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Mid-Infrared (2.1-25 um) Spectra of Minerals: First Edition

by

John W. Salisbury
U.S. Geological Survey[1]

Louis S. Walter
NASA Goddard Space Flight Center[2]

Norma Vergo
U.S. Geological Survey[1]

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[1]Mail Stop 927
Reston, VA 22092

[2]Laboratory for Terrestrial Physics
Greenbelt, MD 20771

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1.0 ABSTRACT

Almost all libraries of mineral spectra in the mid-infrared are in the form of transmittance spectra. Although useful in a laboratory setting, such spectra are of limited benefit for interpreting remote sensing observations because they do not include the effects of scattering. Presented here are both transmittance and reflectance spectra of 78 minerals, the latter obtained from different particle size ranges to document particle size effects on scattering. Samples are also completely documented with regard to source and both mineral and chemical composition. Most of the minerals in this first edition of our spectral library are silicates. Subsequent editions will contain spectra of additional non-silicate minerals, as well as rocks and soils.

2.0 INTRODUCTION

In her thorough review of the use of infrared spectroscopy in mineralogy, Estep-Barnes (1977) listed infrared spectral libraries for minerals, rocks and inorganic compounds published prior to 1975. Only Hunt and Salisbury (1975, 1976), Vincent et al. (1975), and Ferraro, (1982) have been published subsequently. Most of these libraries consist of transmittance measurements, which have limited application to remote sensing problems because they do not include the effects of scattering (Salisbury et al., 1987).

Only the works of Lyon (1963, 1964), Hunt and Salisbury (1974, 1975, 1976) and Vincent et al. (1975) contain reflectance and/or emittance data that can be used to predict the spectral behavior of minerals and rocks in a remote sensing situation. However, these data lack the potentially significant 3-5 um region of the spectrum, do not document the effects of different particle sizes on the spectra of all samples, generally lack complete chemical and mineralogical sample characterization and are not available in digital form. The present work seeks to remedy all of these defects. It is a continuing effort that will include future editions that contain spectra of additional non-silicate minerals, as well as rocks and soils. User recommendations for improvement are welcome.

3.0 EXPERIMENTAL TECHNIQUE

3.1 Sample Acquisition and Preparation. Most samples were acquired, often as single crystals, from the Smithsonian National Museum of Natural History. Other samples were obtained from the Hunt and Salisbury collection in Denver or from individuals.

Most samples were crushed in a steel percussion mortar and magnetic particles removed with a hand magnet. Crushed samples were hand-picked when impurities were present, ultrasonically cleaned, and then subjected, when necessary, to an acid wash to insure purity. Samples were ground in a sintered sapphire mortar under either acetone or (more commonly) alcohol, which facilitated grinding, avoided disordering of the sheet silicates and prevented the finest particles from drifting away as aerosols.

Particulate samples were dry-sieved to two different particle size ranges (74-250 um and 0-74 um) and the coarser particle size range was subsequently washed in acetone or alcohol to remove clinging fines. Clay samples were disaggregated ultrasonically and the <2 um size fraction was concentrated with a centrifuge.

3.2 Sample Characterization. Mineral specimens were initially examined as hand samples and, after grinding, under a petrographic microscope. This examination, combined with X-ray diffraction and microprobe analysis generally served to identify those samples that were pure mineral phases and establish their chemical and mineral compositions. Unless otherwise noted, petrography and microprobe analyses were performed by Louis Walter and X-ray diffraction analysis by Norma Vergo.

The <74 um fraction (except where noted) of all samples was characterized by X-ray diffraction using a Siemens* D-500 X-ray diffractometer with CuKα radiation. Samples were mounted using a side pack sample holder to achieve random orientation. There were several samples that were reported to be monomineralic using optical methods but that had "extra" peaks in the X-ray patterns compared to the Joint Committee on Powder Diffraction Standards (JCPDS) file cards. These patterns were modeled by calculating allowed d-spacings from input unit cell dimensions using the Appleman and Evans cell refinement program (1973). The differences between the JCPDS and modeled patterns typically could be attributed to differences in ionic substitutions.

Additional tests were done to characterize the clay minerals. The <2 um fraction was oriented on a glass slide using a Millipore filter setup (Drever, 1973). These slides were then analyzed in the air-dried and glycol-solvated states. K-saturation was done on the vermiculite sample. The mixed-layer clay minerals were modeled using methods outlined in Reynolds (1980) and using the NewMod computer program written by R.C. Reynolds (Dartmouth College).

Microprobe analyses were performed on 70-250 micrometer sample fractions. Through kind permission, the Applied Research Laboratory instrument at the Smithsonian Institution Division of Mineral Sciences was used. Six fixed wavelength dispersive detectors were used to analyze for Si, Al, Fe, Mg, Ca and K. Three movable, wavelength-dispersive detectors were used to analyze for Na, Ti and Mn. Quartz was used as a background standard for Al; alumina was used as a background standard for all other elements.

Standards employed were selected from those offered generally by the Smithsonian: Rhodonite for Mn and Kakanui Hornblende for all other elements. The Bence-Albee correction procedure was used to convert intensity ratios to element/oxide abundances. As usual, Fe is reported as FeO; ferric and ferrous iron were not distinguished.

In analyzing a mineral, points were accumulated for 10 second integration times. Normally, four or five randomly selected points were analyzed on one or two grains. Then, individual points were run on five or six additional grains. If these analyses were equivalent within statistical counting error, the material was assumed to be homogeneous. In some cases small deviations from homogeneity were found and these are noted in the text.

Estimated errors (as determined by replicate analyses) are:

Oxide	Coefficient of Variation (Rel. %)
SiO_2	1.7
Al_2O_3	2
FeO	2
MgO	2
CaO	2
K_2O	3
Na_2O	5
TiO_2	2
MnO	1

These estimates apply to cases in which the oxide abundance is greater than 3%. The limit of reliable detection is generally about 0.5%.

Based on this sample characterization processes, only one out of every three mineral samples was found to be sufficiently pure to be included in this compilation. The results of the analyses are documented on each sample description sheet. Mineral names and ideal formulae used on these sheets were taken from Fleischer (1983).

3.3 Acquisition of Spectra. Spectra were acquired at $4cm^{-1}$ resolution using a Nicolet* 5 DxB interferometer spectrometer with a triglycine sulfate (TGS) detector. Spectral data were recorded from 4809 to 349 cm^{-1} (2.08 to 28.6 um), but are displayed over a nominal range of 4600 to 400 cm^{-1} (2.17 to 25.0 um) because both ends of the spectral range tend to be noisy. This occurs because the infrared source peaks in the middle of the wavelength range and the signal declines on either end.

Transmittance was measured by passing the focused beam (6 mm dia.) of the interferometer through a KBr disk (commonly referred to as a pellet) containing sample material made in the manner of Stimson and O'Donnell (1952). A detailed description of pellet production is given in Appendix 2. Briefly, these pellets consist of 300 mg of KBr mixed with about 0.7 mg of sample ground under alcohol to a size range less than 2 um. The pellets were pressed in a dye under vacuum for five minutes at 10,000 kg/cm^2 pressure to produce transparent disks 13 mm in diameter and 1 mm thick. A reference pellet composed of pure KBr was used to record a background against which to ratio the sample pellet transmittance.

Reflectance spectra were recorded using a Spectra Tech "Collector" diffuse reflectance attachment which uses two 90^{o} off-axis ellipsoids that act as 6x beam condensers. Consequently, the focused beam diameter is reduced to 1 mm and illumination and reflection take place over a solid angle that closely approaches pi steradians. Thus, our bidirectional reflectance measurements actually record biconical reflectance over a large solid angle.

An aluminum mirror was used as the background reference against which sample reflectance is ratioed. A mirror is used as the reference instead of Halon, because the latter exhibits strong absorption bands in most of the spectral range measured here. Not only does the mirror provide a spectrally flat reference, its high reflectance is required when measuring the reflectance of solid samples at the wavelengths of the fundamental molecular vibration bands. As described below (section 4.21) minerals have a mirror-like opacity at such wavelengths, and solid samples may have reflectances close to that of a mirror. Use of biconical reflectance with a mirror reference makes the measured reflectance of a diffusely reflecting particulate sample roughly a factor of five lower at 2.17 um than it would be for the integrating sphere measurments commonly made in the visible and near-infrared.

*Use of tradenames is for descriptive purposes only and does not imply indorsement by the U.S. Geological Survey or NASA.

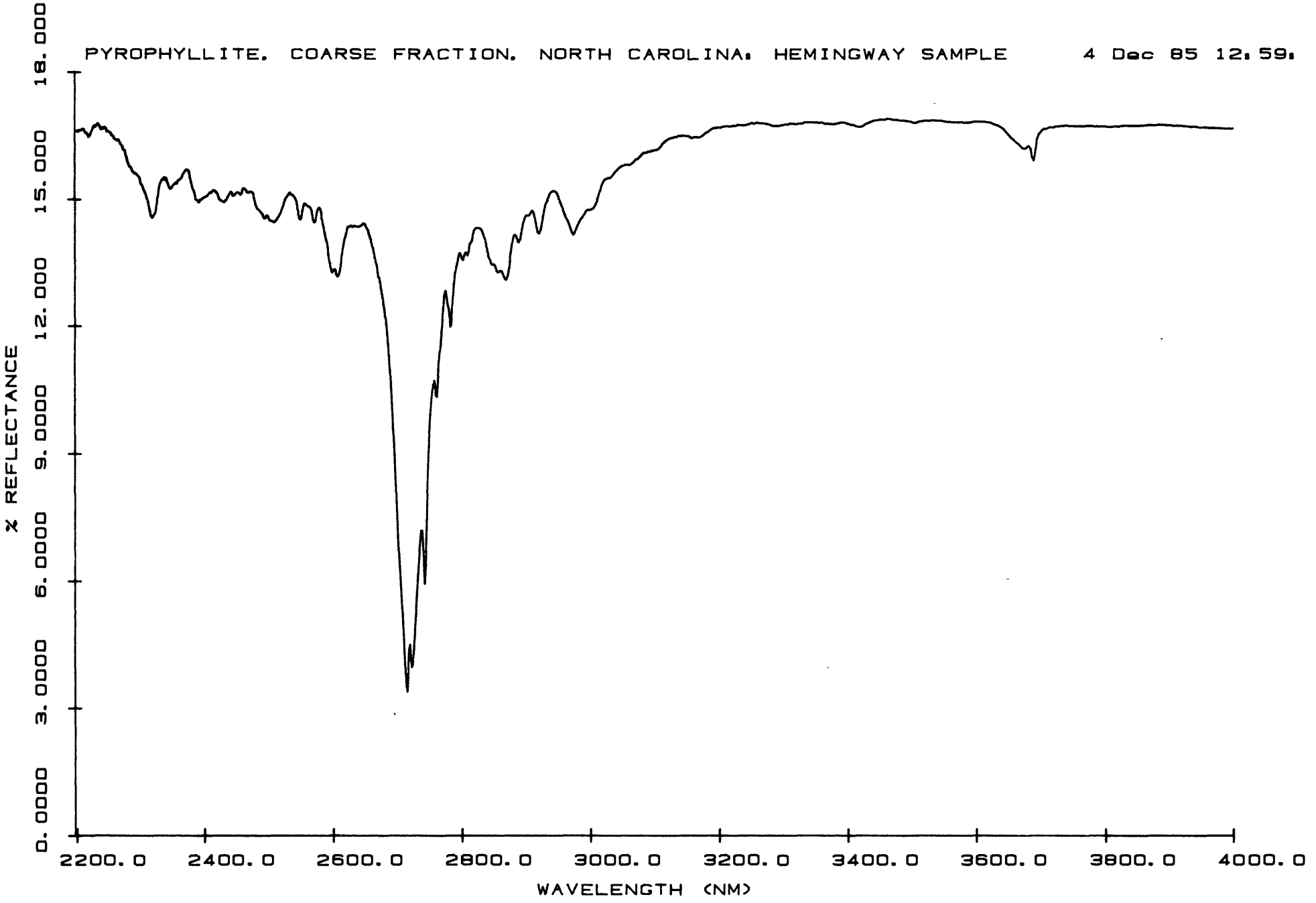

FIGURE 1. REFLECTANCE SPECTRUM OF PYROPHYLLITE LINEAR IN NANOMETERS.

The usual sample holder for reflectance measurements is 13 mm in diameter and 2 mm deep, although a "microreflectance" holder 3 mm x 2 mm can also be used for small samples. All particulate samples were sifted into the sample holders to attempt to achieve random orientation of grains. Solid samples were fixed in a bed of moldable erasure to hold the surface being measured in a horizontal position. For some samples, including most of the clay minerals, solid samples were not available. In these cases, the fine powder samples were pressed into a pseudo-solid sample so that the reststrahlen bands could be seen (see section 4.4). This was accomplished with <2 um clays by placing them in a folded weighing paper and gently rolling a sample bottle over the outside surface. This produced cohesive flakes that could be readily transferred to the reflectance attachment and measured. Some samples such as the olivines, were not sufficiently fine-grained to produce flakes. To make solid sample measurements of these samples, they were simply pressed into a sample cup with the flat side of a spatula. Samples could be raised or lowered by a micrometer screw mechanism so that the measurement surface was at the beam focus.

The Nicolet scans a complete spectrum each second. Scans are then co-added or averaged to provide the desired signal-to-noise. This normally required 100 scans for transmittance measurements and 500 scans for reflectance.

3.4 Data Storage and Retrieval. Data are initially stored in digital form on 8-inch floppy disks in the Nicolet format. Copies of these disks may be obtained by sending blank double-sided, double-density, unformatted disks to: J.W. Salisbury, MS 927, USGS, Reston, VA 22092. Each spectrum type (ie. transmittance, solid sample reflectance, 74-250 um and 0-74 um reflectance) is stored on a separate disk. Thus, four disks are required to store the spectral data presented here. The sample description data, on the other hand, are recorded digitally on an NBI word processor and can be obtained in NBI format by sending a blank single-sided, single-density, 8-inch floppy disk to the same Reston address. Further information can be obtained from J.W. Salisbury at commercial telephone number (703) 648-6382 or FTS 959-6382. We are also in the process of transferring both sample description and spectral data to our Reston VAX 11/780 in ASCII format (VMS operating system), and to Roger Clark in Denver in SPECPR format (UNIX operating system). At the present time (April 87), individual spectra have been successfully transferred, although with some difficulty. We plan to transfer the entire data file in the near future when this transfer process is reduced to practice. For more information on data availability and formats, contact Roger Clark, USGS MS 964, Box 25046 Denver Federal Center, Denver, Col. 80225. Telephone commercial (303) 236-1332 or FTS 776-1332.

The graphic plots of spectral data presented in Appendix 1 are plotted in normal spectroscopic format--ie. in frequency space with the X-axis plotted at 800 cm^{-1}/inch from 4600 to 2200 cm^{-1}, 400 cm^{-1}/inch from 2200 to 1000cm^{-1}, and 200 cm^{-1}/inch from 100 to 400 cm^{-1}. This format is the one normally used by spectroscopists because it displays the entire spectral range on a single 8.5 x 11-inch sheet of paper with spectral features of intrinsically different bandwidths all at generally useful scales. However, some very sharp O-H stretching features (see Discussion below) near 3600 cm^{-1} (2.77 um) are not well resolved in such a plot (eg. see talc and pyrophyllite spectra in Appendix 1). The Nicolet is capable of plotting this portion of each spectrum

at an expanded scale to take full advantage of the 4 cm^{-1} resolution (3.1 nm at 2770 nm) of the data. It can also plot these data linearly in nanometers. If there is sufficient interest, subsequent editions can include linear nanometer plots from 2200 to 4000 nm as shown in figure 1. Also, if sufficient interest is shown, spectra can be recorded at 2 cm^{-1} resolution and/or extended further into the near-infrared.

4.0 DISCUSSION OF SPECTRA

4.1 Major Spectral Features of Minerals. Estep-Barnes (1977) presented an excellent review of the major spectral features of minerals, accompanied by an exhaustive bibliography, and it is not our intent to reproduce that effort here. Rather, this report will provide a brief overview of major spectral features and then focus on spectral effects of such variables as particle size and packing, which have not been addressed by earlier thermal infrared researchers because they worked almost entirely with transmittance spectra.

The most intense spectral features of a mineral are best displayed in transmittance or in reflectance or emittance from a solid surface. Generally, these are due to fundamental stretching and bending vibrational motions of the component atoms. The most intense features in silicate spectra occur between 1176 and 833 cm^{-1} (8.5 and 12.0 um). This range is generally referred to as the Si-O stretching region and primarily involves displacements of the oxygen atoms, resulting in an asymmetric stretching mode. Because these intense features fall in the 8-14 um atmospheric window, they have been most useful for terrestrial remote sensing (Kahle and Goetz, 1983).

The second most intense silicate bands are due to deformation or bending modes, which occur in the 600-400 cm^{-1} (16.6-25.0 um) region, falling most often near 500 cm^{-1} (20 um). Less intense bands in the 833-600 cm^{-1} (12.0 - 16.7 um) region typically are due to Si-O-Si, Si-O-Al and (Si, Al)-O-(Si, Al) symmetric stretching motions, in which the silicon or aluminum atoms, rather than the oxygens, are most displaced from their equilibrium positions (Hunt and Salisbury, 1975). Other metal cations may also contribute to bending or stretching modes (Stubican and Roy, 1964).

The carbonate ion, on the other hand displays strong bands 1400 cm^{-1} (7 um) due to asymmetric C-O stretching vibrations and weaker bands near 875 and 700 cm^{-1} (11.4 and 14.3 um) due to bending modes, which can be seen in the spectrum of calcite in Appendix 1. The sulfate ion displays its intense stretching fundamental near 1150 cm^{-1} (8.7 um) and bending modes near 600 cm^{-1} (16.7 um), which can be seen in the spectrum of gypsum in Appendix 1.

Other common fundamental vibrations are due to water and hydroxyl, the spectral features of which have recently been reviewed by Aines and Rossman (1984). When water is not fixed in a crystal lattice, but is hydrogen-bonded to other water molecules, it results in a broad spectral feature near 3400 cm^{-1} (2.9 um) due to O-H stretching vibrations, and another near 1630 cm^{-1} (6.1 um) due to H-O-H bending vibrations. Such water may be present in fluid inclusions, as interlayer water in sheet silicates, or as water of hydration. Water in a crystalline environment produces sharper O-H stretching absorption features than occur in the liquid water spectrum, which typically

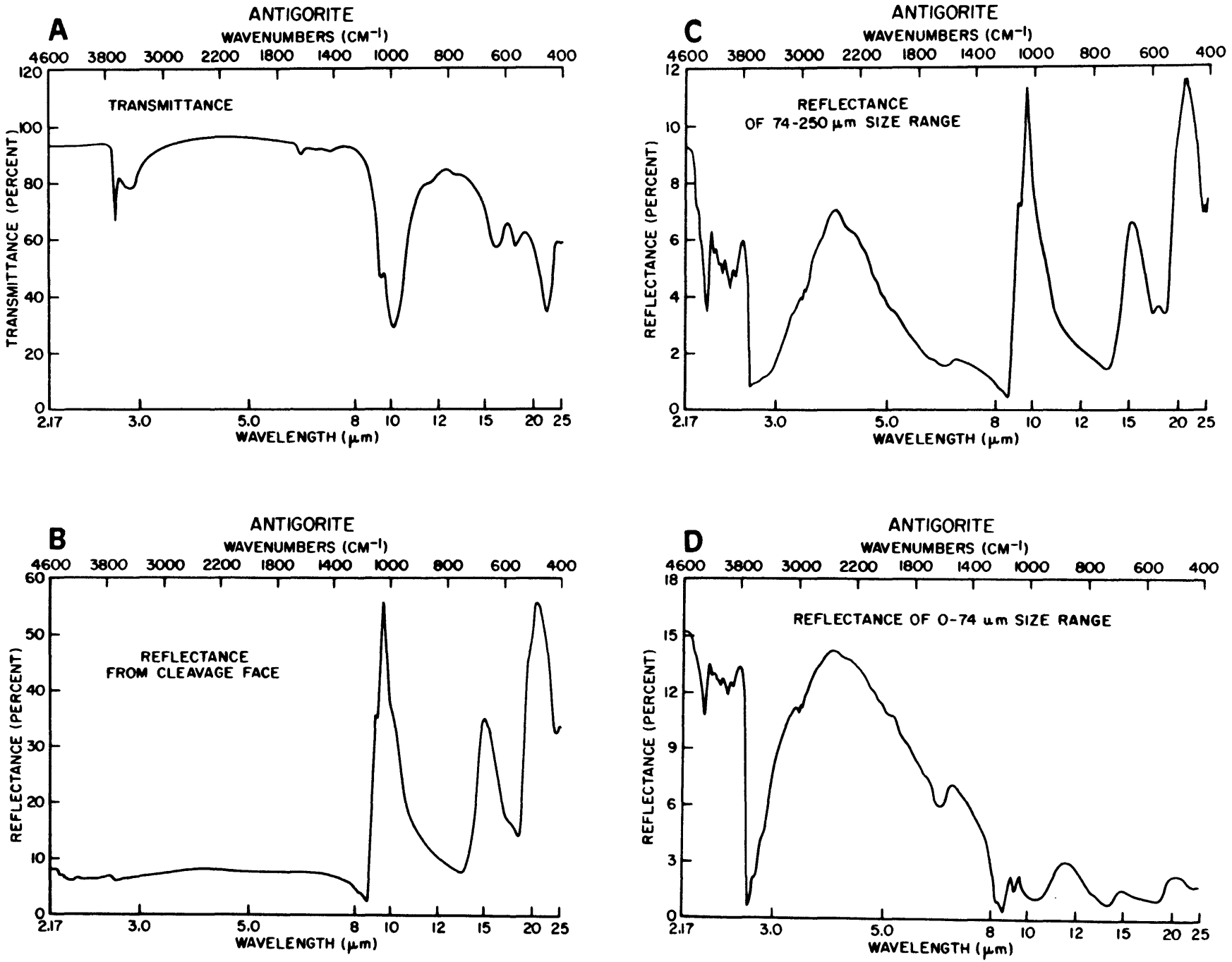

FIGURE 2. TRANSMITTANCE AND REFLECTANCE SPECTRA OF ANTIGORITE.

also occur at a higher frequency. These features are further discussed in section 4.21 and examples of both kinds of features can be seen in Figure 2. Multiple O-H stretching vibrations can result when water is present at several sites in the crystal lattice. Beryl and cordierite, for example, contain water that resides at specific sites in channels parallel to the C axis (Aines and Rossman, 1984). These minerals are also interesting because they also typically have CO_2 trapped in these channels, which produces sharp bands near 2300 cm^{-1} (4.3 um) (compare atmospheric CO_2 bands in Figure 3 with spectra of beryl and cordierite in Appendix 1).

Minerals containing hydroxyl without water display O-H stretching features near 3600 cm^{-1} (2.8 um), but lack the broad feature at 3400 cm^{-1} (2.9 um) and the H-O-H bending mode at lower frequency. A good example is kaolinite, which has no interlayer water.

Some minerals commonly contain a trace of OH, although this is not reflected in their chemical formulae. A good example is quartz, which typically displays multiple sharp O-H stretch features near 3400 cm^{-1} superimposed on a weak broad water band (seen best in the spectra of the 74-250 um particle size range in Appendix 1). The broad water band is probably due to a small amount of liquid water in fluid inclusions. The sharper hydroxyl features are associated with hydroxylated alkali metals that serve to balance charges when aluminum substitutes for silicon (Aines and Rossman, 1984).

Finally, most silicate minerals have undergone incipient alteration to hydrous phases, even when appearing quite fresh, because of the ubiquity of water in the terrestrial environment. This is in marked contrast to other environments, such as that of the moon (Roedder, 1984). It should be pointed out that water and hydroxyl are usually not present in large amount where they are not part of the mineral stoichiometry. However, spectral features due to water and hydroxyl may be prominent, especially in reflectance spectra of fine particulate materials. This is due to the spectral effect of fine particle size on absorption bands of intermediate intensity, which is discussed below (see section 4.22). An estimate of the abundance of water and hydroxyl relative to other phases can best be obtained from transmittance spectra, although the hygroscopic nature of KBr (see Effect of Impurities in section 4.6) will tend to maximize the estimated amount of water.

4.2 Effect of Particle Size. It is apparent from inspection of the spectra in Appendix 1 that particle size has a very significant effect on reflectance spectra. A mathematical model of reflectance from particulate samples has been developed by Hapke (1981) and Clark and Roush (1984). We focus here on a qualitative physical model to provide a basic understanding of how and why spectral features change with particle size, addressing the role of surface and volume scattering, changes of band intensity or spectral contrast, and the occurrence of the principal Christiansen frequency. We also point out a spectral feature that may be used to infer composition at fine particle size: a transparency peak lying between the reflectance peaks which are due to the fundamental stretching and bending vibration bands of silicates.

4.21 Role of surface and volume scattering. The radiation returned to the observer in reflectance from a particulate sample has been scattered by the particles. This scattering takes place by two processes: surface scattering,

which involves rays that have reflected from the surfaces of grains without penetration; and volume scattering, which involves rays that have been refracted into grain interiors and then scattered or refracted back out. Which of these processes dominates returned radiation is determined primarily by the absorption coefficient and particle size.

The wavelength variation in absorption coefficient can be determined from a transmittance spectrum. This can be illustrated in Figure 2A, where the highest absorption coefficient for the mineral antigorite is associated with the Si-O stretching vibration bands near 1000 cm^{-1} (10 um) and the Si-O-Si bending modes near 425 cm^{-1} (23 um). The O-H stretching fundamental vibration associated with hydroxyl produces a sharp band of intermediate intensity and absorption coefficient near 3700 cm^{-1} (2.7 um), adjacent to the weaker and broader feature due to the O-H stretching vibration of water at 3400 cm^{-1} (2.9 um). The still weaker band near 1625 cm^{-1} (6.15 um) is due to the H-O-H bending vibration of water.

The transmittance spectrum in Figure 2A shows, then, spectral features with a wide range of absorption coefficient; and Figures 2B, C and D illustrate the effects of particle size on those spectral features in reflectance.

Figure 2B shows reflectance from a solid sample which, of course, eliminates multiple particle scattering. As a result, almost the entire spectrum is dominated by a single reflectance from the surface (simple Fresnel reflectance, Salisbury, et al, 1987), and the most prominent spectral features are reflectance peaks associated with the strongest molecular vibration bands. The correlation of reflectance peaks with very strong absorption bands is counterintuitive to those accustomed to working in the visible and near-infrared. This effect is due to the very strong absorption coefficient associated with these bands, which induces a mirror-like opacity at those wavelengths.

A small portion of the spectrum near 4300 cm^{-1} (2.3 um) in Figure 2B is dominated by volume scattering. Here a very weak hydroxyl combination tone band can be seen as a trough. This band, so weak that it was not discernible in the transmittance spectrum, has an absorption coefficient so low that photons at this wavelength can penetrate deep into the sample without complete absorption. Consequently, they encounter refractive index discontinuities associated with crystal boundaries and internal imperfections such as micro-inclusions, bubbles and density striations, and are scattered back out (Hapke, 1981).

Comparison of Figures 2B and 2C shows the effect on spectral reflectance of changing from a very large particle size (single slab surface) to a 74-250 um particle size range. The so-called "reststrahlen bands", or reflectance peaks associated with the fundamental Si-O vibrations, are still apparent near 1000 cm^{-1} (10 um) and 425 cm^{-1} (23 um). However, the appearance of the spectrum between 4600 and 1165 cm^{-1} (2.17 and 8.58 um) has changed significantly. The band at 4300 cm^{-1} (2.3 um) is now well-defined and new features have appeared, most prominently a deep asymmetric O-H band associated with water and hydroxyl near 3700 cm^{-1} (2.7 um). These spectral features are all expressed as troughs, not peaks, showing that this region of the spectrum is dominated by volume scattering. What has occurred is that the particle size has become small enough, on the average, to allow passage of photons completely through the grains in this spectral region of relatively low absorption coefficient. That is, the grains

have become optically thin. More photons are absorbed in band centers than in band wings during volume scattering and reflectance minima (troughs) occur.

Thus, for particulate silicates, the spectral range documented in this library is generally dominated by volume scattering and absorption band troughs on the left side of each figure and by surface scattering and absorption band peaks on the right side. The dividing line is the sharp minimum in reflectance due to the principal christiansen frequency (discussed below in Section 4.24) displayed in Figure 2 at 1165cm^{-1} (8.58 um).

4.22 Changes in spectral contrast. Considering first the reflectance minima associated with volume scattering, band depth (Clark and Roush, 1984) is a measure of band intensity commonly referred to as spectral contrast. It is apparent in Figure 2 C and D that this spectral contrast changes with changing particle size. However, the change is not consistent; spectral contrast sometimes increasing and sometimes decreasing with decreasing particle size. The explanation for this behavior lies in the relationship between mean optical path length and particle size, which can be illustrated with three cases. Mean optical path length (MOPL) is the mean distance photons will pass through a material before total absorption takes place (Clark and Roush, 1984). When the absorption coefficient is relatively high and the MOPL is much less than the mean grain diameter in a particulate sample, all photons entering the grains are absorbed. If the MOPL remains smaller than mean particle diameter, even at a finer particle size range, photon absorption remains essentially unchanged. This first case is seen in the O-H band center of hydroxyl at 3700 cm^{-1} (2.7 um). The reflectance at this wavelength remains close to 1% (ie. the band remains saturated) in spectra of both particle size ranges shown in Figures 2C and D. The small amount of reflected energy seen here is due to weak surface scattering.

A second case occurs at intermediate absorption coefficient when the MOPL is on the order of the mean grain diameter. As the particle size decreases, more photons survive passage through several grains and a significant portion of the incoming radiation will be scattered back in the direction of the observer. This second case applies to the wings of the O-H fundamental, which roughly double in reflectance at the 0-74 um particle size range as compared to 74-250 um size range (fig. 2C and D).

When the reflectance in the wings of a band rise (case 2), while the band center remains saturated (case 1) an increase in spectral contrast occurs. This effect causes absorption bands having the right ranges of absorption coefficient between band wings and band centers to display intense bands at fine particle size. This is typically true of the O-H stretching fundamental and of carbonate and sulfate overtones in the 4000-2000 cm^{-1} (2.5-5 um) region. Thus, these materials may dominate the reflectance spectrum of a mineral mixture, even when present in relatively small amounts.

A third illustrative case occurs when the MOPL is much greater than mean particle diameter. The bulk of potentially backscattered radiation will be returned to the observer after relatively few grain encounters by surviving photons. Thus, a reduction in mean grain diameter, D, when MOPL is much greater than D, has proportionally less effect than when MOPL is on the order of D. This third case applies to the wings of the weak combination tone near 4300 cm^{-1} (2.3 um). Here the wings rise relatively little in reflectance compared to the band center,

which is affected by Case 2 scattering. Thus, this band decreases in spectral contrast, with decreasing particle size, which is the norm for weak bands displayed in the near-infrared.

We turn now to bands dominated by surface scattering, such as the Si-O stretching vibration bands near 1000 cm^{-1} (10 um) and the Si-O-Si bending vibration bands near 425 cm^{-1} (23 um) in Figure 2. These absorption bands produce prominent reflectance peaks in Figure 2B and C, which are greatly reduced in Figure 2D. While changing particle size may have resulted in changes in single particle albedo and scattering geometry (Conel, 1969), Salisbury and Eastes (1985) focussed on a physical model depending on porosity to explain this effect. They noted that when a fine powder is packed to reduce porosity, its spectrum displays reflectance peaks as prominent as those displayed by the coarser particle size ranges. They suggested that the increased porosity associated with fine particle size resulted in formation of photon traps. That is, increasing porosity allows more photons to pass between grains and penetrate on the average deeper into the powder. Greater depth of penetration requires an increasing number of scattering encounters for photon escape. Because energy is lost at each encounter to absorption, reflectance decreases. This is analogous to the formation of carbon black or gold black in the visible, where highly opaque materials also show very low reflectance at very fine particle size.

4.23 Transparency peaks. We have referred to the region of the spectrum where the fundamental Si-O and Si-O-Si vibration bands occur as dominated by surface scattering. This is obviously true for solid samples of silicates and for the coarse particle size range, which exhibit prominent reflectance peaks, (eg. Figs. 2B and C). However, it can be seen in the transmittance spectrum of antigorite (fig. 2A) that a region of relatively high transparency exists between the stretching and bending vibrational features in the vicinity of 800 cm^{-1} (12.5 um). The absorption coefficient here is low enough so that grains become optically thin and volume scattering of the Case 2 type (see section 4.22) occurs as the particle size range is reduced from 74-250 um to 0-74 um (figs. 2C and D). Because the strong reststrahlen reflectance peaks are greatly diminished at fine particle size, a broad transparency peak results, centered at 875 cm^{-1} (11.4 um).

Transparency peaks were first noted without explanation in reflectance spectra of rocks by Hovis and Callahan (1966). Conel (1969) described and explained such features (expressed as troughs in emittance-see Section 4.7) in spectra of quartz. Documented here for the first time is the spectral behavior of a wide range of rock-forming minerals, showing the nature and magnitude of transparency peaks that occur in reflectance of fine particulate samples.

Note that the prominence of this feature is dependent on the degree to which the adjacent reflectance peaks associated with the stretching vibration bands are diminished in spectra of the fine particle size range (compare acmite.2 and acmite.1). As explained above (section 4.22), the loss of these peaks appears to be related to the increased porosity and scattering in a sample due to very fine particle size. When a sample is sifted into a sample cup, the finest particles tend to be suspended in air and drift away during sifting. Thus, a sample sifted and measured repeatedly will tend to increase in mean grain diameter and to display progressively stronger reststrahlen bands. We have attempted to avoid this with our samples, but there is some obvious variability of reststrahen band

spectral contrast (compare acmite.1 and acmite.2). Also olivine.1 through olivine.10 display a variety of particle size ranges due to the preparation procedures used on these samples, and olivine.4 is completely lacking in fines.

Despite the fact that some minerals fail to display transparency features, it is apparent from the data shown in Appendix 1 that such peaks (expressed as troughs in emittance) could be the most prominent spectral features in the 8-14 um spectrum of a fine particulate regolith. Hovis and Callahan (1966) looked on such features as a confusion factor. However, they lie between the fundamental molecular vibration bands and shift wavelength position when the bands do, and so can be used as an indirect indicator of composition.

4.24 Christiansen frequency. A final spectral feature that is prominent at fine particle size is the principal Christiansen frequency. This is a reflectance minimum that occurs because the real part of the refractive index undergoes rapid changes (anomalous dispersion) at a slightly shorter wavelength than the most intense molecular vibration band. Consequently, the refractive index approaches 1, resulting in a minimum of scattering at a wavelength where absorption is still relatively low. With little scattering and little absorption, infrared radiation can penetrate a sample relatively easily, resulting in a minimum in reflectance or a maximum in emittance. This feature can be seen in reflectance at all particle size ranges, but is one of the more easily recognized spectral features in reflectance of the finest particle size range, as can be seen in Figure 2D at 1175 cm^{-1} (8.5 um). Conel (1969) first showed that the wavelength of this feature is a good indicator of mineralogy (eg. see the Christiansen reflectance minima near 1025 cm^{-1} (9.75 um) for olivine, 1200 cm^{-1} (8.3 um) for acmite and 1300 cm^{-1} (7.7 um) for albite in Appendix 1). Logan et al (1972) showed that the wavelength of this feature can also be used to determine rock type and demonstrated its utility for mapping compositional variations in the lunar regolith.

4.3 Effect of Crystallographic Orientation. Many minerals are birefrigent and have a different spectral response depending on crystallographic orientation. This can be illustrated in the solid sample spectra of orthoclase in Appendix 1. (Note that orthoclases.1 and .2 are missing because they were dropped from the library due to inadequate purity).

The occurrence of such orientation effects is what makes it necessary to sift samples, or at least their upper millimeter, into sample cups for measurement. Tapping a cup or using a knife edge to level a sample tends to orient the grains, especially if the mineral has a prominent cleavage. Some samples, of course, such as micas, will tend to develop grain orientation despite sifting.

4.4 Effect of Packing. It has been shown that packing a fine particulate sample to reduce its porosity will greatly increase the prominence of the fundamental molecular vibration bands (Salisbury & Eastes, 1985). Thus, spectra of packed samples are presented for some minerals, such as clays, for which coarse-grained samples showing the fundamental molecular vibration bands were not available. Packing will tend to orient the grains parallel to their strongest cleavage or parting, so that these spectra are most similar to solid sample spectra obtained in that orientation. This can be illustrated with olivine.11, which is a magnesian olivine with a very weak cleavage. However, the spectrum of the packed 0-74 um sample is much closer to the solid sample spectrum than it is to the

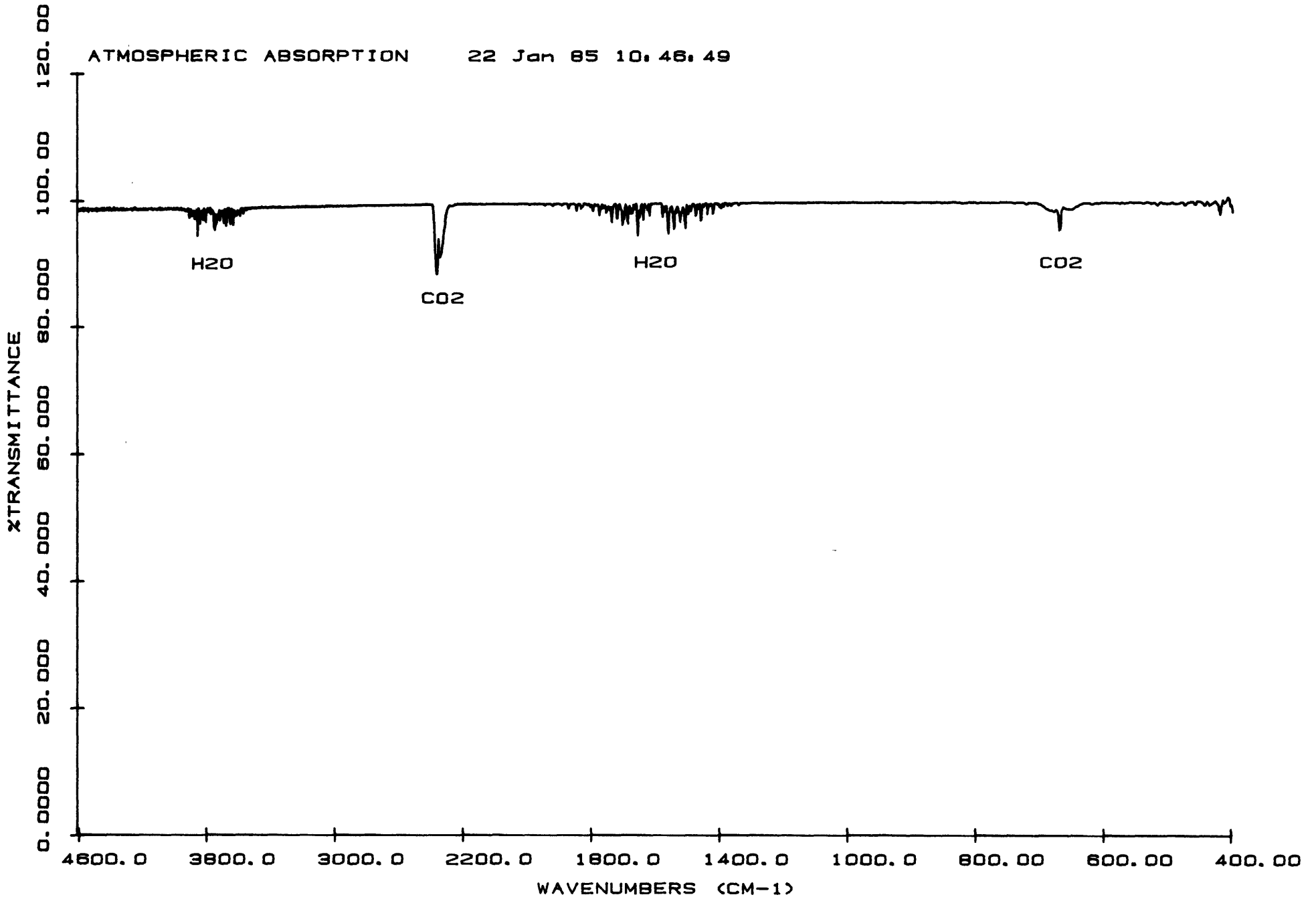

FIGURE 3. TRANSMITTANCE SPECTRUM OF ATMOSPHERIC GASES.

randomly oriented 74-250 um size range spectrum. Consequently, we have stored the spectra of packed samples on the solid sample disk.

4.5 Effect of Atmospheric Gases. A spectrometer must be vigorously purged with dry nitrogen (or dry air from which CO_2 has been removed) in order to avoid incorporating band structure due to atmospheric H_2O and CO_2 in the spectra. Spectra of some solid samples were obtained without adequate purging and suffer from this defect (compare Figure 3 and the solid sample spectrum of acmite .1). These atmospheric bands provide a fine structure that is usually easy to identify and does not interfere with the major molecular vibration bands of the silicates, so these spectra were retained in the library.

Occasionally, a very small amount of water vapor in the optical path could be confusing. The 74-250 um particle size range of andradite, for example, displays several very weak, sharp bands in its spectrum due to water vapor just to higher frequency than 3800 cm^{-1} (2.6 um). The spectrum of the same particle size range of anorthite shows a similarly weak feature near 3700 cm^{-1} (2.7 um) that bears a superficial resemblance to a weak water vapor band. However, it lies at the wrong wavelength for water vapor and can be seen to be a sharp O-H stretching vibration due to hydroxyl in the spectrum of the 0-74 um size range, where it is well-displayed.

All spectral artifacts due to atmospheric gases are marked with an arrow. Note that if the gas was present in greater amount in the sample spectrum, which is usually the case, its spectral features will be displayed as troughs. If the greater amount of gas was present in the reference spectrum, however, its spectral features will be inverted. In such cases, we have also inverted the arrows.

4.6 Effect of Impurities. Two kinds of impurities introduce spectral artifacts, those that are added to the sample during laboratory processing and those that were an original part of the sample. Impurities added include water (in KBr pellets) and hydrocarbon, while the most common impurities within samples are quartz, calcite and exsolution and alteration products.

KBr pellets are pressed under vacuum to remove water, but the material is so hygroscopic that this process quickly begins to reverse. The method chosen to compensate for this was to ratio the sample pellet transmittance against that of a blank pellet made under identical circumstances (see Appendix 2 for details of pellet making). If the KBr for both pellets was initially ground to the same particle size so that the same surface area was available to atmospheric water vapor, held under vacuum for the same amount of time to remove water, and then exposed to humid room air for the same amount of time in transfer (as pellets) to the purged and dry environment of the spectrometer sample compartment, both pellets should contain the same amount of water. Then a ratio of sample transmittance to that of the blank pellet should display water bands that are intrinsic to the sample only. However, in practice the sample transmittance spectrum often displays more of a water band than the reflectance data suggest is reasonable (eg. see quartz). This appears to result from the addition of adsorbed water on the particulate sample grains to the mixture of sample and KBr. We have tried to avoid this effect, but it remains a source of error in the spectral data. Thus, the broad water absorption bands centered at 3400 cm^{-1} (2.9 um) in transmittance should be used with caution to estimate sample water content and should be verified with reflectance data.

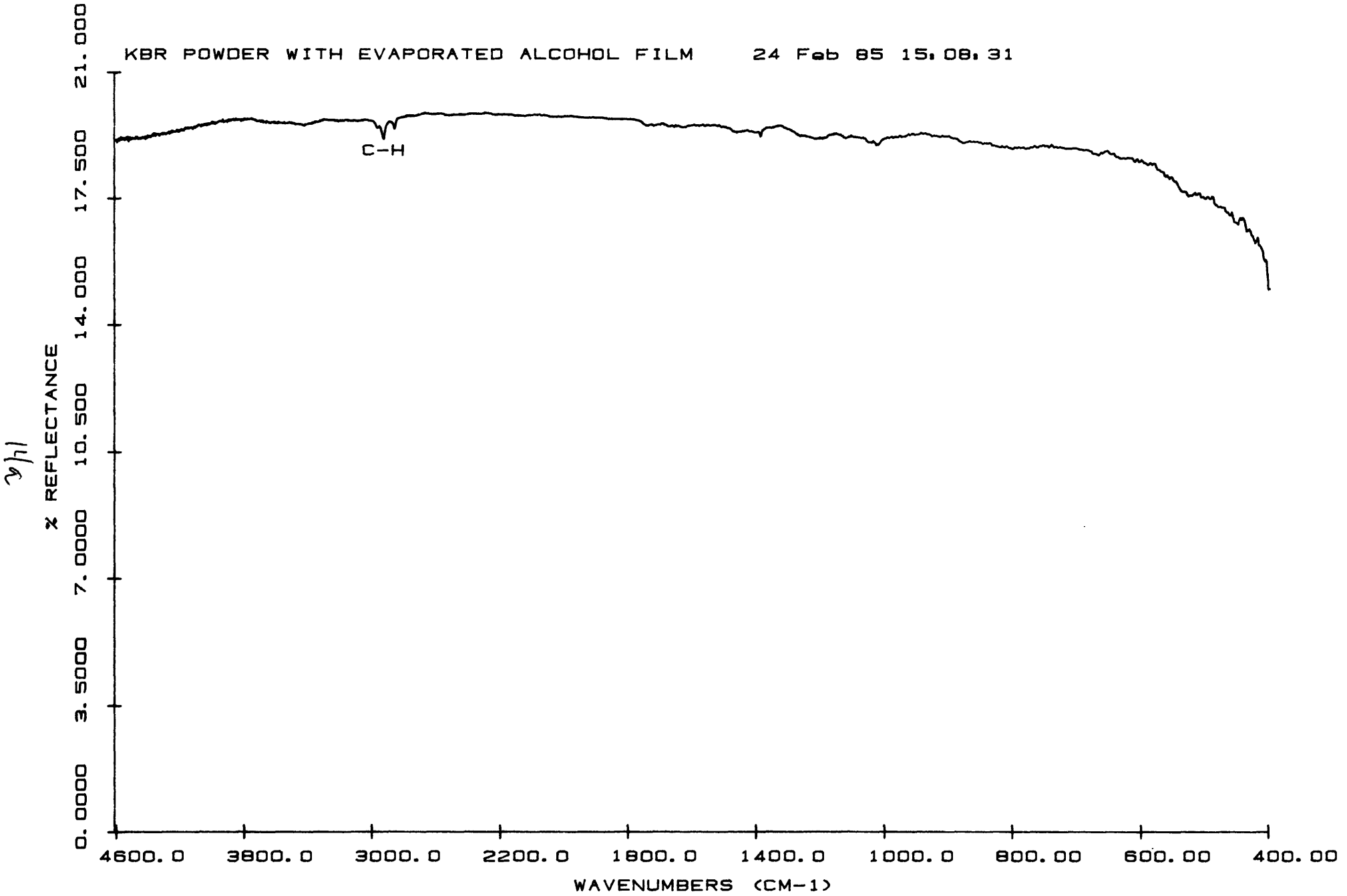

FIGURE 4. REFLECTANCE SPECTRUM OF KBR CONTAMINATED WITH HYDROCARBON.

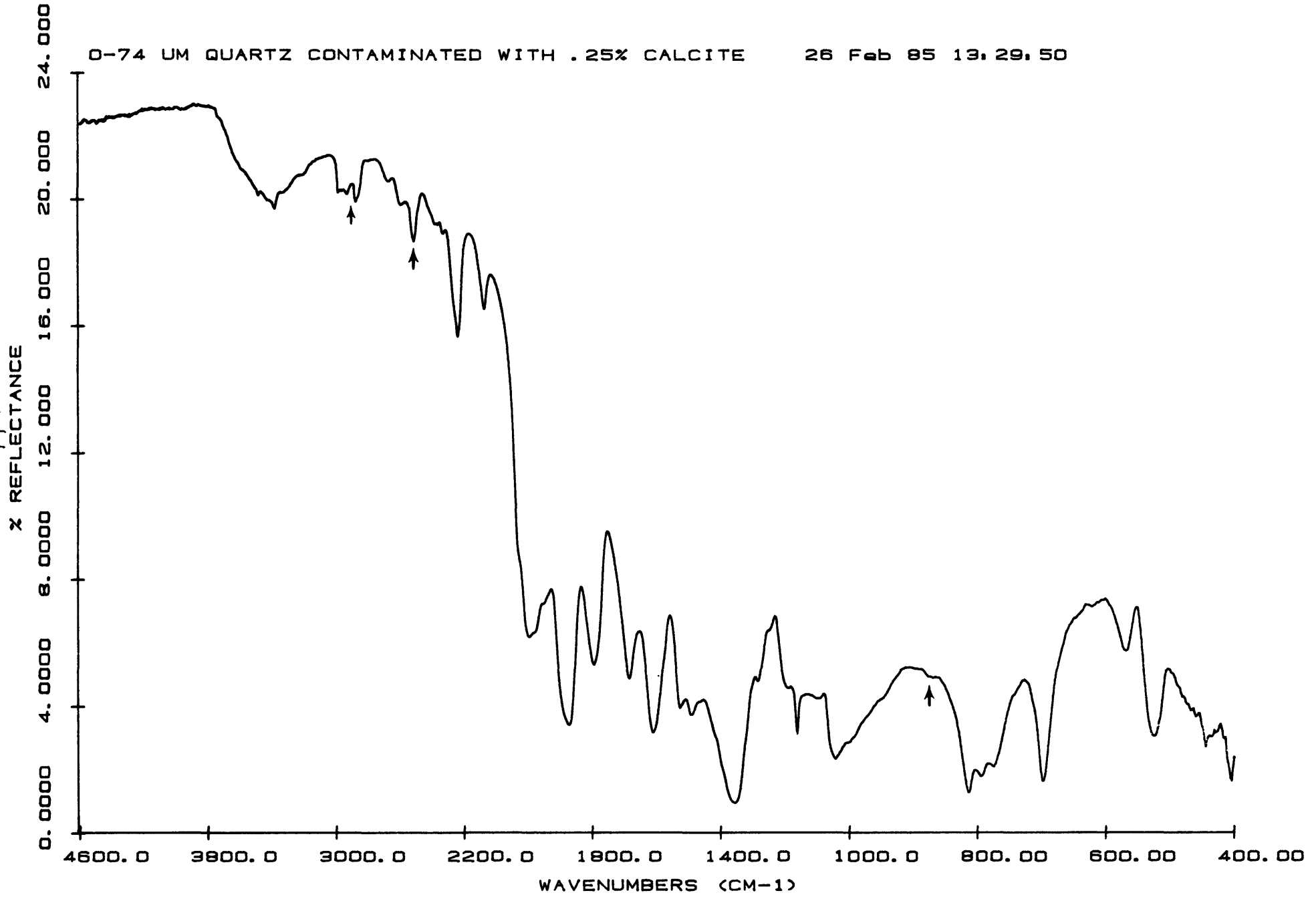

FIGURE 5. REFLECTANCE SPECTRUM OF QUARTZ CONTAMINATED WITH CALCITE.

It should also be noted that sample pellet and blank pellet sometimes do not contain an identical amount of KBr because of lost material squeezed past the die during pressing. This has caused a few transmittance spectra to exceed 100%, but is only a significant problem at the short wavelength end of the spectrum where the samples typically have very low absorbance.

Samples were ground under alcohol or acetone as described above. Despite oven drying of these samples, a hydrocarbon film remains which yields C-H stretching vibrations near 3000 cm^{-1} (3.3 um), as shown in Figure 4. We also find that particulate samples simply exposed to laboratory air will develop hydrocarbon bands due to adsorbed species. These spectral artifacts are marked with an arrow on each spectrum.

Samples contaminated with quartz were rejected, but those contaminated with calcite (or dolomite) were treated with either acetic or hydrochloric acid to remove the contaminant. It was found that an exceedingly small amount of carbonate can make a significant spectral difference, because several of the carbonate overtone/combination bands that become quite prominent at fine particle size occur where silicates tend to be transparent. Figure 5 shows a reflectance spectrum of 0-74 um quartz (quartz.2), to which has been added 0.25% by weight calcite. Even this extremely small amount results in detectable bands near 3000 and 2500 cm^{-1} (3.3 and 4 um), which are marked with arrows. Where the quartz has absorption bands, the effect of the calcite is not seen, except perhaps very weakly near 870 cm^{-1} (11.5 um), which is also marked with an arrow. Note that the calcite doublet near 3000 cm^{-1} overlaps the hydrocarbon stretching vibrations, but its presence can be confirmed by other calcite bands. Our diopside .2, for example, displays a rather prominent hydrocarbon feature in its 0-74 um size range spectrum, but the presence of a trace amount of calcite is shown by the very weak calcite features marked with arrows.

Some minerals tend to contain exsolution products and we have included several of these in our collection, despite their lack of purity, because exsolution is so common. Microcline.1, for example, contains cryptoperthitic high albite, as does sanidine.2. Hypersthene.1 contains a small amount of exsolved clinopyroxene. Most samples are, however, pure phases with the exception of alteration products.

As discussed above under the section on Major Spectral Features, water is ubiquitous in terrestrial environments and terrestrial minerals have inevitably undergone minor alteration, even when quite fresh in appearance. Hydroxyl O-H stretching vibration bands tend to become more prominent (ie. gain spectral contrast) as particle size decreases, as discussed above under section 4.22. At the same time, silicate minerals normally lacking hydroxyl tend to be quite transparent in the 3800 to 3300 cm^{-1} (2.6 to 3.0 um) region. Consequently, hydroxyl bands due to a very small amount of alteration product typically are very prominently expressed in reflectance spectra of the 0-74 um particle size range. Transmittance spectra give a better idea of the absolute amount of alteration product present, and the typical sharp hydroxyl bands of alteration minerals can be distinguished from the broad water band that may arise from the hygroscopic nature of KBr (see, for example, spectra of kyanite, which has undergone kaolinitic alteration).

4.7 Using Laboratory Data to Predict Remote Sensing Measurements. The crossover point (ie. point of equal energy) for reflectance and emittance for most solar

system remote sensing targets lies somewhere in the 2.5-5 um region, depending on the albedo and temperature of the surface. Thus, most of the spectral range presented here is dominated by emittance. Yet the data presented are in reflectance. Spectral emittance is usually predicted from reflectance for opaque materials using Kirchhoff's Law, typically stated as E=1-R, where E and R are total emittance and reflectance (Nicodemus, 1965). However, the physical basis for this relationship is not intuitively obvious from the equation given above. Another way of stating Kirchhoff's Law is E=A, where A is absorptance. Thus, wavelengths emitted from a warm radiating mineral surface will be identical to the wavelengths absorbed in an infrared reflectance measurement. This is because photons that can successfully enter a mineral and be absorbed during reflectance are identical to those that can successfully exit the mineral during emittance.

The E=1-R relationship arises because, for one unit of incoming radiation, absorbtance and reflectance must add up to one for an opaque material. Thus, A (and consequently E) =1-R. Most minerals are effectively opaque in the region of the fundamental molecular vibration bands, so that this relationship should hold for them in that region. Thus, reflectance peaks will be expressed as throughs in emittance.

However, we are not interested in total emittance in a remote sensing situation, but rather in directional emittance - i.e. emittance in the direction of the observer. This property is determined by measuring the directional hemispherical reflectance (Nicodemus, 1965). That is, a material is illuminated from the direction of the observer and the resulting reflectance measured over two pi steradians. The reflectance measurement determines what infrared photons were able to penetrate the surface and be absorbed from the observer's direction (A=1-R). And, because what can get in can also get out, this result can be used to predict directional emittance - i.e. in the direction towards the observer.

The only practical way to measure directional hemispherical reflectance of natural materials like minerals and rocks is to use an integrating sphere. Unfortunately, the sphere must be coated on the inside with rough gold in order to function optimally in this wavelength region, which requires custom manufacture. Such a sphere will be operational in our laboratory shortly, but the measurements described here were necessarily made with the commercially available bidirectional reflectance attachment described above. Data obtained in this way accurately display spectral features, but cannot be interpreted in terms of directional emittance. However, comparisons of laboratory and field measurements by Hoover and Kahle (1986) have shown good qualitative agreement between laboratory bidirectional (actually biconical) measurements of spectral reflectance such as shown in Appendix 1 and field measurements of directional spectral emittance in a terrestrial environment.

The effects of various space environments on spectral emittance were considered by Logan et al (1974). They showed that a vacuum environment may exaggerate spectral contrast, except for dark materials. The presence of an atmosphere, even a thin Martian-type atmosphere leaves the spectral contrast little changed from terrestrial conditions, again especially for dark materials. Thus, it appears that the reflectance spectra in Appendix 1 may be used to qualitatively predict spectral emittance in a variety of environments in the region of the fundamental molecular vibration bands.

As minerals become more transparent (for example at frequencies higher than about 1400 cm^{-1} or wavelengths shorter than 7 um for silicates), spectral behavior becomes dominated by volume scattering at all particle sizes and the scattering model of Hapke (1981) and Clark and Roush (1984) must be used to quantitatively predict spectral features. However, laboratory measurements of spectral emittance indicate that Kirchloff's Law is still qualitatively valid. That is, reflectance troughs are expressed as peaks in emittance (Hunt and Vincent, 1968), and the transparency peak in reflectance is expressed as a trough in emittance (Conel, 1969). This becomes, of course, extremely complex in the region of cross-over between reflectance and emittance.

5.0 Acknowledgements

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6.0 APPENDIX 1

Mineral spectra and description sheets are in alphabetical order as shown below:

Mineral Name	Sample Number or Source	File Name
Acmite	NMNH95506	Acmite.1
Acmite	NMNH133746	Acmite.2
Albite	NMNHC5390	Albite.1
NH_4-Alunite	Synthetic	Alunite.1
K-Alunite	H&S 295B	Alunite.2
K-Alunite	Synthetic	Alunite.3
Na-Alunite	Synthetic	Alunite.4
Andalusite	NMNHR17898	Andalusite.2
Andradite	NMNH113829	Andradite.1
Anorthite	Synthetic	Anorthite.1
Antigorite	NMNHB17958	Antigorite.1
Augite	NMNH117461	Augite.1
Augite	NMNH120049	Augite.2
Beryl	H&S 180B	Beryl.1
Beryl	NMNH134700	Beryl.2
Bustamite	NMNHR3099	Bustamite.1
Calcite	H&S 194B	Calcite.1
Mg-Clinochlore	NMNH83369	Clinochlore.1
Fe-Clinochlore	CMS CCa-1	Clinochlore.2
Cordierite	NMNH78228	Cordierite.2
Diopside	NMNHC2393	Diopside.1
Diopside	NMNHR18685	Diopside.2
Enstatite	NMNH128288	Enstatite.1
Epidote	Hem. sample	Epidote.1
Grossular	NMNH155371	Grossular.2
Gypsum	H&S 26B	Gypsum.1
Hedenbergite	NMNH119197	Hedenbergite.1
Hemimorphite	NMNH161931	Hemimorphite.1
Hornblende	H&S 177B	Hornblende.1
Hornblende	NMNH117329	Hornblende.2
Hornblende	NMNH78662	Hornblende.3
Hyperthsene	NMNHC2368	Hypersthene.1
Illite	CMSIMt-1	Illite.1
Illite/smectite	H&S 31	Illsmec.1
Kaolinite	CMS KGa-2	Kaolinite.2
Kaolinite	CMS KGa-1	Kaolinite.3
Kyanite	NMNH139740	Kyanite.1
Labradorite	NMNH115500	Labradorite.1
Microcline	NMNH135231	Microcline.1
Montmorillonite	CMS SCa-2	Montmor.1
Montmorillonite	CMS STx-1	Montmor.2
Montmorillonite	CMS SAz-1	Montmor.3
Muscovite	Hem. sample	Muscovite.1
Nontronite	CMS NG-1	Nontronite.1
Olivine (F011)	KI3005	Olivine.1
Olivine (F018)	KI3377	Olivine.2

Mineral Name	Sample Number or Source	File Name
Olivine (FO29)	KI3291	Olivine.3
Olivine (FO41)	KI4143	Olivine.4
Olivine (FO51)	KI3188	Olivine.5
Olivine (FO60)	KI3189	Olivine.6
Olivine (FO66)	KI3054	Olivine.7
Olivine (FO88)	Brenh	Olivine.8
Olivine (FO88)	GSB	Olivine.9
Olivine (FO91)	TSD	Olivine.10
Olivine (FO92)	NMNH137044	Olivine.11
Orthoclase	NMNH113188	Orthoclase.3
Pectolite	NMNH94865	Pectolite.2
Phlogopite	NMNH124158	Phylogopite.1
Pyrophyllite	Hem. sample	Pyrophyllite.1
Quartz	Hem. sample	Quartz.1
Quartz	H&S 32B	Quartz.2
Rhodonite	NMNHC6148	Rhodonite.1
Richterite	NMNH150800	Richterite.1
Riebeckite	NMNH122689	Riebeckite.1
Sanidine	Strt.sample	Sanidine.1
Sandine	NMNH103200	Sanidine.3
Saponite	CMSSapCa-1	Saponite.1
Sepiolite	CMSSepNev-1	Sepiolite.1
Smectite	CMSSWa-1	Smectite.1
Spessartine	NMNH114143	Spessartine.2
Spodumene	NMNH12430-1	Spodumene.1
Talc	Crow. sample	Talc.1
Tourmaline	NMNH94217-1	Tourmaline.1
Tourmaline	H&S 120B	Tourmaline.2
Tremolite	Hem.sample	Tremolite.1
Tremolite	NMNH117611	Tremolite.2
Vermiculite	CMSVTx-1	Vermiculite.1
Wollastonite	NMNH131913	Wollastonite.1

MINERALS BY CLASS, SUBCLASS AND GROUP:
(number of mineral samples in parenthesis)

1. Carbonates

1.1 No subclass or Group
Calcite

2. Silicates

2.1 Cyclosilicates (no group)
Beryl (2)
Corderite
Tourmaline (2)

2.2 Inosilicates
2.21 Amphibole Group
Hornblende (3)
Richterite
Riebeckite

2.22 Pyroxene Group
Acmite (2)
Augite (2)
Diopside (2)
Enstatite
Hedenbergite
Hypersthene
Spodumene
Tremolite (2)

2.23 Pyroxenoid Group
Bustamite
Pectolite
Rhodonite
Wollastonite

2.3 Nesosilicates

2.31 Garnet Group
Andradite
Grossular
Spessartine

2.32 Olivine Group
Olivine (11)

2.33 No Group
Andalusite
Kyanite

2.4 Phyllosilicates

2.41 Serpentine/Kaolin Group* (1:1, x=0)

Antigorite
Kaolinite (2)

2.42 Talc/Pyrophyllite Group (2:1, x=0)

Talc
Pyrophyllite

2.43 Smectite Group (2:1, x=0 = 0.2-0.6)

Montmorillonite (3)
Nontronite
Saponite
Smectite

2.44 Vermiculite Group (2:1, x=0.6-0.9)

Vermiculite

2.45 Mica Group (2:1, x=1.0)

Illite
Illite/smectite
Muscovite
Phlogopite

2.46 Chlorite Group (2:1, x=variable)

Clinochlore (2)

2.47 Sepiolite Group (2:1, x=variable)

Sepiolite

*Layer silicate minerals can be conveniently classified on the basis of layer type and layer charge. We designate tetrahedral and octahedral layering (1:1 and 2:1) and charge per formula unit (x). For more information see Bailey (1980).

2.5 Sorosilicates

2.51 No Group

Epidote
Hemimorphite

2.6 Tektosilicates

2.61 Feldspar Group

Albite
Anorthite
Labradorite
Microcline
Orthoclase
Sanidine

2.62 Silica Group

Quartz (2)

3.0 Sulfates

3.1 No subclass or group

Alunite (4)
Gypsum

Species name: Acmite Na Fe^{+3} Si_2O_6

Locality: Narsarsuk, Greenland

Last Donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 95506

Results of petrographic examination: Black radiating acicular crystals with some contamination which dissolves to a brown color in dilute HCl. Sample is 2cm x 1cm. Contamination hand picked out and remaining dissolved with dilute HCl.

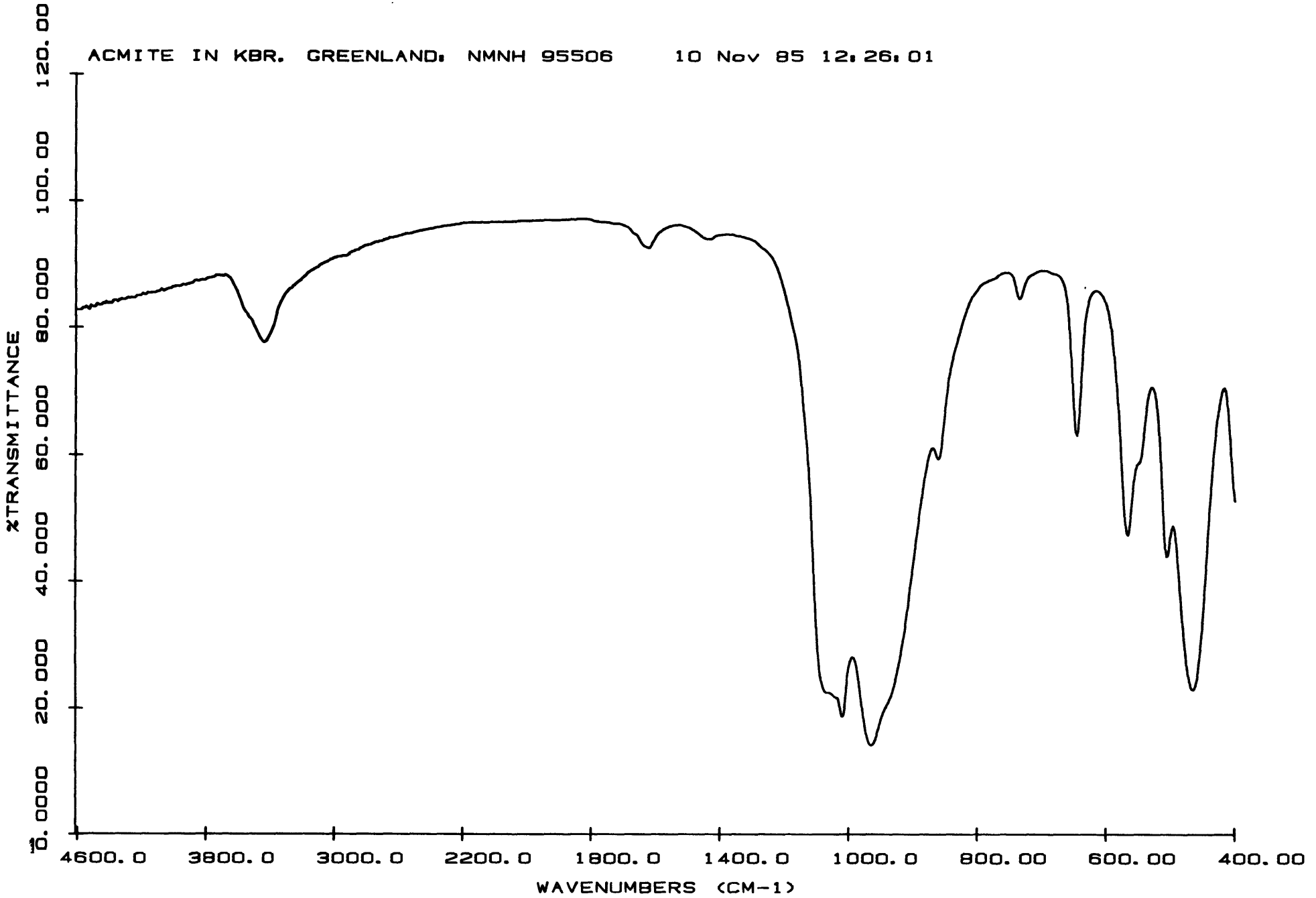
Results of XRD: Pure acmite

Results of XRF or other compositional analysis: Microprobe measurement shows a small (ca. 1 wt %) variability in FeO, CaO, MgO and TiO_2 within grains. The average of 15 analyses indicates close to end member composition is:

SiO_2	- 52.68
Al_2O_3	- 0.35
FeO	- 28.87
MgO	- 0.55
CaO	- 1.28
K_2O	- 0.02
Na_2O	- 12.98
TiO_2	- 0.65
MnO	- 0.65
# Total	98.01

Spectra on file:

Acmite.1 Reflectance spectrum from prismatic cleavage side of a cluster of radiating acicular crystals. Solid sample Disk #1.
Acmite.1 Reflectance spectrum of 0-74 um size range on Disk #1.
Acmite.1 Reflectance spectrum of 74-250 size range um on Disk #1.
Acmite.1 Transmittance spectrum on Disk #1.


ACMITE IN KBR. GREENLAND. NMNH 95506 10 Nov 85 12:26:01
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3800.0
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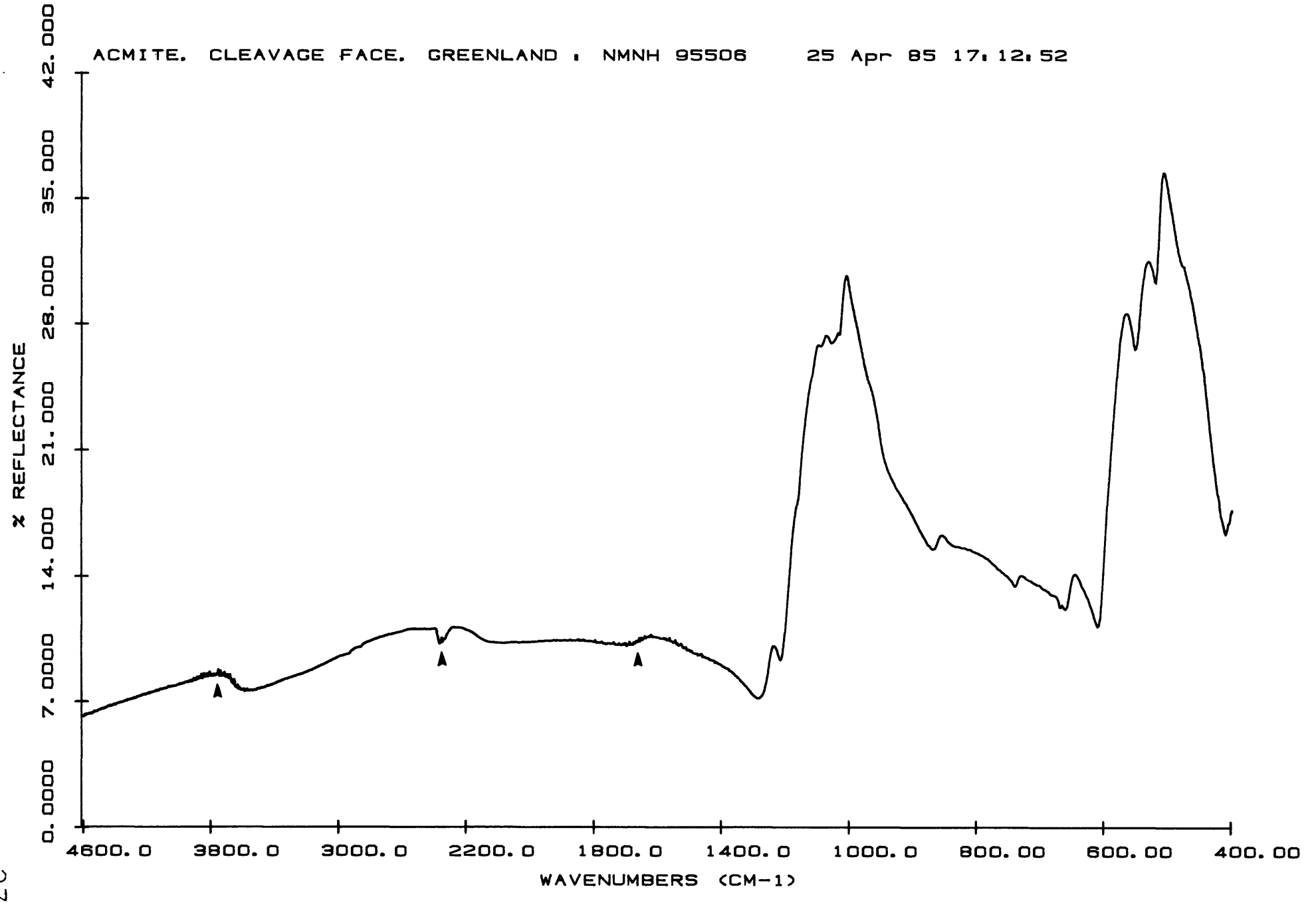
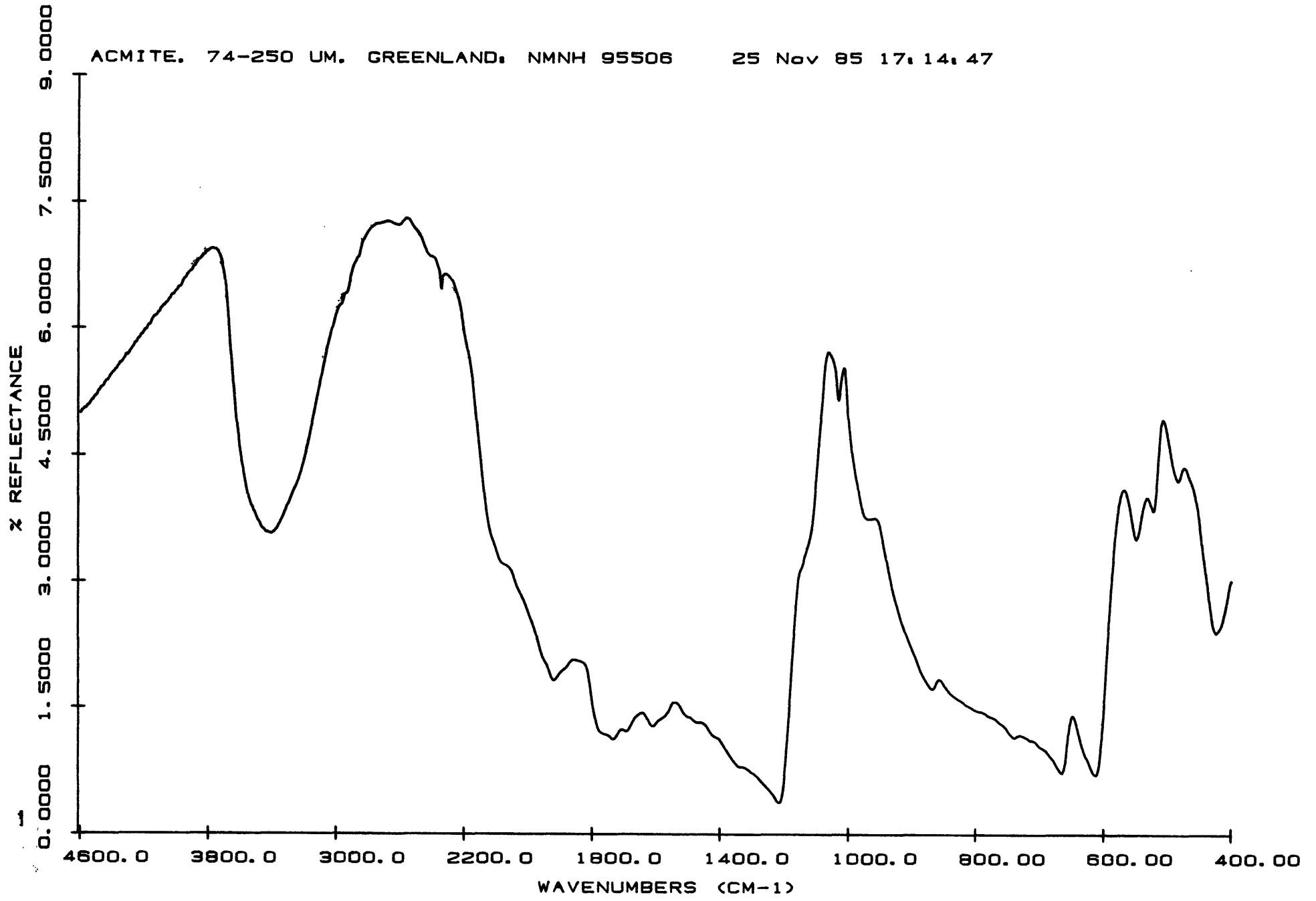
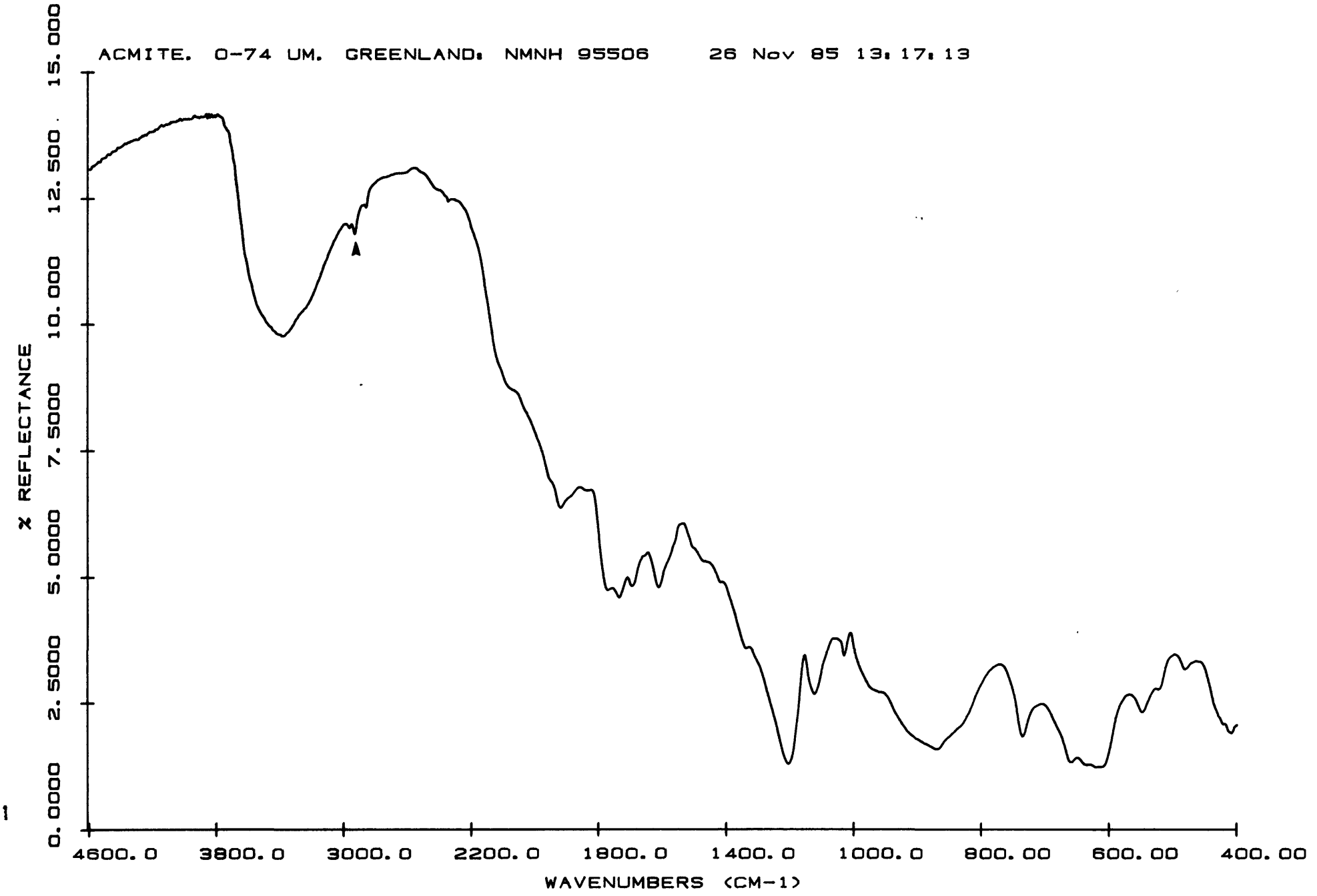
WAVENUMBERS (CM-1)


ACMITE. CLEAVAGE FACE. GREENLAND : NMNH 95506 25 Apr 85 17:12:52
% REFLECTANCE
0.0000
7.0000
14.000
21.000
28.000
35.000
42.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ACMITE. 74-250 UM. GREENLAND: NMNH 95506 25 Nov 85 17:14:47
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ACMITE. 0-74 UM. GREENLAND: NMNH 95506 26 Nov 85 13:17:13
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Acmite $NaFe^{+3}Si_2O_6$

Locality: Kangerdluarssuk, Narssaq (near), Greenland

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 133746

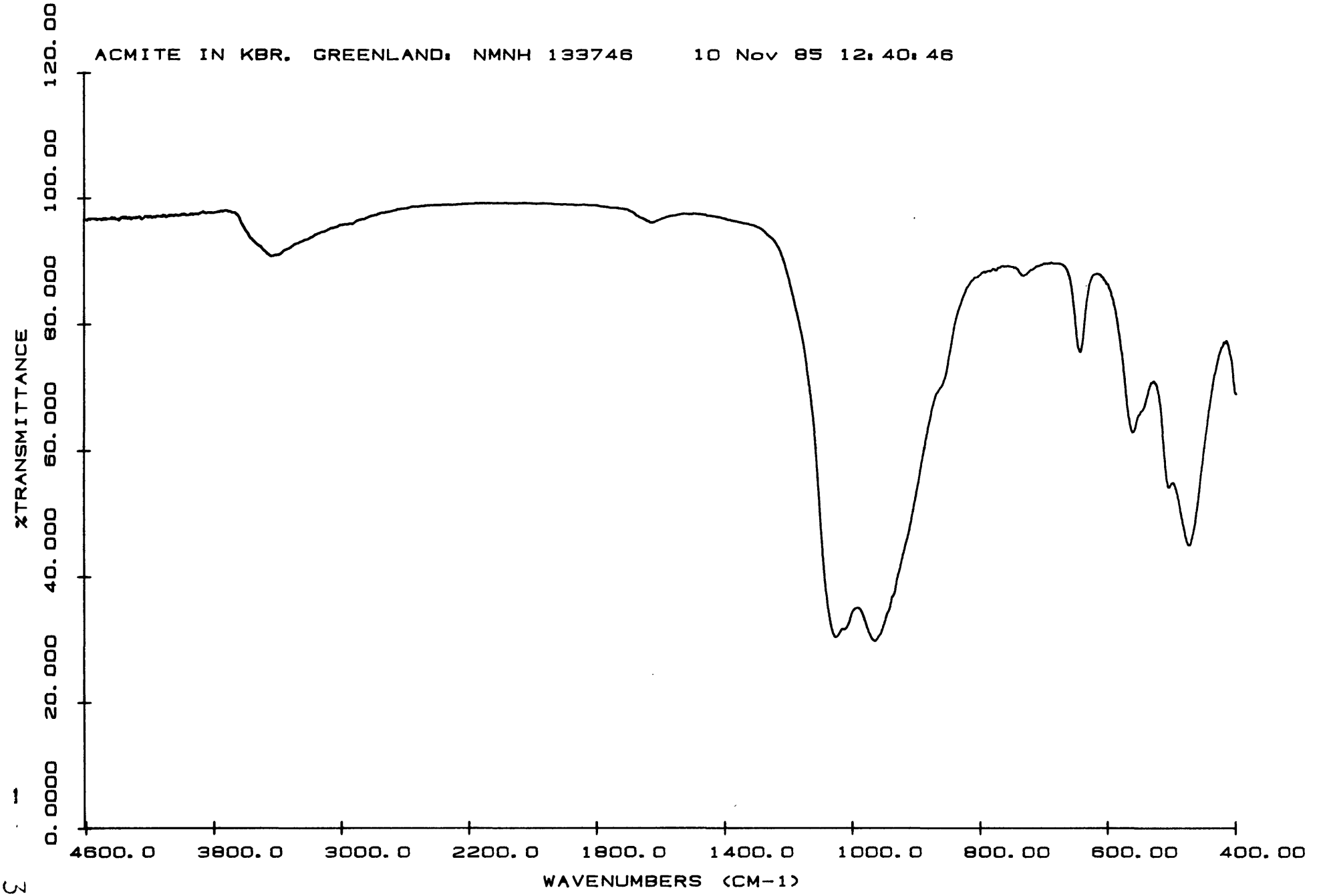
Results of petrographic examination: Large (up to 2 cm), very dark green prismatic crystals of acmite intergrown with albite (?). Material was crushed and hand picked for single crystal measurements and grinding. Seems pure in microscopic examination.

