Structure and mineralogy of a sediment core from the Colville River delta, Alaska

By W. Fürbringer and H. J. Walker *

Summary: In August 1971, sedimentological field work was carried out by the authors in the Colville River delta, Alaska. Short cores (length up to 1 m) were taken from several deltaic environments and analyzed for structure and composition. Results are presented here from one characteristic sediment profile.
The research reported was supported by the Arctic Program and Geography Programs, Office of Naval Research.

Zusammenfassung: Im August 1971 wurden von den Verfassern Feldarbeiten zur Sedimentologie des Colville Deltas, Alaska, durchgeführt. An charakteristischen Delta-Standorten wurden Probenkerne (Länge bis zu 1 m) gezogen und auf Strukturen und Mineralogie hin untersucht. Methoden und Ergebnisse werden stellvertretend an einem charakteristischen Profil demonstriert.
Die Arbeiten wurden unterstützt von: Arctic Program and Geography Programs, Office of Naval Research.

Introduction

Arctic river deltas have been the object of relatively little research. Petroleum discoveries in the Arctic have resulted in a sudden increase in the interest in such environments. One of the deltaic systems which has recently received much attention is that of the Colville River which is located near Prudhoe Bay, Alaska. However, even to date, most studies have been cursory not only because of the recency of interest in the area but also because of the logistic problems attendant with detailed investigations in this remote environment. The results of studies dealing with the chemical and nutrient nature of the seawater (Kinney et al, 1971, 1972; Walker and Ho, 1971), of sea ice

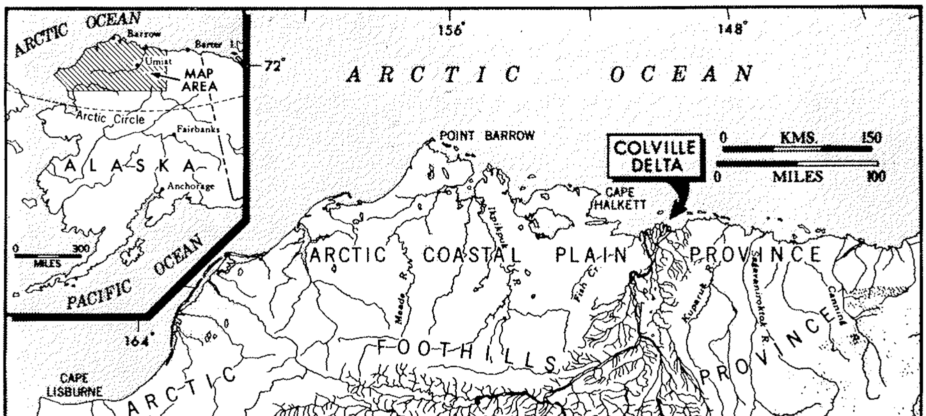

Fig. 1: Arctic Alaska and the Colville River delta.
Abb. 1: Nordalaska mit Colville Delta.

---

* Dr. Werner Fürbringer, Dept. of Geography, University of Munich, was a Post-Doctoral Fellow with the Department of Geography and Anthropology, Louisiana State University, at time the resarch reported on here was conducted.

Dr. H . J. Walker, Professor of Geography and Research Associate in Costal Studies Institute at Louisiana State University, Baton Rouge, Louisiana, U.S.A.

