UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Follow-up examination of field areas with gold potential in Costa Rica - analytical results

by

Steve Ludington[1] and William C. Bagby[2]

Open-file Report 88-0522

[1]Mailstop 984, 345 Middlefield Road, Menlo Park, CA 94025

[2]Mailstop 913, 12201 Sunrise Valley Drive, Reston, VA 22092

1988

Follow-up Examination of Field Areas with Gold Potential in Costa Rica --- Analytical Results

by Steve Ludington and William C. Bagby

Introduction

After completion of the first phase of a mineral resource assessment of Costa Rica (U.S. Geological Survey, 1987), and publication of results of a geochemical survey of the San José 1:200,000 map sheet (Los Alamos National Laboratories, 1987), we made a short return visit to Costa Rica to follow up on new ideas for possible areas of occurrence of gold deposits that resulted from the earlier work. This report consists of a very brief description of the field observations made at that time, a summary of analytical results for the samples collected, and a few speculations on the possible significance of the results. Figure 1 shows the general location of the areas visited, and Table 1 contains the analytical results.

This research was carried out in cooperation with the Ministry of Natural Resources, Energy and Mines of the Republic of Costa Rica and with the Central American School of Geology at the University of Costa Rica. Funding was provided by the United States Agency for International Development through Los Alamos National Laboratories.

The Quesada area

Stream-sediment samples from the area northeast of Ciudad Quesada (Los Alamos National Laboratories, 1987) are anomalous in a number of elements indicative of epithermal gold deposits, especially gold, silver, arsenic, antimony, and mercury. Because the area is one of very young volcanic rocks, apparently primarily products of Platanar Volcano, we felt that the anomalies were possibly due to a hot-spring gold deposit.

The anomalous areas are in the Aguas Zarcas Quadrangle, at the base of the northern flank of Platanar Volcano, between the towns of Ciudad Quesada and Aguas Zarcas, in Alajuela Province. The area, which covers more than 100 km^2, is largely devoted to grazing and farming, though the steeper slopes of the volcano are primarily forested. Outcrops are scarce, and during our 2-day visit, we saw no obviously mineralized rock in outcrop. To the south, higher on the slopes of the volcano, Huber and others (1987) report some native sulfur prospects. We were able to find no new information about these. There is a modern hot spring in the area (La Marina) that is being developed as a bathing resort. Sample 87CRB15 is of a siliceous sinter at that locality, and shows no unexpected geochemical concentrations other than an elevated As value of 76 ppm.

