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PARTICLE SIZE OF SEDIMENTS COLLECTED FROM THE BED OF THE
AMAZON RIVER AND ITS TRIBUTARIES IN JUNE AND JULY 1976

By Carl F. Nordin, Jr., Robert H. Meade, Holly A. Mahoney,
and Bruce M. Delaney

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Abstract

Sixty-five samples of bed material were collected from the Amazon River and its major tributaries between Belém, Brazil, and Iquitos, Peru. Samples were taken with a standard BM-54 sampler, a pipe dredge, or a Helley-Smith bedload sampler. Most of the samples have median diameters in the size range of fine to medium sand and contain small percentages of fine gravel. Complete size distributions are tabulated.

Introduction

Samples from the bed of the Amazon River and the lower reaches of some of the larger tributaries were collected between June 10 and July 8, 1976, during a cruise of Research Vessel Alpha Helix between Belém, near the mouth of the river in Brazil, and Iquitos, some 4,000 km up the river in Peru (fig. 1). This report (1) describes shipboard procedures for collecting and preserving bed samples and laboratory procedures for determining particle sizes, and (2) lists the particle-size data. Interpretive reports of these data will be published later.

Acknowledgments

The research vessel "Alpha Helix" is operated for the U.S. National Science Foundation by Scripps Institution of Oceanography, University of California, San Diego, Calif. The research of the geochemistry and sediment of the Amazon was initiated and organized by John M. Edmond, Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Mass., who was Chief Scientist on the cruise. The study was an international cooperative effort involving scientists from Woods Hole Oceanographic Institute, Massachusetts Institute of Technology, and the U.S. Geological Survey, of the United States; University of Edinburgh, Scotland; University of Pisa, Italy; State University of São Paulo at Rio Claro, Brazil; the Columbian Navy; the Brazilian Navy; Companhia de Pesquisa de Recursos Minerais (CPRM), Belém, Brazil; and the consulting firm Hidrologia S.A., Rio de Janeiro, Brazil. The Brazilian agencies Centrais Elétricas Brasileiras, S.A. (Eletrobrás), and Divisão de Concessão de Recursos Hídricos of the Departamento Nacional de Águas e Energia Elétrica (DNAEE) were involved in planning these studies and supported a part of the Brazilian participation.

The U.S. Geological Survey participation is a contribution to the International Hydrologic Program of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) under the guidance of the U.S. National Committee on Scientific Hydrology, Joseph S. Cragwell, Jr., Chief Hydrologist, U.S. Geological Survey, Chairman.

Sampling locations

Samples were taken from the bed of the rivers at locations shown in figure 1. Cruise station numbers were given to most of the sampling localities and were also used by other investigators on the cruise. Some of the stations in the tributaries are not numbered. Other unnumbered samples were taken at river-gaging sections, named below, where streamflows are regularly measured by Companhia de Pesquisa de Recursos Minerais (CPRM) and by Hidrologia, S.A. for the Divisão de Concessão de Recursos Hídricos of the Departamento Nacional de Águas e Energia Elétrica (DNAEE) and for Centrais Elétricas Brasileiras, S.A. (Eletrobrás). These measuring sections are:

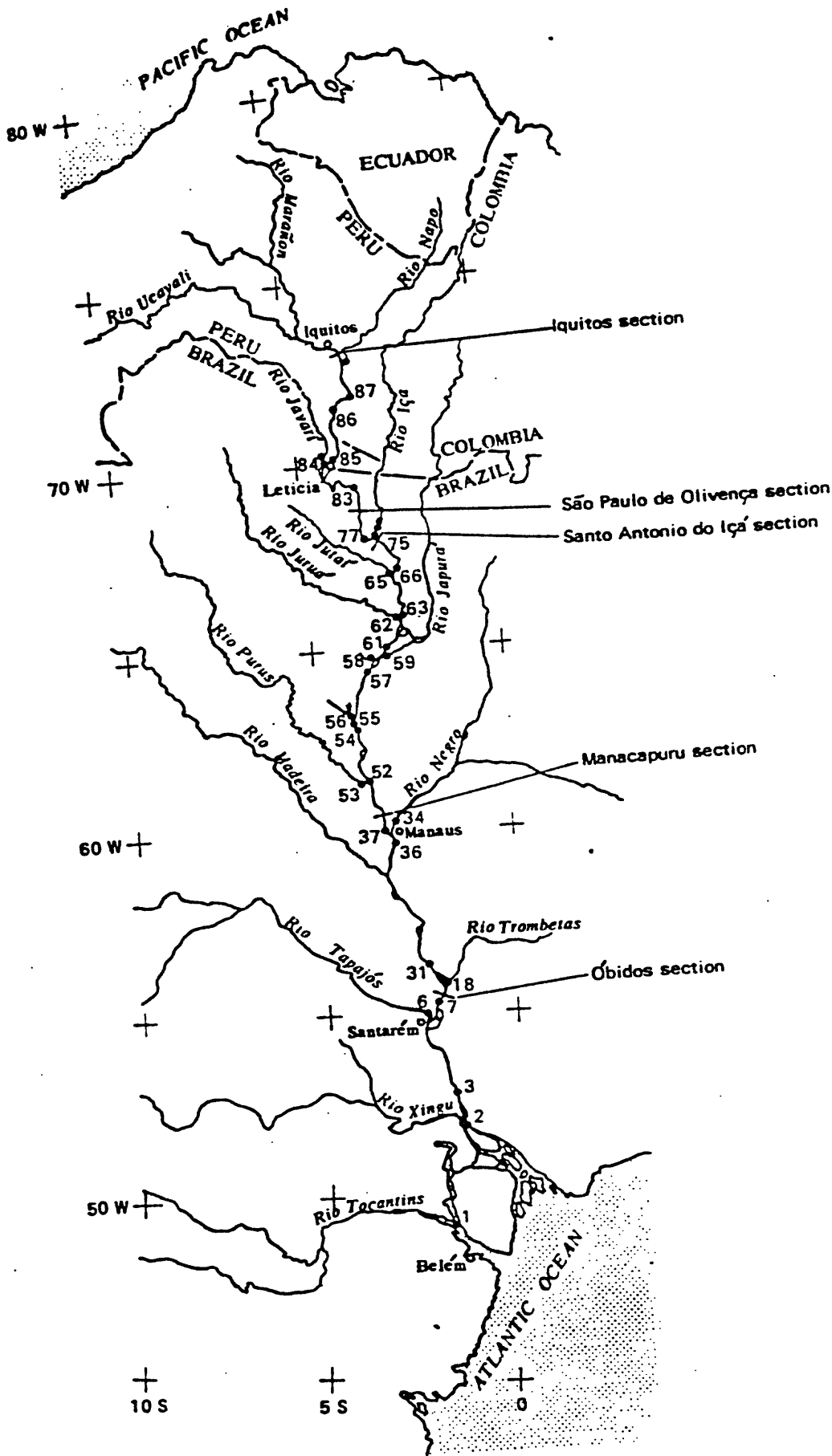


Figure 1. Location map for bed samples.

Section	Location	Longitude (W) at middle of section
Óbidos	2 km below town	55°30.5' (Chart P 4 104 A)
Manacapuru	6 km below town	60°34' (Chart P 4 107 A)
Santo Antonio do Icaá	9 km below town	68°00' (Chart P 4 112 A)
São Paulo de Olivenca	6 km below town	69°00' . (Chart P 4 112 B)

In addition, samples were collected at a section in Peru some 25 km below Iquitos.

Iquitos	25 km below city	73°14.5' (Chart P 4 116 A)
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When reporting locations on the Amazon in degrees and minutes of latitude and longitude, one must also refer to the map or chart from which the coordinates were taken. Different series of maps and charts (and even charts in the same series) often disagree on the latitudes and longitudes of specific localities such as towns.

The charts referred to in the series P 4 101 A, and so forth, are the 1- to 100,000-scale piloting charts of the river published by the Hydrography and Navigation Office (Diretoria de Hidrografia e Navegação) of the Brazilian Navy under the name of Cartas de Practicagem da Flotilha do Amazonas--Marinha do Brasil. These charts cover the river from Macapá (near the mouth) to Iquitos, which is the part of the river that is generally navigated by ocean-going ships.

The maps referred to in the series SA 18, SB 19, and so forth, are parts of the world 1- to 1,000,000-scale map (1301 series), which are available from the U.S. Defense Mapping Agency.

When we refer in this report to samples from the main stem of the Amazon River system, we follow the Brazilian usage. That is, the river is called Amazonas from the mouth to the confluence with Rio Negro, Solimões from the Negro confluence to the western border of Brazil, and Marañon in Colombia and Peru.

Sampling equipment

Four pieces of equipment were used to sample the river bed: a standard BM-54 bed-material sampler, a pipe dredge, a Helley-Smith bedload sampler, and an improvised bucket dredge.

BM-54

Some of the samples were collected with a standard BM-54 bed-material sampler (U.S. Inter-Agency Report no. 14, 1963, p. 97). This sampler is designed to collect about 500 mL of material off the top 5 cm of the river bed and to bring it to the surface in a closed semicylindrical cavity. Although we planned to use it at all stations, our BM-54 sampler did not operate properly, so at Manaus we constructed the pipe dredge described in the next section.

