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**Relation between partial melting, granulite metamorphism,
crystallization, deformation of leucosome and the influence
of these processes in the rheology of the lower continental
crust**

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*Dedicated to my beloved parents Marilse and Alvaro,
to my siblings Aleidys, Alvaro Jose and Maria Jose
and to my dear Luca,
to all of them for their unconditional love and support*

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ABSTRACT

The main objective of this study is to contribute to the understanding of deformation of leucosome and its residue, in diatexites and granulites, using as examples two units of the Nappe Socorro-Guaxupé, the metatexite unit and the basal granulite unit, from the southernmost portion of the Brasília Orogen. The first is dominated by metasedimentary rocks, although has a name of metatexite unit, it is dominated by diatexite at its base, and the second, is composed primarily by felsic granulite. In oriented samples, after textural characterization, the quartz c-axis fabric thermomether and cathodoluminescence (CL) images, where Ti in quartz evidences temperature domains, were used to determine the deformation temperature, which was compared with thermobarometry data in the respective residues. In this way, it was established that the crystallization in the basal granulite and metatexite units occurred along the cooling portion of the P - T path, but in some portions, it was deformed and might be related to medium and high temperatures. During the metamorphism of the amphibolite and granulite facies, syn-anatectic deformation with melt crystallization and late deformation in solid-state occurred. Therefore, when the granulite is in the solid state, the diatexite is still in the dominantly liquid state, causing the granulite to register those higher deformation temperatures that the diatexite cannot register due to its still mostly liquid state.

Keywords: Nappe Socorro-Guaxupé; partial melting; leucosome; quartz c-axis fabric; Ti in quartz

RESUMO

O objetivo principal deste estudo é contribuir para o entendimento da deformação do leucossoma e seus resíduos, em diatexitos e granulitos, utilizando como exemplos duas unidades da *Nappe* Socorro-Guaxupé, a unidade metatexito e a unidade granulito basal, da porção mais meridional do Orógeno Brasília. A primeira é dominada por rochas metassedimentares, embora tenha o nome de unidade metatexito, é dominada por diatexito em sua base, e a segunda, é composta principalmente por granulito félsico. Nas amostras orientadas, após a caracterização textural, o termômetro do eixo c de quartzo e imagens de catodoluminescência (CL), em que o Ti no quartzo indica temperatura, foram utilizados para determinar a temperatura de deformação, a qual foi comparada com os dados de termobarometria nos respectivos resíduos. Desta forma, foi estabelecido que a cristalização nas unidades basais de granulito e metatexito ocorreu ao longo da porção de resfriamento da trajetória *P-T*, mas em algumas porções foi deformada e pode estar relacionada a médias e altas temperaturas. Durante o metamorfismo das fácies anfibolito e granulito, ocorreu deformação sin-anatética com cristalização por fusão e deformação tardia no estado sólido. Portanto, quando o granulito está no estado sólido, o diatexito ainda está no estado predominantemente líquido, fazendo com que o granulito registre aquelas temperaturas de deformação mais altas que os diatexitos não puderam registrar devido ao seu estado ainda predominantemente líquido.

Palavras-chave: *Nappe* Socorro-Guaxupé; fusão parcial; leucossoma; eixo-c de quartzo; Ti em quartzo.

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1. INTRODUCTION

The investigation of granulites and migmatites allows access and understanding of the rocks formed in the lower continental crust, unveiling the processes at work in that portion of the crust that does not allow direct access. For example, the tectonic transport of large volumes of migmatites, especially diatexites, which involves magmatic flow, and for this, it is necessary that the volume of melt in the rock exceeds the amount that maintains its solid coherence, or what is called the solid-liquid limit (Rosenberg and Handy, 2005). In this case, pieces of residue or rocks that are resisters to melting (diatexites with schollen) are not suffering any more deformation, which is absorbed by magmatic mush that surrounds it. With the decrease in temperature, the liquid crystallizes and as soon as it gains a net of touching crystals, the mass starts to behave as a solid again, and the partially crystallized leucosome can be subjected to the mechanisms of deformation of the solid state. In large areas where granulite predominates, partial melted residue can be deformed in a broader temperature spectrum, with the possibility of recording the entire deformational history, from the pre-partial melting / pre-peak, metamorphic peak, post-peak stages and leucosome crystallization. Thus, the investigation of the deformational history of diatexites and granulites, with different amounts of coupled leucosome, associated with the temperature determinations of the metamorphic peak and the deformation registered in the leucosome minerals, allows establishment the relationship between partial melting temperatures, metamorphism, crystallization and deformation in order to increase the understanding of the thermal dynamics of the base of the continental crust.

As a material for study, rock samples from Nappe Socorro-Guaxupé, southernmost portion of the Brasília Orogen, were collected in the Alfenas region, MG, Brazil. The Nappe Socorro-Guaxupé is constituted of granulites, at its base, overlaid by an igneous derived diatexite and a metasedimentary derived metatexite units (Campos Neto and Caby, 2000). Considering that the samples investigated in the present work were collected in outcrops whose geochronological database were recent detailed (Rocha et al., 2017, 2018; Motta, 2018), the results of the *P-T* calculations for the metamorphic peak of granulite and for the residue of a diatexite (at the base of the metasedimentary derived metatexite unit), when compared with the deformation temperatures of the associated leucosomes, allowed to understand the cooling rate and the time elapsed between the metamorphic peak and the leucosome crystallization, in the metatexite and basal granulite units, which overlaps it and, thus, to compare whether or not if

there was a change in the kinematics and pattern of the deformation during the metamorphic peak and in the exhumation of rocks, which was done by the pattern of quartz c-axis stereograms and corroborated with CL images of Ti-in-quartz. With this investigation, it is intended to contribute to the understanding with the dynamics of the cooling of hot orogens.

2. GEOLOGICAL SETTING

The collision between the São Francisco and Paranapanema plates during the Neoproterozoic resulted in formation of the Southern Brasília Orogen (Campos Neto and Caby, 2000). Rocks belonging to the Southernmost Brasília Orogen are exposed in south of Minas Gerais, and are structured in a series of stacked nappes with transport from WSW to ENE (Campos Neto et al., 2007; Cioffi et al., 2016). The nappes are organized in three main tectonic settings, from top to bottom: Socorro-Guaxupé Nappe, magmatic arc domain, developed on the active continental margin of the Paranapanema plate, Andrelândia Nappe System, subducted continental domain, and Carrancas and Lima Duarte Nappe Systems, domain with passive margin affinity related to the São Francisco plate (Campos Neto et al., 2011; Campos Neto and Caby, 1999).

Figure 1 - Geological map of the Southern Brasília Orogen with the location of the study area (cut and modified from Campos Neto et al., 2011)

The Socorro-Guaxupé Nappe is consisted of granulite, granite and migmatitic units (Figure 1), with high pressure and high temperature at its base (Campos Neto and Caby, 1999, 2000). It is organized in three- alloctone units: basal granulite unit, diatexite unit, derived from igneous rocks, and metatexite unit, derived from metasedimentary rocks (Campos Neto and Caby, 2000).

Thermobarometric calculations show that there is significant variation in pressure and temperature within the basal granulite unit with pressure increase from south to north (Campos Neto and Caby, 1999; Del Lama et al., 2000; Zanardo et al., 2006). Calculations from the association of garnet, pyroxene, hornblende, biotite, plagioclase and quartz estimate extreme conditions of 900 °C - 1040 °C and 12.5-14.5 kbar (Del Lama et al., 1994, 2000). Likewise, calculations for granulites with garnet, clinopyroxene, orthopyroxene, plagioclase and quartz temperatures of 890 °C and pressures between 11.5 to 14 kbar are calculated (Campos Neto and Caby, 2000; Nascimento and Oliveira, 2012; Moraes et al., 2015). Data recorded from amphibole-plagioclase calculations suggest retrograde conditions at 740–980 °C and 5-8 kbar (Campos Neto and Caby, 2000; Del Lama et al., 2000; Rocha, 2016). In migmatite units, high temperature conditions are also recorded, reaching peak metamorphic conditions of ~ 1030 °C and 12 kbar in garnet-orthopyroxene pairs and retrogression of 865 °C and 9 kbar in amphibole-plagioclase pairs (Rocha et al., 2017). The melt of the Socorro-Guaxupé Nappe units was formed through hornblende-dehydration melting reactions, which suggest temperatures between 850 and 900 °C, in addition to the absence of peritectic garnet indicating pressures below 10 kbar (Salazar Mora et al., 2014).

3. GOALS, MATERIALS AND METHODS

The main objective of the present investigation is to study diatexites, granulites and their leucosomes, in order to establish the temperatures of metamorphism / partial melting and crystallization and subsequent deformation of their leucosome, in order to understand the processes acting at the base of the continental crust. Thus, the rate of cooling between the metamorphic peak and the crystallization of the leucosome was established, rocks of basal granulite and metatexite units (which is dominated by diatexite at its base, derived from metasedimentary rocks), comparing the kinematics of the deformation in both. A regional-lithological survey was made for recognition in ten localities at south of Minas Gerais on the Socorro-Guaxupé Nappe, through metatexite and basal granulite units (Figure 1), collecting samples for subsequent petrographic analysis, estimates of deformation temperatures and thermobarometric calculations.

3.1 Deformation Temperatures Calculation

3.1.1 Quartz recrystallization microstructures

The microstructures induced by quartz deformation can generate approximate estimates of the temperature at which they were induced (Kruhl, 1996), the type of grain boundary, like bulging recrystallization (BLG) that indicates low temperatures between 280 to 400 °C, subgrain rotation recrystallization (SGR) for moderate temperatures about 400 - 500 °C, and recrystallization by grain boundary migration (GBM), which begins to dominate at ~500 °C onwards (Stipp et al., 2002). However, more precise calculations can be done using the opening angle of quartz c-axis fabric (Faleiros et al., 2016), as described below. Thirty-five thin sections of leucosome, and their residue, from metatexite unit and basal granulite unit were analyzed using the Zeiss or Olympus transmitted light microscope, in order to recognize the quartz recrystallization textures, for application of thermometers.

3.1.2 Quartz c-axis fabrics opening angles

The application of the thermometer of quartz c-axis fabrics opening angles consists in determining the deformation temperature in the rock, with the advantage that can even separates more than one deformational episode of different temperatures. The thermometer is based on

quartz c-axis fabrics opening angle (AO) proposed by Kruhl (1998), developed by Law (2014), and implemented for larger application range by Faleiros et al. (2016). The calculation of deformation temperature is determined from the opening angle formed by the figure defined in stereogram when the orientation of the quartz c-axis fabrics is plotted in the lower hemisphere on a Schmidt-Lambert equal-area network. Various patterns can be formed and the opening angle is proportional to the deformation temperature (Law, 2014; Faleiros et al., 2016).

Thin sections of deformed neosome from the metatexite unit (LHT-2C, LHT-6A) and leucosomes from the granulites of the basal granulite unit (LHT-10A, LHT 10G) were made, in which the orientation of the c-axis of recrystallized quartz populations of different textural types were measured and analyzed in six thin sections. The measurements of the quartz c-axis were realized in a 4-axis universal stage in a Zeiss microscope and made from 197 to 235 c-axes per study samples in existing quartz populations in thins sections made in the same slab. No more measurements were possible to do in the same thin section due the very coarse-grained nature of the grains. The data obtained were treated in Excel spreadsheets and plotted in the program stereo32, version 1.0.3, in order to estimate quartz c-axis fabric opening-angle and calculate the deformational temperature by means of the linear adjustments proposed by Faleiros et al. (2016) using their equation number 2.

3.1.3 Ti in quartz (TitaniQ)

In most of the moderate to high temperature quartz crystals, the intensity of the cathodoluminescence (CL) shows positive correlation with the Ti concentration (Müller et al., 2003; Wark and Watson, 2006), it is a qualitative measure of relative Ti concentration. The Ti is the most influential factor on the CL intensity of quartz with blue filter (Spear and Wark, 2009).

All the CL imaging was performed in twenty quartz grains from four thin section using JEOL JXA-FE-8530 microprobe with a beam current 100 nA, acceleration voltage 15 kV and a blue filter in the Electron Microprobe Laboratory, NAP Geoanalitica, Institute of Geosciences, University of São Paulo. The obtained images were treated with ImageJ program to improve the heterogeneity of colors and facilitate interpretation.

3.2 Metamorphic Pressure-Temperature Calculations

Samples of four localities in the metatexite unit with felsic granulite lenses were collected, where either orthopyroxene + clinopyroxene or garnet + orthopyroxene + plagioclase mineral assemblages were present for thermometry and thermobarometry.

Mineral chemical analyses were made on samples LHT-2C, LHT-5A, LHT-6A and LHT-9B with garnet, orthopyroxene, clinopyroxene and plagioclase (Table 1) using a JEOL JXA-FE-8530 microprobe with a beam current of 20nA and 15 kV acceleration voltage in the Electron Microprobe Laboratory, NAP Geoanalitica, Institute of Geosciences, University of São Paulo. Mineral chemistry data were treated with the Tim Holland Ax program and Excel spreadsheets.