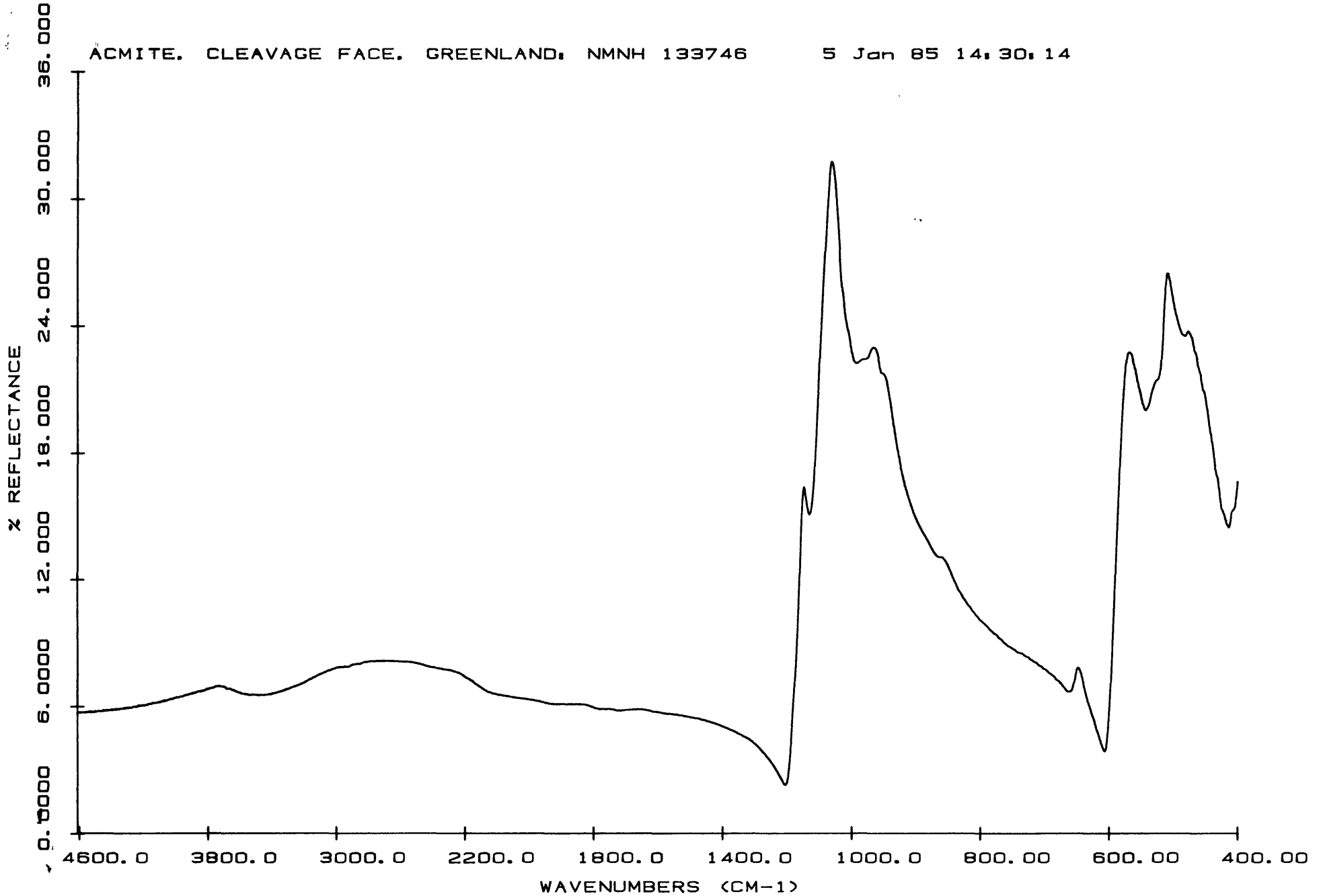
Results of XRD: 74-250 um size grains x-rayed. Resulting pattern showed acmite and an unidentified peak of trace proportions at 4.48 angstroms.

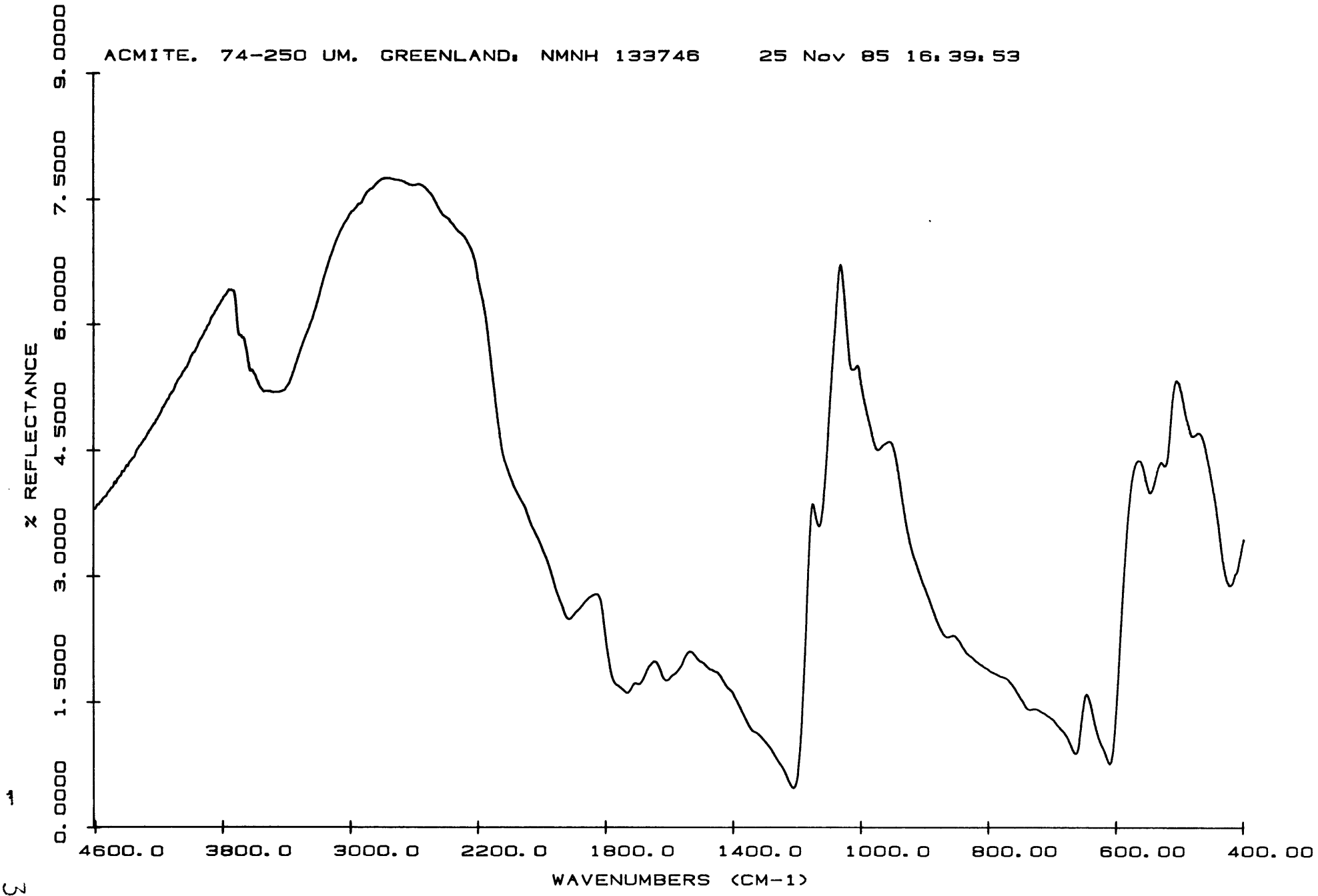
Results of XRF or other compositional analysis: Microprobe analysis showed that one grain out of four examined had about 2 wt % more CaO and correspondingly less Na_2O. Otherwise homogeneous, especially within grains. Average of 13 analyses, which indicates close to end member composition, is:

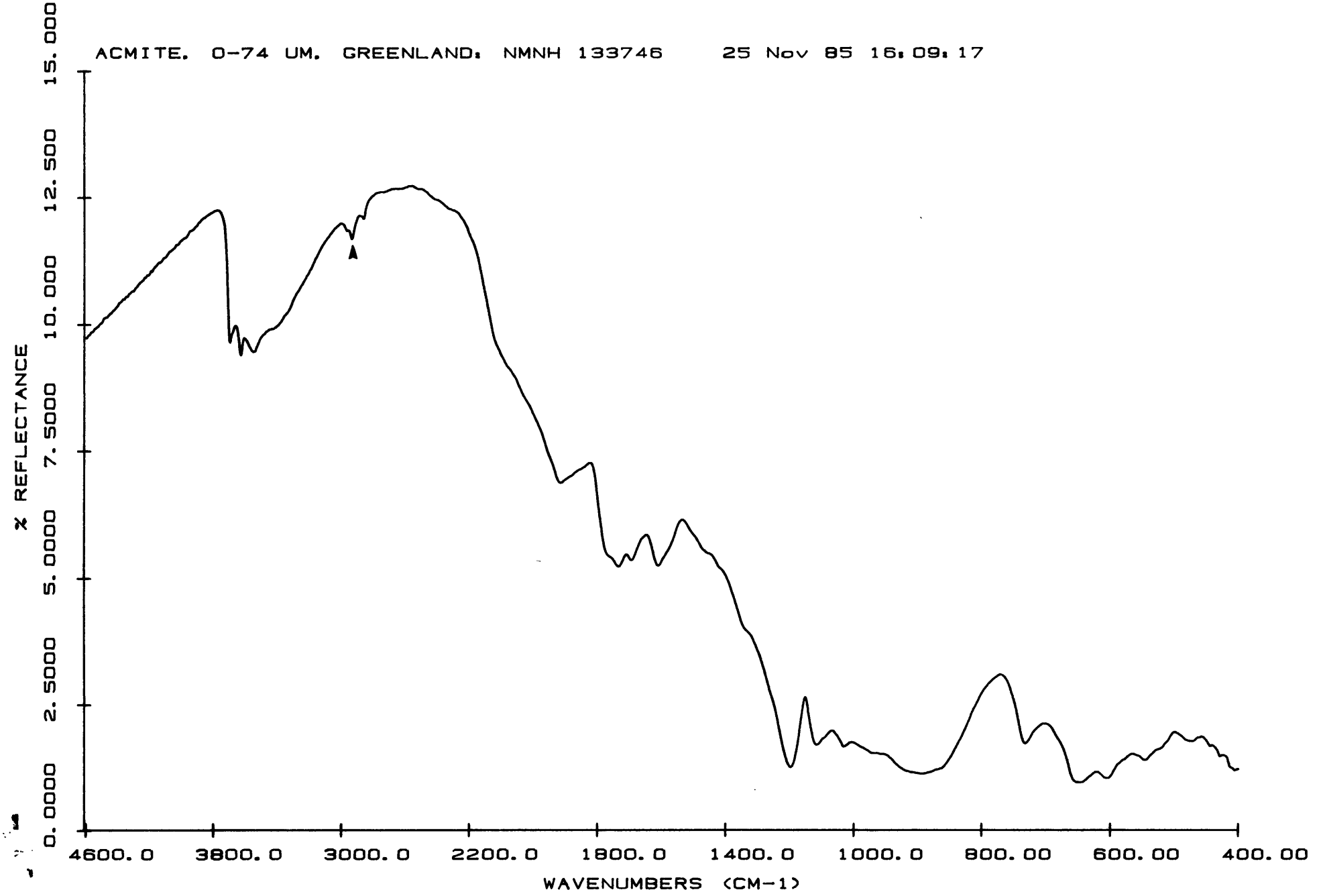
SiO_2	- 52.08
Al_2O_3	- 0.98
FeO	- 29.22
MgO	- 0.06
CaO	- 3.84
K_2O	- 0.02
Na_2O	- 11.87
TiO_2	- 0.56
MnO	- 0.24
Total	- 98.87

Spectra on file:
Acmite.2 Reflectance spectrum of 74-250 um size range on Disk #1.
Acmite.2 Reflectance spectrum of 0-74 size range Disk 1.
Acmite.2 Reflectance spectrum of cleavage face on solid sample Disk #1
Acmite.2 Transmittance spectrum on Disk #1.


ACMITE IN KBR. GREENLAND: NMNH 133746 10 Nov 85 12:40:46
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ACMITE. CLEAVAGE FACE. GREENLAND: NMNH 133746
5 Jan 85 14:30:14
% REFLECTANCE
36.000
30.000
24.000
18.000
12.000
6.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ACMITE. 74-250 UM. GREENLAND. NMNH 133746 25 Nov 85 16:39:53
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ACMITE. 0-74 UM. GREENLAND: NMNH 133746 25 Nov 85 16:09:17
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Albite $NaAlSi_3O_8$

Locality: Rutherford, Va.

Last donor: Bruce Hemingway

Intermediate donor:

Ultimate donor: Smithsonian

Catalog numbers, etc.: NMNH C5390

Results of petrographic examination: Hand specimen is large (2 cm) fragment of twinned crystal. Appears very fresh. Is translucent and light gray to white in color. This is the classic Amelia albite.

Results of XRD: Pure albite

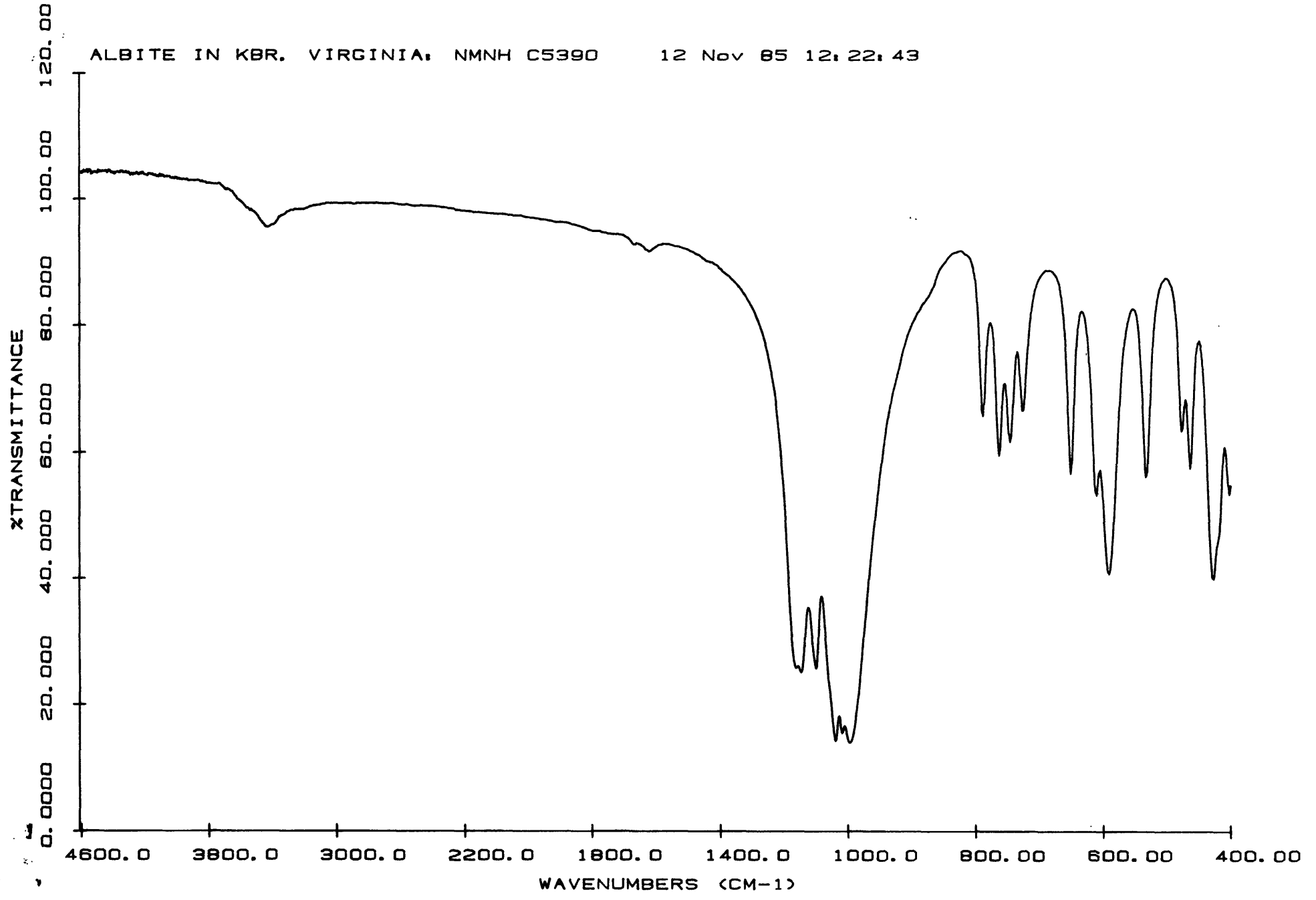
Results of XRF or other compositional analysis: See Openshaw et al, 1976, Jour. Res. U.S. Geol. Survey, Vol. 4, No. 2, p. 195-204. Flame photometry and atomic absorption analysis of samples from the same location (not same sample) show 98.42 mole percent albite.

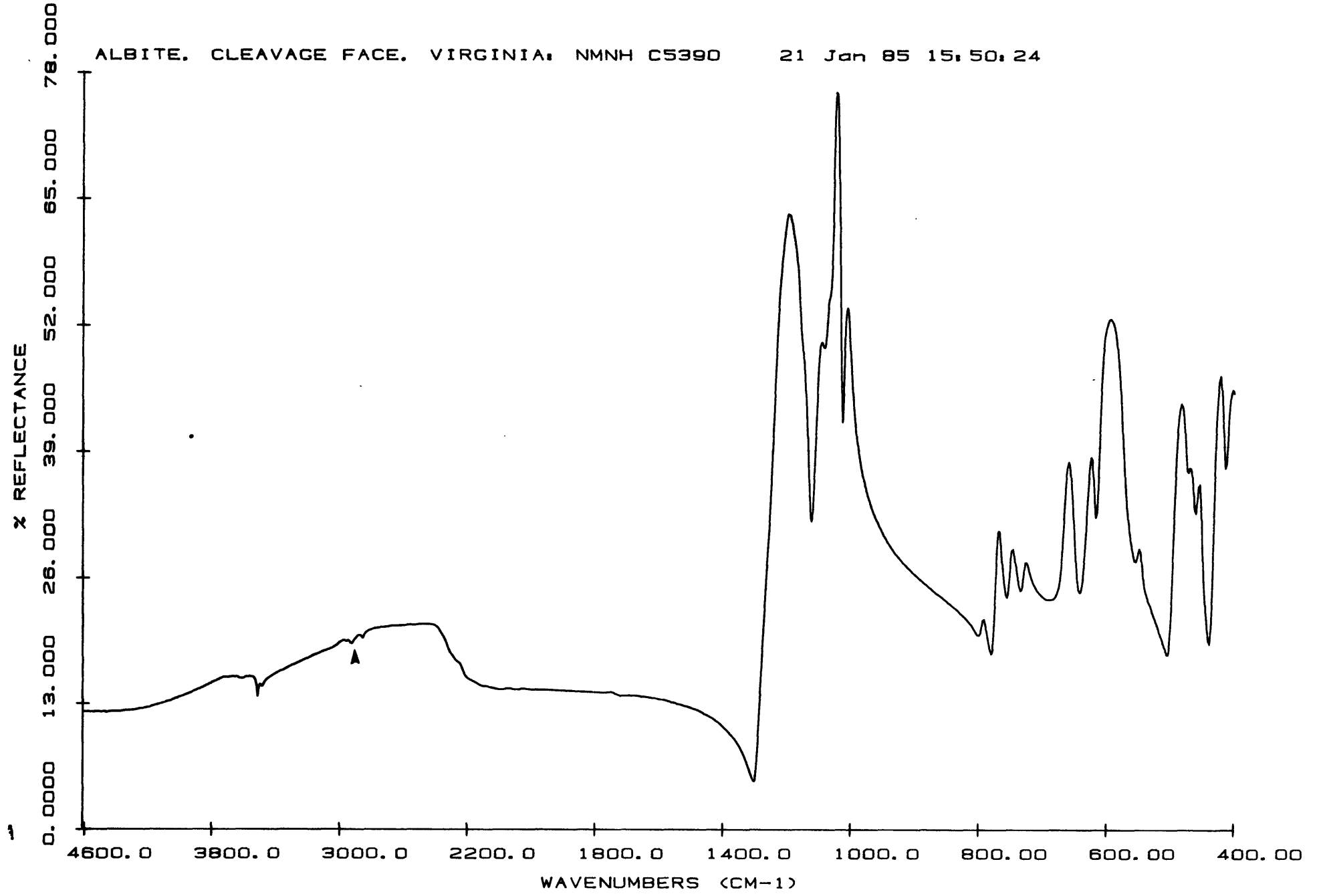
Microprobe analysis shows sample to be homogeneous within and between grains. Ten analysis indicate pure albite end member composition:

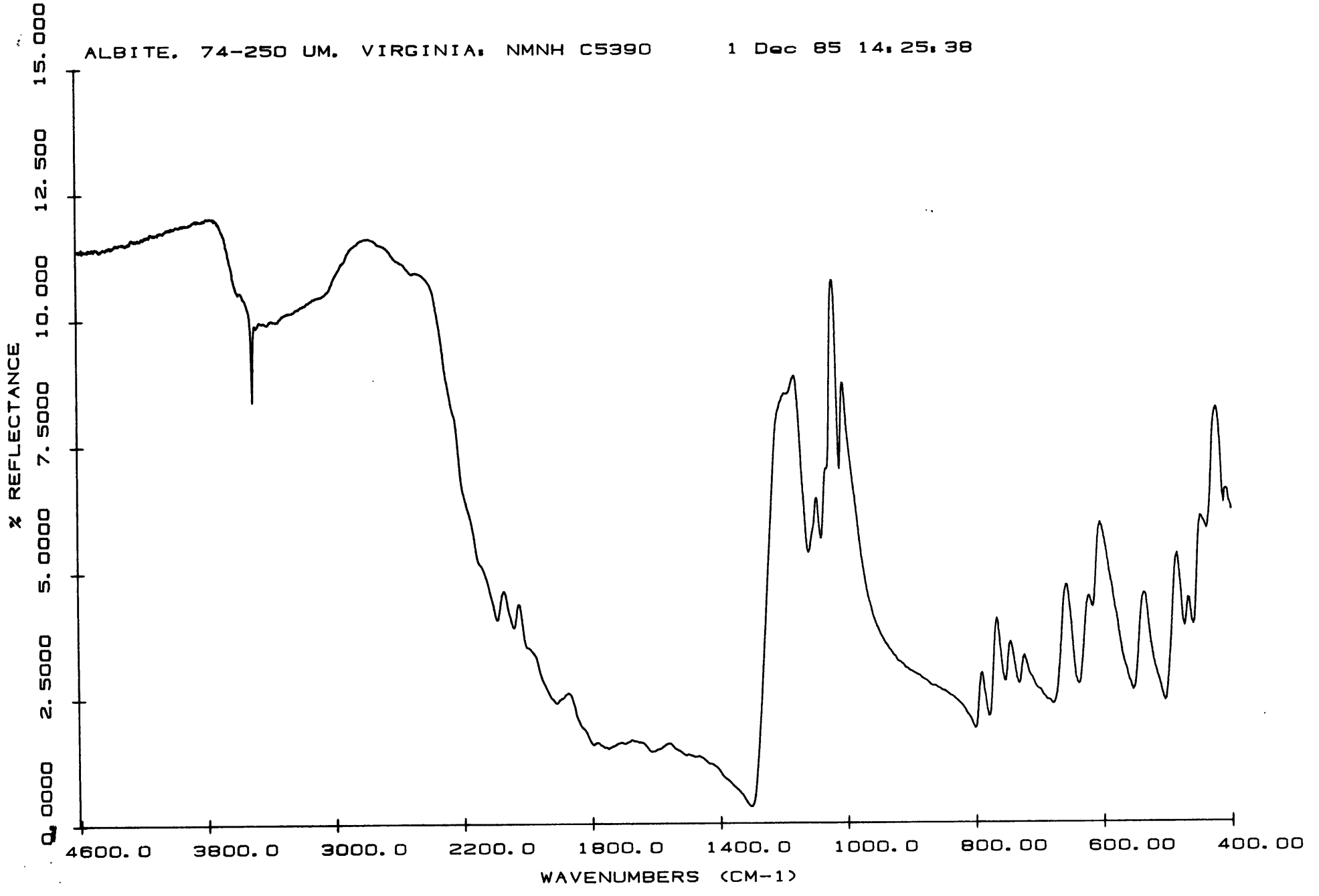
SiO_2	- 68.18
Al_2O_3	- 20.07
FeO	- 0.01
MgO	- 0.02
CaO	- 0.02
K_2O	- 0.20
Na_2O	- 10.37
TiO_2	- 0.01
MnO	- 0.01
Total	- 99.88

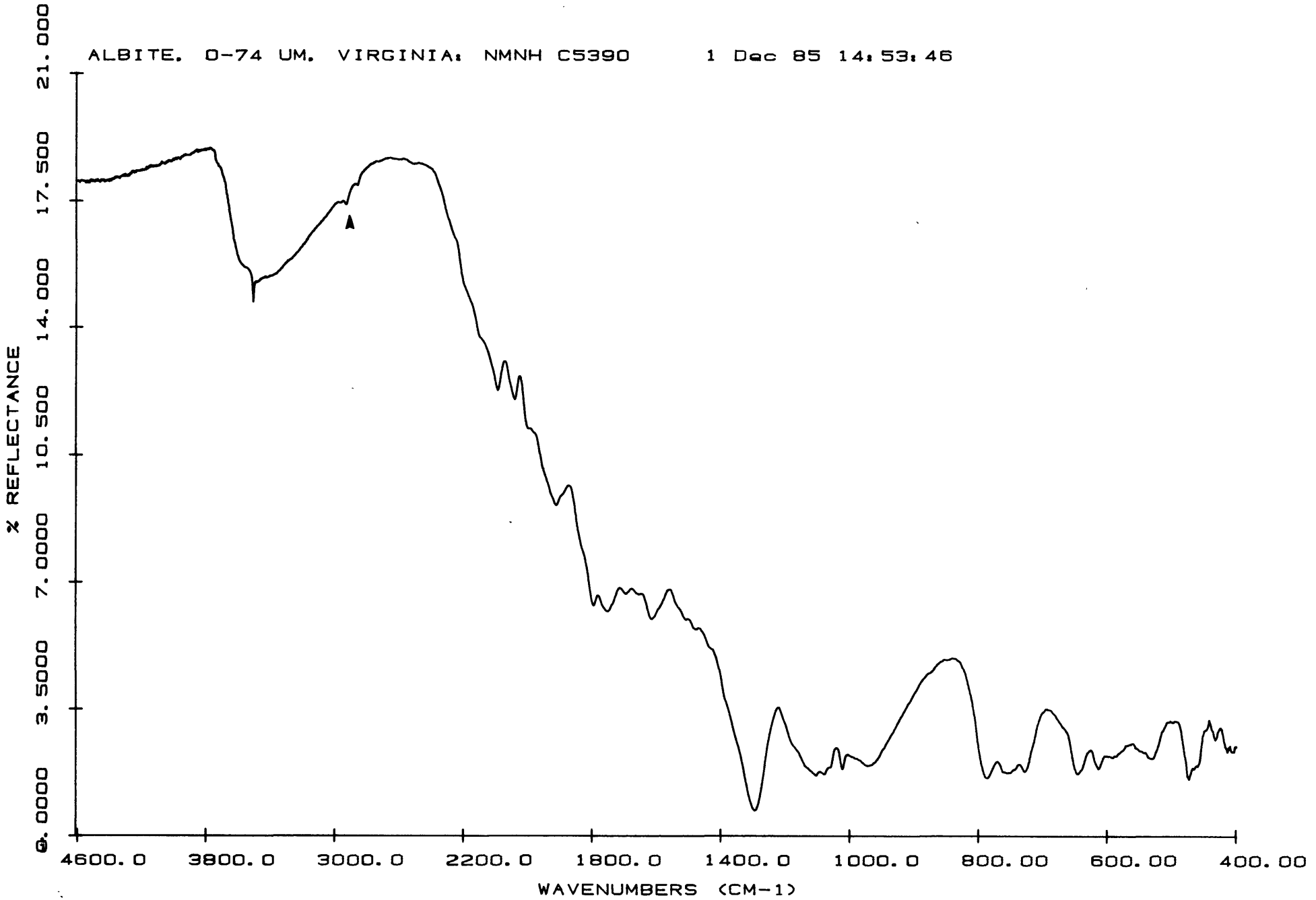
Spectra on file:

Albite.1 Reflectance spectrum from cleavage face (?) on solid sample Disk #1.
Albite.1 Reflectance spectrum of 74-250 um size range on Disk #1.
Albite.1 Reflectance spectrum of 0-74 um size range on Disk #1.
Albite.1 Transmittance spectrum on Disk #1.


ALBITE IN KBR. VIRGINIA: NMNH C5390 12 Nov 85 12:22:43
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ALBITE. CLEAVAGE FACE. VIRGINIA: NMNH C5390 21 Jan 85 15:50:24
% REFLECTANCE
0.0000
13.000
26.000
39.000
52.000
65.000
78.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ALBITE. 74-250 UM. VIRGINIA: NMNH C5390
1 Dec 85 14:25:38
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ALBITE. 0-74 UM. VIRGINIA: NMNH C5390 1 Dec 85 14:53:46
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Alunite (ammonioalunite) $NH_4\ Al_3(SO_4)_2(OH)_6$

Locality: Synthetic

Last donor: Dennis Krohn, USGS

Intermediate donor:

Ultimate donor: Phil Bethke, USGS

Catalog numbers, etc.: None

Results of petrographic examination: White in color.

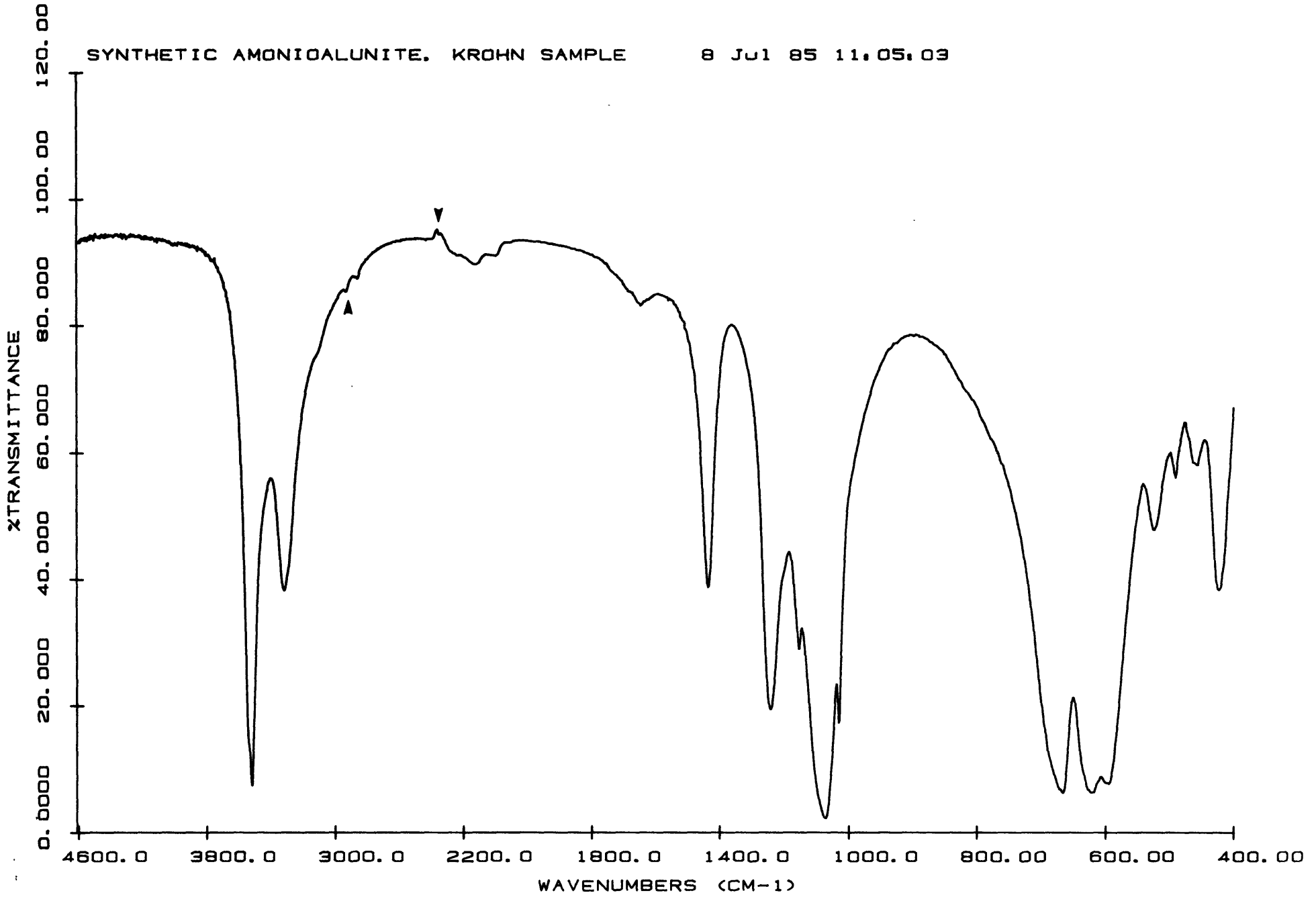
Results of XRD: The five strongest x-ray diffraction lines for this new mineral are (dÅ(Irel)(hkl)): 3.023 (100) (113); 5.04 (93) (012); 2.996 (50) (021); 1.917 (32) (303); and 2.53 (31) (205), (S. Altaner unpublished data).

Results of XRF or other compositional analysis:

Chemical analyses by USGS analytical Laboratory, Reston, shows that this synthetic NH_4-alunite has high H_2O and low Al and NH_4 contents, yielding the following chemical formula: $(NH_4)_{.81}\ (H_3O)_{.19}\ [Al_{2.72}(SO_4)_{1.95}(H_2O)_{.75}\ (OH)_{5.26}]$, assuming electrostatic neutrality and that excess H_2O exists as H_3O^+ and as H_2O in $AlO_2\ (OH)_4$ octahedra (S. Altaner, unpublished data).

Conditions of Synthesis: Na-, K- and NH_4- alunites were initially synthesized by the method of Parker (Am. Min., v. 437, p. 127-136., 1962). They were prepared from Fisher certified ACS reagent $Al_2(SO_4)_3\ .\ nH_2O$ and Na_2SO_4, K_2SO_4 or $(NH_4)_2SO_4$ respectively, in the mole ratio 4:1. Approximately 30 grams of solid reagent was heated with 150 ml deionized water in a teflon-lined autoclave at 150°C for 3 days. The alunite product was rinsed by boiling in deionized water for 2 hours. Synthesis in this manner produces alunites with considerable substitution of hydronium for Na^+, K^+ or NH_4^+ in the structure. In order to exchange the hydronium with Na^+, K^+ or NH_4^+. The alunites were heated in gold-lined Morey bombs to 300°C in 1.0 molar Na_2SO_4 or $(NH_4)_2\ SO_4$, or saturated K_2SO_4, for a period of two weeks. The products were again rinsed by boiling in deionized water for 2 hours. Comparison of the spectra of the alunites so prepared to that of natural alunite suggests that the synthetics still contain some water, the role of which in the structure is not known.

Spectra on file: Alunite.1 Transmittance spectrum on Disk #1.


SYNTHETIC AMONIOALUNITE. KROHN SAMPLE 8 Jul 85 11:05:03
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Alunite $KAl_3(SO_4)_2(OH)_6$

Locality: Utah

Last donor: Hunt and Salisbury collection

Intermediate donor:

Ultimate donor: Wards Scientific

Catalog numbers, etc.: H & S 295 B

Results of petrographic examination: Slightly pink in color, the sample appears pure.

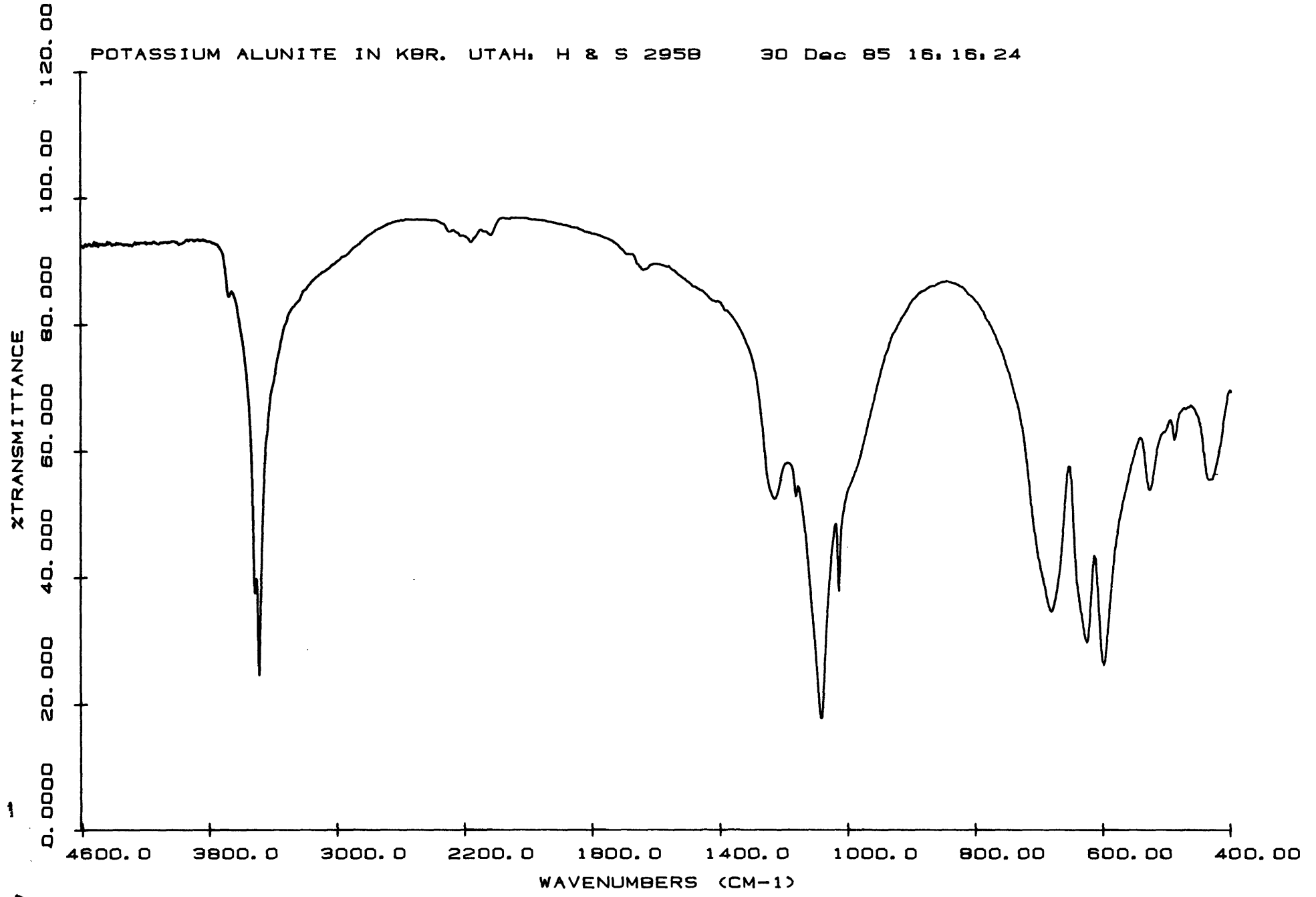
Results of XRD: Pure alunite

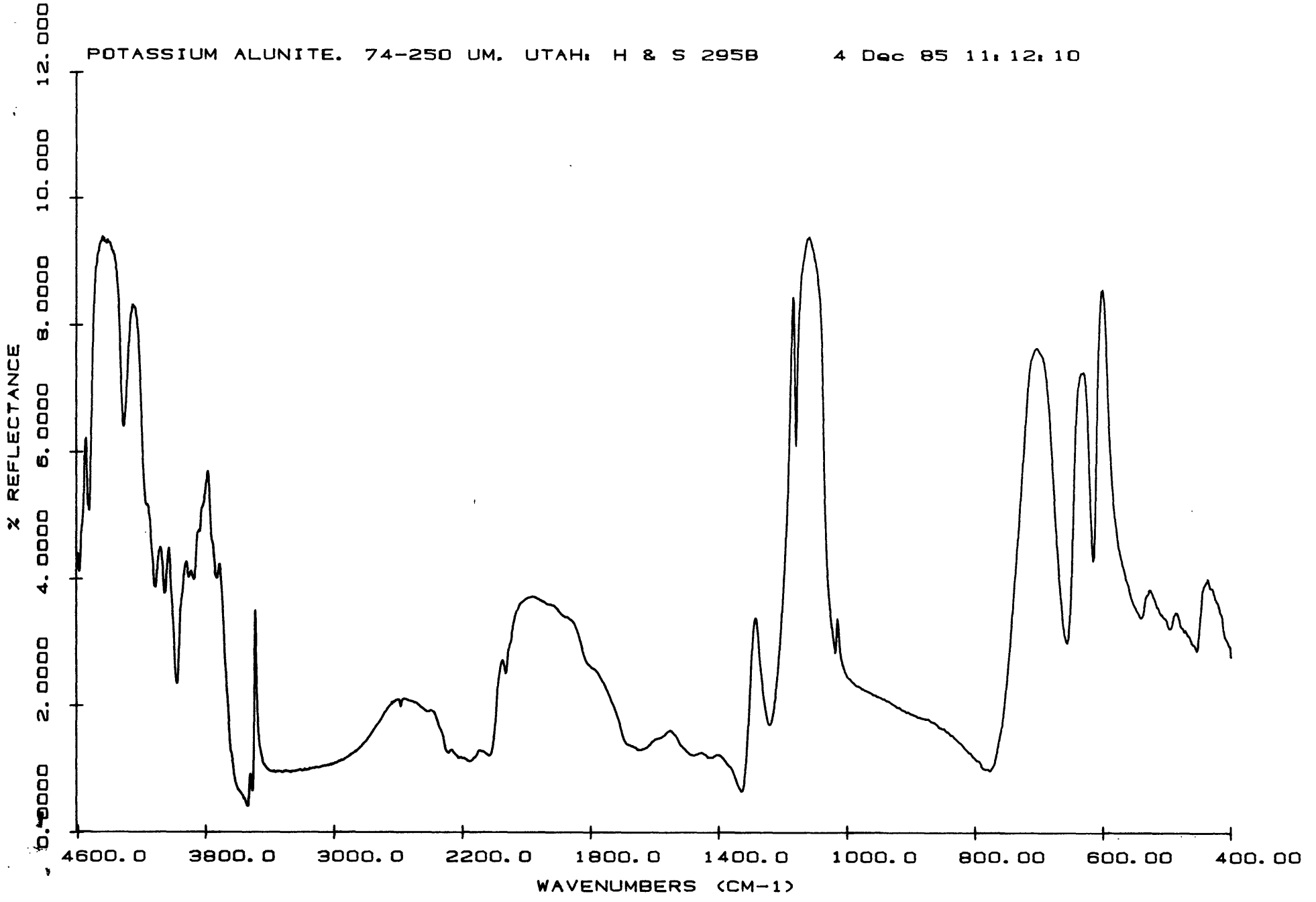
Results of XRF or other compositional analysis:

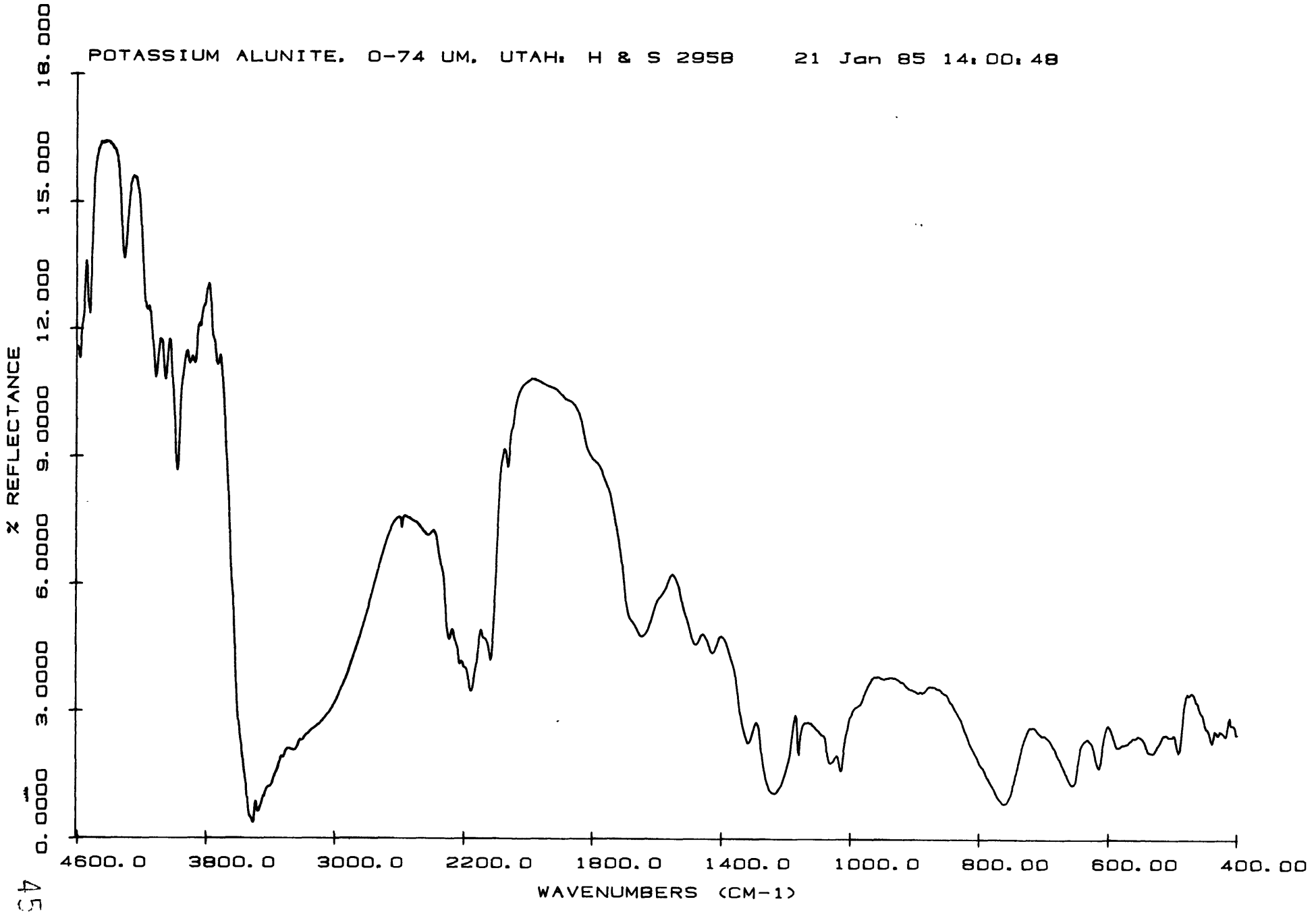
XRF analysis by J. Foggert, Ardith Bartel, and K. Stewart, USGS Branch of Analytical Chemistry, Denver, shows this to be a potassium alunite:

SiO	- 0.17
Al_2O_3	- 35.6
Fe_2O_3	- 0.14
MgO	- <0.1
CaO	- <0.02
Na_2O	- 0.34
K_2O	- 10.2
TiO_2	- <0.02
P_2O_5	- 0.75
MnO	- <0.02
Loss on ignition at 900°C	- 44.2

Spectra of file:
Alunite.2 Reflectance spectrum of 74-250 um size range on disk #1.
Alunite.2 Reflectance spectrum of 0-74 um size range on disk #1.
Alunite.2 Transmittance spectrum on disk #1.


POTASSIUM ALUNITE IN KBR. UTAH. H & S 2958 30 Dec 85 16:16:24
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


POTASSIUM ALUNITE. 74-250 UM. UTAH: H & S 295B
4 Dec 85 11:12:10
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


POTASSIUM ALUNITE. 0-74 UM. UTAH: H & S 295B 21 Jan 85 14:00:48
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Alunite (synthetic potassuim alunite) $KAl_3(SO_4)_2(OH)_6$

Locality: Synthetic

Last donor: Phil Bethke (USGS)

Intermediate donor:

Ultimate donor: Roger Stoffregen

Catalog numbers, etc.: None

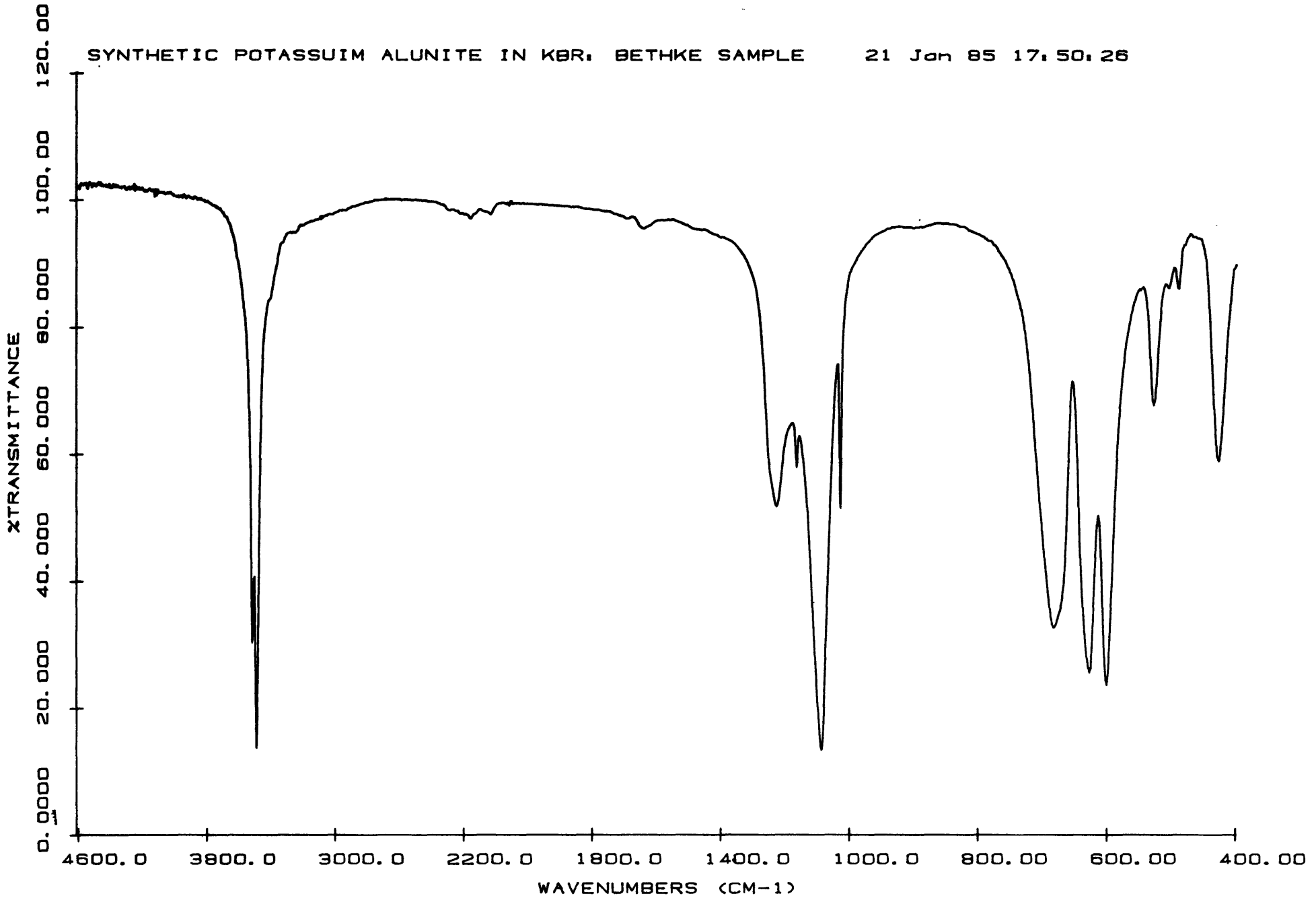
Results of petrographic examination: Light gray microcrystalline powder composed of equant or lath-shaped crystallites from 1 to 15 um in largest dimension.

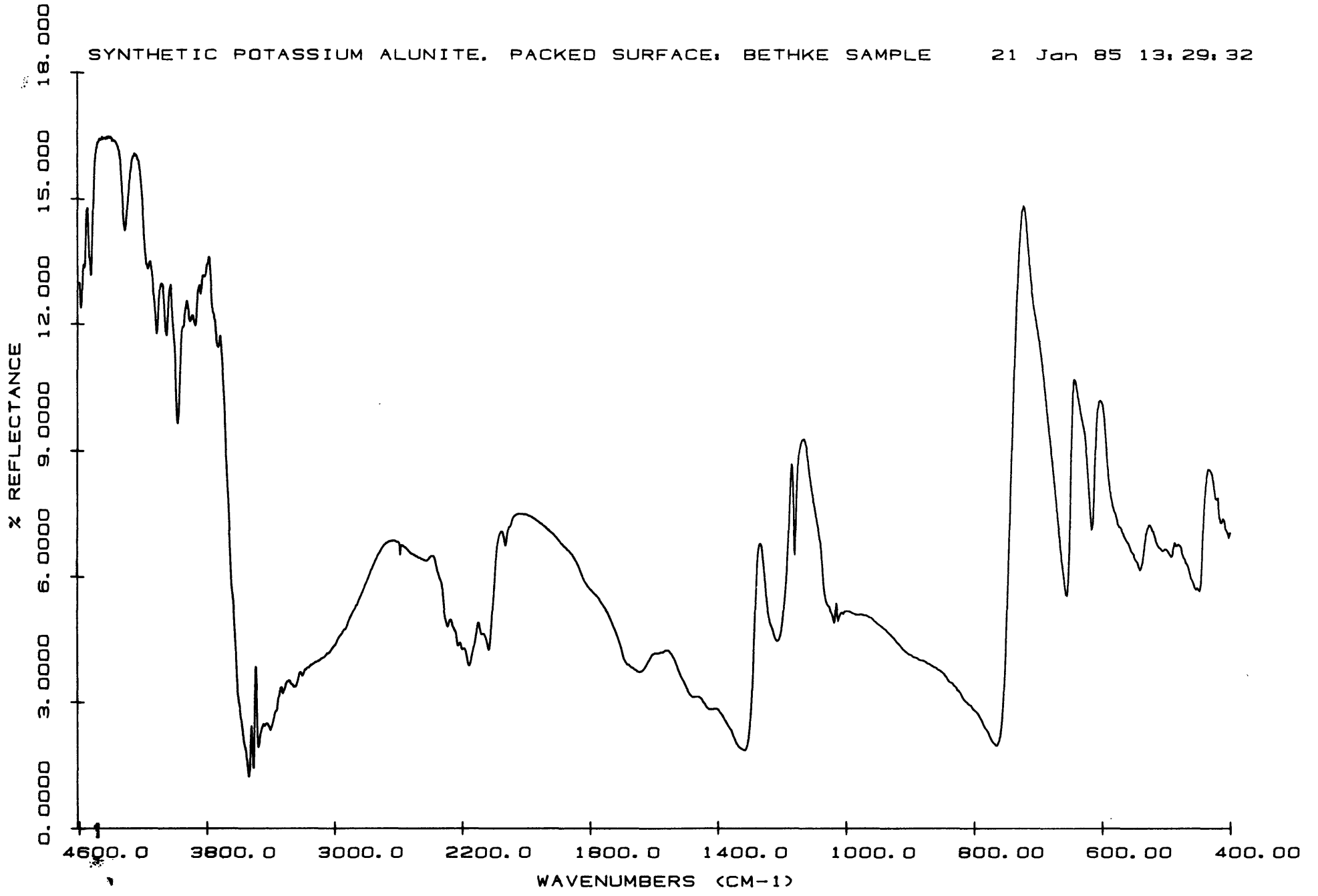
Results of XRD: Pure alunite

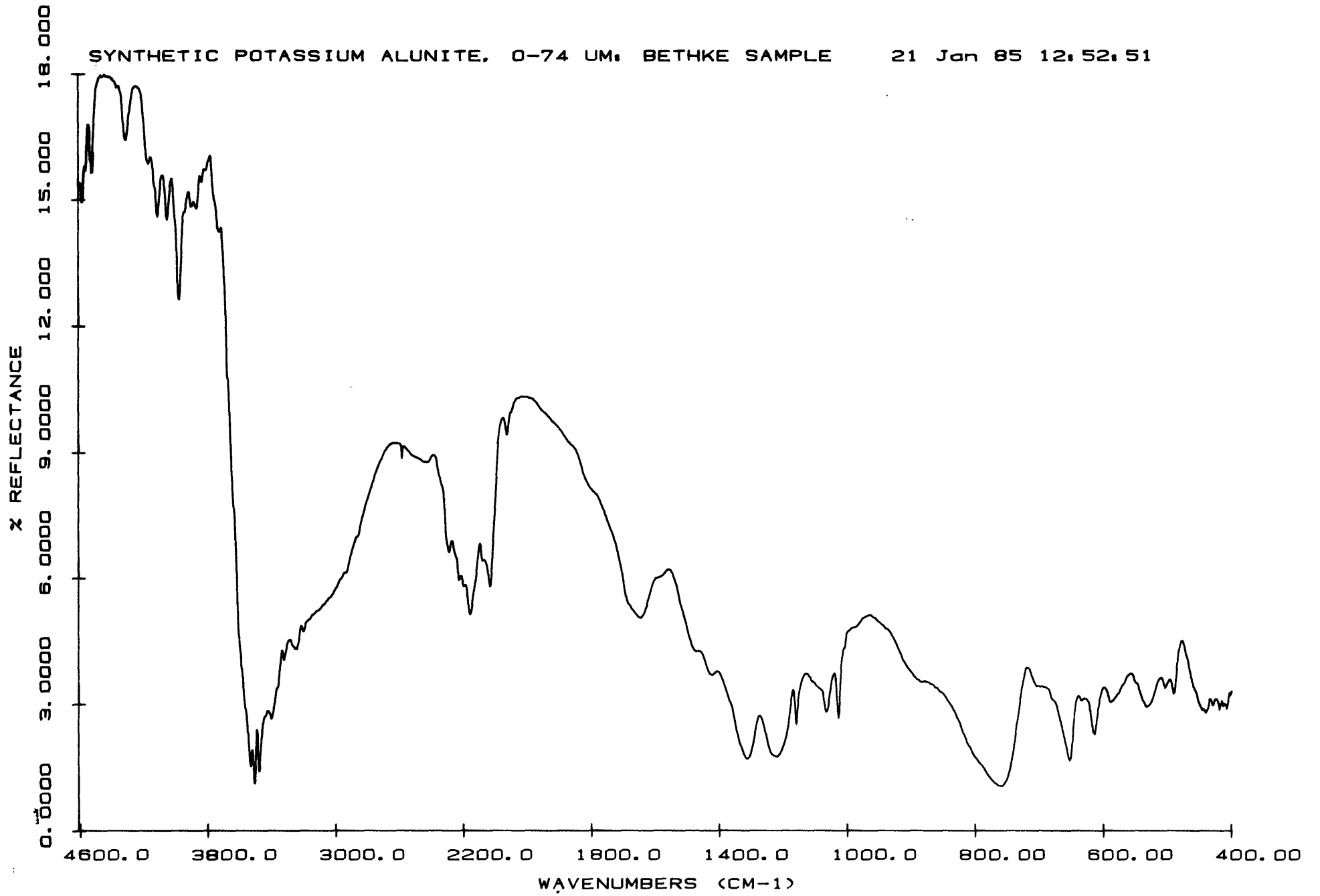
Results of XRF or other compositional analysis: None

Condiditions of Synthesis: See Alunite.1 sample description sheet.

Spectra of file:
Alunite.3 Transmittance spectrum on disk #1.
Alunite.3 Reflectance spectrum of 0-74 um size range on disk #1.
Alunite.3 Reflectance spectrum of packed surface on solid sample disk #1.


SYNTHETIC POTASSUIM ALUNITE IN KBR: BETHKE SAMPLE 21 Jan 85 17:50:26
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SYNTHETIC POTASSIUM ALUNITE. PACKED SURFACE: BETHKE SAMPLE 21 Jan 85 13:29:32
% REFLECTANCE
0.0000
3.0000
6.0000
9.0000
12.000
15.000
18.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SYNTHETIC POTASSIUM ALUNITE, 0-74 UM: BETHKE SAMPLE 21 Jan 85 12:52:51
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Alunite (synthetic sodium alunite) $NaAl_3(SO_4)_2(OH)_6$

Locality: Synthetic

Last donor: Phil Bethke (USGS)

Intermediate donor:

Ultimate donor: Roger Stoffregen

Catalog numbers, etc.: None

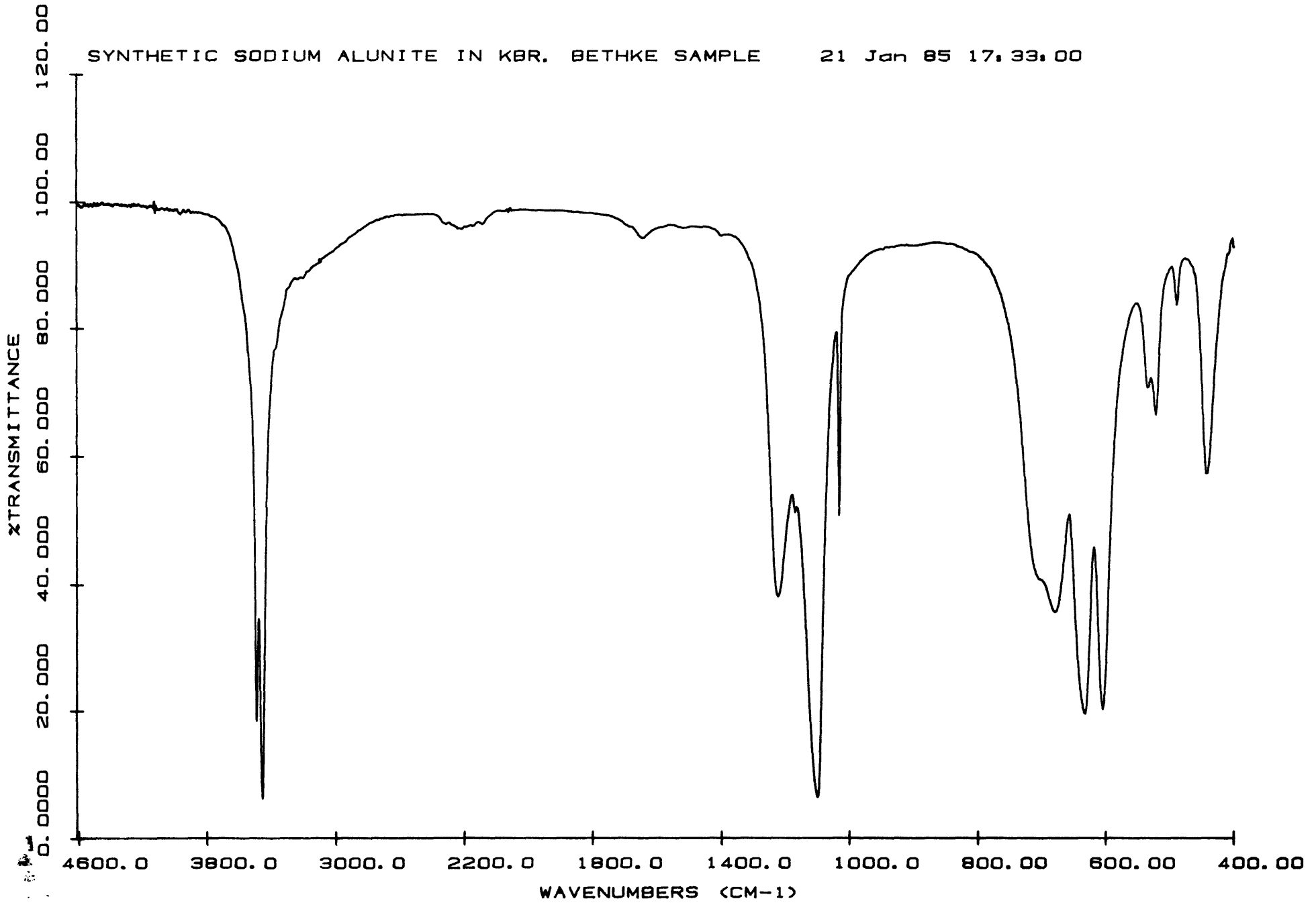
Results of petrographic examination: White microcrystalline powder composed of equant or lath-shaped crystallites from 1 to 15 um in largest dimension.

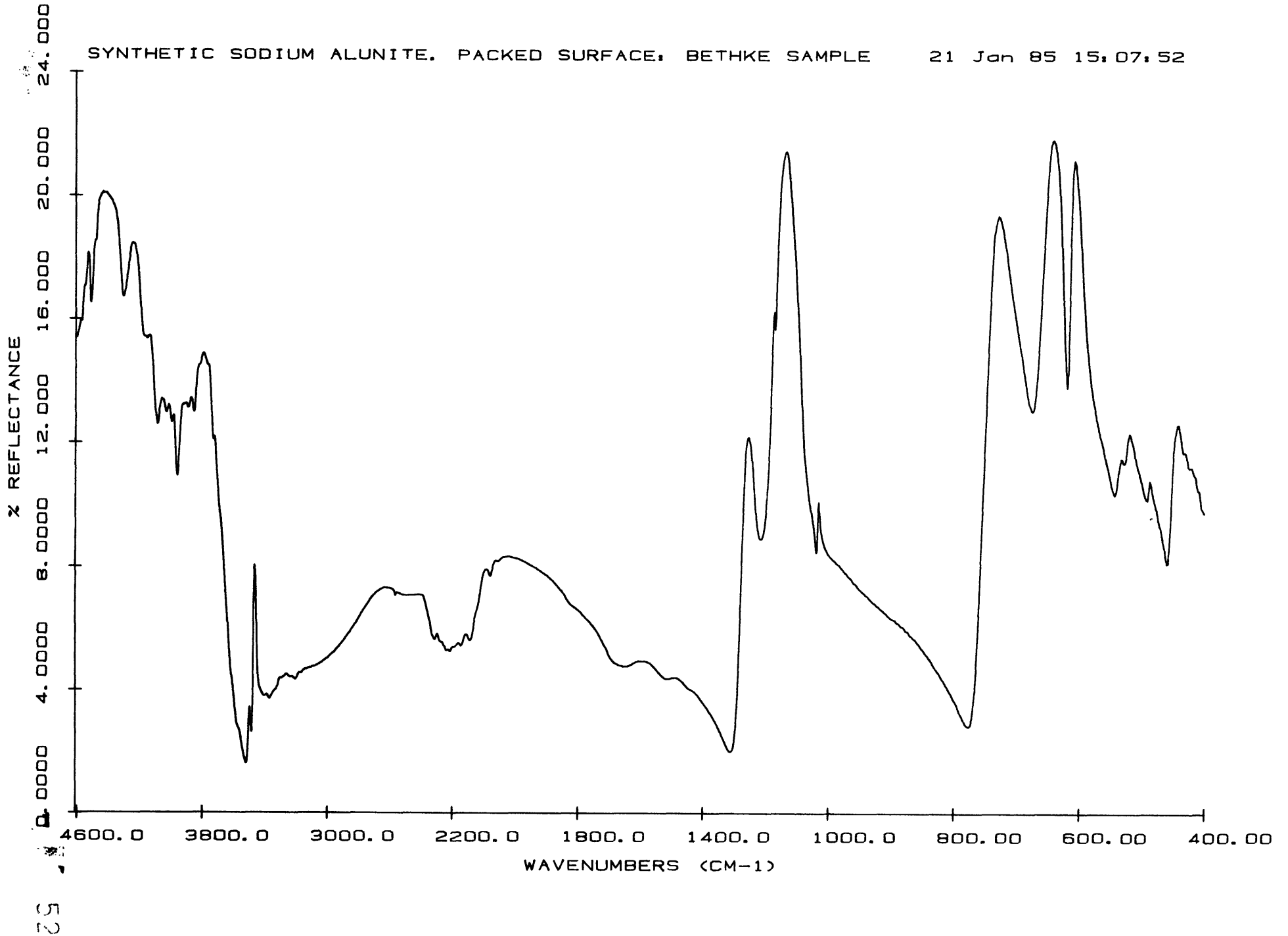
Results of XRD: Pure alunite

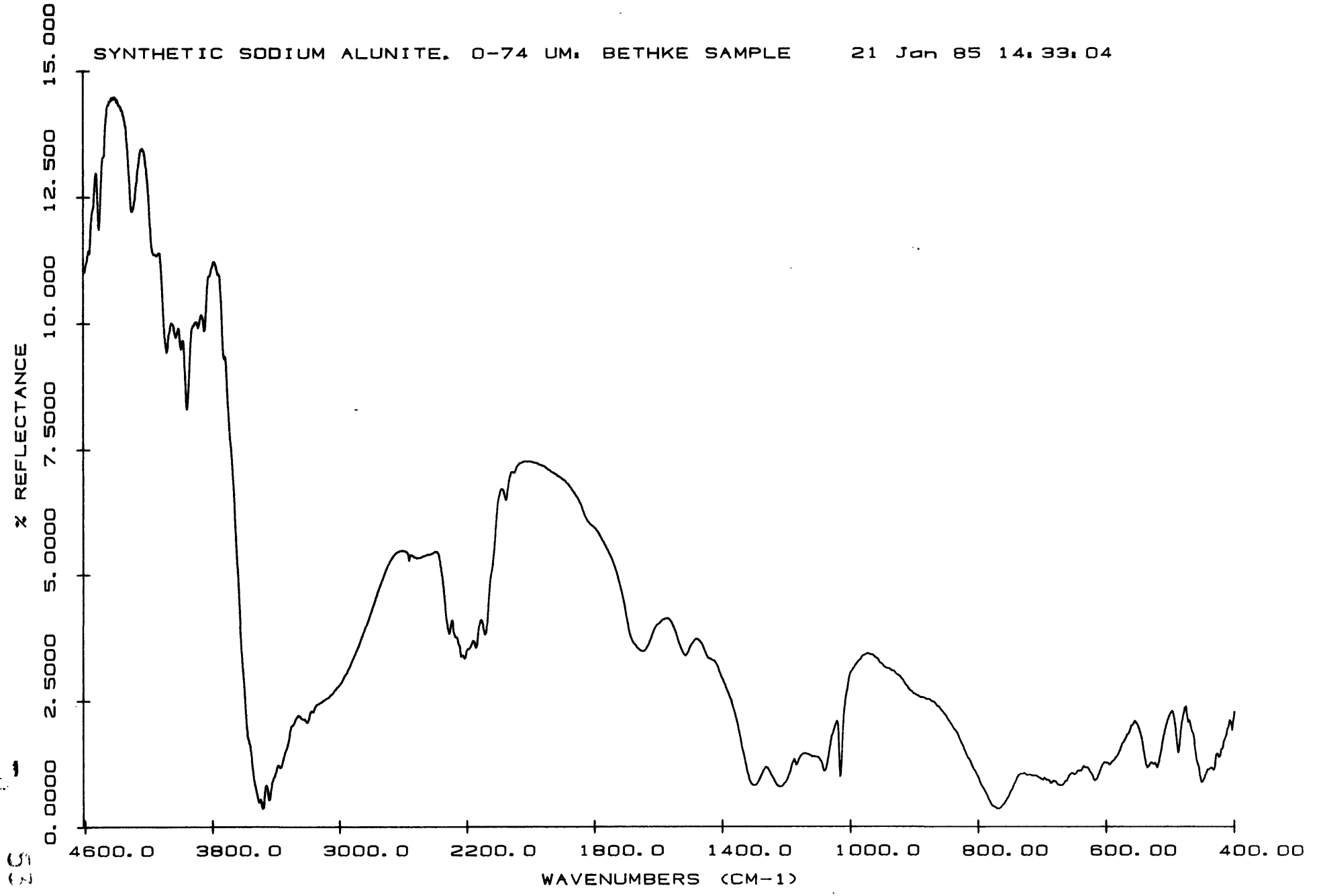
Results of XRF or other compositional analysis: None

Conditions of Synthesis: See Alunite.1 sample description sheet.

Spectra of file:
Alunite.4 Transmittance spectrum on disk #1.
Alunite.4 Reflectance spectrum of packed surface on solid sample disk #1.
Alunite.4 Reflectance spectrum of 0-74um size range ondisk #1.


SYNTHETIC SODIUM ALUNITE IN KBR. BETHKE SAMPLE 21 Jan 85 17:33:00
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SYNTHETIC SODIUM ALUNITE. PACKED SURFACE: BETHKE SAMPLE 21 Jan 85 15:07:52
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SYNTHETIC SODIUM ALUNITE. 0-74 UM: BETHKE SAMPLE 21 Jan 85 14:33:04
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Andalusite Al_2SiO_5

Locality: St. Theresa, Espirito Santo, Brazil

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH R17898

Results of petrographic examination: Sample is composed of two crystals, one clear and one pale pink. Both appear pure, both 1 x 0.5 cm. Examination under petrographic microscope indicates pure and clean sample. Sample grains chosen for microprobe analysis are clear but with poor polish in part.

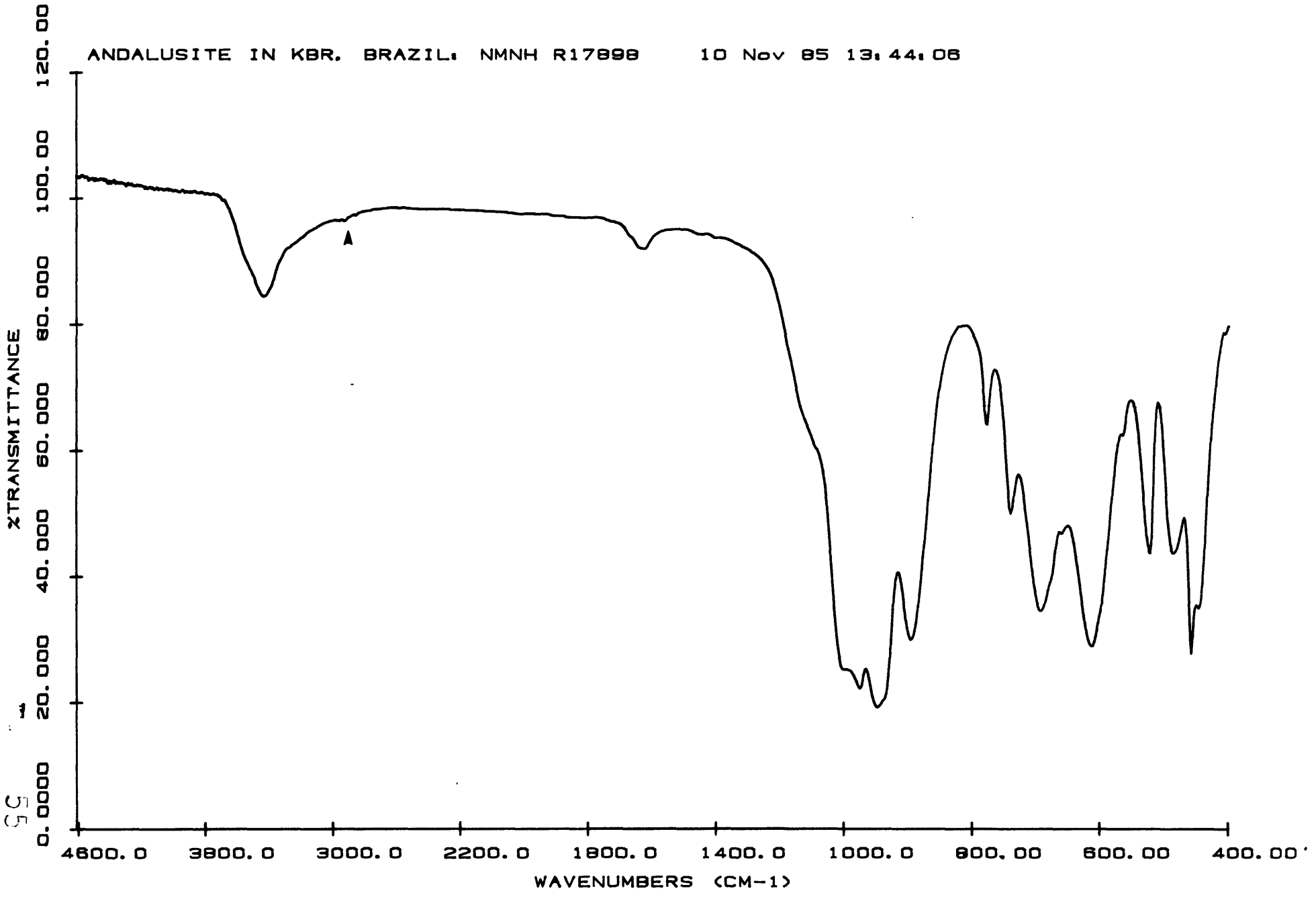
Results of XRD: Pure andalusite

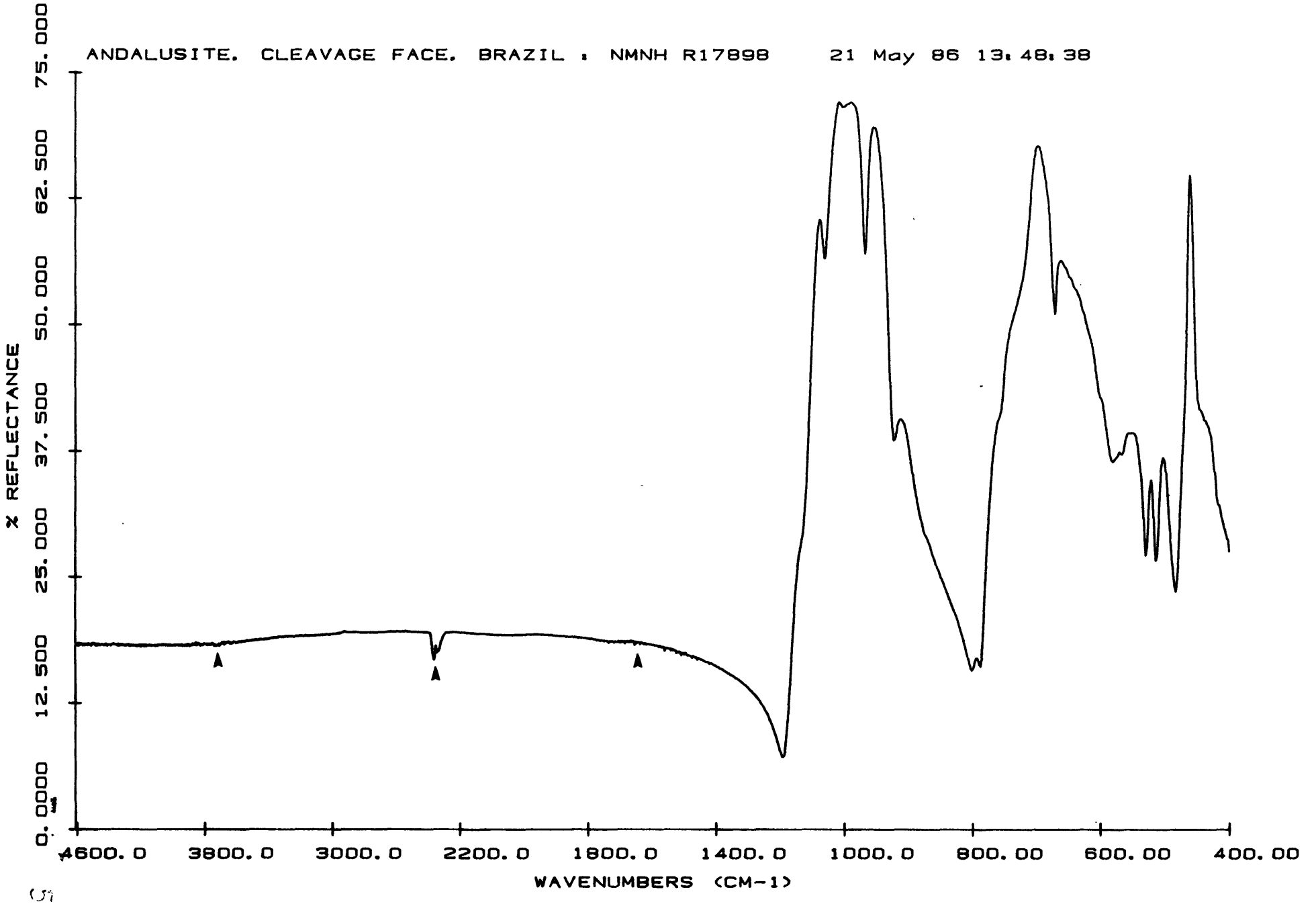
Results of XRF or other compositional analysis: Microprobe analysis shows the sample to be homogenous within and between grains. Average of 10 analyses, indicating close to end member composition, is:

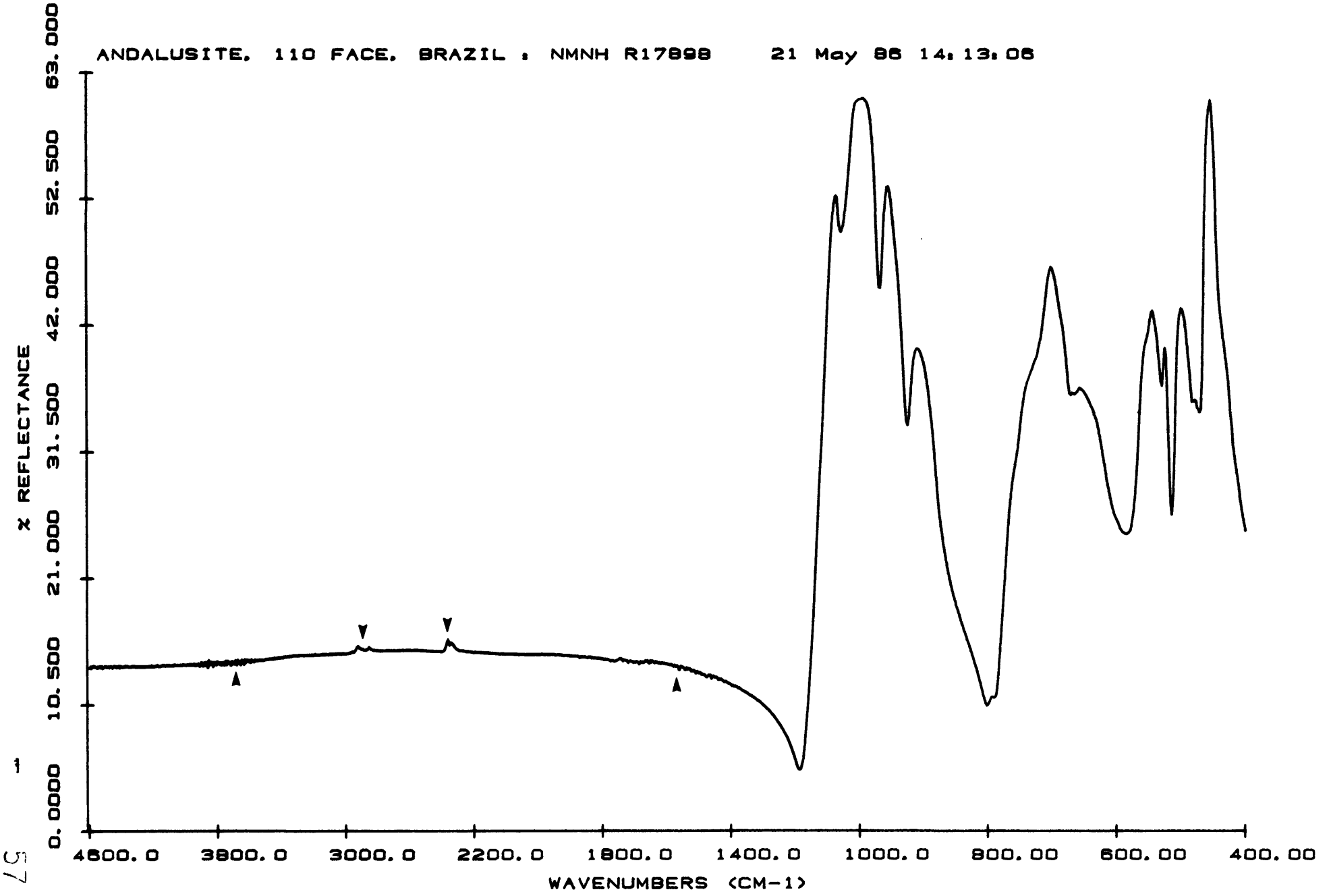
SiO_2	-	37.19
Al_2O_3	-	63.62
FeO	-	0.26
MgO	-	0.06
CaO	-	0.02
K_2O	-	0.01
Na_2O	-	0.02
TiO_2	-	0.03
MnO	-	0.01
Total	-	101.22

Spectra on file:

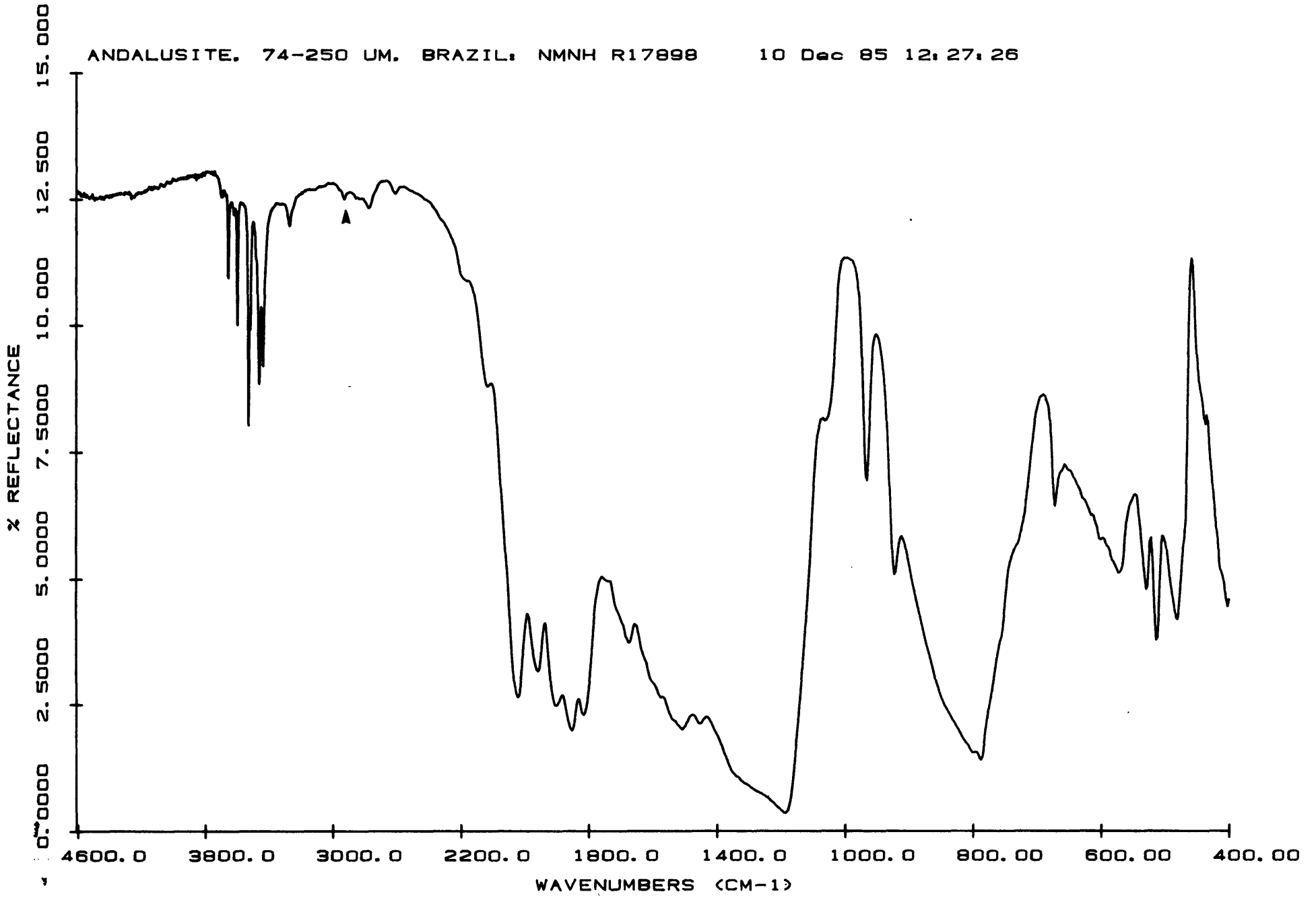
Andalusite.2 Reflectance spectrum of cleavage face on solid sample Disk #1.
Andalusite.2a Reflectance spectrum of 110 face on solid sample Disk #1.
Andalusite.2 Reflectance spectrum of 0-74 um size range on Disk #1.
Andalusite.2 Reflectance spectrum of 74-250 um size range on Disk #1.
Andalusite.2 Transmittance spectrum on Disk #1.

