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Guidebook

2. THE ALKALINE DISTRICT OF LAGES, SC

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Geographical setting

The city of Lages, in the SW part of the Lages Dome, is 365 km from Porto Alegre and 356 km from Curitiba, via BR-116 highway. Florianópolis, the capital of the State of Santa Catarina, can be reached by highway BR-282, and is 230 km from Lages (Fig. 1). Air transport is available through RIOSUL, which operates only small planes.

Because of its altitude (900 m), climate can be quite cold; frost is common is winter, and it snows an average of one day each year. Warm clothes are recommended for this trip.

The Lages Dome: regional geology

The "Lages Dome", occupying about 2100 km^2 made up mainly of rocks of the Gondwana Sequence, lies at the border of the basaltic trapp. It is a major feature of the southern Brazilian geology (e.g. Maack, 1947; Takeda, 1958; Loczy, 1966, 1968).

A great variety of alkaline rocks is found in the district, dispersed as relatively small outcrops. The age span of intrusion is apparently restricted to a short interval. The entire alkaline district is as large as any of the Brazilian alkaline provinces, as indicated by Ulbrich & Gomes (1981).

The domic character of the area is evidenced by the concentric arrangement of the Gondwanic sedimentary rocks, showing the entire Gondwanic succession, from the Triassic Botucatu Sandstone in the northern, western and southern borders, to the Permian Itararé beds which outcrop in the center, at altitude similar to those of the base of the basalts. A series of minor domes, inside the major structure, are depicted by local drainage system.

Guazelli & Feijó (1970) stressed in their maps the annular and radial character of the inverse faults described by Loczy (1966, 1968) as responsible for vertical displacements of up to 350 m in some cases.

