THE DEPARTMENT OF ENVIRONMENTAL QUALITY

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SURFACE GEOCHEMISTRY OF MISSISSIPPI TO BE SURVEYED

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and

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INTRODUCTION

The Mississippi Office of Geology is participating in a regional soil and sediment geochemical sampling program with the state geological surveys of Alabama, Georgia, and Florida and the U.S. Geological Survey (USGS). Over a year of planning and training went into the implementation of this project.

The objectives of the project are to 1) determine baseline (naturally occurring) values for chemical elements based on stream sediment and soil samples, 2) prepare statistically reliable geochemical maps for individual elements where possible, and 3) identify areas favorable for mineral exploration. The soil and sediment sampling program, the first statewide effort in Mississippi, will yield important information regarding the state's mineral and environmental characteristics.

BACKGROUND

The existence, quality and survival of life depend upon the availability of elements in the correct proportions and combinations. Sometimes where certain chemical elements are present in excessive or deficient quantities, there may be some risk to humans, animals, or plants. Therefore, it may be both useful and important to determine the present abundance and spatial distribution of the elements across the Earth's surface in a systematic manner.

The history of systematic geochemical surveys in the United States began in the late 1960s. The USGS developed its first national geochemical database in 1968. The data set was given the acronym RASS (Rock Analysis Storage System) and contained a large quantity of geochemical exploration data gathered across the country by the USGS. The geochemical data are primarily from analyses of stream

sediments and soils from potential uranium-bearing igneous and metamorphic terranes of the "hard rock" west and east, but geochemical analyses of rock, soil, sediments, and sometimes plants were conducted for exploration for other metals, such as copper, lead, zinc, and nickel.

In the early 1970s, the USGS developed a second geochemical database known as PLUTO. PLUTO continued to incorporate small-scale geochemical survey data gathered by the USGS, as well as a large quantity of geochemical analyses done mainly on rocks and ores by a multitude of USGS projects. The RASS and PLUTO data sets are currently being released by the USGS on CD-ROM (Baedecker et al., 1998).

In the mid-1970s, the National Uranium Resource Evaluation program, or NURE program, was begun. The program was funded and managed by the newly created Department of Energy. The NURE program gathered data to evaluate uranium resources for the United States and to identify areas favorable for uranium deposits (Averett, 1984). Between 1975 and 1983, the NURE program acquired ground-based geochemical data and airborne spectral gamma-ray radiation data for much of the conterminous 48 states and Alaska.

The Hydrogeochemical Stream Sediment Reconnaissance (HSSR), one component of the NURE program, entailed collection and analysis of samples of sediment (stream, soil, talus, playa, and others), ground water, surface water, and vegetation to determine concentrations of uranium and other selected elements (Arendt and others, 1980). These data helped to outline geochemical provinces and to show favorable areas for more detailed investigation. Averett (1984) gives tabulations of areas surveyed during the HSSR and the available information for those areas.

Another component of the NURE program was aerial gamma-ray surveying. These NURE data compose the only nationwide data set on natural radiation in the environment. The U.S. Geological Survey has reprocessed the aerial gamma-ray data to produce maps showing surface concentrations of potassium (K), uranium (U), and thorium (Th) for the conterminous United States (Duval and others, 1989, 1990; Phillips and others, 1993).

HSSR data reports were issued for 330 (70.5 percent) of the 468 1°x2° quadrangles in the 48 conterminous states and for 104 (68 percent) of the 153 quadrangles in Alaska. Thus, about 70 percent of the nation has such geochemical coverage. Almost all samples were analyzed for uranium, and most were analyzed also for as many as 59 elements (Averett, 1984).

By the early 1980s the NURE database consisted of 894

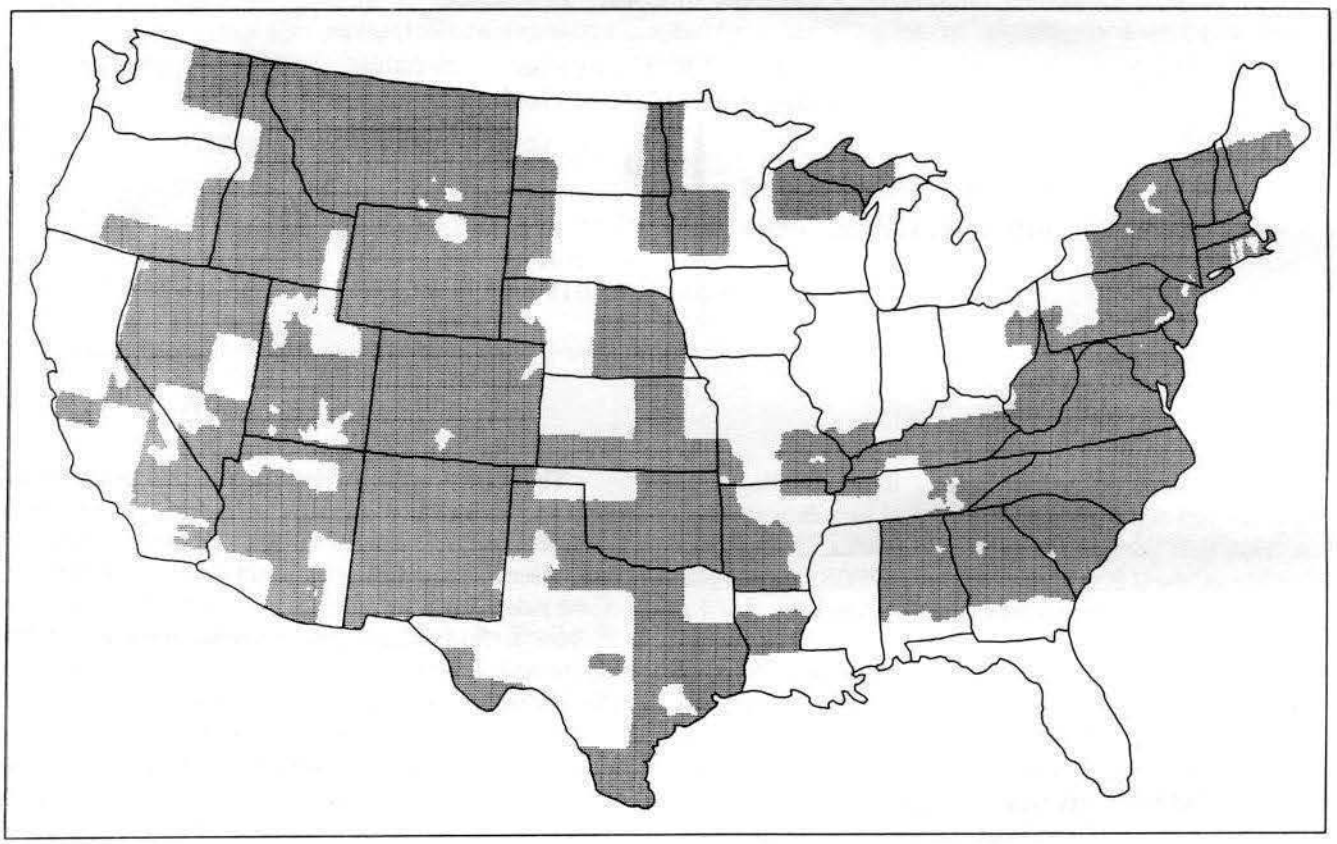

Figure 1. NURE sample location map for the conterminous U.S.

files in 49 different formats. For this reason, the University of Oklahoma was funded to compile and synthesize the various formats into one. They managed to combine 817 of the 894 files into one format before funding ran out. So the format problem, while improved, remains an obstacle when considering the entire database.

