



**In cooperation with the Geological Survey of Bangladesh and Bangladesh Water Development Board**

# **Compositional Data for Bengal Delta Sediment Collected from a Borehole at Rajoir, Bangladesh**

By George N. Breit, James C. Yount, Md. Nehal Uddin, Ad. Atual Muneem, Heather A. Lowers, Cyrus J. Berry, and John W. Whitney

Open-File Report 2007–1022

U.S. Department of the Interior  
U.S. Geological Survey

**U.S. Department of the Interior**  
DIRK KEMPTHORNE, Secretary

**U.S. Geological Survey**  
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia 2007

For product and ordering information:  
World Wide Web: <http://www.usgs.gov/pubprod>  
Telephone: 1-888-ASK-USGS

For more information on the USGS—the Federal source for science about the Earth,  
its natural and living resources, natural hazards, and the environment:  
World Wide Web: <http://www.usgs.gov>  
Telephone: 1-888-ASK-USGS

Suggested citation:  
Breit, G.N., Yount, J.C., Uddin, Md. N., Muneem, Ad., A., Lowers, H.A., Berry, C.J., and Whitney, J.W., 2007,  
Compositional data for Bengal delta sediment collected from boreholes at Rajoir, Bangladesh: U.S.  
Geological Survey Open-File Report 2007-1022.

Any use of trade, product, or firm names is for descriptive purposes only and does not imply  
endorsement by the U.S. Government.

Although this report is in the public domain, permission must be secured from the individual  
copyright owners to reproduce any copyrighted material contained within this report.

## Contents

Abstract .....	1
Introduction.....	1
Setting.....	2
Methods.....	2
Sample collection .....	2
Grain-size analysis .....	3
Mineralogy.....	4
Bulk Chemical Analyses .....	4
Chemical Extraction Analyses.....	4
Results.....	5
Physical and Mineralogical Characteristics .....	5
Bulk Chemical Composition .....	6
Chemical Extractions .....	10
References Cited.....	11

## Figures

1. Location of Rajoir, Bangladesh .....	3
2. Ternary diagram of sand, silt and clay abundances.....	6
3. Plot of potassium vs. barium in Rajoir sediment.....	7
4. Comparison of measured and corrected sulfur concentrations .....	8

## Table

1. Median, minimum, and maximum concentrations of chemical constituents.....	9
--	---

## Appendices

1. Depth and description of air-dried sediment samples.....	14
2. Depth of preserved sediment samples .....	15
3. Results of grain-size analysis .....	16
4. Major minerals present in air-dried sediment samples as determined by X-ray diffraction.....	17
5. Results of quantitative mineralogical analysis of air-dried sediments using X-ray diffraction .....	18
6. Results of carbon and sulfur analysis of air-dried samples.....	19
7. Results of ICP-AES analyses of air-dried samples.....	20
8. Results of EDXRF analysis of air-dried samples.....	26
9. Results of arsenic analyses by HGAAS of air-dried samples.....	32
10. Total iron and ferrous iron extracted by 0.5 N HCl from preserved sediment samples.....	33
11. Results of analyses of 0.5 N HCl extract solutions from preserved sediment samples .....	34
12. Concentrations of acid-volatile sulfide, reducible sulfide and acid-soluble sulfate .....	40

SI to Inch/Pound

<b>Multiply</b>	<b>By</b>	<b>To obtain</b>
<b>Length</b>		
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
<b>Volume</b>		
milliliter	0.03382	ounce, fluid (fl. oz)
milliliter	0.002113	pint (pt)
milliliter	0.001057	quart (qt)
milliliter	0.06102	cubic inch (in <sup>3</sup> )
<b>Mass</b>		
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8$$

Horizontal coordinate information is referenced to World Geodetic System 1984 (WGS 84)

## Chemical Symbols

Abbreviation	Chemical Species
Ag	silver
Al	aluminum
As	arsenic
Au	gold
B	boron
Ba	barium
Be	beryllium
Bi	bismuth
C	carbon
C-total	total carbon
C-carbonate	carbonate carbon
Ca	calcium
Cd	cadmium
Ce	cerium
Co	cobalt
Cr	chromium
Cu	copper
Cs	cesium
Eu	europium
Fe	iron
Ga	gallium
Ge	germanium
Ho	holmium
K	potassium
La	lanthanum
Li	lithium
Mg	magnesium
Mn	manganese
Mo	molybdenum
Na	sodium
Nb	niobium
Nd	neodymium
Ni	nickel
P	phosphorous
Pb	lead
Rb	rubidium
S	sulfur
Sb	antimony
Sc	scandium
Se	selenium
SiO <sub>2</sub>	silicon dioxide (silica)
Sn	tin
Sr	strontium

<b>Abbreviation</b>	<b>Chemical Species</b>
Ta	tantalum
Th	thorium
Ti	titanium
U	uranium
V	vanadium
W	tungsten
Y	yttrium
Yb	ytterbium
Zn	zinc
Zr	zirconium

# Compositional Data for Bengal Delta Sediment Collected from a Borehole at Rajoir, Bangladesh

By George N. Breit, James C. Yount, Md. Nehal Uddin, Ad. Atual Muneem, Heather A. Lowers, Cyrus J. Berry, and John W. Whitney

## Abstract

Processes active within sediment of the Bengal basin have attracted world concern because of the locally high content of arsenic dissolved in ground water drawn from that sediment. Sediment samples were collected from a borehole in the town of Rajoir, Rajoir upazila, Madaripur district, Bangladesh, to investigate the processes contributing to arsenic contamination. The samples were mineralogically and chemically analyzed to determine compositional variations related to the arsenic content of the sediment. Mineralogy of the sediment was determined using powder X-ray diffraction. Bulk chemical composition was measured by Combustion; Inductively Coupled Plasma Atomic Emission Spectroscopy; Energy Dispersive X-ray Fluorescence; and Hydride Generation Atomic Absorption Spectrophotometry. Sediment was treated with 0.5 N HCl and resulting solutions were analyzed, primarily to evaluate the abundance and oxidation state of acid-soluble iron. Acid-volatile sulfide, acid-soluble sulfate, and reducible sulfide were also measured on a few samples. Sediment sampled at Rajoir is typically unlithified, gray, micaceous, feldspathic arenaceous sand with a few silt and clay layers. Arsenic content of the sediment ranges from 0.6 to 21 ppm with a median of 1.2 ppm.

## Introduction

The ingestion of arsenic-rich ground water was first proposed as the cause for a range of health problems experienced by residents of the Bengal basin in India in 1983 (Gorair and others, 1984; Saha, 1984; 1995). Subsequent testing of wells across the basin has determined that ground water locally contains high concentrations of arsenic. An estimated 40 million residents (20% of the population) consume water that exceeds the local arsenic drinking water standard of 50  $\mu\text{g/L}$  (World Bank, 2005). In addition, this contaminated water is used to irrigate agricultural land needed to supply food for an increasing population. Explanations for the contamination have generally proposed that naturally occurring arsenic is released from ferric oxyhydroxide grain coatings in response to microbially facilitated reduction in the subsurface (Nickson and others, 2000; Smedley and Kinniburgh, 2002; Harvey and others, 2002; Horneman and others, 2004; Ravenscroft and others, 2005). This report presents the results of characterization of sediment samples in south-central Bangladesh within the town of Rajoir (fig. 1).

A primary concern for aid agencies that seek to alleviate the health crisis caused by the consumption of arsenic-rich water is to identify methods to supply safe drinking water. One of the proposed mitigation strategies is to install water wells to depths below 150 m. Water analyses

summarized in the National Arsenic Mitigation Information Center (NAMIC) and other databases ([www.bamwsp.org](http://www.bamwsp.org)) show that the frequency of wells that produce water exceeding the drinking water standard decrease with increasing depth. Although the lack of arsenic in water produced by these deeper wells has been attributed to removal of arsenic in the sediment by ground-water flow, no evidence has been offered to verify the loss of arsenic. This investigation determined the composition of sediment from depths as great as 450 meters to provide the data to support an evaluation of the viability of deeper aquifers to sustain production of water with low arsenic contents. Funding support for USGS work on this project was provided by the U.S. Agency for International Development.

## Setting

The village of Rajoir is located approximately 65 kilometers southwest of the capital city of Dhaka in Rajoir upazila, Madaripur District (fig. 1). Testing of 13,000 tubewells in the Rajoir upazila determined that more than 75% produce water containing dissolved arsenic concentrations greater than 50  $\mu\text{g/L}$  ([www.bamwsp.org](http://www.bamwsp.org)). Rajoir is 50 km west of the Meghna Estuary, which is currently the principal discharge for the Ganges, Brahmaputra, and Meghna River drainage basins, and 35 km south of the Padma River (Ganges). The borehole site is located on the Ganges floodplain near the Gopalganj beel (a shallow ephemeral lake characterized by carbonaceous sediment) (Brammer, 1996). Much of the sediment transported by the rivers and deposited in the basin originates in crystalline rocks of the high Himalayas, with lesser additions from the Indian Shield to the west, the Shillong Plateau to the north, and Tertiary-age sedimentary rocks that are exposed in the foothills to the Himalayas. The Tertiary rock is composed mostly of sediment originally shed from the ancestral Indian Shield and early Himalaya uplift, which was buried along the paleo-Indian continental margin, lithified, and tectonically uplifted into the weathering zone during the India-Asia collision. Holocene sediment accumulation rates for the Bengal delta range up to 1 cm per year as a result of the large amount of sediment transport, sea level rise, and accommodation space created by subsidence (Goodbred and Kuehl, 2000).

## Methods

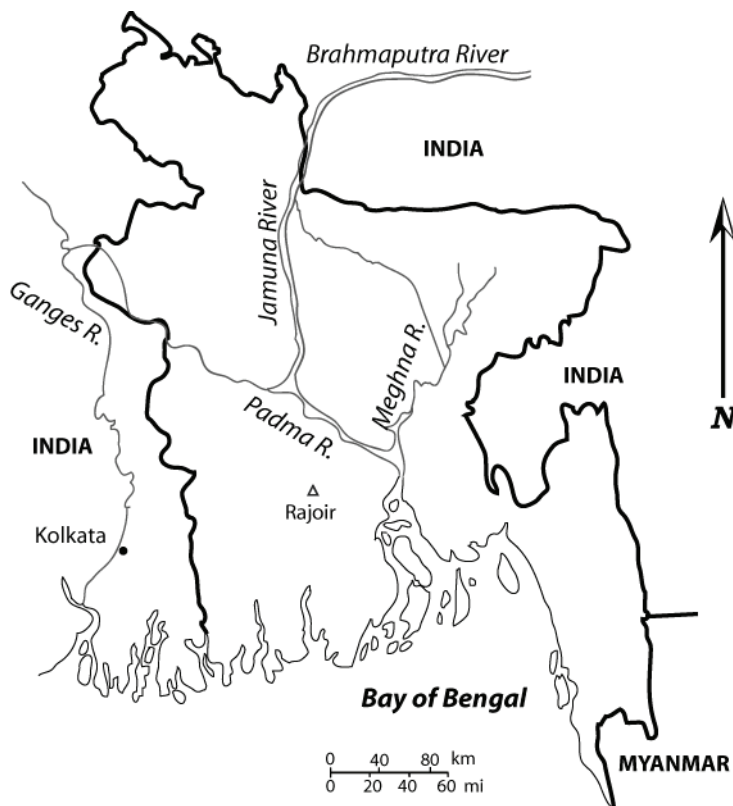
### Sample Collection

Sediment samples were collected from a borehole by coring selected depth intervals during the spring and summer of 2004. The borehole was drilled by the Geological Survey of Bangladesh (GSB); borehole SH-2 was located at 23.205483° N latitude and 90.069361° E longitude (WGS84 datum) and was drilled to a total depth of 450 meters. Drilling fluid used by the GSB was a mix of water and bentonite with the addition of barite when drilling advanced below approximately 230 m depth. Thirty-seven samples of sediment were collected from the 450 m borehole at approximately 10 m intervals. Recovered sediment was described in the field (Appendix 1). Bulk samples were air-dried prior to analysis and are designated as –AD in the appendices.

Aliquots of each sample were placed in glass vials filled with argon gas at the drill site to preserve the oxidation state of iron and arsenic. These preserved samples are identified as –P in subsequent tables. Some preserved samples were collected at slightly different depth intervals than the –AD samples, as listed in Appendix 2. Preserved samples were collected using a detipped 10 mL syringe that was used to extract the sediment recovered in the lowest section of the core barrel (immediately above the coring bit). This material was considered to be the least contaminated by



drilling fluid. The sediment collected in the detipped syringe was then transferred to an amber glass vial equipped with a Teflon-coated septum. Sediment was transferred into the vial while the vial was purged with flowing argon gas. The vial was capped and flushed with additional argon for five minutes using needles to introduce and vent the gas through the septum. After purging with the gas, the vial was frozen until shipment to the United States. During shipment the vials thawed but remained sealed; they were promptly refrozen upon arrival at the USGS laboratories.



**Figure 1.** Map showing the location of the Rajoir study site in south-central Bangladesh.

### **Grain-size Analysis**

Aliquots of the bulk sediment samples were analyzed to determine grain size using a Malvern Mastersizer S long bed laser refraction instrument. Approximately 3 gram splits of sediment were soaked overnight in 40 mL of distilled water amended with 20 mL of 0.25 weight percent sodium hexametaphosphate to enhance particle disaggregation and dispersion. Consistent with the observed lack of cementation, Rajoir sediment samples dispersed easily. Grain-size characteristics of the samples are presented in Appendix 3.