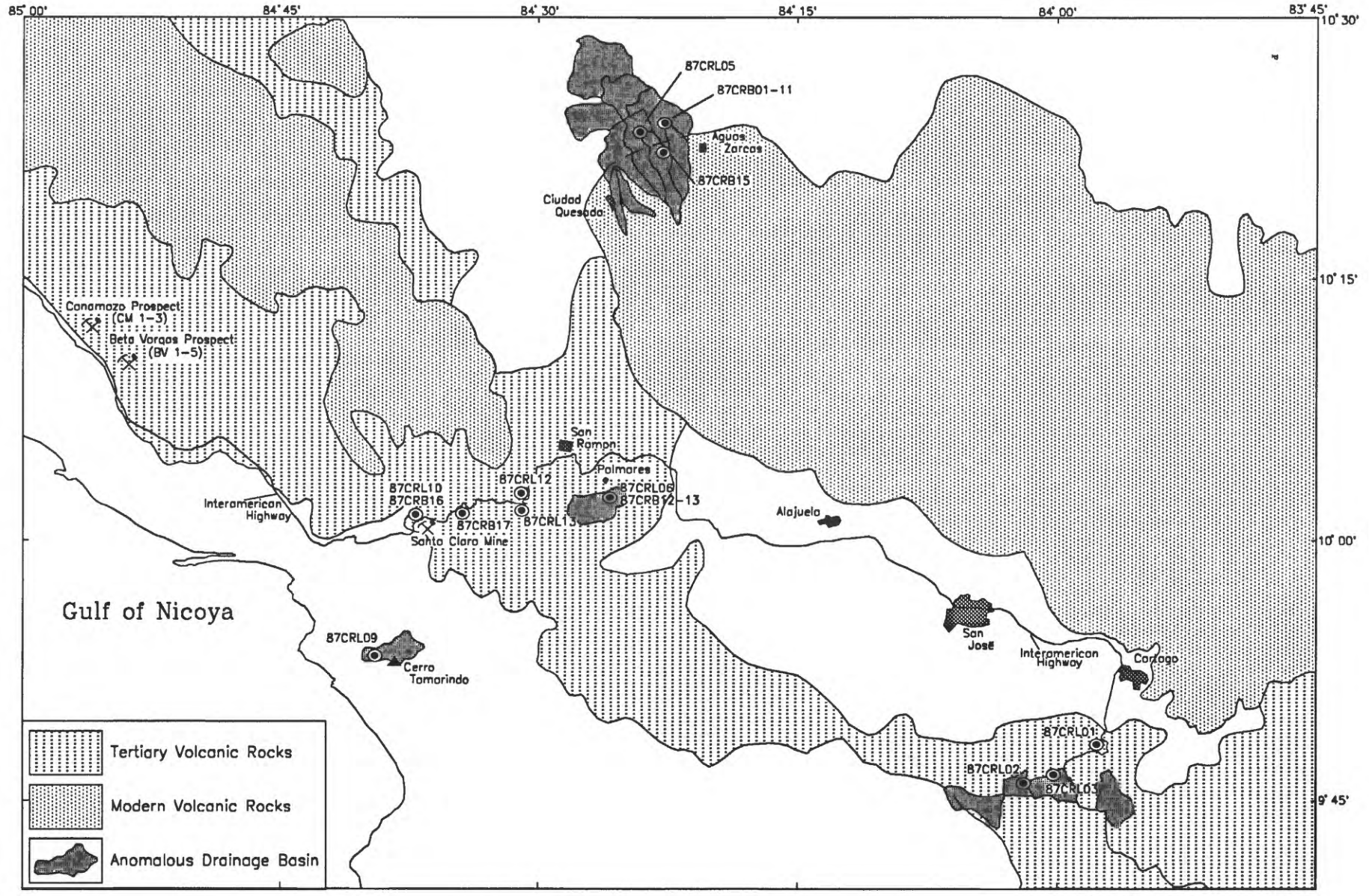

Figure 1. Map of the San Josē Quadrangle, showing sample locations for samples listed in Table 1 and described in text. Geology modified from Sāenz (1982).

Table 1. Analytical results for samples from Costa Rica. Location of samples is described in text and shown on Figure 1.