Thermometry calculation was performed by the calibration of Kretz, (1982), that uses Ca-rich and Ca-poor pyroxenes and is based on an exchange reaction between Mg and Fe^{2+} . *P-T* calculations were also performed using THERMOCALC, average *P-T* mode, using version 3.26 (Holland and Powell, 2011), following all steps described on Powell and Holland (1994). In addition, there were some calculations done by calibrations available on program PTMAFIC (Soto and Soto, 1995).

Table 1- Summary of mineral compositions.

W%	Garnet		Orthopyroxene			Clinopyroxene			Plagioclase
	LHT-9B	LHT-9B	LHT-6A	LHT-5A	LHT-2C	LHT- 6A	LHT- 5A	LHT- 2C	LHT-9B
SiO ₂	38.38	49.48	47.22	47.8	51.71	48.5	49.22	51.1	61.46
TiO ₂	0	0.08	0.09	0.11	0.08	0.14	0.32	0.14	0
Al ₂ O ₃	22.16	3.32	0.43	0.62	1.27	1.47	1.87	2.7	24.97
Cr ₂ O ₃	0.04	0.04	0.05	0	0.03	0.05	0.02	0.01	0
Fe ₂ O ₃	0.47	3.45	1.31	0.94	2.23	2.59	0.54	2.29	0.11
FeO	28.73	25.93	43.21	39.73	24.08	22.1	21.68	9.29	0
MnO	1.34	0.46	1.66	1.75	1.09	0.81	0.96	0.52	0.01
MgO	7.75	18.21	5.91	7.1	20.02	4.87	5.93	12.48	0
CaO	1.5	0.28	0.84	2.24	0.74	18.81	18.19	19.87	5.68
Na ₂ O	0.01	0.01	0.01	0.05	0.02	0.52	0.57	0.8	7.9
K ₂ O	0	0	0.01	0.01	0	0.01	0	0	0.34
total	100.4	101.26	100.73	100.34	101.27	99.86	99.28	99.2	100.47
Endmember concentration							Endmember concentration		
Alm	0.62						x(An)	28.47	
Prp	0.30						x(Ab)	71.53	
Grs	0.03								
Sps	0.03								

4. ROCK DESCRIPTION: MESO AND MICROSTRUCTURE

The study area was delimited to the analysis of granulites and diatexites and their respective leucosomes of the Socorro-Guaxupé Nappe, specifically in the metatexite unit and basal granulite unit. The first is dominated by metasedimentary derived protoliths, although has a name of metatexite unit, it is dominated by diatexites at its base, and the second, is composed primarily by felsic granulites, which are derived from igneous protoliths.

4.1 Basal Granulite Unit

The basal granulite unit is defined by banded structure, represented by an intercalation between mafic and felsic granulite residues (Figure 2A), which dominates over the leucosome layers that vary from thick ones of pegmatitic texture, with hornblende, garnet and pyroxene megacrystals (Figure 2B), to thin ones that are fine-grained, and can either cut the main foliation or form lenses and pockets of more than 1 meter in length. The foliation is marked by the preferential direction WNW-ESE and strike NNE of the mafic minerals and quartz ribbons.

Mafic and felsic granulites, have inequigranular and granoblastic texture, are fine to medium grained, with porphyroblasts of garnet (LHT-04) and hornblende (LHT-10). The felsic granulite is mainly composed of plagioclase, quartz, K-feldspar, garnet, hornblende and orthopyroxene (Figure 2A). The mineral assemblage of mafic granulite comprises quartz, plagioclase, hornblende, biotite, orthopyroxene and clinopyroxene (Figure 2B). It is characteristic to find in both types zircon, apatite and opaque minerals that occur as accessory minerals. Retrograde phases such as muscovite, chlorite, and amphibole are common. Plagioclase and K-feldspar show polygonal and poorly interlobate contacts, it is common to observe antiperthitic plagioclase. The quartz grains are rounded to xenoblastic, present lobed contacts and is interstitial. Garnet might be present or not, as poikiloblasts, with inclusions of biotite, quartz and plagioclase and some with amphibole corona. The hornblende has straight contacts with other hornblende crystals, but in lobed to interdigitated contact with other minerals, its common symplectitic texture with quartz or plagioclase, and others consisting of pseudomorphs of pyroxenes. Orthopyroxene has irregular edges in contact with the quartz and feldspars, and interdigitated with the other minerals, it can be replaced by hornblende, biotite and clinopyroxene, and when in contact with the last one, it has irregular and corroded edges.

Clinopyroxene is more common in mafic granulite, generally presents with fractures and edges being consumed and replaced by hornblende and biotite.

Figure 2 – General characteristic of basal granulite unit. (A) intercalation between mafic and felsic granulite residues. (B) pegmatitic leucosome with hornblende, garnet and pyroxene megacrystals. General assemblages of (C) Felsic granulite, sample LHT-4A and (D) mafic granulite, sample LHT-10F.

The leucosome is composed of plagioclase, K-feldspar and quartz, with garnet, orthopyroxene, clinopyroxene, hornblende and biotite occurring as minor phases (Figure 4A, B). Quartz shows an elongated appearance and defines the foliation and occurs as interstitial phase in general as micrograin agglomerates between the feldspars, denoting it was the last phase to crystallize. The feldspars have interlocking contacts and K-feldspar commonly present perthite exsolutions. Pyroxenes can be present as very coarse grained subedric porphyroblasts oriented parallel to foliation, sometimes with exsolution lamellae. Hornblende might be present as selvage on the edge of leucosome.

4.2 Metatexite Unit

The metatexite unit is characterized for presenting a variability in the degree of partial melting, this being higher towards its the base. A garnet-biotite diatexite present schollen of stromatic residue (Figure 3A) and also lenses of mafic (Figure 3B) and felsic granulites (Figure 3C), as well as voluminous coarse to fine grained leucosome, sometimes pegmatite-grained, is the dominant lithotype at the base of this unit.

The garnet-biotite diatexite is accompanied by lenses composed of felsic and mafic granulites, as well as schollen of its own residue that occur as stromatic rock within the voluminous leucosome. These lenses have inequigranular and granoblastic texture with pyroxene and garnet porphyroblasts. Mineralogically, felsic granulite is composed of quartz, plagioclase, K-feldspar, orthopyroxene, garnet and biotite, rarely clinopyroxene (Figure 3D). The mafic granulite presents a mineral assemblage characterized by plagioclase, quartz, hornblende, biotite, orthopyroxene and clinopyroxene, occasionally garnet (Figure 3E). The residue occurs as schollen of a stromatic garnet-biotite migmatite, with an inequigranular granolepidoblastic texture, from very fine to coarse-grained texture. It is composed of quartz, plagioclase, biotite and K-feldspar, garnet and rarely presents orthopyroxene (Figure 3F). Accessory minerals such as apatite, monazite, zircon and opaque minerals are common in these rocks. Muscovite, chlorite, amphibole and carbonate minerals are frequently observed as retrograde phases. The felsic crystals are anhedral with interlobed edges and some plagioclase are anhedral to subhedral, in addition quartz can appear interstitial or elongated with evidences of intracrystalline deformation such as undulose extinction, sometimes with chessboard patterns and recrystallization edges. K-feldspar occurs in two polymorphs, orthoclase and microcline. In mafic granulite, it is common to observe two generations of hornblende, one slightly oriented parallel to the foliation and the other non-oriented that occurs in reactional contact with biotite and pyroxenes. Biotite is present with preferential orientation, and a few non-oriented, crisscrossed with each other and have elongated shape and lobed edges. Orthopyroxene is anhedral, with grains up to 0.5 mm, it can be observed in reactional contact with biotite and hornblende, also to being slightly oriented, parallel to main foliation. Clinopyroxene is more common in mafic granulite. In felsic granulite, exsolution lamellae are observed in both pyroxenes. The accessory minerals are in contact or included with the other minerals, with rounded shapes.

Figure 3 – General characteristic of metatexite unit. (A) General occurrence of schollen with no preferred orientation. Lenses of (B) mafic and (C) felsic granulite. General assemblages of (D) felsic granulite, sample LHT-1, (E) mafic granulite, sample LHT-2C2 and (F) schollen of a stromatic garnet-biotite migmatite, sample LHT-1F. The red arrow points schollen structure and the yellow arrow points schlieren structure.

Through the unit it is possible to see a variation in the degree of partial melting. At its base, three leucosome domains are differentiated: leucosome layers from schollen, coarse-grained leucosome and very coarse-grained leucosome, this one without any preferred orientation. Nevertheless, intracrystalline deformation is commonly observed in quartz crystals of all leucosome types. Several compositional variations are observed in leucosome types, from

plagioclase-rich granodiorite to sienogranite. Basically, its mineral assemblage is composed of quartz, plagioclase and K-feldspar, with mafic phases of biotite $\pm$ garnet $\pm$ orthopyroxene $\pm$ hornblende. Quartz occurs as inclusions in garnet, K-feldspar and orthopyroxene, or as interstitial phase between other minerals. The main deformation microstructures are marked by chessboard and undulose extinction, further, recrystallization of mineral edges and a development of quartz ribbons and deformation twins in plagioclase. A detailed description of each leucosome type is presented by Tasco and Moraes (2019).

5. DEFORMATION TEMPERATURES

The leucosome crystallized along the cooling portion of the P - T path, in some portions it is deformed and therefore, it was possible to calculate deformation temperatures based on the quartz recrystallization microstructures, calculation based on the quartz c -axis fabrics opening angle thermometer and the analyses of Ti-in-quartz by CL imaging.

GBM and SGR microstructures are textures recognized in quartz crystals from the leucosome and residue (Figure 4), which indicate deformation temperature ranges from high to medium temperatures, respectively. Some quartz grains in the residue show signs of equilibrium texture with triple intersections approaching 120° suggesting a quasi-static regime (Figure 4B)

Figure 4 - examples of deformational microstructures. From metatexite unit: (A) sample LHT2C showing the leucosome quartz, and (B) sample LHT6A showing the residue quartz. From basal granulite unit: (C) sample LHT10A presenting leucosome quartz and (D) sample LHT9B showing the residue quartz. Note how the quartz ribbons follow the foliation marked by the red line; the yellow arrow points GBM; the blue arrow points equilibrium texture between quartz grains; the red arrow points SBG.

Four different OA were defined (Figure 5), related to high deformation temperatures which contrast with likely higher temperature GBM microstructures. In the metatexite unit, 94° was established in the leucosome and 91° for the residue, obtaining 690°C and 677°C , respectively.

In the basal granulite unit, the OA vary from 102° for leucosome, to 117° for the residue, acquiring temperatures between 727 °C to 796 °C, correspondingly (Table 2).

Figure 5 - Stereograms of measured quartz c-axis data. A, B Samples for metatexite unit. C, D Samples for basal granulite unit. The red arcs show the maximum OA.

Table 2 - Results of deformation temperatures and quartz c-axis opening angles (OA).

Sample	Unit	Analyzed domain	Larger OA	Temperature (°C)
RGM54	Metatexite	Leucosome	86*	639
LHT-2C	Metatexite	Leucosome	94	690
LHT-6A	Metatexite	Residue	91	677
LHT-10A	Basal granulite	Leucosome	102	727
RGM29	Basal granulite	Leucosome	130*	855
LHT-10G	Basal granulite	Residue	117	796
VAB-1	Basal granulite	Residue	154**	966

*OA extracted from Motta (2018)

**OA extracted from Faleiros et al. (2016).

Quartz grains from the metatexite unit (LHT2C and LHT6A) and basal granulite unit (LHT10E) were analyzed with CL images with blue filter to observe the areas with the highest content of Ti related to the high intensity of CL. In the residue, quartz grains present cores of high intensity of CL (green part), but showing a gradual decrease towards the rims of each grain (red part; Figure 6A, F, I, L). Despite the core of quartz grains in the leucosome shows a high intensity of CL uniformly in each individual grain, there is an abrupt decrease at their edges (Figure 6B, C, D, E, G, H, J, K). Furthermore, an intergrowth of quartz crystals, distinguishing themselves by showing different intensities of CL in each grain is observed (Figure 6B, C, D, G).

Figure 6 - Scan of the thin section showing the position of CL image quartz crystal A-M. Samples LHT2C and LHT6A are from the metatexite unit and LHT10E from basal granulite unit.

6. MINERAL CHEMISTRY AND METAMORPHIC PRESSURE-TEMPERATURE ESTIMATES IN FELSIC GRANULITE FROM METATEXITE UNIT

6. 1 Mineral Chemistry

Mineral chemistry is concentrated on granulite samples for thermobarometry purposes.