### **Mineralogy**

To determine the major mineral phases in the sediment, splits of 37 bulk samples were ground to < 50  $\mu\text{m}$  (micrometer) in an agate shatterbox prior to analysis by X-ray diffraction. Side-packed

mounts were prepared by loading the powdered sample against frosted glass to minimize preferential orientation. The mounts were analyzed using Ni-filtered, Cu K $\alpha$  radiation on a Siemens D500 equipped with a graphite monochromator. Samples were scanned from 4 to 64 degrees 2 $\theta$  with a 0.02 degree step size and count time of 2 seconds per step.

Ten samples were prepared according to the methods described in Eberl (2002) for quantitative mineral analysis. This method requires micronizing the sample with ZnO as an internal standard. The ROCKJOCK (Eberl, 2002) program was then used to calculate the abundance of major mineral constituents. Analytical precision of the ROCKJOCK method is estimated to be within ten relative percent. Results of the qualitative and quantitative XRD analyses are listed in Appendices 4 and 5.

### **Bulk Chemical Analyses**

Air-dried samples were analyzed to determine chemical composition by Combustion; Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES); Energy Dispersive X-ray Fluorescence (EDXRF); and Hydride Generation Atomic Absorption Spectrophotometry (HGAAS). All samples were homogenized using a mortar and pestle, then split and ground in an agate shatterbox prior to analysis. The combustion procedure of Brown and Curry (2002a, 2002b) determined the total carbon and sulfur concentrations. Carbonate carbon was measured by evolution of carbon dioxide using the Chittick method (Dreimanis, 1962). Samples analyzed by ICP-AES were first dissolved using the four acid digestion as described in Briggs (2002). ICP-AES determined the concentration of 40 elements. EDXRF analyses followed the procedure of Siems (2002) in which a pressed powder mount was analyzed directly for 30 elements. Arsenic concentrations were also obtained using HGAAS according to the method of Hageman and others (2002). HGAAS was used as an additional technique to measure arsenic content because of its lower detection limit, and higher precision and accuracy. Results of the chemical analyses of the bulk samples are listed in Appendices 6 through 9.

Precision of duplicate splits of the same sample were within 10 relative percent for elements with concentrations greater than 3 times the detection limit for Combustion, Chittick, ICP-AES, and EDXRF methods. Elements present in lower concentrations were reproduced within 30 relative percent. Duplicate total arsenic measurements by HGAAS were consistently within 4 relative percent. Analyses of solid and rock standards submitted with the samples yielded results within the precision and accuracy described in Taggart (2002).

### **Chemical Extraction Analyses**

Selected sediment samples were treated with 0.5 N HCl primarily to determine the oxidation state and abundance of acid-soluble iron. A 3 to 5 gram aliquot of each of the 37 frozen, preserved sediment samples was transferred to an acid-washed amber serum vial under flowing high-purity nitrogen. The sediment was exposed to air for a few minutes during the transfer, but experiments determined that a minimum of 30 minutes of exposure of the cold sediment was needed before iron oxidation was detectable in the extract solutions. Forty mL of 0.5 N hydrochloric acid was added; the vial was sealed with a rubber septum, purged with nitrogen gas, wrapped with aluminum foil, and shaken periodically. Following 24 hours, 30 mL of the acid solution was withdrawn through the septum and filtered through a 0.2  $\mu$ m syringe filter. An aliquot of the solution was immediately analyzed to determine the concentration of dissolved ferrous iron and dissolved total iron using the Orthophenanthroline method (Clesceri and others, 1998) (Appendix 10). A second aliquot of the remaining solution was analyzed by ICP-AES for 25 elements and for arsenic by HGAAS. Results

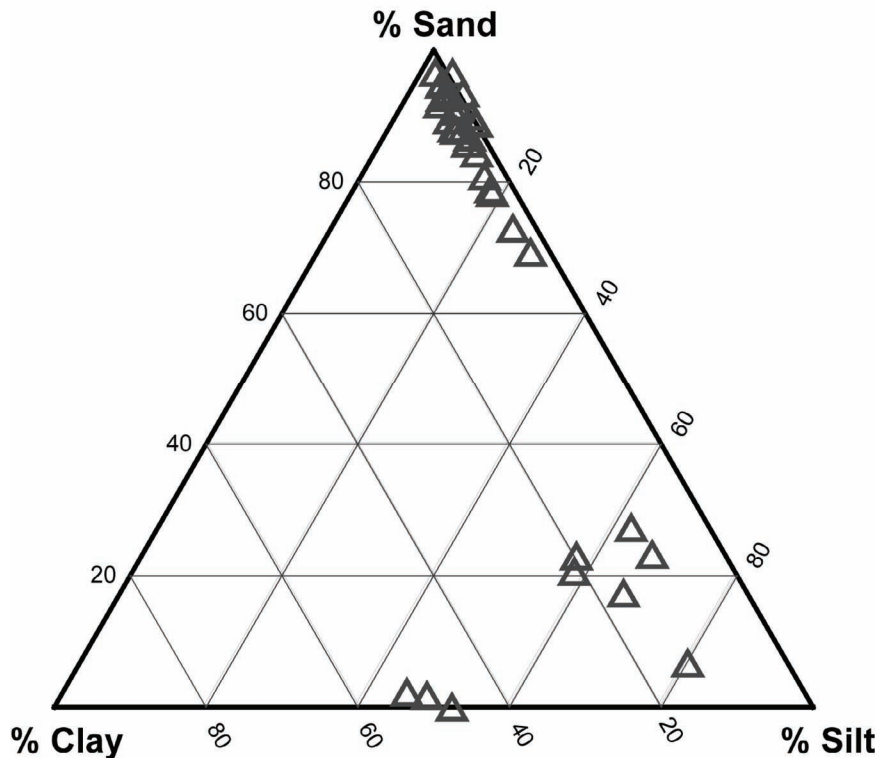
of the analyses are presented in Appendices 10 and 11. Measured concentrations of extractions with 0.5 N HCl of replicate samples of the sediment typically reproduced within 15 percent, but ratios of ferrous to total extractable iron were reproduced within 3 percent. Variations in element concentrations in the replicates are attributed to sample heterogeneity.

The abundances of acid-volatile sulfide (AVS), acid-soluble sulfate, and reducible sulfide (DI), which is mainly pyritic sulfur, were determined following the extraction scheme of Tuttle and others (1986). Sulfur speciation was determined on a 2 to 5 gram aliquot of preserved sediment that was transferred while only partially thawed into the reaction vessel. Under flowing nitrogen, the sample was combined with 80 mL of 6 N HCl that contained 2 grams of stannous chloride ( $\text{SnCl}_2$ ). The  $\text{SnCl}_2$  was added to reduce ferric iron in the samples that might oxidize evolved hydrogen sulfide ( $\text{H}_2\text{S}$ ) in the reaction vessel (Rice and others, 1993). After 15 to 30 minutes, the reaction vessel was heated to boiling to increase the reaction rate. The evolved  $\text{H}_2\text{S}$  was carried in flowing nitrogen through a reservoir of buffer solution (pH 4) to remove HCl and bubbled through a trap containing 1 N silver nitrate ( $\text{AgNO}_3$ ) until the reaction was complete. The resulting silver sulfide ( $\text{Ag}_2\text{S}$ ) was collected by filtration, air-dried, and weighed to measure the abundance of AVS. The acid solution was separated from the residual solid by filtration, and the residual solid was air-dried and weighed. The acid solution was reacted with 10 mL of 10% barium chloride to precipitate dissolved sulfate as barium sulfate, which is considered acid-soluble sulfate. The residual sediment from the AVS extraction was placed in a reaction vessel under flowing nitrogen and combined with 50 mL of 1M chromous chloride ( $\text{CrCl}_2$ ) in 4 N HCl containing 10 milliliters of ethanol. Chromium (II) converts reducible sulfide minerals (i.e., pyrite) to  $\text{H}_2\text{S}$ . The  $\text{H}_2\text{S}$  is transferred to a 1N  $\text{AgNO}_3$  trap as described for the AVS extraction. The solution is boiled for approximately 1 hour or until evolution of  $\text{H}_2\text{S}$  has stopped. Results of the sulfur speciation are listed in Appendix 12.

## Results

### Physical and mineralogical characteristics

Sediment samples from the Rajoir borehole are typically gray and range from silty clay to pebbly sand. The relative grain size distribution of the sample materials from the borehole are plotted in Figure 2. XRD analyses identified quartz as the major constituent of the sediment with minor amounts of plagioclase, potassium feldspar, mica, chlorite, and amphiboles (Appendices 4 and 5). Confirmed authigenic phases detected by XRD in a few samples include siderite and pyrite; calcite was not detected in any of the samples.



**Figure 2.** Ternary diagram of results of grain size analyses (Appendix 3) in sediment samples recovered from the borehole at Rajoir, Bangladesh.

### Bulk Chemical Composition

The median, minimum, and maximum concentrations of chemical constituents measured in bulk air-dried sediment from the SH-2 borehole are listed in Table 1. Compared to the sediment analyzed from the Srirampur borehole located approximately 70 km east of the current study site (Breit and others, 2006), Rajoir sediment has lower contents of arsenic, organic carbon, and sulfur. Total arsenic concentrations of the Rajoir sediment range from 0.6 to 21 ppm based on the HGAAS analyses.

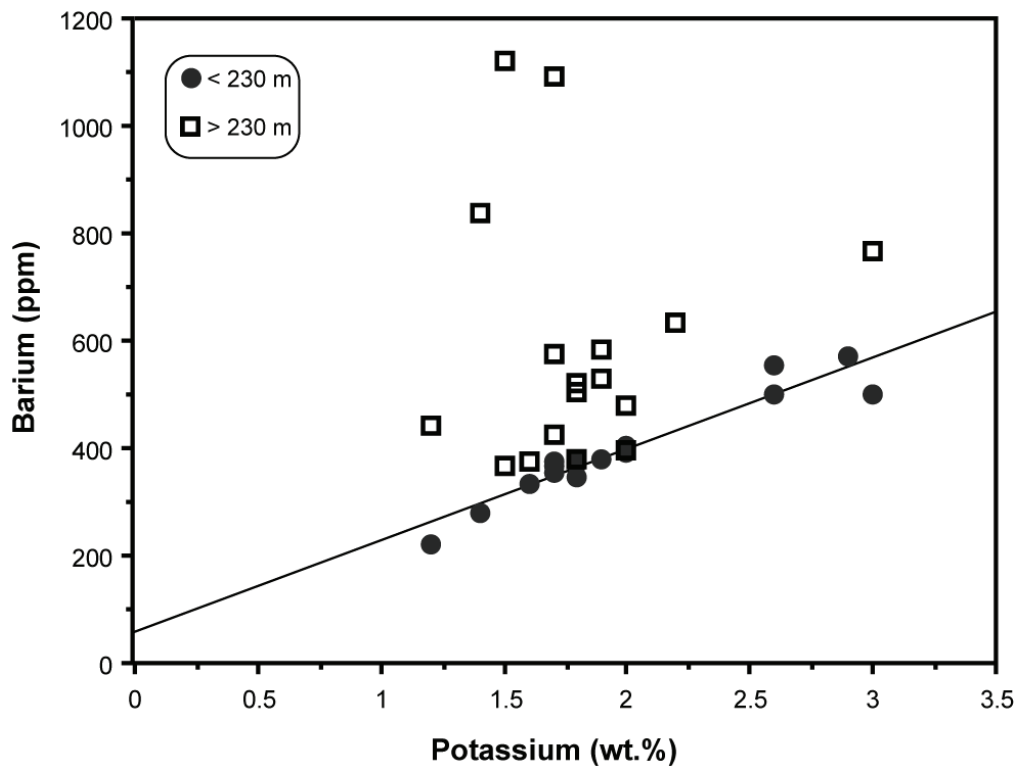
Unusually high concentrations of barium (>500 ppm) were detected in sediment collected below depths of approximately 230 meters. The drilling engineer reported that 230 m was the depth at which barite was added to the drilling fluid to prevent potential blowouts. Because sulfur is an important component of the processes active within the sediment, the following procedure was used to correct sulfur concentrations based on the excess barium content.

