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Bedrock Topography Beneath the Des Moines Lobe Drift Sheet, North-Central Iowa

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The bedrock surface beneath the Des Moines Lobe Drift Sheet in Iowa contains the junction of the paleo-drainage divides between pre-glacial north, southeast and southwest flowing drainage. The bedrock uplands containing these divides have controlled the shape and location of the Des Moines Lobe as well as the location and shape of the end moraines upon the drift sheet. The total drift thickness beneath the lobe is commonly 100 to 150 feet but ranges from 20 to 500 feet. The relatively uniform thickness of the drift means that the surface topography mimics the bedrock topography. Hummocky end moraines and three of Ruhe's end moraines appear to overlie bedrock slopes opposed to glacial flow and bedrock uplands, whereas minor moraine topography and the Bemis end moraine overlie bedrock slopes on lee sides of uplands.

INDEX DESCRIPTORS: Iowa, Des Moines Lobe, Bedrock Topography, Drift Thickness.

Only three maps of the bedrock topography of the entire state of Iowa are known to exist. These are by Kay and Apfel (1928), Horberg and Anderson (1955) and Hale (1948). Hale's map is unpublished and the former two maps are extremely generalized. During a recent study on the distributional pattern of minor moraines in Iowa, a comparison was attempted between the minor moraine pattern and bedrock topography (Palmquist, 1972a, 1972b). The need for a detailed bedrock topographic map became apparent at that time. This paper presents a preliminary bedrock topographic map for those counties on the Des Moines Lobe Drift Sheet in north-central Iowa (Figure 1).

The preliminary bedrock topographic map and total drift isopachous map contained in this paper are presented with this quote from Sendlein (1968, p. 195) in mind.

> . . . it is unfortunate that Hale's map was not published in 1950. Of course, hindsight is always better than foresight, but perhaps a valuable lesson can be learned from this. No matter how limited the data, it should be published in some form so that researchers will have access to it. An incomplete or preliminary map can raise questions and stimulate discussion and perhaps further study.

The utility of these preliminary maps is evidenced by their use in the analysis of minor moraine trends (Palmquist, 1972a, 1972b), karst development (Palmquist, Madenford and Van Driel, 1974) and variations in glacial topography (Palmquist, Connor and Bible, 1974). As a further example of their utility, the shape of the Des Moines Lobe Drift Sheet and the morainal distribution upon it will be compared to the bedrock topography.

Sendlein (1968) has summarized most of the work on the bedrock topography of Iowa up to 1968. Absent from Sendlein's summary are some county reports wherein mention was made of possible bedrock valleys but no maps were included. Since 1968, bedrock topographic maps have been published for southeastern and eastern Iowa (Hansen, 1972, 1973), southern Iowa (Cagle, 1973), southwestern Iowa (Sendlein and others, 1968) and central Iowa (Kent, 1969; Schoell, 1967).

The bedrock topography beneath the Des Moines Lobe Drift Sheet has been mapped, either in part or fully, by 11 workers. Hale (1948) has produced the only complete map for the lobe. Twenter and Coble (1965) have produced a detailed bedrock topographic map for the nine counties form-

