ANCIENT GEOGRAPHY AND RIVER HYDRAULICS, EASTERN MONTANA

Faculty

E. S. Belt, Amherst
J. A. Diemer, Franklin and Marshall
R. S. Sternberg, Franklin and Marshall

Students

Daniel McCarthy, Franklin and Marshall
Genga Theri Nadaraju, Wooster
David Parse, Franklin and Marshall
Susan Sakimoto, Whitman
Sharon Stern, Carleton
Valerie Tamm, Amherst

Visitors

Kenneth Coles, Wooster
Kirk Johnson, Yale
Mark Sholes, Montana Bureau of Mines

EARLY PALEOCENE FLUVIAL SEDIMENTOLOGY, PALEOBOTANY, AND PALEOMAGNETISM

Edward S. Belt
Department of Geology
Amherst College
Amherst, MA 01002

Geologic setting of the Montana project:

The field area lies in the High Plains, 200 miles east of the Rocky Mountains, along the southwestern edge of the Williston Basin (Figure 1A). The strata examined are exposed within badland topography on either side of the Powder River, which flows northward to join the Yellowstone River (Figure 1B). The plateau to the west of the badlands, the Pine Hills plateau, is underlain by resistent clinker where the Dominy coal burned, and fused the clastic sediment above and below it. All strata other than clinker are unconsolidated and easily exposed by excavating sloughed surface material.

Because no faults or folds interrupt the original horizontality of the strata, and because the vegetation is sparse, this is an ideal region for student studies. Correlation from one measured section to another can, in many instances, be physically walked out, thereby assuring the sort of control rarely found elsewhere. Each student in the Montana project learns to measure sections, identify various fluvial depositional environments, and collect specific samples for laboratory analysis.

Geologic studies on Late Cretaceous and Early Paleocene strata in the study area (MC, Figure 1) have been in progress since 1981 (Belt et al., 1984; Diemer and Belt, 1988; Belt, Sakimoto, and Rockwell, in press). Funding prior to KECK was by U.S. Geological Survey (Belt, 1982), Shell Foundation (Rockwell, 1982), North Dakota Geol. Survey (Belt, 1983), grants stretched from other projects in SE Montana (see Belt and Murphy, in press), and personal funds (Belt, 1984-86).

The objectives have mainly been to develop a 3-dimensional control on facies so that actualistic paleogeographic maps could be made. The construction of 15 different paleogeographical horizons within the 100 meters of the Lebo and 100 meters of the Tongue River Members of the Fort Union Formation (Figure 2). These maps have defined river channel patterns and scale of the floodbasins for both members. They also show the major changes in paleodrainage direction over the 200 m study interval. This information has implictions for positon of uplifted source areas, paleoclimate, and the development of regionally extensive coal beds.

Paleogeography, however, was not the only aspect studied. Certain clay minerals are found in Lebo Member channels and levees, while other clay minerals are found on the adjacent floodbasins. The composition of sand from the channel deposits reflects source area contributions and paleoclimate effects. This information, when coupled with paleodrainage directions from the paleogeographic maps allows regional tectonic setting to be deduced. It became apparent by 1986 that a great deal more work was needed to tackle some of these problems.

The KECK funding for the summers of 1987 and 1988 enabled the previous paleogeographic map coverage to be extended to the north and east of the original area (Figure 1B). It also allowed clay mineral and sand petrographic studies to be initiated. For the first time, a single coal zone could be analysed throughout the entire region. The region studied prior to 1987 covered 75 mi^2 (200 km^2) and consisted of 97 measured sections prior to KECK funding; at the end of 1988 field season the study area covered 110 mi^2 (290 km^2) and included more than 180 measured sections.

The enclosed abstracts show the range of 1988 projects: sand provenance, paleobotany, facies comparisions of Lebo and Tongue River Members, and paleomagnetism of the clinkers. The common thread that runs through all of them is now discussed.

Results of the 1988 field season:

All projects had successful outcomes, although some will have more far-reaching influence than others in the years to come. One of the many advantages of the KECK funding is the opportunity for students to try out a line of research that would otherwise be considered risky. The usual funding for professors makes them more conservative in the type of project they take on.

(a) Project of Sharon Stern: A significant sedimentological change occurs as Lebo Member facies pass stratigraphically upwards into Tongue River Member facies. Sharon studied these field relationships over a wide area east of the Powder River and she comments on the physical features represented by the differences.