In 1985, and by agreement with the Department of Energy, since the NURE program had concluded, the USGS became the repository for the NURE data, samples, and field maps. Currently, the USGS maintains the National Geochemical Data Base composed of all three databases. The geochemical data for all quadrangles surveyed in the conterminous states are available on compact disc (Hoffman and Buttleman, 1994, 1996); the geochemical data for the western states are also available separately on compact disc (Hoffman and others, 1991); data for Alaska were released by Hoffman and Buttleman (1996).

Significantly, throughout the course of these previous geochemical sampling efforts, Mississippi was not a high priority target, and consequently very little is known about its geochemical characteristics (Figure 1).

The current sampling program in Mississippi will be incorporated into the National Geochemical Data Base. Sample materials include stream sediment, soil, bedrock, surface water, ground water, and vegetation. With respect to the NURE database, stream sediment sample coverage dominates over other types of sampling, and is generally thought to be the most useful type of sample in assessing mineral resource potential and determining geochemical backgrounds. Stream sediments generally represent a composite of materials shed from upstream areas and, when properly sampled, provide averaged geochemical signatures derived from rock units and soils within the drainage basin.

Ideally, bedrock or mineral specimens of interest could be analyzed to determine a "fingerprint" which might be compared to stream sediment analysis in order to identify terranes which are consistent with a particular mineral deposit type. Soil samples, on the other hand, are considered point-source data and are thought to be less useful in determining the overall elemental constituents of an area, but must be utilized in areas where suitable streams do not exist. However, soil samples typically provide site-specific geochemistry—the type of data most valuable to soil scientists and agricultural stakeholders.

METHODS AND TECHNIQUES

The planning effort for Mississippi identified the desired sample type and the number of samples required for regional coverage. It was decided that stream sediment samples would best characterize the state's overall geochemical make-up for this initial investigation, except for the "Delta" region, where soil samples were employed due to a lack of suitable streams and associated sediments. The sampling program, to be consistent with existing geochemical data for the Coastal Plain province, and to be managed within fiscal constraints, determined that a 10 km x 10 km grid spacing of sample locations across Mississippi was the optimum sampling objective. This was a convenient grid size since Universal Transverse Mercator (UTM) projection lines provide just such a framework on USGS topographic maps. For Mississippi, each 10 km x 10 km cell was given a unique sample number created from the easting and northing coordinates of the southwestern corner. The target stream population designated first order streams with drainage basins in the range of 2 - 10 km^2. Suitable streams within the cells were randomly selected for sampling by coin toss. The coin toss procedure was as follows: 1) Quarter the cell. 2) Flip a coin to select the northern or southern half. 3) Flip again to select the eastern or western half. 4) Repeat for each cell to be sampled. Furthermore, within that quarter cell randomly selected, the ideal sediment sample should be taken from the upstream side of bridge crossings in order to avoid downstream dumping scenarios.

In the "Delta" region soil sample sites were also selected within cells randomly, via a series of coin tosses. Most sample locations were situated near roads for convenience, but far enough away to avoid fill material. A minimum of three hand auger samples of the plow zone (upper 22 cm) were taken, about 35 meters apart, in a triangular spacing, and composited. This procedure reduces sampling errors and fosters the development of statistically reliable geochemical maps.

The geochemical sampling project includes an analysis of variance (AOV) in order to provide even coverage and to test differences in stream sediment chemistry 1) between cells, 2) within cells, 3) within streams, and 4) between chemical analyses. Approximately 5 percent of the cells were selected for AOV sampling and were chosen with the assistance of a random numbers table. For these AOV cells, a second stream location is randomly selected for sampling, along with an upstream sample to be split for analysis. Sampling for AOV purposes was carried out for soil sampled regions also.

An essential component in collecting a sample that represents the stream's geochemistry is compositing. Ideally, 6 to 10 depositional zones within a 100-meter-long stream reach containing fine-grained particulate matter at each site are sampled, with the goal being to select depositional zones that represent upstream influences and various flow regimes. This practice reduces the local-scale variability and allows for a more accurate representation of the average geochemical values at the site. Keeping sampling error at a minimum improves the possibility of being able to produce a stable geochemical map. The data will be used to determine geochemical baselines of statistically known reliability. Study of the data is likely to identify geochemically unusual samples or samples that represent specific types of mineral deposits.

A number of these will be analyzed in more detail geochemically and mineralogically to help determine the mode of occurrence of the elements in the samples. Such information is often useful for mineral exploration and environmental purposes.

Sampling was begun in September of 1997 and continued at a frantic pace through the first week of April of 1998. Field work and sample collection were performed primarily by two individuals of the Office of Geology's Surface Geology Division—David Thompson and Seth Berman. Several individuals of the Environmental Geology Division also provided much-appreciated help in collecting samples: Trey Magee, Archie McKenzie, and Robert Ingram. During this 7-month period, 1,462 samples were collected statewide (Figure 2).

A field sheet was completed for each sample location in order to characterize the setting in a manner useful for the project and for future reference. Recorded information includes: geology, latitude/longitude ascertained by global positioning system (GPS), elevation, relief, vegetation, channel width, water depth, water color, stage, flow rate, setting, possible contaminants, and the alkalinity of the stream water, measured with titration test kits and expressed in ppm total alkalinity as calcium carbonate.

After air drying, samples were shipped to the USGS in Denver for processing and chemical analysis. Preparation of sediment samples for chemical analyses involved screening of the bulk sediment samples through a 100 mesh (150 micrometer aperture) U.S. Standard stainless steel sieve. The -100 mesh fraction was split into analytical and archival samples. In cases where insufficient -100 mesh fraction was recovered, the sample was recombined and ground by use of a ceramic-lined grinder to pass through the 100 mesh sieve.

Analytical techniques utilized on the samples include the following.

1. ICP 40. Forty major, minor, and trace elements are determined by ICP-AES (Induction Coupled Plasma-Atomic Emission Spectroscopy) after the sample is decomposed using a mixture of hydrochloric, nitric, perchloric, and hydrofluoric acids at low temperature. Elements determined and their lower and upper detection limits are given below.