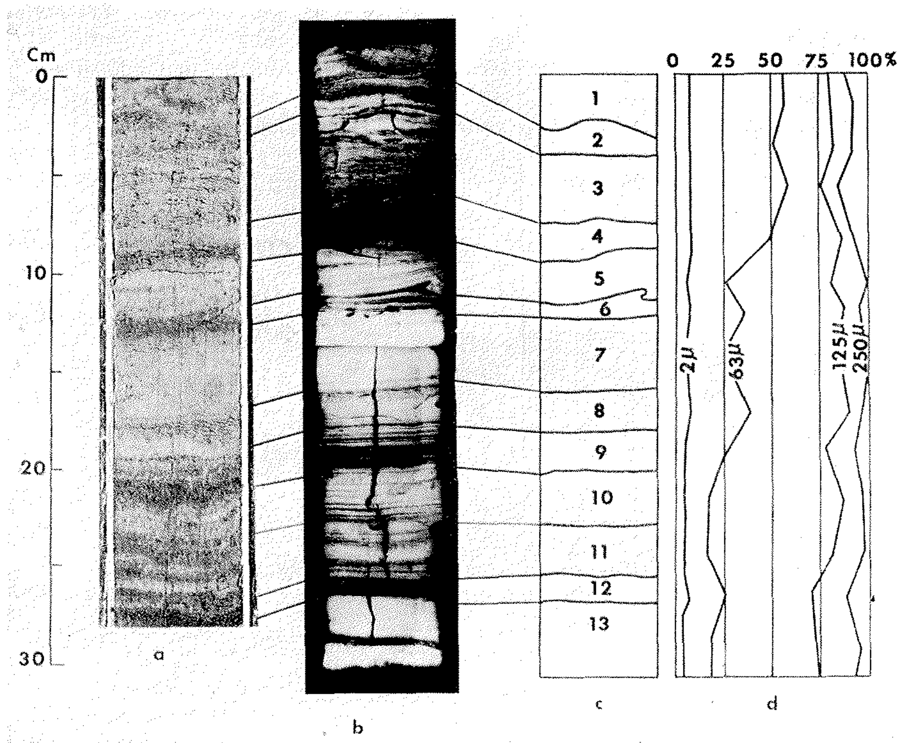

Fig. 2: Core no. 331. a. photograph, b. radiograph, c. band numbers, and d. grain size distribution.
Abb. 2: Profil Nr. 331: a. Photographie, b. Radiographie, c. Schichtnummern, d. Korngrößenverteilung.

breakup (Reimnitz and Bruder, 1972; Walker, 1973) and of clay mineralogy (Naidu et al, 1971) are only now becoming available.

The Colville River which drains 60,000 km^2 of the North Slope of Alaska flows from the Brooks Range across the Arctic Foothills and Arctic Coastal Plain Provinces to the Arctic Ocean (Fig. 1). There the river has created a 610 km^2 delta which is actively advancing northward. About 75% of the annual discharge of the Colville River flows through the eastern branch; most of the rest moves through the western branch (Arnborg et al, 1966).

In 1971, short cores were taken from several deltaic environments and analyzed for structure, texture and composition. The results of these analyses for core no. 331, obtained from a bar off the mouth of the eastern branch in 1.6 m of water, are presented here for the purpose of adding a new dimension (the vertical) to the knowledge about the near-shore bottom sediments of the subaqueous portion of the Colville delta.

Texture and Structure

This core, like the others, was returned to the laboratory in the plastic tube (7.5 cm in diameter) in which it was collected and was prepared by cutting in half lengthwise with a bandsaw. One side was photographed with Kodak Panatomic-X film (Fig. 2a); the other was cut into slabs one cm thick and x-rayed with Kodak Type M film (Fig. 2b) after the technique outlined by Hamblin (1962). Light colored areas on the print of the radiograph represent high x-ray absorption; dark areas, low x-ray absorption.

Lithologically, core 331 consists of a series of layers of fine sands and silts (Fig. 2b). Many of these mineral bands are separated by thin layers of peat, riverborne woodchips

and other plant fragments most of which are highly elongated. The core was divided into 13 bands (Fig. 2c), each of which was individually analyzed.
The texture of these bands was determined by using the standard methods of sieving and pipette analysis. The variation of grain size vertically is shown in Fig. 2d. Cumulative curves for three of the bands (bands 4, 8 and 10) have been graphed as Fig. 3. The core, which ranges in grain size from less than 2 μ to over 400 μ, contains approximately 10% medium and fine sand, 50% very fine sand, 30% silt and 10% clay.

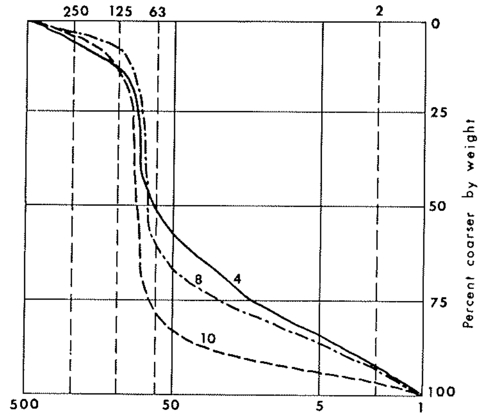

Fig. 3: Grain size distribution for selected bands, core no. 331.
Abb. 3: Korngrößensummenkurven ausgewählter Sedimentschichten, Profil Nr. 331.