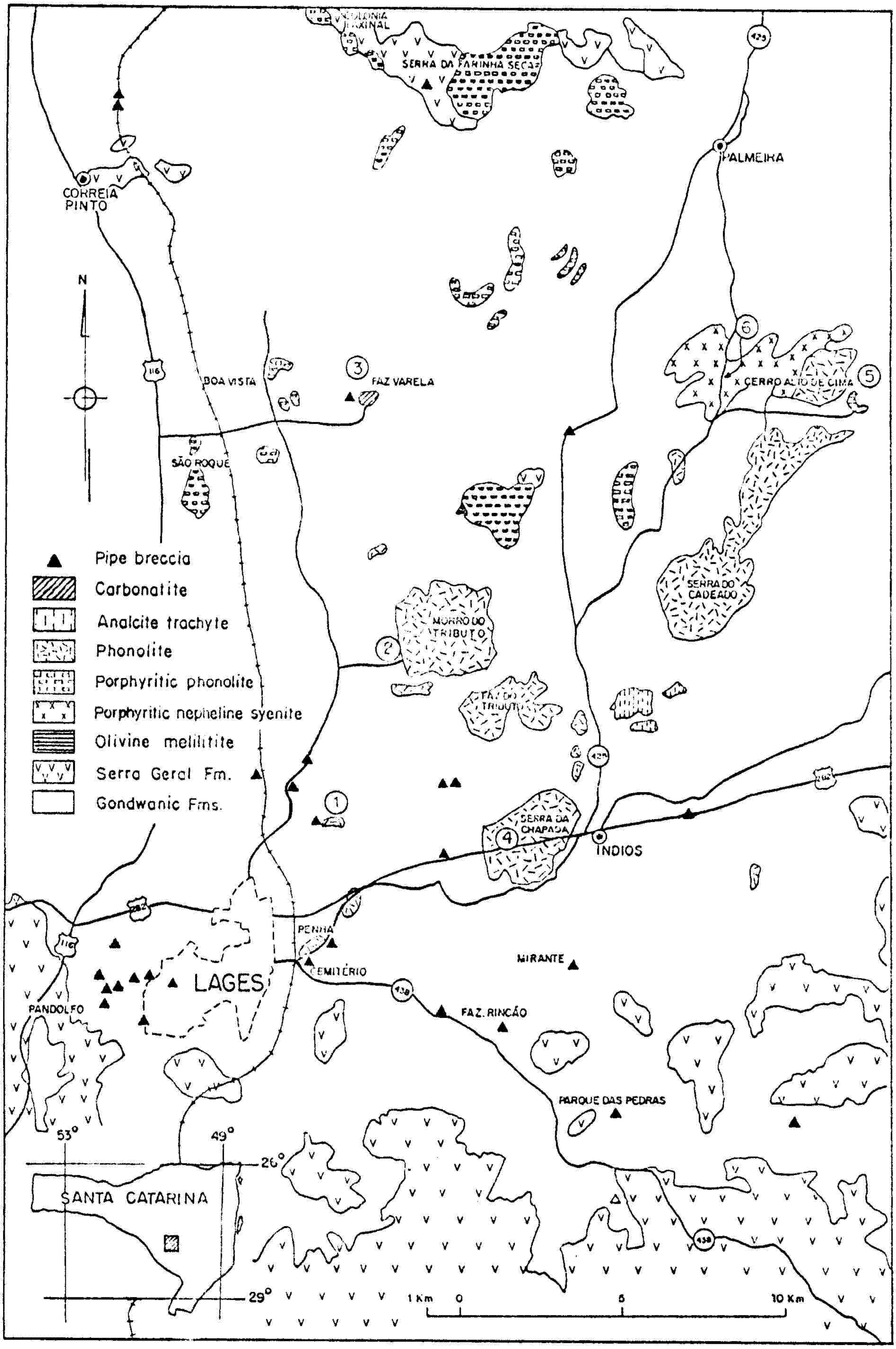

Figure 1 -- Outcrops to be visited in the Lages Alkaline District.

Working on the bauxite occurrences in the area, Szubert & Vergara (1975) emphasized the importance of diabase sills and dykes close to the northern outcrops of leucocratic alkaline rocks.

The alkaline rocks which constitute the District of Lages represent shallow levels of intrusion; extrusive rocks and deep intrusions are unknown to the moment.

Scheibe et al. (1984) grouped the alkaline rocks from this district in four classes:

Leucocratic alkaline rocks

Ultrabasic alkaline rocks

Carbonatites and associated rocks

Pipe breccias and Kimberlites

Leucocratic alkaline rocks

The total outcropping area of alkaline rocks in the district is little over 50 km^2, mostly represented by this first group. It is represented by phonolitic dykes, analcitic trachytes and phonolites in the southeast, and porphyritic nepheline syenites more to the north. The preferred level of intrusion is the contact between sedimentary beds ofthe Guatá and the Passa Dois Groups giving this suite of leucocratic rocks an annular outcrop pattern, which was stressed in the early descriptions cited above. The map presented by Scheibe (1986), however, shows that the larger intrusions are concentrated in a northeastern belt, 10 km wide.

Phonolites

Main occurrences are found at the Morro do Tributo (and Fazenda do Tributo), the Serra da Chapada and the Serra do Cadeado; besides many minor bodies are also present.

The Morro do Tributo (1220 m high) is the dominant elevation in the region, and the outcropping area of alkaline rocks is about 4 km in diameter. The Fazenda do Tributo area, to the southeast, could represent an early extension of the same set of bodies. Many blocks of sedimentary rocks, upheld by the intrusion, are still present in the slopes of Morro do Tributo.

A special petrographic feature of these phonolites is the appearance of poikilitic aegirine crystals, which occur as centimetric spots, especially in the central parts of the massif.

In the Serra da Chapada (1000 m high) and at higher stratigraphic levels, the aegirine aggregates are submillimetric. In the outcrops along the BR-282 highway, the lateral and upper contacts with the Serra Alta shales, which cover the central part of the hill, are metamorphosed by the intrusion.

The Serra do Cadeado, to the east, is made up by a set of phonolite outcrops, representative of one or several intrusions; individual forms of the intrusions were not defined.

Many other minor intrusions of phonolites, some of them several hundred meters wide, are found in the region, mainly as smaller aphanitic dykes.

Analcite trachytes

A few small bodies of leucocratic rocks occur to the south of the Serra do Cadeado, and were called "analcite trachytes" by Scheibe et al. (1984); they present trachytic textures and minor amounts of normative quartz, which sometimes can be also observed as an occasional modal mineral.

Porphyritic phonolites

They constitute some relatively larger massifs, like those of the Serra da Farinha Seca and the Córrego dos Sete Passos, as well as smaller intrusions, like those from the Colônia Faxinal and the Córrego da Farinha Seca, the Boa Vista and the Fazenda São Roque.

The Serra da Farinha Seca, located in the northern part of the major circle of leucocratic alkaline rocks, is a hill with altitudes of ca. 900 m. It was originally thought to be constituted entirely by a continuous dyke, 17 km long (e.g. Lindstaedt, 1972). Guazelli & Feijó (1970) and Szubert & Vergara (1975) showed in their maps that the alkaline rocks in this area were emplaced as almost equidimensional bodies cutting the sedimentary Gondwanic rocks and also diabases (possibly a sill at the level of the Irati Formation, practically absent in this area).

The prophyritic phonolites which outcrop to the north of the Morro do Tributo (at the site of the Córrego dos Sete Passos) intrude the sedimentary rocks of the Itararé Group, at the base of the Gondwanic sequence. An almost circular later occurrence of phonolites and a pipe breccia of probable kimberlitic affinity are in turn intrusive into the porphyritic phonolites of this area.