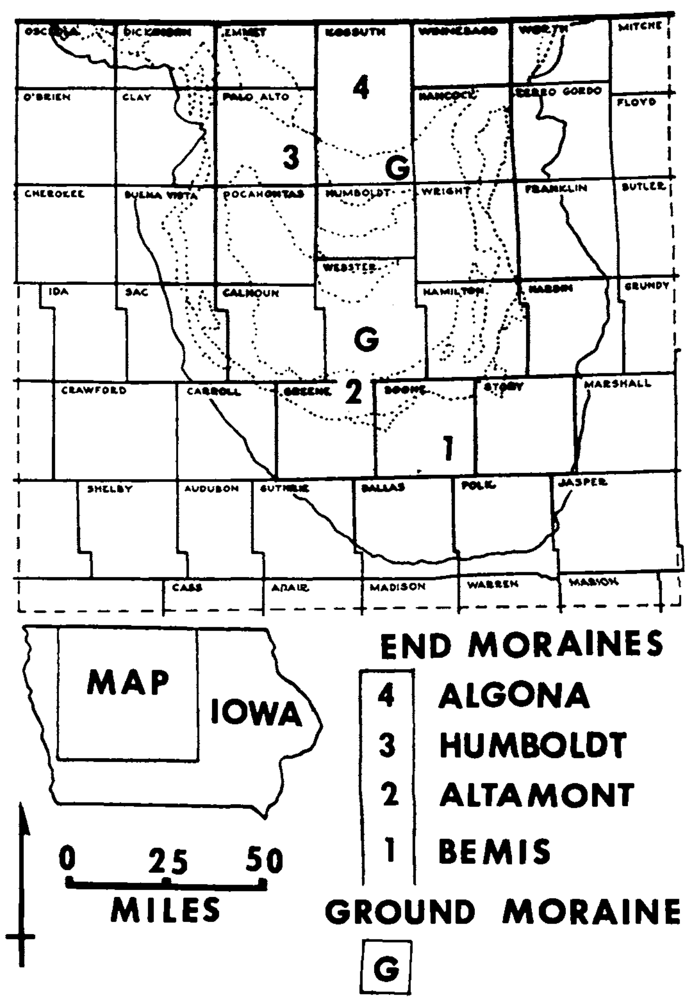

Figure 1. The location of the Cary-age Des Moines Lobe Drift Sheet in north-central Iowa. The margins of the drift sheet and morainal systems are from Ruhe (1969).

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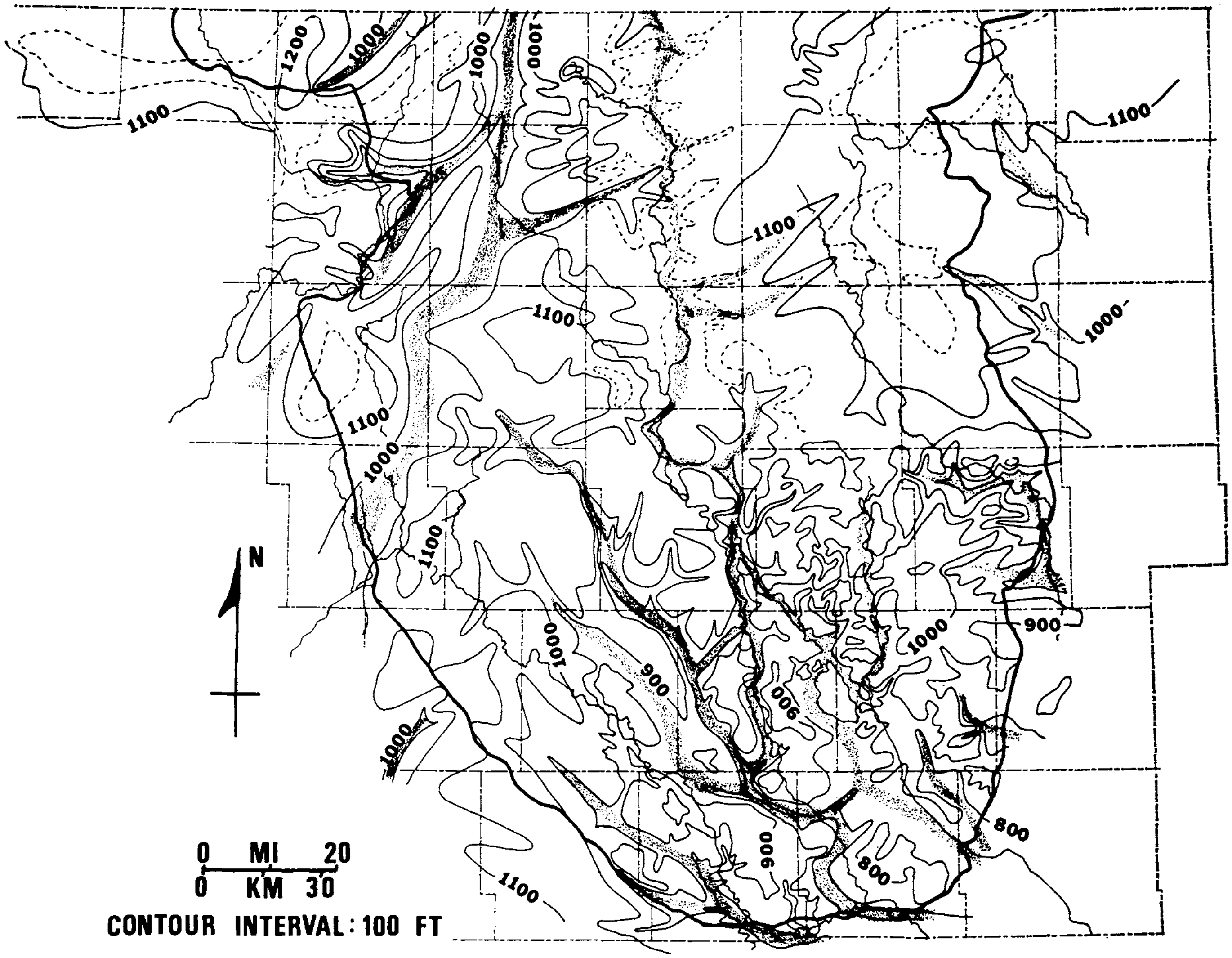