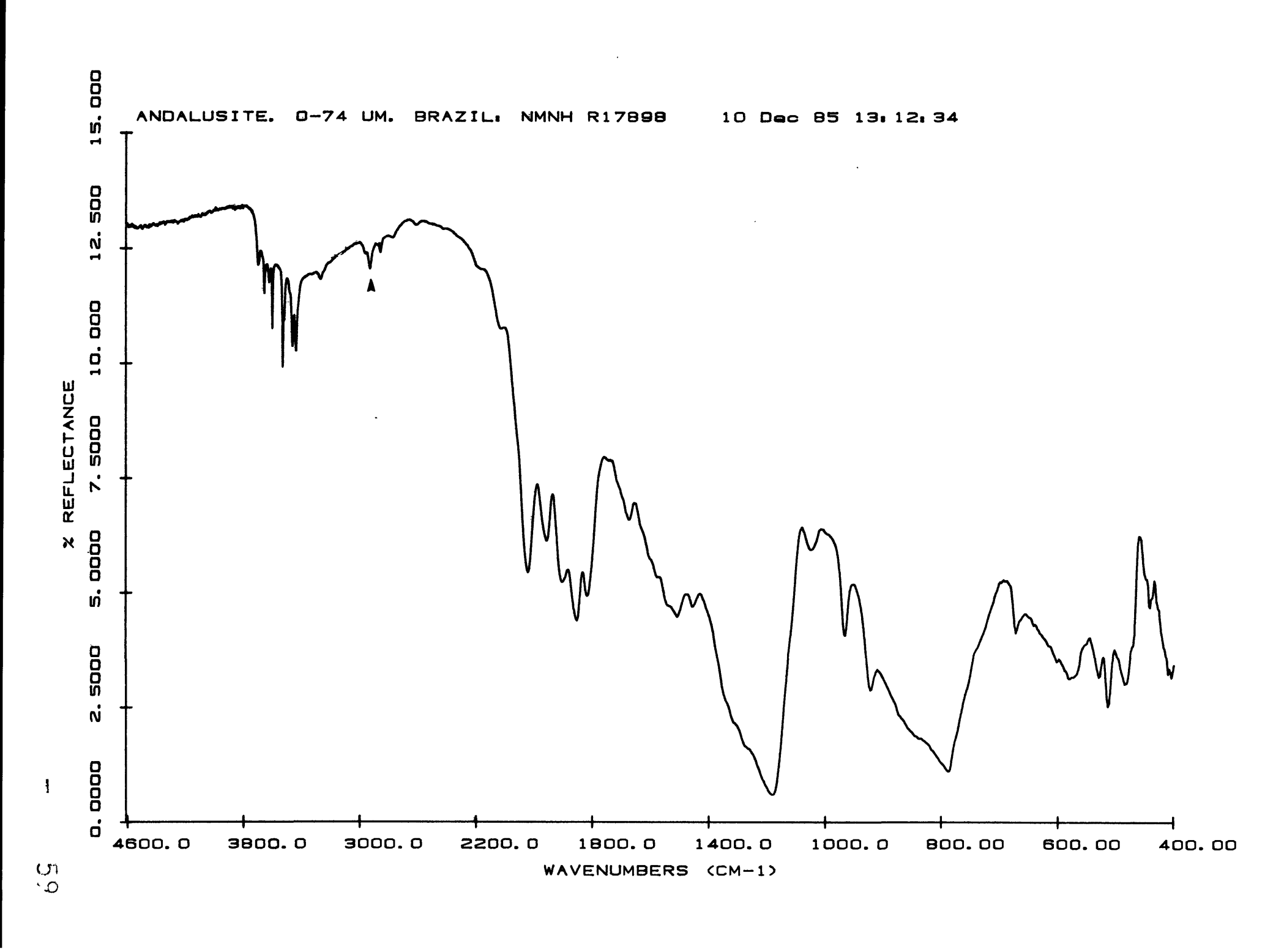

ANDALUSITE IN KBR. BRAZIL: NMNH R17898 10 Nov 85 13:44:06
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ANDALUSITE. CLEAVAGE FACE. BRAZIL : NMNH R17898 21 May 86 13:48:38
% REFLECTANCE
75.000
62.500
50.000
37.500
25.000
12.500
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ANDALUSITE. 110 FACE. BRAZIL : NMNH R17898 21 May 86 14:13:06
% REFLECTANCE
0.0000
10.500
21.000
31.500
42.000
52.500
63.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

57


ANDALUSITE. 74-250 UM. BRAZIL: NMNH R17898 10 Dec 85 12:27:26
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ANDALUSITE. 0-74 UM. BRAZIL: NMNH R17898 10 Dec 85 13:12:34
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Andradite $Ca_3Fe_2^{+3}(SiO_4)_3$

Locality: Rimpfischwange, Zermatt, Valais, Switzerland

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 113829

Results of petrographic examination: Sample is a cluster of subhedral crystals, green in color varying slightly in shade. Some are coated with a white contaminant that is soft. Under the microscope, one can also see some dark impurities. White contaminant does not disappear when treated with HCl. Sample was lightly crushed to free individual 3mm crystals and then hand-picked to assemble only clean, bright green crystals. Under petrographic microscope, sample appears pure, clean and unaltered. A few grains have light brownish tinge on some edges. Sample chosen for probe appears pure.

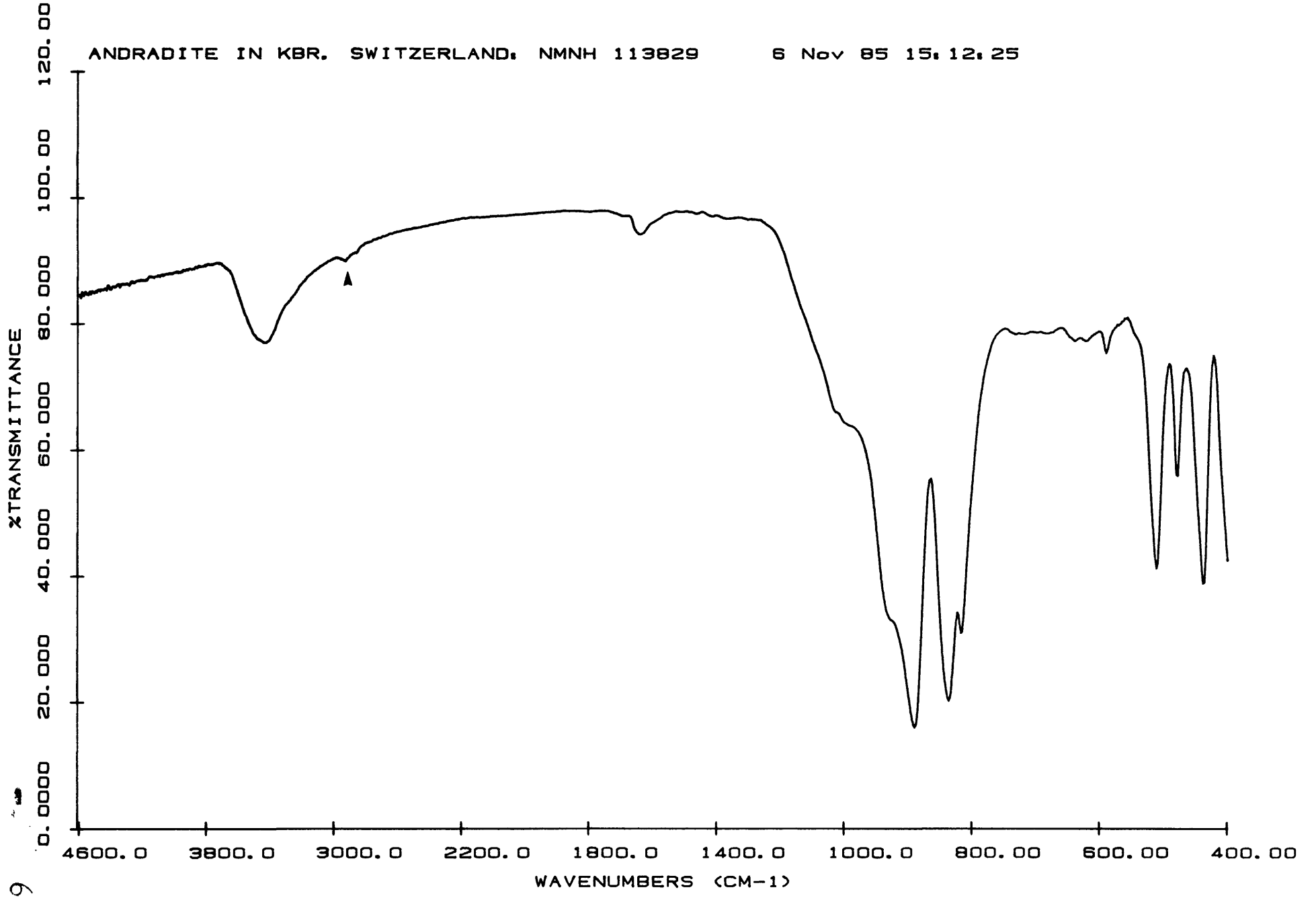
Results of XRD: Hand-picked sample is pure andradite.

Results of XRF or other compositional analysis: Microprobe analysis shows sample to be homogeneous within and between grains. Average of 8 analyses indicates close to end member composition:

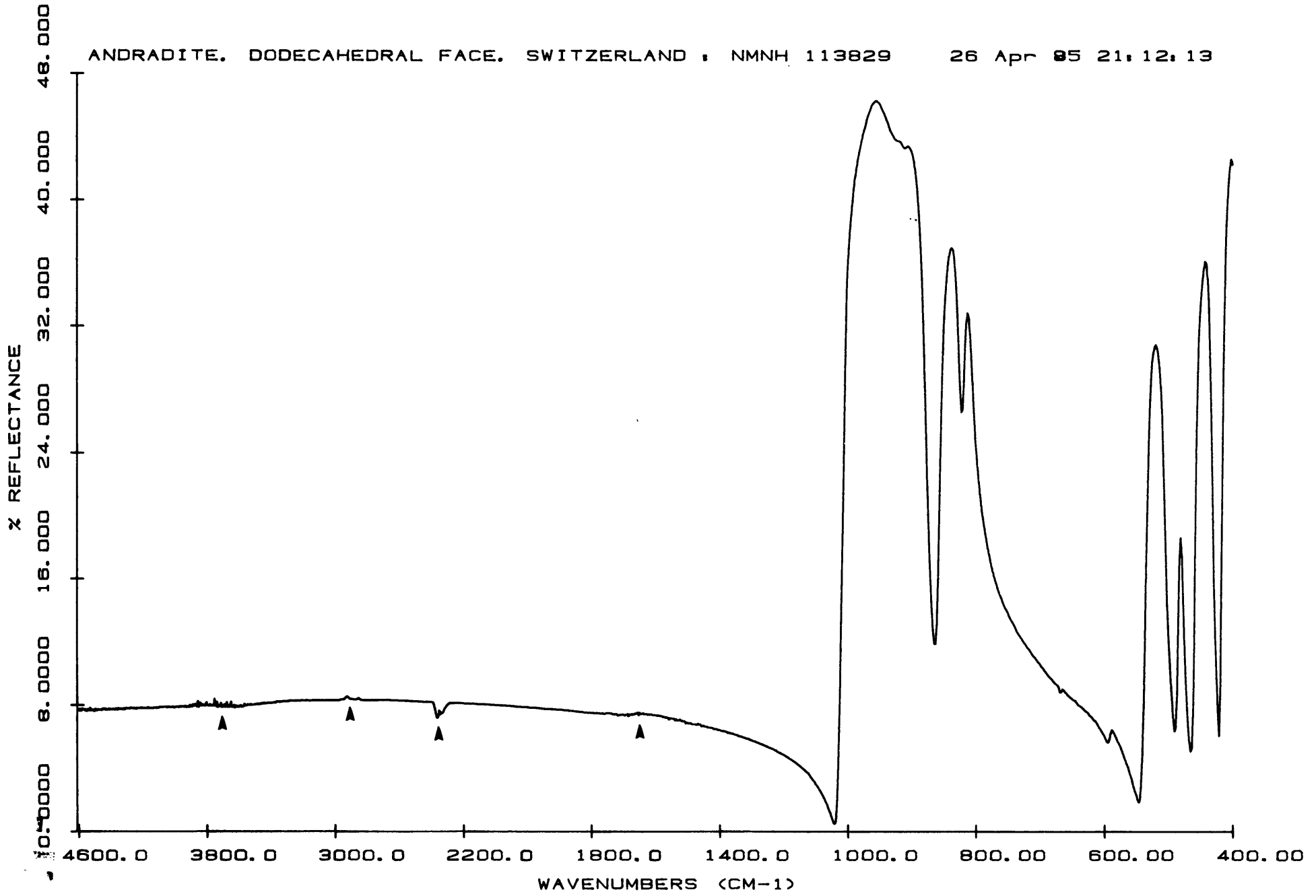
SiO_2	- 35.50
Al_2O_3	- 0.29
FeO	- 28.17
MgO	- 0.14
CaO	- 33.11
K_2O	- 0.01
Na_2O	- 0.02
TiO_2	- 0.07
MnO	- 0.11
Total	- 97.42

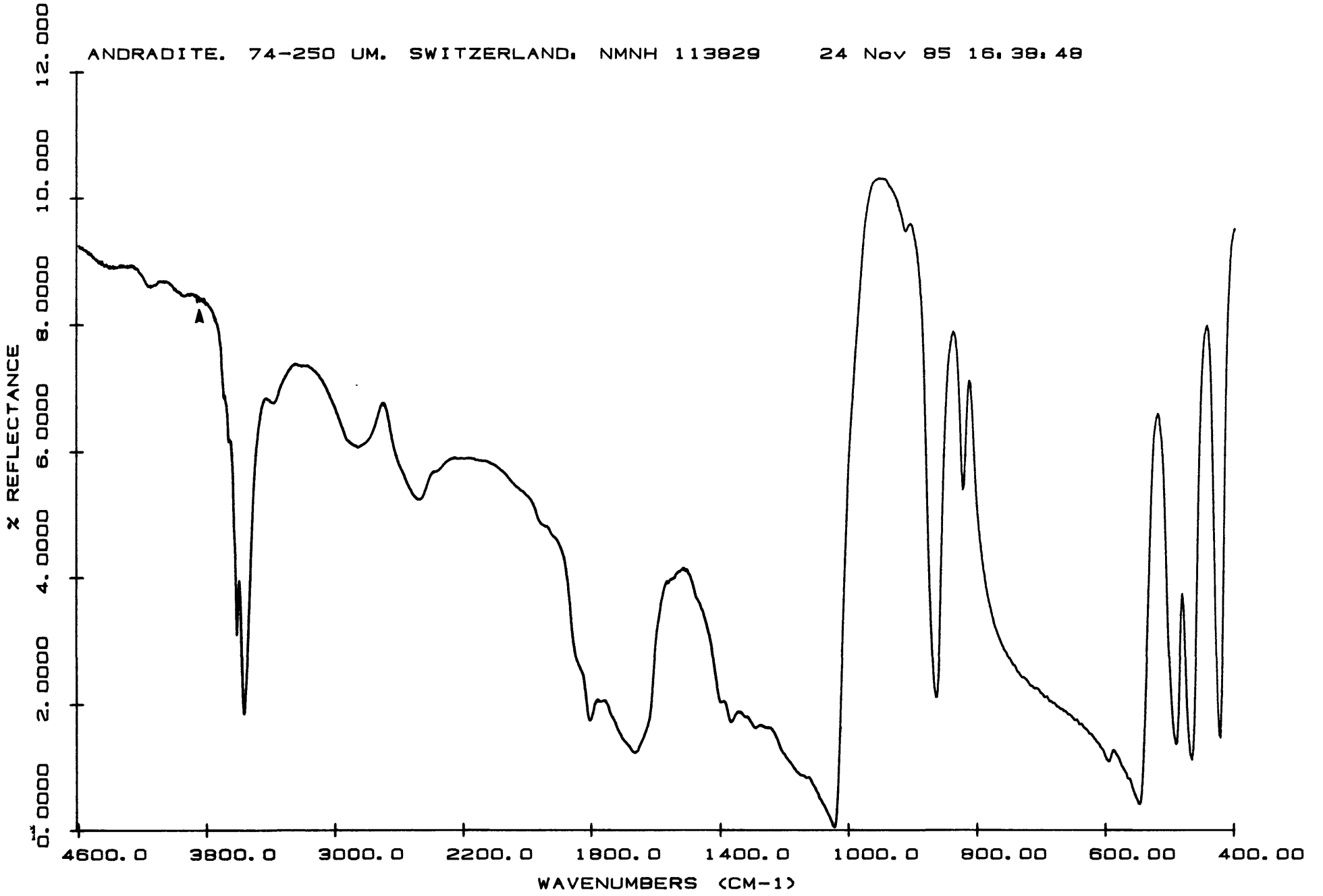
Spectra on file:

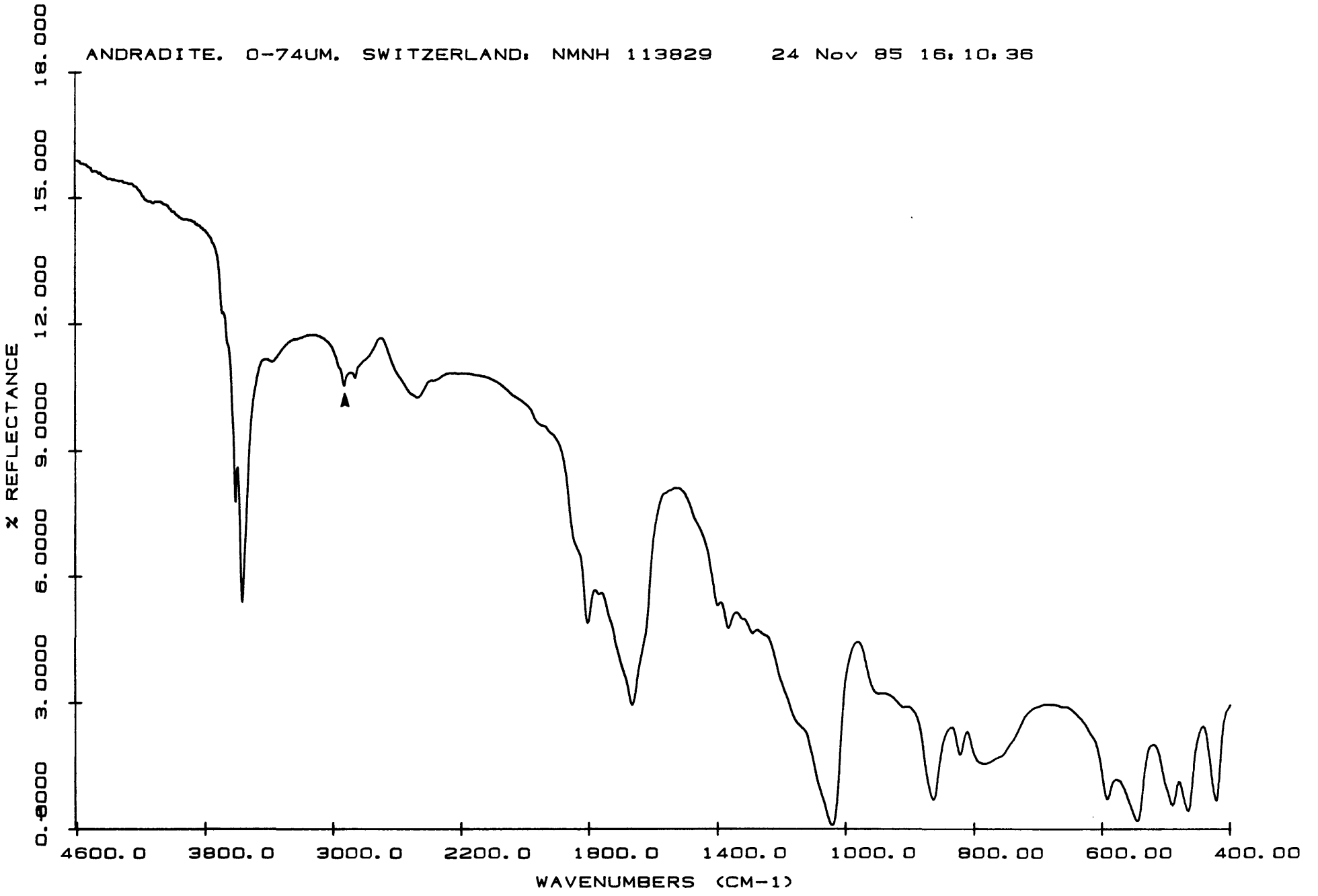
Andradite.1	Reflectance spectrum of clean dodecahredral face on solid sample Disk #1.
Andradite.1	Reflectance spectrum of 74-250 size range on disk #1.
Andradite.1	Reflectance spectrum of 0-74 um size range on disk #1.
Andradite.1	Transmittance spectrum on disk #1.


ANDRADITE IN KBR. SWITZERLAND: NMNH 113829 6 Nov 85 15:12:25
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

19


ANDRADITE. DODECAHEDRAL FACE. SWITZERLAND : NMNH 113829 26 Apr 85 21:12:13
% REFLECTANCE
48.000
40.000
32.000
24.000
16.000
8.0000
-10.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ANDRADITE. 74-250 UM. SWITZERLAND: NMNH 113829 24 Nov 85 16:38:48
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ANDRADITE. 0-74UM. SWITZERLAND: NMNH 113829 24 Nov 85 16:10:36
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Synthetic Anorthite $CaAl_2Si_2O_8$

Locality: N/A

Last donor: Bruce Hemingway, USGS

Intermediate donor:

Ultimate donor: James Woodhead, Princeton Un.

Catalog numbers, etc.: None

Results of petrographic examination: Under microscope, sample appears pure, with very fine (cryptocrystalline) texture.

Results of XRD: Pure anorthite.

Results of XRF or other compositional analysis: See Robie, R.A., Hemingway, B.S and Wilson, W.H., 1978, Amer. Min., vo. 63, p. 109-123.
Microprobe analysis of glass used to make crystals:

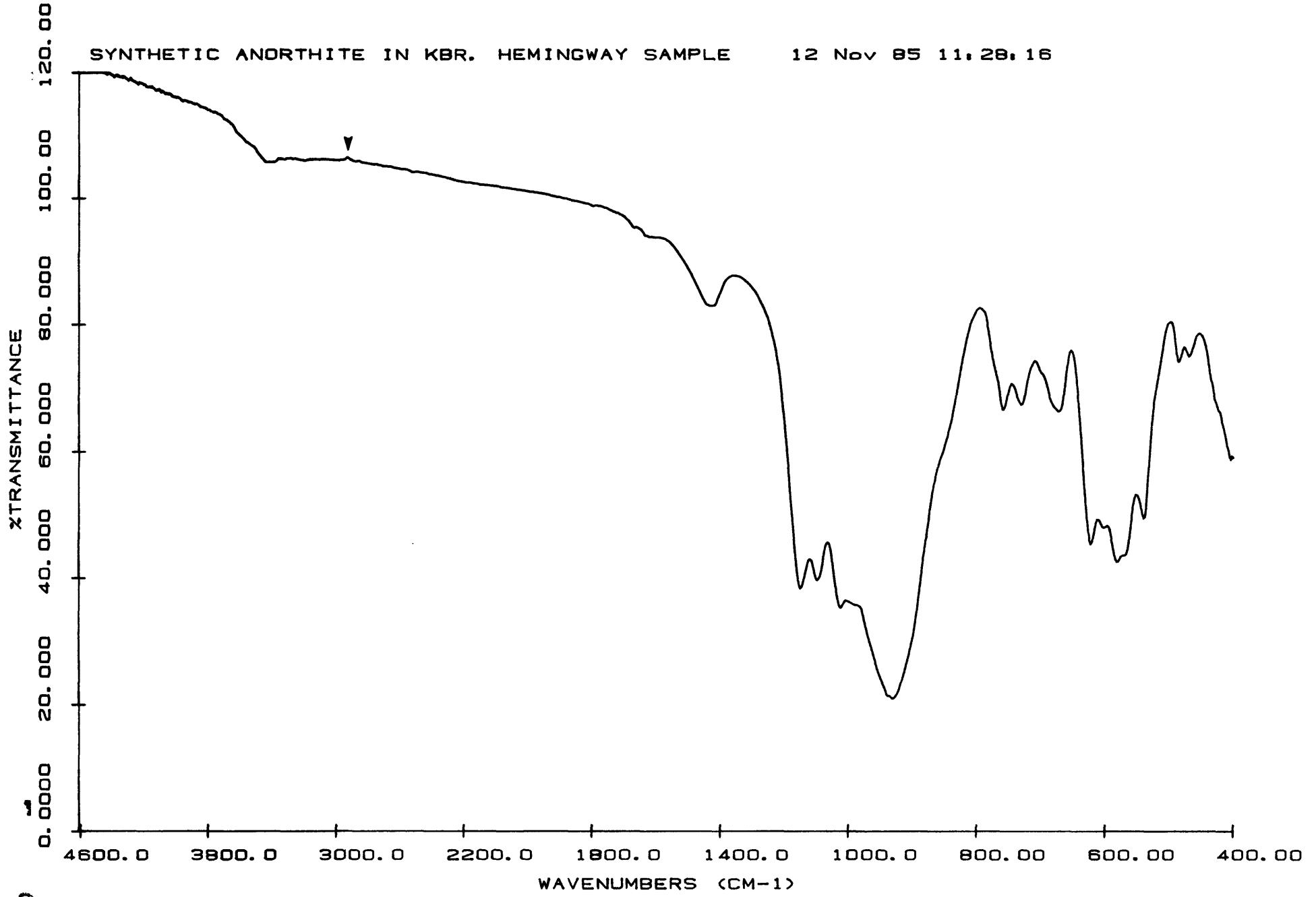
SiO_2	- 42.09
Al_2O_3	- 37.05
Fe_2O_3	-
Na_2O	-
K_2O	-
CaO	- 20.18
H_2O	-
H_2O^+	-

Microprobe analysis of recrystallized mineral shows sample to be homogeneous within and between grains. Average of 10 analyses:

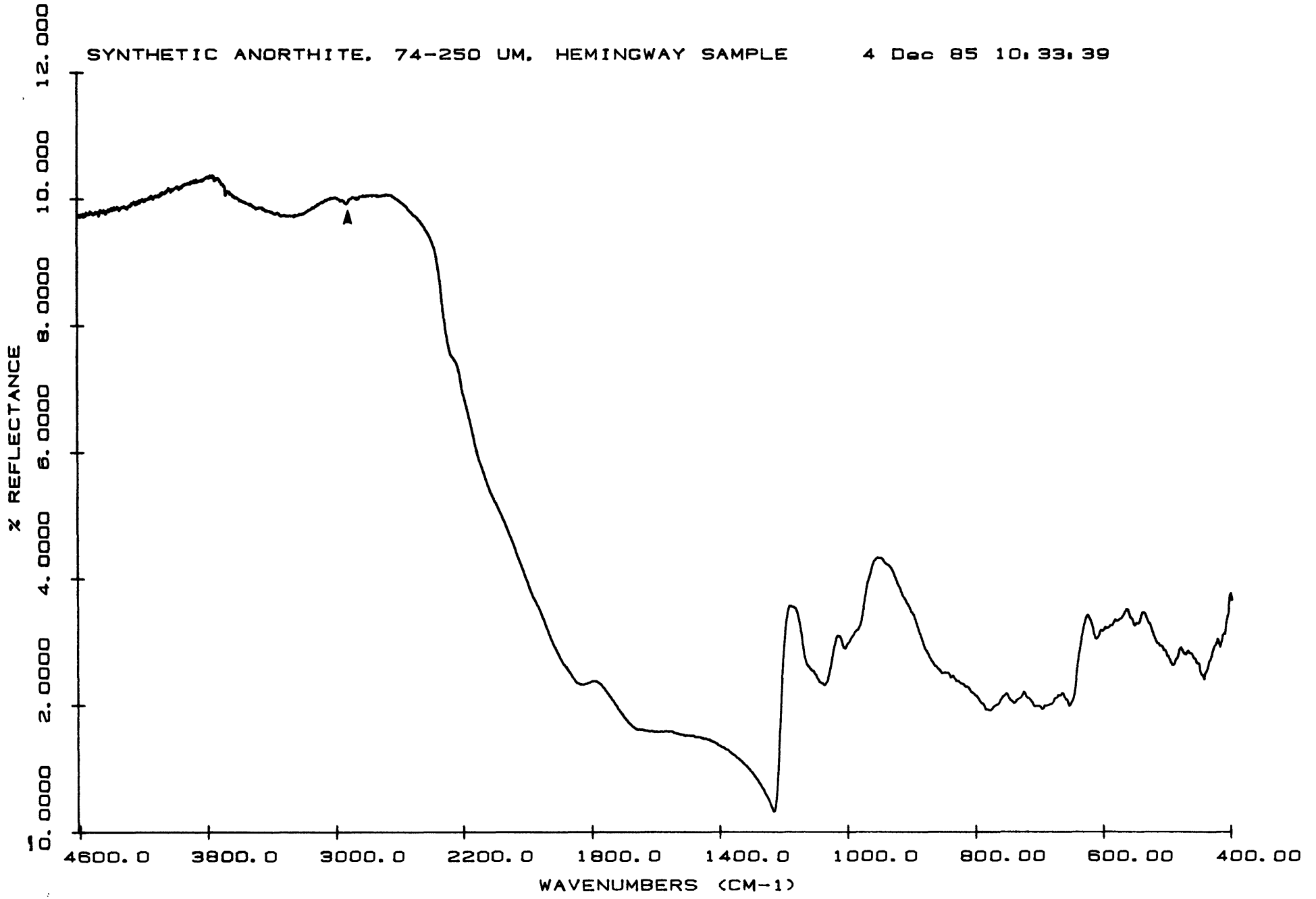
SiO_2	- 43.53
Al_2O_3	- 37.36
FeO	- 0.02
MgO	- 0.03
CaO	- 19.26
K_2O	- 0.04
Na_2O	- 0.03
TiO_2	- 0.01
MnO	- 0.03
Total	-100.32

Spectra on file:

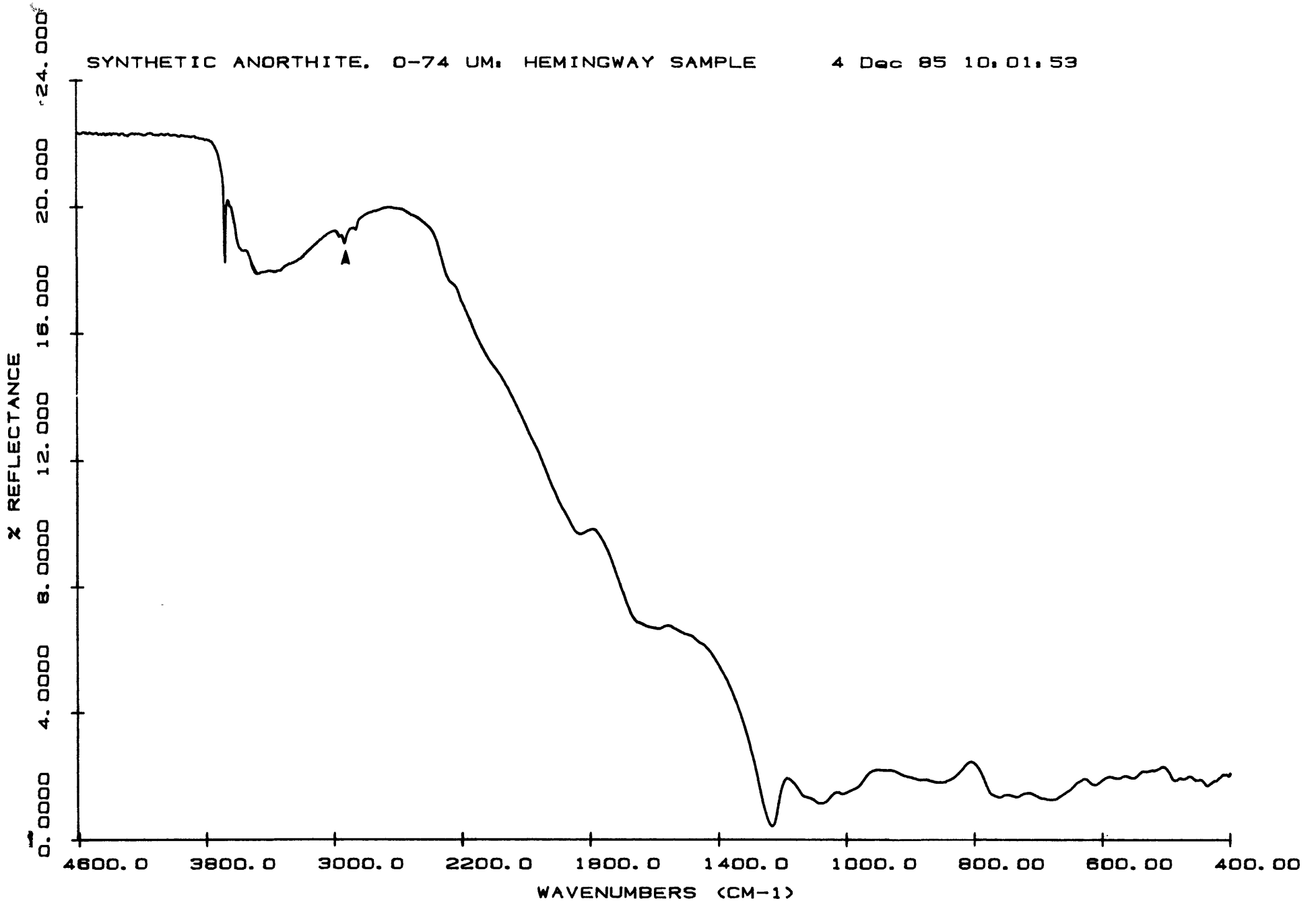
Anorthite.1	Reflectance spectrum on 0-74 um size range on Disk #1.
Anorthite.1	Reflectance spectrum on 74-250 um size range on Disk #1.
Anorthite.1	Transmittance spectrum on Disk #1.


SYNTHETIC ANORTHITE IN KBR. HEMINGWAY SAMPLE 12 Nov 85 11:28:16
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

99


SYNTHETIC ANORTHITE. 74-250 UM. HEMINGWAY SAMPLE
4 Dec 85 10:33:39
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

67


SYNTHETIC ANORTHITE. 0-74 UM: HEMINGWAY SAMPLE 4 Dec 85 10:01:53
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

69

Species name: Antigorite $(Mg, Fe^{+2})_3 Si_2)_5(OH)_4$

Locality: Kalsertal, Tyrol, Austria

Last donor: Jim Crowley, USGS

Intermediate donor:

Ultimate donor: Smithsonian

Catalog numbers, etc.: NMNH B17958

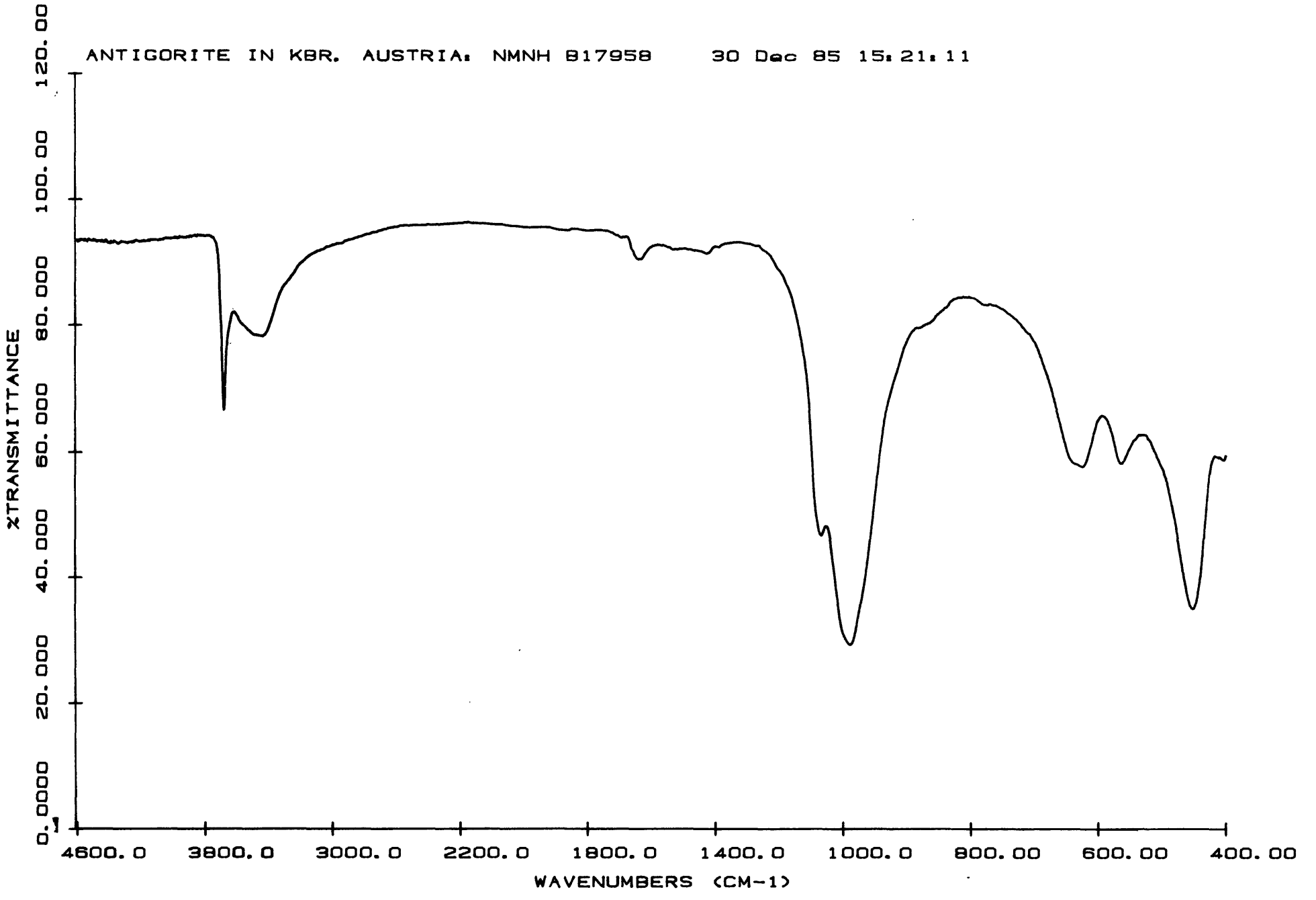
Results of petrographic examination: Large green single crystal. Under the microscope, appears mostly pure antigorite, but some (<3%) alteration or impurity, possibly chrysotile.

Results of XRD: Pure magnesian antigorite (Jim Crowley).

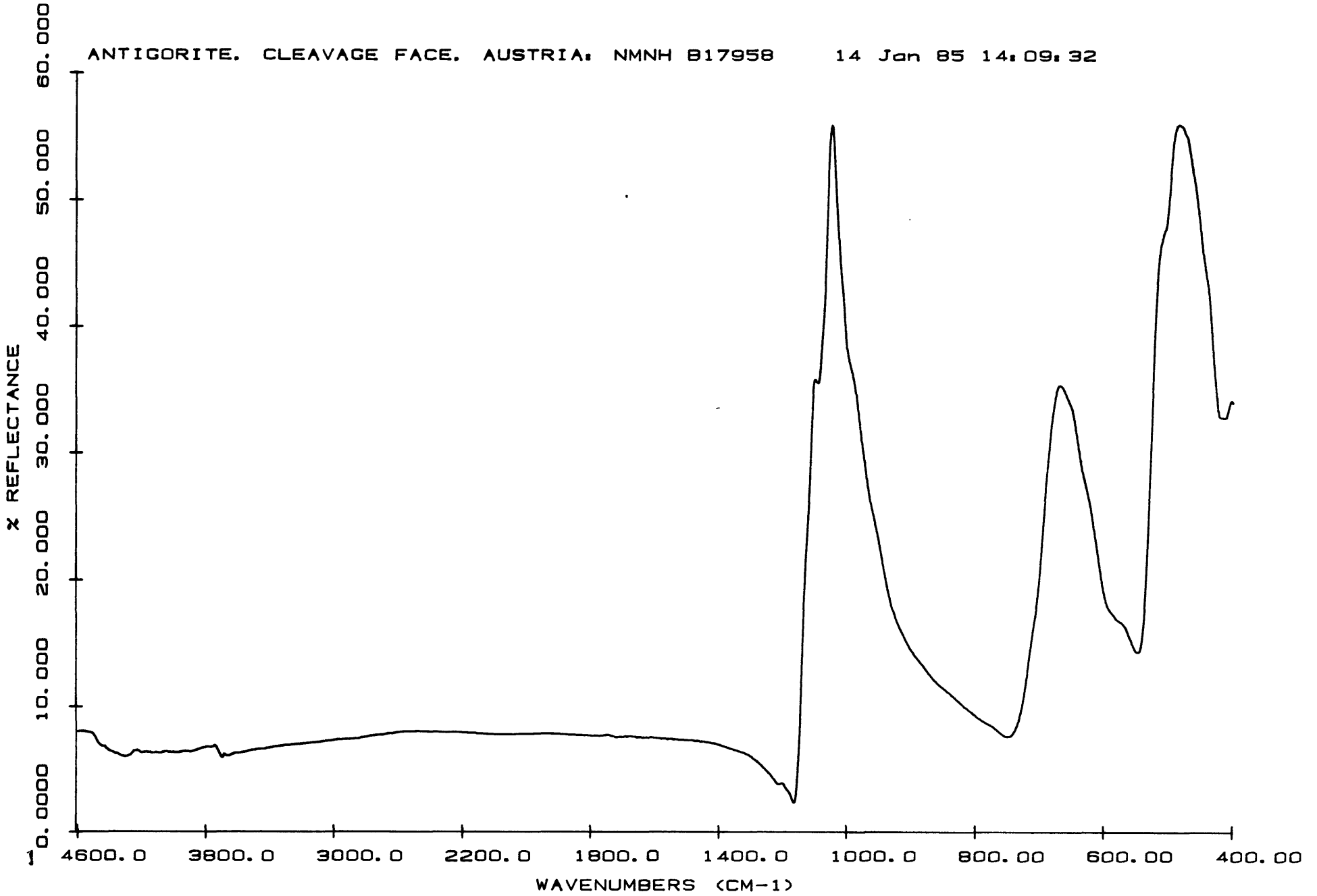
Results of XRF or other compositional analysis: To be determined.

Spectra of file:

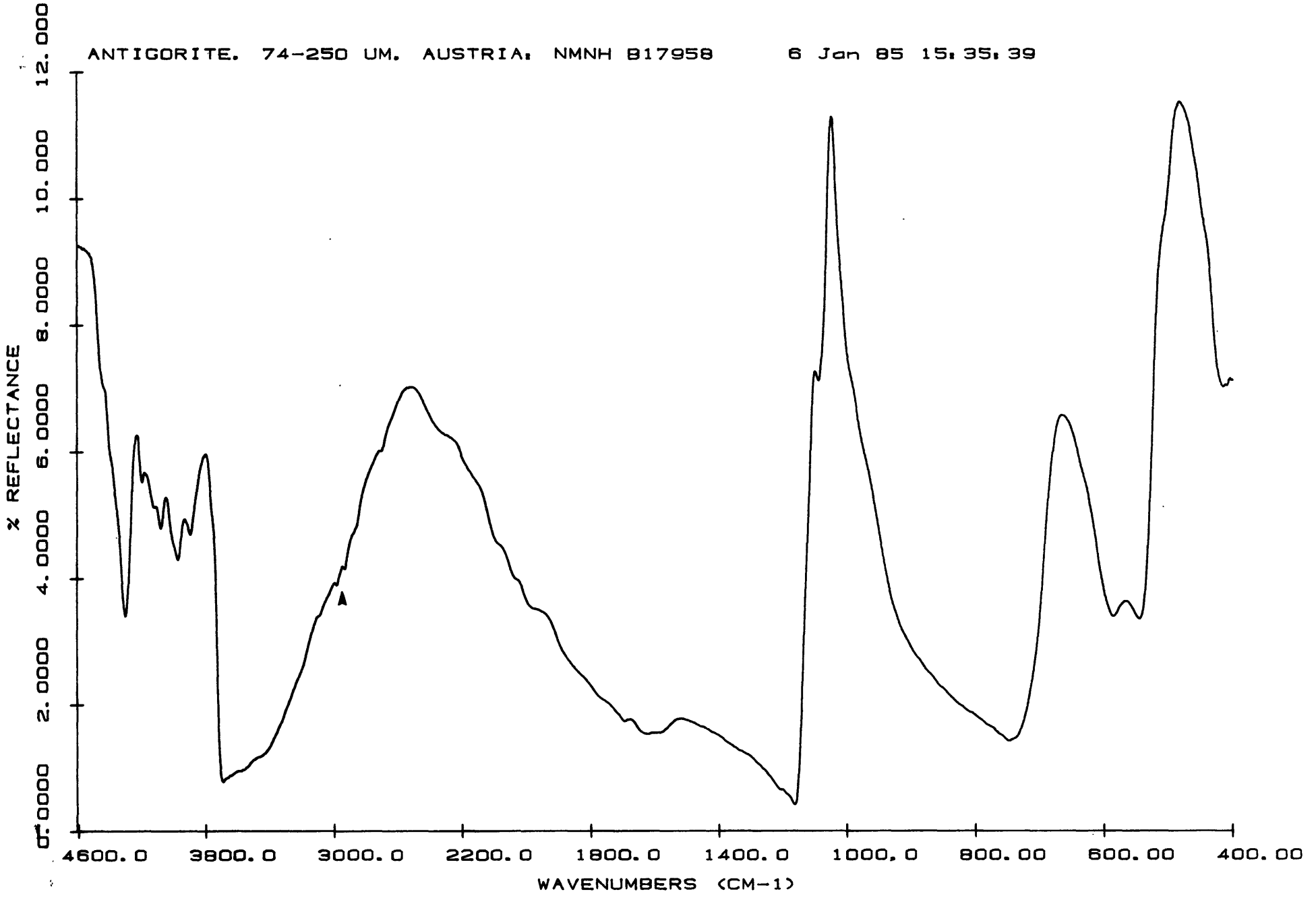
Antigorite.1	Transmittance spectrum on disk #1.
Antigorite.1	Reflectance spectrum of 0-74 um size on disk #1.
Antigorite.1	Reflectance spectrum of 74-250 um size on disk #1.
Antigorite.1	Reflectance spectrum of cleavage face on solid sample disk #1.

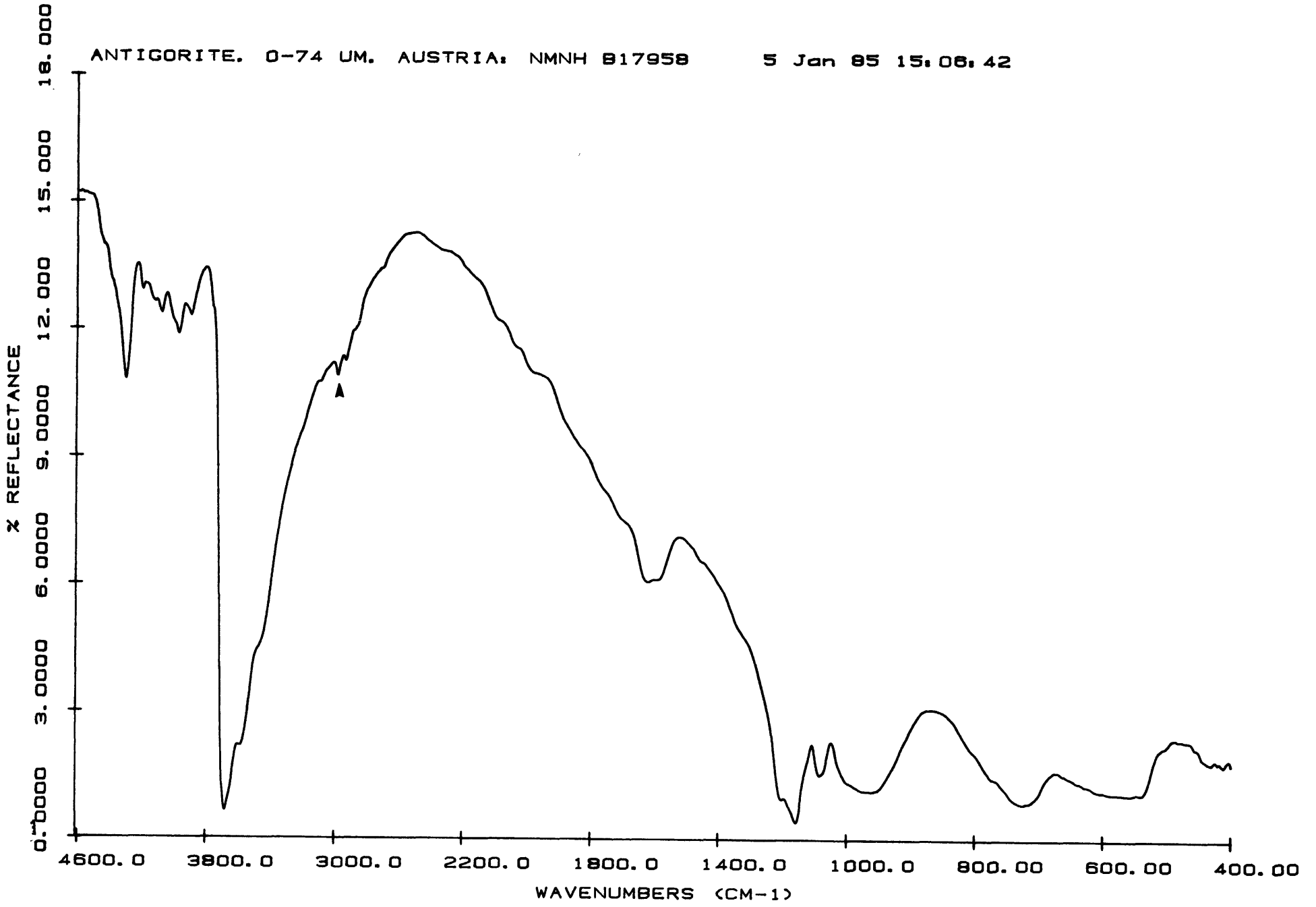

ANTIGORITE IN KBR. AUSTRIA: NMNH B17958 30 Dec 85 15:21:11
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

70


ANTIGORITE. CLEAVAGE FACE. AUSTRIA: NMNH B17958 14 Jan 85 14:09:32
% REFLECTANCE
60.000
50.000
40.000
30.000
20.000
10.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

17


ANTIGORITE. 74-250 UM. AUSTRIA: NMNH B17958
6 Jan 85 15:35:39
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ANTIGORITE. 0-74 UM. AUSTRIA: NMNH B17958 5 Jan 85 15:06:42
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Augite (Ca, Na) (Mg, Fe, Al, Ti) $(Si, Al)_2 O_6$

Locality: Monteagle Township, Hostings Co., Ontario, Canada

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 117461

Results of petrographic examination: Two black pieces, 7.24 and 4.34 g, and several small fragments totaling 9.3 g.; parts of single crystal(s). Some surface contamination (calcite) which may be removed by brushing or scratching the surface. Under the microscope, the sample displays very little alteration and seems to be pure. Grains are deep green and generally clear. Ground sample washed in dilute HCl to remove residual calcite, but extremely weak carbonate bands are still seen in the spectrum of the 74-250 um size range.

Results of XRD: Pure augite.

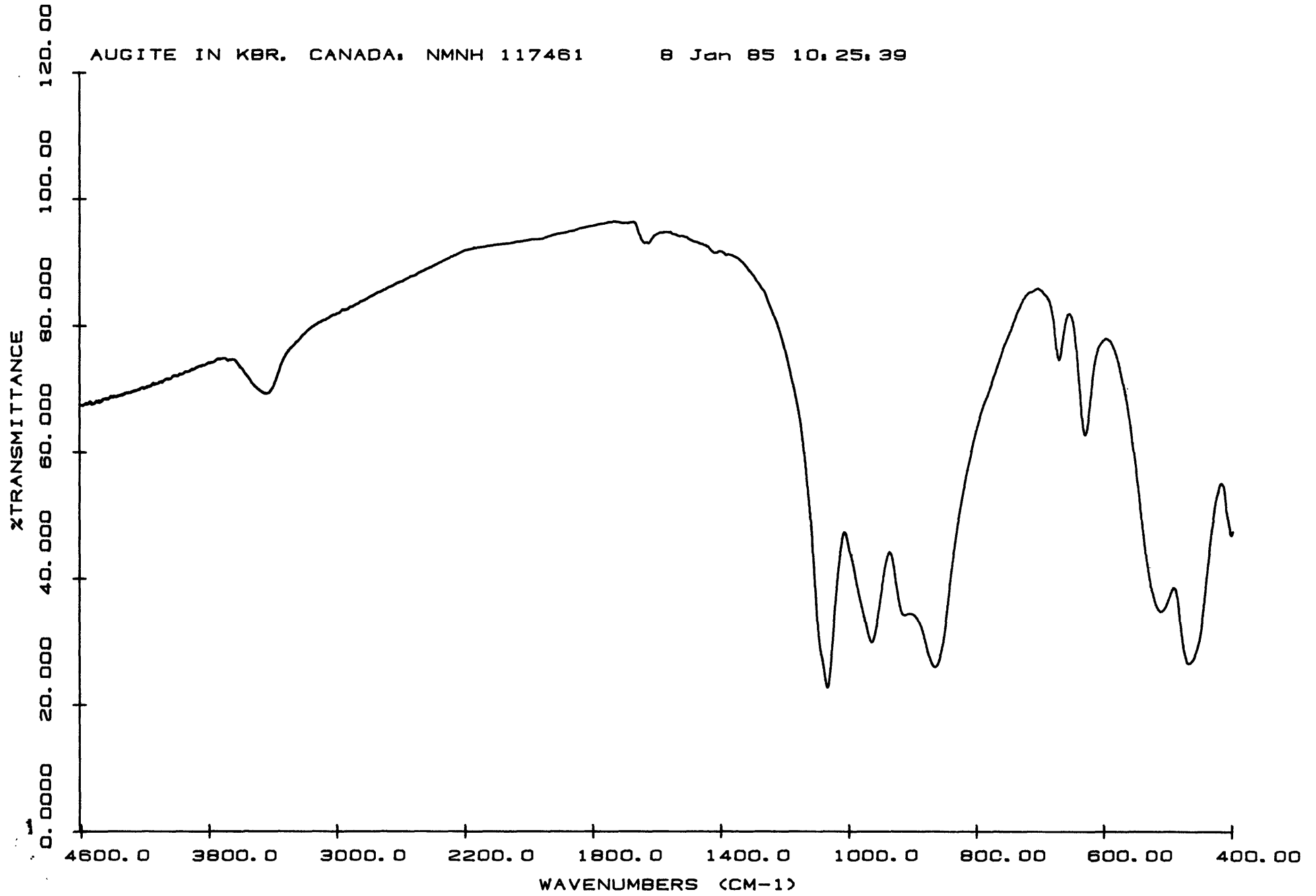
Results of XRF or other compositional analysis:

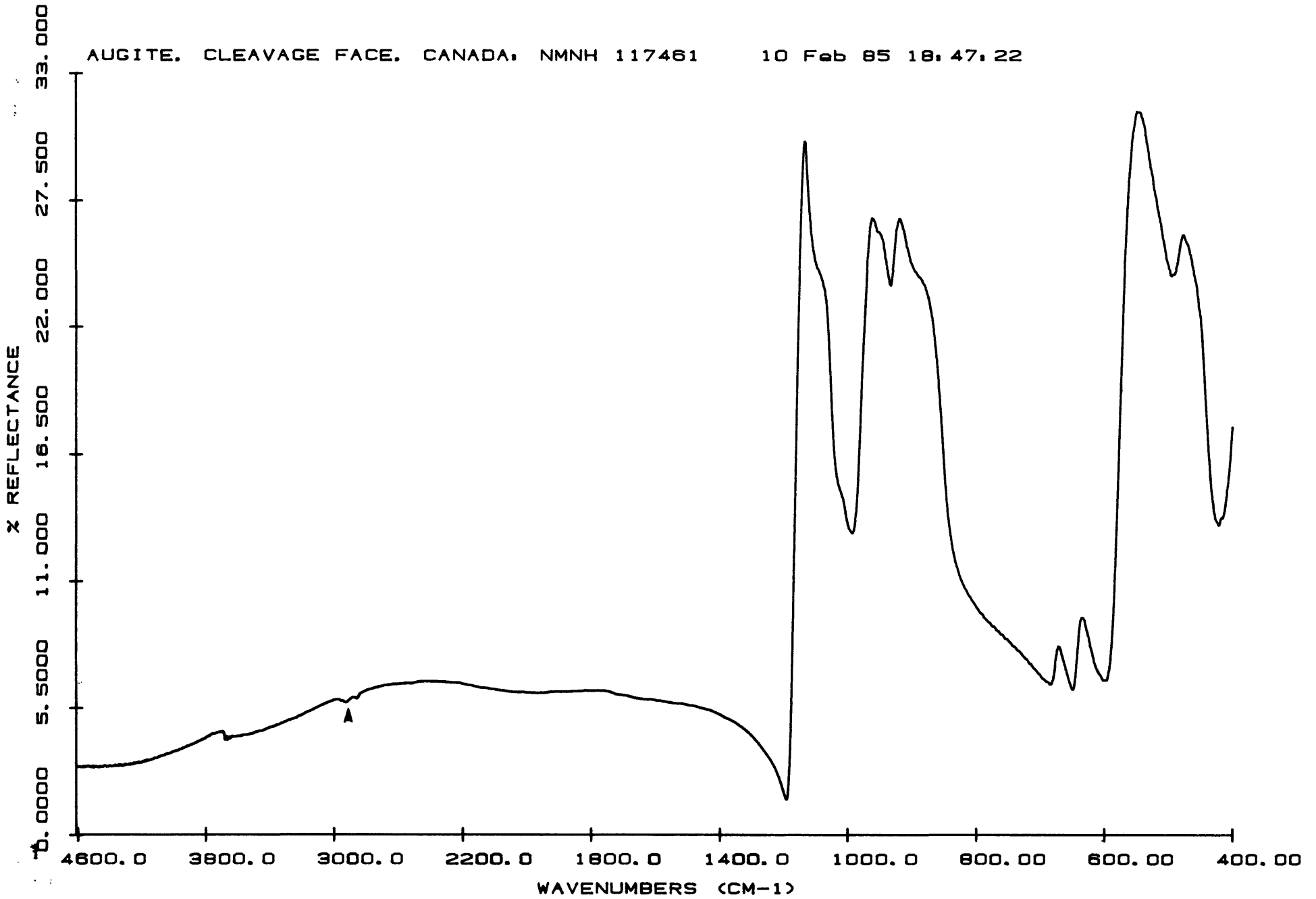
Microprobe analysis shows the sample to be fairly homogeneous, with a slight (± 0.5%) variation in alumina that cannot be balanced against any other chemical variation. Analysis indicates WO50, EN13, FS37 composition. Average of 10 analyses:

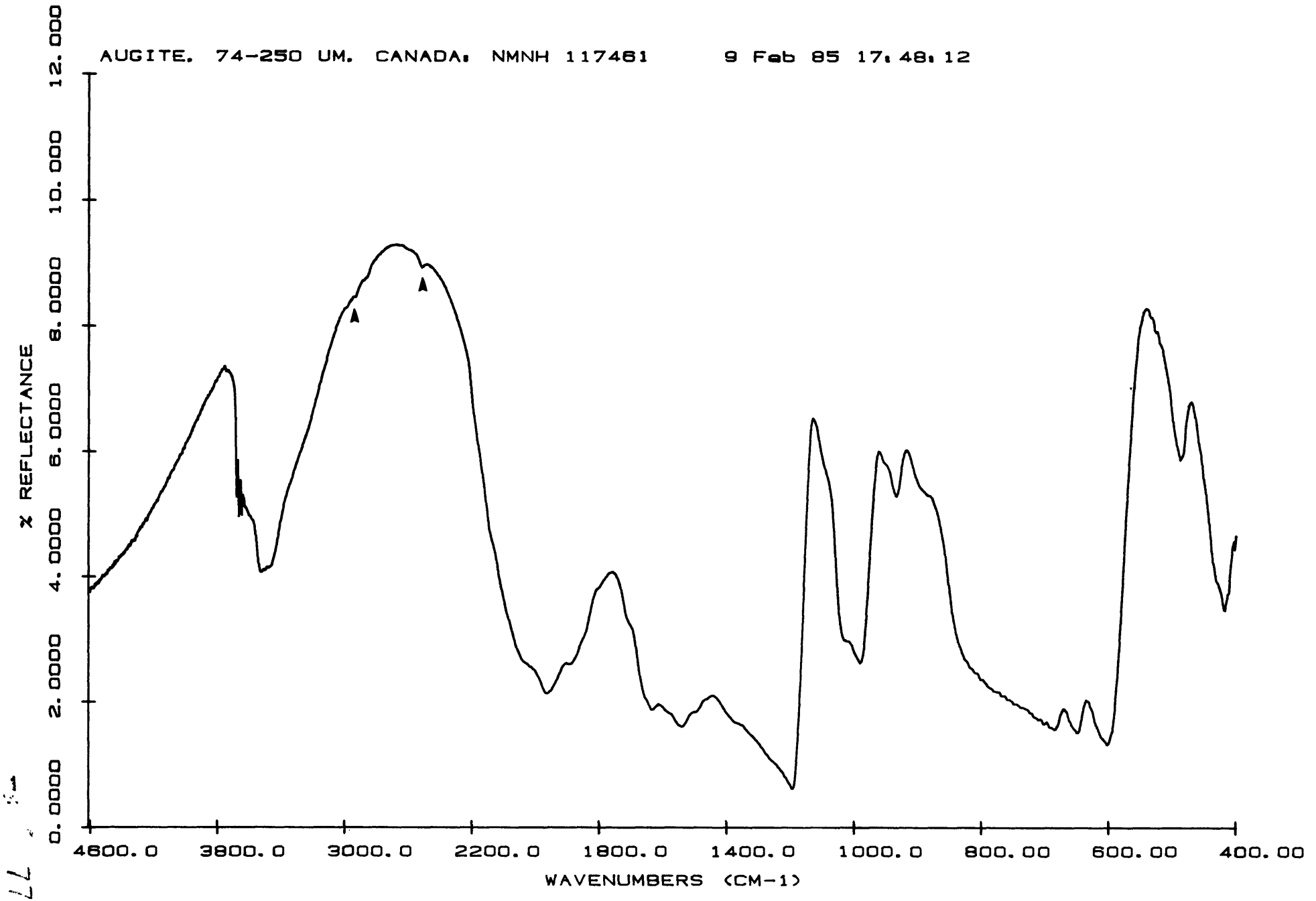
SiO_2	- 49.92
Al_2O_3	- 0.92
FeO	- 19.26
MgO	- 5.33
CaO	- 22.21
K_2O	- 0.03
Na_2O	- 0.99
TiO_2	- 0.06
MnO	- 1.62
Total	-100.34

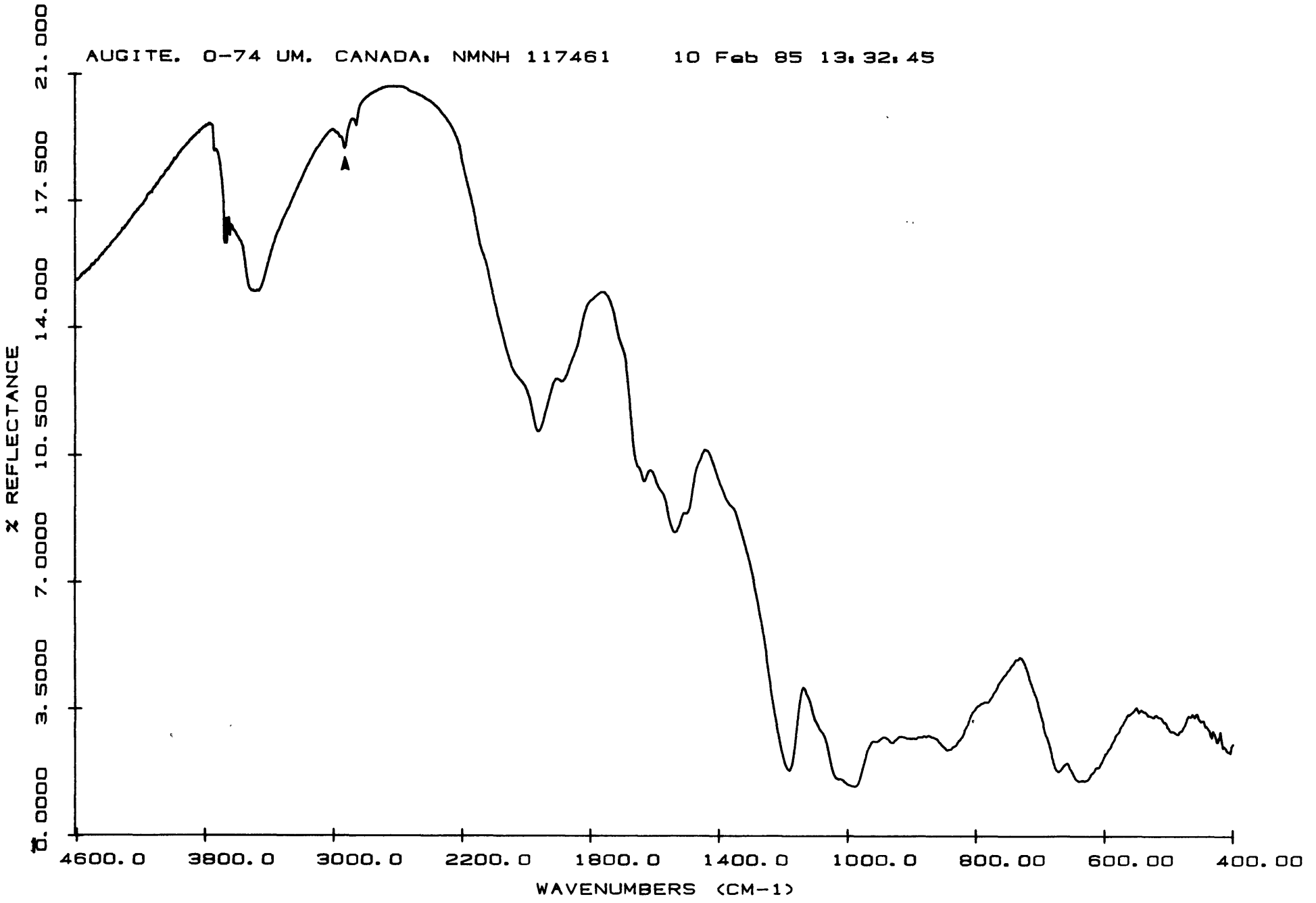
Spectra of file:

Augite.1 Reflectance spectrum of cleavage face on solid sample disk #1.
Augite.1 Reflectance spectrum of 0-74 um size range on disk #1.
Augite.1 Transmittance on disk #1.
Augite.1 Reflectance spectrum of 74-250 um size range on disk #1.


AUGITE IN KBR. CANADA: NMNH 117461 8 Jan 85 10:25:39
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


AUGITE. CLEAVAGE FACE. CANADA: NMNH 117461 10 Feb 85 18:47:22
% REFLECTANCE
33.000
27.500
22.000
16.500
11.000
5.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


AUGITE. 74-250 UM. CANADA: NMNH 117461 9 Feb 85 17:48:12
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


AUGITE. 0-74 UM. CANADA: NMNH 117461 10 Feb 85 13:32:45
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Augite (Ca, Na) (Mg, Fe, Al, Ti) $(Si, Al)_2O_6$

Locality: Rozier (nr.), Gorges du Tarn, Tarn, France

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 120049

Results of petrographic examination: One 22.31g. piece, black, probably part of one crystal; some veining with lighter mineral (serpentine?) difficult to remove. Microscopic examination of hand-picked sample indicates about 1-2% contamination by low-index, iron stained mineral. Cleavage is virtually non-existent, however, index of refraction and 2V point to augite.

Results of XRD: Sample is augite plus a moderate amount of dolomite. Sample subsequently treated with warm HCl to remove dolomite.

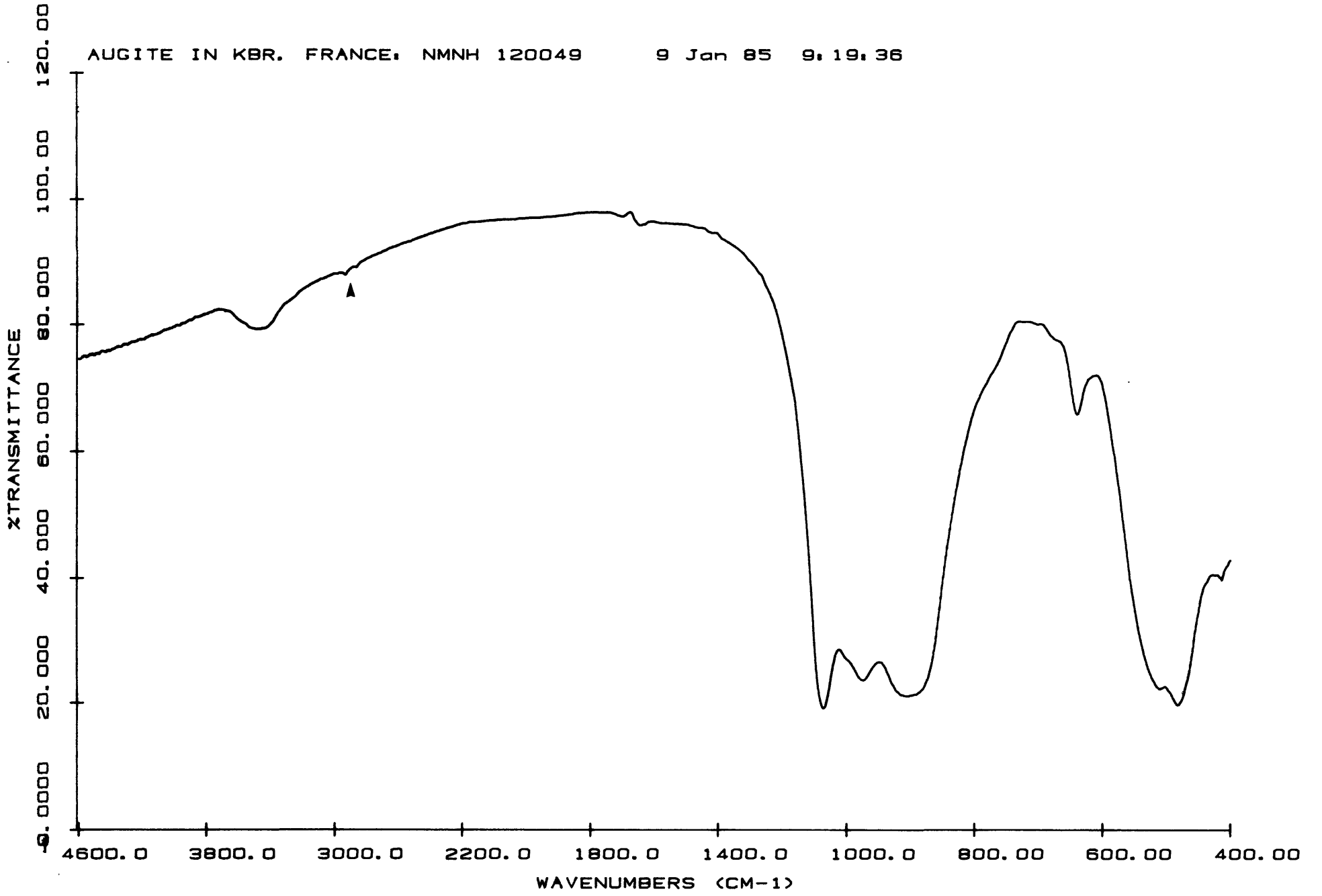
Results of XRF or other compositional analysis:

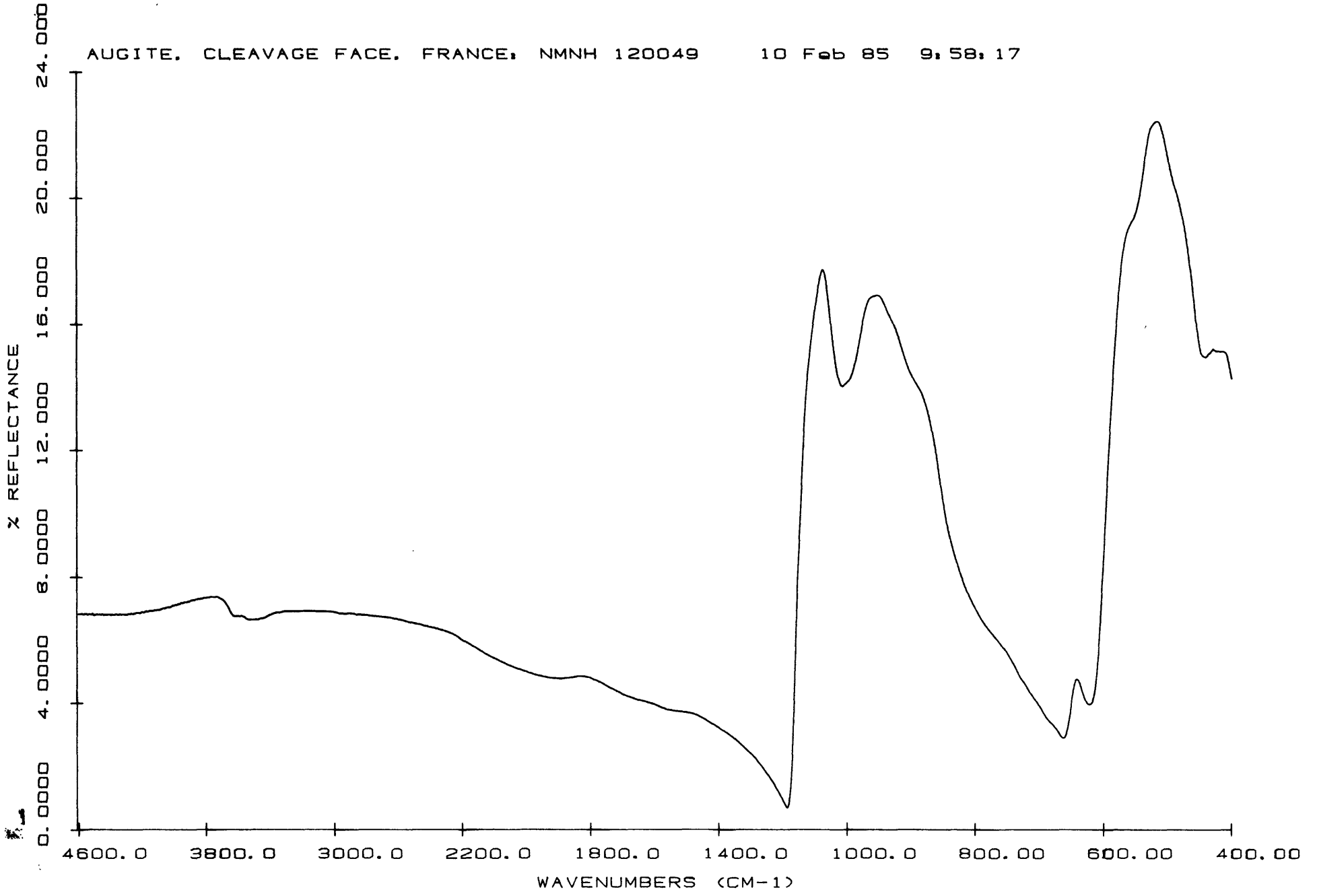
Microprobe analysis shows the sample to be homogenous within and between grains. Sample could be classified as "ferroan augite". It has relatively high alumina, iron and soda, and low calcuim. Analysis indicates WO34, EN45, FS21 composition. Average of 10 analyses:

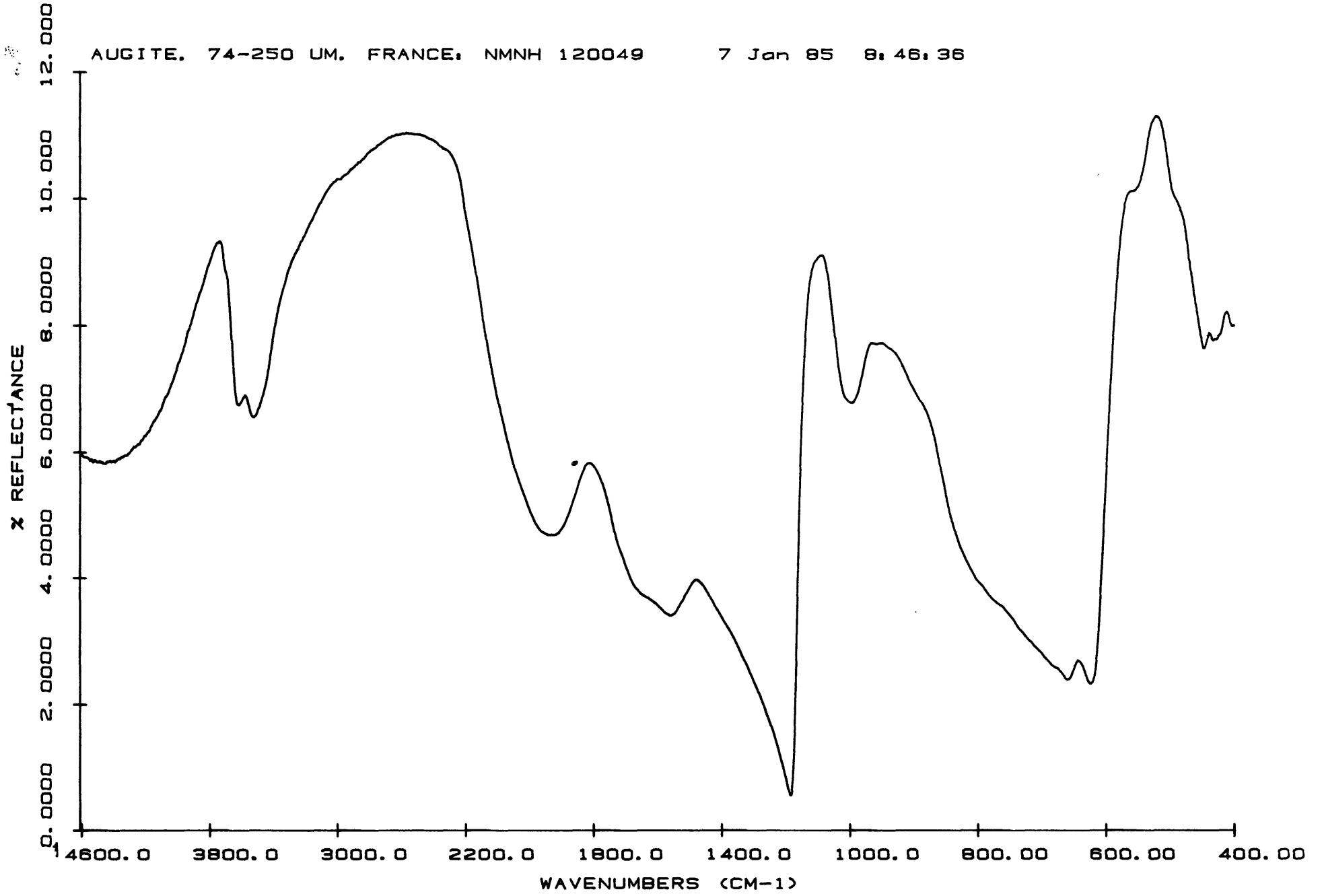
SiO_2	- 48.93
Al_2O_3	- 8.44
FeO	- 8.59
MgO	- 14.37
CaO	- 16.87
K_2O	- 0.02
Na_2O	- 1.57
TiO_2	- 1.38
MnO	- 0.21
	Total -100.38

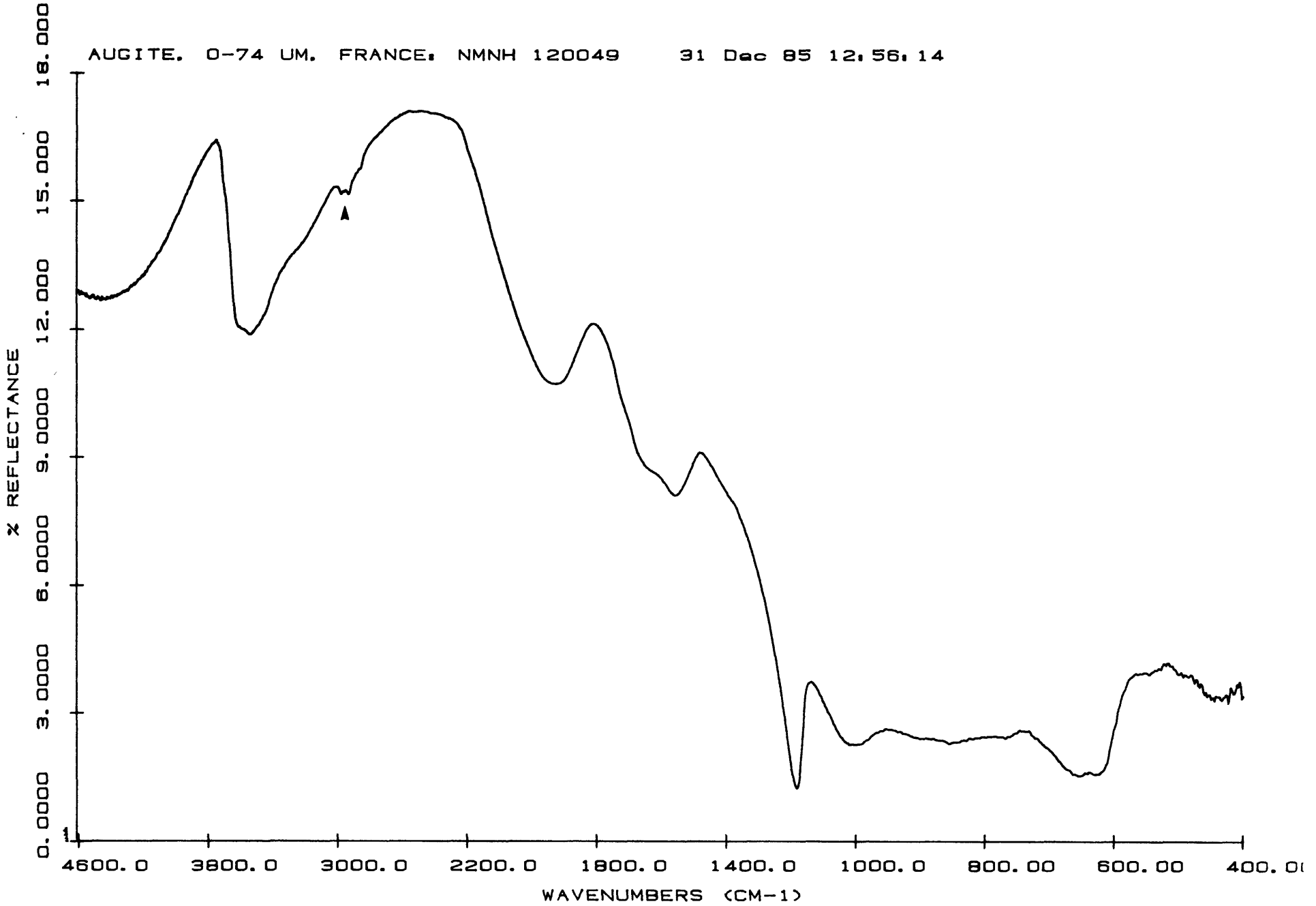
Spectra of file:

Augite.2	Reflectance spectra of cleavage face on solid sample disk #1.
Augite.2	Reflectance of 0-74 um size range on disk #1.
Augite.2	Transmittance on disk #1.
Augite.2	Reflectance spectrum of 74-250 um size range on disk #1.
Augite.2A	Reflectance spectrum of 74-250 um size range, treated with HCl, on disk #1.


AUGITE IN KBR. FRANCE: NMNH 120049 9 Jan 85 9:19:36
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


AUGITE. CLEAVAGE FACE. FRANCE: NMNH 120049 10 Feb 85 9:58:17
% REFLECTANCE
0.0000
4.0000
8.0000
12.000
16.000
20.000
24.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


AUGITE. 74-250 UM. FRANCE: NMNH 120049 7 Jan 85 8:46:36
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


AUGITE. 0-74 UM. FRANCE: NMNH 120049 31 Dec 85 12:56:14
% REFLECTANCE
0.0000
3.0000
6.0000
9.0000
12.000
15.000
18.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.0
WAVENUMBERS (CM-1)

Species name: Beryl $Be_3Al_2Si_6O_{18}$

Locality: Maine

Last donor: Hunt and Salisbury Collection

Intermediate donor:

Ultimate donor: Ward's Scientific

Catalog numbers, etc.: H & S 180B

Results of petrographic examination: Hand sample is pale green and appears pure. Microscopic examination shows that there is a small amount (2% or less) of very fine, low birefringent material in the sample. The grains occasionally have rhombic or cubic shape. These grains unidentifiable.

