UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Analytical results for stream sediment and soil samples from the Commonwealth of Puerto Rico, Isla de Culebra, and Isla de Vieques

By
Sherman P. Marsh

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U.S. Geological Survey, DFC, Box 25046, MS 973, Denver, CO 80225

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CONTENTS

ILLUSTRATIONS

TABLES

INTRODUCTION

This report presents the results of a geochemical survey of the Commonwealth of

Puerto Rico, Isla de Culebra, and Isla de Vieques as digital data files on a 1.2 megabyte floppy disk. A regional stream-sediment geochemical survey of Puerto Rico began in the early 1970's as an outgrowth of the cooperative exploration geochemical studies by the Department of Natural Resources of Puerto Rico (DNR) and the U.S. Geological Survey (USGS) on the Rio Tanama and Rio Vivi copper projects. From the early 1970's through the mid-1980's stream sediment sampling continued over a large part of the island. In 1980 a cooperative project between DNR and the USGS was started to continue the regional stream sediment sampling program and continued for several years. A total of 2560 stream sediment samples were collected during this phase of the project. In 1990 a systematic search of USGS computer records yielded a geochemical data set for the stream sediments which indicated that the geochemical sample net for the island was incomplete. In 1991 two field trips were made to Puerto Rico and an additional 292 stream sediment samples were collected and analyzed in order to complete the regional geochemical survey. The analytical results of a total of 2852 stream sediment samples are included on the floppy disk. In addition to the main island of Puerto Rico, the islands of Culebra and Vieques were sampled.

GEOLOGY (from Schellekens, 1991)

Puerto Rico, the eastern-most island of the Greater Antilles, is a translational island-arc terrane with a geologic record of 140 million years. The island lies within the seismically active Caribbean-North American Plate boundary zone. The relative motion between the two plates is on the order of 2 cm per year and is mainly taken up by strong oblique underthrusting and left-lateral faulting in the Puerto Rico trench. A well defined southward dipping Benioff zone occurs under the eastern half of the island but is missing under the west side (McCann and Sykes, 1984; Schell and Tarr, 1978). Some plate motion and underthrusting also occurs south of Puerto Rico in the Muertos Trough.

Puerto Rico and the Virgin Islands appear to be a separate tectonic block within the plate boundary zone. Puerto Rico is separated from Hispaniola on the west by a zone of active extension, which runs from the Mona canyon through the southwestern quarter of the island. On land extensional faulting has produced the distinctive ridge and valley topography and generally low elevations of southwestern Puerto Rico. Eastern Puerto Rico and the northern Virgin Islands are separated from St. Croix and the Lesser Antilles by another active zone of extension which formed the Whiting Basin (south of Puerto Rico, the Virgin Islands basin, and the Anegada Passage.

Puerto Rico consists of volcanic, volcaniclastic, and sedimentary rocks of Late Jurassic to Early Tertiary age, which were intruded by felsic plutonic rocks during the Late Cretaceous and Early Tertiary, and are overlain by slightly tilted Oligocene and younger sedimentary rocks and sediments (Briggs and Akers, 1965).

Island-wide lithostratigraphic correlation within the basement rocks is difficult because individual units appear to have limited original lateral extent and the rocks have been subsequently strongly deformed and faulted. To overcome these correlation problems earlier workers divided the island into structural blocks (Cox and Briggs, 1973) or subprovinces (Barabas, 1977).

Figure 1. The Commonwealth of Puerto Rico, Isla de Culebra, and Isla de Vieques

METHODS OF STUDY

Sample Media and Collection

During the cooperative project between the USGS and DNR sediment samples were

collected from first order streams that drained basins from less than 1 square kilometer to as much as 3 square kilometers. The sediment samples were collected from the main channel of mostly active streams. The sediment samples collected in 1991 were from first and second order streams and represented drainage basins as large as 10 square kilometers. These samples were also collected from the main channel of active streams. The island of Vieques was geochemically sampled for soils in 1972 and a report describing the results are discussed in Learned and Boissen (1972). A soil sample survey for Isla de Vieques was conducted, rather than a stream sediment survey, because stream drainages were poorly developed and commonly filled with colluvium and, when near populated areas, highly contaminated. A total of 421 soil samples were taken of the C horizon (weathered bedrock) on 0.5 kilometer centers on northwest trending traverses spaced approximately 1 kilometer apart. The small island of Culebra was sampled geoochemically in late 1970 as part of a study to determine the islands natural resources, development potential, and socio-economic aspects (Commonwealth of Puerto Rico, 1970). Because of the lack of active streams on the island geochemical samples of dry stream bed material were collected. This material included pebbles and cobbles showing the most intense iron staining and any material showing traces of mineralization. A total of 46 samples were collected.

Sample Preparation

All samples were sieved to minus 80 mesh (0.18 mm) and then pulverized to approximately minus-100 mesh (minus-0.15 mm) with a grinder using ceramic plates.

Sample Analysis

All samples were analyzed for 35 elements using a semiquantitative, direct-current arc emission spectrographic method (Grimes and Marranzino, 1968). The elements analyzed and their limits of determination are listed in table 2. Values determined for the major elements (iron, magnesium, calcium, phosphorus, sodium, sulfur and titanium) are given in weight percent; all others are given in parts per million (micrograms/gram).

