INTENSITY AND EXTENSITY OF MINERALS FROM BARRA VERDE AND BREJUI MINES, CURRAIS NOVOS, RN

Por

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PREVIOUS WORK

Niggli and Niggli (1948) elaborated the contribution of Niggli and Huber (1943) indicating the possibility of statistical studies of minerals specially applied to elucidate the economic aspects. Epprecht (quoted by Niggli & Niggli, 1948) applied this method to ore bodies and their mineralogical components from the Iron and Manganese ore deposits of the limestones near Gonzen, Switzerland, treating separately the ore body of iron and of manganese. He further classified them as "ore body" and "fissures". His correlation with intensity and extensity thus leads to valuable conclusions, on the economic aspects of the deposit.

Schneiderhohn (quoted by Niggli & Niggli, 1948) represented them in diagrams with squares filled according as the intensities permit, wherein a fine line in a complete square represents the last category of intensity. This has been successfully applied by Cissarz in the table of intensity of minerals in the tin-ore deposits of the Erzbirge compiling information on the genetic relationship of minerals with their localities.

Bhaskara Rao (1957) studying the Simplon Tunnel fissure minerals of the Northern Swiss Part, made a singular elaborative work of the collections of the tunnel, distributed all over Switzerland, for the first time. Tables were presented of the extensity and intensity of the tunnel minerals in general, and then in particular relating to the rock types, in which they were formed. The studies elucidate the relationship of the fissure minerals to the associated rock, thus suggesting the probable origin of the fissure minerals. Anomalies in the sympathetic and antipathetic relations between the intensity and extensity were found commonly, while the minerals quite extensive were not always quite intensive, and vice-versa.

Kaaden (1958) studying the genesis and mineralisation of the tungsten deposit Uludag, Turkey, related the abundance of ore zone minerals and the sequence of deposition, with nomenclature similar to the extensity factor.

Inspiration from these studies was taken by many scientific workers, in applying statistical methods to solve several geological problems.

THE PROBLEM AND THE METHOD OF STUDY

During excursions to the Barra Verde and Brejui mines located nearly 10 km south of Currais Novos of the Rio Grande do Norte State, with the students of the Curso de Geologia of Recife, several samples have been collected from the calcareous and skarn rocks of the mines where scheelite is explored. Also a few samples bought by this Course, included some samples from the mines. Oportunity was availed only to limit the studies to the samples from the mineralised zone of the mines, with special attention to the minerals present there. However much possibility existed in the Barra Verde mines due to the availability and variety present in the dumps, and several scheelite samples from both the mines were donated by the staff of the mines.

The study is limited further to the collections present in the Mineral Museum of this Course of Geology, made mainly by the author and Prof. H. Ebert.

Statistical study of the mineralised regions is indicative of the potentiality of the deposit. Two types of works could be undertaken on such a collection of samples, as elucidated above, namely extensity and intensity relations.

The extensity of a mineral is the measure of its distribution all through the region, or the bed, or the deposit, or the collection, whichever be the case. The samples are, however, obtained from various localities of the mine, and thus they are representative. This is called the extensity of distribution, or the extensity factor, and was classified by earlier workers in the following way (Table I).

TABLE I

NIGGLI & NIGGLI (1948) (FOR ORE DEPOSITS)	BHASKARA RAO (1957) (FOR A COLLECTION)
(1) Common minerals that appear in all or practically all the examined sub-units.	Group A: Common minerals appearing in all the samples.
(2) Wide-spread minerals, i. e. those that appear in a considerable percentage of the examined subunits.	Group B: Frequent minerals appearing in most of the samples.
(3) Occasional minerals that appear here and there and are on the whole, rather frequently met with.	Group C: Widespread minerals appearing in a considerable percentage of the samples.
(4) Sporadic minerals.	Group D: Occasional minerals appearing rather frequently.
(5) Rare minerals.	Group E: Sporadic minerals.
	Group F: Rare minerals.
	Group G: Very rare minerals.

Here, in this work, some minor changes are made, as the problem is neither related only to an ore deposit nor just to a collection of fissure filling materials of irregular distribution.