Three structurally distinct types of laminae stand out on the radiograph; namely: 1. relatively undisturbed parallel laminae, 2. disturbed parallel laminae and 3. cross-laminae. Parallel laminae which have been relatively undisturbed are the most common. These layers are especially well preserved in the lower half of the core. The thickness of the parallel layers varies greatly. No evidence suggesting seasonal layering was detected.
The parallel laminae in the upper half of the core have been disturbed, apparently by reworking of the sediment by currents, waves and possibly sea ice (Walker, 1970). Gas heave and burrowing animals have had little, if any, effect on the core.
Those layers which are more or less steeply inclined to the principal surfaces of accumulation form cross-laminae (Allen, 1968). An example of this stratification type is seen in band 6 (Fig. 2). The cross-laminae in this core are apparently the result of varying currents, although again ice shove after deposition could have been responsible.

Clay Minerals

The clay mineralogy of the 13 bands was studied by the x-ray diffraction method. Samples of the minus 2 μ clay fraction were placed on glass slides from suspensions which had been treated with H_2O_2 in order to remove the organic matter. After air drying, the samples were analyzed with a Norelco x-ray diffractometer using Cu Kα radiation.

The diffraction patterns of all 13 samples show basically the same mineral assemblage. The x-ray curve for band 9 (Fig. 4) is typical. The untreated sample shows good peaks for illite, kaolinite, montmorillonite and quartz (an accessory mineral). Because of the proximity of the first-order reflection of kaolinite and the second-order reflection of chlorite near 7 Å, chlorite is not visible on the diffractogram of the untreated sample. Therefore, diffraction patterns were obtained after heat-treating the samples at 600° C for one hour (Grim, 1968). Upon heating to 600° C both kaolinite and montmorillonite

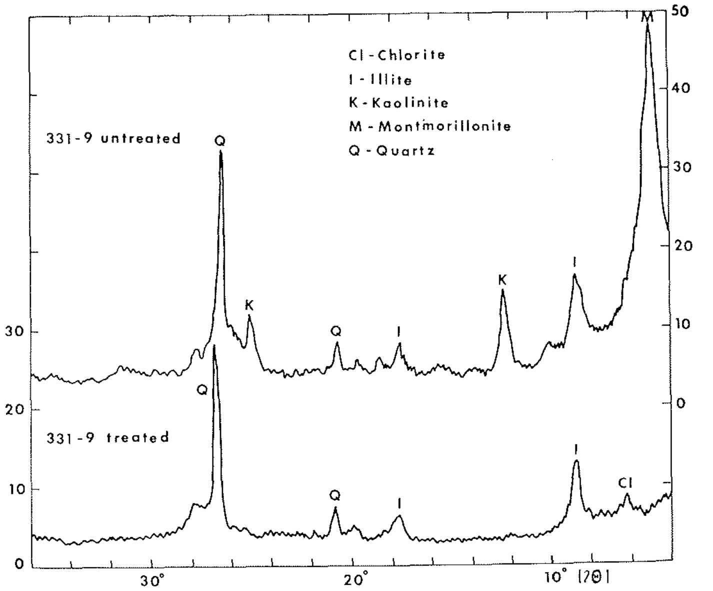

Fig. 4: X-ray diffractograms of the clay mineral assemblage, band 9, core no. 331.
Abb. 4: Diffraktogramme der Fraktion < 2 μ, Schicht 9, Profil Nr. 331.

loose their crystalline character whereas chlorite is only partially dehydrated and thus shows up as a peak on the trace (Fig. 4).
Although there is no universally accepted method for precisely quantifying the clay components of sediment samples (Pierce and Siegel, 1969) relative abundances have been estimated by calculation of the area beneath the peaks of each mineral (Naidu, Burrell and Hood, 1971). Using this scheme the samples for the 13 bands of core 331 show that montmorillonite is the most abundant clay mineral. Kaolinite and illite are about equal in amount although kaolinite is slightly more abundant in 8 of the 13 bands than illite, one of which is band 9 (Fig. 4). Chlorite, by this method of determination, is the least abundant of the clay minerals in the samples examined.
The report by Naidu, Burrell and Hood (1971) which deals with the clay minerals of some Beaufort Sea sediments includes the analyses of one sample from the Colville River. The clay mineral assemblages in our cores are similar to that in the sample analyzed earlier by Naidu et al.