Porphyritic nepheline syenites

The porphyritic nepheline syenites form one of the larger massifs, at the Cerro Alto de Cima (altitude 1040 m), covering about 9 km^2. Compositional variations are found and were interpreted by Scheibe et al. (1984) as indicative either of zoning in the intrusion or of the existence of several separate intrusions, whose contacts could not be defined. The northeastern part of this area is formed mostly by phonolites, very similar to the southern occurrences of these rocks (Morro do Tributo, Serra da Chapada).

Ultrabasic alkaline rocks

This group embodies nephelinitic and melilititic rocks, many of them lamprophyric, which outcrop as dykes or as matrix material of pipe breccias (in the rare cases in which the material was fresh and it was possible to determine their mineralogy).

Scorza (1965) described samples of olivine melilitites collected by Loczy (1966), emphasizing the fact that rocks with melilite were unknown in the Brazilian literature. Barbosa (1933) referred to lamprophyres and augitites, collected by Paiva (1933) in the Lages area.

The main occurrence is a semi-annular dyke of olivine melilitite, to the east of Cerro Alto de Cima. It presents a large exposure at the Indios-Palmeira highway, and intrudes sedimentary rocks of the Irati and Serra Alta Formations.

Carbonatites and associated rocks

The Fazenda Varela carbonatites, situated in the central area of the Lages Dome, were studied with some detail (Scheibe, 1978, 1979; Scheibe & Formoso, 1982).

The carbonatites and the associated rocks are characterized by a distinct scintillometric anomaly. They are found in a lozange-shaped area, limited by N-S and NE-SW faults with an extension of the order of 600 m.

The country rocks (shales and sandstones of the Guatá Group) are fenitized feldspathic breccias with schlieren-like carbonatite veins, making up a contact zone with a width of several cm to dm, eventually, it may reach up to 20 m in width (excavation and drill core samples). The drill cores are constituted by an irregular alternance of carbonatites and feldspathic breccias, attesting to the local importance of internal explosive processes.

Pipe breccias and kimberlites

References to an "agglomeratic dyke of olivinic rock with mica, pyroxene and magnetite, with fragments of red sandstone, shale and other sedimentary rocks" were first recorded by Oliveira (1927), which suggested that it could be an alnoite.

Several other occurrences of volcanic breccias were described in the Lages region by Paiva (1933), Loczy (1968) and Arioli (1974). The Janjão kimberlite was first referenced by Scheibe (1978), describing prospecting work done by Joao Lemos da Silva (better known by his nickname "Janjão").

The Janjão kimberlite occurs in the Guarujá area of the city of Lages. A series of geophysical data were interpreted by Svisero et al. (1985) as indicative of an irregular diatreme with reverse polarity and dimensions of at least 190x50 m. This diatreme is cut by a later kimberlitic dyke with normal polarity, about 10 m wide, intruding the Rio do Rastro Formation sedimentary rocks.

Scheibe (1986) briefly described 35 occurrences of such diatremes, some of them with kimberlitic, and since then, some new occurrences were added to this total number.

Petrography

Detailed petrographic descriptions for the main rock types are found in

Scheibe et al. (1984) and Scheibe (1986), being the mineralogy and paragenesis summarized in Tables 1 and 2 (after Scheibe et al., 1984). Specific descriptions and representative chemical analyses given below are of rocks found in the outcrops to be visited.

Geochemistry and petrogenesis

Chemical data are presented in Figure 2, showing a large variation in SiO_2 values of the rocks in the district, the correlation between these values and those of the sum Na_2O+K_2O, and the clear distinction between phonolites (with $SiO_2>57\%$) and porphyritic nepheline syenites, always below this value. The chemistry of pipe breccias is not well correlated with the chemistry of other rocks, in part because of contamination problems brought about by country rocks.

Scheibe (1986) shows that the porphyritic nepheline syenites are miaskitic while the phonolites are agpaitic; the porphyritic phonolites are intermediate rocks. In the same complex, representatives of the three kinds of rocks may be found, as demonstrated also by detailed study of other large alkaline complexes.

Even in the phonolites, the minerals which are characteristic of peralkaline compositions crystallized just in the last phases. In the porphyritic phonolites, the formation of phenocrysts and microphenocrysts of miaskitic character occurred first (v.g. salite, feldspar, nepheline, titanite and apatite); followed by an agpaitic paragenesis (with aegirine both as microcrysts and rims on phenocrysts; pectolite; and matrix nepheline and analcite). The porphyritic nepheline syenites, in turn, maintain their miaskitic character till the end of the crystallization processes: Scheibe (1986) interprets this as an indication that crystallization at a deeper levels favours the seggregation of residual liquids, which could have been expected up to upper levels, where they crystallized as agpaitic phonolites.