The intensity of a mineral is the measure of its participation in any locality of the region, or in any sample of the collection. When a mineral is present in high amount in any particular sample of the collection the intensity of participation of that particular mineral is obtained, which in the cited case be "very great." Thus could be obviously minerals distributed well all over the region but in small quantity, which means that the mineral has a low intensity factor. The modes of classification or representation of this factor could be different, but the essential points are the same. The following are cited from Niggli & Niggli (1948), and Bhaskara Rao (1957).

Class A: In large amounts (Intensity very great);
Class B: In considerable amounts (Intensity great);
Class C: In moderate amounts (Intensity marked);
Class D: In small amounts (Intensity small);
Class E: In very small amounts (Intensity very small).

It is possible that there could be overlap, as strict limits are not possible in such classifications. However, still. it could represent the essential factor in that the mineral under study could be economic or academic in interest, both in quantity and quality.

As a natural consequence, the paragenesis of minerals which throw much light on the evolution, could be obtained, through the sympathetic and anti-pathetic relations of the participants by the graphical method, which is attempted here.

OBSERVATIONS

a) *Extensity of distribution in Barra Verde Mine*:

Minor modification is made by grouping together F & G in the above cited classification.

Among the 298 samples studied, strangely, none are found in all the samples as common minerals, and also as frequent minerals in most of the samples. This suggests that the original sediment have had heterogeneous composition and localised impurities. Thus groups A and B are unrepresented. Scheelite and garnet dominate in the group C, with the subordination of quartz, chalcopyrite, epidote, and vesuvianite, which are quite characteristic as skarn minerals, as the normal calcareous rock is not considered here as a mineral constituent, and only representative coloured calcites, which are coarse crystalline, are brought in later stages as to show their affinity to other minerals.

Molybdenite and pyrite are mentionable in the group D, as the sulphides. Chabazite, stilbite, and fluorite appear as the hydrothermal minerals in paragenetic association with the pegmatites which are frequently intruded into the skarnite rock. Malachite, turquois, and bornite are present as the alteration and secondary products of the copper suphides, in group E. The minerals dominating in the group F, are the silicates such as amphiboles, tremolite, actinolite and phlogopite. Selenite is found isolated in a locality.

All the coloured calcites are mostly afiliated with the group E and group F, where the secondary or metamorphic minerals are present of Fe, and Mg.

b) *Extensity of distribution in Brejui Mine*:

No mineral is recorded in both the groups A and B, as common and frequent minerals, of the 96 samples studied. Epidote as widespread mineral is subordinated by quartz. The typical scheelite paragenesis in garnet, vesuvianite, pyrite, chalcopyrite, are noted along with scheelite in the category of occasional minerals. Molybdenite and fluorite appear as sporadic minerals, with malachite as alteration of copper minerals. Scapolite, as well as covellite appear here and there. The coloured calcites, few in number, appear in closest association with iron minerals in the last two groups.

Classification	*EXTENSITY**	
	Barra Verde Mine (298)	Brejuí Mine (96)
GROUP A	None	None
GROUP B	None	None
GROUP C	Scheelite (91), Garnet (85), Quartz (49), Chalcopyrite (46), Epidote (44), Vesuvianite (35)	Epidote (40), Quartz (20), White Calcite (20)
GROUP D	Grey calcite (18), Molybdenite (17), Yellow calcite (15), Pyrite (14), White calcite (12), Malachite (12), Chrysocolla (10)	Garnet (19), Chalcopyrite (18), Vesuvianite (13), Scheelite (11), Pyrite (11)
GROUP E	Scapolite (9), Turquois (8), Red calcite (8), Pinguite (8), Rose calcite (7), Limonite (7), Cordierite (7), Stilbite (7), Chabazite (6), Fluorite (5), Bornite (4)	Malachite (10), Yellow calcite (10), Pinguite (7), Fluorite (7), Limonite (6), Molybdenite (5)
GROUP F	Green calcite (3), Tremolite (2), Actinolite (2), Aragonite (2), Selenite (2), Apatite (2), Blue calcite (2), Biotite (1), Arsenopyrite (1)	Scapolite (4), Red calcite (4), Cordierite (4), Grey calcite (3), Rhodocrosite (3), Covellite (2), Green calcite (1)

*The numbers of specimens are indicated in the brackets.

c) *Intensity of participation in Barra Verde Mine*:

It is beyond doubt that the calcites are large amounts. The crystalline calcite masses, which in general are representated by white and colourless varieties, are generally in medium to coarse granularity, while the coloured calcites are as bigger crystals with defined rhomboedral cleavages. Since classify them among intensity relations of both the mines dit not seem very necessary and as such they are eliminated from these lists.