Potassium and barium have a recognized geochemical association in potassium feldspars and micas (Puchelt, 1978), which are the most common residence of barium in sediments. This association is evident in the sediment collected at Rajoir and elsewhere in Bangladesh (Breit and others, 2006). Samples recovered from depths less than 230 meters (uncontaminated with barite) have a strong correlation of barium with potassium ( $r^2 = 0.9$ ; fig. 3). The amount of excess barium in the deeper

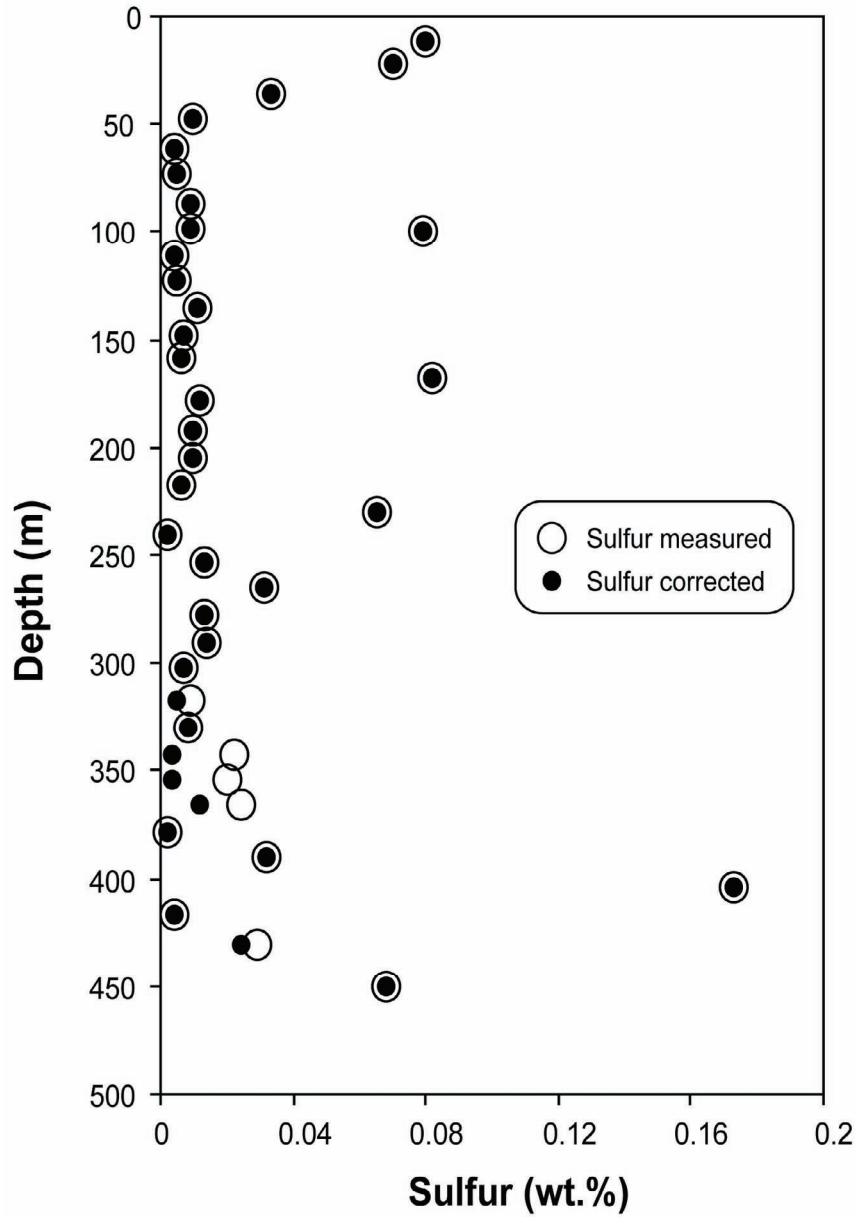
samples was then calculated based on the amount of barium expected for the measured amount of potassium (equation 1). Because of the uncertainty in the analytical data and the deviation from an ideal relation between Ba and K, only samples with greater than 200 ppm excess barium were considered to have sufficient contamination to merit correction. In addition, barium contents of 200 ppm, if contained in barite, would correspond to approximately 0.005 weight percent sulfur, which is close to the detection limit for sulfur analyses. Accordingly, sulfur concentrations in the samples were corrected using equation 2. Results of the recalculation of sulfur concentration are plotted in Figure 4. Note that the high sulfur concentrations detected in the samples are unaffected by the barite correction.

$$\text{Ba (ppm) excess} = \text{Ba (ppm) measured} - (170 * \text{K (wt. \%)} + 60) \quad (1)$$

$$\text{Sulfur (wt.\%)}_{\text{corrected}} = \text{Sulfur (wt.\%)}_{\text{measured}} - (0.233 * \text{Ba (wt.\%)}_{\text{excess}}) \quad (2)$$



**Figure 3.** Plot of potassium vs. barium content of the Rajoir borehole sediment. Regression line was calculated using samples from depths less than 230 m ( $r^2 = 0.9$ ), which are unaffected by barite in the drilling mud. Scatter above the line is attributed to barite contamination.



**Figure 4.** Depth profile comparing bulk sulfur concentration of the sediment from the Rajoir borehole with concentrations corrected for barite contamination. Only five of the 37 samples required significant correction. (wt.%, weight percent).

**Table 1.** Median, minimum and maximum concentrations of chemical constituents of sediment recovered from the SH-2 borehole in Rajoir, Bangladesh.

[ wt.%, weight percent; ppm, parts per million; ICP-AES, Inductively Coupled Plasma Atomic Emission Spectroscopy; EDXRF, Energy Dispersive X-ray Fluorescence Spectrometry; HGAAS, Hydride Generation Atomic Absorption Spectrophotometry; \*, sulfur concentrations are values corrected for barite contamination; detection ratio is the number of analyses above the detection limit/total number of analyses; nr, not reported]

Element (units)	Analytical Method	Median	Minimum	Maximum	Detection Ratio
Al (wt.%)	ICP-AES	4.9	3.2	11	37/37
Ca (wt.%)	ICP-AES	0.83	0.4	1.5	37/37
Fe (wt.%)	ICP-AES	2.1	0.79	6.5	37/37
K (wt.%)	ICP-AES	1.8	1.2	3.0	37/37
Mg (wt.%)	ICP-AES	0.47	0.19	1.6	37/37
Na (wt.%)	ICP-AES	1.1	0.22	1.4	37/37
P (wt.%)	ICP-AES	0.025	0.009	0.061	37/37
Ti (wt.%)	ICP-AES	0.24	0.098	0.48	37/37
C-total (wt.%)	Combustion	0.11	<0.04	1.1	34/37
C-carbonate (wt.%)	Chittick	0.05	0.01	0.42	37/37
S (wt.%)*	Combustion	0.01	<0.005	0.17	36/37
Ag (ppm)	ICP-AES	<2	<2	<2	0/37
Ag (ppm)	EDXRF	<1	<1	<1	0/37
As (ppm)	ICP-AES	<10	<10	25	2/37
As (ppm)	EDXRF	<2	<2	21	10/37
As (ppm)	HGAAS	1.2	0.6	21	37/37
Au (ppm)	ICP-AES	<8	<8	<8	0/37
Ba (ppm)	ICP-AES	400	220	1100	37/37
Ba (ppm)	EDXRF	440	250	1200	37/37
Be (ppm)	ICP-AES	2.1	1.3	4.2	37/37
Bi (ppm)	ICP-AES	<10	<10	<10	37/37
Bi (ppm)	EDXRF	<5	<5	<5	0/37
Br (ppm)	EDXRF	<1	<1	6	33/37
Cd (ppm)	ICP-AES	<2	<2	<2	37/37
Cd (ppm)	EDXRF	<1	<1	<1	0/37
Ce (ppm)	ICP-AES	67	29	110	37/37
Ce (ppm)	EDXRF	71	29	130	37/37
Co (ppm)	ICP-AES	7.9	2.4	48	37/37
Cr (ppm)	ICP-AES	36	12	110	37/37
Cr (ppm)	EDXRF	36	17	120	37/37
Cs (ppm)	EDXRF	8	<5	18	32/37
Cu (ppm)	ICP-AES	6.6	2.1	76	37/37
Cu (ppm)	EDXRF	nr	nr	nr	nr
Eu (ppm)	ICP-AES	<2	<2	2	1/37
Ga (ppm)	ICP-AES	9.6	<4	30	33/37
Ga (ppm)	EDXRF	11	6	24	37/37
Ge (ppm)	EDXRF	<2	<2	4	1/37
Ho (ppm)	ICP-AES	<4	<4	<4	0/37
La (ppm)	ICP-AES	33	14	58	37/37
La (ppm)	EDXRF	39	15	66	37/37

**Table 1.** Median, minimum and maximum of chemical constituents—Continued.

Element (units)	Analytical Method	Median	Minimum	Maximum	Detection Ratio
Li (ppm)	ICP-AES	16	9.6	67	37/37
Mn (ppm)	ICP-AES	470	110	2800	37/37
Mo (ppm)	ICP-AES	<2	<2	3.4	3/37
Mo (ppm)	EDXRF	<2	<2	2	2/37
Nb (ppm)	ICP-AES	10	<4	19	32/37
Nb (ppm)	EDXRF	9	5	19	37/37
Nd (ppm)	ICP-AES	30	12	44	37/37
Nd (ppm)	EDXRF	32	<10	48	36/37
Ni (ppm)	ICP-AES	17	8.5	60	37/37
Ni (ppm)	EDXRF	nr	nr	nr	nr
Pb (ppm)	ICP-AES	19	9.4	39	37/37
Pb (ppm)	EDXRF	18	13	37	37/37
Rb (ppm)	EDXRF	100	65	210	37/37
Sb (ppm)	EDXRF	<2	<2	<2	0/37
Sc (ppm)	ICP-AES	7.6	3.2	18	37/37
Se (ppm)	EDXRF	<1	<1	<1	0/37
Sn (ppm)	ICP-AES	<5	<5	30	6/37
Sn (ppm)	EDXRF	3	<2	6	32/37
Sr (ppm)	ICP-AES	130	51	160	37/37
Sr (ppm)	EDXRF	140	54	170	37/37
Ta (ppm)	ICP-AES	<20	<20	<20	37/37
Th (ppm)	ICP-AES	nr	nr	nr	nr
Th (ppm)	EDXRF	11	5	24	37/37
U (ppm)	ICP-AES	<100	<100	<100	0/37
U (ppm)	EDXRF	<4	<4	7	12/37
V (ppm)	ICP-AES	50	22	140	37/37
V (ppm)	EDXRF	51	24	140	37/37
W (ppm)	EDXRF	<5	<5	160	1/37
Y (ppm)	ICP-AES	16	7.6	29	37/37
Y (ppm)	EDXRF	22	12	37	37/37
Yb (ppm)	ICP-AES	1.8	<1	3.6	34/37
Zn (ppm)	ICP-AES	39	24	120	37/37
Zn (ppm)	EDXRF	46	30	110	37/37
Zr (ppm)	EDXRF	130	98	290	37/37

## Chemical Extractions

Analyses of the 0.5 N HCl extraction solutions verified that the sediment is chemically reduced with respect to iron.  $Fe^{2+}/Fe_{total}$  values are typically greater than 0.9 (Appendix 10). As much as 1 wt.% iron was dissolved from the Rajoir sediment, which is tentatively attributed to dissolution of siderite. Substantial amounts of aluminum, calcium, magnesium, manganese, potassium, sodium, and silicon were also dissolved by 0.5 N HCl (Appendix 11). These elements are attributed to dissolution of detrital silicates and siderite. Reaction of the acid with portions of feldspars, micas, and other detritus weathered during transport and shallow burial likely accounts for Al, Si, K, Na, and some of the Ca, Mg, and Mn. Dissolution of siderite likely released Ca, Mg, and Mn, as well as iron, based on preliminary analyses of siderite grains using a scanning electron microscope equipped with energy dispersive spectroscopy.



Wilkin and Ford (2002) noted loss of dissolved arsenic in sulfidic sediment treated with HCl solutions that were intended to evaluate the abundance of labile arsenic. They attributed the arsenic loss to precipitation of amorphous orpiment ( $\text{As}_2\text{S}_3$ ) by reaction of dissolved arsenic and  $\text{H}_2\text{S}$  evolved by reaction of the AVS with HCl. Therefore, the arsenic concentrations of the 0.5 N HCl extract solutions in this study should be viewed with caution. The potential of orpiment precipitation in the 0.5 N HCl extraction was evaluated using Geochemist's Workbench with the LLNL V8 R6 combined database, which was modified with the thermodynamic data of Nordstrom and Archer (2003) and Pokrovski and others (2002). Results of AVS extraction (Appendix 12) and the abundance of arsenic and iron in the 0.5 N HCl solutions (Appendix 11) were used to evaluate the degree of saturation of amorphous orpiment. The amount of AVS extracted by the 0.5 N HCl is likely to be smaller than the AVS extracted by hot 6 N HCl, so the calculations are considered to indicate the maximum saturation values. One of the 8 samples analyzed for sulfur speciation was oversaturated with respect to amorphous orpiment. Samples selected for sulfur speciation generally contain greater contents of sulfur than most of the sediment samples; therefore, the remaining samples are unlikely to produce HCl extract solutions saturated with amorphous orpiment. This evaluation does not eliminate the concern for orpiment precipitation in the Rajoir sediment, but the problem is likely to be less significant than in the sediment evaluated by Wilkin and Ford (2002).

Sulfur speciation extractions detected AVS, acid-soluble sulfate, and reducible sulfur (DI) in the borehole sediment (Appendix 12). Concentrations of AVS ranged from 10 to 5250 ppm, acid-soluble sulfate measured 30 to 130 ppm, and DI was typically the most abundant form of sulfur, 30 to 9580 ppm. Reducible sulfide (DI) is attributed to pyrite. For several samples, the total amount of sulfur extracted is substantially different than the total sulfur concentrations measured for the bulk, air-dried sediment. The speciation scheme was evaluated with synthetic standards and determined to be reliable; therefore, the contrasting values are attributed to sample heterogeneity.