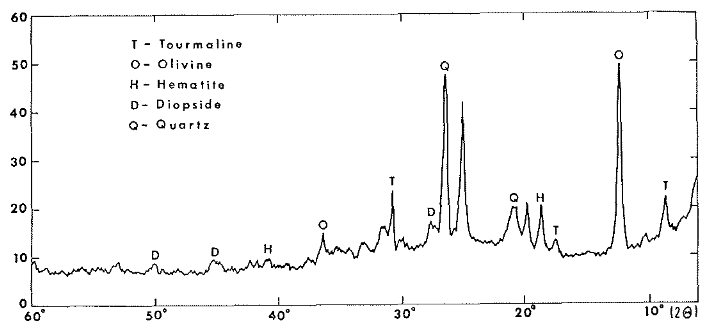

Fig. 5: Typical x-ray diffractogram of the heavy mineral assemblage, core no. 331.
Abb. 5: Diffraktogramm der Schwermineralien, Profil Nr. 331.

Heavy Minerals

The heavy minerals in the 13 bands were determined basically by using the procedure outlined by Ferrell (1971). After the minerals were separated by the use of bromoform they were ground into a fine-grained powder. This powder was prepared for x-ray by drying a sample from suspension onto a glass slide. Air-dried samples were x-rayed from 6° 2Θ through 60° 2Θ at 2 degrees/minute in a Norelco x-ray diffractometer using Cu $K\alpha$ radiation at 40 KV and 20 mA.

A typical x-ray diffraction pattern from core 331 is presented as Fig. 5. The major heavy minerals identified are: olivine, tourmaline, diopside and hematite. An examination of selected samples by microscope confirmed the presence of all of these minerals.

Acknowledgements

The research reported here was supported by the Arctic Program and Geography Programs, Office of Naval Research, under Contract NOOO14-69-A-0211-0003, Project NR 388 002, with Coastal Studies Institute, Louisiana State University. Logistic support was provided by the Naval Arctic Research Laboratory, Barrow, Alaska.

We wish to thank H. Roberts, Coastal Studies Institute, for assistance with the radiography, R. E. Ferrell, Department of Geology, for laboratory and technical assistance and W. E. Harrison, Department of Geology, for assistance in the microscopic identification of the heavy minerals.

References

Allen, J. R. L., Current ripples, Amsterdam, 1968.

Arnborg, L., H. J. Walker and J. Peippo, Water discharge in the Colville River, Alaska, 1962, Geogr. Ann., 48, 195—210, 1966.

Ferrell, R. E. Jr., X-ray diffraction of heavy minerals, in Quaternary Geology of the Louisiana continental shelf, USGS Tech. Rept. 3, 1971.

Grim, R. E., Clay mineralogy, 2nd ed., New York, 1968.

Hamblin, W. K., X-ray radiography in the study of structures in homogeneous sediments, Journ. Sed. Petrol., 32, 201—210, 1962.

Kinney, P. J., D. Schell, V. Alexander, S. Naidu, C. McRoy and D. Burrell, Baseline study of the Alaskan arctic aquatic environments: eight months progress report, 1970, Institute of Marine Science, Univ. of Alaska, 1971.

Kinney, P. J., D. Schell, V. Alexander, D. Burrell, R. Cooney and S. Naidu, Baseline study of the Alaskan arctic aquatic environment, Institute of Marine Science, Univ. of Alaska, 1972.

Naidu, A. S., D. Burrell and D. Hood, Clay mineral composition and geologic significance of some Beaufort Sea sediments, Journ. Sed. Petrol., 41, 691—694, 1971.

Pierce, J. W. and F. R. Siegel, Quantification in clay mineral studies of sediments and sedimentary rocks, Journ. Sed. Petrol., 39, 187—193, 1969.

Reimnitz, E. and K. Bruder, River discharge into an ice-covered ocean and related sediment dispersal, Beaufort Sea, coasts of Alaska, Geol. Soc. Amer. Bull., 83, 861—866, 1972.

Walker, H. J., Some aspects of erosin and sedimentation in an arctic delta during breakup, in Symposium on the Hydrology of Deltas, 11, 209—219, Unesco, Louvain, Belgium, 1970.

Walker, H. J., Spring discharge of an arctic river determined from salinity measurements beneath sea ice, Water Resources Research, 9, 474—480, 1973.

Walker, H. J., C. Ho and J. Lane, Nutrient distribution in the sub-ice waters of the Colville River delta, Alaska, in Abstract Volume, Second National Coastal and Shallow Water Research Conference, 248. Office of Naval Research, Washington, D. C., 1971.