Highly intense and in great masses are scheelite and selenite of whom the latter was only found in two large pieces. Big crystals of scheelite have been recorded. In considerable quantities are the skarnite minerals epidote and vesuvianite, with chalcopyrite subordinating. Garnet, pyrite are the other two from that group which are found in moderate amounts. Fluorite is noted in the same group which is a difficult mineral for distinction in the mines, except under UV lamp. Molybdenite appears in small amounts and as shabby masses. The amphiboles, and other copper minerals are in very small quantities, along with the zeolites.

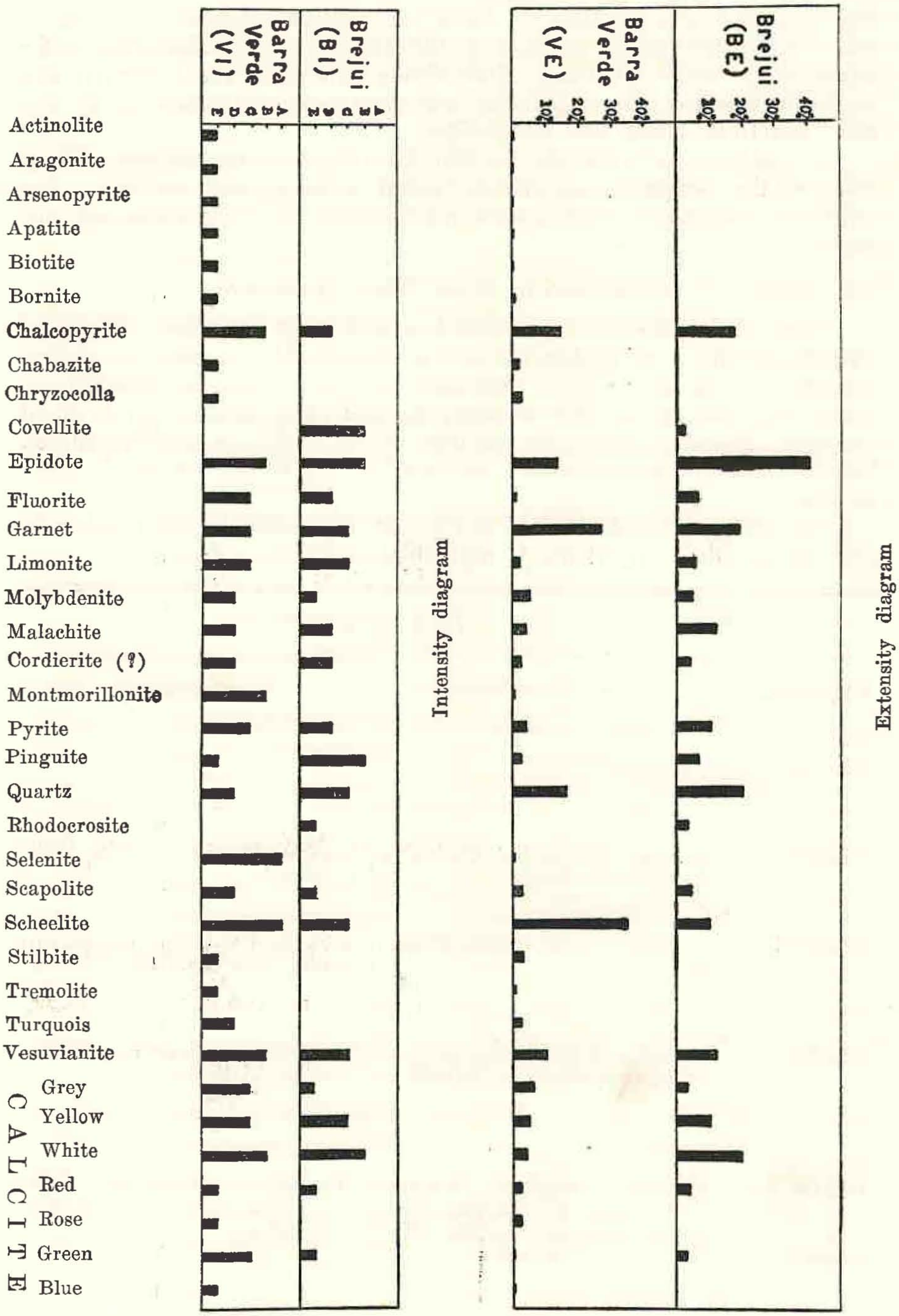
It could be seen from the list that the affinity of the minerals reflects much on the paragenetic association, typical of the skarnite minerals. The sulphides, chalcopyrite, pyrite, show much affinity with malachite and turquois.

