NEOGENE GRABENS IN SOUTHERNMOST ILLINOIS

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Annual Project Summary

Investigations undertaken

During the project period (January 1999 through January 2000) we drilled numerous test holes to investigate faults that displace Tertiary and Quaternary sediments in southernmost Illinois. The sites are located in Massac and Pulaski Counties, at the northern end of the Mississippi Embayment. The test drilling supplemented seismic reflection surveys previously run at three of the sites, and outcrops studies carried out at all sites.

Two drill rigs were used in this project. An AMS Power Probe, a small rig mounted on a 1-ton pickup truck, was used to drill most of the holes. The AMS drives and hammers the drill string into the ground, recovering continuous cores of soft sediments to a maximum depth of about 30 m. Because the drill string does not rotate, oriented cores can be taken, and the dip direction of inclined bedding or lamination can be determined. Three holes for this project were drilled by the USGS using a wireline coring rig capable of drilling to depths in excess of 300 m, and of drilling both bedrock and soft sediments.

The following is a list of test holes drilled for this project.

Site	No. of Holes	Total of Depths (m)	Deepest Hole (m)
Choat	7	94	18
Maple Grove	9	185	110
Massac Creek	17	441	174
Post Creek	13	150	21
Total	46	820	

Results

Massac Creek. The Massac Creek site is located about 13 miles north of Metropolis in Massac County. Previous work (including outcrop study, analysis of subsurface data, and two high-resolution seismic profiles) indicated a complex graben structure displacing units as young as Pleistocene. To investigate this site further, we drilled 15 shallow test holes using the AMS Power Probe. Five holes were drilled along the line of the southern seismic profile, and ten along the line of the northern profile. Finally, the USGS rig drilled a cored test hole 173 m deep (ISGS #7 J. Weaver) into the central graben along the northern seismic line.

On the southern (Rosebud Road) seismic line, the five boreholes verified displacement of Pleistocene sediments. Holes drilled near the eastern and western

ends of the seismic line encountered Pleistocene loess overlying McNairy Formation (Cretaceous) having horizontal bedding. Two holes drilled near Massac Creek, where seismic data indicate the central graben, encountered Metropolis Formation (Pleistocene) to depths of 15 and 18 m without reaching underlying units. A fifth hole, drilled along the western margin of the seismically-defined graben, encountered 10 m of Metropolis Formation overlying McNairy Formation in which the lamination dips 20 to 40 degrees southeast. Thus, the drilling showed that the Metropolis Formation was displaced a minimum of 18 m downward into the central graben.

Drilling along the northern seismic line (Weaver Farms) provided greater detail on the tectonic history of the Massac Creek structure. The Metropolis Formation is downthrown 32 m in the central graben relative to holes outside the graben. Below the Metropolis in #7 J. Weaver is 79 m of fine sand, silt, and clay containing abundant peat and organic matter in the lower part. Fossil pollen from a depth of 101 meters, near the base of this interval, was examined by Norm Frederiksen of the USGS in Reston, Va. In a written report dated 8/15/00, Frederiksen reports, "...there is no evidence that the sample is Pliocene in age, and it probably represents some temperate part of the Quaternary." The sedimentary unit in which this pollen occurs is unknown elsewhere in the northern Mississippi Embayment, and apparently is confined to the graben.

Continuing deeper, the #7 J. Weaver hole encountered the Mounds Gravel (late Miocene to early Pleistocene?) at a depth of 115 to 127 m. This is 150 m lower than its position in outcrops along the margin of, but outside the graben. Below the Mounds were found two Paleocene units, the Porters Creek Clay (younger) and the Clayton Formation. These formations are unknown in Massac County outside of a few grabens. Finally, the #7 Weaver penetrated the Owl Creek Formation and the upper part of the McNairy Formation, both of Cretaceous age. The base of the McNairy was not reached.