Spectrographic results were obtained by visual comparison of spectra derived from the sample against spectra obtained from standards made from pure oxides and carbonates. Standard concentrations are geometrically spaced over any given order of magnitude of concentration as follows: 100, 50, 20, 10, and so forth. Samples whose concentrations are estimated to fall between those values are assigned values of 70, 30, 15, and so forth. The precision of the analytical method is approximately plus or minus one reporting interval at the 83 percent confidence level and plus or minus two reporting intervals at the 96 percent confidence level (Motooka and Grimes, 1976).

Atomic absorption results for gold were obtained after preparing the samples for analysis using the method of Thompson and others (1968) for samples collected between 1970 and 1985 and by the method of O'Leary and Meier (1986) for samples collected in 1991. Atomic absorption results for zinc were obtained by using a nitric acid digestion method described by Ward and others, (1969) for the samples collected between 1970 and 1985. for samples collected in 1991 zinc, and 9 other elements, were analyzed using ICP-AES by the method of Motooka (1988) (Table 2).

DATA STORAGE SYSTEM

Upon completion of the analytical work, the results were entered into a U.S. Geological Survey computer data base called RASS. This data base contains both descriptive geological

information and analytical data. Any or all of this information may be retrieved and converted to a binary form (STATPAC) for computerized statistical analysis or publication (VanTrump and Miesch, 1977).

COMPUTER DISKETTE

The following text is included on the 1.2 megabyte diskette as a readme file titled "README.DOC". In addition to this file there are data files and a file containing the complete text of this report.

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FILES ON THIS DISK

CULEBRA.STP is a binary file of chemical data for Isla de Culebra
VIEQUES.STP is a binary file of chemical data for Isla de Vieques
PRNEW.STP is a binary file of 1991 chemical data for Puerto Rico
PROLD.STP is a binary file of 1975-1985 chemical data for Puerto Rico
STP2DAT.EXE is a conversion program from "STP" data file to other commonly used data files (DBF, CMN, PST, DIF, and others).
PROFR.ASC is an ASCI text file of the U.S. Geological Survey Open-File Report 92-
README.DOC is an ASCI text file explaining the files on this diskette

The data tables (*.STP) can be converted into several formats, including DBF, DIF, and ASCII by using the program STP2DAT, authored by W.D. Grundy of the USGS. This program is included on this disk.

This disk contains geochemical data from 2560 stream sediment samples collected in Puerto Rico, 421 soil samples collected on Isla de Vieques, and 35 soil samples were collected on Isla de Culebra. Each rock sample was analyzed for 35 elements by semiquantitative spectrographic method and for gold and zinc by other chemical methods. Requirements: IBM PC or compatible, 1.2 megabyte disk drive, and a minimum 512K RAM. To order a paper or microfiche copy of this report, order OF92-353A, p. and to order an executable

diskette, order OF92-353B.

Disclaimer:
Although the program STP2DAT.EXE has been used by the U.S. Geological Survey, no warranty,
expressed or implied is made by the USGS as to the accuracy and functioning of the program and related material, nor shall the fact of distribution constitute any such warranty, and no responsibility is assumed by the USGS in connection therewith.

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TABLE 1. Limits of determination for spectrographic analysis of stream sediment and soil samples

Elements	Lower determination limits	upper determination limits
	Percent	
Iron (Fe)	0.05	20
Magnesium (Mg)	0.02	10
Calcium (Ca)	0.05	20
Titanium (Ti)	0.002	1
	Parts per million (ppm)	
Manganese (Mn)	10	5,000
Silver (Ag)	0.5	5,000
Arsenic (As)	200	10,000
Gold (Au	10	500
Boron (B)	10	20,000
Barium (Ba)	20	5,000
Beryllium (Be)	1	1,000
Bismuth (Bi)	10	1,000
Cadmium (Cd)	20	500
Cobalt (Co)	5	2,000
Chromium (Cr)	10	5,000
Copper (Cu)	5	20,000
Lanthanum (La)	20	1,000
Molybdenum (Mo)		2,000
Niobium (Nb)	20	2,000
Nickel (Ni)	5	5,000
Lead (Pb)	10	20,000
Antimony (Sb)	100	10,000
Scandium (Sc)	5	100
Tin (Sn)	10	1,000
Strontium (Sr)	100	5,000
Vanadium (V)	10	10,000
Tungsten (W)	50	10,000
Yttrium (Y)	10	2,000
Zinc (Zn)	200	10,000
Zirconium (Zr)	10	1,000

Thorium (Th)	100	2,000

Table 2. Limits of determination for atomic absorption[a] and inductively coupled plasma-atomic emission spectroscopic analysis of stream sediment and soil samples

Element determined	Method	Lower Limit of Determination (ppm)	References
Gold (Au)	aa	0.05	Thompson and others, 1968
Gold (Au)	aa	0.002	O'Leary and Viets, 1986
Zinc (Zn)	aa	5	Ward and others, 1969
Zinc (Zn)	ICP	0.05	Motooka, 1988
Copper (Cu)	"	0.05	" "
Lead (Pb)	"	0.60	" "
Silver (Ag)	"	0.10	" "
Gold (Au)	"	0.15	" "
Bismuth (Bi)	"	1.0	" "
Cadmium (Cd)	"	0.05	" "
Molybdinum (Mo)	"	0.09	" "
Antimony (Sb)	"	1.0	" "
Arsenic (As)	"	1.0	" "