Figure 2. Map of the bedrock topography beneath the Des Moines Lobe Drift Sheet. Dashed lines represent 50-foot contour intervals. Shaded areas are the axes of buried bedrock valleys (modified from Hale, 1948; Twenter and Coble, 1955; Kent and Sendlein, 1969).

ing the southeast quarter of the lobe. Kent (1969) has mapped portions of four counties, already covered by Twenter and Coble (1965), but in much greater detail. Backsen (1963), Schoell (1967), Akhavi (1970), Nicklin (1974) and Palmquist and Bible (1974) have mapped a small area around Ames in great detail, and Smith (1969) has mapped a small area around Manson. Hansen (personal communication) is currently making a detailed bedrock topographic map which includes the northeastern five counties.

The major bedrock uplands and valleys recognized on the bedrock topographic map are given informal names in this paper. These names have been given to provide convenient reference terms for these regions. These reference terms facilitate the comparison of bedrock and surface topographic features. The purpose of this paper is not to describe the bedrock physiography but to present the bedrock map and illustrate one of its uses.

METHODS

The topography of the bedrock surface and the drift thickness within the Des Moines Lobe Drift Sheet were determined from previous maps as modified by well logs available (1973) on magnetic tape from the Iowa Geological Survey. The computerized well log data were used to modify the bedrock topographic maps constructed by Hale (1948), Twenter and Coble (1965) and Kent (1972). Where data from one of the more recent maps or from the computerized well logs conflicted with an earlier map, the older map was changed to conform to the newer data. The contour lines must be considered generalized inasmuch as the bedrock topography was not made to conform to outcrops and the well data in many of the northern counties are sparse. Additional data should make many of the smoothly curving contours around the bedrock uplands more crenulate. This paper has not utilized the large number of well logs on file at the Iowa Geological Survey. The use of these data would have prolonged map presentation though they would have added to the detail shown on the map.

The total drift isopach map was constructed solely from the well logs on magnetic tape. The computerized well logs are not sufficiently detailed to allow discrimination of separate till sheets or determination of the thickness of sand and gravel deposits within the till. The isopachous map must be considered to show only total thickness of unconsolidated deposits overlying the bedrock surface. No attempt was made to make the contours conform to the trends established on the bedrock topographic map.

The two maps (Figures 2 and 3) can be considered only first approximations which will be modified as more detailed data become available. It is believed that the maps are useful in presenting the regional patterns. It is not believed that future mapping will change the locations and gross configurations of major uplands and drainage trends. The additional detail presented in this paper has not changed the general trends shown in Hale's (1948) preliminary bedrock topographic map.

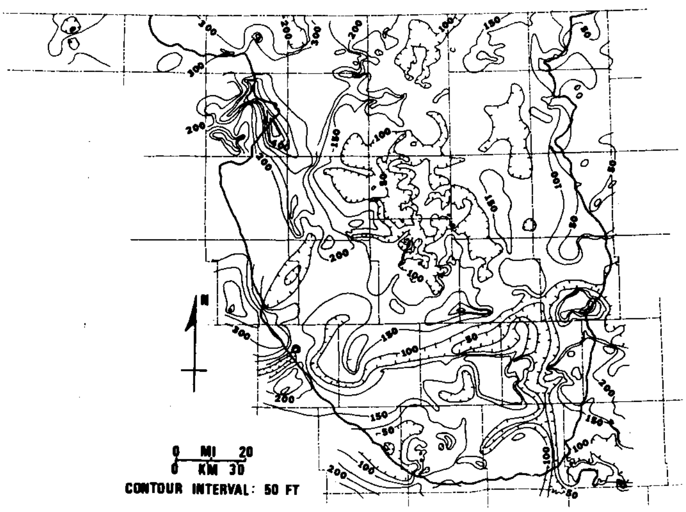

Figure 3. Isopachous map of the total drift overlying the bedrock surface beneath the Des Moines Lobe Drift Sheet. Thickness data from Iowa Geological Survey computerized well logs (1974).

