FINAL REPORT FOR FULBRIGHT COLLEGE OF ARTS AND SCIENCES RESEARCH INNOVATION GRANT: FLOOD DYNAMICS ON THE RED RIVER OF THE NORTH, USA-CANADA:

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EXECUTIVE SUMMARY

My participation in the AAAS Great Plains EPSCOR workshop in November 1997 led to a collaborative relationship with a colleague at the University of North Dakota to develop a multidisciplinary program to investigating the geological record of flooding along the Red River of the North (North Dakota and Canada). We hoped to correlate existing data on stream discharge with preserved sediment layers corresponding to known floods. These correlations are expected to serve as a basis for interpreting the long-term geologic record of Red River flooding.

A Research Incentive Grant (RIG) of $2000 was awarded for the 1998-1999 academic year in order to stimulate this project. The following report provides a summary of work accomplished to date regarding this project and is submitted in accordance with the terms of the RIG award.

From 11 – 25 May 1998, Dr. Stephen K. Boss towed the R/V *Ozark Traveler* from Fayetteville to Grand Forks, ND and then to the southern shore of Lake Winnipeg, Manitoba, Canada in order to conduct a reconnaissance geophysical survey of the lower Red River of the North with Dr. Will Gosnold of the University of North Dakota. This represented a round-trip of approximately 2,200 miles and demonstrated that R/V *Ozark Traveler* could be successfully mobilized and deployed to remote locations.

During this trip, Boss and Gosnold deployed the Knudsen Engineering, Ltd. KEL 320 B/P Dual Frequency Echo Sounding System from an experimental hovercraft and R/V *Ozark Traveler* in an attempt to determine the utility of this system for sub-bottom imaging of oxbow lakes and wetland areas marginal to the Red River of the North. Results of these experiments were favorable, and the P.I.'s identified a target area in a shallow lake near the southernmost shore of Lake Winnipeg for further research.

Following the field portion of this work, Boss and Gosnold collaborated with J.H. Hartman and R.D. LeFever (both of UND) in preparing a proposal to the National Science Foundation. This proposal was submitted 1 June 1998. The proposal was not successful; reviewers' cited primarily the P.I.'s lack of expertise and track record in this subject area, though comments were constructive, supportive, and we were encouraged to continue to develop the concept and to enlist support of recognized experts in the field.

Boss and Gosnold continue to discuss options for refining the proposed research and obtaining suitable funding. Both P.I.'s have communicated with prominent individuals in the field (Vic Baker of U. of Arizona and Harvey Thorliefson of Geological Survey of Canada) and received encouragement and advice. Thorliefson has recently given Boss' name to Dr. Tim Fisher (Indiana University Northwest), who is engaged in coring studies of the southern outlet of glacial Lake Agassiz. Discussion between Boss and Fisher is ongoing, and some collaboration may result.

In addition, Boss currrently has a graduate student (Mantez McDonald) using historical streamflow data for the Red River of the North from USGS as the basis for his Master's Thesis in Geosciences. It is anticipated that Mr. McDonald will be supported through a USGS internship beginning Fall 1999. This thesis will be key to establishing a track record of research results relevant to this project for Boss.

A limitation in developing the project has been that both Gosnold and Boss have other substantial funded research projects that have taken priority over the past year. However, both P.I.'s continue to have a strong interest in developing Red River of the North research, and are confident given the importance of this international river system that funded projects will eventually emerge.

INTRODUCTION

In November 1997, the P.I. participated in a workshop on research competitiveness in the Great Plains states (including Arkansas) which was sponsored by the American Association for the Advancement of Science. As a result of this conference, an interest in a study of flood dynamics on the Red River of the North was developed with Dr. Will Gosnold (University of North Dakota).

In Spring 1998, a Research Incentive Grant (RIG) from the Fulbright College of Arts and Sciences was awarded to the P.I. in order to stimulate this project. The purpose of the award was to provide travel funds so Boss and Gosnold could conduct reconnaissance research along the Red River of the North, with the intent of locating suitable sites where long-term geologic records of floods might be preserved. The foci of this search were oxbow lakes along the Red River and wetland areas adjacent to the lower Red River and immediately south of Lake Winnipeg, Manitoba, Canada.