6.1.1 Plagioclase

Plagioclase in felsic granulite shows no significant variation in compositions from rim-to-core, with average of An₂₈ (Figure 7).

Figure 7 - A, B, C Backscatter electron image of plagioclase grains. D Corresponding microprobe chemical transects illustrating end-members anorthite (An) and albite (Ab). Samples from the metatexite unit in the specimen LHT9B.

6.1.2 Pyroxenes

Orthopyroxene shows minor variation from rim-to-core in magnesium content (0.362-0.388 apfu in LHT6A, 0.426-0.473 apfu in LHT5A, 1.014-1.081 apfu in LHT9B and 1.063-1.143 apfu in LHT2C; Figure 8). However, regionally richer Mg orthopyroxene is observed towards the base of the metatexite unit, which means, enstatite content is higher in LHT9B and LHT2C, than in LHT5A and LHT 6A (Figures 8, 9). Nevertheless, the Al content in the samples varies from rim to core, this last one being richer in Al (0.015-0.024 apfu in LHT6A, 0.025-0.049 in LHT5A, 0.045-0.072 apfu in LHT2C and 0.119-0.164 apfu in LHT9B). The absence of clinopyroxene in LHT9B allows a significant increase in Al content in orthopyroxene (Figure 8).

Figure 8 - Compositional variation from rims to core in regard to Mg and Al content of clinopyroxenes (Cpx) and orthopyroxenes (Opx) in each representative sample of metatexite unit.

Clinopyroxene is richer in Al than orthopyroxene, and also show rim-to-core variations (0.089-0.152 apfu in LHT2C, 0.056-0.102 apfu in LHT5A and 0.040-0.070 apfu in LHT6A). Magnesium content is lower (0.313-0.291 apfu in LHT6A, 0.357-0.377 apfu in LHT5A and 0.762-0.666 apfu in LHT2C) compared to the orthopyroxene values of the same sample (Figure 8). These pyroxenes are Ca-rich with an average ~ 0.797 apfu of Ca (Figure 9).

Figure 9 - The pyroxene quadrilateral, showing associated clinopyroxene and orthopyroxene from the metatexite unit. Temperatures on the Mg-Ca side are from the Kretz (1982) calibration, using Ca-rich and Ca-poor pair data from metatexite unit. [EnFs] refers to the mole fraction of components (Enstatite + Ferrosilite).

6.1.3 Garnet

Based on the chemical analyzes carried out in felsic granulite from metatexite unit on garnet crystals, it was obtained that its dominant end member is the almandine with an average of 63%, in which a slight variation from rim to the core, this last one is distinguished by being richer. In addition, it is observed that the content in grossular towards its rims exhibits a composition of ~ 5%, but the core presents an oscillation, in which the increase in the Fe^{2+} and Mg content generates a decrease in the Ca concentration, going from ~ 4% to ~ 2%. The garnet core has a final composition of $alm_{63}prp_{29}grs_{4}sps_3$ and $alm_{63}prp_{28}grs_{5}sps_3$ for the rims (Figure 10).

6.2 P-T Conditions

For temperature calculation, it was used the calibration of orthopyroxene + clinopyroxene pairs and for pressure calculation, it was used the quartz + garnet + plagioclase + orthopyroxene barometer (Table 1).

Thermometric calculations with the Kretz (1982) calibration obtained ultra-high temperature (UHT) results, between 877 °C and 1164 °C, thus being higher than those acquired by the calibrations in the THERMOCALC, 808 °C-1122 °C, and calibrations available on PTMAFIC by Wood and Banno (1973), 796 °C-880 °C (Table 3).

Figure 10 - A, C, E Backscatter electron image of garnet grain. B, D, F Corresponding microprobe chemical transects illustrating endmembers almandine (alm), spessartine (sps), pyrope (pyp), and grossular (grs). Samples from the metatextite unit in the specimen LHT9B.

Table 3 - Temperature conditions results.

Sample	Temperatures (°C)			
	Mineral	PTMAFIC	THERMOCALC	Kretz (1982)
	assemblages used	Wood and Banno (1973)		
LHT9B	Grt+Opx+Pl	-	808 ± 86	-
LHT6A	Opx+Cpx	796	723 ± 419*	877 ± 60
LHT5A	Opx+Cpx	861	896 ± 365*	1032 ± 60
LHT2C	Opx+Cpx	880	1122 ± 333*	1164 ± 60

* Calculations for 11 kbar

Barometric calculations were performed on the LHT9B sample using THERMOCALC and PTMAFIC. The first one obtains a result of 7.3 ± 0.9 kbar at 808 °C, and for the second one, temperatures of 800 °C, 900 °C and 1000 °C were used for the pressure, applying the calculations made by Perkins and Chipera (1985), obtaining for the Mg-reaction 7.7, 8.6 and 9.5 kbar and for the Fe-reaction 8.4, 10 and 11.5 kbar respectively. Perkins and Chipera (1985) conclude that for rocks whose reason $X_{Fe}(Fe^{2+}/[Fe^{2+} + Mg])$ is greater than 0.5, Fe-reaction would be more stable than Mg-reaction. Thereby, X_{Fe} for sample LHT9B is 0.57, consequently the results of Fe-reaction are considered. In this way, for the same temperature (800 °C) the pressure variability for calculations made in each program was low, obtaining an approximate difference of 1 kbar (Table 4).

Table 4 - Pressure conditions results from sample LHT9B. Grt+Opx+Pl+Qtz mineral assemblages used.

Temperatures (°C)	Pressures (kbr)		
	THERMOCALC	PTMAFIC**	
		Mg-reaction	Fe-reaction
800	7.3 ± 0.9*	7.7 ± 0.05	8.4 ± 0.05
900	-	8.6 ± 0.05	10 ± 0.05
1000	-	9.5 ± 0.05	11.5 ± 0.05

* Calculations made together with the temperature in table 3

**Results by Perkins and Chipera (1985) calibration.

7. DISCUSSION

Rocks that underwent high-grade metamorphism are commonly known to record a complex P - T and deformation histories. The crystallization history identified in basal granulite and metatexite units are related to deformational history. The quartz studied in both parts of the rocks, residue and leucosome, present SGR and GBM microstructures, related to medium and high temperatures, this last one consistent with the quartz c-axis fabrics, which exhibits temperatures between 677 °C and 690 °C for metatexite unit and 727 °C to 796 °C for basal granulite unit. Other studies by Motta (2018) and Faleiros et al. (2016), concluded elevated temperatures for the basal granulite unit reaching 966 °C in the residue and 855 °C in the leucosome. In the metatexite unit, Motta (2018) registered temperatures of 639 °C, being the lowest calculated for these leucosomes (Table 2). Likewise, the CL images in the residue present brighter cores showing a slight gradation towards the rims with less luminescence, due to growth during the decrease in temperature. Instead, quartz in the leucosomes registered uniform cores with a luminescence greater than that of their rims, this might mean different stages of crystallization, similar to studies done on migmatites by Spear and Wark (2009). Therefore, considering the crystallization temperature calculations of the leucosome carried out in previous works in the metatexite and basal granulite unit with results of ~ 720 °C and ~ 5.5 kbar for the first unit (Rocha et al., 2017), while the second was of 800 °C and 9 kbar (Motta, 2018), the CL images and the quartz c-axis fabrics temperatures indicate that after the crystallization of this melt, the deformation still intervened on these rocks, acting on amphibolite facies for the metatexite unit and between granulite to amphibolite facies for the basal granulite unit.

Previous studies on the metamorphic peak in metatexite unit concluded UHT conditions, about 1000 °C and ~11 kbar (Motta, 2018; Tadeschi et al., 2018; Rocha et al., 2017), close to temperature values obtained using the thermometer calibrated by Kretz (1982) for 11 kbar and pressure acquired by the PTMAFIC program for 1000 °C in this study for the felsic granulite from metatexite unit.

In this way, the crystallization in the basal granulite and metatexite units occurred along the cooling portion of the P - T path, but in some portions, it was deformed and might be related to medium and high temperatures. The high concentration of fluids is a factor that can favor prismatic slide due to high temperatures (Tullis et al., 1973; Kirschner and Teyssier, 1991). It

means that these high temperatures favoring the concentration of existing fluids in the migmatites, making the composition more fertile and consequently, generate more liquid and causing different stages of crystallization in the residue and leucosome. Studies in metatexite unit by Tasco and Moraes (2019) indicate that its protolith may have been a mixture between pelites and wackes, or that partial melting must have had an external contribution of H₂O, since the melt volume is larger than the proportional volume inferred from the amount of present peritectic phases, in addition, crystallization of leucosome occurred by combining more than one stage of segregation/fractional and crystallization/segregation.

Pieces of residue, schollen within the diatexite, or rocks that are resisters to melting, such as the granulite lenses, are not suffering any more deformation, which is absorbed by magmatic mush that surrounds them, and it makes difficult to calculate the initial deformation temperature in the metatexite unit. With the decrease in temperature, the liquid crystallizes and as soon as it gains a net of touching crystals, the mass starts to get solid again, and the partially crystallized leucosome can be subjected to the mechanisms of deformation of the solid state, achieving to register temperatures between 690-639 °C, passing the limit wet solid. In the basal granulite unit, partial melting residue can be deformed in a broader temperature spectrum, passing from 966 °C, near the metamorphic peak, to 796 °C near the crystallization temperature, and in the leucosome, from 855 °C, post metamorphic peak, to 727 °C, being close to the crystallization temperature of metatexite unit. Thus, when the basal granulite is in the solid state, the metatexite is still in the liquid state, causing the basal granulite to register those higher deformation temperatures that the metatexites cannot register due to their still liquid state. In this sense, during the metamorphism of the amphibolite and granulite facies, syn-anatectic deformation with melt crystallization and late deformation in solid-state occurred.

8. CONCLUSIONS

1. Microstructures, quartz c-axis fabrics temperatures and CL images indicate that:
 - The quartz studied in both parts of the rocks, residue and leucosome, presents SGR and GBM microstructures, related to high and medium temperatures;
 - The quartz c-axis fabrics exhibit temperatures in the basal granulite unit between 796-966 °C for the residue and 727-855 °C for the leucosome. In the metatexite unit, the leucosome registered temperatures between 639-690 °C and approximately 677 °C for the residue;
 - Different stages of crystallization were observed. The CL images in the residue present brighter cores showing a slight gradation towards the rims with less luminescence, due to growth during the decrease in temperature. Instead, quartz in the leucosomes registered uniform cores with a luminescence greater than that of their rims;
 - The CL images and the quartz c-axis fabrics temperatures indicate that after the crystallization of this melt, the deformation still intervened on these rocks, acting on amphibolite facies for the metatexite unit and between granulite to amphibolite facies for the basal granulite unit.
2. The metamorphic peak conditions in the felsic granulite of the metatexite unit were UHT, about 1000 °C and ~ 11 kbar.

The crystallization in the basal granulite and metatexite units occurred along the cooling portion of the *P-T* path, but in some portions, it was deformed and might be related to medium and high temperatures. When the basal granulite is in the solid state, the metatexite is still in the liquid state, causing the basal granulite to register those higher deformation temperatures that the metatexites cannot register due to their still liquid state. In this sense, during the metamorphism of the amphibolite and granulite facies, syn-anatectic deformation with melt crystallization and late deformation in solid-state occurred.

