Gold and Diamond Resources of the Icabarú Sur Study Area, Estado Bolívar, Venezuela

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ABSTRACT

The Icabarú Sur study area is in the southern part of Estado Bolívar, Venezuela, in a transition zone between savanna and jungle. The study area is 15 km southwest of Icabarú, the supply town for miners in the area. Access to the 50-km^2 study area is by helicopter or by unimproved road from Santa Elena de Uairén, approximately 80 km to the east.

Exposed in the study area are Early Proterozoic rhyolitic ash-flow tuffs and a porphyritic rhyolite of the Cuchivero Group and sandstone of the Early to Middle Proterozoic Roraima Group. These rocks have not been affected by regional metamorphism; the ash-flow tuffs have well-preserved compaction foliation, shards, and pumice. Three zircon fractions from one pyrite-bearing sample of the Cuchivero Group have consistent U-Pb ages of about 1.98 Ga. Northeast- to east-striking faults separate the Roraima Group to the north from the volcanic province to the south.

One diamond mine is active in the study area, and numerous small prospects dot streams. Diamonds are panned from gravels derived from the Roraima Group. The presence of placer diamonds suggests a kimberlitic source; however, diamonds were not found in stream-sediment samples from the study area, and minerals indicative of a kimberlitic source have not been identified in the study area or in the outcrop area of the Roraima Group elsewhere in the shield. The primary source of the diamonds remains undetermined.

The presence of silicic volcanic rocks in the study area suggests a potential for epithermal gold deposits. Minor pyrite, a fluorite veinlet in one sample, and small quartz veins cutting the volcanic rocks are the only indications of mineralized rock.

RESUMEN

El área de estudio Icabarú Sur tiene 50 km^2 de área, está localizada a 15 km al suroeste del poblado minero de Icabarú al sur del Estado Bolívar, Venezuela, y está ubicado en una zona transicional entre vegetación sabana y selva. El acceso se realiza desde Santa Elena de Uairén, a 80 km al este de Icabarú, ya sea por helicóptero o por carreteras para vehículos de doble tracción.

En el área de estudio están expuestas toba riolítica de flujo de ceniza y riolita porfirítica, ambas del Grupo Cuchivero, además aflora arenisca perteneciente al Grupo Roraima de edad Proterozoico Temprano a Medio. Estas rocas no han sido afectadas por metamorfismo regional; la toba riolítica de flujo de ceniza presenta foliación por compactación, esquirlas y fragmentos de pómez. Las tres fracciones de circón de una muestra que contiene pyrita arrojaron edades consistentes por el método U-Pb de aproximadamente 1.98 Ga. El Grupo Roraima, al norte, está separado de la provincia volcánica, al sur, por fallas que tienen un rumbo noreste a este.

Hay una mina de diamante activa en el área, y numerosos prospectos pequeños a lo largo de las quebradas. Los diamantes son extraidos con suruca (wire-mesh pan) a partir de grava derivada del Grupo Roraima. La presencia de diamante en depósitos tipo placer sugiere una fuente kimberlítica, sin embargo, no se encontraión diamantes en sedimentos de quebradas, además, no se han encontrado minerales indicativos de una fuente kimberlítica en el área de estudio o en rocas del Grupo Roraima a través del Escudo de Guayana. La fuente primaria de los diamantes permanece indeterminada.

La presencia de rocas volcánicas siliceas en Icabarú Sur sugiere un potencial de depósitos auríferos epitermales. La única indicación de mineralización en el área es trazas de pirita, una venilla de fluorita en una muestra y vetas pequeñas de cuarzo que invaden las rocas volcánicas.