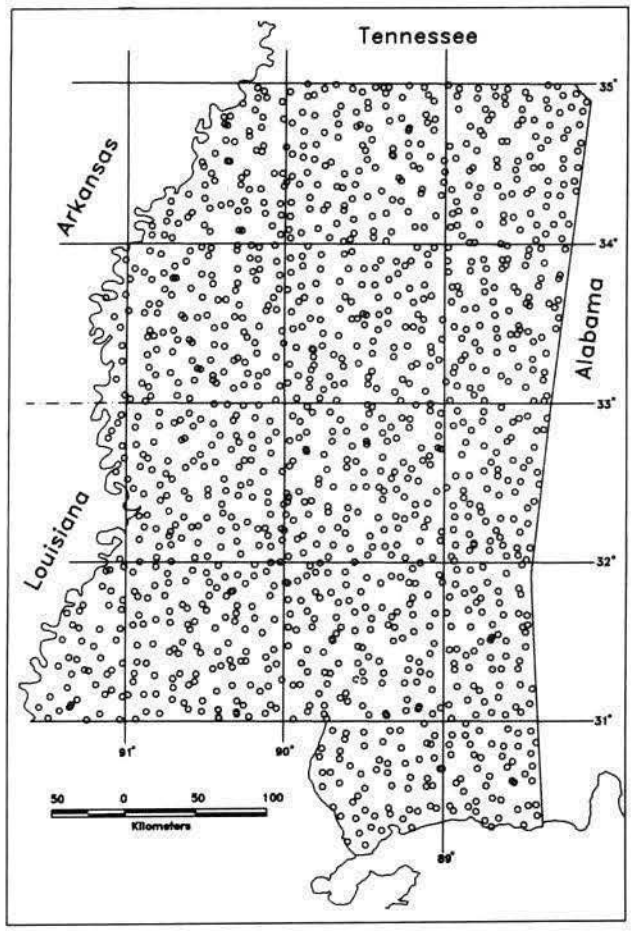

Figure 2. Location map of the 1,462 sample collection sites from Mississippi utilized in the current study.

Al	.005-50%
Ca	.005-50%
Fe	.02-25%
K	.01-50%
Mg	.005-5%
Na	.005-50%
P	.005-50%
Ti	.005-25%
Ag	2-10,000 ppm
As	10-50,000 ppm
Au	8-50,000 ppm
Ba	1-35,000 ppm
Be	1-5,000 ppm
Bi	10-50,000 ppm
Cd	2-25,000 ppm
Ce	5-50,000 ppm
Co	2-25,000 ppm
Cr	2-50,000 ppm
Cu	2-15,000 ppm
Eu	2-5,000 ppm
Ga	4-50,000 ppm
Ho	4-5,000 ppm
La	2-50,000 ppm
Li	2-50,000 ppm
Mn	4-50,000 ppm
Mo	2-50,000 ppm
Nb	4-50,000 ppm
Nd	9-50,000 ppm
Ni	3-50,000 ppm
Pb	4-50,000 ppm
Sc	2-50,000 ppm
Sn	5-50,000 ppm

Sr 2-15,000 ppm
Ta 40-50,000 ppm
Th 6-50,000 ppm
U 100-100,000 ppm
V 2-30,000 ppm
Y 2-25,000 ppm
Yb 1-5,000 ppm
Zn 2-15,000 ppm

2. ICP 10. Ten elements are determined using ICP-AES following a hydrochloric acid - hydrogen peroxide digestion and aliquot 336-diisobutylketone extraction. Elements determined and their lower and upper detection limits are given below.

Ag 0.08-400 ppm
As 1.0-6,000 ppm
Au 0.10-1,500 ppm
Bi 1.0-6,000 ppm
Cd 0.05-500 ppm
Cu 0.05-500 ppm
Mo 0.10-900 ppm
Pb 1.0-6,000 ppm
Sb 1.0-6,000 ppm
Zn 0.05-500 ppm

3. Mercury. Continuous-flow cold vapor atomic absorption spectrometry is used for the determination of mercury. Lower reporting limit is 0.02 ppm.

4. Arsenic, Antimony, and Selenium. Samples are digested using a multi-acid procedure; oxidation states of the three elements are reduced; sodium borohydride is added to the solution to form gaseous hydrides; these hydrides are stripped from the analytical stream and transported with inert gas to the atomic absorption spectrophotometer where the elements of interest are determined. Optimum analytical ranges are: As 0.6-20 ppm, Sb 0.6-20 ppm, and Se 0.2-4 ppm.

5. WDXRF—Wavelength Dispersive X-Ray Fluorescence. Major elements are determined using the method of Taggart and others (1987). This involves a lithium tetraborate fusion of the powdered sample, followed by measurement of K X-ray intensities on a Phillips PW1606 spectrometer. A wide range of USGS and NIST rock standards is used for calibration. The method has been proven to be highly accurate for most rock and sediment samples. Analytical precision is mainly determined by counting statistics, and is better than 0.05% (absolute) for most oxides (SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5 and MnO).

6. INAA—Instrumental Neutron Activation Analysis. The procedure used at the USGS is a multi-element technique capable of simultaneously determining up to about 50 elements. The technique has very high sensitivities for most of the elements that can be determined—most detection limits range from 0.05 to 50 ppm. Further, the INAA technique is highly precise and accurate—overall errors of less than 2% relative standard deviation can be achieved for many elements.

Sample aliquots weighing typically about 0.5 g are irradiated for six hours in the TRIGA reactor at the USGS, Denver, Colorado, at a flux of 2.5×10^{12} n/cm^2/s. Standards consisting of spiked silicate powders are irradiated together with the samples. Following a decay period of 6-8 days, the samples and standards are counted for one hour on a pair of high purity germanium (HPGe) detectors, one coaxial and one planar, coupled to a multichannel analyzer system. After an additional 26-32 day decay period, the samples and standards are counted for two hours on a coaxial HPGe detector. The coaxial HPGe detectors have resolutions of about 1.9 KeV measured at 1.33 MeV, and efficiencies between 18 and 25%. The planar HPGe detector has a resolution of 0.80 KeV measured at 122 KeV. Gamma-ray peaks are integrated using the SAMPO program. Corrections for dead time, decay during counting, and spectral interferences are made using an in-house data reduction program to calculate elemental concentrations. Samples of SAR-L, SAR-M (USGS analytical standards) and/or NIST2710 are included in each irradiation as quality control standards.

ANTICIPATED BENEFITS

So what kind of benefits can the State of Mississippi expect to realize from this ambitious project? The Mississippi Office of Geology is contacted frequently by environmental engineering firms and other interested parties requesting data on naturally occurring levels of potentially dangerous chemical elements at specific sites in Mississippi. As Figure 1 illustrates, that type of information has not been available, and only average elemental levels for the southeastern Gulf Coastal Plain at large could be cited. As a result of this effort, geochemical data will be available for small watersheds all across Mississippi. Currently, analysis of the samples is underway and should be 90% completed by the fall of 1998.