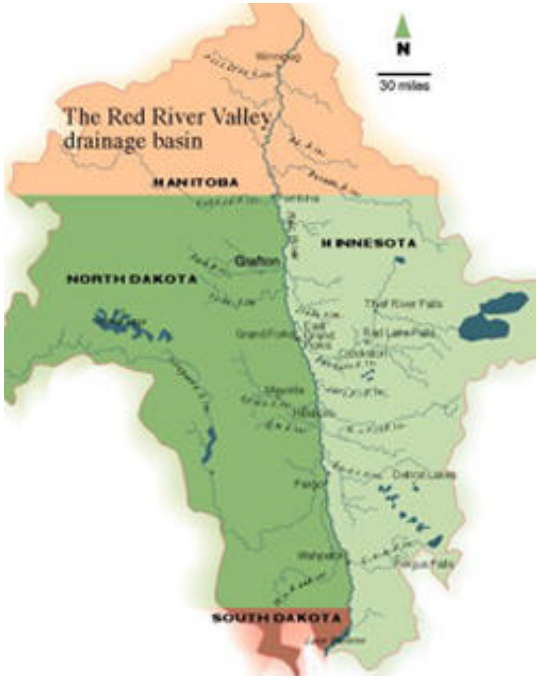

Fig. 1 Schematic image showing area of the Red River of the North Basin in South Dakota, North Dakota, Minnesota, and Manitoba.

The Red River of the North Basin occupies primarily eastern North Dakota, northwestern Minnesota, and southern Manitoba, Canada with a minor extension into South Dakota. In the United States, the Red River of the North (Fig. 1) is among the rivers most prone to flooding because 1) winter conditions often persist well into spring, with rapid onset of warm weather causing rapid snow melt; 2) rapid spring snowmelt is often accompanied by heavy spring rainfall; 3) the Red River of the North basin is characterized by very low gradients (typically less than 6 cm km^{-1}) and slight surface relief such that even moderate floods inundate large areas; 4) northward warming and associated snowmelt combined with northward flow of tributaries and the Red River frequently results in coincidence of flood peaks (Chandler, 1911, 1918; Matheson, 1947; Pritchard, 1947; Anonymous, 1952, 1955; Harrison, 1968; Harrison & Bluemle, 1980; Miller & Frink, 1984; Bluemle, 1997)

Over the preceding century, dramatic changes in population and land use patterns along the Red River of the North have occurred, and these complicate analysis and understanding of flood dynamics along this river.

FIELD WORK

On 11 May 1998, S.K. Boss departed Fayetteville, AR with R/V *Ozark Traveler* in tow for two weeks of field reconnaissance in North Dakota and Manitoba. This excursion represented an approximately 2,200 mile round trip and was the first attempt to mobilize and deploy R/V *Ozark Traveler* to a remote field location outside northwest Arkansas.

A major mechanical problem required repairs to the USGS truck used for this trip in St. Joseph, MO. Repairs required 1.5 days and delayed arrival in North Dakota until 14 May 1998. However, following repairs to the truck, the remainder of the trip was uneventful and the P.I. arrived in Grand Forks, ND in the early afternoon of 14 May. Once in Grand Forks, Boss and Gosnold met and arranged for living quarters for Boss through the University housing office.

During the late afternoon and evening, Boss and Gosnold visited several prospective research sites along the Red River of the North in the vicinity of Grand Forks.

UN-NAMED COULEE, GRAND FORKS, NORTH DAKOTA

The first site visited during this trip was an un-named coulee on the southern border of Grand Forks adjacent to the main channel of the Red River of the North. This coulee is a permanent small lake that is inundated when the Red River is at or above flood stage. It was chosen as a candidate for this study because sedimentation in the coulee is likely to have a bi-modal character composed of flood sediments and organic sediments deposited during non-flood intervals.

To access this coulee for reconnaissance geophysical profiling, the echo sounding system was mated to an experimental hovercraft that was capable of traversing the boggy margins of the coulee (Fig. 2). Though the echo profile data are somewhat noisy, it appears to have imaged at least one reflecting horizon in the lake sub-bottom which might be a flood deposit. The poor quality of the echogram is likely due to coherent vibration and noise induced by the hovercraft. Modifications to the mounting mechanism for the echo sounder would probably alleviate some of these problems.