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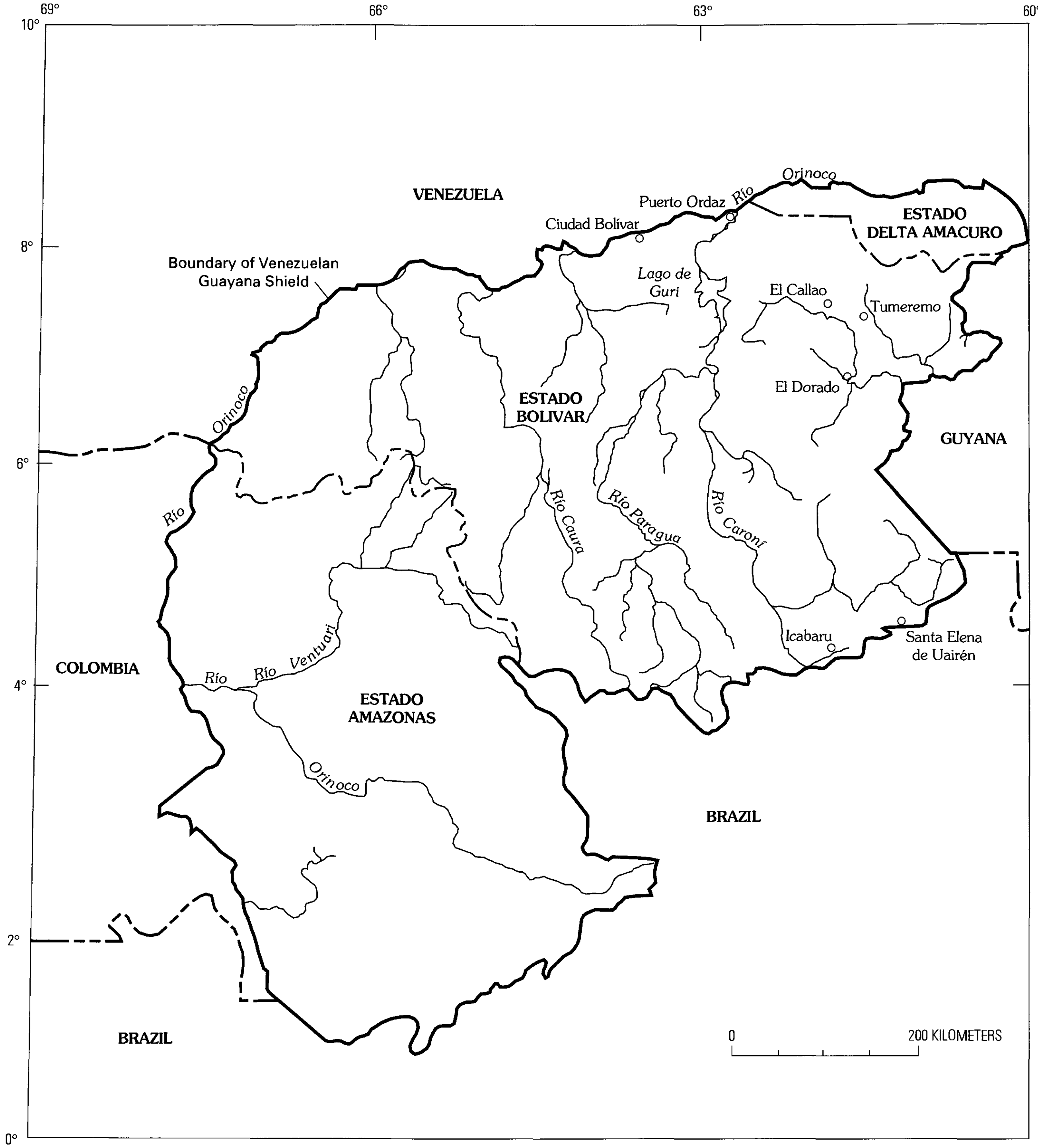

Figure 1. Location of Icabarú in southeastern Estado Bolívar, Venezuela. The Icabarú Sur study area is 15 km southwest of the town of Icabarú.

INTRODUCTION

The Icabarú Sur study area is in the southern part of Estado Bolívar, Venezuela (fig. 1). The study area is approximately 50 km^2 in size and is 15 km southwest of Icabarú, a mining supply town for the region, in a transition zone between savanna in the north and dense jungle to the south. Access to the study area is by hard surface to unimproved road from Santa Elena de Uairén, approximately 80 km to the east, or by helicopter.

In this part of the Guayana Shield, Early Proterozoic rhyolitic ash-flow tuffs, rhyolite of the Cuchivero Group, and sandstone of the Early to Middle Proterozoic Roraima Group (Gibbs and Barron, 1983; Sidder and Mendoza, this volume) are exposed. Rocks of the Roraima Group are commonly considered to be the source of placer gold and diamonds recovered from streams in the region. During a geologic reconnaissance of the area, Contreras and Page (1988) recommended additional field studies to investigate the potential of epithermal gold deposits in the region.

GEOLOGIC SETTING

The Icabarú Sur study area is within the central part of the Guayana Shield and contains volcanic rocks of the Early Proterozoic Uatuma Supergroup and sedimentary rocks of the Early to Middle Proterozoic Roraima Group (Gibbs and Barron, 1993) (fig. 2). Recent work by Sidder and Mendoza (this volume) indicates that the ash-flow tuff units and rhyolite are included in the Early Proterozoic Caicara Formation of the Cuchivero Group in Venezuela.

Silicic, relatively unmetamorphosed, volcanic rocks of the Caicara Formation of the Cuchivero Group crop out in the southern part of the study area. Three distinctive ash-flow tuffs and a porphyritic rhyolite are exposed. Compaction foliation visible in hand sample and outcrop indicates deposition as a subaerial ash-flow tuff. The silica content of these volcanic rocks ranges from 67.1 to 73.8 weight percent SiO_2. Descriptions of the tuffs and the rhyolite are given in figure 2, and analytical data are in table 1. A source for these tuffs has not been identified.