RESULTS

Bedrock Topography

The bedrock topographic map (Figure 2) indicates a range in bedrock elevations from over 1,200 feet under the northeast and northwest portions of the drift sheet to less than 700 feet under the southeastern portion of the drift sheet. Three extensive bedrock uplands are delineated by the 1,100-foot contour lines in the northeastern, northwestern and central to southwestern portions of the drift sheet. An apparently highly dissected lowland is indicated by the 800- and 900-foot contours in the southeastern portion of the drift sheet. The contrast in the degree of dissection between the southeastern portion and the rest of the drift sheet is the result of more detailed mapping by Kent (1972) and Twenter and Coble (1965) in the southeastern portion than by Hale (1948) in the remainder of the drift sheet.

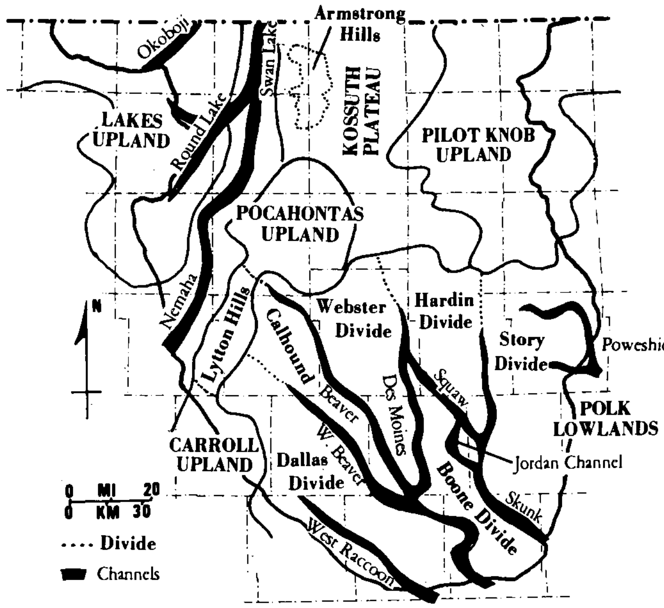

Figure 4. Physiographic regions of the bedrock surface beneath the Des Moines Lobe Drift Sheet. Region boundaries are tentative and region names are informal.

For convenience, the bedrock uplands and valleys are given informal names (Figure 4). The Pilot Knob Upland, underlying the northeastern portion of the drift sheet, is named for Pilot Knob in northeastern Hancock County. It is defined by the 1,100-foot contour and contains two highs. The northern high, in Winnebago and Worth counties, reaches elevations in excess of 1,200 feet. The southern high, in Hancock and Franklin counties, exceeds 1,150 feet in elevation. A topographic saddle, at less than 1,150 feet and underlying the town of Garner in Hancock County, separates the two highs. The Lakes Upland, underlying the northwestern portion of the drift sheet, is named for the Iowa Great Lakes in Dickinson County. It is defined by the 1,100-foot contour and contains three highs. The northern high, in Dickinson County, exceeds 1,200 feet in elevation; the middle high, in Clay County, also exceeds 1,200 feet; whereas the southern high, in Buena Vista County, exceeds 1,150 feet in elevation. Both the Pilot Knob and Lakes uplands are L-shaped with a north-south arm parallel to and approximately coincident with the eastern and western boundaries of the drift sheet and an east-west arm parallel to and coincident with the state line. The last major upland is defined by the 1,050-foot contour and extends from Pocahontas County southwestward into Carroll County. Three portions of this linear upland rising above 1,100 feet have been named. The northern high in Pocahontas and Humboldt counties is called the Pocahontas Upland and exceeds 1,150 feet in elevation. The southern high, in Carroll County, is called the Carroll Upland and exceeds 1,100 feet in elevation. The central two highs, in Sac and Pocahontas counties, which exceed 1,100 feet in elevation, are called the Lytton Hills, after the town of Lytton in Carroll County. The Kossuth Plateau, with elevations around 1,050 feet, lies to the west of the Pilot Knob Upland and to the north of Pocahontas Upland. It is named after Kossuth County, which it underlies. Most of the plateau is highly dissected and the borehole data do not allow determination of even major drainage trends. The north-south valley bisecting the plateau must, therefore, be considered largely conjectural. Along the west boundary of Kossuth County, a few isolated bedrock highs at elevations of 1,100 to 1,200 feet are called the Armstrong Hills after the town of Armstrong in Emmet County.

