats on two transect lines were usually used. In all a total of 61 sample areas were studied in detail.

## Results

## Composition of legume flora:

Of the 57 legume species known to occur in North Dakota, 27 were found in the study area. As shown in Table 1, 13 species are of sufficient abundance to be of some importance in the vegetation. Of these 13 species, one is a locoweed (*Oxytropis* sp.), one a scurfpea (*Psoralea* sp.), two are prairie clovers (*Petalostemum* spp.), one is an annual trefoil (*Lotus* sp.), three are milkvetches (*Astragalus* spp.), two are vetches (*Vicia* spp.), two are leadplants (*Amorpha* spp.), and one is a vetchling (*Lathyrus* sp.).

TABLE I

Composition of Legume Flora in Three Sections of North Dakota

Species	Western		Central		Eastern	
	No. of Stalks	Per cent of Total Stalks	No. of Stalks	Per cent of Total Stalks	No. of Stalks	Per cent of Total Stalks
<i>Oxytropis lambertii</i>	2962	28.6	81	1.0	—	—
<i>Psoralea argophylla</i>	1374	13.3	1751	20.7	70	5.5
<i>Petalostemum purp.</i>	1209	11.7	701	8.3	172	13.6
<i>Petalostemum cand.</i>	364	3.5	6	0.1	70	5.5
<i>Lotus americanus</i>	332	3.2	13	0.2	—	—
<i>Astragalus striatus</i>	867	8.4	225	2.7	—	—
<i>Astragalus missour.</i>	323	3.1	—	—	—	—
<i>Astragalus goniatus</i>	255	2.5	2645	31.3	74	5.9
<i>Vicia sparsifolia</i>	149	1.4	1912	22.6	—	—
<i>Vicia americana</i>	—	—	—	—	228	18.1
<i>Amorpha canescens</i>	—	—	284	3.4	162	12.8
<i>Amorpha nana</i>	—	—	—	—	209	16.6
<i>Lathyrus palustris</i>	—	—	—	—	245	19.4
All others	2512	24.3	832	9.7	32	2.6
Totals:	10,347	100.0	8,450	100.0	12.62	100.0

Thirteen of the 27 species found on the study areas are *Astragalus* species. Thus on a species basis the milkvetches comprise about 50 per cent of the number of legume species commonly appearing in the native grassland flora. However, as shown in Table 1, the milkvetches are not as important on a quantitative basis, based on stalk counts, as their species importance would indicate.

In the western section four species make up 62 per cent of the legume population of the natural grassland. These are locoweed (*Oxytropis lambertii*), silver-leaf scurfpea (*Psoralea argophylla*), purple prairie clover (*Petalostemum purpureum*), and ascending milkvetch (*Astragalus striatus*). The locoweed is the most common and abundant of the group.

In the central section four species make up about 83 per cent of the legume population of the native grassland. Two of these species, silver-leaf scurfpea and purple prairie clover, were of considerable importance in the western section, but the other two, cock's head

(*Astragalus goniatus*) and prairie vetch (*Vicia sparsifolia*), were of only minor importance in the legume population there. In the central section these latter two species comprise about 55 per cent of the population, based on stem counts. On the basis of total number of stems, cock's head is the most important legume in the central section.

In the eastern section five species make up over 80 per cent of the legume population of the tall grass prairie. These are purple prairie clover, wild vetch (*Vicia americana*), the two leadplants (*Amorpha canescens* and *A. nana*), and marsh vetchling (*Lathyrus palustris*).

All of the legume population cannot be considered as forage for grazing livestock. Some species are too short to provide any feed, while others apparently are unpalatable at most growth stages. In Table 2 the legume species which, in the broadest sense might be considered palatable and as making sufficient growth to provide some forage, are listed, and their importance as components of the entire legume population summarized for each of the three sections of the state. The table shows that 63.3 per cent of the legume population of the western section could be considered as livestock forage, 67.2 per cent of the population in the central section, and 63.8 per cent in the eastern section. It could be said that roughly 65 per cent of the total legume stems produced in the native grassland constitute forage for grazing livestock.