Three fractions of a zircon concentrate from one of the ash-flows (IC–001, fig. 2) have consistent U-Pb ages that imply the rock is about 1.98 Ga (fig. 3). The U-Pb geochronologic data are listed in table 2. Abundant sulfide minerals, which if not removed can contribute lead to the analysis, and the very fine grain size of the zircon were problems in the analysis; however, the age is relatively accurate based on the transparent character of the zircons, which indicates that not much damage has occurred to the zircon crystal lattice, on the fact that the least discordant data point is close to concordia, and on comparison with other published ages (Sidder and Mendoza, this volume).

Red to orange, well-sorted sandstone of the Uairén Formation of the Roraima Group crops out in the northern part of the study area. Grains are subrounded, 0.3–0.5 mm in diameter, and cemented with hematite. Bedding is massive, and sedimentary structures are rare. The Roraima Group is a thick continental sedimentary sequence composed of four formations (Reid and Bisque, 1975) and is present in Venezuela, Guyana, Suriname, and northern Brazil. Regional thickness of the Roraima Group is estimated to be 2,600 m or more (Dalton *in* Reid and Bisque, 1975). Rocks mapped as the Roraima Group in southeastern Venezuela are at least 1,670 Ma in age; some are possibly as old as about 1,900 Ma and others as young as about 1,500 Ma or younger (Priem and others, 1973; Sidder and Mendoza, this volume). A study of heavy minerals in streams that flow through and over rocks of the Uairén Formation in the region near Icabarú (Del Ollo and others, 1989) indicates that the original source of the Roraima Group sediments was complex and included granitic, volcanic, alkaline, and metasedimentary rocks.

Sandstone of the Roraima Group is separated from the volcanic rocks to the south by northeast- to east-striking high-angle normal faults (Contreras and Page, 1988) that juxtapose rocks of the Roraima Group against the volcanic rocks of the older Caicara Formation. The amount of vertical displacement is unknown. Neither quartz veins, hydrothermal alteration, nor other physical evidence of mineralization is associated with these faults.

WEATHERING EFFECTS ON TRACE ELEMENTS

Exposures in the study area present an opportunity to study trace element variation between weathered and unweathered volcanic rocks in a tropical environment. The behavior of trace elements, especially zirconium, during weathering is not well known (Erlank and others, 1978). In chemical variation studies of metamorphic rocks in a tropical environment, Montero and others (1989) used zirconium content as an immobile reference element.

Five rock samples from the study area were collected and then sawed in order to separate the unweathered core from the weathered rind. These two splits were crushed, pulverized, and analyzed on an energy-dispersive analyzer that allows rapid analysis for Zr, Rb, Sr, Y, Nb, and Ba. Results of this study are presented in table 3. The zirconium content of the weathered samples is dramatically higher than that of the unweathered samples. Weathering did not affect the niobium content in most of the samples, but the strontium content is lower in weathered samples. Changes in content of rubidium, yttrium, and barium with weathering are erratic.

Presumably, most of the zirconium in these silicic rocks is contained in zircon, a mineral that commonly is resistant to chemical weathering (Deer and others, 1982). Therefore, it is likely that zirconium is released during the weathering of minerals other than zircon or from minerals of which zirconium is a minor component (Erlank and others, 1978). Dennen and Anderson (1962) compared the compositions of various fresh rocks with their respective weathering rinds. The zirconium content was little changed or slightly enriched (as much as twofold) in most samples and was depleted in only one sample.