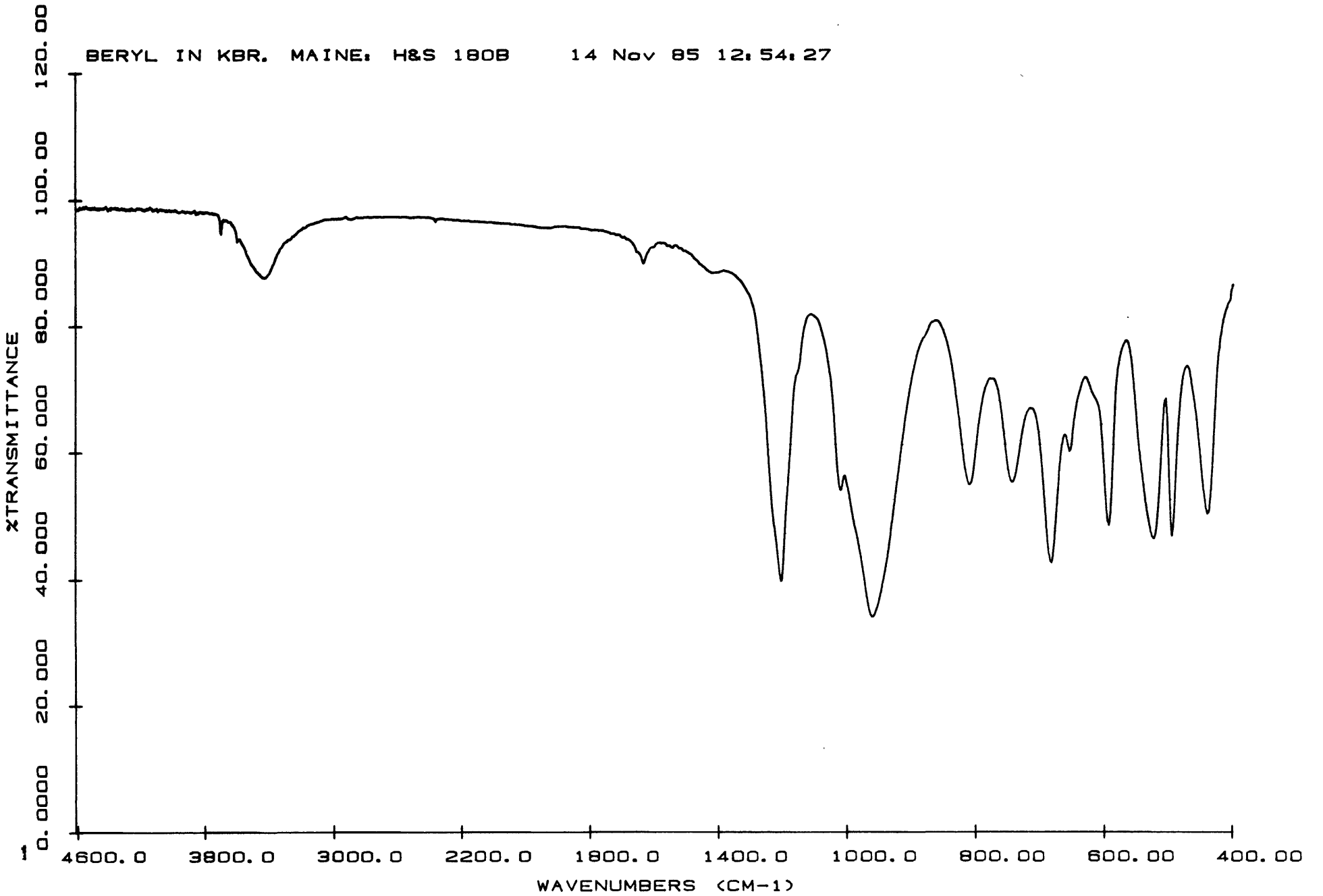
Results of XRD: Pure beryl.

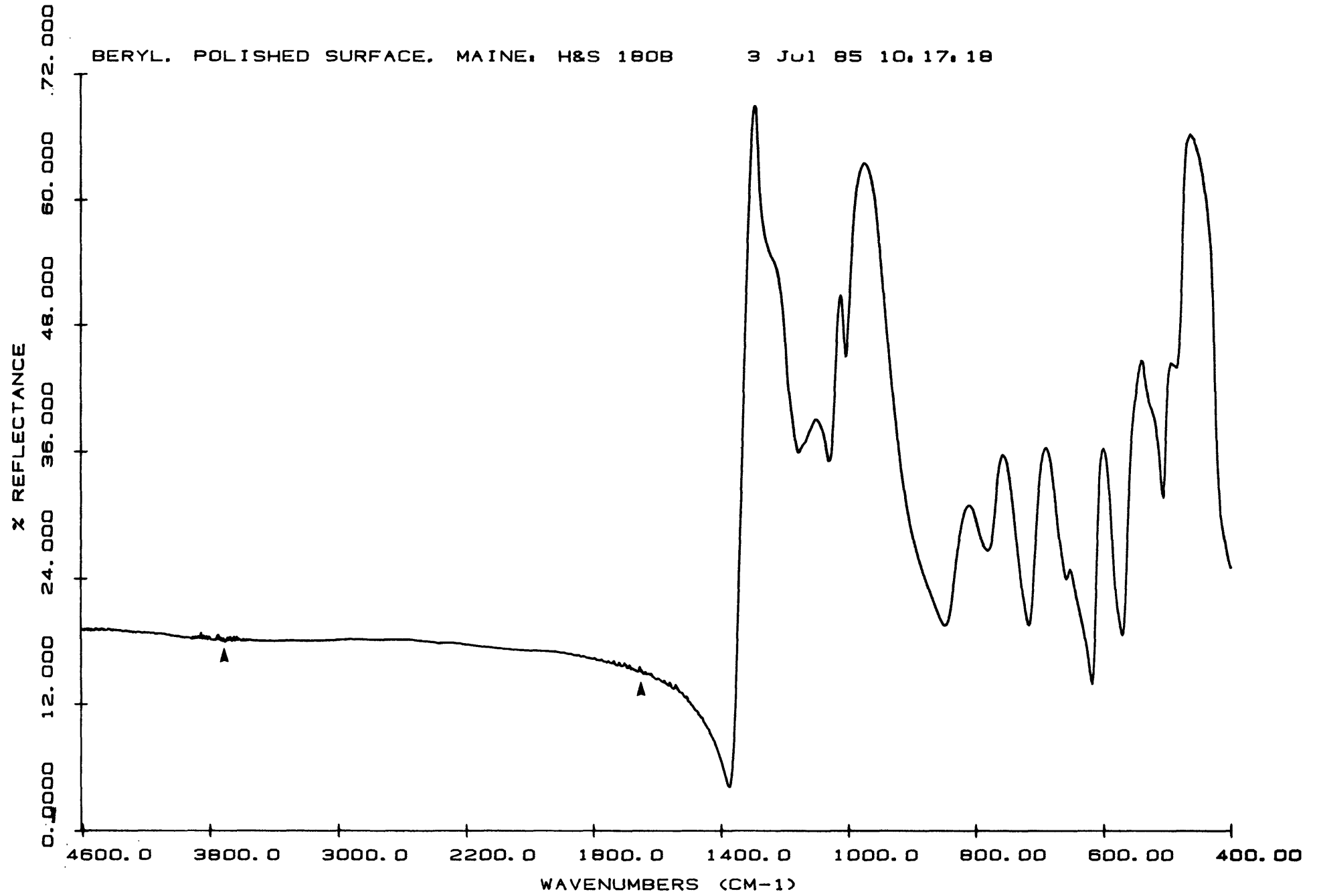
Results of XRF or other compositional analysis: Microprobe analysis shows that grains selected are homogeneous within and between grains. Average of 10 analyses lacking beryllium indicates silica and alumina content appropriate for beryl:

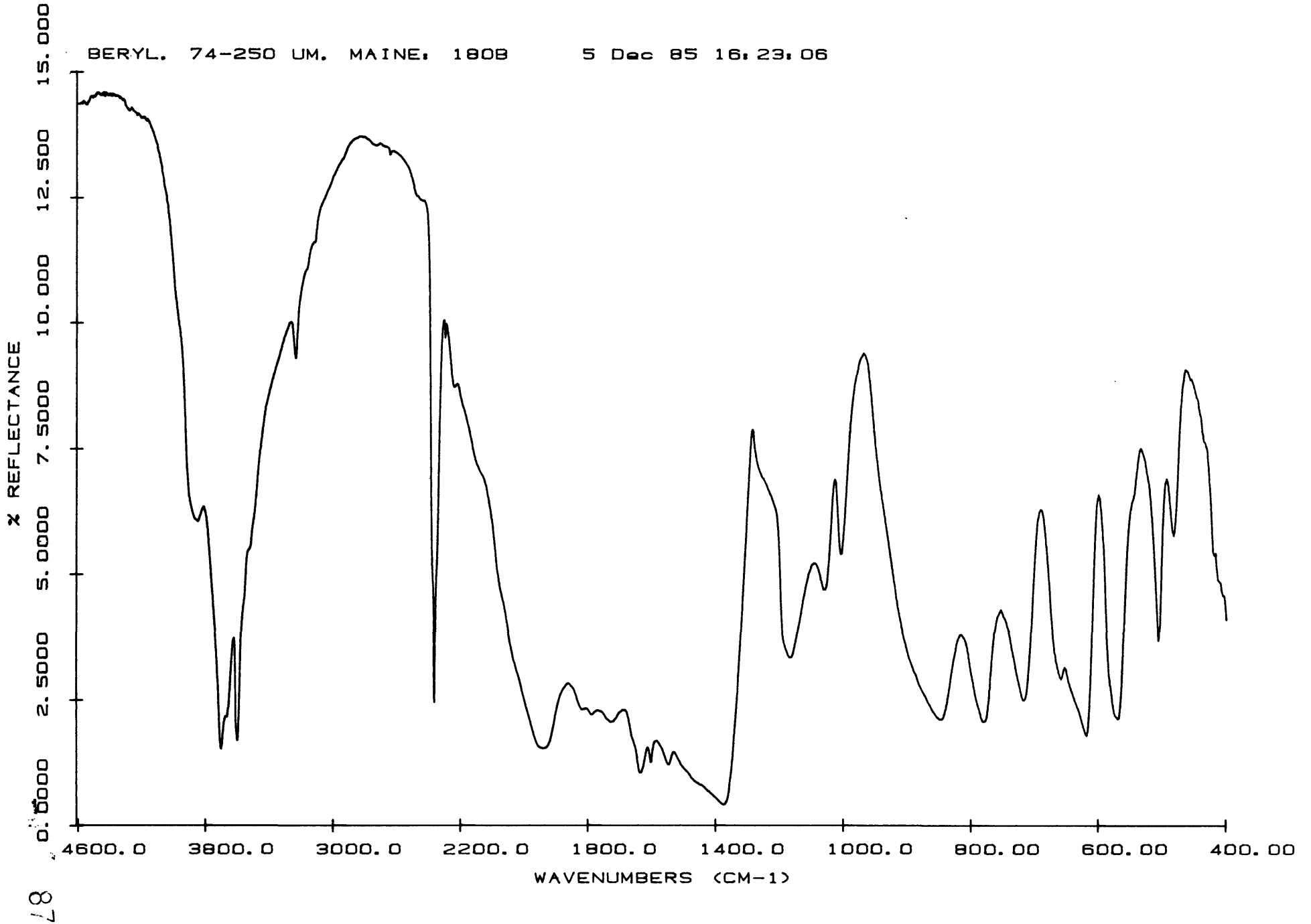
SiO_2	-	66.12
Al_2O_3	-	17.36
FeO	-	0.48
MgO	-	0.17
CaO	-	0.01
K_2O	-	0.03
Na_2O	-	0.35
TiO_2	-	0.01
MnO	-	0.00
Total	-	84.53 (without beryllium)

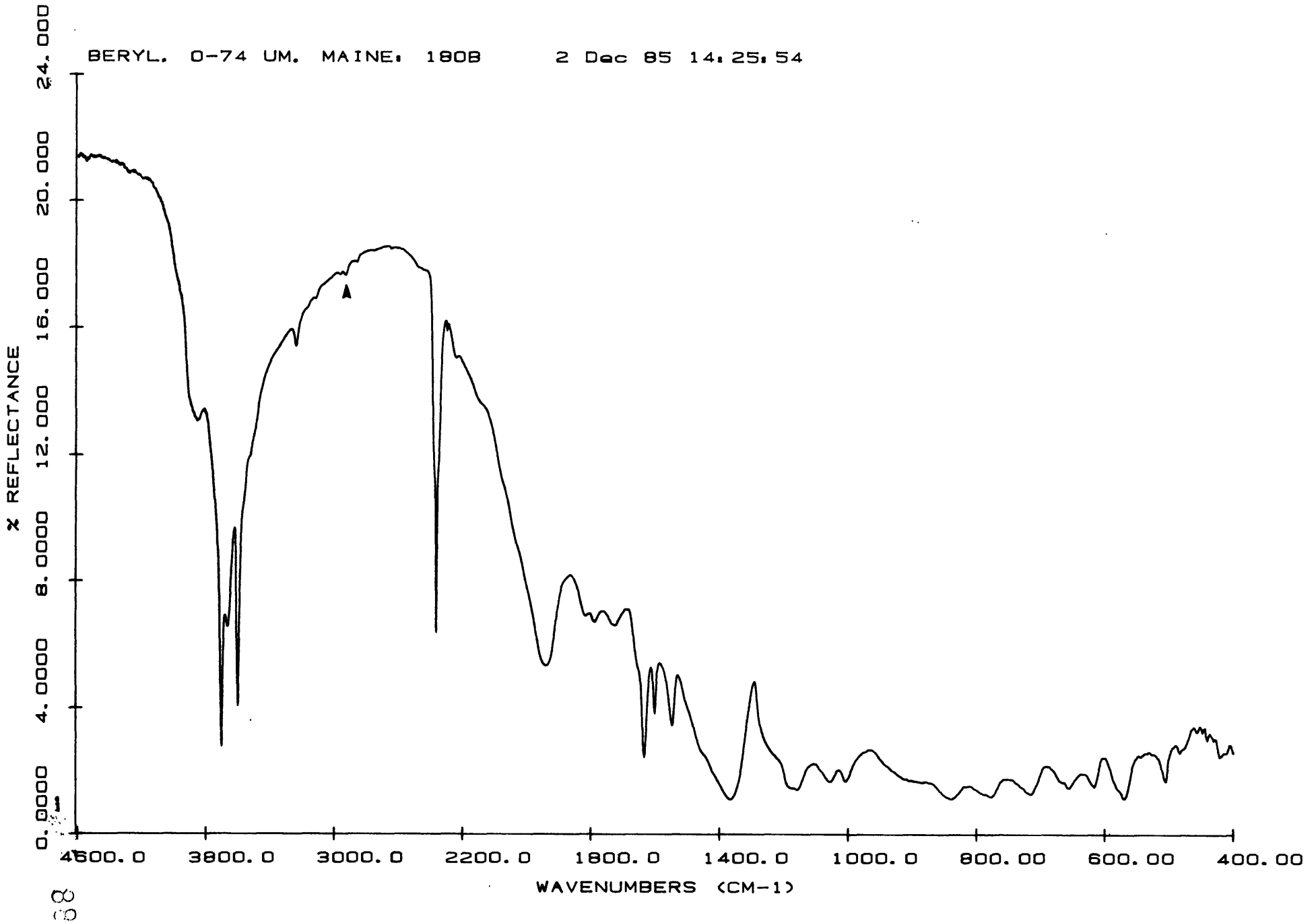
Spectra on file:

Beryl.1 Reflectance spectrum of 0-74 um size range disk #1.
Beryl.1 Reflectance spectrum of 74-250 um size range on Disk #1.
Beryl.1 Reflectance spectrum of polished surface on solid sample disk #1.
Beryl.1 Transmittance spectrum on disk #1.


BERYL IN KBR. MAINE: H&S 180B 14 Nov 85 12:54:27
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


BERYL. POLISHED SURFACE. MAINE: H&S 180B
3 Jul 85 10:17:18
% REFLECTANCE
72.000
60.000
48.000
36.000
24.000
12.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


BERYL. 74-250 UM. MAINE: 1808
5 Dec 85 16:23:06
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


BERYL. 0-74 UM. MAINE: 1808
2 Dec 85 14:25:54
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Beryl $Be_3Al_2Si_6O_{18}$

Locality: Palermo Mine, North Groton, New Hampshire

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 134700

Results of petrographic examination: Hand sample is pale green to white in color and appears pure. Small amount of surface discoloration. Sample is large, about 2cm cubed. Microscopic examination indicates it is pure with a very small amount (much less than 1%) alteration.

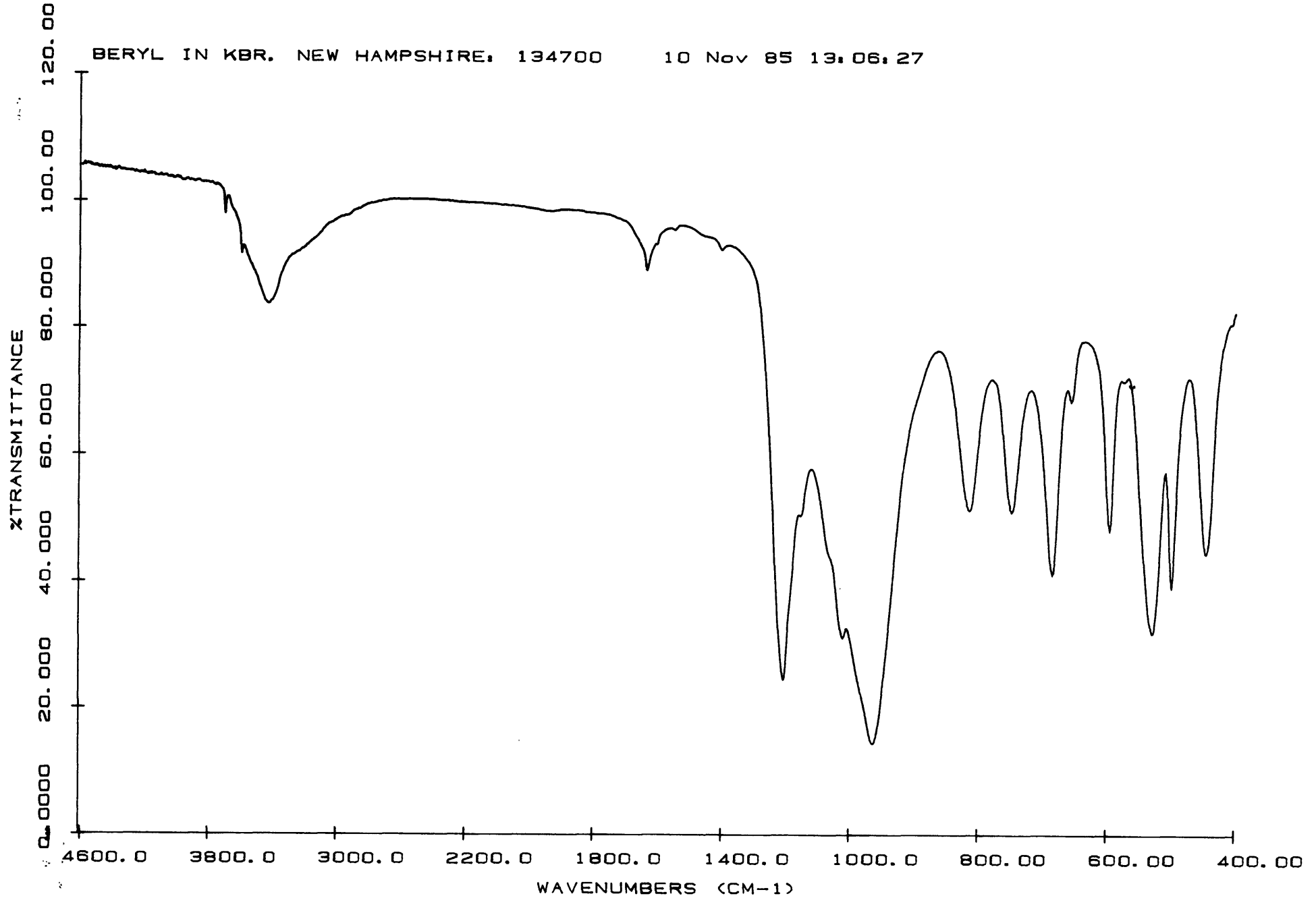
Results of XRD: Pure beryl.

Results of XRF or other compositional analysis: Microprobe analysis shows that grains selected are homogeneous within and between grains. Average of 7 analyses lacking beryllium indicates silica and alumina content appropriate for beryl:

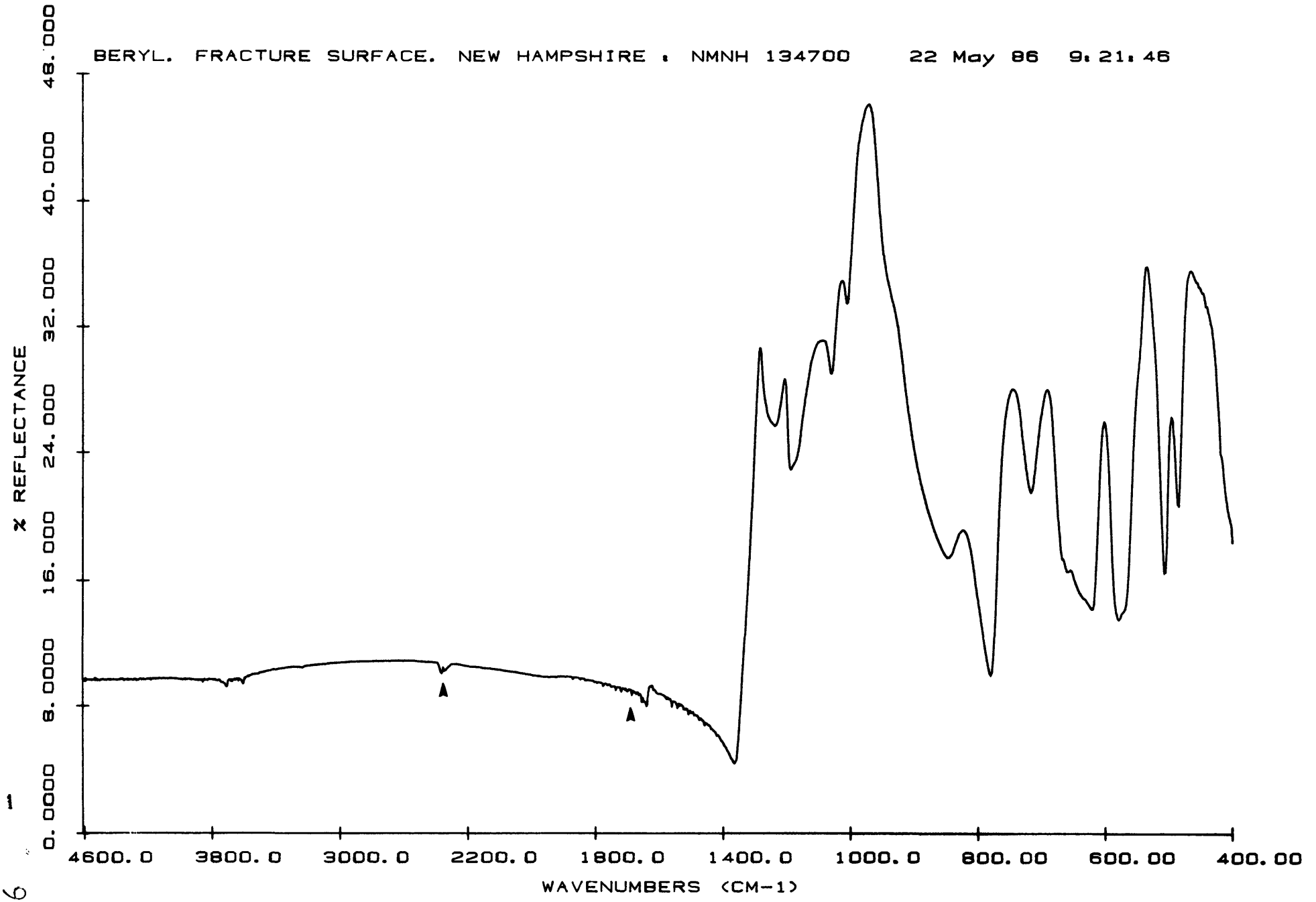
SiO_2	- 64.62
Al_2O_3	- 17.20
FeO	- 0.17
MgO	- .0.05
CaO	- 0.01
K_2O	- 0.03
Na_2O	- 0.72
TiO_2	- 0.01
MnO	- 0.00
Total	- 82.81 (without beryllium)

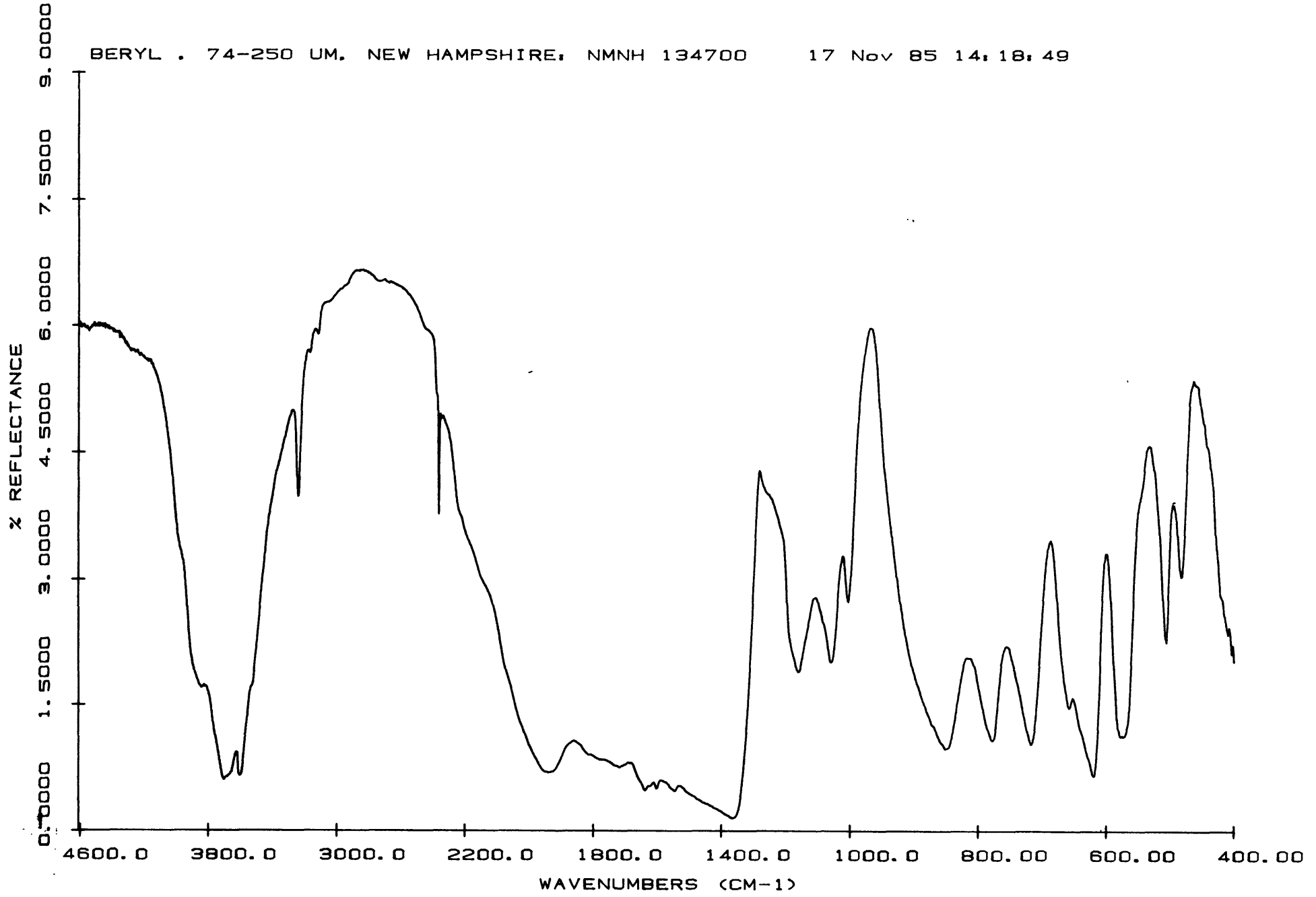
Spectra on file:

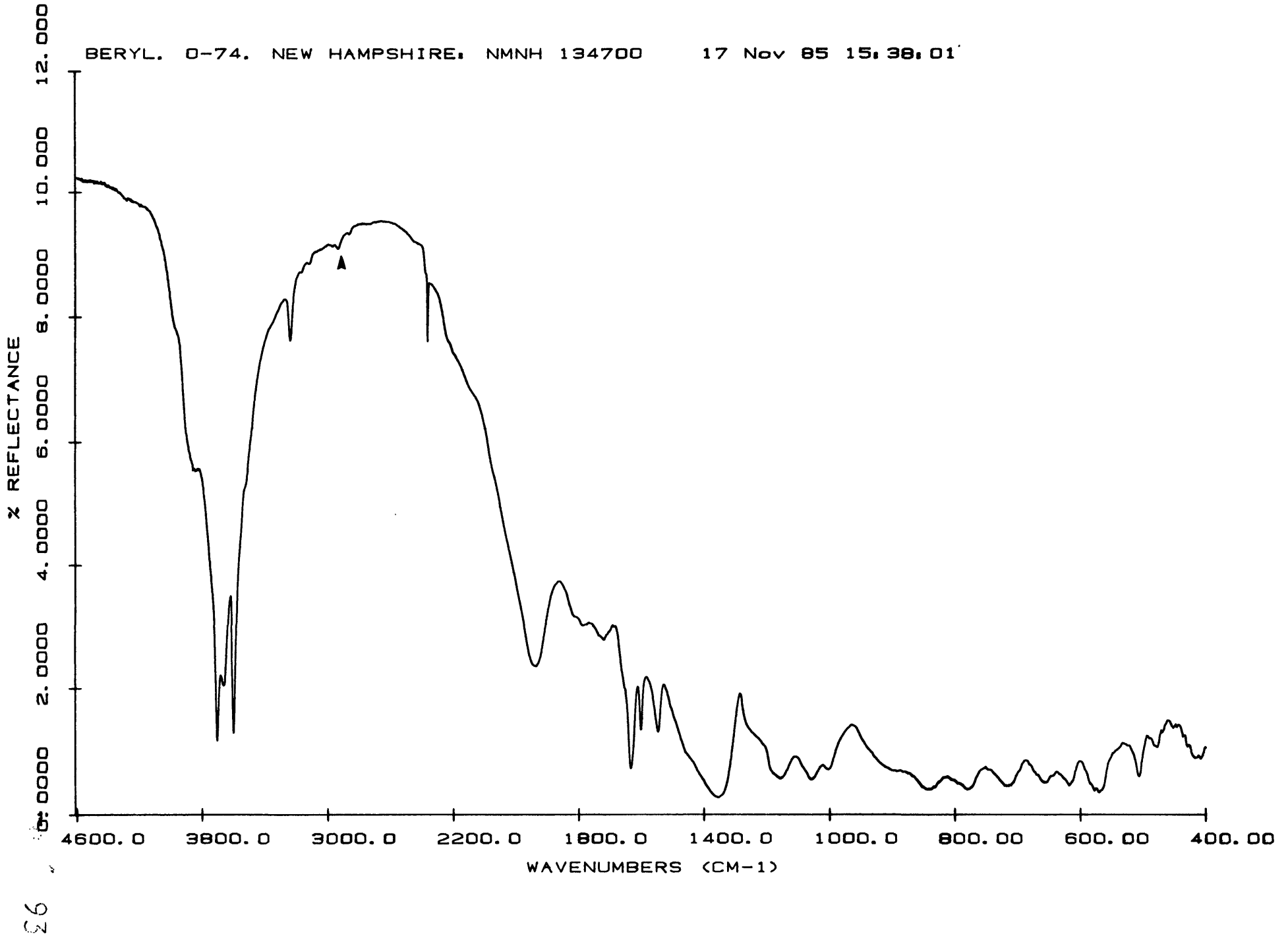
Beryl.2	Reflectance spectrum of fracture surface using SpectroTech attachment. Solid sample Disk #1.
Beryl.2	Reflectance spectrum of 0-74 um on Disk #1.
Beryl.2	Reflectance spectrum of 74-250 um on Disk #1.
Beryl.2	Transmittance spectrum on Disk #1.


BERYL IN KBR. NEW HAMPSHIRE: 134700 10 Nov 85 13:06:27
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

06


BERYL. FRACTURE SURFACE. NEW HAMPSHIRE : NMNH 134700 22 May 86 9:21:46
% REFLECTANCE
48.000
40.000
32.000
24.000
16.000
8.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


BERYL . 74-250 UM. NEW HAMPSHIRE: NMNH 134700 17 Nov 85 14:18:49
% REFLECTANCE
9.0000
7.5000
6.0000
4.5000
3.0000
1.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


BERYL. O-74. NEW HAMPSHIRE: NMNH 134700 17 Nov 85 15:38:01
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

26

Species name: Bustamite $(Mn, Ca)_3 Si_3O_9$

Locality: Franklin, New Jersey

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH R3099

Results of petrographic examination: Hand sample is pink in color, 2-3 cm in length x 1-2 cm wide and appears pure except for a few grains of calcite that were removed. Under petrographic microscope, about 2% of grains show some light alteration. Sample chosen for probe analysis is comprised of clean, homogenous grains. Sample was treated with acetic acid to remove remaining calcite.

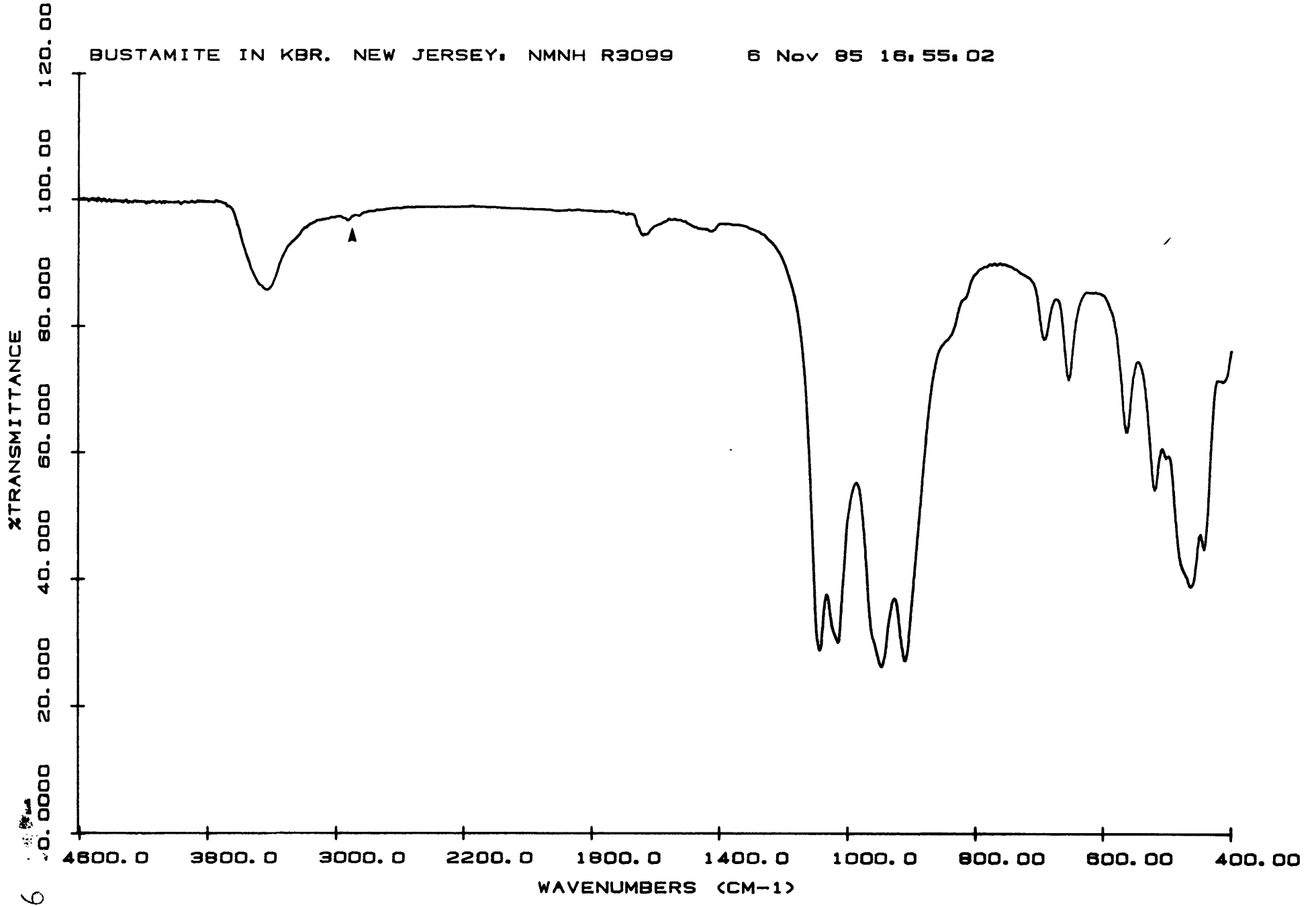
Results of XRD: Pure bustamite (Jim Crowley).

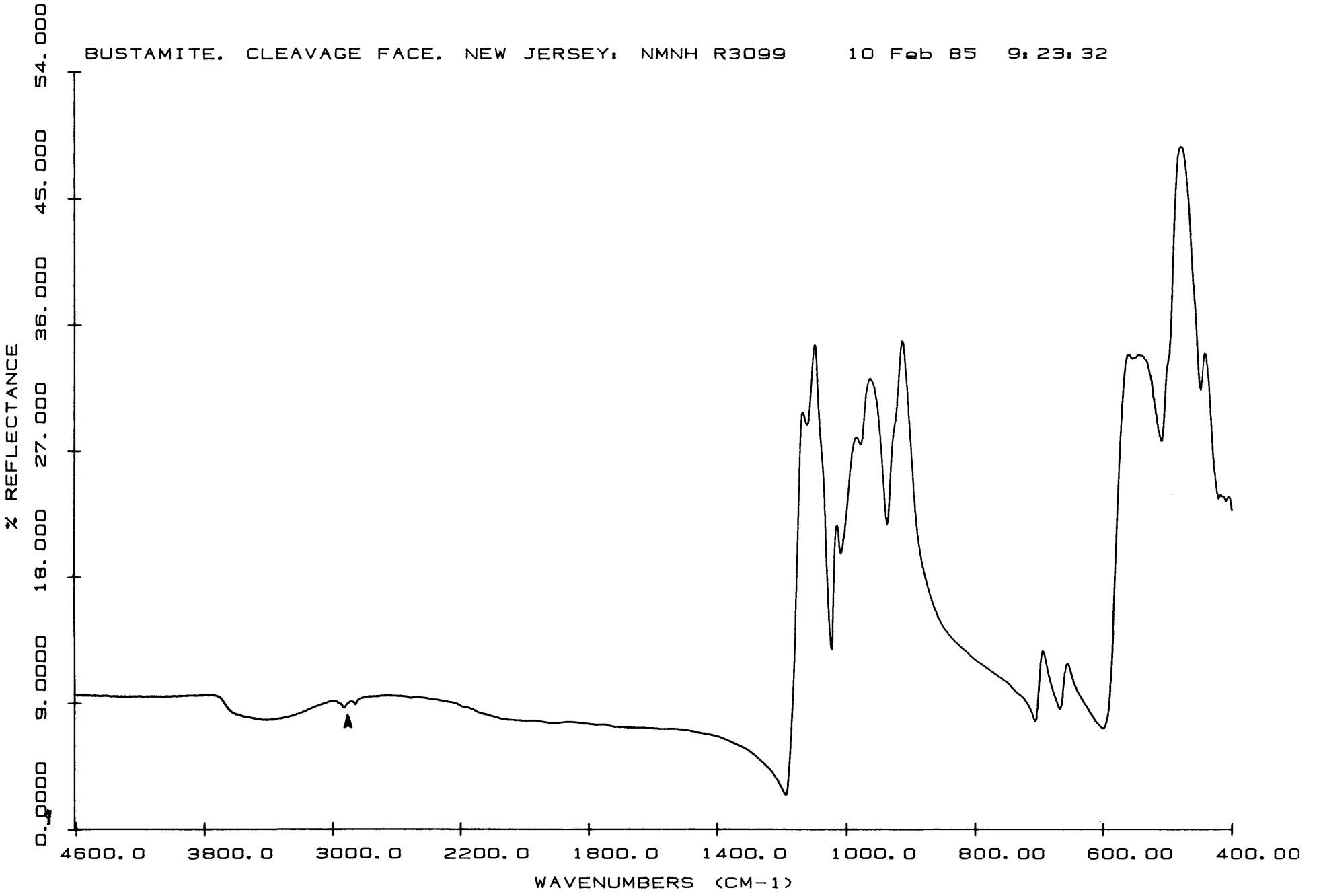
Results of XRF or other compositional analysis: Microprobe analysis shows grains selected to be homogeneous within and between grains. Average of 12 analyses:

SiO_2	- 47.91
Al_2O_3	- 0.05
FeO	- 0.31
MgO	- 0.20
CaO	- 20.20
K_2O	- 0.03
Na_2O	- 0.11
TiO_2	- 0.07
MnO	- 31.73
Total	-100.58

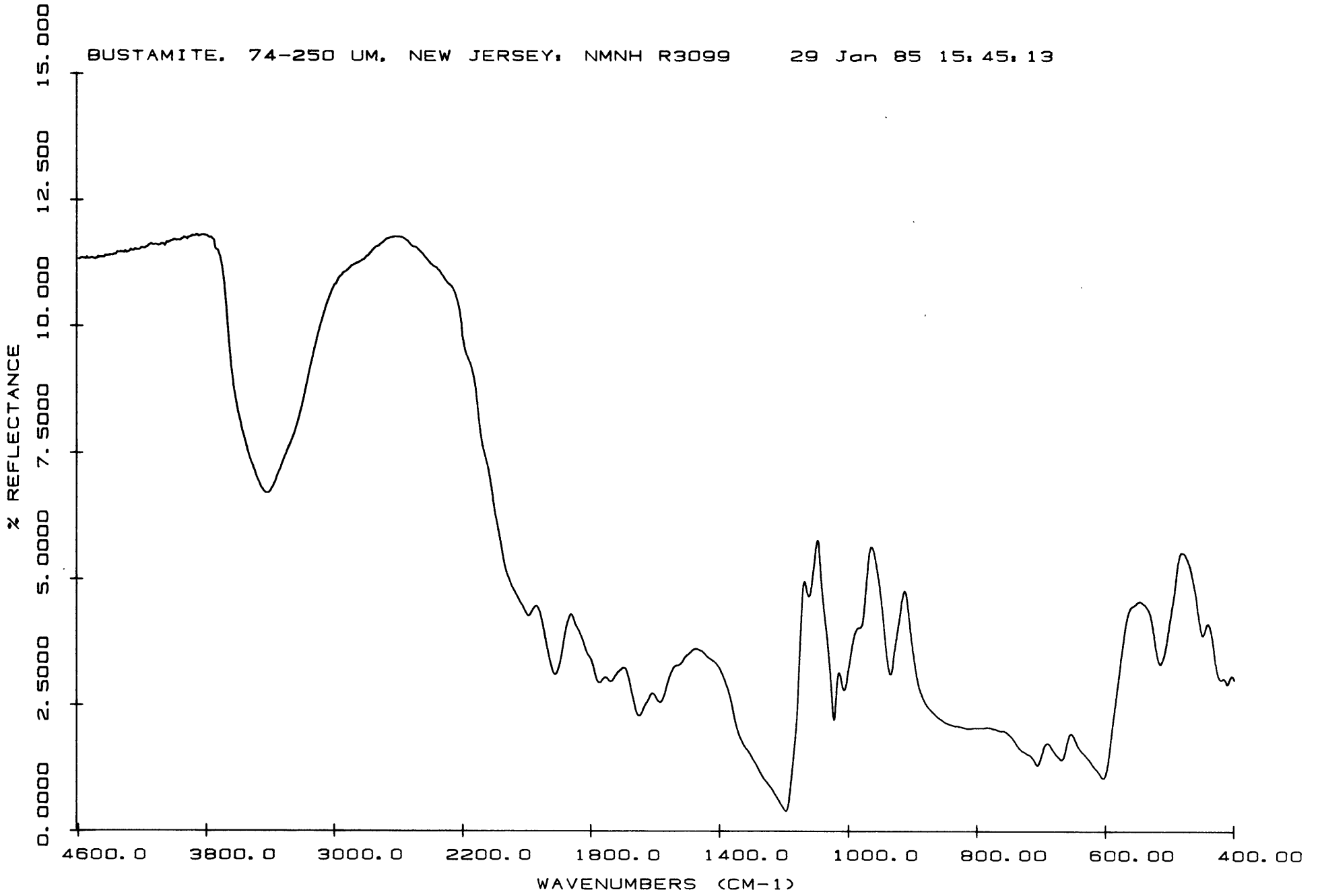
Spectra on file:

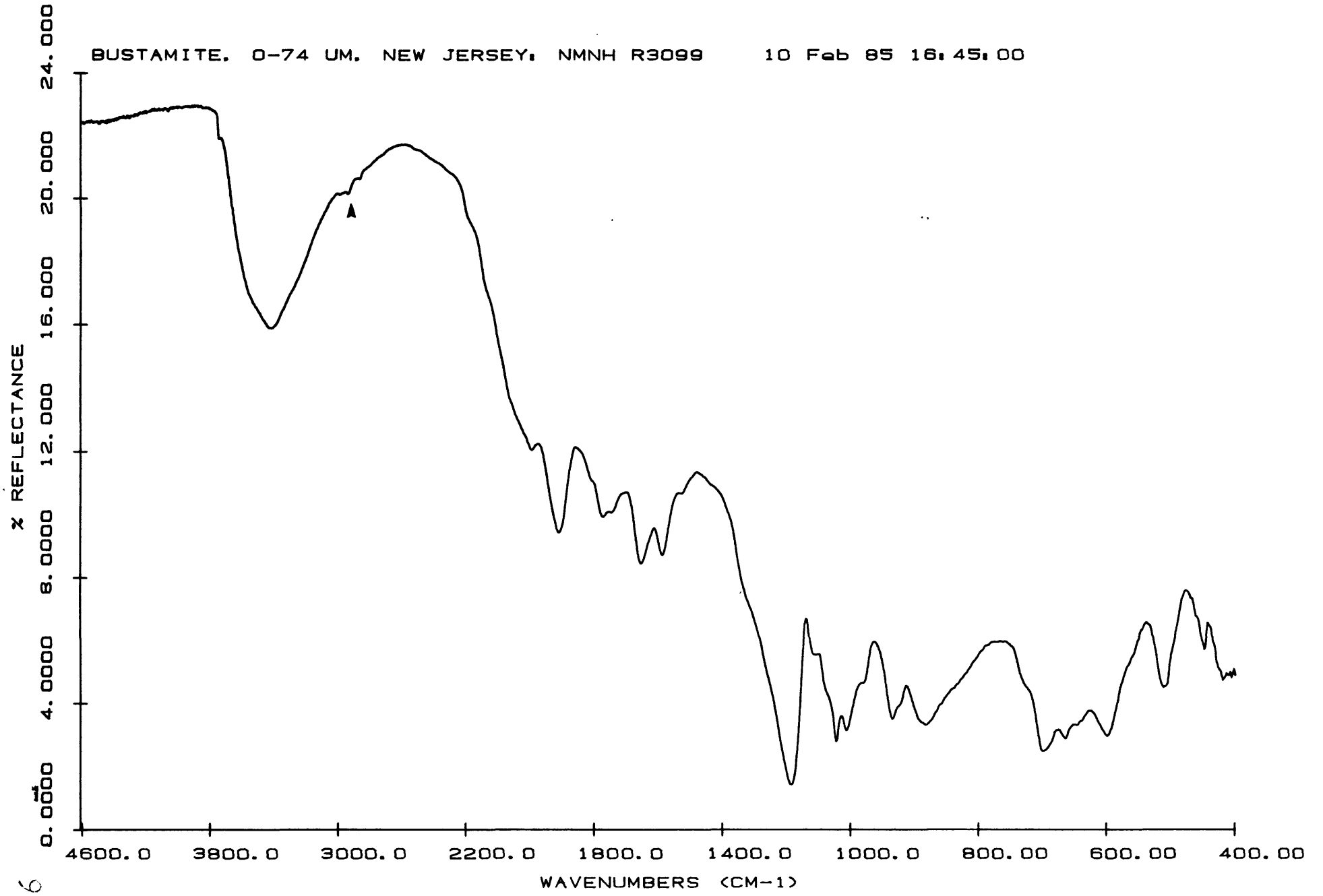
Bustamite.1	Reflectance spectrum of 100 cleavage face (?) on solid sample Disk #1.
Bustamite.1	Reflectance spectrum of 74-250 um size range on Disk #1.
Bustamite.1	Reflectance spectrum of 0-74 um size range on Disk #1.
Bustamite.1	Transmittance spectrum on Disk #1.


BUSTAMITE IN KBR. NEW JERSEY: NMNH R3099 6 Nov 85 16:55:02
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


BUSTAMITE. CLEAVAGE FACE. NEW JERSEY: NMNH R3099 10 Feb 85 9:23:32
% REFLECTANCE
54.000
45.000
36.000
27.000
18.000
9.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

25


BUSTAMITE. 74-250 UM. NEW JERSEY: NMNH R3099 29 Jan 85 15:45:13
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


BUSTAMITE. 0-74 UM. NEW JERSEY: NMNH R3099 10 Feb 85 16:45:00
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Calcite $CaCo_3$

Locality: Mexico

Last donor: Hunt and Salisbury collection

Intermediate donor:

Ultimate donor: Ward's Scientific

Catalog numbers, etc.: Hunt and Salisbury 194B

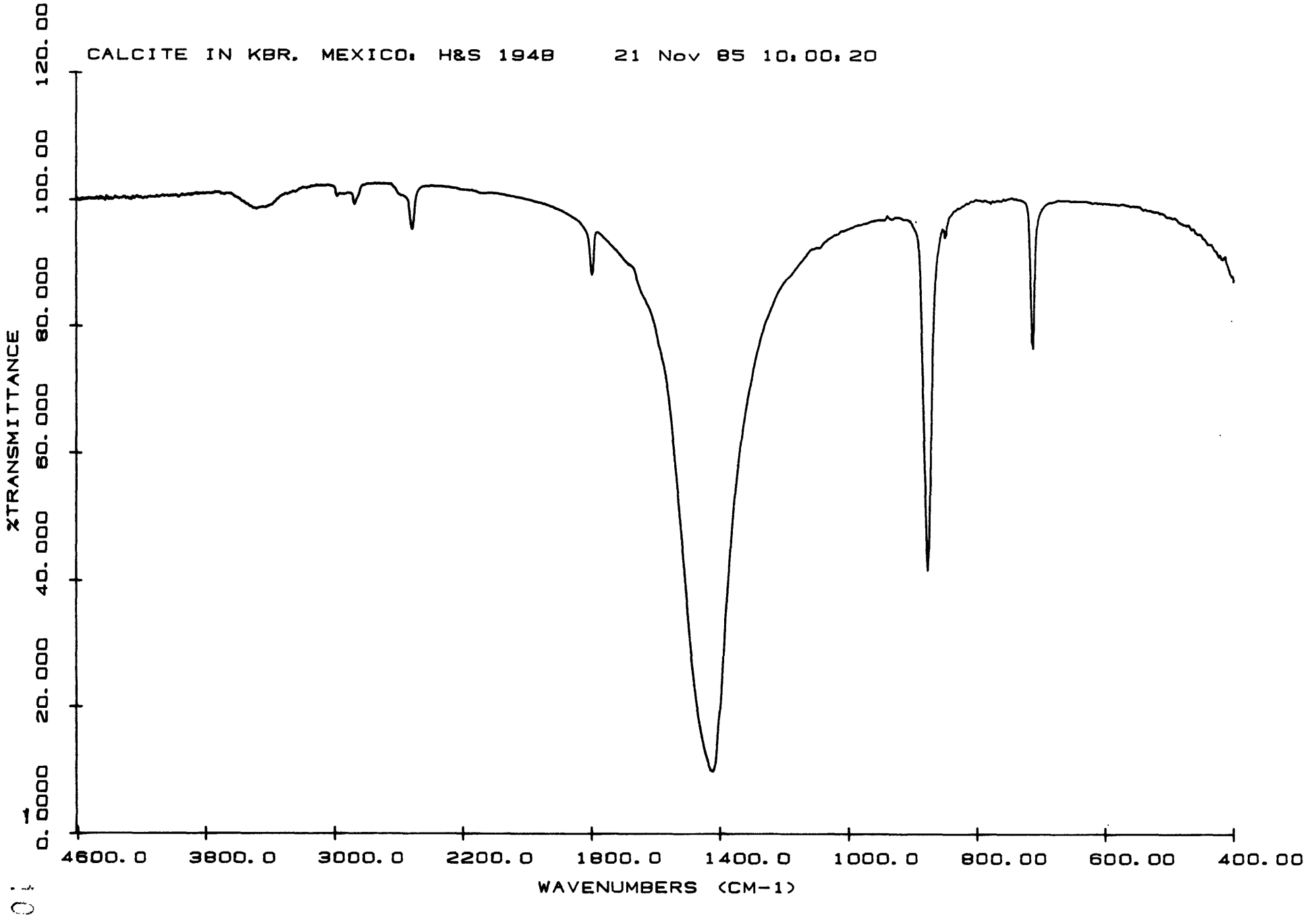
Results of petrographic examination: Hand samples are transparent euhedral crystals. The largest is approx. 2cm x 2cm. Obviously pure optical quality calcite.

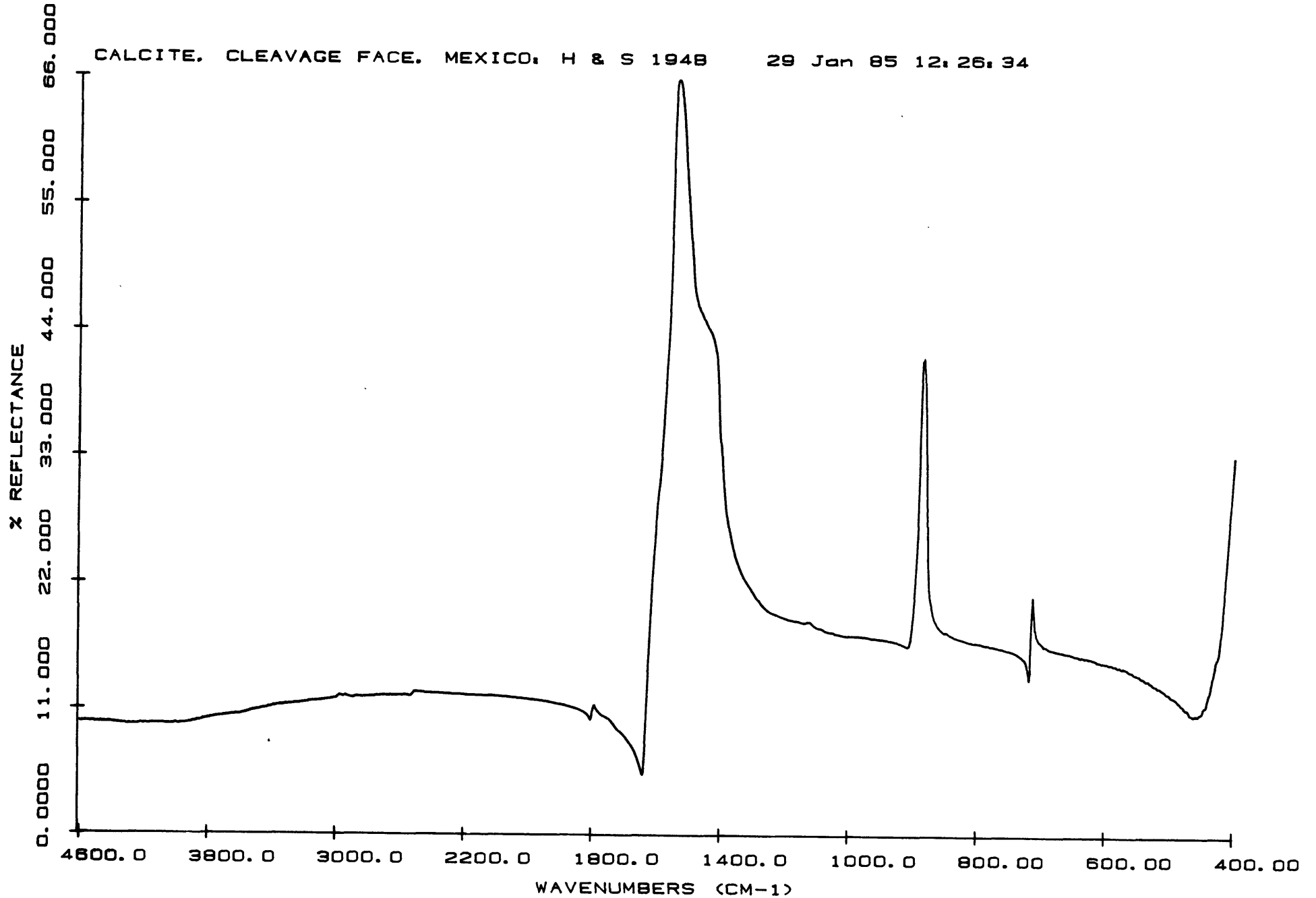
Results of XRD: Pure calcite.

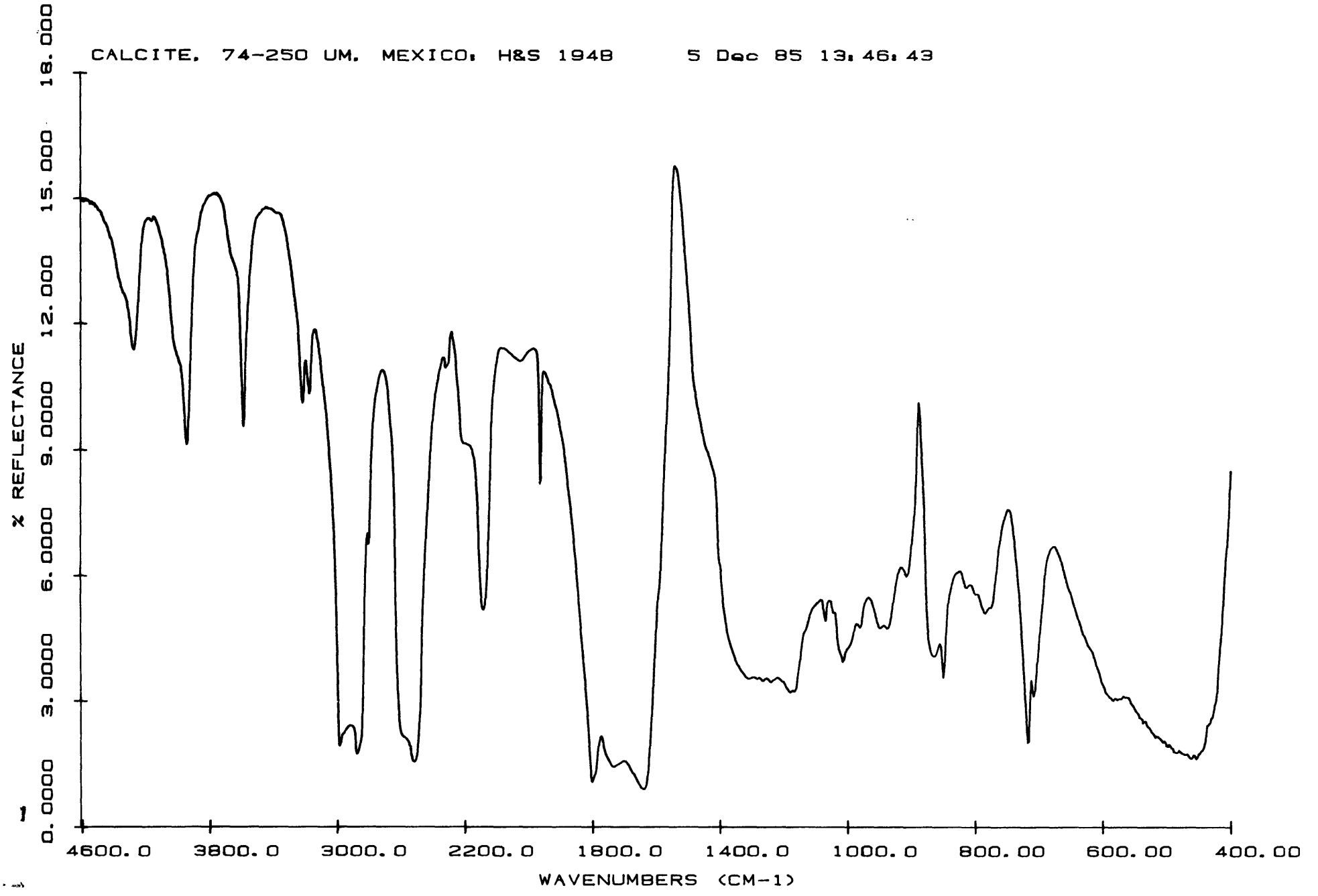
Results of XRF or other compositional analysis: Not necessary.

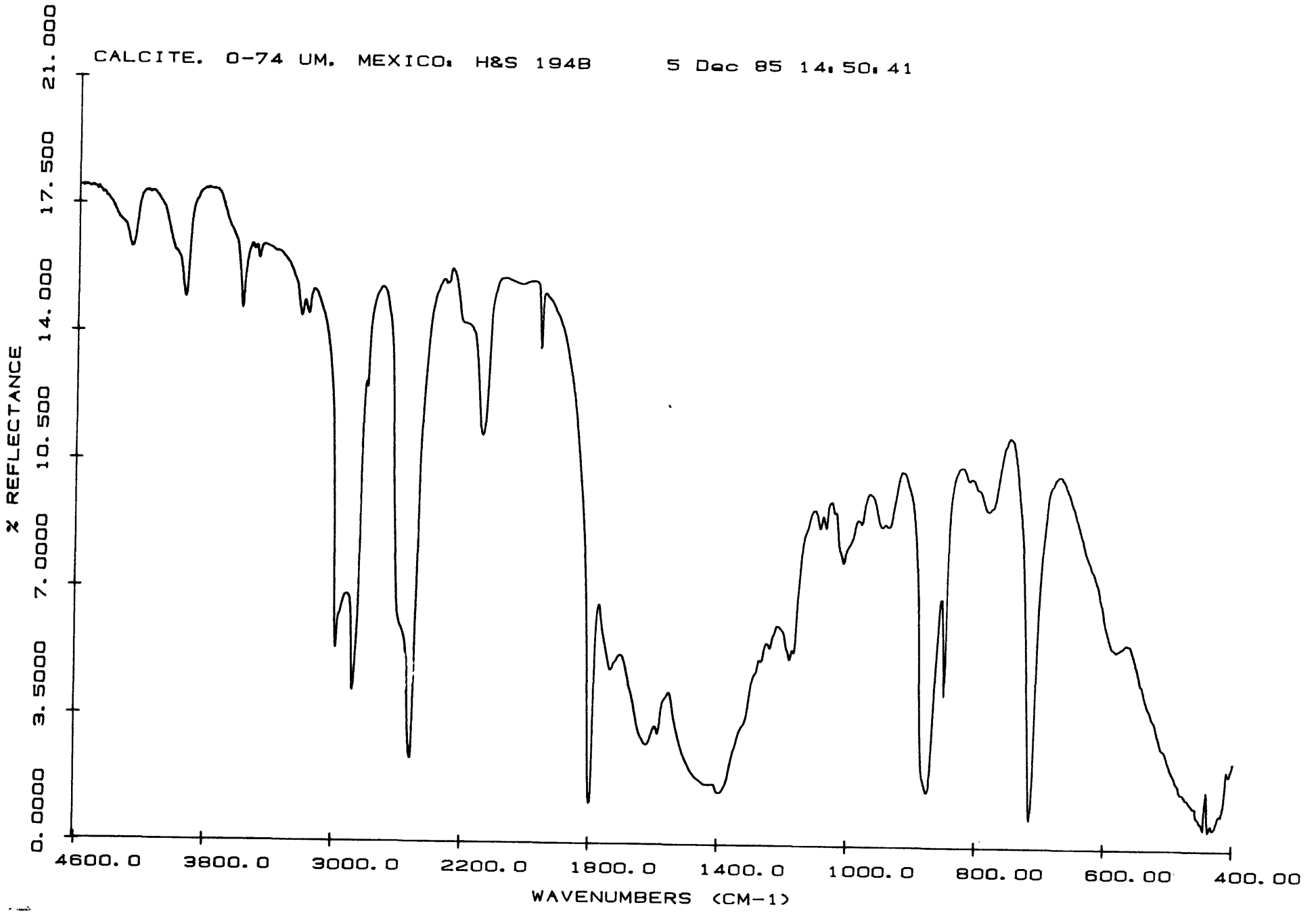
Spectra on file:

Calcite.1	Reflectance spectrum of cleavage face on solid sample Disk #1.
Calcite.1	Reflectance spectrum of 74-250 um size range on disk #1.
Calcite.1	Transmittance on Disk #1.
Calcite.1	Reflectance spectrum of 0-74 size range on Disk #1.


CALCITE IN KBR. MEXICO: H&S 1948 21 Nov 85 10:00:20
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


CALCITE. CLEAVAGE FACE. MEXICO: H & S 1948
29 Jan 85 12:26:34
% REFLECTANCE
66.000
55.000
44.000
33.000
22.000
11.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


CALCITE. 74-250 UM. MEXICO: H&S 1948
5 Dec 85 13:46:43
% REFLECTANCE
0.0000
3.0000
6.0000
9.0000
12.000
15.000
18.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


CALCITE. 0-74 UM. MEXICO: H&S 194B
5 Dec 85 14:50:41
% REFLECTANCE
21.000
17.500
14.000
10.500
7.0000
3.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Clinochlore $(Mg, Fe^{+2})_5\ Al(Si_3Al))_{10}(OH)_8$

Locality: Tilly Foster mine, Brewster, New York

Last donor: Jim Crowley (USGS)

Intermediate donor:

Ultimate donor: Smithsonian

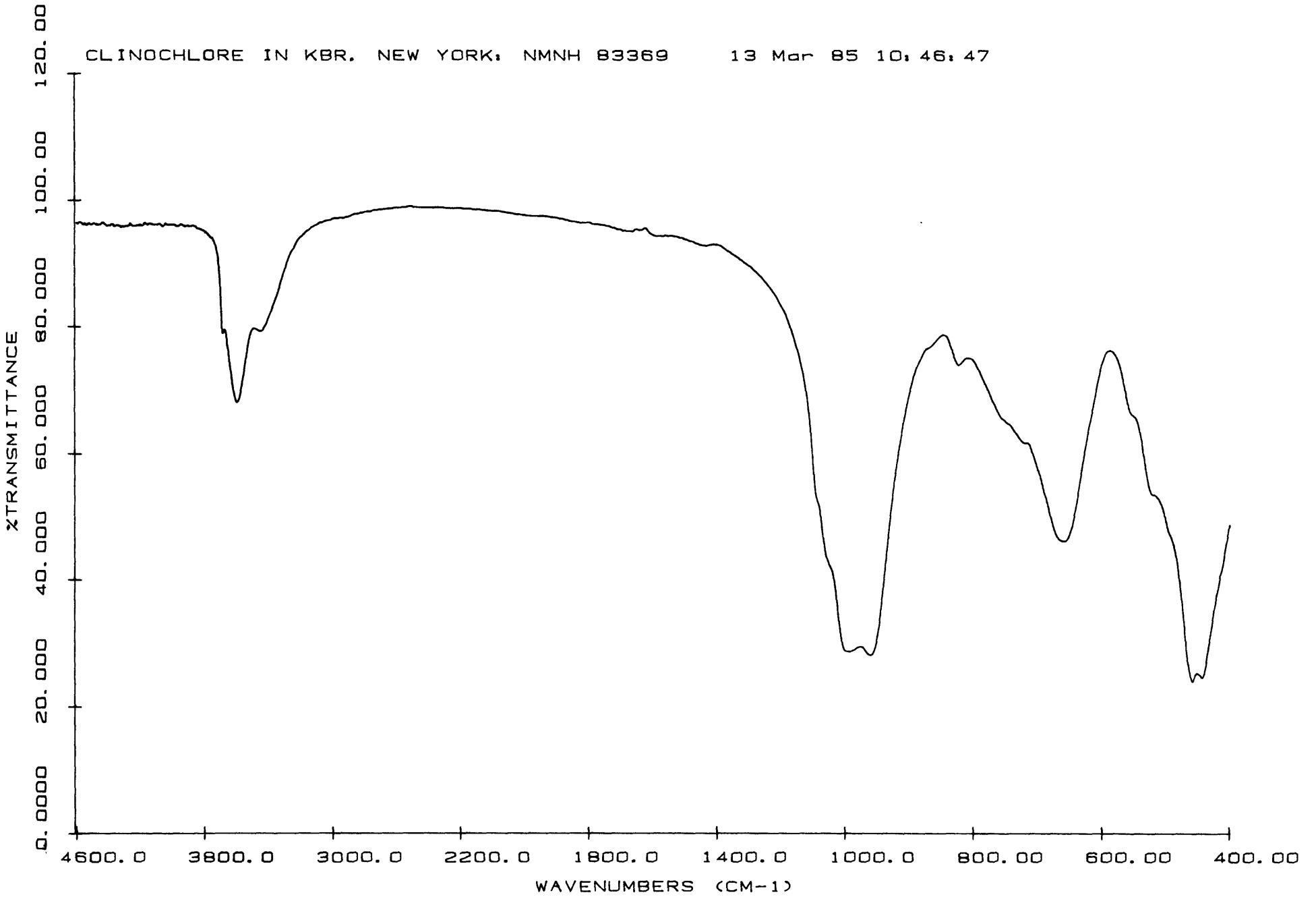
Catalog numbers, etc.: NMNH 83369

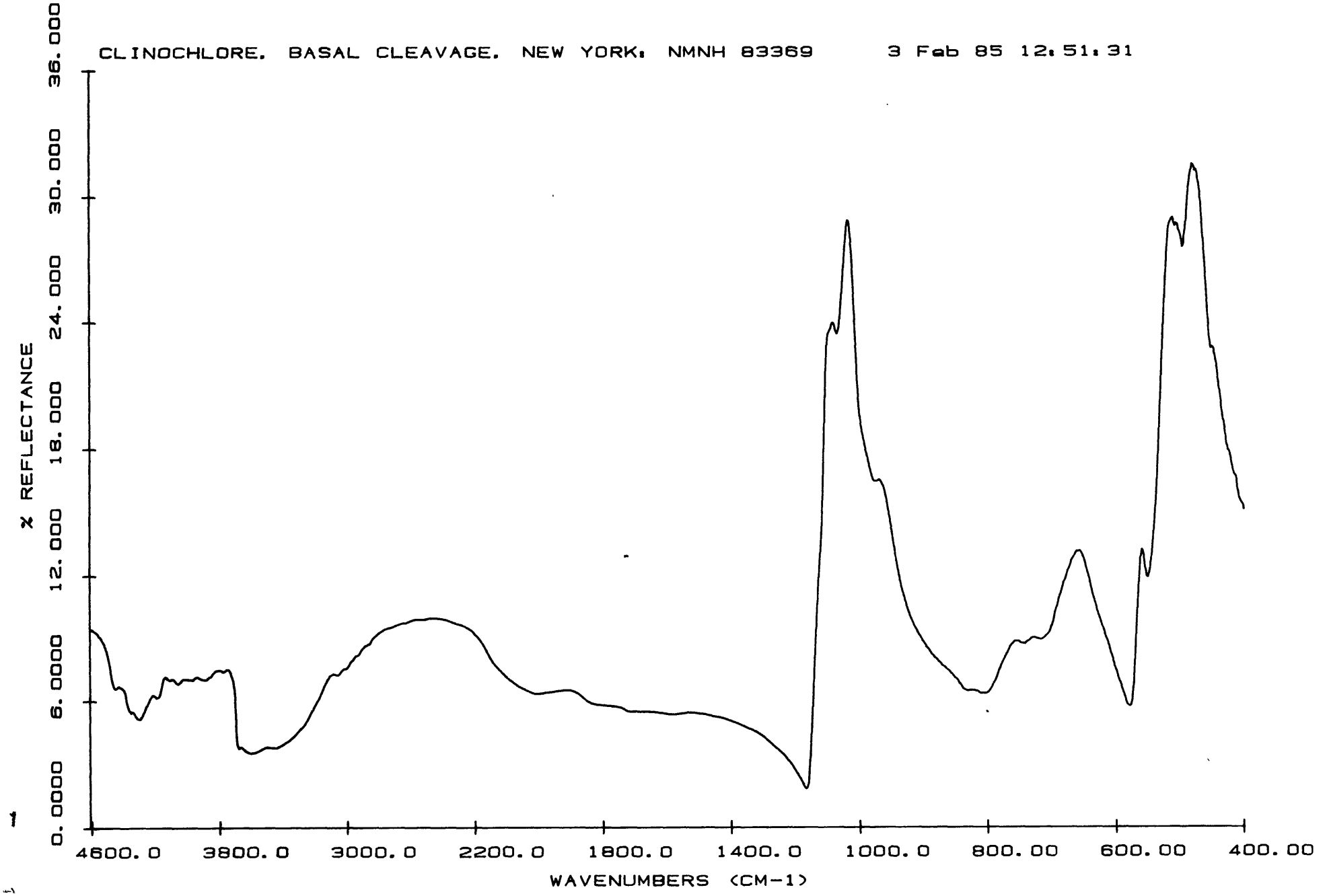
Results of petrographic examination:

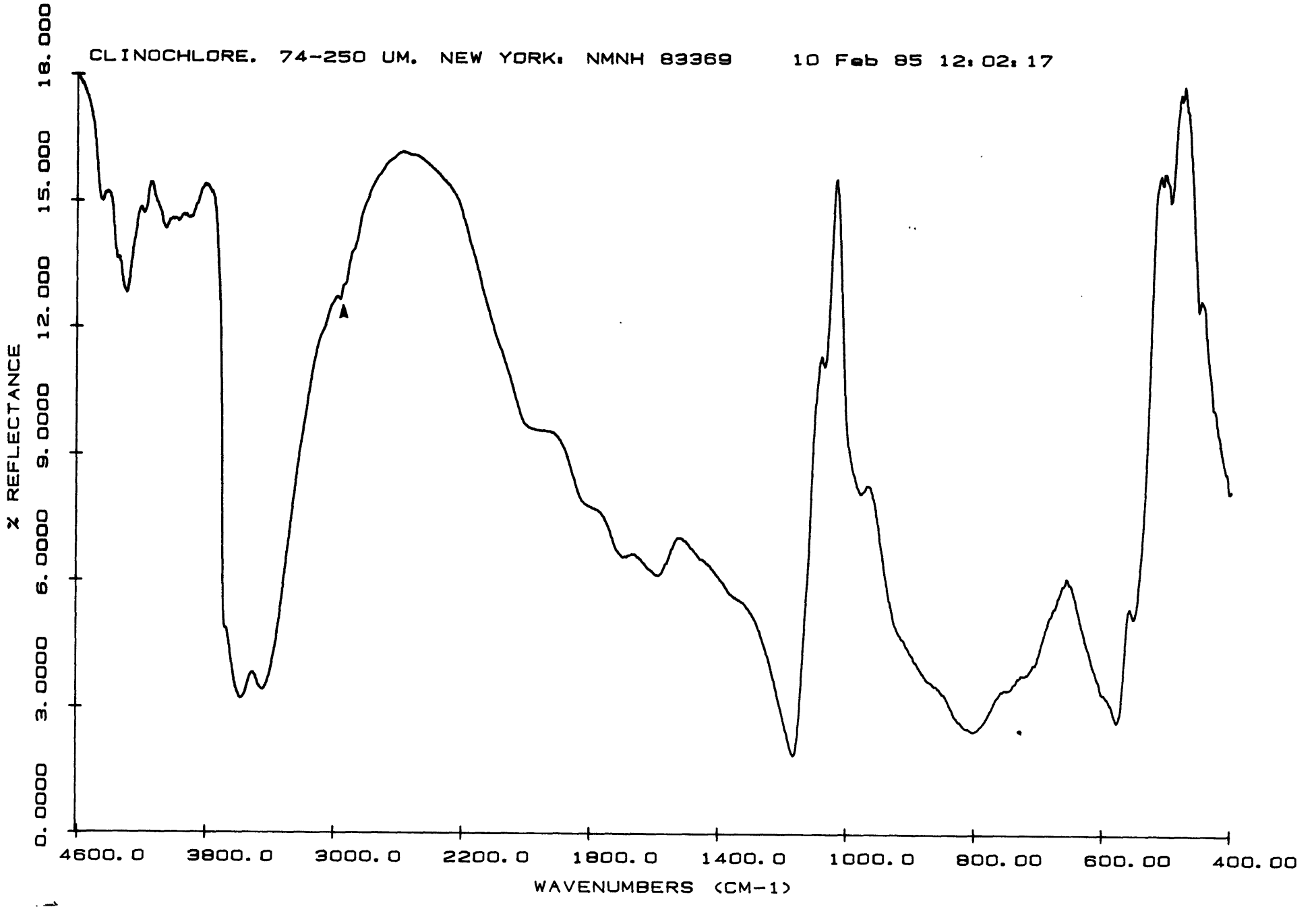
Results of XRD: Pure magnesian clinochlore (Jim Crowley).

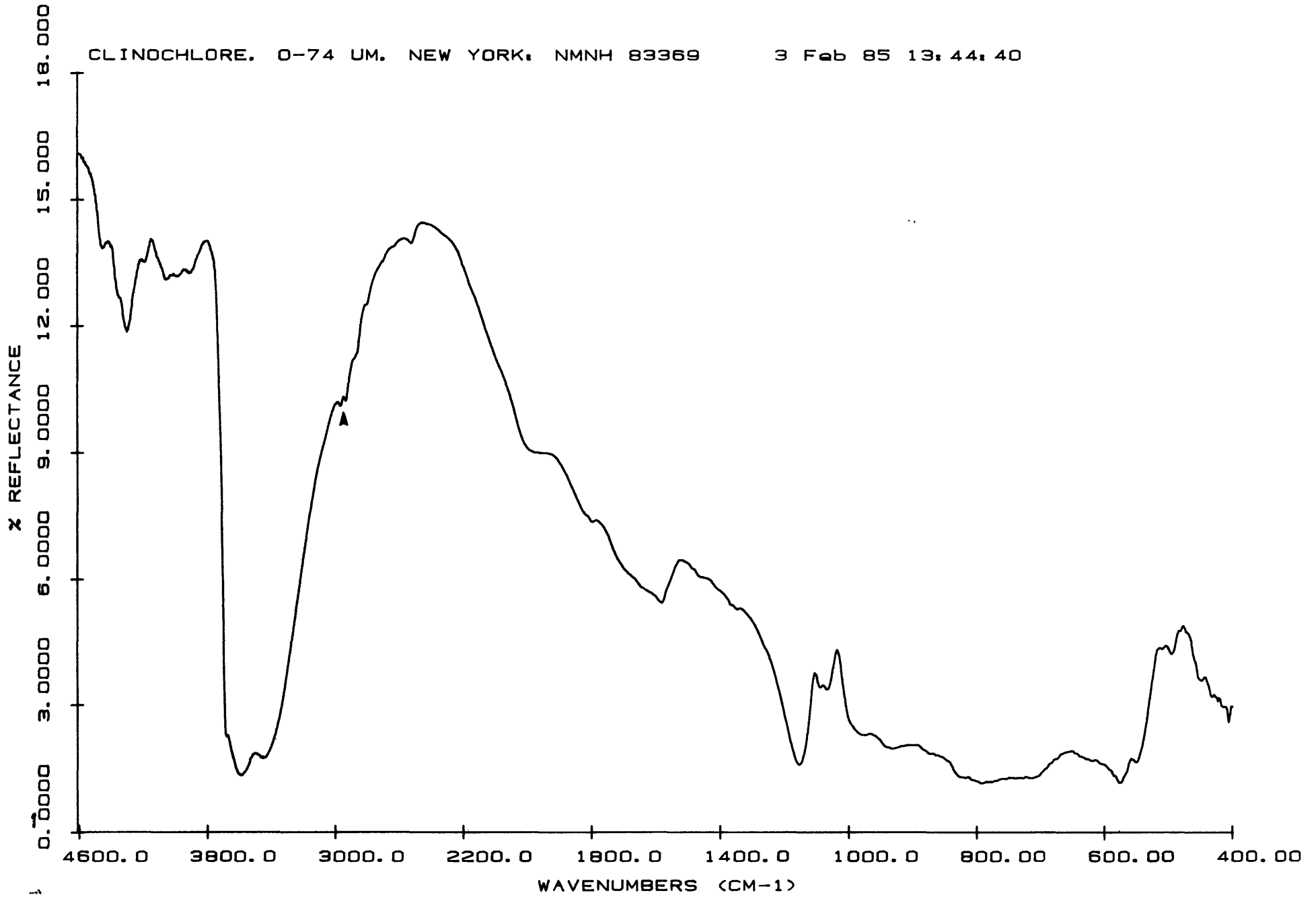
Results of XRF or other compositional analysis: To be determined.

Spectra of file:
Clinochlore.1 Reflectance spectrum of basal cleavage on solid sample disk #1.
Clinochlore.1 Reflectance spectrum of 0-74 um size range on disk #1.
Clinochlore.1 Reflectance spectrum of 74-250 um size range on disk #1.
Clinochlore.1 Transmittance spectrum on disk #1.


CLINOCHLORE IN KBR. NEW YORK: NMNH 83369 13 Mar 85 10:46:47
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


CLINOCHLORE. BASAL CLEAVAGE. NEW YORK: NMNH 83369
3 Feb 85 12:51:31
% REFLECTANCE
36.000
30.000
24.000
18.000
12.000
6.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


CLINOCHLORE. 74-250 UM. NEW YORK: NMNH 83369
10 Feb 85 12:02:17
% REFLECTANCE
0.0000
3.0000
6.0000
9.0000
12.000
15.000
18.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


CLINOCHLORE. 0-74 UM. NEW YORK: NMNH 83369
3 Feb 85 13:44:40
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Ferroan clinochlore (ripidolite) $(Fe^{+2}, Mg)_5$ Al $(Si_3Al)O_{10}(OH)_8$

Locality: Flagstaff Hill Eldorado Co., California

Last donor: Hunt and Salisbury Collection

Intermediate donor:

Ultimate donor: Clay Mineral Society Source Clay Mineral Repository

Catalog numbers, etc.: CMS CCA-1

Results of petrographic examination: Sample made up of chunks of coarsely crystalline minerals. Looks pure.

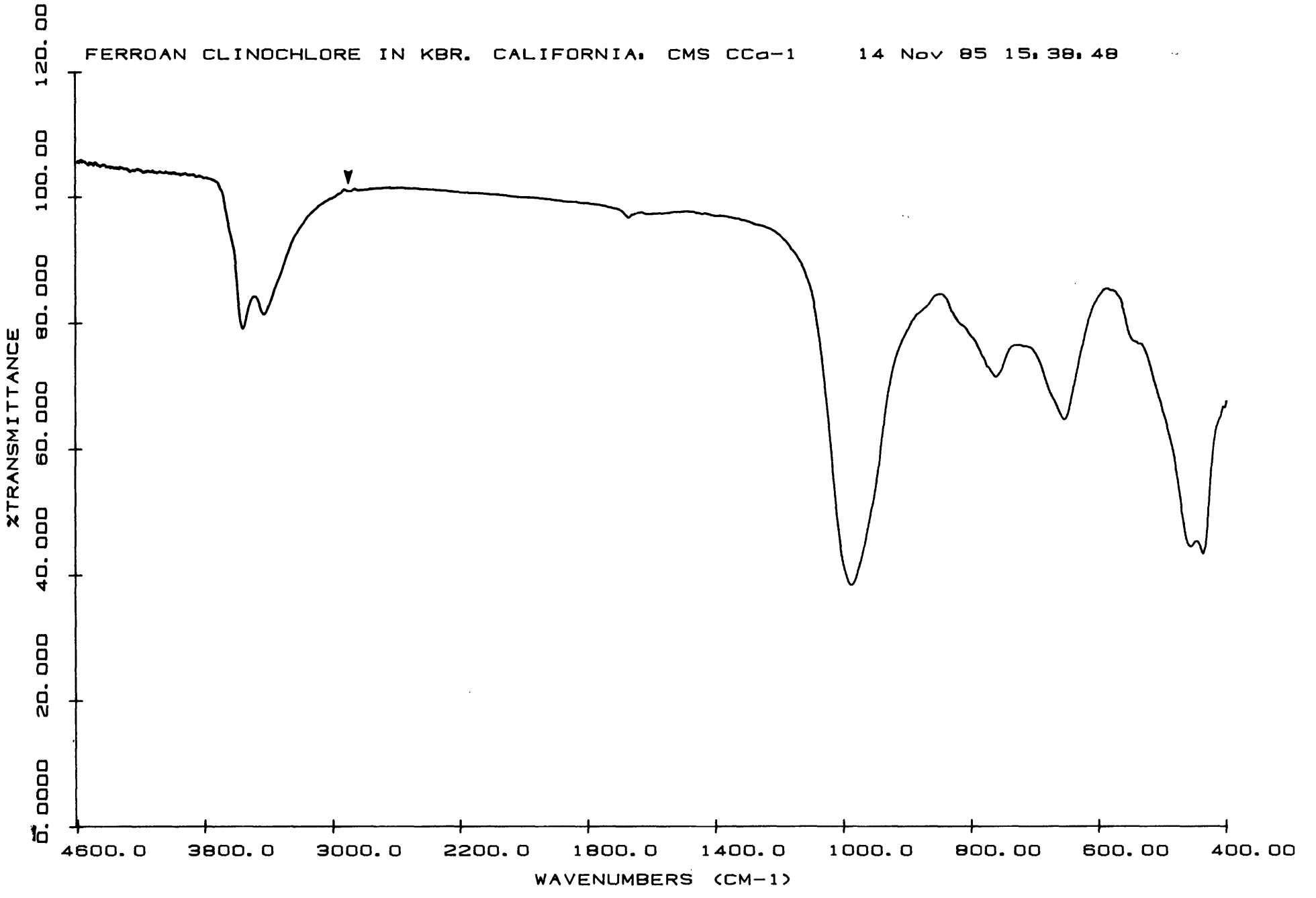
Results of XRD: Pure ferroan clinochlore (ripidolite).