TABLE II

Forage Producing Legume Flora of Three Sections of North Dakota

Species	Western		Central		Eastern	
	No. of Stalks	Per cent of Total Stalks	No. of Stalks	Per cent of Total Stalks	No. of Stalks	Per cent of Total Stalks
<i>Oxtropis lambertii</i>	2362	28.6	81	1.0	—	—
<i>Petalostemum purp.</i>	1209	11.7	701	8.3	172	13.6
<i>Petalostemum cand.</i>	364	3.5	6	0.1	70	5.5
<i>Lotus americanus</i>	332	3.2	13	0.2	—	—
<i>Astragalus striatus</i>	867	8.4	225	2.7	—	—
<i>Astragalus missour.</i>	332	3.1	—	2.7	—	—
<i>Astragalus goniatus</i>	255	2.5	2645	31.3	74	5.9
<i>Astragalus caryo</i>	9	0.1	33	0.4	5	0.4
<i>Astragalus flexuosus</i>	—	—	51	0.6	—	—
<i>Astragalus canad.</i>	—	—	—	—	11	0.9
<i>Vicia sparsifolia</i>	149	1.4	1912	22.6	—	—
<i>Vicia americana</i>	—	—	—	—	228	18.1
<i>Thermopsis rhomb.</i>	62	0.6	—	—	—	—
<i>Hedysarum boreale</i>	19	0.2	—	—	—	—
<i>Lathyrus palustris</i>	—	—	—	—	245	19.4
Totals:	6551	63.3	5667	67.2	805	63.8

**Abundance, distribution, and production:**

Table 3 summarized important characteristics of the legume flora

as to abundance, distribution, and dry weight production, without reference to the individual species which comprise the flora. The data of the table serve to emphasize the relative scarcity of the legumes as compared to the grass component of the natural grassland, the general lack of uniformity in the distribution of the legumes, and the relatively low yields of dry matter or forage that the legumes normally produce as they occur in natural association with the other components of the native grassland vegetation.

**TABLE III**

Abundance, Distribution, and Production of Native Grassland Legume Flora

Characteristic	Western N. Dak.	Central N. Dak.	Eastern N. Dak.
Ave. No. Plants/Quad. <sup>1</sup>	30	15.8	3.1
Ave. No. Stalks/Quad. <sup>1</sup>	8.2	18.4	5.0
% Quads without stalks	44.6	22.6	66.3
Ave. No. Species/area	6.1	6.5	3.1
Range-species/area	2.11	4-9	1-6
Ave. yield (lbs./acre) <sup>2</sup>	36.6	82.1	22.5
Ave yield pal. forage (lbs./acre <sup>2</sup> )	23.2	55.1	14.4
Yield or highest prodcng area (lbs./acre) <sup>2</sup>	83.4	248.7	55.0

<sup>1</sup> Square meter quadrat.

<sup>2</sup> Dry weight yield calculated at 0.50 g./stalk.

The number of legume stems per quadrat averaged 8.2 in the western section, 18.4 in the central section, and 5.0 in the eastern section. Some idea of the scarcity of the legume population in relation to the grass population in the native grassland can be gained by the realization that listing of the grass population on the same basis that the legume population has been listed would show from 1000 to several thousand grass stems per square meter quadrat.

The general lack of uniformity of distribution of the legume flora in the native grassland is shown by the relatively high percentage of quadrats in each section in which no legumes were found. In the western section 44.6 per cent of the total number of quadrats examined on all sample areas had no legumes in them. In the eastern section 66.3 per cent of all quadrats had no legume stems. The sample areas in the central section showed greater uniformity of legume distribution with only 22.6 per cent of the total number of quadrats lacking completely in legume stems.