The southeastern portion of the lobe is underlain by the Polk Lowlands, which are named after Polk County wherein the lowest elevations are found. The Polk Lowlands range in elevation from 700 to 1,100 feet, with the most common elevations around 800 to 900 feet. The Polk Lowlands are traversed by five major buried valleys which trend northwest-southeast. The buried valleys are bounded by six uplands with a bedrock relief of over 100 feet. The second-order uplands are designated the Story, Hardin, Boone, Webster, Calhoun and Dallas divides. The Story and Hardin divides are the southern extensions of the Pilot Knob Upland and trend north-south. The Webster and Boone divides are the southeastward extensions of the Pocahontas Upland, and the Dallas and Calhoun divides are the southeastward extensions of the Carroll Upland and Lytton Hills, respectively.

The bedrock uplands are separated by buried bedrock valleys, known as channels. The channels in Polk Lowlands are the Poweshiek Channel in Hamilton County (Twenter and Coble, 1955; Hansen, 1972), the Skunk Channel in Story and Polk counties (Twenter and Coble, 1955; Beyer, 1898; Kent, 1969), the Squaw Channel in Story County (Kent, 1969; Beyer, 1969), the Jordan Channel in Boone County (Twenter and Coble, 1955; Kent, 1969), the Beaver Channel in Polk, Boone and Webster counties (Twenter and Coble, 1955), the West Beaver Channel in Green County and the West Raccoon Channel in Guthrie County. The exact location and trend of the Jordan and Squaw-Skunk channels as shown in Figure 2 for Story and Boone counties differ from those in Twenter and Coble (1965). Most of the difference resulted from the detailed work of Kent (1969).

The Lakes Upland is separated from the Kossuth Plateau and Pocahontas Upland by the north-south trending Nemaha-Swan Lake Channel. Data are not available to establish the divide between the Swan Lake Channel, which drains north into Minnesota, and the Nemaha Channel, which drains southwest into the Missouri River. The divide is either in northern Buena Vista County or southern Palo Alto County. Within the Lakes Upland, two channels are recognized. The North and South Round Lake channels in Clay County are major northeast-flowing tributaries to the Swan Lake Channel. The Okoboji Channel, in Dickinson County, which drains northward, underlies the Iowa Great Lakes and has bedrock elevations below 800 feet.

The distribution of uplands and channels indicates that the Des Moines Lobe Drift Sheet overlies the intersection of the paleo-divide between pre-glacial drainage north into Minnesota, southeast into the Mississippi River and southwest into the Missouri River. The paleo-divide between southeast and southwest flowing drainage is formed by the Carroll and Pocahontas uplands. The paleo-divide between drainage north into Minnesota and drainage south into Iowa lies along the Lakes, Pocahontas and Pilot Knob uplands. The location of the divide cannot be exactly determined in two places. The probable location of the divide between the Nemaha and Swan Lake channels has already been discussed. The exact location of the divide on the Kossuth Plateau is unknown but is most probably either in central Kossuth County near the town of Bancroft or in southern Kossuth County near the town of Irvington.

Drift Thickness

The total thickness of the glacial drift overlying bedrock (Figure 3) ranges from less than 25 feet in portions of Humboldt, Guthrie, Worth, Franklin, Story and Polk counties to over 500 feet in Clay County. Over most of the southern and eastern portions of the drift sheet, the total thickness is between 100 and 150 feet, with only small areas exceeding 150 feet and somewhat larger areas having less than 100 feet. In the northwestern portion, the total drift thickness everywhere exceeds 150 feet, and is most commonly 200 to 300 feet thick. In Dickinson and Clay counties the total drift thickness exceeds 300 feet. In Sac and Carroll counties the total drift thickness abruptly increases just outside of the edge of the Des Moines Lobe Drift Sheet, as shown in Figure 3. In all other counties, little change in total drift thickness is apparent across the margin of the lobe.

A comparison of the total drift thickness (Figure 3) to the bedrock topography (Figure 2) indicates that the total drift thickness is locally less over the bedrock uplands. The common total drift thickness of 150 feet decreases over the Pilot Knob Upland in Hancock County to about 75 feet; over the Pocahontas Upland in Humboldt, Pocahontas and Webster counties to less than 25 feet; over the Lytton Hills in Calhoun County to less than 100 feet; in an east-west trending band in Greene, Boone and Story counties to between 25 to 75 feet; and in a north-south band in Story and Polk counties to less than 50 feet. However, except for the extensive area of reduced total drift thickness over the Pocahontas Upland, the area of reduced drift thickness over uplands is small. This latter conclusion is confirmed by a comparison of "county modal drift thickness," i.e., the most common drift thickness within a county, to the average bedrock slope direction as related to glacier flow direction (Figure 5). The "county modal drift thickness" is greatest for those counties overlying the opposed slopes and crests of bedrock uplands and less for those counties overlying bedrock slopes parallel to glacier flow and in the lee of bedrock uplands. The average modal drift thickness is 137 feet in the former two groups of counties and 107 feet in the latter group of counties.