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APPENDIX i:
Mineral chemistry analyses by electron microprobe

Plagioclase chemical analyses (LHT 9B)

Sample	LHT-9B	LHT-9B	LHT-9B	LHT-9B	LHT-9B	LHT-9B	LHT-9B	LHT-9B	LHT-9B	LHT-9B	LHT-9B	LHT-9B	LHT-9B	LHT-9B	LHT-9B
Min	P12.1	P12.2	P12.3	P12.4	P12.5	P14.1	P14.2	P14.3	P14.4	P14.5	P15-1	P15-2	P15-3	P15-4	P15-5
SiO ₂	61.22	61.78	61.46	61.58	61.18	60.99	61.67	61.62	61.85	61.33	61.43	60.75	61.44	61.8	61.9
TiO ₂	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Al ₂ O ₃	25.05	25.08	24.97	24.89	24.91	25.1	24.83	24.88	24.84	24.7	24.9	24.44	25.11	24.78	24.87
Cr ₂ O ₃	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fe ₂ O ₃	0.09	0.05	0.11	0.03	0.03	0.13	0.09	0.05	0.01	0.58	0.06	0.73	0.07	0.09	0.03
FeO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MnO	0.01	0.01	0.01	0	0.01	0.02	0	0.02	0.01	0.02	0	0.01	0	0	0
MgO	0	0	0	0	0	0	0	0	0	0.14	0	0.29	0	0.01	0
CaO	5.76	5.67	5.68	5.74	5.79	5.8	5.71	5.67	5.59	5.84	5.74	5.61	5.85	5.66	5.67
Na ₂ O	7.86	8.07	7.9	7.89	8.06	8.18	8.23	8.18	8.17	8.04	8.11	7.9	8	8.1	8.28
K ₂ O	0.21	0.34	0.34	0.31	0.27	0.2	0.28	0.32	0.31	0.22	0.23	0.33	0.31	0.43	0.33
Totals	100.19	100.99	100.47	100.44	100.26	100.41	100.82	100.75	100.77	100.87	100.47	100.06	100.78	100.86	101.08
Oxygens	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Si	2.709	2.714	2.714	2.719	2.709	2.699	2.716	2.716	2.722	2.704	2.713	2.702	2.707	2.721	2.719
Ti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Al	1.307	1.299	1.3	1.295	1.3	1.309	1.289	1.293	1.289	1.284	1.297	1.282	1.304	1.286	1.288
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fe ₃	0.003	0.002	0.004	0.001	0.001	0.004	0.003	0.002	0	0.019	0.002	0.024	0.002	0.003	0.001
Fe ₂	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mn	0	0	0	0	0.001	0.001	0	0.001	0	0.001	0	0	0	0	0
Mg	0	0	0	0	0	0	0	0	0	0.009	0	0.019	0	0	0
Ca	0.273	0.267	0.269	0.272	0.275	0.275	0.269	0.268	0.264	0.276	0.272	0.267	0.276	0.267	0.267
Na	0.674	0.687	0.676	0.675	0.692	0.702	0.703	0.699	0.697	0.687	0.695	0.681	0.683	0.691	0.705
K	0.012	0.019	0.019	0.017	0.015	0.011	0.016	0.018	0.017	0.012	0.013	0.019	0.017	0.024	0.019
Sum	4.979	4.989	4.982	4.979	4.994	5.001	4.997	4.996	4.99	4.994	4.991	4.995	4.99	4.992	4.999
An	0.288	0.280	0.285	0.287	0.284	0.281	0.277	0.277	0.275	0.287	0.281	0.282	0.288	0.279	0.275
Ab	0.712	0.720	0.715	0.713	0.716	0.719	0.723	0.723	0.725	0.713	0.719	0.718	0.712	0.721	0.725

Orthopyroxene chemical analyses (LHT 9B)

Sample	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B
Min	Opx1.1	Opx1.2	Opx1.3	Opx1.4	Opx1.5	Opx1.6	Opx1.7	Opx1.9	Opx1.10	Opx1.11	Opx1.12	Opx1.13	Opx1.14	Opx1.15
SiO2	49.65	49.14	49.82	49.59	49.64	49.48	49.55	48.95	49.55	49.18	49.62	49.82	49.34	49.71
TiO2	0.15	0.04	0.07	0.06	0.17	0.08	0.11	0.13	0.09	0.12	0.06	0.06	0.09	0.11
Al2O3	3.37	3.33	3.27	3.26	3.25	3.32	3.49	3.38	3.32	3.65	3.3	2.96	3.17	3.11
Cr2O3	0.07	0.16	0.09	0.07	0.11	0.04	0.11	0.09	0.11	0.1	0.11	0.02	0.11	0.08
Fe2O3	1.49	2.02	2.25	2.73	1.67	3.45	2.9	3.77	3.02	3.48	3.14	2.4	3.15	2.67
FeO	26.81	26.36	26.68	26.01	27.02	25.93	25.97	24.86	25.66	25.51	26.03	26.27	25.72	25.9
MnO	0.44	0.46	0.43	0.46	0.45	0.46	0.47	0.43	0.47	0.46	0.44	0.46	0.43	0.41
MgO	17.89	17.75	18.03	18.11	17.78	18.21	18.19	18.48	18.36	18.26	18.28	18.26	18.27	18.44
CaO	0.28	0.26	0.24	0.29	0.26	0.28	0.31	0.26	0.25	0.25	0.26	0.25	0.27	0.25
Na2O	0	0	0.01	0.03	0	0.01	0.01	0.02	0.03	0.02	0	0	0	0.01
K2O	0	0	0.01	0.02	0	0	0.01	0	0	0	0	0.01	0	0.01
Totals	100.16	99.51	100.9	100.64	100.35	101.26	101.13	100.37	100.87	101.02	101.24	100.5	100.54	100.68
Oxygens	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Si	1.897	1.892	1.892	1.887	1.896	1.874	1.877	1.866	1.88	1.865	1.878	1.897	1.88	1.888
Ti	0.004	0.001	0.002	0.002	0.005	0.002	0.003	0.004	0.003	0.004	0.002	0.002	0.002	0.003
Al	0.152	0.151	0.146	0.146	0.146	0.148	0.156	0.152	0.148	0.163	0.147	0.133	0.142	0.139
Cr	0.002	0.005	0.003	0.002	0.003	0.001	0.003	0.003	0.003	0.003	0.003	0.001	0.003	0.002
Fe3	0.043	0.058	0.064	0.078	0.048	0.098	0.083	0.108	0.086	0.099	0.089	0.069	0.09	0.076
Fe2	0.857	0.849	0.847	0.828	0.863	0.821	0.823	0.792	0.814	0.809	0.824	0.837	0.819	0.823
Mn	0.014	0.015	0.014	0.015	0.015	0.015	0.015	0.014	0.015	0.015	0.014	0.015	0.014	0.013
Mg	1.019	1.018	1.02	1.027	1.012	1.028	1.027	1.05	1.038	1.032	1.031	1.036	1.037	1.044
Ca	0.011	0.011	0.01	0.012	0.011	0.011	0.013	0.011	0.01	0.01	0.011	0.01	0.011	0.01
Na	0	0	0.001	0.002	0	0	0.001	0.001	0.002	0.001	0	0	0	0
K	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0
Sum	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Orthopyroxene chemical analyses (LHT 9B)

Sample	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B
Min	Opx2.29	Opx2.30	Opx2.31	Opx2.32	Opx2.33	Opx2.34	Opx2.35	Opx2.36	Opx2.37	Opx2.38
SiO ₂	50.14	49.43	49.42	49.65	50.12	49.67	49.69	49.46	49.61	49.88
TiO ₂	0.1	0.12	0.11	0.16	0.12	0.04	0.17	0.12	0.03	0.05
Al ₂ O ₃	2.64	2.93	2.9	2.87	3.1	3.12	3.2	2.93	2.85	2.64
Cr ₂ O ₃	0.08	0.07	0.05	0.07	0.09	0.04	0.03	0.15	0.08	0.1
Fe ₂ O ₃	2.12	3.19	3.63	2.76	2.6	2.7	2.28	3.02	3.5	2.72
FeO	26.14	24.8	24.19	25.21	25.52	25.37	25.89	25.13	25.07	24.83
MnO	0.41	0.43	0.39	0.42	0.42	0.4	0.41	0.4	0.39	0.4
MgO	18.58	18.8	19.18	18.84	18.84	18.66	18.46	18.68	18.82	19.05
CaO	0.25	0.26	0.25	0.24	0.27	0.23	0.23	0.22	0.24	0.27
Na ₂ O	0.01	0.02	0.02	0	0.04	0.02	0.02	0.03	0	0.02
K ₂ O	0.01	0.01	0.01	0	0	0	0	0	0.01	0.02
Totals	100.47	100.06	100.15	100.21	101.12	100.26	100.38	100.15	100.6	99.99
Oxygens	6	6	6	6	6	6	6	6	6	6
Si	1.907	1.885	1.88	1.89	1.891	1.89	1.891	1.886	1.884	1.9
Ti	0.003	0.003	0.003	0.005	0.003	0.001	0.005	0.004	0.001	0.002
Al	0.118	0.132	0.13	0.129	0.138	0.14	0.144	0.132	0.128	0.119
Cr	0.002	0.002	0.001	0.002	0.003	0.001	0.001	0.004	0.002	0.003
Fe ₃	0.061	0.092	0.104	0.079	0.074	0.077	0.065	0.087	0.1	0.078
Fe ₂	0.831	0.791	0.77	0.803	0.805	0.808	0.824	0.802	0.796	0.791
Mn	0.013	0.014	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Mg	1.053	1.069	1.087	1.069	1.059	1.058	1.047	1.062	1.065	1.081
Ca	0.01	0.011	0.01	0.01	0.011	0.009	0.009	0.009	0.01	0.011
Na	0.001	0.002	0.001	0	0.003	0.002	0.001	0.002	0	0.002
K	0	0	0	0	0	0	0	0	0	0.001
Sum	4	4	4	4	4	4	4	4	4	4

Orthopyroxene chemical analyses (LHT 9B)

Sample	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B
Min	Opx3.18	Opx3.19	Opx3.20	Opx3.21	Opx3.22	Opx3.24	Opx3.25	Opx3.26	Opx3.27
SiO2	49.86	49.98	49.26	49.36	49.58	49.23	48.79	48.9	48.99
TiO2	0.17	0.15	0.03	0.12	0.09	0.1	0.09	0.08	0.09
Al2O3	3.17	3.33	3	3.66	3.43	3.48	3.59	3.32	3.24
Cr2O3	0.06	0.03	0.1	0.07	0.11	0.08	0.06	0.1	0.07
Fe2O3	2.05	1.75	4.01	2.33	1.9	3.07	2.91	4.22	3.79
FeO	26.37	26.47	24.49	26.46	26.64	25.82	25.67	24.84	24.96
MnO	0.45	0.46	0.45	0.43	0.44	0.43	0.4	0.47	0.46
MgO	18.28	18.24	18.83	17.86	17.92	18.08	17.91	18.42	18.45
CaO	0.26	0.28	0.29	0.24	0.27	0.28	0.27	0.3	0.26
Na2O	0.01	0.02	0	0.02	0	0.03	0.01	0	0
K2O	0	0	0.02	0.01	0	0	0.01	0	0
Totals	100.67	100.71	100.48	100.56	100.37	100.59	99.72	100.65	100.31
Oxygens	6	6	6	6	6	6	6	6	6
Si	1.894	1.897	1.873	1.881	1.892	1.875	1.874	1.861	1.869
Ti	0.005	0.004	0.001	0.003	0.002	0.003	0.003	0.002	0.003
Al	0.142	0.149	0.135	0.164	0.154	0.156	0.163	0.149	0.146
Cr	0.002	0.001	0.003	0.002	0.003	0.002	0.002	0.003	0.002
Fe3	0.059	0.05	0.115	0.067	0.055	0.088	0.084	0.121	0.109
Fe2	0.838	0.84	0.779	0.843	0.85	0.822	0.825	0.791	0.797
Mn	0.014	0.015	0.015	0.014	0.014	0.014	0.013	0.015	0.015
Mg	1.035	1.031	1.067	1.014	1.019	1.026	1.025	1.045	1.049
Ca	0.01	0.011	0.012	0.01	0.011	0.011	0.011	0.012	0.011
Na	0.001	0.002	0	0.001	0	0.002	0.001	0	0
K	0	0	0.001	0	0	0	0	0	0
Sum	4	4	4	4	4	4	4	4	4

Orthopyroxene chemical analyses (LHT 6A)

Sample	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A
Min	Opx1.16	Opx1.17	Opx1.18	Opx1.19	Opx1.20	Opx2.26	Opx2.27	Opx2.28	Opx2.29	Opx2.30
SiO2	47.03	46.75	47.22	47.23	47.31	46.62	47.66	47.15	46.99	47.21
TiO2	0.1	0.09	0.09	0.11	0.06	0.02	0.05	0.14	0.14	0.07
Al2O3	0.37	0.36	0.43	0.47	0.47	0.3	0.41	0.44	0.49	0.46
Cr2O3	0.04	0.03	0.05	0	0	0.02	0.05	0	0	0
Fe2O3	1.3	3.25	1.31	1.67	1.33	2.06	1.05	1.63	2.23	1.26
FeO	43.08	42.83	43.21	43	43.41	42.16	44.02	42.82	42.45	42.68
MnO	1.65	1.66	1.66	1.68	1.69	1.66	1.6	1.67	1.69	1.65
MgO	5.95	5.87	5.91	5.93	5.92	6.2	5.88	6.04	6.26	6.22
CaO	0.64	0.72	0.84	0.97	0.73	0.62	0.71	0.84	0.7	0.72
Na2O	0.01	0	0.01	0.01	0	0	0	0.03	0.01	0.03
K2O	0.04	0.03	0.01	0	0.01	0.03	0	0	0.01	0.01
Totals	100.2	101.59	100.73	101.06	100.93	99.68	101.42	100.76	100.97	100.31
Oxygens	6	6	6	6	6	6	6	6	6	6
Si	1.968	1.938	1.966	1.96	1.966	1.96	1.972	1.961	1.95	1.968
Ti	0.003	0.003	0.003	0.003	0.002	0.001	0.002	0.004	0.004	0.002
Al	0.018	0.018	0.021	0.023	0.023	0.015	0.02	0.022	0.024	0.023
Cr	0.001	0.001	0.002	0	0	0.001	0.001	0	0	0
Fe3	0.041	0.101	0.041	0.052	0.042	0.065	0.033	0.051	0.07	0.04
Fe2	1.507	1.485	1.504	1.492	1.509	1.482	1.523	1.489	1.473	1.488
Mn	0.058	0.058	0.059	0.059	0.059	0.059	0.056	0.059	0.059	0.058
Mg	0.371	0.363	0.367	0.367	0.367	0.388	0.362	0.374	0.387	0.386
Ca	0.028	0.032	0.038	0.043	0.033	0.028	0.031	0.038	0.031	0.032
Na	0.001	0	0	0.001	0	0	0	0.002	0.001	0.002
K	0.002	0.001	0	0	0	0.002	0	0	0	0.001
Sum	4	4	4	4	4	4	4	4	4	4