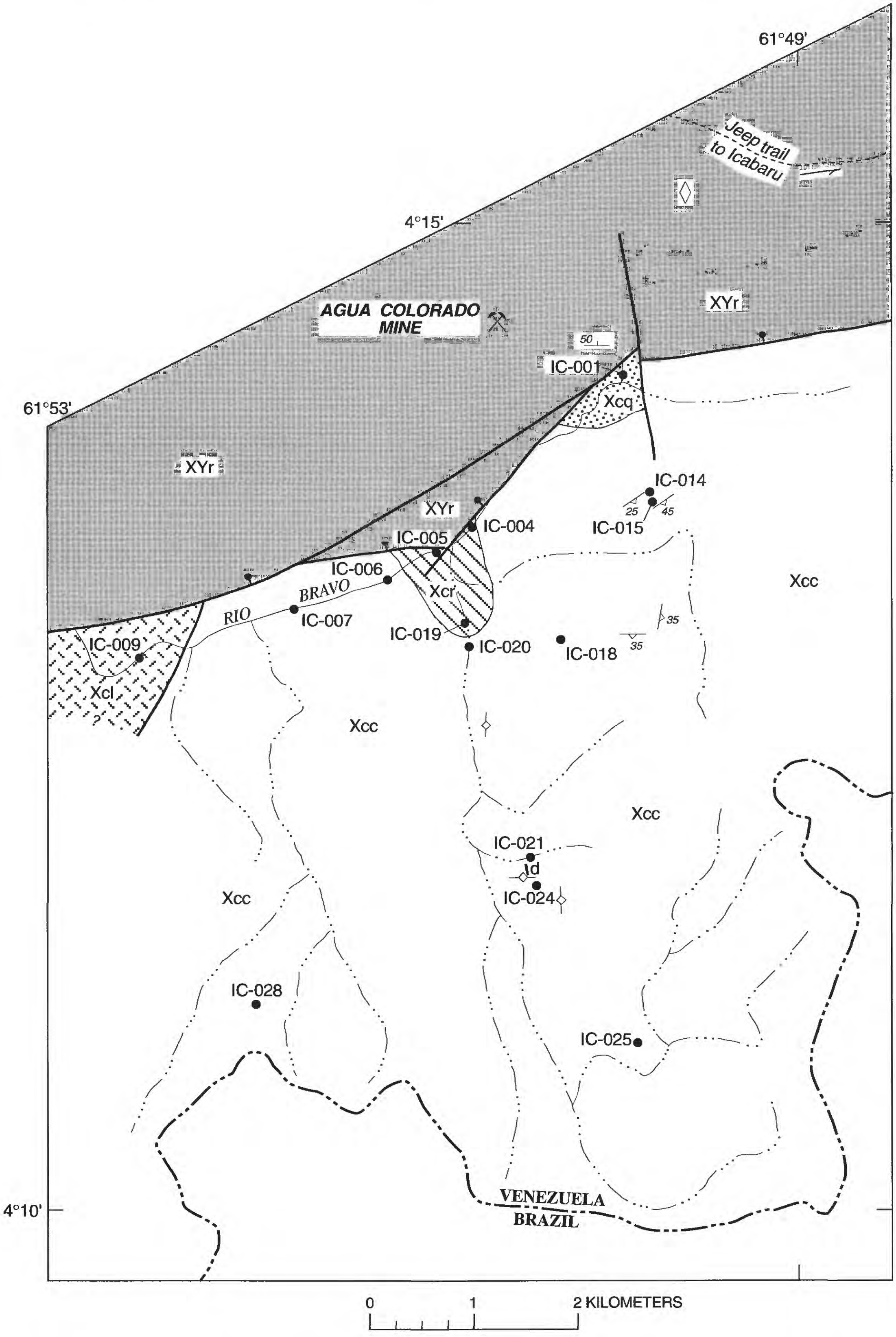

Figure 2. Geology of the Icabarú Sur study area, Estado Bolívar, Venezuela. Drainage base from Icabarú Sur, 1985, hoja 7828. Geologic mapping by Brooks and Nuñez, 1988.

EXPLANATION

XYr — **Roraima Group (Early to Middle Proterozoic)**—Red to orange, well-sorted (~0.3–0.5 mm diameter) quartz sandstone. Grains of subrounded quartz and polycrystalline quartz predominate; sparse subrounded zircon, muscovite, and opaque minerals are present; cement is hematite. Massive bedding. Neither metamorphic textures nor quartz overgrowths are present

Caicara Formation of the Cuchivero Group (Early Proterozoic)

Xcr — **Rhyolite (Early Proterozoic)**— Green to gray porphyritic rhyolite. Phenocrysts and clots of sanidine are from 0.5 to 1 cm in length. Devitrified groundmass contains opaque minerals and trace zircon

Xcc — **Ash-flow tuff**—Gray-green to black, crystal-rich plagioclase ash-flow tuff. Groundmass is devitrified and contains minor iron-titanium oxide minerals and zircon. Phenocrysts include plagioclase, sanidine, quartz, and altered biotite. Vitroclastic texture and compaction foliation are well preserved. **d** indicates a dikelike feature, 20 m long and 5 m wide, apparently a crystal-rich ash-flow tuff, that has horizontal cordwoodlike structure and polygonal faces 30–40 cm on a side

Xcl — **Ash-flow tuff**—Gray-green, lithic ash-flow tuff. Lithic fragments are fine grained, angular, and from 0.5 to 2 cm in diameter. May be white to black

Xcq — **Ash-flow tuff**—Dark-gray-green, crystal-poor, quartz-bearing ash-flow tuff. Groundmass is devitrified and contains trace iron-titanium oxide minerals and zircon. Well-preserved vitroclastic texture. U-Pb age of 1.98 Ga (sample IC-001)