The behaviour of minor and trace elements corroborates these observations about major elements, emphasizing the importance of fractionation processes in the origin of the several petrographic varieties of this complex.

The petrogenetic model (Fig. 3) developed by Scheibe (1986) is based on

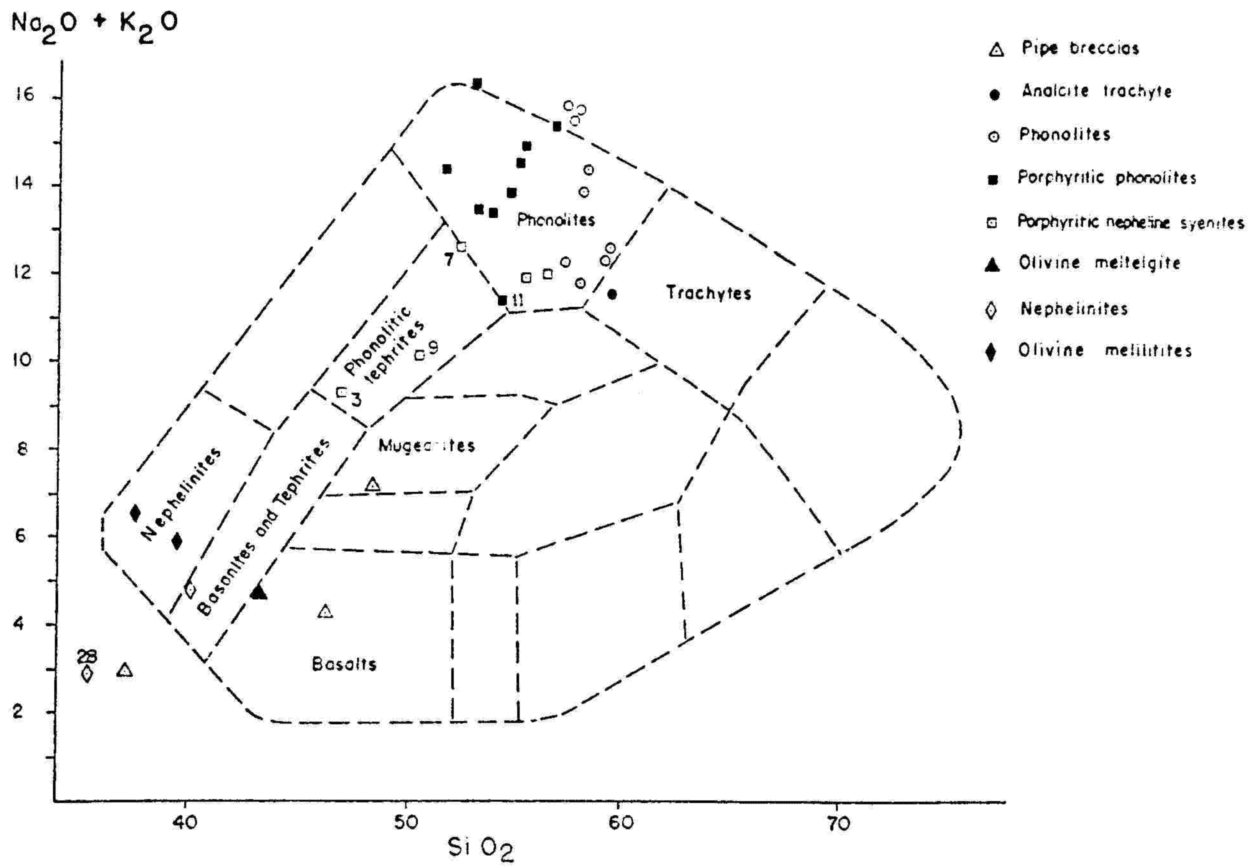

Figure 2 -- The alkaline rocks from Lages in the SiO_2 x (Na_2O+K_2O) diagram (after Scheibe, 1986).