## References Cited

- Brammer, Hugh, 1996, The geography of the soils of Bangladesh: Dhaka, Bangladesh, The University Press Limited, 287 p.
- Breit, G.N., Yount, J.C., Uddin, Md. N., Muneem, Ad. A., Lowers, H.A., Berry, C.J. and Whitney, J.W., 2006, Compositional data for Bengal delta sediment collected from boreholes at Srirampur, Kachua, Bangladesh: U.S. Geological Survey Open-File Report 2006-1222, 51 p. (<http://pubs.er.usgs.gov/usgspubs/ofr/ofr20061222>)
- Briggs, P.H., 2002, Determination of forty elements in geological and botanical samples by inductively coupled plasma atomic emission spectrometry, in Taggart, J.E., ed., Analytical methods for chemical analysis of geologic and other materials: U.S. Geological Survey Open-File Report 02-223, p. G1-G18. ([http://pubs.usgs.gov/of/2002/ofr-02-0223/G01fortyelementICP-AESSolid\\_M.pdf](http://pubs.usgs.gov/of/2002/ofr-02-0223/G01fortyelementICP-AESSolid_M.pdf))
- Brown, Z.A., and Curry, K.J., 2002a, Total sulfur by combustion, in Taggart, J.E., ed., Analytical methods for chemical analysis of geologic and other materials: U.S. Geological Survey Open-File Report 02-223, p. Q1-Q4. ([http://pubs.usgs.gov/of/2002/ofr-02-0223/Q25TotS\\_M.pdf](http://pubs.usgs.gov/of/2002/ofr-02-0223/Q25TotS_M.pdf))
- Brown, Z.A., and Curry, K.J., 2002b, Total carbon by combustion, in Taggart, J.E., ed., Analytical methods for chemical analysis of geologic and other materials: U.S. Geological Survey Open-

File Report 02-223, p. R1-R4. ([http://pubs.usgs.gov/of/2002/ofr-02-0223/R10TotalCarbon\\_M.pdf](http://pubs.usgs.gov/of/2002/ofr-02-0223/R10TotalCarbon_M.pdf))

Clesceri, L.S., Freenber, A.E., and Eaton, A.D., eds., 1998, 3500-Iron B. Phenanthroline method, *in* Standard methods for the examination of water and wastewater, 20<sup>th</sup> edition: Washington, D.C., American Public Health Association, p. 3-76 to 3-78.

Dreimanis, A. 1962, Quantitative gasometric determination of calcite and dolomite by using Chittick apparatus: *Journal of Sedimentary Petrology*, v. 32, p. 520-529.

Eberl, D.D., 2003, A user's guide to ROCKJOCK—A program for determining quantitative mineralogy from powder x-ray diffraction data: U.S. Geological Survey Open-File Report 2003-78, 41 p.

Goodbred, S.L., and Kuehl, S.A., 2000, The significance of large sediment supply, active tectonism, and eustasy on margin sequence development: Late Quaternary stratigraphy and evolution of the Ganges—Brahmaputra delta: *Sedimentary Geology*, v. 133, p. 227-248.

Gorair, R., Chakraborty, K.A., and Pyne, R., 1984, Chronic arsenic poisoning from tubewell water: *Journal of the Indian Medical Association*, v. 82, p. 34-35.

Hageman, P.L., Brown, Z.A., and Welsch, Eric, 2002, Arsenic and selenium by flow injection or continuous flow generation atomic absorption spectrophotometry, *in* Taggart, J.E., ed., Analytical methods for chemical analysis of geologic and other materials: U.S. Geological Survey Open-File Report 02-223, p. L1-L7. ([http://pubs.usgs.gov/of/2002/ofr-02-0223/L06AS24Se\\_M.pdf](http://pubs.usgs.gov/of/2002/ofr-02-0223/L06AS24Se_M.pdf))

Harvey, C.F., Swartz, C.H., Badruzzaman, A.B.M., Keon-Blute, Nicole, Yu, Winston, Ali, M.A., Jay, Jenny, Beckie, Roger, Niedan, Volker, Brabander, Daniel, Oates, P.M., Ashfaque, K.N., Islam, Shafiqul, Hemond, H.F., and Ahmed, M.F., 2002, Arsenic mobility and ground water extraction in Bangladesh: *Science*, v. 298, p. 1602-1606.

Horneman, Alex, van Geen, Alex, Kent, D.V., Mathe, P.E., Zheng, Yan, Dhar, R.K., O'Connell, S., Hoque, M.A., Aziz, Z., Shasudduha, M., Seddique, A.A., and Ahmed, K.M., 2004, Decoupling of As and Fe release to Bangladesh groundwater under reducing conditions; Part 1, Evidence from sediment profiles: *Geochimica et Cosmochimica Acta*, v. 68, p. 3459-3473.

Nickson, R.T., McArthur, J.M., Ravenscroft, Peter, Burgess, W.G., and Ahmed, K.M., 2000, Mechanism of arsenic release to groundwater — Bangladesh and West Bengal: *Applied Geochemistry*, v. 15, p. 403-413.

Nordstrom, D.K. and Archer, D.G., 2003, Arsenic thermodynamic data and environmental geochemistry, *in* Welch A.H., and Stollenwerk, K.G., eds., *Arsenic in groundwater*: Dordrecht, Netherlands, Kluwer Academic Publishers, p. 1-26.

Pokrovski, G.S., Kara, Sami, and Roux, Jacques, 2002. Stability and solubility of arsenopyrite, FeAsS, in crustal fluids: *Geochimica et Cosmochimica Acta*, v. 66, p. 2361-2378.

- Puchelt, H., 1978, Barium, *in* Wedepohl, K.H., ed., Handbook of geochemistry, vol. II/4, Chapter O: Berlin, Germany, Springer-Verlag.
- Ravenscroft, Peter, Burgess, W.G., Ahmed, K.M., Burren, Melanie, and Perrin, Jerome, 2005, Arsenic in groundwater of the Bengal basin, Bangladesh — Distribution, field relations and hydrogeological setting: *Hydrogeology Journal*, v. 13, p. 727-751.
- Rice, C.A., Tuttle, M.L., and Reynolds, R.L., 1993, The analysis of forms of sulfur in ancient sediments and sedimentary rocks — Comments and cautions: *Chemical Geology*, v. 107, p. 83-95.
- Saha, K.C., 1984, Melanokeratosis from arsenical contamination of tubewell water: *Indian Journal of Dermatology*, v. 29, p. 37-46.
- Saha, K.C., 1995, Chronic arsenic dermatosis from tubewell water in West Bengal during 1983-87: *Indian Journal of Dermatology*, v. 40, p. 1-12.
- Siems, D.F., 2002, The determination of 30 elements in geological materials by energy dispersive x-ray fluorescence spectrometry, *in* Taggart, J.E. ed., Analytical methods for chemical analysis of geologic and other materials: U.S. Geological Survey Open-File Report 02-223, p. U1-U11. ([http://pubs.usgs.gov/of/2002/ofr-02-0223/U27edsfinal\\_U.pdf](http://pubs.usgs.gov/of/2002/ofr-02-0223/U27edsfinal_U.pdf))
- Smedley, P.L., and Kinniburgh, D.G., 2002, A review of the source, behavior and distribution of arsenic in natural waters: *Applied Geochemistry*, v. 17, p. 517-568.
- Taggart, J.E., 2002, Analytical methods for chemical analysis of geologic and other materials: U.S. Geological Survey Open-file Report 02-223. <http://pubs.usgs.gov/of/2002/ofr-02-0223/OFR-02-0223.pdf>
- Tuttle, M.L., Goldhaber, M.B., and Williamson, D.L., 1986, An analytical scheme for determining forms of sulfur in oil shales and associated rocks: *Talanta*, v. 33, p. 953-961.
- Wentworth, C.K., 1922, A scale of grade and class terms for clastic sediments: *Journal of Geology*, v. 30, p. 377-392.
- Wilkin, R.T., and Ford, R.G., 2002, Use of hydrochloric acid for determining solid-phase arsenic partitioning in sulfidic sediments: *Environmental Science and Technology*, v. 36, p. 4921-4927.
- World Bank, 2005, Arsenic Contamination in Asia: [http://siteresources.worldbank.org/INTSAREGTOPWATRES/Resources/ARSENIC\\_BRIEF.pdf](http://siteresources.worldbank.org/INTSAREGTOPWATRES/Resources/ARSENIC_BRIEF.pdf)

**Appendix 1.** Depth interval and description of air-dried sediment samples from the SH-2 borehole, Rajoir, Bangladesh.

<b>Sample</b>	<b>Depth (meters)</b>	<b>Description</b>
SH-2/1-AD	11.0-11.1	light greenish-gray (10Y 7/1), silty clay
SH-2/2-AD	21.6-21.9	greenish-gray (5GY 6/1), fine sand
SH-2/3-AD	35.5-35.7	greenish-gray (10GY 6/1), fine sandy silt
SH-2/4-AD	47.9-48.2	greenish gray (5GY 5/1), fine sand
SH-2/5-AD	60.5-60.8	light greenish-gray (5GY 7/1), fine sand
SH-2/6-AD	72.5-72.8	greenish-gray (10GY 6/1), fine sand
SH-2/7-AD	86.3-86.6	greenish-gray (5GY 5/1), fine sand
SH-2/8-AD	98.5-98.9	greenish gray (5GY 5/1), clayey medium sand
SH-2/9-AD	98.9-99.1	light greenish gray (10GY 7/1), clay
SH-2/10-AD	110.6-110.9	dark greenish gray (10Y 4/1) pebbly medium sand
SH-2/11-AD	122.2-123.1	light greenish gray (5BG 8/1), medium sand
SH-2/12-AD	135.2-135.9	greenish gray, (5GY 5/1), fine sand
SH-2/13-AD	147.8-148.7	light greenish gray (5GY 7/1), fine sand
SH-2/14-AD	158.5-159.4	greenish gray (10Y 6/1), fine sand
SH-2/15-AD	167.0-167.6	light greenish gray, (5GY 7/1), clayey fine sand
SH-2/16-AD	178.9-179.8	light gray, (2.5Y 7/2), silty fine sand
SH-2/17-AD	192.3-193.2	light gray (5Y 7/2), pebbly medium sand
SH-2/18-AD	204.2-205.1	light greenish gray (5BG 7/1), fine sand
SH-2/19-AD	217.3-217.8	light greenish gray (10Y 7/1), medium sand
SH-2/20-AD	229.5-230.4	light greenish gray (5GY 7/1), medium sand
SH-2/21-AD	240.8-241.7	greenish gray (10Y 6/1), pebbly medium sand
SH-2/22-AD	253.0-253.9	greenish gray (10Y 6/1), pebbly medium sand
SH-2/23-AD	265.2-266.1	light greenish gray (5GY 7/1) clayey fine sand
SH-2/24-AD	277.4-278.0	greenish gray (5BG 6/1), clayey medium sand
SH-2/25-AD	289.6-290.3	light greenish gray (10BG 7/1) fine sand
SH-2/26-AD	301.8-302.7	light greenish gray (5BG 7/1), medium sand
SH-2/27-AD	316.8-317.0	light bluish gray (5B 7/1), fine sandy clay
SH-2/28-AD	329.8-330.1	light greenish gray (10GY 7/1), medium sand
SH-2/29-AD	342.6-343.2	very pale brown (10YR 7/3), fine sand
SH-2/30-AD	353.6-354.5	light brownish gray (10YR 6/2), medium sand
SH-2/31-AD	365.8-366.7	pale brown (10YR 6/3) medium sand
SH-2/32-AD	378.6-378.9	mottled light gray (10YR7/1) and brown-yellow (10YR 6/6) clay
SH-2/33-AD	390.1-391.1	light greenish gray (10GY 7/1) fine sandy, silty clay
SH-2/34-AD	403.3-404.2	light greenish gray (10GY 7/1) fine sandy clay
SH-2/35-AD	416.4-417.3	greenish gray (5GY 6/1) fine sand
SH-2/36-AD	429.8-430.7	very pale brown (10YR 7/3), fine sand
SH-2/37-AD	449.6-450.5	greenish gray (5GY 6/1) fine sandy clay

**Appendix 2.** Depth of sediment samples that were preserved in glass vials, flushed with argon, and frozen after collection from the SH-2 borehole, Rajoir, Bangladesh.

<b>Sample</b>	<b>Depth (meters)</b>
SH-2/1-P	11.6
SH-2/2-P	21.9
SH-2/3-P	35.7
SH-2/4-P	48.2
SH-2/5-P	60.8
SH-2/6-P	72.8
SH-2/7-P	86.6
SH-2/8-P	98.9
SH-2/9-P	99.1
SH-2/10-P	110.9
SH-2/11-P	123.1
SH-2/12-P	135.9
SH-2/13-P	148.7
SH-2/14-P	159.4
SH-2/15-P	167.6
SH-2/16-P	179.8
SH-2/17-P	193.2
SH-2/18-P	205.1
SH-2/19-P	217.8
SH-2/20-P	230.4
SH-2/21-P	241.7
SH-2/22-P	253.9
SH-2/23-P	266.1
SH-2/24-P	278.0
SH-2/25-P	290.3
SH-2/26-P	302.7
SH-2/27-P	317.0
SH-2/28-P	330.1
SH-2/29-P	343.2
SH-2/30-P	354.5
SH-2/31-P	366.7
SH-2/32-P	378.9
SH-2/33-P	391.1
SH-2/34-P	404.2
SH-2/35-P	417.3
SH-2/36-P	430.7
SH-2/37-P	450.5

**Appendix 3.** Results of grain size analysis of air-dried sediment samples collected from the SH-2 borehole, Rajoir village, Bangladesh. Designations as sand, silt, and clay follow the size definitions of Wentworth (1922).

