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Geophysical investigation using the GPR method: a case study of the lead contamination in the Santo Amaro, Bahia, Brazil

Geological Survey of Brazil

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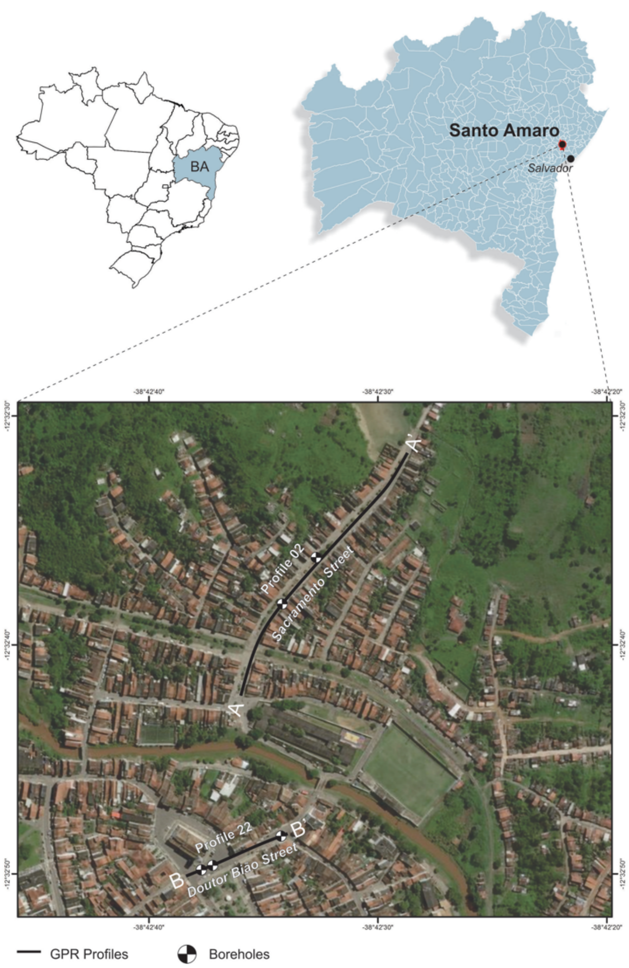
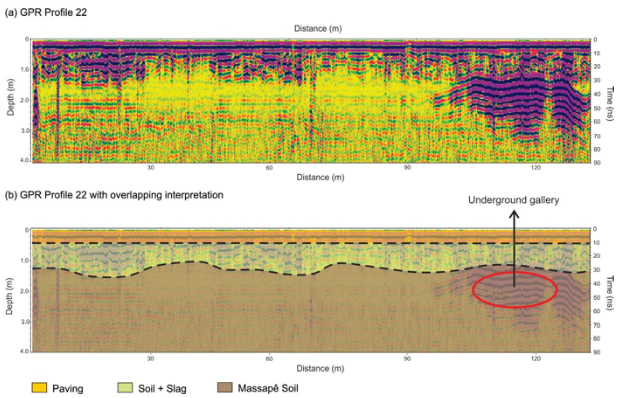
The results obtained by this study show the potential of applying the GPR method to the environmental characterization of the subsoil of paved streets in the town of Santo Amaro, making it possible to identify the resistive material contaminants (lead slag) as well as the various layers: paving, soil-slag and massapê soil.

These layers are characterized by distinct reflection patterns. The first reflection pattern has high amplitude, horizontal and continuous reflectors. The second reflection pattern is characterized by reflectors with amplitude variations, horizontal and inclined, continuous and discontinuous, which evidences the heterogeneity of the medium. The third reflection pattern is characterized by low amplitude, chaotic and totally discontinuous reflectors.