Pipe dredge

Most of the bed samples were taken with a steel pipe dredge, about 30 cm in diameter and 90 cm long, closed at one end. The open end was beveled to a cutting edge and secured to the winch cable by a loop of chain. The dredge was lowered to the bottom, and an amount of wire equal to about twice the depth of the water was played out. The ship was allowed to drift with the river current, dragging the dredge along the bottom. This procedure never failed to collect a sample. The dredge was usually recovered more than half full.

Most of the samples recovered with the pipe dredge were of uniform grain size. Each time the dredge was recovered, the topmost 20 cm or so of material was discarded to allow for the possibility that the sediment at the exposed surface of the sample might have been washed on the way up from the river bottom. About 500 mL of sediment from the dredge was preserved for grain-size analysis. The remaining material was washed out of the pipe dredge and was checked visually to make sure the grain-size distribution was uniform throughout. Some of the occasional pebbles, if there were any, were saved for petrographic analysis.

In a few samples taken with the pipe dredge, the recovered material was nonuniform in grain size. In the sample from station 55, sand of two size populations, which seemed to have been distinct from each other on the river bottom, were collected in the dredge. As we were unable to take an uncontaminated subsample of each size distribution, we collected one subsample of mostly the coarser distribution and another of mostly the finer distribution: the bimodal distributions shown in the two size analyses from this station reflect the contamination of each size population by an admixture of the other. In other places, the dredge recovered sand along with pieces of the claystone bedrock that lay just beneath the sand. In these samples, we analyzed the size distributions of only the sands, on the presumption that the sand was being moved over a stationary claystone substrate.

Helley-Smith bedload sampler

In the river below Manaus, we occasionally used a large Helley-Smith bedload sampler (Helley and Smith, 1971). The sampler had a 15-cm square opening and weighed 250 kg. It was the heaviest Helley-Smith sampler built to date, having been specially constructed to operate in the strong currents and deep waters of the Amazon.

The Helley-Smith sampler is designed to rest on the streambed and trap bedload, the coarser material moving in more-or-less continuous contact with the bed. Judging from the large volume of most of the samples it collected during short periods on the bottom, the sampler usually collected more bed material than bed load. The combination of the weight of the sampler and the softness of the sand bed in many places apparently caused the orifice of the sampler to go into the bottom and scoop up stationary bed material. On three occasions, however (twice in the Obidos measuring section and once at station 31), we recovered samples that we judge to represent bedload rather than bed material.

We lost this sampler in a deep (100 m) bend of the river between Obidos and Manaus.

Bucket dredge

Because most of the tributaries were sampled from a 16-foot Boston whaler rather than from Alpha Helix, we had to devise a light-weight sampler that could be operated by handline from a small boat. Therefore we improvised a bucket dredge from a 2-pound coffee can.

Shipboard processing of samples

All samples for size analyses were placed in plastic bags aboard ship. Most of the excess water was poured out of the bags, and we were careful not to elutriate micas and small mineral grains in the process. Clayey samples were not dried further but were double wrapped in plastic bags to remain damp during shipment. Sand samples were dried further aboard ship, either in the sun on deck or under an infrared lamp in the ship's laboratory. They were then double wrapped for shipment to the laboratory.

Laboratory procedures

Sands

Particle sizes of the sands were determined in the U.S. Bureau of Reclamation's soil-testing laboratory in Denver. The sand samples were dumped and washed from their plastic bags into evaporating dishes and dried overnight in an oven at 200°C. Each sample was then measured over

a splitter and divided into four more-or-less equal fractions. Two of the fractions were bottled separately for reference samples. A third sample was bottled and set aside for petrographic analysis. The fourth fraction was split further, if necessary, to 50 to 100 grams for particle-size analysis. In one instance (station 36), where the sediment contained an appreciable proportion of material coarser than 4 mm, the entire sample was screened through sieves with openings of 4 mm and larger before being split.

All samples were sieved through a standard set of 20-cm (8-inch) sieves. Each sample was shaken mechanically on a Ro-tap machine for 15 minutes, and the weight of the material retained on each sieve and on the pan was recorded to the nearest 0.01 gram.

Finer materials

Ten of the samples contained mostly clay and silt-size particles. These samples were analyzed by pipet and visual accumulation tube or by pipet and wet sieving (Guy, 1969) at the U.S. Geological Survey's laboratory in Albuquerque, N. Mex.