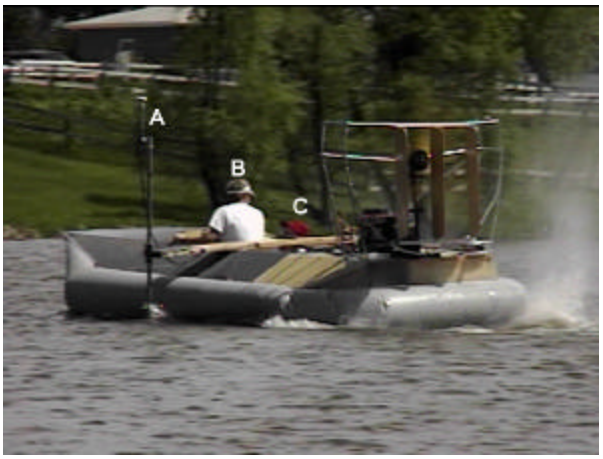

Fig. 2. Experimental hovercraft with KEL 320 B/P echo sounder deployed on un-named coulee south of Grand Forks, ND 15 May 1999. "A" is pole-mounted transducer and GPS receiver, "B" is Dr. Will Gosnold at helm of hovercraft, "C" is Dr. S.K. Boss monitoring echo sounder computer and electronics package.

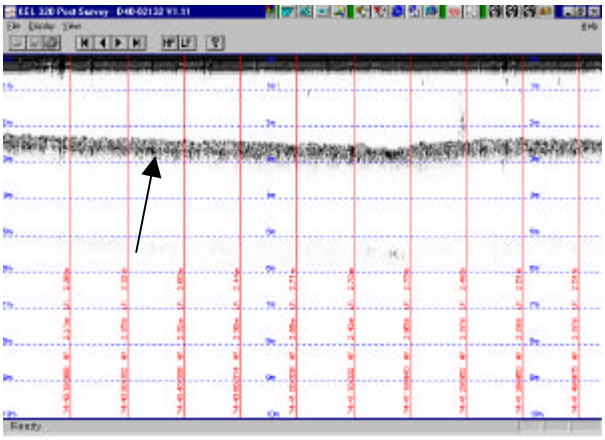

Fig. 3. Section of echogram from un-named coulee showing lake bottom sediment. Arrow indicates faint reflecting horizon which could be top of sediment deposited during 1997 flood of the Red River of the North.

SOUTHERN LAKE WINNIPEG, MANITOBA, CANADA

In addition to reconnaissance in the vicinity of Grand Forks, ND, Boss and Gosnold traveled north into Canada (Fig. 4) to conduct field reconnaissance along southern Lake Winnipeg and the lower Red River of the North. The goal of this work was to locate areas along the lower Red River wetlands that might serve as repositories of flood deposits. Coring in these locations would then provide data which could be used to calibrate the geologic record of floods from historical records.

South of Lake Winnipeg, there is an area of extensive wetlands developed along the margins of the Red River of the North. Separating the main channel of the river from these wetlands is a low, narrow natural levee. The levee is rarely more than 1 m above the river level, so it is clear that the wetland areas may be frequently flooded by the Red River of the North. It is anticipated that these wetland areas contain sediment deposited by floods, which most commonly occur related to Spring runoff. However, access to these wetland areas is difficult due to the boggy conditions. Indeed, these areas are best sampled during the winter when surface water as well as the ground itself is frozen. Ideally, though, it would be convenient to know where the best samples might be obtained. In this regard, visiting the site during summer affords some opportunity to use a boat for survey purposes.

R/V *Ozark Traveler* was launched into the lower Red River on 17-18 May 1998, and echo sounder surveys of the main river channel, southern Lake Winnipeg, and navigable wetlands conducted.

Fig. 4. R/V *Ozark Traveler* and USGS field vehicle at US-Canada border, May 1998.

Following several hours of surveying on the first day, the P.I.'s focused on a stretch of the Red River bordering Netley Lake (Fig. 5, highlighted). At this point, the Red River has breached its levee, and an active crevasse splay is present in Netley Lake. At the time of this survey, the water level was sufficiently high that R/V *Ozark Traveler* was able to cross the breached levee into Netley lake and commence surveying the area of crevasse splay.

Echo sounder data from Netley Lake confirm the presence of crevasse splay deposits in the lake. In addition, a map dated 1976 was observed at the campground, and this map illustrates the breach in the levee, indicating that it is at least 23 – 24 years old. Thus, it seems reasonable to suppose that Netley Lake has received flood sediments for some time and is a logical place to attempt to obtain cores to document the flooding history of the Red River of the North.

Presently, Boss and Gosnold are discussing methods for obtaining cores from this lake. Discussions are ongoing with Dr. Harvey Thorliefson (Geological Survey of Canada) and Dr. Tim Fisher (Indiana University Northwest). In addition, we are contemplating appropriate funding outlets for this work.

Boss also has a graduate student (Mantez McDonald) analyzing the historical record of floods on the Red River of the North using USGS streamflow data. This work will form the basis of McDonald's M.S. thesis in Geosciences and is likely to be supported by the USGS beginning in Fall 1999. This work will also help Boss to establish a track record of research in this area.