In order to arrive at an expression of yield for the legume components of the native grassland vegetation of the three sections of the state a calculation of yield has been made by multiplying number of stems by a weight allowance of 0.5 grams per stem. The fig-

ures thus derived are given in Table 3. The value of 0.5 gram per stem was arrived at by weighing a number of individual stems of the different legumes. The yield figures should be regarded only as rough approximations.

The yield figures serve to emphasize again the relatively low contribution of the legumes to the over-all dry matter production of the native grassland vegetation. It is apparent that in most cases the native legumes provide very little forage for grazing livestock. However, the yield of the highest producing sample are in the central section, 248.7 lbs. per acre, would represent a very substantial proportion of the total per acre yield of the area. A yield of this magnitude would represent about 15 to 25 per cent of the total dry matter yield of the type.

### Discussion

The results of this study show that for the most part the native legumes are not an important forage producing constituent of the natural grasslands of North Dakota. Not only are the relatively scarce in natural grassland, but they show a considerable lack of uniformity in distribution. While 17 of the 27 species found in the study areas have been listed as providing forage, this does not mean that they are highly palatable. Most of the legumes under normal grazing pressures would not be sought out by grazing animals, but would largely go untouched. Only when grazing pressure becomes heavy, are the legumes consumed to any great extent.

One contribution that the native legumes do make to the quality and quantity of the natural grassland vegetation should not be overlooked. Most of the species found on the study areas have been observed to be well nodulated. It is probably a justified assumption that all of the native legume will be nodulated under most conditions. Over the many thousand of years that the native legumes have been growing in the natural grassland their contribution of available nitrogen to the soil has no doubt been tremendous. And they must contribute each year a small but important amount of nitrogen to aid in maintaining the fertility of natural grassland soils.

Five native legumes have been selected and are being increased for their possible use as cultivated forage plants. All of these are perennial. These species are ascending milkvetch (*Astragalus striatus*), cocks head (*Astragalus goniatus*), slender milkvetch (*Astragalus flexuosus*), little rattlepod (*Astragalus canadensis*), and sweet vetch (*Hedysarum boreale*). It should be pointed out that these legumes do not approach in forage production such species as alfalfa and sweet clover.

### Summary and Conclusions

Detailed quadrat studies of the occurrence, distribution, and abundance of native legumes have been made on 61 sample areas of



natural grassland vegetation in the western, east-central, and eastern sections of North Dakota.

Twenty-seven native legume species of the 57 known to occur in North Dakota were found on the study areas. As a whole the native legumes are a minor constituent of the native grassland. However, 13 species are of sufficient abundance to be of some importance in the vegetation, but these show a lack of uniformity in distribution.

Of the four species making up 62 per cent of the legume population, in the mixed prairie of the western section, locoweed (*Oxytropis lambertii*) and the silver-leaf scurfspea (*Psoralea argophylla*), were the most common and abundant of the species of this section.

In the mixed prairie of the central section four species made up 83 per cent of the legume population. Cock's head (*Astragalus goniatus*), prairie vetch (*Vicia sparsifolia*), and silver-leaf scurfspea were the most abundant species in this section.

In the tall grass prairie of eastern North Dakota, five species made up over 80 per cent of the legume population. These were purple prairie clover (*Petalostemum purpureum*), wild vetch (*Vicia americana*), the two leadplants (*Amorpha canescens* and *A. nana*), and marsh vetchling (*Lathyrus palustris*).

The legume flora of the central section is somewhat richer than that of the other sections as shown by the average number of stalks per square meter quadrat. The central section showed an average of 18.4 stalks per quadrat in contrast to 8.2 stalks in the western section and 5.0 stalks in the eastern section.

Forage production of the native legumes for the period covered by the study has been calculated at 36.6 lbs. dry weight per acre in the western section, 82.1 lbs. per acre in the central section, and 22.5 lbs. per acre in the eastern section. These low yields indicate that the native legume flora of the state in most cases provides but little forage for grazing livestock.

Five native legume species have been selected and are being increased for purposes of studying their possible use as cultivated forage plants.