Contact—Approximately located

Fault—Approximately located; bar and ball on downthrown side

35 — **Strike and dip of sedimentary rock**

Strike and dip of compaction foliation in tuff

25 — **Inclined**

Vertical

IC-014 — **Sample locality and number**—Analytical results are given in tables 1 and 3

Mine

Heliport

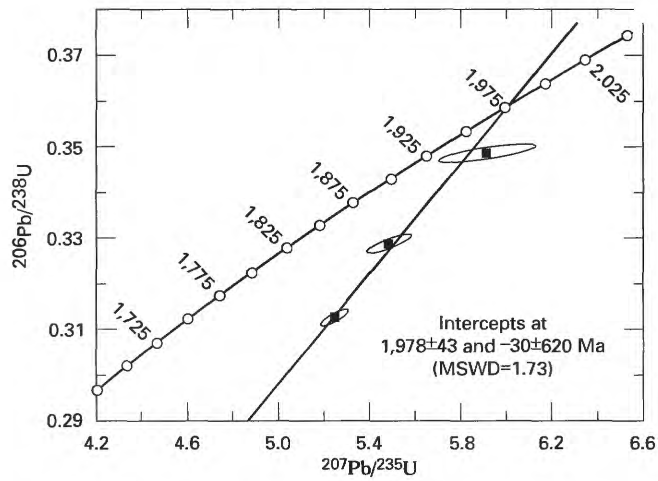

Figure 3. Concordia diagram for felsic tuff from the Icabarú Sur study area (sample IC–001), Estado Bolívar, Venezuela. Geochronologic data are given in table 2.

GOLD AND DIAMOND PROSPECTING

Gold and diamonds are recovered from alluvium down slope from conglomeratic horizons in the Uairén Formation of the Roraima Group (Reid and Bisque, 1975). Dohrenwend and others (this volume) indicate that the gold and diamond resources in the Gran Sabana are in the following geologic-geomorphologic environments: (1) placer deposits downstream from extensive exposures of the Uairén Formation; (2) colluvial-alluvial placer deposits adjacent to exposures of the Uairén Formation; and (3) paleoplacer deposits associated with conglomeratic lenses in the lower 500–600 m of the Uairén Formation.

The Roraima Group is commonly considered to be the immediate source of the modern placers and kimberlite in West Africa or possibly Brazil or Venezuela the initial primary source. Diamond placer deposits in Venezuela are the result of the following sequence of events, as proposed by Reid (1974): (1) intrusion of diamond-bearing kimberlite, possibly in West Africa; (2) uplift and erosion of the kimberlite and transport of the diamonds to an area in South America now known as Suriname before the separation of Africa and South America by rifting and continental drift; (3) erosion of the diamond-bearing rocks and redeposition as Roraima Group sediments; and (4) uplift and erosion of Roraima Group sediments and concentration of the diamonds in alluvium derived from the Roraima Group. In an overview discussion of diamonds in Venezuela, Nixon (1988) attributed the source of the diamonds to be recently discovered kimberlitic intrusions in the Quebrada Grande area in the northern part of the shield in Venezuela; however, sedimentological features such as cross-stratification, ripple marks, and pebble orientation indicate that sediments in the lower part of the Roraima Group were derived from an easterly, not a northwesterly, source (Keats, 1974; Reid and Bisque, 1975; Ghosh, 1985). Meyer and McCallum (1993) concluded, on the basis of both physical characteristics of the diamonds and their distribution, that the source for diamonds both in and derived from the Roraima Group is neither West Africa nor the Quebrada Grande area and that a primary source remains to be discovered.

Rock and stream-sediment samples were collected in the study area; however, only rock samples were returned to U.S. Geological Survey laboratories in Denver. The stream-sediment (panned concentrate) samples were kept by Corporación Venezolana de Guayana, Técnica Minera, C.A., in Tumeremo. Stream-sediment samples, which initially weighed 2–3 kg, were collected from 29 localities in the study area. These samples were panned in the field; none of the panned concentrates contained visible gold, and only 1 of the 29 samples contained a diamond. This milli- meter-size diamond was found at Agua Colorada, an active prospect in the northern part of the study area (fig. 3), when the prospector allowed us to sample his workings.