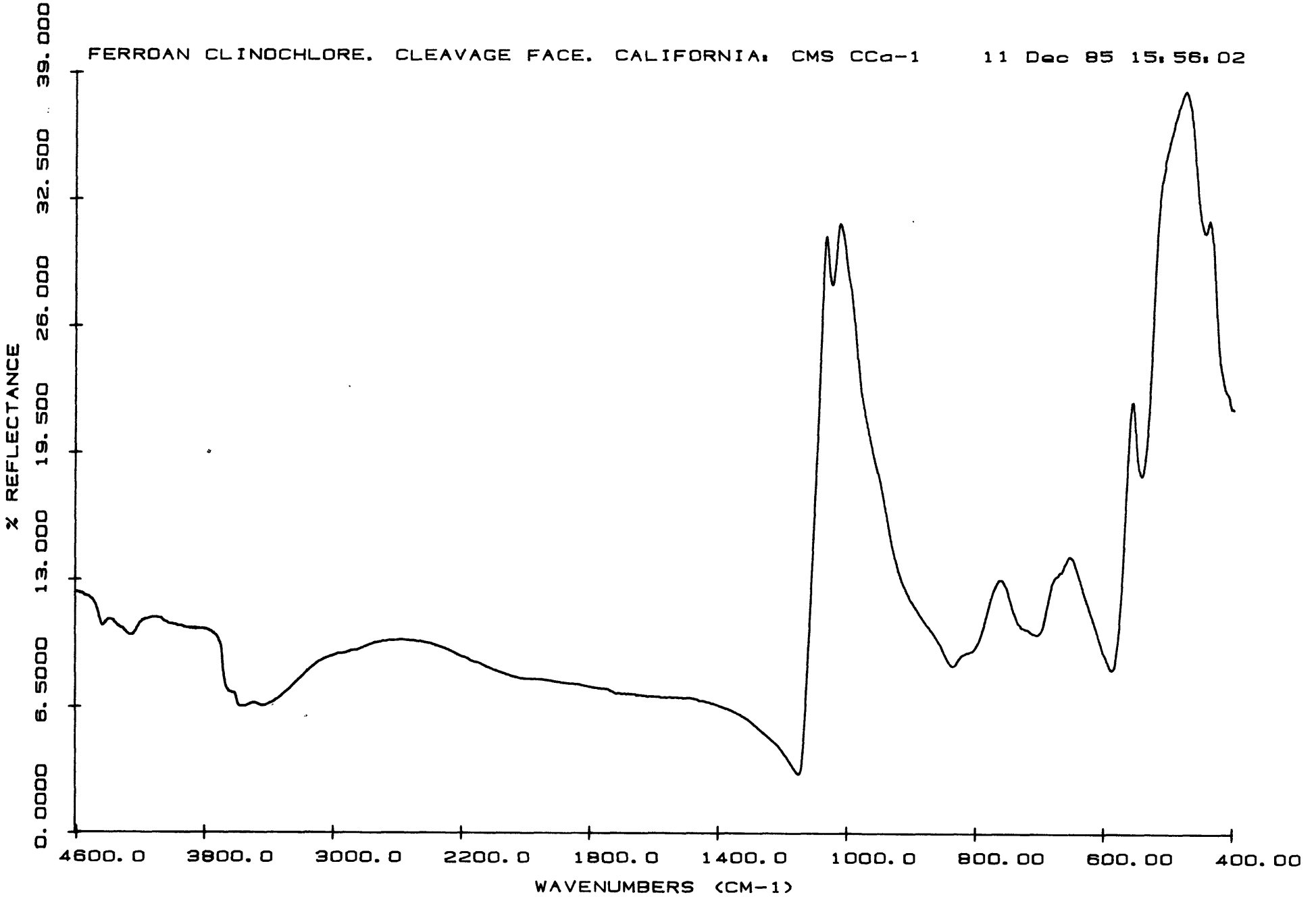
Results of XRF or other compositional analysis:

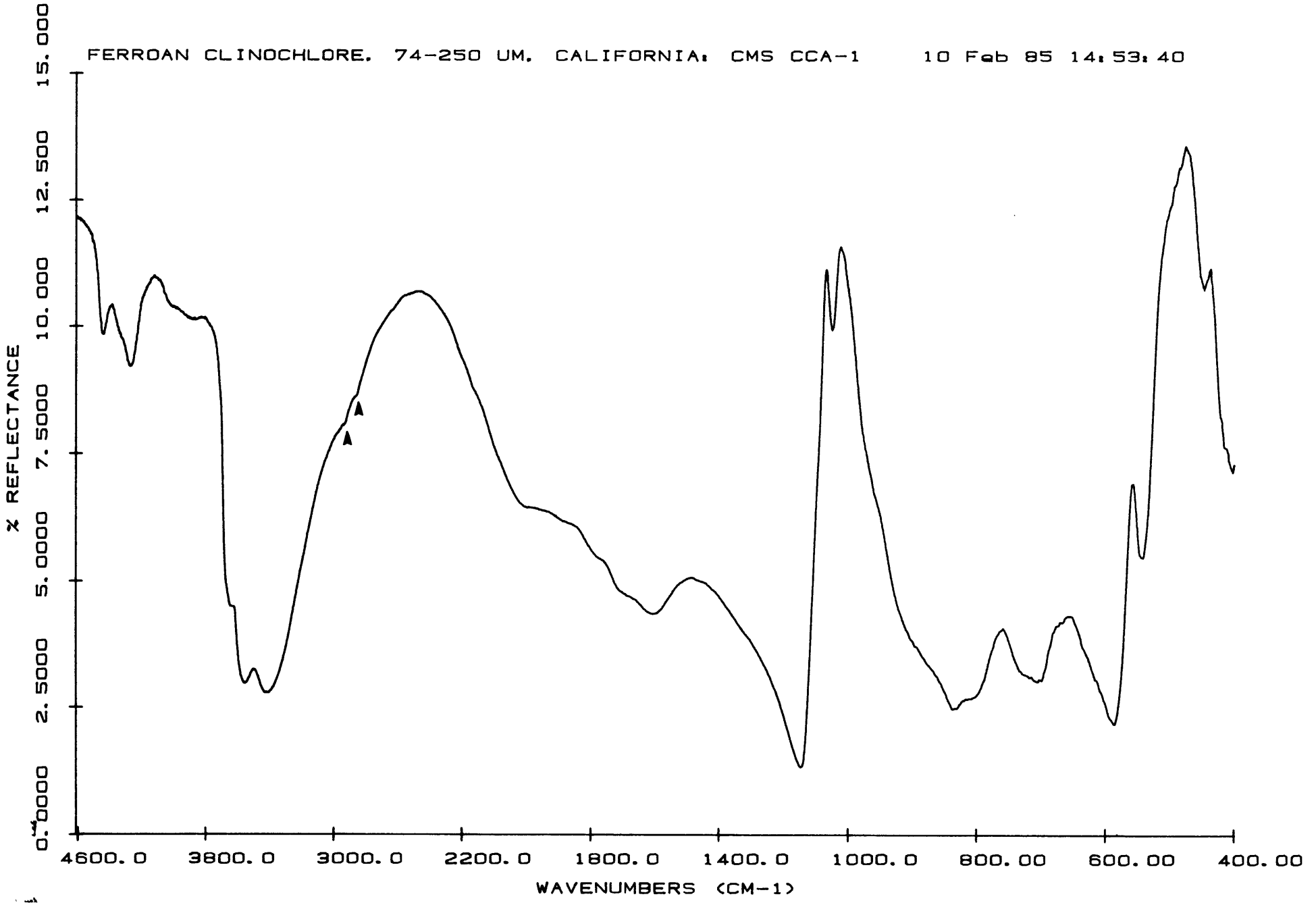
XRF analysis by Ardith Bartel, USGS Branch of Analytical Chemistry, Denver, gave the following composition:

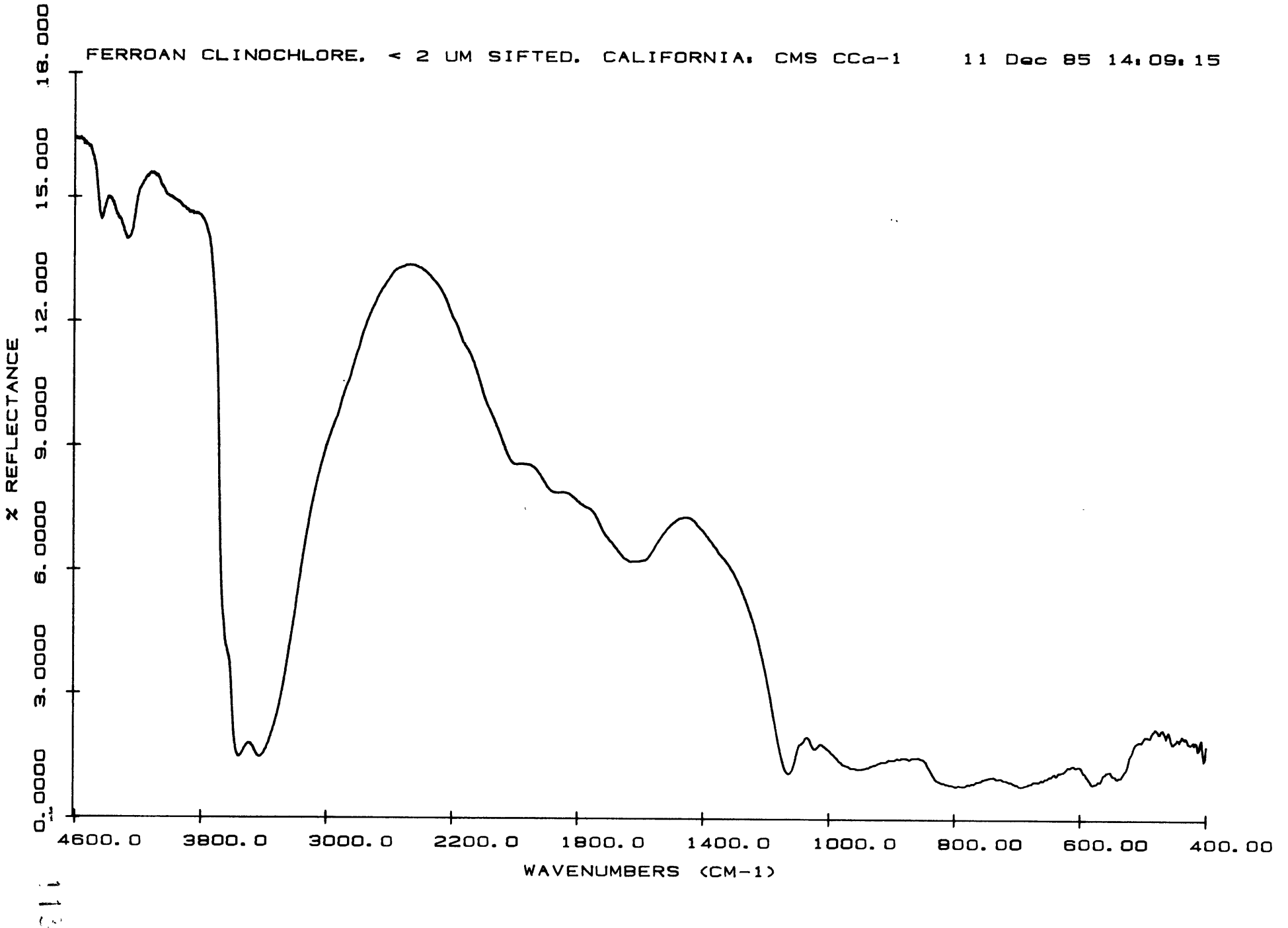
SiO_2	- 25.8
Al_2O_3	- 20.7
Fe_2O_3	- 26.1
MgO	- 17.7
CaO	- <0.02
K_2O	- <0.02
Na_2O	- 0.22
TiO_2	- 0.85
MnO	- 0.09
P_2O_5	- <0.05
Loss on ignition at 900° C	- 9.23
Total	-100.78

Spectra of file:
Clinochlore.2 Reflection spectrum of cleavage face using SpectraTech on solid sample disk #1.
Clinochlore.2 Reflection spectrum of clay powder on 0-74 um disk #1.
Clinochlore.2 Transmission spectrum on disk #1.
Clinochlore.2 Reflectance spectrum of 74-250 um size range on disk #1.


FERROAN CLINOCHLORE IN KBR. CALIFORNIA. CMS CCa-1 14 Nov 85 15:38:48
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


FERROAN CLINOCHLORE. CLEAVAGE FACE. CALIFORNIA: CMS CCa-1 11 Dec 85 15:56:02
% REFLECTANCE
0.0000
6.5000
13.000
19.500
26.000
32.500
39.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


FERROAN CLINOCHLORE. 74-250 UM. CALIFORNIA: CMS CCA-1
10 Feb 85 14:53:40
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


FERROAN CLINOCHLORE. < 2 UM SIFTED. CALIFORNIA: CMS CCa-1 11 Dec 85 14:09:15
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Cordierite $Mg_2Al_4Si_5O_{18}$

Locality: Orijarvi, Finland

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 78228

Results of petrographic examination: Several samples, blue-gray in color, appear pure. There are some heterogenieties in color, and a few veins seem to have discoloration along them. Three pieces, on the avg. 2cm x 4cm x 1cm. Under petrographic microscope, all samples are cordierite but grains have small amount of alteration or microsrystalline inclusions.

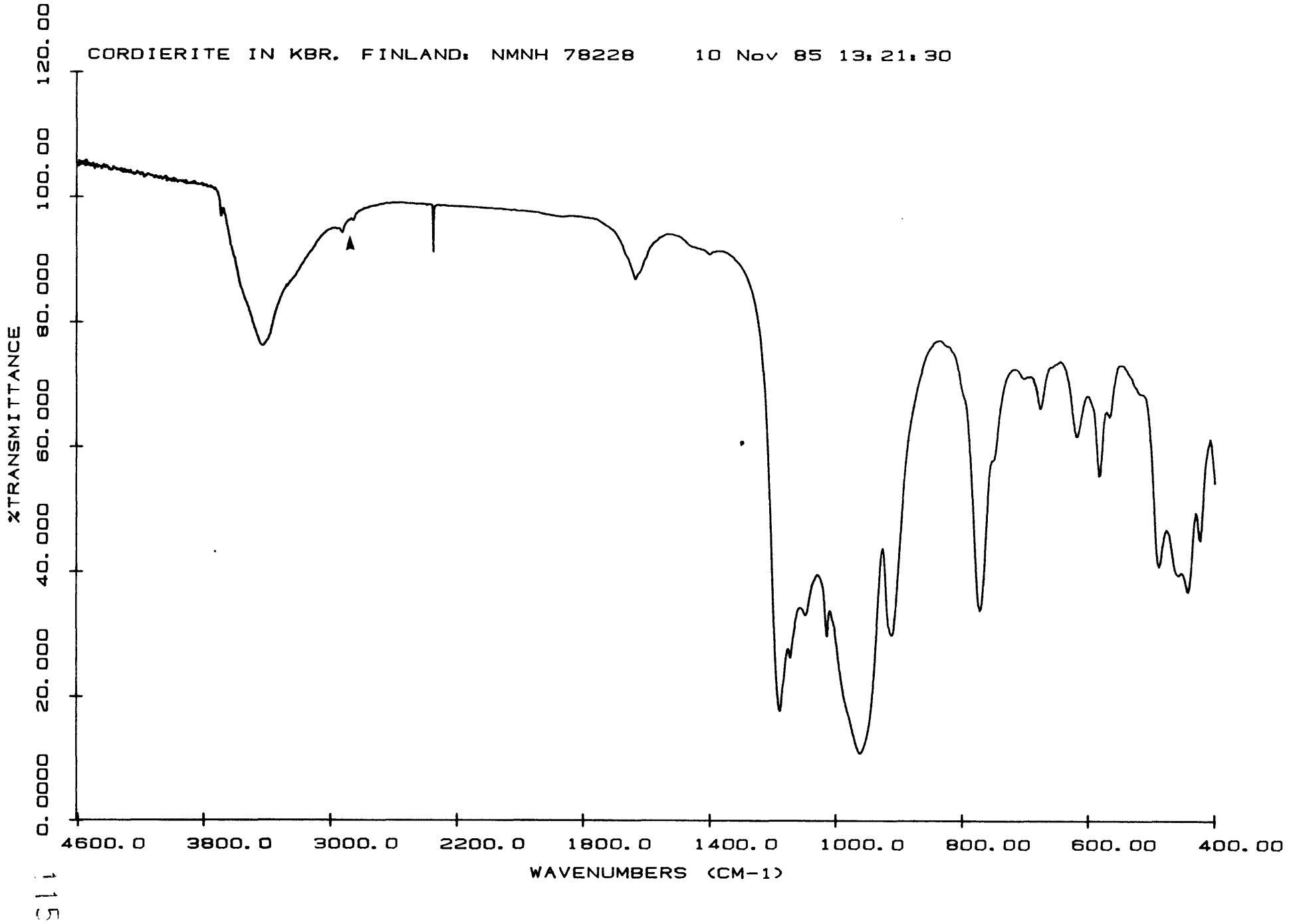
Results of XRD: Sample contains cordierite, but is contaminated with another unknown mineral with a major peak at 3.015A.

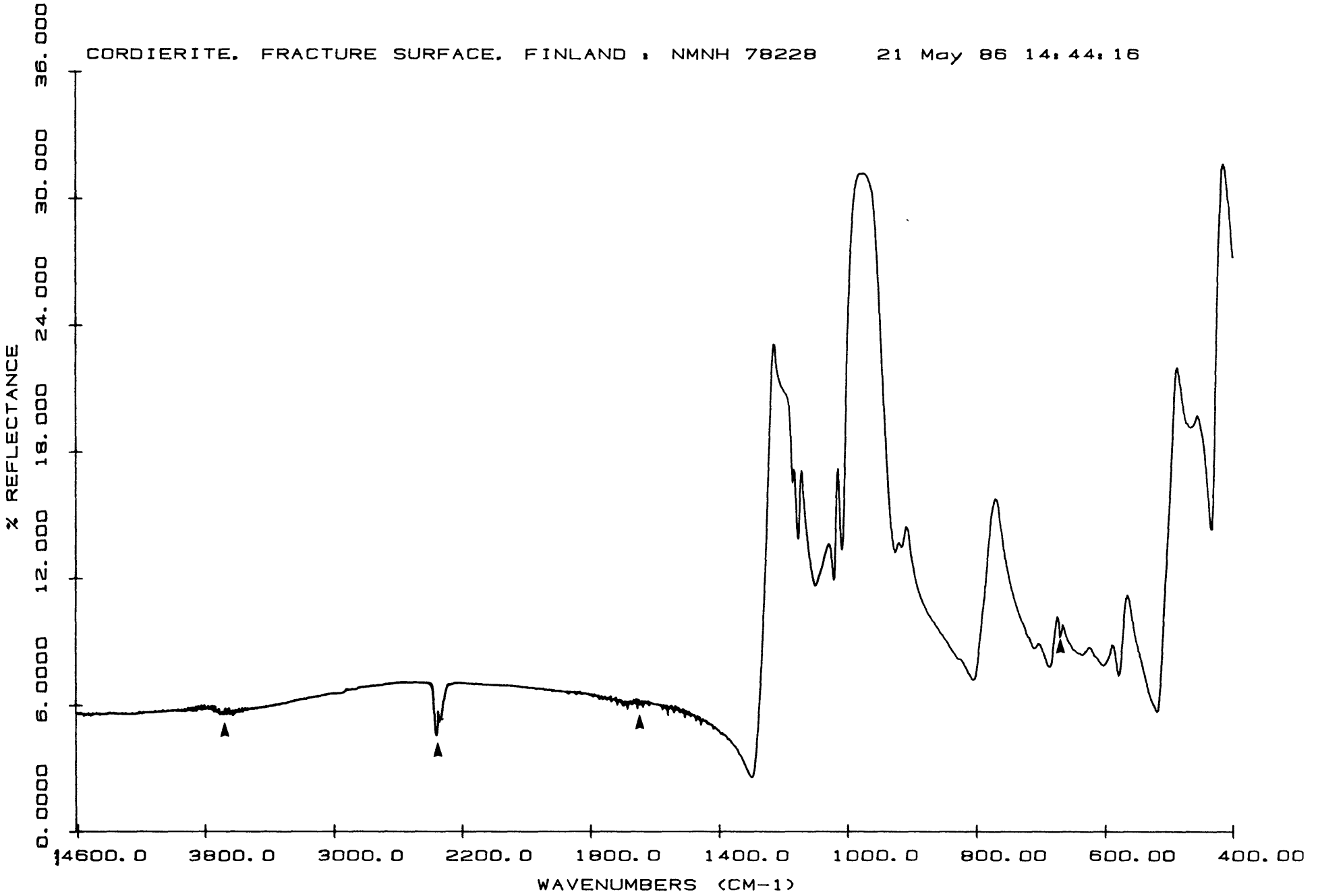
Results of XRF or other compositional analysis: Microprobe analysis found grains measured to be homogeneous within and between grains. Average of 9 analyses shows that this is not the pure magnesian end member of the series with Sekaninaite, $(Fe^{+2}, Mg)_2 Al_4Si_5O_{18}$:

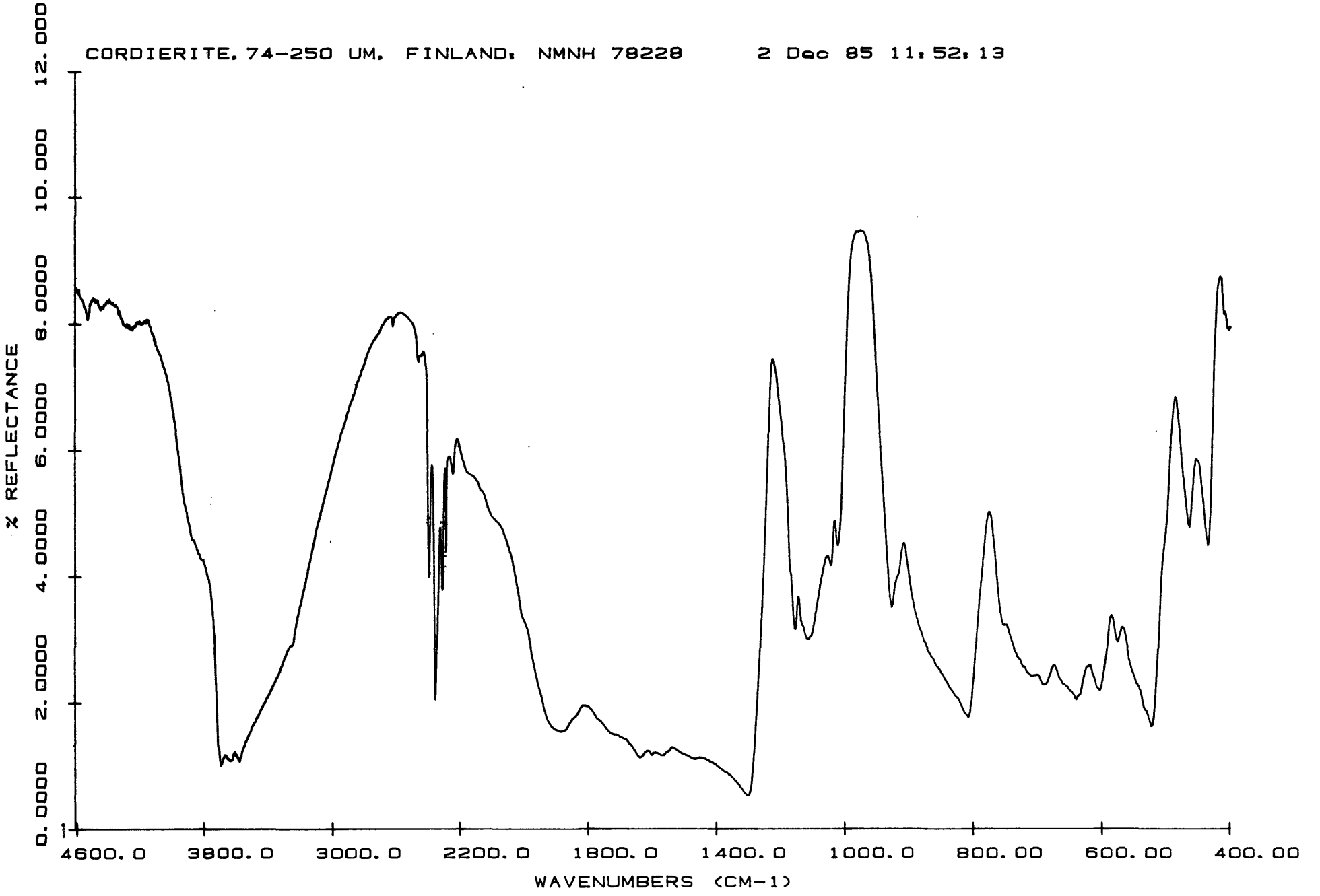
SiO_2	- 49.02
Al_2O_3	- 35.33
FeO	- 4.50
MgO	- 11.04
CaO	- 0.04
K_2O	- 0.02
Na_2O	- 0.33
TiO_2	- 0.01
MnO	- 0.07
Total	-100.44

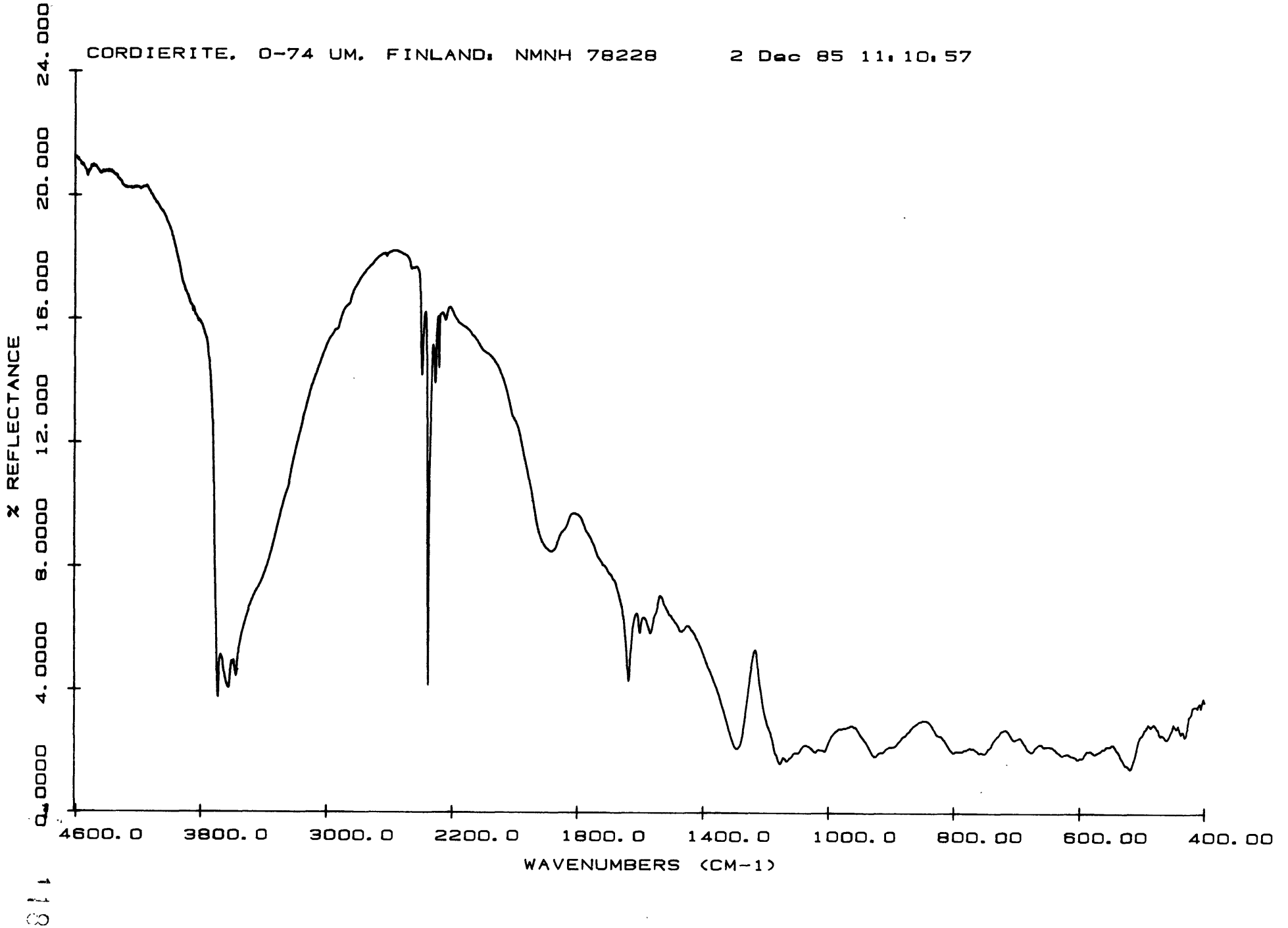
Spectra on file:

Cordierite.2	Reflectance spectrum of fracture surface on Solid Sample Disk #1.
Cordierite.2	Reflectance spectrum of 0-74 um size range on Disk #1.
Cordierite.2	Reflectance spectrum of 74-250 um size range on Disk #1.
Cordierite.2	Transmittance spectrum on disk #1.


CORDIERITE IN KBR. FINLAND: NMNH 78228 10 Nov 85 13:21:30
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


CORDIERITE. FRACTURE SURFACE. FINLAND : NMNH 78228 21 May 86 14:44:16
% REFLECTANCE
36.000
30.000
24.000
18.000
12.000
6.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


CORDIERITE. 74-250 UM. FINLAND: NMNH 78228
2 Dec 85 11:52:13
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


CORDIERITE. 0-74 UM. FINLAND: NMNH 78228
2 Dec 85 11:10:57
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Diopside $CaMgSi_2O_6$

Locality: St. Lawrence Co., New York

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH C2393

Results of petrographic examination: Hand sample consists of two green subhedral crystal 1-2 cm in length and width. Samples appear pure. Under petrographic microscope, diopside appears pure except for one small, moderately birefringent grain with parallel extinction. Some possible exsolution. Very little weathering, but a trace amount (much less than 1%) of sericite seen along cleavage planes.

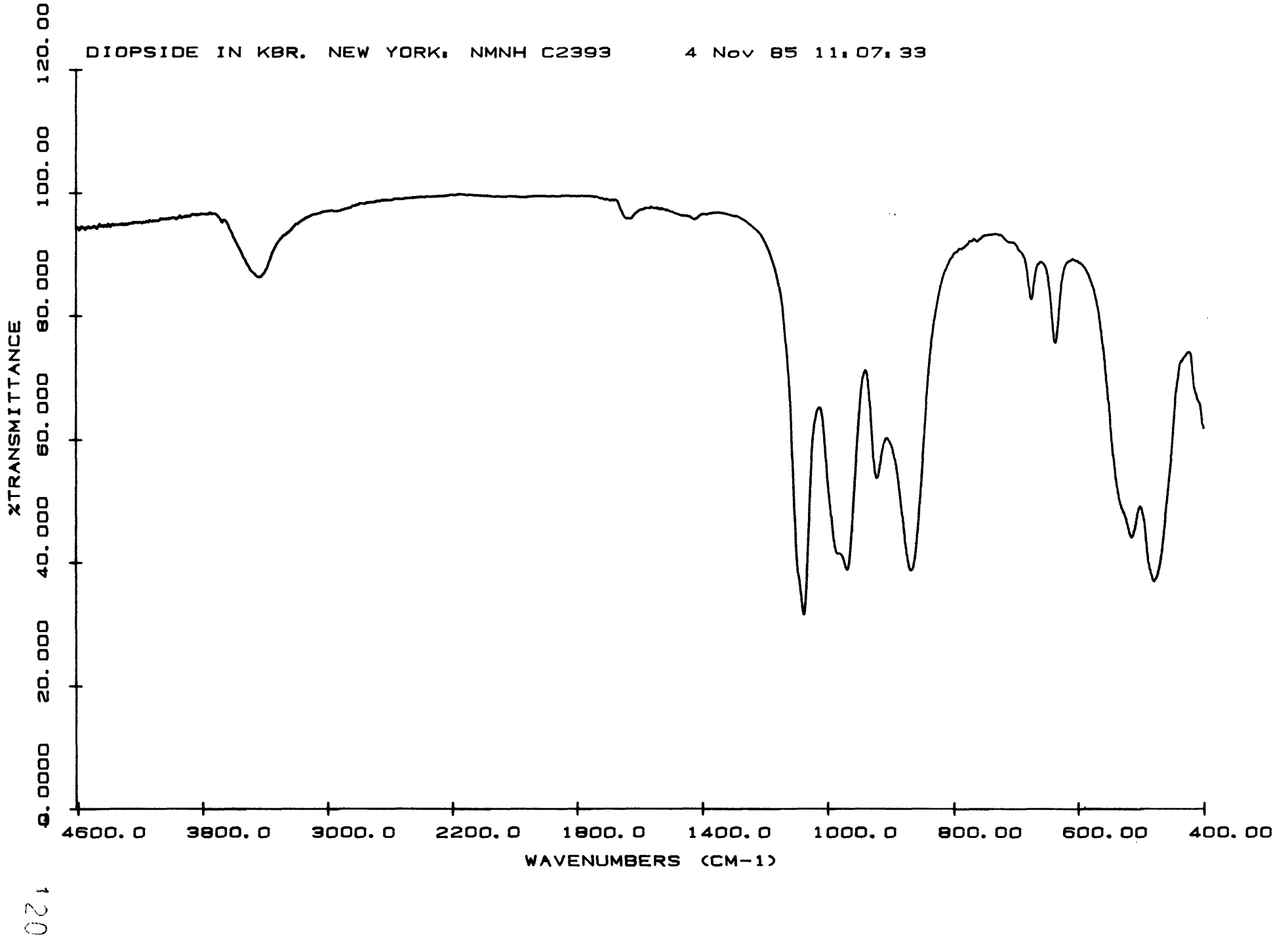
Results of XRD: Diopside plus a trace of mica. Spectra do not show a mica hydroxyl band, but do show a trace of carbonate in reflectance of the fine particle size range, even after HCL treatment.

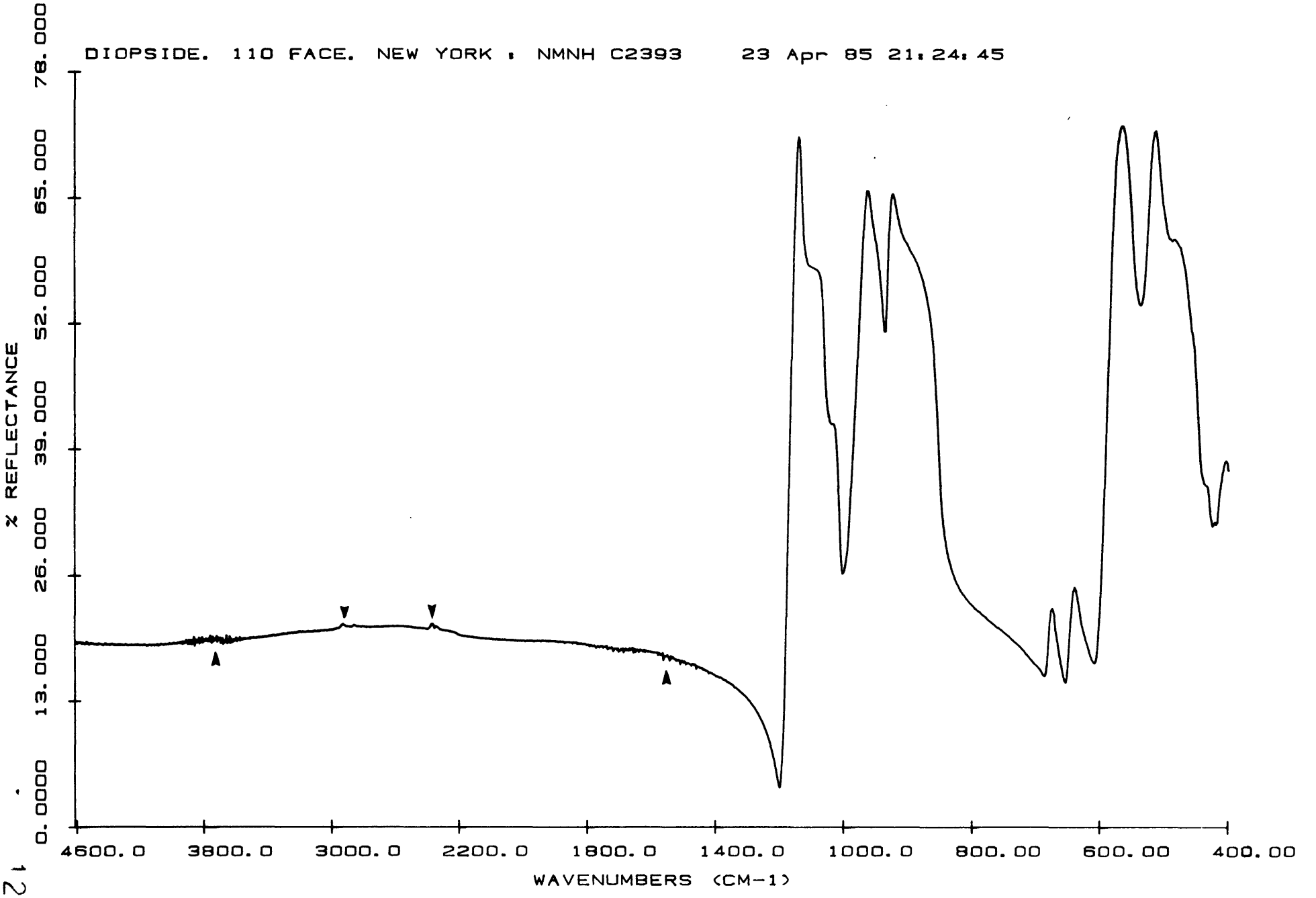
Results of XRF or other compositional analysis: Microprobe analysis showed grains selected to be homogeneous within and between grains. Average of 9 analyses indicates that this sample is close to end member composition:

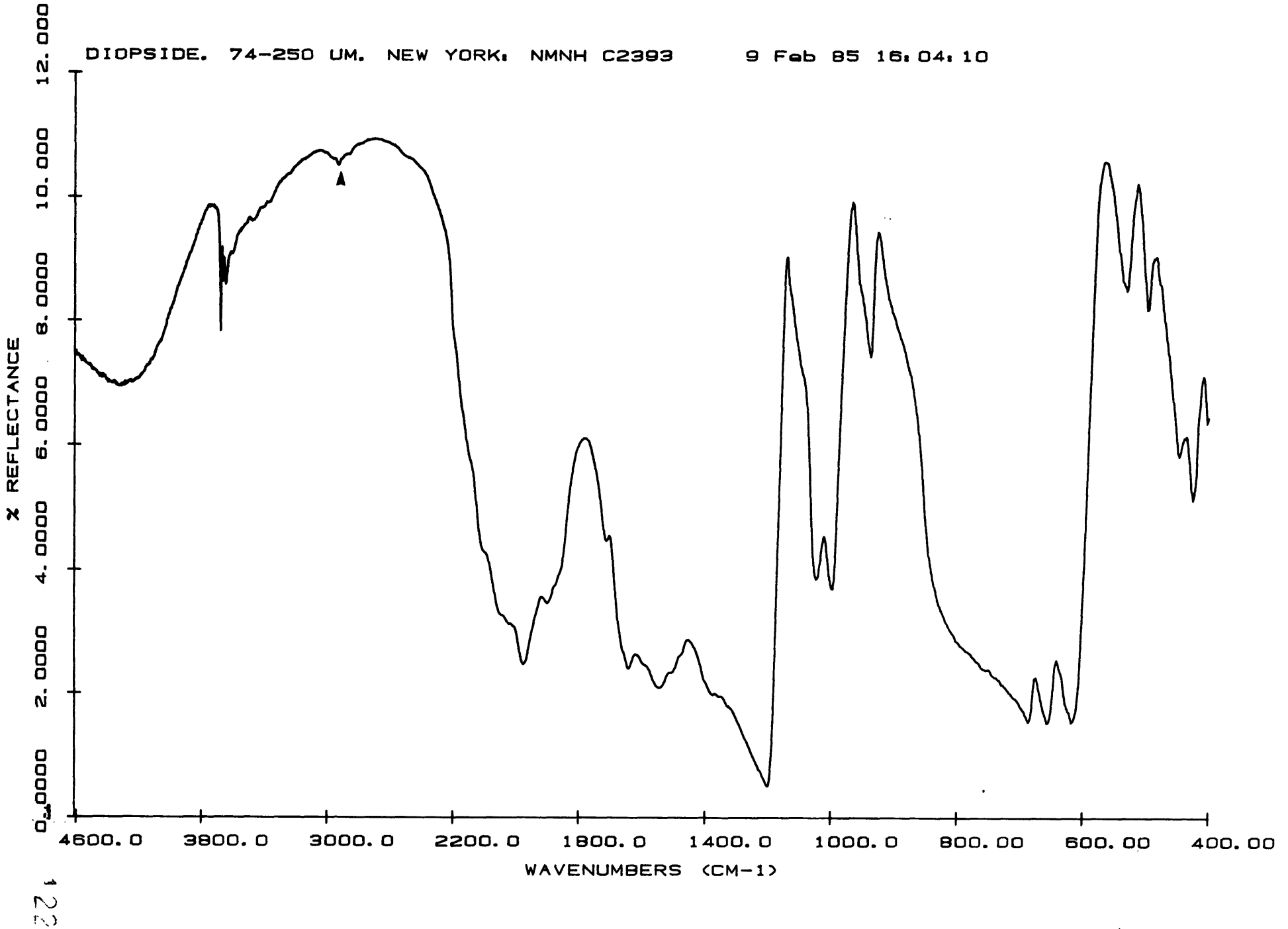
SiO_2	- 54.00
Al_2O_3	- 0.23
FeO	- 2.63
MgO	- 17.71
CaO	- 25.52
K_2O	- 0.02
Na_2O	- 0.28
TiO_2	- 0.07
MnO	- 0.18
Total	-100.64

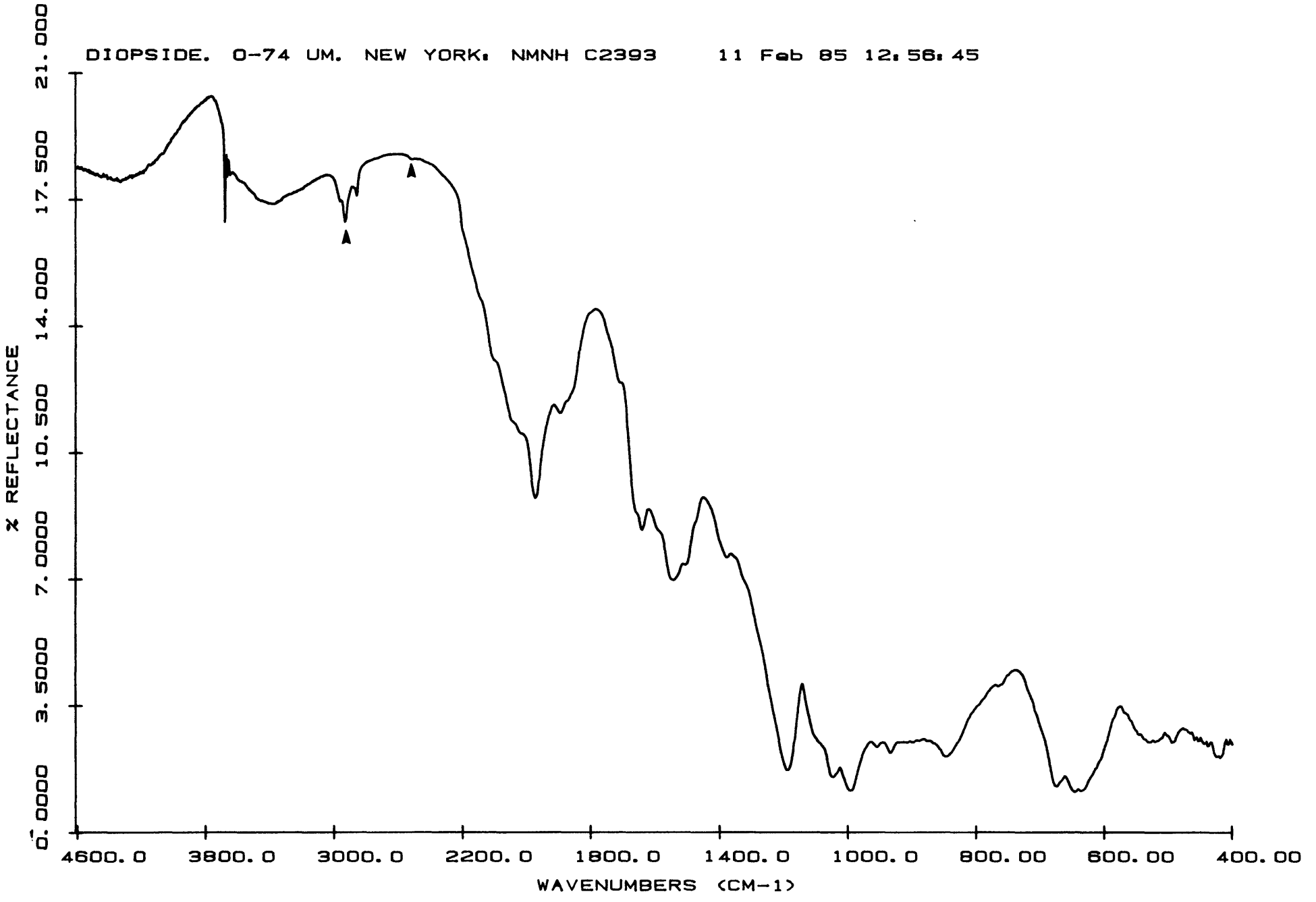
Spectra on file:

Diopside.1	Reflectance spectrum of 110 crystal face on Solid Sample Disk #1.
Diopside.1	Reflectance spectrum of 0-74 um size range on disk #1.
Diopside.1	Reflectance spectrum of 74-250 um size range on disk #1.
Diopside.1	Transmittance spectrum on disk #1.


DIOPSIDE IN KBR. NEW YORK. NMNH C2393 4 Nov 85 11:07:33
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


DIOPSIDE. 110 FACE. NEW YORK : NMNH C2393 23 Apr 85 21:24:45
% REFLECTANCE
78.000
65.000
52.000
39.000
26.000
13.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


DIOPSIDE. 74-250 UM. NEW YORK: NMNH C2393 9 Feb 85 16:04:10
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


DIOPSIDE. 0-74 UM. NEW YORK: NMNH C2393 11 Feb 85 12:56:45
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Diopside $CaMgSi_2O_6$

Locality: DeKalb, New York

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH R18685

Results of petrographic examination: Most of the sample, which is green and about 13 mm x 10 mm x 6 mm is clean, fresh. There is one area which is eroded and weathered and probably impure. Crushed sample was hand-picked to avoid impurities.

Under petrographic microscope, there is a moderate amount of weathering and alteration. Alteration is brown in color (limonite?).

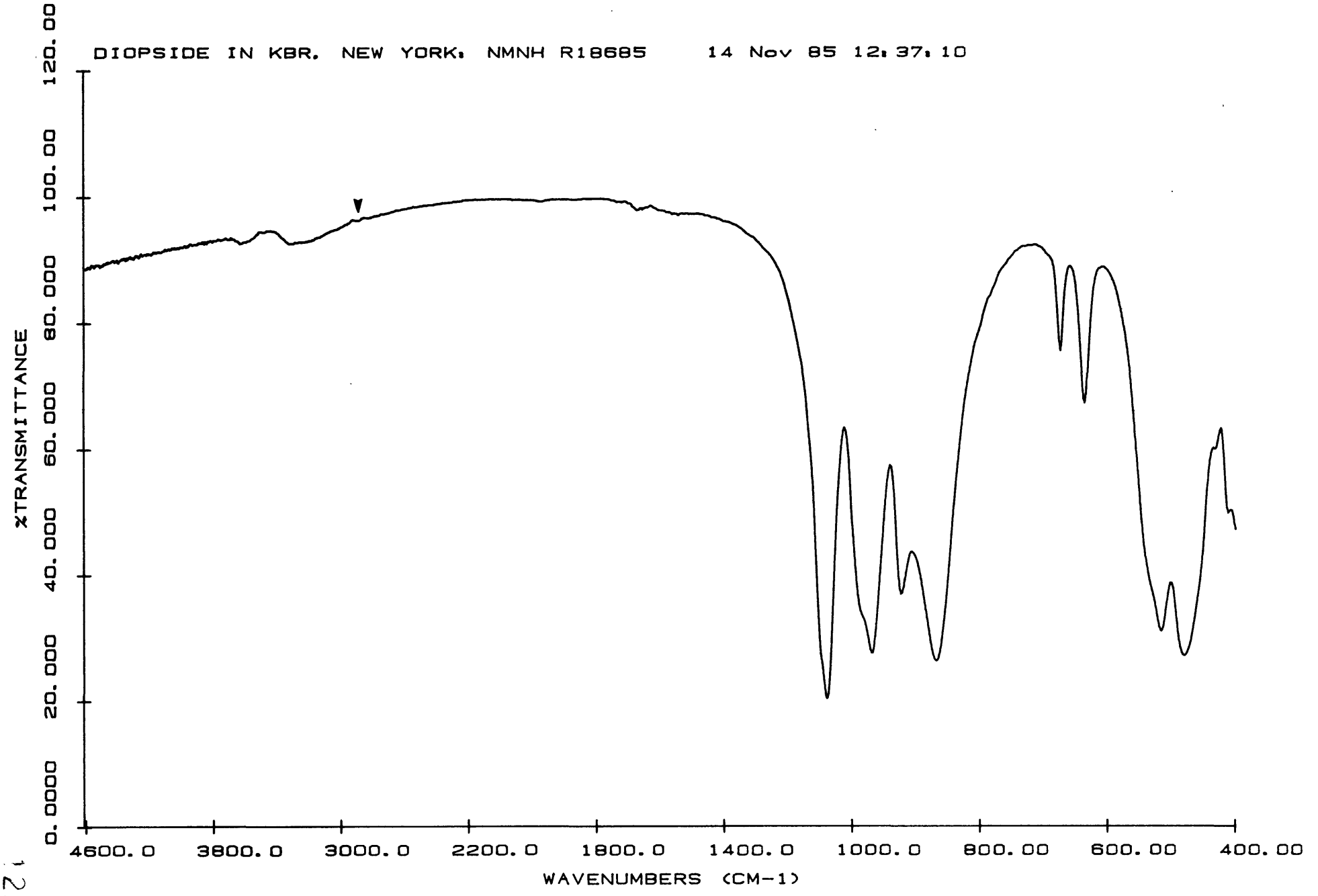
Results of XRD: Diopside plus a trace of quartz. Spectra show no quartz bands, but do show a trace of carbonate in reflectance of 74-250 um and 0-74 um size ranges.

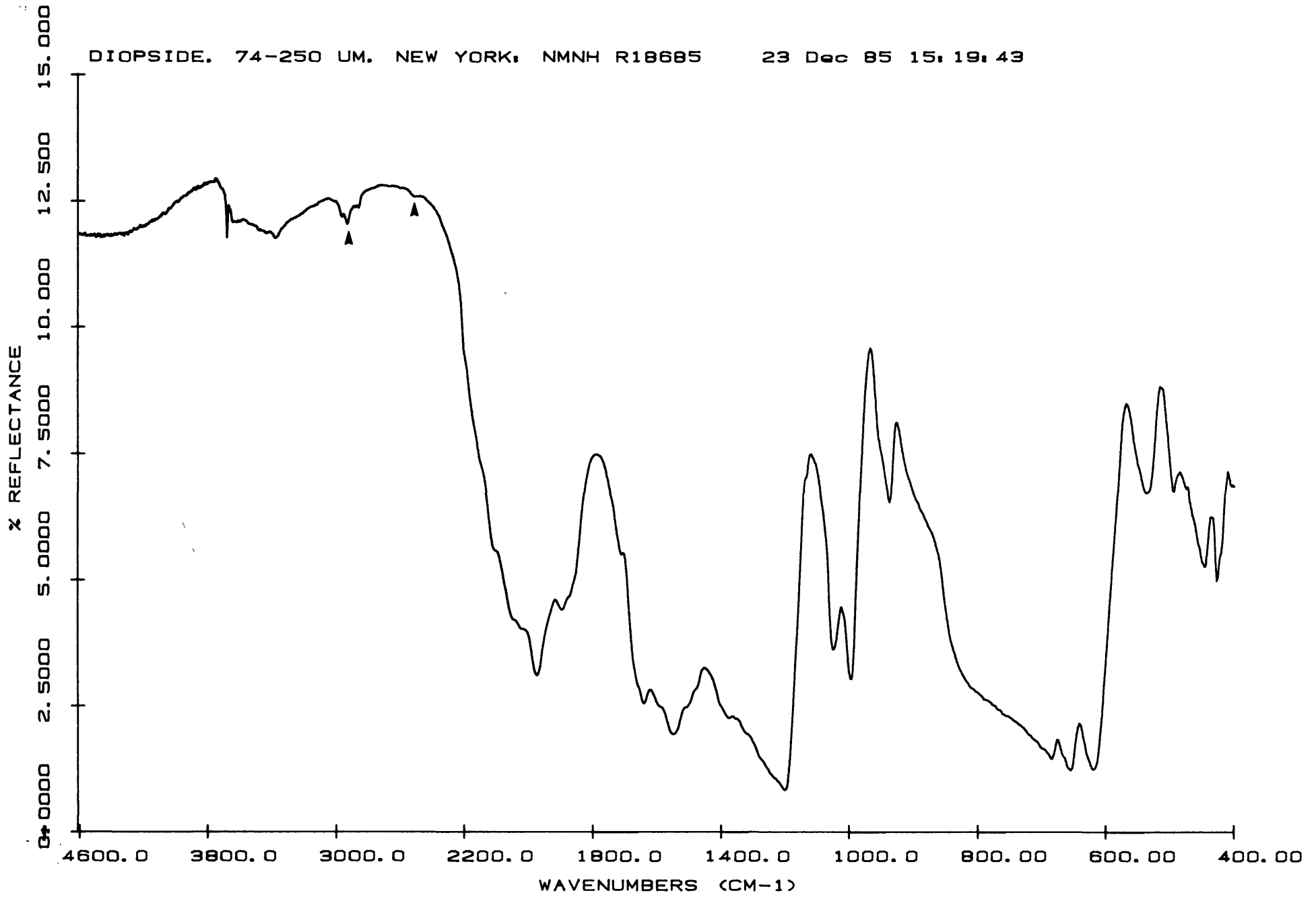
Results of XRF or other compositional analysis: Microprobe analysis showed sample to be homogeneous within and between grains examined. Average of 12 analyses indicates that this sample is close to end member composition:

SiO_2	- 54.77
Al_2O_3	- 0.49
FeO	- 0.87
MgO	- 18.26
CaO	- 25.60
K_2O	- 0.01
Na_2O	- 0.39
TiO_2	- 0.05
MnO	- 0.06
Total	-100.49

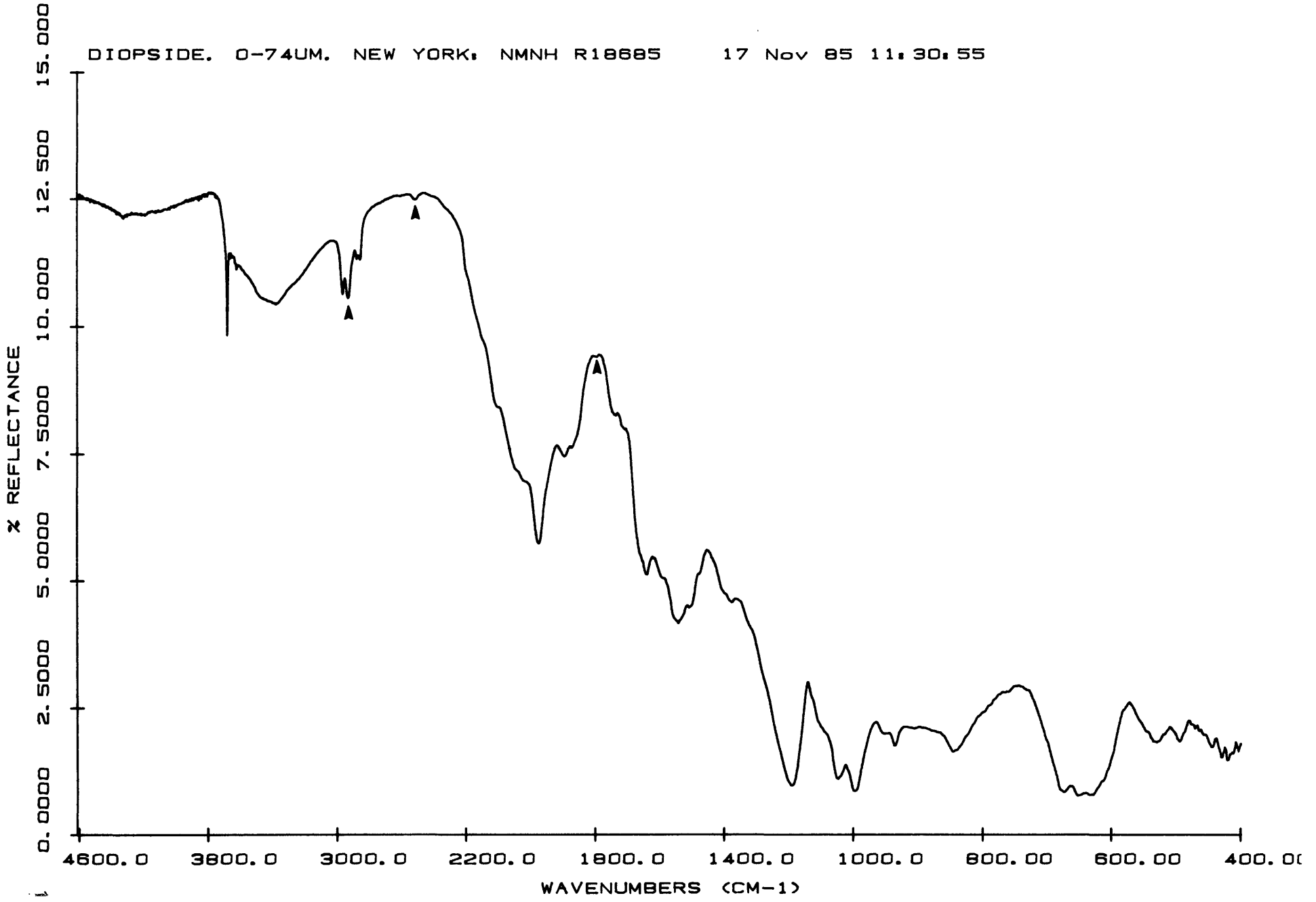
Spectra on file:

Diopside.2	Reflectance spec of 0-74 um size range on disk #1.
Diopside.2	Reflectance spectrum of 74-250 um size range on disk #1.
Diopside.2	Transmittance spectrum on Disk #1.


DIOPSIDE IN KBR. NEW YORK: NMNH R18685 14 Nov 85 12:37:10
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


DIOPSIDE. 74-250 UM. NEW YORK: NMNH R18685 23 Dec 85 15:19:43
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

124


DIOPSIDE. 0-74UM. NEW YORK: NMNH R18685 17 Nov 85 11:30:55
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.0
WAVENUMBERS (CM-1)

121

Species name: Enstatite $Mg_2Si_2O_6$

Locality: Frank Smith Mine, Barkly West (near), South Africa

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 128288

Results of petrographic examination: One 13.24 g. piece, light green in color, appears to be part of a single crystal. It has a large area of contamination by dark green mineral. Should be avoided in crushing. Very very small amount of veining by black mineral. Too small to worry about.

Under the microscope, hand-picked material appears moderately altered. Higher index of refraction than expected indicates probable higher iron content than pure enstatite.

Results of XRD: Enstatite plus a small amount of kaolinite and mica.

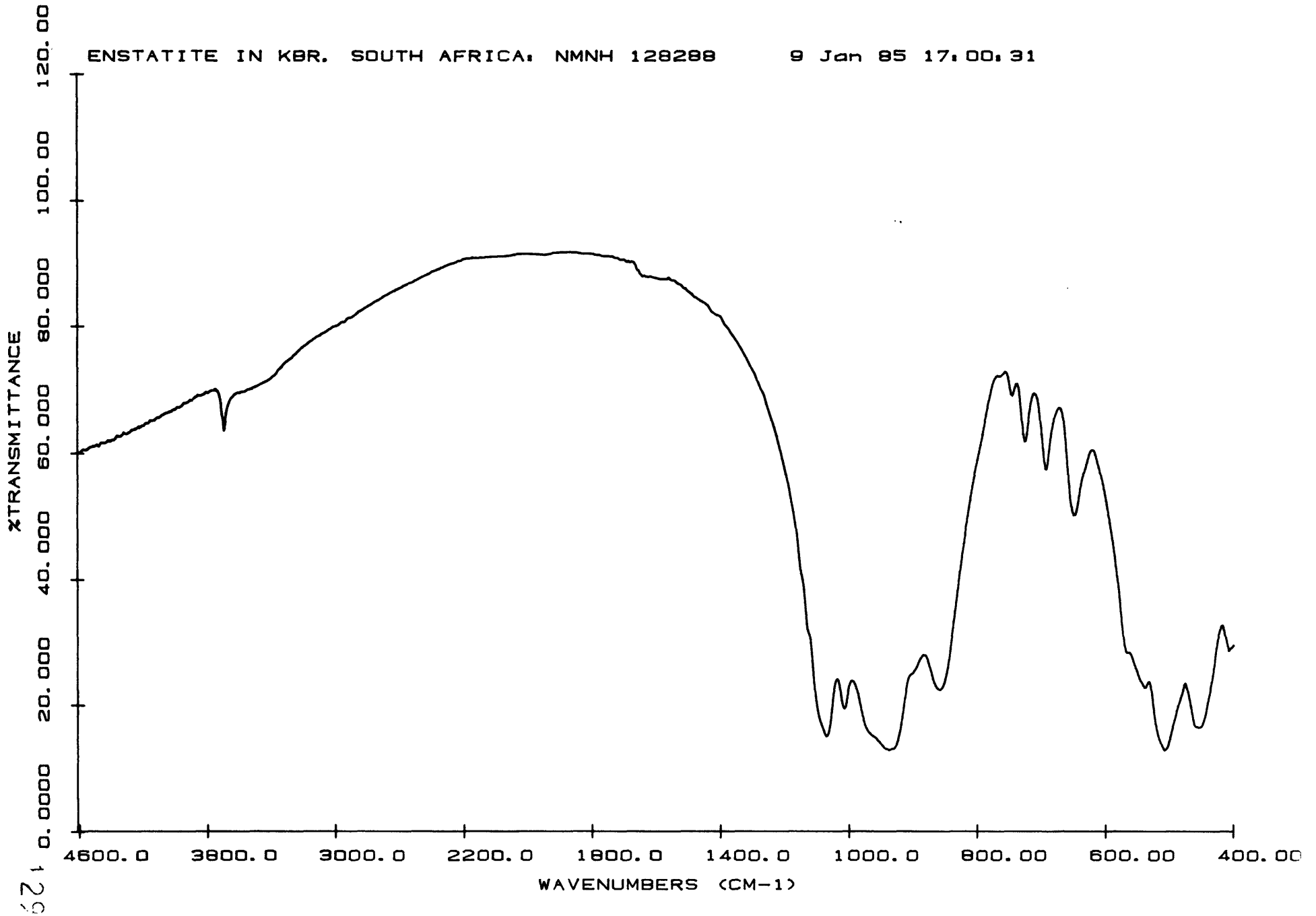
Results of XRF or other compositional analysis:

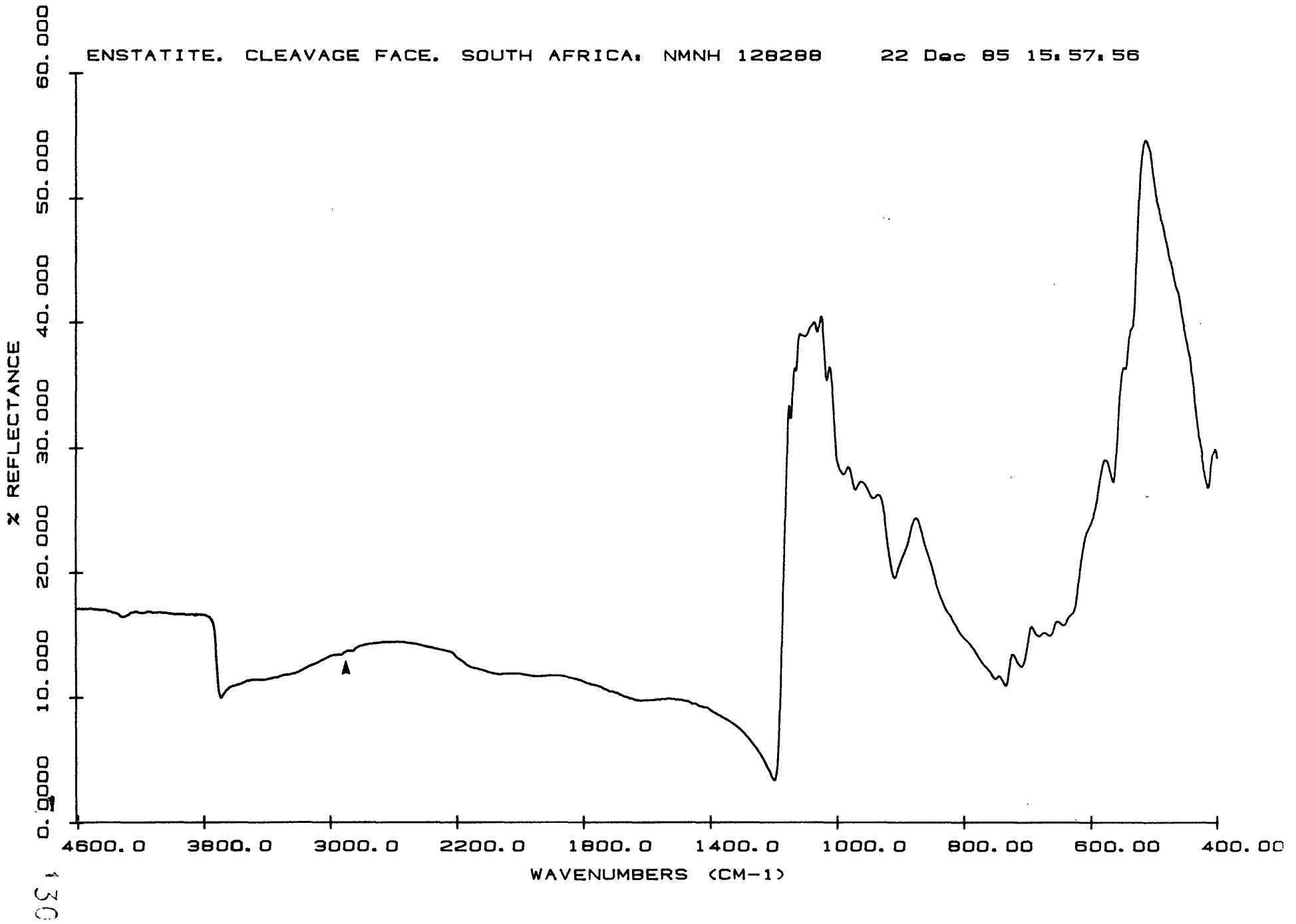
Microprobe analysis showed some heterogeneity. Six out of seven analyses were of enstatite bearing about 13% ferrosilite molecule. One analysis had slightly over 2% CaO, with a concomitant decrease in MgO, whereas the other analysis have 0.5% CaO. An average of the seven analyses is:

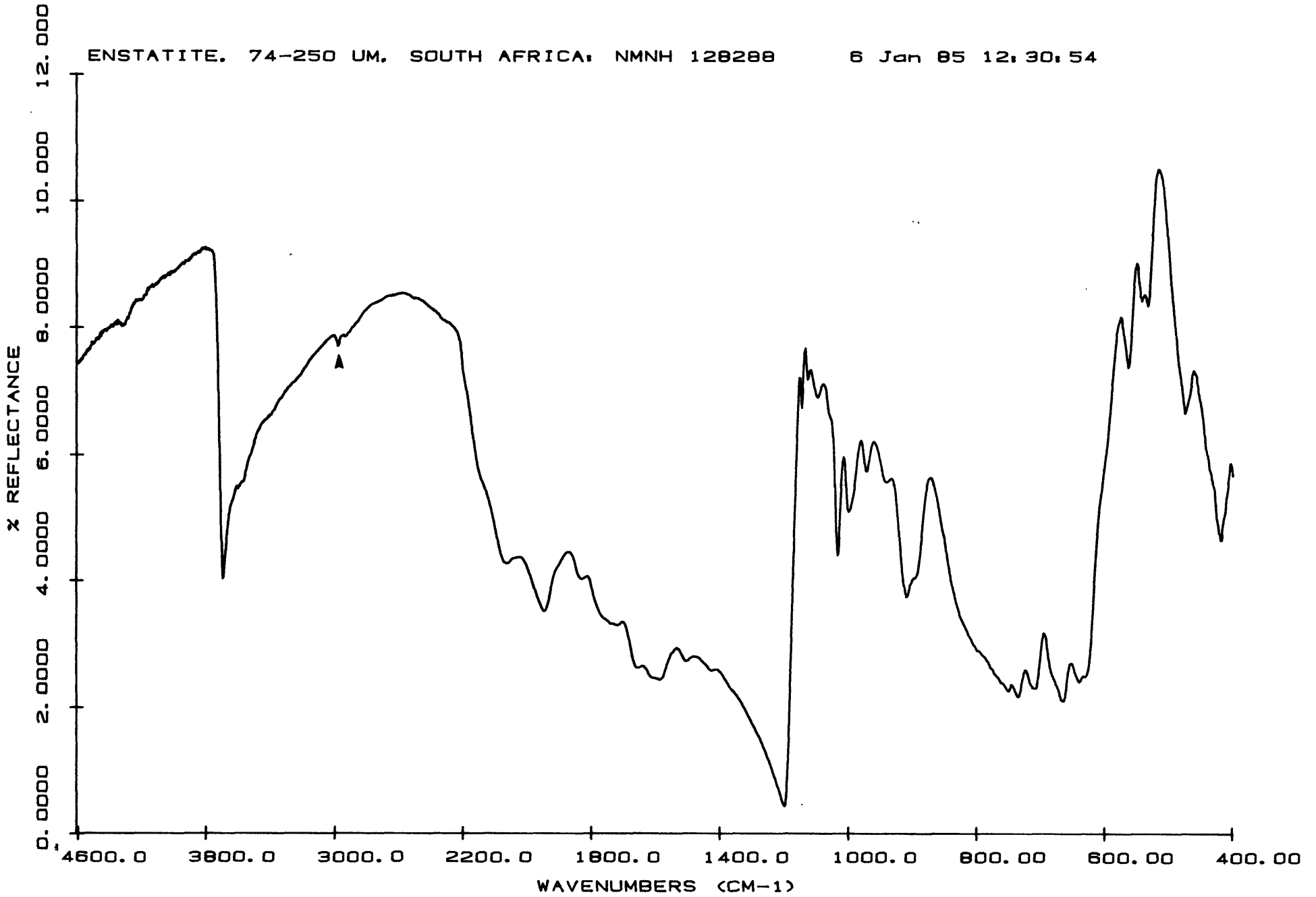
SiO_2	- 56.70
Al_2O_3	- 1.69
FeO	- 4.97
MgO	- 35.25
CaO	- 0.85
K_2O	- 0.02
Na_2O	- 0.02
TiO_2	- 0.01
MnO	- 0.15
Total	- 99.66

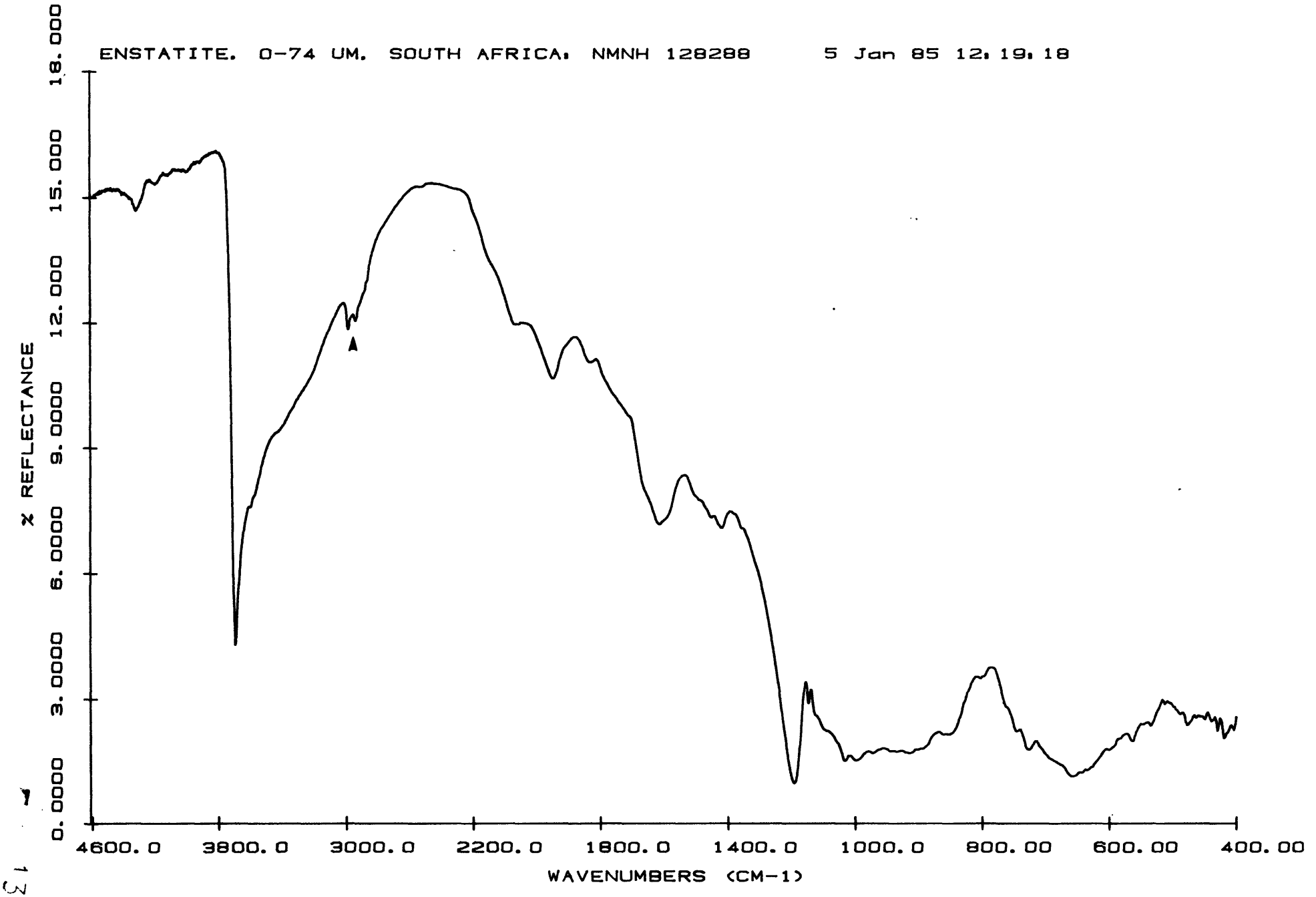
Spectra of file:

Enstatite.1	Reflectance spectrum of cleavage face on solid sample disk 1.
Enstatite.1	Reflectance spectrum of 0-74 um size range on disk #1.
Enstatite.1	Reflectance spectrum of 74-250 um size range on disk #1.
Enstatite.1	Transmittance spectrum on disk #1.


ENSTATITE IN KBR. SOUTH AFRICA: NMNH 128288
9 Jan 85 17:00:31
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ENSTATITE. CLEAVAGE FACE. SOUTH AFRICA: NMNH 128288 22 Dec 85 15:57:56
% REFLECTANCE
60.000
50.000
40.000
30.000
20.000
10.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ENSTATITE. 74-250 UM. SOUTH AFRICA: NMNH 128288
6 Jan 85 12:30:54
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ENSTATITE. 0-74 UM. SOUTH AFRICA. NMNH 128288 5 Jan 85 12:19:18
% REFLECTANCE
0.0000
3.0000
6.0000
9.0000
12.000
15.000
18.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Epidote $Ca_2(Al, Fe^{+3})_3 (SiO_4)_3 (OH)$

Locality: Prince of Wales Island, Alaska

Last donor: Bruce Hemingway

Intermediate donor:

Ultimate donor: Burminco, 128 S. Encinitas Ave., Monrovia, CA

Catalog numbers, etc.: None

Results of petrographic examination: Deep green colored epidote crystals 2 cm x 1 cm in size. Looks pure. Microscopic examination indicates pure clean epidote with no alteration.

Results of XRD: Epidote plus a trace of quartz. No quartz bands are apparent in the spectrum, however spectral features due to trace of a carbonate were seen and the sample was given acid treatment to remove this contaminent.

