SCANNING ELECTRON MICROSCOPIC INVESTIGATION OF NICKEL BEARING-MINERALS ASSOCIATED WITH A BRAZILIAN LATERITIC ORE

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Presentation

Samples from a Ni-lateritic ore associated with intemperic material formed from mafic-ultramafic rocks, were object of a characterization study. Due to the several geological processes, meaning alteration in igneous and supergenic environments, a very complex mineralogical assembly was developed, with phases presenting peculiar textural relationships.

A detailed mineralogical investigation applying scanning electronic microscopic with backscattered detector associated with EDS microanalysis was the only possible way to define minerals composition and associations. The SEM used was a Stereoscan 440, Leo, coupled to an Isis EDS System, Oxford, with Ge detector and ultra thin window.

Textural Aspects of the Ore

The material had a typical lateritic appearance of a red soil, with large quantity of argillaceous fraction and a very friable aggregates (dimensions of one to ten millimeters) portion.

Under microscopic observation the ore showed three distinct features: individual grains with dimensions of 10 to 50 µm, aggregates with a matrix of fine crystallised alteration mineral phases and immerses grains (photos n. 1 and 2), and aggregates composed only by the alteration phases.

The individual grains are not frequent and correspond to primary and some secondary minerals. Micro to cryptocrystalline aggregates (the alteration matrix) are the predominant feature and seam to be originated both by igneous and supergenic processes.

The great variation of chemical composition in the matrix of the aggregates, as well as the imbrication of crystallites, made the differentiation of mineral phases and its chemical characterization a hard task.

The adopted procedure for the investigation was a first scanning of several aggregates and several sections in order to recognized distinct phases by their BSE contrast, with textural features characterization. In each grain and each phase was also qualitatively verified all the elements present by the microanalysis system.

In a second step the semiquantitative chemical composition were performed by EDS as routine analysis. All the elements identified in the previous step - Si, Al, Mg, Fe, Cr, Mn, Ni, Co, S, Ba and also oxygen – were quantified in the different mineral species. Non normalised procedure was applied due to the large amount of hydrated mineral phases.

Based on these chemical composition data was possible to group of phases with similar grades range of SiO_2, Fe_2O_3, Cr_2O_3, Mn and Ba, as showed in table 2. Some of these groups could be well identified with X-ray powder diffraction aiding.

Ni- Mineralogical Assembly

Several mineral phases of the ore, primary and mainly secondary, contained nickel in their crystalline structure.

At least three silicate phases containing nickel could be recognised, as shown in table 1. Among the typical primary silicates minerals, in grains associated or not with alteration phases, only olivine (forsterite - fayalite) showed an insignificant Ni grade (< 0,1%), photo n. 1.

Two different secondary silicates have important Ni grade (1 to 16%), both normally occur fine crystallised forming aggregates, monomineralic or limonitic argillaceous associated with quartz, opal and Fe-oxides (photo n. 2).

Table 1- Ni-Silicates Composition – EDS Determination

	SiO_2	Al_2O_3	MgO	Fe_2O_3	Cr	Mn	Ni	Co	S	Ba	sum
Olivine	54,40	5,97	31,52	7,89	0,33	0,27	0,01	nd	0,07	nd	100
	55,66	4,29	32,00	7,74	0,36	0,16	0,08	0,01	0,07	nd	100
	44,22	5,03	25,58	6,51	0,33	0,08	0,11	0,01	nd	nd	82
Garnierite	40,05	6,27	2,42	6,93	1,81	0,05	4,62	nd	0,15	nd	62
	44,78	6,37	1,93	5,860	1,39	0,03	6,23	0,02	0,06	nd	67
	35,37	4,50	0,94	4,83	1,26	0,02	13,60	0,09	0,13	nd	61
	37,56	5,25	1,00	5,14	1,44	0,03	13,75	0,15	0,12	nd	64
	36,20	4,19	1,06	4,53	1,01	nd	15,57	0,20	0,06	nd	63
	27,75	1,38	11,79	6,00	0,18	nd	4,65	nd	0,09	nd	52
Nepouite	33,15	7,63	11,05	5,56	1,46	0,06	6,26	nd	0,14	nd	65
	29,41	7,60	16,30	7,14	0,54	nd	4,58	0,06	0,13	nd	66
	28,00	6,21	13,24	5,66	0,91	0,02	5,38	0,07	0,11	nd	60
	29,03	7,42	16,20	6,64	0,39	0,07	4,53	0,05	0,15	nd	65
	30,26	3,30	1,72	25,76	0,20	0,09	1,86	nd	0,10	nd	63

nd = not detected, grade below the analytic limit of detection

Some spinels belonging to chromites and Al-chromites groups, that are primary minerals, showed a bigger content of nickel than the olivine (table 2).