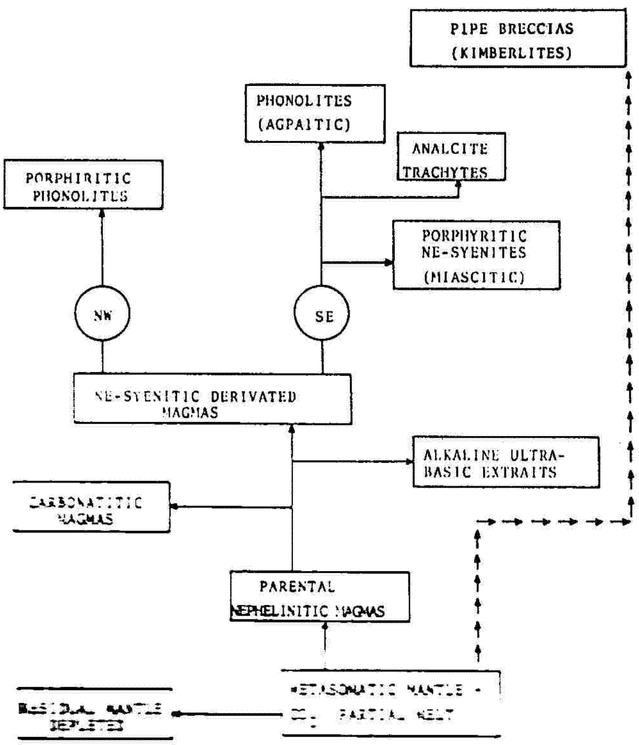

Figure 3 -- Derivation of the alkaline rocks from the Lages Alkaline District (NW) and (SE) indicate the preferred position of the lithologies. Pipe preccias are widespread all over the district (modified from Scheibe, 1986).

Table 1 - Mineralogy and paragenesis from the leucocratic alkaline rocks from Lages, SC (according to Scheibe et al., 1984).

Porphyritic nepheline syenites

(Kaersutite) Phx
- corroded phenocrysts

(Phlogopite-biotite) Phx
- corroded phenocrysts; Ti-bearing, highly pleochroic, zoned

Opaque minerals mPhx
- xenomorphic, probably ilmenite

(Melanite) mPhx
- zoned

Titanite mPhx
- idiomorphic, rounded by 2nd generation of opaque minerals

Apatite mPhx
- idiomorphic, in association with clinopyroxenes and opaque minerals

Sodalite Phx
- idiomorphic or lobated, many opaque inclusions, altered

Salite Phx
- idiomorphic, zoned, darker where Hd-richer

K-Feldspar Phx
- Carlsbad twins zoned, with other minerals included in the enlarged margins

Nepheline Phx
- idiomorphic, isolated, well developed basal cleavage

K-Feldspar Mz
- tabular, no visible orientation

Nepheline Mz
- idiomorphic and interstitial

(Aegirine- aegirine-augite) Mz
- single microlites or rims around mafic phenocrysts

(Fluorite) Mz
- purple, in cavities

Analcite Mz
- clean, interstitial, also secondary

Natrolite Mz
- secondary, substitutes sodalite, K-feldspar and nepheline

(Carbonate)
- secondary, substitutes sodalite

Porphyritic phonolites

(Kaersutite) Phx
- corroded xenocrysts

(Biotite) Phx
- corroded xenocrysts

(Melanite) Phx
- xenocrysts with aegirine rim

Opaque minerals mPhx
- with aegirine rim

Apatite mPhx
- included or as corroded phenocrysts, many inclusions

Sodalite Phx
- lobated, many opaque inclusions

Salite Phx
- idiomorphic, zoned, with aegirine rim

K-Feldspar Phx
- Carlsbad or complex twin;zoned, with recrystallized margin; altered to zeolite and/or gibbsite

Nepheline Phx
- idiomorphic, isolated, well developed basal cleavage

K-Feldspar Mz
- tabular, weakly oriented (trachytic texture)

Nepheline Mz
- idiomorphic to interstitial, very fine grained

Aegirine Mz
- single microlites in matrix and as rims on mafic phenocrysts

(Pectolite) Mz
- poikilitical

(Fluorite) Mz
- purple and colourless, in cavities

Analcite Mz
- interstitial and also secondary after nepheline

Natrolite Mz
- secondary, tabular, radiating crystals

Gibbsite
- alteration after nepheline and K-feldspar; bauxite deposits.

Phonolites

(Arfvedsonite) Phx
- corroded xenocrysts

(Biotite) Phx
- corroded xenocrysts

(Opaque minerals) mPhx
- inside sodalite or associated with aegirine

Titanite mPhx
- associated with aegirine

(Apatite) mPhx
- associated with aegirine

Sodalite Phx
- rounded, with many opaque inclusions

K-Feldspar Phx
- sanidine, zoned, partial alteration to zeolite

K-Feldspar Mz
- tabular, oriented except around nepheline; zoned sanidine to albite

Nepheline Mz
- equidimensional, idiomorphic, zoned

(Zoisite) Mz
- colourless

(Clinozoisite) Mz
- lemmon yellow

Aegirine Mz
- skeletal, poikilitic, single grains or with radial crystallization

Pectolite Mz
- poikilitic, high-Mn

Eudialyte-eucolite Mz
- oriented, colourless to pleochroic from yellowish pink to bluish red

(Neptunite) Mz
- xenomorphic, brownish red

(Murmanite) Mz
- square sheets with strong pink to brown pleochroism

(Lavenite) Mz
- fine prisms, pleochroic on yellow

(Astrophyllite) Mz
- radial, intergrown with aegirine

(Fluorite)
- colourless, purple

(Cryolite)
- low birrefringence

Natrolite
- secondary, substitutes nepheline and the whole matrix of rock

Analcite trachytes

(Opaque minerals) mPhx
- associated with pyroxenes

(Apatite) mPhx
- associated with pyroxenes

(Sodalite) mPhx
- altered to analcite

Diopside mPhx
- colourless to light green to intense green, low extinction angle: aegirine-augite?