This type of geochemical data has wide-ranging environmental use. For example, one will be able to consider the natural concentration of lead in sediments of southwestern Noxubee County prior to industrial development, or compare a known mercury-contaminated site in Hinds County to surrounding baseline, naturally occurring levels.

These data will have considerable mineral assessment/exploration potential (for example, Grosz and Schruben, 1994) and will supplement the existing NURE aeroradiometric coverage. It is anticipated that heavy-mineral-bearing (ilmenite, rutile, zircon, and monazite) prospective terranes will be recognized in the Cretaceous and Tertiary outcrop

belts in Mississippi, an extension of known prospects in Alabama and Tennessee. A poorly understood thorium-dominated aeroradiometric anomaly associated with the Jackson Group will be investigated. It may represent a previously unrecognized deposit type for placer resources. Additionally, prospective terranes for kaolin, bauxite, and uranium may be recognized as a result of this sampling program. As unusual geochemical situations are identified, it is expected that additional follow-up sampling by the Mississippi Office of Geology will be conducted.

The geochemical data can be utilized to create interpretive derivative maps involving polygons of watershed, lithology, geology, mineral deposits, and political boundaries.

The first likely publication related to the data will be a series of Open-File Reports with listings of concentrations of chemical elements in spreadsheet form. Later, the Mississippi Office of Geology in collaboration with the USGS anticipates the publication of a geochemical atlas or maps that will highlight the distribution of particular chemical elements, combinations of chemical elements, and elemental ratios. It is anticipated that these data also will be available on the Internet at USGS and Mississippi Office of Geology Web sites.

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Figure 3. David Thompson collects stream sediment sample #27360 along a tributary of Tuscolameta Creek in northeastern Scott County. Photograph by Cletus Magee, November 6, 1997.

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NEW PUBLICATION AVAILABLE FROM THE MISSISSIPPI OFFICE OF GEOLOGY

GEOLOGIC MAP OF THE SAPA QUADRANGLE, WEBSTER AND CHOCTAW COUNTIES, MISSISSIPPI

The Mississippi Office of Geology announces the availability of Open-File Report 58, "Geologic Map of the Sapa Quadrangle, Webster and Choctaw Counties, Mississippi," by David E. Thompson.

Open-File Report 58 is a geologic map of the Sapa 7.5-minute quadrangle, printed in color at the scale 1:24,000. It is one of our series of geologic quadrangles, created in a geographic information system using ARC/INFO software and printed on an inkjet plotter. The geologic map differentiates five geologic units in the Midway and Wilcox groups of the Paleocene Series. From oldest to youngest, the units are the Porters Creek Formation, the Oak Hill Member and the Coal Bluff Member of the Naheola Formation, and the Gravel Creek Sand Member and the Grampian Hills Member of the Nanafalia Formation. Holocene alluvium is mapped also. This geologic map provides vital information about the area's water-bearing sands and economically important lignite resources.

Open-File Report 58 may be purchased from the Office of Geology at Southport Center, 2380 Highway 80 West, for $5.00 per copy. Mail orders will be accepted when accompanied by payment ($5.00 per copy, plus a postage and handling charge of $5.00 for rolled maps (1-3 maps) or $2.00 for folded maps (1-3 maps)). Send mail orders (with check or money order) to:

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An up-to-date index of *Mississippi Geology* is available from the Office of Geology. Open-File Report 15, "Current Index to *Mississippi Geology*," compiled by Michael B. E. Bograd, is available for $2.00 (plus $2.00 postage by mail) from the Office of Geology, P.O. Box 20307, Jackson, MS 39289.

NEW PUBLICATION AVAILABLE FROM THE MISSISSIPPI OFFICE OF GEOLOGY

GEOLOGIC MAP OF THE EUPORA QUADRANGLE, WEBSTER AND CHOCTAW COUNTIES, MISSISSIPPI

The Mississippi Office of Geology announces the availability of Open-File Report 59, "Geologic Map of the Eupora Quadrangle, Webster and Choctaw Counties, Mississippi," by David E. Thompson.

Open-File Report 59 is a geologic map of the Eupora 7.5-minute quadrangle, printed in color at the scale 1:24,000. It is one of our series of geologic quadrangles, created in a geographic information system using ARC/INFO software and printed on an inkjet plotter. The geologic map differentiates three geologic units in the Wilcox Group of the Paleocene Series. From oldest to youngest, the units are the Gravel Creek Sand Member and the Grampian Hills Member of the Nanafalia Formation, and the Tuscahoma Formation. Holocene alluvium is mapped also. This geologic map provides vital information about the area's water-bearing sands and economically important lignite resources.

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NEW PUBLICATION AVAILABLE FROM THE MISSISSIPPI OFFICE OF GEOLOGY

GEOLOGIC MAP OF THE BELLEFONTAINE QUADRANGLE, WEBSTER AND CALHOUN COUNTIES, MISSISSIPPI

The Mississippi Office of Geology announces the availability of Open-File Report 60, "Geologic Map of the Bellefontaine Quadrangle, Webster and Calhoun Counties, Mississippi," by David E. Thompson.

Open-File Report 60 is a geologic map of the Bellefontaine 7.5-minute quadrangle, printed in color at the scale 1:24,000. It is one of our series of geologic quadrangles, created in a geographic information system using ARC/INFO software and printed on an inkjet plotter. The geologic map differentiates four geologic units in the Midway and Wilcox groups of the Paleocene Series. From oldest to youngest, the units are the Coal Bluff Member of the Naheola Formation, the Gravel Creek Sand Member and the Grampian Hills Member of the Nanafalia Formation, and the Tuscahoma Formation. Holocene alluvium is mapped also. This geologic map provides vital information about the area's water-bearing sands and economically important lignite resources.

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MISSISSIPPI EXPERIENCES OF WALTER BELT

Walter E. Belt, Jr.
Retired
Flatonia, Texas

[In 1945 the Mississippi Geological Society and the U.S. Geological Survey cooperatively published the first geologic map of Mississippi at the scale 1:500,000. This map is sometimes cited as "Belt et al., 1945" because W. E. Belt is listed first among the compilers. Following are some reminiscences by Walter Belt of his time in Mississippi working for the USGS and the oil industry. The editors]

INTRODUCTION

In 1943 the Good Lord decided to send me to Mississippi
Because He liked me
I'm glad He did because I grew
to like and love Mississippi
And
Here is the long-winded (probably too many details)
How things developed for me to go to Mississippi
And some of what I did while there

DRAFT BOARD INSTRUCTIONS

I was a geology/micropaleontology student at the University of Texas when Japan attacked Pearl Harbor. Shortly thereafter I wanted to enter the Air Force in aerial photographic interpretation. My draft board said "No, stay in school and get your degree so you can help find oil."

