Environment Canada / Environnement Canada

National Water Research Institute / Institut National de Recherche sur les Eaux

DATA ON NEARSHORE SAND AND GRAVEL DEPOSITS IN LAKE ERIE

by

N.A. Rukavina

Inland Waters Directorate / Direction Générale des Eaux Intérieures

Rukavina (40)

Study 83-352

Report prepared for The Ontario Ministry of Natural Resources

Industrial Minerals Section

LIMITED DISTRIBUTION

DATA ON NEARSHORE SAND AND GRAVEL DEPOSITS IN LAKE ERIE

by

N.A. Rukavina

Shore Processes Section
Hydraulics Division
National Water Research Institute
Canada Centre for Inland Waters

December 1983

TABLE OF CONTENTS

1.0 INTRODUCTION

This report summarizes NWRI data on the major Canadian nearshore sediment deposits of Lake Erie. It has been prepared in response to a request from the Industrial Minerals Section of the Ontario Ministry of Natural Resources (Appendix 1) for a compilation of existing data useful to the assessment of Lake Erie nearshore deposits as reserves of sand and gravel. The report consists of a series of maps and tables indicating the extent, grain-size, depth range and thickness of nearshore deposits at Pelee, Long Point, and Port Maitland (Figure 1), and a documentation of the procedures used to acquire and compile the data. Deposits at Rondeau and Fort Erie-Buffalo (Appendix 1) have not been included because they are respectively too small in extent and too fine-grained.

2.0 BACKGROUND

2.1 General

The data reported herein were collected during a program of nearshore sediment surveys undertaken by the Hydraulics Division of the National Water Research Institute to map the bottom sediments of the nearshore zone of the Great Lakes in the depth range 0-20 m. Surveys based on collection of surface sediment samples and echo-sounding data were conducted in eastern Lake Erie in 1970-71 (Rukavina and St. Jacques, 1971), in central Lake Erie in 1972-74 (St. Jacques and Rukavina, 1973; Rukavina and St. Jacques, 1978), and western Lake Erie in 1975. The survey results indicate that there are three major deposits of sand- and gravel-rich sediment in nearshore Lake Erie (Figure 1). They occur at Pelee, Long Point and Port Maitland and consist of a combination of residual crestal deposits on submerged moraines, and littoral deposits on the inshore slope (Rukavina, 1976). The balance of the nearshore zone consists mainly of exposed and eroding bedrock (the eastern basin) or glacial sediment (the central basin), fine-grained fluvial deposits (the western basin), and small, littoral deposits on the updrift side of shoreline promonitories.

Delineation of the areas of unconsolidated sediment by the original surveys was followed by jetting surveys to establish sediment thickness and coring surveys to determine sediment variability with depth. Jetting surveys were conducted in 1973-74 and coring surveys in 1974-76.

2.2 Field Survey Procedures

Bottom sediment samples were collected with a Shipek sampler (Sly, 1969) and sub-samples for grain-size analysis, with a small box sampler which removes a 5-cm square, 3-cm thick portion of the surface sediment.

Echo sounder surveys were run to hydrographic standards with an Atlas Deso 10 sounder (30 kHz, 200 kHz). Sounding traverses were run along north-south or east-west lines at a 0.5- or 1-km spacing with positional fixes at intervals of about 250 m. Accuracy of depth readings was ±0.3 m.

The thickness of modern sediments was measured by hydraulic jetting to refusal (Appendix 10), a procedure which uses a high-speed, high-pressure water jet to fluidize and penetrate the sediment column. Depth of the sediment-water interface and of the sediment base were read from 0.25 m calibrations on the jet pipe and hose. Dependent upon working conditions, accuracy of site depth and sediment thickness measurements ranged from ±0.25 to ±0.5 m.

Sediment cores were collected with a Benthos corer (Sly, 1969), or with an impact corer (Sly and Gardener, 1970) powered by compressed air or a hydraulic pump. Water depth at the core sites was measured by echo sounder with an accuracy of ±0.5 m.

Electronic positioning equipment was used to locate sampling sites and echo-sounding traverses. Fix accuracy depends upon the position of the site relative to shore reference stations, accuracy of shore station positions, equipment errors, and weather and sea state. Conservative estimates of fix accuracy based on the first three factors are as follows:

Sample sites, echo-sounding fixes:	Pelee	- ± 25 m
	Long Point	- ±100 m
	Port Maitland	- ± 25 m
Jet sites:	Pelee	- ± 25 m
	Long Point	- ±200 m
	Port Maitland	- ±100 m
Core sites:	Pelee	- ± 25 m
	Long Point	- ± 50 m
	Port Maitland	- ± 25 m

2.3 Laboratory Analysis

Sub-samples of the Shipek bottom sediment samples were analyzed for grain size with the standard procedures of the NWRI Sedimentology Laboratory (Appendix 11). Reproducibility of the method is in the range of 2-4 percent for grain size expressed in terms of class percentages (gravel/sand/silt/clay) (Rukavina and Duncan, 1970). Size statistics were computed and formatted by the computer program SIZDIST (Appendix 12).

Sediment cores were split, x-radiographed, and logged. One or more channel samples were collected from each unit for grain-size analysis. Selected cores were analyzed for fossil pollen.

3.0 DATA COMPILATION

The terms of reference of this report (Appendix 1) specify a series of maps and data listings for the sediment deposits, and specifically for the portion of the deposits with a combined sand and gravel content greater than 90 percent. The approach used to select and assemble the data was as follows:

1. Plot the sand and gravel content for the bottom samples and determine the position of the 90 percent contour. Appendix 3 is the resultant plot and Appendix 2 is the site map for the bottom sample, jet and core stations selected.
2. Select sounding fixes falling within the 90 percent contours and draw depth contours at 2-m intervals. Plots are shown in Appendix 5 with sample station depths superimposed.
4. Produce SIZDIST listings of grain-size data for the selected bottom samples and core samples. The output format for size data has been altered from that described in Appendix 12. Size-fraction boundaries have been described in millimetres rather than the logarithmic PHI units conventionally used. Listings of size data appear in Appendix 6.
5. Summarize field data for bottom sediment samples in Appendix 7.
6. Edit field data for jet sites and summarize in tabular form in Appendix 8.
7. Merge field data and descriptive logs for sediment cores, edit to produce a consistent format and list in Appendix 9.
8. All maps in Appendices 2 to 5 have the same scale, shoreline and UTM reference coordinates and have been produced on transparent film so that they may be overlaid on each other or on the 1:50000 scale maps of the National Topographic Series.

4.0 LIMITATIONS OF THE DATA

This report is based solely on data from the files of the NWRI Nearshore Sediment Survey program. No other data sources have been used.

Accuracy of the individual depth, grain-size, thickness and positional data has already been discussed. In the preparation of contour maps, continuity of data has been assumed over distances of 1 km (depth data) to as much as 3 km (grain-size and thickness data). Reliability of contour position should be judged accordingly.

The jetting procedure measures the thickness of unconsolidated sediment over a sub-bottom horizon which resists penetration. Where the underlying bottom type is rock, boulders or cohesive glacial sediment, refusal is abrupt and unconsolidated sediment thickness is well-defined. In some cases, however, sediment base is difficult to define because penetration continues at a reduced rate. This tends to occur in coarse gravels where high permeability reduces the cutting action of the jet, or in softer glaciolacustrine sediments which permit penetration by the jet, but at a slower rate. Notes in Appendix 7 indicate where thickness is uncertain.

Grain-size data in Appendix 3 refer to the grain size of surface sediments and do not necessarily apply at depth. Size data for sediment cores (Appendix 6) should be consulted for local trends in grain size with increasing depth in the deposit.

The three major deposits described in this report account for only a small proportion of the gravel in the nearshore zone. Gravel tends to be associated instead with areas of exposed and eroding glacial sediments, where it develops as a thin, discontinuous lag deposit, the residue of selective erosion of the finer sizes of the parent glacial material. Gravel is difficult to sample adequately with the Shipek sampler and difficult to distinguish from underlying glacial material in echo-sounder records because of its low concentration and patchy distribution. Proper definition of gravel occurrence would require more detailed surveys based on some combination of underwater television or diver observation, and collection of diver or dredge samples.

ACKNOWLEDGEMENTS

D.A. St. Jacques was the field officer responsible for the nearshore sampling and sounding surveys. G. LaHaie managed the jetting and coring surveys and logged the sediment cores. G. Duncan and NWRI Sedimentology Laboratory staff ran the grain-size analyses.

REFERENCES

Duncan, G.A. and G.G. LaHaie. 1979 Size analysis procedures used in the Sedimentology Laboratory, NWRI - Manual. NWRI Unpublished Report.

Rukavina, N.A. 1976. Nearshore sediments of Lakes Ontario and Erie. Proc. Great Lakes Basin Symposium, May 1975. Geoscience Canada, v. 3, p. 185-190.

Rukavina, N.A. and G.A. Duncan. 1970. F.A.S.T. - Fast analysis of sediment texture. Proc. 13th Conf. Great Lakes Res., IAGLR, p. 274-281.

Rukavina, N.A. and D.A. St. Jacques. 1971. Lake Erie nearshore sediments, Fort Erie to Mohawk Point, Ontario. Proc. 14th Conf. Great Lakes Res., IAGLR, p. 387-393.

Rukavina, N.A. and G.G. LaHaie. 1977. Measurement of thickness of nearshore sands by hydraulic jetting. NWRI Hydraulics Division Technical Note 77-13

Rukavina, N.A. and D.A. St. Jacques. 1978. Lake Erie nearshore sediments, Point Pelee to Port Burwell, Ontario. IWD Scientific Series No. 99, 44 p.

St. Jacques, D.A. and N.A. Rukavina. 1973. Lake Erie nearshore sediments, Mohawk Point to Port Burwell, Ontario. Proc. 16th Conf. Great Lakes Res., IAGLR, p. 454-467.

Sandilands, R.G. and G.A. Duncan. 1980. SIZDIST - A computer program for size analysis. NWRI Hydraulics Division Technical Note 80-08.

Sly, P.G. 1969. Bottom sediment sampling. Proc 12th Conf. Great Lakes Res., IAGLR, p. 883-898.

Sly, P.G. and K. Gardener. 1970. A vibro-corer and portable tripod-winch assembly for through-ice sampling. Proc. 13th Conf. Great Lakes Res. IAGLR, p. 297-307.

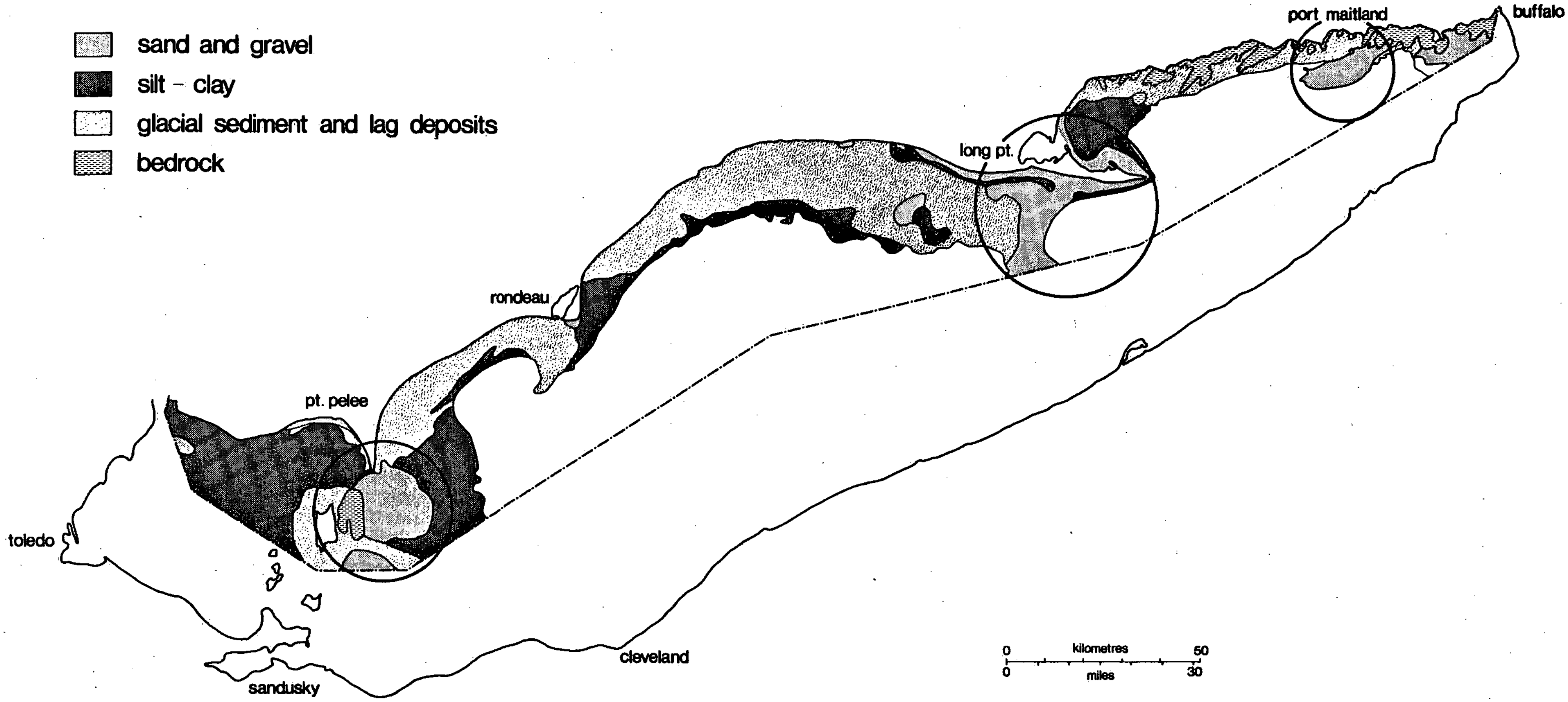


Figure 1. Lake Erie Nearshore Sediments (after Rukavina, 1976)

APPENDIX 1

MEMORANDUM OF UNDERSTANDING

BETWEEN

THE PROVINCE OF ONTARIO

(MINISTRY OF NATURAL RESOURCES, INDUSTRIAL MINERALS SECTION)

AND

THE GOVERNMENT OF CANADA

Date 21 June 1983

Preamble

The Ontario Ministry of Natural Resources has requested nearshore sediment information for the Niagara, Burlington, Toronto and Presqu'ile areas of Lake Ontario and the Buffalo-Fort Erie, Port Maitland, Long Point, Rondeau and Pelee areas of Lake Erie. In particular, the following has been requested for all surface, jetting and core samples as per existing N.W.R.I. data defined by the greater than 90% total sand and gravel fraction:

1. Key maps at 1:50,000 scale, showing:
   - i) all station locations, referenced to U.T.M. co-ordinates,
   - ii) sample numbers,
   - iii) shoreline.

2. Maps at 1:50,000 scale showing:
   - i) shoreline,
   - ii) sample locations and sample numbers,
   - iii) size distribution:
     - a) % sand and gravel,
     - b) % gravel (greater than approx. 1/4 inch)

       contoured at

       1) 90% sand and gravel,

       2) 35% gravel (greater than approx. 1/4 inch),

       and patterned or toned (shaded).

3. Maps at 1:50,000 scale showing:

   i) shoreline,

   ii) sample locations and sample numbers,

   iii) deposit thickness (from jetting and core samples where available), to be contoured if practicable.

4. Maps at 1:50,000 scale showing:

   i) shoreline,

   ii) sample locations and sample numbers,

   iii) spot water depths at sample locations,

   iv) 2 meter water depth contours developed from more detailed echo sounding data.

5. A listing of percentage size distributions of the sand and gravel fractions.

6. A listing of U.T.M. coordinates for each sample location with the year of sampling, corrected water depths, and related data.

7. Logs of sediment cores and listings of available grain-size data.

8. A brief descriptive appendix on,

   i) the field jetting procedure,

   ii) comments on limitations and defensibility of the data,

iii) the size analysis procedure,

iv) the statistical analysis by computer,

v) reasons for selecting the four areas in Lake Ontario and five in Lake Erie.

Staff of the Hydraulics Division will undertake this work and prepare two reports, one for Lake Ontario, and one for Lake Erie data. Four copies of each report will be provided to the Ministry of Natural Resources.

This proposal outlines the work conditions and cost estimates which are based in accordance with the Cost Recovery Policy of the Department of the Environment for special services.

For purposes of this memorandum of understanding, the Ontario Ministry of Natural Resources, will be called the "Contractor".

APPENDIX 2

Maps of Jet/Sample/Core Sites
(under separate cover)

APPENDIX 3

Maps of Percent Sand + Gravel
(under separate cover)

APPENDIX 4

Maps of Sediment Thickness Based on Jetting
(under separate cover)

APPENDIX 5

Maps of Depth Contours and Sample Station Depths
(under separate cover)

APPENDIX 6

Grain-Size Data
(under separate cover)

APPENDIX 7

Field Data - Bottom Sediment Samples

SAMPLE NO.	UTM NORTHING/EASTING		DEPTH IGLD(M)	DATE
E53	4744011	640001	16.0	23-06-70
E54	4742007	639996	19.3	23-06-70
E56	4743999	638000	13.1	23-06-70
E57	4742004	637993	17.1	23-06-70
E58	4740003	637998	19.5	23-06-70
E60	4744025	635993	12.7	23-06-70
E61	4742007	636009	13.5	23-06-70
E62	4740002	636011	15.2	23-06-70
E63	4738007	635991	19.9	23-06-70
E66	4741047	633722	13.3	25-06-70
E67	4740000	634007	15.5	25-06-70
E68	4738004	634013	15.5	25-06-70
E69	4736008	634001	16.5	13-07-70
E73	4740007	631979	15.6	13-07-70
E74	4738017	632010	15.1	13-07-70
E75	4735999	632018	13.1	13-07-70
E76	4734004	632030	18.4	13-07-70
E80	4740011	629984	17.1	13-07-70
E81	4738001	630000	16.2	13-07-70
E82	4736000	629993	15.1	13-07-70
E83	4733991	630022	13.6	13-07-70
E88	4738020	627989	17.5	22-07-70
E89	4735996	628008	15.7	22-07-70
E90	4733960	627864	14.9	22-07-70
E91	4731984	628047	25.9	23-07-70
E96	4738010	626015	18.6	22-07-70
E97	4736014	625994	16.0	22-07-70
E98	4734015	625983	15.1	22-07-70
E103	4737998	623992	21.1	28-08-71
E104	4735994	624003	17.8	28-08-71
E105	4733997	623998	17.1	28-08-71
E106	4732001	623999	25.2	28-08-71
E111	4735997	621994	18.4	28-08-71
E112	4734003	621999	19.7	28-08-71
E113	4731997	621995	24.2	28-08-71
E118	4735992	619988	19.0	29-08-71
E119	4733998	619999	22.0	29-08-71
E239	4718006	572010	11.5	12-05-72
E240	4716001	572005	9.0	12-05-72
E241	4713998	571990	6.1	12-05-72
E251	4718014	570014	9.9	12-05-72
E252	4716008	570011	8.2	12-05-72
E262	4717994	568001	9.2	23-05-72
E263	4716005	568007	7.8	23-05-72
E264	4714011	567986	.9	23-05-72
E275	4716004	565995	7.9	23-05-72
E276	4714017	565996	4.3	23-05-72
E287	4715996	564000	7.3	26-05-72
E288	4713995	563997	4.1	26-05-72

SAMPLE NO.	UTM NORTHING/EASTING		DEPTH IGLD(M)	DATE
E298	4716010	562003	6.3	26-05-72
E299	4713997	562008	3.4	26-05-72
E308	4716013	560004	3.7	26-05-72
E319	4712042	574018	.5	29-05-72
E320	4714004	574001	8.4	29-05-72
E321	4715999	574020	10.6	29-05-72
E323	4711999	576000	6.0	29-05-72
E324	4714005	576041	11.3	29-05-72
E326*	4712002	578049	16.4	29-05-72
E327*	4709999	578025	7.2	07-06-72
E328*	4710045	575978	13.4	07-06-72
E329	4708017	575997	33.0	07-06-72
E330*	4709915	574019	1.6	07-06-72
E331	4707986	574005	20.2	07-06-72
E332*	4709428	572064	3.2	07-06-72
E333	4708031	571993	12.9	07-06-72
E334	4709569	570001	3.2	07-06-72
E335	4708037	569993	11.6	07-06-72
E337	4709798	568013	2.8	07-06-72
E338	4708007	567996	12.2	07-06-72
E340	4709933	565984	3.8	07-06-72
E341	4708016	566002	12.9	07-06-72
E343	4709990	563995	6.2	27-06-72
E344	4707939	563949	13.7	27-06-72
E345	4706810	564472	24.9	27-06-72
E346	4709208	561739	9.8	27-06-72
E347	4708021	561995	13.7	27-06-72
E348	4705953	561971	20.4	27-06-72
E349	4709990	559982	8.5	27-06-72
E350	4708011	559991	14.2	27-06-72
E352	4710002	557995	10.2	27-06-72
E353	4707974	557980	14.6	27-06-72
E354	4705997	557987	17.8	27-06-72
E355	4711886	555963	4.4	04-07-72
E356	4709958	555953	11.4	04-07-72
E357	4707995	555956	14.5	04-07-72
E358	4706008	555972	14.0	04-07-72
E359	4704051	556106	19.2	04-07-72
E360	4711959	553942	5.4	04-07-72
E361	4709963	553941	12.1	04-07-72
E362	4708028	553985	14.6	04-07-72
E363	4706029	554013	15.3	04-07-72
E364	4704075	554018	17.1	04-07-72
E365	4701987	553953	19.1	04-07-72
E366	4700006	553996	21.5	04-07-72
E368	4710009	552007	12.5	04-07-72
E369	4707993	552005	15.2	04-07-72
E370	4704011	552010	12.8	04-07-72
E371	4700007	551993	18.5	04-07-72

* WEAK FIX

SAMPLE NO.	UTM NORTHING/EASTING		DEPTH IGLD(M)	DATE
E372	4695999	551974	20.4	07-07-72
E373	4692012	551990	19.9	07-07-72
E374	4688001	551958	18.6	07-07-72
E375	4713577	549908	1.0	07-07-72
E376	4712036	549987	9.4	07-07-72
E377	4709996	549997	12.6	07-07-72
E378	4708007	549989	15.2	07-07-72
E379	4706010	549995	15.1	07-07-72
E380	4704007	549990	15.6	07-07-72
E381	4702007	549994	12.9	07-07-72
E382	4700004	549988	14.4	07-07-72
E383	4698006	550001	14.1	07-07-72
E384	4696015	549988	17.3	07-07-72
E385	4692017	550001	15.8	07-07-72
E386	4689997	549989	14.1	07-07-72
E387	4688016	550006	13.4	07-07-72
E388	4713584	547975	3.0	12-07-72
E389	4712015	547995	9.6	12-07-72
E390	4710019	547989	12.3	12-07-72
E391	4708001	547999	14.4	12-07-72
E392	4706020	548003	15.3	12-07-72
E393	4704000	547992	16.0	12-07-72
E395	4698008	547999	14.8	12-07-72
E396	4696006	547985	13.5	12-07-72
E397	4694019	548012	13.2	12-07-72
E398	4692012	548002	14.7	12-07-72
E399	4690005	547966	16.3	12-07-72
E400	4688009	547969	17.4	12-07-72
E401	4713535	546057	2.9	12-07-72
E402	4712014	546000	9.6	12-07-72
E403	4710008	545995	12.2	17-07-72
E404	4707999	546006	14.5	17-07-72
E405	4706006	546007	17.2	17-07-72
E409	4690014	546009	17.0	12-07-72
E410	4712008	543996	8.8	19-07-72
E411	4710017	543997	12.2	19-07-72
E412	4708014	543991	15.2	19-07-72
E417*	4690007	544015	18.7	19-07-72
E418	4711993	542008	8.4	27-07-72
E419	4710018	541997	13.3	27-07-72
E425	4712029	539997	7.0	27-07-72
E427	4708014	540003	14.7	01-08-72
E428	4706004	540005	16.3	01-08-72
E1104	4639989	377795	10.2	08-06-74
E1109	4638026	376003	5.4	16-07-74
E1110	4638043	378005	9.0	09-06-74
E1111	4638139	380011	11.1	09-06-74
E1113	4637902	384070	13.5	09-06-74
E1119	4636009	376010	6.0	16-07-74

* WEAK FIX

SAMPLE NO.	UTM NORTHING/EASTING		DEPTH IGLD(M)	DATE
E1120	4636032	378011	6.0	16-07-74
E1121	4635875	379959	10.8	09-06-74
E1122	4635883	381947	12.0	09-06-74
E1123	4636037	384053	12.3	09-06-74
E1124	4636291	385900	13.2	09-06-74
E1127	4634018	376007	6.7	16-07-74
E1128	4634013	378017	6.4	16-07-74
E1129	4634199	380079	10.8	09-06-74
E1130	4634119	382074	10.8	09-06-74
E1131	4634122	384102	11.4	09-06-74
E1132	4634057	386026	12.6	09-06-74
E1133	4634010	388018	14.1	09-06-74
E1138	4632022	376030	11.2	16-07-74
E1139	4632084	378059	5.9	16-07-74
E1140	4631913	380141	10.0	10-06-74
E1141	4632039	382011	10.6	10-06-74
E1142	4631798	383903	11.2	10-06-74
E1143	4632345	385994	12.7	10-06-74
E1144	4631982	388022	13.9	10-06-74
E1145	4630056	375997	10.8	16-07-74
E1146	4630014	378016	11.5	16-07-74
E1147	4630102	379981	11.8	10-06-74
E1148	4630047	382137	11.5	10-06-74
E1149	4630001	383970	12.1	10-06-74
E1150	4630003	385979	13.0	10-06-74
E1151	4629906	388075	14.2	10-06-74
E1156	4628162	376040	11.2	10-06-74
E1157	4628064	378021	9.9	16-07-74
E1158	4627918	379877	11.5	10-06-74
E1159	4627965	381905	12.1	10-06-74
E1160	4627996	384033	12.4	10-06-74
E1161	4628067	386057	13.3	10-06-74
E1163	4625814	376059	10.0	10-06-74
E1164	4625971	378098	11.5	10-06-74
E1165	4625963	379987	12.1	10-06-74
E1166	4626012	382054	12.4	10-06-74
E1167	4626095	384122	13.0	10-06-74
E1212	4615902	368118	10.7	03-06-75
E1213	4616020	366214	10.4	03-06-75
E1214	4616103	363777	8.8	03-06-75
E1220	4618092	368134	10.4	03-06-75
E1221	4617979	366068	8.5	03-06-75
E1222	4617974	364025	6.1	03-06-75
E1223	4617989	361998	5.3	11-08-75
E1224	4617989	360002	8.0	11-08-75
E1225	4619959	374134	11.0	03-06-75
E1226	4620039	372084	10.7	03-06-75
E1227	4620005	370185	10.4	03-06-75
E1228	4620055	367879	9.8	03-06-75

SAMPLE NO.	UTM NORTHING/EASTING		DEPTH IGLD(M)	DATE
E1231A	4619980	361999	4.4	11-08-75
E1233	4621944	372081	9.2	03-06-75
E1234	4621935	370111	9.8	03-06-75
E1239	4624024	373731	11.2	10-06-74
E1240	4623920	371839	10.9	10-06-74
E1241	4624001	370003	7.9	03-06-75
E1242	4623870	368120	10.1	03-06-75
E1244	4625636	373975	10.9	10-06-74
E1245	4625843	372021	10.3	10-06-74
E1247	4626015	367903	8.8	03-06-75
E1249	4627998	373665	10.6	10-06-74
E1250	4628040	372068	9.1	10-06-74
E1251	4628059	370028	9.8	03-06-75
E1252	4628086	367909	8.8	03-06-75
E1254	4630181	374048	10.4	03-06-75
E1255	4630027	371986	9.8	03-06-75
E1257	4629956	368126	7.9	03-06-75
E1262	4632001	367999	5.8	03-06-75
E1267	4633811	373855	11.0	03-06-75
E1270	4634106	367993	7.6	03-06-75
E1275	4635797	373881	9.5	03-06-75
E1276	4636005	371967	11.3	03-06-75
E1283	4637858	373970	8.2	03-06-75
E1284	4637958	371977	10.1	03-06-75
E1292	4640042	372065	9.1	04-06-75

APPENDIX 8

Jetting Data

STATION NO.	DATE	UTM NORTHING	UTM EASTING	DEPTH, M (IGLD)	DEPTH TO REFUSAL, M	NOTES
JE36	19-06-73	4745230	641938	15.4	1.50	BOTTOMED ON BEDROCK.
JE37	19-06-73	4743709	640466	17.5	2.00	BOTTOMED ON BEDROCK.
JE38	18-06-73	4742837	638647	16.9	4.25	BOTTOMED ON BEDROCK?
JE38A	13-08-73	4742928	638353	16.6	4.00	BOUNCED HARD THROUGHOUT PENETRATION. BOTTOMED ON GLACIAL SEDIMENT.
JE39	18-06-73	4742867	636610	13.2	2.75	BOTTOMED ON BEDROCK.
JE39A	13-08-73	4742882	636402	13.3	3.50	BOTTOMED ON GLACIAL SEDIMENT.
JE40	18-06-73	4740868	636839	15.0	3.50	LAST METRE OF PENETRATION WAS THROUGH STIFF SEDIMENT. BOTTOMED ON BEDROCK.
JE40A	13-08-73	4740829	636384	16.4	4.25	BOUNCED HARD AT BASE. BOTTOMED ON GLACIAL SEDIMENT.
JE41	18-06-73	4738751	636408	20.4	1.75	BOTTOMED ON GLACIAL SEDIMENT.
JE42	18-06-73	4742789	634496	13.7	3.75	BOTTOMED ON BEDROCK.
JE42A	13-08-73	4742726	634023	14.1	3.50	BOUNCED DURING PENETRATION. BOTTOMED ON BEDROCK?
JE43	18-06-73	4740698	634717	14.4	4.75	PENETRATED GLACIAL SEDIMENT IN LAST METRE. BOTTOMED ON BEDROCK?
JE43A	13-08-73	4740720	633988	16.1	4.50	BOTTOMED ON GLACIAL SEDIMENT.
JE44	18-06-73	4738553	634976	17.0	5.25	BOTTOMED ON BEDROCK.
JE44A	13-08-73	4738507	634328	16.4	5.25	BOUNCED THROUGH FIRM SEDIMENT WHICH GOT STIFFER TOWARDS THE BASE. BOTTOMED ON GLACIAL SEDIMENT.
JE45	18-06-73	4736601	635085	17.8	4.75	BOTTOMED ON BEDROCK.
JE45A	13-08-73	4736444	634489	17.6	5.25	BOUNCED THROUGH VERY HARD SEDIMENT NEAR THE BASE. BOTTOMED ON GLACIAL SEDIMENT.

STATION NO.	DATE	UTM NORTHING	UTM EASTING	DEPTH, M (IGLD)	DEPTH TO REFUSAL, M	NOTES
JE46	19-06-73	4740658	632747	16.9	2.00	BOTTOMED ON BEDROCK.
JE46A	13-08-73	4740811	632117	16.5	.75	BOTTOMED ON GLACIAL SEDIMENT.
JE47	19-06-73	4738504	632648	16.5	4.50	STIFF SEDIMENT AT BASE. BOTTOMED ON GLACIAL? SEDIMENT.
JE48	19-06-73	4736562	632647	14.2	5.50	BOTTOMED ON BEDROCK.
JE48A	13-08-73	4736732	632084	15.1	5.25	VERY HARD BASE. BOUNCED DURING PENETRATION. BOTTOMED ON GLACIAL SEDIMENT.
JE49	19-06-73	4734553	633174	20.4	2.50	BOTTOMED ON BEDROCK.
JE49A	13-08-73	4734665	631893	19.2	3.25	VERY HARD BOTTOM. BOTTOMED ON GLACIAL SEDIMENT.
JE51	19-06-73	4740552	630427	17.8	.75	BOTTOMED ON BEDROCK.
JE51A	13-08-73	4740932	629827	20.2	.75	VERY HARD SEDIMENT. BOTTOMED ON GLACIAL? SEDIMENT.
JE52	19-06-73	4738562	630931	18.5	1.25	BOUNCED DURING PENETRATION. BOTTOMED ON BEDROCK.
JE52A	13-08-73	4738876	630103	16.7	3.00	BOTTOM 1.5 M WAS VERY HARD. BOTTOMED ON GLACIAL SEDIMENT.
JE53	19-06-73	4736505	630498	16.0	2.25	BOTTOMED ON BEDROCK.
JE53A	13-08-73	4736698	630497	17.1	2.75	BOTTOMED ON HARD GLACIAL SEDIMENT.
JE55	19-06-73	4738377	628300	18.9	.25	BOTTOMED ON BEDROCK.
JE55A	13-08-73	4738839	628122	17.6	1.25	BOUNCED DURING PENETRATION NEAR BASE OF HOLE. BOTTOMED BOTTOMED ON GLACIAL SEDIMENT.
JE56	19-06-73	4736399	628396	17.6	2.25	BOTTOMED ON GLACIAL? SEDIMENT.
JE57	19-06-73	4734350	628418	15.0	3.25	BOTTOMED ON GLACIAL SEDIMENT.
JE59	19-06-73	4738332	626395	18.6	.75	BOTTOMED ON BEDROCK.
JE59A	13-08-73	4738569	626227	19.7	2.25	BOTTOM 1.25 M WAS VERY STIFF. BOTTOMED ON GLACIAL SEDIMENT.

STATION NO.	DATE	UTM NORTHING	EASTING	DEPTH, M (IGLD)	DEPTH TO REFUSAL, M	NOTES
JE60	19-06-73	4736486	626716	16.5	2.50	TIP OF JET PIPE SHOWED SMEAR OF GLACIAL SEDIMENT. BOTTOMED ON BEDROCK?
JE60A	13-08-73	4736760	626344	18.3	2.75	FAST PENETRATION THROUGH UPPER 2 M, THEN JET SLOWED IN VERY HARD MATERIAL. BOTTOMED ON GLACIAL SEDIMENT.
JE61	19-06-73	4734468	626372	15.6	2.25	BOTTOMED ON GLACIAL SEDIMENT.
JE62	19-06-73	4732410	626440	23.7	2.25	BOTTOMED ON GLACIAL SEDIMENT.
JE63	19-06-73	4738509	624521	20.3	1.50	BOTTOMED ON BEDROCK.
JE63A	12-08-73	4738697	623783	21.2	2.25	BOUNCED HARD DURING PENETRATION. VERY HARD MATERIAL IN BOTTOM 0.5 M. BOTTOMED ON GLACIAL SEDIMENT.
JE64	19-06-73	4736470	624589	17.9	.50	BOTTOMED ON BEDROCK.
JE64A	12-08-73	4736649	623874	16.5	3.00	BOUNCED DURING PENETRATION. BOTTOMED ON GLACIAL SEDIMENT.
JE65	19-06-73	4734338	624551	17.2	3.25	BOUNCED VIOLENTLY DURING PENETRATION. BOTTOMED ON BEDROCK.
JE65A	12-08-73	4734973	624349	16.0	6.00	BOUNCED VIOLENTLY THROUGH UPPER 4 M. BOTTOMED ON GLACIAL? SEDIMENT.
JE66	19-06-73	4732390	624637	25.3	2.00	BOTTOMED ON BEDROCK.
JE67	24-06-73	4736545	622140	18.5	2.25	
JE68	C21-06-7	4734355	622643	19.3	1.50	
JE69	24-06-73	4732517	622423	23.1	1.00	
JE70	21-06-73	4736281	620700	18.7	1.50	BOTTOMED ON BEDROCK.
JE70A	11-08-73	4736496	620033	19.0	4.25	BOUNCED DURING PENETRATION. VERY STIFF MATERIAL AT 2-M DEPTH. BOTTOMED ON GLACIAL? SEDIMENT.

STATION NO.	DATE	UTM NORTHING	UTM EASTING	DEPTH, M (IGLD)	DEPTH TO REFUSAL, M	NOTES
JE71	21-06-73	4734612	620877	21.7	2.75	BOTTOMED ON GLACIAL SEDIMENT.
JE72	21-06-73	4735374	619566	18.6	4.50	BOTTOMED ON GLACIAL SEDIMENT?
JE104	04-07-73	4717018	573166	0.0	5.00	SLOW PENETRATION WITH BOUNCING THROUGH STICKY SEDIMENT.
JE105	04-07-73	4716994	569034	0.0	3.50	SLOW PENETRATION WITH BOUNCING THROUGH STIFF SEDIMENT. BOTTOMED ON GLACIAL SEDIMENT.
JE109	05-07-73	4711333	579068	0.0	10.50	FAST PENETRATION IN UPPER PART OF HOLE, GRADUALLY SLOWING WITH DEPTH. REFUSAL OCCURED IN FIRMER SEDIMENT (GLACIAL?). REFUSAL DEPTH LESS WELL-DEFINED THAN AT OTHER SITES.
JE110	05-07-73	4713036	576954	0.0	3.75	FAST PENETRATION. BOTTOMED ON GLACIAL SEDIMENT.
JE111	05-07-73	4713276	572988	0.0	6.00	SLOW PENETRATION WITH BOUNCING THROUGH STIFF SEDIMENT WITH PEBBLES, COBBLES. BOTTOMED ON GLACIAL SEDIMENT.
JE112	04-07-73	4714598	568144	0.0	8.50	UPPER 6 M WERE COARSE SEDIMENT, BOTTOM 2.5 M HARD, STIFF SEDIMENT. BOTTOMED ON GLACIAL SEDIMENT.
JE113	04-07-73	4714066	565616	6.0	11.25	BOUNCED VIOLENTLY IN UPPER PART OF HOLE, THEN SLOW PENETRATION THROUGH VERY STIFF SEDIMENT NEAR BASE OF HOLE. BOTTOMED ON GLACIAL SEDIMENT.
JE114	04-07-73	4714490	562612	3.4	9.50	BOTTOMED ON GLACIAL SEDIMENT.
JE115	05-07-73	4712163	575027	0.0	.50	BOTTOMED ON VERY HARD (GLACIAL?) SEDIMENT.
JE120	15-07-73	4708726	561149	13.4	3.75	FAST PENETRATION THROUGH UPPER 2.25 M, SLOW PENETRATION THROUGH STIFF SEDIMENT IN LOWER 1.5 M. BOTTOMED ON GLACIAL SEDIMENT.