DISCUSSION

The most significant descriptive aspects of the bedrock topographic and the total drift isopach maps are, respectively, the close correlation between bedrock and surface topography, and the relatively uniform drift thickness. These two aspects are, of necessity, related, in that the relatively uniform drift thickness gives rise to the mimicking of the bedrock topography by the surface topography. This mimicking is evident in the paleo-drainage system on the bedrock surface, which is similar to the modern drainage system in that with only a few exceptions the same counties which contain modern divides also contain the paleo-divides on the bedrock surface. The main exception is the Minnesota-Iowa drainage divide which, on the bedrock surface, everywhere lies south of the state line of Iowa, whereas on the present land surface it lies in part north of the state line in Minnesota at the headwaters of the Des Moines River. This picture of the paleo-drainage does not agree with that presented in Horberg and Anderson (1956) and in Flint (1971).

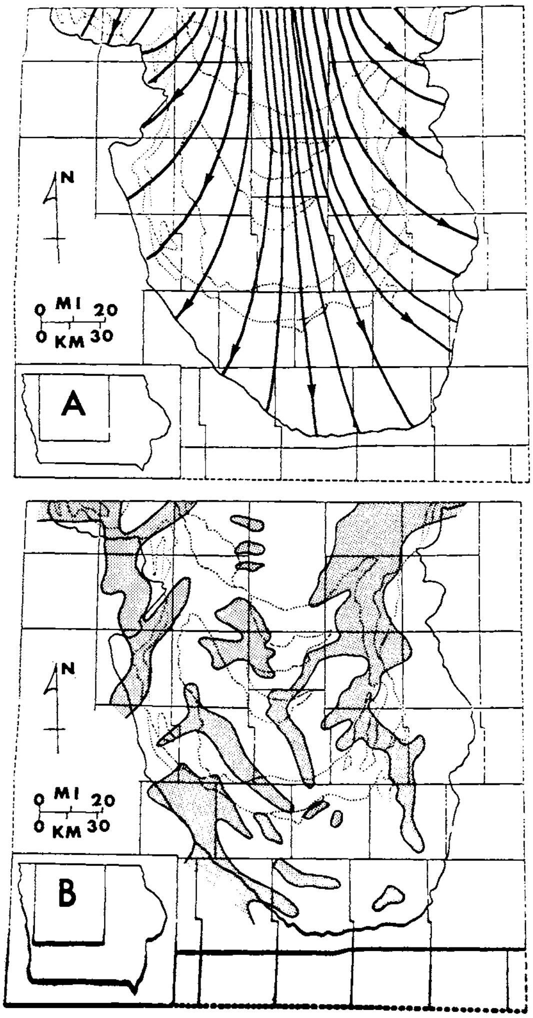

Figure 5. Distribution of bedrock slopes opposed to glacial flow direction. Broken lines delimit the end moraines as recognized by Ruhe. (A) Hypothetical flow lines in the Cary-age Des Moines Lobe (modified from Foster, 1969). (B) Areas of bedrock slope opposed to the glacial flow direction. Opposed slopes are shaded and extend to divide.

One of the more significant uses of the bedrock topographic data is, as previously mentioned, the comparison of surface and bedrock topography. Horberg and Anderson (1956) have shown that the Pleistocene ice sheets were lobate and that each lobe tended to follow bedrock lowlands. Clayton (1972) has shown that bedrock topography influenced the stress field within the glacier and thus controlled the thickness of the tills and the type of moraine found. Similar comparisons can be made for the Des Moines Lobe Drift Sheet.

The shape of the Des Moines Lobe Drift Sheet and the distribution of moraines upon that drift sheet can be related to the bedrock topography. The elongate, tongue-shape of the Des Moines Drift Sheet, with its slight southeastwardly curved axis, can be attributed to the influence of the Pilot Knob and Lakes uplands and the Polk Lowlands upon the direction of glacial flow. The Des Moines glacial lobe crossed the state line through the topographic saddle formed by the Swan Lake Channel and the Kossuth Plateau. It was then funneled southward for 60 miles between the Pilot Knob and Lakes uplands into northern Webster County. In Webster County the glacier was both guided to the southeast by the southeastward trending valleys of the Polk Lowlands and further deflected to the southeast by the Carroll Upland along the southwest margin. The gross form of the drift sheet is thus controlled by the bedrock topography.