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# POWER REQUIREMENTS FOR PULVERIZING LIGNITE IN THE INTERMEDIATE SIZE RANGE

*A. M. Cooley*

*Department of Chemical Engineering  
University of North Dakota, Grand Forks, North Dakota*

During the past forty years, considerable study has gone into methods of improving and beneficiating lignite as a fuel. Firing equipment, specially designed for lignite in minus 2 inch sizes, is very efficient and most of the power generated in North Dakota and western Minnesota is generated from lignite stoker units.

Recent advances in firing methods in which minus  $\frac{1}{4}$  inch material is burned in a cyclone type burner requires preparation of lignite in intermediate sizes and yet overcomes some of the disadvantages of fine pulverization which for lignite has been considered too costly because of the large amounts of power consumed for fine pulverization.

Sutherland, Bourke, and O'Keefe determined the power needed to pulverize lignite in a Unipulvo pulverizer and concluded that in general the power consumption decreased with decrease in initial and final moisture content of the lignite. Heated air was used to effect some drying pulverization. The power necessary for pulverization was so high, 19.83 to 25.41KWhr. per ton, that this method of burning lignite is little used; and spreader type stokers are used in practically all installations burning lignite.

In 1950 the Ottertail Power Company installed a 5000 KW plant at Crookston, Minn. in which lignite pulverized in Riley Attrita mills was used. The performance of this plant has been so encouraging that it seemed that further study of equipment and the factors affecting the grindability of lignite was in order.

The present study sponsored by the North Dakota Research Foundation at the University of North Dakota has for its aims the determination of the power requirements for crushing and pulverizing lignite in the intermediate and fine size ranges and a comparison of these power requirements with standard grindability indices such as the Hardgrove grindability index.

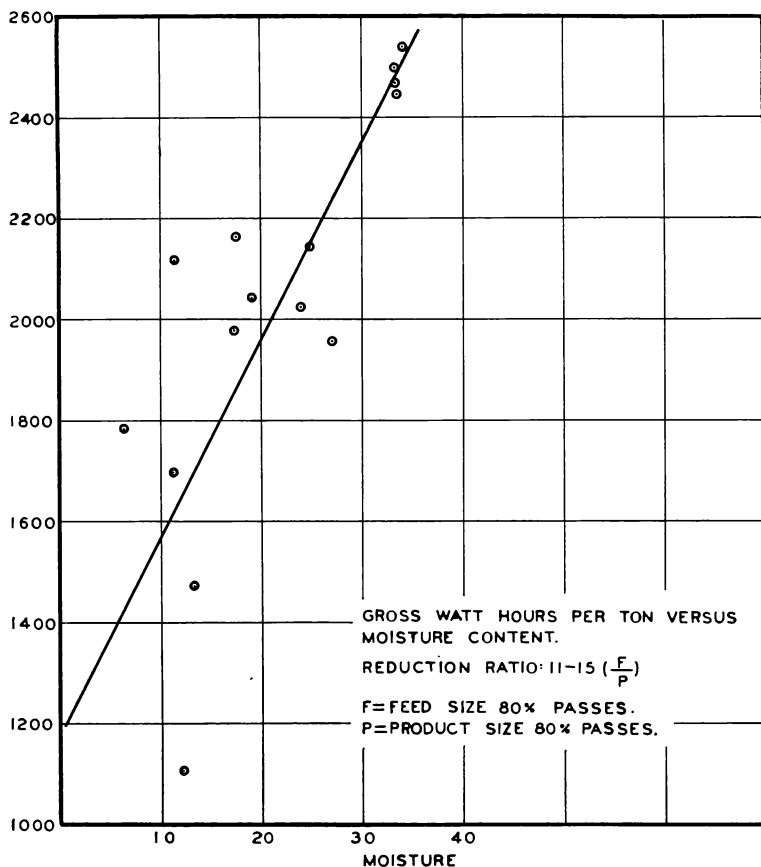
Results in the present paper cover grinding in the intermediate size range, and the equipment used was a Williams swing hammer crusher. A feed table was installed in order to control the rate of feed to the mill, and the mill motor was connected to a watt hour meter for determination of power consumption.