Results

Table 1 identifies the samples and gives the locations in upstream order where the samples were taken and the equipment used to obtain them. Sampling locations correspond to those shown on figure 1. Tables 2 and 3 list the particle-size distribution.

References

- Guy, H. P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geol. Survey Techniques Water-Resources Inv., book 5, chap. C1, 58 p.
- Helley, E. J. and Smith, Winchell, 1971, Development and calibration of a pressure-difference bedload sampler: U.S. Geol. Survey open-file rept, 18 p.
- U.S. Interagency Committee on Water Resources, 1963, Determination of fluvial sediment discharge: Washington, U.S. Govt. Printing Office, Rept. no. 14, 151 p.

Table 1.--Sample locations

Cruise station, measuring section, or sampling site	Distance from left bank (m)	Water depth (m)	Date of sampling (1976)	Latitude (S.)	Longitude (W.)	Chart or Map		Sampling equipment	Table containing size analysis	Remarks
1	-----	15	June 10	1°42.7'	49°08.7'	-----		Helley-Smith	3	Mouth of Rio Tocantins; bed material.
2	-----	25	June 11	1°25.5'	51°59.1'	P4102A		BM 54	2	Amazonas near Punta do Jariúba.
3	-----	26	June 12	1°38.5'	52°52.5'	P4102B		BM 54	2	Amazonas at Ilha Jurupari.
6	-----	21	June 13	2°23.0'	54°50.2'	P4103B		BM 54	3	Rio Tapajós, 10 km above Santarém.
7	-----	40	June 13	2°03'	55°23'	P4104A		BM 54	2	Amazonas, 20 km below Óbidos.
Óbidos	400	60	June 14	1°56'	55°30.5'	P4104A		Helley-Smith	2	First lowering; bed load.
Óbidos	400	62	June 14	1°56'	55°30.5'	P4104A		Helley-Smith	2	Second lowering; bed load.
Óbidos	1,100	64	June 14	1°56'	55°30.5'	P4104A		Helley-Smith	2	Bed material.
Óbidos	1,300	56	June 14	1°56'	55°30.5'	P4104A		Helley-Smith	2	Midchannel, bed material.
Óbidos	1,700	60	June 14	1°56'	55°30.5'	P4104A		BM 54	2	Sample partly washed.
Óbidos	2,000	64	June 14	1°56'	55°30.5'	P4104A		Helley-Smith	3	Probably "bedrock" (Alter do Chão Formation?); recovered in cohesive lumps.
Óbidos	2,100	50	June 14	1°56'	55°30.5'	P4104A		BM 54	2	Sample partly washed.
Óbidos	2,400	42	June 14	1°56'	55°30.5'	P4104A		BM 54	2	Rio Trombetas, 15 km above mouth; bed material.
	-----	27	June 14	-----	-----	-----		Helley-Smith	2	

Table 1.--Sample Locations--Continued

Cruise station, measuring section, or sampling site	Distance from left bank (m)	Water depth (m)	Date of sampling (1976)	Latitude (S.)	Longitude (W.)	Chart or Map	Sampling equipment	Table containing size analysis	Remarks
31	-----	30	June 16	2°20.0'	56°21.0'	P4104B	Helley-Smith	2	Amazonas near Ilhas Caldeirão; bed load.
34	-----	-25	June 21	3°06.8'	60°5.4'	P4106B	BM 54	3	Rio Negro; loose creamy clay.
36	-----	54	June 21	3°07'	59°53'	P4106B	Pipe dredge	2	Solimões-Negro confluence.
37	-----	37	June 21	3°17.4'	60°01.2'	P4106B	BM 54	2	Solimões near Ilha dos Mouras.
Manacapuru	350	26	June 22	3°20'	60°34'	P4107A	Pipe dredge	2	0.4 km downstream of section.
Manacapuru	1,300	25	June 22	3°20'	60°34'	P4107A	Pipe dredge	2	1 km downstream of section.
Manacapuru	1,700	36	June 22	3°20'	60°34'	P4107A	BM 54	2	1 km downstream of section.
Manacapuru	2,100	42	June 22	3°20'	60°34'	P4107A	BM 54	2	In section.
Manacapuru	2,600	32	June 22	3°20'	60°34'	P4107A	Pipe dredge	2	1 km downstream of section.
Manacapuru	2,600	-30-35	June 22	3°20'	60°34'	P4107A	Pipe dredge	2	Solimões at Ilha Gabriel.
52	-----	40	June 23	3°37.9'	61°26.5'	P4107B	Pipe dredge	2	Rio Purus, 22 km above mouth.
53	-----	45	June 23	3°51.1'	61°23.0'	P4107B	Pipe dredge	2	Solimões at 63°W.
54	-----	42	June 24	4°01.8'	62°59.8'	P4108B	Pipe dredge	2	Coarse with fine sand; Solimões at Costa do Coari.
55	-----	60	June 24	4°03.8'	63°03.1'	P4108B	Pipe dredge	2	Fine with coarse sand; Solimões at Costa do Coari.
55	-----	60	June 24	4°03.8'	63°03.1'	P4108B	Pipe dredge	2	Costa do Coari.