In the meantime, at the University of Texas, I worked as micropaleontology lab assistant under Dr. Robert H. Cuyler. Later he joined the Air Force as assistant in charge of ground training at Randolph Field and was replaced by Mrs. Esther Applin, one of the three lady micropaleontologists who took the study out of academics and made it a practical tool to use in geological/petroleum exploration. She retained me as her lab assistant. I also assisted her research with Dr. Joseph Cushman of Harvard and had an "invite" to attend Harvard for post-graduate work under Dr. Cushman, then the world's number one authority on micropaleontology. World War II killed my Harvard dream.

A horrible shock came—Dr. Cuyler had died in a plane crash just north of Randolph Field. Had he lived I would have made every effort to have spent my professional life associated with that wonderful man. (The Texas Bureau of Economic Geology published the Geologic Atlas of Texas, and on the San Antonio sheet they have shown the crash site where Dr. Cuyler died—A rare tribute!)

When a senior at the University of Texas I was president of the Triarthus Club, a student organization for weekend geology field trips. No faculty were involved. We thought we were the top of the class and admission was by secret vote; one black ball meant that admission was denied. We even had one of the voting "things" where you put in a white or black ball.

It was then I learned about the Mississippi people from the HILLS versus those from the DELTA. Mike was from the Hills and had been a member for a couple of years. We had a membership request from Joe, a sophomore from the Delta. Joe was not real well liked, and we really expected him to be blackballed.

The night of the vote in the closed door paleo lab when it came time for Mike to vote he reached under the table and unwrapped about a 3-pound chunk of black coal. It had to be a true expression of the Hills against the Delta.

Then it was about time to receive my degree. I contacted the Air Force and said "I am ready to join you for aerial photo interpretation." They said, basically, so what, we don't have an opening for you now. CRISIS..CRISIS..CRISIS. So I talked to my draft board and again they had their eyes on oil supply to win the war. They said "get a job that has significant promise of aiding the effort to find oil."

I then accepted an offer from International Petroleum Canada to go to Colombia and Peru to do micropaleo research with their oil/gas exploration group Tropical Oil Company. My draft board said "That is fine, we think you can do more for the war effort by helping to find oil—we will issue deferments as needed."

So I purchased an "iron trunk" to go on the trip by ship, bought all supplies recommended for a two year stay, sent my application for a passport and started waiting for the passport. After about 60 days no passport. So International Petroleum sent a man to Washington to see Mrs. Shipley, then in charge of the passport division of the State Department. She said "I will NOT issue a passport to that young man; he should go into the armed forces." International reported "We are a foreign corporation, and we cannot do anything further; you are on your own."

CRISIS..CRISIS. I tried several things and nothing would fit. So I decided the best deal for me was to join the Navy as a gunner trainee. It was about the only choice other than being drafted. So I was to report to be taken into the Navy on a Monday morning in the Esperson Building in downtown Houston. The Friday before, however, I received a telegram from the War Manpower Commission in Washington, D.C., that essentially said "You can go into the Navy if you wish,

but we prefer that you join the U.S. Geological Survey as a Civilian Junior Geologist. Please answer by return telegram." I had filled out a questionnaire from the War Manpower Commission just before leaving the University of Texas.

My choice (are you surprised?) was to be a Civilian Junior Geologist.

U.S. GEOLOGICAL SURVEY CAREER

Information then came that the "super war project" was to map the Wilcox/Midway contact in northeastern Mississippi, as bauxite "could" possibly be there. I was to report to Mr. Watson H. Monroe at the USGS office in the basement of the Chemistry Building on the Ole Miss campus in Oxford, Mississippi. I wasn't too impressed with the war needs of bauxite then or now but felt I just didn't have the full picture. I rode a train all night from Houston in a chair car (no A/C or heat or dining car) to reach Oxford. There Harlan R. Bergquist of the USGS had arranged for me to rent a room at 331 West van Buren Street, next door to his rooming house. My wonderful landlords were Mr. and Mrs. Sykes Haney. He was the Chevrolet dealer and each evening after work would sit on the front porch on a swing, smoke a cigar, and think. Harlan Bergquist was like a father to a very lonesome country young Texas geologist and will always have the most wonderful respect and thanks from me. His roommate was Phil Howard who taught (not geology) at Ole Miss and was a Kentucky native who also was wonderful in helping me to try to grow up and not go home.

Mr. Monroe and most of the other USGS people had not arrived and I had several days before they were expected. So, not knowing better I guess, I went to the Mississippi State Geological Survey, then on the Ole Miss campus, and lo and behold found a two-year-old study that seemed to me to be the same thing we were planning to do. I quickly purchased a copy and sent it (by train in those days) Special Delivery to Dr. Hugh D. Miser, the director of the Non-Fuels Section of the USGS in Washington with a note "Our project has already been done, we don't have to do it." That was in the latter part of 1943 or early part of 1944. It is now 1998, and I have not yet received an answer.

My assignment was to do surface mapping in Monroe and Itawamba counties. They gave me an old blue Chevrolet panel truck with no heater and a road map. I presume we were doing the preliminary outcrop definition for the core drill units to follow later. When I found out the final map would be about 8 miles to the inch I was dejected and mapped most of the area sitting on top of hills with a topog sheet. Prior to that I was apparently doing my work in too much detail. My co-workers in USGS, especially Mr. Bergquist and Mr. Monroe, treated me like a son and tried hard to teach this young micropaleontologist how to do top quality surface mapping.

One day Bergquist, Monroe, and I had lunch in Forest, Mississippi, at a hotel that served family-style meals including super fried chicken. After lunch I decided I just had to call Virginia who was in school in Texas and ask her to marry me. I did so, and she said yes. So Forest, Mississippi, will always be a precious memory for us. The next Friday I rode a train to Houston. We were married Saturday evening, and on Sunday I returned to Jackson and Virginia returned to graduate school.

In a matter of a few months Mrs. Applin decided she would join the USGS, and her husband, Paul R. Applin, a Cornell geology graduate and Chief Geologist for Danciger Oil Company in Fort Worth, Texas, also joined. Their project was to tie in the big East Texas field Woodbine sand reservoir across the southeastern states through Florida. This was to involve micropaleontology, lithology, study of electric logs and many kinds of mapping projects. I was delighted to accept their invitation to join the project.

I was to be initially based in Jackson where I was to borrow and study well samples, electric logs, and other material from Jackson-based exploration organizations and prepare many types of maps. Many of my samples were borrowed from Atlantic Refining whose District Geologist was K. K. (Bob) Spooner. His assistant was Lester somebody.

Walter Belt and his wife Virginia in 1945.

They were a unique and delightful team.

The Christmas after we were married Virginia rode a train to Jackson to visit me over the holidays. At the time we were based in the Robert E. Lee Hotel. She decided then not to return to school, and we were very lucky to find the duplex to rent at 4025 Pinehill Drive from the Copeland family. During WWII, housing was as scarce as honor in politics. I remember we especially enjoyed eating breaded veal cutlets at a café just beyond the Deposit Guaranty Building toward the Capitol. Later Virginia was able to purchase a new portable lightweight Singer sewing machine that she still uses occasionally, and it has become quite a collector's item.