STATION NO.	DATE	UTM NORTHING	UTM EASTING	DEPTH, M (IGLD)	DEPTH TO REFUSAL, M	NOTES
JE126	18-07-73	4712667	552154	4.8	6.75	JET MOVEMENT SUGGESTED ALTERNATING COHESIVE AND LOOSE SEDIMENT. BOTTOMED ON VERY STIFF SEDIMENT.
JE128	18-07-73	4704922	552128	13.4	3.25	FIRM BOTTOM. BOUNCED DURING PENETRATION. BOTTOMED ON GLACIAL SEDIMENT.
JE129	19-07-73	4701047	552498	19.9	8.25	FAST PENETRATION THROUGH UPPER 4 M, THEN SLOW THROUGH FIRMER BASAL SEDIMENT. BOTTOMED ON GLACIAL SEDIMENT.
JE131	18-07-73	4707076	550532	16.0	2.75	SLOW PENETRATION WITH BOUNCING. BOTTOMED IN GLACIAL SEDIMENT. LOWER METRE OF HOLE MAY BE IN GLACIAL SEDIMENT.
JE132	19-07-73	4703153	550449	13.3	4.75	FAST PENETRATION THROUGH UPPER 3 M, THEN SLOW ADVANCE THROUGH FIRM SEDIMENT. BOTTOMED ON GLACIAL SEDIMENT.
JE133	19-07-73	4699285	550043	13.9	6.50	FAST PENETRATION THROUGH UPPER 5 M, THEN SLOW ADVANCE THROUGH FIRM SEDIMENT. BOTTOMED ON GLACIAL? SEDIMENT.
JE135	19-07-73	4691611	550649	16.4	4.25	PENETRATION SLOWED WITH DEPTH. BOTTOMED ON GLACIAL SEDIMENT.
JE137	18-07-73	4712850	548365	7.2	3.75	HARD BOTTOM. SLOW PENETRATION WITH BOUNCING. END OF JET PIPE SHOWS SMEAR OF GLACIAL SEDIMENT. BOTTOMED ON GLACIAL SEDIMENT.
JE138	18-07-73	4708960	548453	16.1	3.50	SLOW PENETRATION WITH BOUNCING. END OF JET PIPE SHOWS SMEAR OF GLACIAL SEDIMENT. BOTTOMED ON GLACIAL SEDIMENT.
JE139	19-07-73	4704983	548446	17.0	4.50	FAST PENETRATION THROUGH UPPER 2 M, THEN SLOW. BOTTOMED ON GLACIAL SEDIMENT.

STATION NO.	DATE	UTM NORTHING	UTM EASTING	DEPTH, M (IGLD)	DEPTH TO REFUSAL, M	NOTES
JE140	19-07-73	4701145	548274	17.6	6.00	PENETRATION SLOWED WITH DEPTH. BOTTOMED ON GLACIAL SEDIMENT.
JE141	19-07-73	4697363	548104	15.4	4.25	HARD BOTTOM. BOUNCED DURING PENETRATION. BOTTOMED ON GLACIAL SEDIMENT.
JE142	19-07-73	4693505	548587	18.1	2.50	VERY HARD BOTTOM. BOUNCED DURING PENETRATION. LAST METRE OF JET PIPE SHOWS SMEAR OF GLACIAL SEDIMENT.
JE143	19-07-73	4689582	548536	15.5	2.75	VERY HARD BOTTOM. BOTTOMED ON GLACIAL SEDIMENT.
JE144	18-07-73	4712512	544939	5.5	3.25	UPPER 2 M FELT LIKE COARSE SEDIMENT, STIFF SEDIMENT BELOW THAT. BOTTOMED ON GLACIAL SEDIMENT.
JE146	19-07-73	4689558	544659	19.3	3.75	BOUNCED DURING PENETRATION. BOTTOMED ON GLACIAL SEDIMENT.
JE195	08-10-74	4637981	376043	5.2	4.25	FAST PENETRATION THROUGH UPPER 3.25 M, THEN SLOW. BOTTOMED ON HARD GLACIAL? SEDIMENT.
JE196	08-10-74	4634008	375993	6.2	4.00	FAST PENETRATION THROUGH UPPER 1.75 M, THEN ALTERNATING SLOW, FAST TO BASE. LAST 2.25 M OF JET PIPE SHOWS SMEAR OF GLACIAL SEDIMENT. BOTTOMED ON GLACIAL SEDIMENT.
JE197	08-10-74	4629998	376011	10.7	4.50	FAST PENETRATION THROUGH UPPER 4 M, THEN SLOW. BOTTOMED ON GLACIAL SEDIMENT.
JE198	08-10-74	4637996	380027	10.6	8.00	FAST PENETRATION THROUGH UPPER 5 M, THEN SLOW. LAST METRE OF JET PIPE SHOWS SMEAR OF GLACIAL SEDIMENT. BOTTOMED ON GLACIAL SEDIMENT.

STATION NO.	DATE	UTM NORTHING	UTM EASTING	DEPTH, M (IGLD)	DEPTH TO REFUSAL, M	NOTES
JE199	08-10-74	4633996	380041	10.2	5.25	FAST PENETRATION THROUGH UPPER 4 M, THEN SLOW. VERY HARD BOTTOM. BOTTOMED ON GLACIAL? SEDIMENT.
JE200	08-10-74	4630004	380007	11.4	4.00	FAST PENETRATION THROUGH UPPER 3 M, THEN SLOW PENETRATION WITH BOUNCING. BOTTOMED ON GLACIAL SEDIMENT.

APPENDIX 9

Sediment Core Logs

KEY TO SEDIMENT CORE LOGS

CORE: /LAKE   CORE TYPE:

DATE: LENGTH:

UTM N: E: IGLD DEPTH:

PHOTOS: SLIDES-   LOGGED BY:

X-RAY-   DATE:

UNIT 1:

STANDARD ORDER OF PROPERTIES IS AS FOLLOWS:

- COLOUR
- CONSISTENCY
- TEXTURE
- STRUCTURE
- COMPOSITION- SHELLS
  -MINERALOGY/PETROLOGY
- HCL REACTION
- AVAILABILITY OF GRAIN-SIZE DATA
- AVAILABILITY OF POLLEN DATA
- OTHER COMMENTS

SEDIMENT CORE LOG

CORE: CE5 /LAKE ERIE

DATE: 9 JUNE 1974

UTM N: 4714411 E: 565184

PHOTOS: SLIDES- NO

X-RAY- YES

CORE TYPE: BENTHOS

LENGTH: 9 CM

IGLD DEPTH: 4.6 M

LOGGED BY: G. LAHAIE

DATE: 6 SEPTEMBER 1974

UNIT 1: 0-2.5 CM

- DARK GREYISH BROWN (2.5Y 4/2)
- LOOSE
- MEDIUM TO COARSE SAND
- ANGULAR PEBBLE, 0.5 CM IN DIAMETER AT 1.5 CM
- MODERATE HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE

UNIT 2: 2.5-9 CM

- VERY DARK GREY (5Y 3/1)
- LOOSE
- COARSE SAND, SILTY AT TOP OF UNIT
- ROUNDED LIMESTONE PEBBLE AT 8 CM
- MODERATE HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 2.5-6 CM AND 6-9 CM

SEDIMENT CORE LOG

CORE: CE29 /LAKE ERIE

DATE: 9 SEPTEMBER 1975

UTM N: 4705510 E: 550843

PHOTOS: SLIDES- YES

X-RAY- YES

CORE TYPE: IMPACT

LENGTH: 49 CM

IGLD DEPTH: 13.5 M

LOGGED BY: G. LAHAIE

DATE: 9 FEBRUARY 1977

UNIT 1: 0-32 CM

- MEDIUM BROWN TO 12 CM; OXIDIZED LAYER FROM 12-14 CM; VERY DARK GREYISH BROWN (2.5Y 3/2) FROM 14-32 CM; SURFACE OF CORE IS OXIDIZED FROM 14-32 CM
- FIRM
- MEDIUM TO COARSE SAND
- APPEARS MASSIVE BUT X-RADIOGRAPHS SHOW FAINT HORIZONTAL AND DISTURBED LAMINATION THROUGHOUT THE UNIT; INCLINED BASAL CONTACT
- SCATTERED BROKEN SHELLS
- HIGH CONTENT OF HEAVY MINERALS IN LOWER PART OF UNIT
- WEAK HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 0-10, 10-20 AND 20-32 CM

UNIT 2: 32-34.5 CM

- GREYISH BROWN (10YR 5/2)
- STIFF
- SILT
- MASSIVE
- SOME VERY SMALL LENSES OF ORGANIC MATERIAL
- MODERATE TO STRONG HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE

UNIT 3: 34.5-39 CM

- DARK GREY (5Y 4/1)
- FIRM
- FINE SAND
- DISTURBED HORIZONTAL LAMINATION; STEEPLY-INCLINED BASAL CONTACT
- HIGH CONTENT OF HEAVY MINERALS; SMALL PATCHES OF ORGANIC MATERIAL
- WEAK HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

UNIT 4: 39-49 CM

- DARK GREYISH BROWN (10YR 4/2)
- STIFF
- SILT
- INTERFINGERED FINE SAND AT 41, 43 AND 46 CM; SMALL LENS OF ORGANIC MATERIAL AT 46 CM
- MODERATE TO STRONG HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE

SEDIMENT CORE LOG

CORE: CE30 /LAKE ERIE

CORE TYPE: IMPACT

DATE: 9 SEPTEMBER 1975

LENGTH: 33 CM

UTM N: 4701505 E: 550806

IGLD DEPTH: 13.5 M

PHOTOS: SLIDES- NO

X-RAY- YES

LOGGED BY: G. LAHAIE

DATE: 9 FEBRUARY 1977

UNIT 1: 0-16.5 CM

- GREYISH BROWN FROM 0-7 CM, MEDIUM BROWN FROM 7-9 CM, BROWNISH GREY FROM 9-16.5 CM
- FIRM
- MEDIUM SAND
- HORIZONTAL LAMINATIONS RESULTING FROM VARYING CONCENTRATION OF HEAVY MINERALS FROM 10-16.5 CM; LAMINATIONS ARE DISTURBED TOWARDS BASE OF UNIT; LOWER CONTACT IS SHARP AND INCLINED
- SCATTERED BROKEN SHELLS
- CONCENTRATION OF HEAVY MINERALS FROM 6-7 CM; CORE SURFACE IS OXIDIZED FROM 10-16.5 CM
- WEAK HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 0-10 AND 10-16.5 CM

UNIT 2: 16.5-33 CM

- BROWNISH GREY
- FIRM
- FINE TO MEDIUM SAND
- DISTURBED HORIZONTAL LAMINATION; LAMINATION RESULTS FROM VARYING CONCENTRATION OF HEAVY MINERALS
- SCATTERED BROKEN SHELLS
- OUTER RIM OF CORE IS OXIDIZED
- WEAK HCL REACTION
- GRAIN-SIZE DATA AVAILABLE FOR 16.5-25 AND 25-33 CM

SEDIMENT CORE LOG

CORE: CE31 /LAKE ERIE

CORE TYPE: IMPACT

DATE: 9 SEPTEMBER 1975

LENGTH: 101.5 CM

UTM N: 4697496 E: 550931

IGLD DEPTH: 16.6 M

PHOTOS: SLIDES- NO

X-RAY- YES

LOGGED BY: G. LAHAIE

DATE: 9 FEBRUARY 1977

UNIT 1: 0-67 CM

- DARK BROWN FROM 0-2 CM, DARK BROWNISH GREY FROM 6-67 CM, OXIDIZED FROM 5-6 CM
- FIRM
- FINE TO MEDIUM SAND
- A FEW HEAVY MINERAL BANDS AND LENSES OF SILTY CLAY
- SCATTERED BROKEN SHELLS
- HIGH HEAVY MINERAL CONTENT; SURFACE OF CORE IS OXIDIZED FROM 9-67 CM
- WEAK HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 0-10, 10-35 AND 35-67 CM

UNIT 2: 67-101.5 CM

- DARK GREY (5Y 4/1)
- STIFF
- SANDY CLAY
- MASSIVE; SMALL UNITS OF CLAYEY SAND AT 73-75 CM AND 77 CM
- SCATTERED BROKEN SHELLS
- MODERATE HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 67-85 AND 85-101.5 CM

SEDIMENT CORE LOG

CORE: CE33 /LAKE ERIE

CORE TYPE: IMPACT

DATE: 9 SEPTEMBER 1975

LENGTH: 99 CM

UTM N: 4713034 E: 544281
(WEAK FIX)

IGLD DEPTH: 2.5 M

PHOTOS: SLIDES- YES

X-RAY- YES

LOGGED BY: G. LAHAIE

DATE: 9 FEBRUARY 1977

UNIT 1: 0-33.5 CM

- DARK GREYISH BROWN
- FIRM
- FINE TO MEDIUM SAND
- DISTURBED LAMINAE, MOST PROMINENT BETWEEN 10-18 AND 27-33.5 CM; LAMINATION RESULTS FROM VARYING CONCENTRATION OF HEAVY MINERALS; INCLINED BASAL CONTACT
- MINOR SCATTERED BROKEN SHELLS
- CONCENTRATION OF HEAVY MINERALS FROM 18-26 CM
- MODERATE HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 0-15 AND 15-33.5 CM

UNIT 2: 33.5-39.5 CM

- LIGHT BROWN
- FIRM
- FINE SAND
- MASSIVE
- MODERATE HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE

UNIT 3: 39.5-51 CM

- GREYISH BROWN
- FIRM
- FINE SAND
- HEAVY MINERAL LAMINAE CLOSE TO BASE OF UNIT; SMALL LENSES OF SOFT SILTY CLAY AT 43 AND 49 CM
- MODERATE HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE

UNIT 4: 51-58 CM

- LIGHT BROWN
- FINE SAND
- MASSIVE
- GRAIN-SIZE DATA AVAILABLE

UNIT 5: 58-63.5 CM

- GREYISH BROWN
- FINE SAND
- HORIZONTAL LAMINATION
- HIGHER HEAVY MINERAL CONTENT THAN UNIT ABOVE
- GRAIN-SIZE DATA AVAILABLE

UNIT 6: 63.5-70.5 CM

- LIGHT BROWN
- FINE SAND
- MASSIVE
- GRAIN-SIZE DATA AVAILABLE

UNIT 7: 70.5-99 CM

- GREYISH BROWN TO 77 CM, THEN MEDIUM BROWN
- FIRM
- MEDIUM SAND, SLIGHTLY COARSER AT BASE OF UNIT
- HORIZONTAL LAMINATION (HEAVY MINERALS) FROM 70.5-75.5 CM
- SCATTERED BROKEN SHELLS
- MODERATE HCL REACTION
- GRAIN-SIZE DATA AVAILABLE FOR 70.5-75.5 AND 75.5-99 CM

SEDIMENT CORE LOG

CORE: CE36 /LAKE ERIE

DATE: 10 SEPTEMBER 1975

UTM N: 4708651 E: 563264

PHOTOS: SLIDES- NO

X-RAY- YES

CORE TYPE: IMPACT

LENGTH: 82.5 CM

IGLD DEPTH: 9.8 M

LOGGED BY: G. LAHAIE

DATE: 9 FEBRUARY 1977

UNIT 1: 0-59 CM

- DARK BROWNISH GREY
- FIRM
- FINE SAND COARSENING TOWARDS BASE OF UNIT
- SCATTERED BROKEN SHELLS
- VERY HIGH HEAVY MINERAL CONTENT
- WEAK HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 0-20, 20-40 AND 40-59 CM

UNIT 2: 59-61 CM

- DARK BROWNISH GREY
- FINE TO COARSE SAND, A FEW SMALL PEBBLES
- SCATTERED BROKEN SHELLS
- VERY HIGH HEAVY MINERAL CONTENT
- WEAK HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE

UNIT 3: 61-80 CM

- DARK BROWNISH GREY
- PREDOMINANTLY FINE SAND; MINOR COARSE SAND
- BASE OF UNIT IS HORIZONTALLY LAMINATED
- SCATTERED BROKEN SHELLS
- VERY HIGH HEAVY MINERAL CONTENT
- WEAK HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 61-70 AND 70-80 CM

UNIT 4: 80-82.5 CM

- LIGHT BROWN
- FIRM
- FINE SAND
- MASSIVE; SHARP UPPER CONTACT
- WEAK HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

SEDIMENT CORE LOG

CORE: CE50 /LAKE ERIE

CORE TYPE: IMPACT

DATE: 09 JULY 1976

LENGTH: 162 CM

UTM N: 4742447 E: 637687

IGLD DEPTH: 15.6 M

PHOTOS: SLIDES- NO

X-RAY- YES

LOGGED BY: G. LAHAIE

DATE: 24 FEBRUARY 1977

UNIT 1: 0-81 CM

- DARK BROWNISH-GREY
- FIRM
- COARSE TO MEDIUM SAND
- DISTURBED STRUCTURE; SHARP BOTTOM CONTACT; LENSES OF SOFT, LIGHT BROWNISH-GREY CLAY AT 32, 58-60, 78CM
- SCATTERED BROKEN SHELLS THROUGHOUT; HIGH CONCENTRATION OF SHELLS AT 22-32 CM
- MODERATE HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 0-20 CM, 20-30 CM, 30-55 CM, AND 55-81 CM
- SULPHIDE CONCENTRATION AT 22 CM

UNIT 2: 81-162 CM

- DARK GREY (5Y 4/1)
- SOFT
- SANDY MUD
- DISTURBED STRUCTURE; SMALL POCKETS OF SILTY-SAND SCATTERED THROUGHOUT THE UNIT; POCKET OF SILTY-SAND ALONG ONE EDGE OF THE CORE FROM 136-162 CM; FAINT SULPHIDE MOTTLING
- LARGE BROKEN SHELLS SCATTERED THROUGHOUT
- MODERATE HCL REACTION INCREASING TO STRONG TOWARDS THE BASE WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 81-110 CM, 110-140 CM AND 140-162 CM

SEDIMENT CORE LOG

CORE: CE53 /LAKE ERIE

CORE TYPE: IMPACT

DATE: 26 AUGUST 1976

LENGTH: 30 CM

UTM N: 4633996 E: 379980

IGLD DEPTH: 10.6 M

PHOTOS: SLIDES- NO

X-RAY- YES

LOGGED BY: G. LAHAIE

DATE: 14 MARCH 1977

UNIT 1: 0-7 CM

- DARK BROWNISH-GREY
- FIRM
- MEDIUM SAND
- MASSIVE
- SCATTERED BROKEN SHELLS THROUGHOUT
- HEAVY MINERAL CONCENTRATION AT 4.5-5.5 CM
- MODERATE HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE

UNIT 2: 7-12 CM

- DARK BROWNISH-GREY
- LOOSE
- GRAVEL
- SHARP TOP AND BOTTOM CONTACT
- CONCENTRATION OF WHOLE AND BROKEN SHELLS
- GRAIN-SIZE DATA AVAILABLE

UNIT 3: 12-30 CM

- DARK BROWNISH-GREY WITH THE EXCEPTION OF 28-30 CM WHICH IS MEDIUM-BROWN
- FIRM
- MEDIUM SAND
- MASSIVE
- SCATTERED BROKEN SHELLS THROUGHOUT
- HEAVY MINERAL LENSES AT 16-17.5 CM
- STRONG HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 12-20 CM AND 20-30 CM

SEDIMENT CORE LOG

CORE: CE54 /LAKE ERIE

DATE: 26 AUGUST 1976

UTM N: 4632016 E: 377982

PHOTOS: SLIDES- NO

X-RAY- YES

CORE TYPE: IMPACT

LENGTH: 88 CM

IGLD DEPTH: 6.2 M

LOGGED BY: G. LAHAIE

DATE: 16 MARCH 1977

UNIT 1: 0-25 CM

- MEDIUM BROWN
- 0-3 CM LOOSE, 3-25 CM FIRM
- COARSE SAND
- MASSIVE; SURFACE OF CORE IS DISTURBED
- SCATTERED BROKEN SHELLS THROUGHOUT
- WEAK HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 0-12 CM AND 12-25 CM

UNIT 2: 25-88 CM

- DARK GREY (5Y 4/1)
- FIRM
- MEDIUM SAND
- DISTURBED HEAVY MINERAL LAMINAE THROUGHOUT; LENS OF MEDIUM-BROWN COARSE SAND AT 76-78 CM SIMILAR IN TEXTURE TO UNIT 1
- MANY SCATTERED BROKEN SHELLS
- MODERATE HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 25-50 CM, 50-76 CM, 76-78 CM, AND 78-88 CM
- OXIDATION AT THE BASE OF THE CORE

SEDIMENT CORE LOG

CORE: CE55 /LAKE ERIE

CORE TYPE: IMPACT

DATE: 26 AUGUST 1976

LENGTH: 37 CM

UTM N: 4628011 E: 378105

IGLD DEPTH: 9.8 M

PHOTOS: SLIDES- NO

X-RAY- YES

LOGGED BY: G. LAHAIE

DATE: 16 MARCH 1977

UNIT 1: 0-25 CM

- MEDIUM GREYISH-BROWN
- FIRM
- MEDIUM-COARSE SAND
- DISTURBED SURFACE; THIN LENS OF COARSE SAND AT 24-25 CM
- SCATTERED BROKEN SHELLS
- WEAK HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 0-12 CM AND 12-25 CM

UNIT 2: 25-37 CM

- DARK GREY
- FIRM
- MEDIUM SAND
- MASSIVE
- SCATTERED BROKEN SHELLS
- HIGH HEAVY MINERAL CONTENT
- WEAK HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE

SEDIMENT CORE LOG

CORE: CE59 /LAKE ERIE

CORE TYPE: IMPACT

DATE: 26 AUGUST 1976

LENGTH: 51 CM

UTM N: 4630002 E: 383997

IGLD DEPTH: 12.3 M

PHOTOS: SLIDES- NO

X-RAY- YES

LOGGED BY: G. LAHAIE

DATE: 21 MARCH 1977

UNIT 1: 0-10 CM

- MEDIUM BROWN
- FIRM
- FINE SAND
- 0-5 CM MASSIVE; 5-10 CM INCLINED LAMINAE COMPOSED OF HEAVY MINERALS; LAMINAE ARE VERY DISTINCT
- COAL FRAGMENTS AND CINDERS AT SURFACE
- NO HCL REACTION
- GRAIN-SIZE DATA AVAILABLE FOR 0-5 CM AND 5-10 CM

UNIT 2: 10-19.5 CM

- DARK BROWNISH-GREY
- FIRM
- FINE SAND AT TOP GRADING DOWNWARDS TO SILTY-SAND
- GRADATIONAL CONTACT AT BASE OF UNIT; SULPHIDE CONCENTRATIONS ASSOCIATED WITH LENSES OF SILTY-SAND
- CONCENTRATION OF SHELL FRAGMENTS AT 13-15 CM
- SUB-ANGULAR PEBBLE AT 16.5 CM
- WEAK HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

UNIT 3: 19.5-23.5 CM

- MEDIUM BROWN
- FIRM
- FINE SAND
- LOWER CONTACT IS SHARP; VERY CLOSELY PACKED FINE LAMINAE FROM 19.5-21 CM WITH WIDER SPACING TOWARDS BOTTOM OF UNIT
- SCATTERED BROKEN SHELL FRAGMENTS
- NO HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

UNIT 4: 23.5-25.5 CM

- DARK GREY
- SOFT
- MUD; SAND LENSES NEAR BASE
- CONTACT WITH LOWER UNIT IS GRADATIONAL- MUD ALTERNATES WITH SAND LENSES
- WEAK HCL REACTION IN THE MUD WITH MODERATE TO STRONG REACTION IN THE SAND LENSES
- GRAIN-SIZE DATA AVAILABLE

UNIT 5: 25.5-38.5 CM

- MEDIUM GREYISH-BROWN
- FIRM
- FINE SAND
- DISTURBED; RIPPLED CONTACT WITH LOWER UNIT
- MANY SCATTERED BROKEN SHELLS
- SUB-ROUNDED, FLAT, CARBONATE PEBBLE AT 27 CM
- VERY WEAK HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

UNIT 6: 38.5-41.5 CM

- DARK GREY
- SOFT
- MUD
- SAND INTRUSION AT THE BASE OF THE UNIT
- WEAK HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

UNIT 7: 41.5-51 CM

- GREYISH-BROWN
- FIRM
- FINE SAND GRADING TO VERY FINE SAND TOWARDS THE BASE
- LENS OF COARSE SAND AND SHELLS AT 45 CM; HEAVY MINERAL LAMINAE 41.5-47 CM; MASSIVE SAND 47 CM TO BASE; SMALL AMOUNT OF MUD AT 45 CM
- CONCENTRATION OF BROKEN SHELLS AT 45 CM
- WEAK HCL REACTION WITH H_2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 41.5-45 CM AND 46-51 CM

SEDIMENT CORE LOG

CORE: CE61 /LAKE ERIE

DATE: 26 AUGUST 1976

UTM N: 4633998 E: 384018

PHOTOS: SLIDES- NO

X-RAY- YES

CORE TYPE: IMPACT

LENGTH: 50.5 CM

IGLD DEPTH: 11.2 M

LOGGED BY: G. LAHAIE

DATE: 21 MARCH 1977

UNIT 1: 0-50.5 CM

- DARK BROWNISH-GREY
- FIRM
- FINE SAND
- VERY FINE LAMINAE AT 2-13 CM; COARSER SAND LENS WITH SHELLS AT 13 CM; COARSE SANDY-GRAVEL LAYER AT 17-18 CM WITH A HIGH CONCENTRATION OF SHELLS; DISTURBED LAMINAE FROM 18-50.5 CM WITH FAINT CROSS-BEDDING AT 23-25 CM; SMALL PATCH OF MUD AT 40 CM
- SCATTERED BROKEN SHELLS
- HIGH CONCENTRATION OF HEAVY MINERALS
- GRAIN-SIZE DATA AVAILABLE FOR 0-13 CM, 13-18 CM, 18-35 CM AND 35-50.5 CM
- POLLEN DATA AVAILABLE FOR 0-2 CM, 2-4 CM AND 4-6 CM

SEDIMENT CORE LOG

CORE: CE72 /LAKE ERIE
CORE TYPE: IMPACT

DATE: 09 SEPTEMBER 1976
LENGTH: 29 CM

UTM N: 4734971 E: 633237
IGLD DEPTH: 17.3 M

PHOTOS: SLIDES- NO
LOGGED BY: G. LAHAIE

X-RAY- YES
DATE: 23 MARCH 1977

UNIT 1: 0-8 CM

- MEDIUM BROWN
- FIRM
- MEDIUM-COARSE SAND
- MASSIVE
- SCATTERED BROKEN SHELLS
- HIGH CONCENTRATION OF HEAVY MINERALS AT 3.5-4.5 CM
- STRONG HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

UNIT 2: 8-17 CM

- DARK GREY
- FIRM
- MEDIUM-COARSE SAND
- LAMINAE AT TOP OF UNIT COMPOSED OF HEAVY MINERALS; SLIGHTLY FINER CLAYEY-SAND MIXTURE AT 13 CM
- SCATTERED BROKEN SHELLS THROUGHOUT
- HIGH CONTENT OF HEAVY MINERALS
- STRONG HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

UNIT 3: 17-22 CM

- BROWNISH-GREY
- FIRM
- MUDDY SAND
- MASSIVE
- MODERATE HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

UNIT 4: 22-29 CM

- DARK GREY
- FIRM
- MEDIUM-COARSE SAND
- SMALL LENS OF MUDDY-SAND AT 26.5 CM; FINER SAND FROM 28-29 CM
- HEAVY MINERAL CONTENT IS HIGH
- STRONG HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

SEDIMENT CORE LOG

CORE: CE73 /LAKE ERIE

CORE TYPE: IMPACT

DATE: 09 SEPTEMBER 1976

LENGTH: 76 CM

UTM N: 4737430 E: 631296

IGLD DEPTH: 17.9 M

PHOTOS: SLIDES- NO

X-RAY- YES

LOGGED BY: G. LAHAIE

DATE: 23 MARCH 1977

UNIT 1: 0-13.5 CM

- DARK GREYISH-BROWN
- FIRM
- MEDIUM SAND
- TEXTURE FINES TOWARDS BASE OF UNIT; SHARP BOTTOM CONTACT; SULPHIDE CONCENTRATION AT 9 9.5 CM
- CONCENTRATION OF SHELL FRAGMENTS AT 11-13.5 CM
- HEAVY MINERAL CONTENT IS HIGH
- MODERATE HCL REACTION INCREASING TO STRONG TOWARDS BASE OF UNIT
- GRAIN-SIZE DATA AVAILABLE FOR 0-6 CM AND 6-13.5 CM
- LARGE CLINKER AT 7 CM

UNIT 2: 13.5-76 CM

- BROWNISH-GREY
- FIRM
- SILT AND FINE SAND
- ALTERNATING LENSES OF SILT AND FINE SAND, HORIZONTAL DOWN TO 50 CM THEN CONVEX UPWARD
- STRONG HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 13.5-30 CM, 30-50 CM, 50-55 CM AND 55-76 CM

SEDIMENT CORE LOG

CORE: CE74 /LAKE ERIE

DATE: 09 SEPTEMBER 1976

UTM N: 4740240 E: 630772

PHOTOS: SLIDES- NO

X-RAY- YES

CORE TYPE: IMPACT

LENGTH: 158.5 CM

IGLD DEPTH: 18.9 M

LOGGED BY: G. LAHAIE

DATE: 23 MARCH 1977

UNIT 1: 0-3.5 CM

- MEDIUM BROWN
- FIRM
- MEDIUM SAND
- MASSIVE
- WEAK HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

UNIT 2: 3.5-8 CM

- DARK BROWNISH-GREY
- SOFT
- SILTY SAND
- MASSIVE
- SCATTERED BROKEN SHELLS THROUGHOUT
- MODERATE HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

UNIT 3: 8-147 CM

- DARK GREY (5Y 4/1)
- SOFT
- MUD
- ALTERNATING LAMINAE OF CLAY, SILTY-CLAY, AND SAND; LAMINAE RANGE FROM VERY THIN TO 1-2 CM THICK; SULPHIDE CONCENTRATIONS AT 10-12 CM AND 17-18 CM
- STRONG HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 8-16 CM, 16-17 CM, 17-50 CM 50-85 CM, 85-120 CM, 120-147 CM

UNIT 4: 147-148.5 CM

- STICKY
- CLAYEY-COARSE SAND
- BROKEN SHELLS THROUGHOUT
- GRAIN-SIZE DATA AVAILABLE

UNIT 5: 148.5-158.5 CM

- DARK GREY
- SANDY CLAY
- COARSER SEDIMENT AT BASE OF UNIT
- BROKEN SHELL FRAGMENTS AT THE BASE OF UNIT
- VERY STRONG HCL REACTION
- GRAIN-SIZE DATA AVAILABLE

SEDIMENT CORE LOG

CORE: CE75 /LAKE ERIE
CORE TYPE: IMPACT

DATE: 09 SEPTEMBER 1976
LENGTH: 145.5 CM

UTM N: 4738647 E: 626157
IGLD DEPTH: 19.9 M

PHOTOS: SLIDES- NO
LOGGED BY: G. LAHAIE

X-RAY- YES
DATE: 28 MARCH 1977

UNIT 1: 0-122 CM

- BROWNISH-GREY
- FIRM
- CLAY
- SMALL, IRREGULARLY-SHAPED LENSES OF FINE-MEDIUM SAND THROUGHOUT THE UNIT; BOTTOM 10 CM OF UNIT IS COARSER; X-RADIOGRAPH SHOWS FAINT HORIZONTAL LAMINAE FROM 0-50 CM; FAINT SULPHIDE MOTTLING THROUGHOUT MOTTLING THROUGHOUT THE UNIT
- STRONG HCL REACTION
- GRAIN-SIZE DATA AVAILABLE FOR 0-1 CM, 1-25 CM, 25-50 CM, 50-75 CM, 75-100 CM, AND 100-122 CM

UNIT 2: 122-141 CM

- BROWNISH-GREY
- FIRM
- SANDY CLAY TO CLAYEY SAND
- TEXTURE COARSENS BASEWARD;
- SCATTERED BROKEN SHELLS THROUGHOUT
- SCATTERED SMALL PEBBLES
- STRONG HCL REACTION WITH H2S ODOUR
- GRAIN-SIZE DATA AVAILABLE FOR 122-132 CM, 132-141 CM

UNIT 3: 141-145.5 CM

- MEDIUM BROWN
- FIRM
- SILT
- MASSIVE
- GRAIN-SIZE DATA AVAILABLE

SEDIMENT CORE LOG

CORE: CE78 /LAKE ERIE

DATE: 09 SEPTEMBER 1976

UTM N: 4733639 E: 624193

PHOTOS: SLIDES- NO

X-RAY- YES

CORE TYPE: IMPACT

LENGTH: 27.5 CM

IGLD DEPTH: 16.5 M

LOGGED BY: G. LAHAIE

DATE: 28 MARCH 1977

UNIT 1: 0-18.5 CM

- DARK GREY
- FIRM
- FINE TO MEDIUM SAND
- OXIDIZED LAYER 0-2 CM; HORIZONTAL LAMINAE 8-14 CM; SMALL CLAY LENS AT 14 CM; TEXTURE GETS COARSER FROM 15 CM DOWN TO BASE OF UNIT; VENEER OF MUD OOZE AT TOP
- SCATTERED BROKEN SHELLS
- HIGH CONCENTRATION OF HEAVY MINERALS
- MODERATE HCL REACTION
- GRAIN-SIZE DATA AVAILABLE FOR 0-1 CM, 1-4 CM, 4-12 CM AND 12-18.5 CM

UNIT 2: 18.5-27.5 CM

- DARK BROWNISH-GREY
- FIRM
- PEBBLY, MUDDY MEDIUM TO COARSE SAND
- SCATTERED POCKETS OF SILT
- SCATTERED BROKEN SHELLS
- GRAIN-SIZE DATA AVAILABLE

APPENDIX 10

Jetting Procedure

HYDRAULICS RESEARCH DIVISION

Technical Note

Date: September , 1977 Report No: 77-13

Title: Measurement of Thickness of Nearshore Sands by Hydraulic Jetting

Authors: N. A. Rukavina and G. G. LaHaie

Reason for Report:

Documentation of jetting procedure in response to several requests for published description of method.

ABSTRACT

Hydraulic jetting provides a fast and inexpensive method for direct measurement of the thickness of unconsolidated shallow-water sediments of sand size. The equipment is portable and can be operated from a small launch or barge. Sediment thickness can be resolved to 0.25 m and in some instances it is possible to identify the underlying material.

INTRODUCTION

Conventional acoustic techniques (echo-sounding, sub-bottom profiling) are of limited use in measuring the thickness of Great Lakes' nearshore sand deposits. Higher frequencies give inadequate penetration, lower frequencies inadequate resolution; in both cases noisy records result from the reverberation experienced in shallow water.

As an alternative to the geophysical approach, we have developed a procedure of direct measurement of sediment thickness by hydraulic jetting to refusal. The method was suggested by the previous use of jetting as an aid to sampling unconsolidated sediments by Wilson (1941), Pincus et al (1951) and Coffee (1968). It consists simply of fluidizing bottom sediment with a water jet and recording jet penetration to refusal. We offer it as a simple, inexpensive alternative to, or control procedure for, shallow-water geophysical surveys of sediment thickness.

EQUIPMENT

Jetting equipment (Figure 1) consists of a jet pipe, reinforced flexible intake and discharge hoses and a high pressure water pump. We use a 7.5 m long pipe made up of 1.5 m sections of aluminum (2", schedule 40) and an end section of steel to provide weight and resistance to abrasion. The working end of the steel pipe is threaded to serve as a sampler of the material in which refusal occurs. Hose is standard 2 inch fire hose or flexible reinforced plastic hose with clamp connectors. Both pipe and hose are calibrated in units of 0.25 m. A short length of flexible hose with a screened end piece serves as the water intake. The water pump is a 6 H.P. gasoline-powered fire pump with a discharge of 60 gpm at 60 psi.