Table 1. Analytical results for rock samples of the Early Proterozoic Caicara Formation of the Cuchivero Group, Icabarú Sur study area, Estado Bolívar, Venezuela.
[Location of samples shown in figure 2 by field number. Major-element oxides (weight percent, uncorrected) were determined by X-ray spectroscopy; analysts: J. Taggart, A. Bartel, and D. Siems; $FeTO_3$ indicates total iron reported as Fe_2O_3. Trace elements (in parts per million) determined by an energy-dispersive analyzer Cd^{109} source for Rb, Sr, Y, Zr, and Nb and Am^{95} source for Ba; analyst: E. Rivera; N, not detected at value listed; L, limit of determination. Spectrographic analyses are in parts per million unless noted; analyst R. Hopkins; lower limit of detection is given in parentheses after element symbol; N, not detected at lower limit of determination shown; L, detected but below lower limit of determination shown. Atomic absorption analyses are in parts per million; analyst J. McHugh; L, detected but below lower limit of determination shown]

	Rhyolite (unit Xcr)		Crystal-rich ash-flow tuff (unit Xcc)								Lithic ash-flow tuff (unit Xcl)	Crystal-poor ash-flow tuff (unit Xcq)
Lab No.	D–316929	D–316930	D–316931	D–316932	D–316934	D–316935	D–316937	D–316938	D–316939	D–316940	D–316933	D–316928
Field No.	IC–004	IC–005	IC–006	IC–007	IC–014	IC–018	IC–021	IC–024	IC–025	IC–028	IC–009	IC–001
Major elements												
SiO_2	71.7	69.9	71.9	70.2	73.8	73.0	72.9	72.4	70.4	72.3	67.1	74.9
Al_2O_3	14.1	14.9	14.7	13.5	13.3	13.3	13.6	13.7	14.4	13.8	15.1	12.8
$FeTO_3$	2.19	3.00	1.86	3.34	1.63	1.70	1.79	1.91	2.26	2.01	4.68	1.71
MgO	0.27	0.32	0.40	0.30	0.23	0.37	0.31	0.35	0.46	0.37	0.94	0.21
CaO	0.45	0.13	0.09	0.78	0.52	0.82	0.62	0.71	1.10	0.77	0.35	0.68
Na_2O	3.62	3.80	2.83	3.65	3.48	3.82	4.35	3.99	4.14	3.94	3.46	1.28
K_2O	5.20	5.66	5.57	4.95	5.14	5.01	4.60	5.15	5.07	5.04	4.39	6.54
TiO_2	0.41	0.49	0.44	0.48	0.34	0.33	0.34	0.39	0.46	0.38	0.60	0.26
P_2O_5	0.05	0.08	0.08	0.11	<0.05	0.05	0.05	<0.05	0.08	0.06	0.15	<0.05
MnO	0.09	0.12	L0.02	0.12	0.04	0.06	0.08	0.06	0.07	0.07	0.34	0.06
LOI 900°C	1.19	1.03	1.49	1.62	0.95	0.79	0.60	0.39	0.55	0.49	2.20	1.51
Total	99.27	99.43	99.36	99.05	99.43	99.25	99.24	99.05	98.99	99.23	99.31	99.95
Trace elements												
Rb	98	130	142	102	125	136	129	165	147	158	101	171
Sr	123	84	106	187	94	86	96	120	179	108	241	96
Y	57	44	42	40	28	37	36	36	36	32	34	53
Zr	595	662	354	391	316	293	297	347	416	339	292	373
Nb	17	13	17	17	18	15	15	19	16	17	14	26
Ba	1,314	1,939	1,525	2,685	1,153	1,310	1,246	1,438	1,900	1,368	1,581	694
Spectrographic analyses												
Ca (percent) (0.05)	0.2	0.07	0.07	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.15	0.3
Fe (percent) (0.05)	2	2	2	2	2	2	2	2	2	1.5	3	2
Mg (percent) (0.02)	0.2	0.2	0.3	0.2	0.2	0.5	0.3	0.3	0.3	0.3	0.7	0.1
Na (percent) (0.2)	3	3	2	2	2	3	2	2	2	3	2	2
P (percent) (0.2)	N0.2	N0.2	N0.2	N0.2	N0.2	N0.2	N0.2	N0.2	N0.2	N0.2	N0.2	N0.2
Ti (percent) (0.002)	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.3	0.3	0.2	0.3	0.2
Ag (0.5)	N0.5	N0.5	N0.5	N0.5	N0.5	N0.5	N0.5	N0.5	N0.5	N0.5	N0.5	N0.5
As (200)	N200	N200	N200	N200	N200	N200	N200	N200	N200	N200	N200	N200
Au (10)	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10
B (10)	L10	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10	L10
Ba (20)	1,500	1,500	1,500	2,000	1,500	2,000	1,500	1,500	2,000	2,000	1,500	1,000
Be (1)	3	2	3	3	2	3	3	3	3	3	3	3
Bi (10)	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10
Cd (20)	N20	N20	N20	N20	N20	N20	N20	N20	N20	N20	N20	N20
Co (10)	N10	L10	N10	10	N10	N10	N10	N10	N10	N10	15	N10