d) *Intensity of participation in Brejui Mine*: (Table IV)

None of the minerals are observed in very great quantities. Masses of pinguite, covellite, and epidote are seen as considerable amounts. In moderate amounts appear scheelite, vesuvianite and garnet in the characteristic paragenetic association, while chalcopyrite, and pyrite grade lower in small amounts. Fluorite, usually seen in these mines is also in small quantities. Small granules of molybdenite is recovered during the extraction of scheelite ore.

The alteration products such as limonite, and malachite are noted quite often though their importance is negligible.

Classification	*INTENSITY*	
	Barra Verde Mine	Brejuí Mine
CLASS A	Scheelite, Selenite	None
CLASS B	Epidote, Vesuvianite, Chalcopyrite, Montmorillonite	Epidote, Pinguite, Covellite, White calcite
CLASS C	Limonite, Garnet, Pyrite, Fluorite	Scheelite, Vesuvianite, Garnet, Limonite, Quartz, Yellow Calcite.
CLASS D	Scapolite, Molybdenite, Quartz, Turquois, Malachite, Cordierite	Cordierite, Chalcopyrite, Pyrite, Fluorite, Malachite
CLASS E CLASS F	Aragonite, Pinguite, Bornite, Chrysocolla, Arsenopyrite, Tremolite, Actinolite, Apatite, Biotite, Stilbite, Chabazite	Molybdenite, Rhodocrosite, Scapolite, Green calcite, Red calcite, Grey calcite


Barra Verde (VI)
Brejui (BI)
Barra Verde (VE)
Brejui (BE)
10%
20%
30%
40%
Intensity diagram
Extensity diagram
Actinolite
Aragonite
Arsenopyrite
Apatite
Biotite
Bornite
Chalcopyrite
Chabazite
Chryzocolla
Covellite
Epidote
Fluorite
Garnet
Limonite
Molybdenite
Malachite
Cordierite (?)
Montmorillonite
Pyrite
Pinguite
Quartz
Rhodocrosite
Selenite
Scapolite
Scheelite
Stilbite
Tremolite
Turquois
Vesuvianite
CALCITE
Grey
Yellow
White
Red
Rose
Green
Blue

A NOTE ON THE PARAGENESIS

The paragenetic association of minerals in both the mines is well defined. Both of them show the typical scarn minerals in close relationship.

It is remarkable that the extensity and intensity relations indicate mostly in equal quantities both the calc-silicates, and also the sulphide minerals. Mention may be made of epidote, vesuvianite, garnet, and in some places scapolite, tremolite, and actinolite which are in very close association. Further all show the metasomatic nature of the deposit and their metamorphic origin in their distribution.

The sulphide minerals, such as chalcopyrite, covellite, pyrite, arsenopyrite, molybdenite, must have been the secondary sulphide minerals. Much metamorphism has been imposed on these rocks, as there is evidence of recrystallisation.

It has been observed by Johnston and Vasconcellos (1944, 1945) that the deposit is contact metasomatic in origin and that there has been some molybdenium in the scheelites, thus giving rise to powellite. Verification has been made by Bhaskara Rao (1960) in a note, that there exists a scheellite-powellite variation in the deposit. Thus as there is enough evidence to say that during the oxidation of molybdenite there has been metasomatic deposition of the scheelite ore, and during its formation obvious diffusion or replacement has taken place to give rise to powellite. Thus it is not possible to distinguish the two species from one another for the present study.

COMPARATIVE STUDY OF THE EXTENSITY AND INTENSITY DIAGRAM

Representation of the extensity and intensity of the minerals from both the mines is made for a comparative study through histogrammes. For the sake of brevity, the following representing symbols are used.