Orthopyroxene chemical analyses (LHT 6A)

Sample	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A
Min	Opx3.36	Opx3.37	Opx3.38	Opx3.39	Opx3.40	Opx3.41	Opx4.46	Opx4.47	Opx4.48	Opx4.49	Opx4.50
SiO ₂	47.03	47	46.92	47.41	46.71	48.84	47.11	46.86	47.07	47.18	47.14
TiO ₂	0.13	0.08	0.16	0.07	0.1	0.25	0.14	0.14	0.11	0.08	0.03
Al ₂ O ₃	0.49	0.47	0.44	0.44	0.4	1.24	0.36	0.46	0.39	0.45	0.39
Cr ₂ O ₃	0.01	0.02	0	0	0.01	0	0	0	0.08	0	0.03
Fe ₂ O ₃	1.22	1.25	1.77	1.33	2.54	1.95	1.67	2.45	2.11	1.45	2.21
FeO	43.17	43.17	43.12	43.45	42.7	22.54	43.49	42.84	42.83	43.24	43.29
MnO	1.66	1.66	1.65	1.72	1.71	0.83	1.6	1.57	1.59	1.59	1.56
MgO	5.8	5.81	5.84	5.89	5.79	4.97	5.87	5.96	6	5.9	5.93
CaO	0.8	0.75	0.82	0.82	0.84	18.7	0.64	0.86	0.89	0.78	0.64
Na ₂ O	0.02	0.02	0	0	0.02	0.52	0.02	0	0.02	0.03	0.03
K ₂ O	0.01	0	0	0	0.01	0	0	0	0	0	0
Totals	100.35	100.23	100.72	101.12	100.84	99.85	100.9	101.13	101.1	100.69	101.25
Oxygens	6	6	6	6	6	6	6	6	6	6	6
Si	1.966	1.967	1.956	1.967	1.948	1.954	1.961	1.946	1.954	1.965	1.956
Ti	0.004	0.003	0.005	0.002	0.003	0.008	0.004	0.004	0.004	0.002	0.001
Al	0.024	0.023	0.022	0.021	0.02	0.059	0.018	0.022	0.019	0.022	0.019
Cr	0	0.001	0	0	0	0	0	0	0.003	0	0.001
Fe ₃	0.039	0.039	0.056	0.041	0.08	0.059	0.052	0.076	0.066	0.046	0.069
Fe ₂	1.509	1.511	1.503	1.507	1.489	0.754	1.514	1.488	1.487	1.506	1.502
Mn	0.059	0.059	0.058	0.06	0.06	0.028	0.056	0.055	0.056	0.056	0.055
Mg	0.361	0.362	0.363	0.364	0.36	0.296	0.364	0.369	0.371	0.366	0.367
Ca	0.036	0.034	0.036	0.036	0.037	0.802	0.028	0.038	0.04	0.035	0.028
Na	0.002	0.002	0	0	0.001	0.041	0.001	0	0.002	0.002	0.002
K	0.001	0	0	0	0.001	0	0	0	0	0	0
Sum	4	4	4	4	4	4	4	4	4	4	4

Clinopyroxene chemical analyses (LHT 6A)

Sample	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A
Min	Cpx1.1	Cpx1.2	Cpx1.3	Cpx1.4	Cpx1.5	Cpx2.6	Cpx2.7	Cpx2.8	Cpx2.9	Cpx2.10
SiO2	48.85	48.74	48.5	48.84	48.89	49.38	49.16	48.6	49.07	49.77
TiO2	0.16	0.16	0.14	0.22	0.15	0.14	0.14	0.2	0.04	0.11
Al2O3	1.13	1.37	1.47	1.37	1.17	1.11	1.27	1.4	1.34	1.14
Cr2O3	0	0	0.05	0.03	0	0.01	0.04	0	0	0.01
Fe2O3	2.59	2.32	2.59	1.87	1.84	1.19	1.98	2.59	2.11	1
FeO	21.02	22.14	22.1	23.23	22.87	22.99	21.48	21.03	22.55	22.31
MnO	0.75	0.81	0.81	0.87	0.87	0.85	0.82	0.77	0.81	0.8
MgO	5.08	4.86	4.87	5.1	4.97	5.04	5.04	4.91	4.91	5.05
CaO	19.69	18.89	18.81	18.04	18.34	18.76	19.54	19.53	19	19.24
Na2O	0.54	0.56	0.52	0.49	0.53	0.49	0.55	0.58	0.48	0.57
K2O	0	0	0.01	0	0.02	0.01	0	0	0	0.06
Totals	99.81	99.86	99.86	100.05	99.64	99.97	100.03	99.61	100.31	100.06
Oxygens	6	6	6	6	6	6	6	6	6	6
Si	1.951	1.95	1.942	1.952	1.961	1.971	1.957	1.945	1.954	1.979
Ti	0.005	0.005	0.004	0.007	0.005	0.004	0.004	0.006	0.001	0.003
Al	0.053	0.065	0.07	0.065	0.055	0.052	0.059	0.066	0.063	0.053
Cr	0	0	0.002	0.001	0	0	0.001	0	0	0
Fe3	0.078	0.07	0.078	0.056	0.056	0.036	0.059	0.078	0.063	0.03
Fe2	0.702	0.741	0.74	0.776	0.767	0.767	0.715	0.704	0.751	0.742
Mn	0.025	0.027	0.027	0.029	0.03	0.029	0.028	0.026	0.027	0.027
Mg	0.302	0.29	0.291	0.304	0.297	0.3	0.299	0.293	0.291	0.299
Ca	0.842	0.81	0.807	0.772	0.788	0.802	0.834	0.837	0.811	0.82
Na	0.042	0.043	0.04	0.038	0.041	0.038	0.043	0.045	0.037	0.044
K	0	0	0	0	0.001	0	0	0	0	0.003
Sum	4	4	4	4	4	4	4	4	4	4

Clinopyroxene chemical analyses (LHT 6A)

Sample	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A
Min	Cpx3.11	Cpx3.12	Cpx3.13	Cpx3.14	Cpx3.15	Cpx 21	Cpx 22	Cpx 23	Cpx 24	Cpx 25
SiO ₂	49.02	49.36	49.22	49.05	48.88	49.06	48.89	49.34	40.06	49.42
TiO ₂	0.09	0.13	0.08	0.2	0.16	0.17	0.12	0.12	0.82	0.08
Al ₂ O ₃	1	1.14	1.13	1.15	1.18	1.02	1.05	0.84	11.47	1.08
Cr ₂ O ₃	0	0	0.01	0	0.07	0.04	0.05	0.03	0	0.02
Fe ₂ O ₃	2.33	2.14	1.67	2.36	2.06	2.19	0.95	1.69	11.51	1.58
FeO	21.11	22	21.99	21.03	21.42	21.09	23.55	21.71	18.32	21.95
MnO	0.78	0.79	0.74	0.79	0.76	0.73	0.81	0.74	0.38	0.7
MgO	5.13	5.13	4.94	5.13	4.94	5.14	4.94	5.27	3.7	5.09
CaO	19.64	19.24	19.39	19.9	19.44	19.64	18.25	19.64	10.39	19.54
Na ₂ O	0.51	0.55	0.55	0.51	0.58	0.53	0.42	0.44	1.17	0.52
K ₂ O	0.04	0	0	0	0	0.07	0.02	0.01	1.51	0
Totals	99.64	100.48	99.72	100.13	99.49	99.67	99.06	99.83	99.33	99.98
Oxygens	6	6	6	6	6	6	6	6	6	6
Si	1.96	1.959	1.967	1.951	1.958	1.96	1.973	1.968	1.613	1.968
Ti	0.003	0.004	0.002	0.006	0.005	0.005	0.004	0.003	0.025	0.002
Al	0.047	0.053	0.053	0.054	0.056	0.048	0.05	0.04	0.544	0.051
Cr	0	0	0	0	0.002	0.001	0.002	0.001	0	0.001
Fe ₃	0.07	0.064	0.05	0.071	0.062	0.066	0.029	0.051	0.349	0.047
Fe ₂	0.706	0.73	0.735	0.7	0.717	0.705	0.795	0.724	0.617	0.731
Mn	0.026	0.027	0.025	0.027	0.026	0.025	0.028	0.025	0.013	0.024
Mg	0.306	0.303	0.294	0.304	0.295	0.306	0.297	0.313	0.222	0.302
Ca	0.841	0.818	0.83	0.848	0.834	0.841	0.789	0.84	0.448	0.834
Na	0.04	0.042	0.042	0.039	0.045	0.041	0.033	0.034	0.091	0.04
K	0.002	0	0	0	0	0.004	0.001	0.001	0.078	0
Sum	4	4	4	4	4	4	4	4	4	4

Clinopyroxene chemical analyses (LHT 6A)

Sample	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A	LHT 6A
Min	Cpx 31	Cpx 32	Cpx 33	Cpx 34	Cpx 35	Cpx-42	Cpx-43	Cpx-44	Cpx-45
SiO2	48.65	49.05	49.24	49.01	49.18	48.94	48.73	49.21	49.26
TiO2	0.17	0.17	0.17	0.16	0.15	0.17	0.1	0.13	0.09
Al2O3	1.09	1.1	1.24	1.19	1.08	1.27	1.28	1.25	1.01
Cr2O3	0	0	0.02	0	0	0	0.06	0	0
Fe2O3	2.64	2.41	3.27	2.15	0.94	2.42	1.66	1.42	1.61
FeO	20.82	21.54	21.1	21.57	24.8	21.39	25.23	21.95	21.46
MnO	0.79	0.79	0.77	0.74	0.83	0.81	0.89	0.83	0.73
MgO	5.24	5.39	5.32	5.19	5.28	5.02	4.98	4.95	5.12
CaO	19.58	18.86	19.77	19.24	16.86	19.62	16.6	19.38	19.73
Na2O	0.49	0.58	0.5	0.54	0.48	0.51	0.44	0.54	0.51
K2O	0	0	0.01	0	0.02	0	0.01	0	0.01
Totals	99.49	99.9	101.41	99.78	99.63	100.15	99.98	99.66	99.53
Oxygens	6	6	6	6	6	6	6	6	6
Si	1.948	1.955	1.937	1.956	1.975	1.949	1.958	1.966	1.969
Ti	0.005	0.005	0.005	0.005	0.005	0.005	0.003	0.004	0.003
Al	0.052	0.052	0.057	0.056	0.051	0.059	0.06	0.059	0.048
Cr	0	0	0.001	0	0	0	0.002	0	0
Fe3	0.08	0.072	0.097	0.064	0.028	0.073	0.05	0.043	0.049
Fe2	0.697	0.718	0.694	0.72	0.833	0.712	0.848	0.733	0.717
Mn	0.027	0.027	0.026	0.025	0.028	0.027	0.03	0.028	0.025
Mg	0.313	0.32	0.312	0.309	0.316	0.298	0.298	0.295	0.305
Ca	0.84	0.806	0.833	0.823	0.725	0.837	0.715	0.83	0.845
Na	0.038	0.045	0.038	0.042	0.038	0.04	0.034	0.042	0.039
K	0	0	0	0	0.001	0	0.001	0	0
Sum	4	4	4	4	4	4	4	4	4

Orthopyroxene chemical analyses (LHT 5A)