ID	Description	Au	Ag	As	Sb	Mo	Cu	Pb	Zn
Quesada Area									
87CRB15	La Marina Hot Spring, sinter	<.001	<.1	76	6	<1	6	<2	5
87CRL05	siliceous chips	<.001	<.1	47	<2	3	39	<2	12
87CRB01	opaline sinter	.053	.2	<2	<2	<1	5	3	3
87CRB02	altered basalt?, trace native sulfur	.019	<.1	10	<2	4	99	9	3
87CRB03	opaline silica breccia	.011	<.1	50	<2	264	26	120	10
87CRB04	silicified rock with pyrite	.014	<.1	99	3	3	467	11	29
87CRB05	altered rock with pyrite	.002	<.1	7	<2	8	41	19	11
87CRB06	sulfide-silica breccia	<.001	<.1	5	<2	2	156	<2	10
87CRB07	sulfide and silica rich rock	.002	<.1	23	<2	2	111	<2	6
87CRB08	sulfide-silica breccia	<.001	<.1	3	<2	2	114	4	9
87CRB09	altered rock with pyrite	<.001	<.1	4	<2	<1	122	6	11
87CRB10	silica rock with massive pyrite	<.001	.8	131	12	55	910	93	92
87CRB11	sulfide-silica breccia	<.001	<.1	41	4	90	363	19	19
Naranjo Quadrangle									
87CRB12	quartz vein material	.076	.3	39	19	23	144	61	106
87CRB13	quartz vein material	.009	<.1	113	<2	5	24	<2	46
87CRL06a	granodiorite with sulfides	<.001	<.1	<2	<2	2	53	<2	48
87CRL06b	granodiorite with sulfides.	<.001	<.1	<2	<2	3	97	7	69
87CRL06c	andesite with coarse pyrite	.004	<.1	13	<2	<1	154	<2	36
87CRB17	quartz veins	.012	<.1	<2	<2	<1	13	<2	2
Beta Vargas and Cañamazo									
BV1	banded quartz vein	.930	<.1	8	<2	<1	5	5	4
BV2	banded quartz vein	.840	<.1	8	3	<1	3	4	<1
BV3	banded quartz vein	.430	16.8	46	6	48	46	29	99
BV4	banded quartz vein	3.170	25.4	27	<2	4	14	42	19
BV5	banded quartz vein	40.700	12.0	184	50	13	27	23	27
CM1	banded quartz vein	1.490	7.9	20	3	2	4	5	3
CM2	banded quartz vein	2.010	11.4	11	<2	<1	20	7	9
CM3	banded quartz vein	2.490	6.9	6	<2	<1	6	14	3
Southeastern Anomalies									
87CRL01	altered andesite	.007	<.1	4	<2	<1	9	4	24
87CRL02a	granodiorite with disseminated sulfide	.002	<.1	3	<2	2	87	5	52
87CRL02b	altered andesite with sulfides	<.001	<.1	96	<2	<1	6	4	59
87CRL03	monzogranite	.003	<.1	<2	<2	<1	90	<2	57
Quebrada Trinidad									
87CRL09	silicified rhyolite with pyrite	<.001	.6	6	7	<1	18	11	5
Sinter(?) Breccia at Santa Clara									
87CRB16	sinter(?) breccia	1.720	1.7	84	4	<1	8	4	14
87CRL10	sinter(?0 breccia	8.450	1.8	423	27	<1	23	40	27
Aphyric Rhyolites									
87CRL12	aphyric rhyolite	.410	.2	105	3	2	43	4	11
87CRL13	aphyric rhyolite	.290	<.1	<2	3	6	9	5	4

All results are reported in parts per million (ppm)

Analyses are by inductively coupled plasma (ICP) method, except gold, which is by atomic absorbtion (AA) method.
C. Leong (Acme Analytical Laboratories, Vancouver, B.C.) performed the analyses.

We visited two of the stream-sediment sampling sites, in an attempt to see a wider variety of rock types from the area. At site 4923E - 2636N (UTM co-ordinates, Aguas Zarcas Quadrangle), the vast majority of the rocks were unaltered mafic volcanic rocks. No large fragments of mineralized rock were found. A very few small (<5 cm), rounded fragments of siliceous material mixed with pyrite were found. The small size of the fragments and the ambiguous nature of the textures precludes identification of the source of these fragments. A selection of them were analyzed as sample 87CRL05. Like the modern sinter, As (47 ppm) is the only anomalous element. The stream-sediment sample at this locality yielded the highest As and Sb values of the entire Quesada anomaly (192 and 1.95 ppm, respectively) (Los Alamos National Laboratories, 1987).

The other site, 4947E - 2642N, yielded more interesting results. A significant proportion of the stream boulders (>1%) were composed of silica- and sulfide-rich material. No microscopic examination of these samples has been made, but the textures appear to be consistent with formation in a hot-spring environment. Much of the silica is opaline, and much is dark grey, suggestive of finely-divided sulfide minerals. Eleven samples were taken of this material (87CRB01-011); the results are shown in Table 1. Precious-metal contents are disappointingly small; the highest Au value is .053 ppm in 87CRB01 and the highest Ag value is 0.8 ppm in 87CRB10. Enrichment in As and Sb is moderate; maximum values are 131 and 12 ppm, respectively. Unexpected in this probable hot-spring environment is the base-metal enrichment shown by these samples. Sample 87CRB03 contains 264 ppm Mo, and two other samples contain more than 10 ppm. Sample 87CRB10 contains 910 ppm Cu, and 7 of the 11 samples contain more than 100 ppm. Maximum Pb and Zn values are120 and 92 ppm, respectively. The stream-sediment sample from this site does not contain abnormal amounts of base metals. Other stream-sediment samples within the Quesada area are, however, anomalous in Zn and Mo (Los Alamos National Laboratories, 1987).