The bedrock topography also influenced the detailed shape of the drift sheet margin. Where the glacier was flowing down a bedrock low, the margin is convex outward; where the glacier was flowing against a bedrock high, the margin is concave outward. The best example of convex margins is the pronounced lobe in Cerro Gordo County which contains Clear Lake and which resulted from the pronounced saddle in the Pilot Knob Upland in Hancock County. Other examples are the broadly convex margin in Hardin County which resulted from the Poweshiek Channel and the small convexity and concavity in the margin in Clay County which resulted from, respectively, the north Round Lake Channel and the divide just to the south of it. Exceptions exist; for instance, the large Nemaha Channel had no apparent effect on the drift margin.

The bedrock topography has influenced the location and shape of the end moraines (Figure 1). The convergence of the morainal systems in the north can be attributed to the width restriction imposed by the Lakes and Pilot Knob uplands. The location of the moraines is controlled by bedrock uplands. The Algona end moraine forms an arc tied to the Pilot Knob Upland on the northeast and Armstrong Hills on the northwest. It thus outlines the eastern half of the Minnesota-Iowa paleo-drainage divide. The partial Humboldt end moraine is best developed over the crest of the Pocahontas Uplands where it bifurcates into the northern, Rutland, member and the southern, Fort Dodge, member (Ruhe, 1969), each of which overlies an easterly extension of the upland. The Humboldt end moraine system disappears to the east over the lower-lying Kossuth Plateau. The Altamont end moraine overlies the inner, opposed slopes of the Pilot Knob and Lakes uplands and overlies the crests of higher portions of the Hardin and Webster divides and the Lytton Hills in the south. Only over the Nemaha Channel in the southwest does a major portion of the Altamont end moraine not overlie a bedrock high. The lobate form of the Altamont end moraine in Dickinson County, which results from the Okoboji Channel, is an excellent example of the detailed control exerted by the bedrock topography. The Bemis end moraine in the west and southwest overlies opposed slopes of the Lakes and Carroll uplands and the crest of the Lytton Hills. However, in the southeast it overlies the Polk Lowlands south of the area of prominent bedrock divides. On the east the Bemis end moraine overlies the Pilot Knob Upland, but on the downsloping lee side east of the divide. The Bemis end moraine shows neither the same degree nor the same kind of bedrock topographic control as do the younger three moraines.

The distribution of end moraines (Figure 1) as recognized by Ruhe (1969) is neither the same as that of the hummocky morainal areas recognized by earlier investigators (Figure 6) nor as that of minor moraines (Figure 7) as recognized by Gwynne (1942). Regardless of this difference, these latter two morainal forms are also controlled by the bedrock topography. The prominent southward loop of hummocky topography between Hancock County on the east

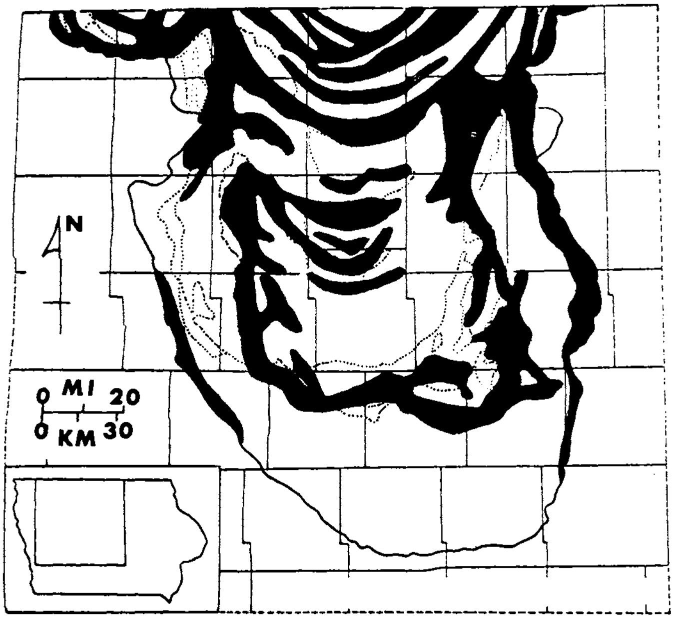

Figure 6. Areas of hummocky end morainal topography (Kay and Graham, 1943). Broken lines delimit end moraines as recognized by Ruhe (1969).