Sample	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A
Min	Opx1.23	Opx1.24	Opx1.25	Opx1.26	Opx1.27	Opx2.13	Opx2.15	Opx2.16	Opx2.17
SiO2	47.6	47.59	47.8	47	47.32	47.7	47.23	48.18	47.75
TiO2	0.09	0.09	0.11	0.17	0.2	0.15	0.11	0.19	0.13
Al2O3	0.78	0.54	0.62	0.69	0.67	0.63	0.67	1	0.51
Cr2O3	0	0	0	0.01	0.02	0	0.04	0	0
Fe2O3	0	1.44	0.94	1.15	1.32	1.39	2.22	0	0.88
FeO	40.51	40.86	39.73	40.91	40.87	40.61	39.43	39.79	40.92
MnO	1.75	1.81	1.75	1.87	1.86	1.78	1.86	1.73	1.78
MgO	6.87	7.36	7.1	6.85	7.02	7.47	7.71	7.18	7.57
CaO	0.77	0.9	2.24	1.01	1.04	0.96	1.13	0.97	0.78
Na2O	0.01	0	0.05	0	0.04	0.04	0.02	0.04	0
K2O	0.03	0.01	0.01	0.01	0	0.01	0	0.01	0
Totals	98.41	100.6	100.34	99.69	100.35	100.74	100.42	99.09	100.32
Oxygens	6	6	6	6	6	6	6	6	6
Si	1.995	1.962	1.969	1.96	1.958	1.96	1.946	1.994	1.97
Ti	0.003	0.003	0.003	0.005	0.006	0.005	0.003	0.006	0.004
Al	0.039	0.026	0.03	0.034	0.033	0.03	0.033	0.049	0.025
Cr	0	0	0	0	0.001	0	0.001	0	0
Fe3	0	0.045	0.029	0.036	0.041	0.043	0.069	0	0.027
Fe2	1.42	1.409	1.369	1.427	1.414	1.396	1.359	1.377	1.412
Mn	0.062	0.063	0.061	0.066	0.065	0.062	0.065	0.061	0.062
Mg	0.429	0.452	0.436	0.426	0.433	0.458	0.473	0.443	0.465
Ca	0.035	0.04	0.099	0.045	0.046	0.042	0.05	0.043	0.034
Na	0.001	0	0.004	0	0.003	0.004	0.001	0.004	0
K	0.002	0	0	0.001	0	0	0	0	0
Sum	3.984	4	4	4	4	4	4	3.977	4

Orthopyroxene chemical analyses (LHT 5A)

Sample	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A
Min	Opx3.28	Opx3.29	Opx3.30	Opx3.31	Opx3.32
SiO2	47.73	47.36	47.45	47.48	47.81
TiO2	0.08	0.03	0.13	0.08	0.11
Al2O3	0.49	0.52	0.63	0.63	0.58
Cr2O3	0	0	0	0	0
Fe2O3	0.93	1.76	1.39	1.83	1.68
FeO	40.45	39.8	40.21	39.8	40.67
MnO	1.88	1.92	1.87	1.87	1.91
MgO	7.63	7.66	7.54	7.73	7.6
CaO	0.82	0.94	0.94	0.94	0.84
Na2O	0.03	0.01	0.02	0.03	0.01
K2O	0	0	0.01	0.02	0
Totals	100.05	100.01	100.18	100.42	101.22
Oxygens	6	6	6	6	6
Si	1.972	1.959	1.96	1.955	1.957
Ti	0.003	0.001	0.004	0.003	0.004
Al	0.024	0.026	0.031	0.031	0.028
Cr	0	0	0	0	0
Fe3	0.029	0.055	0.043	0.057	0.052
Fe2	1.398	1.377	1.389	1.371	1.392
Mn	0.066	0.067	0.065	0.065	0.066
Mg	0.47	0.472	0.464	0.474	0.464
Ca	0.036	0.042	0.042	0.042	0.037
Na	0.003	0.001	0.001	0.002	0.001
K	0	0	0.001	0.001	0
Sum	4	4	4	4	4

Clinopyroxene chemical analyses (LHT 5A)

Sample	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A
Min	Cpx1.7	Cpx1.8	Cpx1.9	Cpx1-c	Cpx2.1	Cpx2.2	Cpx2.3	Cpx2.4	Cpx2.5	Cpx2-c
SiO ₂	49.56	49.05	49.22	48.84	49.78	49.11	49.16	48.99	48.74	49.1
TiO ₂	0.18	0.28	0.32	0.2	0.11	0.22	0.19	0.17	0.17	0.22
Al ₂ O ₃	1.38	1.7	1.87	1.75	1.35	1.59	1.44	1.49	1.58	1.52
Cr ₂ O ₃	0.01	0.03	0.02	0	0.02	0.05	0.02	0	0	0
Fe ₂ O ₃	1.75	1.68	0.54	2.85	0.88	1.96	1.58	2.27	0	0.9
FeO	22.49	20.21	21.68	20.54	20.95	20.77	24.99	22.08	24.89	22.65
MnO	1.01	0.98	0.96	1.06	0.95	0.95	1.1	1.03	1.04	1.01
MgO	6.15	6.15	5.93	6.3	6.18	6.3	6.19	6.35	6.2	6.11
CaO	17.66	18.73	18.19	17.96	18.88	18.22	15.46	17.05	15.08	16.98
Na ₂ O	0.5	0.59	0.57	0.59	0.53	0.56	0.43	0.53	0.43	0.56
K ₂ O	0	0.01	0	0	0.03	0	0	0	0.03	0
Totals	100.69	99.4	99.28	100.1	99.64	99.72	100.55	99.96	98.17	99.05
Oxygens	6	6	6	6	6	6	6	6	6	6
Si	1.956	1.949	1.96	1.933	1.973	1.948	1.954	1.946	1.975	1.966
Ti	0.005	0.008	0.01	0.006	0.003	0.006	0.006	0.005	0.005	0.007
Al	0.064	0.079	0.088	0.082	0.063	0.074	0.067	0.07	0.076	0.072
Cr	0	0.001	0.001	0	0.001	0.001	0.001	0	0	0
Fe ₃	0.052	0.05	0.016	0.085	0.026	0.058	0.047	0.068	0	0.027
Fe ₂	0.742	0.672	0.722	0.68	0.694	0.689	0.831	0.734	0.843	0.758
Mn	0.034	0.033	0.032	0.036	0.032	0.032	0.037	0.035	0.036	0.034
Mg	0.362	0.364	0.352	0.372	0.365	0.372	0.367	0.376	0.374	0.365
Ca	0.747	0.797	0.776	0.762	0.802	0.774	0.658	0.726	0.655	0.728
Na	0.038	0.045	0.044	0.045	0.04	0.043	0.033	0.041	0.034	0.043
K	0	0	0	0	0.001	0	0	0	0.001	0
Sum	4	4	4	4	4	4	4	4	4	4

Clinopyroxene chemical analyses (LHT 5A)

Sample	LHT 5A	LHT 5A	LHT 5A	LHT 5A	LHT 5A
Min	Cpx3.18	Cpx3.19	Cpx3.20	Cpx3.21	Cpx3.22
SiO ₂	50.73	48.96	49.57	49.3	49.37
TiO ₂	0.15	0.19	0.22	0.26	0.17
Al ₂ O ₃	1.2	1.49	1.49	1.54	1.59
Cr ₂ O ₃	0.01	0	0	0.01	0.01
Fe ₂ O ₃	0	0.38	1.55	1.42	0.83
FeO	20.29	21.06	20.82	20.98	21.94
MnO	0.83	1.17	0.92	0.92	0.94
MgO	6.07	5.9	6.32	6.11	6.08
CaO	19.56	18.4	18.65	18.76	17.86
Na ₂ O	0.52	0.5	0.55	0.5	0.54
K ₂ O	0.11	0.02	0	0.01	0.02
Totals	99.48	98.06	100.09	99.8	99.35
Oxygens	6	6	6	6	6
Si	2.001	1.973	1.957	1.955	1.966
Ti	0.005	0.006	0.007	0.008	0.005
Al	0.056	0.071	0.069	0.072	0.075
Cr	0	0	0	0	0
Fe ₃	0	0.011	0.046	0.042	0.025
Fe ₂	0.669	0.71	0.687	0.696	0.731
Mn	0.028	0.04	0.031	0.031	0.032
Mg	0.357	0.354	0.372	0.361	0.361
Ca	0.827	0.795	0.789	0.797	0.762
Na	0.04	0.039	0.042	0.038	0.042
K	0.006	0.001	0	0.001	0.001
Sum	3.989	4	4	4	4

Orthopyroxene chemical analyses (LHT 2C)

Sample	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C
Min	Opx1.1	Opx1.2	Opx1.3	Opx1.4	Opx1.5	Opx2.6	Opx2.7	Opx2.8	Opx2.9	Opx2.10
SiO2	52.16	51.1	50.72	50.72	50.88	51.3	51.29	51.71	50.79	51.67
TiO2	0.1	0.05	0.09	0.08	0.15	0.07	0.06	0.08	0.06	0.17
Al2O3	1.56	1.63	1.58	1.55	1.54	1.53	1	1.27	1.15	1.5
Cr2O3	0.03	0	0	0.03	0.03	0.02	0.02	0.03	0	0.06
Fe2O3	0.45	2.65	3.46	2.62	2.71	1.43	2.74	2.23	3.62	1.67
FeO	26.57	24.25	23.07	23.95	23.49	25.27	23.82	24.08	23.07	25.49
MnO	1.06	1.06	1.04	1.05	1.06	1.11	1.16	1.09	1.13	1.11
MgO	19.02	19.5	19.75	19.45	19.92	19.16	19.87	20.02	19.95	19.37
CaO	0.62	0.67	1.06	0.71	0.64	0.57	0.62	0.74	0.63	0.63
Na2O	0.02	0.04	0.01	0.03	0.02	0.01	0.04	0.02	0.04	0
K2O	0.01	0.01	0	0	0	0.03	0	0	0.01	0
Totals	101.61	100.96	100.79	100.18	100.44	100.49	100.61	101.27	100.44	101.67
Oxygens	6	6	6	6	6	6	6	6	6	6
Si	1.957	1.927	1.914	1.926	1.923	1.944	1.938	1.938	1.923	1.938
Ti	0.003	0.001	0.003	0.002	0.004	0.002	0.002	0.002	0.002	0.005
Al	0.069	0.072	0.07	0.069	0.069	0.068	0.045	0.056	0.051	0.066
Cr	0.001	0	0	0.001	0.001	0.001	0.001	0.001	0	0.002
Fe3	0.013	0.075	0.098	0.075	0.077	0.041	0.078	0.063	0.103	0.047
Fe2	0.834	0.765	0.728	0.761	0.743	0.801	0.753	0.755	0.73	0.799
Mn	0.034	0.034	0.033	0.034	0.034	0.036	0.037	0.035	0.036	0.035
Mg	1.063	1.096	1.11	1.101	1.122	1.082	1.119	1.118	1.126	1.083
Ca	0.025	0.027	0.043	0.029	0.026	0.023	0.025	0.03	0.026	0.025
Na	0.001	0.003	0.001	0.002	0.001	0.001	0.003	0.001	0.003	0
K	0	0	0	0	0	0.001	0	0	0	0
Sum	4	4	4	4	4	4	4	4	4	4

Orthopyroxene chemical analyses (LHT 2C)

Sample	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C
Min	Opx3.28	Opx3.29	Opx3.30	Opx3.31	Opx3.32
SiO ₂	50.74	50.77	50.84	50.08	51.24
TiO ₂	0.06	0.12	0.14	0.13	0.03
Al ₂ O ₃	1.39	1.35	1.5	1.49	1.4
Cr ₂ O ₃	0.01	0.02	0	0.02	0.01
Fe ₂ O ₃	2.53	2.01	2.86	3.75	3.51
FeO	24.05	23.92	23.44	22.95	22.86
MnO	1.13	1.14	1.12	1.09	1.09
MgO	19.54	19.56	19.88	19.68	20.48
CaO	0.52	0.63	0.62	0.65	0.58
Na ₂ O	0.01	0.01	0.02	0.01	0.02
K ₂ O	0	0.01	0.01	0	0
Totals	99.97	99.54	100.43	99.85	101.22
Oxygens	6	6	6	6	6
Si	1.931	1.938	1.923	1.909	1.919
Ti	0.002	0.003	0.004	0.004	0.001
Al	0.062	0.061	0.067	0.067	0.062
Cr	0	0.001	0	0.001	0
Fe ₃	0.072	0.058	0.081	0.108	0.099
Fe ₂	0.765	0.763	0.741	0.732	0.716
Mn	0.036	0.037	0.036	0.035	0.035
Mg	1.108	1.113	1.121	1.118	1.143
Ca	0.021	0.026	0.025	0.027	0.023
Na	0.001	0.001	0.001	0.001	0.001
K	0	0	0	0	0
Sum	4	4	4	4	4

Clinopyroxene chemical analyses (LHT 2C)