Nepheline Mz
- equidimensional, altered to analcite

K-Feldspar Mz
- laths, trachytic to bostonitic texture

Analcite Mz
- interstitial, triangular between feldspar laths; also as alteration, and filling vesicles

(Carbonate)
- in vesicles

(Catapleiite)
- in vesicles

Minerals listed according to crystallization sequence.
Major minerals in capital letters; rare ones in parenthesis, common one without parenthesis.

Phx - phenocrysts
mPhx - microphenocrysts
Mz - matrix

Table 2 - Mineralogy and paragenesis of the ultrabasic alkaline rocks from Lages, SC (according to Scheibe et al., 1984).

Olivine melilitites	Porphyritic olivine melilitites	Olivine nephelinites	Olivine melteigites
Opaque minerals - included in other minerals Diopside - corroded by biotite or with melilite, biotite and olivine rim: xenocryst *Olivine* - idiomorphic, well preserved, opaque inclusions Perovskite - associated with melilite, corroded borders *Melilite* - zoned, corroded, with peg structure *Nepheline* - interstitial *Phlogopite* - poikilitic, weak normal pleochroism also as microcrysts	Opaque minerals mPhx *Olivine Phx* - idiomorphic, well preserved, includes opaque minerals *Melilite Phx* - zoned, with reabsorbtion Phlogopite Phx - weak normal pleochroism Perovskite mPhx - associated with melilite, corroded borders Melilite Mz Olivine Mz Clinopyroxene Mz - light green pleochroism Nepheline Mz - interstitial Phlogopite Mz - interstitial	Diopside Phx - with reaction borders *Olivine Phx* - reaction with the matrix: rimmed by phlogopite Opaque minerals mPhx Perovskite mPhx Apatite mPhx (Melilite) mPhx *Diopside Mz* - idiomorphic, light green, weak pleochroism *Nepheline Mz* - interstitial, includes melilite *Phlogopite Mz* - as rims on olivine; in one sample, titaniferous barium phlogopite, golden yellow to dark reddish brown Carbonates - secondary	Opaque minerals - included in other minerals (Diopside cores) - in zoned, recrystallized grains *Olivine* - idiomorphic, weak alteration Apatite - included in diopside and nepheline Perovskite - included in, or direct contact with, diopside *Diopside* - light green, weak pleochroism; idiomorphic, zoned, or growing around early cores *Nepheline* - interstitial, altered to analcite Phlogopite - interstitial, strong pleochroism from golden yellow to pink brown; associated with isotropic minerals Volcanic glass - light brown, altered to zeolites

See Table 1 for conventions.

geotectonic, geochronological, isotopic and mineral chemistry observations. It comprises limited partial melting of a previously metassomatized mantle with CO_2 contribution in a region submitted to decompression, because of reactivation of a crustal block, limited by deep Precambric structures, in the Jurassic and Cretaceous. Olivine melilitites and olivine nephelinites would be seggregated from the parental nephelinitic melts, close to the surface; at deeper levels, peridotites, phlogopite pyroxenites and Ca-rich olivine melteigites would form. Carbonatites would be originated by the seggregation of immiscible carbonate fractions, whereas the remaining liquids would evolve, by crystal fractionation, forming miaskitic porphyritic nepheline syenites and agpaitic phonolites, on the one hand, and porphyritic phonolites, on the other characterized by a lower degree of seggregation between early crystals (Al-rich salites, K-feldspars and nephelines) and residual melts richer in alkalies and SiO_2. Smaller fractions, richer in feldspars, would crystallize as analcite trachytes. Volatile-rich final volcanic activity, from deep origins, formed the pipe breccias; some of them have their kimberlitic character evidenced by structure and the presence of heavy minerals, probably derived from garnet-lherzolites.

Acknowledgments

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Field Trip

Departure from the hotel at 7:30.

1st stop: *Janjão kimberlite* (from 8:00 to 9:00)

The occurrence is of a completely altered rock, bluish-green coloured when wet and rapidly turning to yellowish-green on drying. Besides angular fragments of several kinds of sedimentary rocks, several mineral fragments are recovered on sieving: a deep red, pyrope-rich garnet; subvitreous rounded ilmenite, with a "chagrinee" surface; centimetric corroded and fracturated dark pyroxenes; partially altered phlogopite; and zircon. Grass-yellow Cr-diopside, spinels and perovskite may also be recovered, by panning.