The ten shallow boreholes drilled on the Weaver Farms filled in more details about the structure. Near the two ends of the seismic line, the McNairy Formation is at the surface and its bedding is horizontal. Approaching the graben from both sides, the bedding of the McNairy dips into the graben. A hole (ISGS #3 D. Weaver) near the western edge of the graben encountered sand believed to represent the Wilcox Formation, an Eocene unit previously unknown this far north in the Embayment. Shallow test holes within the central graben entered the Metropolis Formation, but were unable to penetrate its base.

Thus the drilling at Massac Creek documents recurrent development of a complex and narrow, northeast-trending graben. The graben was active during the Tertiary Period, when Paleocene and Eocene sediments were downdropped and preserved. At least 150 m of throw occurred after deposition of the Neogene to early Pleistocene Mounds Gravel. Of this amount, at least 101 m took place during the Pleistocene, as sediments of that age are involved. The time of the last fault activity is not tightly constrained, but we have observed no displacement of a Wisconsinan unit, the Equality Formation, which occupies Massac Creek valley south of the seismic profiles. The Holocene alluvium along Massac Creek directly overlying the central graben bears no evidence of any tectonic disturbance.

Choat. The Choat site is located in western Massac County, 8 km northwest of Metropolis. Outcrop mapping, water-well records, and a seismic reflection profile run in

1998 indicated a fault zone displacing units at least as young as the Mounds Gravel (late Miocene to early Pleistocene?). Additional drilling carried out in 1999 expanded our understanding of tectonic faulting at Choat.

Four shallow test holes were drilled at an abandoned landfill south of the seismic traverse. They depict a graben in which the Mounds Gravel is downthrown and tilted to the southeast. As at Massac Creek, Paleocene sediment is present below the Mounds, indicating that the graben subsided before Mounds deposition also. In a bulldozed area of the landfill, brightly colored sand of the Mounds is exposed and its bedding dips 30 to 40 degrees southeast. The tilted sand is overlain by horizontal, unfaulted loesses, including the Loveland Silt (Illinoian) and the Roxana and Peoria Silts (Wisconsinan). The unconformable relationship is evidence that the faulting at the landfill took place during late Neogene to early Pleistocene (pre-Illinoian) time.

Another test hole was drilled on the farm of Melfred Krueger, Jr., where previous well records and the seismic data indicated a graben parallel to the one at the landfill. The new drilling confirmed that Mounds Gravel and Paleocene strata are present in the graben on the Krueger property. No offset of loess is evident. Hence, both grabens at Choat underwent a similar succession of movements.

Maple Grove. A water well at Maple Grove School, 3 km northwest of Joppa in western Massac County, suggested a graben in which the Cretaceous strata are displaced at least 36 m downward relative to nearby wells. A seismic reflection profile, run in 1998 on the Jimmy Rodgers farm north of the school, indicated numerous high-angle faults displacing both Paleozoic bedrock and overlying Cretaceous or younger sediments. To verify these interpretations, we drilled cored test holes in 1999 on the Rodgers farm and also at the school.

Seven shallow test holes were drilled on the Rodgers farm along the line of the seismic section. All seven penetrated Pleistocene loess at the surface and bottomed in the Cretaceous McNairy Formation. Bedding or lamination of the McNairy dipped at 20 to 40 degrees from horizontal in several holes, indicative of post-Cretaceous tectonic movements. One hole found a thin deposit of Mounds Gravel overlying the McNairy, but this hole was at the top of a hill, where the Mounds is at its normal elevation as found away from grabens. So far as evidence on the Rodgers farm indicates, faulting here took place after Cretaceous Period but before deposition of the Mounds Gravel.

At Maple Grove School the USGS rig drilled a test hole 110 m deep into Mississippian limestone. Samples from this hole demonstrate that a graben is present beneath the school. The strata penetrated, from surface downward, are: 3 m of Pleistocene loess, 15 m of Pleistocene Metropolis Formation, 15 m of sand, 5 m of gravel, 61 m of Cretaceous McNairy Formation, 10 m of Cretaceous Post Creek Formation and 1 m of Mississippian Salem Limestone. The base of Cretaceous is downthrown more than 50 m relative to a nearby water well located barely outside the graben. The gravel and sand overlying the McNairy are unidentified, but closely resemble Eocene strata found south and west of Massac County. The Mounds Gravel is not present, and whether the Metropolis Formation is displaced is not certain. However, small faults and planar, northeast-trending joints are visible along the banks of a stream a short distance west of Maple Grove School.