Sample	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C
Min	Cpx1.12	Cpx1.13	Cpx1.14	Cpx1.15	Cpx1.16	Cpx2.22	Cpx2.23	Cpx2.24	Cpx2.25	Cpx2.26
SiO ₂	51.69	51.33	51.8	52.74	52.04	51.28	51.33	51.1	51.3	51.64
TiO ₂	0.26	0.29	0.24	0.07	0.1	0.23	0.22	0.14	0.23	0.18
Al ₂ O ₃	2.79	3.06	2.67	1.32	1.99	2.63	2.66	2.7	2.67	2.4
Cr ₂ O ₃	0	0.02	0.01	0.01	0.01	0.02	0.04	0.01	0	0.01
Fe ₂ O ₃	1.11	2.21	0.1	1.07	1.02	2.97	2.16	2.29	2.36	2.39
FeO	10.15	9.47	10.75	7.56	8.72	7.7	7.88	9.29	8.03	8.31
MnO	0.53	0.53	0.48	0.42	0.41	0.49	0.47	0.52	0.45	0.46
MgO	12.21	12.12	12.2	13.65	12.95	12.84	12.54	12.48	12.31	12.78
CaO	19.95	20.11	19.73	21.99	20.48	20.89	20.95	19.87	21.18	20.87
Na ₂ O	0.87	0.92	0.84	0.57	0.82	0.78	0.87	0.8	0.86	0.78
K ₂ O	0	0	0	0	0.02	0.02	0	0	0	0
Totals	99.56	100.06	98.82	99.4	98.56	99.86	99.12	99.2	99.39	99.82
Oxygens	6	6	6	6	6	6	6	6	6	6
Si	1.947	1.926	1.963	1.974	1.969	1.922	1.935	1.932	1.932	1.936
Ti	0.007	0.008	0.007	0.002	0.003	0.006	0.006	0.004	0.007	0.005
Al	0.124	0.135	0.119	0.058	0.089	0.116	0.118	0.12	0.119	0.106
Cr	0	0.001	0	0	0	0.001	0.001	0	0	0
Fe ₃	0.031	0.062	0.003	0.03	0.029	0.084	0.061	0.065	0.067	0.067
Fe ₂	0.32	0.297	0.341	0.237	0.276	0.241	0.248	0.294	0.253	0.261
Mn	0.017	0.017	0.015	0.013	0.013	0.016	0.015	0.017	0.014	0.015
Mg	0.685	0.678	0.689	0.762	0.73	0.717	0.705	0.703	0.691	0.714
Ca	0.805	0.809	0.801	0.882	0.83	0.839	0.846	0.805	0.855	0.839
Na	0.064	0.067	0.062	0.041	0.06	0.057	0.064	0.059	0.063	0.057
K	0	0	0	0	0.001	0.001	0	0	0	0
Sum	4	4	4	4	4	4	4	4	4	4

Clinopyroxene chemical analyses (LHT 2C)

Sample	LHT 2C	LHT 2C	LHT 2C	LHT 2C	LHT 2C
Min	Cpx3.17	Cpx3.18	Cpx3.19	Cpx3.20	Cpx3.21
SiO2	51.92	51.21	50.73	50.95	51.49
TiO2	0.22	0.29	0.37	0.31	0.24
Al2O3	2.62	3.25	3.38	3.26	2.75
Cr2O3	0	0.08	0.04	0.03	0
Fe2O3	1.62	1.4	0.81	1.46	2.04
FeO	9.16	10.68	10.51	9.56	8.76
MnO	0.47	0.49	0.48	0.48	0.48
MgO	12.5	11.74	11.72	11.66	12.37
CaO	20.59	19.69	19.5	20.09	20.59
Na2O	0.86	0.9	0.89	1	0.88
K2O	0	0	0	0	0.01
Totals	99.96	99.73	98.43	98.8	99.61
Oxygens	6	6	6	6	6
Si	1.944	1.931	1.934	1.934	1.936
Ti	0.006	0.008	0.011	0.009	0.007
Al	0.116	0.144	0.152	0.146	0.122
Cr	0	0.002	0.001	0.001	0
Fe3	0.046	0.04	0.023	0.042	0.058
Fe2	0.287	0.337	0.335	0.303	0.275
Mn	0.015	0.016	0.016	0.015	0.015
Mg	0.698	0.66	0.666	0.66	0.693
Ca	0.826	0.796	0.797	0.817	0.829
Na	0.062	0.066	0.066	0.074	0.064
K	0	0	0	0	0
Sum	4	4	4	4	4

Garnet chemical analyses (LHT 9B)

Sample	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B
Min	Grt1.21	Grt1.22	Grt1.23	Grt1.24	Grt1.25	Grt1.26	Grt1.27	Grt1.28	Grt1.29	Grt1.30
SiO2	38.37	38.29	37.93	37.99	37.87	37.96	38.09	38.04	38.34	37.83
TiO2	0	0	0	0	0	0	0	0	0	0
Al2O3	22.13	22.17	22.18	22.19	22.31	22.31	22.2	22.23	22.25	22.18
Cr2O3	0.08	0.07	0.02	0.07	0.04	0.06	0.04	0.09	0.11	0.06
Fe2O3	0.55	0.93	1.42	1.4	1.62	2.08	1.22	1.74	0.54	1.42
FeO	28.2	28.56	28.24	28.23	28.13	28.11	28.44	28.22	28.7	27.99
MnO	1.19	1.22	1.28	1.23	1.28	1.26	1.24	1.26	1.2	1.24
MgO	7.56	7.89	8.04	8.08	8.07	7.96	7.98	8.01	8	7.77
CaO	2.34	1.5	1.14	1.15	1.15	1.37	1.24	1.33	1.29	1.64
Na2O	0	0	0.01	0.02	0	0.01	0.01	0	0.01	0.01
K2O	0	0	0	0	0	0	0	0	0	0
Totals	100.42	100.62	100.25	100.35	100.46	101.13	100.45	100.92	100.43	100.15
Oxygens	12	12	12	12	12	12	12	12	12	12
Si	2.971	2.961	2.944	2.945	2.933	2.925	2.95	2.936	2.967	2.941
Ti	0	0	0	0	0	0	0	0	0	0
Al	2.02	2.021	2.029	2.028	2.037	2.027	2.027	2.023	2.03	2.033
Cr	0.005	0.004	0.001	0.004	0.002	0.004	0.002	0.005	0.006	0.004
Fe3	0.032	0.054	0.083	0.082	0.094	0.12	0.071	0.101	0.032	0.083
Fe2	1.827	1.847	1.833	1.83	1.822	1.812	1.843	1.821	1.857	1.82
Mn	0.078	0.08	0.084	0.081	0.084	0.082	0.081	0.082	0.078	0.082
Mg	0.873	0.909	0.93	0.933	0.932	0.914	0.921	0.921	0.923	0.9
Ca	0.194	0.124	0.095	0.095	0.095	0.113	0.103	0.11	0.107	0.137
Na	0	0	0.001	0.003	0	0.002	0.001	0	0.001	0.001
K	0	0	0	0	0	0	0	0	0	0
Sum	8	8	8	8	8	8	8	8	8	8
alm	0.615	0.624	0.623	0.623	0.621	0.620	0.625	0.621	0.626	0.619
prp	0.294	0.307	0.316	0.317	0.318	0.313	0.312	0.314	0.311	0.306
grs	0.047	0.014	-	-	-	-	0.002	-	0.018	0.006
sps	0.026	0.027	0.029	0.028	0.029	0.028	0.027	0.028	0.026	0.028

Garnet chemical analyses (LHT 9B)

Sample	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B
Min	Grt2.1	Grt2.2	Grt2.3	Grt2.4	Grt2.5	Grt2.6	Grt2.7	Grt2.8	Grt2.9	Grt2.10
SiO2	38.47	38.14	38.51	38.73	38.52	38.38	38.35	38.38	38.48	38.25
TiO2	0	0	0	0	0	0	0	0	0	0
Al2O3	22.11	22.09	21.96	22.11	22.11	22.16	22.07	22.17	22.09	22.05
Cr2O3	0.03	0	0.09	0.05	0.05	0.04	0.03	0.04	0.04	0.03
Fe2O3	1	1.42	0.23	0	0	0.47	0.87	1.04	0.87	0.83
FeO	28.37	28.09	28.7	28.7	28.87	28.73	28.55	28.51	28.62	28.26
MnO	1.29	1.33	1.32	1.35	1.35	1.34	1.31	1.3	1.37	1.3
MgO	7.41	7.49	7.55	7.65	7.57	7.75	7.76	7.64	7.48	7.32
CaO	2.39	2.18	1.99	1.88	1.73	1.5	1.62	1.86	2.08	2.38
Na2O	0.01	0.01	0	0	0	0.01	0.02	0.02	0	0.01
K2O	0	0	0	0	0	0	0	0	0	0
Totals	101.08	100.74	100.36	100.47	100.2	100.4	100.58	100.95	101.04	100.44
Oxygens	12	12	12	12	12	12	12	12	12	12
Si	2.966	2.952	2.987	2.995	2.989	2.974	2.968	2.961	2.969	2.967
Ti	0	0	0	0	0	0	0	0	0	0
Al	2.01	2.015	2.008	2.016	2.023	2.024	2.014	2.017	2.009	2.017
Cr	0.002	0	0.006	0.003	0.003	0.003	0.002	0.002	0.002	0.002
Fe3	0.058	0.082	0.013	0	0	0.028	0.051	0.06	0.051	0.049
Fe2	1.829	1.818	1.862	1.856	1.874	1.862	1.848	1.84	1.847	1.833
Mn	0.084	0.087	0.087	0.088	0.089	0.088	0.086	0.085	0.09	0.085
Mg	0.851	0.864	0.873	0.882	0.876	0.895	0.895	0.879	0.86	0.846
Ca	0.197	0.181	0.165	0.156	0.144	0.125	0.134	0.154	0.172	0.198
Na	0.002	0.001	0	0	0	0.002	0.002	0.002	0	0.002
K	0	0	0	0	0	0	0	0	0	0
Sum	8	8	8	7.996	7.998	8	8	8	8	8
alm	0.618	0.616	0.623	0.622	0.628	0.627	0.624	0.622	0.622	0.619
prp	0.287	0.293	0.292	0.296	0.294	0.301	0.302	0.297	0.290	0.286
grs	0.038	0.022	0.046	0.051	0.047	0.027	0.020	0.022	0.032	0.042
sps	0.028	0.029	0.029	0.030	0.030	0.030	0.029	0.029	0.030	0.029

Garnet chemical analyses (LHT 9B)

Sample	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B
Min	Grt3.11	Grt3.12	Grt3.13	Grt3.14	Grt3.15	Grt3.16	Grt3.17	Grt3.18	Grt3.19	Grt3.20
SiO ₂	38.61	38.29	38.23	38.42	38.51	37.99	38.39	38.29	38.13	38.43
TiO ₂	0	0	0	0	0	0	0	0	0	0
Al ₂ O ₃	22.22	22.06	22.2	22.15	22.18	22.18	22.3	22.06	22.26	22.09
Cr ₂ O ₃	0.05	0.02	0.03	0.05	0.02	0.05	0.01	0.08	0.03	0.06
Fe ₂ O ₃	0.52	0.9	1.56	1.34	0.63	1.75	0.45	1.19	1.5	1.05
FeO	28.06	27.86	27.96	27.99	28.24	27.75	28.42	27.95	27.61	28.14
MnO	1.33	1.32	1.34	1.36	1.4	1.32	1.33	1.32	1.36	1.3
MgO	7.59	7.6	7.74	7.83	7.8	7.88	7.81	7.81	7.65	7.42
CaO	2.47	2.36	2.01	2.04	1.94	1.71	1.69	1.97	2.26	2.54
Na ₂ O	0.01	0.01	0.01	0	0	0.02	0.01	0.01	0.02	0
K ₂ O	0	0	0	0	0	0	0	0	0	0
Totals	100.87	100.41	101.07	101.18	100.72	100.65	100.41	100.68	100.82	101.03
Oxygens	12	12	12	12	12	12	12	12	12	12
Si	2.975	2.966	2.946	2.955	2.972	2.938	2.97	2.959	2.944	2.964
Ti	0	0	0	0	0	0	0	0	0	0
Al	2.019	2.015	2.017	2.009	2.018	2.022	2.034	2.01	2.026	2.008
Cr	0.003	0.001	0.002	0.003	0.001	0.003	0.001	0.005	0.002	0.004
Fe ₃	0.03	0.053	0.09	0.078	0.037	0.102	0.026	0.069	0.087	0.061
Fe ₂	1.809	1.805	1.802	1.801	1.823	1.795	1.839	1.807	1.782	1.815
Mn	0.087	0.087	0.087	0.089	0.092	0.086	0.087	0.086	0.089	0.085
Mg	0.872	0.877	0.889	0.898	0.897	0.908	0.901	0.899	0.88	0.853
Ca	0.204	0.196	0.166	0.168	0.16	0.142	0.14	0.163	0.187	0.21
Na	0.002	0.001	0.001	0	0	0.003	0.002	0.002	0.003	0.001
K	0	0	0	0	0	0	0	0	0	0
Sum	8	8	8	8	8	8	8	8	8	8
alm	0.609	0.609	0.612	0.609	0.613	0.612	0.62	0.612	0.607	0.613
prp	0.293	0.296	0.302	0.304	0.302	0.31	0.304	0.304	0.3	0.288
grs	0.053	0.04	0.013	0.018	0.035	-	0.034	0.02	0.022	0.04
sps	0.029	0.029	0.030	0.030	0.031	0.029	0.029	0.029	0.030	0.029