2nd stop: *Phonolites from Morro do Tributo* (from 9:30 to 10:00)

The highest summit from the Lages Dome is sustained by large outcrops of a light gray rock with an aphanitic matrix and millimetric to centrimetric spots of deep green aegirine. A very thin granular hypidiomorphic texture is visible on the microscope; rectangular or hexagonal nepheline sections are surrounded by non-oriented feldspar laths, and the aegirine is poikilitic to skeletal, forming also radiated aggregates of very thin fibers. Pectolite, not recognizable with the naked eye but invariably present, has a poikilitical habit similar to that of aegirine, indicative that these two minerals formed in the last crystallization stages. Also late phases are murmanite, lavenite, cryolite and eudialyte, sometimes visible, with a bluish-red tint, in hand samples. A representative analysis of this rock is no. 18 (Tables 3 and 4).

3rd stop: *Fazenda Varela Carbonatite* (from 11:00 to 1:00; lunch)

Recent exploration work in this area removed the vegetation and soil cover, allowing a good observation of a light yellow carbonatite dyke and its country rock (a feldspathic breccia).

The carbonatite has sacharoidal texture and high density, because of the presence of barite. Well crystallized millimetric crystals of pyrite are frequent, as well as pink feldspar grains. Sometimes, yellow radiating aggregates of synchysite, a calcium and REE fluor-carbonate, may also be seen.

Microscopic texture is quite variable, but granular, medium, hypidiomorphic facies are dominant. Also present are hematite, apatite, and, very rarely, quartz, pyrochlore and monazite.

The feldspathic breccia has its hybrid character evidenced at the microscope by the oriented growth of new orthoclase over the original rounded grains of sandstones, also intergrown with goethite.

A representative chemical analysis of this carbonatite is given as sample 33 (Tables 3 and 4).

Scheibe & Formoso (1982) present the REE and yttrium distribution in five carbonatite samples, interpreting the extreme enrichment in absolute and relative contents in light lanthanides as a result of concentration processes acting during the carbonatitic phase of crystallization; they represent final stages of a fractionation process from which the initial stages were not known.

4th stop: *Phonolites from the Morro da Chapada* (from 2:00 to 2:30)

The Morro da Chapada, between Lages and the locality of Indios, is sustained by a phonolite intrusion in sedimentary rocks of the Terezina Formation, from the Passa Dois Group.

These phonolites are very similar to those from the Morro do Tributo, except for the smaller development of the aegirine aggregates, which are millimetric at the most. Zr- and/or Ti-minerals are also frequent; neptunite, astrophyllite and lamprophyllite were already identified.

In the upper and lateral contacts, the phonolites are almost completely altered to clay minerals, whereas the shales are hardened by the intrusion. Many fracture zones are also intensely altered to clay minerals.

A representative analysis of these phonolites is given under no. 24 (Tables 3 and 4).

5th stop: *Quarry in olivine melilitite* (from 3:00 to 4:00)

This olivine melilitite is a massive, dense, black rock in which milimetric to centimetric mica crystals are evidenced by their bronze coloured shine. With incipient alteration, surfaces become lighter, and sparse black clinopyroxene crystals may also be seen.

At the microscope, a granular xenomorphic texture, with grains between 0.2 and 2.0 mm, and bigger poikilitic crystals of phlogopite may be observed. The melilite occurs as elongated prisms with equidimentional base, and shows peg-

Table 3 - Chemical composition (major and minor elements in %) and CIPW norm of some alkaline rocks from Lages, SC (according to Scheibe, 1986).

	18 Phonolite	24 Phonolite	33 Carbonatite	4 Porphyritic phonolite	9 Porphyritic nepheline syenite	12 Olivine melilitite
SiO_2	57.25	58.2	2.0	55.0	50.3	37.5
TiO_2	0.21	0.13	0.14	0.23	1.4	1.8
Al_2O_3	22.4	23.0	1.5	22.8	18.7	7.5
Fe_2O_3	2.7	1.7	1.6	2.7	4.0	5.0
FeO	0.57	0.93	11.31	0.46	3.29	6.01
MnO	0.17	0.12	2.00	0.45	0.19	0.20
MgO	0.07	0.15	8.8	0.16	1.2	17.4
CaO	0.51	0.85	29.5	1.1	6.22	14.4
Na_2O	10.41	9.17	0.12	8.98	5.90	2.67
K_2O	5.42	5.28	0.17	5.71	4.31	3.08
H_2O^+	0.53	0.41		2.58	3.06	1.59
CO_2	0.06	0.03	37.57	0.06	0.06	0.13
P_2O_5			0.54		0.49	1.1
Cl	0.28	0.26		0.07		0.13
S	0.02	0.02	0.10	0.11	0.10	0.10
SO_3			1.6		0.15	0.83
F	0.22	0.16	0.18	0.12	0.15	0.08
Cr_2O_3			0.01			0.13
ZrO_2	0.04	0.06	0.01	0.05	0.01	0.04
Total	101.41	100.46	97.15	100.46	99.53	99.69