OPERATION

Jetting is most conveniently carried out from a small catamaran or barge with low freeboard and a large deck area to facilitate handling of the hose. The minimal requirement for the operation in terms of space and stability would be a small Boston Whaler or equivalent.

The jetting platform is manoeuvred onto station and anchored fore and aft to minimize drift. The jet pipe is assembled and coupled to the pump with a hose length at least twice the water depth. The pipe is then lowered by hand (or by winch, if available) into contact with the bottom and the water depth is read from the hose markings (Figure 2). The pump is started and the water jet from the pipe fluidizes a sediment column into which the pipe is advanced. Penetration continues until the jet encounters bedrock or semi-consolidated glacial sediment and no further progress is possible (Figure 2). Pipe behaviour at this stage is often a clue to the type of underlying material. The pipe tends to bounce on bedrock or boulder bottoms and to stick in glacial till or glaciolacustrine sediment. When refusal occurs, depth of penetration is recorded from the hose markings and the pipe is withdrawn and examined for evidence of underlying material retained in its end threads.

The jetting operation itself generally takes about 10 minutes in water depths of less than 20 m. Total site time including anchoring is about 20 minutes. Maximum penetration achieved to date has been 18 m.

APPLICATIONS

The jetting procedure was designed specifically for thickness measurement of nearshore lake sands and gravels as an aid to, or substitute for, conventional acoustic techniques. It should apply equally well to measurements in stream or beach deposits or in finer-grained basin or bay sediments. Limiting grain size with the equipment described is about 2-3 cm gravel beyond which pressure is lost because of the high permeability and material cannot be fluidized.

We use jetting in advance of coring to define the geometry of the sediment body being investigated and to provide a basis for optimum siting of cores. Jetting itself should be able to provide a coarse sediment stratigraphy if descent rate is monitored and contacts defined by abrupt changes in the rate of penetration. Further refinement would involve calibration of descent rates with geotechnical information from adjacent cores. There has not yet been a serious effort to explore this potential use.

In instances where point data on thickness are inadequate to the job at hand and geophysical profiling techniques must be employed, jetting can still be of use in calibration of the geophysical records.

REFERENCES

Coffee, C. E., 1968. "A New Technique in Sand Coring". UnderSea Technology, March 1968.

Pincus, H. J., Roseboom, M. L. and C. C. Humphris, 1951. "1950 Investigation of Lake Erie Sediments, Vicinity of Sandusky, Ohio". Ohio Division of Geological Survey, Report of Investigations No. 9.

Wilson, I. T., 1941. "A New Device for Sampling Lake Sediments". Jour. Sed. Petrology, 11:73-79.

FIGURE LEGEND

Figure 1 Water jet system

Figure 2 Jetting operation

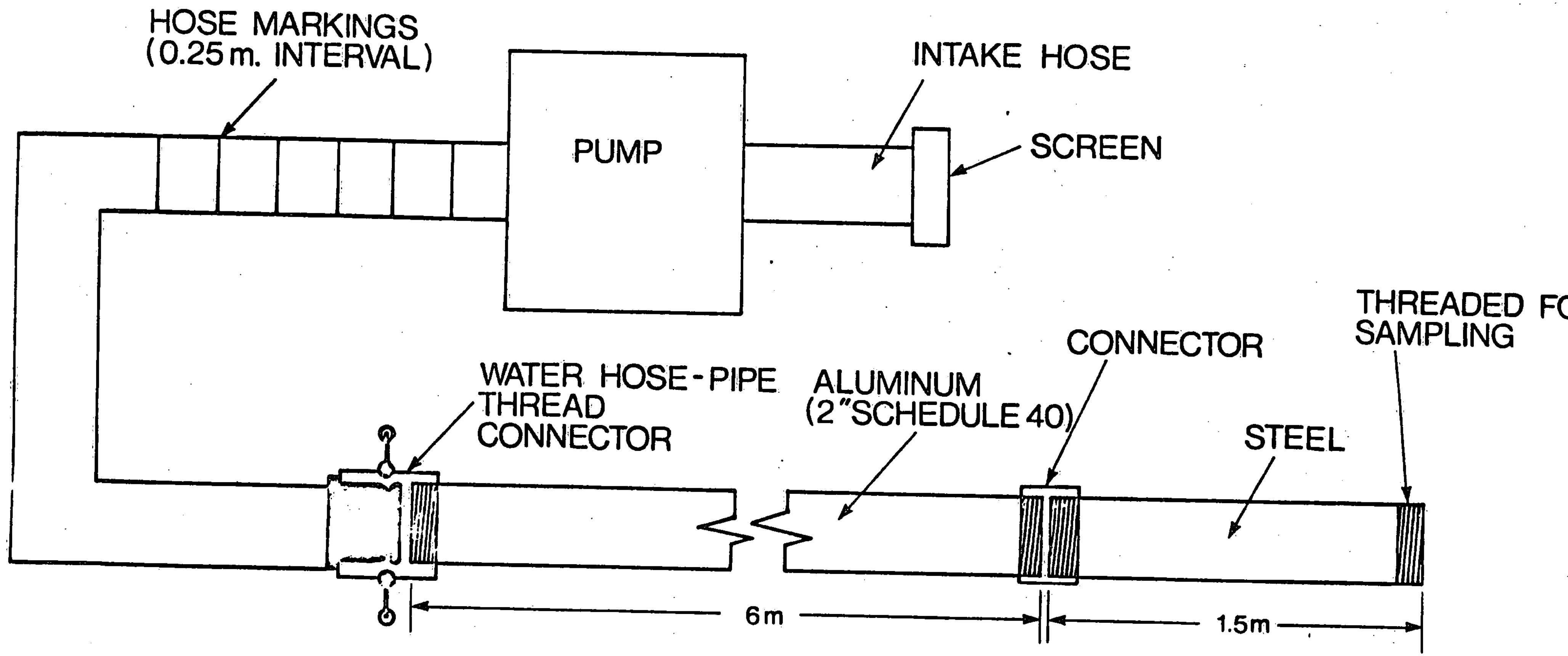

HOSE MARKINGS
(0.25 m. INTERVAL)
PUMP
INTAKE HOSE
SCREEN
WATER HOSE-PIPE
THREAD
CONNECTOR
ALUMINUM
(2"SCHEDULE 40)
CONNECTOR
STEEL
THREADED FO
SAMPLING
6 m
1.5m

FIGURE 1

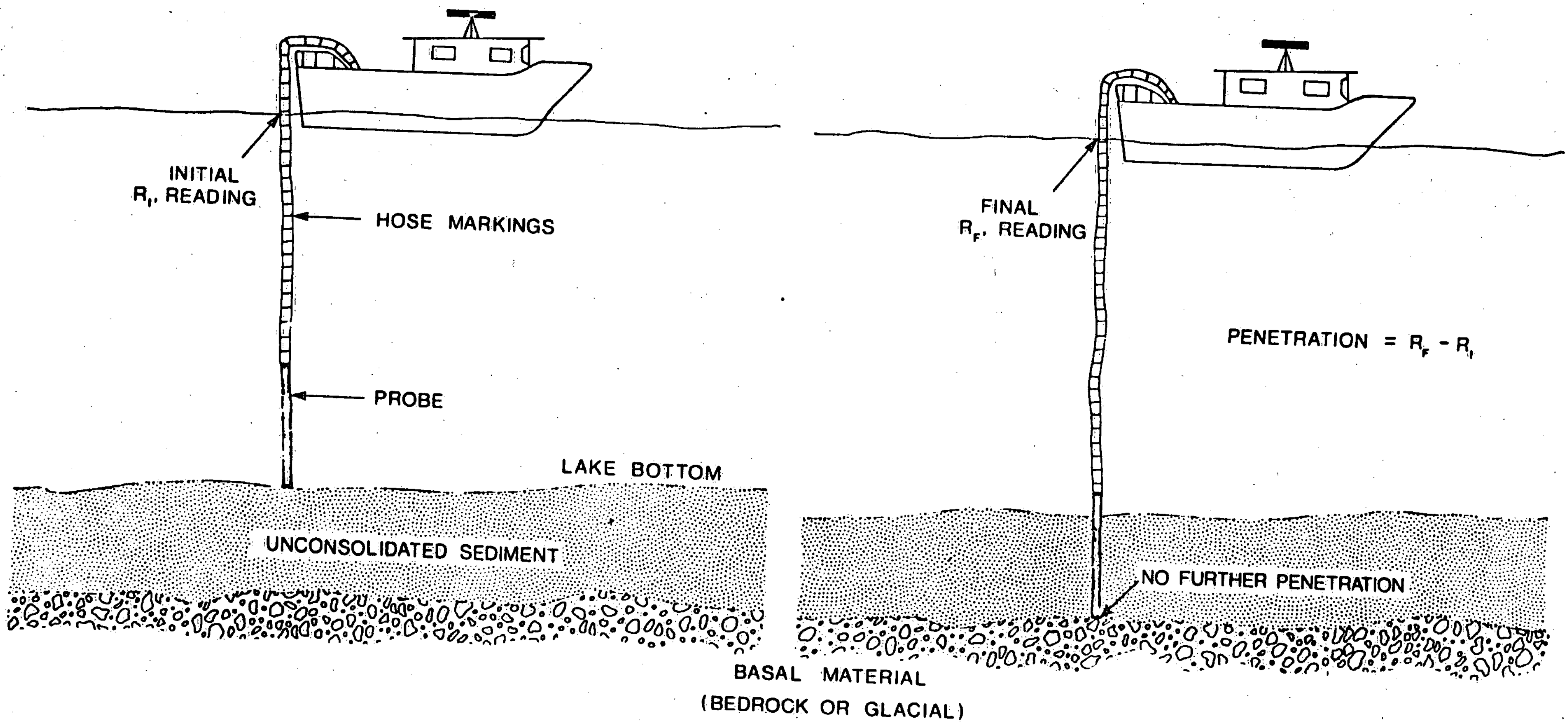

INITIAL
R_I, READING
HOSE MARKINGS
PROBE
LAKE BOTTOM
UNCONSOLIDATED SEDIMENT
FINAL
R_F, READING
PENETRATION = R_F - R_I
NO FURTHER PENETRATION
BASAL MATERIAL
(BEDROCK OR GLACIAL)

FIGURE 2

APPENDIX 11

Size-Analysis Procedure

Duncan (1)
LaHaie (2)

SIZE ANALYSIS PROCEDURES USED IN THE SEDIMENTOLOGY LABORATORY, NWRI

MANUAL

by

G. A. Duncan & G. G. LaHaie

Shore Processes Section
Hydraulics Division
National Water Research Institute
Canada Centre for Inland Waters
September 1979

TABLE OF CONTENTS

ILLUSTRATIONS

Figures

Tables

1.0 INTRODUCTION

The purpose of this manual is to describe the five standard methods used in the CCIW Sedimentology Laboratory to measure particle size. These are:

1) Sieve Analysis - For samples comprised of mainly sand and gravel. Two levels of analysis are possible: gravel-sand and silt-clay percentages, or greater resolution of the gravel and sand fractions to a maximum of ¼ PHI. (PHI, $\phi = -\log_2 \xi$ (where ξ is the diameter in mm).

2) Sieve and Short Pipette Analysis - This procedure provides a fast, simple method of determining the percentage of gravel, sand, silt and clay. The gravel percentage is determined by sieving at the gravel-sand boundary (-1.0 PHI) and the remaining sample is resolved by short pipette analysis.

3) Sieve, Short Pipette and Settling Tube Analysis - This procedure, known as F.A.S.T. (Rukavina and Duncan, 1970), provides gravel, sand, silt and clay percentages with ½ PHI resolution of the sand by the settling tube procedure.

4) Sieve, Settling Tube, Pipette and Sedigraph Analysis - This procedure, introduced as F.A.S.T.'R (Rukavina and LaHaie, 1976), provides gravel, sand, silt and clay percentages with ½ PHI resolution to the silt-clay boundary. The sand is resolved by the settling tube procedure, following that given in Rukavina and Duncan (1970). The silt and clay are resolved with the Sedigraph Grain-Size Analyzer*.

5) Sedigraph Analysis - Designed to process samples weighing less than 5g and composed mainly of silt and clay. The procedure yields percentages of sand, silt and clay with a maximum resolution of ¼ PHI of the silt and clay to 12 PHI (0.00024 mm).

Throughout this manual, the emphasis is placed on equipment and procedures rather than on the theoretical considerations underlying each method. It was felt that the theoretical aspects of the work had been adequately discussed in the standard sedimentological texts and, therefore, should not be repeated here. Each procedure described in this manual is complete in itself and does not require cross-referencing.

---

* Micromeritics Instrument Corporation, Norcross, Georgia.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. N. A. Rukavina, HRD, Mr. D. A. St. Jacques, O&AS, and Mr. R. G Sandilands, PRD for their generous assistance in the preparation of this manual. Thanks also to Mr. K. Salisbury, HRD for his photographic assistance, the drafting section, CCIW and Mrs. E. J. Jones, HRD for the typing of this manual.

PROCEDURES

2.0 SIEVE ANALYSIS

2.1 General

Sieving consists of separating a sediment sample into particle size fractions by passing it through a series of sieves with successively smaller mesh openings (Krumbein & Pettijohn, 1938). At CCIW, this procedure is used only when most of the sample is gravel and sand. The amount of sample used in sieve analysis is determined by two criteria: the sample should not clog the screens, and the removal of one particle from a sieve fraction should not significantly effect the weight of that fraction. Two levels of analysis are possible : gravel, sand and silt-clay percentages can be provided by sieving only at the gravel-sand (-1.0 PHI) and sand-silt boundaries (4.0 PHI) or greater resolution of the gravel and sand fractions is possible by adding more sieves. The maximum resolution available at CCIW is ¼ PHI.

A Pulverit* electromagnetic sieve shaker is used for sieving instead of the more conventional Ro-Tap** mechanical shaker. The Pulverit has the advantages of being easier and quieter to operate, more compact and capable of wet sieving, while still producing results comparable to the Ro-Tap (Appendix 4).

Figure 2 shows the details of the procedure as described in the following section.

2.2 Procedure

1) Label the Sizdist Coding Form (Figure 1) with the Analyst and Laboratory Number*** and enter the SAMPLE DESIGNATION, date of analysis (DAY, MO. YR.) and ANALYSIS CODE NO. (1 for sieve analysis) for each sample to be analysed.
2) Freeze-dry the sample (Appendix 2).
3) Split the sample (Table 1) with a Jones-type riffle splitter or the cone and quarter method (Appendix 3). Store the remaining portion of the sample.
4) Remove shells, wood, cinders, etc. from the split, weigh them to 0.01 g and record the weight and composition as a Comment on the Sizdist Coding Form (indicate that the weight of this material is not included in the total sample weight). Discard the material.

* Geoscience Instrument Corporation, Mount Vernon, N.Y.

** W. S. Tyler Co., Cleveland, Ohio.

*** Each sample entering the CCIW Sedimentology Laboratory is given an independent laboratory number.

5) Disaggregate conglomerates in the working sample with a rubber-tipped pestle and mortar or a wooden rolling pin.

6) Weigh the split to 0.01 g and record the weight as SAMPLE WT. on the Sizdist Coding Form.

7) Put the sample in a vertical stack of sieves (Plate 1) with a catch pan at the bottom (only the -1.0 PHI (2.0 mm) and the 4.0 PHI (0.0625 mm) sieves are required to determine gravel, sand and silt+clay percentages). Shake the sieves gently by hand and remove any empty sieves from the top of the stack.

8) Place the stack of sieves on the electromagnetic sieve shaker for ten minutes at a rheostat setting of 10 (this is equivalent to ten minutes on a Ro-Tap mechanical shaker).

9) After the sieving is completed, remove the sieves from the shaker and record the PHI size of the first sieve that has retained any material as ∅ (PHI) ORIGIN on the Sizdist Coding Form.

10) Empty the contents of the first sieve onto a large piece of paper and gently tap the side of the sieve along the mesh diagonal.

11) Transfer the sediment from the paper to a tared aluminum dish.

12) Replace the paper and remove any particles trapped in the sieve mesh by striking the sieve sharply on the paper. To prevent damage to the sieve or loss of material, be careful to strike it squarely on the paper. Do not pry or brush particles from the sieve mesh as this may alter the size of the mesh openings.

13) Add the dislodged particles to the material in the tared aluminum dish, weight to 0.01 g and enter the weight on the Sizdist Coding Form in the first space under SIEVE WTS. + SETTLING TUBE CUMULATIVE HTS.

14) Repeat steps 10 to 13 for each sieve in the stack and enter the weights of each sieve fraction on the Sizdist Coding Form in the space to the right of the previous entry. If there is no sediment on a sieve, enter a value of 0.00 in the appropriate space on the Sizdist Coding Form.

15) Weigh the pan fraction to 0.01 g and enter the weight on the Sizdist Coding Form after the last sieve weight.

16) Recover and store the sieve working sample.

17) Add the following to the Sizdist Coding Form:

a) DATA PTS.* - the total number of sieve weights + 1 (for the pan fraction).

b) NO. COMMENT CARDS - the total number of comment cards.

c) SIEVE/ST. PTS. - The total number of sieve weights (Do not include the pan fraction).

d) ϕ INTERVAL - the ϕ interval used in sieving. If the sample is analysed for gravel, sand and silt/clay percentages only, leave ϕ INTERVAL blank.

18) Keypunch the data on the Sizdist Coding Form alloting one computer card for each line of data.

19) Process the data with SIZDIST: a FORTRAN IV computer program (Report in Progress).

3.0 SIEVE AND SHORT PIPETTE PROCEDURE

3.1 General

This procedure provides a fast, simple method of determining the percentage of gravel, sand, silt and clay. First the gravel is separated from the sample by sieving at the gravel-sand boundary -1.0 PHI (2.0 mm). The remainder of the sample is then resolved by short pipette analysis (Rukavina and Duncan, 1970). Briefly, short pipette analysis consists of withdrawing two aliquots from a sediment suspension at predetermined depths and times. The first aliquot contains the proportion of silt+clay in the sample, the second aliquot only the clay. Figure 3 shows the details of the procedure as described in the following section.

3.2 Procedure

1) Label the Sizdist Coding Form (Figure 1) with the Analyst and Laboratory Number* and enter the SAMPLE DESIGNATION, date of analysis (DAY, MO. YR.) and ANALYSIS CODE NO. (2 for sieve and short pipette) for each sample to be analysed.

2) Freeze-dry the sample (Appendix 2).

3) Split the sample to 20 g with a Jones-type riffle splitter or the cone and quarter method (Appendix 3). Store the remaining portion of the sample.

---

* Each sample entering the CCIW Sedimentology Laboratory is given an independent laboratory number.

4) Remove shells, wood, cinders, etc. from the split, weigh them to 0.01 g and record the weight and composition as a Comment on the Sizdist Coding Form (indicate that the weight of this material is not included in the total sample weight). Discard the material.

5) Disaggregate conglomerates in the working sample with a rubber-tipped pestle and mortar or a wooden rolling pin.

6) Weigh the split to 0.0001 g and record the weight as SAMPLE WT. g on the Sizdist Coding Form.

7) Remove the gravel fraction by sieving the split at -1.0 PHI (2.00 mm). Weigh the material retained on the sieve to 0.0001 g and record the weight on the Sizdist Coding Form in the first space provided under SIEVE WTS. + SETTLING TUBE HTS. Discard the gravel fraction.

8) Transfer the material finer than -1.0 PHI (2.0 mm) to a mixing cup (ASTM designation D-422-63, 1963) and add 50 ml of dispersant (50 g of Calgon/litre of distilled water) and 300 ml of distilled water. Make necessary adjustments for non-standard sample size according to Table 2.

9) Mix suspension for 15 minutes on an electric mixer (ASTM designation D422-63, 1963).

10) Transfer the suspension to a prelabelled, 500 ml cylinder and add distilled water to bring the suspension to the 500 ml level.

11) Allow the suspension to stand for one hour.

12) Transfer 50 ml of dispersant to two preweighed, aluminum dishes; oven dry at 90°C, remove and place in a dessicator to cool, weigh to 0.0001 g, and record the weight of the dispersant as WT. DISPERSANT on the Sizdist Coding Form. Repeat approximately every 15 samples.

13) Number and weigh two aluminum dishes for each sample and enter the numbers and weights as TARE# and TARE WT. respectively on the Sizdist Coding Form for each sample.

14) Check the suspension for complete dispersion of the particles (Krumbein and Pettijohn, 1938). If flocculation has occurred, the suspension will separate into layers of clear water and flocculent precipitate. In this event, stop the analysis and note that there has been flocculation as a Comment on the Sizdist Coding Form. Should the person requesting the analysis require complete dispersion of the sample, refer to Krumbein and Pettijohn (1938) for additional procedures. If flocculation does not occur, continue with the next step.

15) Mix the suspension for 30 seconds by repeatedly inverting and righting the cylinder. Set the cylinder down and take the temperature of the suspension to determine correct pipette withdrawal times (Table 3).

16) Mix the suspension for one minute by repeatedly inverting and righting the cylinder, set it down carefully at time 0.

17) Immerse a pipette in the suspension to the 20 cm mark on the pipette (Appendix 1, Section 3.2) and withdraw 25 ml of suspension at the elapsed time since set down (Table 3).

18) Empty the pipette into the first prenumbered aluminum dish, rinse with distilled water and add the rinse to the same aluminum dish.

19) Take a second, 25 ml, pipette aliquot at the 5 cm mark on the pipette (Appendix 1, Section 3.2) at the time given in Table 3. Empty and rinse the pipette into the second aluminum dish. Table 6 provides a schedule of consecutive pipette withdrawal times for batch processing.

20) Discard the remaining suspension.

21) Oven dry the pipette samples at 90°C and place them in a desiccator to cool.

22) Weigh the dried samples to 0.0001 g and record the weights as GROSS WT. PIP. FR. on the Sizdist Coding Form. Be careful to record the weight adjacent to the appropriate Tare #.

23) Discard the dried sample.

24) Add the following to the Sizdist Coding Form:

    a) Data Pts.* - the total number of sieve and pipette weights.

    b) NO. COMMENT CARDS - the total number of comment cards.

    c) SIEVE/ST. PTS. - the total number of sieve weights.

    d) ϕ INTERVAL - leave blank.

    e) CYL. SIZE ml - the volume of the cylinders used for short pipette analysis (500 cc for standard analysis).

    f) ϕ ORIGIN - -1.0 if sieve fraction; leave blank if no sieve fraction.

25) Keypunch the data on the Sizdist Coding Form alloting one computer card for each line of data.

26) Process the data with SIZDIST: A Fortran IV computer program (Report in Progress).

4.0 SIEVE, SHORT PIPETTE AND SETTLING TUBE

4.1 General

This procedure provides gravel, sand, silt and clay percentages with ½ PHI resolution on the sand (Rukavina and Duncan, 1970). First the gravel is separated from the sample by sieving at -0.5 PHI (1.41 mm). The silt and clay is then resolved by short pipette analysis. Briefly, short pipette consists of withdrawing two aliquots from a sediment suspension at predetermined depths and times. The first aliquot contains the proportion of silt and clay in the sample, the second aliquot only the clay. The settling tube is used to obtain the size distribution of the sand fraction. Sand is released from the top of an Emery settling tube (Emery, 1938) and the amount of accumulation is measured at pretimed intervals. Figure 4 shows the details of the procedure as described in the following section.

4.2 Procedure

1) Label the Sizdist Coding Form (Figure 1) with the Analyst and Laboratory Number* and enter the SAMPLE DESIGNATION, date of analysis (DAY, MO. YR.) and ANALYSIS CODE NO. (4 for sieve, short pipette and settling tube) for each sample to be analysed.
2) Freeze-dry the sample (Appendix 2).
3) Split the sample to 20 g with a Jones-type riffle splitter or the cone and quarter method (Appendix 3). Store the unused portion of the sample.
4) Remove shells, wood, cinders, etc. from the split, weigh them to 0.01 g and record the weight and composition as a Comment on the Sizdist Coding Form (indicate that the weight of this material is not included in the total sample weight). Discard the material.
5) Disaggregate conglomerates in the working sample with a rubber-tipped pestle and mortar or a wooden rolling pin.
6) Weigh the split to 0.0001-g and record the weight as SAMPLE WT. g on the Sizdist Coding Form.
7) Remove the gravel fraction by sieving the split at -0.5 PHI (1.41 mm). Weigh the material retained on the sieve to 0.0001 g and record the weight on the Sizdist Coding Form in the first space provided under SIEVE WTS. + SETTLING TUBE HTS. Discard the gravel fraction.

---

* Each sample entering the CCIW Sedimentology Laboratory is given an indepen-ent laboratory number.

8) Transfer the material finer than -0.5 PHI (1.41 mm) to a mixing cup (ASTM designation D-422-63, 1963) and add 50 ml of dispersant (50 g of Calgon/litre of distilled water) and 300 ml of distilled water. Make necessary adjustments for non-standard sample size according to Table 2.

9) Mix suspension for 15 minutes on an electric mixer (ASTM designation D422-63, 1963).

10) Transfer the suspension to a prelabelled, 500 ml cylinder and add distilled water to bring the suspension to the 500 ml level.

11) Allow the suspension to stand for one hour.

12) Transfer 50 ml of dispersant to two preweighed, aluminum dishes; oven dry at 90°C, and remove and place in a dessicator to cool, weight to 0.0001 g, and record the weight of the dispersant as WT. DISPERSANT on the Sizdist Coding Form. Repeat approximately every 15 samples.

13) Number and weigh two aluminum dishes for each sample and enter the numbers and weights as TARE# and TARE WT. respectively on the Sizdist Coding Form for each sample.

14) Check the suspension for complete dispersion of the particles (Krumbein and Pettijohn, 1938). If flocculation has occurred, the suspension will separate into layers of clear water and flocculent precipitate. In this event, stop the analysis and note that there has been flocculation as a Comment on the Sizdist Coding Form. Should the person requesting the analysis require complete dispersion of the sample, refer to Krumbein and Pettijohn (1938) for additional procedures. If flocculation does <u>not</u> occur, continue with the next step.

15) Mix the suspension for 30 seconds by repeatedly inverting and righting the cylinder. Set the cylinder down and take the temperature of the suspnesion to determine correct pipette withdrawal times (Table 3).

16) Mix the suspension for one minute by repeatedly inverting and righting the cylinder, set it down carefully at time 0.

17) Immerse a pipette in the suspension to the 20 cm mark on the pipette (Appendix 1, Section 3.2) and withdraw 25 ml of suspension at the elapsed time since set down (Table 3).

18) Empty the pipette into the first prenumbered aluminum dish, rinse with distilled water and add the rinse to the aluminum dish.

19) Take a second, 25 ml, pipette aliquot at the 5 cm mark on the pipette (Appendix 1, Section 3.2) at the time given in Table 3.

20) Empty and rinse the pipette into the second aluminum dish. Table 6 provides a schedule of consecutive pipette withdrawal times for batch processing.

21) Oven dry the second pipette samples at 90°C and place them in a desiccator to cool.

22) Wet sieve the remaining suspension at 4.5 PHI (0.044 mm) and split the residue to 3-5 g with a Jones-type riffle splitter. This is the settling tube working sample.

23) Discard the remaining suspension and proceed with settling tube analysis. Check the settling tube with a level to determine if it is vertical and adjust if necessary.

24) Fill the tube with distilled water and record the water temperature. Table 4 gives the times at which cumulative height readings are taken for various water temperatures. At CCIW, the times have been prerecorded on cassette tapes which are played back during the analysis.

25) Set the tape recorder to the start of the time signals for the appropriate water temperature.

26) Inflate the balloon-release mechanism (Plate 2) at the top of the settling tube by depressing the propipette bulb.

27) Wash the working sample into the settling tube with distilled water. The bottom of the sample should be level with the start line at the top of the tube (Plate 2).

28) Start the tape recorder and deflate the balloon on the prerecorded signal by depressing the "A" and "S" valves on the propipette (Plate 2).

29) At each subsequent signal, record the height of sediment accumulation at the base of the settling tube (Plate 3) and enter the height for each reading on the Sizdist Coding Form as SIEVE WTS. + SETTLING TUBE CUMULATIVE HTS. immediately following the sieve weights.

30) Recover and store the settling tube working sample.

31) Weigh the dried samples to 0.0001 g and record the weights as GROSS WT. PIP. FR. on the Sizdist Coding Form. Be careful to record the weight adjacent to the appropriate Tare #.

32) Add the following to the Sizdist Coding Form:

    a) DATA PTS* - the total number of sieve weights, settling tube heights and pipette drawoffs.

b) NO COMMENT CARDS - the total number of comment cards.

c) SIEVE/S.T. PTS. - the total number of sieve weights and settling tube heights.

d) ϕ INTERVAL - 0.5 for this procedure.

e) CYL. SIZE ml - the volume of the cylinders used for pipette analysis (500 ml for standard analysis).

33) Keypunch the data on the Sizdist Coding Form alloting one computer card for each line of data.

34) Process the data with SIZDIST: A Fortran IV computer program (Report in progress).

5.0 SIEVE, SETTLING TUBE, PIPETTE AND SEDIGRAPH ANALYSIS

5.1 General

This procedure, introduced as F.A.S.T.'R. (Rukavina and LaHaie, 1976), provides gravel, sand, silt and clay percentages with ½ PHI resolution of each case. It consists of:

1) sieving the sediment larger than 0 PHI (1.00 mm)
2) settling tube analysis for the sand fraction between 0 PHI and 4 PHI (1.00-0.0625 mm).
3) pipette analysis to obtain the Sedigraph working sample.
4) Sedigraph analysis.

The sieving is conducted in accordance with the procedures outlined in Section 1.2 of this report. The settling tube procedure follows that given in Rukavina and Duncan (1970). Sand is released from the top of an Emery settling tube (Emery, 1938) and the amount of accumulation is measured at pretimed intervals.

The pipette procedure (Section 3.2) is used to collect a representative sample of the silt-clay fractions. The first aliquot is processed automatically by the Sedigraph. The second aliquot is oven dried, weighed and recorded. The Sedigraph measures particle size by recording the amount of X-rays absorbed by a suspension of sedimenting particles in the silt-clay size range. The lower limit for Sedigraph analysis is 12 PHI (0.00024 mm).

The details of the procedure are shown in Figure 5 and described in the following section.

5.2 Procedure

1) Label the Sizdist Coding Form (Figure 1) with Analyst and Laboratory Number* and enter the SAMPLE DESIGNATION, date of analysis (DAY, MO., YR.) and ANALYSIS CODE NO. (5 for sieve, settling tube, pipette and sedigraph analysis) for each sample to be analysed.
2) Freeze-dry the sample (Appendix 2).
3) Split the sample to approximately 20 g with a Jones-type riffle splitter or the cone and quarter method (Appendix 3). Store the unused portion of the sample.

---

* Each sample entering the CCIW Sedimentology Laboratory is given an independent laboratory number.

4) Remove shells, wood, cinders, etc. from the split, weigh them to 0.01 g and record the weight and composition as a Comment on the Sizdist Coding Form (indicate that the weight of this material is not included in the total sample weight).

5) Disaggregate conglomerates in the working sample with a rubber-tipped pestle and mortar or a wooden rolling pin.

6) Weigh the split to 0.0001 g and record the weight as SAMPLE WT. g on the Sizdist Coding Form.

7) Prepare a stack of sieves beginning at -½ PHI (1.41 mm) and extending at ½ PHI intervals, beyond the estimated size of the largest particle in the sample. Put a catch pan on the bottom of the stack.

8) Put the sample in the stack of sieves, shake gently by hand and remove any empty sieves from the top of the stack. If a particle is retained on the first sieve, add additional sieves until the particle passes through.

9) Place the stack of sieves on the electromagnetic sieve shaker for ten minutes at a rheostat setting of 10 (this is equivalent to ten minutes on a Ro-Tap mechanical shaker).

10) After sieving is completed, remove the sieves from the shaker and record the PHI size of the first sieve that has retained any material as ϕ ORIGIN on the Sizdist Coding Form.

11) Empty the contents of the first sieve onto a large piece of paper and gently tap the side of the sieve along the mesh diagonal.

12) Transfer the sediment from the paper to a tared aluminum dish.

13) Replace the paper and remove any particles trapped in the sieve mesh by striking the sieve sharply on the paper. To prevent damage to the sieve or loss of material, be careful to strike it squarely on the paper. Do not pry or brush particles from the sieve mesh as this may alter the size of the mesh openings.

14) Add the dislodged particles to the material in the tared aluminum dish, weigh to 0.0001 g and enter the weight on the Sizdist Coding Form in the first space under SIEVE WTS. + SETTLING TUBE CUMULATIVE HTS.

15) Repeat steps 11 to 14 for each sieve in the stack and enter the weights of each sieve fraction on the Sizdist Coding Form in the space to the right of the previous entry. If there is no sediment on a sieve, enter a value of 0.00 in the appropriate space on the Sizdist Coding Form.

16) Recover and store the sieve working sample.

17) Transfer the pan fraction to a mixing cup (ASTM designation D-422-63, 1963) and add 50 ml of dispersant (50 g of Calgon/litre of distilled water) and 300 ml of distilled water. Make necessary adjustments for nonstandard sample size according to Table 2.

18) Mix the suspension for 15 minutes on an electric mixer (ASTM designation D-422-63, 1963).

19) Transfer the suspension to a prelabelled, 500 ml cylinder and add distilled water to bring the suspension to the 500 ml level.

20) Allow the suspension to stand for one hour.

21) Transfer 50 ml of dispersant to two, preweighed, aluminum dishes; oven dry at 90°C; remove and place in a dessicator to cool, weight to 0.0001 g and record the weight of the dispersant as WT. DISPERSANT on the Sizdist Coding Form. Repeat approximately every 15 samples.

22) Number and weigh two aluminum dishes for each sample and enter the numbers and weights as TARE# and TARE WT. respectively on the Sizdist Coding Form for each sample.

23) Check the suspension for complete dispersion of particles (Krumbein and Pettijohn, 1938). If flocculation has occurred, the suspension will separate into layers of clear water and flocculent precipitate. In this event, stop the analysis and note that there has been flocculation as a Comment on the Sizdist Coding Form. Should the person requesting the analysis require complete dispersion of the sample, refer to Krumbein and Pettijohn (1938) for additional procedures. If flocculation does <u>not</u> occur, continue with the next step.

24) Mix the suspension for 30 seconds by repeatedly inverting and righting the cylinder. Set the cylinder down and take the temperature of the suspension to determine correct pipette withdrawal times (Table 3).

25) Mix the suspension again for one minute and set it down carefully at time 0.

26) Immerse a pipette in the suspension to the 20 cm mark on the pipette (Appendix 1, Section 3.2) and withdraw 25 ml at the elapsed time since set down (Table 3).

27) Empty the pipette into a prelabelled 16 dram vial, rinse with distilled water and add the rinse to the same 16 dram vial. This is the Sedigraph working sample.

28) Take a second, 25 ml, pipette aliquot at the 5 cm mark on the pipette (Appendix 1, Section 3.2) at the time given in Table 3.

29) Empty and rinse the pipette into the second aluminum dish. Table 6 provides a schedule of consecutive pipette withdrawal times for batch processing.

30) Oven dry the second pipette samples at 90°C and place them in a desiccator to cool.

31) Wet sieve the remaining suspension at 4.5 PHI (0.044 mm) and split the residue to 3-5 g with a Jones-type riffle splitter. This is the settling tube working sample.

32) Discard the remaining suspension and proceed with settling tube analysis.

33) Check the settling tube with a level to determine if it is vertical and adjust if necessary.

34) Fill the tube with distilled water and record the water temperature. Table 4 gives the times at which cumulative height readings are taken for various water temperatures. At CCIW, the times have been prerecorded on cassette tapes which are played back during the analysis.

35) Set the tape recorder to the start of the time signals for the appropriate water temperature.

36) Inflate the balloon-release mechanism (Plate 2) at the top of the settling tube by depressing the propipette bulb.

37) Wash the working sample into the settling tube with distilled water. The bottom of the sample should be level with the start line at the top of the tube (Plate 2).

38) Start the tape recorder and deflate the balloon on the prerecorded signal by depressing the "A" and "S" valves on the propipette (Plate 2).

39) At each subsequent signal, record the height of sediment accumulation at the base of the settling tube (Plate 3) and enter the height for each reading on the Sizdist Coding Form as SIEVE WTS. + SETTLING TUBE CUMULATIVE HTS. immediately following the sieve weights.

40) Recover and store the settling tube working sample. Proceed to Sedigraph analysis.

41) At CCIW, the Sedigraph is left running continuously so that the X-ray tube is always warm and the compartment temperature is stable. If the Sedigraph is not running, turn the MASTER, X-RAY, and recorder ON-OFF switches (Plate 4) to ON and wait one hour.

42) Set the recorder LOAD-LIFT-ON switch (Plate 4) to LOAD and insert a sheet of graph paper (Micromeritics Instrument Corporation Form 500/42701) under the clips along the top and left sides of the recorder and against the stops under the hold-down bar at the bottom of the recorder.