Garnet chemical analyses (LHT 9B)

Sample	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B	LHT 9B
Min	Gr4.32	Gr4.33	Gr4.34	Gr4.35	Gr4.36	Gr4.37
SiO2	38.26	38.41	38.22	38.07	38.05	37.78
TiO2	0	0	0	0	0	0
Al2O3	21.84	21.93	21.82	21.63	21.73	21.42
Cr2O3	0.08	0.13	0.07	0.13	0.13	0.13
Fe2O3	0.31	0.69	0.62	1.12	1.08	0.97
FeO	29.52	29.63	29.7	29.59	30.05	29.66
MnO	1.39	1.32	1.39	1.41	1.43	1.43
MgO	6.37	6.43	6.38	6.32	6.06	5.92
CaO	2.68	2.66	2.46	2.45	2.46	2.69
Na2O	0.01	0.02	0.02	0.02	0.01	0.02
K2O	0	0	0	0	0	0
Totals	100.45	101.22	100.67	100.74	100.99	100.01
Oxygens	12	12	12	12	12	12
Si	2.985	2.976	2.979	2.97	2.967	2.974
Ti	0	0	0	0	0	0
Al	2.009	2.003	2.005	1.989	1.997	1.988
Cr	0.005	0.008	0.005	0.008	0.008	0.008
Fe3	0.018	0.04	0.036	0.066	0.063	0.057
Fe2	1.926	1.92	1.935	1.931	1.959	1.953
Mn	0.092	0.087	0.092	0.093	0.094	0.095
Mg	0.741	0.742	0.741	0.735	0.704	0.695
Ca	0.224	0.221	0.205	0.205	0.206	0.227
Na	0.001	0.003	0.002	0.003	0.002	0.002
K	0	0	0	0	0	0
Sum	8	8	8	8	8	8
alm	0.646	0.646	0.651	0.651	0.661	0.658
prp	0.248	0.25	0.249	0.248	0.238	0.234
grs	0.064	0.051	0.049	0.033	0.035	0.045
sps	0.031	0.029	0.031	0.031	0.032	0.032

APPENDIX ii:
Quartz c-axis fabrics data

#	LHT - 2C		LHT - 6A		LHT - 10A		LHT - 10D	
	Azimut	Dip	Azimut	Dip	Azimut	Dip	Azimut	Dip
1	353	73	230	25	340	2	340	2
2	338	31	254	27	335	8	335	8
3	338	15	228	25	331	5	333	14
4	333	24	237	3	327	14	325	8
5	331	20	229	11	326	9	322	25
6	330	79	225	7	326	13	318	8
7	330	79	230	8	326	2	317	3
8	326	34	231	12	325	14	316	4
9	325	15	232	7	325	25	316	14
10	325	17	235	10	325	25	315	7
11	322	4	252	16	324	16	314	5
12	322	8	246	19	323	6	314	9
13	321	20	250	27	323	3	314	2
14	321	19	212	27	323	13	313	8
15	319	15	256	26	323	12	313	5
16	319	12	224	14	321	5	313	13
17	319	5	202	27	321	9	313	14
18	318	6	224	28	320	12	312	3
19	316	70	225	10	320	3	311	22
20	316	21	230	32	320	1	311	5
21	316	26	254	20	319	6	311	10
22	316	35	230	29	319	2	311	14
23	315	16	241	27	318	8	310	9
24	313	20	242	28	316	4	309	2
25	312	30	217	37	316	14	309	4
26	312	35	205	40	315	7	308	17
27	312	24	200	21	314	2	308	3
28	312	33	208	12	314	5	307	7
29	311	16	216	31	313	14	307	4
30	311	34	224	28	313	9	306	20
31	311	78	226	22	313	8	306	13
32	311	13	213	34	312	3	306	14
33	311	6	207	24	312	15	305	3
34	310	31	209	23	312	2	305	10
35	310	20	208	13	311	21	305	5
36	308	23	203	24	311	9	305	16
37	308	2	238	14	311	6	304	14
38	308	4	214	16	309	2	303	2
39	308	14	248	20	309	4	302	7
40	308	19	245	18	308	17	302	2
41	307	11	225	17	308	13	302	6
42	307	24	321	8	307	7	302	6
43	306	4	334	12	306	20	301	1
44	306	17	331	20	306	14	301	19
45	303	11	340	20	306	6	300	9

#	LHT - 2C		LHT - 6A		LHT - 10A		LHT - 10D	
	Azimut	Dip	Azimut	Dip	Azimut	Dip	Azimut	Dip
46	302	15	314	20	305	3	300	25
47	302	16	334	8	305	10	299	1
48	301	21	342	10	305	6	298	4
49	301	83	320	23	305	5	297	14
50	300	12	325	14	304	14	296	7
51	300	26	334	15	303	2	295	5
52	300	6	328	10	303	4	295	3
53	300	31	321	21	302	6	294	4
54	297	15	343	14	302	7	294	7
55	294	18	306	5	301	1	293	8
56	294	24	337	22	301	19	293	2
57	294	69	327	15	297	14	292	6
58	291	30	324	25	295	3	291	2
59	291	4	318	14	295	5	290	7
60	288	30	320	10	294	7	290	5
61	288	20	299	24	294	4	290	6
62	287	77	60	18	290	5	288	1
63	286	18	53	6	287	3	288	3
64	286	35	38	20	286	4	287	3
65	285	29	33	10	253	3	287	7
66	285	17	16	9	249	6	287	4
67	284	28	33	24	248	3	286	4
68	284	31	32	27	245	8	284	2
69	280	25	62	25	245	2	283	6
70	265	70	64	38	245	5	282	5
71	264	80	43	25	245	3	282	12
72	246	65	69	35	242	12	282	11
73	245	23	74	15	242	4	275	40
74	245	14	46	11	241	29	259	7
75	245	67	47	22	241	3	256	3
76	244	33	22	26	240	7	255	9
77	243	30	29	34	238	3	250	4
78	243	22	53	15	238	13	247	8
79	242	20	34	15	236	5	247	2
80	241	9	29	25	236	2	246	5
81	240	16	55	15	236	8	245	3
82	239	69	63	13	236	1	244	3
83	239	23	66	21	235	6	242	12
84	238	70	58	39	234	2	242	4
85	238	30	69	26	233	11	241	3
86	237	26	35	10	232	7	240	7
87	237	29	36	9	232	3	238	3
88	236	9	50	28	233	11	238	13
89	236	20	44	26	229	7	236	1
90	235	21	50	26	228	22	235	6

#	LHT - 2C		LHT - 6A		LHT - 10A		LHT - 10D	
	Azimut	Dip	Azimut	Dip	Azimut	Dip	Azimut	Dip
91	235	13	51	5	228	4	235	5
92	235	33	69	15	227	12	234	2
93	235	16	30	30	225	5	233	11
94	234	32	55	36	225	2	233	4
95	234	63	26	30	224	8	232	7
96	233	77	39	15	223	4	232	3
97	233	35	24	40	222	3	231	11
98	233	23	36	31	220	9	229	7
99	233	65	53	17	219	4	228	4
100	232	19	64	30	219	14	228	2
101	231	26	154	15	219	3	227	3
102	230	21	106	15	215	16	227	2
103	230	15	156	15	213	6	225	4
104	230	21	131	21	205	12	225	6
105	230	20	109	26	159	11	225	2
106	230	26	141	43	159	6	224	8
107	229	29	104	8	156	5	223	4
108	228	7	140	20	156	18	223	23
109	227	20	117	29	156	12	222	11
110	227	24	114	22	154	10	222	1
111	226	13	143	31	151	6	220	9
112	225	26	139	20	150	3	219	4
113	225	19	152	15	150	27	219	3
114	224	24	130	5	149	19	219	7
115	222	82	124	4	149	12	215	11
116	222	14	160	24	149	6	213	6
117	221	26	161	20	147	11	211	40
118	220	70	155	20	147	15	205	12
119	219	18	115	21	145	4	155	9
120	219	21	141	11	145	7	148	19
121	208	64	140	20	145	12	145	3
122	197	70	135	21	143	20	141	2
123	195	70	145	11	143	10	141	13
124	190	65	143	5	143	25	139	5
125	189	78	73	30	141	8	136	36
126	188	56	112	18	141	14	136	2
127	187	72	131	4	140	15	135	9
128	176	60	137	22	139	11	134	4
129	164	69	135	17	139	5	133	11
130	160	61	124	38	137	17	133	13
131	151	18	119	34	135	9	131	6
132	151	20	118	25	134	34	131	5
133	148	20	137	15	134	4	131	18
134	147	62	144	11	133	13	131	18
135	146	10	125	29	131	3	131	25

#	LHT - 2C		LHT - 6A		LHT - 10A		LHT - 10D	
	Azimut	Dip	Azimut	Dip	Azimut	Dip	Azimut	Dip
136	145	23	126	24	131	18	131	3
137	144	79	140	6	131	8	131	12
138	141	19	135	10	131	25	131	8
139	140	25	122	20	130	5	130	10
140	139	29	133	12	129	23	130	5
141	138	15	134	13	125	11	128	23
142	138	21	129	16	125	7	128	6
143	136	26	125	16	121	22	127	7
144	135	26	131	27	121	13	125	3
145	135	31	231	21	120	2	125	5
146	134	70	235	22	118	8	125	10
147	133	35	236	19	117	2	125	11
148	133	35	231	23	113	12	121	8
149	132	34	231	21	111	7	121	6
150	132	19	325	13	109	5	121	22
151	131	24	330	14	103	13	120	2
152	131	24	335	12	102	10	120	5
153	131	31	326	15	99	8	118	8
154	129	33	49	18	97	10	118	7
155	129	30	51	22	70	4	117	2
156	129	30	39	26	70	3	117	15
157	129	33	30	19	69	9	113	4
158	128	18	234	27	65	2	113	12
159	128	28	226	29	65	6	111	7
160	128	22	203	21	65	14	111	7
161	127	25	209	24	64	6	109	2
162	127	30	202	17	63	5	109	5
163	126	32	325	17	63	7	80	3
164	126	30	74	36	62	4	78	8
165	125	64	48	29	60	27	78	4
166	125	31	23	30	60	9	78	1
167	125	26	19	28	60	2	76	2
168	125	34	26	29	59	8	76	4
169	125	30	219	40	58	5	75	11
170	124	21	225	40	57	2	75	5
171	124	31	257	27	55	12	74	1
172	124	34	206	10	55	7	74	3
173	124	32	216	7	55	6	72	2
174	120	24	235	25	53	2	72	6
175	120	24	217	20	52	9	72	4
176	118	26	238	12	51	5	70	5
177	117	71	246	7	50	3	70	2
178	110	80	231	19	48	21	69	9
179	83	33	215	18	46	9	68	4
180	81	74	213	11	46	7	68	6

#	LHT - 2C		LHT - 6A		LHT - 10A		LHT - 10D	
	Azimut	Dip	Azimut	Dip	Azimut	Dip	Azimut	Dip
181	78	25	252	28	45	3	67	2
182	70	28	69	15	45	12	67	4
183	69	36	54	28	43	9	65	14
184	66	32	38	20	43	3	65	6
185	65	20	52	29	42	5	65	2
186	65	29	18	16	42	15	64	4
187	63	31	55	29	41	12	64	6
188	60	15	40	27	39	11	63	5
189	60	10	36	20	38	15	63	7
190	60	30	17	7	36	5	62	4
191	59	81	20	4	28	9	60	27
192	59	8	15	7			60	2
193	59	81	60	20			60	9
194	58	24	319	20			59	13
195	57	19	304	30			59	8
196	57	22	335	15			58	5
197	56	11	300	17			58	10
198	56	18	296	14			57	8
199	56	73	296	10			57	2
200	55	38	297	20			56	4
201	55	26	291	25			55	4
202	55	31	295	20			55	12
203	54	30	287	15			55	6
204	52	24	301	30			54	3
205	52	34	309	32			53	2
206	51	10	330	5			52	9
207	51	18	325	31			51	5
208	51	20	131	35			50	3
209	49	34	105	10			48	21
210	49	30	141	14			46	7
211	47	25	130	5			46	9
212	46	27	136	12			45	12
213	45	2	132	6			45	3
214	45	19	130	20			39	8
215	44	31	130	12				
216	44	25	126	4				
217	44	34	129	24				
218	44	24	110	25				
219	43	19	121	8				
220	43	31	124	23				
221	43	22	130	6				
222	39	32	135	16				
223	39	36	239	22				
224	37	72	64	17				
225	27	24	43	17				

#	LHT - 2C		LHT - 6A		LHT - 10A		LHT - 10D	
	Azimut	Dip	Azimut	Dip	Azimut	Dip	Azimut	Dip
226	21	69	323	14				
227	17	76	321	7				
228			323	10				
229			326	19				
230			320	17				
231			329	19				
232			328	23				
233			313	15				
234			126	19				
235			131	17				