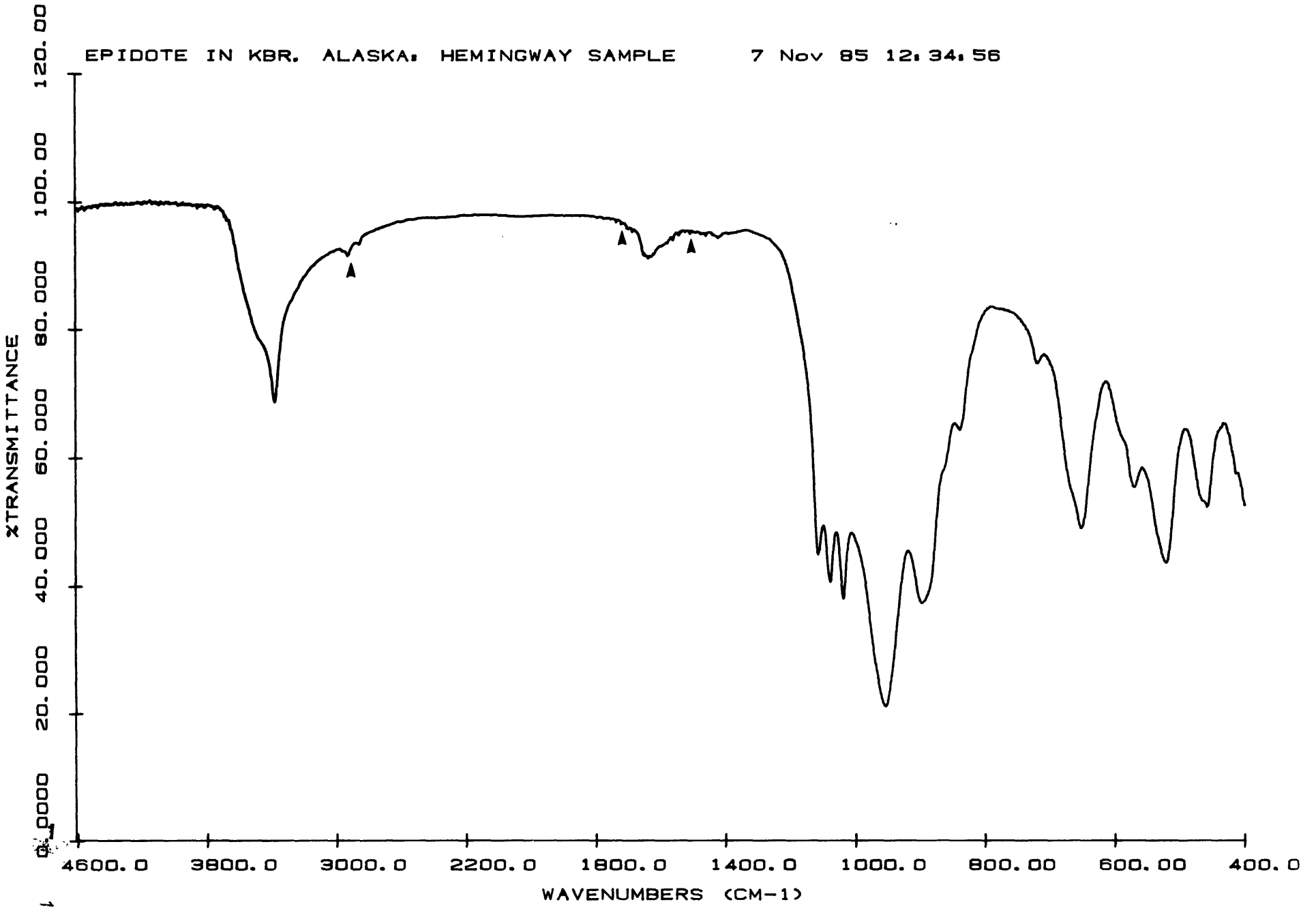
Results of XRF or other compositional analysis:

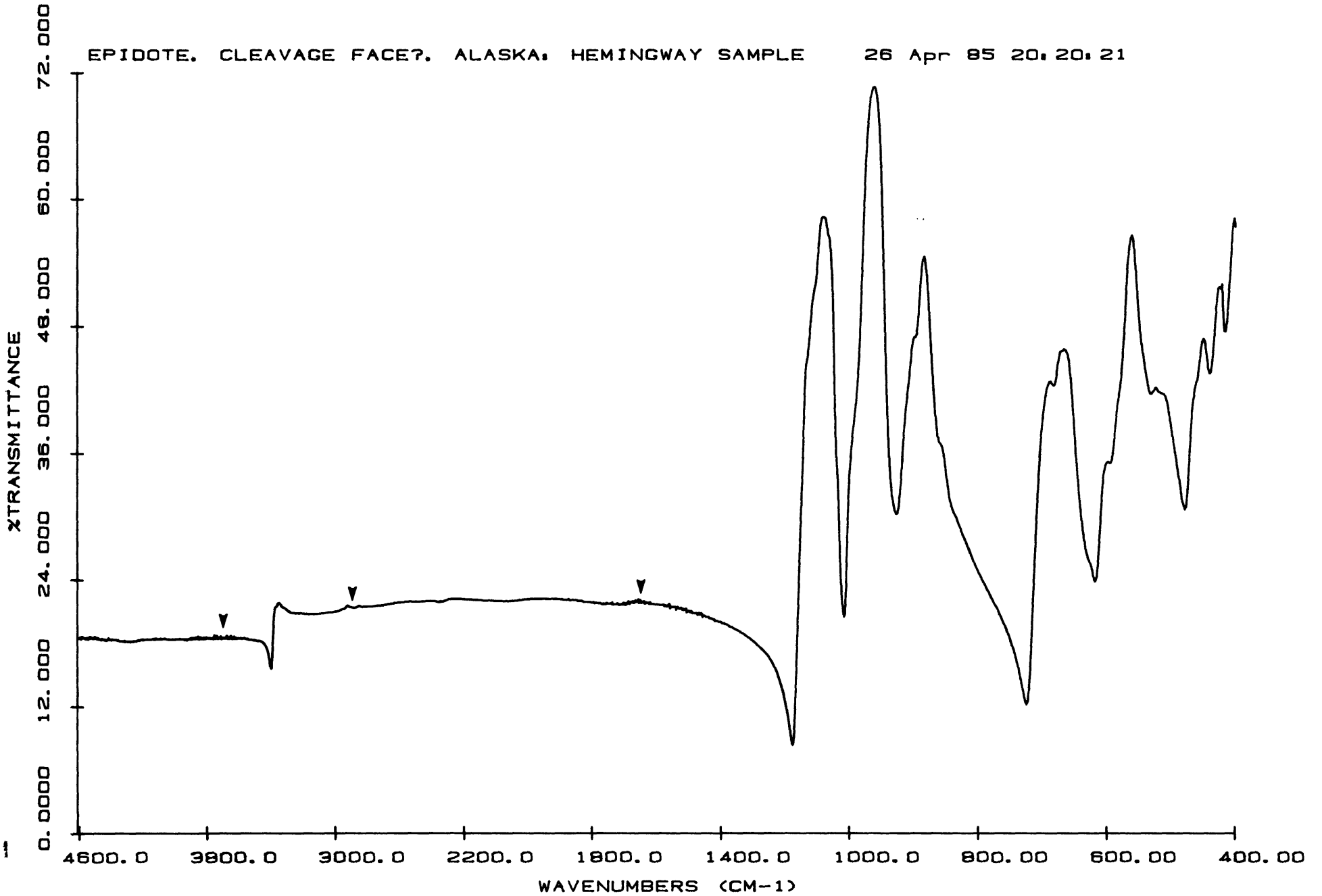
Microprobe analysis by indicates that the sample is homogeneous within and between grains, and has typical epidote composition:

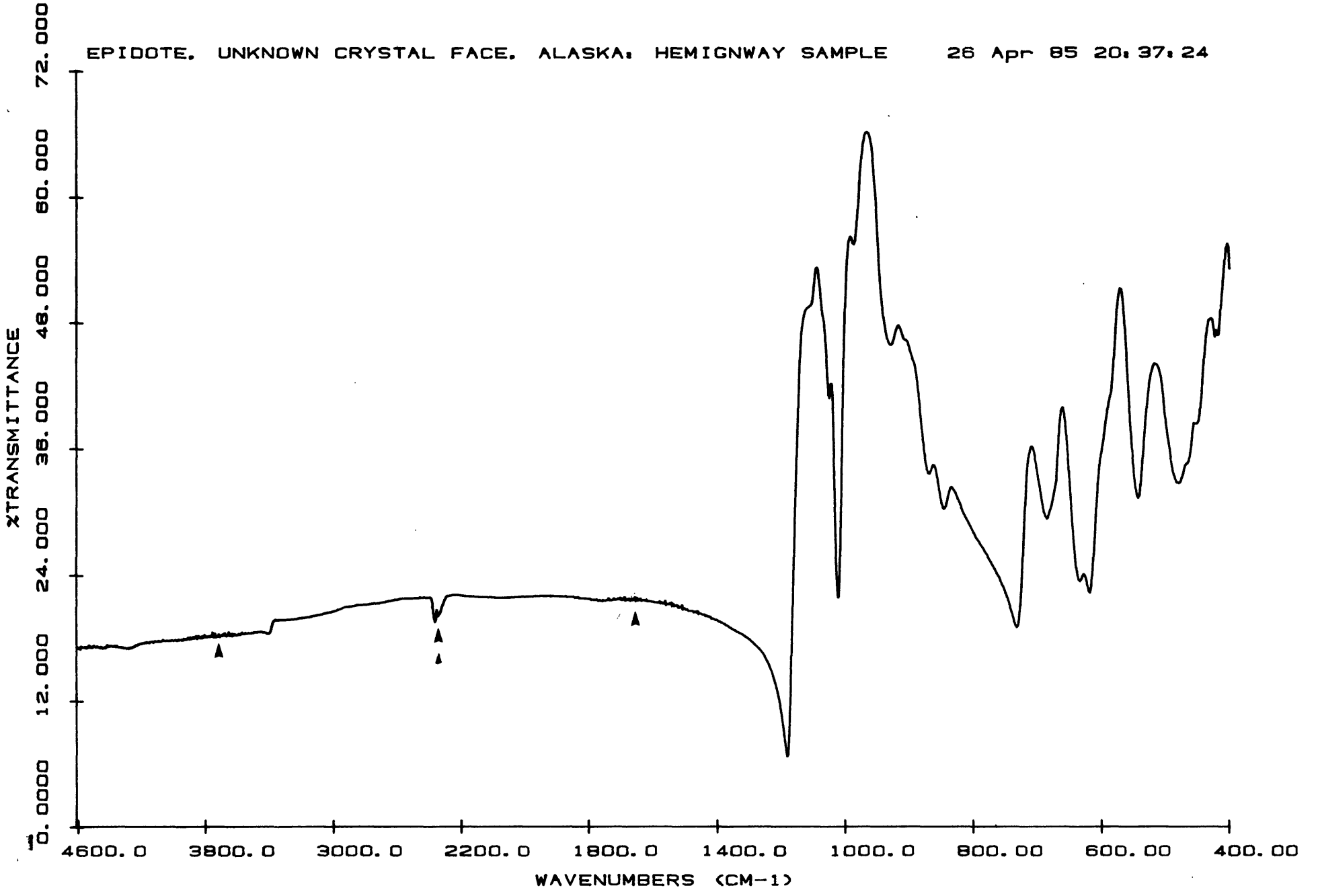
SiO_2	- 37.14
Al_2O_3	- 23.05
FeO	- 14.5
MgO	- 0.06
CaO	- 22.85
K_2O	- 0.02
Na_2O	- 0.01
TiO_2	- 0.16
MnO	- 0.18
Total	- 97.97

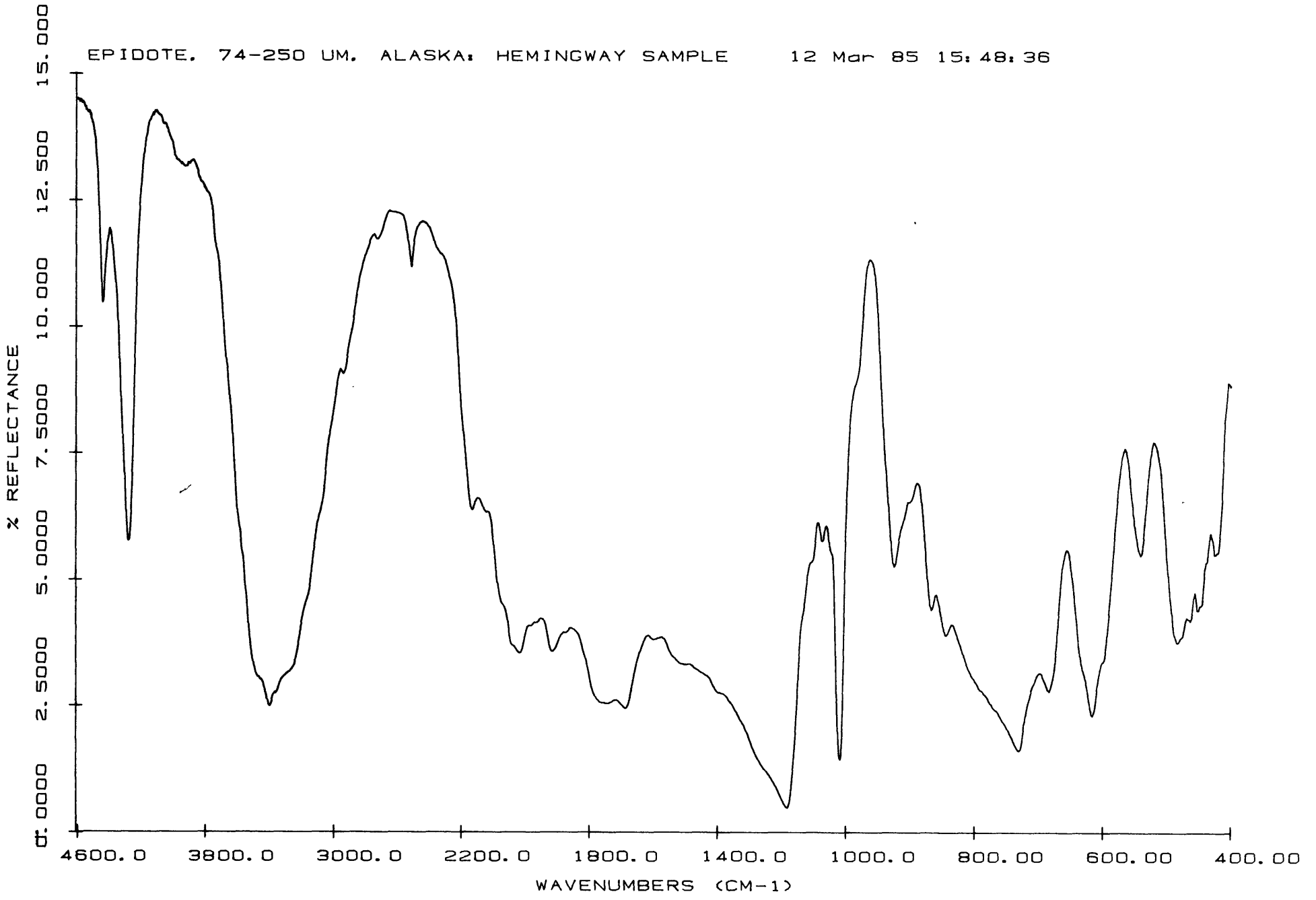
Spectra on file:

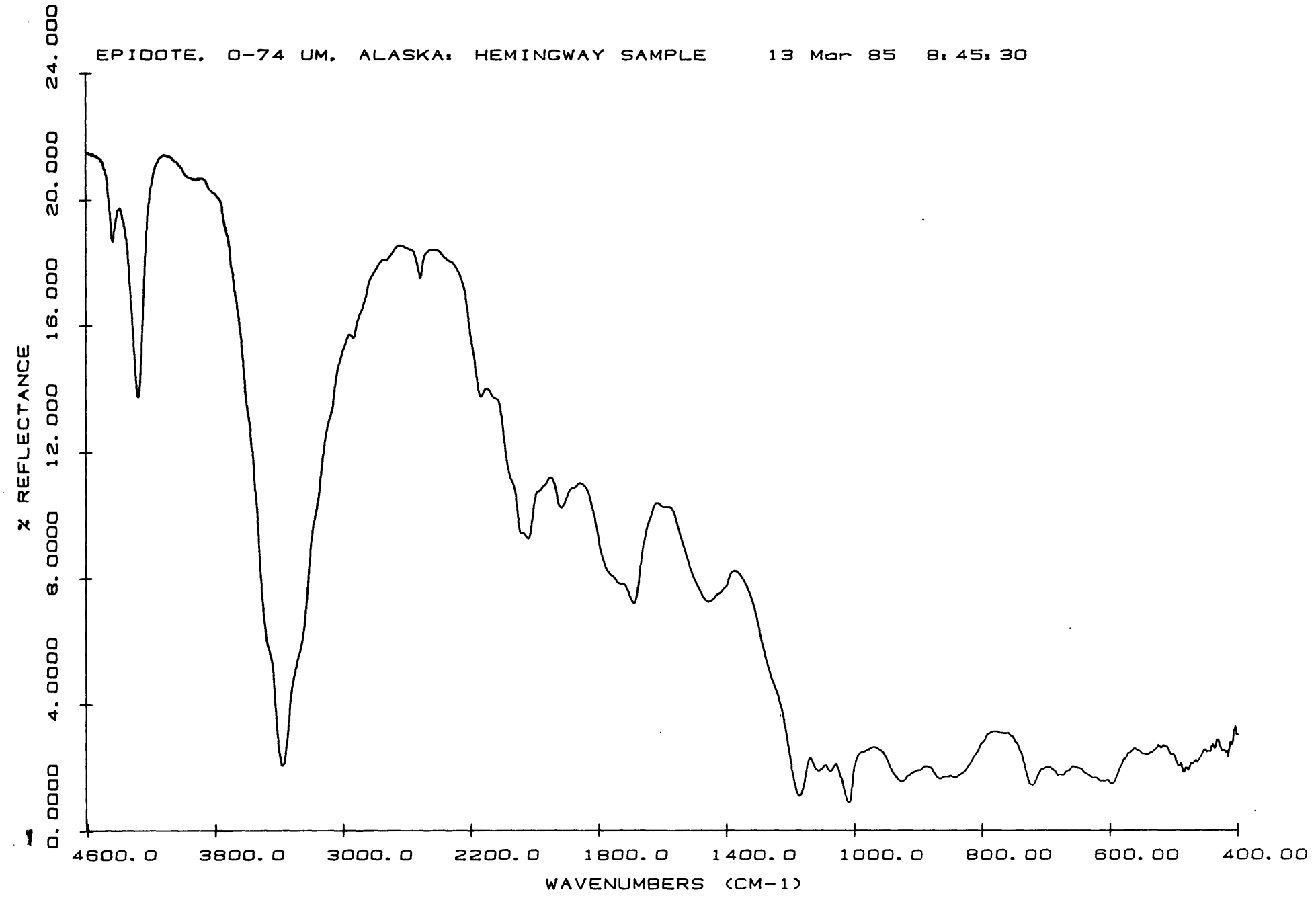
Epidote.1	Reflectance spectrum of 001 cleavage face (?) on solid sample disk #1.
Epidote.1A	Reflectance spectrum of unknown crystal face, disk #1.
Epidote.1	Reflectance spectrum of 0-74 um size fraction on disk #1.
Epidote.1	Reflectance spectrum of 74-250 um size fraction on disk #1.
Epidote.1	Transmittance spectrum on disk #1.


EPIDOTE IN KBR. ALASKA. HEMINGWAY SAMPLE 7 Nov 85 12:34:56
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.0
WAVENUMBERS (CM-1)


EPIDOTE. CLEAVAGE FACE?. ALASKA. HEMINGWAY SAMPLE 26 Apr 85 20:20:21
%TRANSMITTANCE
72.000
60.000
48.000
36.000
24.000
12.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


EPIDOTE. UNKNOWN CRYSTAL FACE. ALASKA: HEMIGNWAY SAMPLE 26 Apr 85 20:37:24
%TRANSMITTANCE
72.000
60.000
48.000
36.000
24.000
12.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


EPIDOTE. 74-250 UM. ALASKA: HEMINGWAY SAMPLE 12 Mar 85 15:48:36
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


EPIDOTE. 0-74 UM. ALASKA: HEMINGWAY SAMPLE 13 Mar 85 8:45:30
% REFLECTANCE
0.0000
4.0000
8.0000
12.000
16.000
20.000
24.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Grossular $Ca_3Al_2(SiO_4)_3$

Locality: Pear Gillis Farm, Beach Glen, Buncombe Co, North Carolina

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 155371

Results of petrographic examination: Hand sample very impure. Green interstitical material - probable diopside, occurs between many small brown euhedral crystals of grossular. Sample is about 1.5 cm sphere. Under petrographic microscope, very, very small amount of alteration of grossular crystals is seen. Hand picked for sample to be analyzed.

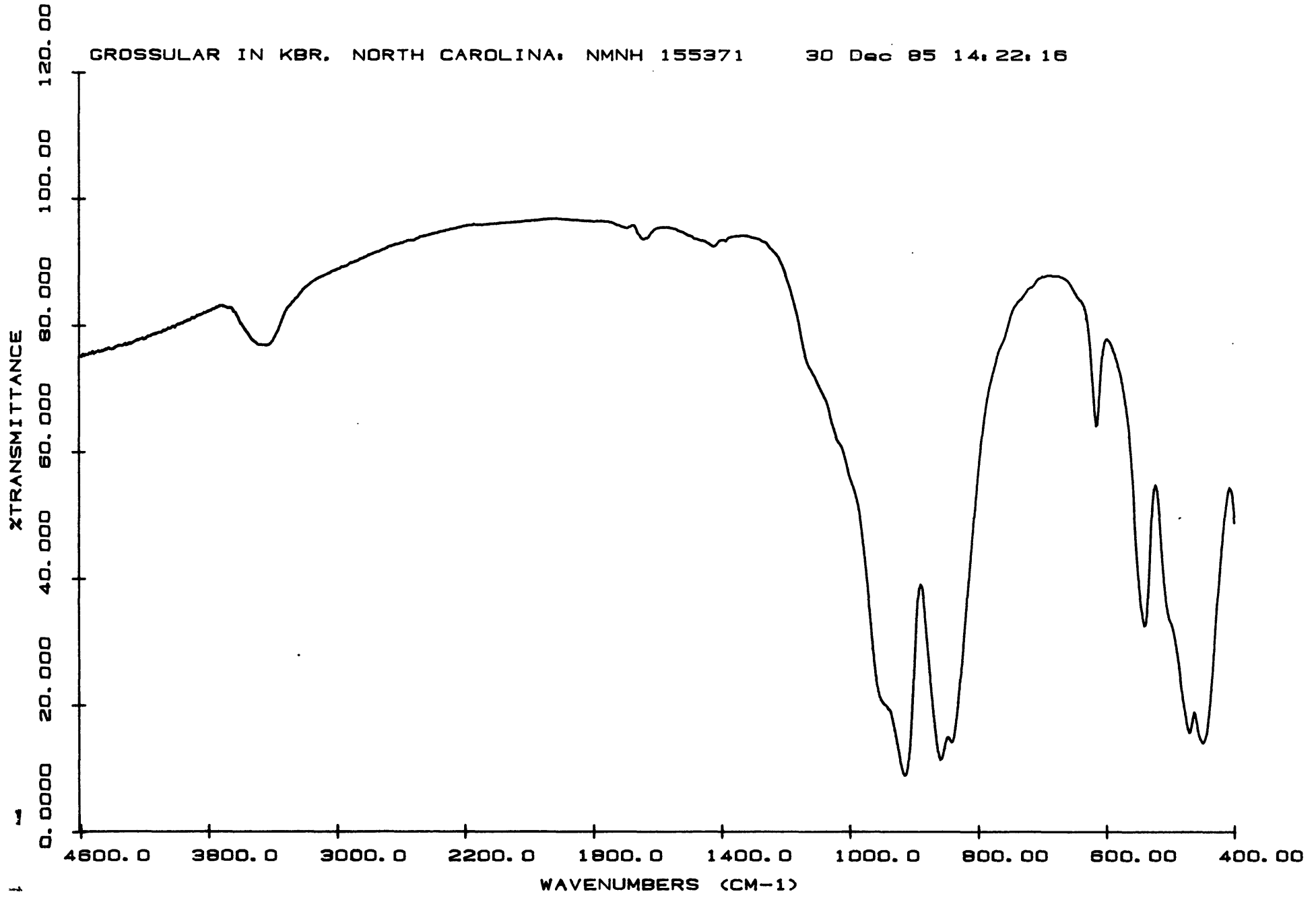
Results of XRD: Sample is grossular plus a very small peak at 1.879 A due to a trace of unknown contaminant.

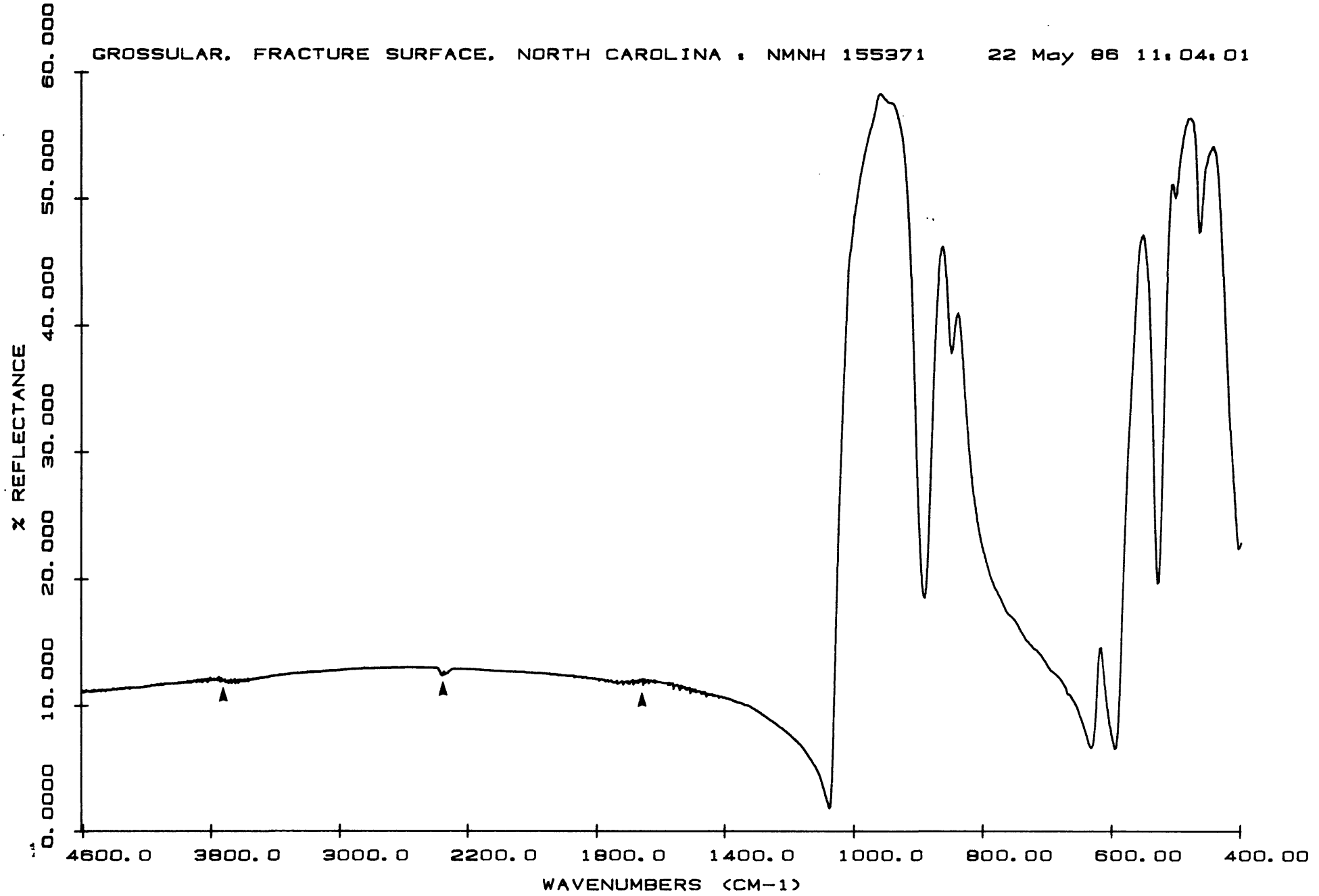
Results of XRF or other compositional analysis: Microprobe analysis shows hand-picked grains to be relatively homogeneous, with only about a 1 wt % variation in FeO and CaO. Average of 11 analyses indicates that this sample is a solid solution of grossulerite with andradite:

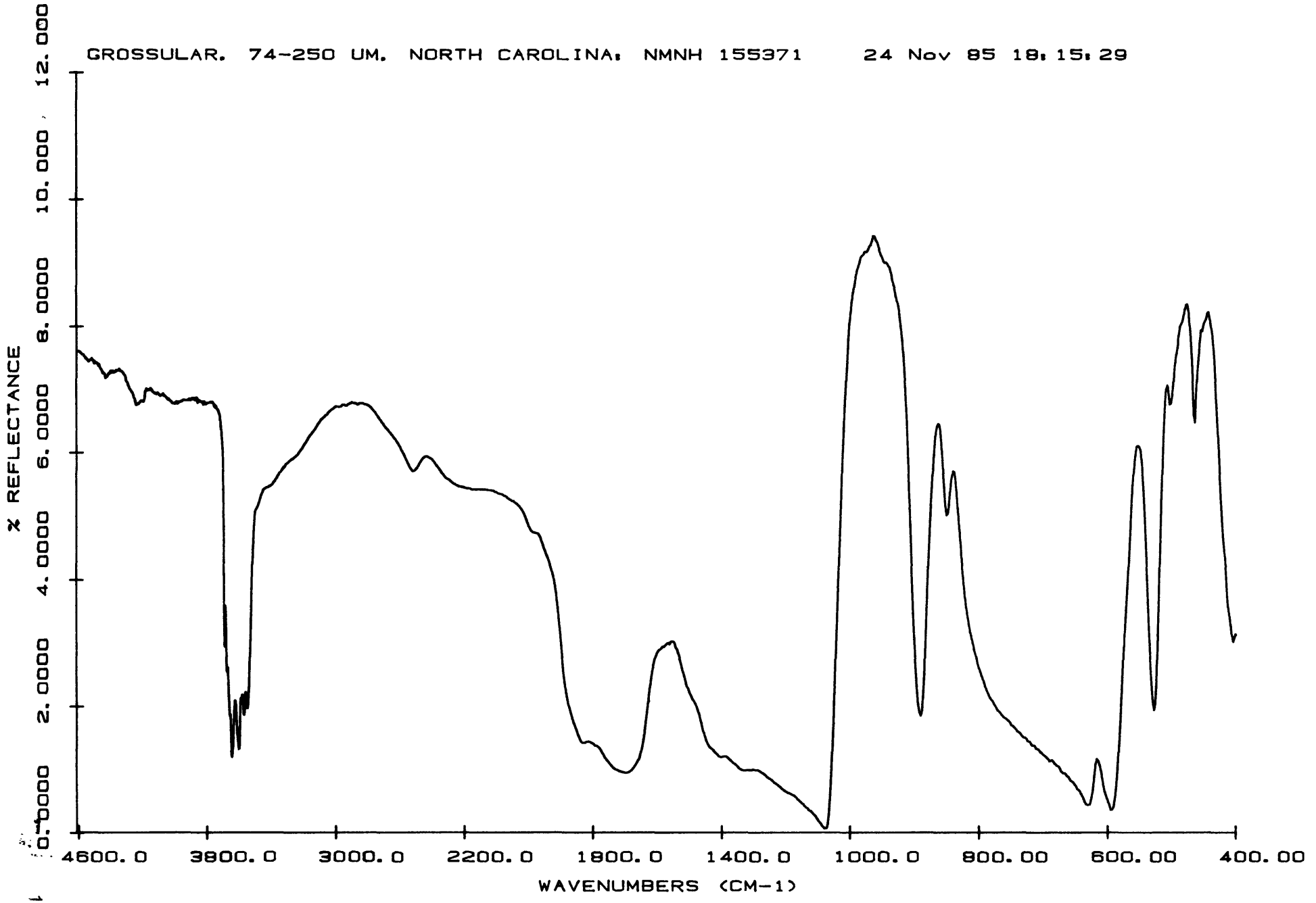
SiO_2	- 38.84
Al_2O_3	- 17.95
FeO	- 7.08
MgO	- 0.15
CaO	- 35.81
K_2O	- 0.03
Na_2O	- 0.05
TiO_2	- 0.70
MnO	- 0.51
Total	-101.11

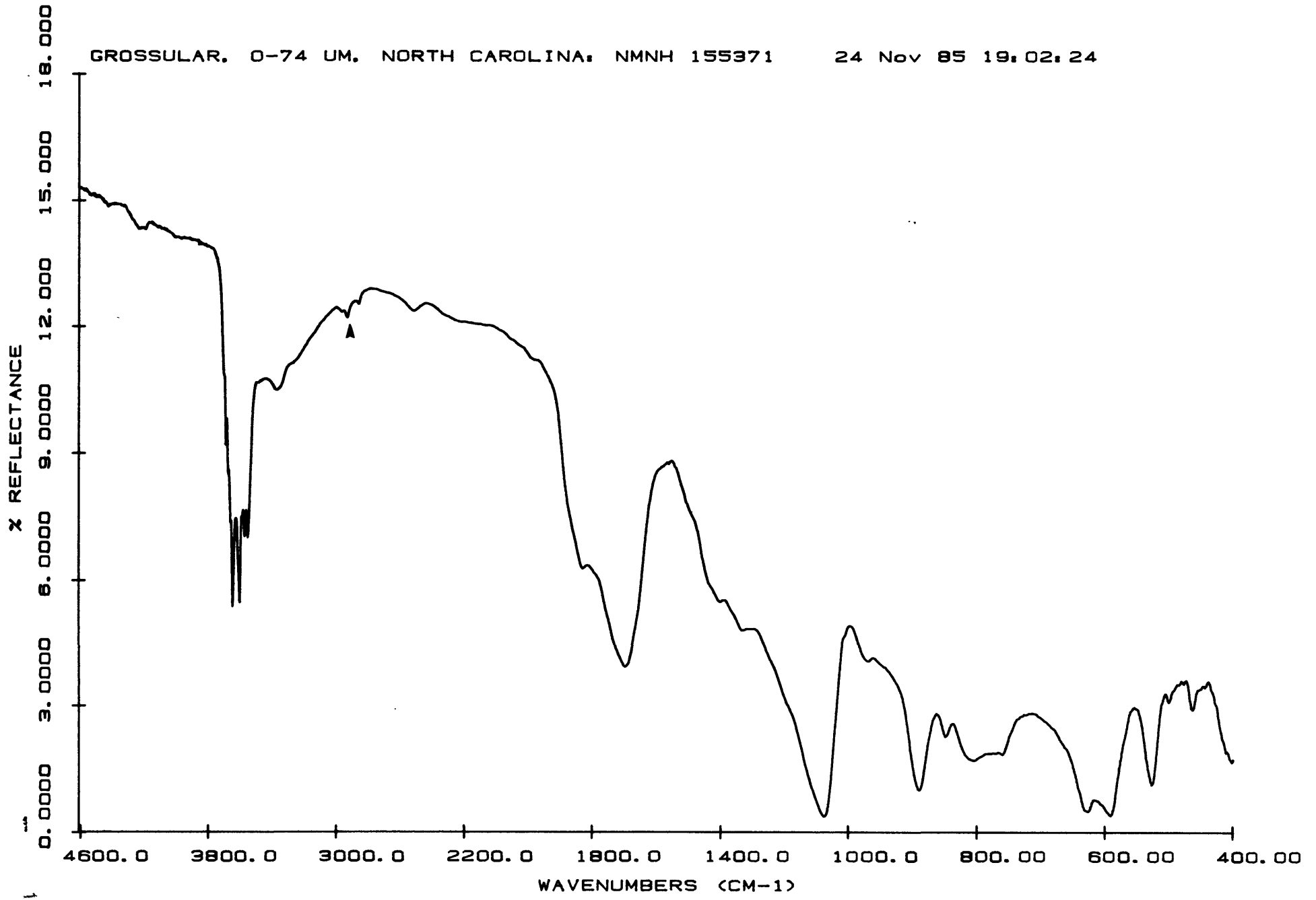
Spectra on file:

Grossular.2	Reflectance spectrum of fracture surface on solid sample disk #1.
Grossular.2	Reflectance spectrum of 0-74 size fraction on disk #1.
Grossular.2	Reflectance spectrum of 74-250 um size fraction on disk #1.
Grossular.2	Transmittance spectrum on disk 1.


GROSSULAR IN KBR. NORTH CAROLINA: NMNH 155371 30 Dec 85 14:22:16
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


GROSSULAR. FRACTURE SURFACE. NORTH CAROLINA : NMNH 155371 22 May 86 11:04:01
% REFLECTANCE
60.000
50.000
40.000
30.000
20.000
10.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


GROSSULAR. 74-250 UM. NORTH CAROLINA: NMNH 155371 24 Nov 85 18:15:29
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


GROSSULAR. 0-74 UM. NORTH CAROLINA: NMNH 155371 24 Nov 85 19:02:24
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Gypsum (alabaster) $CaSo_4.2H_2O$

Locality: Pomaia, Italy

Last donor: Hunt and Salisbury

Intermediate donor:

Ultimate donor: Ward's Scientific

Catalog numbers, etc.: H & S 26B

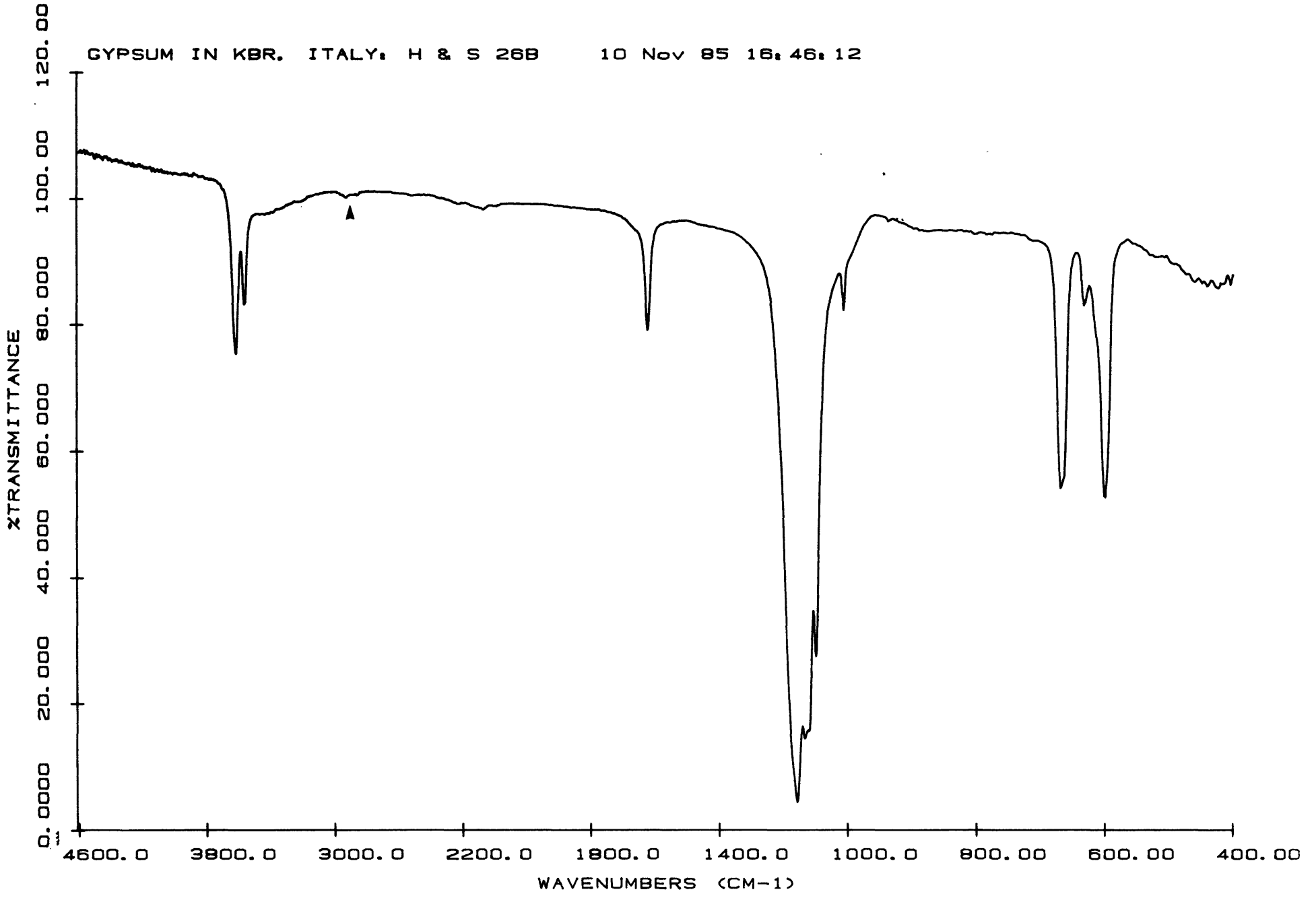
Results of petrographic examination: Hand sample is white, translucent and appears pure.

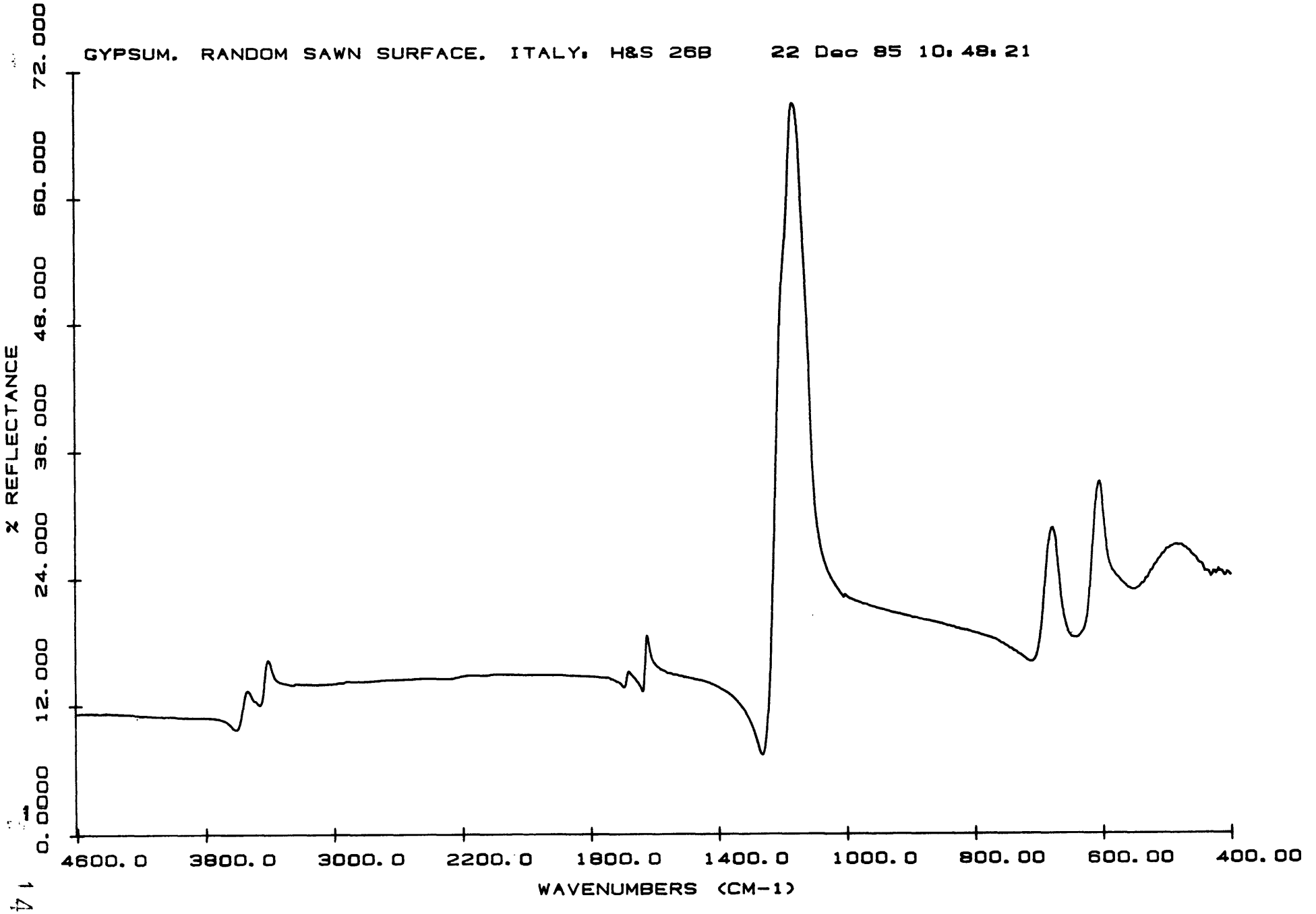
Results of XRD: Pure gypsum.

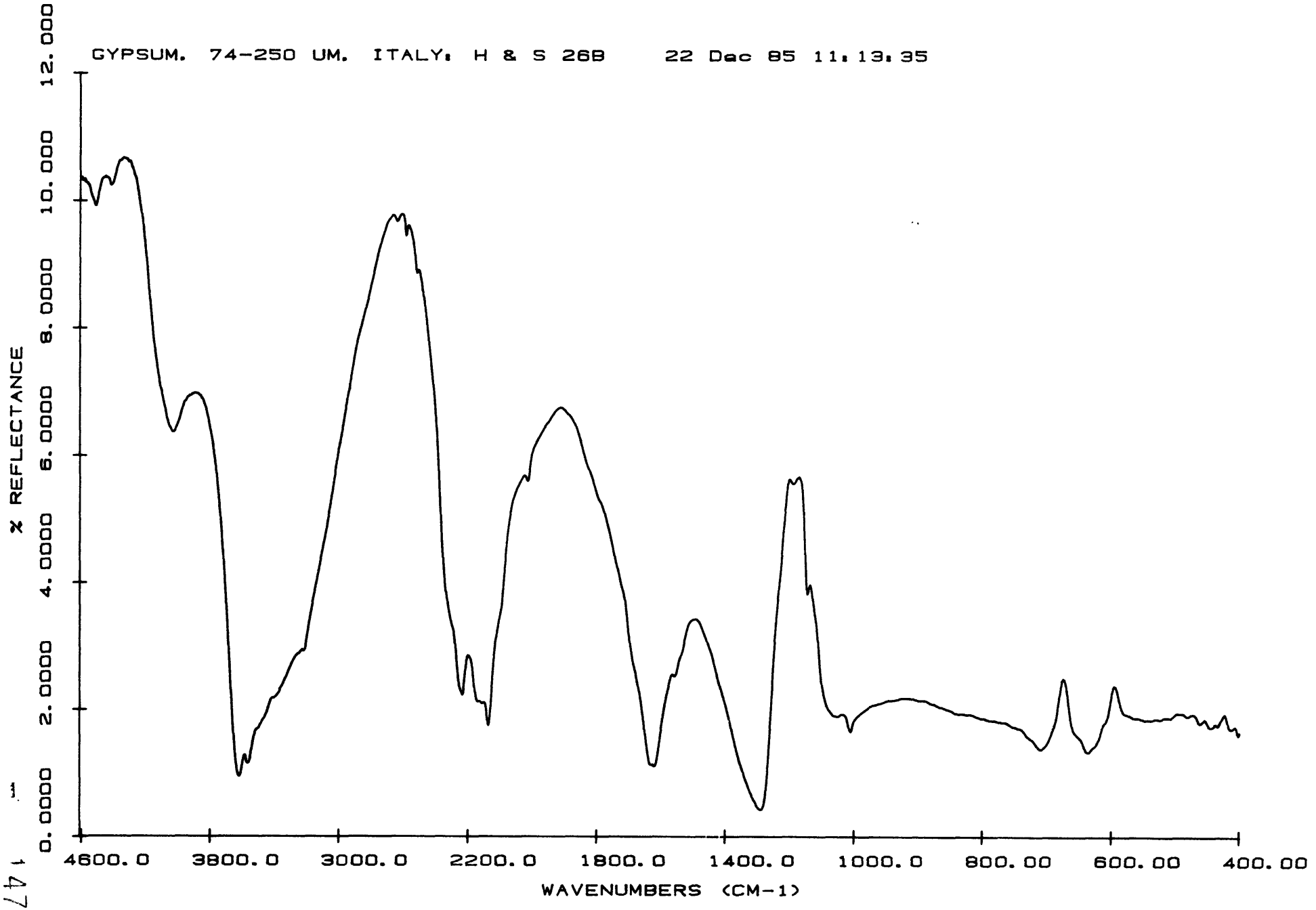
Results of XRF or other compositional analysis: None

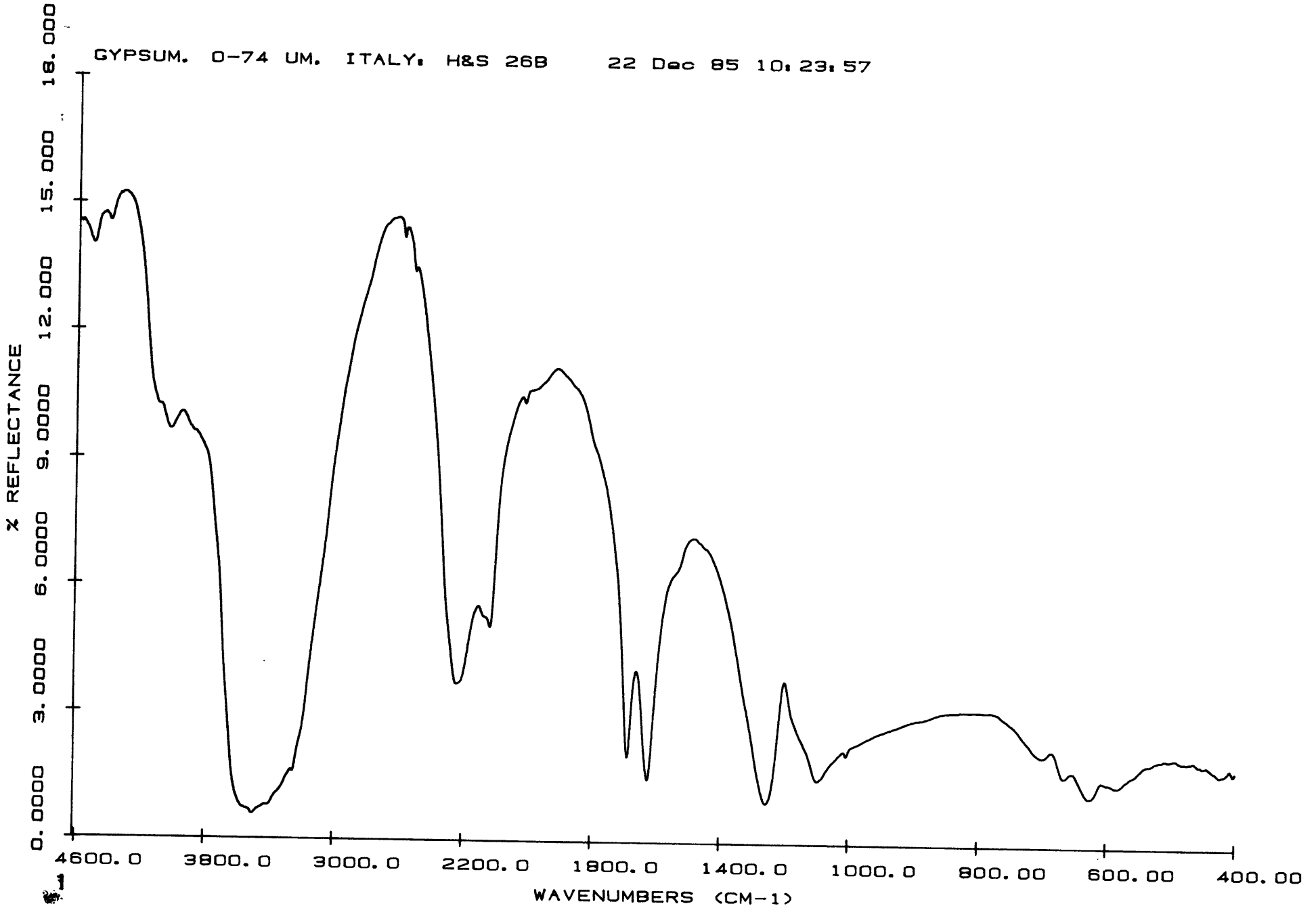
Spectra on file:

Gypsum.1	Reflectance spectrum of random sawed surface on solid sample disk #1.
Gypsum.1	Diffuse reflectance spectrum of 0-74 um size range on disk #1.
Gypsum.1	Diffuse reflectance spectrum of 74-250 um size range on disk #1.
Gypsum.1	Transmittance spectrum on disk #1.


GYPSUM IN KBR. ITALY: H & S 26B 10 Nov 85 16:46:12
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


GYPSUM. RANDOM SAWN SURFACE. ITALY: H&S 26B 22 Dec 85 10:48:21
% REFLECTANCE
72.000
60.000
48.000
36.000
24.000
12.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


GYPSUM. 74-250 UM. ITALY: H & S 26B 22 Dec 85 11:13:35
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


GYPSUM. 0-74 UM. ITALY: H&S 26B 22 Dec 85 10:23:57
% REFLECTANCE
0.0000
3.0000
6.0000
9.0000
12.000
15.000
18.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Hedenbergite $CaFe^{+2}Si_2O_6$

Locality: Eureka 2nd Level, Sub-level 1, 135 N, 645E, Ducktown, Tenn.

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 119197

Results of petrographic examination: About 28 g. made up of 3 pieces and 3 fragments, which are deep green and part of single crystals. Very small amount of veining. Surfaces of the pieces have a veneer of contamination - probably the same as the veining. Also some sulphide contamination (extremely small amount).

Under the microscope this appears to be largely pure hedenbergite with a rather small (<1%) degree of alteration. A few large, high-birefringent grains are present with a platy cleavage that look like mica, but have too high a refractive index.

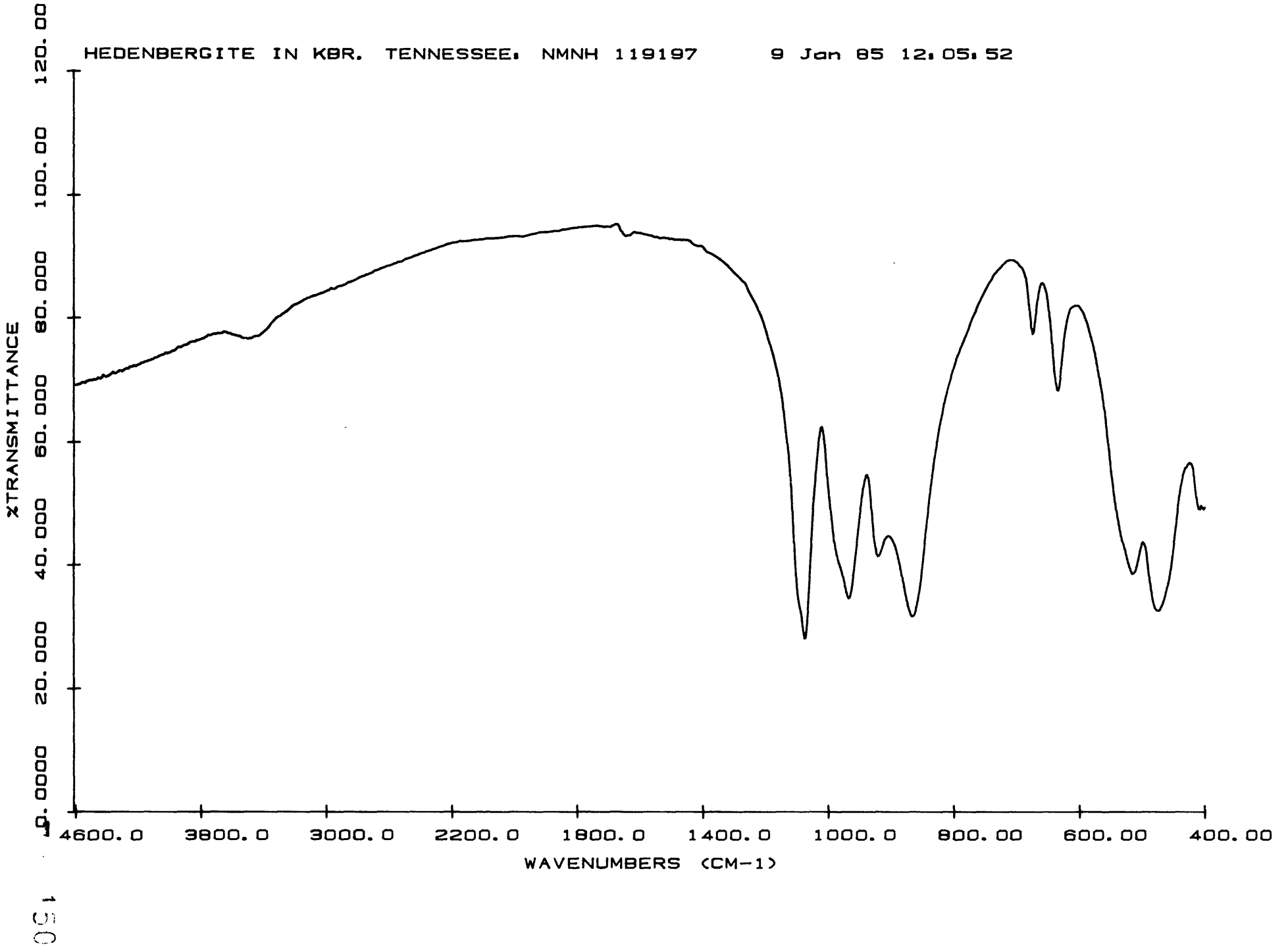
Results of XRD: XRD indicates pure hedenbergite, with no sign of exsolved orthopyroxene or mica, but finest partical size range in particular displays spectral features due to a trace of carbonate.

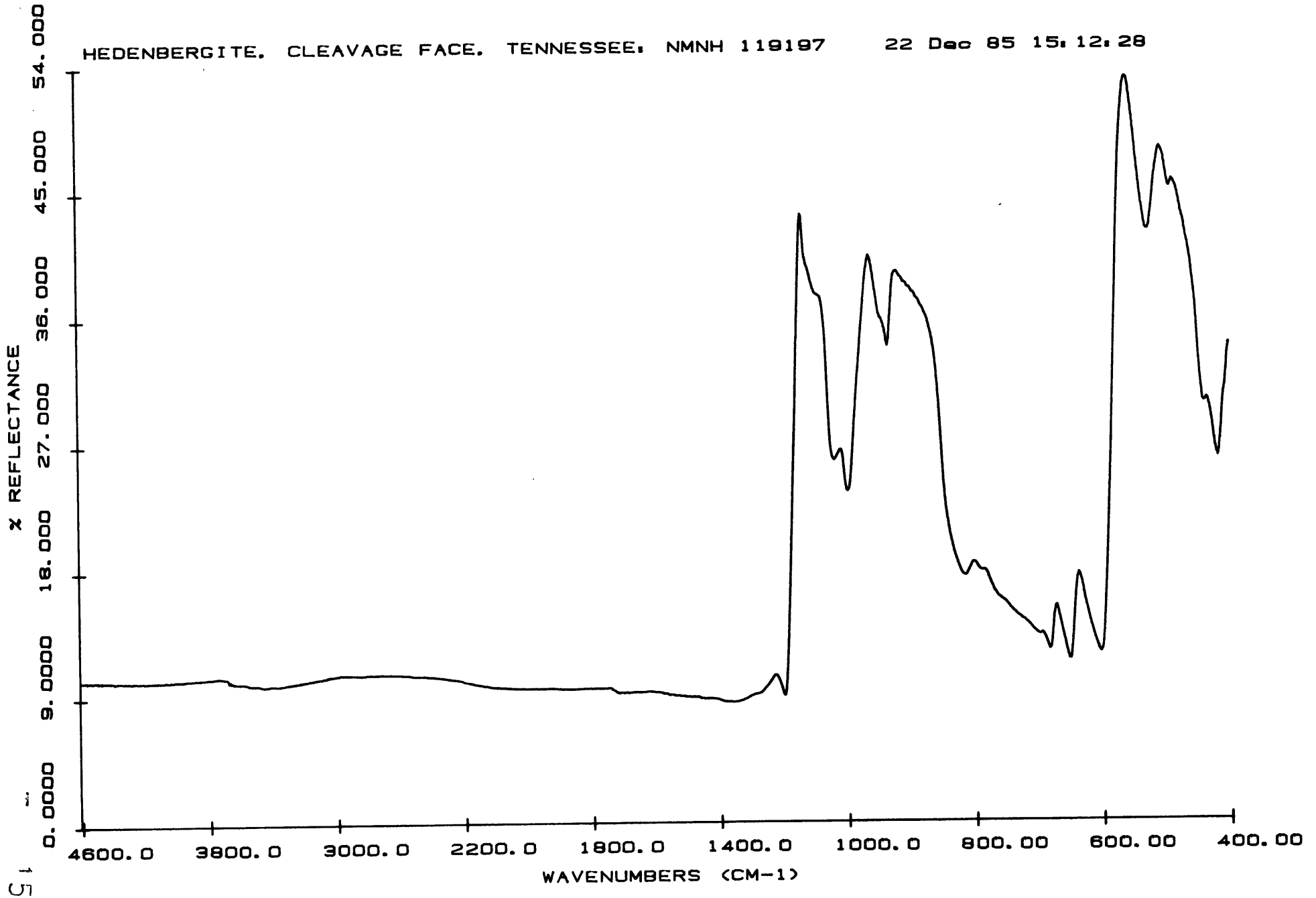
Results of XRF or other compositional analysis:

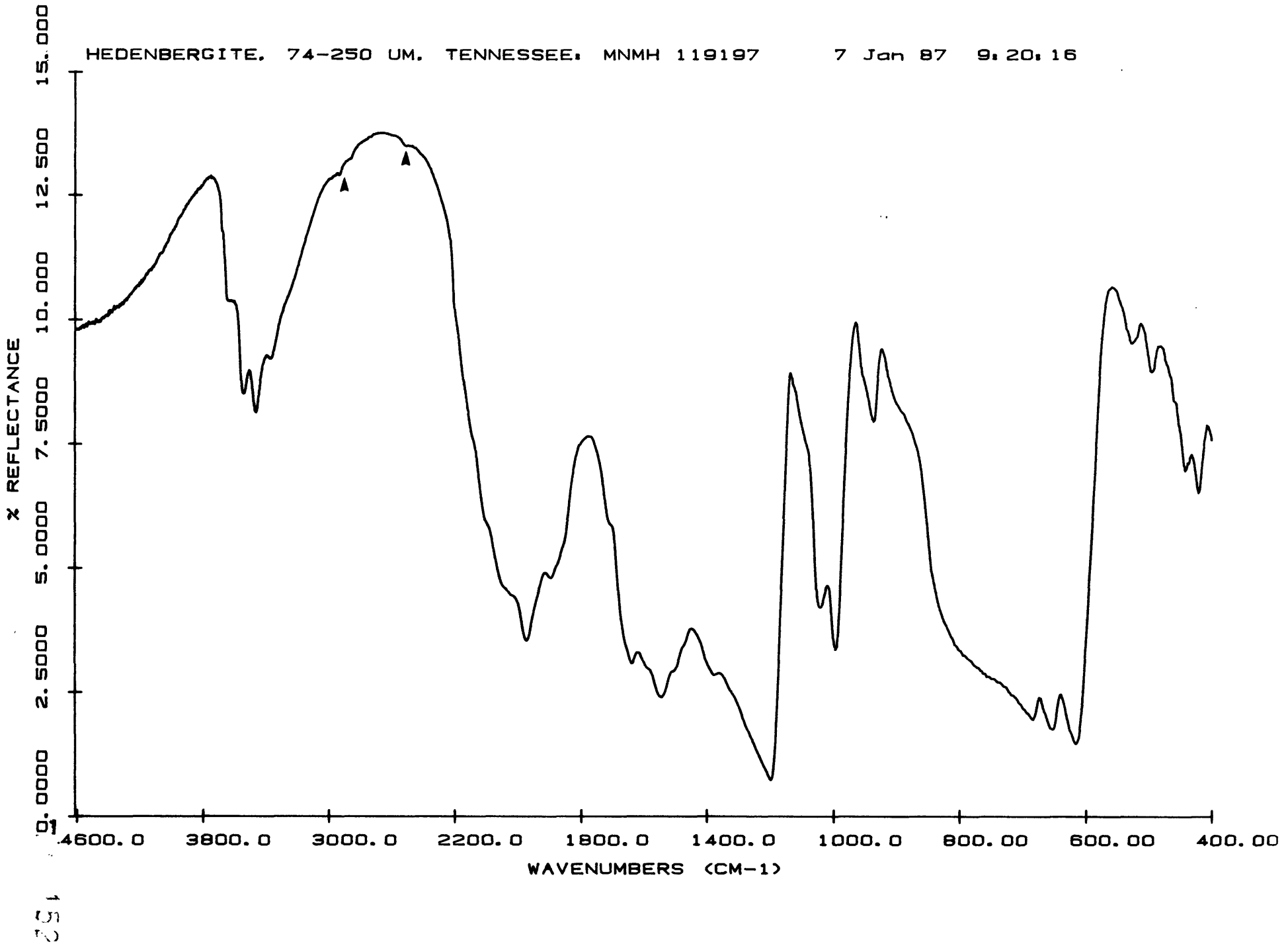
Microprobe analysis shows slight heterogeneity within and among grains - ie. alumina varies between 0.5 and 1.5% with no concomitant variation of the other oxides measured. Average of nine analyses:

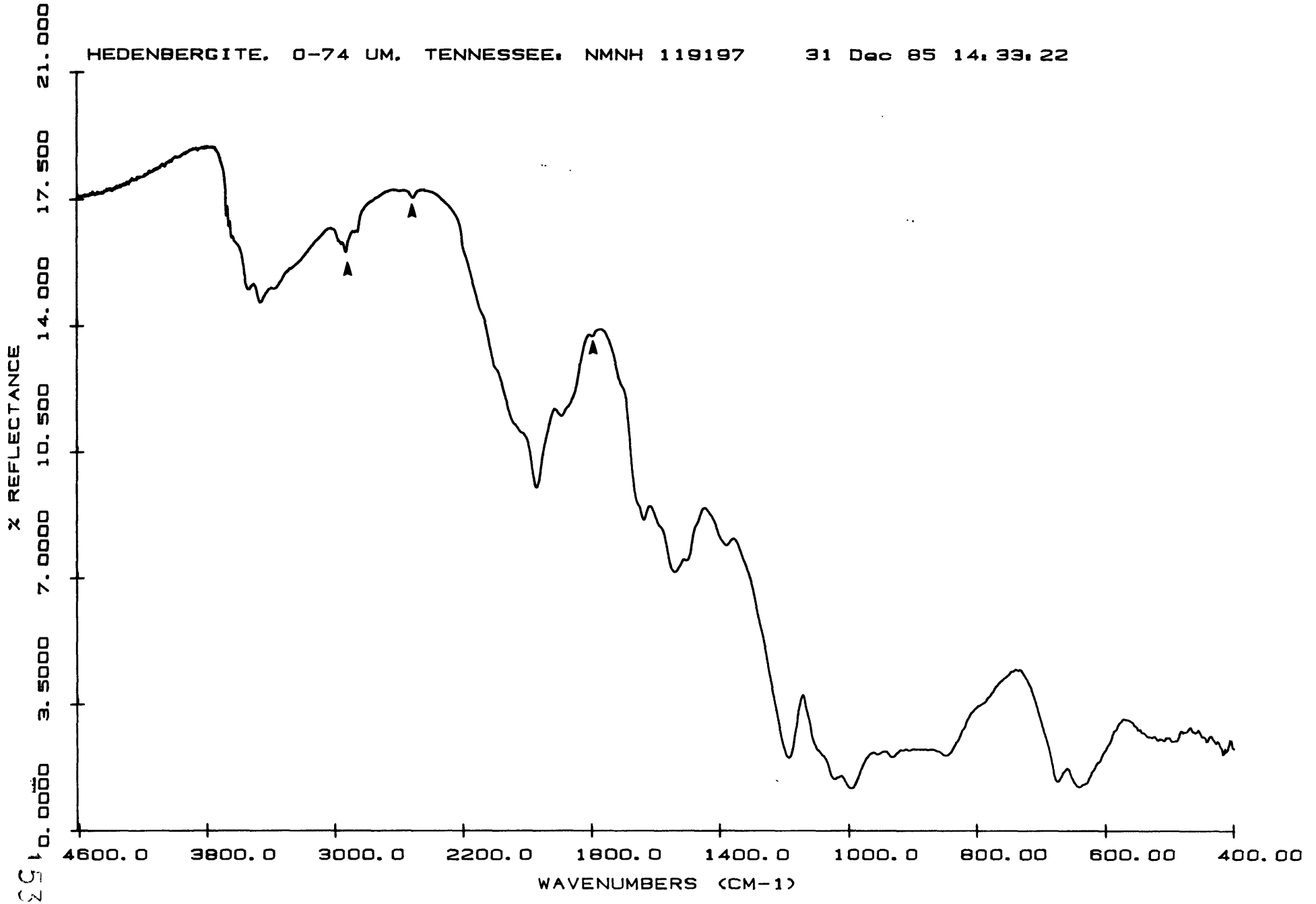
SiO_2	- 53.36
Al_2O_3	- 0.87
FeO	- 6.45
MgO	- 14.35
CaO	- 24.53
K_2O	- 0.03
Na_2O	- 0.48
TiO_2	- 0.04
MnO	- 0.73
Total	-100.84

Spectra of file:
Hedenbergite.1 Reflectance spectrum of cleavage face on solid sample disk 1.
Hedenbergite.1 Reflectance spectrum of 0-74 um size range on disk #1
Hedenbergite.1 Transmittance spectrum on disk 1.
Hedenbergite.1 Reflectance spectrum of 74-250 um size range on disk #1.


HEDENBERGITE IN KBR. TENNESSEE: NMNH 119197 9 Jan 85 12:05:52
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HEDENBERGITE. CLEAVAGE FACE. TENNESSEE: NMNH 119197 22 Dec 85 15:12:28
% REFLECTANCE
0.0000
9.0000
18.000
27.000
36.000
45.000
54.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HEDENBERGITE, 74-250 UM. TENNESSEE: MNMH 119197
7 Jan 87 9:20:16
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HEDENBERGITE. 0-74 UM. TENNESSEE. NMNH 119197 31 Dec 85 14:33:22
% REFLECTANCE
21.000
17.500
14.000
10.500
7.0000
3.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Hemimorphite $Zn_4Si_2O_7(OH)_2 \cdot H_2O$

Locality: Mapami, Durango, Mexico

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 161931

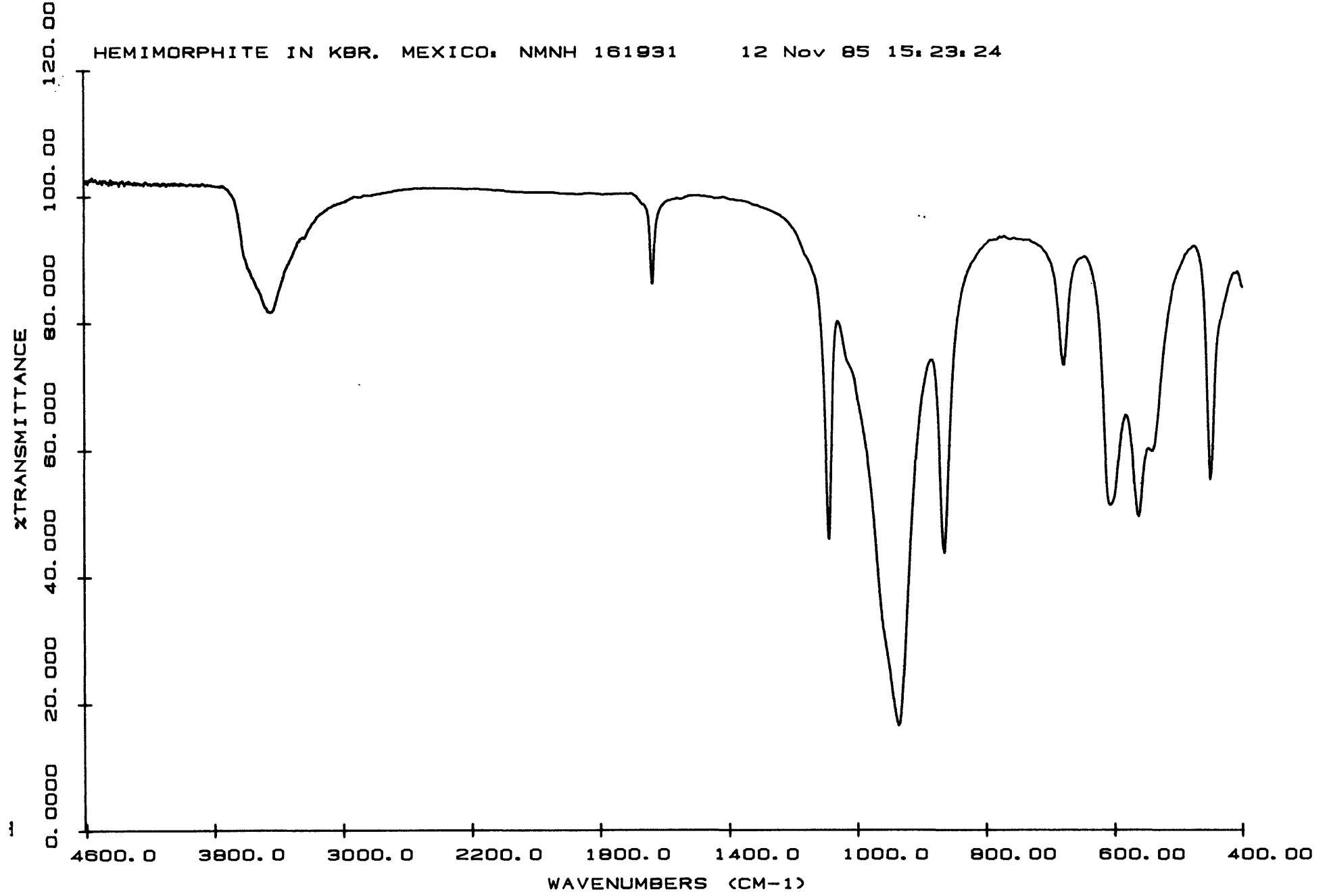
Results of petrographic examination: Hand samples are white, transluscent and appear pure. Two fragments 1 cm long. One has some iron staning which was removed by picking. Microscopic examination indicates it is pure and clean.

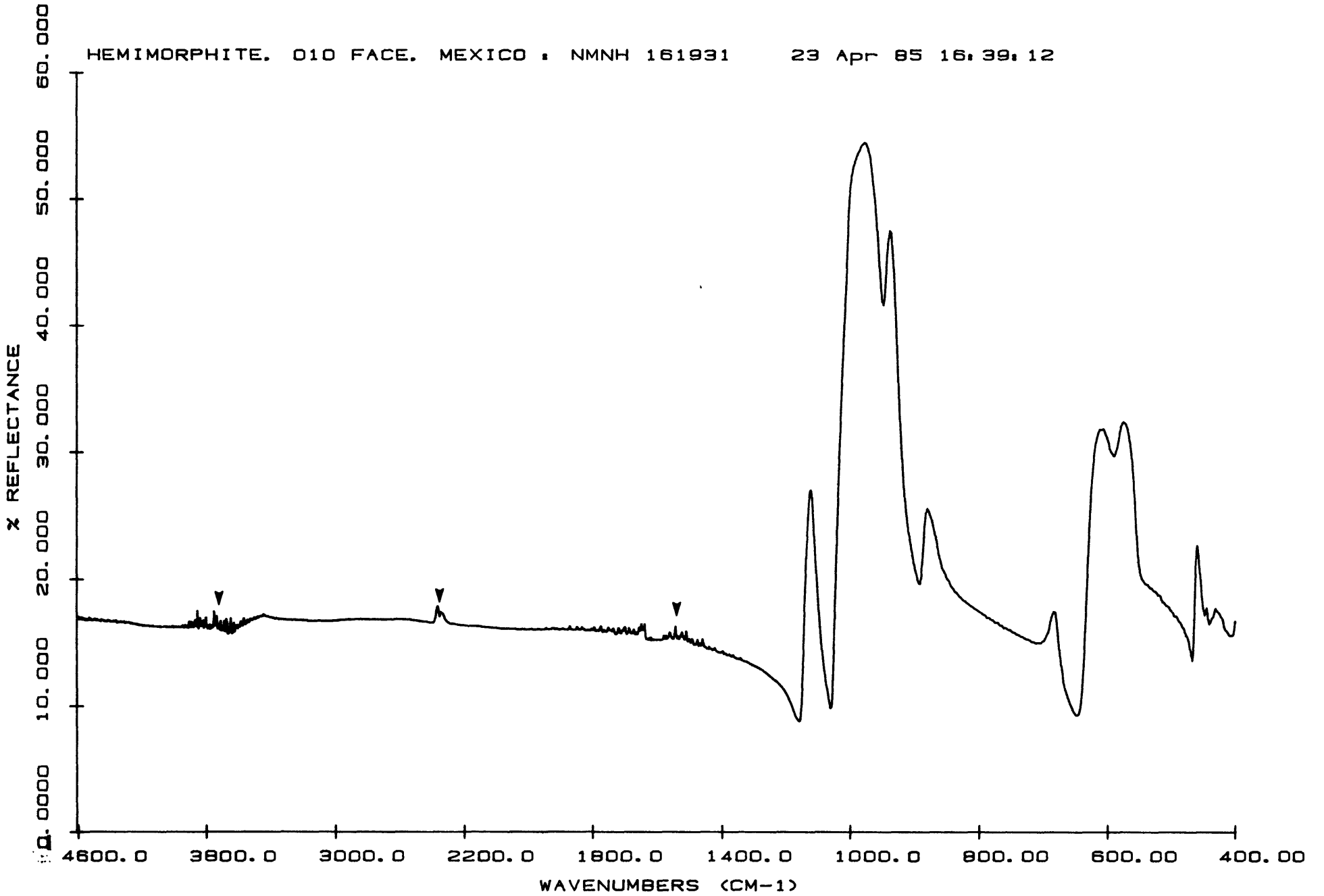
Results of XRD: Pure hemimorphite.

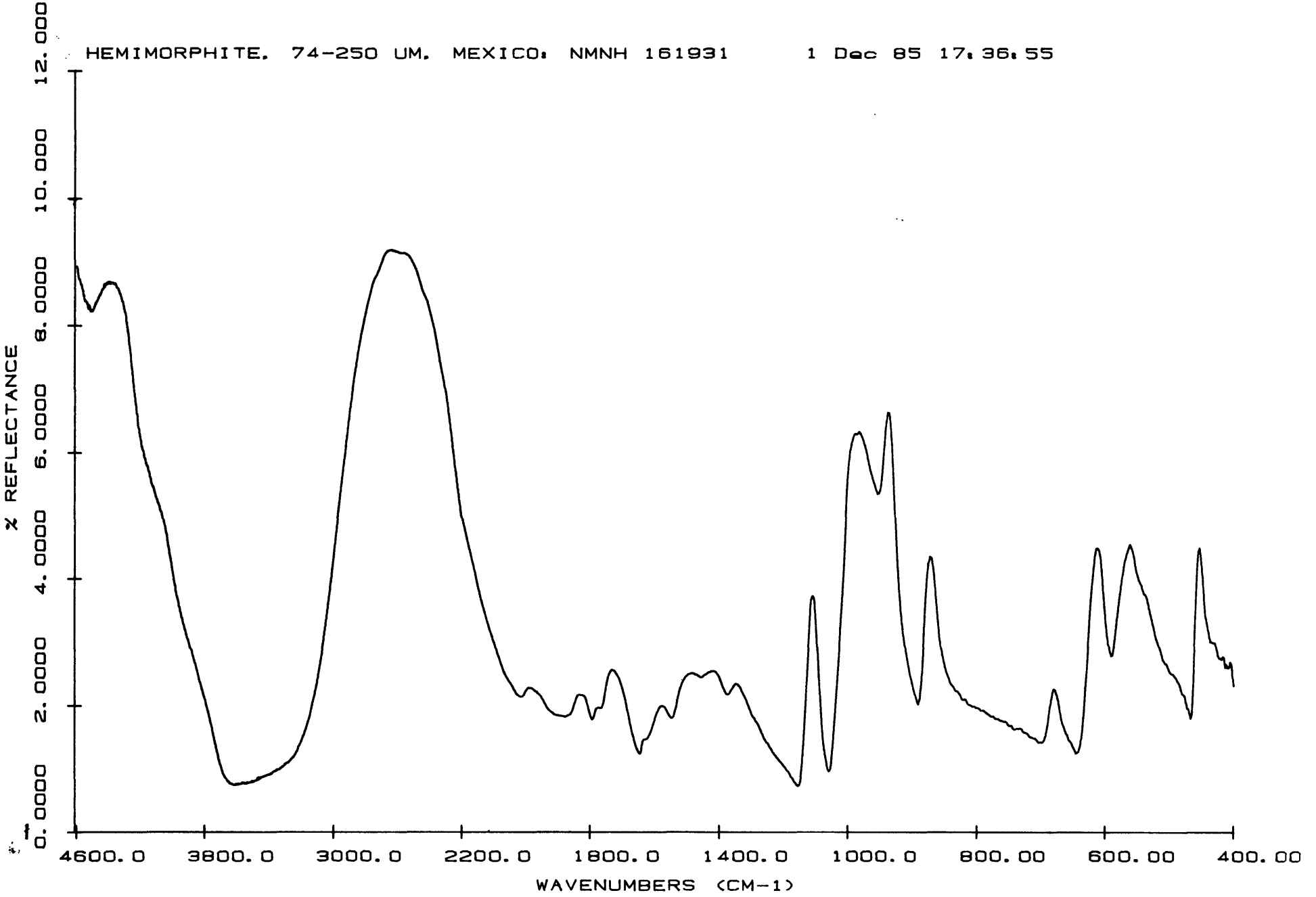
Results of XRF or other compositional analysis: Microprobe analysis shows sample is homogeneous within and between grains. Average of 10 analyses:

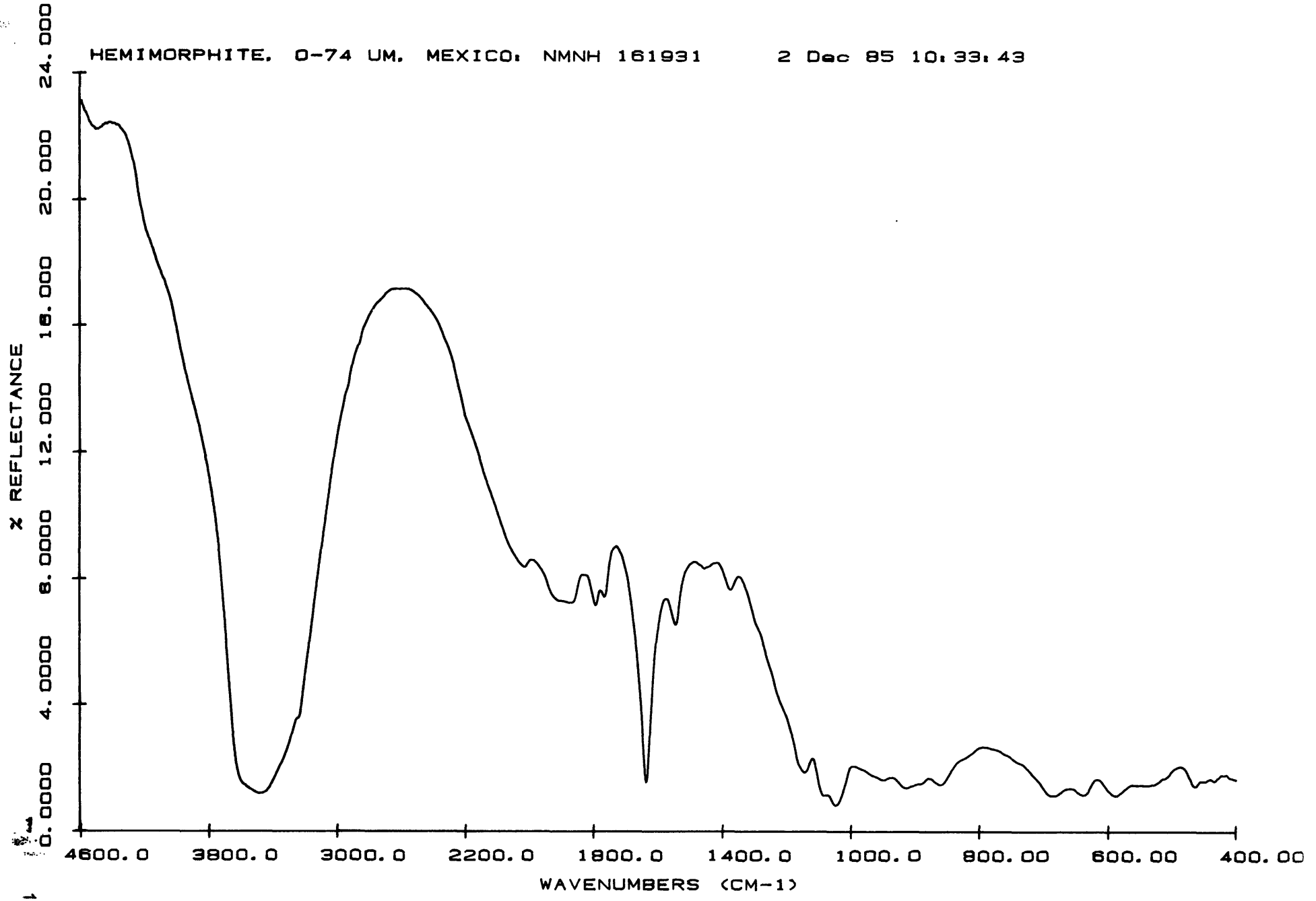
SiO_2	- 22.51
Al_2O_3	- 0.09
FeO	- 0.25
MgO	- 0.07
CaO	- 0.04
K_2O	- 0.04
Na_2O	- 3.24
TiO_2	- 0.11
MnO	- 0.22
Total	- 26.57 (lacking zinc and H_2O)

Spectra on file:
Hemmorphite.1 Reflectance spectrum of 010 crystal face on solid sample disk #1.
Hemmorphite.1 Reflectance spectrum of 74-250 um size range. Disk #1
Hemmorphite.1 Reflectance spectrum of 0-74 size on disk 1.
Hemmorphite.1 Transmittance spectrum on disk #1.


HEMIMORPHITE IN KBR. MEXICO: NMNH 161931 12 Nov 85 15:23:24
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HEMIMORPHITE. 010 FACE. MEXICO : NMNH 161931 23 Apr 85 16:39:12
% REFLECTANCE
60.000
50.000
40.000
30.000
20.000
10.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HEMIMORPHITE. 74-250 UM. MEXICO: NMNH 161931 1 Dec 85 17:36:55
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HEMIMORPHITE, 0-74 UM, MEXICO: NMNH 161931
2 Dec 85 10:33:43
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species Name: Hornblende $Ca_2(Fe^{+2}, Mg)_4\ Al(Si_7Al)O_{22}(OH,F)_2$

Locality: Gore Mt., NY

Last donor: Hunt and Salisbury collection

Intermediate donor:

Ultimate donor: Ward's Scientific

Catalog numbers, etc.: Hunt and Salisbury no. 177.B

Results of petrographic examination: Specimen is a cluster of very dark green single crystals half a centimeter to one centimeter in length and almost as wide.

Results of XRD: Hornblende plus trace of unidentifable mineral.