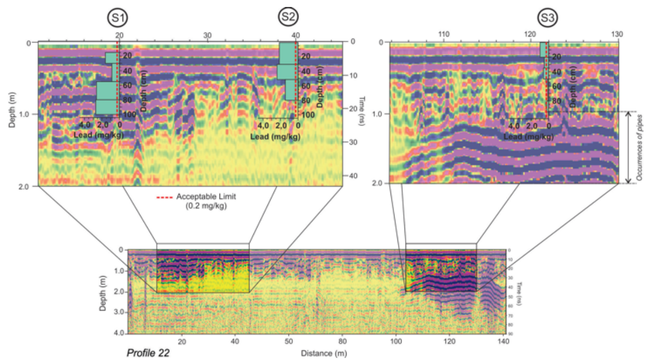
GPR data also enabled the identification of reflectors associated with anthropogenic interferences (manholes, train lines, pipelines, etc.). Borehole samples confirm the existence of the contaminant (lead slag). Anomalous concentrations of heavy metals, mainly lead, were observed in the locations indicated by the geophysical results using the GPR method, showing the importance of the use of geophysics in environmental characterization programs.



Study area, GPR survey locations and borehole locations



GPR profile 22 carried out at Doutor Bião Street and the overlapping interpretation



GPR profile 22 with the S1, S2 and S3 borehole positions and the lead levels in depth

The positions of the boreholes were suggested based on the results obtained from the GPR method. The boreholes were performed in specific positions to the depth of 1 meter below the layer of asphalt.

The direct research conducted at points where the geophysical investigation suggested the presence of slag material actually confirmed the existence of this material concentrated below the asphalt layer and cobblestone streets. The values of the heavy metals obtained for the soils in the samples S1 to S5 are shown in Table 1.

The results obtained for the soil samples show higher lead concentration in the S1, S2 and S3 boreholes; while in S4 the values are equal to, or lower than, the limit of quantification of the analytical equipment (0.2 mg/kg). High grades of aluminum, calcium, iron and magnesium are also observed in soil samples. The lead content that was detected in the soil samples in the first three boreholes is derived from the metallurgic activities that existed in the region, which had the objective of processing lead ore and generating a hazardous waste site. This material (slag) was used by the Santo Amaro city hall to pave the streets and backyards of the residences and has lead as its main chemical component. The soil of the region is massapê, very clayey, which presents low permeability and high retention capacity of heavy metals.

On the other hand, the soil samples from the S4 and S5 boreholes show very low lead contents due to their sandier composition and corresponding high permeability and low retention capacity of heavy metals.

Table 1- Results of soil chemical analysis

Sample	Depth Sample (cm)	Aluminum (0.01 %*)	Lead (0.20 mg/kg*)	Calcium (0.01 %*)	Iron (0.01 %*)	Magnesium (0.01 %*)	Sodium (0.01 %*)
S1	15 - 30	2.47	1.60	1.50	7.37	1.58	0.12
	30 - 55	1.22	0.80	1.46	2.11	0.75	<0.01
	55 - 80	0.69	2.60	0.71	1.67	0.27	<0.01
	80 - 100	1.01	2.70	0.54	4.80	0.61	0.68
S2	0 - 30	1.5	2.10	4.03	2.78	1.46	<0.01
	30 - 50	4.63	2.40	13.1	7.22	4.51	0.42
	50 - 80	1.54	1.50	2.50	5.03	2.26	<0.01
S3	0 - 20	1.23	0.90	2.29	2.08	0.31	<0.01
	20 - 35	0.84	0.50	2.46	1.06	0.62	<0.01
	35 - 50	0.80	0.60	0.85	7.59	0.71	<0.01
	50 - 80	1.56	<0.20	3.45	1.46	1.77	0.68
	89 - 95	0.71	0.20	0.64	2.67	0.43	<0.01
S4	0 - 30	2,72	<0,2	0,41	1,3	0,54	<0,01
	30 - 50	2,26	<0,2	0,83	1,1	0,76	<0,01
	50 - 100	1,96	<0,2	0,43	0,98	0,15	<0,01
S5	0 - 30	0,61	<0,2	0,6	1,55	0,19	<0,01
	30 - 40	3,45	<0,2	10,2	5,94	0,61	<0,01
	40 - 80	3,37	<0,2	1,38	6,95	2,2	<0,01
	80 - 100	0,24	<0,2	0,3	1,78	0,08	<0,01
	100 - 110	0,15	<0,2	0,05	0,94	<0,01	<0,01

** Maximum allowed concentration*