Cr (10)	L10	L10	L10	10	L10	L10	N10	L10	L10	L10	15	10
Cu (5)	L5	5	L5	5	5	L5	5	L5	5	L5	20	15
Ga (5)	50	30	30	30	30	30	30	30	30	50	30	30
Ge (10)	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10
La (50)	200	100	70	70	100	100	100	70	70	100	50	150
Mn (10)	700	1000	300	1000	700	700	700	700	500	500	1500	700
Mo (5)	N5	50	N5	N5	N5	N5	N5	N5	N5	N5	N5	N5
Nb (20)	20	L20	L20	20	20	L20	20	L20	20	L20	L20	20
Ni (5)	N5	N5	N5	N5	N5	L5	L5	N5	N5	N5	5	N5
Pb (10)	30	50	50	50	30	30	30	50	50	30	30	30
Sb (100)	N100	N100	N100	N100	N100	N100	N100	N100	N100	N100	N100	N100
Sc (5)	7	10	7	7	7	7	7	7	7	7	10	7
Sn (10)	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10	N10
Sr (100)	N100	N100	L100	150	100	100	L100	L100	150	100	200	100
Th (100)	N100	N100	N100	N100	N100	N100	N100	N100	N100	N100	N100	N100
V (10)	10	10	30	50	30	15	20	20	30	30	70	L10
W (20)	N20	N20	N20	N20	N20	N20	N20	N20	N20	N20	N20	N20
Y (10)	50	30	30	30	30	30	30	30	20	30	20	50
Zn (200)	N200	N200	N200	N200	N200	N200	N200	N200	N200	N200	N200	L200
Zr (10)	700	1000	300	500	300	200	300	300	500	300	300	500
Atomic absorption analyses												
Au	L0.001	0.001	0.001	0.001	0.001	L0.001	0.001	0.001	0.001	0.001	0.001	L0.001

Table 2. U-Pb geochronologic data (zircon) for felsic tuff (IC–001) from the Icabarú Sur study area, Estado Bolívar, Venezuela.

[Location of sample shown in figure 2; major- and trace-element data for sample given in table 1. Asterisk (*) following element symbol denotes radiogenic Pb. Sample dissolution and ion-exchange chemistry modified from Krogh (1973) and Mattinson (1987). Fraction: N, nonmagnetic; M, magnetic; amperes/side slope on a Franz Isodynamic separator; 140 and 230 denote standard mesh size. Observed ratios corrected for 0.125 per unit mass fractionation, based on replicate analyses of NBS 981. Uncertainties in the measured $^{208}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ ratios are less than 0.1 percent and uncertainties in the measured $^{206}Pb/^{204}Pb$ ratios are between 0.5 and 2 percent at the 2 sigma level(σ). Isotopic data measured on a Finigan-Mat MAT 262 multiple collector mass spectrometer at the U.S. Geological Survey in Menlo Park. Atomic ratios calculated using the following constants: $^{238}U/^{235}U=137.88$; $^{235}U=0.98485\times10^{-9}yr^{-1}$; $^{238}U=0.155125\times10^{-9}yr^{-1}$. Observed ratios are corrected for common Pb ratios: 208:207:206:204 Pb of 34.6:15.1:14.9:1 using average crustal growth model of Stacey and Kramers (1975). All errors are reported to two-sigma (σ); error analysis follows Mattinson (1987)]

Fraction	Weight (mg)	$^{206}Pb^*$ (ppm)	^{238}U (ppm)	Observed ratios $\frac{^{206}Pb}{^{204}Pb}$	Observed ratios $\frac{^{207}Pb}{^{206}Pb}$	Observed ratios $\frac{^{208}Pb}{^{206}Pb}$	Atomic ratios $\frac{^{206}Pb^*}{^{235}U}$	Atomic ratios $\frac{^{207}Pb^*}{^{235}U}$	Atomic ratios $\frac{^{207}Pb^*}{^{206}Pb^*}$	Age and error (Ma) $\frac{^{206}Pb^*}{^{238}U}$	Age and error (Ma) $\frac{^{207}Pb^*}{^{235}U}$	Age and error (Ma) $\frac{^{207}Pb^*}{^{206}Pb^*}$
N(1.8/1, <140)	1.7	43.7	142.8	104.7	0.2502	0.5774	0.348723	5.91752	0.123072	1,928±2	1,963±25	2,001±50
M(1.8/1.5, >230)	2.7	39.4	145.3	316.5	0.1637	0.3499	0.313032	5.25247	0.121696	1,756±2	1,861±6	1,981±10
M(1.8/1.5, <230)	4.1	75.6	266.0	183.8	0.1937	0.4276	0.328726	5.48515	0.121019	1,832±2	1,898±10	1,971±30

Table 3. Trace-element contents of unweathered and weathered sample pairs from the Early Proterozoic Caicara Formation of the Cuchivero Group, Icabarú Sur study area, Estado Bolívar, Venezuela.