BE — Extensity in Brejuí Mine;
BI — Intensity in Brejuí Mine;
VE — Extensity in Barra Verde Mine;
VI — Intensity in Barra Verde Mine.

The comparative status of the minerals reveal the abundance in both the mines of: chalcopyrite, epidote, garnet, quartz, scheelite, vesuvianite, excluding the calcites. This is in consonance with the typical skarn paragenesis.

Grading next are: molybdenite, pyrite, malachite, scapolite, which are comparatively similar in both the cases.

Speaking of contrast, Barra Verde mine shows a more variety of mineral species than Brejui mine. This is best noted in the presence of actinolite, aragonite, arsenopyrite, apatite, biotite, bornite, chabazite, chrysocolla, montmorillonite, selenite, stilbite, tremolite, turquois, along with rose and blue calcites, in Barra Verde only; and covellite, and rhodocrosite, which are present in Brejui only.

Considerations on the relations between the extensity and intensity of minerals in the mines individually treated, allow the following observations.

Brejui Mine:

a) *Uniform BE and BI relations*: Epidote, fluorite, garnet, malachite, molybdenite, pyrite, quartz, rhodocrosite, scapolite, scheelite, vesuvianite, and the calcites.

b) *BE greater than BI*: Chalcopyrite.

c) *BE lesser than BI*: Covellite, limonite, cordierite (?), and pinguite.

Barra Verde Mine:

a) *Uniform VE and VI relations*: Chalcopyrite, chrysocolla, epidote, garnet, molybdenite, and calcites (rose, and red).

b) *VE greater than VI*: Quartz, and scheelite.

c) *VE lesser than VI*: Actinolite, aragonite, arsenopyrite, apatite, biotite, bornite, chabazite, fluorite, limonite, malachite, cordierite (?), montmorillonite, pyrite, pinguite, selenite, scapolite, stilbite, tremolite, turquois, vesuvianite, and calcites (grey, yellow, white, green and blue).

It could be inferred that all the minerals which are of any importance appear in the first two categories where extensity controls the classifications. Those minerals grouped in the last category where intensity dominates, are of less importance as they are less distributed, detached and inconsistent, and as a consequence are of little importance.

SUMMARY AND CONCLUSIONS:

Statistical studies of minerals indicate in an illustrative way the various types of minerals which participate and distribute in the samples collected from the mines. Obviously not all minerals show great distribution and participation, thus giving variations in their extensity and intensity factors which are the qualitative and quantitative indicators in the applied mineralogical studies. They also reflect to a great extent the paragenetic associations of the minerals.

The minerals of the skarnite rocks are taken for study from the collections in the Mineralogical Museum of the course of Geology in Recife, which are collected from the Brejui and Barra Verde Mines.

The typical calc-minerals associated are: epidote, vesuvianite, garnet, scheelite, scapolite, and in some cases tremolite-actinolite-fluorite-apatite, along with various types of coarsely crystalline calcites. The sulphide minerals in close paragenetic association are: chalcopyrite-pyrite-covellite-molybdenite and in some cases bornite-arsenopyrite. Other copper minerals include limonite-pinguite. The calcites show their variation in coloration in relation to the various minerals which are rich in copper or iron thus resulting in rose, red, green, and blue colours.

Johnston & Vasconcellos (1944, 1945) conclude contact metasomatic origin for the deposit. In the present study the paragenetic relations are revealed to a great extent, indicate that there has been more to account for the origin.

In the first place there has been the metamorphism of high temperature phase, later falling slowly and accounting to another phase. The metasomatic replacement of the deposit has taken place because of the hydrothermal solutions. Ample recrystallisation of the original sediment has taken place and it could be observed that the original sediment has irregularly distributed impurities, thus giving rise to various types of minerals with differing composition.

It is also true that the minerals which are not predominant and which take an insignificant part in the study of the deposit show antipathetic relations between extensity and intensity factors, whereas the common minerals taking part in typical paragenesis show sympathetic relation with one another. Further it is observed that the mineral variation in Barra Verde is more ample than in Brejui. This could not be generalised since the number of specimens are less in the Brejui mine in relation to Barra Verde Mine (1:3) in the collection under study.

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