Table 1.--Sample locations--Continued

Cruise station, measuring section, or sampling site	Distance from left bank (m)	Water depth (m)	Date of sampling (1976)	Latitude (S.)	Longitude (W.)	Chart or Map		Sampling equipment	Table containing size analysis	Remarks
						P4108B	P4110A			
56	-----	15-20	June 24	4°04.1'	63°09.3'	P4108B	P4108B	Pipe dredge	3	Lago Coari; soupy silt.
57	-----	23	June 25	3°31.1'	64°25.2'	P4109B	P4109B	Pipe dredge	2	Solimões near São Francisco.
58	-----	15	June 25	3°19.1'	64°44.9'	P4110A	P4110A	Pipe dredge	3	Lago Tefé; probably "bedrock" (Solimões Formation?).
59	-----	20	June 25	3°09.1'	64°44.9'	P4110A	P4110A	Pipe dredge	2	Rio Japurá at mouth.
61	-----	32	June 26	3°05.5'	64°55.6'	P4110A	P4110A	Pipe dredge	2	Solimões at Pedras Canarias.
62	-----	-20	June 27	2°32.0'	65°48.2'	P4110B	P4110B	BM 54	2	Rio Juruá near mouth.
63	-----	-25	June 27	2°24.6'	65°52.3'	P4110B	P4110B	Pipe dredge	2	Solimões near Tupé; 1/4 from left bank.
63	-----	-26	June 27	2°24.5'	65°52.7'	P4110B	P4110B	BM 54	2	Solimões near Tupé; 1/4 from left bank.
65	-----	-----	June 28	2°49.5'	66°54'	P4111B	P4111B	Pipe dredge	2	Rio Jutai near mouth; sand (above clay).
65	-----	-----	June 28	2°49.5'	66°54'	P4111B	P4111B	Pipe dredge	3	Rio Jutai near mouth; clay (below sand).
66	-----	25-30	June 28	2°44.7'	67°10.4'	P4111B	P4111B	Pipe dredge	2	Solimões near Petrolina.
Santo Antonio do Itá	200	25	June 30	3°08'	68°00'	P4112A	P4112A	Pipe dredge	2	-200 m downriver of section.
Santo Antonio do Itá	750	20	June 30	3°08'	68°00'	P4112A	P4112A	Pipe dredge	2	-200 m downriver of section.
Santo Antonio do Itá	1,050	17	June 30	3°08'	68°00'	P4112A	P4112A	Pipe dredge	2	-200 m downriver of section; midchannel.

Table 1.--Sample locations--Continued

Cruise station, measuring section, or sampling site	Distance from left bank (m)	Water depth (m)	Date of sampling (1976)	Latitude (S.)	Longitude (W.)	Chart or Map	Sampling equipment	Table containing size analysis	Remarks
Santo Antonio do Içá	1,350	19	June 30	3°08'	68°00'	P4112A	Pipe dredge	2	-200 m downriver of section.
Santo Antonio do Içá	1,850	25	June 30	3°08'	68°00'	P4112A	Pipe dredge	2	-300 m downriver of section.
75	-----	20	June 30	3°14.2'	68°04.1'	P4112A	Pipe dredge	2	Rio Içá at mouth.
Rio Içá	-----	9	June 30	3°05'	68°03'	SA19	Bucket dredge	2	10 km above mouth.
Rio Içá	-----	7	June 30	3°02'	68°05'	SA19	Bucket dredge	3	16 km above mouth; soupy clay.
77	-----	25	June 30	3°27.2'	68°03.4'	P4112A	Pipe dredge	2	Solimões near Ilha Amateura
São Paulo de Olivença	330	32	July 1	3°35'	69°00'	P4112B	Pipe dredge	2	
São Paulo de Olivença	760	33	July 1	3°35'	69°00'	P4112B	Pipe dredge	2	
São Paulo de Olivença	960	14	July 1	3°35'	69°00'	P4112B	Pipe dredge	2	
83	-----	30	July 1	3°45.8'	69°26.9'	P4113A	Pipe dredge	2	Solimões near Ilha Santa Rita.
Rio Javari	-----	8-10	July 2	4°15'	70°05'	SB19	Bucket dredge	3	15 km above mouth; sand with some clay mixture.
Rio Javari	-----	8-10	July 2	4°15'	70°05'	SB19	Bucket dredge	2	12 km above mouth; sand.
84	-----	20	July 3	4°26.9'	70°02.6'	P4113B	Pipe dredge	2	Solimões below Tabatinga.
Ilha St. Helena	-----	0	July 5	4°04.0'	70°07.6'	P4114A	Spatula	3	Flood-plain sediment on downstream tip Ilha St. Helena No. 1.
85	-----	20	July 6	3°59.4'	70°13.2'	P4114A	Pipe dredge	2	Marsh on near Ilha St. Helena No. 3.