(b) Project of Susan Sakimoto (née Hubbard): Previous mapping in the area indicated that the basal coal of the Lebo Member was extremely widespread, having been reported down the Yellowstone River from Miles City to Terry, and up the Powder River from Terry to Mizpah. South of Mizpah, this coal bed has not been reported east of the Powder. Susan's project was to concentrate on the C-coal throughout the study region (Figure 2). She found that the C-coal was not a bed, but a coal zone, and that while several beds of the C-coal zone pinched out, one bed extended through 40 sections of the study area. This result has important paleogeographic significance.

(c) Project of Thavi Nadaraju: The 1987 Montana project resulted in sand petrology and provenance studies of the Lebo and Tongue River Members of the study area (Bonnie Wong). Laura Sloan (colleague of Bonnie's, not a recipient of KECK funding) studied additional thinsections of Lebo Member from the study area, and compared these with thinsections from the Hell Creek Formation of the Ekalaka area (Belt and Murphy, in press). In 1988-89, Thavi completed the story by examining the Tullock Member in the study area, and comparing the petrographic results with those of Wong. When coupled with paleocurrent directions, it becomes apparent that a major paleodrainage shift (from SE to NE) took place at the Tullock-Lebo contact.

(d) Project of Valerie Tamm: A sizeable gap in knowledge has long existed for leaves of Torrejonian age. New understanding of leaf fossils of this age has resulted from the studies of Beth Williams (1987 KECK recipient) and Tamm (this volume). Tamm not only collected and identified hundreds of specimens, but has placed her and Beth's specimens in proper stratigraphic context within middle and upper Lebo and lower Tongue River strata. These leave collections are certainly of Torrejonian age (independently checked by Howard Hutchison who identified newly discovered vertebrate remains), and may indicate early Tiffanian age. The dating of the facies change from Lebo Member to Tongue River Member has important regional implications for an understanding of the timing of paleotectonic and paleoclimatic changes in the Western Interior.

(e) Projects of David Parse and Dan McCarthy: The burning of coal beds (mostly from lightning strikes of outcrops during the last 20,000 years) in eastern Montana resulted in moderate to intense fusion of the strata that enclosed the coal. The paleomagnetic sense at that time was locked into the strata. The projects of David and Dan focused on the magnetic evidence from the Dominy coal zone of the Tongue River Member in the study area.

The Montana project was designed to include professional advisors to the students. The following advisors, all external to the KECK consortium agreed to advise and also to attend a day-long Winter Workshop with the students in January 1989. Drs. Mark Sholes (Montana State Univ and Montana Bureau of Mines), Kirk Johnson (Yale) and Ken Coles (College of Wooster) put in many long hours at the workshop held this year at Franklin & Marshall College. All three of them visited the ranch during the summer and helped the students in the field. In addition, Leo Hickey and Kirk Johnson (Yale) advised Vali Tamm's paleobotany project. Ken Coles and Mike Velbel (Michigan State Univ.) advised Thavi Nadaraju's project. Howard Hutchison (Mus. Paleont., Univ. Calif. - Berkeley) identified fossil vertebrate remains from 9 stratigraphic horizons within the upper Tullock, Lebo, and lower Tongue River Members.

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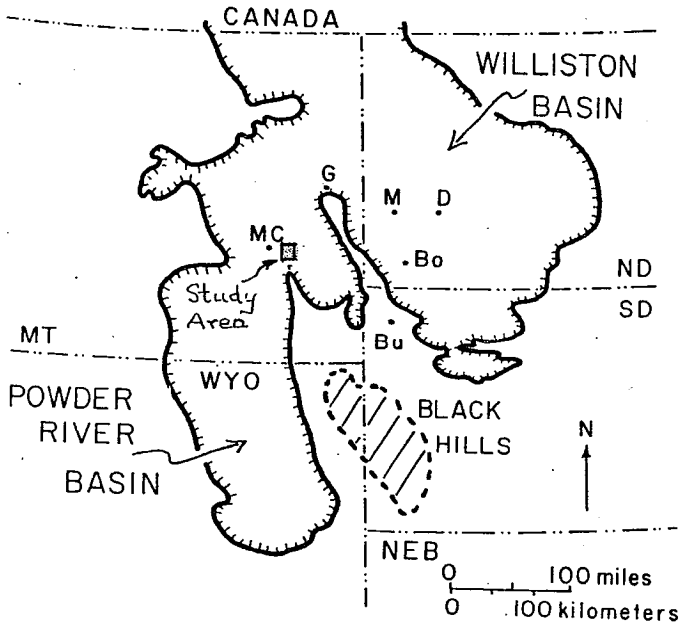