43) Check the alignment of the graph paper by moving the LOAD-LIFT-ON switch to LIFT, depressing the ZERO button (Plate 4) and sighting along the horizontal pen carriage. Adjust as required.

44) Screw the pen into the pen holder.

45) Rinse the interior of the sedimentation cell with distilled water by inserting the suction and discharge tubes into distilled water and turning the FLOW switch to ON. Return FLOW switch to OFF after rinsing..

46) Clean the exterior of the cell with lens paper.

47) Calibrate the cell by:

a) rotating the recorder 100 PERCENT dial fully clockwise (maximum sensitivity).

b) filling the cell with dispersant (5 g Calgon/cubic decimetre of distilled water) as above and inspecting the cell for air bubbles.

c) removing the lead shield* from the photomultiplier tube and seating the cell in position.

<u>Caution:</u> Do not put your fingers between the cell and the X-ray beam.

d) setting the RATE switches to maximum (up position is on).

e) adjusting the recorder 0 PERCENT dial until the recorder reads 10% on the Y-axis.

f) depressing the DIAMETER SET button until the recorder pen reads 62 microns (the starting diameter) on the X-axis.

g) turning the SCAN switch to ON and observing the scan. The trace should remain within ±2% of the 10% line on the Y-axis. If not, check the cell for air bubbles, dirty or warped cell windows; make the necessary adjustments; and repeat the calibration.

h) turning the SCAN switch to OFF, the recorder LOAD-LIFT-ON switch to LIFT and momentarily holding the ON-RESET switch at RESET after the scan is completed.

48) Zero the baseline as follows:

a) press the DIAMETER SET button until the recorder pen reads 62 microns on the X-axis.

---

* A lead shield has been fitted over the photomultiplier tube to protect it from receiving X-rays when no samples are being analysed.

b) press and hold ZERO button while simultaneously adjusting the ZERO dial until it reads 0 percent on the Y-axis. Lock ZERO dial in position.

c) release ZERO button and, if necessary, readjust 0 PERCENT dial until pen is at 0 percent on the Y-axis. Lock 0 PERCENT dial in position.

d) repeat the baseline adjustment every five samples.

49) Remove dispersant from the cell.

50) Put a magnetic stirring bar in the sample vial (from step 27), place the vial in the sample compartment and turn the STIRRER dial clockwise from the OFF position until all the particles are in suspension.

51) Remove the cell from the holder, load the sample as before (Step 45), and inspect the cell for air bubbles.

52) Replace the cell in the holder, and close the compartment door. The intensity meter should now read between 30 and 50. If not, refer to trouble shooting in the Sedigraph manual (Micromeretics, 1973).

53) Adjust the recorder 100 PERCENT dial until the recorder pen is at 100% on the Y-axis and lock the dial in position. If the recorder pen is less than 100% and cannot be set to 100%, leave it at its maximum value.

54) Set the RATE switches to the setting that corresponds with the compartment temperature (Table 5).

55) Begin the analysis by momentarily holding the ON-RESET switch at ON. This automatically stops the circulating pump and sedimentation begins.

56) Permit the analysis to continue until one of the following occurs:

a) the program ends and the pen returns to its rest position. Move the ON-RESET switch momentarily to RESET and the LOAD-LIFT-ON switch to LOAD.

b) the cumulative percent (Y-axis) equals zero. The analysis is stopped by turning the recorder LOAD-LIFT-ON switch to LOAD and the ON-RESET switch momentarily to RESET.

c) the sample flocculates. Flocculation is easily recognized as an abrupt vertical drop in the size distribution curve (Figure 7). If this happens, hold the ON-RESET switch momentarily at RESET, the LOAD-LIFT-ON switch to LOAD, remove the flocculated suspension and proceed with the next sample.

57) Recover the sample from the cell and rinse with distilled water as before.

58) Transfer the entire Sedigraph working sample to the first aluminum dish for each sample (see Step 22), oven dry at 90°C and place in a desiccator to cool.

59) Weigh the dried sample in the first aluminum dish to 0.0001 g and record the weight on the Sizdist Coding Form as the first entry beneath GROSS WT. PIP. FR.

60) Weigh the other dried sample and the second aluminum dish (Step 30) to 0.0001 g and record the weight on the Sizdist Coding Form as the second entry beneath GROSS WT. PIP. FR.

61) Transfer the cumulative percentages from the Sedigraph graph paper to the Sizdist Coding Form as SEDIGRAPH PERCENTAGES beginning with the coarsest particles. At CCIW, an overlay, scaled in ½ PHI units, is used to extract the percentages.

62) Add the following to the Sizdist Coding Form:

   a) DATA PTS* - the total number of sieve weights, settling tube heights, pipette drawoffs and Sedigraph percentages.

   b) NO. COMMENT CARDS - the total number of comment cards.

   c) SIEVE/S.T. PTS. - the total number of sieve weights and settling tube heights.

   d) ∅ INTERVAL - 0.5 for this procedure.

   e) CYL. SIZE ml - the volume of the cylinders used for pipette analysis (500 ml for standard analysis).

63) Keypunch the data on the Sizdist Coding Form alloting one computer card for each line of data.

64) Process the data with SIZDIST: a Fortran IV computer program (Report in Progress).

6.0 SEDIGRAPH ANALYSIS

6.1 General

Sedigraph analysis was designed to process samples weighing less than 5 g and composed mainly of silt and clay. The procedure yields percentages of sand, silt and clay with a maximum resolution of ¼ PHI of the silt and clay to 12 PHI (0.00024 mm). Basically the method consists of:

1) removal of particles large enough to block Sedigraph suction tube 3.5 PHI (0.088 mm).

2) dispersing sample in a Calgon suspension.

3) automatic analysis with the Sedigraph.

The details of the procedure are shown in Figure 6 and described in the following section.

6.2 Procedure

1) Label a Sizdist Coding Form (Figure 1) with Analyst and Laboratory No.* and enter the SAMPLE DESIGNATION, date of analysis (DAY, MO., YR.) and ANALYSIS CODE NO. (7 for Sedigraph analysis) for each sample to be analysed.

2) Freeze-dry the sample (Appendix 2).

3) Split the sample to approximately 3 g with a Jones-type riffle splitter or the cone and quarter method (Appendix 3). Store the unused portion of the sample.

4) Remove shells, wood, cinders, etc. from the split, weigh them to 0.01 g and record the weight and composition as a Comment on the Sizdist Coding Form (indicate that the weight of this material is not included in the total sample weight). Discard the material.

5) Disaggregate conglomerates in the sample with a rubber-tipped pestle and mortar.

6) Weigh the split to 0.0001 g and record the weight as SAMPLE WT. g on the Sizdist Coding Form.

7) Put the sample into a 50 ml beaker, add approximately 25 ml distilled water, cover with a watch glass and let the sample soak overnight.

8) Wet sieve the sample at 3.5 PHI (0.0888 mm) sieve with a catch pan on the bottom. Use as little water as possible.

9) Wash the residue from the sieve into a preweighed aluminum dish, oven dry and place in a desiccator to cool.

10) Weigh the residue to 0.0001 g and record weight in the first space under SIEVE WTS. + SETTLING TUBE CUMULATIVE HTS.

11) Record the ϕ ORIGIN of the residue as 3.5 on the Sizdist Coding Form. If no material is retained on the sieve, leave ϕ ORIGIN blank.

---

* Each sample entering the CCIW Sedimentology Laboratory is given an independent laboratory number.

12) Centrifuge the pan fraction at 2500 RPM for 30 minutes.

13) Pour off the clear liquid. Transfer the sample from the centrifuge tube, using a spatula and approximately 25 ml dispersant (Calgon, 5 g/litre) to a 16 dram plastic vial and mix the suspension for 20 minutes on a paint shaker. (Duncan,1976).

14) At CCIW, the Sedigraph is left running continuously so that the X-ray tube is always warm and the compartment temperature is stable. If the Sedigraph is not running, turn the MASTER, X-RAY and recorder ON-OFF switches (Plate 4) to ON and wait one hour.

15) Set the recorder LOAD-LIFT-ON switch (Plate 4) to LOAD and insert a sheet of graph paper (Micromeritics Instrument Corporation Form 500/42701) under the clips along the top and left sides of the recorder and against the stops under the hold-down bar at the bottom of the recorder.

16) Check the alignment of the graph paper by moving the LOAD-LIFT-ON switch to LIFT, pressing in the ZERO button (Plate 4) and sighting along the horizontal pen carriage. Adjust as required.

17) Screw the pen into the pen holder.

18) Rinse the interior of the sedimentation cell with distilled water by inserting the suction and discharge tubes into distilled water and turning the FLOW switch to ON. Return FLOW switch to OFF after rinsing.

19) Clean the exterior of the cell with lens paper.

20) Calibrate the cell by:

a) rotating the recorder 100 PERCENT dial fully clockwise (maximum sensitivity).

b) filling the cell with dispersant (5 g Calgon/cubic decimetre of distilled water) as above and inspecting the cell for air bubbles.

c) removing the lead shield* from the photomultiplier tube and seating the cell in position.

<u>Caution:</u> Do not put your fingers between the cell and the X-ray beam.

d) Setting the rate switches to maximum (up position is on).

e) adjusting the recorder 0 PERCENT dial until the recorder reads 10% on the Y-axis.

f) depressing the DIAMETER SET button until the recorder pen reads 62 microns (the starting diameter) on the X-axis.

g) turning the SCAN switch to ON and observing the scan. The trace should remain within ±2% of the 10% line on the Y-axis. If not, check the cell for air bubbles, dirty or warped cell windows; make the necessary adjustments; and repeat the calibration.

h) turning the SCAN switch to OFF, the recorder LOAD-LIFT-ON switch to LIFT and momentarily holding the ON-RESET switch at RESET after the scan is completed.

21) Zero the baseline as follows:

a) press the DIAMETER SET button until the recorder pen reads 62 microns on the X-axis.

b) press and hold ZERO button while simultaneously adjusting the ZERO dial until it reads 0 percent on the Y-axis. Lock ZERO dial in position.

c) release ZERO button and, if necessary, readjust 0 PERCENT dial until pen is at 0 percent on the Y-axis. Lock 0 PERCENT dial in position.

d) repeat the baseline adjustment every five samples.

22) Remove dispersant from the cell.

23) Put a magnetic stirring bar in the sample vial (from step 14), place the vial in the sample compartment and turn the STIRRER dial clockwise from the OFF position until all the particles are in suspension.

24) Remove the cell from the holder, load the sample as before (step 19), and inspect the cell for air bubbles.

25) Replace the cell in the holder, and close the compartment door. The intensity meter should now read between 30 and 50. If not, refer to trouble shooting in the Sedigraph Manual (Micromeretics, 1973).

26) Adjust the recorder 100 PERCENT dial until the recorder pen is at 100% on the Y-axis and lock the dial in position. If the recorder pen is less than 100% and cannot be set to 100%, leave it at its maximum value.

27) Set the rate switches to the settings that correspond with the compartment temperature (Table 5).

28) Begin the analysis by momentarily holding the ON-RESET switch at ON. This automatically stops the circulating pump and sedimentation begins.

29) Permit the analysis to continue until one of the following occur:

a) the program ends and the pen returns to its rest position. Move the ON-RESET switch momentarily to RESET and the LOAD-LIFT-ON switch to LOAD.

---

* A lead shield has been fitted over the photomultiplier tube to protect it from receiving X-rays when no samples are being analysed.

b) the cumulative percent (Y-axis) equals zero. The analysis is stopped by turning the recorder LOAD-LIFT-ON switch to LOAD and the ON-RESET switch momentarily to RESET.

c) the sample flocculates. Flocculation is easily recognized as an abrupt vertical drop in the size distribution curve (Figure 6). If this happens, hold the ON-RESET switch momentarily at RESET, turn the LOAD-LIFT-ON switch to LOAD, remove the flocculated suspension and proceed with the next sample.

30) Recover the sample from the cell and discard.

31) Clean the cell with distilled water as before.

32) Transfer the cumulative percentages from the Sedigraph graph paper to the Sizdist Coding form as SEDIGRAPH PERCENTAGES beginning with the coarsest particles. Always enter two data points for the 62 micron reading. This will account for any sand in the Sedigraph analysis. At CCIW, an overlay, scaled in ½ PHI units, is used to extract the percentages.

33) Add the following to the Sizdist Coding Form:

a) DATA PTS* - The total number of Sedigraph percentages plus one sieve weight if present.

b) NO COMMENT CARDS - The total number of comment cards.

c) SIEVE/S.T. PTS. - 1 if sieve fraction present, leave blank if no sieve fraction.

d) ϕ ORIGIN - 3.5 if sieve fraction present, leave blank if no sieve fraction.

e) INTERVAL - The PHI interval at which the Sedigraph readings are taken.

34) Keypunch the data on the Sizdist Coding Form alloting one computer card for each line of data.

35) Process the data with SIZDIST: A Fortran IV computer program (report in progress).

7.0 REFERENCES

ASTM, 1964. "Procedures for Testing Soils". American Society for Testing and Materials, Philadelphia, Pa., 535 p.

Duncan, G. A., 1976. "Paint Shaker for Small Sample Dispersant". Unpublished Test Results.

Emery, K. O., 1938. "Rapid Method of Mechanical Analysis of Sands". J. Sediment. Petrol. 8:105-111.

Geoscience, not dated. "Pulverit 3 - Electromagnetic Sieving Machine for Dry and Wet Operation". Geoscience Instruments Corporation, Mount Vernon, New York.

Krumbein, W. C. and F. J. Pettijohn, 1938. "Manual of Sedimentary Petrography". Appleton-Century-Crofts, New York, 549 p.

Micromeritics, not dated. "Instruction Manual - Model 5000 Particle Size Analyzer". Micromeritics Instrument Corporation, Norcross, Georgia.

Rukavina, N. A. and G. A. Duncan, 1970. "F.A.S.T. - Fast Analysis of Sediment Texture". Proc. 13th Conf. Great Lakes Res., p. 274-281.

Rukavina, N. A. and G. G. LaHaie, 1976. "Changes in Size-Analysis Procedures". CCIW Sedimentology Laboratory, Hydraulics Research Division, Technical Note, Report No. 76-1.

Virtis, not dated. "Instruction Manual for Virtis Freeze Dryers: Model 10-146 MR-BA and Model Unitrap 10-100". The Virtis Company Inc., Gardiner, New York.

W. S. Tyler Company, not dated. "Operating Instructions for Ro-Tap Testing Sieve Shaker". The W. S. Tyler Company, Cleveland, Ohio.

ILLUSTRATIONS

FIGURES

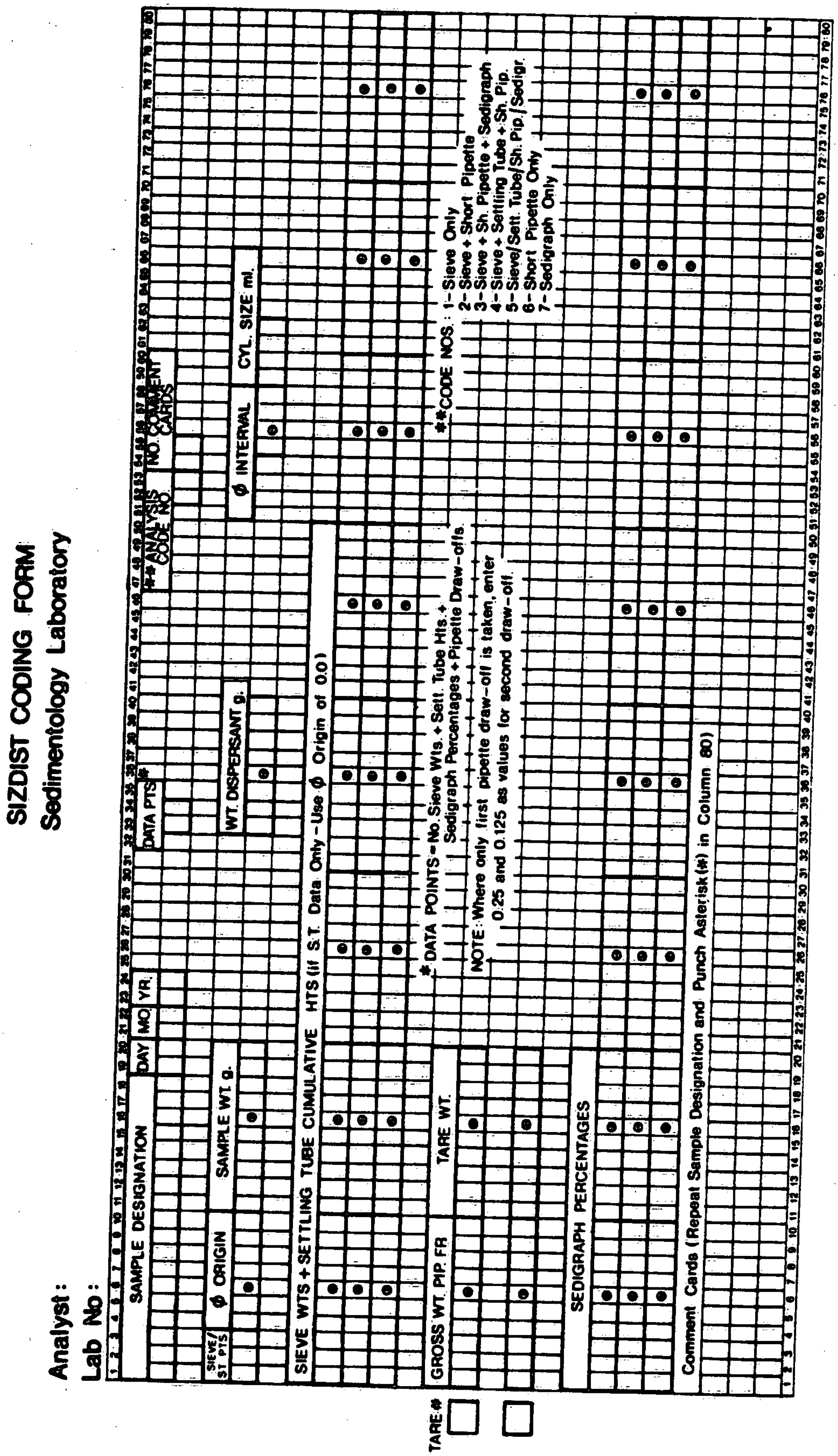


Figure 1 Sizdist Coding Form

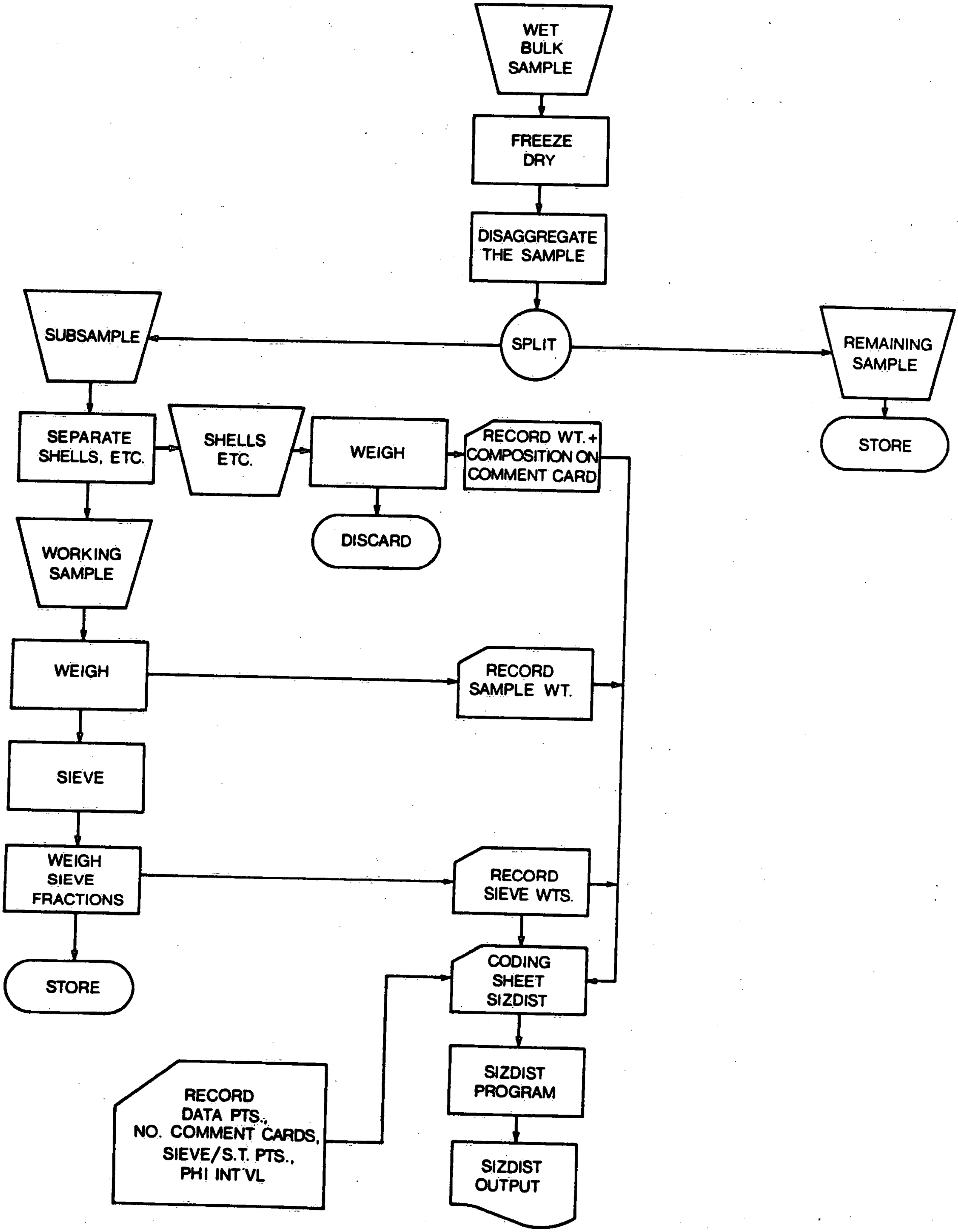


Figure 2 Flow Sheet - Sieve Analysis

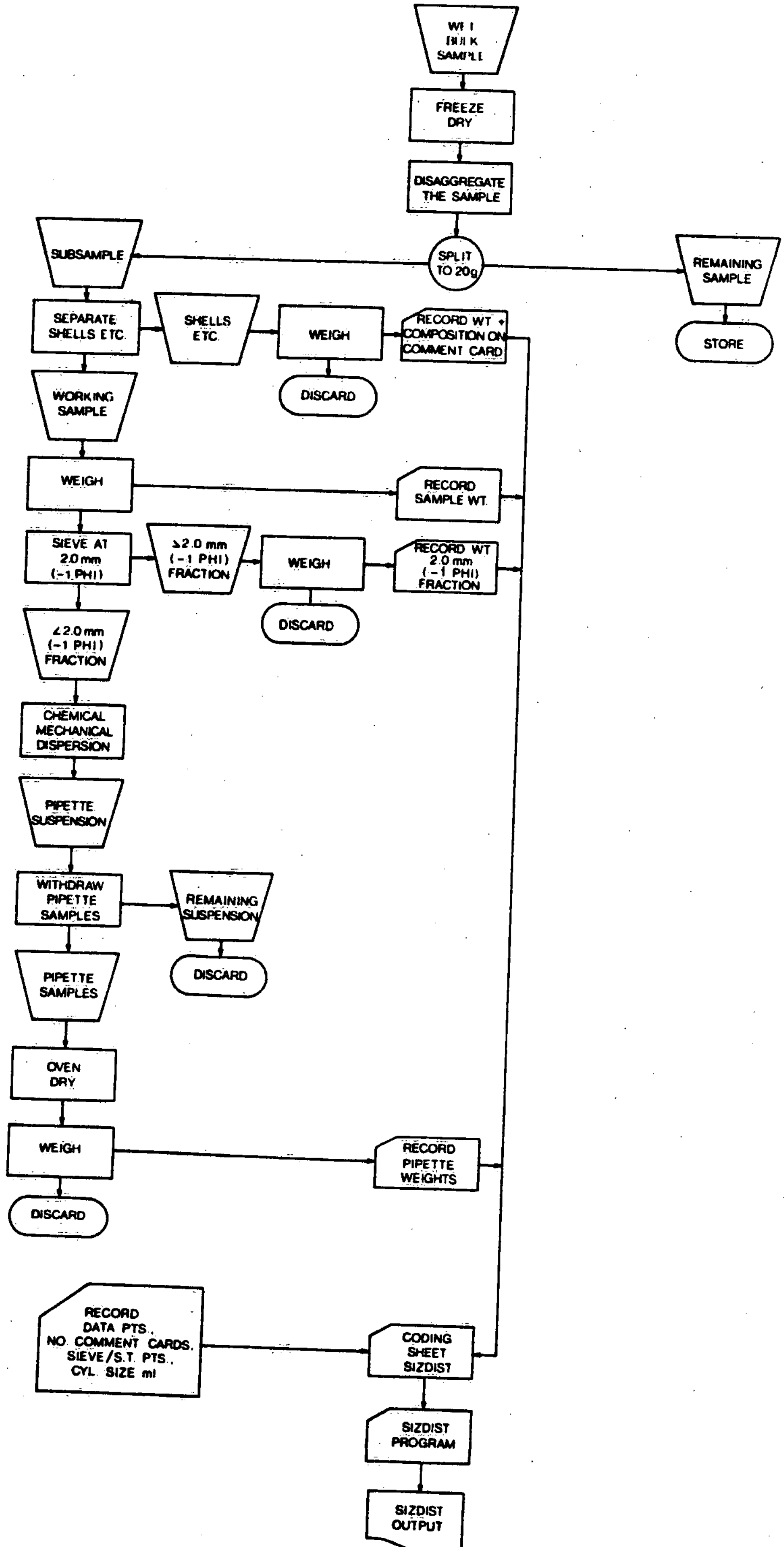


Figure 3 Flow Sheet - Sieve and Short Pipette Analysis

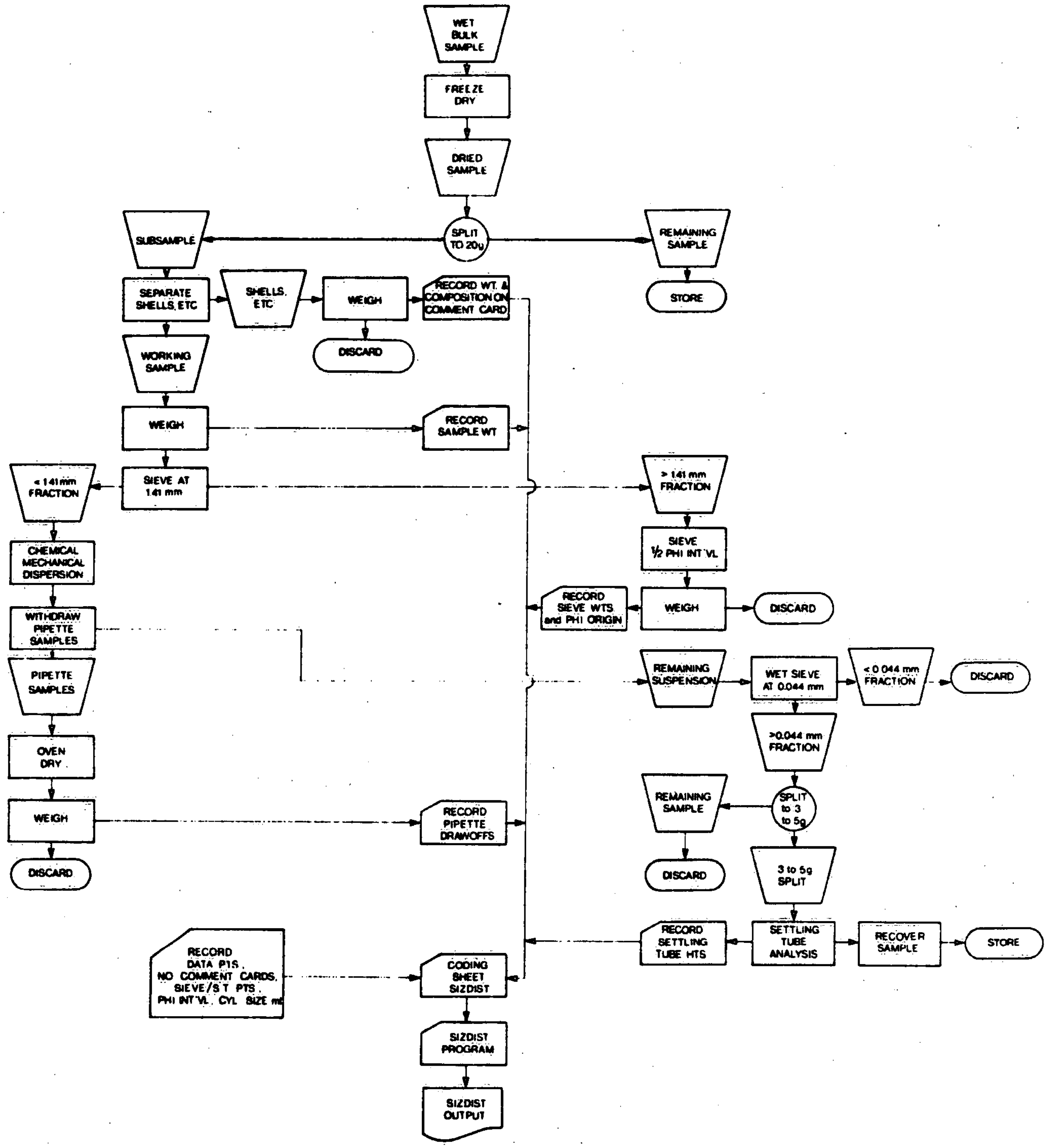


Figure 4 Flow Sheet - Sieve, Short Pipette and Settling Tube Analysis

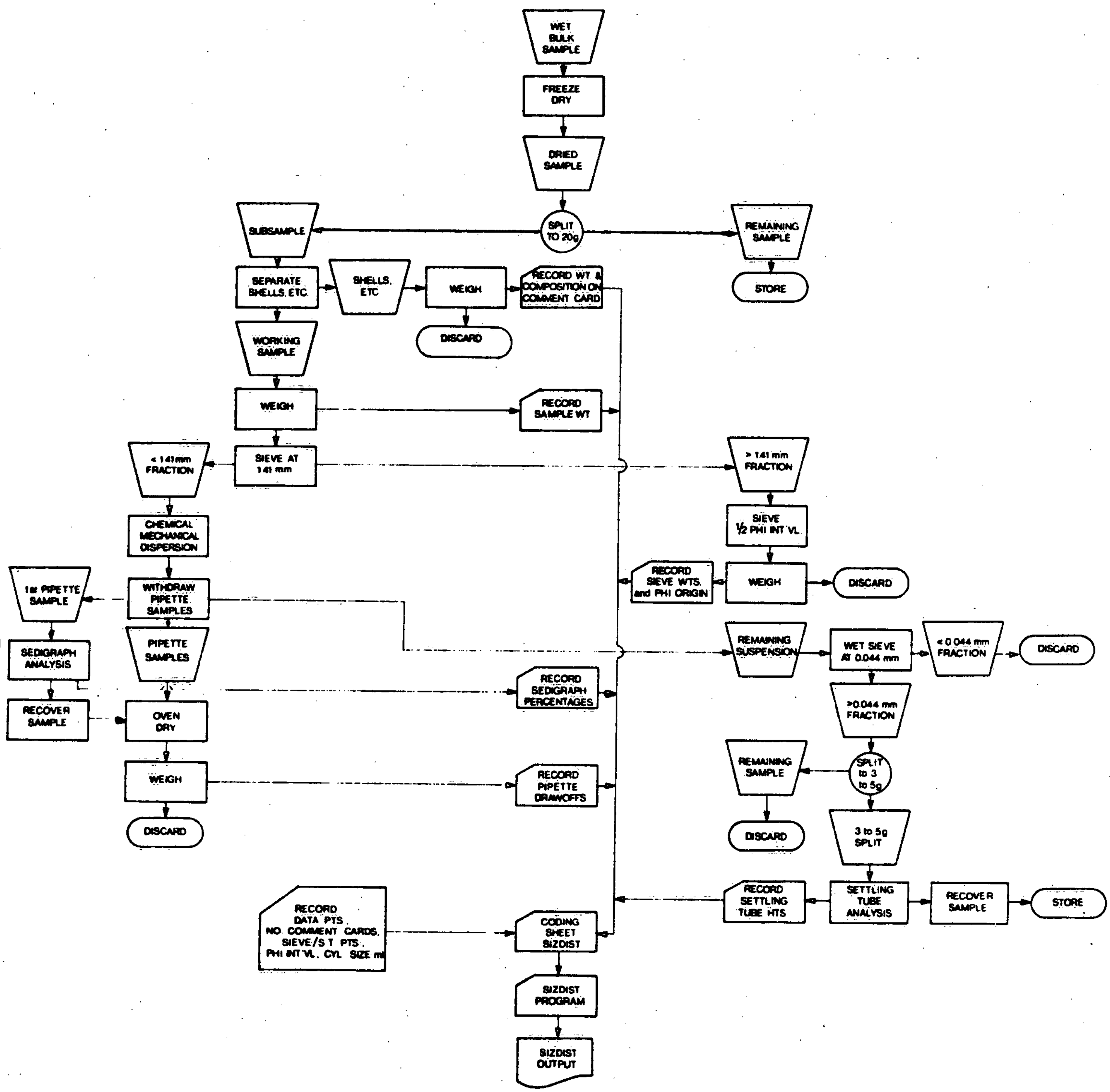


Figure 5 Flow Sheet - Sieve, Settling Tube, Pipette and Sedigraph Analysis

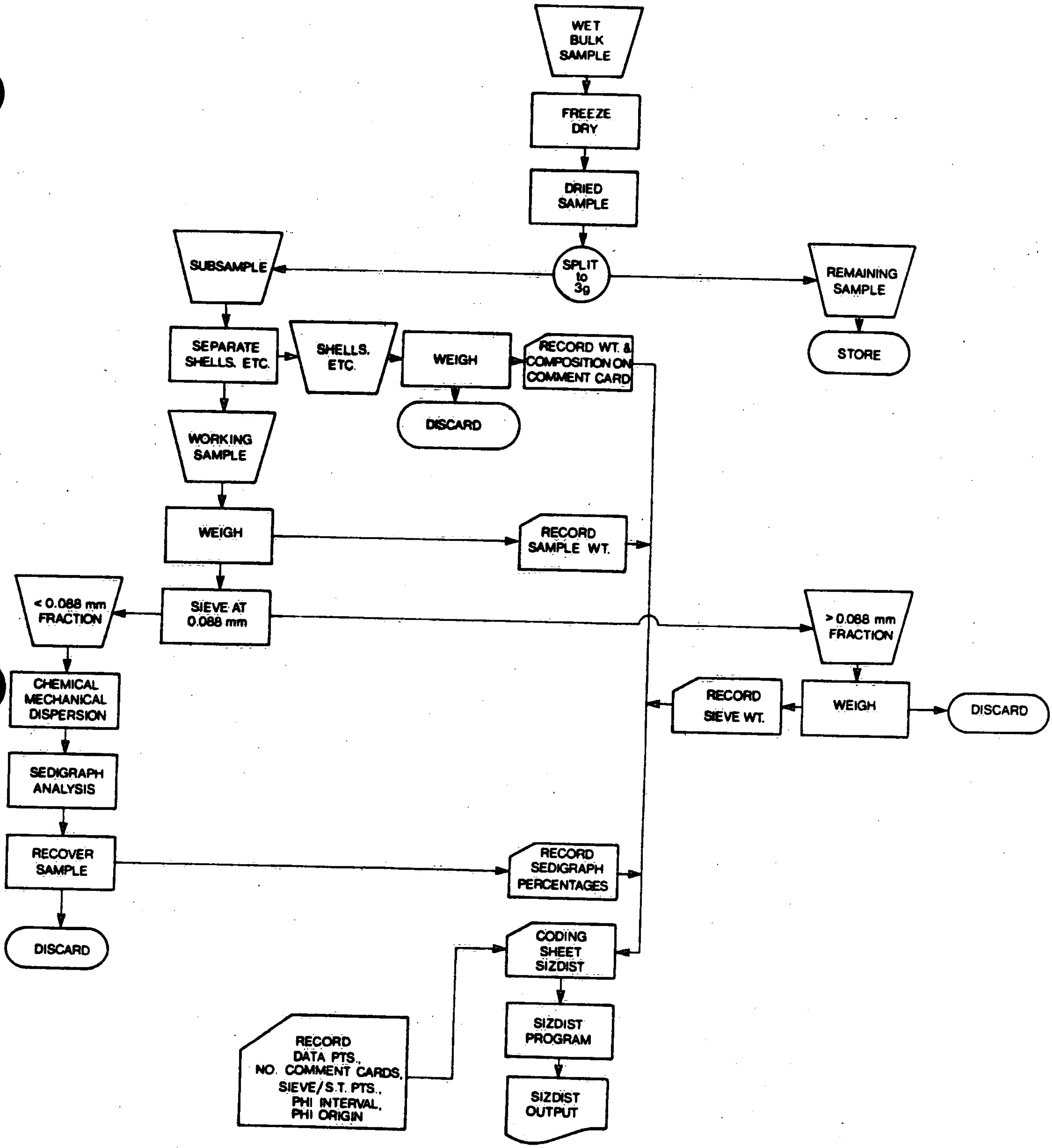
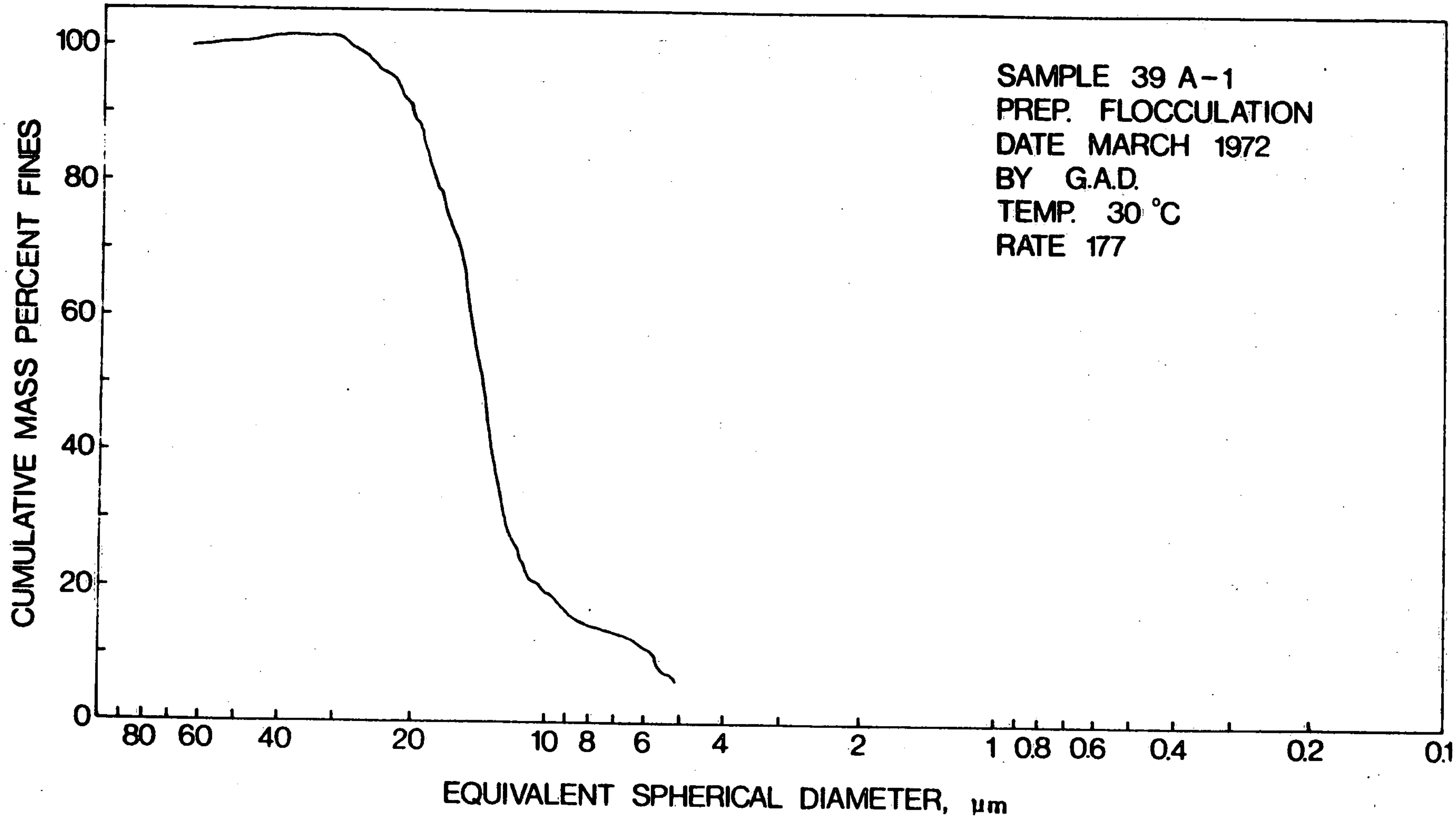


Figure 6 Flow Sheet - Sedigraph Analysis

FIGURE 7



Flocculation is recognizable by a rise at the beginning above 100% followed by a sharp drop then a leveling of the curve.