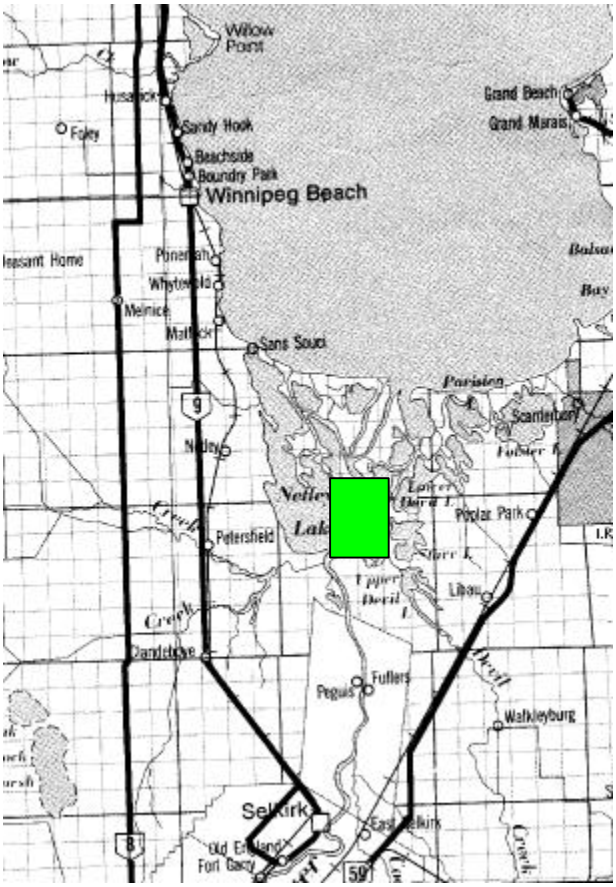

Fig. 5 Map of southern portion of Lake Winnipeg and the lower Red River of the North. The highlighted area of the map indicates the location of a breached levee which has permitted development of a crevasse splay into Netley Lake.

FLOOD DYNAMICS OF THE RED RIVER OF THE NORTH: FUTURE PLANS

Boss and Gosnold continue to discuss options for funding studies of flood dynamics on the Red River of the North. The field reconnaissance conducted during May 1998 was very successful. It demonstrated that R/V *Ozark Traveler* could be transported and deployed to remote locations to conduct research. In addition, the reconnaissance appears to have identified a good location in Netley Lake for coring to delineate the geologic record of Red River flooding.

This RIG generated a proposal to the National Science Foundation last summer. Though this proposal was not successful, reviewers' comments were constructive and supportive of the concept, and the P.I.'s were encouraged to continue developing the proposal.

A limiting factor in developing this proposal over the last year has been the fact that both Boss and Gosnold have had substantial funded projects which took priority over the Red River of the North proposal. However, both P.I.'s are still very enthusiastic about developing the research and pursuing funding for it through appropriate agencies. Both P.I.'s are confident that a funded project will eventually emerge.

REFERENCES

Anonymous, 1952, Floods of 1950 in the Red River of the North and Winnipeg River basins: United States Geological Survey Water Supply Paper 1137-B, p.115-325.

Anonymous, 1955, Floods of 1952 in the basins of the upper Mississippi River and Red River of the North: United States Geological Survey Water Supply Paper 1260-C, p.303-529.

Bluemle, J.P., 1997, Factors affecting flooding in the Red River Valley, Proceedings of the North Dakota Academy of Sciences, v. 51, supplement 1., p. 17-20.

Chandler, E.F. 1918, The floods of the Red River Valley: North Dakota University Quarterly Journal, v.8, p.207-232.

Chandler, E.F., 1911, The Red River of the North: North Dakota University Quarterly Journal, v.1, p.227-255.

Harrison, S.S., 1968, The flood problem in Grand Forks-East Grand Forks: North Dakota Geological Survey Miscellaneous Series 35, 42p.

Harrison, S.S. and Bluemle, J.P., 1980, Flooding in the Grand Forks-East Grand Forks area: North Dakota Geological Survey Educational Series 12, 66p.

Matheson, S.P., 1947, Floods at Red River, Papers read before the Historical and Scientific Society of Manitoba, Series III, no.3, p.6-8, Winnipeg.

Miller, J.E., and Frink, D. L., 1984, Changes in flood response of the Red River of the North Basin, North Dakota-Minnesota, U.S. Geol. Surv. Water-Supply Paper 2243.