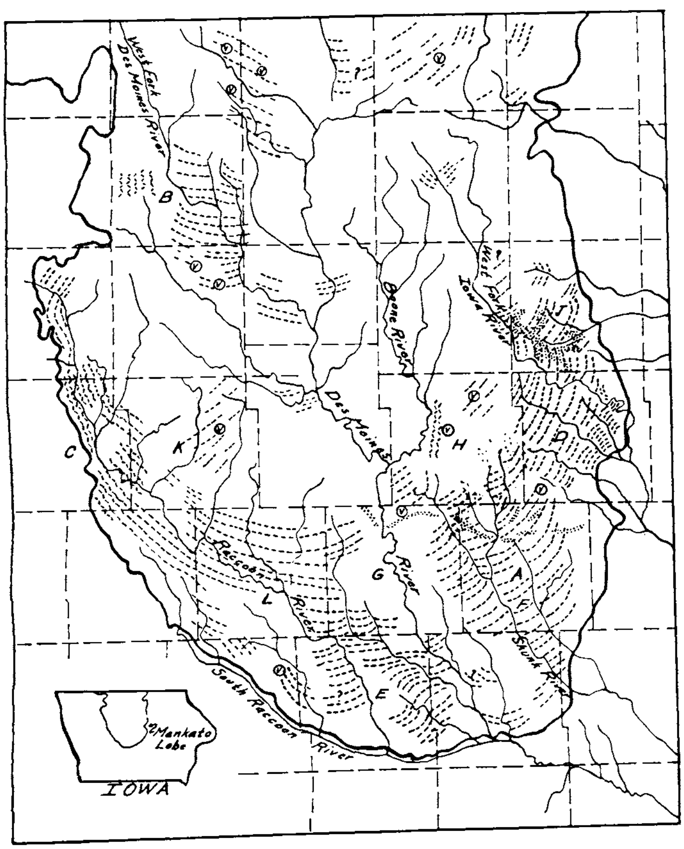

Figure 7. Distribution of minor moraines (Gwynne, 1942).

and Pocahontas County on the west follows bedrock highs. On the east, the hummocky topography overlies the opposed slopes (Figure 5) on the Pilot Knob Upland and the Story Divide. Across the south it overlies the higher portions of the Boone Divide, and in the southwest it overlies the opposed slopes of the Carroll Upland and Lytton Hills. The central hummocky topography and the northern hummocky topography which essentially correlate with the Humboldt and Algona moraines of Ruhe (1969) illustrate the same bedrock control. The minor moraines (Figure 7) as recognized by Gwynne (1942) are most abundant on the southern and eastern portions of the Bemis end moraine. These are the portions which overlie the downslipping lee side of the Pilot Knob Upland and the Polk Lowland. It thus appears that areas of hummocky moraine tend to overlie opposed slopes and crests of bedrock uplands, whereas areas of minor moraine tend to overlie the lee slopes of bedrock uplands. The difference in topography between the Altamont, Humboldt and Algona end moraines (hummocky morainal topography) and the Bemis end moraine (minor moraine topography), as well as the difference in location relative to the bedrock topography, suggests that a difference in origin may also exist. It has been suggested that the hummocky morainal areas may have thick drift ice stagnation origin whereas the minor moraine areas may have either a "live-ice" or thin drift ice stagnation origin (Palmquist, Connor and Bible, 1974). These concepts are compatible with those presented by Palmquist, Bible and Sendlein (1974) for central Iowa and with those of Clayton and Freers (1967) for North Dakota.

The local thinning of the drift over some portions of the bedrock uplands may be the result of glacial erosion. The thinning of Tazewell Drift over the southern portion of the Hardin Divide in Story County is attributed to erosion by the Cary glacier by Palmquist and Bible (1974). The large area of thin drift over the Pocahontas Upland in Humboldt County may have a similar origin. The attractiveness of this erosion concept is increased by location of the area along the axis of the Des Moines Lobe Drift Sheet. Erosion of bedrock highs situated along the axis of the lobe should be the most extensive because of a combination of compressive flow, established by the wedge effect of the bedrock obstruction, and the more active flow. The localization of the Cary-age Humboldt end moraine over this bedrock upland further suggests the thinning of older till by pre-Cary or Cary erosion rather than non-deposition of till.

SUMMARY

The bedrock surface beneath the Des Moines Lobe Drift Sheet contains the paleo-drainage divides between southwest-, southeast- and north-flowing streams. These divides follow three major bedrock uplands. The bedrock surface is mantled with drift which ranges in thickness from 25 to 500 feet but which tends to be uniformly around 100-150 feet thick. The uniform drift thickness has caused the surface topography to mimic the bedrock topography, and modern and paleo-drainage divides lie within the same counties. The location and shape of the Des Moines Lobe Drift Sheet is controlled by the distribution of bedrock uplands, and Cary-age end moraines tend to overlie bedrock uplands.

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