TABLES

TABLE 1

SAMPLE WEIGHTS FOR SIEVING

Sample	20.32 cm (8") Sieves			7.62 cm (3") Sieves		
	¼ PHI	½ PHI	1 PHI	¼ PHI	½ PHI	1 PHI
Coarse sand and gravel	300 g	250 g	200 g	-	-	-
Coarse sand	150 g	100 g	75 g	15-20 g	15-20 g	15-20 g
Medium sand	100 g	50 g	50 g	2.5-15 g	2.5-15 g	2.5-15 g
Fine sand	50 g	20 g	20 g	2.5 g	2.5 g	2.5 g

TABLE 2

<u>Adjustment for Non-Standard Sample Size</u>

10 g to 30 g:	No adjustment necessary.
Greater than 30 g:	1000 ml suspension volume and cylinder size, 100 ml of dispersant, 25 ml pipette drawoff.
Less than 10 g:	250 ml suspension volume and cylinder size, 25 ml of dispersant, 10 ml pipette drawoff.

TABLE 3

SHORT PIPETTE WITHDRAWAL TIMES

Suspension Temperature °C	Sample 1 (20 cm)*	Sample 2 (5 cm)**		
	sec	hr	min	sec
18	60	1	4	9
19	59	1	2	34
20	58	1	1	3
21	56	0	59	34
22	55	0	58	9
23	53	0	56	51
24	52	0	55	29
25	51	0	54	13
26	50	0	53	1
27	49	0	51	51
28	48	0	50	41
29	46	0	49	36
30	45	0	48	34

* Particles finer than 4.0 PHI (0.063 mm)

** Particles finer than 8.0 PHI (0.004 mm)

TABLE 4

SETTLING TUBE READING TIMES

Size		Times, sec					
PHI	mm	18°C	20°C	22°C	24°C	26°C	28°C
0.0	1.00	11	10	10	10	10	10
0.5	0.71	15	15	15	14	14	14
1.0	0.50	22	21	21	21	20	20
1.5	0.35	31	31	30	29	29	28
2.0	0.25	48	47	46	45	44	43
2.5	0.18	80	77	74	72	70	68
3.0	0.13	142	137	132	126	121	117
3.5	0.09	261	251	240	232	221	215
4.0	0.06	493	469	448	428	407	392

TABLE 4

SETTLING TUBE READING TIMES

Size		Times, sec					
PHI	mm	18°C	20°C	22°C	24°C	26°C	28°C
0.0	1.00	11	10	10	10	10	10
0.5	0.71	15	15	15	14	14	14
1.0	0.50	22	21	21	21	20	20
1.5	0.35	31	31	30	29	29	28
2.0	0.25	48	47	46	45	44	43
2.5	0.18	80	77	74	72	70	68
3.0	0.13	142	137	132	126	121	117
3.5	0.09	261	251	240	232	221	215
4.0	0.06	493	469	448	428	407	392

TABLE 5
SEDIGRAPH RATES

Starting Diameter - 62.5 microns

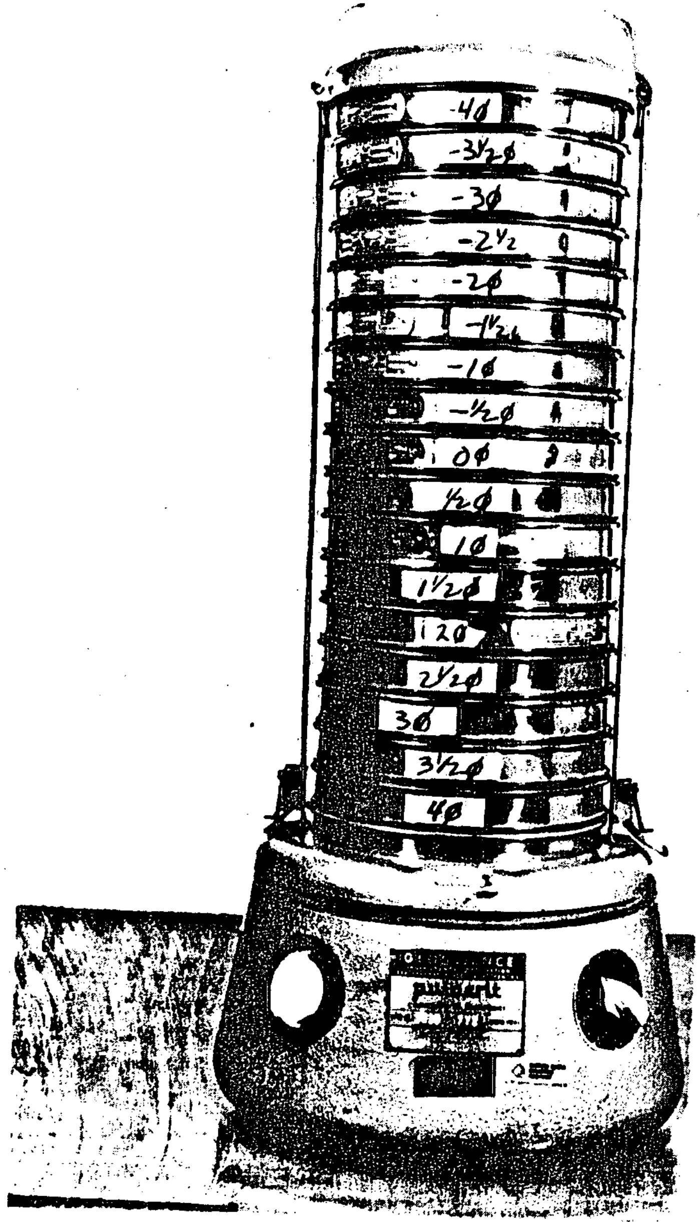
Temperature (^{o}C) (Cell Compartment)	Rate
26	162
28	170
30	177
32	185
34	193

TABLE 6

CONSECUTIVE PIPETTE WITHDRAWAL TIMES FOR BATCH PROCESSING AT 20°C

Cylinder Number	Set Down Time	First Drawoff 20 cm	Second Drawoff 5 cm
1	9:00:00	9:00:58	10:01:03
2	9:03:00	9:03:58	10:04:03
3	9:06:00	9:06:58	10:07:03
4	9:09:00	9:09:58	10:10:03
5	9:12:00	9:12:58	10:13:03
6	9:15:00	9:15:58	10:16:03
7	9:18:00	9:18:58	10:19:03
8	9:21:00	9:21:58	10:22:03
9	9:24:00	9:24:58	10:25:03
10	9:27:00	9:27:58	10:28:03
11	9:30:00	9:30:58	10:31:03
12	9:33:00	9:33:58	10:34:03
13	9:36:00	9:36:58	10:37:03
14	9:39:00	9:39:58	10:40:03
15	9:42:00	9:42:58	10:43:03

PLATES



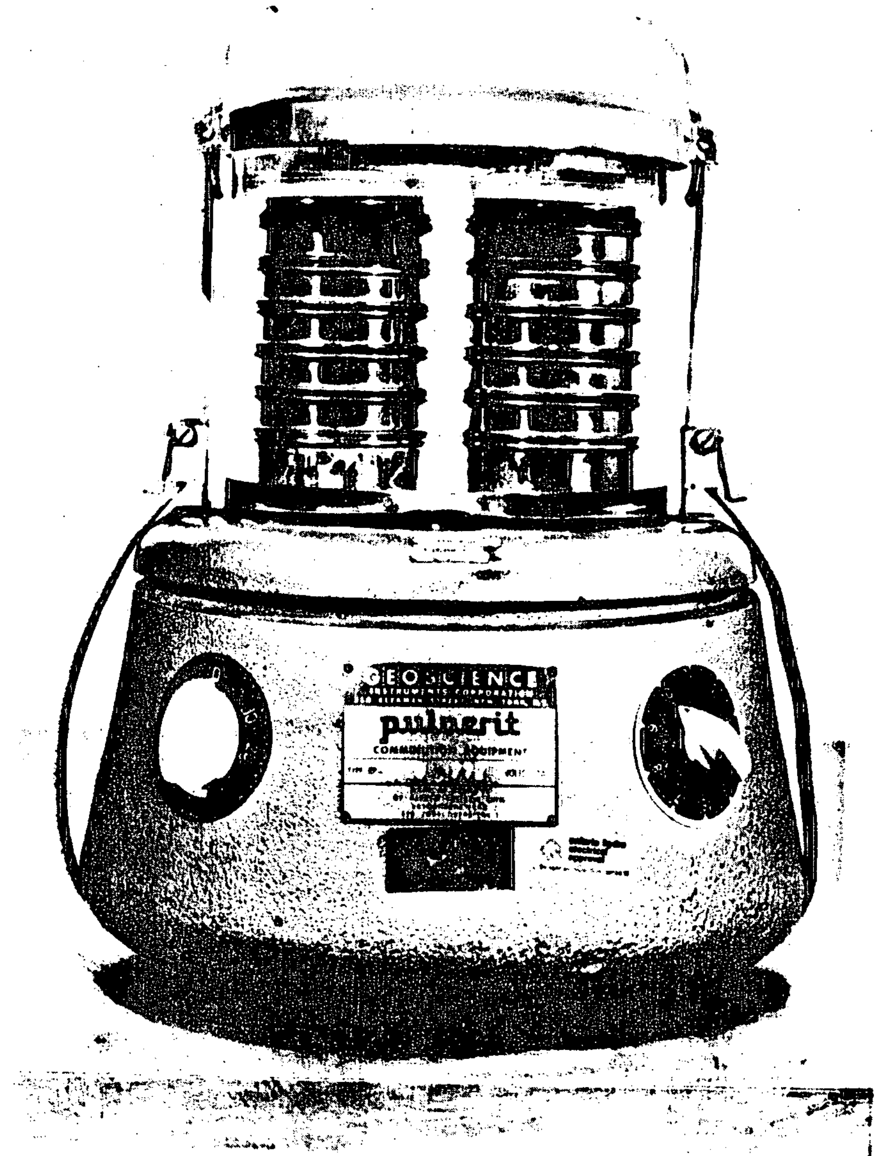


Plate 1 Sieves and Pulverit Sieving Machine

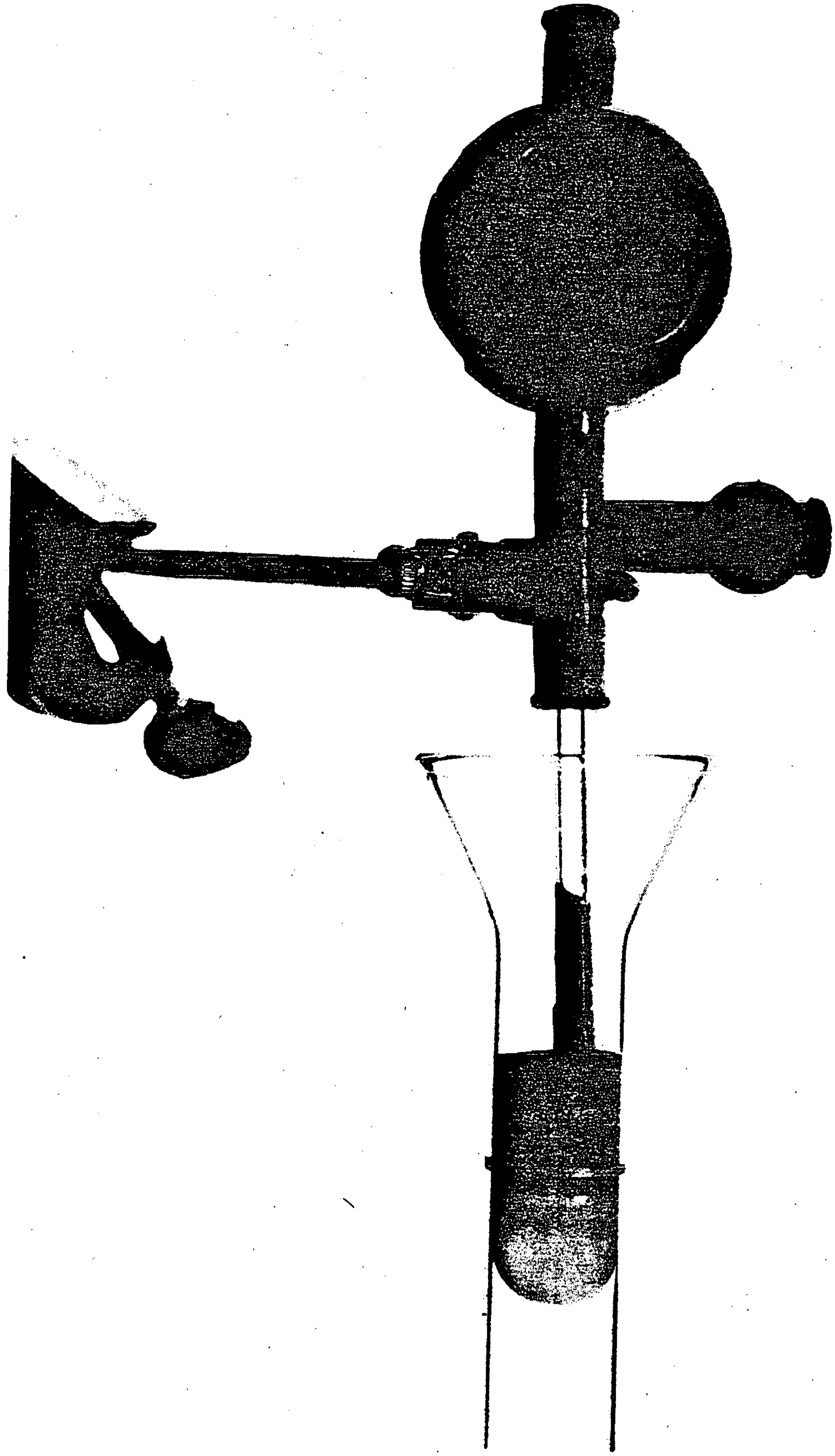


Plate 2 Settling Tube Balloon Release Device
(After Rukavina and Duncan. 1970)

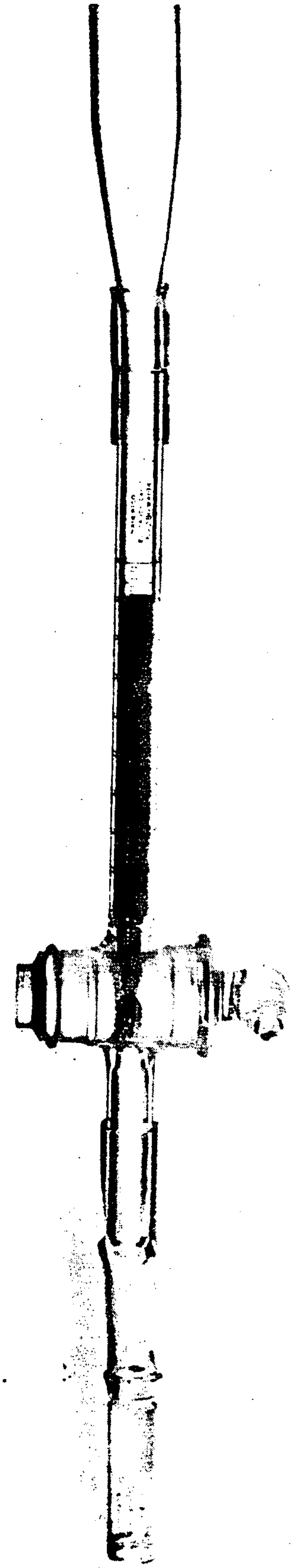


Plate 3 Settling Tube Graduated Stopcock

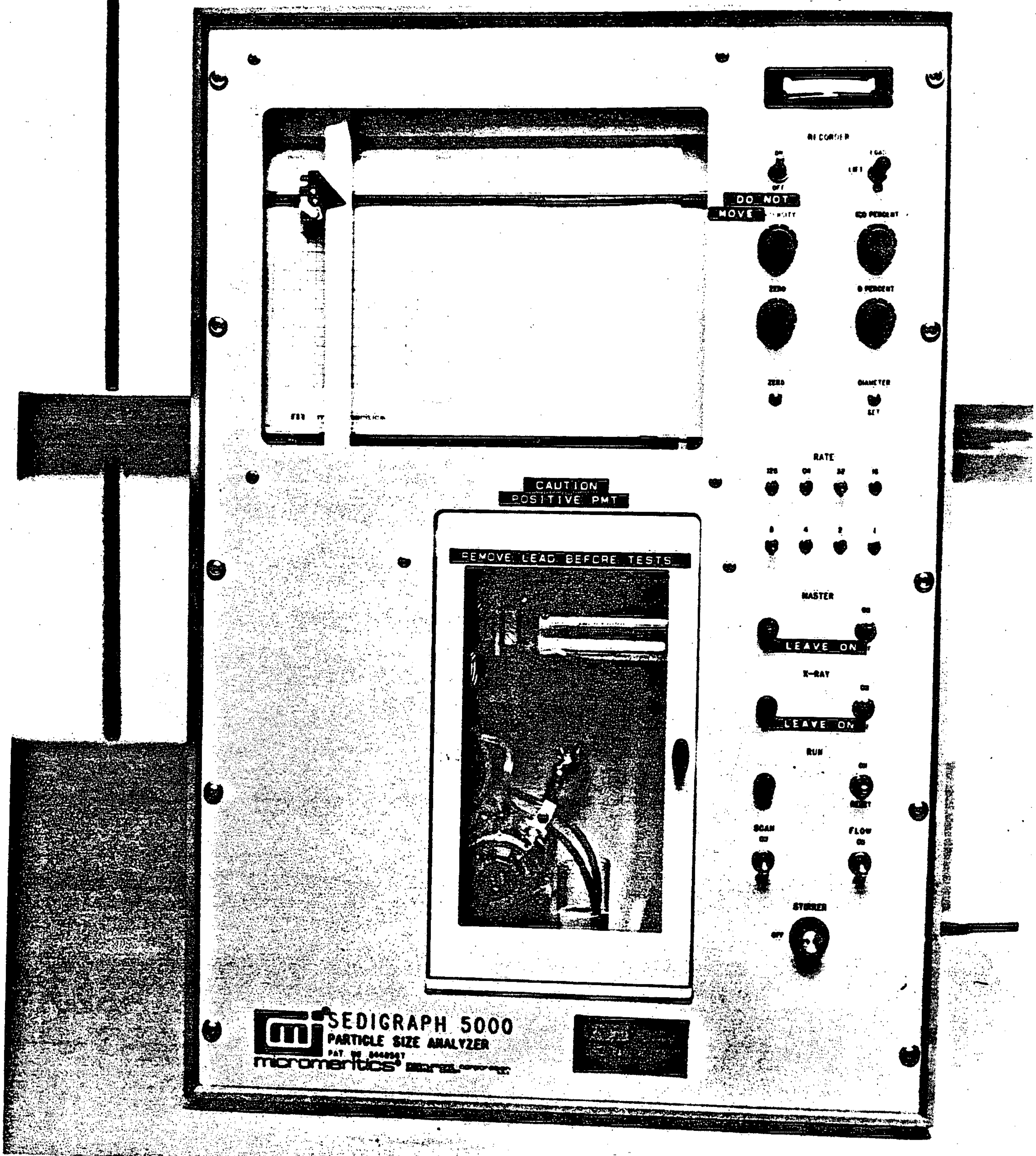


Plate 4 View of Sedigraph 5000 Particle Size Analyzer

APPENDICES

APPENDIX 1

EQUIPMENT AND MATERIALS

1.0 INTRODUCTION

The following is a complete list of the equipment and materials required for the four size analysis procedures. The items have been organized into those having general application to all five procedures and those with limited usage. Manufacturer's names have been used to identify some items; but, in most cases, equivalent equipment and supplies may be substituted.

2.0 GENERAL

2.1 Equipment and Materials

1. Freeze-drier
2. Balance (sensitivity of 0.0001 g)
3. Jones riffle splitter
4. Coning and quartering tool
5. Mechanical numbering stamp (optional)
6. Sizdist computer coding forms (Fig. 1)
7. 50 ml, disposable, aluminum dishes
8. 16 dram vials

3.0 SPECIFIC EQUIPMENT

In addition to the general equipment and materials, the items listed below will be required if the following procedures are used:

3.1 Sieve Analysis

1. 20.32 cm (8 inch) and/or 7.62 cm (3 inch) Tyler sieves in ¼ or ½ PHI intervals from - 4½ PHI to 4 PHI.
2. Pulverit electromagnetic sieve shaker (60 vibrations/sec) (Plate 1).
3. Mortar and rubber-tipped pestle or a wooden rolling pin.
4. Large sheets of paper

3.2 Pipette Analysis

1. 250 ml, 500 ml, or 1000 ml cylinders.

2. 10 ml or 25 ml narrow stem at least 20 cm long pipette (calibrated at 5 cm and 20 cm from the tip).
3. Electric mixer and mixing cups (ASTM designation: D 422-63).
4. Drying oven
5. Desiccator
6. Thermometer (°C)
7. Clock with a sweep second hand
8. Wash bottle
9. Pipette filler (Fisherbrand, Cat. No. 13-681-50)
10. 4½ PHI (0.044 mm), 20.32 cm (8 inch), stainless steel sieve
11. Rubber stoppers (optional)
12. Dispersant - 50 g of sodium hexametaphosphate (Calgon-unadjusted RS brand)/ litre of distilled water
13. Distilled water

3.3 Settling Tube

1. 164 cm Emery settling tube equipped with a graduated stopcock.
2. Balloon-release device (Plate 2) consisting of brand name propipette, glass tube, balloon and electrical tape.
3. Tape recorder and tapes with prerecorded release and reading times.
4. Thermometer (°C)
5. Wash bottle
6. 1 dram glass vial
7. Distilled water

3.4 Sedigraph

1. Sedigraph 5000 fine particle analyzer (Plate 4)
2. Magnetic stirrer and stirring bar (glass coated)
3. Graph paper (Micromeritics Instrument Corporation Form 500/42701) and marking pens
4. Dispersant - 5 g of sodium hexametaphosphate (Calgon-unadjusted RS brand)/litre of distilled water
5. Paint shaker.

APPENDIX 2

FREEZE-DRYING

1.0 INTRODUCTION

Freeze-drying is the process of removing water from a frozen substance by sublimation. In the sedimentology laboratory, the process is used to extract water from sediment samples. Freeze-drying has the advantages of arresting any chemical or physical alteration to the samples prior to analysis and providing a dried sample that is easy to disaggregate.

2.0 EQUIPMENT

The sedimentology laboratory operates two models of Virtis freeze-dryers: Model 10-146 MR-BA and Model Unitrap 10-100. The detailed specifications of the equipment are available in the appropriate Virtis Manuals.

The procedure outlined below is applicable to both models.

3.0 PROCEDURE

The procedure most frequently used is the bulk drying method in which a number of samples are processed in a large drying chamber. Although it is more difficult to determine when the samples are dry, the original container (plastic vials) used to collect the sample in the field can be used when freeze-drying. This eliminates the extra handling involved in transferring samples to freeze-drier bottles and the resultant potential for sample contamination. The following is an outline of the freeze-drying procedure:

1) Freeze the samples for approximately 18 hours. Remove the caps on the vials to permit expansion.
2) Turn the freeze-drier condenser on and wait until the condenser temperature reaches -40°C.
3) Remove the samples from the freezer and cover the vials with filter paper (5.5 cm in diameter) and a special freeze-drier top (a regular vial cap with a 4 cm round hole in it). The filter paper allows water vapour to escape while retaining the sediment particles.
4) Place the vials on a heat tray and put the tray into the drying chamber.
5) Connect the electrical plug on the heat tray to the outlet in the lid of the drying chamber.

6) Apply a light coating of silicone grease to the perimeter of the sealing ring at the top of the drying chamber.

7) Install the lid of the drying chamber.

8) Turn on the vacuum pump and check the seal between the top and the drying chamber. The vacuum should reach 100 microns Hg within ½ hour. If not, inspect and adjust Quickseal Valves or clean and regrease the sealing ring.

9) Connect the heat tray outlet to the power supply after the vacuum and condenser temperature reach their prescribed values.

10) Check vacuum and condenser temperature regularly during drying. If the vacuum goes above 100 microns, check Quickseal Valves and sealing ring. If the condenser temperature rises above -40°C, disconnect the heat tray.

11) Allow drying to continue for at least 24 hours; then inspect samples to determine if they are dry.

12) When samples are dry, release the vacuum by opening a Quickseal Valve or the Vacuum Release Valve.

13) Turn the vacuum pump off.

14) Disconnect heat tray and remove lid from drying compartment.

15) Remove samples from drying compartment, remove freeze-drying lids and filter paper and reseal with original vial caps.

16) Turn condenser off and open Vacuum Release Valve completely (12-14 turns).

17) Defrost the freeze-dryer by:

    a) removing dryer chamber and the condenser drain plug
    b) placing drain tube into three litre container
    c) turning on Defrost switch
    d) waiting two hours or until no water drains from tube and then turning off Defrost switch
    e) replace condenser drain plug and drying chamber.

APPENDIX 3

Coning and Quartering and Riffle Splitter

Coning and Quartering

1) Pour the sample onto a flat surface so as to form a cone.
2) Use the cone and quarter tool(1b) and separate the cone into four quarters.
3) Push aside two of the alternate quarters, mix the remaining two quarters and form another cone.
4) Continue the quartering process until the desired sample size is obtained. Do not attempt to get a sample of an exact size. For example, if a 20 g sample is wanted, a sample within the range of 15 g to 25 g is acceptable.

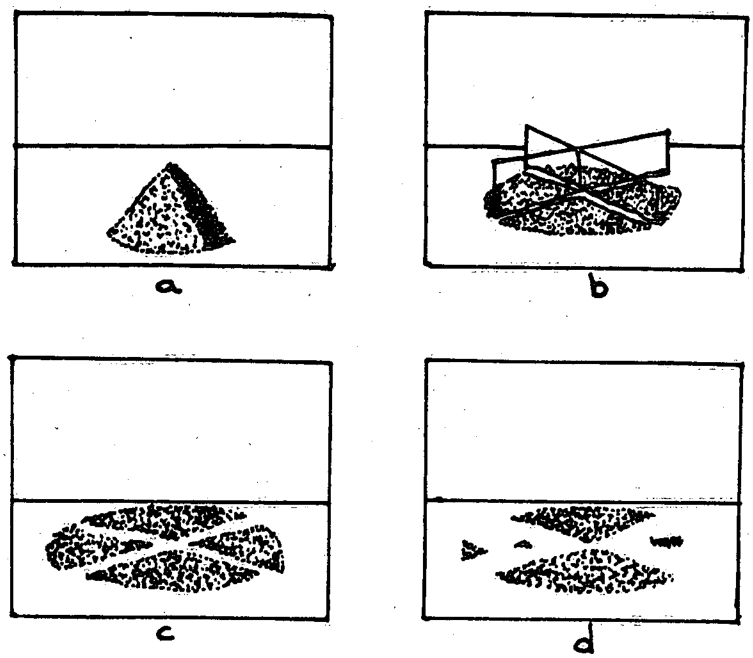


Fig. 1 Splitting the Sample by Coning and Quartering.

Jones Riffle Splitter

The Jones riffle splitter is used in the CCIW Sedimentology Laboratory. The procedure is simply:

1) Pouring the sample through the splitter will divide the sample in half.
2) Replacing one of the pans containing one-half of the sample with a clean pan and pouring this half through the splitter again. The clean pan will then receive one-fourth of the original sample.
3) Repeating step 2 until the desired sample weight is obtained.

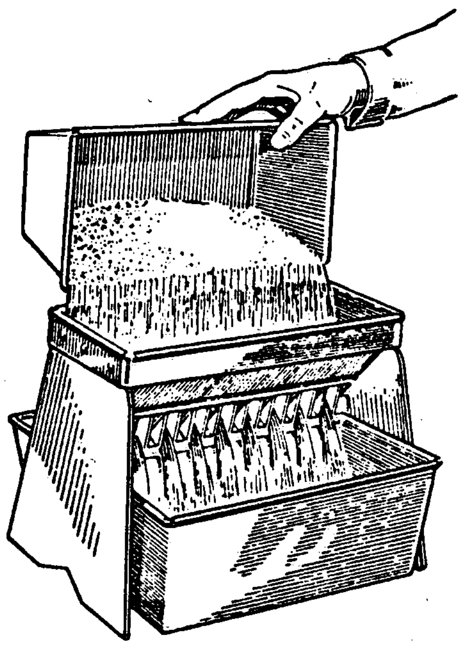


Fig. 2 Riffle Splitter

APPENDIX 4

COMPARISON OF RO-TAP AND PULVERIT SIEVING MACHINES

The Ro-Tap* has been the conventional machine for sizing gravel and/or sand. In this machine, a nest of sieves is swirled around in a horizontal plane while, at the same time, the column of sieves is rapped on top by a hammer. The aim of the combined sieving action is to simulate the type of motion which has proved to be successful when sieving shallow beds of sediment by hand. (W. S. Tyler Company, Cleveland, Distribution of test sieves and sieving machines.) The Ro-Tap is used only for dry sieving.

The Pulverit** Electromagnetic Sieving Machine can be used either with single sieves or a nest of sieves. The sieve nest is placed on the oscillating disc and held by two straps with quick-locking handles. The vertical oscillations from the disc are used to agitate the sediment on the sieve. An accessory available for wet sieving is used when sediments subject to high electrostatic forces are to be fractionated by sieve analysis (Geoscience Instrument Corporation, Pulverit 8 - an air elutriator).

Tables 1 and 2, and plate 1, show the results of a comparison test on the two sieving machines.

Table 1 lists the results of four runs using one sample (medium sand) and sieving at ½ PHI interval on the Ro-Tap and Pulverit machines.

Table 2 lists the results of six splits from one sample (medium-fine sand) sieved at ¼ PHI interval on the Ro-Tap and Pulverit machines.

Figure 1 is a graph of the averaged results obtained from Table 2.

The results indicate that the two machines are comparable and it was decided that the Pulverit would be used in the Sedimentology Laboratory instead of the Ro-Tap for the following reasons:

1) ease of operation
2) adaptable for wet sieving
3) lower noise level
4) less space requirement
5) capable of holding a greater number of sieves.

---

* Ro-Tap - W. S. Tyler Co., Cleveland, Ohio.