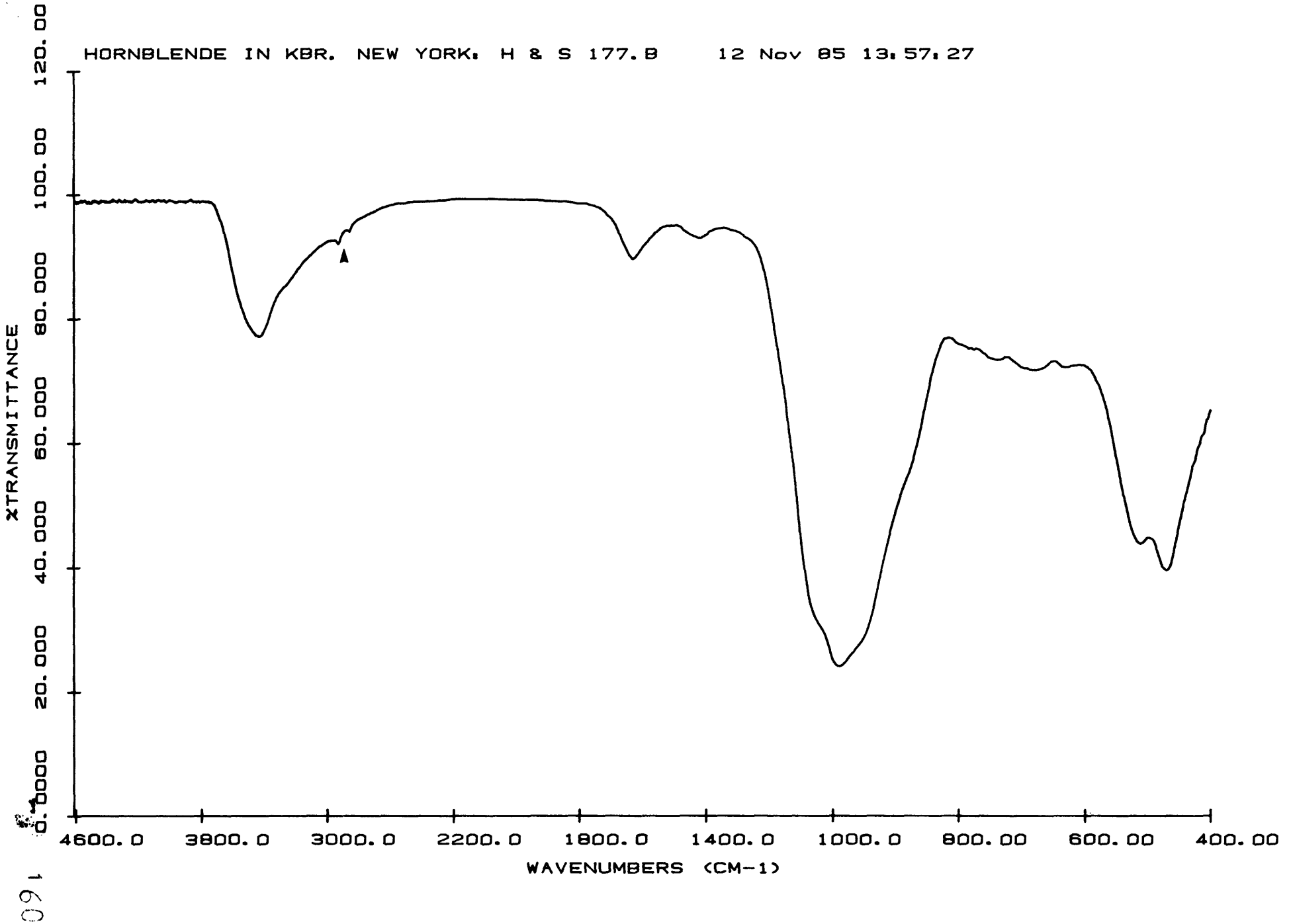
Results of XRF or other compositional analysis:

Microprobe analysis shows the sample to be homogeneous within and between grains. Average of 10 analyses:

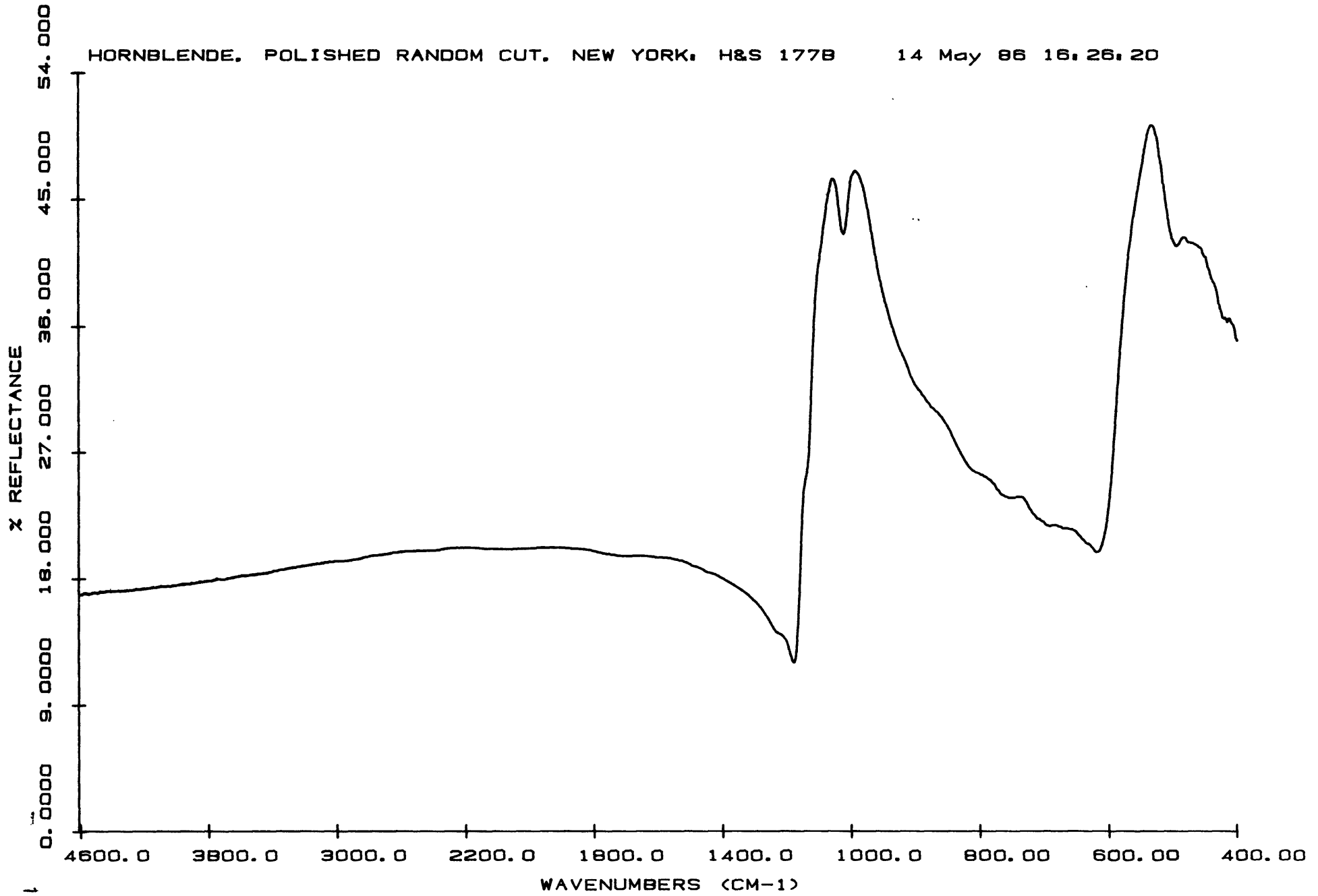
SiO_2	- 41.5
Al_2O_3	- 12.97
FeO	- 15.43
MgO	- 11.49
CaO	- 11.34
K_2O	- 1.71
Na_2O	- 1.61
TiO_2	- 2.89
MnO	- 0.13
Total	- 99.08

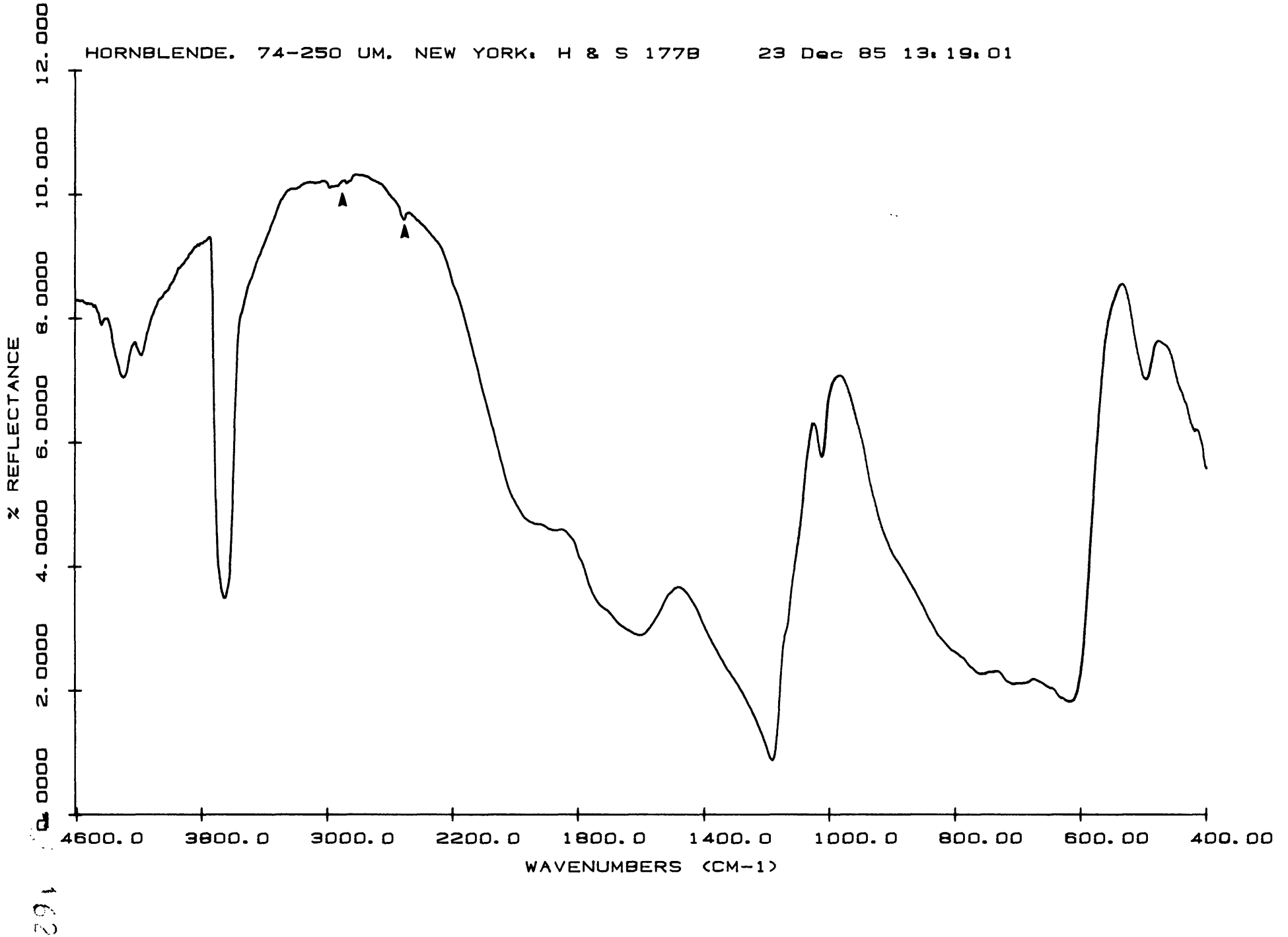
Spectra on file:

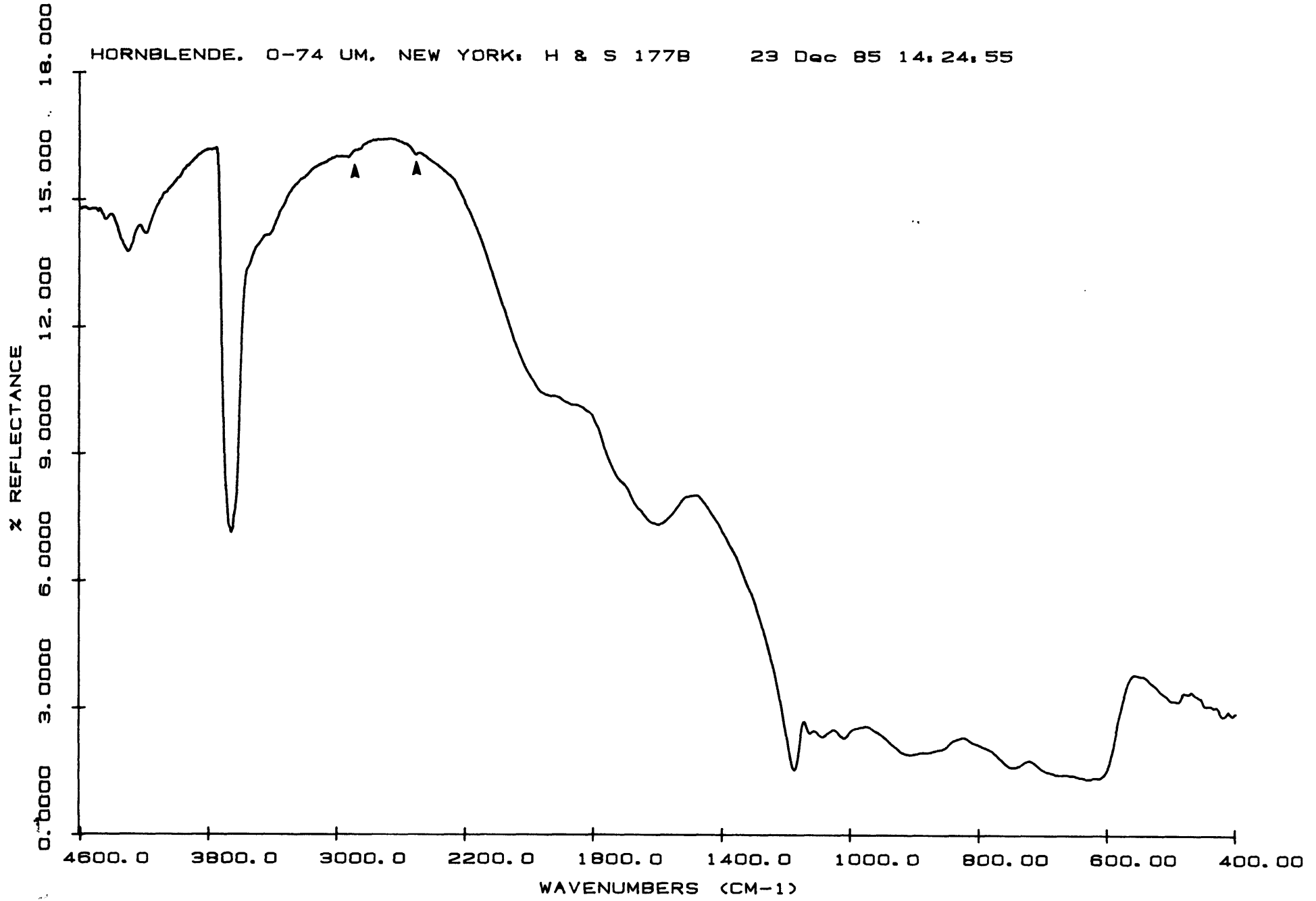
Hornblende.1	Reflectance spectrum of random cut and polished surface on solid sample disk #1.
Hornblende.1	Reflectance of 0-74 um size range on disk 1.
Hornblende.1	Reflectance of 74-250 um size range on disk 1.
Hornblende.1	Transmittance spectrum on disk #1.


HORNBLENDE IN KBR. NEW YORK. H & S 177.B 12 Nov 85 13:57:27
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

091 160


HORNBLENDE. POLISHED RANDOM CUT. NEW YORK. H&S 1778 14 May 86 16:26:20
% REFLECTANCE
0.0000
9.0000
18.000
27.000
36.000
45.000
54.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HORNBLENDE. 74-250 UM. NEW YORK: H & S 1778 23 Dec 85 13:19:01
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HORNBLENDE. 0-74 UM. NEW YORK: H & S 177B 23 Dec 85 14:24:55
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Hornblende $Ca_2(Fe^{2+}, Mg)_4Al(Si_7,Al)O_{22}(OH,F)_2$

Locality: Kragero, Norway

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 117329

Results of petrographic examination: One piece, weighing 14.37 g., black. Part of single crystal. Contaminated on one end with clay cover and quartz growth. This can be removed. Contaminated by light coating of fibrous mineral which can be removed by scraping. Small amount of internal contamination by fibrous minerals.

Under the microscope this appears to be generally good intermediate hornblende. A very few grains show mild alteration and there is about 1% contamination by a low refractive index material with low birefringence.

Results of XRD: Pure magnesiohornblende.

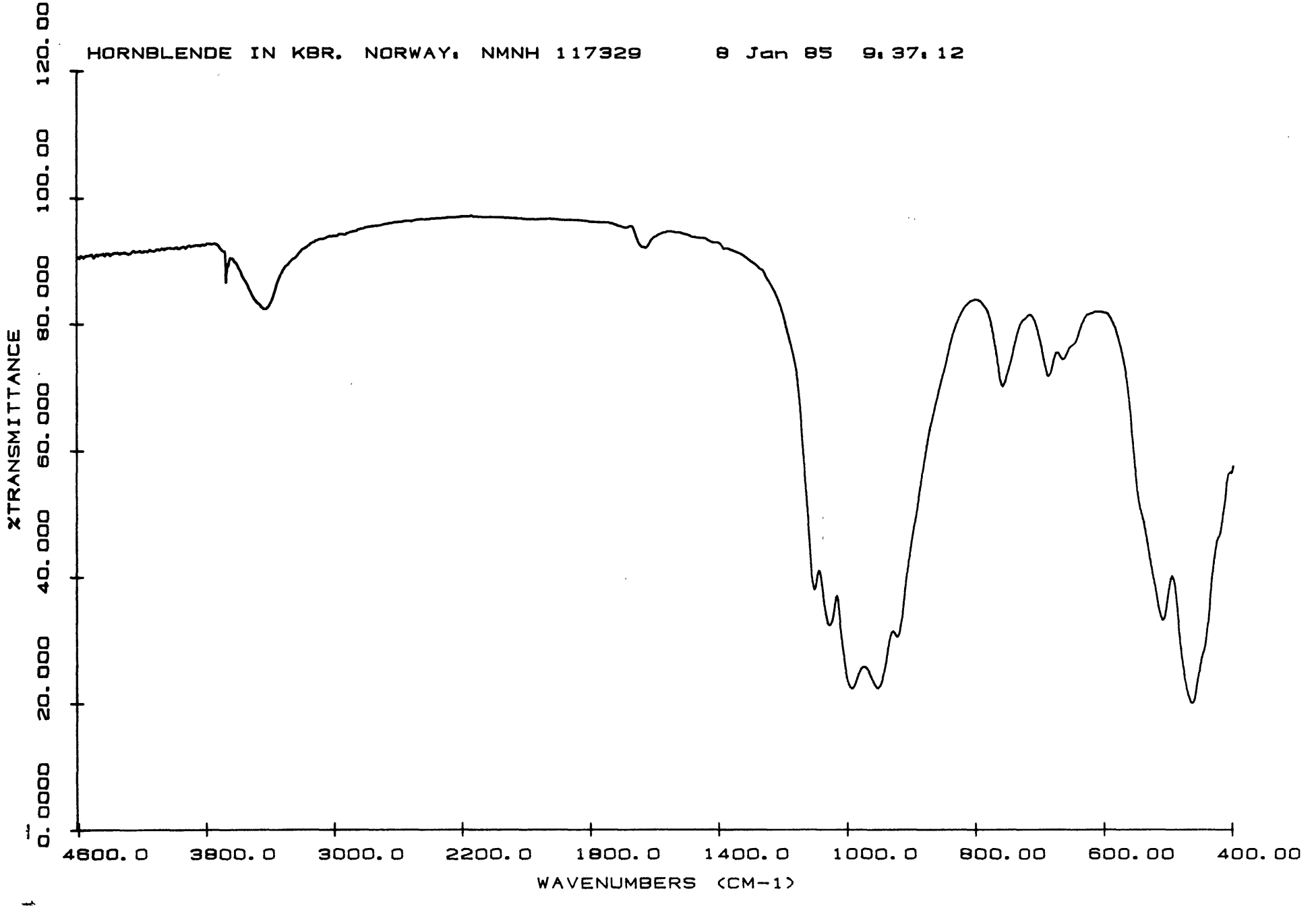
Results of XRF or other compositional analysis:

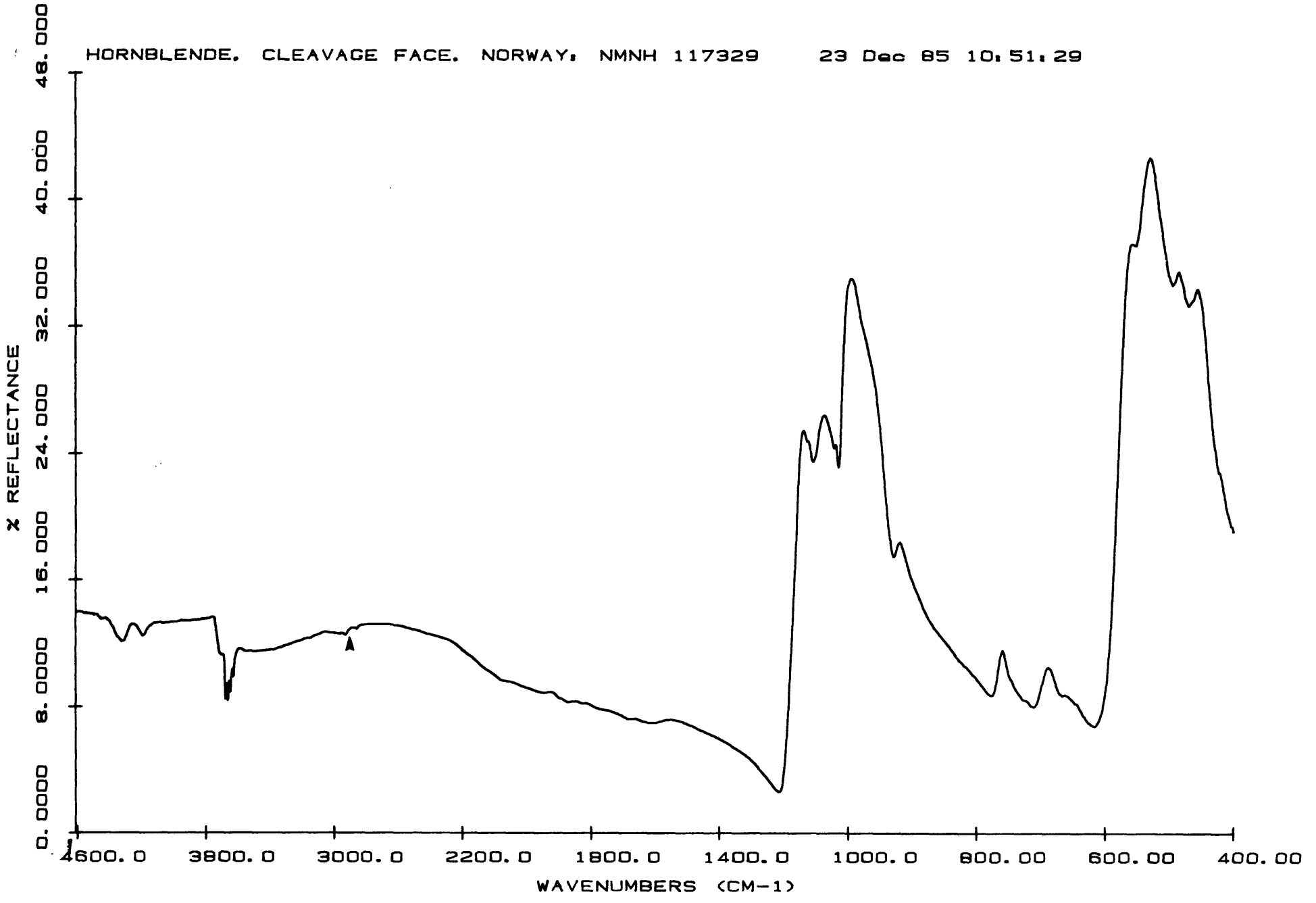
Microprobe analysis shows that grains selected are homogeneous within and between grains. The relatively high soda shows some solid solution towards edenite. Average of 12 analyses:

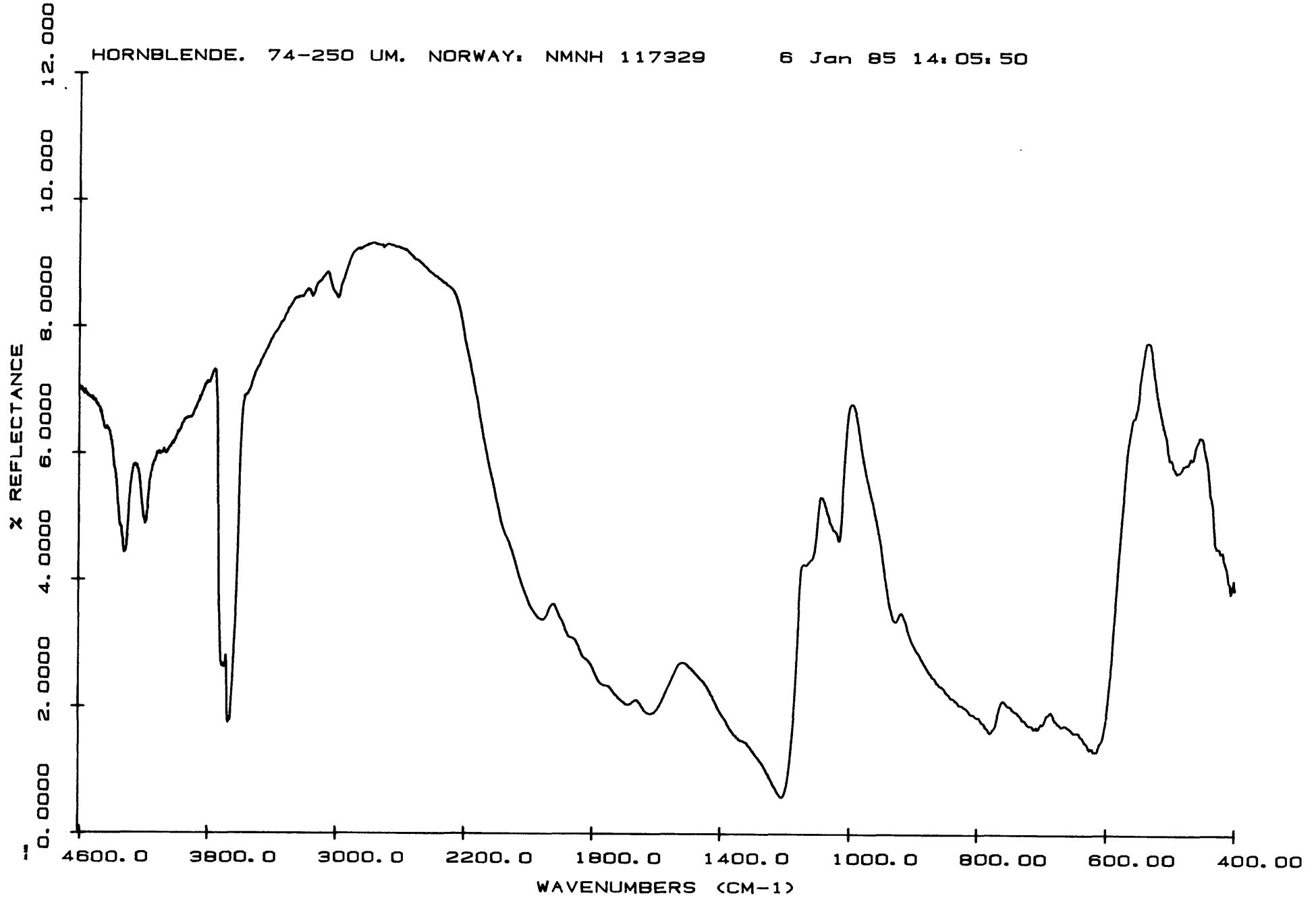
SiO_2	- 50.66
Al_2O_3	- 5.45
FeO	- 7.73
MgO	- 19.33
CaO	- 10.84
K_2O	- 0.30
Na_2O	- 2.40
TiO_2	- 1.28
MnO	- 0.07
Total	- 98.06

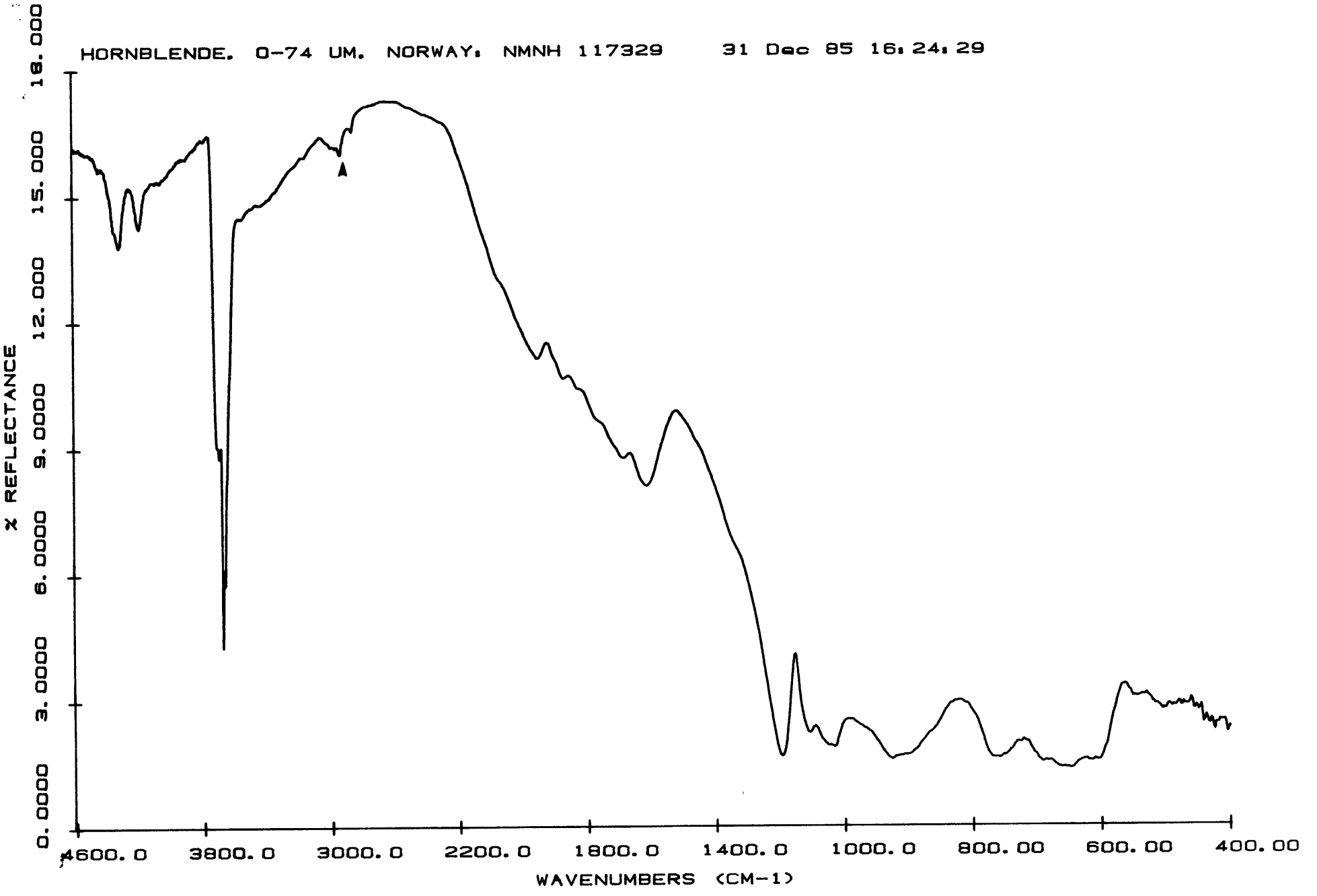
Spectra of file:

Hornblende.2	Reflectance spectrum of cleavage face on solid sample disk 1.
Hornblende.2	Reflectance spectrum of 0-74 um size range on disk #1.
Hornblende.2	Transmittance spectrum on disk #1.
Hornblende.2	Reflectance spectrum of 74-250 um size range on disk #1.


HORNBLENDE IN KBR. NORWAY: NMNH 117329 8 Jan 85 9:37:12
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HORNBLENDE. CLEAVAGE FACE. NORWAY: NMNH 117329 23 Dec 85 10:51:29
% REFLECTANCE
0.0000
8.0000
16.000
24.000
32.000
40.000
48.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HORNBLENDE. 74-250 UM. NORWAY: NMNH 117329 6 Jan 85 14:05:50
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HORNBLENDE. 0-74 UM. NORWAY: NMNH 117329 31 Dec 85 16:24:29
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Hornblende (magnesian)

Locality: Calumet Island, Ottawa River, Canada

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 78662

Results of petrographic examination: Sample is a cluster of several large deep green crystals. Very, very small amount of contamination in thin veins along cleavage planes. Microscopic examination indicates sample is almost pure with less than 1% impurities of low index grains. Index (<1.64) and pleochroism (slight green to green brown) indicates that it is probably magnesian hornblende.

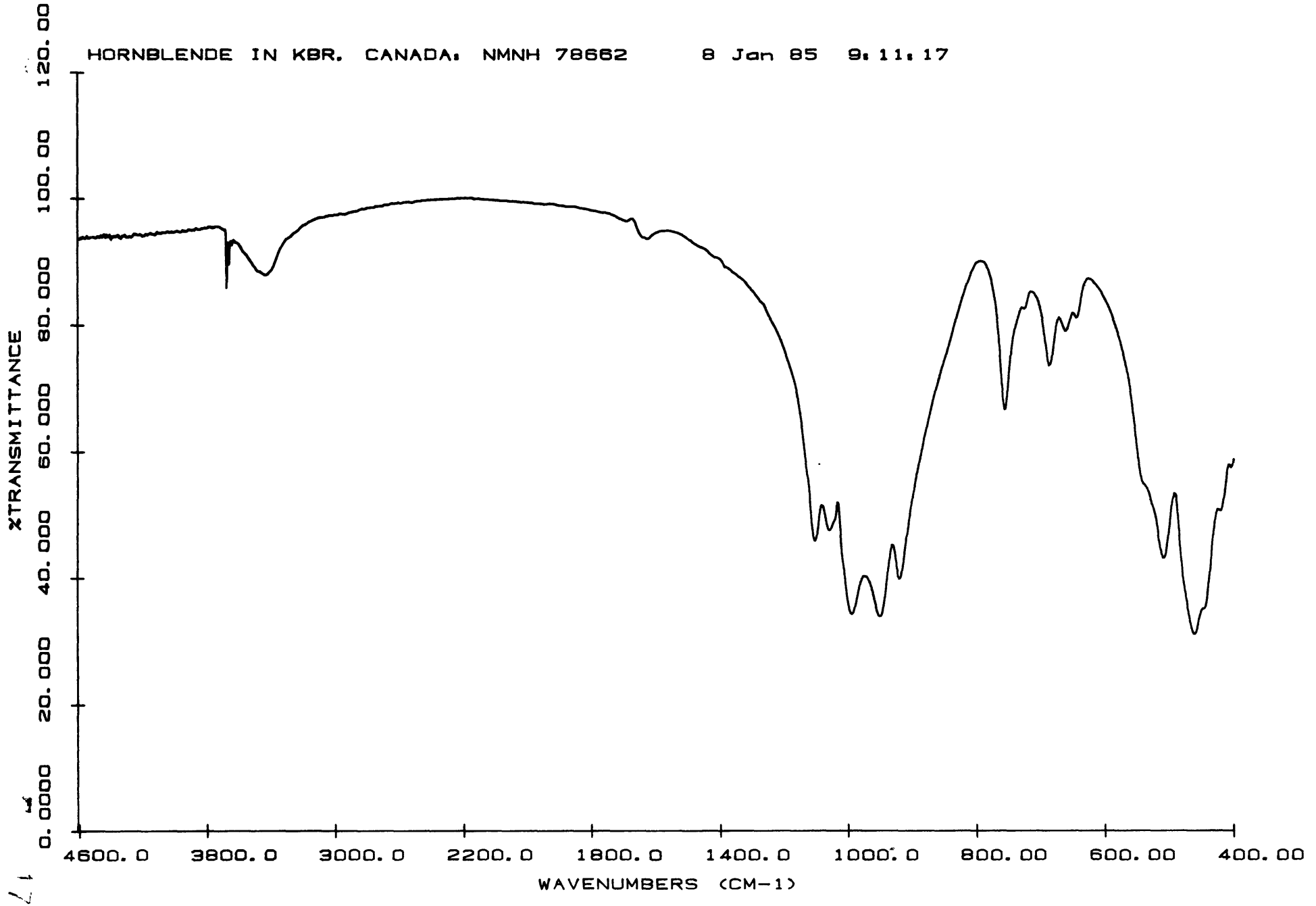
Results of XRD: Pure magnesian hornblende.

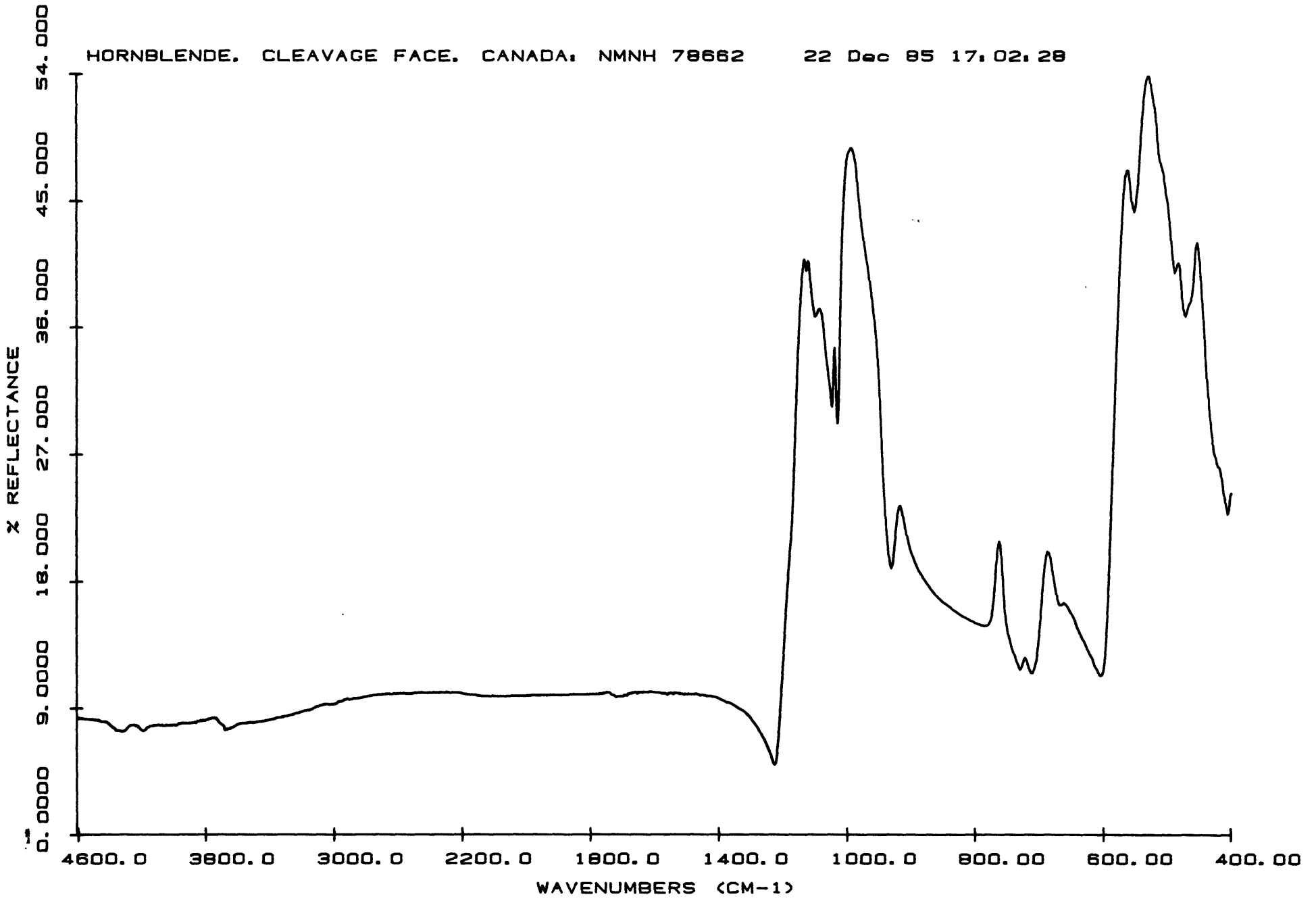
Results of XRF or other compositional analysis:

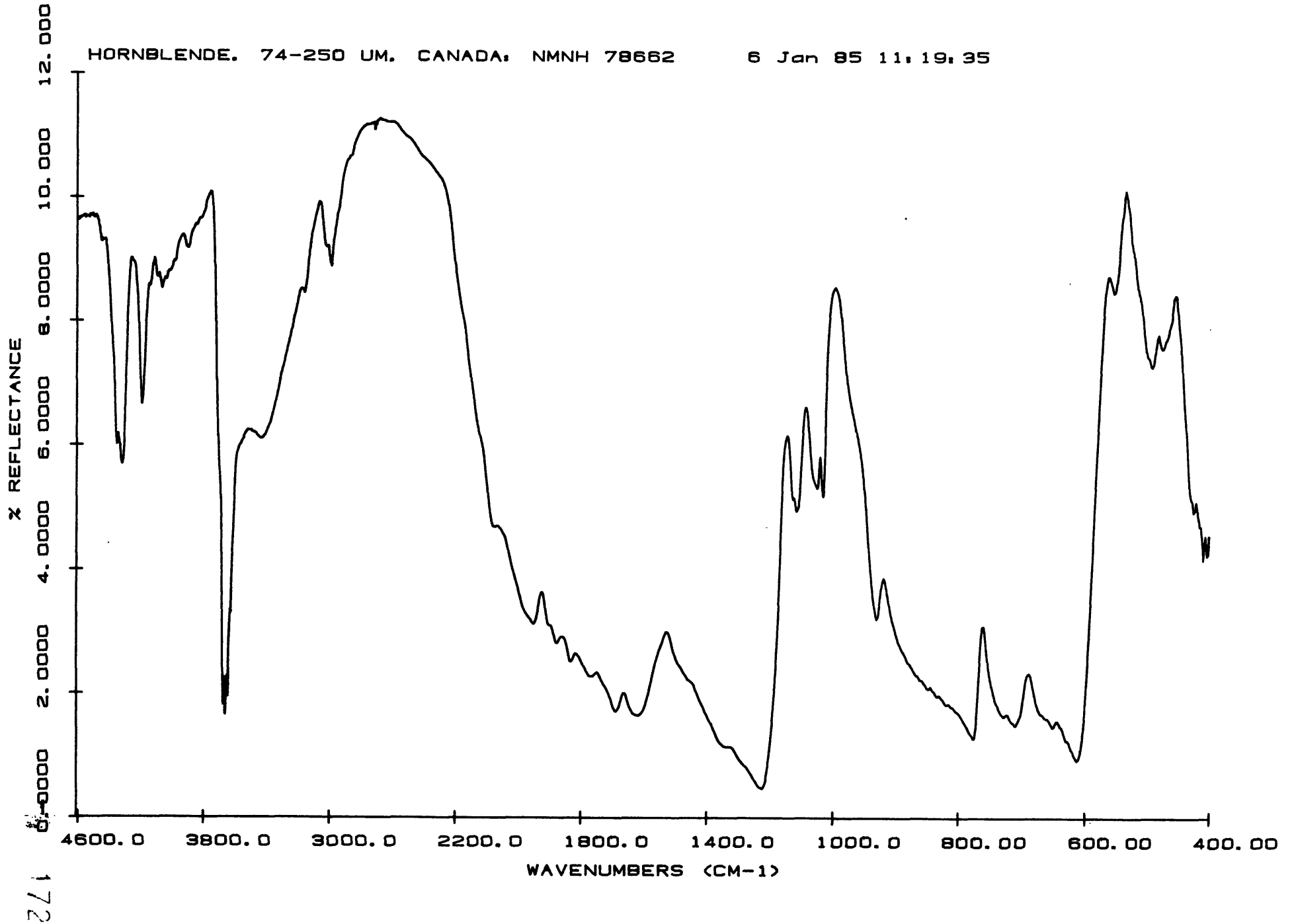
Microprobe analysis shows a slight variation in alumina (0.5 to 2.5%) which is, oddly enough, offset by inverse variation in magnesia. With that minor exception, the sample appears homogeneous. Average of 15 analyses:

SiO_2	- 56.14
Al_2O_3	- 1.24
FeO	- 6.46
MgO	- 20.90
CaO	- 13.17
K_2O	- 0.12
Na_2O	- 0.32
TiO_2	- 0.04
MnO	- 0.18
Total	- 98.55

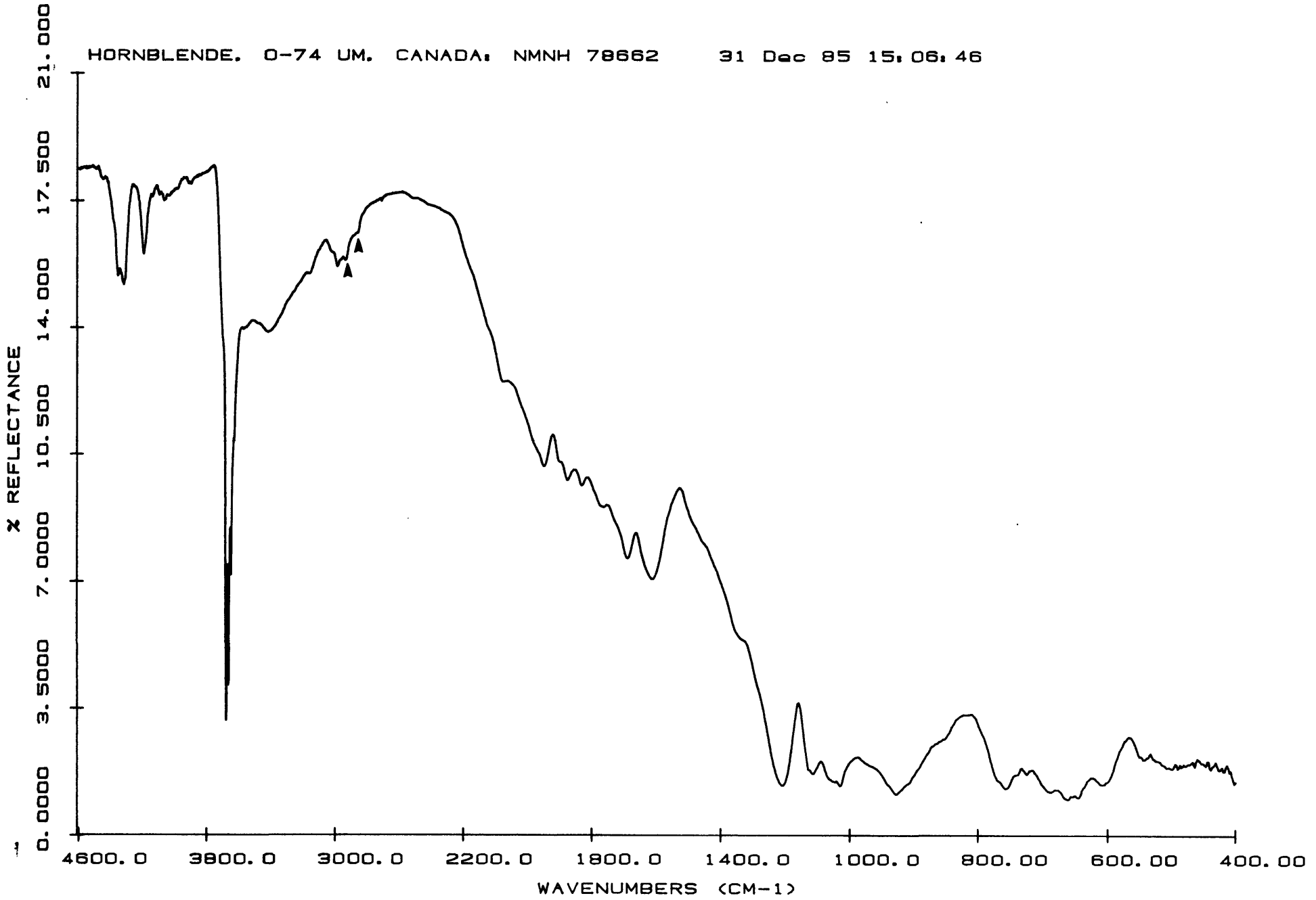
Spectra of file:
Amphibole.1 Reflectance spectrum of cleavage face on solid sample disk 1
Amphibole.1 Reflectance spectrum of 0-74 um size range on disk #1.
Amphibole.1 Transmittance spectrum on disk #1.
Amphibole.1 Reflectance spectrum of 74-250 um size range on disk #1.


HORNBLENDE IN KBR. CANADA: NMNH 78662 8 Jan 85 9:11:17
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HORNBLENDE. CLEAVAGE FACE. CANADA: NMNH 78662 22 Dec 85 17:02:28
% REFLECTANCE
54.000
45.000
36.000
27.000
18.000
9.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HORNBLENDE. 74-250 UM. CANADA: NMNH 78662 6 Jan 85 11:19:35
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

172


HORNBLENDE. 0-74 UM. CANADA: NMNH 78662 31 Dec 85 15:06:46
% REFLECTANCE
21.000
17.500
14.000
10.500
7.0000
3.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Hypersthene $(Mg, Fe^{+2})_2Si_2O_6$

Locality: Western Greenland

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH C2368

Results of petrographic examination: One piece and one small fragment weighing 21.59 g. Part of single crystal; black. Very small amount of surface contamination which may be removed by scratching. Also some quartz inclusions which may be possible to break free.

Under the microscope it is green-brown pleochroic with a relatively high index of refraction. It appears mildly altered with some (2%) iron-stained opaque material present.

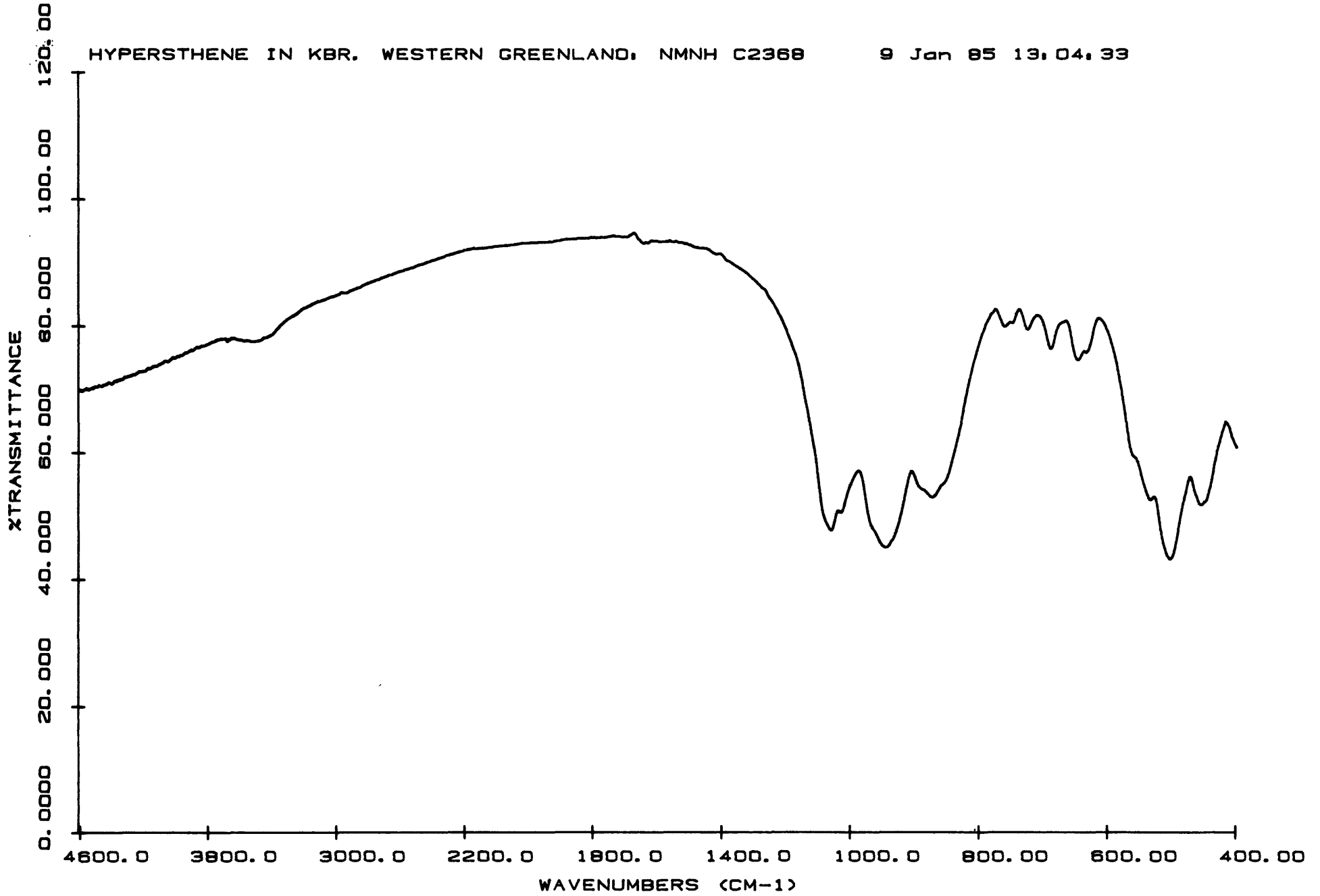
Results of XRD: This sample is predominantly hypersthene with a small amount of talc and a small amount of other mineral(s). However, the amount of talc appears insufficient to affect the infrared spectrum, because even the strong hydroxyl bands of talc between 3600 and 4600 cm^{-1}, which are extremely prominent in the spectrum of the 0-74 um particle size range of talc, are not obvious in the spectrum of the 0-74 um size range of hypersthene.

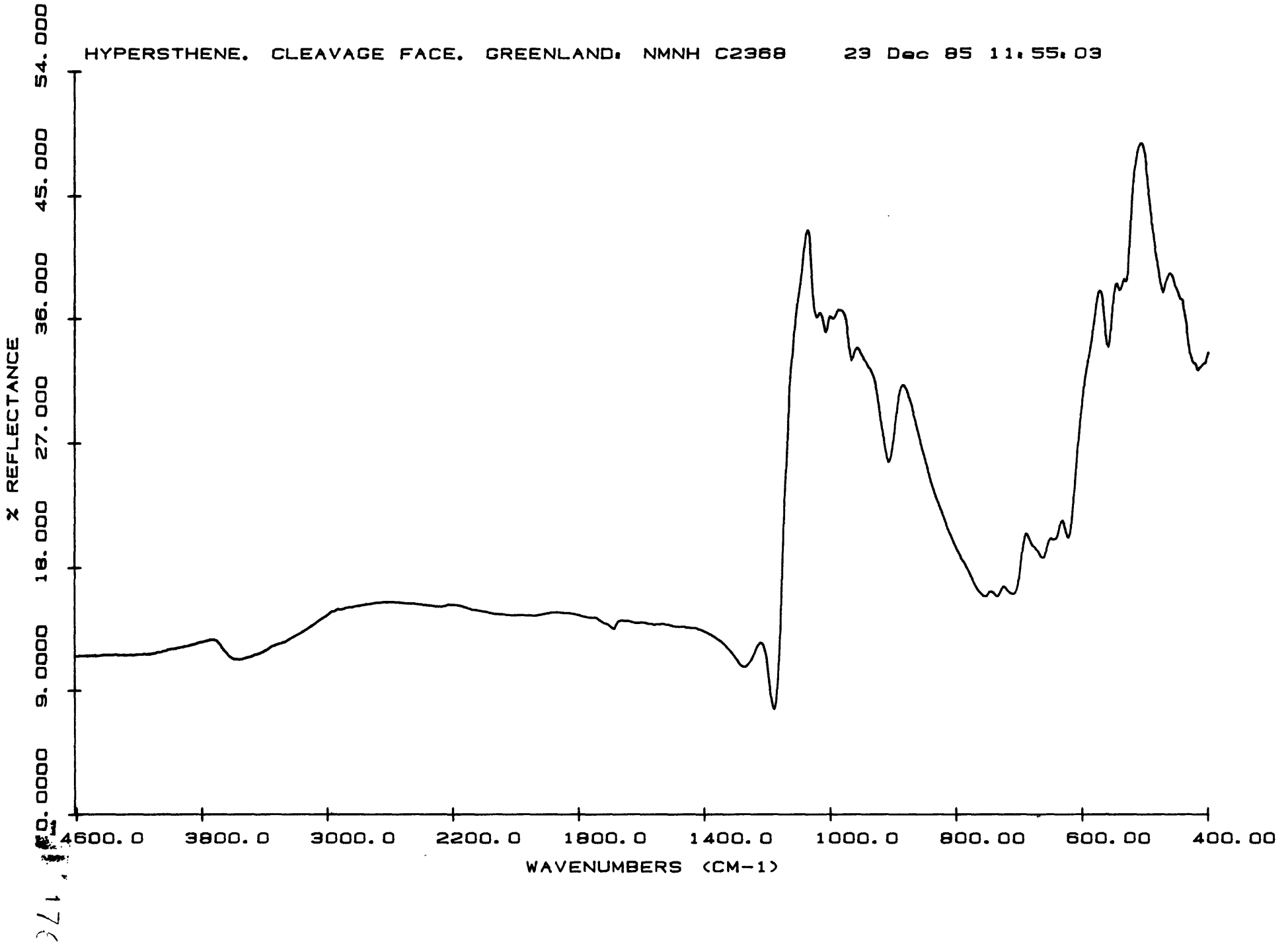
Results of XRF or other compositional analysis: Microprobe analysis indicates exsolution of a small amount of clinopyroxene as shown by presence of Ca and concomitment loss of magnesium and iron for 2 out of 20 analyses. Average composition:

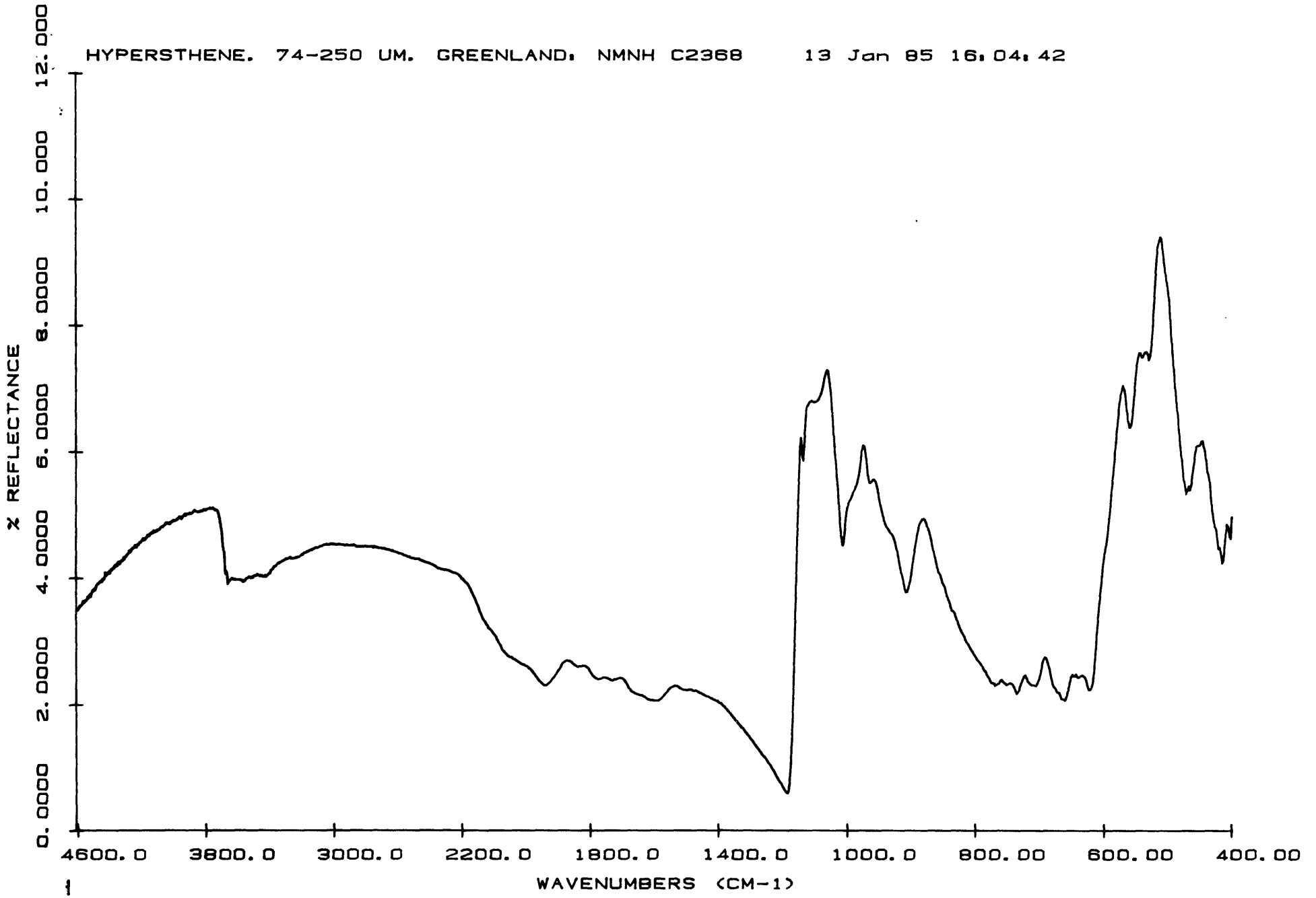
SiO_2	- 51.32
Al_2O_3	- 4.89
FeO	- 17.07
MgO	- 26.09
CaO	- 1.27
K_2O	- 0.02
Na_2O	- 0.05
TiO_2	- 0.29
MnO	- 0.35
Total	-101.33

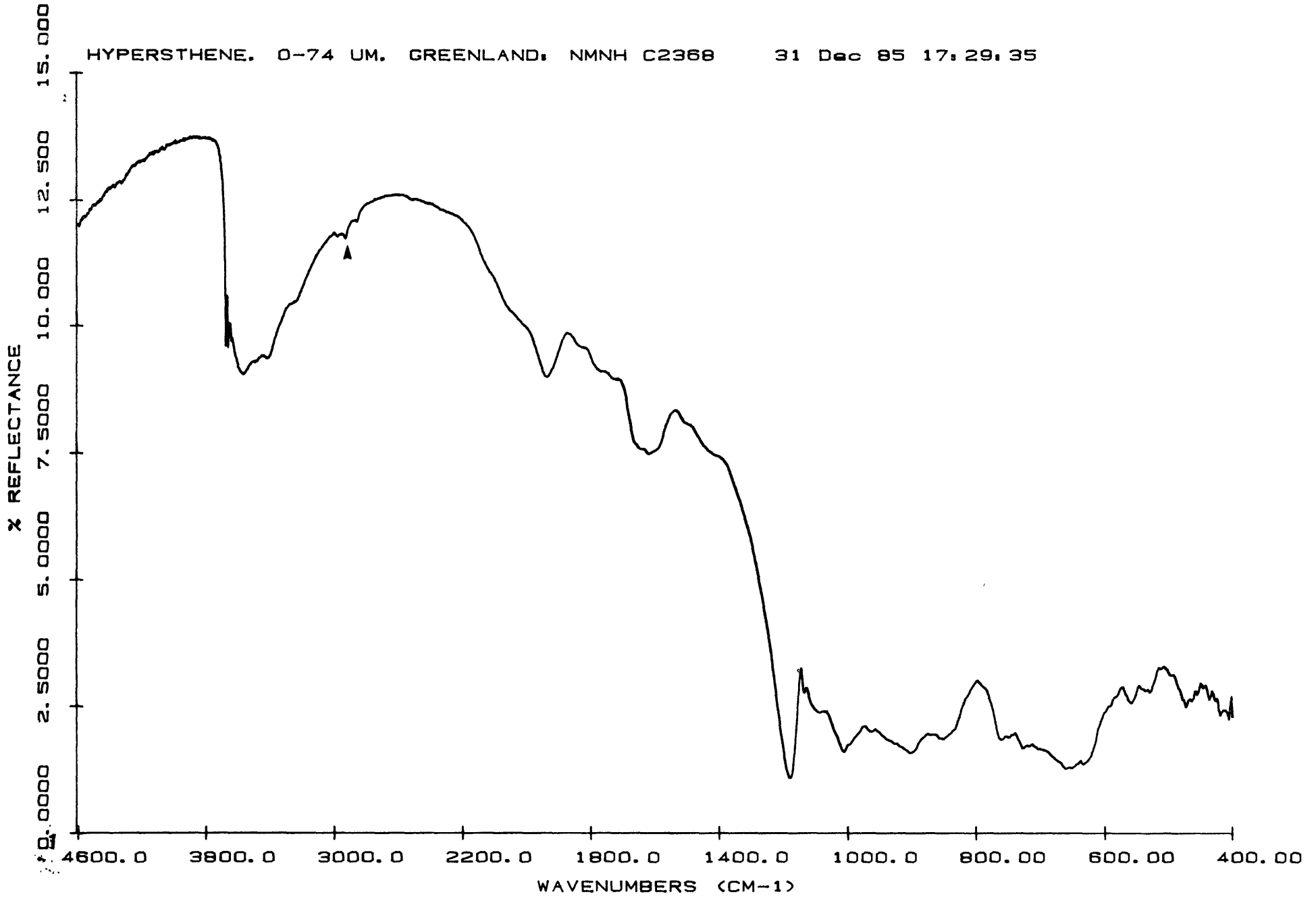
Spectra of file:

Hypersthene.1 Reflectance spectrum of cleavage face on solid sample disk #1.
Hypersthene.1 Reflectance spectrum of 0-74 um size range on disk #1.
Hypersthene.1 Transmittance spectrum on disk 1.
Hypersthene.1 Reflectance spectrum of 74-250 um size range on disk #1.


HYPERSTHENE IN KBR. WESTERN GREENLAND: NMNH C2368
9 Jan 85 13:04:33
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HYPERSTHENE. CLEAVAGE FACE. GREENLAND: NMNH C2368 23 Dec 85 11:55:03
% REFLECTANCE
54.000
45.000
36.000
27.000
18.000
9.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HYPERSTHENE. 74-250 UM. GREENLAND: NMNH C2368 13 Jan 85 16:04:42
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


HYPERSTHENE. 0-74 UM. GREENLAND: NMNH C2368 31 Dec 85 17:29:35
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Illite $(K, H_3O)\ (Al, Mg, Fe)_2\ (Si, Al)_4\ O_{10}\ [(OH)_2, H_2O]$ general formula according to Fleischer (1983), but presence of hydronium is doubtful (Norma Vergo).

Locality: Silver Hill, Montana

Last donor:

Intermediate donor: Clay Mineral Society Source Mineral Repository.

Ultimate donor:

Catalog numbers, etc.: IMT-1 (CMS)

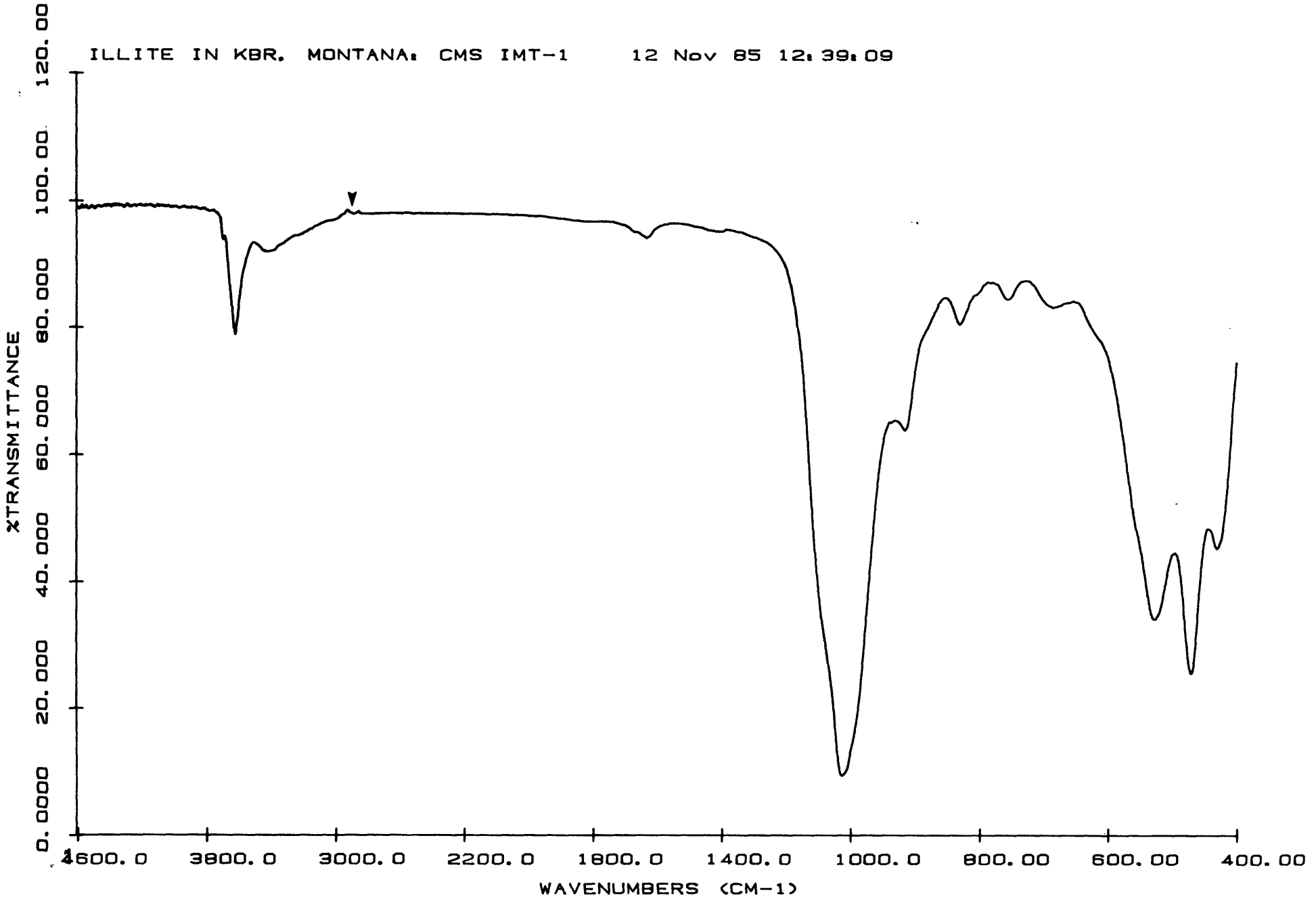
Results of petrographic examination: Greenish color.

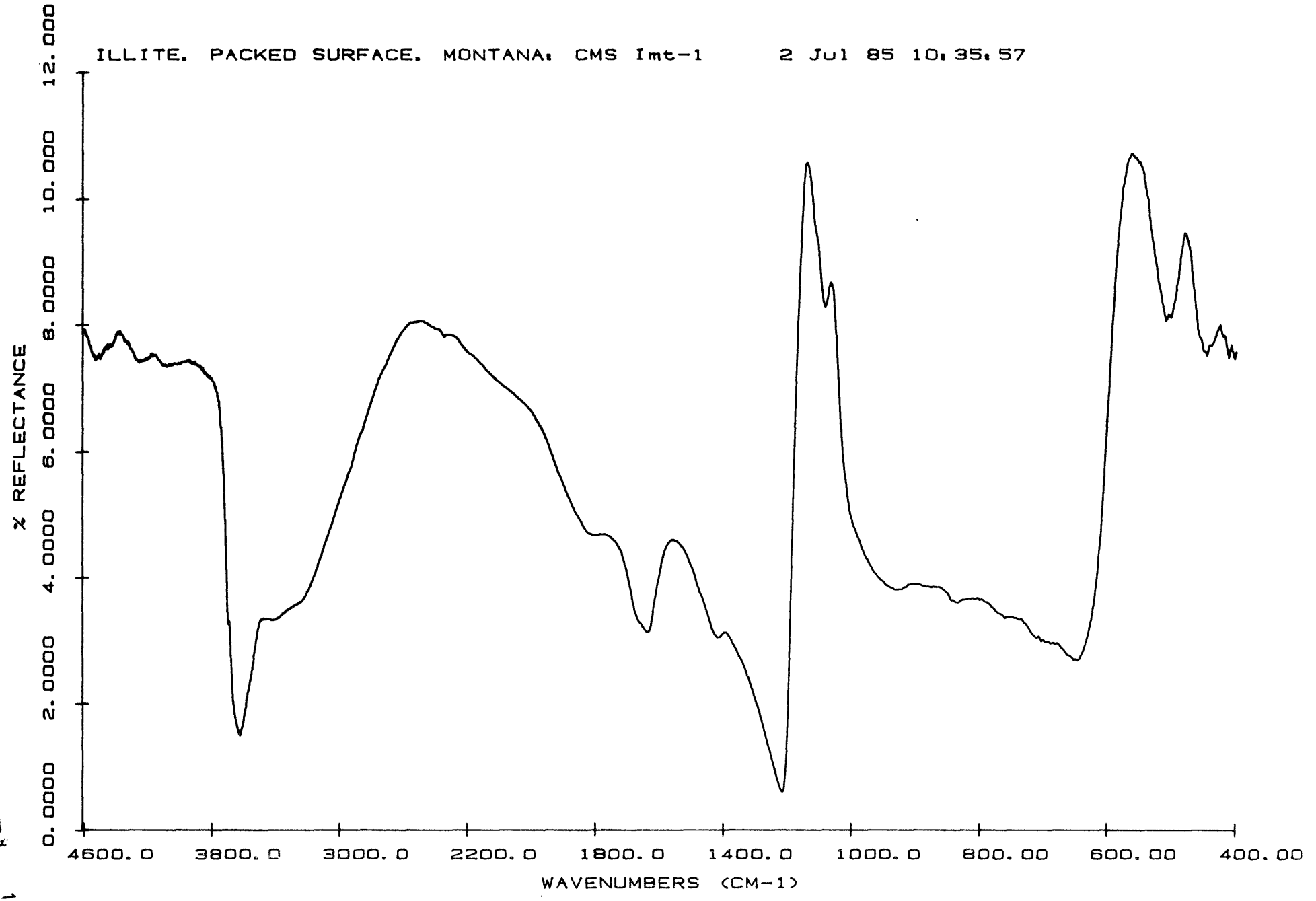
Results of XRD: Bulk sample contains quartz and illite/smectite, but 2 um separate is pure illite/smectite, 95% illite layers.

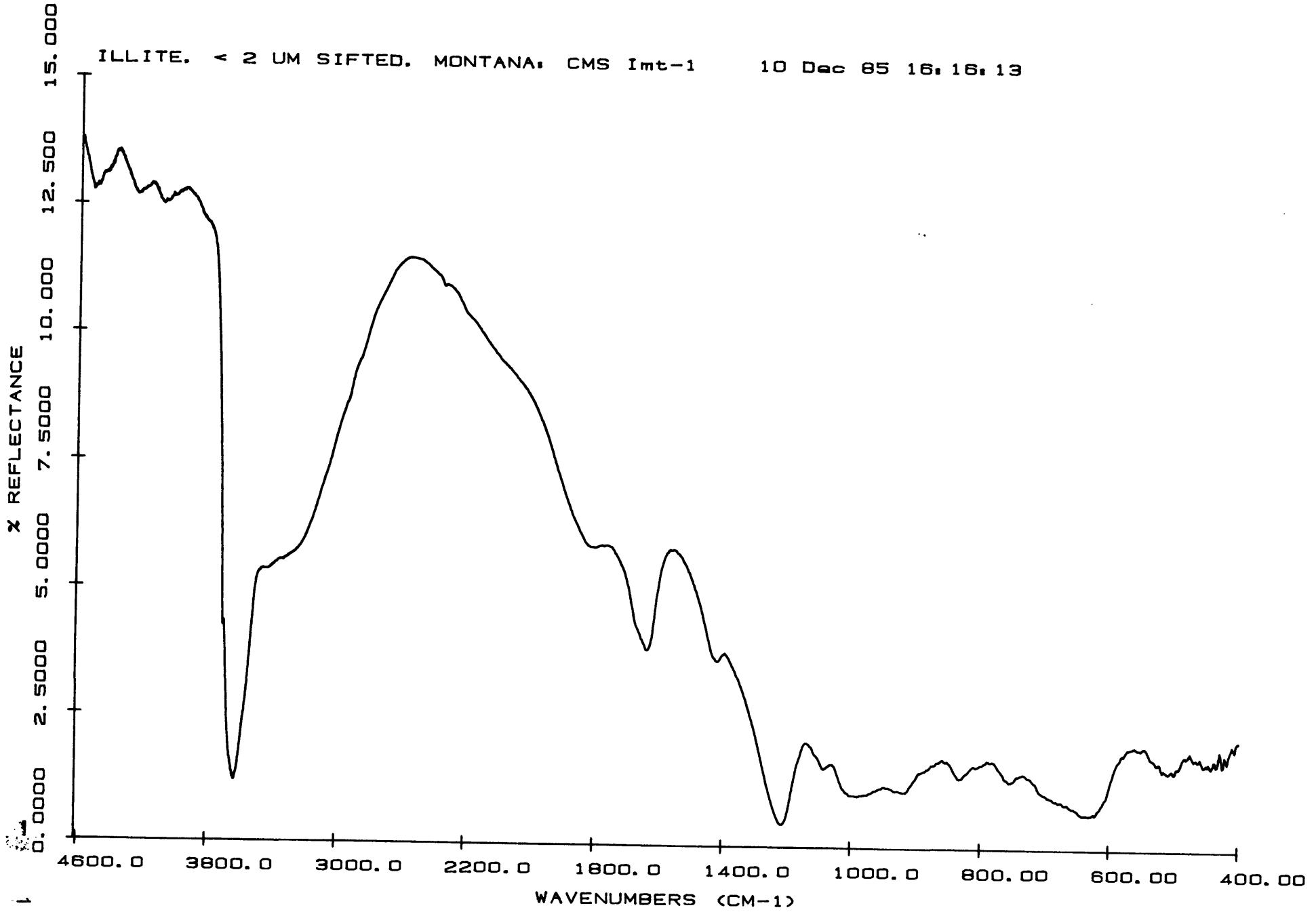
Results of XRF or other compositional analysis: None

Spectra on file:

Illite.1 Reflectance spectrum of packed sample on solid sample disk #1.
Illite.1 Reflectance spectrum of sifted <2 um on 0-74 um disk #1.
Illite.1 Transmittance spectrum on disk #1.


ILLITE IN KBR. MONTANA: CMS IMT-1 12 Nov 85 12:39:09
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ILLITE. PACKED SURFACE. MONTANA: CMS Imt-1 2 Jul 85 10:35:57
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ILLITE. < 2 UM SIFTED. MONTANA: CMS Imt-1 10 Dec 85 16:16:13
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Illite/smectite (35% illite layers)

Locality: Cameron, Arizona

Last donor: Hunt and Salisbury

Intermediate donor:

Ultimate donor: Wards Clay Mineral Standards

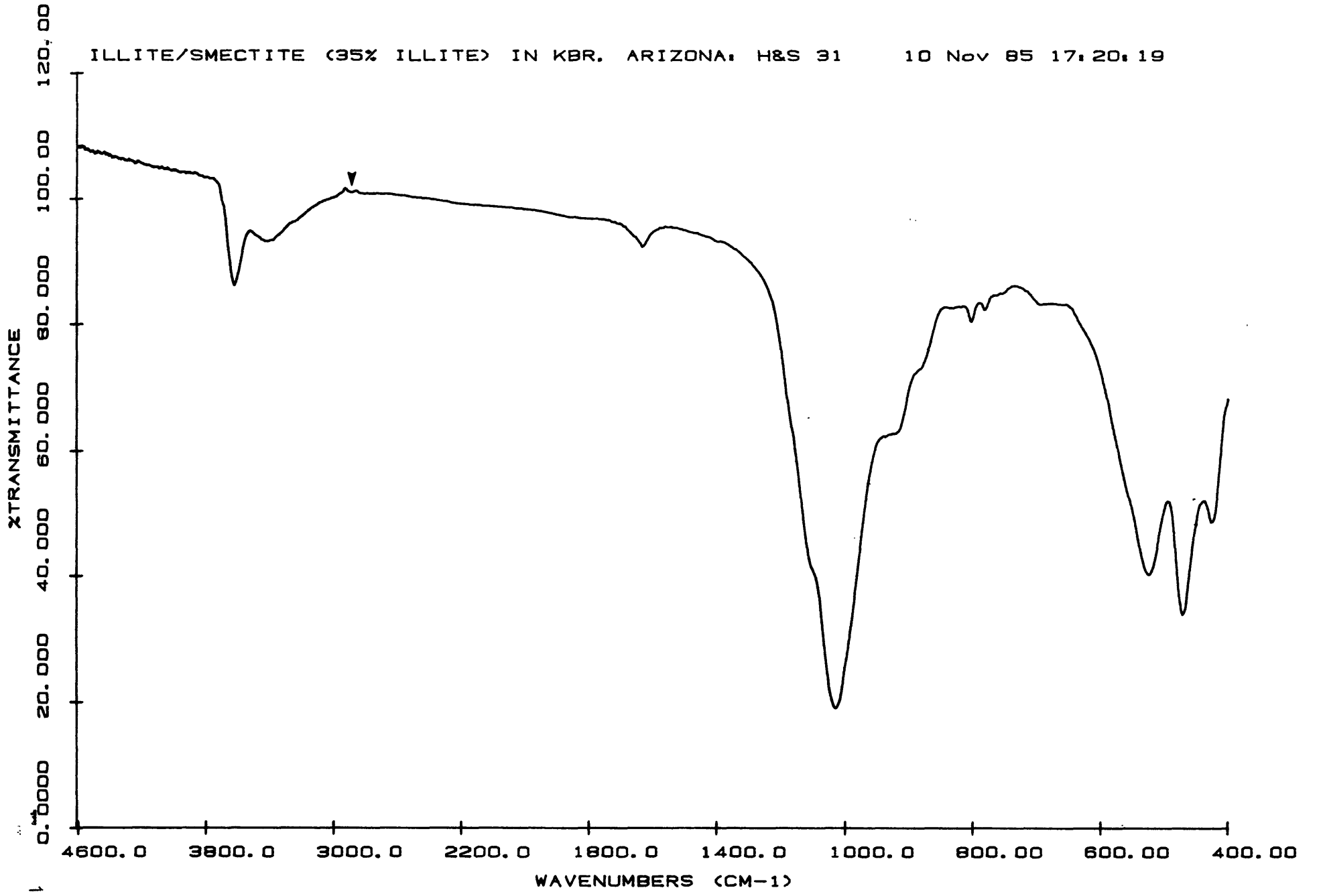
Catalog numbers, etc.: H and S #31, Wards 48-W-1310.

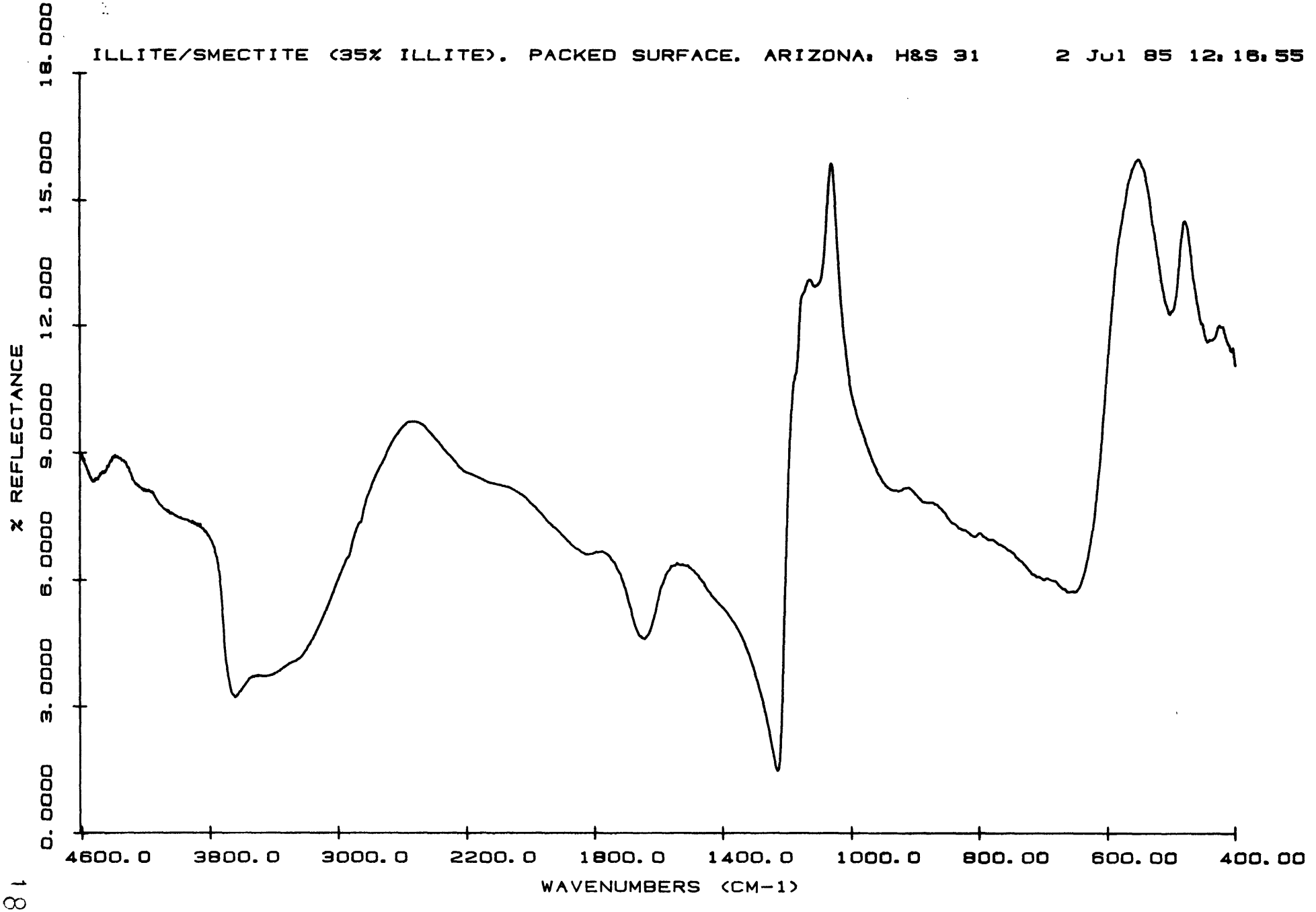
Results of petrographic examination:

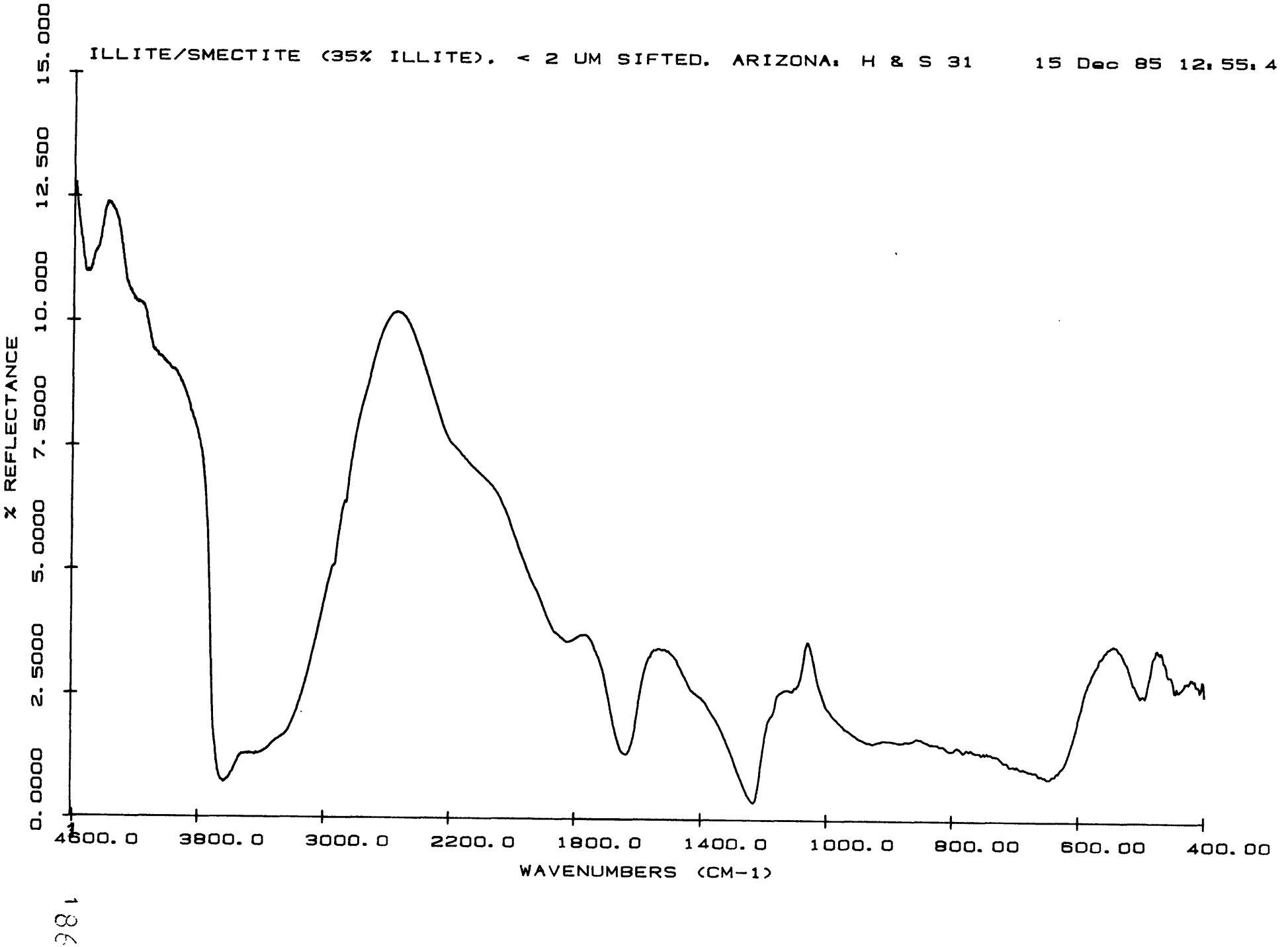
Results of XRD: Called montmorillonite by Wards, the bulk sample and the less than 2 um separate are pure illite/smectite, 35% illite layers.

Results of XRF or other compositional analysis: None

Spectra on file:
Montmor.2 Reflectance spectrum of packed sample on solid sample disk #1.
Montmor.2 Reflectance spectrum of <2 um sifted sample on 0-74 disk #1.
Montmor.2 Transmittance spectrum on disk #1.