Iron oxides, both in individual grains and microcrystalline aggregates, always have an expressive Ni grade, although the higher Ni values (similar to that of the secondary silicates) are associated with manganese oxides. Manganese oxides, with or without barium associated, always appear with botrioidal texture in microcrystalline aggregates, typical aspect of secondary minerals (photo n. 3).

Table 2 - Ni-Oxides Composition – EDS Determination

	SiO_2	Al_2O_3	MgO	Fe_2O_3	Cr	Mn	Ni	Co	S	Ba	sum
Al-Cr spinels	nd	52,27	14,46	10,14	1,04	0,08	0,16	0,02	0,03	nd	78
	1,06	58,92	15,36	19,74	4,01	0,27	0,26	0,09	0,07	nd	100
	nd	46,39	12,95	11,66	5,31	0,05	0,13	0,07	0,05	nd	77
	nd	33,23	9,59	13,51	12,96	0,08	0,17	0,05	0,03	nd	70
	nd	29,82	7,70	19,53	13,86	0,19	0,20	0,08	0,03	nd	71
	nd	26,06	7,63	17,56	16,23	0,13	0,04	0,04	nd	nd	68
	nd	26,43	7,32	17,67	16,39	0,31	0,10	0,06	0,03	nd	68
Iron Oxides	4,74	3,73	0,07	45,31	0,54	0,04	1,54	0,07	0,01	0,03	56
	2,91	2,63	0,16	41,87	0,45	0,14	1,20	0,06	0,17	0,16	50
	2,20	2,42	0,04	34,81	0,38	0,20	1,02	nd	0,16	0,24	42
	2,49	2,78	nd	38,57	0,06	0,36	1,24	0,16	0,14	0,41	46
	5,14	2,39	0,41	31,27	0,08	0,16	0,64	0,03	0,01	nd	40
	4,68	2,65	0,42	37,19	0,26	0,19	0,83	nd	0,13	nd	46
Mn-Oxides	1,01	6,08	0,43	14,38	0,36	10,07	5,44	3,45	nd	nd	41
	6,54	7,27	0,68	3,01	0,30	17,66	7,96	5,07	0,08	1,76	49
	nd	7,62	0,66	5,02	0,33	14,27	9,69	5,90	nd	nd	43
	nd	6,82	0,93	4,96	0,23	15,62	9,03	5,77	nd	nd	43
	1,06	5,90	0,43	5,89	0,22	15,18	9,86	5,75	nd	nd	44
	nd	7,13	0,31	6,08	0,35	15,23	10,75	6,64	nd	nd	46
	nd	4,55	1,03	5,34	0,23	19,19	10,20	4,22	nd	nd	45
	0,48	13,84	0,39	1,46	0,13	21,38	2,58	6,30	nd	0,93	47
	0,62	14,09	0,32	1,61	nd	21,39	2,51	6,33	nd	0,73	47
	0,48	13,76	0,45	1,73	0,04	20,60	2,67	6,89	nd	0,51	47
Mn-Oxides with Ba	1,23	23,5	nd	4,36	0,14	32,7	2,85	5,84	0,08	4,04	71
	0,81	5,96	0,20	2,65	0,07	29,25	1,38	2,57	0,10	4,78	43
	0,63	9,03	0,27	1,10	0,08	28,26	1,87	3,77	0,03	4,35	45
	0,36	3,71	0,30	0,62	0,15	42,47	1,0	1,96	0,05	5,85	51
	1,27	0,85	0,11	2,17	0,06	42,50	0,67	1,41	nd	9,02	49
	1,45	0,76	0,29	2,81	0,04	41,57	0,68	1,73	0,01	8,90	49
	0,12	1,29	0,09	3,85	0,16	70,91	0,25	1,05	0,02	14,37	78
	0,52	0,85	0,25	2,37	0,18	70,87	0,39	1,13	0,06	13,83	77
	0,42	0,70	0,03	2,73	0,09	69,23	0,27	0,86	0,01	13,25	74
	0,79	1,07	0,18	3,39	0,20	68,34	0,34	1,09	0,06	13,30	75

nd = not detected, grade below the analytic limit of detection

Conclusion

In the study of complex mineral assembly in a lateritic material composed by high amount of fine and poorly crystallized phases, scanning electron microscopy associated with microanalysis was one of the most appropriated tool for mineral species characterization.

The results obtained were the clue to understand the mineralogy and also helpful in the mineral phase's identification done by other analytical techniques.