The sum of the evidence at Maple Grove is that considerable fault movement

took place during the Tertiary Period, displacing the Cretaceous succession and the unnamed Eocene (?) sand and gravel. Movements continued into the Pleistocene, but these later displacements were minor.

Post Creek. Previous geologists reported structural disturbances, which they attributed to solution-collapse of limestone bedrock, at Post Creek Cutoff (an artificially straightened and deepened drainage ditch) in eastern Pulaski County. In 1998, we conducted a high-resolution seismic survey at Post Creek, and it showed several faults displacing the Paleozoic bedrock. This year, we drilled test holes along the seismic line and elsewhere at Post Creek in an attempt to verify presence of tectonic faults.

The drilling disclosed clear evidence of post-Cretaceous faulting, as several cores showed bedding or lamination of the McNairy Formation to dip steeply. In particular, cores indicated displacements of at least 10 m, along with sheared sediments and near-vertical bedding, at the place where the seismic line implies a large fault in the bedrock. None of the holes along the seismic line, however, encountered Mounds Gravel or younger units of abnormal elevation, thickness, or lithology. Therefore, from these holes we cannot infer faulting younger than the early Tertiary.

During a dry spell early in 2000 when streams were unusually low, we walked the length of Post Creek Cutoff searching for evidence of deformed sediments reported to us in 1997 by Martitia Tuttle (then of the University of Maryland). We found not only the structure reported by Tuttle, but another area of deformed strata exposed in the banks and bed of the ditch. Both structures feature complex, narrow grabens in which the Mounds Gravel and Pleistocene Metropolis Formation are downthrown, with bedding steeply dipping to vertical. The Equality Formation (Wisconsinan clay and silt) and Illinoian and Wisconsinan loess units, directly overlying both disturbances, are horizontal and undeformed. The question is whether deformation is due to tectonic activity, solution collapse, or a combination of processes. We drilled test holes as close as we could to the newly discovered structures, and our findings were inconclusive. In one case, the drill holes failed to encounter downthrown strata. In the other case, the drill encountered a mixture of mud and weathered chert fragments, then the drill rods dropped freely and jammed into a crevice in limestone bedrock. The presence of karst features along Post Creek cannot be doubted following this incident.

Summarizing cautiously, investigations at Post Creek reveal several narrow graben-like structures that (in some cases) affect units as young as the Metropolis Formation, which is Illinoian and older. The seismic profile shows definite offset of reflectors in the Paleozoic bedrock, but there is also convincing evidence for karst. It is likely that tectonic fractures have been widened by solution, and that Neogene sediments have both collapsed into caverns or crevices and been lowered into tectonic grabens. The youngest possible deformation was Illinoian; Wisconsinan and Holocene sediments are not affected.

Summary

During this project we drilled 46 test holes, having cumulative depth of 840 m, at four study sites to investigate faults displacing Neogene and Quaternary sediments in southern Illinois. Drilling results indicate faults at these sites were active repeatedly

during Tertiary and Pleistocene time. At Massac Creek, a graben 100 to 150 feet deep formed and was filled with sediment during the Pleistocene. Quaternary movements at the other three sites were much smaller, and some of the deformation at Post Creek is a product of karst activity. The last fault movements we can document at the four sites took place during the Illinoian Age, which ended approximately 125,000 years ago.

Reports published

Nelson, W.J., F.B. Denny, L.R. Follmer, and J.M. Masters, 1999, Quaternary grabens in southernmost Illinois, deformation near an active intraplate seismic zone: Tectonophysics, v. 305, p. 381-397.

No seismic, geodetic, or processed data were acquired during the course of this year's work.