Tinsley had been discovered, I think in 1939, based on a surface inlier of Moodys Branch Marl (with the green glauconite). Fred Mellen was the hero because he made the discovery working on a WPA mapping project under the State Geological Survey, and put a notice in the paper which led to the discovery. As far as I ever knew Fred got nothing directly from the discovery.

It was the heyday of Eutaw/Tuscaloosa discoveries in the Laurel and Brookhaven areas. The hero geologist was Tom McGlothlin with Gulf, and the local boy hero conservative was Urban Hughes, an independent tied closely to a large southeastern Mississippi corporate landowner. Other significant "players" that I knew then included: John Berg of Pure Oil Co.; Bert Gamble of Lion; David Harrell and Mrs. Harrell both with Sun (Mrs. Harrell was a micropaleontologist so I naturally had a special affinity for her since that was my first love, but it was hardly ever used in that area. I had learned to "pick bugs" at about age 12. My Dad was a lease broker, and his partner, Frank Roper, was a University of Texas geology graduate in about 1930. Frank did much contract micropaleo work on drilling wells and taught me to wash samples and pick the *Discorbis*, *Het.*, and *Marg.* bugs and zones—that is *Discorbis*, *Heterostegina*, and *Marginulina.*); L. R. McFarland of Magnolia; Dick Priddy who I think was with Millsaps College and later with Texaco; Gilbert Talley with Exchange; and Joe B. Wheeler with Stanolind (note many of those company names are no longer alive).

After I left Jackson and returned to Houston, Virginia and I were riding near Port Lavaca on Lavaca Bay, and I saw a sign that said DICK PRIDDY FISH HOUSE. I took a snapshot and mailed the picture to Dick. I never heard from him again.

Several Mississippi geologists stationed there during my time enjoyed exceptional careers, including Grover Murray then of Magnolia who was elected President of Texas Tech University and was recognized for many accomplishments by the AAPG. Also George Mussleman then with Carter Oil Co., moved to San Antonio, Texas, and became one of the most successful independents in Texas. Then there was Jules Braunstein with Shell who also accomplished much and was also recognized for many accomplishments by the AAPG—and many others.

Downtown Jackson "headquarters" for the "oil bidness trading" was the Edwards Hotel, where C. M. Dorchester was probably the "leader."

W. J. Gillingham lived in New Iberia, Louisiana, in 1940 and was a member of the Mississippi Geological Society. He became the top man for Schlumberger in North America.

People of all levels were coming from "everywhere" to the Mississippi "oil boom." A unique and delightful young man, "Immigrant" Bob Baker came from Houston as a scout for Navarro Oil Company. His dad and uncle, at the time, were the leaders of Humble Oil Company based in Houston, now Exxon.

In those days with the USGS we were on expense account as long as we did not stay more than 60 days in one town. So my schedule was to spend 59 days in Jackson in the Robert E. Lee Hotel (I understand it is now a state office building). Then I would drive to Tuscaloosa, Alabama (stopping on the way in Meridian, Mississippi, for a piece of black bottom pie at Weidmann's Restaurant), live in the McLester Hotel (still there?), and work samples at the Alabama survey in the office of micropaleontologist Ms. Winnie McGlamery, for 59 days. Then to Tallahassee and then back to Jackson. That way I almost had enough money coming in to pay my bills. The best thing that happened to me in Tuscaloosa was getting to know, and totally respect, Phil E. LaMoreaux and his wife Bunny. Phil was also with the USGS in Tuscaloosa working in the ground water division.

Occasionally Mr. Applin would join me with a black Chevrolet worn out USGS coupe to do field work, and we measured many sections in many areas. He was a wonderful man, a typical Yankee conservative. In those war days of gas rationing I was always wary when the gas gauge showed about one fourth. But Mr. Applin would NOT agree for me to buy gas until it was about on empty, and finding a station in those days in the backwoods many times was not as simple as today.

One time Mr. and Mrs. Applin came to Jackson to view, discuss, and plan my work. My wife and I were having dinner with them in the Robert E. Lee Hotel dining room. Mr. Applin had clam chowder and found a piece of shell in the bowl. My wife told him "that is to prove it is really clam chowder." Mr. Applin answered my wife, who was having chicken soup, "Well, Virginia, do you have feathers in your soup?"

Later I learned that all USGS employees underwent an annual efficiency rating examination which could generate a salary increase for a high rating or worse happenings for lower ratings. The date was set for my exam. By that time I had married and Virginia and I were living in our first home at 4025 Pinehill Drive in Jackson, renting a duplex from wonderful landlords Clyde and Dorothy Copeland. (Mrs. Copeland is still living in Jackson.)

The then big man (loved and respected by everyone who

knew him) Dr. Hugh Miser would chair the exam with Watson Monroe and Mr. Applin present. The place would be our living room where I could spread out the maps and have table areas for looking at reports, logs, etc. They arrived shortly after 10 a.m. I was nervous but READY, with MAPS, REPORTS, OPINIONS, etc. Dr. Miser started telling Arkansas jokes (he was a native of Arkansas). He told more jokes, more jokes, more jokes, and I was getting more nervous with every joke. Finally my wife offered coffee and everything was at a standstill for that. Then non-business talk until noontime when my wife offered lunch, and a long lunch ensued...still no talk of my report.

More of the same after lunch. About 2:15 Dr. Miser said "Well I have to catch the train to New Orleans. Walter, you come along so we can talk." There was no geology talk on the trip to the station. Before he got on the train he said "Walter, you are doing a fine job—keep it up." When the efficiency ratings came out I received the highest rating available to my level. I had never heard of a bureaucrat.

In the fall of 1997, Virginia and I had an overnight stay in Jackson. We took a cab out to see and photograph our first home, the duplex at 4025 Pinehill Drive. On the way out we looked for the old Baptist Hospital on North State Street, where our first child (a son) was born, but it wasn't there.

That night we found our first landlady, Mrs. (Dorothy) Clyde X. Copeland's phone number and called her. The conversation was a delight, proving again that she was and is the perfect Southern LADY. She promised and later sent to us a photograph of the old Baptist Hospital that she acquired from the daily newspaper *Clarion-Ledger* photo files. We felt so good that she remembered us.

Later that night we also found the phone number of Mrs. Henry Toler (the widow of my boss at Southern Natural Gas). She proved again that she was and still is a totally forthright, honest person because her reply to me on the phone was "Mr. Belt, I don't remember your name or anything about you."

CAREER WITH HENRY TOLER AND SOUTHERN NATURAL GAS

I continued my really quite serious efforts, including map making, until the war was drawing to an end. The Applin project was drawing to a close. Watson H. Monroe then suggested to his friend Henry N. Toler of Southern Natural Gas that I might be a good young employee for him. Again the Good Lord liked me, for Mr. Toler was a super man, and he had a super capability to be "tight" with not only money but information too.