** Pulverit - Geoscience Instrument Corporation, Mount Vernon, N.Y.

TABLE 1

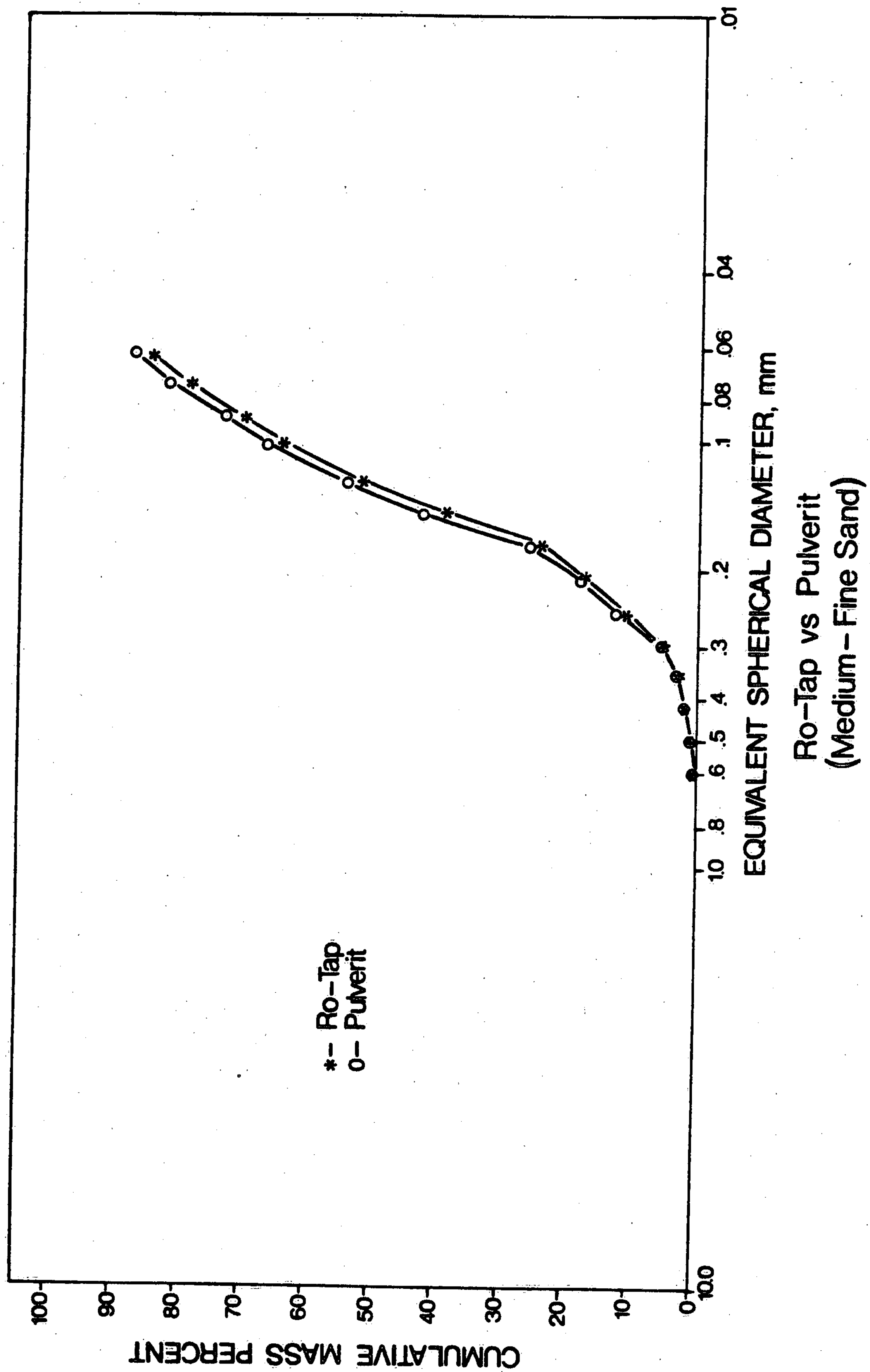
SIEVE TESTS RO-TAP VS. PULVERIT
TEN-MINUTE SIEVE TEST ON SAME SET OF SIEVES
Medium Sand

PHI Size	Ro-Tap				Pulverit				Average	
	Run 1	Run 2	Run 3	Run 4	Run 1	Run 2	Run 3	Run 4	Ro-Tap	Pulverit
	Cumulative %				Cumulative %					
½	.86	.77	.85	.94	.91	.87	.87	.82	.85	.87
1	2.88	2.91	2.92	3.00	2.54	2.57	2.51	2.41	2.92	2.51
1½	12.05	12.17	12.63	12.06	10.37	11.37	10.38	10.69	12.22	10.69
2	43.57	42.45	42.64	42.08	42.38	43.86	41.99	42.48	42.68	42.60
2½	81.41	81.31	81.34	81.73	87.07	89.79	88.48	87.63	81.44	88.24
3	96.87	96.99	97.00	97.07	97.58	97.47	97.61	97.49	96.98	97.53
3½	98.67	98.78	98.77	98.79	98.92	98.88	98.89	98.80	98.75	98.87
4	99.19	99.29	99.29	99.32	99.49	99.49	99.47	99.41	99.27	99.46

TABLE 2

SIEVE TESTS RO-TAP VS. PULVERIT
TEN-MINUTE SIEVE TIME ON SAME SET OF SIEVES
Medium-Fine Sand

MM	PHI Size	Ro-Tap						Pulverit						Average	
		Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Ro-Tap	Pulverit
		Cumulative %						Cumulative %							
.59	3/4	0.8	0.7	0.7	0.8	0.8	0.8	0.7	0.7	0.8	0.8	0.8	0.7	0.8	0.8
.50	1	1.2	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.2	1.2	1.3
.42	1-1/4	2.0	2.0	1.8	2.0	2.0	2.0	2.0	1.9	2.1	2.1	2.1	2.1	2.0	2.1
.35	1-1/2	3.5	3.4	3.1	3.3	3.2	3.2	3.5	3.3	3.6	3.5	3.4	3.5	3.2	3.4
.30	1-3/4	5.6	5.4	5.0	5.3	4.8	4.8	5.8	5.3	5.5	5.5	5.6	5.3	5.1	5.5
.25	2	13.5	13.1	11.7	11.5	11.8	11.6	13.1	13.2	13.3	13.1	13.2	13.1	12.2	13.1
.210	2-1/4	18.4	18.1	17.0	17.3	17.0	17.2	18.5	18.0	18.3	18.5	18.2	18.7	17.5	18.3
.177	2-1/2	25.8	25.8	24.3	24.3	24.1	24.1	25.9	26.1	26.0	26.2	26.6	26.8	24.7	26.2
.149	2-3/4	40.8	41.5	38.4	38.4	38.2	38.5	42.2	43.2	42.9	42.7	43.7	43.8	39.3	43.0
.125	3	53.3	53.9	50.0	51.3	52.3	52.7	52.7	54.3	53.8	55.9	58.2	54.7	52.2	54.9
.105	3-1/4	64.9	65.8	63.7	64.0	64.1	64.3	66.3	67.3	67.7	66.8	68.9	68.0	64.4	67.5
0.088	3-1/2	71.8	72.4	69.9	70.8	70.5	70.4	71.9	73.2	73.5	73.3	74.8	74.3	70.9	73.5
0.074	3-3/4	79.3	80.0	78.7	78.6	80.1	80.0	81.4	81.5	83.2	82.4	84.2	82.9	79.4	82.6
0.0625	4	85.6	86.0	85.0	84.2	85.7	85.6	86.9	87.8	87.7	87.8	88.9	86.5	85.3	87.6



CUMULATIVE MASS PERCENT
100
90
80
70
60
50
40
30
20
10
0
10.0
1.0
.8
.6
.5
.4
.3
.2
.1
.08
.06
.04
.01
EQUIVALENT SPHERICAL DIAMETER, mm
*– Ro–Tap
0– Pulverit
Ro–Tap vs Pulverit
(Medium–Fine Sand)

Figure 1

APPENDIX 12

Statistical Analysis of Grain-Size Data

HYDRAULICS DIVISION

Technical Note

DATE: February 1980 **REPORT NO:** 80-08

TITLE: "SIZDIST - A Computer Program for Size Analysis"

AUTHORS: R. G. Sandilands and G. A. Duncan

REASON FOR REPORT: This report gives the computer program used to compute size analysis results in the Sedimentology Laboratory, NWRI, and, combines with a report on size analysis procedures to form the Sedimentology Laboratory Manual.

CORRESPONDENCE FILE NO:
2550

1.0 INTRODUCTION

SIZDIST is a Fortran IV computer program that is used to process particle size data generated in the sedimentology laboratory at the National Water Research Institute (NWRI), Canada Centre for Inland Waters (CCIW). A preliminary form of the program was reported by Rukavina and Dolling (1973). The program has been extensively modified since then to accept additional laboratory procedures and to report additional results.

This report describes the input requirements, the output options, and explains the statistical parameters used and the default conditions present. A complete listing of the program is found in Appendix A. An explanation of parameter names is listed in Appendix B. Examples of input data and program results are shown in Appendix C.

The following statistical information is produced as printed and/or punched output.

(1) A histogram of particle-size frequency distribution by weight percentages.

(2) Moment measure statistics (Krumbein & Pettijohn, 1938).

(3) Modified Folk graphic statistics (Folk, 1968)

(4) Percent gravel, sand, silt and clay.

(5) Shepard's (1954) and Folk's (1968) Ternary Classifications.

2.0 SIZE ANALYSIS PROCEDURES

A detailed description of the size analysis procedures can be found in a sedimentology manual by Duncan and LaHaie (1979). The laboratory results are written onto a SIZDIST Coding Form (see examples in Appendix C). For simplicity, the different laboratory procedures are referred to by a code number (ICODE 1, 2, ...) and are processed by separate program subroutines of the same number.

A brief summary of the different laboratory procedures and any special features follow:

(1) ICODE 1 - Sieve Only

- at variable (¼, ½, 1) PHI interval*
- for gravel and sand-sized material
- the fines are usually represented as a pan weight.

---

* See Section 4.5 for definition of PHI (ϕ).

In addition, a special procedure of boundary sieving (i.e. sieving at the gravel/sand and sand/silt boundaries) only, to determine size class percentages, is allowed. This procedure is recognized automatically by the program, when the PHI interval is recorded as zero and when there are less than four data points. Since there is no resolution of the data in this procedure, the PHI interval of zero resets the ICODE value to 6, so that the statistical calculations are bypassed.

(2) ICODE 2 - Sieve and pipette (short or long)

- same as ICODE 1 but with pipette analysis to resolve the fines (silt and clay).

This procedure incorporates a number of combinations:

(1) sieve and short pipette (2 draws at 4 and 8 PHI to give percent silt and percent clay).

(2) single sieve to remove gravel and then short pipette (2 draws) (PHI interval to zero and PHI origin to -1).

(3) short pipette only (PHI origin and PHI interval zero).

(4) sieve and long pipette. Three to nine draws are allowed at 1 PHI interval only. The fifth draw is required to determine percent clay.

(5) single sieve to remove gravel and long pipette (PHI interval is zero and PHI origin is -1)

(6) long pipette only (PHI origin and PHI interval zero).

(3) ICODE 3 - Sieve, short pipette and Sedigraph*

- the first pipette draw supplies the sample for the sedigraph and also gives the total percentage of silt and clay. The second draw will give a clay percentage which can be compared with the sedigraph value.

(4) ICODE 4 - Sieve, settling tube and pipette (short or long)

- A common PHI interval is used for both sieving and settling tube and the number of settling tube data points is set by the PHI interval used.

---

* Sedigraph is the trade name of an apparatus for automated size analysis and is manufactured by Micromeritics Inc., Norcross, Georgia.

		Column	Format
Card 1:	Sample label	1-24	6A4
	Total number of data points	33-34	I2
	Analysis code number (ICODE)	52-53	I2
	Number of comment cards	54-55	I2
Card 2:			
	Number of sieve and/or settling tube points	2- 3	I2
	PHI (ϕ) origin	4- 8	F5.2
	Sample weight	11-20	F10.4
	Weight of dispersant	33-40	F8.4
	PHI (ϕ) interval	55-58	F4.2
	Cylinder size	59-62	I4
Card 3:		1-80	8F10.4
	These cards record sieve weights and/or settling tube heights. The number of data points recorded here must equal the number of sieve/settling tube points on card 2.		
Card 4:			
	Gross weight of pipette fraction	1-10	F10.4
	Tare weight	11-20	F10.4
	These cards are not required for ICODE 1 and ICODE 7. Use a minimum of two and a maximum of nine cards of this type.		
Card 5:		1-80	8F10.4
	These cards are for sedigraph percentages. Use as many cards as required for this data.		
Card 6:		1-80	20A4
	These cards are for comments and require an asterisk (*) in column 80 of each card. Use as many cards as indicated in Number of comment cards on data card 1.		

4.0 PRINTED OUTPUT

The SIZDIST output is available in two forms: printed output and punched cards. The data provided on the printed output are determined by the control card and may include the following:

1) Sample label, date of analysis, type of lab analysis, sample weight and the date when program was run.
2) A histogram of the particle size distribution by PHI interval, percentage in each interval and cumulative percentages.
3) The four moment measures and the size range to which they apply. For example, if sieve analysis is used, the material finer than 4 PHI (0.063 mm) is not resolved and, therefore, is excluded from the moment measure calculations.
4) The four graphic statistics. They are not calculated if more than five percent of the size distribution at either the fine or coarse end is not resolved.
5) The median and 5th, 16th, 25th, 75th, 84th and 95th percentiles.
6) Percentage of gravel, sand, silt, and clay.
7) The amount of gravel + sand and the ratios of silt/(silt+clay) and (gravel+sand)/(silt+clay).
8) The Ternary labels (Shepard and Folk).

4.1 Histogram:

The printed output includes a histogram of particle size distribution using the weight percentages (rounded off to nearest whole number) as class heights. Each asterisk in the class height represents one percent.

In almost all sediment analyses, there is a quantity of fines for which the exact size cannot be resolved because of procedural limitations. In sieving for example, a pan weight can only be defined as finer than the last sieve. Therefore, the histogram shows the last PHI size as being undefined "*****".

In long pipette or sedigraph, the coarse end of the distribution may not be resolved. Therefore, the program indicates on the histogram that the boundary of the coarsest fraction is an "assumed upper limit".

The other procedures assume that the analysis will start at a point which will incorporate the coarsest particles. It is possible in some procedures that the gravel will be sieved off, but not resolved because of insufficient material; in these cases, a comment card should be used to record this information.

4.2 Percentiles:

A percentile is a particle-size value in PHI units, which corresponds to a particular cumulative percentage. The percentiles for 5, 16, 25, 50, 75, 84 and 95 percent of the sample are calculated for use later in Folk's graphic formulae.

The program uses linear interpolation between data points to calculate percentile values and may give slightly different values than Folk's procedure of plotting cumulative curves on probability paper to improve accuracy of extrapolation and interpolation. To guard against invalid extrapolations, the program will not compute percentiles for open-ended portions of the size distributions. If more than five percent of the sample is unresolved, the percentiles affected are blanked out with "*****".

4.3 Graphic Statistics:

These statistics apply to the total particle-size distribution, and are computed from percentile values. The graphic statistics are not calculated if any percentiles are blank. In this case, the data can be plotted by hand and the values for the missing percentiles determined by extrapolation.

Folk's (1957) formulae are used to give the following statistics:

Graphic Mean $= \dfrac{\phi 16 + \phi 50 + \phi 84}{3}$

Inclusive Graphic Standard Deviation $= \dfrac{\phi 84 - \phi 16}{4} + \dfrac{\phi 95 - \phi 5}{6.6}$

Inclusive Graphic Skewness $= \dfrac{\phi 16 + \phi 84 - 2(\phi 50)}{2(\phi 84 - \phi 16)} + \dfrac{\phi 5 + \phi 95 - 2(\phi 50)}{(\phi 95 - \phi 5)}$

Graphic Kurtosis $= \dfrac{\phi 95 - \phi 5}{2.44\,(\phi 75 - \phi 25)}$

A normal distribution gives a skewness of zero and a kurtosis value of one.

4.4 Moment Measures:

These statistics are calculated only for that portion of the size distribution that is resolved at the same PHI interval. For example, in the sieve and short pipette procedure, moment measures apply only to the gravel and sand portion of the distribution. Since these statistics usually apply to less than the total samples, they may not be compared with Folk graphic statistics. The moment measures are not calculated if more than five percent of the distribution falls in an undefined size range.

The method of moments (Krumbein and Pettijohn 1938) is used to calculate the PHI mean, standard deviation, skewness and kurtosis. It gives zero skewness and kurtosis values for a normal distribution. The formulae used are:

1) Mean PHI size

$$\bar{X} = \frac{1}{\Sigma f(X_i)} \sum_{i=1}^{K} f(X_i) \bullet X_i$$

$f(X_i)$ = frequency (weight percents) of a size class
X_i = class mid-point
K = number of class intervals (number of resolved data points)

2) Standard Deviation

$$S = \sqrt{X_2}$$

3) Measure of Skewness

$$M_3 = \frac{X_3}{2(S)^3}$$

4) Measure of Kurtosis

$$M_4 = \frac{X_4}{S^4} - 3$$

where

$$X_N = \frac{1}{\Sigma f(X_i)} \sum_{i=1}^{K} f(X_i) \bullet (X_i - \bar{X})^N$$

for N = 2, 3 and 4

4.5 Size Fractions:

Particle size is expressed by the SIZDIST program in a PHI scale devised by Krumbein and Pettijohn (1938) which is a logarithmic transformation of the Wentworth (1922) grade scale;

$$\text{i.e PHI } (\phi) = -\log_2 (\text{diameter in millimetres})$$

Each size fraction is given as a weight percentage of the total sample. The size range for each size class is:

	PHI	MILLIMETRES
Gravel	<-1.0	> 2.0
Sand	>-1.0 to 4.0	2.0 to 0.0625
Silt	> 4.0 to 8.0	0.0625 to 0.0039
Clay	> 8.0	< 0.0039

The values for percent silt and clay may be determined from sedigraph data and/or pipette draws. Both results are shown, when available, or one may be set to zero when that procedure is not used.

4.6 Classification Labels:

Based on the values and ratios of size fractions, the sediment classification labels of Shepard (1954) and Folk (1968) are presented. If gravel is $\leq$ five percent, a label from the sand, clay, silt (SCS) triangular graph is also given.

5.0 PUNCHED CARD OUTPUT

5.1 Card 1

		Column	Format
1)	Sample designation	1-24	6A4
2)	Date these cards were punched	25-32	A8
3)	PHI interval	33-36	F4.2
4)	PHI range of moment measures	37-48	2F6.2
5)	Sample weight	64-71	F8.4
6)	ICODE - type of lab analysis	78	I2

The sample weight punched is the weight calculated from the sample distribution and may differ slightly from the original sample weight.

For short pipette only and boundary sieving only procedures, the punched ICODE value will be six. This will allow identification of those outputs which have all zero values except for size fractions and labels.

Format = (6A4, A8, F4.2, 2F6.2, 15X, F8.4, 6X, I2)

5.2 <u>Cards 2 and 3:</u>

These cards contain up to 32 data points of the weight fractions as a percent of total weight. The first value on the card will be for a PHI size of -3.0 if PHI interval is 1.0 and -3.5 if PHI interval is 0.5 or 0.25. The following values on the card will be for a PHI size of the previous size plus the PHI interval.

Format = (16F5.2/16F5.2)

5.3 <u>Card 4:</u>

		Column	Format
1)	Moment measures: Mean	1-6	F6.2
2)	Moment measures: Standard deviation	7-12	F6.2
3)	Moment measures: Skewness	13-18	F6.2
4)	Moment measures: Kurtosis	19-24	F6.2
5)	Graphical statistics: Mean	25-30	F6.2
6)	Graphical statistics: Standard deviation	31-36	F6.2
7)	Graphical statistics: Skewness	37-42	F6.2
8)	Graphical statistics: Kurtosis	42-48	F6.2
9)	Percent gravel	49-54	F6.2
10)	Percent sand	55-60	F6.2
11)	Percent silt-as determined from pipette draw	61-66	F6.2
12)	Percent silt-as determined from sedigraph data	67-72	F6.2
13)	Percent clay-as determined from pipette draw	73-78	F6.2

Format = (13F6.2)

5.4 Card 5

		Column	Format
1)	Percent clay-as determined from sedigraph data	1-6	F6.2
2)	Percentiles in the following order - 50, 5, 16, 25, 75, 84, 95th	7-48	7F6.2
3)	Percent silt + clay	55-60	F6.2
4)	Percent sand + gravel	61-66	F6.2
5)	Ratio - percent silt/percent silt + clay	67-72	F6.2
6)	Ratios - percent sand + gravel/ percent silt + clay	73-80	F8.2

Format = (8F6.2, 6X, 3F6.2, F8.2)

5.5 Card 6

		Column	Format
1)	Shepard classification label	18-29	3A4
2)	Folk classification label (from gravel, sand, mud triangular graph)	40-59	5A4
3)	Folk classification label (from sand, clay, silt triangular graph, if applicable)	67-78	3A4

Format = (17X, 3A4, 10X, 5A4,7X, 3A4)

5.6 Card(s) Type 7:

If there are any comments, comment cards will be created and will follow the six data cards.

6.0 DEFAULT CONDITIONS

1) There is a test to determine if there are enough data points for the PHI start and PHI interval used. An error message will be printed if there is a discrepancy and the program will proceed to the next sample. Correct error and resubmit.

2) Most ICODE subroutines sum the calculated weight fractions and compare with the original sample weight. If the weight difference exceeds a specified amount, an error message is printed and the program proceeds to the next sample. Check for data or card punch errors. If the error is a function of the lab procedure, re-analyse the sample.

3) In ICODE 1, special boundary sieving requires three or less sieve data points. If there are more, an error message is printed and the program proceeds to thenext sample. Check for error in PHI interval or number of sieve points.

4) In ICODE 2 and 4, there must be at least two pipette data points, or an error message is printed. Check for errors in total data points and sieve points.

5) A test is made for a negative percent in a class interval. If one is found, an error message gives its location and the program proceeds to the next sample. Check for continuously increasing settling tube data, for continuously decreasing sedigraph data or, for a pipette draw that is negative when tare and dispersant are subtracted.

6) If ICODE on input data card one is equal to 99, no other input data cards are required, just comment cards. This procedure is used to indicate why a sample analysis is not present.

ACKNOWLEDGEMENTS

The helpful discussions with N. A. Rukavina, D. A. St. Jacques, G. G. LaHaie and W. G. Booth in developing this program and eliminating its errors are gratefully appreciated. The manuscript was reviewed by J. P. Coakley and N. A. Rukavina.

BIBLIOGRAPHY

Duncan, G. A. and LaHaie, G. G., 1979. "Size Analysis Procedures in the Sedimentology Laboratory, NWRI". Unpulished Report, CCIW.

Folk, R. L., 1968. "Petrology of Sedimentary Rocks". Austin Texas, Hemphill's.

Krumbein, W. C. and Pettijohn, F. J., 1938. "Manual of Sedimentary Petrology". New York: Appleton, Century, Crofts.

Rukavina, N. A. and Dolling, R. K., 1973. "SIZDIST: Statistical Analysis of FAST Grain-Size Data". IAGLR, Proc. 16th Conf. Great Lakes Research: 1044-1045.

Shepard, F. P., 1954. "Nomenclature Based on Silt-Sand-Clay Ratios". J. Sediment. Petrol. 24: 151-158.