Such high base-metal contents are not typical of hot-spring gold deposits, although high Mo values are known from at least one other hot spring environment, at Sulphur Springs, Valles Caldera, New Mexico (Hulen and others, 1987). These results remain enigmatic.

Veins in Naranjo Quadrangle

Among the stream-sediment samples from the San José 1:200,000 Quadrangle that are anomalous in Au and Ag, and related "pathfinder" elements (As, Sb, Hg) (Los Alamos National Laboratories, 1987), most can be explained as due to known precious-metal deposits. Among those that cannot is the one at 4907E - 2246N, in the Naranjo Quadrangle. The sample site is on the Quebrada Grande, where it empties into the Río Grande, about 2 km southeast of Palmares. We paid a one-day visit to this area to search for any visible signs of epithermal mineralization. The drainage basin that the

sample represents is elongate east-west, and extends from the mouth of the Quebrada Grande to the crest of the Montes del Aguacate, which form the rim of the basin that contains the towns of Palmares and San Ramón. The area is about 6 km north of the Sacra Familia group of mines (Bagby and others, 1987), but no known mines are in the drainage basin. The human population is considerable; much of the area essentially forms a suburb of Palmares. No outcrops of mineralized rock were seen during road traverses of the area. However, mineralized rock is present in the stream, in the form of transported boulders. Samples 87CRL06a and 87CRL06b are of a medium-grained granodiorite with several percent disseminated, fine-grained sulfide minerals, primarily pyrite. These two samples do not contain anomalous amounts of any of the elements of interest. Sample 87CRL06c is of a volcanic rock, an andesite that also contains disseminated pyrite, with some larger sulfide grains that are nearly 1 cm in largest dimension. This sample contains 0.004 ppm Au and 13 ppm As. Samples 87CRB12 and 87CRB13 are of massive quartz, with minor sulfides, apparently from veins. Both contain detectable As and 87CRB12 contains 0.076 ppm Au and 0.3 ppm Ag.

These results confirm that there is rock within the drainage basin that is mineralized in a style similar to the known epithermal veins in the region. This is consistent with the geochemical signature seen in the stream-sediment sample.

Sample 87CRB17 is of quartz vein material, not seen in our earlier studies, that crops out near the Angostora Church, on the Interamerican Highway at 4732E - 2235N, about 11 km west of the crest of the Montes del Aguacate. These veins are small (<2 cm thick), and the sample contained only 0.012 ppm Au.

Beta Vargas and Cañamazo

Beta Vargas (~4373E - 2396N) and Cañamazo (~4342E - 2429N) are two known gold prospects (Huber and others, 1987) that we had not studied earlier. They are described in detail in unpublished reports available from Minera Nacional S.A., Apartado 5398, 1000 San José, Costa Rica. Both deposits show many characteristics of hot-spring gold deposits. The analyses presented here (BV1-5 and CM1-3) are all of select samples of banded quartz veins, and undoubtedly have precious-metal contents distinctly higher than average rocks from the deposits. All the samples contained detectable gold; the results range from 0.43 ppm to 40.7 ppm. Ag contents range from <0.1 ppm up to 25.4 ppm. The Ag/Au ratio is highly variable. Arsenic contents range from 6 ppm to 184 ppm, whereas Sb, Cu, Pb, and Zn are very low. Interestingly, Mo contents of some of these samples are quite high, as high as 48 ppm in sample BV3.