Figure 1 A

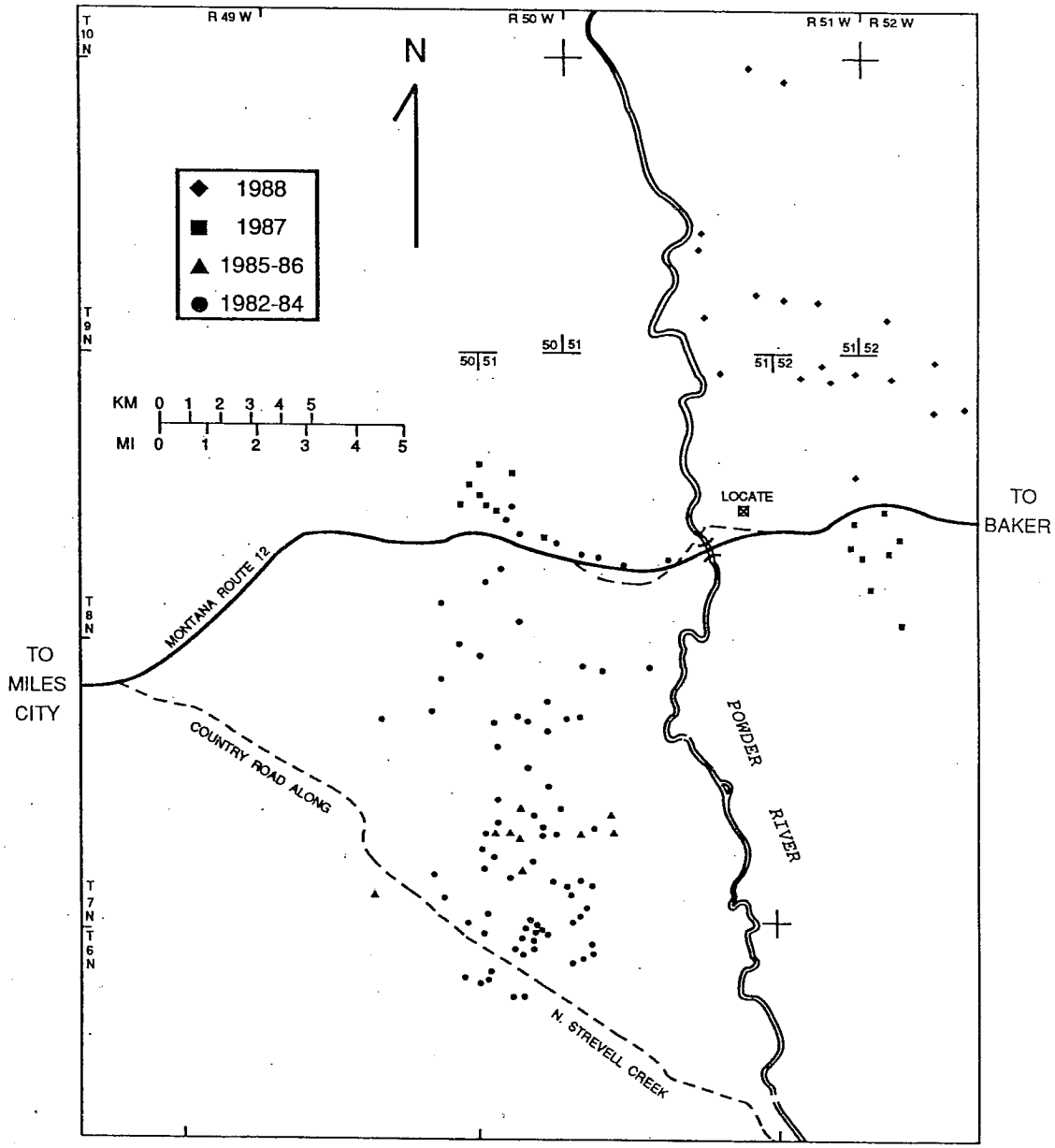

Figure 1 B

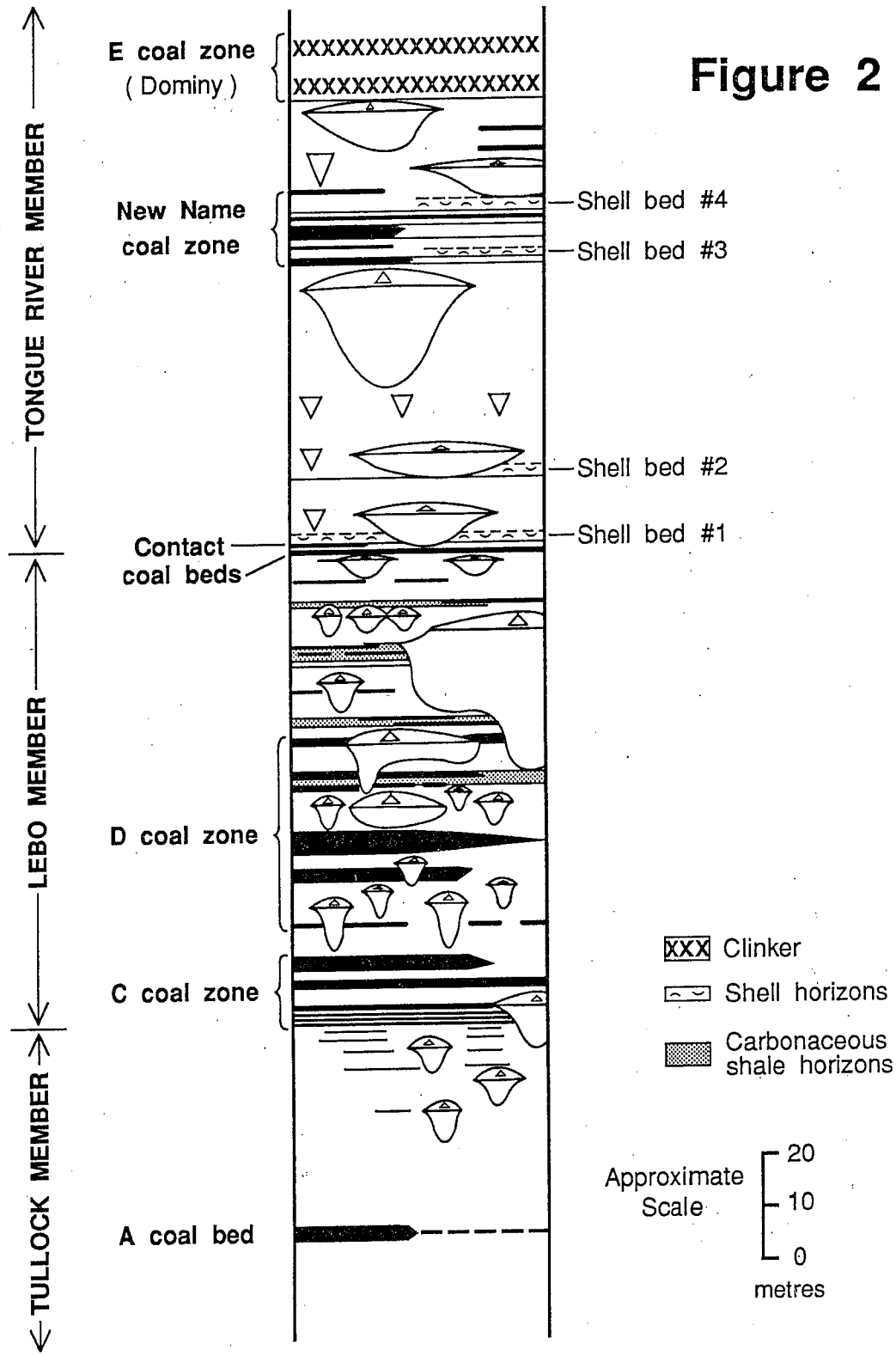
TONGUE RIVER MEMBER
LEBO MEMBER
TULLOCK MEMBER
E coal zone
(Dominy)
XXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXX
New Name
coal zone
Shell bed #4
Shell bed #3
Shell bed #2
Shell bed #1
Contact
coal beds
D coal zone
C coal zone
A coal bed
XXX Clinker
Shell horizons
Carbonaceous
shale horizons
Approximate
Scale
20
10
0
metres

Figure 2