My job put me in the Deposit Guaranty Bank Building in downtown Jackson, two blocks from the Robert E. Lee Hotel and one block from a service station, between us and the hotel, where we parked and purchased tires and gasoline (of super importance in those days of "fake" rubber tires and rationed gasoline). Our office building was not air conditioned. I was there when the "bomb" was dropped on Japan.

One major project was core drilling the Moodys Branch Formation in Yazoo County about nine miles southwest of Tinsley near the town of Satartia on the Yazoo River. It was a large tract owned by a Mr. Gammill, who also owned the Robert E. Lee Hotel in Jackson. We had two Failing 1500 rigs, and the top of the Moodys was around 450 feet. We had a Halliburton jeep to do the logging on full time contract, and the logger stayed in a Vicksburg hotel. I had to determine the location from Mr. Toler on a topog sheet, determine the elevation with a Paulin Altimeter, arrange landowner permission, have the pits dug (by shovel in those days), determine when the Moodys top was reached, have the Jeep logger on hand, see the hole properly plugged, have the pits covered, pay damages if any, report the top and elevation to Mr. Toler....This was 24 hours a day and 7 days a week with two rigs. I slept in the car, on the ground, on an army cot and sometimes my wife would drive out with food. The usual food was canned wieners, cheese crackers, canned beans, and other gourmet selections. The rotary would rattle a telltale noise when it hit the top of the Moodys that would wake me up. I would go over and see the green glauconite and start the procedure all over again.

I remember once, and the thought gives me a sweat again, waking up about five one morning on the road between Vicksburg and Satartia at the steering wheel, IN A DITCH and going about 30 miles per hour.

Making the trip occasionally from Jackson to the field was quite an experience with those fake rubber tires. In some cases I would make no more than three blocks from the service station with a new tire. But we had the top grade allocation/ration and were able to get an unlimited supply.

Communication in those days from the field was a hassle—no rig or car radio or phone. One night when we were drilling a deep test (deep for those days), on the Gammill tract near Satartia, I needed to talk to Mr. Toler. So I drove from the well to Satartia and saw a light in a home. I knocked on the door, and Joe Shepherd came to the door. He introduced me to his wife Caroline, his young daughter, and his father-in-law and allowed me to use the phone and invited me to use it in the future when needed. I developed a habit of going to that home almost nightly when working that area and Joe and Caroline developed to be wonderful friends to my wife and me. Joe was a Mississippi state highway engineer. The young daughter later married a professional Big League baseball player.

Another time in Satartia I was making a morning report phone call to Mr. Toler on the overnight drilling progress of the same well. I was giving him the drilling time in feet per minute on the phone in the Giles Lewis grocery store, and several locals were very quiet and listening to my every word. When I finished the call one of the listening men said "We know you were using a secret code there on the phone so we couldn't know what is going on out there at the well."

The man who knew it was a secret code was Myron Kelly, one of the then owners of the Annandale Plantation. On a later project, Mr. and Mrs. Kelly had my wife and young son as house guests for several days to help me be with them more. I understand that Annandale Plantation acreage now is part of a beautiful golf course that attracts people from Jackson.

When we were drilling the first "deep" well near Satartia, the #1 Gammill, we had a steam rig and wood derrick (Does that date me?). My wife was then working as secretary to Barnsdall Oil Company in Jackson. In those days I slept in the car, and I also slept on an army cot behind the steam engines just back of the draw works with a mosquito net—SAFE???? Then a new concept developed...a two-wheel trailer with a bed was brought to the location for this geologist to sleep. NOTE, with a two-wheel trailer the tongue must be put on a piece of timber to keep the trailer level. Well, my wife elected one Friday night after work to come out and spend the weekend with me in the trailer. A young somewhat freshly married geologist and his wife in that trailer at night was just too much for the roughnecks. At about 2 a.m. when we were asleep, all of a sudden I thought the wooden derrick had fallen over on us. I looked outside and of course the roughnecks had taken a sledge and knocked the timber out from under the tongue...and of course by then they were all up on the derrick floor working very intensely at something and knew nothing about the "Accident."

After many many shows in the Gammill #1 we "KNEW" the #2 would be a major field discovery. We were so sure that we sold our 1941 four-door Ford to buy royalty under a nearby tract that Mr. Toler arranged for us. YES, we lost the car, the royalty, the money, but boy oh boy did we learn a lesson. We recovered a jello-like 12 gravity oil.

In Jackson I was a member of the Mississippi Geological Society and participated in what I think was the first major project there—to construct cross sections as a major cooperative effort. If I remember correctly, the Skelly geologist that I worked with most on our portion was a most capable Lee Spyres.

Jules Braunstein lived in Jackson and worked for Shell Oil Company. I remember visiting the Moodys Branch type locality in the Jackson city limits with Jules and picking up samples there in the creek area.

Southern Natural Gas would often contribute dry hole money to a wildcat located near the pipeline. A contribution was given for a well in Georgia, and it was my pleasure to visit that well at log time and try to guess what part of the section was penetrated. Yes, it was a dry hole but a very early well for Georgia.

Southern Natural had a prospect in Wilcox County, Alabama, and I was assigned to do a core drill project there. We had only one rig and jeep (Halliburton electric log) and an army command car with four-wheel drive and a back and front winch. Many times we had to use all three to get out of a bad area. Communication with Mr. Toler was more difficult, and I was given more and more authority on the holes. One Friday afternoon I felt we badly needed one more point, and I could not find the landowner where I thought best to drill. It was getting late, and I badly wanted the point. Next to the private land was some state highway land next to a bridge, and I decided to take a chance and do a quick drill there for the point. MISTAKE MISTAKE MISTAKE.... We drilled into a water flow that we just could not seem to stop. There I was on highway ROW land without a permit. The water could have caused wrecks, even hurt people. It was a sweat until about 3 a.m. that night when we finally stopped the flow. The rig roughnecks saved my neck and never reported to their owner what we had done that afternoon and night. IT WAS ANOTHER LESSON LEARNED.

One of many good friends we made in Monroeville, Alabama (Virginia and I lived there in a rented bedroom with kitchen rights when we were core drilling in Wilcox County) was neighbor and local banker Loxley Dees. He was very interested in the "Oil Bidness" and made us very welcome. I heard in later years that he had accumulated a significant collection of major producing royalty.

When I was working with Southern Natural in Jackson, the best known oil scouts that I knew were Ray Stevens with Shell and H. L. Francis with Carter Oil. One day Southern Natural's scout, Vent B. Speaker, who lived in Birmingham, could not make the weekly Jackson Scout Check. I filled in for him, and it was one of those very good unexpected experiences. It was in a Jackson hotel and lasted about six hours.

