could not be detected by x-rays (*2*) reflects the slightness of the effect, as shown by the very weak birefringence, and it is a common situation in weakly birefringent cubic crystals. The permanent destruction of the birefringence on heating (*2*) must correspond, in this interpretation, to breaking of carbon-carbon bonds in the long-chain hydrocarbons.

It will be interesting to see whether the ideas advanced here are confirmed by a detailed single-crystal structural study, which is reported to be underway (*2*). Such a study is necessary to delineate detailed structural features such as Si—O—Si linkage bending, and distribution of guest molecules in the polyhedral cavities.

If the clathrate structure is correct, melanophlogite constitutes the first known example of a silica or tectosilicate framework in which the pentagonal dodecahedron occurs as a structural unit.

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Wisconsinan Age of the Titusville Till (formerly called "Inner Illinoian"), Northwestern Pennsylvania

Abstract. *Peat discovered below drift near Titusville, Pennsylvania, formerly called "inner Illinoian," has a carbon-14 age of 31,400 ± 2,100 years. The overlying drift, herein named Titusville Till, is therefore not Illinoian but is "late early Wisconsinan" or late Altonian of the Lake Michigan lobe classification.*

The correlation of glacial deposits in the Allegheny plateau in northeastern Ohio and northwestern Pennsylvania with those in other regions, especially with the type sections in the Mississippi valley, has been somewhat imprecise because organic material for C^{14} dating has been most elusive. The correlation and age assignment of the drift in the Grand River lobe outside the "Wisconsin" border in northwestern Pennsylvania are particularly uncertain. Peat, which by C^{14} assay is 31,400 ± 2,100 years old, has been discovered at Titusville, Pennsylvania, below drift called "Illinoian." For the first time this makes possible precise age assignment and provides a point of reference in the stratigraphic column for other tills at the surface and in the subsurface.

Beyond the Kent Till of Wisconsinan age in northwestern Pennsylvania (Fig. 1) a belt of older drift, mainly till, is from less than a mile (about 1 km) to 15 miles (24 km) wide. This drift was assigned an Illinoian age by Leverett (*1*); our studies during the years 1952 to 1957 showed that this older drift is of two ages, which we called "inner Illinoian" and "outer Illinoian" (*2*). Stratigraphic studies conducted in 1964, which were facilitated by deep new strip mines for coal and for limestone and by cuts for interstate highways, show that the "inner Illinoian" till extends westward beneath the Kent Till continuously to the Ohio-Pennsylvania state line and thence further west in Ohio. The color of this till, where it is oxidized, is so distinctly olive brown, in contrast to the yellow brown color of the Kent Till, that we have called it "olive till." At a few places beneath the Kent Till a truncated weathered zone on the "olive till" is preserved, which at some places consists of as much as 5 feet (1.5 m) of leached till with 1 foot or more of silty clay loam that is the preserved lower part of the B horizon of an ancient soil. At some deeper cuts, one to four tills are present below the "olive till," but which of these may be the "'outer Illinoian" is not yet determined.

Extensive bodies of gravel in the form of kames and kame terraces associated with the till called "inner Illinoian" are large enough to be commercial sources of sand and gravel and to be shown on a geologic map (*2*). Lewis C. Strawbridge operates a large gravel pit 0.5 mile (800 m) south of East Titusville, in the eastern part of the large kame terrace that extends for almost a mile on the south side of the valley of Pine Creek eastward from its junction with Oil Creek. In prospecting other parts of the deposit in the late spring of 1964, Strawbridge found at the base of the kame terrace, at the Venango-Crawford county line, 0.3 mile east of the SE corner of Titusville corporation, and 0.9 mile ENE of the famous Drake oil well, 1 foot of peat below 15 feet of gravel. The exploratory excavation was filled in, but shreds of peat are scattered on the surface and Strawbridge had saved a sample of compressed, silty, humic peat of about 100 cubic inches. The age of this peat is 31,400 ± 2,100 years (*3*). It is hoped that the existing gravel pit, the margin of which is now 0.25 mile to the E, will eventually be expanded so the peat may again be exposed, but this is some years in the future.

Till is associated with the gravel at several places in the terrace and is exposed at several places nearby. An extensive exposure of the till is in the south margin of a large gravel pit and in an adjacent deep cut (*4*) along Pennsylvania highway 8, Cherry Tree township, Venango County, about 1.6 miles S of the post office in Titusville, 1.2 miles SW of the Drake well, and 1.7 miles W of the Strawbridge pit. The till in the highway cut was described by Droste and Tharin (*5*), who made detailed analyses of the texture and clay minerals of the till in both unweathered and weathered zones. The till here is leached to a depth of 8.5 feet and oxidized to a depth of 16 feet.