[In parts per million. Location of samples shown in figure 2 by number; map unit symbols are defined in figure 2. Determined by an energy-dispersive analyzer Cd^{109} source for Rb, Sr, Y, Zr, and Nb, Am^{95} source for Ba; analyst E. Rivera. U indicates unweathered sample; W indicates weathered sample. More complete analytical data for samples ICU–001, –004, and –014 are given in table 1]

Sample No.	IC–001		IC–004		IC–014		IC–015		IC–019	
Map unit	Xcq		Xcr		Xcc		Xcc		Xcr	
Sample type	U	W	U	W	U	W	U	W	U	W
Rb	171	167	98	108	125	152	139	173	127	206
Sr	96	20	123	70	94	73	144	90	81	60
Y	53	40	57	40	28	34	36	24	45	48
Zr	373	490	595	769	316	400	339	388	678	1,270
Nb	26	26	17	16	18	23	19	21	20	36
Ba	694	207	1,314	1,390	1,153	1,117	1,227	1,430	1,346	1,498

The presence of silicic volcanic rocks, ash-flow tuff, and rhyolite of the Caicara Formation in the Icabarú Sur study area suggests a possible epithermal source for the gold (Contreras and Page, 1988). Quartz veins (2–3 mm) cut the ash-flow tuff, but alteration minerals such as alunite, sericite, montmorillonite, adularia, silica, tourmaline, and carbonate are not present in the veinlets or host rocks. Gold was not present in stream-sediment samples taken downstream from the veinlets. One sample of ash-flow tuff (IC–021, fig. 3) had a millimeter-thick veinlet of fluorite.

Ten rock samples and one quartz-vein sample were submitted for spectrographic and trace element (gold) analysis (table 1). Results for gold are uniformly low (~1 ppb), and neither arsenic nor silver were detected. One sample of porphyritic rhyolite (IC–005) contains 50 ppm Mo. Anomalous concentrations of metals are not present in the sample that contains the fluorite veinlet.

ASSESSMENT OF MINERAL POTENTIAL

The geologic setting of the Icabarú Sur study area permits consideration of the following deposit models: epithermal veins and diamond-bearing kimberlite pipes. The only feature common to both the Icabarú Sur study area and a generalized (Sado, Creede, Comstock) epithermal quartz-gold model is the presence of silicic volcanic rocks. Hypabyssal intrusive rocks are not present in the area, unless further mapping proves that the porphyritic rhyolite is intrusive. Similarly, neither faults and fractures related to doming nor ring-fracture zones associated with mineralized calderas have been identified (Mosier, Berger, and Singer, 1986; Mosier, Sato, and others, 1986; Mosier, Singer, and Berger, 1986). Therefore, the Icabarú Sur study area is assigned a low potential for an epithermal gold system; however, additional regional mapping, with attention to altered rock, intrusive rocks, quartz, and fluorite veins, would better define this assessment.

The presence of placer diamond production in the area of Icabarú is the strongest evidence for consideration of the descriptive model for diamond-bearing kimberlite pipes (Cox, 1986). Kimberlite is commonly highly fractured and deeply weathered, which typically produces topographic lows and which would be inconspicuous in such an environment (W.H. Raymond, U.S. Geological Survey, written commun., 1991). Therefore, the apparent absence of kimberlite pipes, perhaps unrecognized due to their small diameter and inconspicuous weathering style, might be due to the relatively small degree of coverage of the area by geologic mapping. Nonetheless, kimberlitic indicator minerals have not been identified from any of the alluvial diamond-bearing deposits associated with the Roraima Group (Briceño, 1984; Meyer and McCallum, 1993). Potential for diamond-bearing kimberlitic pipe deposits is, therefore, low.

CONCLUSIONS

In the Icabarú Sur study area of Venezuela, sandstones of the Early to Middle Proterozoic Roraima Group and ash-flow tuffs and rhyolite of the Early Proterozoic Caicara Formation of the Cuchivero Group are exposed. The absence of visible gold in stream-sediment samples and the minor amount of gold (~1 ppb) in analyses of rock samples eliminate the volcanic terrane as a possible source for the gold commonly found in placer deposits in the region. Therefore, conglomerates of the Uairén Formation of the Roraima Group remain the immediate source for gold and diamonds in the area. The geologic setting of the Icabarú region is generally favorable for mineral deposits, but the resource potential of the Icabarú Sur study area is apparently low.

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