Southeastern Anomalies

A number of stream-sediment samples southeast of San José show a similar geochemical signature to samples from known mineralized areas, but at a lesser intensity. Because we had published the opinion that this area was favorable for the occurrence of Sado-type gold deposits (Singer and others, 1987), we visited this area to search for signs of visible mineralization. No indications of quartz veins were seen. However, numerous occurrences of hydrothermally-altered rock are present.

Sample 87CR01 is from 5413E - 1995N, in the Tapantí Quadrangle. The sample is a hydrothermally-altered andesite collected from a road cut along the Interamerican Highway, south of Cartago. This sample contains 0.007 ppm Au. Samples 87CRL02a and 87CRL02b are from 5332E - 1945N, from outcrops beneath a bridge over the Río Santa Elena, about 5 km west of the Interamerican Highway in the Caraigres Quadrangle. Sample 87CRL02a is an altered granodiorite that contains disseminated pyrite. It contains 0.002 ppm Au. Sample 87CRL02b is an altered volcanic rock, and andesite that also contains disseminated pyrite. It does not contain detectable gold, but does contain 96 ppm As. Sample 87CRL03 is another intrusive rock, a monzodiorite that shows only mild affects of hydrothermal alteration. It was collected in a road cut at 5368E - 1955N, in the Tapantí Quadrangle, about 1 km west of the Interamerican Highway. Although no sulfides were noted, this sample also contains detectable Au, 0.003 ppm.

Although our examination revealed no direct evidence of quartz veins, the widespread occurrence of hydrothermally-altered volcanic rocks and the presence of low-grade Au and As mineralization in our samples suggests that the area retains potential for the occurrence of Sado-type gold deposits.

Quebrada Trinidad

Another stream-sediment sample that was indicative of precious-metal mineralization, but had no obvious explanation was that at 4632E - 2082N, in the Barranca Quadrangle, collected from a small stream, Quebrada Trinidad, whose drainage basin lies completely outside the permissive area outlined by Singer and others (1987). This basin lies about 10 km southwest of the nearest known outcrops of permissive Tertiary volcanic rocks, and according to published mapping (Madrigal, 1970), is entirely within the Plio-Pleistocene Tivives Formation, which is composed of fluvially transported volcanic debris, and is a product of erosion of the permissive area. We found this to be the case; the few outcrops in the area are primarily of volcanogenic sedimentary rock. However, at locality 4644E - 2080N, near a ford across Quebrad Trinidad, we encountered and collected (87CRL09) stream boulders of a different lithology, a strongly silicified intrusive rhyolite porphyry, with disseminated pyrite. Although it did not contain detectable Au, this sample contains 0.6 ppm Ag and 7 ppm Sb. Though we were unable to reach the

locality, we believe these boulders are being eroded from Cerro Tamarindo, a small hill near 4666E - 2075N that appears to be an erosional remnant of Tertiary volcanic rocks that protrudes from the surrounding Tivives Formation.

Sinter(?) Breccia at Santa Clara

The Santa Clara mine (Bagby and others, 1987), presently being exploited by open-pit methods, has been described as a stockwork of Au-bearing quartz-pyrite veinlets, aligned along an easterly trend, and closely related to the Sado-type epithermal vein model. Subsequent visits to the mine area have revealed the existence of another rock type, possible siliceous sinter breccia, that raises the possibility that the present ore zone represents the lower part of a hot-spring Au deposit. We collected two samples (87CRB16 and 87CRL10) of this possible sinter breccia from a quarry immediately across the Interamerican Highway from the mine at 4693E - 2222N in the Miramar Quadrangle. Both are strongly mineralized, containing up to 8.45 ppm Au, 1.8 ppm Ag, 423 ppm As, and 27 ppm Sb. These observations, combined with the recognition of Beta Vargas and Cañamazo as probable hot-spring deposits, raise the possibility that the classification of Santa Clara should be revised. Only detailed geologic mapping in the vicinity of the mine can resolve this question.