CIPW norm

	18	24	33	4	9	12
Qz						
C		1.53		0.33		
Or	30.08	31.23		33.77	25.18	
Ab	15.39	42.03		30.20	28.39	
An		2.86		4.46	11.77	
Lc			0.84			13.51
Ne	34.93	18.26	0.58	24.55	11.36	10.39
Ms	10.60					0.43
Ln						18.17
Wo					2.36	
En						
Fs						
Di	0.08				6.44	
Hd	0.37				1.08	
Ac	7.33					13.67
Fo	0.09	0.26	15.83	0.28		28.74
Fa	0.56	0.23	15.61			5.93
Mt		2.46	2.46	1.49	5.73	
Cr			0.02			0.18
Hm				1.67		
Il	0.37	0.25	0.28	0.44	2.63	3.23
Ap			1.36		1.15	2.44
Py	0.04	0.02	3.18	0.21	0.18	0.18
Cc	0.13	0.07	56.20	0.14	0.14	0.28
Fr	0.42	0.33	0.29	0.26	0.22	
Hl	0.43	0.43		0.12		0.20
Ad					0.26	1.34
Zr	0.06	0.09	0.02	0.07	0.01	0.06
Sp			0.99			
Hc			0.82			
Total	100.88	100.05	99.03	97.99	96.90	98.49
Na_2O+K_2O	1.03	0.90	0.25	0.92	0.77	1.03

Table 4 - Chemical composition (minor and trace elements, in ppm) of alkaline rocks from Lages, SC (according to Scheibe, 1986).

	18 Phonolite	24 Phonolite	33 Carbonatite	4 Porphyritic phonolite	9 Porphyritic nepheline syenite	12 Olivine melilitite
Rb	367	283	< 10	224	92	86
Sr	< 50	< 50	2480	390	2225	1640
Ba	< 10	< 10	12500	548	1730	1770
Cu	< 5	< 5	< 5	< 5	< 5	49
Ni	< 5	< 5	11	< 5	< 5	300
U	< 5	10	192	22	60	220
Co	< 5	< 5	< 5	< 5	< 5	53
Cr	< 5	< 5	32	< 5	< 5	860
Pb	10	61	60	30	10	26
Y	< 10	< 10	310	< 10	10	33
La	< 30	102	5700	60	47	108
Yb	2	< 1	10	< 1	< 1	2
Sc	< 5	< 5	44	< 5	< 5	20
Be	4	6	2	5	2	2
B	< 10	< 10	< 5	16	< 10	< 5
Ga	42	33	7	38	16	20
Nb	61	31	530	92	30	116
Zr	340	470	112	410	86	328

structure and zonation. The olivine is well preserved but intensely fracturated, sometimes almost imitating a pyroxene cleavage. Modal proportion of nepheline may attain 10%, and the rock may then be classified as a "nepheline-olivine-phlogopite melilitolite"; the samples with lower nepheline contents could in turn be classified as alnoites.

Incipient alteration of this rock displays banded structure, not recognized in fresh samples.

A representative analysis is given under no. 12 (Tables 3 and 4).

6th stop: *Porphyritic nepheline syenites from Cerro Alto de Cima* (from 4:30 to 5:00)

This occurrence, on the old Indios-Palmeiras road, is made up of a few little blocks of a rock with a felsic phaneritic matrix (0.5 to 1.0 mm) with K-feldspar and nepheline, with larger K-feldspar, nepheline and clinopyroxene phenocrysts (5 to 20 mm).

At the microscope, a porphyritic texture with an intergranular matrix may be observed, with dominant K-feldspar and nepheline and subordinate aegirine. Phenocrysts are K-feldspar, nepheline, sodalite and salite; titanite, apatite, opaque minerals and analcite are common accessories. Natrolite, analcite, carbonates and chlorite are frequent alteration products. The feldspar phenocrysts are zoned, which may be responsible for the early classifications of this rock as a dancalite (Scorza, 1955). The salite phenocrysts are also frequently zoned, with variable Mg and Fe contents.

A representative analysis of this occurrence is given under no. 9 in Tables 3 and 4, which also contains, for comparison, a representative analysis (no. 4) of the porphyritic phonolites from the Serra de Farinha Seca, which shall not be visited in this trip.

Obs: program may be abridged, depending on weather conditions)