APPENDIX A:
Program Listing

```
      PROGRAM SIZDIST(INPUT,OUTPUT,PUNCH,TAPE60=INPUT,TAPE61=OUTPUT,
     $ TAPE62=PUNCH)
      INTEGER COMNTS,CYLSIZ,SAMPID,R
      INTEGER AST,XN
      DIMENSION PCT(80),CUMPCT(80),PTILE(7),FREQ(80),PFF(80),ARRAY(80),
     $ RMOM(4),PHIP(7),R(100),COMNTS(20),DUM(10)
      COMMON WG(80),PHI(80),N,NS,NN,START,PHINT,GRAV,SAND,SILT,CLAY,
     $SAMPWT,NO,SANDGRV ,FOLK,SNDMUD,CLYSED,SLTSED,DISP,GSMUD,NNN,IOPT(8
     $),SAMPID(6),FACT,INTRPT,LAB1(3),LAB2(5),LAB3(3),PSILT,PCLAY,PSLCLY
     $,JOUTPUT
      DATA XN/1H*/
      CALL DATE(RR)
      DECODE(10,90,RR) IY,IM,ID
   90 FORMAT(3(1X,A2),1X)
      ENCODE(10,100,RR) IM,ID,IY
  100 FORMAT(A2,1H/,A2,1H/,A2,2X)
      WRITE (61,740)
      READ 750, IPUNCH,(IOPT(I),I=1,8)
  110 CONTINUE
      READ 760,(DUM(I),I=1,9),AST
      IF(EOF(60) .NE. 0) GO TO 730
      IF (AST.EQ.XN) GO TO 110
      DECODE (55,770,DUM) (SAMPID(I),I=1,6),NO,ICODE,NCOM
      IF (ICODE.LE.0) GO TO 110
      IF (ICODE.NE.99) GO TO 120
      PRINT 800
      GO TO 680
  120 CONTINUE
      READ 780, N,START,SAMPWT,DISP,PHINT,CYLSIZ
      IF (ICODE.GT.5) GO TO 140
      IF (PHINT.EQ.0.0.AND.ICODE.LE.2) GO TO 140
      IF(PHINT .EQ. (.) GO TO 130
      TEST = (ABS(START-4.0)/PHINT)+1.0
      ITEST = TEST
      IF (ITEST-N) 130,140,130
C
C     TEST APPLIES ONLY TO SUBROUTINES 1-5
  130 PRINT 790, SAMPID
      GO TO 110
  140 CONTINUE
      PRINT 800
      IF(CYLSIZ.EQ.25)FACT = 1.
      IF(CYLSIZ.EQ.500)FACT = 20.
      IF(CYLSIZ.EQ.550)FACT = 22.
      IF(CYLSIZ.EQ.250)FACT = 25.
      IF(CYLSIZ.EQ.1000)FACT = 40.
      INTRPT = 0
      JOUTPUT = 0
      NOMOM = 0
      NP = 0
      IF(ICODE.EQ.2.OR.ICODE.EQ.4)NP = NO-N
      IF (NP.LE.2) GO TO 150
      IF(PHINT.NE.1.0)NOMOM = 1
      IF(N.EQ.0)NOMOM = 0
  150 CONTINUE
C
C     CHOOSE APPROPRIATE SUBROUTINE ACCORDING LAB METHOD DATA FORMAT AND
C     COMPUTE AN ARRAY OF WEIGHT PERCENTAGES (WG) FOR SIZE RANGE PRESENT
      GO TO (160,190,200,210,220,180,170), ICODE
  160 CALL ICODE1
      GO TO 230
  170 CALL ICODE7
      GO TO 230
  180 CALL ICODE2
      GO TO 230
  190 CALL ICODE2
      GO TO 230
  200 CALL ICODE3
      GO TO 230
  210 CALL ICODE4
      GO TO 230
  220 CALL ICODE5
  230 CONTINUE
      IF (INTRPT.EQ.1) GO TO 110
C
C     IF ICODE=6, HISTOGRAM,MOMENTS,PERCENTILES AND PUNCHED OUTPUT NOT P
      IF(PHINT.EQ.0.)ICODE = 6
```

```
      IF (ICODE.EQ.6) GO TO 520
C
C     CALCULATE PERCENTAGES AND CUMULATIVE PERCENTAGES FOR EACH PHI
      SUM = 0.
      LPHI = 0
      MM = NNN
      DO 250 I=1,MM
        IF(PHI(I).GT.12.0)LPHI = I
        PCT(I) = (WG(I)/SAMPWT)*100.
        ICHK = I-1
        IF (PCT(I).GE.0.) GO TO 240
        PRINT 810, ICHK,I
        GO TO 110
  240   SUM = SUM+WG(I)
        CUMPCT(I) = (SUM/SAMPWT)*100.
  250 CONTINUE
C
C     PRINT HISTOGRAM OF WEIGHT PERCENTAGES
      ICHK = 0
C
      IF(CUMPCT(NNN-1) .LT. 94.99999) ICHK = 1
      PHI(NNN) = PHI(NNN)*1000.
      IF (IOPT(2).NE.2) GO TO 340
      IF (INTRPT.EQ.7.AND.PCT(2).GT.0.0) GO TO 260
      PRINT 820, RR,PHI(1)
      GO TO 270
  260 PRINT 830, RR,PHI(1)
  270 CONTINUE
      DO 330 I=2,MM
        DO 280 J=1,100
          R(J) = 1H
  280   CONTINUE
        IF (PCT(I).LT.0.5) GO TO 320
        IF (PCT(I).LT.100.0) GO TO 300
        DO 290 J=1,100
          R(J) = 1H*
  290   CONTINUE
        GO TO 320
  300   CONTINUE
        IY = PCT(I)+0.5
        DO 310 J=1,IY
          R(J) = 1H*
  310   CONTINUE
  320   CONTINUE
        PRINT 840, PCT(I),(R(J),J=1,100),PHI(I),CUMPCT(I)
  330 CONTINUE
      IF (LPHI.EQ.0) GO TO 340
      PRINT 850, LPHI
      GO TO 110
  340 CONTINUE
C
C     SET DESIRED PERCENTILES
      PTILE(1) = 50.
      PTILE(2) = 5.
      PTILE(3) = 16.
      PTILE(4) = 25.
      PTILE(5) = 75.
      PTILE(6) = 84.
      PTILE(7) = 95.
      NPER = 7
C
C     FIND PHI VALUE FOR EACH PERCENTILE
      DO 370 IP=1,NPER
        M = NNN-1
        DO 350 I=1,M
          IF (PTILE(IP).GE.CUMPCT(I).AND.PTILE(IP).LE.CUMPCT(I+1))
     $    GO TO 360
  350   CONTINUE
C
C     CALCULATE STRAIGHT LINE PASSING THROUGH DESIRED PERCENTILE
  360   BETA = (PHI(I+1)-PHI(I))/(CUMPCT(I+1)-CUMPCT(I))
  370 PHIP(IP) = PHI(I)+BETA*(PTILE(IP)-CUMPCT(I))
      FMEAN = 0.
      FSTDEV = 0.
      FSKEW = 0.
      FKURT = 0.
      PMEAN = 0.
```

```
      STDV = 0.
      SKEW = 0.
      RKURT = 0.
      EXFOLK = 0.
C
C     IF MORE THAN 5 PERCENT OF FINE SEDIMENT IS NOT RESOLVED AT THE PHI
C     DO NOT COMPUTE FOLK STATISTICS. AND STAR OUT AFFECTED PERCENTILES.
      IF (ICHK.EQ.0) GO TO 390
      EXFOLK = 1.0
      DO 380 I=1,NPER
        IF(PHIP(I).GT.CUMPCT(NNN-1))PHIP(I) = PHIP(I)*1000.
  380 CONTINUE
  390 CONTINUE
      IF (INTRPT.NE.7.OR.PCT(2).LE.5.0) GO TO 410
      PRINT 450
      DO 400 I=1,NPER
        IF(PHIP(I).LT.PHI(2))PHIP(I) = PHIP(I)*1000.
  400 CONTINUE
      GO TO 510
  410 CONTINUE
      IF (EXFOLK.EQ.1.0) GO TO 420
C
C     COMPUTE FOLK GRAPHIC STATISTICAL PARAMETERS OF GRAIN SIZE
C
C     GRAPHIC MEAN (FMEAN) =(16TH + 50TH + 84TH)/ 3
      FMEAN = (PHIP(3)+PHIP(1)+PHIP(6))/3.
C
C     INCLUSIVE GRAPHIC STANDARD DEVIATION (FSTDEV) =(84TH-16TH)/4. +
C                                                    (95TH-5TH)/ 6.6
      FSTDEV = (PHIP(6)-PHIP(3))/4.+(PHIP(7)-PHIP(2))/6.6
C
C     INCLUSIVE GRAPHIC SKEWNESS (FSKEW) =(16+84-2*50)/2*(84-16)+
C                                         (5 +95-2*50) / 2*(95-5)
C
      FSKEW = (PHIP(3)+PHIP(6)-2.*PHIP(1))/(2.*(PHIP(6)-PHIP(3)))+(PHIP
     $(2)+PHIP(7)-2.*PHIP(1))/(2.*(PHIP(7)-PHIP(2)))
C
C     GRAPHIC KURTOSIS (FKURT) = 95TH-5TH /2.44 * (75TH-25TH)
C
      FKURT = (PHIP(7)-PHIP(2))/(2.44*(PHIP(5)-PHIP(4)))
  420 CONTINUE
C
C     COMPUTE PHI MEAN
C
C     IF SIEVE AND LONG PIPETTE PROCEDURE AT SIEVE INTERVAL OTHER THAN 1
C      PHI, DO NOT CALCULATE MOMENT MEASURES
      IF (NOMOM.GT.0) GO TO 460
      SUM = 0.
      TPCT = 0.
      DO 430 I=1,NN
        FREQ(I) = (PHI(I)-PHINT/2.)*PCT(I)
        TPCT = TPCT+PCT(I)
  430 SUM = SUM+FREQ(I)
      PMEAN = SUM/TPCT
C
C     COMPUTE PHI STANDARD DEVIATION, SKEWNESS, AND KURTOSIS USING
C     THE DEFINITIONS OF KRUMBEIN AND PETTIJOHN, 1938
C     CHECK IF ENOUGH DATA POINTS FOR MOMENT MEASURES.
      IF (NN.LE.2) GO TO 460
      DO 450 MOM=2,4
        FMOM = MOM
        SUM = 0.
        DO 440 I=1,NN
          PFF(I) = PCT(I)*((PHI(I)-PHINT/2.)-PMEAN)**MOM
  440   SUM = SUM+PFF(I)
        RMOM(MOM) = SUM/TPCT
  450 CONTINUE
        STDV = RMOM(2)**0.5
      IF(STDV .EQ. 0.) GO TO 460
        SKEW = RMOM(3)/(2.*STDV**3.0)
        RKURT = (RMOM(4)/STDV**4.0)-3.
  460 CONTINUE
      IF (IOPT(3).NE.3) GO TO 510
      PRINT 870
      IF (NOMOM.GT.0) GO TO 470
      PRINT 880, PMEAN,STDV,SKEW,RKURT,PHI(2),PHI(NN)
      GO TO 480
```

```
  470 PRINT 890
  480 CONTINUE
      IF (EXFOLK.GT.0.0) GO TO 490
      PRINT 900, FMEAN,FSTDEV,FSKEW,FKURT
      GO TO 500
  490 CONTINUE
      PRINT 910
  500 CONTINUE
  510 CONTINUE
      IF (IOPT(4).NE.4) GO TO 520
      PRINT 920, (PHIP(I),I=1,7)
  520 CONTINUE
      IF (IOPT(5).NE.5) GO TO 560
C
C     IF NO SEDIGRAPH DATA SET CLYSED,SLTSED TO ZERO
      IF (ICODE.EQ.3) GO TO 530
      IF (ICODE.EQ.5) GO TO 530
      IF (ICODE.EQ.7) GO TO 530
      SLTSED = 0.
      CLYSED = 0.
  530 CONTINUE
      IF (JOUTPUT.NE.1) GO TO 540
      PRINT 930, GRAV,SAND,PSLCLY
      GO TO 550
  540 CONTINUE
      PRINT 940, GRAV,SAND,PSILT,PCLAY,SLTSED,CLYSED
  550 CONTINUE
  560 CONTINUE
      IF (IOPT(6).NE.6) GO TO 580
      IF (JOUTPUT.NE.1) GO TO 570
      FOLK = 10000.
      PRINT 950, SANDGRV ,GSMUD
      GO TO 580
  570 CONTINUE
      PRINT 960, SANDGRV ,FOLK,GSMUD
  580 CONTINUE
C
C     OPTION FOR PUNCHED OUTPUT  CARD 1 - CARD 5
      IF (IPUNCH.NE.1) GO TO 640
C
C     BLANK ARRAY FOR PERCENTAGES OVER WHOLE RANGE OF CLASS INTERVALS
      DO 590 I=1,32
  590 ARRAY(I) = 0.
C
C     IF  ICODE=6 INITIALIZE MISSING PARAMETERS TO ZERO FOR PUNCHING
      IF (ICODE.NE.6) GO TO 610
      NN = 1
      PHI(2) = 0.
      PHI(NN) = 0.
      PMEAN = 0.
      STDV = 0.
      SKEW = 0.
      RKURT = 0.
      FMEAN = 0.0
      FSTDEV = 0.0
      FSKEW = 0.0
      FKURT = 0.0
      DO 600 I=1,NPER
  600 PHIP(I) = 0.
  610 CONTINUE
      WRITE (62,970) SAMPID,RR,PHINT,PHI(2),PHI(NN),SAMPWT,ICODE
      IF (ICODE.EQ.6) GO TO 630
C
C     COMPUTE STARTING INDEX IN ARRAY
      INO = ABS(((-3.5-(PHI(2)))/PHINT))+1
      DO 620 I=2,NN
        ARRAY(INO) = PCT(I)
        INO = INO+1
  620 CONTINUE
  630 CONTINUE
      WRITE (62,980) (ARRAY(I),I=1,32)
      WRITE (62,990) PMEAN,STDV,SKEW,RKURT,FMEAN,FSTDEV,FSKEW,FKURT,GRAV
     $,SAND,PSILT,SLTSED,PCLAY,CLYSED,(PHIP(I),I=1,7),PSLCLY,SANDGRV,
     $FOLK,GSMUD
  640 CONTINUE
C
C     CLASSIFY THE SEDIMENT ACCORDING TO SHEPARD AND FOLK
```

```
              CALL SHEPARD
              CALL FOLKL
              IF (IOPT(7).NE.7) GO TO 670
              IF (JOUTPUT.NE.1) GO TO 660
              DO 650 L=1,3
        650   LAB3(L) = 4H
        660   CONTINUE
              PRINT 1030, (LAB1(L),L=1,3),(LAB2(L),L=1,5),(LAB3(L),L=1,3)
        670   CONTINUE
C
C             PUNCH CARD 5
              IF (IPUNCH.NE.1) GO TO 680
              WRITE (62,1010) (LAB1(L),L=1,3),(LAB2(L),L=1,5),(LAB3(L),L=1,3)
        680   CONTINUE
              IF (NCOM.GE.1) GO TO 690
              GO TO 110
        690   IF (IOPT(8).NE.8) GO TO 700
              PRINT 1020
        700   DO 710 ICOM=1,NCOM
                READ 1030, (COMNTS(I),I=1,20)
              IF(IOPT(8) .NE. 8) GO TO 715
                PRINT 1040, (COMNTS(I),I=1,20)
        715   CONTINUE
                IF (IPUNCH.NE.1) GO TO 710
                WRITE (62,1030) (COMNTS(I),I=1,20)
        710   CONTINUE
        720   GO TO 110
        730   STOP
C
        740   FORMAT (1H1)
        750   FORMAT (915)
         760  FORMAT(7A10,A9,A1)
        770   FORMAT (6A4,8X,I2,17X,2I2)
        780   FORMAT (1X,I2,F7.0,F10.0,10X,F10.0,10X,F8.0,I4)
        790   FORMAT (1H1,1X,6A4,44H  ERROR IN START,N,OR PHINT-CORRECT AND RESU
             $BMIT)
        800   FORMAT (1H1/1H0)
        810   FORMAT (/,1X,33HNEGATIVE PCT FOR CLASS INTERVAL  ,I2,4H OR ,I2,
             $21H-CORRECT AND RESUBMIT)
        820   FORMAT(//3X,#PHI   PCT.  CUMPCT.#,40X,A8//1X,F5.2)
        830   FORMAT(//3X,#PHI   PCT.  CUMPCT.#,40X,A8//1X,F5.2,# ASSUMED UPPER LI
             $MIT#)
        840   FORMAT (7X,F5.2,12X,100A1/1X,F5.2,6X,F5.2)
        850   FORMAT(/1X,I4,# TH PHI CLASS GREATER THAN 12. DATA ENTRY ERROR#)
        860   FORMAT(/1X,# NO STATISTICS ARE COMPUTED BECAUSE THE UPPER SIZE LIM
             $IT IS ASSUMED   #/2X,#AND THIS AFFECTS MORE THAN 5 PERCENT OF THE
             $SAMPLE #/)
        870   FORMAT(/1X,#  MEAN   ST.DEV. SKEWNESS KURTOSIS#/)
        880   FORMAT(/1X,4(F7.2,1X),3X,#KRUMBEIN + PETTIJOHN (1938) MOMENT MEASU
             $RES#/36X,#FOR SIZE RANGE#,F5.1,# TO #,F5.1,# PHI#/)
        890   FORMAT(/1X,#MOMENT MEASURES ARE NOT CALCULATED SINCE DATA CONTAINS
             $ MIXED PHI INTERVAL#/)
        900   FORMAT(1H ,4(F7.2,1X),3X,#FOLK GRAPHIC STATISTICAL PARAMETERS#/40X
             $,#FOLK AND WARD,1957#/)
        910   FORMAT(1X,# > 5 PERCENT OF THE FINES ARE NOT RESOLVED, OBTAIN FOLK
             $ STATS. GRAPHICALLY#/)
        920   FORMAT(/1X,#PERCENTILES      MEDIAN#,F6.2,5X,#5TH#,F6.2,5X,#16TH#,
             $F6.2,5X,#25TH#,F6.2//33X,#75TH#,F6.2,5X,#84TH#,F6.2,5X,#95TH#,F6.2
             $/)
        930   FORMAT(/1X,#PCT.  GRAVEL #,F6.2,#  SAND #,F6.2,#  SILT+CLAY #,F6.2
             1)
         940  FORMAT(1H ,#PCT.  GRAVEL #,F6.2,#  SAND #,F6.2,#  SILT (PIPETTE) #
             $,F6.2,#  CLAY (PIPETTE) #,F6.2/1H0,37X,#(SEDIGRAPH) #,F6.2,5X,
             $#(SEDIGRAPH) #,F6.2)
        950   FORMAT(/1X,#GRAVEL+SAND #,F6.2,30X,#GRAV+SAND/SILT+CLAY #,F8.2/)
        960   FORMAT (/1X,12HGRAVEL+SAND ,F6.2,20H   SILT/(SILT+CLAY) ,F6.2,#PCT
             $.GRAV+SAND/SILT+CLAY#,F8.2/)
         970  FORMAT(6A4,A9,F4.2,2F6.2,15X,F8.4,4H GM.,2X,I2)
        980   FORMAT (15F5.2)
        990   FORMAT (13F5.2/9F6.2,5X,3F6.2,F8.2)
       1000   FORMAT (1X,15HLABELS SHEPARD -,3A4,10HFOLK(GMS)-,5A4,7H (SCS)-,3A4
             $)
       1010   FORMAT (16HLABELS SHEPARD -,3A4,10HFOLK(GMS)-,5A4,7H (SCS)-,3A4)
       1020   FORMAT (/2X,10HCOMMENTS -)
       1030   FORMAT (20A4)
       1040   FORMAT (1X,20A4)
              END
```

```
      SUBROUTINE FOLKL
      INTEGER SEDTYPE,SAMPID
      COMMON WS(80),PHI(80),N,NS,NN,START,PHINT,GRAV,SAND,SILT,CLAY,
     $SAMPNT,NO,SANDGRV ,FOLK,SNDMUD,CLYSEC,SLTSED,DISP,GSMUD,NNN,IOPT(8
     $),SAMPID(6),FACT,INTPPT,LAB1(3),LAB2(5),LAB3(3),PSILT,PCLAY,PSLCLY
     $,JCUTOUT
      DIMENSION SEDTYPE(85)
      DATA SEDTYPE/4HMUD ,4*4H    ,4HSAND,4HY MU,4HD    ,2*4H    ,4HMUDD,
     $4HY SA,4HND  ,2*4H    ,4HSAND,4*4H    ,4HGRAV,4HELLY,4H MUD,2*
     $4H   ,4HGRAV,4HELLY,4H MUD,4HDY S,4HAND ,4HGRAV,4HELLY,4H SAN,
     $4HD  ,4H   ,4HMUDD,4HY GR,4HAVEL,2*4H    ,4HMUDD,4HY SA,4HNDY ,
     $4HGRAV,4HEL  ,4HSAND,4HY GR,4HAVEL,2*4H    ,4HGRAV,4HEL  ,3*4H
     $,4HCLAY,2*4H    ,4HMUD ,2*4H    ,4HSILT,2*4H    ,4HSAND,4HY CL,
     $4HAY  ,4HSAND,4HY MU,4HD    ,4HSAND,4HY SI,4HLT  ,4HSAND,4HY CL,
     $4HAND ,4HMUDD,4HY  S,4HAND ,4HSILT,4HY SA,4HND  ,4HSAND,2*4H    /
      NCLA33 = 0
      CLYST = 0.
      IF(SILT .EQ. 0.) GO TO 5
      CLYST = CLAY/SILT
    5 CONTINUE
      IF (GRAV.GE.4.99999) GC TO 10
      IF (SNDMUD.LT.1./9.) GC TO 40
      IF (SNDMUD.LT.0.99999) GO TO 50
      IF (SNDMUD.LT.8.99999) GO TO 60
      GO TO 70
   10 IF (GRAV.GE.29.99999) GO TC 20
      IF (SNDMUD.LT.0.99999) GO TO 80
      IF (SNDMUD.LT.9.99999) GO TO 90
      GO TO 100
   20 IF (GRAV.GE.79.99999) GO TO 30
      IF (SNDMUD.LT.0.99999) GO TO 110
      IF (SNDMUD.LT.8.99999) GO TO 120
      GO TO 130
   30 GC TO 140
   40 LL = 1
      GO TO 150
   50 LL = 6
      GO TO 150
   60 LL = 11
      GO TO 150
   70 LL = 16
      GO TO 150
   80 LL = 21
      GO TO 290
   90 LL = 26
      GO TO 290
  100 LL = 31
      GO TO 290
  110 LL = 36
      GO TO 290
  120 LL = 41
      GO TO 290
  130 LL = 46
      GO TO 290
  140 LL = 51
      GO TO 290
  150 IF (SANDGRV .GE. 9.99999) GO TC 160
      IF (CLYST.GT.2.) GO TO 190
      IF (CLYST.GT.0.5) GO TC 200
      GO TO 210
  160 IF (SANDGRV .GE.49.99999) GO TC 170
      IF (CLYST.GT.2.) GO TC 220
      IF (CLYST.GT.0.5) GO TC 230
      GO TO 240
  170 IF (SANDGRV .GE.89.99999) GO TC 180
      IF (CLYST.GT.2.) GO TO 250
      IF (CLYST.GT.0.5) GO TC 260
      GO TO 270
  180 GO TO 280
  190 MM = 56
      GO TO 300
  200 MM = 59
      GC TO 300
  210 MM = 62
      GC TO 300
  220 MM = 65
      GO TO 300
```

```
  230 MM = 69
      GO TO 300
  240 MM = 71
      GO TO 300
  250 MM = 74
      GO TO 300
  260 MM = 77
      GO TO 300
  270 MM = 80
      GO TO 300
  280 MM = 83
      GO TO 300
  290 NOLAB3 = 1
  300 LLL = LL+4
      I = 0
      DO 310 L=LL,LLL
        I = I+1
  310 LAB2(I) = SEDTYPE(L)
      IF (NOLAB3.NE.1) GO TO 330
      DO 320 I=1,3
  320 LAB3(I) = 4H
      RETURN
  330 MMM = MM+2
      I = 0
      DO 340 M=MM,MMM
        I = I+1
  340 LAB3(I) = SEDTYPE(M)
      RETURN
      END
```

```
      SUBROUTINE SHEPARD
      INTEGER SEDTYPE,SAMPIC
      COMMON WG(80),PHI(80),N,NS,NN,START,PHINT,GRAV,SAND,SILT,CLAY,
     $SAMPWT,NO,SANDGRV ,FOLK,SNDMUD,CLYSED,SLTSED,DISP,GSMUD,NNN,IOPT(8
     $),SAMPID(6),FACT,INTRPT,LAB1(3),LAB2(5),LAB3(3),PSILT,PCLAY,PSLCLY
     $,JOUTPUT
      DIMENSION SEDTYPE(30)
      DATA SEDTYPE/4HSAN ,4HSIL ,4HCLY ,4HCLAY,4HEY S,4HAND ,4HSILT,
     $4HY SA,4HND  ,4HSAND,4HY SI,4HLT  ,4HCLAY,4HEY S,4HILT ,4HSILT,
     $4HY CL,4HAY  ,4HSAND,4HY CL,4HAY  ,4HCLAY,4H    ,4H    ,4HSILT,
     $4H    ,4H    ,4HSAND,4H    ,4H    /
      IF (SAND) 20,10,20
   10 SAND = .001
   20 IF (SILT) 40,30,40
   30 SILT = .001
   40 IF (CLAY) 50,50,60
   50 CLAY = .001
   60 SAND = SAND+GRAV
      IF (SAND-75.) 70,180,180
   70 IF (SILT-75.) 80,190,190
   80 IF (CLAY-75.) 90,200,200
   90 SANSIL = SAND/SILT
      CLYSND = ABS(CLAY/SAND)
      SILCLY = ABS(SILT/CLAY)
      IF (SAND-20.) 100,100,130
  100 IF (SANSIL-1.) 110,110,210
  110 IF (SILCLY-1.) 220,120,120
  120 IF (CLYSND-1.) 240,240,230
  130 IF (CLAY-20.) 140,140,160
  140 IF (SANSIL-1.) 240,150,150
  150 IF (SILCLY-1.) 250,250,250
  160 IF (SILT-20.) 170,170,270
  170 IF (CLYSND-1.) 250,260,210
  180 LL = 28
      GO TO 280
  190 LL = 25
      GO TO 280
  200 LL = 22
      GO TO 280
  210 LL = 19
      GO TO 280
  220 LL = 16
      GO TO 280
  230 LL = 13
      GO TO 280
  240 LL = 10
      GO TO 280
  250 LL = 7
      GO TO 280
  260 LL = 4
      GO TO 280
  270 LL = 1
  280 LLL = LL+2
      I = 0
      DO 290 L=LL,LLL
      I = I+1
  290 LAB1(I) = SEDTYPE(L)
      RETURN
      END
```

```
      SUBROUTINE ICODE1
      INTEGER SAMPIC
      COMMON WG(80),PHI(80),N,NS,NN,START,PHINT,GRAV,SAND,SILT,CLAY,
     $SAMPWT,NO,SANDGRV ,FOLK,SNDMUD,CLYSED,SLTSED,DISP,GSMUD,NNN,IOPT(8
     $),SAMPID(6),FACT,INTRPT,LAB1(3),LAB2(5),LAB3(3),PSILT,PCLAY,PSLCLY
     &,JCUTPUT
      IF (IOPT(1).NE.1) GO TO 10
      PRINT 140, SAMPID,SAMPWT
   10 CONTINUE
      NN = NO
      NNN = NO+1
      WG(1) = 0.
      READ 150, (WG(I),I=2,NNN)
      IF (PHINT.NE.0.) GO TO 30
C     SPECIAL CASE FOR SIEVING AT SIZE BOUNDARIES - 2 OR 3 DATA POINTS 0
      IF (NO.LE.3) GO TO 20
      PRINT 160, SAMPID
      INTRPT = 1
      RETURN
   20 CONTINUE
      PHI(1) = START-1.0
      PHI(2) = START
      PHI(3) = 4.0
      PHI(NNN) = 12.
      GO TO 50
   30 CONTINUE
      PHI(1) = START-PHINT
      DO 40 I=2,NNN
        PHI(I) = PHI(I-1)+PHINT
   40 CONTINUE
      PHI(NNN) = 12.
   50 CONTINUE
      TOTWT = 0.
      DO 60 I=1,NNN
   60 TOTWT = TOTWT+WG(I)
      ERROR = (ABS(SAMPWT-TOTWT)/SAMPWT)*100.
      IF (ERROR.LT.0.5) GO TO 70
      PRINT 170, SAMPID,SAMPWT,TOTWT
      INTRPT = 1
      RETURN
   70 CONTINUE
      SAMPWT = TOTWT
C
C     COMPUTE GRAVEL, SAND, SILT-CLAY PERCENTAGES
      GRAV = 0.
      DO 90 I=1,NNN
        IF (PHI(I).GT.-1.0) GO TO 90
        GRAV = GRAV+WG(I)
   80 CONTINUE
   90 GRAV = 100.*(GRAV/SAMPWT)
      IB = I
C
C     IB DEFINES FIRST SAND CLASS
      SAND = 0.
      DO 110 I=IB,NNN
        IF (PHI(I).GT.4.0) GO TO 110
        SAND = SAND+WG(I)
  100 CONTINUE
  110 SAND = 100.*(SAND/SAMPWT)
      PSILT = 0.
      PCLAY = 0.
      PSLCLY = 100.-(GRAV+SAND)
      JOUTPUT = 1
      IF(ABS(PSLCLY).LT.0.005)PSLCLY = 0.
      SILT = PSILT
      CLAY = PCLAY
      SANDGRV = GRAV+SAND
      IF (PSLCLY.NE.0.) GO TO 120
      FOLK = 0.
      SNDMUD = 99999.99
      GSMUD = 99999.99
      GO TO 130
  120 CONTINUE
      FOLK = SILT/PSLCLY*100.
      SNDMUD = SAND/PSLCLY
      GSMUD = SANDGRV /PSLCLY
  130 CONTINUE
```

```
      RETURN
C
  140 FORMAT (1X,6A4,4I4        SIEVE ONLY                 SAMPLE WT.=,F8.4)
  150 FORMAT (8F10.0)
  160 FORMAT(/1X,*SINCE PHINT = 0, THIS IS SPECIAL BOUNDARY SIEVING; HOW
     $EVER, TOTAL NUMBER*/1X,*OF DATA POINTS IS GREATER THAN 3 IN SAMPLE
     $*,F14)
  170 FORMAT(/1X,*SAMPLE WEIGHT INCORRECT ON *,6A4,2F10.4)
      END
```

```
      SUBROUTINE ICODE2
      INTEGER SAMPID
      COMMON WG(80),PHI(80),N,NS,NN,START,PHINT,GRAV,SAND,SILT,CLAY,
     &SAMPWT,NO,SANDGRV ,FOLK,SNDMUD,CLYSED,SLTSED,DISP,GSMUD,NNN,IOPT(8
     &),SAMPID(5),FACT,INTRPT,LAB1(3),LAB2(5),LAB3(3),PSILT,PCLAY,PSLCLY
     &,JOUTPUT
      DIMENSION PIPET(10)
      DIMENSION TEMP(10), REMP(10)
C
C      NP = NUMBER OF PIPETTE DRAWS : NP=2 - SHORT PIPETTE AT 4 PHI INTE
C                                   NP>2 - LONG  PIPETTE AT 1 PHI INTE
      NP = NO-N
      IF (NP.GT.2) GO TO 10
      PRINT 200, SAMPID
      INTRPT = 1
      RETURN
   10 CONTINUE
C
C     NN = NUMBER OF SIEVE DATA POINTS PLUS ONE
C     NNN= NUMBER OF DATA POINTS PLUS ONE
      NN = N+1
      NNN = NO+1
      IF (IOPT(1).NE.1) GO TO 20
      PRINT 210, SAMPID,NP,SAMPWT
   20 CONTINUE
      PHI(1) = START-PHINT
      WG(1) = 0.
      IF (N.LE.0) GO TO 40
      READ 220, (WG(I),I=2,NN)
      DO 30 I=2,NN
   30 PHI(I) = PHI(I-1)+PHINT
   40 CONTINUE
C
C     OMPUTE WEIGHTS OF PIPETTE DRAWS
      DO 50 I=1,NP
        READ 230, PIPET(I),TARE
   50 PIPET(I) = (PIPET(I)-TARE)*FACT-DISP
      IF (NP.EQ.2) GO TO 80
C
C     LONG PIPETTE DATA
      PHINT = 1.0
      NT = NN+1
      PHI(NT) = 5.0
      NT = NT+1
      DO 60 I=NT,NO
   60 PHI(I) = PHI(I-1)+1.0
      PHI(NNN) = 12.
      DO 70 I=2,NP
        IP = NN+(I-1)
   70 WG(IP) = PIPET(I-1)-PIPET(I)
      WG(NNN) = PIPET(NP)
      GO TO 90
   80 CONTINUE
C
C     SHORT PIPETTE DATA
      WG(NN+2) = PIPET(2)
      WG(NN+1) = PIPET(1)-PIPET(2)
      PHI(NN+1) = 9.0
      PHI(NN+2) = 12.0
   90 CONTINUE
C
C
C     IF SIEVE DATA IS NOT RESOLVED, CAN NOT DO A SAMPLE WEIGHT CHECK
      IF (N.LT.2) GO TO 120
C     SUM SAMPLEWEIGHT AND COMPARE WITH TOTAL SAMPLE WEIGHT GIVEN
      TOTWT = 0.
      DO 100 I=1,NNN
  100 TOTWT = TOTWT+WG(I)
      ERROR = (ABS(SAMPWT-TOTWT)/SAMPWT)*100.
      IF (ERROR.LT.2.5) GO TO 110
      PRINT 240, SAMPID,SAMPWT,TOTWT
      INTRPT = 1
      RETURN
  110 CONTINUE
      SAMPWT = TOTWT
  120 CONTINUE
C
```

```
C     COMPUTE CLAY,SILT,      PERCENTAGES
      PSILT = 0.
      PCLAY = 0.
      PSLCLY = 100.*(PIPET(1)/SAMPWT)
      IF (NP.GT.2) GO TO 130
      PCLAY = 100.*(PIPET(2)/SAMPWT)
      PSILT = PSLCLY-PCLAY
      GO TO 140
  130 CONTINUE
      NN = NN+NP-1
      IF(NP.LT.5)JOUTPUT = 1
      IF (NP.LT.5) GO TO 140
      PCLAY = 100.*PIPET(5)/SAMPWT
      PSILT = PSLCLY-PCLAY
  140 CONTINUE
C
C     COMPUTE CLAY,SILT,SAND,GRAVEL PERCENTAGES
      GRAV = 0.
      DO 150 I=1,NN
        IF (PHI(I).GT.-1.0) GO TO 160
        GRAV = GRAV+WG(I)
  150 CONTINUE
  160 GRAV = 100.*(GRAV/SAMPWT)
      SAND = 100.-(PSLCLY+GRAV)
      SILT = PSILT
      CLAY = PCLAY
      IF(PSLCLY .NE. 0.) GO TO 165
      FCLK = 0.
      SNDMUD = 99999.99
      GSMUD  = 99999.99
      GO TO 166
  165 CONTINUE
      FCLK = SILT/PSLCLY*100.
      SANDGRV  = GRAV+SAND
      SNDMUD = SAND/PSLCLY
      GSMUD = SANDGRV /PSLCLY
  166 CONTINUE
C
C     SPECIAL CASE OF LONG PIPETTE ONLY WITH SIEVING LIMITED TO REMOVING
      IF (NP.EQ.2) GO TO 190
      IF (N.GT.1) GO TO 190
      IF (START.EQ.4.0) GO TO 190
      JJ = 3
      IF(START.EQ.0.0)START = 4.0
      IF(START.EQ.4.0)JJ = 2
      NNN = NNN+1
C
C     SHIFT PHI AND WEIGHT ARRAYS TO ALLOW INSERTION OF SAND WEIGHT
      DO 170 I=JJ,NNN
        TEMP(I) = PHI(I)
  170 REPP(I) = WG(I)
      JK = JJ+1
      DO 180 I=JK,NNN
        PHI(I) = TEMP(I-1)
  180 WG(I) = REPP(I-1)
      PHI(2) = START
      PHI(1) = START-1.0
      WG(JJ) = SAND*SAMPWT/100.
      IF(JJ.EQ.3)PHI(3) = 4.0
      NN = NN+1
      INTRPT = 7
  190 CONTINUE
      RETURN
C
  200 FORMAT(/1X,*PIPETTE DRAWS LESS THAN 2 ON *,6A4)
  210 FORMAT(1X,6A4,7X,*SIEVE AND PIPETTE(*,I2,*)     SAMPLE WT.=*,F8.4)
  220 FORMAT (AF10.0)
  230 FORMAT (2F10.0)
  240 FORMAT (/1X,27HSAMPLE WEIGHT INCORRECT ON ,6A4,2F10.4)
      END
```

```
      SUBROUTINE ICODE3
      INTEGER SAMPID
      COMMON WG(90),PHI(90),N,NS,NN,START,PHINT,GRAV,SAND,SILT,CLAY,
     $SAMPWT,NO,SANDGRV ,FOLK,SNDMUD,CLYSED,SLTSED,DISP,GSMUD,NNN,IOPT(8
     $),SAMPID(6),FACT,INTRPT,LAB1(3),LAB2(5),LAB3(3),PSILT,PCLAY,PSLCLY
     $,JOUTPUT
      DIMENSION PIPET(2), SEDO(50)
      IF (IOPT(1).NE.1) GO TO 10
      PRINT 140, SAMPID,SAMPWT
   10 CONTINUE
C
C     READ SIEVE DATA
      NN = N+1
      READ 150, (WG(I),I=2,NN)
      PHI(1) = START-PHINT
      WG(1) = 0.
      DO 20 I=2,NN
   20 PHI(I) = PHI(I-1)+PHINT
      DO 30 I=1,2
        READ 150, PIPET(I),TARE
   30 PIPET(I) = (PIPET(I)-TARE)*FACT-DISP
      NNS = NO-N-2
      NS = NNS-1
      READ 150, (SEDO(I),I=1,NNS)
      AJSTWT = 100./SEDO(1)
      DO 40 I=1,NNS
   40 SEDO(I) = SEDO(I)*AJSTWT
      DO 50 I=1,NS
        NNN = NN+I
        WG(NNN) = ((SEDO(I)-SEDO(I+1))/100.)*PIPET(1)
   50 PHI(NNN) = PHI(NNN-1)+PHINT
      NNN = NN+NNS
      WG(NNN) = (SEDO(NNS)/100.)*PIPET(1)
      PHI(NNN) = 12.
C
C     COMPUTE SILT AND CLAY FROM SEDIGRAPH
C     COMPUTE NUMBER OF SILT CLASSES CORRESPONDING TO GIVEN PHINT
      ISC = 4./PHINT
      IB1 = ISC+1
      IB2 = NNS
      CLYSED = 0.
      IF (ISC-NNS) 60,80,80
   60 IB2 = ISC
      DO 70 I=IB1,NNS
        NNN = NN+I
   70 CLYSED = CLYSED+WG(NNN)
   80 SLTSED = 0.
      DO 90 I=1,IB2
        NNN = NN+I
   90 SLTSED = SLTSED+WG(NNN)
C
C     SUM SAMPLEWEIGHT AND COMPARE WITH TOTAL SAMPLE WEIGHT GIVEN
      NNN = NN+NNS
      TOTWT = 0.
      DO 100 I=1,NNN
  100 TOTWT = TOTWT+WG(I)
      TEST = 0.025*SAMPWT
      IF (ABS(TOTWT-SAMPWT).LE.TEST) GO TO 110
      PRINT 170, SAMPID,SAMPWT,TOTWT
      INTRPT = 1
      RETURN
  110 CONTINUE
      SAMPWT = TOTWT
      PSLCLY = 100.*(PIPET(1)/SAMPWT)
      PCLAY = 100.*(PIPET(2)/SAMPWT)
      PSILT = PSLCLY-PCLAY
      GRAV = 0.
      DO 120 I=1,NN
        IF (PHI(I).GT.-1.0) GO TO 130
  120 GRAV = GRAV+WG(I)
  130 GRAV = 100.*(GRAV/SAMPWT)
      SLTSED = 100.*(SLTSED/SAMPWT)
      CLYSED = 100.*(CLYSED/SAMPWT)
      SAND = 100.-(PSLCLY+GRAV)
      SILT = SLTSED
      CLAY = CLYSED
      SANDGRV  = GRAV+SAND
```

```
      IF(PSLCLY .NE. 0.) GO TO 165
      FCLK = 0.
      SNDMUD = 99999.99
      GSMUD  = 99999.99
      GO TO 166
  165 CONTINUE
      FCLK = SILT/PSLCLY*100.
      SNDMUD = SAND/PSLCLY
      GSMUD = SANDGRV /PSLCLY
  166 CONTINUE
      NN = NN+NS
      RETURN
C
  140 FORMAT (1X,6A4,46H         SIEVE, SH. PIP., SEDIGRAPH  SAMPLE WT.=,
     *F8.4)
  150 FORMAT (8F10.0)
  160 FORMAT (2F10.0)
  170 FORMAT (/1X,27HSAMPLE WEIGHT INCORRECT ON ,6A4,2F10.4)
      END
```

```
      SUBROUTINE ICOCE4
      INTEGER SAMPID
      COMMON WG(80),PHI(80),N,NS,NN,START,PHINT,GRAV,SAND,SILT,CLAY,
     $SAMPWT,NO,SANDGRV ,FOLK,SNDMUD,CLYSED,SLTSED,DISP,GSMUD,NNN,IOPT(8
     $),SAMPID(5),FACT,INTRPT,LAB1(3),LAB2(5),LAB3(3),PSILT,PCLAY,PSLCLY
     $,JOUTPUT
      DIMENSION PIPET(10), FWT(50)
C
C      NP = NUMBER OF PIPETTE DRAWS : NP=2 - SHORT PIPETTE AT 4 PHI INTE
C                                     NP>2 - LONG  PIPETTE AT 1 PHI INTE
      NP = NC-N
      IF (NP.GE.2) GO TO 10
      PRINT 180, SAMPID
      INTRPT = 1
      RETURN
   10 CONTINUE
C
C     NN = NUMBER OF SIEVE DATA POINTS PLUS ONE
C     NNN= NUMBER OF DATA POINTS PLUS ONE
C     NCL  =   NUMBER OF SETTLING TUBE DATA POINTS
C     NGS  =   NUMBER OF SIEVE DATA POINTS
      NN = N+1
      NNN = NO+1
      IF(PHINT.EQ.1.0)NCL = 5
      IF(PHINT.EQ.0.5)NCL = 9
      IF(PHINT.EQ.0.25)NCL = 18
      NGS = NN-NCL
      IF (IOPT(1).NE.1) GO TO 20
      PRINT 190, SAMPID,NP,SAMPWT
   20 CONTINUE
      PHI(1) = START-PHINT
      WG(1) = 0.
      READ 200, (WG(I),I=2,NN)
      DO 30 I=2,NN
   30 PHI(I) = PHI(I-1)+PHINT
      DO 40 I=1,NP
        READ 210, PIPET(I),TARE
   40 PIPET(I) = (PIPET(I)-TARE)*FACT-DISP
      IF (NP.EQ.2) GO TO 70
C
C     LONG PIPETTE DATA
      PHINT = 1.0
      NT = NN+1
      PHI(NT) = 5.0
      NT = NT+1
      DO 50 I=NT,NO
   50 PHI(I) = PHI(I-1)+1.0
      PHI(NNN) = 12.
      DO 60 I=2,NP
        IP = NN+(I-1)
   60 WG(IP) = PIPET(I-1)-PIPET(I)
      WG(NNN) = PIPET(NP)
      GO TO 90
   70 CONTINUE
C
C     SHORT PIPETTE DATA
      WG(NN+2) = PIPET(2)
      WG(NN+1) = PIPET(1)-PIPET(2)
      PHI(NN+1) = 8.0
      PHI(NN+2) = 12.0
   80 CONTINUE
C
C     SUM GRAVEL + 1ST SAND CLASS(ES)
      GS = 0.
      DO 90 I=1,NGS
   90 GS = GS+WG(I)
      SANDWT = SAMPWT-GS-PIPET(1)
C
C     COMPUTE FRACTION WEIGHTS OVER SAND RANGE
      NC = NGS+1
      II = 1
      FWT(II) = 0.
      DO 100 I=NC,NN
        II = II+1
  100 FWT(II) = WG(I)
      II = 0
      DO 110 I=NC,NN
```

```
          II = II+1
  110     WG(I) = SANDWT*((WG(I)-FWT(II))/WG(NN))
C
C         SUM SAMPLEWEIGHT AND COMPARE WITH TOTAL SAMPLE WEIGHT GIVEN
          TOTWT = 0.
          DO 120 I=1,NNN
  120     TOTWT = TOTWT+WG(I)
          IF (ABS(TOTWT-SAMPWT).LE.0.01) GO TO 130
          PRINT 220, SAMPID,SAMPWT,TOTWT
          INTRPT = 1
          RETURN
  130     CONTINUE
          SAMPWT = TOTWT
C
C         COMPUTE CLAY,SILT,      PERCENTAGES
          PSILT = 0.
          PCLAY = 0.
          PSLCLY = 100.*(PIPET(1)/SAMPWT)
          IF (NP.GT.2) GO TO 140
          PCLAY = 100.*(PIPET(2)/SAMPWT)
          PSILT = PSLCLY-PCLAY
          GO TO 150
  140     CONTINUE
          NN = NN+NP-1
          IF(NP.LT.5) JOUTPUT = 1
          IF (NP.LT.5) GO TO 150
          PCLAY = 100.*PIPET(5)/SAMPWT
          PSILT = PSLCLY-PCLAY
  150     CONTINUE
C
C         COMPUTE CLAY,SILT,SAND,GRAVEL PERCENTAGES
          GRAV = 0.
          DO 160 I=1,NN
            IF (PHI(I).GT.-1.0) GO TO 170
            GRAV = GRAV+WG(I)
  160     CONTINUE
  170     GRAV = 100.*(GRAV/SAMPWT)
          SAND = 100.-(PSLCLY+GRAV)
          SILT = PSILT
          CLAY = PCLAY
          SANDGRV  = GRAV+SAND
          IF(PSLCLY .NE. 0.) GO TO 165
          FOLK = 0.
          SNDMUD = 99999.99
          GSMUD  = 99999.99
          GO TO 166
  165     CONTINUE
          FOLK = SILT/PSLCLY*100.
          SNDMUD = SAND/PSLCLY
          GSMUD = SANDGRV /PSLCLY
  166     CONTINUE
          RETURN
C
  180     FORMAT(/1X,*PIPETTE DRAWS LESS THAN 2 ON *,6A4)
  190     FORMAT(1X,6A4,*  SIEVE,SETT.TUBE,PIPETTE(*,I2,*)   SAMPLE WT.=*,
         $ F8.4)
  200     FORMAT (8F10.0)
  210     FORMAT (2F10.0)
  220     FORMAT (/1X,27HSAMPLE WEIGHT INCORRECT ON ,6A4,2F10.4)
          END
```

```
      SUBROUTINE ICODES
      INTEGER SAMPID
      COMMON WG(80),PHI(80),N,NS,NN,START,PHINT,GRAV,SAND,SILT,CLAY,
     $SAMPWT,NO,SANDGRV ,FOLK,SNDMUD,CLYSED,SLTSED,DISP,GSMUD,NNN,IOPT(8
     $),SAMPID(6),FACT,INTPPT,LAB1(3),LAB2(5),LAB3(3),PSILT,PCLAY,PSLCLY
     $,JCUTPUT
      DIMENSION PIPET(2), SEDO(50), FWT(50)
      IF (IOPT(1).NE.1) GO TO 10
      PRINT 170, SAMPID,SAMPWT
   10 CONTINUE
C
C     READ SIEVE AND SETTLING TUBE DATA
      NN = N+1
      READ 180, (WG(I),I=2,NN)
      PHI(1) = START-PHINT
      WG(1) = 0.
      DO 20 I=2,NN
   20 PHI(I) = PHI(I-1)+PHINT
      DO 30 I=1,2
        READ 190, PIPET(I),TARE
   30 PIPET(I) = (PIPET(I)-TARE)*FACT-DISP
      NNN = NN+2
C
C     SUM GRAVEL + 1ST SAND CLASS(ES)
      IF(PHINT.EQ.1.0)NCL = 7
      IF(PHINT.EQ.0.5)NCL = 11
      IF(PHINT.EQ.0.25) NCL = 20
      NGS = NNN-NCL
      GS = 0.
      DO 40 I=1,NGS
   40 GS = GS+WG(I)
      SANDWT = SAMPWT-GS-PIPET(1)
C
C     COMPUTE FRACTION WEIGHTS OVER SAND RANGE
      NC = NGS+1
      II = 1
      FWT(II) = 0.
      DO 50 I=NC,NN
        II = II+1
   50 FWT(II) = WG(I)
      II = 0
      DO 60 I=NC,NN
        II = II+1
   60 WG(I) = SANDWT*((WG(I)-FWT(II))/WG(NN))
      NNS = NO-N-2
      NS = NNS-1
      READ 130, (SEDO(I),I=1,NNS)
      AJSTWT = 100./SEDO(1)
      DO 70 I=1,NNS
   70 SEDO(I) = SEDO(I)*AJSTWT
      DO 80 I=1,NS
        NNN = NN+I
        WG(NNN) = ((SEDO(I)-SEDO(I+1))/100.)*PIPET(1)
   80 PHI(NNN) = PHI(NNN-1)+PHINT
      NNN = NN+NNS
      WG(NNN) = (SEDO(NNS)/100.)*PIPET(1)
      PHI(NNN) = 12.
C
C     COMPUTE SILT AND CLAY FROM SEDIGRAPH
C     COMPUTE NUMBER OF SILT CLASSES CORRESPONDING TO GIVEN PHINT
      ISC = 4./PHINT
      I31 = ISC+1
      I32 = NNS
      CLYSED = 0.
      IF (ISC-NNS) 90,110,110
   90 I32 = ISC
      DO 100 I=I31,NNS
        NNN = NN+I
  100 CLYSED = CLYSED+WG(NNN)
  110 SLTSED = 0.
      DO 120 I=1,I32
        NNN = NN+I
  120 SLTSED = SLTSED+WG(NNN)
C
C     SUM SAMPLEWEIGHT AND COMPARE WITH TOTAL SAMPLE WEIGHT GIVEN
      NNN = NN+NNS
      TOTWT = 0.
```

```
      DO 130 I=1,NNN
  130 TOTWT = TOTWT+WG(I)
      IF (ABS(TOTWT-SAMPWT).LE.0.01) GO TO 140
      PRINT 200, SAMPID,SAMPWT,TOTWT
      INTRPT = 1
      RETURN
  140 CONTINUE
      SAMPWT = TOTWT
      PSLCLY = 100.*(PIPET(1)/SAMPWT)
      PCLAY = 100.*(PIPET(2)/SAMPWT)
      PSILT = PSLCLY-PCLAY
      GRAV = 0.
      DO 150 I=1,NN
        IF (PHI(I).GT.-1.0) GO TO 160
  150 GRAV = GRAV+WG(I)
  160 GRAV = 100.*(GRAV/SAMPWT)
      SLTSED = 100.*(SLTSED/SAMPWT)
      CLYSED = 100.*(CLYSED/SAMPWT)
      SAND = 100.-(PSLCLY+GRAV)
      SILT = SLTSED
      CLAY = CLYSED
      SANDGRV  = GRAV+SAND
      IF(PSLCLY .NE. 0.) GO TO 165
      FOLK = 0.
      SNDMUD = 99999.99
      GSMUD  = 99999.99
      GO TO 166
  165 CONTINUE
      FOLK = SILT/PSLCLY*100.
      SNDMUD = SAND/PSLCLY
      GSMUD = SANDGRV /PSLCLY
  166 CONTINUE
      NN = NN+NS
      RETURN
C
  170 FORMAT (1X,6A4,46H  SIEVE,SETT.TUBE,PIPET,SEDIGRAPH  SAMPLE WT.=,
     $F8.4)
  180 FORMAT (8F10.0)
  190 FORMAT (2F10.0)
  200 FORMAT (/1X,27HSAMPLE WEIGHT INCORRECT ON ,6A4,2F10.4)
      END
```

```
      SUBROUTINE ICODE7
      INTEGER SAMPID
      COMMON WG(80),PHI(80),N,NS,NN,START,PHINT,GRAV,SAND,SILT,CLAY,
     $SAMPNT,NO,SANDGRV ,FOLK,SNDMUD,CLYSED,SLTSED,DISP,GSMUD,NNN,IOPT(8
     8),SAMPID(5),FACT,INTRPT,LAB1(3),LAB2(5),LAB3(3),PSILT,PCLAY,PSLCLY
     $,JOUTPUT
      DIMENSION SEDO(50)
      IF (IOPT(1).NE.1) GO TO 10
      PRINT 30, SAMPID
   10 CONTINUE
      IF(START .EQ. 0.0) START = 4.0 - PHINT
      PERSAND = 0.
      WTSAND = 0.0
      NO = NC - N
      NN = NO+1
      PHI(1) = START
      WG(1) = 0.
      IF(N .EQ. 0) GO TO 15
      IF(N .EQ. 1) GO TO 15
      PRINT 110, SAMPID
      INTRPT = 1
      RETURN
   15 CONTINUE
      READ 100, WTSAND
      PERSAND = (WTSAND / SAMPNT ) * 100.
   16 CONTINUE
      SAMPNT = 100.
      READ 100, (SEDO(I),I=1,NO)
C  COMPUTE ADJUSTMENT VALUE - TO CONVERT SEDIGRAPH VALUES TO 100 PERCENT
C  IF THERE IS NO SIEVE WEIGHT OF SAND
      AJSTMT = (100. - PERSAND ) / SEDO(1)
      DO 20 I=1,NO
   20 SEDO(I) = SEDO(I)*AJSTMT
      DO 30 I=2,NO
   30 WG(I) = SEDO(I-1)-SEDO(I)
C  ADD SIEVE PERCENTAGE OF SAND TO PERCENT OF SAND AS DETERMINED BY THE
C  SEDIGRAPH - SAND IS THE DROP BETWEEN THE FIRST TWO DATA POINTS
      WG(2) = WG(2) + PERSAND
      DO 40 I=2,NO
   40 PHI(I) = PHI(I-1)+PHINT
      PHI(NN) = 12.
      WG(NN) = SEDO(NO)
C     COMPUTE SILT AND CLAY AND SAND
C     COMPUTE NUMBER OF SILT CLASSES CORRESPONDING TO GIVEN PHINT
      ISC = 4./PHINT
      ITEST = ISC+1
      IB1 = ISC+3
C     IB1 DEFINES FIRST CLAY CLASS
      IB2 = NO
C     IB2 DEFINES LAST SILT CLASS
      CLYSED = 0.
      IF (ITEST-NO) 50,70,70
   50 IB2 = ISC+2
      DO 60 I=IB1,NN
   60 CLYSED = CLYSED+WG(I)
   70 SLTSED = 0.
      DO 80 I=3,IB2
   80 SLTSED = SLTSED+WG(I)
      SAND = WG(2)
      SILT = SLTSED
      CLAY = CLYSED
      PSLCLY = SILT+CLAY
      PSILT = 0.
      PCLAY = 0.
      GRAV = 0.0001
      SANDGRV = GRAV+SAND
      IF(PSLCLY .NE. 0.) GO TO 165
      FOLK = 0.
      SNDMUD = 99999.99
      GSMUD = 99999.99
      GO TO 166
  165 CONTINUE
      FOLK = SILT/PSLCLY*100.
      SNDMUD = SAND/PSLCLY
      GSMUD = SANDGRV /PSLCLY
  166 CONTINUE
      NNN = NN
```

```
      NN = NN-1
      INTRPT = 7
      RETURN
C
 90   FORMAT (1X,5A4,20H  SEDIGRAPH ANALYSIS)
 100  FORMAT (3F10.0)
 110  FORMAT(1H0,5A4,45HMORE THAN ONE SIEVE DATA POINT IS NOT ALLOWED)
      END
```

APPENDIX B:

Parameter Names used in Sizdist Program

(1) ARRAYS

- ARRAY - stores weight percents for punched output
- COMNTS - stores for output any comment cards
- CUMPCT - cumulative percent for each size fraction
- DUM - stores first data card for decoding later
- FREQ - stores moment measure frequency in calculations of PHI mean
- IOPT - control card output options
- LAB1 - Shepard classification label
- LAB2 - Folk classification label (G.M.S.)
- LAB3 - Folk classification label (S.C.S.)
- PCT - percent each weight fraction is of the total sample weight
- PFF - used in calculation of last three moment measures
- PHI - stores PHI size that applies to matching weights in array WG
- PHIP - stores PHI size at required percentiles
- PTILE - stores desired percentiles
- R - stores appropriate number of asterisks (*) to generate histogram output
- RMOM - calculation of moment measures
- SAMPID - sample identification
- WG - stores weights of size fractions

(2) PARAMETERS

- CLAY - percent clay
- CLYSED - percent clay from sedigraph data
- CYLSIZ - cylinder size
- DISP - weight of dispersant
- FACT - a factor used in the pipette draw calculations and is equal to cylinder size divided by pipette size
- FOLK - ratio percent silt/percent silt + clay
- GRAV - percent gravel
- GSMUD - ratio percents gravel + sand/silt + clay
- ICODE - type of lab analysis

INTRPT - message carrier from subroutine to main program

JOUTPUT - controls alternative output statement for size percentages

N - number of sieve and/or settling tube data points

NO - total number of data points

NCOM - number of comment cards

NP - number of pipette draws

PCLAY - percent clay from pipette data

PHINT - PHI size interval between data points

PSILT - percent silt from pipette data

PSLCLY - percent silt + clay from first pipette draw

RR - date of run determined by library function (call Date)

SAMPWT - original sample weight

SAND - percent sand

SANDGRV percent sand + gravel

SILT - percent silt

SLTSED - percent silt from sedigraph data

SNDMUD - ratio percents sand/silt + clay

START - PHI size of first data point

TOTWT - calculated sample weight to check for errors

XN - set by data statement to equal *, to identify comment cards

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION	DAY	MO	YR	DATA PTS*	** ANALYSIS CODE NO	NO. COMMENT CARDS
BOUNDARY SIEVE - GRAVEL				3	1	

SIEVE/ ST PTS	ϕ ORIGIN	SAMPLE WT. gm	WT. DISPERSANT gm	ϕ INTERVAL	CYL. SIZE ml.
3	-1.0	20.0	.	.	