The feed material consisted of commercially prepared stoker lignite which was further screened to the size ranges of  $1-\frac{3}{4}$  x  $1-\frac{1}{2}$ ,  $1-\frac{1}{2}$  x  $\frac{1}{2}$ , and  $\frac{1}{2}$  x  $\frac{1}{4}$ .

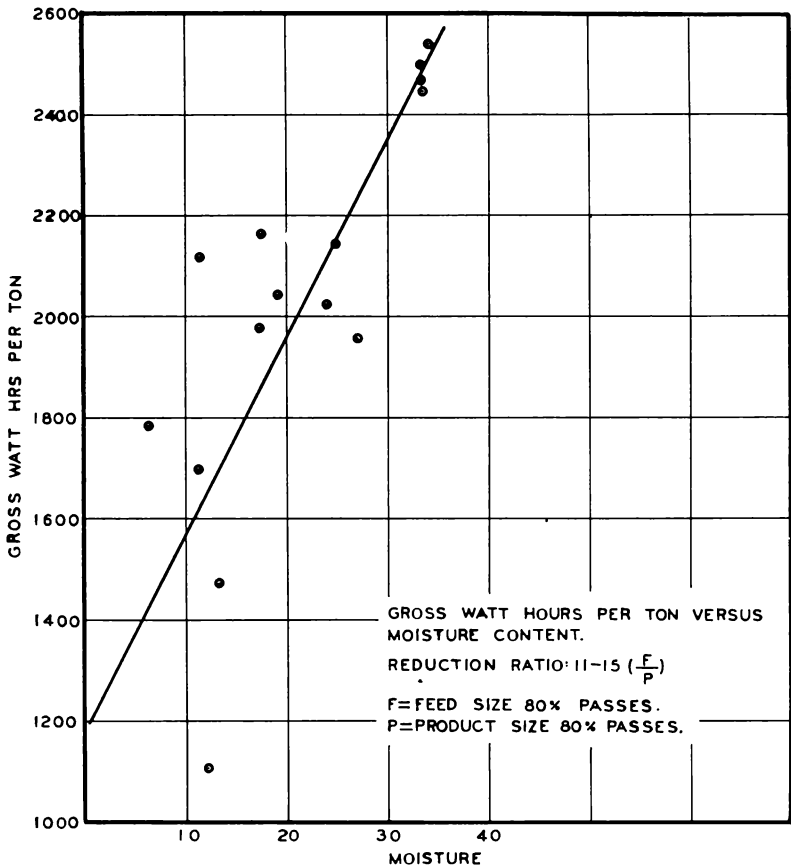
The dried lignite for runs 9-14, 21, and 22 had been steam dried, and all others of low moisture were air dried and sized after drying.

Size distribution was determined for both the feed and product after grinding using a standard Tyler seive series.

In determining the power consumed in grinding, one is confronted with the problems of separating the performance of the equipment from the actual energy requirements for subdividing the material. A given piece of equipment performs at an optimum feed rate for a given material, and other rates of feed may result in entirely different performance characteristics. In order to level out these effects, the results in this paper are expressed in net watt hours per ton of material ground and are calculated by determining the power needed to run the empty equipment and subtracting this from the power required when grinding. This method does not solve the problem since other variables besides the energy input are affected by the feed rate, but it does result in a more consistent method of expressing data for feed rates which are not too different.



Graph No. 1 is a plot of gross power versus moisture content for a size reduction of 11 to 15. The size reduction  $N$  is calculated by dividing the feed size  $F$  at which 80% of the material passes by  $P$  the product at which 80% of the product passes.



Graph No. 2 is a plot of net power per ton of dry substance versus moisture for the same size reduction.