[Eric Fisher, Analyst; wt.%, weight percent]

<b>Sample</b>	<b>Sand (wt.%)</b>	<b>Silt (wt.%)</b>	<b>Clay (wt.%)</b>	<b>Description</b>
SH-2/1-AD	6.5	80.0	13.6	silt
SH-2/2-AD	69.8	27.7	2.4	silty sand
SH-2/3-AD	27.6	62.1	10.3	sandy silt
SH-2/4-AD	89.3	9.1	1.6	sand
SH-2/5-AD	87.4	10.9	1.7	sand
SH-2/6-AD	81.7	16.0	2.3	sand
SH-2/7-AD	89.2	8.5	2.4	sand
SH-2/8-AD	92.3	6.1	1.6	sand
SH-2/9-AD	20.9	57.8	21.3	sandy silt
SH-2/10-AD	73.1	23.7	3.2	silty sand
SH-2/11-AD	86.9	11.1	1.9	sand
SH-2/12-AD	87.6	11.4	1.0	sand
SH-2/13-AD	94.9	4.5	0.6	sand
SH-2/14-AD	90.6	8.2	1.2	sand
SH-2/15-AD	79.9	17.3	2.9	sand
SH-2/16-AD	93.5	5.2	1.3	sand
SH-2/17-AD	89.7	8.5	1.8	sand
SH-2/18-AD	94.8	4.5	0.7	sand
SH-2/19-AD	94.6	4.5	0.9	sand
SH-2/20-AD	96.5	3.0	0.5	sand
SH-2/21-AD	90.6	8.2	1.3	sand
SH-2/22-AD	95.0	4.5	0.5	sand
SH-2/23-AD	85.0	12.6	2.4	sand
SH-2/24-AD	94.2	5.2	0.6	sand
SH-2/25-AD	91.1	8.0	0.9	sand
SH-2/26-AD	98.2	1.4	0.4	sand
SH-2/27-AD	79.2	17.4	3.4	sand
SH-2/28-AD	96.7	2.8	0.5	sand
SH-2/29-AD	92.9	6.2	1.0	sand
SH-2/30-AD	94.2	4.9	1.0	sand
SH-2/31-AD	90.9	7.2	1.9	sand
SH-2/32-AD	1.6	45.4	53.0	silty clay
SH-2/33-AD	22.3	57.0	20.7	sandy silt
SH-2/34-AD	17.1	66.3	16.6	sandy silt
SH-2/35-AD	94.7	4.3	1.0	sand
SH-2/36-AD	94.7	4.2	1.1	sand
SH-2/37-AD	23.6	66.8	9.6	sandy silt

**Appendix 4.** Major and minor minerals detected by X-ray diffraction analysis of air-dried sediment samples from the SH-2 borehole, Rajoir, Bangladesh.

[XX, major constituent; X, minor constituent; TI, tentative identification as minor phase; <, not detected; Plag., plagioclase; K-spar, potassium feldspar; Amph., amphibole]

Sample	Quartz	Plag.	K-spar	Mica	Chlorite	Amph.	Siderite
SH-2/1-AD	XX	X	X	X	TI	TI	<
SH-2/2-AD	XX	X	X	X	TI	X	<
SH-2/3-AD	XX	X	X	X	TI	X	<
SH-2/4-AD	XX	X	X	<	TI	X	<
SH-2/5-AD	XX	X	X	X	TI	X	<
SH-2/6-AD	XX	X	X	X	TI	X	<
SH-2/7-AD	XX	X	X	X	TI	X	<
SH-2/8-AD	XX	X	X	X	TI	TI	<
SH-2/9-AD	XX	X	TI	X	TI	TI	<
SH-2/10-AD	XX	X	TI	X	<	TI	TI
SH-2/11-AD	XX	X	TI	X	TI	TI	<
SH-2/12-AD	XX	X	X	X	TI	<	TI
SH-2/13-AD	XX	X	X	X	TI	TI	<
SH-2/14-AD	XX	X	TI	X	<	TI	<
SH-2/15-AD	XX	X	X	X	TI	<	<
SH-2/16-AD	XX	X	X	TI	<	<	<
SH-2/17-AD	XX	X	X	X	TI	TI	<
SH-2/18-AD	XX	X	X	X	TI	X	<
SH-2/19-AD	XX	X	X	X	TI	TI	TI
SH-2/20-AD	XX	X	X	X	X	X	<
SH-2/21-AD	XX	X	X	X	TI	TI	<
SH-2/22-AD	XX	X	X	X	TI	X	TI
SH-2/23-AD	XX	X	X	X	TI	TI	X
SH-2/24-AD	XX	X	X	X	TI	TI	<
SH-2/25-AD	XX	X	X	X	TI	TI	TI
SH-2/26-AD	XX	X	X	X	TI	X	X
SH-2/27-AD	XX	X	X	X	<	TI	<
SH-2/28-AD	XX	X	X	X	TI	TI	X
SH-2/29-AD	XX	X	X	X	TI	X	<
SH-2/30-AD	XX	X	X	X	<	TI	<
SH-2/31-AD	XX	X	X	X	TI	X	<
SH-2/32-AD	XX	X	X	X	X	TI	<
SH-2/33-AD	XX	X	X	X	<	<	X
SH-2/34-AD	XX	X	X	X	<	TI	<
SH-2/35-AD	XX	X	X	X	TI	X	<
SH-2/36-AD	XX	X	X	X	TI	TI	<
SH-2/37-AD	XX	X	X	X	TI	<	<

**Appendix 5.** Results of quantitative mineralogical analysis by X-ray diffraction of air-dried sediment samples from the GSB borehole SH-2 borehole at Rajoir, Bangladesh. Abundances determined using the ROCKJOCK procedure of Eberl (2002).

[K-spar, potassium feldspars; Plag., plagioclase; Amph., amphibole; Mica, sum of muscovite, phlogopite and biotite; wt.%, weight percent]

<b>Sample</b>	<b>Quartz (wt.%)</b>	<b>K-spar (wt.%)</b>	<b>Plag. (wt.%)</b>	<b>Amph. (wt.%)</b>	<b>Mica (wt.%)</b>	<b>Chlorite (wt.%)</b>	<b>Smectite (wt.%)</b>	<b>Kaolinite (wt.%)</b>	<b>Siderite (wt.%)</b>
SH-2/1-AD	34	8	13	2	30	9	<1	2	<1
SH-2/2-AD	45	12	17	4	13	7	2	<1	<1
SH-2/7-AD	57	14	16	3	6	4	1	<1	<1
SH-2/12-AD	34	14	13	1	22	5	7	2	1
SH-2/15-AD	54	14	9	1	9	3	7	1	2
SH-2/18-AD	50	15	16	3	7	5	3	1	<1
SH-2/24-AD	52	14	14	2	8	5	4	1	<1
SH-2/28-AD	57	13	13	2	6	5	4	<1	1
SH-2/32-AD	22	8	<1	<1	27	5	20	8	<1
SH-2/36-AD	59	14	14	2	6	2	3	<1	<1



**Appendix 6.** Results of carbon and sulfur analyses of air-dried sediment samples from the SH-2 borehole, Rajoir, Bangladesh. Sulfur and total carbon determined by Combustion (Brown and Curry, 2002a; 2002b). Carbonate carbon determined using the Chittick method (Dreimanis, 1962). Sulfur was corrected (Sulfur (corr)) for barite contamination as described in the text.

[wt.%, weight percent]

<b>Sample</b>	<b>Sulfur (wt.%)</b>	<b>Sulfur (corr) (wt.%)</b>	<b>Total Carbon (wt.%)</b>	<b>Carbonate Carbon (wt.%)</b>
SH-1/1-AD	0.080	0.080	0.33	0.05
SH-1/2-AD	0.070	0.070	0.29	0.30
SH-1/3-AD	0.033	0.033	0.60	0.22
SH-1/4-AD	0.010	0.010	0.11	0.07
SH-1/5-AD	0.004	0.004	0.09	0.05
SH-1/6-AD	0.005	0.005	0.11	0.04
SH-1/7-AD	0.009	0.009	0.05	0.04
SH-1/8-AD	0.009	0.009	0.15	0.15
SH-1/9-AD	0.079	0.079	1.1	0.20
SH-1/10-AD	0.004	0.004	0.41	0.14
SH-1/11-AD	0.005	0.005	0.09	0.04
SH-1/12-AD	0.011	0.011	0.21	0.09
SH-1/13-AD	0.007	0.007	0.10	0.07
SH-1/14-AD	0.006	0.006	0.11	0.08
SH-1/15-AD	0.082	0.082	0.46	0.12
SH-1/16-AD	0.012	0.012	0.04	0.04
SH-1/17-AD	0.010	0.010	0.05	0.02
SH-1/18-AD	0.010	0.010	0.07	0.07
SH-1/19-AD	0.006	0.006	0.20	0.07
SH-1/20-AD	0.065	0.065	0.06	0.03
SH-1/21-AD	0.002	0.002	<0.04	0.03
SH-1/22-AD	0.013	0.013	0.10	0.04
SH-1/23-AD	0.031	0.031	0.30	0.06
SH-1/24-AD	0.013	0.013	0.11	0.04
SH-1/25-AD	0.014	0.014	0.13	0.07
SH-1/26-AD	0.007	0.007	0.41	0.03
SH-1/27-AD	0.009	0.005	<0.04	0.04
SH-1/28-AD	0.008	0.008	0.20	0.11
SH-1/29-AD	0.022	0.004	0.06	0.05
SH-1/30-AD	0.020	0.003	<0.04	0.04
SH-1/31-AD	0.024	0.012	0.06	0.04
SH-1/32-AD	<0.002	<0.002	0.10	0.05
SH-1/33-AD	0.032	0.032	0.59	0.42
SH-1/34-AD	0.173	0.173	0.10	0.04
SH-1/35-AD	0.004	0.004	<0.04	0.04
SH-1/36-AD	0.029	0.024	0.05	0.03
SH-1/37-AD	0.068	0.068	0.22	0.09

**Appendix 7. Results of Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) analyses of air-dried samples from the SH-2 borehole, Rajoir, Bangladesh.**

[Paul Briggs, USGS, Analyst; wt.% weight percent; ppm, parts per million; nr, not reported]

<b>Sample</b>	<b>Al wt. %</b>	<b>Ca wt. %</b>	<b>Fe wt. %</b>	<b>K wt. %</b>	<b>Mg wt. %</b>	<b>Na wt. %</b>	<b>P wt. %</b>	<b>Ti wt. %</b>	<b>Ag ppm</b>	<b>As ppm</b>	<b>Au ppm</b>	<b>Ba ppm</b>	<b>Be ppm</b>	<b>Bi ppm</b>
SH-2/1-AD	8.7	0.87	4.0	2.9	1.5	1.1	0.050	0.45	<2	<10	<8	570	3.1	<10
SH-2/2-AD	5.8	1.5	2.9	2.0	1.1	1.3	0.060	0.33	<2	<10	<8	400	2.1	<10
SH-2/3-AD	8.0	1.3	4.2	2.6	1.6	1.2	0.061	0.44	<2	<10	<8	500	2.9	<10
SH-2/4-AD	5.7	1.4	2.5	2.0	0.8	1.4	0.036	0.28	<2	<10	<8	390	2.1	<10
SH-2/5-AD	5.5	1.4	2.3	1.8	0.69	1.4	0.038	0.28	<2	<10	<8	370	2.2	<10
SH-2/6-AD	5.4	1.2	2.1	1.9	0.67	1.4	0.028	0.22	<2	<10	<8	380	2.0	<10
SH-2/7-AD	4.6	1.0	1.6	1.6	0.47	1.3	0.023	0.14	<2	<10	<8	330	1.8	<10
SH-2/8-AD	3.6	0.51	1.9	1.4	0.4	0.77	0.021	0.12	<2	<10	<8	280	1.3	<10
SH-2/9-AD	9.0	1.0	4.7	2.6	1.5	1.1	0.053	0.41	<2	15	<8	550	3.2	<10
SH-2/10-AD	3.2	0.72	2.7	1.2	0.42	0.74	0.024	0.10	<2	<10	<8	220	1.7	<10
SH-2/11-AD	4.9	1.0	1.5	1.8	0.44	1.3	0.023	0.16	<2	<10	<8	350	2.0	<10
SH-2/12-AD	7.5	0.59	4.2	3.0	1.1	1.2	0.019	0.41	<2	<10	<8	500	2.5	<10
SH-2/13-AD	4.8	0.89	1.8	1.7	0.42	1.1	0.027	0.25	<2	<10	<8	350	1.8	<10
SH-2/14-AD	5.4	0.87	2.1	2.0	0.52	1.2	0.028	0.25	<2	<10	<8	390	1.9	<10
SH-2/15-AD	4.9	0.55	3.1	1.7	0.46	0.75	0.023	0.28	<2	<10	<8	370	2.0	<10
SH-2/16-AD	3.9	0.49	0.79	1.8	0.19	0.87	0.009	0.11	<2	<10	<8	380	1.5	<10
SH-2/17-AD	5.4	0.86	1.5	2.0	0.44	1.3	0.024	0.21	<2	<10	<8	390	2.2	<10
SH-2/18-AD	5.2	1.0	1.9	1.7	0.49	1.2	0.028	0.25	<2	<10	<8	380	1.9	<10
SH-2/19-AD	4.9	0.78	2.0	1.8	0.48	1.1	0.023	0.21	<2	<10	<8	380	2.2	<10
SH-2/20-AD	4.9	0.79	1.3	1.8	0.35	1.2	0.019	0.16	<2	<10	<8	380	1.9	<10
SH-2/21-AD	4.5	0.77	1.5	1.7	0.36	1.1	0.023	0.18	<2	<10	<8	430	1.9	<10
SH-2/22-AD	4.9	0.68	1.5	1.8	0.37	1.1	0.020	0.18	<2	<10	<8	520	1.9	<10
SH-2/23-AD	5.2	0.61	2.3	2.0	0.45	1.1	0.021	0.18	<2	<10	<8	480	2.2	<10
SH-2/24-AD	5.4	0.81	1.9	1.9	0.6	1.1	0.025	0.25	<2	<10	<8	530	2.1	<10
SH-2/25-AD	5.4	0.86	2.1	1.8	0.54	1.2	0.034	0.25	<2	<10	<8	380	2.3	<10
SH-2/26-AD	4.6	0.53	2.6	2.0	0.36	1.1	0.022	0.14	<2	<10	<8	400	2.3	<10
SH-2/27-AD	4.9	0.67	1.4	1.9	0.38	1.2	0.021	0.17	<2	<10	<8	590	2.1	<10