We now propose to name this rock-stratigraphic unit the "Titusville Till." The type section is that already re-

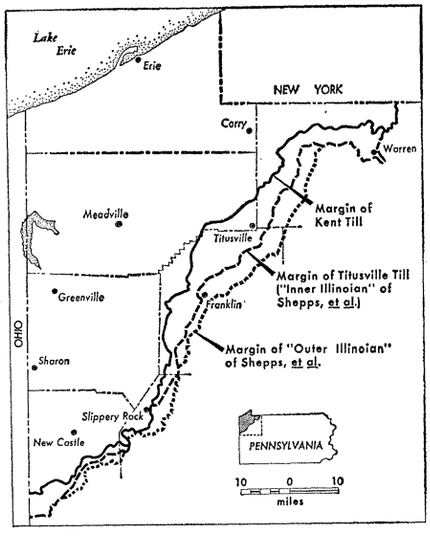

Fig. 1. Glacial boundaries in northwestern Pennsylvania (*2*); 1 mile = 1.6 km.

corded in detail (*5*). The Titusville Till is the surface material between the eastern boundary of that till and the boundary of the Kent Till (Fig. 1). It is overlain by the Kent Till west of the Kent margin. The Titusville Till is usually underlain by sand or gravel ranging from a fraction of an inch to 15 feet in thickness, which in turn lies upon bedrock or upon till of an as yet unknown age.

The Titusville Till is correlated with the Mogadore Till (*6*) of the Akron, Ohio, region and with the Millbrook Till (*7*) of the Killbuck glacial lobe. Its age corresponds almost exactly with that of till previously called "Illinoian" near Lake Geneva, Wisconsin, reported by Black as being 31,800 ± 1,200 years old (*8*) and correlated by him as "Farmdale of Shaffer," a till at the surface in NW Illinois (*9*), which has recently been given the rock-stratigraphic name of Winnebago Till (*10*).

The Kent Till, which is considerably younger than the Titusville Till, has a minimum age of 14,000 years on the basis of dating of marl in a kettle hole near Corry, Pennsylvania (*11*) and is probably correlative with Shelbyville or other tills of Tazewell age in Illinois (*10*), or it may be just slightly younger. The Kent Till is considerably younger than the Titusville Till because there was a pre-Kent and post-Titusville episode of weathering. Organic material beneath tills at Otto, New York, about 65 miles northeast of Titusville, are dated at 52,000 and 63,900 years (*12*) and are therefore older than the peat at Titusville. It is tempting to speculate that the lower of the two upper tills at Otto (Muller's unit 7, *12*) may be correlative with the Titusville Till. The Titusville Till is younger than any of the pre-Farmdalian tills so far dated by Dreimanis in southern Ontario (*13*). The Titusville Till is younger than a pre-Farmdalian till of the Scioto glacial lobe at Gahanna, Ohio, which has been dated (*14*) at 46,600 ± 2,200 years. The relation of the Titusville Till to "early Wisconsin" till near Sydney, Ohio, described by Forsyth (*15*) is uncertain. The Titusville Till may be of about the same age as the Fayette drift of southeastern Indiana described by Gooding (*16*).

In terms of the classification proposed by Frye and Willman (*10*) for the Lake Michigan lobe drifts, the Titusville Till is correlative with the Winnebago Till of northern Illinois (formerly called "Farmdale"), which is pre-Shelbyville of the Woodfordian and pre-Farmdalian and late Altonian in age. The Titusville Till is not Illinoian, but provides evidence for a widespread pre-Farmdalian post-Sangamonian glaciation in the Grand River lobe in western Pennsylvania and northwestern Ohio.

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Temperature Dependence of Carbon Isotope Composition in Marine Plankton and Sediments

Abstract. *Samples of marine plankton collected in high-latitude areas of the South Atlantic where surface water temperatures are near 0°C show a carbon-12 enrichment of 6 per mill relative to samples collected where temperatures are about 25°C. The organic carbon in sediments in the Drake Passage and Argentine Basin also shows a carbon-12 enrichment relative to warmer areas.*

Previous studies (*1–4*) of the isotopic composition of the organic carbon in marine organisms included few samples of marine plankton. Since knowledge of the composition of this group is necessary for understanding the variations observed in marine sediments and petroleum, the work described in this paper was undertaken.

Twenty-five samples of plankton were collected from widely different geographical locations (Table 1) with a ½-meter net with a mesh aperture of 202 μ by workers on Vema cruise No. 18 in 1962 and Eltanin cruises No. 12 and No. 13 in 1964. Samples Nos. 11 and 12 were immediately passed through a glass fiber filter and dried. All the others were kept frozen until analyzed. Samples 1–10, 13, and 22, analyzed at Jersey Production Research Company (JPR) were filtered as described. The remaining samples, analyzed in the Geochemistry Laboratory at the Lamont Geological Observatory, were dried at reduced pressure. Most of the samples had a dry weight over 100 mg; the Antarctic samples were about 1 g or more. One of us (A.H.B.) carefully examined parts of these samples and made the estimates listed in the table on the relative amounts, by weight, of phyto- and zooplankton. No land-derived organic debris was detected.

Homogenized portions of the dried organisms were subjected to combus-