Table 1.--Sample Locations--Continued

Cruise station, measuring section, or sampling site	Distance from left bank (m)	Water depth (m)	Date of sampling (1976)	Latitude (S.)	Longitude (W.)	Chart or Map	Sampling equipment	Table containing size analysis	Remarks
86	-----	27-32	July 7	3°51.7'	71°43.7'	P4115A	Pipe dredge	2	Marañon near Condor.
87	100	32-35	July 7	3°28.2'	71°54.9'	P4115A	Pipe dredge	2	Marañon below Pevas.
87	250	29	July 7	3°28.2'	71°54.9'	P4115A	Pipe dredge	2	Marañon below Pevas.
Rio Napo	-----	7-8	July 8	3°19'	72°39'	SA18	Bucket dredge	2	Near Corococho.
Iquitos	240	23	July 8	3°47'	73°14.5'	P4116A	Pipe dredge	2	25 km below Iquitos.
Iquitos	490	24	July 8	3°47'	73°14.5'	P4116A	Pipe dredge	2	25 km below Iquitos.
Iquitos	730	22	July 8	3°47'	73°14.5'	P4116A	Pipe dredge	2	25 km below Iquitos.

Table 2.--Particle size

Cruise station, measuring section, or sampling site	Distance from left bank (m)	Percent finer than							
		0.053	0.062	0.088	0.125	0.177	0.250	0.350	0.500
2	-----	0.1	0.1	0.3	1.6	15.2	76.7	99.5	99.5
3	-----	.2	.3	.6	2.3	8.4	27.2	75.0	93.5
7	-----	.2	.4	.9	4.4	30.2	67.1	95.9	99.4
Óbidos	400	.3	.3	.6	1.9	27.6	46.0	75.7	98.6
Óbidos	400	.0	.0	.1	.3	4.8	8.8	19.3	68.0
Óbidos	1,100	.1	.2	.3	.8	4.2	8.4	34.7	95.9
Óbidos	1,300	3.0	4.1	9.3	31.3	72.8	93.2	96.3	99.7
Óbidos	1,700	.0	.0	.1	.3	1.7	4.2	23.8	91.2
Óbidos	2,100	.9	1.7	6.3	30.5	89.8	99.8	100.0	-----
Óbidos	2,400	3.5	6.9	24.3	73.0	97.8	99.9	100.0	-----
18	-----	.1	.2	.2	.5	5.2	67.3	97.5	99.3
31	-----	.1	.2	.3	.8	11.0	43.2	64.4	84.6
36	-----	.0	.1	.1	.2	1.0	6.4	17.2	23.4
37	-----	.1	.2	.3	1.2	4.2	15.7	69.1	93.2
Manacapuru	350	.1	.2	.3	1.3	12.3	62.8	98.5	99.9
Manacapuru	1,300	.2	.2	.2	1.0	8.6	53.7	91.6	98.3
Manacapuru	1,700	.0	.0	.2	.8	4.4	36.1	90.4	98.8
Manacapuru	2,100	.0	.1	.4	1.7	7.5	35.0	87.0	98.9
Manacapuru	2,600	.1	.2	.4	1.9	12.6	65.7	98.6	100.0
Manacapuru	2,600	.1	.2	.4	2.5	15.1	66.9	98.7	100.0
52	-----	.1	.1	.3	1.8	8.6	42.9	91.6	98.8
53	-----	.2	.2	.3	.7	6.0	79.3	99.8	100.0
54	-----	.0	.1	.1	.5	2.6	5.6	9.6	57.7
55	-----	.2	.3	1.0	7.9	24.7	28.5	30.5	53.9
55	-----	.2	.5	2.2	15.7	45.9	51.6	54.0	75.4
57	-----	.1	.2	.4	2.1	12.6	55.8	94.6	99.7
59	-----	.4	.6	2.3	20.8	81.0	99.2	99.9	99.9
61	-----	.1	.1	.2	.8	3.1	23.0	85.8	98.8
62	-----	.0	.1	.1	.4	9.5	81.7	99.5	99.9
63	-----	.1	.1	.2	.8	3.3	20.4	83.5	98.7