**Appendix 7. Results of ICP-AES analyses —Continued.**

<b>Sample</b>	<b>Al</b> wt. %	<b>Ca</b> wt. %	<b>Fe</b> wt. %	<b>K</b> wt. %	<b>Mg</b> wt. %	<b>Na</b> wt. %	<b>P</b> wt. %	<b>Ti</b> wt. %	<b>Ag</b> ppm	<b>As</b> ppm	<b>Au</b> ppm	<b>Ba</b> ppm	<b>Be</b> ppm	<b>Bi</b> ppm
SH-2/28-AD	4.6	0.75	2.3	1.6	0.42	1.0	0.027	0.23	<2	<10	<8	370	1.9	<10
SH-2/29-AD	4.8	0.88	1.9	1.5	0.43	1.1	0.026	0.24	<2	<10	<8	1100	2.1	<10
SH-2/30-AD	4.8	0.83	1.5	1.7	0.40	1.2	0.024	0.19	<2	<10	<8	1100	2.1	<10
SH-2/31-AD	4.7	1.1	2.1	1.4	0.49	1.1	0.027	0.24	<2	<10	<8	840	1.8	<10
SH-2/32-AD	11.0	0.4	6.5	3.0	1.4	0.31	0.056	0.48	<2	<10	<8	770	4.2	<10
SH-2/33-AD	6.2	0.47	3.8	1.2	0.38	0.22	0.023	0.37	<2	<10	<8	443	2.6	<10
SH-2/34-AD	7.4	0.47	3.8	2.2	0.98	0.77	0.014	0.42	<2	22	<8	630	2.7	<10
SH-2/35-AD	4.9	1.4	2.4	1.5	0.59	1.2	0.048	0.32	<2	<10	<8	370	1.8	<10
SH-2/36-AD	4.5	0.88	1.6	1.7	0.38	1.2	0.029	0.20	<2	<10	<8	580	2.0	<10
SH-2/37-AD	6.1	0.44	3.3	1.8	0.76	0.94	0.028	0.38	<2	<10	<8	510	2.1	<10

**Appendix 7. Results of ICP-AES analyses—Continued**

<b>Sample</b>	<b>Cd ppm</b>	<b>Ce ppm</b>	<b>Co ppm</b>	<b>Cr ppm</b>	<b>Cu ppm</b>	<b>Eu ppm</b>	<b>Ga ppm</b>	<b>Ho ppm</b>	<b>La ppm</b>	<b>Li ppm</b>	<b>Mn ppm</b>	<b>Mo ppm</b>	<b>Nb ppm</b>	<b>Nd ppm</b>	<b>Ni ppm</b>
SH-2/1-AD	<2	86	19	94	33	<2	21	<4	44	49	430	2	14	38	46
SH-2/2-AD	<2	75	12	53	10	<2	15	<4	40	24	600	<2	6.1	33	26
SH-2/3-AD	<2	86	17	97	36	<2	14	<4	42	36	840	<2	16	42	45
SH-2/4-AD	<2	73	10	47	4.1	<2	10	<4	35	18	490	<2	10	34	22
SH-2/5-AD	<2	80	7.7	43	3.5	<2	9.3	<4	39	16	500	<2	11	37	18
SH-2/6-AD	<2	66	8.3	40	4.5	<2	9.1	<4	33	17	470	<2	11	30	19
SH-2/7-AD	<2	56	5.9	28	6.8	<2	6.9	<4	27	12	390	<2	7.9	24	12
SH-2/8-AD	<2	44	7.3	29	18	<2	5.2	<4	22	14	440	<2	5.1	22	17
SH-2/9-AD	<2	70	21	110	52	<2	17	<4	34	56	470	<2	18	34	60
SH-2/10-AD	<2	29	48	12	10	<2	<4	<4	14	12	2800	<2	<4	12	12
SH-2/11-AD	<2	54	5.3	24	2.1	<2	8.4	<4	26	14	350	<2	9.3	26	11
SH-2/12-AD	<2	36	16	90	22	<2	18	<4	19	31	510	<2	15	17	42
SH-2/13-AD	<2	69	7.8	46	4.3	<2	9.4	<4	33	14	300	<2	11	33	20
SH-2/14-AD	<2	53	8.7	48	6	<2	11	<4	25	15	310	<2	13	26	20
SH-2/15-AD	<2	69	11	49	30	<2	<4	<4	33	20	1100	<2	8.4	31	23
SH-2/16-AD	<2	37	3.9	19	36	<2	6.8	<4	17	9.6	110	<2	7.5	17	8.5
SH-2/17-AD	<2	55	8.2	36	4.8	<2	11	<4	25	16	260	<2	11	24	18
SH-2/18-AD	<2	74	6.3	36	12	<2	8.3	<4	34	14	420	<2	10	32	14
SH-2/19-AD	<2	56	7.8	32	6.2	<2	7.6	<4	27	16	490	<2	9.8	25	17
SH-2/20-AD	<2	44	5.2	19	3.5	<2	9.3	<4	21	12	240	<2	11	18	12
SH-2/21-AD	<2	67	5.5	22	2.4	<2	7.8	<4	31	13	350	<2	10	30	11
SH-2/22-AD	<2	52	6.4	28	3.6	<2	8.9	<4	24	15	330	<2	10	22	14
SH-2/23-AD	<2	43	10	33	7.4	<2	5.2	<4	21	18	820	<2	8.7	20	21
SH-2/24-AD	<2	58	10	39	7.1	<2	10	<4	27	20	400	<2	11	26	22
SH-2/25-AD	<2	59	8	35	4.5	<2	8.1	<4	28	18	580	<2	12	27	17
SH-2/26-AD	<2	29	7.9	20	3.1	<2	<4	<4	14	15	1300	<2	6.2	14	12
SH-2/27-AD	<2	44	6.3	28	42	<2	9.9	<4	21	16	270	<2	12	21	14

**Appendix 7. Results of ICP-AES analyses—Continued**

<b>Sample</b>	<b>Cd ppm</b>	<b>Ce ppm</b>	<b>Co ppm</b>	<b>Cr ppm</b>	<b>Cu ppm</b>	<b>Eu ppm</b>	<b>Ga ppm</b>	<b>Ho ppm</b>	<b>La ppm</b>	<b>Li ppm</b>	<b>Mn ppm</b>	<b>Mo ppm</b>	<b>Nb ppm</b>	<b>Nd ppm</b>	<b>Ni ppm</b>
SH-2/28-AD	<2	73	7.0	36	2.3	<2	<4	<4	34	15	980	<2	7.1	34	13
SH-2/29-AD	<2	82	6.1	36	6.6	<2	6.7	<4	39	14	580	<2	9.1	36	12
SH-2/30-AD	<2	49	2.4	29	3.1	<2	9.6	<4	26	16	320	<2	6.1	20	12
SH-2/31-AD	<2	86	3.8	40	4.7	<2	9.7	<4	46	14	650	<2	<4	34	11
SH-2/32-AD	<2	79	24	80	41	2	30	<4	41	67	610	3.4	19	36	54
SH-2/33-AD	<2	87	13	77	34	<2	14	<4	40	46	1100	<2	<4	34	31
SH-2/34-AD	<2	73	16	77	76	<2	15	<4	38	32	340	2.2	16	32	37
SH-2/35-AD	<2	110	6.6	38	3.2	<2	10	<4	58	14	680	<2	<4	44	13
SH-2/36-AD	<2	67	4.0	29	3.0	<2	9	<4	36	15	390	<2	<4	28	10
SH-2/37-AD	<2	73	16	73	61	<2	17	<4	38	37	750	<2	7.1	32	38

**Appendix 7. Results of ICP-AES analyses—Continued**

<b>Sample</b>	<b>Pb ppm</b>	<b>Sc ppm</b>	<b>Sn ppm</b>	<b>Sr ppm</b>	<b>Ta ppm</b>	<b>Th ppm</b>	<b>U ppm</b>	<b>V ppm</b>	<b>Y ppm</b>	<b>Yb ppm</b>	<b>Zn ppm</b>
SH-2/1-AD	25	14	<5	110	<20	21	<100	100	21	2.3	83
SH-2/2-AD	17	9.4	<5	140	<20	17	<100	66	21	2.4	48
SH-2/3-AD	25	15	<5	140	<20	nr	<100	100	23	2.4	91
SH-2/4-AD	21	9.2	<5	150	<20	nr	<100	60	19	2.0	44
SH-2/5-AD	18	8.6	<5	160	<20	nr	<100	55	21	2.3	38
SH-2/6-AD	19	7.6	<5	150	<20	nr	<100	48	16	1.8	40
SH-2/7-AD	18	5.8	<5	150	<20	nr	<100	34	13	1.5	28
SH-2/8-AD	13	4.7	<5	78	<20	nr	<100	30	10	1.2	34
SH-2/9-AD	39	16	<5	130	<20	nr	<100	120	20	2.2	110
SH-2/10-AD	9.4	3.9	<5	76	<20	nr	<100	22	7.6	<1	30
SH-2/11-AD	17	5.4	<5	150	<20	nr	<100	34	13	1.4	31
SH-2/12-AD	24	12	<5	120	<20	nr	<100	85	14	1.5	96
SH-2/13-AD	18	7.3	<5	120	<20	nr	<100	57	18	1.8	32
SH-2/14-AD	20	7.7	<5	130	<20	nr	<100	52	15	1.5	46
SH-2/15-AD	19	7.9	<5	90	<20	nr	<100	56	17	1.8	76
SH-2/16-AD	19	3.2	<5	100	<20	nr	<100	23	8.9	<1	77
SH-2/17-AD	23	6.2	<5	140	<20	nr	<100	44	14	1.6	34
SH-2/18-AD	21	7.6	<5	140	<20	nr	<100	50	19	2.2	73
SH-2/19-AD	19	6.2	<5	120	<20	nr	<100	42	14	1.6	38
SH-2/20-AD	22	4.9	<5	130	<20	nr	<100	33	12	1.3	33
SH-2/21-AD	19	5.6	<5	120	<20	nr	<100	36	16	1.8	25
SH-2/22-AD	21	5.7	<5	120	<20	nr	<100	38	12	1.3	29
SH-2/23-AD	22	6.4	<5	120	<20	nr	<100	40	11	1.3	74
SH-2/24-AD	19	7.7	<5	130	<20	nr	<100	52	15	1.6	49
SH-2/25-AD	19	7.3	<5	130	<20	nr	<100	50	16	1.6	39
SH-2/26-AD	18	4.5	<5	110	<20	nr	<100	28	8.2	<1	30
SH-2/27-AD	21	5.1	<5	130	<20	nr	<100	35	11	1.2	51

**Appendix 7. Results of ICP-AES analyses—Continued**

<b>Sample</b>	<b>Pb ppm</b>	<b>Sc ppm</b>	<b>Sn ppm</b>	<b>Sr ppm</b>	<b>Ta ppm</b>	<b>Th ppm</b>	<b>U ppm</b>	<b>V ppm</b>	<b>Y ppm</b>	<b>Yb ppm</b>	<b>Zn ppm</b>
SH-2/28-AD	17	7.0	<5	120	<20	nr	<100	45	18	2.0	29
SH-2/29-AD	18	7.6	<5	140	<20	nr	<100	48	21	2.5	34
SH-2/30-AD	18	5.6	23	160	<20	10	<100	40	12	1.3	26
SH-2/31-AD	15	8.3	6.7	150	<20	18	<100	50	22	3.0	28
SH-2/32-AD	34	18	5.4	92	<20	25	<100	140	22	2.5	120
SH-2/33-AD	24	11	30	51	<20	20	<100	100	19	2.1	48
SH-2/34-AD	26	12	8	93	<20	17	<100	87	19	2.2	110
SH-2/35-AD	16	9.3	16	140	<20	24	<100	61	29	3.6	32
SH-2/36-AD	19	5.8	<5	130	<20	14	<100	39	16	1.8	24
SH-2/37-AD	24	9.6	<5	91	<20	16	<100	71	16	1.8	94

**Appendix 8. Results of Energy Dispersive X-ray Fluorescence (EDXRF) analyses of air-dried sediment samples recovered from the SH-2 borehole at Rajoir, Bangladesh.**

[David Siems and Tammy Hannah, USGS, Analysts; wt.% weight percent; ppm, parts per million]