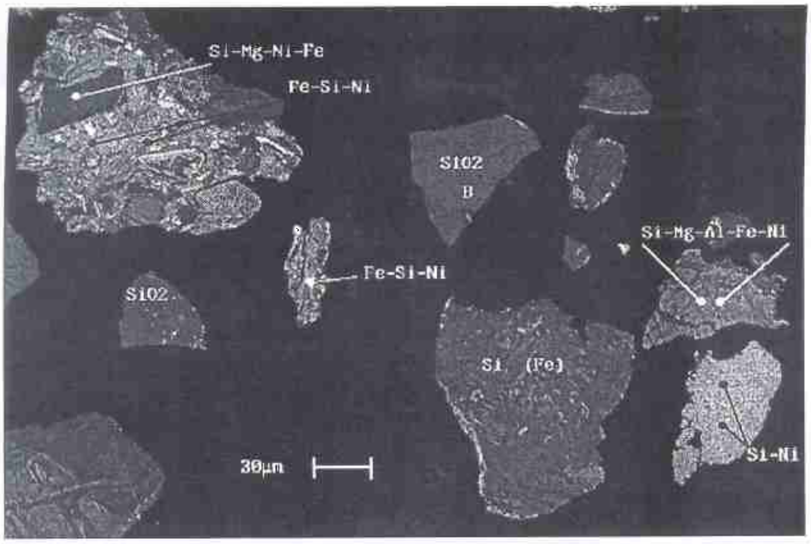

Photo n. 1 –

General aspect of primary and alteration silicates. (A) alteration aggregate containing a grain of primary silicate (B) cryptocrystalline quartz.

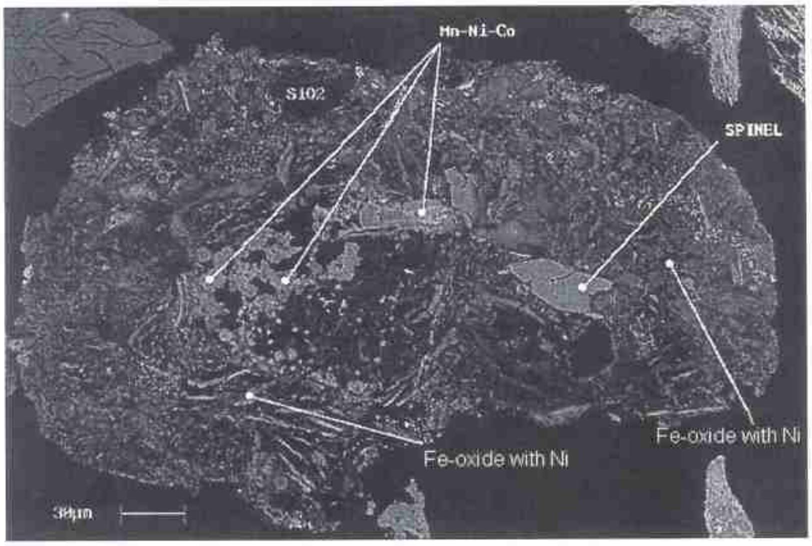

Photo n. 2 –

Argillaceous-limonitic aggregate composed by an iron oxide mass with Ni, containing relicts of quartz and spinel with botrioidal texture Mn-oxide deposition.

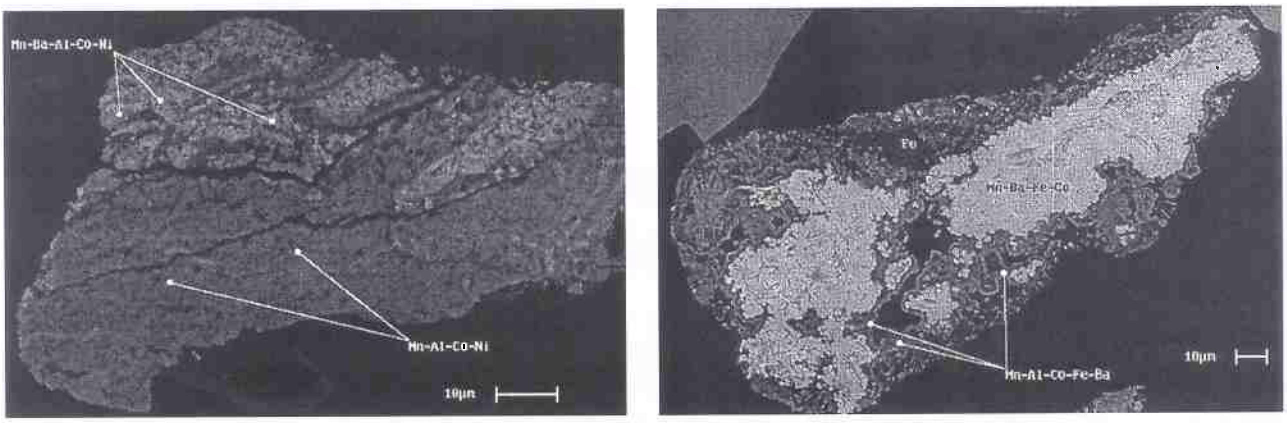

Photo n. 3 – Manganese oxide microcrystalline aggregates, in typical botrioidal texture and showing layers of Ba low and high content both with cobalt associated. Note the high porous frequency.