It will be seen that there is considerably more scattering of data in Graph No. 1 than in the two plots of net power versus moisture. These graphs show that the power needed for a given size reduction is dependent on the moisture content and the lignite of low moisture content required only about  $\frac{1}{3}$  the power needed for the high moisture lignite. This is very important in that a ton of lignite of 35% moisture only contains 1300 lbs. of dry material; and when it is considered that this requires three times the power of a ton

containing 6% moisture in which 1880 lbs. are dry substance, the advantages of grinding dry lignite are much more apparent.

Accordingly, plot No. 2 is power per ton of dry substance versus moisture content and shows the power needed to subdivide the useful material or dry substance.

Drying of lignite causes slacking and internal fissures from which result in a more easily ground material. It is possible also that the dry lignite is more friable and shatters more easily than lignite of high moisture content.

Table No. 1 is a comparison of power consumptions for grinding low moisture lignite and Pocahontas bituminous coal. It will be seen that the power consumptions for comparable size reductions are quite close together and in this size reduction range lignite is only slightly more difficult to pulverize than bituminous coal.

**TABLE 1**

Feed size	Moisture	Net Watt		
		hrs./ton Pulverized	Reduction Ratio	
1½ x ½	1.4	550	26.3	Pocahontas
1½ x ½	11.5	860	22.8	Lignite
½ x ¼	1.0	530	7.5	Pocahontas
½ x ¼	12.1	621	9.0	Lignite

Another advantage of grinding dried lignite is the fact that for comparable feed rates the dry material not only requires less power per ton but also pulverizes to a finer material.

**TABLE 2**

Run No.	Moisture	Net Watt		Reduction Ratio
		hrs./ton Pulverized	Lbs./hr. Feed Rate	
5	29.2	1705	1886	5.6
12	12.1	621	1957	9

The pulverized material from the drier lignite is considerably finer than that from the wetter feed.

Several tests have been developed for expressing the ease of grindability of a substance. One of these which is quite often used for solid fuels is the Hardgrove grindability index.

The test consists in preparing a 50-gram sample of -16+30 mesh material and placing it in a specially designed grindability tester which consists of a bowl shaped container containing 8-1 inch balls. These are weighted down by means of 64 lbs. of lead plates. Sixty complete revolutions of the bowl race are made and the lignite removed and screened through a 200-mesh sieve. The Hardgrove number is expressed as  $H=13.0+6.93 g$ , where  $g$  is the weight in grams of material passing through the -200 mesh screen.

Friable coal such as Pocahontas has a grindability index of around 100. Lignites run from 38 to 50 and according to this test then are more than twice as difficult to pulverize as bituminous coal.

While data for power consumption per ton of lignite versus moisture content shows a very definite relationship, no such relationship could be found when plotting Hardgrove index versus moisture content.

### Summary

1. The Hardgrove index is not a measure of the grindability of lignite in intermediate size ranges.
2. For a given feed rate, the size reduction is greater with lower moisture content.
3. For a given size reduction and feed rate, the power consumption per ton of lignite decreases with decreasing moisture content.

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## SORPTION OF WATER VAPOR BY THERMALLY TREATED NORTH DAKOTA LIGNITE

*Wayne R. Kube*

*Utilization Section,*

*Charles R. Robertson Lignite Research Laboratory,  
Bureau of Mines, Grand Forks, North Dakota.*

### ABSTRACT

Dehydration has long been considered one of the most suitable methods of beneficiation or upgrading lignite. However, the hygroscopic characteristic of the dried lignite is such as to limit the advantages gained by dehydration to the lower moisture contents. Not only is the sorption of moisture important in the storage of dried lignite, it also affects the structural stability of lignite briquets. Gauger and Lavine have shown that a moisture-free lignite dehydrated at room temperature would hydrate to 15 to 16% moisture at a relative humidity of about 68%, which is the average humidity of North Dakota. The resorption of moisture by the dried lignite may be limited or controlled by changing the lignite structure so that its tendency to sorb moisture would be reduced.

Since natural lignite retains or loses its moisture in much the same manner as do partially reversible gels, it was postulated that treatment at rather elevated temperatures should affect the colloidal mass of the lignite by changing either or both the wettability and the number and size of the capillaries, and thus reduce somewhat the sorptive power of lignite.