When we were drilling the Gammill #2 near Satartia, we went even further in hotel type accommodations. A wooden portable building large enough for four double beds was brought in (still no bathroom or kitchen facilities included). There was a large opening "window" on each of the four sides (no screen or glass), and it was set up in a swampy area over water. This time we had a steel derrick and a more modern rig and an opportunity for this geologist to get some rest. (In those days we "sat on a well" 24 hours a day, 7 days a week.) One afternoon I was asleep after about 30 hours of coring and no sleep. I awoke with the darndest loud scary "lump" knocking against the bottom of my bed. I looked under there to stare into the eyes of a two-foot alligator that someone had thrown in the open window. Again, the roughnecks were all seriously working at some job when this happened.

Gammill #2 went pretty deep (for those days). In fact we went below the base of the Tuscaloosa and found some pink limestone pellets and we tried to guess what it was...but it was different from what other wells had found below the Tuscaloosa as far as we knew. The rumor around Jackson was that we had something different. Mr. Toler asked the geologist from Stanolind, Joe B. Wheeler, to see the samples under the microscope. He offered an answer and then asked if he could see the electric log. Here Mr. Toler's base "tight" came to the front. He said "No, that is a tight hole."

In those days the Schlumberger man in Jackson was Henry Guest. Everybody liked Henry.

I was also working some gas reserves for Southern Natural with Mr. Toler. I would attempt making a structure map of the reservoir first, but when I started on Gwinville Field (I think that is the field) I found more than one fault in a single well bore. WHAT THE HECK??? I had real difficulty handling more than one fault per well bore. That is when I realized for the first time that I would never make a good geologist. I did not have adequate 3D. I resorted to peg models but was really saved by guidance from Will Knight, then with United Gas. Later, of course, as happens to all poor geologists, I became a petroleum landman. I had been brought up as a "lease hound" as my Dad was one of the originals who sat on the ground between rows of cotton with his portable typewriter typing a lease form. I actually worked titles and purchased leases for Dad (for majors—they didn't know I was doing the field work) when I was in high school.

Southern Natural Gas had gas production and a drilling/completion/development program at the Bear Creek Field south of the town of Arcadia in Bienville Parish, Louisiana, and the Carthage Field in Panola County, northeast Texas. Occasionally the other Southern Natural geologist would not be able to make those drilling DSTs and logging runs—I would have to make a fast drive to do so. We always had so much trouble setting the packer with the pipe, and I remember on many occasions discussing how someday "I bet we will be able to set the packer and make the DST by wireline."

As WWII was drawing to an end—with a young baby in diapers—our first wish was for an electric washing machine. Our name finally reached the top of the waiting list at a local store, and we saw a shipment being delivered. The owner said other people would be served first—he and I had a CONVERSATION that resulted in our getting the washing machine that afternoon. He is the only "bad guy" that I remember from Mississippi. About that same time we saw our first post-war automobile in a dealer's showroom. It was a dark red Studebaker—but our bank account told us to only look.

One day Mr. Toler asked me to go downstairs across the street with him to a café for a cup of coffee. Over coffee he told me proudly that he was putting in for a raise for me. I asked how much—he said "I imagine we will be able to get at least $5.00 per month." Shortly thereafter I became an independent geologist and lease broker in Houston. This story is NOT a dig at Mr. Toler. If it was ever possible to love an employer, I loved the man for so many thousands of good things in him and his honest and sincere concern for me. He was just TIGHT too.

THE DUCK HUNT (Or was it geese?)

When "sitting" on the #1 Gammill well near Satartia, Mr. Roy Williamson, Manager of Drilling Operations for us, wanted to be kind to this neophyte geologist who hardly ever got away from the well. Mr. Williamson brought his 12-gauge shotgun to the well and took me to a black man who lived in the area and had a rowboat on what I think was called Lake Dick [Lake Dick, an oxbow lake of the Yazoo River, is now called Dump Lake—ed.].

The guide and I went out very late in the evening. The first ducks (or were they geese?) showed up about sundown but not knowing any better I continued shooting well after sundown. Again the Good Lord took care of me....I could not hit anything.

As we came into shore, all of a sudden there were two real bright lights in our faces and a command to put up our hands and stand still. BOY I DID. Of course it was the game wardens who had been noting the time of each shot they heard me make and they KNEW we had hidden the birds somewhere.

There were none to be found. They finally gave up and believed me, I guess. But they gave me a king size talk. I don't even remember if I had a license or if one was needed then.

Learning experience for me Number 1,876,987,234.

CAREER AS A LANDMAN

When we decided to leave Jackson and return to Houston, Virginia and our young son flew from Jackson to Houston in a DC-3. When they left, I drove out to the end of the runway with the plane so I could wave at Virginia and the baby as they were taking off...somewhat different from what would be allowed today.

After becoming an "independent" geologist and "lease hound" in Houston I received a purchase order for landowner royalty on acreage in Issaquena County, Mississippi, that was under land owned by Mr. M. Falkner who lived and ran a store about three miles southwest of Satartia. Mr. Falkner had given me significant help when I was core drilling the Gammill tract near Satartia. I called Mr. Falkner from Houston with the offer. He said he would take it but please send him a telegram making the offer that he could show to the bank in Vicksburg as they were pushing him hard on a loan on the acreage.

I spent a night in the Falkner home to complete the purchase. I remember his son was in the war and his daughter-in-law and grandson were living there along with a married daughter whose husband was also in the war. This daughter was quite pregnant. While I was there Mr. Falkner had a birthday, and the gift from his family was a car heater. Does that date me?

Years later I read with horror that that grandson had murdered Mr. Falkner.

Years later as a landman employee based in Houston I made a trip to Lafayette, New Orleans, Shreveport, and Jackson looking for new opportunities for our organization. While in Jackson I visited Mr. and Mrs. Applin in their home

there. Toward the end of the evening visit I asked to use the phone. They took me to a back bedroom office, and while there I noticed a large wooden box that I recognized as the box that I used to put in all my maps and reports that I had prepared while on their USGS project. I sneaked a look into the box, and I was amazed and shocked to see all my maps and reports there which looked to me as if they had never been touched, much less considered.

1945 GEOLOGIC MAP OF MISSISSIPPI

Then this year, at age 76, I was discussing some World War II times with a geologist friend and mentioning I did not have one tangible piece of evidence that I had ever been involved in doing geological work in Mississippi. He said "Heck, I saw a surface outcrop map of that state one time that had your name in the title and apparently your work in Monroe and Itawamba counties was used in putting the map together." It was then I started the effort with a letter to the state geological survey that was eventually sent to Mr. Mike Bograd who found what is probably the last copy and forwarded it to me. It is now framed and hangs in our home as a precious JEWEL.

God did good to me by sending me to Mississippi.

*****

Walter Belt would be delighted to hear from any of his friends and asks that he be contacted at Box 739, Flatonia, TX 78941; telephone (512) 865-2617; or e-mail at webeltjr@fais.net.

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