Aphyric rhyolites

One of the major contributions of our previous work in Costa Rica was the identification of significant amounts of subvolcanic, intrusive rhyolite (Schultz and others, 1987), and the recognition that these were closely associated with gold mineralization (Bagby and others, 1987). Particularly troubling has been the difficulty of field identification of rhyolites when not present as outcrops. Apparently, many of these felsic intrusions lack quartz phenocrysts. When this is the case, the macroscopic distinction of these rocks from strongly altered intermediate volcanic rocks is problematic. Confounding the problem is the observation that near-complete silicification that is, however, not texture-destructive, has affected these rocks in some areas. Two samples were collected to further study this problem. Sample 87CRL12 is from a quarry that appears to show altered andesite, cut by rhyolite dikes, along the Interamerican Highway in the Miramar Quadrangle (4802E - 2244N). Sample 87CRL13 was collected from float near the village of Río Jesús, in another area with rhyolite nearby (4803E - 2238N). Petrographic studies have not yet been made, but both samples contain substantial Au, 0.410 ppm and 0.290 ppm, respectively. If they are rhyolites, this is further evidence of the close relationship of the rhyolites with gold mineralization.

References Cited

Bagby, W.C., Marsh, S.P., and Enid Gamboa, 1987, An analysis of the epithermal vein deposit type in the Cordillera de Tilarán and Montes del Aguacate, Costa Rica, in U.S. Geol. Survey, Dirección de Geología, Minas y Hidrocarburos, Universidad de Costa Rica, Mineral Resource Assessment of the Republic of Costa Rica: U.S. Geological Survey Miscellaneous Investigations Series Map I-1865, p. 44-57.

Huber, D.E., Page, N.J, Howe, S.S., and Cristina Solano, 1987, Mines, prospects, and mineral occurrences in Costa Rica, in U.S. Geol. Survey, Dirección de Geología, Minas y Hidrocarburos, Universidad de Costa Rica, Mineral Resource Assessment of the Republic of Costa Rica: U.S. Geological Survey Miscellaneous Investigations Series Map I-1865, p. 18-33.

Hulen, J. B., Nielson, D. L., Goff, F., Gardner, J. N., and Charles, R.W., 1987, Molybdenum mineralization in an active geothermal system, Valles Caldera, New Mexico: Geology, 15, p. 748-752.

Los Alamos National Laboratories, 1987, Geochemical Atlas of the San José and Golfito Quadrangles, Costa Rica: U. S. Government Printing Office, Report LA-1065-MS, UC-11, July 1987, 26 pp.

Madrigal, R., 1970, Geología del mapa básico Barranca, Costa Rica: San José, Ministerio de Industria y Comercio, Informes Técnicos y Notas Geológicas, no. 37.

Sáenz, Rodrigo, coordinator, 1982, Mapa geologico de Costa Rica: San José, Dirección de Geología, Minas y Petróleo, Hoja San José, scale 1:200,000.

Schulz, Klaus, Koeppen, Robert, Ludington, Steve, Kussmaul, Siegfried, and Karen Gray, 1987, Volcanological framework for the gold deposits in the Cordillera de Tilarán and Montes del Aguacate, Costa Rica, in U.S. Geol. Survey, Dirección de Geología, Minas y Hidrocarburos, Universidad de Costa Rica, Mineral Resource Assessment of the Republic of Costa Rica: U.S. Geological Survey Miscellaneous Investigations Series Map I-1865, p. 34-43.

Singer, D.A., Page, N.J, Bagby, W.C., Cox, D.P., and Steve Ludington, 1987, Assessment of metallic mineral resources of Costa Rica, in U.S. Geol. Survey, Dirección de Geología, Minas y Hidrocarburos, Universidad de Costa Rica, Mineral Resource Assessment of the Republic of Costa Rica: U.S. Geological Survey Miscellaneous Investigations Series Map I-1865, p. 58-64.

U.S. Geological Survey, Dirección de Geología, Minas y Hidrocarburos, Universidad de Costa Rica, 1987, Mineral Resource Assessment of the Republic of Costa Rica : U.S. Geological Survey Miscellaneous Investigations Series Map I-1865, 75 pp.