<b>Sample</b>	<b>Ag ppm</b>	<b>As ppm</b>	<b>Ba ppm</b>	<b>Bi ppm</b>	<b>Br ppm</b>	<b>Cd ppm</b>	<b>Ce ppm</b>	<b>Cr ppm</b>	<b>Cs ppm</b>	<b>Cu ppm</b>	<b>Ga ppm</b>	<b>Ge ppm</b>	<b>La ppm</b>
SH-2/1-AD	<1	3	530	<5	6	<1	90	90	11	37	19	<2	45
SH-2/2-AD	<1	2	400	<5	<1	<1	93	53	6	19	15	<2	48
SH-2/3-AD	<1	3	520	<5	<1	<1	86	97	10	51	17	<2	43
SH-2/4-AD	<1	<2	410	<5	<1	<1	71	46	8	19	12	<2	38
SH-2/5-AD	<1	<2	390	<5	<1	<1	80	47	7	20	12	<2	43
SH-2/6-AD	<1	<2	410	<5	<1	<1	71	37	8	19	12	<2	40
SH-2/7-AD	<1	<2	360	<5	<1	<1	60	28	5	20	9	<2	36
SH-2/8-AD	<1	<2	290	<5	<1	<1	47	29	<5	41	6	<2	28
SH-2/9-AD	<1	9	580	<5	1	<1	71	110	15	65	20	<2	36
SH-2/10-AD	<1	<2	250	<5	<1	<1	29	17	<5	47	7	4	15
SH-2/11-AD	<1	<2	380	<5	<1	<1	54	24	<5	18	10	<2	32
SH-2/12-AD	<1	<2	530	<5	1	<1	35	84	18	37	18	<2	19
SH-2/13-AD	<1	<2	390	<5	<1	<1	71	42	6	21	11	<2	39
SH-2/14-AD	<1	<2	440	<5	1	<1	58	43	8	21	10	<2	30
SH-2/15-AD	<1	3	390	<5	2	<1	73	52	6	47	13	<2	37
SH-2/16-AD	<1	<2	420	<5	<1	<1	61	20	7	48	8	<2	34
SH-2/17-AD	<1	<2	420	<5	<1	<1	57	34	8	20	12	<2	33
SH-2/18-AD	<1	<2	410	<5	<1	<1	74	36	5	27	11	<2	41
SH-2/19-AD	<1	<2	420	<5	<1	<1	61	35	9	25	10	<2	34
SH-2/20-AD	<1	<2	470	<5	<1	<1	73	28	7	18	9	<2	41
SH-2/21-AD	<1	<2	480	<5	<1	<1	73	29	5	19	9	<2	41
SH-2/22-AD	<1	<2	580	<5	<1	<1	61	33	7	18	10	<2	35
SH-2/23-AD	<1	2	530	<5	<1	<1	49	33	6	26	11	<2	26
SH-2/24-AD	<1	<2	590	<5	<1	<1	63	42	11	23	12	<2	34
SH-2/25-AD	<1	<2	440	<5	<1	<1	34	23	7	18	8	<2	22
SH-2/26-AD	<1	<2	440	<5	<1	<1	32	23	<5	19	10	<2	21
SH-2/27-AD	<1	<2	650	<5	<1	<1	50	30	10	51	10	<2	30



**Appendix 8. Results of EDXRF analyses—Continued.**

<b>Sample</b>	<b>Ag ppm</b>	<b>As ppm</b>	<b>Ba ppm</b>	<b>Bi ppm</b>	<b>Br ppm</b>	<b>Cd ppm</b>	<b>Ce ppm</b>	<b>Cr ppm</b>	<b>Cs ppm</b>	<b>Cu ppm</b>	<b>Ga ppm</b>	<b>Ge ppm</b>	<b>La ppm</b>
SH-2/28-AD	<1	<2	420	<5	1	<1	85	40	8	19	10	<2	45
SH-2/29-AD	<1	<2	1200	<5	<1	<1	90	43	12	22	11	<2	53
SH-2/30-AD	<1	<2	1200	<5	<1	<1	64	31	14	9	10	<2	40
SH-2/31-AD	<1	<2	910	<5	<1	<1	100	36	9	11	11	<2	59
SH-2/32-AD	<1	6	660	<5	<1	<1	78	120	18	45	24	<2	42
SH-2/33-AD	<1	4	420	<5	<1	<1	110	75	9	41	16	<2	47
SH-2/34-AD	<1	21	610	<5	<1	<1	89	85	11	74	18	<2	45
SH-2/35-AD	<1	<2	370	<5	<1	<1	130	36	5	12	11	<2	66
SH-2/36-AD	<1	<2	500	<5	<1	<1	87	87	7	64	13	<2	43
SH-2/37-AD	<1	7	420	<5	1	<1	85	40	8	19	10	<2	45

**Appendix 8. Results of EDXRF analyses—Continued.**

<b>Sample</b>	<b>Mo ppm</b>	<b>Nb ppm</b>	<b>Nd ppm</b>	<b>Ni ppm</b>	<b>Pb ppm</b>	<b>Rb ppm</b>	<b>Sb ppm</b>	<b>Se ppm</b>	<b>Sn ppm</b>	<b>Sr ppm</b>	<b>Th ppm</b>	<b>U ppm</b>
SH-2/1-AD	<2	16	40	53	25	180	<2	<1	5	110	19	<4
SH-2/2-AD	<2	12	44	37	19	110	<2	<1	3	140	16	<4
SH-2/3-AD	<2	16	30	54	25	150	<2	<1	5	140	19	<4
SH-2/4-AD	<2	10	26	32	19	110	<2	<1	3	170	9	5
SH-2/5-AD	<2	10	29	30	17	95	<2	<1	3	170	15	<4
SH-2/6-AD	<2	8	32	28	18	100	<2	<1	2	170	10	<4
SH-2/7-AD	<2	6	33	21	16	78	<2	<1	<2	160	9	<4
SH-2/8-AD	<2	6	22	20	14	70	<2	<1	<2	89	9	4
SH-2/9-AD	<2	14	36	71	37	170	<2	<1	4	140	18	5
SH-2/10-AD	<2	5	<10	23	13	65	<2	<1	2	83	5	<4
SH-2/11-AD	<2	6	16	19	18	88	<2	<1	2	160	9	<4
SH-2/12-AD	<2	13	16	50	22	210	<2	<1	5	120	5	<4
SH-2/13-AD	<2	9	30	26	17	87	<2	<1	2	140	11	<4
SH-2/14-AD	<2	9	26	28	19	110	<2	<1	3	140	9	<4
SH-2/15-AD	<2	10	34	36	18	100	<2	<1	3	110	13	4
SH-2/16-AD	2	5	44	14	19	88	<2	<1	2	110	8	6
SH-2/17-AD	<2	8	26	24	18	100	<2	<1	2	150	6	<4
SH-2/18-AD	<2	9	27	24	18	87	<2	<1	2	160	13	<4
SH-2/19-AD	<2	7	32	24	18	100	<2	<1	2	140	9	<4
SH-2/20-AD	<2	8	36	18	18	85	<2	<1	<2	140	14	4
SH-2/21-AD	<2	7	29	23	17	84	<2	<1	<2	140	11	<4
SH-2/22-AD	<2	7	30	22	18	93	<2	<1	2	140	8	<4
SH-2/23-AD	<2	7	24	31	23	110	<2	<1	2	130	7	<4
SH-2/24-AD	<2	10	30	36	20	120	<2	<1	3	140	13	7
SH-2/25-AD	<2	6	14	21	18	100	<2	<1	<2	120	5	<4
SH-2/26-AD	<2	6	15	23	19	100	<2	<1	2	120	6	<4
SH-2/27-AD	<2	6	22	19	18	98	<2	<1	3	140	7	<4

**Appendix 8. Results of EDXRF analyses—Continued.**

<b>Sample</b>	<b>Mo ppm</b>	<b>Nb ppm</b>	<b>Nd ppm</b>	<b>Ni ppm</b>	<b>Pb ppm</b>	<b>Rb ppm</b>	<b>Sb ppm</b>	<b>Se ppm</b>	<b>Sn ppm</b>	<b>Sr ppm</b>	<b>Th ppm</b>	<b>U ppm</b>
SH-2/28-AD	<2	9	40	25	17	88	<2	<1	2	130	15	6
SH-2/29-AD	<2	9	46	25	16	77	<2	<1	3	160	13	<4
SH-2/30-AD	2	8	37	20	19	89	<2	<1	2	160	9	<4
SH-2/31-AD	<2	8	43	24	16	69	<2	<1	3	160	16	<4
SH-2/32-AD	2	19	32	61	36	200	<2	<1	6	90	24	7
SH-2/33-AD	<2	16	35	45	24	100	<2	<1	4	54	19	6
SH-2/34-AD	<2	17	48	47	26	130	<2	<1	5	97	19	6
SH-2/35-AD	<2	12	47	22	16	76	<2	<1	3	150	22	5
SH-2/36-AD	<2	16	41	49	19	110	<2	<1	4	96	15	<4
SH-2/37-AD	<2	9	40	25	17	88	<2	<1	2	130	15	6

**Appendix 8. Results of EDXRF analyses—Continued.**

<b>Sample</b>	<b>V ppm</b>	<b>W ppm</b>	<b>Y ppm</b>	<b>Zn ppm</b>	<b>Zr ppm</b>
SH-2/1-AD	110	<5	35	84	108
SH-2/2-AD	71	<5	33	55	71
SH-2/3-AD	110	<5	35	83	107
SH-2/4-AD	56	<5	25	48	56
SH-2/5-AD	53	<5	26	41	53
SH-2/6-AD	45	<5	19	43	45
SH-2/7-AD	33	<5	17	33	33
SH-2/8-AD	28	<5	16	46	28
SH-2/9-AD	110	<5	27	103	113
SH-2/10-AD	24	160	12	49	24
SH-2/11-AD	30	<5	16	35	30
SH-2/12-AD	91	<5	17	93	91
SH-2/13-AD	55	<5	21	34	55
SH-2/14-AD	53	<5	18	50	53
SH-2/15-AD	62	<5	26	78	62
SH-2/16-AD	24	<5	15	81	24
SH-2/17-AD	43	<5	18	36	43
SH-2/18-AD	52	<5	25	77	52
SH-2/19-AD	41	<5	17	40	41
SH-2/20-AD	34	<5	22	30	34
SH-2/21-AD	37	<5	19	30	37
SH-2/22-AD	36	<5	16	33	36
SH-2/23-AD	41	<5	14	78	41
SH-2/24-AD	51	<5	23	54	51
SH-2/25-AD	31	<5	13	31	31
SH-2/26-AD	32	<5	13	31	32
SH-2/27-AD	35	<5	15	52	35

**Appendix 8. Results of EDXRF analyses—Continued.**

<b>Sample</b>	<b>V ppm</b>	<b>W ppm</b>	<b>Y ppm</b>	<b>Zn ppm</b>	<b>Zr ppm</b>
SH-2/28-AD	43	<5	25	36	43
SH-2/29-AD	52	<5	26	40	52
SH-2/30-AD	38	<5	16	36	38
SH-2/31-AD	54	<5	28	44	54
SH-2/32-AD	140	<5	35	112	140
SH-2/33-AD	105	<5	34	59	105
SH-2/34-AD	99	<5	36	107	99
SH-2/35-AD	61	<5	37	43	61
SH-2/36-AD	85	<5	33	97	85
SH-2/37-AD	43	<5	25	36	43

**Appendix 9.** Results of arsenic analyses by Hydride Generation Atomic Absorption Spectrophotometry (HGAAS) of air-dried sediment samples from the SH-2 borehole, Rajoir, Bangladesh.

[Zoe Ann Brown, USGS, Analyst; ppm, parts per million]

<b>Sample</b>	<b>As (ppm)</b>
SH-2/1-AD	3.9
SH-2/2-AD	2.5
SH-2/3-AD	4.2
SH-2/4-AD	1.9
SH-2/5-AD	1.3
SH-2/6-AD	1.2
SH-2/7-AD	1.2
SH-2/8-AD	2.7
SH-2/9-AD	11.0
SH-2/10-AD	1.6
SH-2/11-AD	1.1
SH-2/12-AD	1.5
SH-2/13-AD	0.8
SH-2/14-AD	0.7
SH-2/15-AD	4.8
SH-2/16-AD	1.0
SH-2/17-AD	0.7
SH-2/18-AD	1.1
SH-2/19-AD	0.7
SH-2/20-AD	0.6
SH-2/21-AD	0.6
SH-2/22-AD	0.8
SH-2/23-AD	2.4
SH-2/24-AD	1.0
SH-2/25-AD	1.8
SH-2/26-AD	0.9
SH-2/27-AD	0.9
SH-2/28-AD	1.1
SH-2/29-AD	0.8
SH-2/30-AD	0.7
SH-2/31-AD	0.6
SH-2/32-AD	6.5
SH-2/33-AD	5.1
SH-2/34-AD	21.0
SH-2/35-AD	0.6
SH-2/36-AD	1.2
SH-2/37-AD	8.1

**Appendix 10.** Total iron and ferrous iron extracted from preserved sediment samples from the SH-2 borehole, Rajoir, Bangladesh using a solution of 0.5 N HCl.