distribution determined by sieving

than indicated size, in mm

0.707	1.00	1.40	2.00	2.80	4.00	5.60	8.00	11.3	16.0	22.6	32.0	d ₅₀
99.5	100.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.216
96.7	98.4	99.2	99.7	100.0	-----	-----	-----	-----	-----	-----	-----	.295
99.9	99.9	99.9	100.0	-----	-----	-----	-----	-----	-----	-----	-----	.213
99.9	100.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.261
89.0	95.1	97.5	98.8	99.4	99.8	100.0	-----	-----	-----	-----	-----	.443
99.9	100.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.377
100.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.146
99.3	99.6	99.7	99.8	100.0	-----	-----	-----	-----	-----	-----	-----	.398
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.138
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.106
99.7	99.8	99.9	100.0	-----	-----	-----	-----	-----	-----	-----	-----	.232
95.7	99.0	99.5	99.9	100.0	-----	-----	-----	-----	-----	-----	-----	.279
33.9	51.2	66.6	80.8	88.9	94.2	96.6	97.8	98.9	98.9	99.1	100.0	.977
98.0	99.2	99.6	99.7	99.8	100.0	-----	-----	-----	-----	-----	-----	.315
99.9	99.9	99.9	100.0	-----	-----	-----	-----	-----	-----	-----	-----	.232
99.3	99.6	99.8	100.0	-----	-----	-----	-----	-----	-----	-----	-----	.244
99.5	99.6	99.8	99.9	100.0	-----	-----	-----	-----	-----	-----	-----	.269
99.7	99.9	100.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	.273
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.228
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.226
99.6	99.8	99.9	100.0	-----	-----	-----	-----	-----	-----	-----	-----	.260
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.222
86.8	97.7	99.2	99.5	99.7	99.8	100.0	-----	-----	-----	-----	-----	.478
76.7	89.2	94.5	97.6	99.1	99.8	100.0	-----	-----	-----	-----	-----	.473
91.8	97.7	99.1	99.8	100.0	-----	-----	-----	-----	-----	-----	-----	.227
99.9	100.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.240
100.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.148
99.4	99.4	99.4	99.4	99.4	99.4	99.4	100.0	-----	-----	-----	-----	.288
100.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.217
99.7	99.9	100.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	.293

Table 2.—Particle size distribution

Cruise station, measuring section, or sampling site	ftom left bank (m)	Percent finer than							
		0.053	0.062	0.088	0.125	0.177	0.250	0.350	0.500
63	—————	0.1	0.1	0.2	0.3	1.3	10.2	57.8	93.7
65	—————	.9	1.1	2.4	9.1	48.7	83.6	94.5	98.2
66	—————	.1	.1	.3	1.1	7.4	49.9	94.4	99.8
Santo Antonio Do Içá	200	.9	1.9	7.0	36.3	88.9	99.2	99.9	100.0
Santo Antonio Do Içá	750	.1	.1	.2	.5	3.9	25.6	81.2	99.6
Santo Antonio Do Içá	1,050	.1	.1	.1	.4	3.4	32.7	92.5	99.6
Santo Antonio Do Içá	1,350	.1	.1	.3	1.0	6.8	46.0	97.0	100.0
Santo Antonio Do Içá	1,850	.1	.2	.4	1.9	13.8	68.4	97.1	99.3
75	—————	.5	.6	.9	2.7	10.8	38.2	79.6	96.4
Río Içá	—————	.6	.7	1.2	4.3	21.9	59.3	92.1	99.6
77	—————	.2	.2	.3	.5	1.3	3.6	19.2	59.8
São Paulo De Olivença	330	.3	.4	1.1	6.1	19.7	37.3	71.9	93.5
São Paulo De Olivença	760	.3	.4	1.5	10.6	51.0	86.3	98.6	99.9
São Paulo De Olivença	960	.1	.2	.3	1.4	12.8	69.0	98.7	100.0
83	—————	.0	.1	.1	.2	.4	2.6	22.1	71.4
Río Javari	—————	3.3	3.7	4.4	6.8	25.8	75.4	98.6	99.9
84	—————	.1	.1	.2	.8	5.5	45.1	93.2	98.8
85	—————	.1	.1	.3	1.6	10.7	53.3	95.4	99.8
86	—————	.1	.1	.3	1.7	10.1	21.0	35.7	63.3
87	100	.0	.0	.1	.2	.6	1.1	7.9	61.5
87	250	.1	.1	.2	.9	5.2	29.2	86.6	99.4
Río Napo	—————	.1	.2	.4	1.6	7.0	34.8	92.1	99.3
Iquitos	240	.4	.7	2.0	7.1	29.9	87.9	99.5	99.9
Iquitos	490	.1	.1	.2	.7	2.8	12.3	52.9	94.9
Iquitos	730	.2	.3	.8	2.6	11.3	42.9	91.3	99.5