This paper presents the preliminary results of work at the Charles R. Robertson Lignite Research Laboratory, Grand Forks, North Dakota by the U. S. Bureau of Mines, in cooperation with the Interior

Missouri Basin Field Committee in which the influence of thermal treatment on the hygroscopic characteristics of lignite was investigated.

Samples, each representing more than 43 pounds of  $\frac{3}{4}$  by  $\frac{1}{2}$  inch Kincaid lignite, which had been treated at nominal temperatures of 250°, 300°, 400°, 500°, 600°, 700°, 850° and 950° F. in a rotary drier for periods ranging from 120 to 240 minutes, depending upon the treating temperatures, were obtained for these sorption studies. The treating conditions simulated those of a commercial process in that the lignite was held at the treating temperature until the rate of condensate removal reached a practical lower limit, and not until all the condensibles were removed. The sorption data obtained from samples treated by this method should be more applicable to actual processing practice than when the samples had undergone prolonged treatment. Analysis of the original lignite and the products at each treating temperature were available. In addition to the treated Kincaid lignite, a sample of Dakota Star residue, "char", from a gasification process was also obtained for testing.

The representative samples were obtained with minimum handling and were placed in sealed containers until used. Two samples of each treated lignite consisting of an "as treated" and a "pulverized" sample (minus 40 mesh) were hydrated, while the gasification char was tested without further size reduction. The net weight of the "as treated" samples was 200 grams and that of the pulverized sample 40 grams. The samples were retained in a humidity cabinet at least two days after the maximum weight gain was reached. Actually, the final weight varied somewhat owing to changes in humidity and temperature. The relative humidity ranged from 88 to 96%, averaging 92%, and the dry-bulb temperature was 76° to 82° F. By weighing the samples at intervals, data for a sorption curve as a function of the time of exposure was obtained. The final moisture content and total weight gain were also determined.

The data obtained from hydration in an atmosphere of 92% relative humidity cannot be directly compared to the data on storage of lignite, as the average relative humidity for the State of North Dakota is only 68%. However, the general trends should be applicable.

Preliminary conclusion drawn from the analysis of these sorption experiments and the thermal treatment data may be formulated as follows:

1. The equilibrium moisture content of thermally treated lignite after hydration is inversely related to the treating temperature.
2. Analysis of the curve expressing the hydrated equilibrium moisture content of the treated lignite indicates that changes in the structure of lignite are a function of the treating temperature.

(a) Section 1. At temperatures up to nearly 500° F. moisture

is removed without any appreciable chemical change of the lignite substance. Changes in the sorption of water reflects the progressive shrinkage and setting of the lignite structure at the various temperature levels.

- (b) Section 2. At treating temperatures of 500° to 700° F. initial thermal decomposition of the lignite begins with the elimination of water of decomposition, carbon dioxide, and some gaseous hydrocarbons. The equilibrium hydrated moisture content is influenced by the degree of changes in the chemical and physical characteristics of the lignitic material, including continued shrinkage and setting of lignite structure.
  - (c) Section 3. At temperature of 700° to 950° F. additional thermal decomposition of the lignite occurs, with the release of tar in addition to the products of decomposition of section 2. The decrease in sorptive power is a function of chemical changes as well as continued shrinkage.
3. The change in sorptive power of the thermally treated lignite may be estimated and expressed on a percentage basis by comparing the equilibrium moisture content of nonheated lignite at the same relative humidity. On this basis, lignite treated at 500° F. had a sorptive power of 64.5%, and treated at 700° F. it had a sorptive power of 45.9%. Increasing the treating temperature to 950° F. further reduced the sorptive power to 31.4%.
  4. The rate of hydration of lignite treated at 400° F. or above, as well as the total weight gain, is inversely related to the treating temperature.
  5. Exhaustive steam treatment increases the sorptive power of lignite char. The equilibrium weight increase of a steam-treated char was twice that of a nontreated char.