[Values calculated based on dry weight of the post-extraction residue; wt.%, weight percent; Ferrous/Total Iron values >1 are within the 5 % relative error]

	<b>Total Iron (wt. %)</b>	<b>Ferrous (wt.%)</b>	<b>Ferrous / Total Iron</b>
SH-2/1-P	0.36	0.34	0.95
SH-2/2-P	0.65	0.59	0.92
SH-2/3-P	0.84	0.75	0.90
SH-2/4-P	0.36	0.32	0.89
SH-2/5-P	0.22	0.20	0.91
SH-2/6-P	0.40	0.37	0.91
SH-2/7-P	0.19	0.19	0.96
SH-2/8-P	0.29	0.26	0.89
SH-2/9-P	1.13	1.10	0.98
SH-2/11-P	0.13	0.12	0.92
SH-2/12-P	0.82	0.79	0.96
SH-2/13-P	0.66	0.63	0.95
SH-2/14-P	0.30	0.27	0.90
SH-2/15-P	0.63	0.60	0.96
SH-2/16-P	0.07	0.07	0.91
SH-2/17-P	0.32	0.29	0.93
SH-2/18-P	0.21	0.19	0.88
SH-2/19-P	0.24	0.22	0.93
SH-2/20-P	0.14	0.13	0.96
SH-2/21-P	0.10	0.09	0.95
SH-2/22-P	0.21	0.20	0.97
SH-2/23-P	0.82	0.73	0.90
SH-2/24-P	0.55	0.53	0.97
SH-2/25-P	0.62	0.60	0.97
SH-2/26-P	0.22	0.21	0.95
SH-2/27-P	0.20	0.19	0.96
SH-2/28-P	0.63	0.61	0.97
SH-2/29-P	0.11	0.10	0.98
SH-2/30-P	0.15	0.13	0.92
SH-2/31-P	0.13	0.12	0.97
SH-2/32-P	0.11	0.10	0.93
SH-2/33-P	1.02	1.03	1.01
SH-2/34-P	0.93	0.96	1.03
SH-2/35-P	0.13	0.14	1.03
SH-2/36-P	0.10	0.10	0.98
SH-2/37-P	0.70	0.69	0.99

**Appendix 11.** Results of analyses of 0.5 N HCl extract solutions after reaction with preserved sediment samples from the SH-2 borehole Rajoir, Bangladesh. Concentrations determined by ICP-AES unless otherwise indicated.

[Paul Briggs and Z. A. Brown, USGS, Analyses; \*, determined by HGAAS. Values calculated based on dry weight of the post-extraction residue; ppm, parts per million]

Sample	Al (ppm)	As* (ppm)	B (ppm)	Ba (ppm)	Be (ppm)	Ca (ppm)	Cd (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	Fe (ppm)	K (ppm)
SH-2/1-P	2600	1.0	2.7	20	0.4	1600	0.5	4.4	4.0	13	5600	580
SH-2/2-P	2600	0.2	0.9	23	0.2	3400	<0.2	3.6	4.3	6	9500	380
SH-2/3-P	3300	1.5	1.6	44	0.4	3900	0.2	5.1	5.2	28	11,000	390
SH-2/4-P	1400	0.4	1.6	23	0.1	850	<0.2	2.4	3.4	3	4800	270
SH-2/5-P	1100	0.2	0.8	16	0.1	840	<0.2	1.7	1.9	2	3600	260
SH-2/6-P	1600	0.2	0.6	28	0.2	900	<0.2	2.4	2.8	4	5100	280
SH-2/7-P	580	0.2	2.3	13	0.1	460	<0.2	1.2	1.3	17	2500	160
SH-2/8-P	770	0.2	0.6	22	0.1	730	<0.2	1.6	2.0	11	3700	190
SH-2/9-P	570	0.7	1.9	140	0.8	2600	0.2	8.2	7.5	11	18,000	850
SH-2/11-P	540	0.1	0.7	9	0.1	530	<0.2	0.8	1.4	1	1400	160
SH-2/12-P	2200	0.2	0.5	40	0.4	780	<0.2	3.2	14.9	10	7800	520
SH-2/13-P	1700	<0.1	1.6	36	0.4	880	<0.2	3.7	4.6	88	8600	530
SH-2/14-P	930	0.1	2.5	19	0.1	820	<0.2	1.5	3.0	31	3700	350
SH-2/15-P	1300	0.7	1.1	38	0.6	1300	<0.2	6.0	2.0	14	8400	320
SH-2/16-P	330	0.1	0.4	6	0.1	260	<0.2	1.1	1.4	1	950	95
SH-2/17-P	180	0.1	0.8	22	0.3	980	<0.2	4.8	4.3	33	4100	470
SH-2/18-P	1100	0.2	1.3	17	0.1	1000	<0.2	2.0	2.5	11	2700	340
SH-2/19-P	1100	0.1	0.8	16	0.2	580	<0.2	1.8	2.9	11	3200	320
SH-2/20-P	640	<0.1	1.2	9	0.1	560	<0.2	1.4	1.5	1	1800	150
SH-2/21-P	460	<0.1	0.5	10	0.1	510	<0.2	1.0	1.6	1	1400	110
SH-2/22-P	740	0.1	0.6	10	0.1	640	<0.2	1.9	3.3	2	2900	150
SH-2/23-P	1100	6.2	0.6	37	0.4	1000	0.7	18	1.1	6	16,000	310
SH-2/24-P	2700	0.2	1.5	28	0.4	970	<0.2	8.3	4.9	4	7900	260
SH-2/25-P	1500	0.5	0.9	21	0.3	950	<0.2	3.2	2.9	3	8200	290
SH-2/26-P	1000	0.1	1.0	20	0.2	890	<0.2	1.8	2.7	2	2900	240
SH-2/27-P	970	0.1	0.7	220	0.2	630	<0.2	1.8	2.0	11	2700	290



**Appendix 11. Results of analyses of 0.5 N HCl extract solutions—Continued**

<b>Sample</b>	<b>Al (ppm)</b>	<b>As* (ppm)</b>	<b>B (ppm)</b>	<b>Ba (ppm)</b>	<b>Be (ppm)</b>	<b>Ca (ppm)</b>	<b>Cd (ppm)</b>	<b>Co (ppm)</b>	<b>Cr (ppm)</b>	<b>Cu (ppm)</b>	<b>Fe (ppm)</b>	<b>K (ppm)</b>
SH-2/28-P	990	0.1	1.0	40	0.2	750	<0.2	2.3	1.7	20	8000	330
SH-2/29-P	580	0.1	0.8	8	0.1	590	<0.2	1.2	1.6	1	1500	150
SH-2/30-P	630	0.1	1.1	200	0.2	620	<0.2	1.4	1.0	16	2000	220
SH-2/31-P	770	0.1	2.0	220	0.2	780	<0.2	2.3	1.8	62	1800	290
SH-2/32-P	1200	<0.1	1.8	110	0.7	3000	<0.2	0.4	0.4	6	1600	280
SH-2/33-P	1100	0.4	1.2	77	0.7	2900	<0.2	4.1	0.7	21	13,000	180
SH-2/34-P	3800	0.1	1.2	73	0.8	1600	<0.2	4.5	7.7	21	13,000	320
SH-2/35-P	530	0.8	1.1	9	0.1	1100	<0.2	0.9	1.5	1	1900	150
SH-2/36-P	500	0.1	0.7	27	0.1	730	<0.2	1.4	1.6	1	1500	140
SH-2/37-P	2100	0.2	1.3	36	0.5	1800	<0.2	4.9	3.9	9	10,000	360

**Appendix 11. Results of analyses of 0.5 N HCl extract solutions—Continued**

<b>Sample</b>	<b>Li (ppm)</b>	<b>Mg (ppm)</b>	<b>Mn (ppm)</b>	<b>Mo (ppm)</b>	<b>Na (ppm)</b>	<b>Ni (ppm)</b>	<b>P (ppm)</b>	<b>Pb (ppm)</b>	<b>Sb (ppm)</b>	<b>SiO<sub>2</sub> (ppm)</b>
SH-2/1-P	4.1	1900	64	0.33	96	11	360	8.0	<2	3500
SH-2/2-P	4.3	2900	270	0.33	72	10	370	5.2	<2	4000
SH-2/3-P	4.0	3900	440	0.31	280	13	480	13	<2	5400
SH-2/4-P	2.5	1000	75	0.29	210	8	270	3.3	<2	2300
SH-2/5-P	2.1	710	66	0.33	130	6	320	2.6	<2	1700
SH-2/6-P	2.9	1300	96	0.26	250	7	190	4.3	<2	2300
SH-2/7-P	1.0	340	39	0.26	180	3	200	2.4	<2	970
SH-2/8-P	1.5	520	330	0.26	320	3	130	3.6	<2	1200
SH-2/9-P	7.5	3800	120	0.33	950	18	320	23	<2	4700
SH-2/11-P	1.0	360	33	0.27	240	3	140	2.4	<2	1000
SH-2/12-P	2.2	1900	71	0.27	630	13	110	7.7	<2	2900
SH-2/13-P	1.8	1200	160	0.27	590	9	170	7.0	<2	2300
SH-2/14-P	1.5	690	57	0.26	700	4	180	3.8	<2	1400
SH-2/15-P	2.0	1300	340	0.29	1100	10	110	11	<2	1800
SH-2/16-P	0.4	240	7	0.28	100	2	35	2.0	<2	730
SH-2/17-P	2.2	1200	54	0.27	250	10	210	5.6	<2	2500
SH-2/18-P	1.6	700	47	0.27	260	5	310	3.7	<2	2000
SH-2/19-P	1.8	800	68	0.27	250	6	130	2.6	<2	1600
SH-2/20-P	1.0	580	34	0.26	170	4	110	2.3	<2	1100
SH-2/21-P	0.7	390	17	0.28	190	3	110	2.5	<2	890
SH-2/22-P	1.0	570	82	0.27	230	6	160	2.8	<2	1300
SH-2/23-P	1.5	860	970	0.27	230	39	230	26	<2	1700
SH-2/24-P	3.6	2200	160	0.29	360	17	160	5.9	<2	2800
SH-2/25-P	2.0	1200	380	0.29	210	7	290	3.4	<2	2200
SH-2/26-P	1.3	810	46	0.27	170	6	290	2.9	<2	1500
SH-2/27-P	1.6	730	54	0.29	340	5	130	2.4	<2	1800

**Appendix 11. Results of analyses of 0.5 N HCl extract solutions—Continued**

<b>Sample</b>	<b>Li (ppm)</b>	<b>Mg (ppm)</b>	<b>Mn (ppm)</b>	<b>Mo (ppm)</b>	<b>Na (ppm)</b>	<b>Ni (ppm)</b>	<b>P (ppm)</b>	<b>Pb (ppm)</b>	<b>Sb (ppm)</b>	<b>SiO<sub>2</sub> (ppm)</b>
SH-2/28-P	1.6	740	570	0.3	270	4	200	4.0	<2	1800
SH-2/29-P	1.0	430	28	0.3	320	3	190	2.4	<2	1200
SH-2/30-P	1.1	450	61	0.3	300	3	150	3.0	<2	1400
SH-2/31-P	1.1	500	28	0.3	350	3	170	2.6	<2	1700
SH-2/32-P	1.2	1700	51	0.3	850	1	88	13	<2	2100
SH-2/33-P	0.9	1230	540	0.3	440	3	110	18	<2	1900
SH-2/34-P	3.5	2900	91	0.3	470	9	44	13	<2	3700
SH-2/35-P	0.9	350	37	0.3	120	3	440	2.3	<2	1100
SH-2/36-P	0.9	330	23	0.3	150	3	260	1.6	<2	960
SH-2/37-P	3.6	1700	540	0.3	730	11	180	11	<2	3200

**Appendix 11. Results of analyses of 0.5 N HCl extract solutions—Continued**

<b>Sample</b>	<b>Sr (ppm)</b>	<b>Ti (ppm)</b>	<b>V (ppm)</b>	<b>Zn (ppm)</b>
SH-2/1-P	10	54	14	32
SH-2/2-P	8	170	7.1	19
SH-2/3-P	12	140	13	24
SH-2/4-P	3	100	4.2	9
SH-2/5-P	3	73	3.0	8
SH-2/6-P	5	95	5.0	11
SH-2/7-P	2	12	1.7	13
SH-2/8-P	5	20	2.9	11
SH-2/9-P	23	<1	20	37
SH-2/11-P	2	31	1.3	4
SH-2/12-P	6	36	8.6	19
SH-2/13-P	5	<1	7.2	53
SH-2/14-P	5	<1	2.7	27
SH-2/15-P	9	<1	6.1	19
SH-2/16-P	2	6	0.9	4
SH-2/17-P	5	83	6.8	27
SH-2/18-P	5	77	3.2	13
SH-2/19-P	4	76	3.1	14
SH-2/20-P	4	32	1.8	6
SH-2/21-P	3	17	1.5	4
SH-2/22-P	3	55	2.6	7
SH-2/23-P	4	53	9.0	13
SH-2/24-P	6	150	8.8	22
SH-2/25-P	3	150	7.2	13
SH-2/26-P	4	92	3.3	8
SH-2/27-P	10	62	2.2	15

**Appendix 11. Results of analyses of 0.5 N HCl extract solutions—Continued**

<b>Sample</b>	<b>Sr (ppm)</b>	<b>Ti (ppm)</b>	<b>V (ppm)</b>	<b>Zn (ppm)</b>
SH-2/28-P	4	67	5.2	19
SH-2/29-P	2	25	1.8	5
SH-2/30-P	10	25	1.5	15
SH-2/31-P	12	12	1.6	45
SH-2/32-P	28	<1	4.6	9
SH-2/33-P	17	<1	5.9	15
SH-2/34-P	15	71	8.0	29
SH-2/35-P	3	29	1.5	5
SH-2/36-P	3	25	1.3	5
SH-2/37-P	13	9	4.6	20

``**Appendix 12.** Concentrations of acid-volatile sulfide (AVS), reducible sulfide (DI), and acid-soluble sulfate (SO<sub>4</sub>) in selected preserved sediment samples from the SH-2 borehole, Rajoir, Bangladesh.

[ppm, parts per million]

<b>Sample</b>	<b>Sulfide -AVS (ppm)</b>	<b>Sulfide -DI (ppm)</b>	<b>Acid-soluble-SO<sub>4</sub> (ppm)</b>
SH-2/1-P	5250	9580	100
SH-2/2-P	390	350	50
SH-2/3-P	70	210	130
SH-2/9-P	80	214	60
SH-2/15-P	220	400	50
SH-2/29-P	10	30	50
SH-2/34-P	30	150	50
SH-2/37-P	20	300	30