determined by sieving—Continued

indicated size, in mm												
0.707	1.00	1.40	2.00	2.80	4.00	5.60	8.00	11.3	16.0	22.6	32.0	d ₅₀
99.8	100.0	—	—	—	—	—	—	—	—	—	—	0.338
99.4	99.8	100.0	—	—	—	—	—	—	—	—	—	.179
99.8	100.0	—	—	—	—	—	—	—	—	—	—	.250
—	—	—	—	—	—	—	—	—	—	—	—	.135
100.0	—	—	—	—	—	—	—	—	—	—	—	.290
99.8	99.9	100.0	—	—	—	—	—	—	—	—	—	.272
—	—	—	—	—	—	—	—	—	—	—	—	.254
99.9	99.9	100.0	—	—	—	—	—	—	—	—	—	.225
98.9	99.6	99.8	99.9	100.0	—	—	—	—	—	—	—	.274
100.0	—	—	—	—	—	—	—	—	—	—	—	.231
81.6	90.7	94.1	96.0	97.0	97.5	97.9	98.4	100.0	—	—	—	.453
98.1	99.1	99.3	99.5	99.7	100.0	—	—	—	—	—	—	.283
100.0	—	—	—	—	—	—	—	—	—	—	—	.176
—	—	—	—	—	—	—	—	—	—	—	—	.225
95.2	99.2	99.6	99.8	100.0	—	—	—	—	—	—	—	.432
100.0	—	—	—	—	—	—	—	—	—	—	—	.209
99.6	99.9	99.9	99.9	100.0	100.0	—	—	—	—	—	—	.257
99.9	99.9	100.0	—	—	—	—	—	—	—	—	—	.245
79.8	87.8	91.5	94.3	95.7	96.7	97.0	97.0	97.2	100.0	—	—	.423
95.4	99.7	99.9	100.0	—	—	—	—	—	—	—	—	.471
100.0	—	—	—	—	—	—	—	—	—	—	—	.280
99.9	99.9	100.0	—	—	—	—	—	—	—	—	—	.270
99.9	99.9	100.0	—	—	—	—	—	—	—	—	—	.197
99.6	99.9	99.9	99.9	100.0	—	—	—	—	—	—	—	.346
100.0	—	—	—	—	—	—	—	—	—	—	—	.260

Table 3.--Particle size distributions determined by pipet and visual accumulation tube, or wet sieving

[Method of analysis: P, pipet; V, visual accumulation tube; S, wet sieving]

Cruise station, or measuring section, or sampling site	Distance from left bank (m)	Percent finer than indicated size in mm											
		0.001	0.00195	0.0039	0.0078	0.0156	0.0312	0.0625	0.125	0.250	0.500	1.00	2.00
1	-----	19.3	29.3	35.8	35.9	54.5	73.4	91.3	98.1	98.9	100.0	-----	-----
6	-----	16.6	25.9	33.2	46.4	67.2	77.0	85.4	96.8	97.8	100.0	-----	-----
Óbidos	2,000	19.0	28.1	35.0	43.6	62.7	83.8	94.8	99.0	99.5	100.0	-----	-----
34	-----	45.0	50.4	62.3	68.3	80.0	86.6	94.4	96.3	98.5	99.9	100.0	-----
56	-----	9.2	14.3	19.9	23.9	31.5	45.1	68.9	83.7	91.2	100.0	-----	-----
58	-----	17.4	24.1	29.3	37.2	56.2	76.2	93.6	99.1	99.6	100.0	-----	-----
65	-----	36.2	47.4	57.1	62.3	73.3	88.3	98.75	99.24	99.78	99.97	99.98	100.0
Río Ica	-----	26.3	35.6	48.0	61.8	82.7	97.3	99.908	99.940	99.969	99.997	99.998	100.0
Río Javari	-----	6.7	7.8	10.2	11.4	15.6	20.9	24.5	27.9	95.5	100.0	-----	-----
Isla St. Helena	-----	5.4	7.8	11.0	12.5	18.9	33.5	73.3	99.4	100.0	-----	-----	-----