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only - Use ϕ Origin of 0.0)

5.0	10.0	5.0	.	.	.	.	.	

TARE #

GROSS WT. PIP. FR	TARE WT.
.	.
.	.

* DATA POINTS = No. Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

** CODE NOS.:
1 - Sieve Only
2 - Sieve + Short Pipette
3 - Sieve + Sh. Pipette + Sedigraph
4 - Sieve + Settling Tube + Sh. Pip.
5 - Sieve/Sett. Tube/Sh. Pip./Sedigr.
6 - Short Pipette Only
7 - Sedigraph Only

SEDIGRAPH PERCENTAGES

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

BOUNDARY SIEVE - GRAVEL   SIEVE ONLY   SAMPLE WT.= 20.0000

PCT. GRAVEL 25.00 SAND 50.00 SILT+CLAY 25.00

GRAVEL+SAND 75.00   GRAV+SAND/SILT+CLAY 3.00

LABELS SHEPARD -SAND   FOLK(GMS)-GRAVELLY MUDDY SAND (SGS)-

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION: BOUNDARY SIEVE-NO GRAVEL

DAY | MO | YR

DATA PTS*: 2

**ANALYSIS CODE NO.: 1

NO. COMMENT CARDS

SIEVE/ST PTS: 2

Φ ORIGIN: 4.0

SAMPLE WT. gm: 20.0

WT. DISPERSANT gm

Φ INTERVAL

CYL. SIZE ml.

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only – Use Φ Origin of 0.0)

10.0 10.0

TARE #

GROSS WT. PIP. FR

TARE WT.

* DATA POINTS = No. Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

**CODE NOS.:
1 – Sieve Only
2 – Sieve + Short Pipette
3 – Sieve + Sh. Pipette + Sedigraph
4 – Sieve + Settling Tube + Sh. Pip.
5 – Sieve/Sett. Tube/Sh. Pip./Sedigr.
6 – Short Pipette Only
7 – Sedigraph Only

SEDIGRAPH PERCENTAGES

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

BOUNDARY SIEVE-NO GRAVEL   SIEVE ONLY   SAMPLE WT.= 20.0000

PCT. GRAVEL 0.00 SAND 50.00 SILT+CLAY 50.00

GRAVEL+SAND 50.00   GRAV+SAND/SILT+CLAY 1.00

LABELS SHEPARD -CLAYEY SAND FOLK(GHS)-MUDDY SAND   (SCS)-

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION	DAY	MO	YR	DATA PTS*	**ANALYSIS CODE NO	NO COMMENT CARDS
FULL SIEVE SHORT PIPETTE				7	2	

SIEVE/ST PTS	ϕ ORIGIN	SAMPLE WT gm	WT DISPERSANT gm	ϕ INTERVAL	CYL SIZE ml
5	2.0	20.0	2.5	0.5	500

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only - Use ϕ Origin of 0.0)

2.0	2.0	2.0	2.0	2.0	.	.	.
.	.	.	.	.	.	.	.

TARE #	GROSS WT PIP FR	TARE WT
	.650	.025
	.400	.025

* DATA POINTS = No Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

**CODE NOS: 1 - Sieve Only
2 - Sieve + Short Pipette
3 - Sieve + Sh. Pipette + Sedigraph
4 - Sieve + Settling Tube + Sh. Pip.
5 - Sieve/Sett. Tube/Sh. Pip./Sedigr.
6 - Short Pipette Only
7 - Sedigraph Only

SEDIGRAPH PERCENTAGES

.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

```
FULL SIEVE SHORT PIPETTE      SIEVE AND PIPETTE( 2)   SAMPLE WT.= 20.0000

 PHI  PCT. CUMPCT.                                    12/13/79
 1.50
      10.00             **********
 2.00       10.00
      10.00             **********
 2.50       20.00
      10.00             **********
 3.00       30.00
      10.00             **********
 3.50       40.00
      10.00             **********
 4.00       50.00
      25.00             *************************
 8.00       75.00
      25.00             *************************
*****      100.00
 MEAN  ST.DEV. SKEWNESS KURTOSIS

  2.75    .71    0.00   -1.30    KRUMBEIN + PETTIJOHN (1938) MOMENT MEASURES
                                 FOR SIZE RANGE  2.0 TO   4.0 PHI
 > 5 PERCENT OF THE FINES ARE NOT RESOLVED, OBTAIN FOLK STATS. GRAPHICALLY

PERCENTILES    MEDIAN  4.00    5TH  1.75    16TH  2.30    25TH  2.75
                              75TH  8.00    84TH******    95TH******
PCT.  GRAVEL   0.00  SAND  50.00  SILT (PIPETTE)  25.00  CLAY (PIPETTE)  25.00
                                 (SEDIGRAPH)   0.00     (SEDIGRAPH)    0.00
GRAVEL+SAND  50.00   SILT/(SILT+CLAY)  50.00PCT.GRAV+SAND/SILT+CLAY    1.00
LABELS SHEPARD -SAN SIL CLY FOLK(GMS)-MUDDY SAND          (SCS)-MUDDY  SAND
```

SIZDIST CODING FORM

Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION	DAY	MO	YR	DATA PTS*	**ANALYSIS CODE NO.	NO. COMMENT CARDS
SHORT PIPETTE - GRAVEL				3	2	

SIEVE/ST PTS	φ ORIGIN	SAMPLE WT. gm	WT. DISPERSANT gm	φ INTERVAL	CYL. SIZE ml.
1	-1.0	20.0	2.5		500

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only - Use φ Origin of 0.0)

5.0

TARE #	GROSS WT. PIP. FR	TARE WT.
☐	0.650	0.025
☐	0.400	0.025

* DATA POINTS = No Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

**CODE NOS.:
1 - Sieve Only
2 - Sieve + Short Pipette
3 - Sieve + Sh. Pipette + Sedigraph
4 - Sieve + Settling Tube + Sh. Pip.
5 - Sieve/Sett. Tube/Sh. Pip./Sedigr.
6 - Short Pipette Only
7 - Sedigraph Only

SEDIGRAPH PERCENTAGES

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

```
SHORT PIPETTE - GRAVEL          SIEVE AND PIPETTE( 2)   SAMPLE WT.= 20.0000
PCT.  GRAVEL  25.00  SAND  25.00  SILT (PIPETTE)  25.00  CLAY (PIPETTE)  25.00
                                  (SEDIGRAPH)    0.00     (SEDIGRAPH)    0.00
GRAVEL+SAND  50.00   SILT/(SILT+CLAY)  50.00PCT.GRAV+SAND/SILT+CLAY    1.00
LABELS SHEPARD -SAN SIL CLY FOLK(GMS)-GRAVELLY MUD           (SCS)-
```

SIZDIST CODING FORM

Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION	DAY	MO	YR.	DATA PTS*	**ANALYSIS CODE NO.	NO. COMMENT CARDS
SHORT PIPETTE ONLY				2	2	

SIEVE/ ST PTS	ϕ ORIGIN	SAMPLE WT. gm	WT. DISPERSANT gm	ϕ INTERVAL	CYL. SIZE ml.
	.	20.0	2.5	.	500

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only - Use ϕ Origin of 0.0)

TARE #	GROSS WT. PIP. FR.	TARE WT.
	0.650	0.025
	0.400	0.025

* DATA POINTS = No. Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

** CODE NOS.:
1 - Sieve Only
2 - Sieve + Short Pipette
3 - Sieve + Sh. Pipette + Sedigraph
4 - Sieve + Settling Tube + Sh. Pip.
5 - Sieve/Sett. Tube/Sh. Pip./Sedigr.
6 - Short Pipette Only
7 - Sedigraph Only

SEDIGRAPH PERCENTAGES

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

```
SHORT PIPETTE ONLY                     SIEVE AND PIPETTE( 2)   SAMPLE WT.= 20.0000
PCT.  GRAVEL    0.00  SAND  50.00  SILT (PIPETTE)   25.00  CLAY (PIPETTE)  25.00
                                     (SEDIGRAPH)    0.00      (SEDIGRAPH)    0.00
GRAVEL+SAND  50.00   SILT/(SILT+CLAY)  50.00PCT.GRAV+SAND/SILT+CLAY     1.00
LABELS SHEPARD -SAN SIL CLY FOLK(GMS)-MUDDY SAND             (SCS)-MUDDY  SAND
```

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION	DAY	MO	YR	DATA PTS*	**ANALYSIS CODE NO.	NO. COMMENT CARDS
FULL SIEVE LONG PIPETTE				11	2	

SIEVE/ST PTS	φ ORIGIN	SAMPLE WT. gm	WT. DISPERSANT gm	φ INTERVAL	CYL. SIZE ml
5	2.0	20.0	5.0	0.5	1000

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only - Use φ Origin of 0.0)

2.0	2.0	2.0	2.0	2.0

TARE #	GROSS WT. PIP. FR	TARE WT.
☐	.400	.025
☐	.350	.025
	.300	.025
	.250	.025

*DATA POINTS = No Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

**CODE NOS: 1 - Sieve Only
2 - Sieve + Short Pipette
3 - Sieve + Sh. Pipette + Sedigraph
4 - Sieve + Settling Tube + Sh. Pip.
5 - Sieve/Sett. Tube/Sh. Pip./Sedigr.
6 - Short Pipette Only
7 - Sedigraph Only

SEDIGRAPH PERCENTAGES

.200	.025
.155	.025

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

```
FULL SIEVE LONG PIPETTE        SIEVE AND PIPETTE( 6)   SAMPLE WT.= 20.0000

 PHI  PCT. CUMPCT.                                    12/13/79
 1.50
       10.00              **********
 2.00        10.00
       10.00              **********
 2.50        20.00
       10.00              **********
 3.00        30.00
       10.00              **********
 3.50        40.00
       10.00              **********
 4.00        50.00
       10.00              **********
 5.00        60.00
       10.00              **********
 6.00        70.00
       10.00              **********
 7.00        80.00
       10.00              **********
 8.00        90.00
        9.00              *********
 9.00        99.00
        1.00              *
*****       100.00
  MEAN  ST.DEV. SKEWNESS KURTOSIS

MOMENT MEASURES ARE NOT CALCULATED SINCE DATA CONTAINS MIXED PHI INTERVAL
   4.57    2.31     .34     .74     FOLK GRAPHIC STATISTICAL PARAMETERS
                                         FOLK AND WARD,1957

PERCENTILES     MEDIAN  4.00     5TH  1.75     16TH  2.30     25TH  2.75
                                75TH  6.50     84TH  7.40     95TH  8.56
PCT.  GRAVEL   0.00  SAND  50.00  SILT (PIPETTE)  40.00  CLAY (PIPETTE)  10.00
                                  (SEDIGRAPH)   0.00     (SEDIGRAPH)   0.00
GRAVEL+SAND  50.00   SILT/(SILT+CLAY)  80.00PCT.GRAV+SAND/SILT+CLAY    1.00
LABELS SHEPARD -SILTY SAND  FOLK(GMS)-MUDDY SAND            (SCS)-SILTY SAND
```

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION	DAY	MO	YR.	DATA PTS*	**ANALYSIS CODE NO.	NO. COMMENT CARDS
LONG PIPETTE - GRAVEL				7	2	

SIEVE/ST PTS	φ ORIGIN	SAMPLE WT. gm	WT. DISPERSANT gm	φ INTERVAL	CYL. SIZE ml.
1	-1.0	20.0	5.0	.	1000

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only - Use φ Origin of 0.0)

5.0	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.

TARE #

GROSS WT. PIP. FR	TARE WT.
0.400	0.025
0.350	0.025
0.300	0.025
0.250	0.025

* DATA POINTS = No. Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

**CODE NOS.: 1-Sieve Only
2-Sieve + Short Pipette
3-Sieve + Sh. Pipette + Sedigraph
4-Sieve + Settling Tube + Sh. Pip.
5-Sieve/Sett. Tube/Sh. Pip./Sedigr.
6-Short Pipette Only
7-Sedigraph Only

SEDIGRAPH PERCENTAGES

0.200	0.025	.	.	.	.	.	.
0.155	0.025	.	.	.	.	.	.

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

```
LONG PIPETTE - GRAVEL          SIEVE AND PIPETTE( 6)   SAMPLE WT.= 20.0000

 PHI  PCT. CUMPCT.                                           12/13/79
-2.00 ASSUMED UPPER LIMIT
       25.00              *************************
-1.00         25.00
       25.00              *************************
 4.00         50.00
       10.00              **********
 5.00         60.00
       10.00              **********
 6.00         70.00
       10.00              **********
 7.00         80.00
       10.00              **********
 8.00         90.00
        9.00              *********
 9.00         99.00
        1.00              *
*****        100.00

 NO STATISTICS ARE COMPUTED BECAUSE THE UPPER SIZE LIMIT IS ASSUMED
 AND THIS AFFECTS MORE THAN 5 PERCENT OF THE SAMPLE

PERCENTILES     MEDIAN  4.00     5TH******     16TH******     25TH -1.00
                                75TH  6.50     84TH  7.40     95TH  8.56

PCT.  GRAVEL  25.00  SAND  25.00  SILT (PIPETTE)  40.00  CLAY (PIPETTE)  10.00
                                  (SEDIGRAPH)     0.00   (SEDIGRAPH)     0.00
GRAVEL+SAND  50.00   SILT/(SILT+CLAY)  80.00PCT.GRAV+SAND/SILT+CLAY     1.00
LABELS SHEPARD -SILTY SAND  FOLK(GMS)-GRAVELLY MUD          (SCS)-
```

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION	DAY	MO	YR	DATA PTS*	**ANALYSIS CODE NO.	NO. COMMENT CARDS
LONG PIPETTE ONLY				6	2	

SIEVE/ ST PTS	φ ORIGIN	SAMPLE WT. gm	WT. DISPERSANT gm	φ INTERVAL	CYL. SIZE ml.
	.	20.0	5.0	.	1000

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only – Use φ Origin of 0.0)

GROSS WT. PIP. FR	TARE WT.
0.400	0.025
0.350	0.025
0.300	0.025
0.250	0.025

TARE #

*DATA POINTS = No. Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

**CODE NOS.:
1 – Sieve Only
2 – Sieve + Short Pipette
3 – Sieve + Sh. Pipette + Sedigraph
4 – Sieve + Settling Tube + Sh. Pip.
5 – Sieve/Sett. Tube/Sh. Pip./Sedigr.
6 – Short Pipette Only
7 – Sedigraph Only

SEDIGRAPH PERCENTAGES

0.200	0.025
0.155	0.025

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

```
LONG PIPETTE ONLY            SIEVE AND PIPETTE( 6)   SAMPLE WT.= 20.0000

 PHI   PCT.  CUMPCT.                                  12/13/79
3.00 ASSUMED UPPER LIMIT
      50.00              **************************************************
4.00         50.00
      10.00              **********
5.00         60.00
      10.00              **********
6.00         70.00
      10.00              **********
7.00         80.00
      10.00              **********
8.00         90.00
       9.00              *********
9.00         99.00
       1.00              *
*****       100.00

NO STATISTICS ARE COMPLTED BECAUSE THE UPPER SIZE LIMIT IS ASSUMED
AND THIS AFFECTS MORE THAN 5 PERCENT OF THE SAMPLE

PERCENTILES     MEDIAN  4.00     5TH******     16TH******     25TH******
                                75TH  6.50     84TH  7.40     95TH  8.56
PCT.  GRAVEL   0.00  SAND  50.00  SILT (PIPETTE)  40.00  CLAY (PIPETTE)  10.00
                                  (SEDIGRAPH)    0.00     (SEDIGRAPH)    0.00
GRAVEL+SAND  50.00   SILT/(SILT+CLAY)  80.00PCT.GRAV+SAND/SILT+CLAY    1.00
LABELS SHEPARD -SILTY SAND  FOLK(GMS)-MUDDY SAND          (SCS)-SILTY SAND
```

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION	DAY	MO	YR	DATA PTS*	** ANALYSIS CODE NO	NO. COMMENT CARDS
TEST ICODE 3				22	3	

SIEVE/ST PTS	ϕ ORIGIN	SAMPLE WT. gm	WT. DISPERSANT gm	ϕ INTERVAL	CYL. SIZE ml.
10	-0.5	20.0	2.5	0.5	500

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only - Use ϕ Origin of 0.0)

1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.0	1.0	.	.	.	.	.	.

TARE #

GROSS WT. PIP. FR	TARE WT.
2.0	1.375
0.25	0.125

* DATA POINTS = No. Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

**CODE NOS.: 1-Sieve Only
2-Sieve + Short Pipette
3-Sieve + Sh. Pipette + Sedigraph
4-Sieve + Settling Tube + Sh. Pip.
5-Sieve/Sett. Tube/Sh. Pip./Sedigr.
6-Short Pipette Only
7-Sedigraph Only

SEDIGRAPH PERCENTAGES

50.	45.	40.	35.	30.	25.	20.	15.
10.	5.	.	.	.	.	.	.

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION	DAY	MO	YR	DATA PTS*	**ANALYSIS CODE NO	NO COMMENT CARDS
TEST 2CODE 4-1				20	4	1

SIEVE/ST PTS	φ ORIGIN	SAMPLE WT. gm	WT. DISPERSANT gm	φ INTERVAL	CYL. SIZE ml.
18	-4.5	20.0	2.5	0.5	500

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only - Use φ Origin of 0.0)

1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0
8.0	9.0						

TARE #

GROSS WT. PIP. FR	TARE WT.
2.0	1.775
2.0	1.825

* DATA POINTS = No. Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

**CODE NOS.:
1-Sieve Only
2-Sieve + Short Pipette
3-Sieve + Sh. Pipette + Sedigraph
4-Sieve + Settling Tube + Sh. Pip.
5-Sieve/Sett. Tube/Sh. Pip./Sedigr.
6-Short Pipette Only
7-Sedigraph Only

SEDIGRAPH PERCENTAGES

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

SIEVE, SETTLING TUBE AND SHORT PIPETTE *

SIZDIST TEST - ICODE 4-1 SIEVE,SETT.TUBE,PIPETTE(2) SAMPLE WT.= 20.0000

12/13/79

PHI	PCT.	CUMPCT.	
-5.00			
	5.00		*****
-4.50		5.00	
	5.00		*****
-4.00		10.00	
	5.00		*****
-3.50		15.00	
	5.00		*****
-3.00		20.00	
	5.00		*****
-2.50		25.00	
	5.00		*****
-2.00		30.00	
	5.00		*****
-1.50		35.00	
	5.00		*****
-1.00		40.00	
	5.00		*****
-.50		45.00	
	5.00		*****
0.00		50.00	
	5.00		*****
.50		55.00	
	5.00		*****
1.00		60.00	
	5.00		*****
1.50		65.00	
	5.00		*****
2.00		70.00	
	5.00		*****
2.50		75.00	
	5.00		*****
3.00		80.00	
	5.00		*****
3.50		85.00	
	5.00		*****
4.00		90.00	
	5.00		*****
8.00		95.00	
	5.00		*****
*****		100.00	

MEAN	ST.DEV.	SKEWNESS	KURTOSIS	
-.50	2.59	-.00	-1.21	KRUMBEIN + PETTIJOHN (1938) MOMENT MEASURES FOR SIZE RANGE -4.5 TO 4.0 PHI
-.00	3.59	.14	1.02	FOLK GRAPHIC STATISTICAL PARAMETERS FOLK AND WARD,1957

PERCENTILES MEDIAN -.00 5TH -4.50 16TH -3.40 25TH -2.50
75TH 2.50 84TH 3.40 95TH 8.00

PCT. GRAVEL 40.00 SAND 50.00 SILT (PIPETTE) 5.00 CLAY (PIPETTE) 5.00
(SEDIGRAPH) 0.00 (SEDIGRAPH) 0.00

GRAVEL+SAND 90.00 SILT/(SILT+CLAY) 50.00PCT.GRAV+SAND/SILT+CLAY 9.00

LABELS SHEPARD -SAND FOLK(GMS)-MUDDY SANDY GRAVEL (SCS)-

COMMENTS -
SIEVE, SETTLING TUBE AND SHORT PIPETTE

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION: TEST CODE 4 - 2 | DAY | MO | YR | DATA PTS*: 14 | ** ANALYSIS CODE NO.: 4 | NO. COMMENT CARDS: 1

SIEVE/ST PTS: 8 | φ ORIGIN: -3.0 | SAMPLE WT. gm: 20.0 | WT. DISPERSANT gm: 2.5 | φ INTERVAL: 1.0 | CYL. SIZE ml.: 500

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only - Use φ Origin of 0.0)

2.0 | 2.0 | 2.0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0

TARE #

GROSS WT. PIP. FR	TARE WT.
2.0	1.675
2.0	1.700
2.0	1.750
2.0	1.800

* DATA POINTS = No. Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

** CODE NOS.:
1 - Sieve Only
2 - Sieve + Short Pipette
3 - Sieve + Sh. Pipette + Sedigraph
4 - Sieve + Settling Tube + Sh. Pip.
5 - Sieve/Sett. Tube/Sh. Pip./Sedigr.
6 - Short Pipette Only
7 - Sedigraph Only

SEDIGRAPH PERCENTAGES

2.0 | 1.825

2.0 | 1.850

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

SIEVE, SETTLING TUBE AND LONG PIPETTE *

```
SIZCIST TEST - ICOOF 4-2  SIEVE,SETT.TUBE,PIPETTE( 6)  SAMPLE WT.= 20.0000

  PHI  PCT. CUMPCT.
                                                          12/13/79
-4.00
       10.00              **********
-3.00        10.00
       10.00              **********
-2.00        20.00
       10.00              **********
-1.00        30.00
       10.00              **********
 0.00        40.00
       10.00              **********
 1.00        50.00
       10.00              **********
 2.00        60.00
       10.00              **********
 3.00        70.00
       10.00              **********
 4.00        80.00
        2.50              ***
 5.00        82.50
        5.00              *****
 6.00        87.50
        5.00              *****
 7.00        92.50
        2.50              ***
 8.00        95.00
        2.50              ***
 9.00        97.50
        2.50              **
*****       100.00

 MEAN  ST.DEV. SKEWNESS KURTOSIS

  1.14    3.25     .20     -.59    KRUMBEIN + PETTIJOHN (1938) MOMENT MEASURES
                                   FOR SIZE RANGE -3.0 TO   9.0 PHI
  1.30    3.67     .17      .34    FOLK GRAPHIC STATISTICAL PARAMETERS
                                       FOLK AND WARD,1957

PERCENTILES     MEDIAN  1.00     5TH -3.50     16TH -2.40     25TH -1.50
                                75TH  3.50     84TH  5.30     95TH  8.00
PCT.  GRAVEL  30.00  SAND  50.00  SILT (PIPETTE)  15.00  CLAY (PIPETTE)   5.00
                                  (SEDIGRAPH)    0.00     (SEDIGRAPH)    0.00
GRAVEL+SAND  80.00   SILT/(SILT+CLAY)  75.00PCT.GRAV+SAND/SILT+CLAY     4.00
LABELS SHEPARD -SAND          FOLK(GMS)-MUDDY SANDY GRAVEL    (SCS)-
 COMMENTS -
SIEVE, SETTLING TUBE AND LONG PIPETTE
```

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:
Lab No:

SAMPLE DESIGNATION	DAY	MO	YR.	DATA PTS*	**ANALYSIS CODE NO.	NO. COMMENT CARDS
TEST ICODE 5				22	5	

SIEVE/ ST PTS	ϕ ORIGIN	SAMPLE WT. gm	WT. DISPERSANT gm	ϕ INTERVAL	CYL. SIZE ml.
10	-0.5	20.0	2.5	0.5	500

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only - Use ϕ Origin of 0.0)

1.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0
8.0	9.0	.	.	.	.	.	.

TARE #

GROSS WT. PIP. FR	TARE WT.
2.0	1.375
0.25	0.125

* DATA POINTS = No. Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

**CODE NOS.:
1 - Sieve Only
2 - Sieve + Short Pipette
3 - Sieve + Sh. Pipette + Sedigraph
4 - Sieve + Settling Tube + Sh. Pip.
5 - Sieve/Sett. Tube/Sh. Pip./Sedigr.
6 - Short Pipette Only
7 - Sedigraph Only

SEDIGRAPH PERCENTAGES

50.	45.	40.	35.	30.	25.	20.	15.
10.	5.	.	.	.	.	.	.

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

```
SIZDIST TEST - ICODE 7-1  SEDIGRAPH ANALYSIS

  PHI  PCT. CUMPCT.                                   12/13/79
 3.50
        0.00
 4.00         0.00
       10.00          **********
 4.50        10.00
       10.00          **********
 5.00        20.00
       10.00          **********
 5.50        30.00
       10.00          **********
 6.00        40.00
       10.00          **********
 6.50        50.00
       10.00          **********
 7.00        60.00
       10.00          **********
 7.50        70.00
       10.00          **********
 8.00        80.00
       10.00          **********
 8.50        90.00
       10.00          **********
*****       100.00
  MEAN  ST.DEV. SKEWNESS KURTOSIS

   6.25    1.29    -.00    -1.23    KRUMBEIN + PETTIJOHN (1938) MOMENT MEASURES
                                    FOR SIZE RANGE  4.0 TO   8.5 PHI
 > 5 PERCENT OF THE FINES ARE NOT RESOLVED, OBTAIN FOLK STATS. GRAPHICALLY

PERCENTILES     MEDIAN  6.50     5TH  4.25     16TH  4.80     25TH  5.25
                                75TH  7.75     84TH  8.20     95TH******
PCT.  GRAVEL    .00  SAND   0.00  SILT (PIPETTE)   0.00  CLAY (PIPETTE)   0.00
                                  (SEDIGRAPH)  80.00     (SEDIGRAPH)  20.00
GRAVEL+SAND     .00   SILT/(SILT+CLAY)  80.00PCT.GRAV+SAND/SILT+CLAY      .00
LABELS SHEPARD -SILT        FOLK(GMS)-MUD                 (SCS)-SILT
```

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION	DAY	MO	YR	DATA PTS*	** ANALYSIS CODE NO.	NO. COMMENT CARDS
TEST JCODE 7 -1				11	7	

SIEVE/ ST PTS	φ ORIGIN	SAMPLE WT. gm	WT. DISPERSANT gm	φ INTERVAL	CYL. SIZE ml.
	3.5	100.	.	0.5	.

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only – Use φ Origin of 0.01)

TARE #

GROSS WT. PIP. FR	TARE WT.
.	.
.	.

SEDIGRAPH PERCENTAGES

100.	100.	90.	80.	70.	60.	50.	40.
30.	20.	10.	.	.	.	.	.

* DATA POINTS = No. Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

** CODE NOS.:
1 – Sieve Only
2 – Sieve + Short Pipette
3 – Sieve + Sh. Pipette + Sedigraph
4 – Sieve + Settling Tube + Sh. Pip.
5 – Sieve/Sett. Tube/Sh. Pip./Sedigr.
6 – Short Pipette Only
7 – Sedigraph Only

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

```
SIZDIST TEST - ICODE 7-2  SEDIGRAPH ANALYSIS

 PHI  PCT. CUMPCT.                                        12/13/79
3.50 ASSUMED UPPER LIMIT
        37.78                *****************************************
4.00          37.78
        10.37                **********
4.50          49.15
         2.96                ***
5.00          51.11
        10.37                **********
5.50          61.48
        12.59                *************
6.00          74.07
         3.70                ****
6.50          77.78
         3.70                ****
7.00          81.48
        18.52                ******************
*****        100.00

NO STATISTICS ARE COMPUTED BECAUSE THE UPPER SIZE LIMIT IS ASSUMED
AND THIS AFFECTS MORE THAN 5 PERCENT OF THE SAMPLE

PERCENTILES    MEDIAN  4.81    5TH******     16TH******     25TH******
                              75TH  6.13     84TH******     95TH******

PCT.  GRAVEL    .00  SAND  37.78  SILT (PIPETTE)    0.00  CLAY (PIPETTE)    0.00
                                 (SEDIGRAPH)  43.70      (SEDIGRAPH)    0.00

GRAVEL+SAND  37.78   SILT/(SILT+CLAY) 100.00PCT.GRAV+SAND/SILT+CLAY     .86
LABELS SHEPARD -SANDY SILT  FOLK(GMS)-SANDY MUD             (SCS)-SANDY SILT

COMMENTS -
SEDIGRAPH ONLY, WITH ONE SIEVE POINT
```

SIZDIST CODING FORM
Sedimentology Laboratory

Analyst:

Lab No:

SAMPLE DESIGNATION: TEST 2CODE 7-2

DAY | MO | YR

DATA PTS*: 9

**ANALYSIS CODE NO.: 7

NO. COMMENT CARDS: 1

SIEVE/ST PTS: 1

φ ORIGIN: 3.5

SAMPLE WT. gm: 3.0

WT. DISPERSANT gm:

φ INTERVAL: 0.5

CYL. SIZE ml:

SIEVE WTS + SETTLING TUBE CUMULATIVE HTS (if S.T. Data Only – Use φ Origin of 0.0)

1.0

TARE #

GROSS WT. PIP. FR | TARE WT.

* DATA POINTS = No. Sieve Wts. + Sett. Tube Hts. + Sedigraph Percentages + Pipette Draw-offs.

NOTE: Where only first pipette draw-off is taken, enter 0.25 and 0.125 as values for second draw-off.

**CODE NOS.:
1-Sieve Only
2-Sieve + Short Pipette
3-Sieve + Sh. Pipette + Sedigraph
4-Sieve + Settling Tube + Sh. Pip.
5-Sieve/Sett. Tube/Sh. Pip./Sedigr.
6-Short Pipette Only
7-Sedigraph Only

SEDIGRAPH PERCENTAGES

90. 84. 70. 66. 52. 35. 30. 25.

Comment Cards (Repeat Sample Designation and Punch Asterisk (*) in Column 80)

SEDIGRAPH ONLY WITH ONE SIEVE POINT

*

```
SIZCIST TEST - ICODE 5    SIEVE,SETT.TUBE,PIPET,SEDIGRAPH  SAMPLE WT.= 20.0000

  PHI  PCT. CUMPCT.                                      12/13/79
-1.00
       5.00              *****
 -.50         5.00
       5.00              *****
 0.00        10.00
       5.00              *****
  .50        15.00
       5.00              *****
 1.00        20.00
       5.00              *****
 1.50        25.00
       5.00              *****
 2.00        30.00
       5.00              *****
 2.50        35.00
       5.00              *****
 3.00        40.00
       5.00              *****
 3.50        45.00
       5.00              *****
 4.00        50.00
       5.00              *****
 4.50        55.00
       5.00              *****
 5.00        60.00
       5.00              *****
 5.50        65.00
       5.00              *****
 6.00        70.00
       5.00              *****
 6.50        75.00
       5.00              *****
 7.00        90.00
       5.00              *****
 7.50        85.00
       5.00              *****
 8.00        90.00
       5.00              *****
 8.50        95.00
       5.00              *****
*****       100.00

  MEAN  ST.DEV. SKEWNESS KURTOSIS

   3.75    2.74    -.00    -1.21    KRUMBEIN + PETTIJOHN (1938) MOMENT MEASURES
                                    FOR SIZE RANGE  -.5 TO  8.5 PHI
   4.00    3.06     .00      .74    FOLK GRAPHIC STATISTICAL PARAMETERS
                                        FOLK AND WARD,1957

PERCENTILES     MEDIAN  4.00     5TH  -.50     16TH   .60     25TH  1.50
                                75TH  6.50     84TH  7.40     95TH  8.50
PCT.  GRAVEL   0.00  SAND  50.00  SILT (PIPETTE)  50.00  CLAY (PIPETTE)   0.00
                                     (SEDIGRAPH)  40.00     (SEDIGRAPH)  10.00
GRAVEL+SAND  50.00   SILT/(SILT+CLAY)  80.00PCT,GRAV+SAND/SILT+CLAY     1.00
LABELS SHEPARD -SILTY SAND  FOLK(GMS)-MUDDY SAND          (SCS)-SILTY SAND
```

16032