ILLITE/SMECTITE (35% ILLITE) IN KBR. ARIZONA: H&S 31 10 Nov 85 17:20:19
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ILLITE/SMECTITE (35% ILLITE). PACKED SURFACE. ARIZONA: H&S 31 2 Jul 85 12:16:55
% REFLECTANCE
0.0000
3.0000
6.0000
9.0000
12.000
15.000
18.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ILLITE/SMECTITE (35% ILLITE). < 2 UM SIFTED. ARIZONA: H & S 31
15 Dec 85 12:55:4
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

281

Species name: Kaolinite (poorly crystallized) $Al_2Si_2O_5(OH)_4$

Locality: Warren County, Georgia

Last donor: Hunt and Salisbury

Intermediate donor:

Ultimate donor: Clay Mineral Society - Clay Mineral Repository

Catalog numbers, etc.: CMS KGA - 2

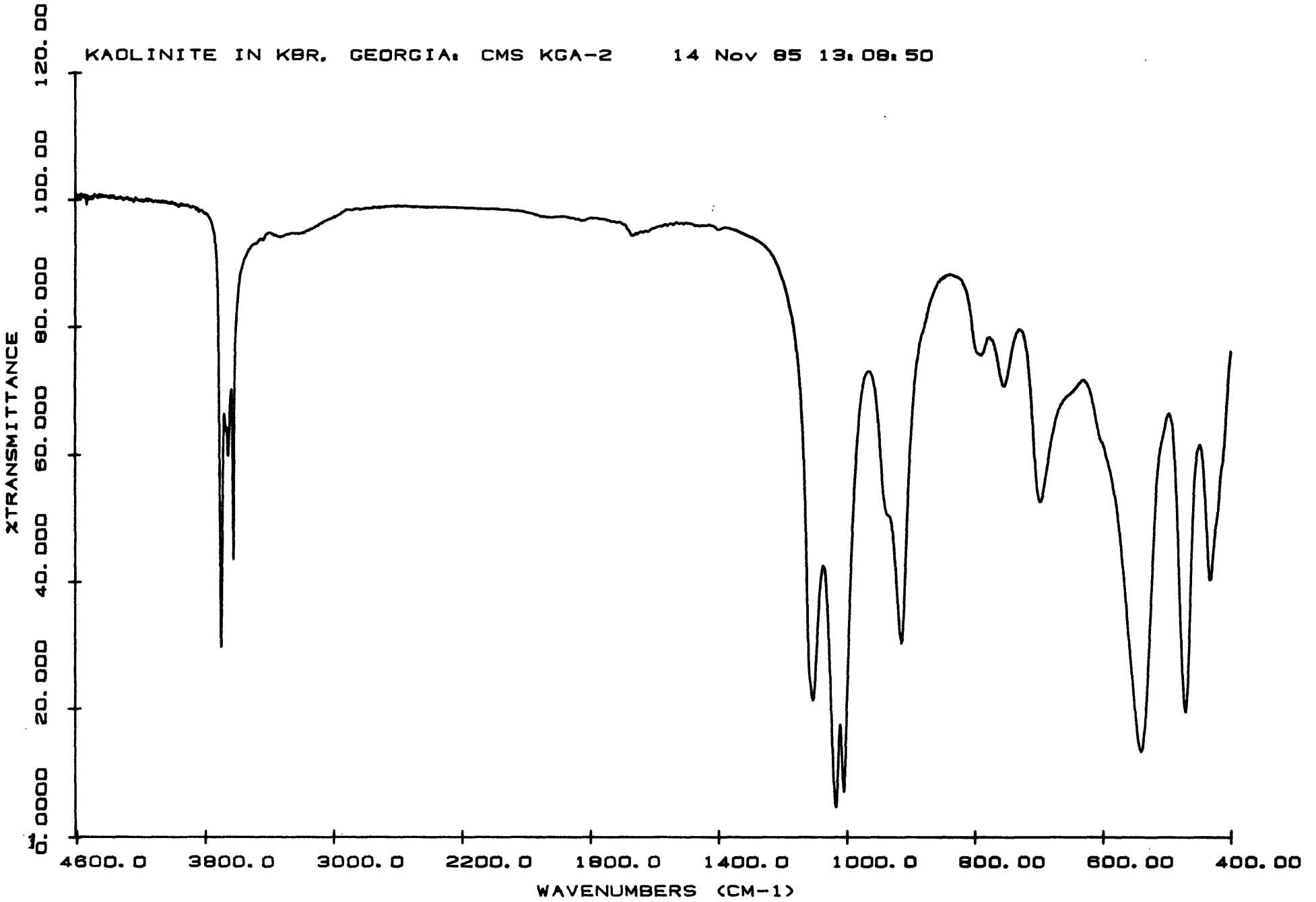
Results of petrographic examination: Cream color

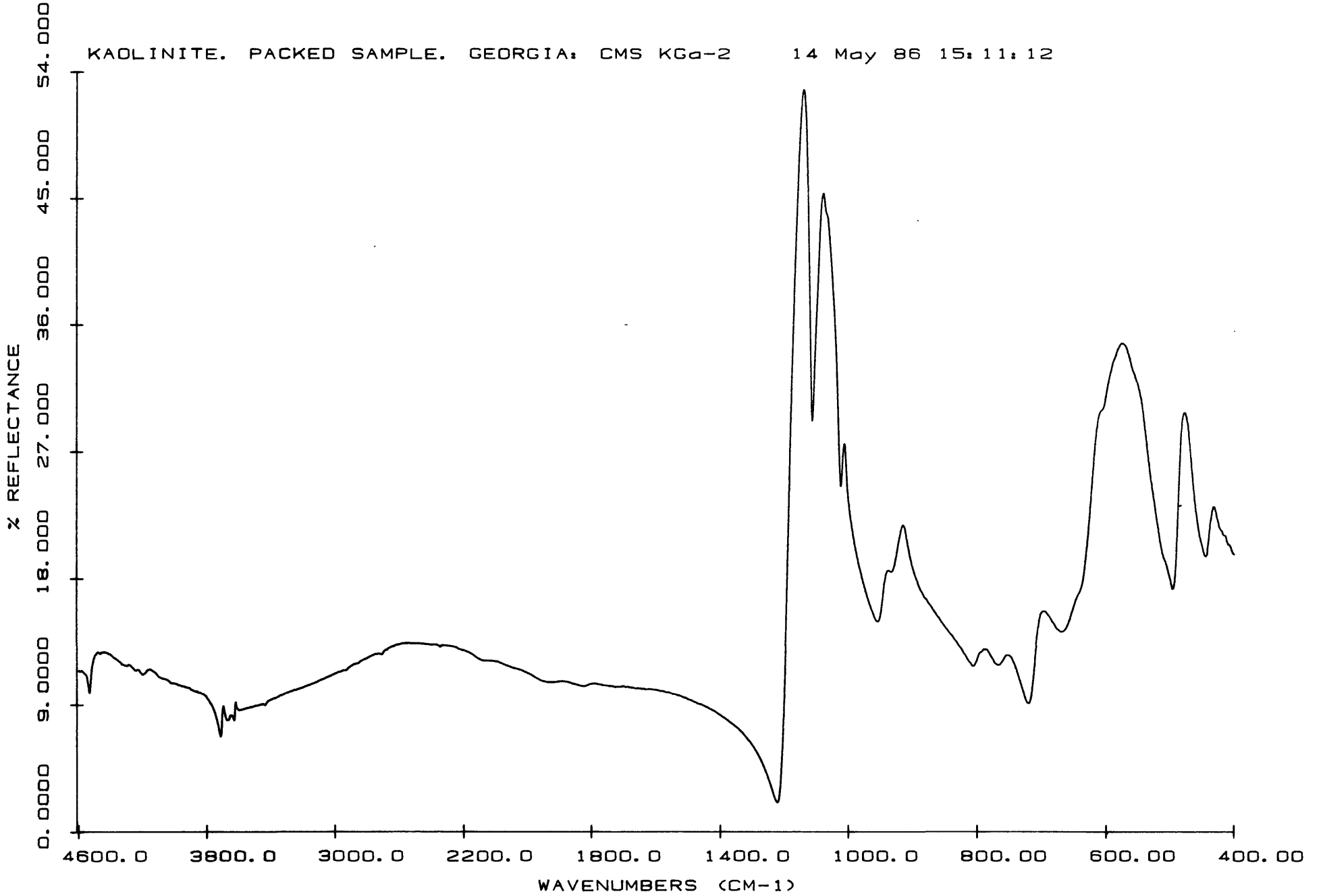
Results of XRD: Norma Vergo reports that sample is completely disordered kaolinite.

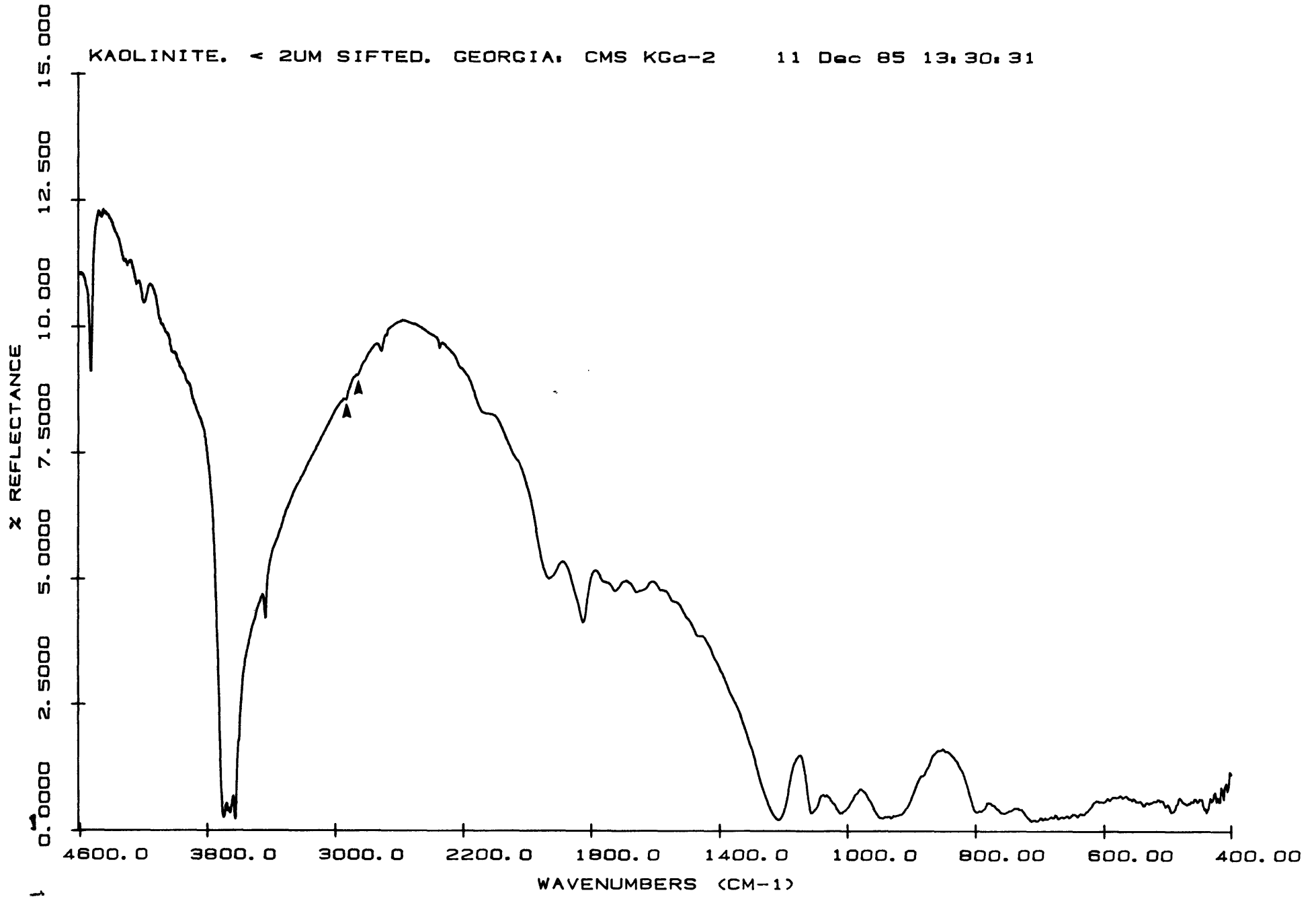
Results of XRF or other compositional analysis: None

Spectra on file:

Kaolinite.2	Reflectance spectrum of sifted <2 um sample on 0-74 um disk #1.
Kaolinite.2	Reflectance spectrum of packed sample on solid sample disk #1.
Kaolinite.2	Transmittance spectrum on disk #1.


KAOLINITE IN KBR, GEORGIA: CMS KGA-2 14 Nov 85 13:08:50
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


KAOLINITE. PACKED SAMPLE. GEORGIA: CMS KGa-2 14 May 86 15:11:12
% REFLECTANCE
0.0000
9.0000
18.000
27.000
36.000
45.000
54.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


KAOLINITE. < 2UM SIFTED. GEORGIA: CMS KGa-2 11 Dec 85 13:30:31
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Kaolinite (well crystallized) $Al_2Si_2O_5(OH)_4$

Locality: Washington, CO, Georgia

Last donor: Hunt & Salisbury collection.

Intermediate donor:

Ultimate donor: Clay Mineral Society Source Clay Mineral Repository

Catalog numbers, etc.: CMS KGA -1

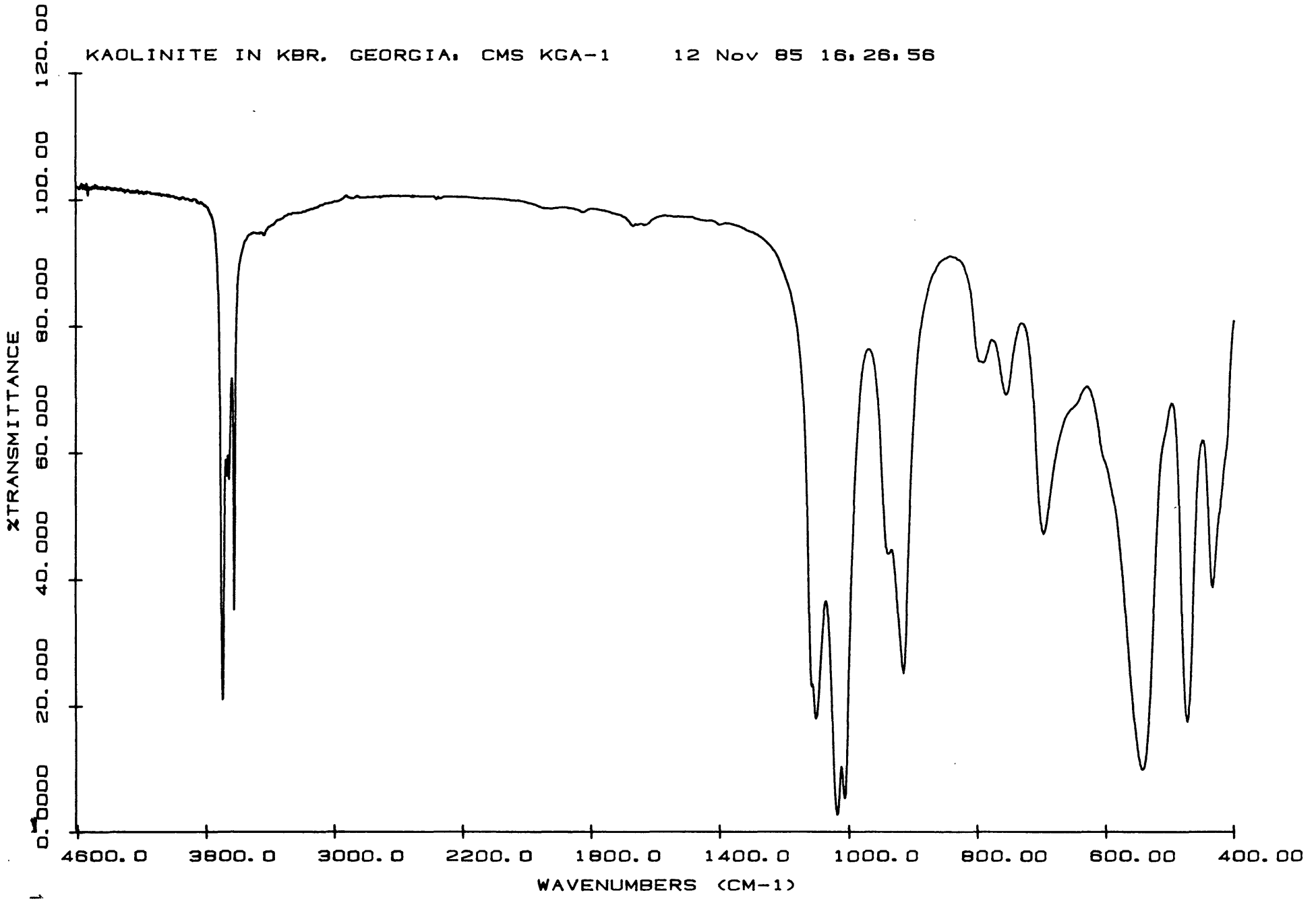
Results of petrographic examination: White in color

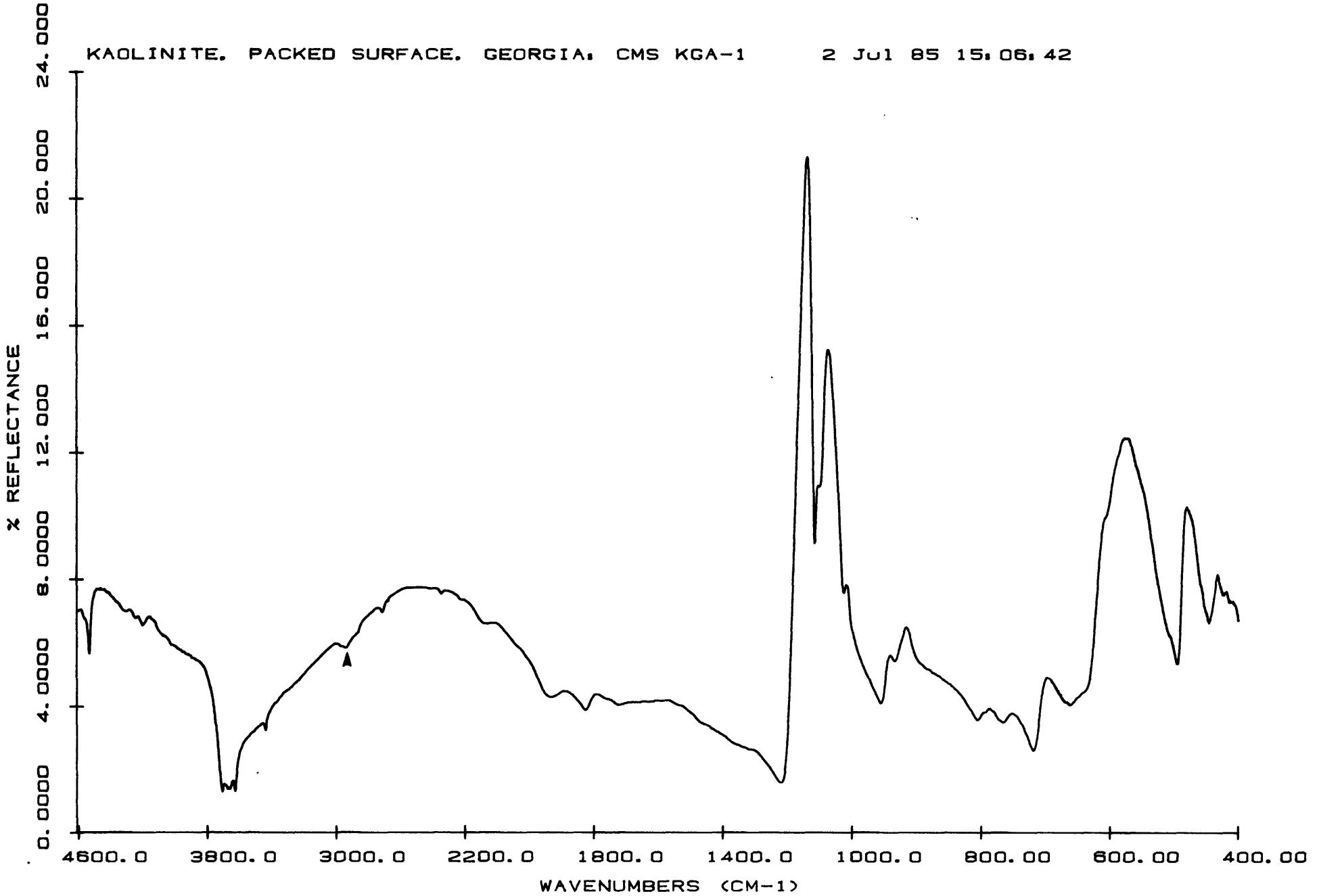
Results of XRD: The <2 um separate is pure kaolinite (well crystallized). Bulk sample is slightly contaminated with anatase.

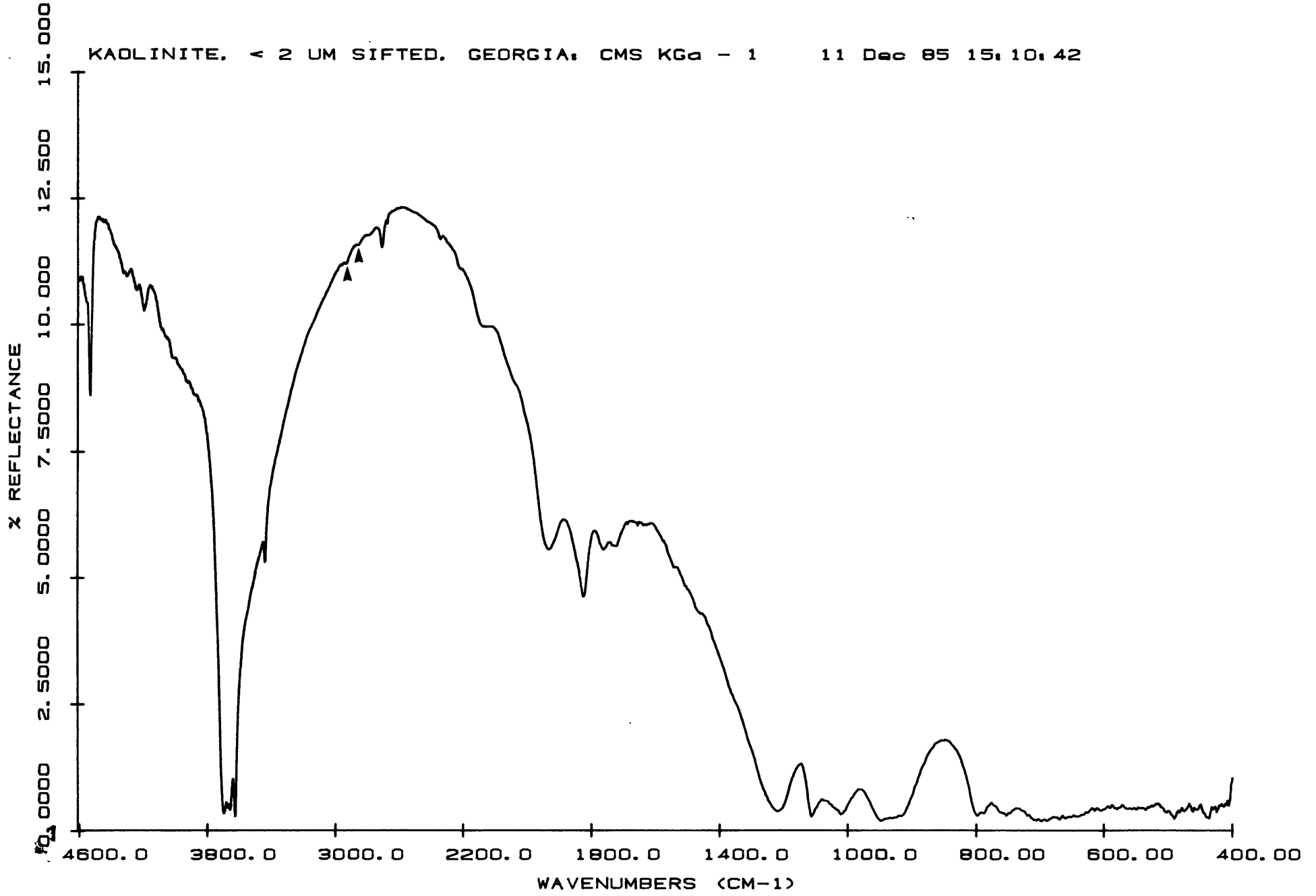
Results of XRF or other compositional analysis: None.

Spectra on file:

Kaolinite.3	Reflectance spectrum of <2 um sifted sample on 0-74 disk #1.
Kaolinite.3	Reflectance spectrum of <2 um packed surface on solid sample disk #1.
Kaolinite.3	Transmittance spectrum on disk #1.


KAOLINITE IN KBR. GEORGIA. CMS KGA-1 12 Nov 85 16:26:56
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


KAOLINITE. PACKED SURFACE. GEORGIA. CMS KGA-1 2 Jul 85 15:06:42
% REFLECTANCE
0.0000
4.0000
8.0000
12.000
16.000
20.000
24.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


KAOLINITE. < 2 UM SIFTED. GEORGIA: CMS KGa - 1 11 Dec 85 15:10:42
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Kyanite Al_2SiO_5

Locality: Brazil (?)

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 139740

Results of petrographic examination: Two crystals about 1.5 x 0.4 x 0.4 cm, blue in color with a very small amount of brown coating (limonite?). Brown coating scraped off and crushed sample hand picked for cleanest material. Under the microscope, resulting sample appears pure and unaltered.

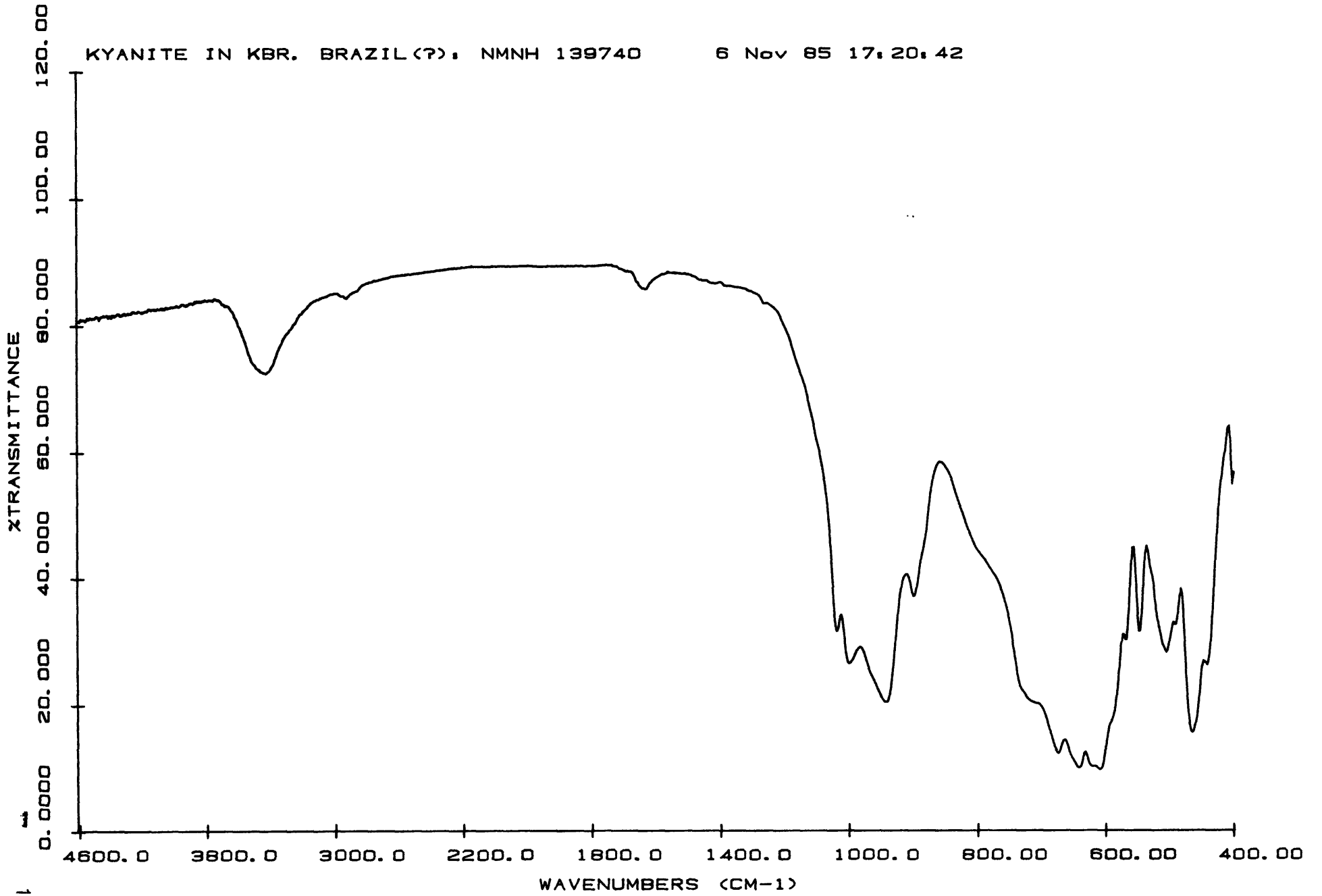
Results of XRD: Pure kyanite according to XRD. However, the slight amount of alteration product is clearly identifiable as kaolinite from its infrared hydroxyl bands near 3700 cm^{-1}.

Results of XRF or other compositional analysis: Microprobe analysis by L. Walter shows hand-picked sample to be homogeneous within and between grains. Average of 9 analyses:

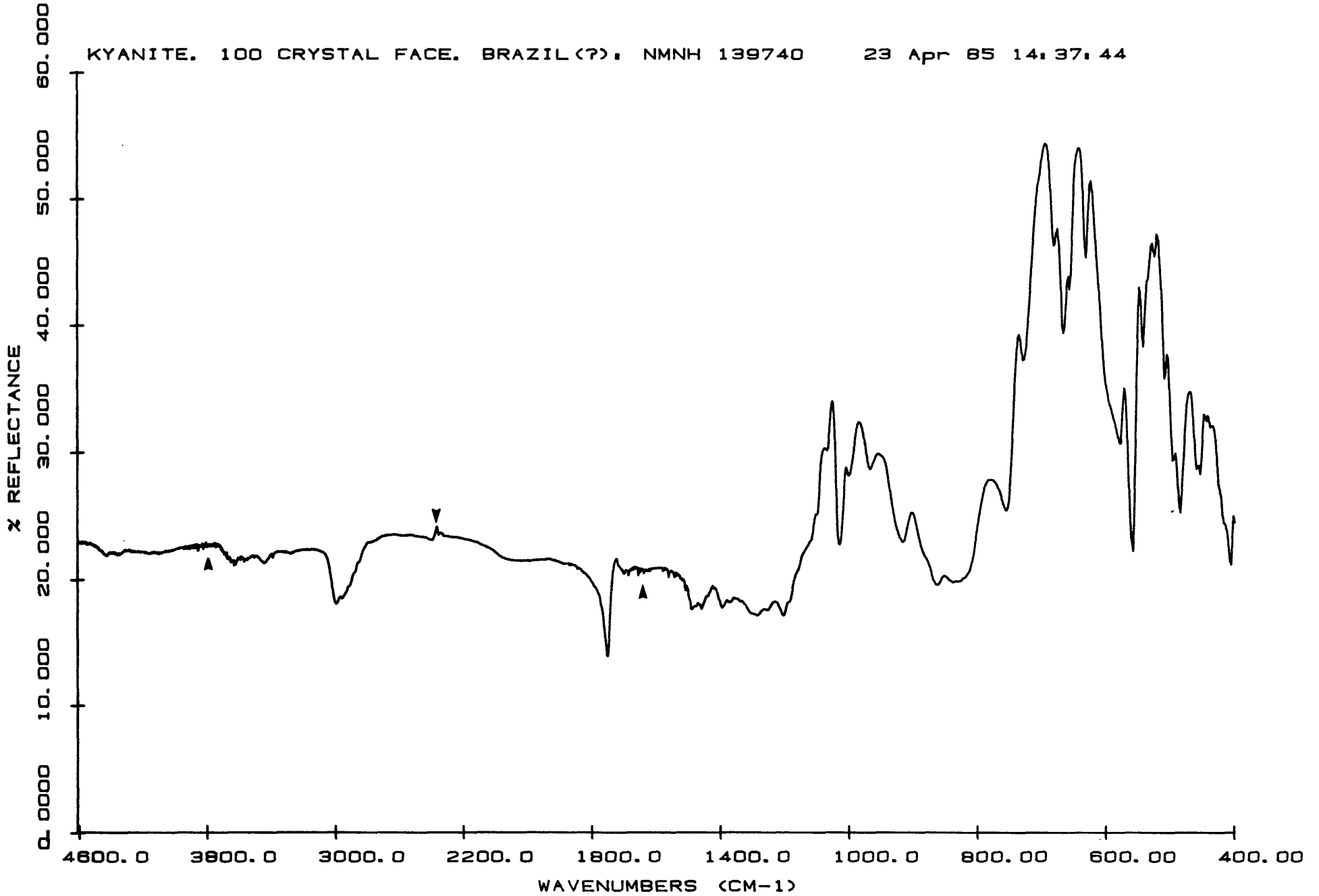
SiO_2	- 36.73
Al_2O_3	- 63.23
FeO	- 0.21
MgO	- 0.02
CaO	- 0.01
K_2O	- 0.01
Na_2O	- 0.02
TiO_2	- 0.01
MnO	- 0.01
Total	-100.25

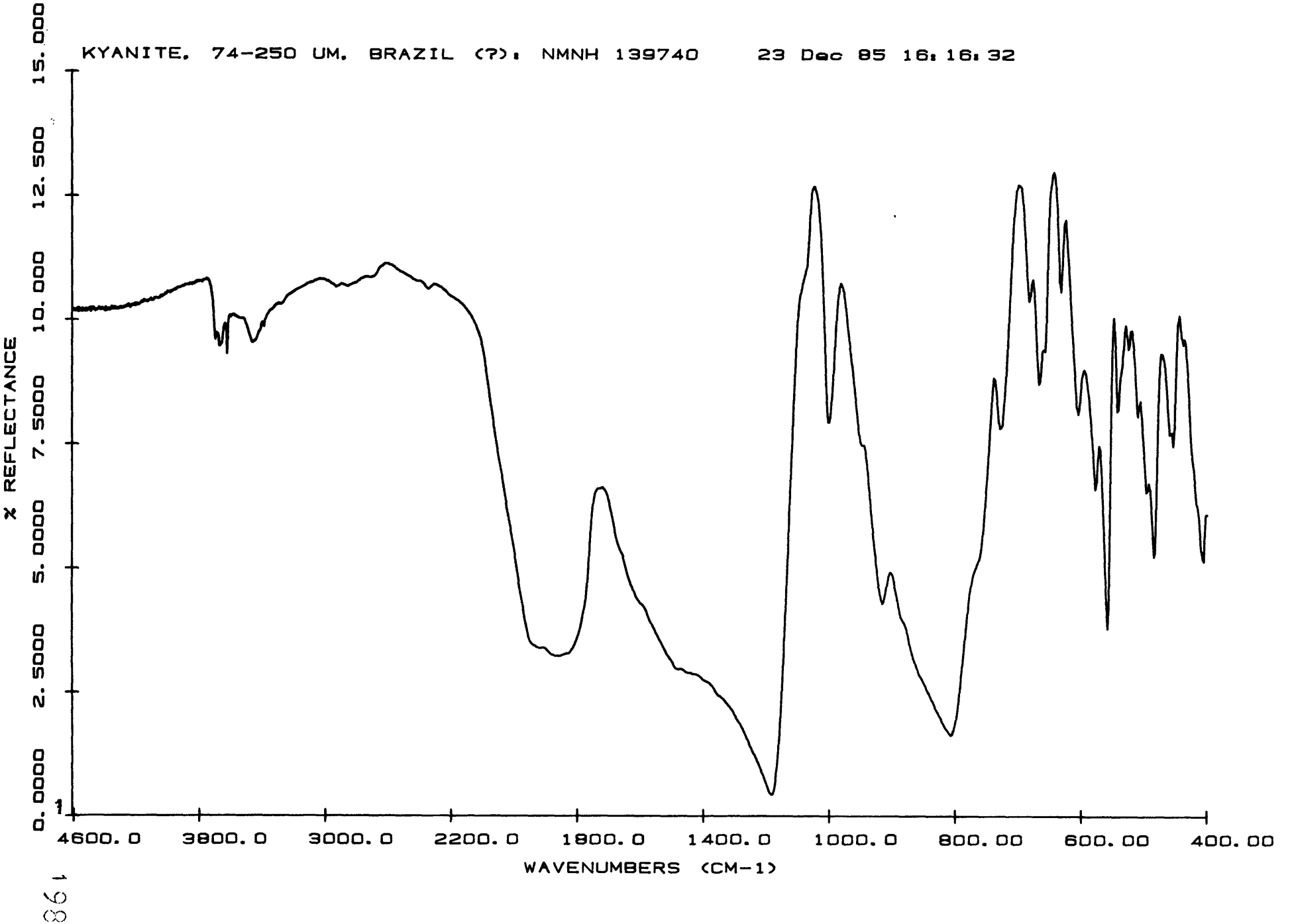
Spectra on file:

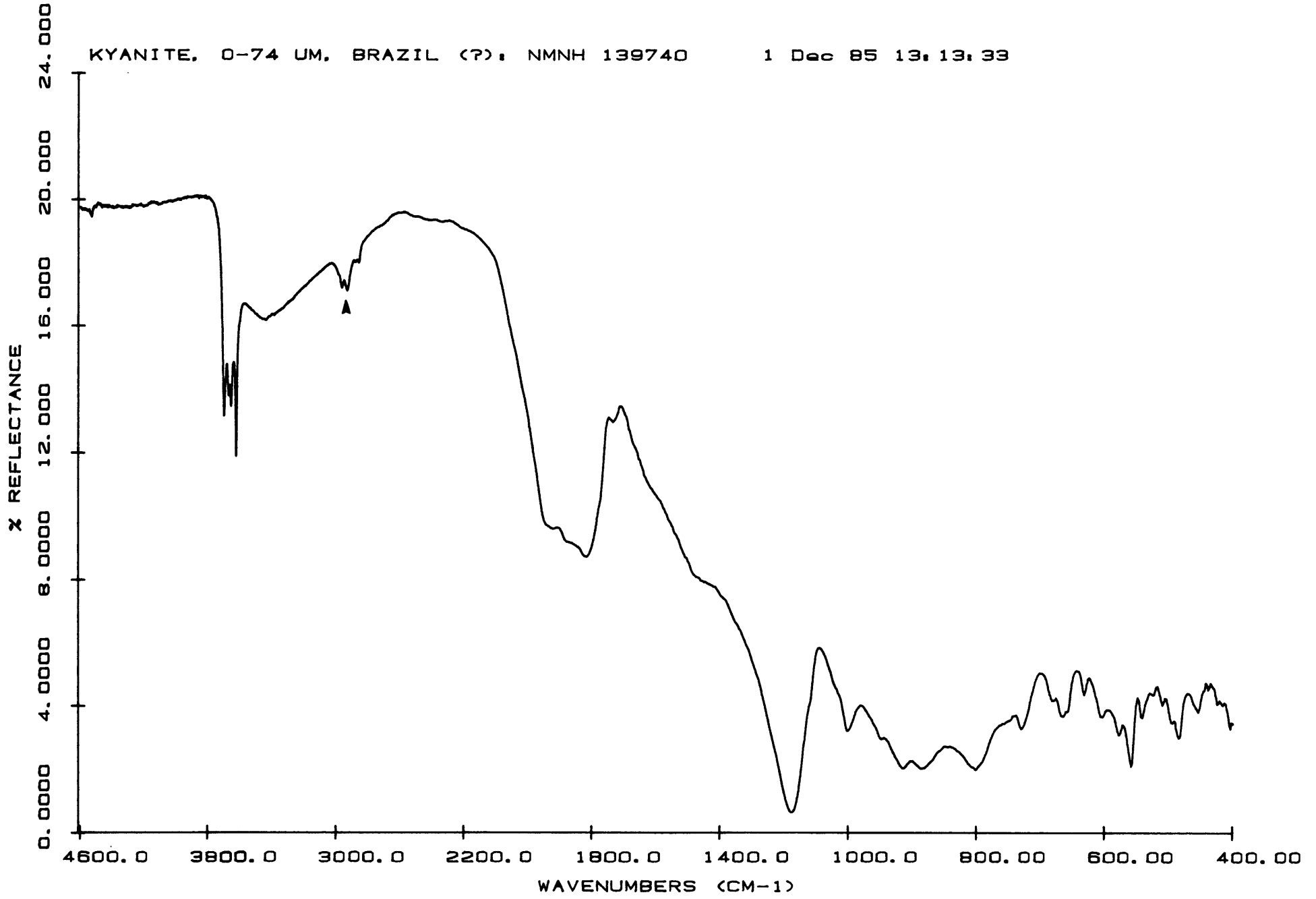
Kyanite.1 Reflectance spectrum of 100 crystal face on solid sample disk #1.
Kyanite.1 Reflectance spectrum of 0-74 um size range on disk #1.
Kyanite.1 Reflectance spectrum of 74-250 on size range disk #1.
Kyanite.1 Transmittance spectrum on disk #1.


KYANITE IN KBR. BRAZIL(?): NMNH 139740 6 Nov 85 17:20:42
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

964


KYANITE. 100 CRYSTAL FACE. BRAZIL(?). NMNH 139740 23 Apr 85 14:37:44
% REFLECTANCE
60.000
50.000
40.000
30.000
20.000
10.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


KYANITE. 74-250 UM. BRAZIL (?): NMNH 139740 23 Dec 85 16:16:32
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


KYANITE, 0-74 UM, BRAZIL (?): NMNH 139740
1 Dec 85 13:13:33
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

1961

Species name: Labradorite (Na, Ca) Al (Al, Si) Si_2O_8

Locality: Lake County, Oregon

Last donor: Dave Stewart, USGS

Intermediate donor:

Ultimate donor: Smithsonian

Catalog numbers, etc.: NMNH 115500

Results of petrographic examination: A 1 x 2 cm 0.536 g. portion of a single transparent crystal. Fragment seems to have been sawn on one side. A very, very small amount of iron oxide stain can be seen on the surface of the fragment and still less on the inside. No impurities detected under the microscope.

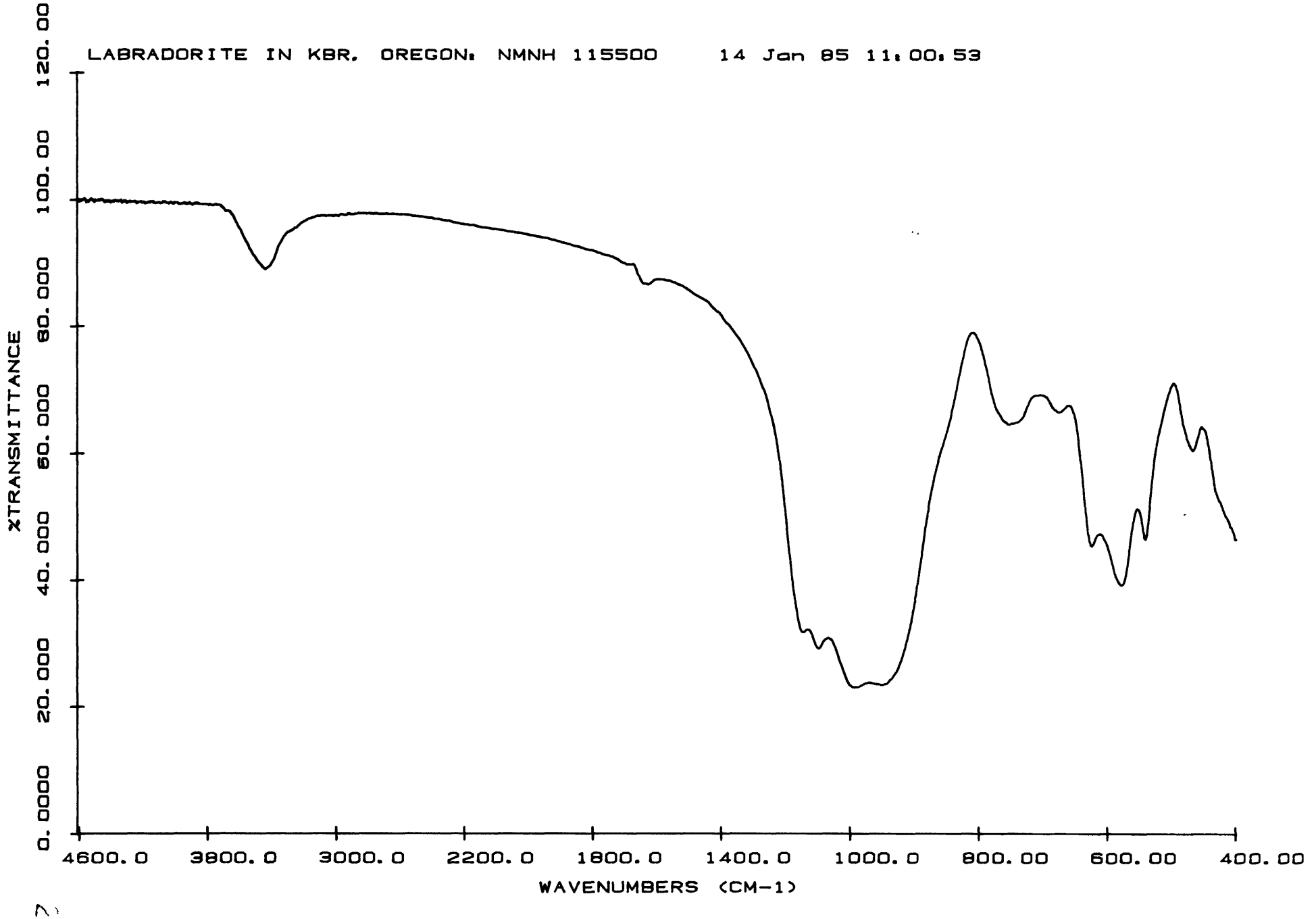
Results of XRD: Pure labradorite.

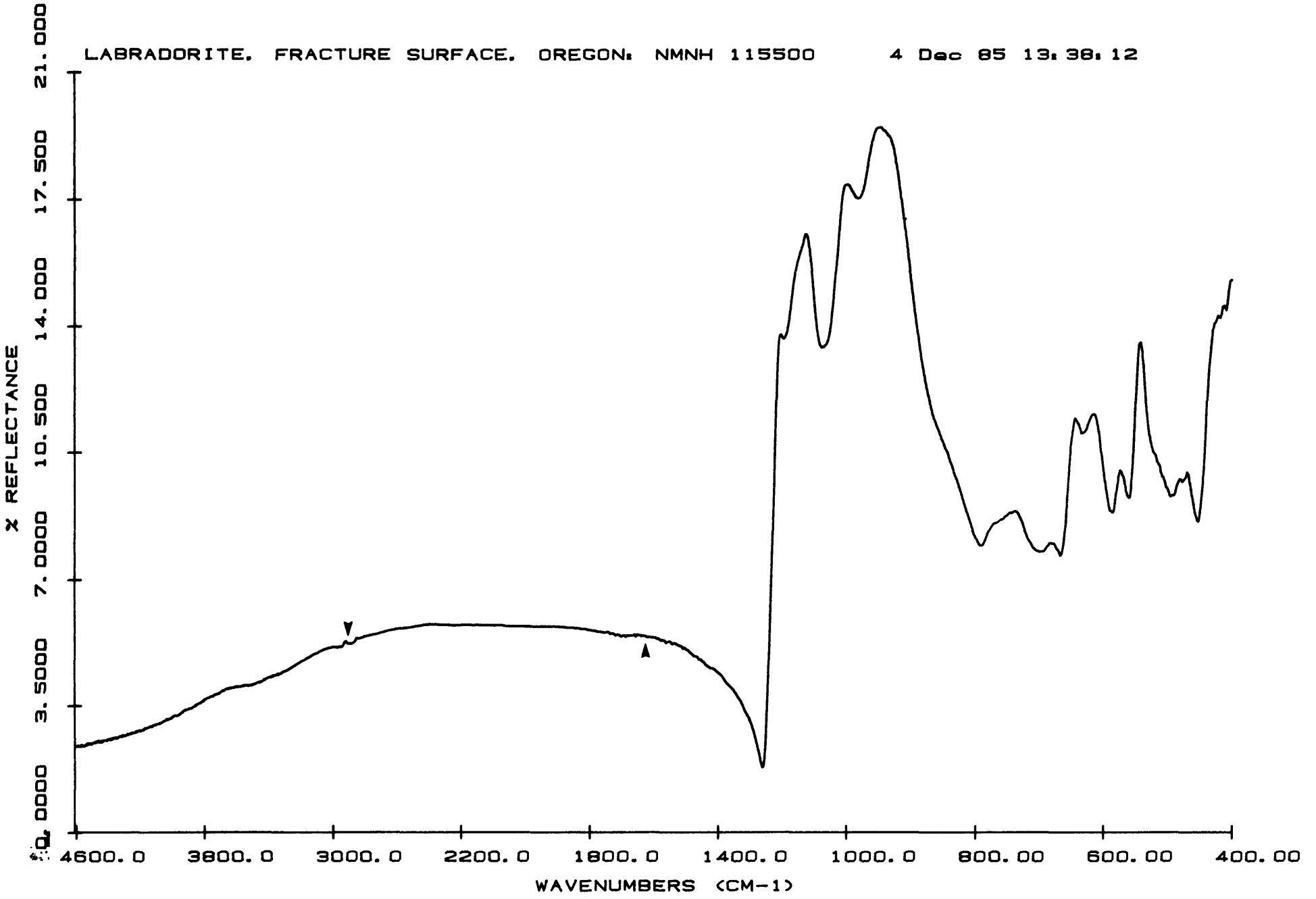
Results of XRF or other compositional analysis: Sample analyzed (see below) and described in Stewart, D.B., Walker, G.W., Wright, T.L., and Fahey, J.J., 1966, Physical properties of calcic labradorite from Lake County, Oregon: American Mineralogist, v. 51, p. 177-197.

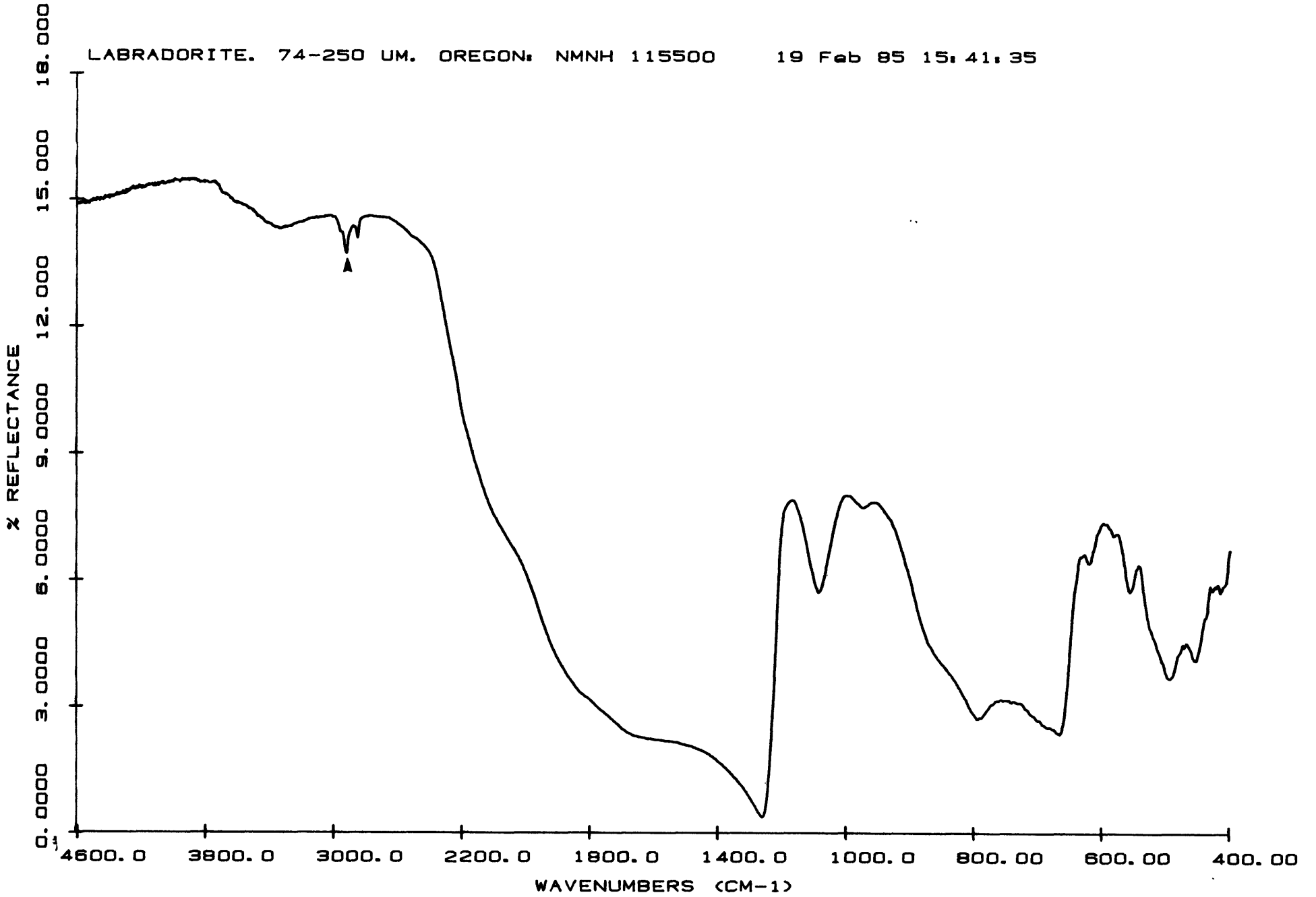
SiO_2	- 51.42
TiO_2	- 0.04
Al_2O_3	- 30.76
Fe_2O_3	- 0.24
FeO	- 0.17
MnO	- not reported
MgO	- 0.05
CaO	- 13.42
Na_2O	- 3.52
K_2O	- 0.23
Total H_2L	- 0.04

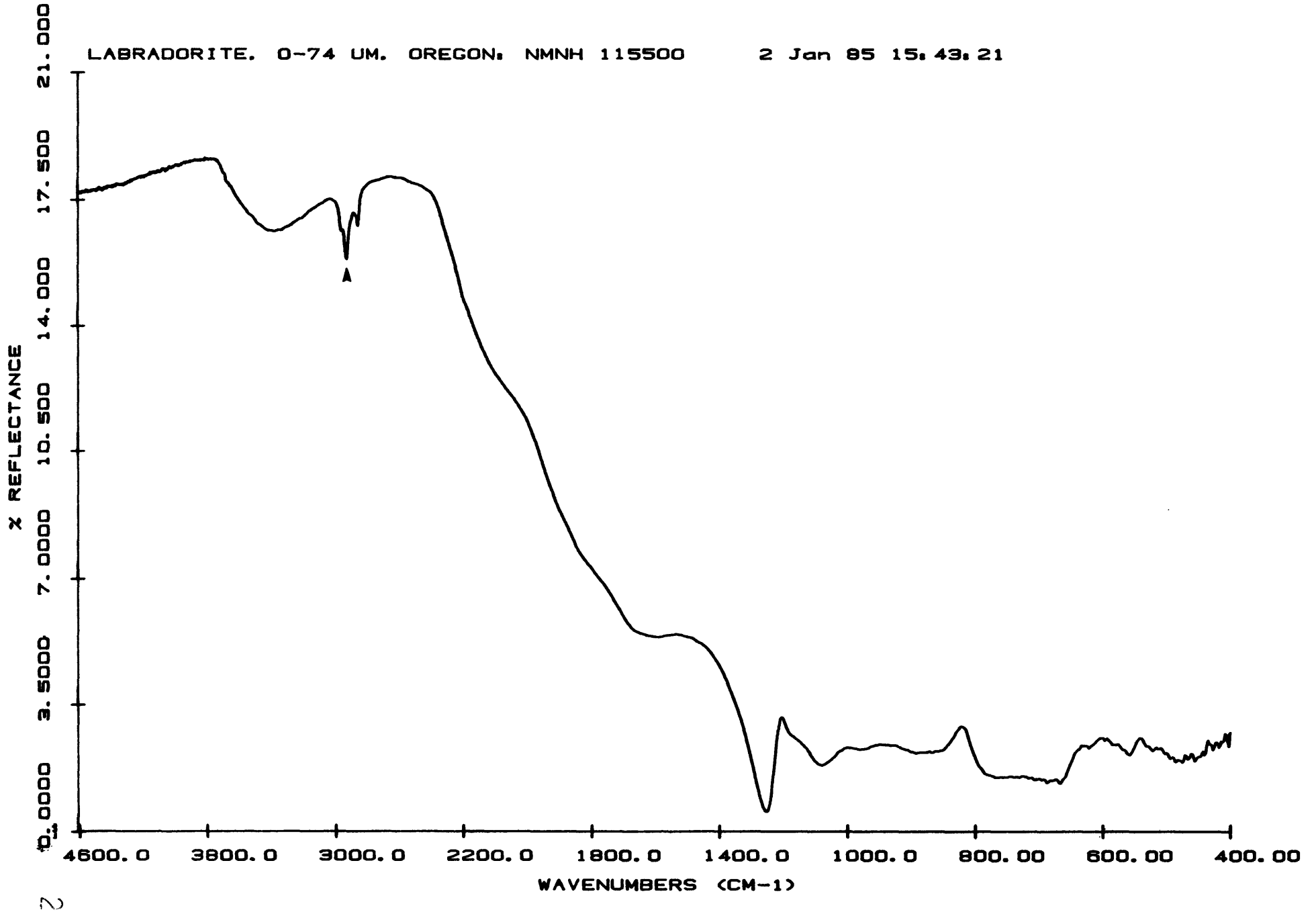
Spectra of file:

Labradorite.1 Reflectance of fracture surface on solid sample disk #1.
Labradorite.1 Reflectance of 0.74 um size range on disk #1.
Labradorite.1 Reflectance spectrum of 74-250 um size range on disk #1.
Labradorite.1 Transmittance spectrum on disk #1.


LABRADORITE IN KBR, OREGON: NMNH 115500 14 Jan 85 11:00:53
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


LABRADORITE. FRACTURE SURFACE. OREGON: NMNH 115500
4 Dec 85 13:38:12
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


LABRADORITE. 74-250 UM. OREGON: NMNH 115500 19 Feb 85 15:41:35
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


LABRADORITE. 0-74 UM. OREGON. NMNH 115500 2 Jan 85 15:43:21
% REFLECTANCE
21.000
17.500
14.000
10.500
7.0000
3.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Microcline

Locality: Park County, Colorado

Last donor: Smithsonian

Intermediate donor:

Ultimate donor: Smithsonian

Catalog numbers, etc.: NMNH 135231

Results of petrographic examination: Hand sample is a 19.5 gram fragment of a single crystal, aqua in color. A slight amount of surface contamination should be removable by brushing and ultrasonic cleaning. One thin (0.5 mm) vein filled with white material cuts across one corner of sample. Sample is not obviously perthitic.

Under the microscope it appears fairly pure. Very little perthite and very little contamination with clay (?) or sericite (?)

Results of XRD: XRD shows microcline plus a small amount of albite.

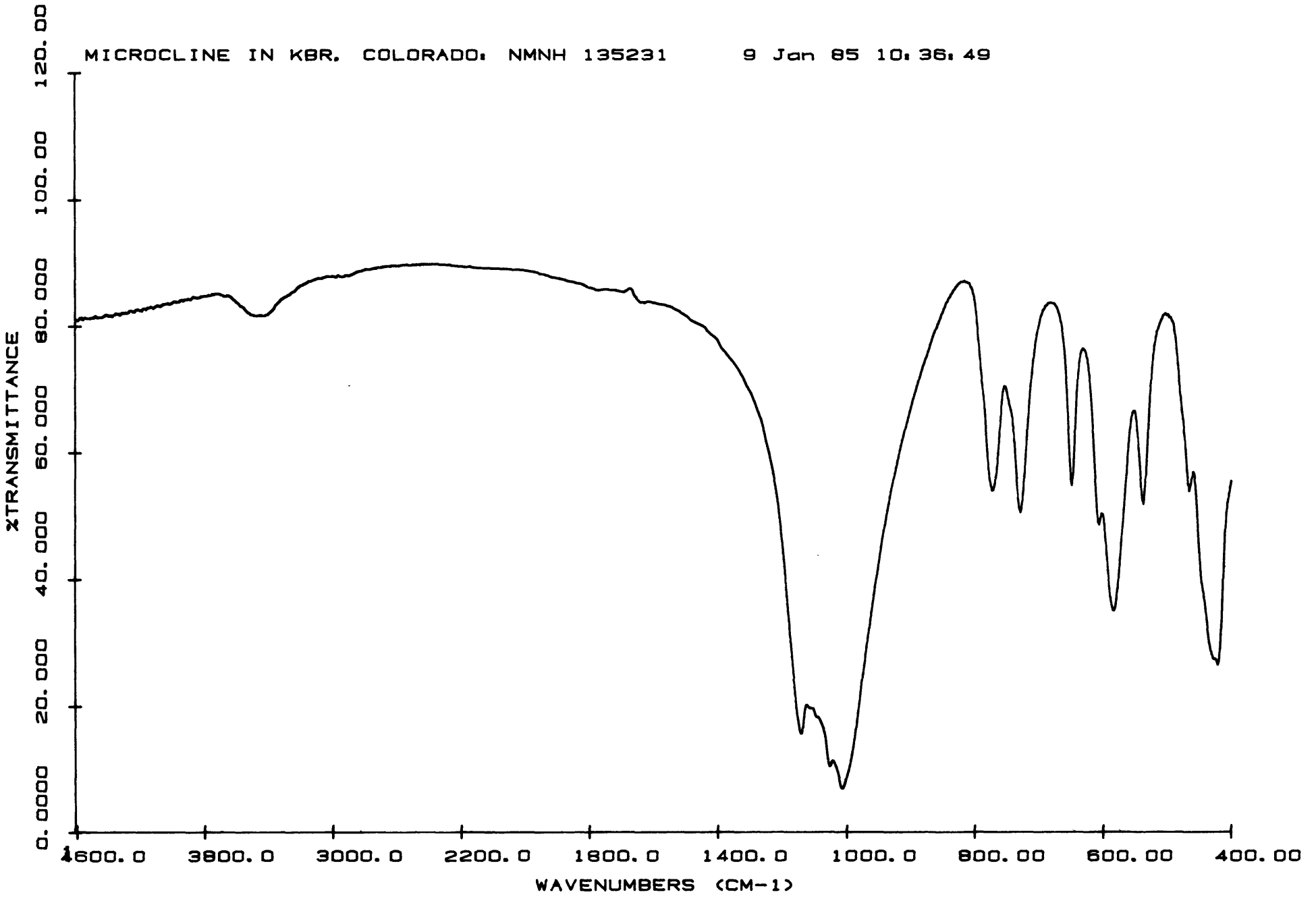
Results of XRF or other compositional analysis:

Microprobe analysis shows sample to be homogeneous within and between grains. Sample is very close to pure microcline, as indicated by soda content less than 1%. Average of 17 analyses:

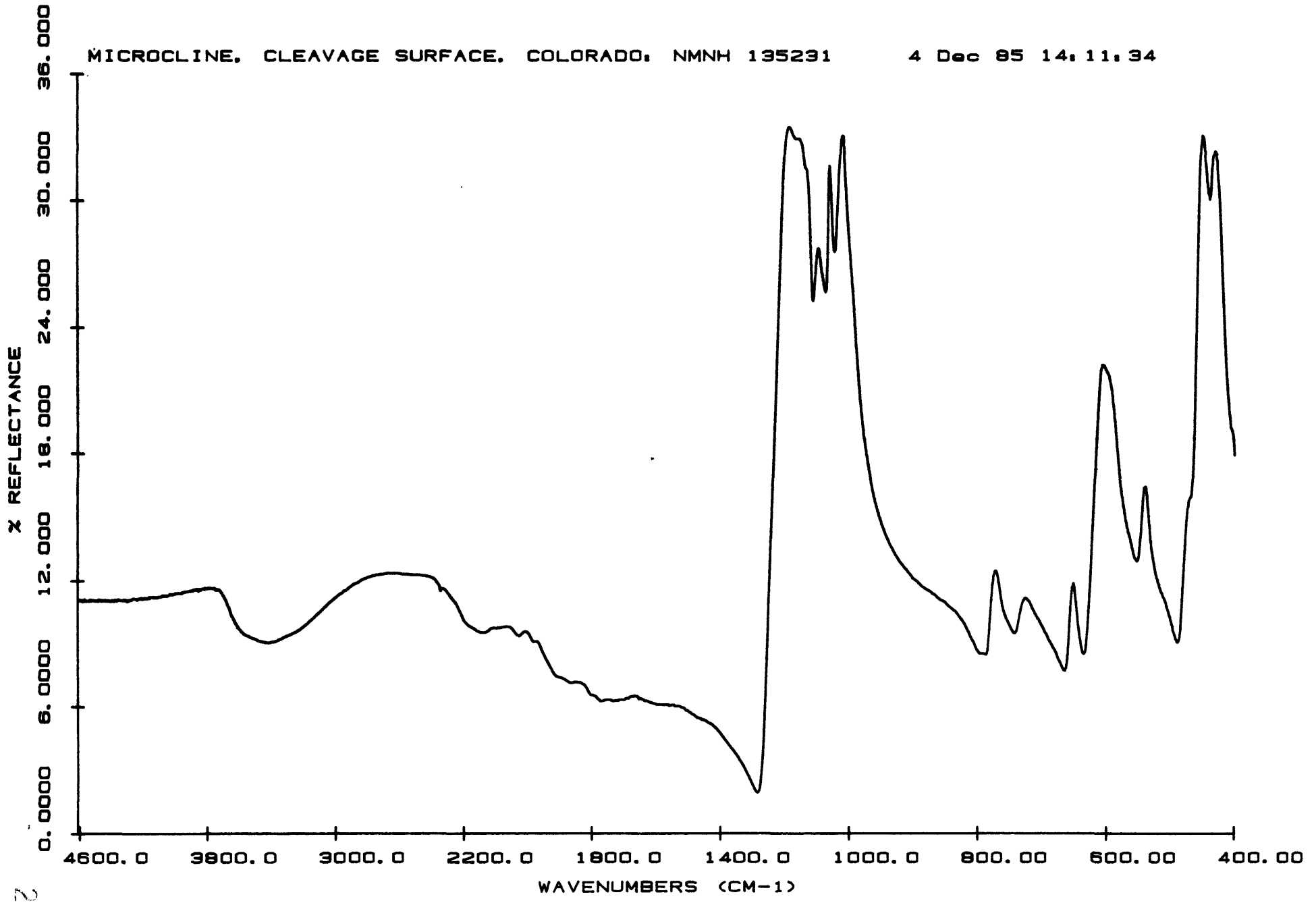
SiO_2	- 64.60
Al_2O_3	- 18.63
FeO	- 0.08
MgO	- 0.04
CaO	- 0.01
K_2O	- 15.04
Na_2O	- 0.53
TiO_2	- 0.02
MnO	- 0.03
Total	- 98.98

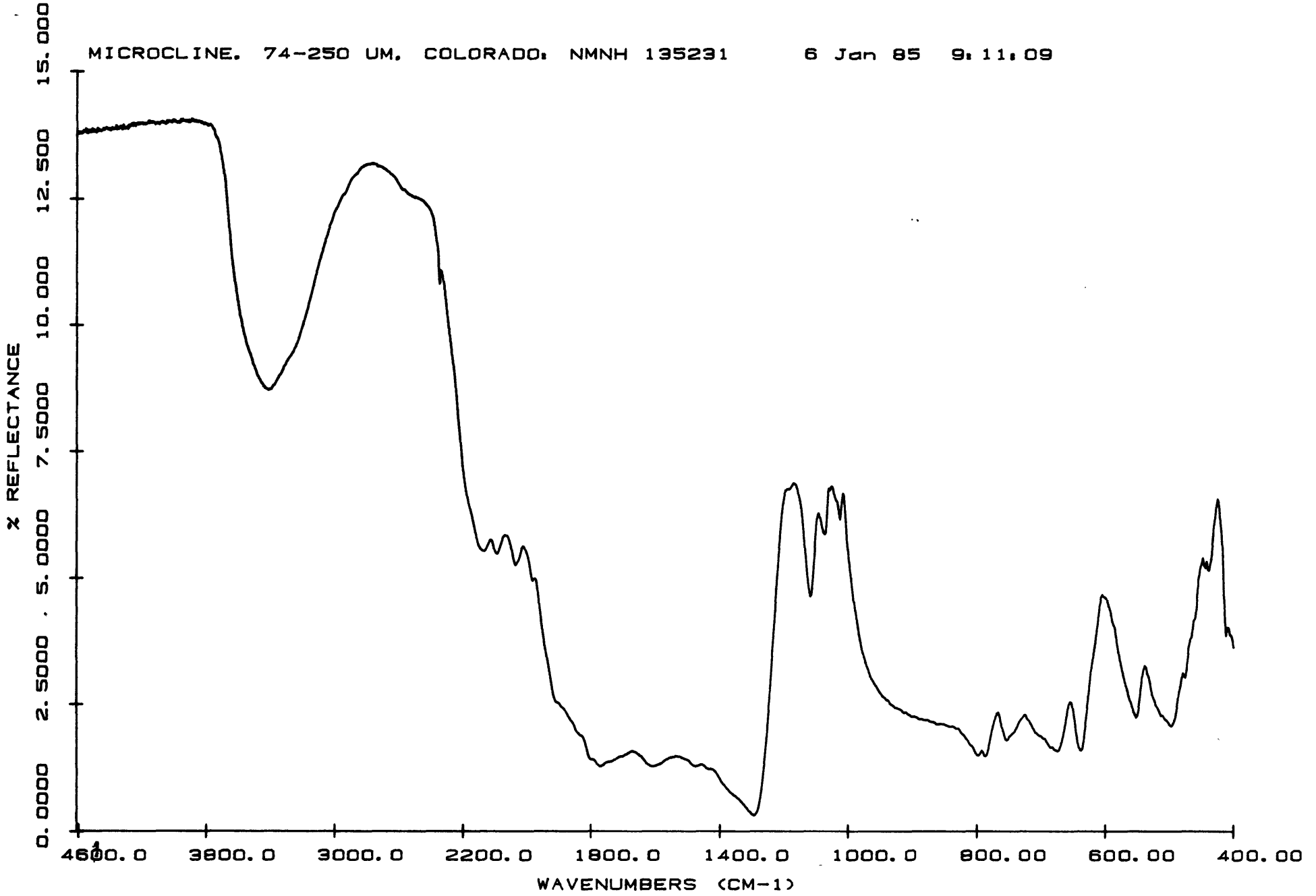
Spectra of file:

Microcline.1	Reflectance of cleavage surface on solid sample disk #1.
Microcline.1	Reflectance spectrum of 0-74 um size range on disk #1.
Microcline.1	Transmittance spectrum on disk #1.
Microcline.1	Reflectance spectrum of 74-250 um size range on disk #1.

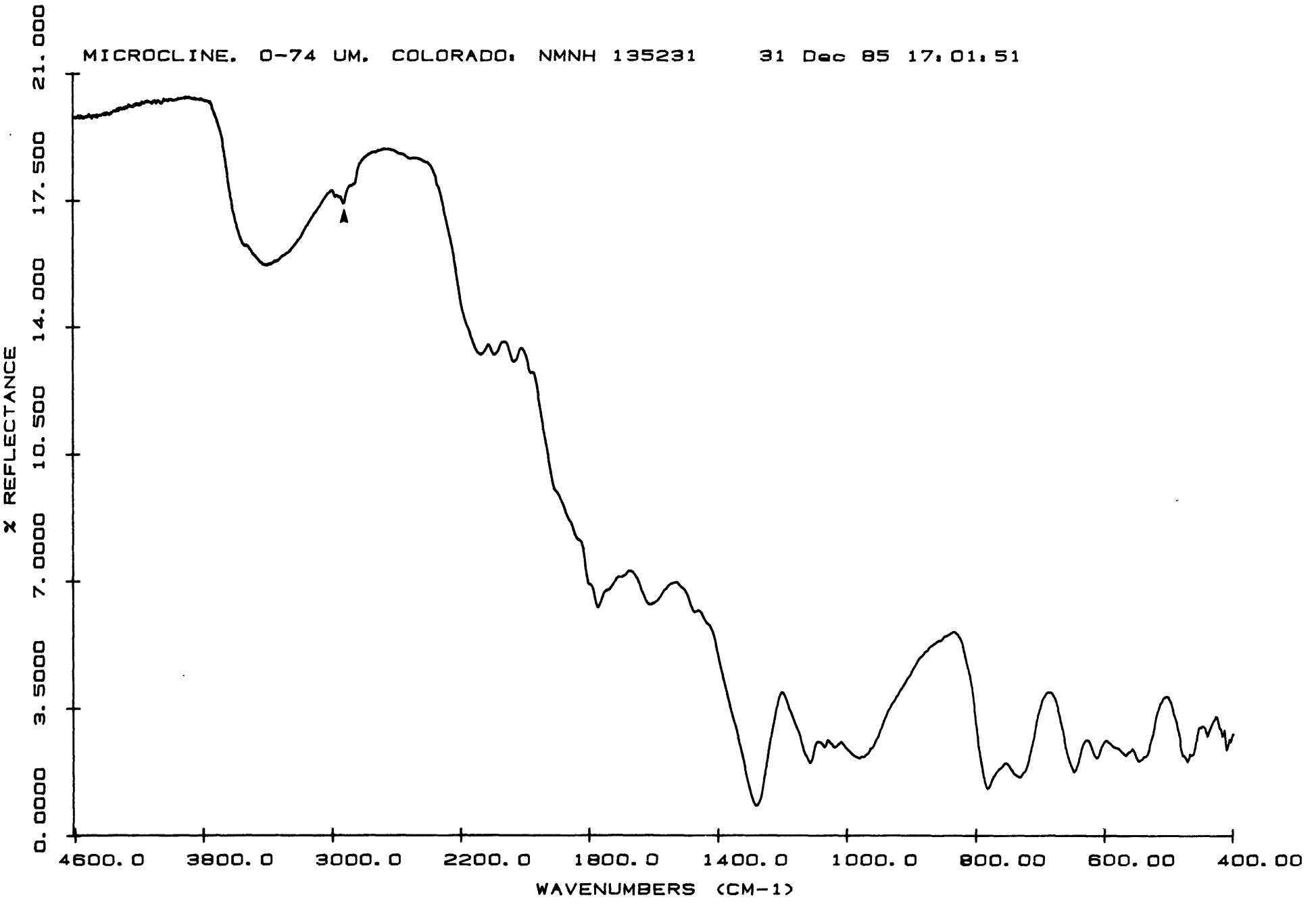

MICROCLINE IN KBR. COLORADO: NMNH 135231 9 Jan 85 10:36:49
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

902


MICROCLINE. CLEAVAGE SURFACE. COLORADO: NMNH 135231 4 Dec 85 14:11:34
% REFLECTANCE
0.0000
6.0000
12.000
18.000
24.000
30.000
36.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


MICROCLINE. 74-250 UM. COLORADO: NMNH 135231 6 Jan 85 9:11:09
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

802


MICROCLINE. 0-74 UM. COLORADO: NMNH 135231 31 Dec 85 17:01:51
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

602

Species name: Montmorillonite (<2 um) (Na, Ca).33 $(Al, Mg)_2$ (Si_4O_{10}) $(OH)_2$. H_2O

Locality: San Diego, California

Last donor:

Intermediate donor:

Ultimate donor: Clay Mineral Society Source Clay Mineral Repository

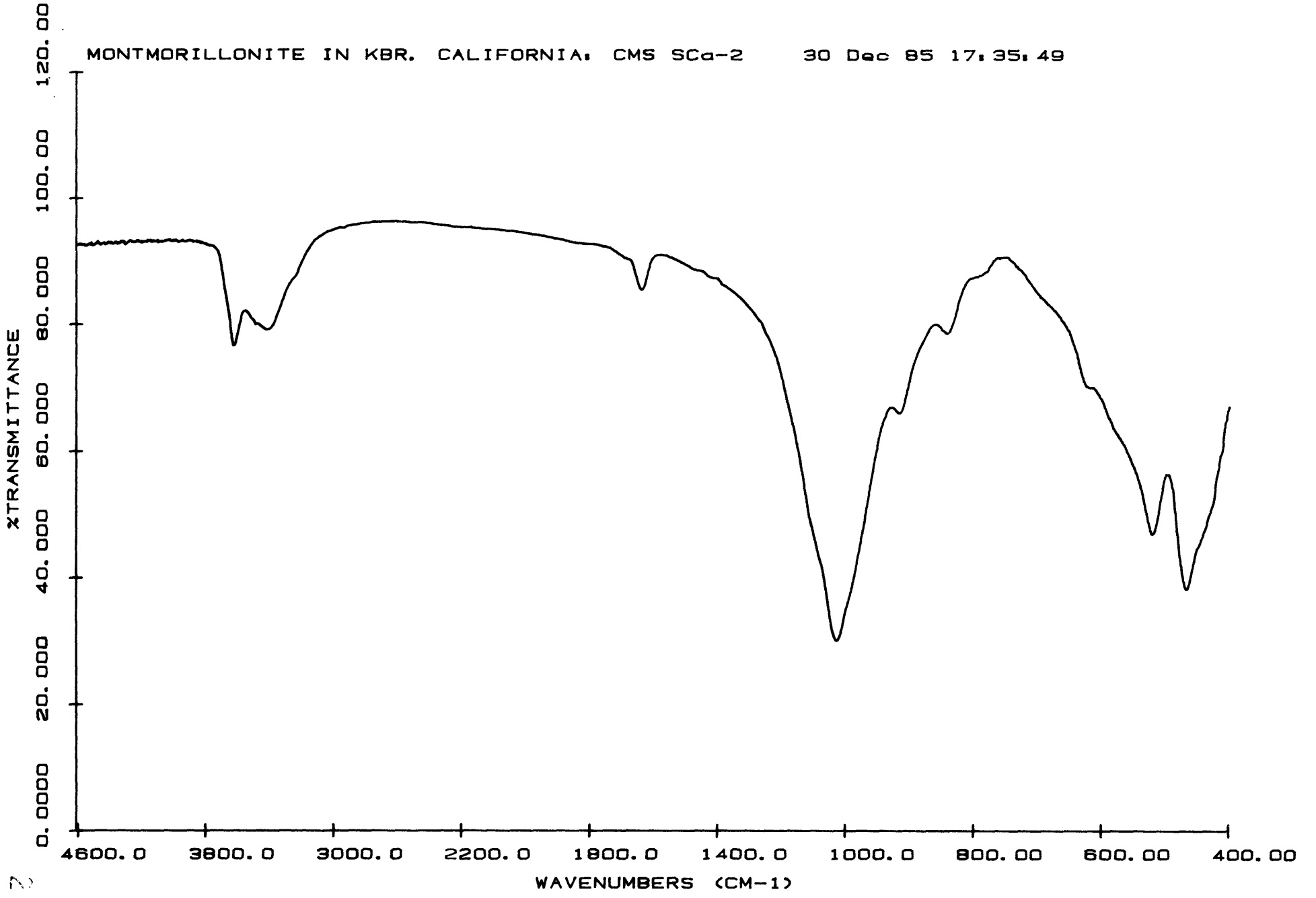
Catalog numbers, etc.: SCa-2 (CMS)

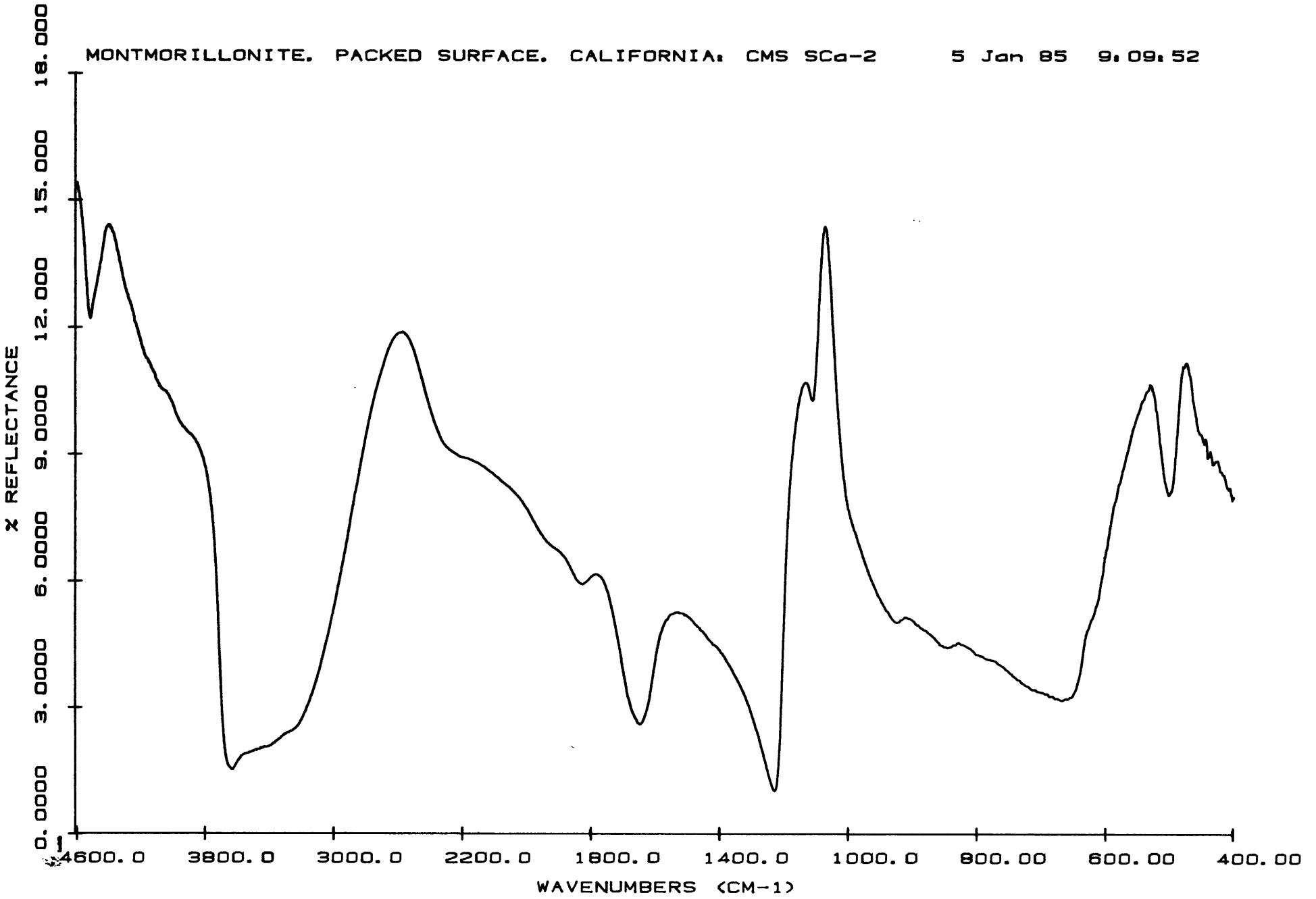
Results of petrographic examination: The bulk sample and the <2 um size fraction are tan in color.

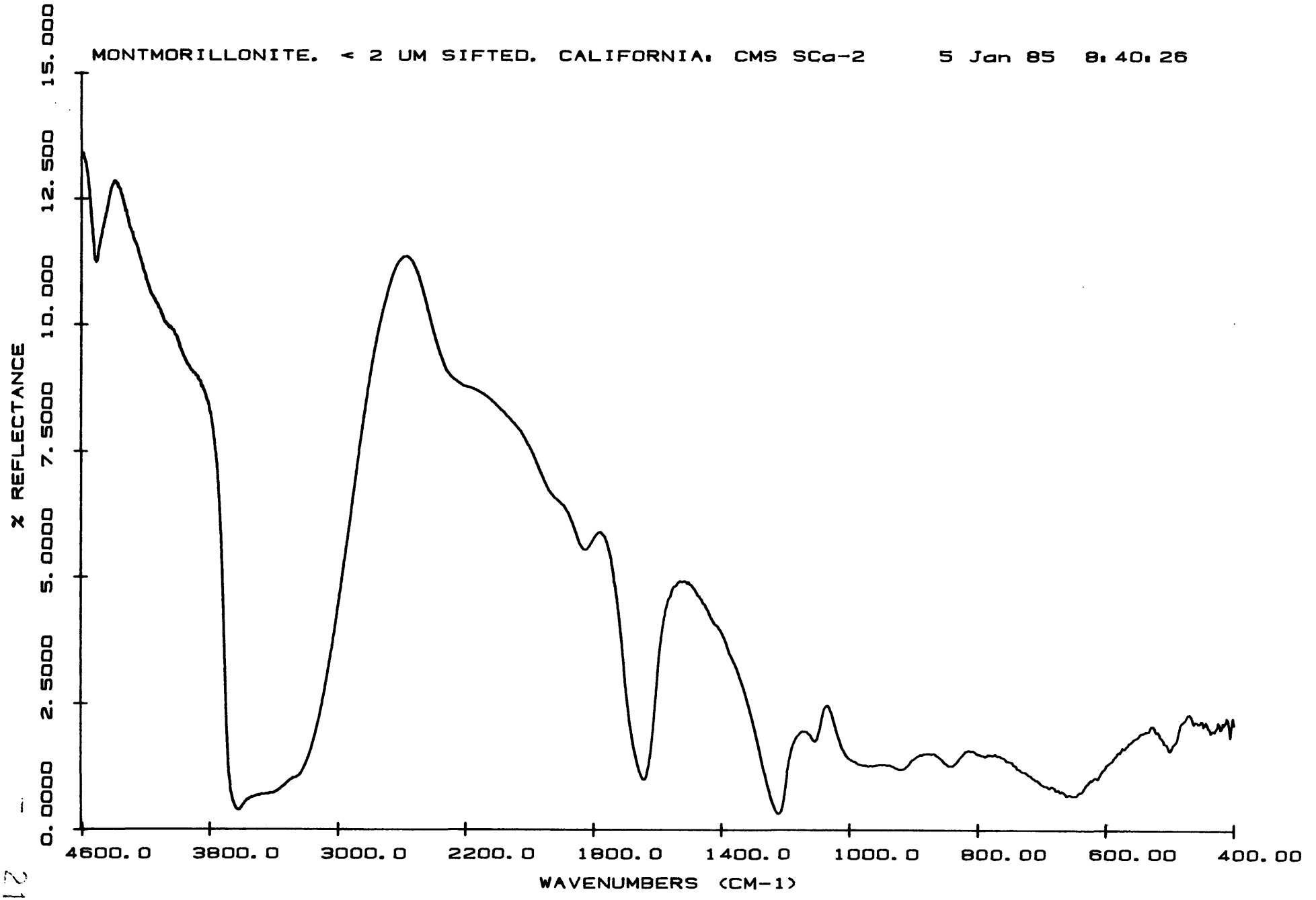
Results of XRD: Bulk sample contains a trace of quartz, but <2 um separate is pure montmorillonite.

Results of XRF or other compositional analysis: None

Spectra on file:
Montmor.1 Reflectance spectrum of packed sample on solid sample disk #1.
Montmor.1 Reflectance spectrum of <2 sifted sample on 0-74 disk #1.
Montmor.1 Transmittance spectrum on disk #1.


MONTMORILLONITE IN KBR. CALIFORNIA: CMS SCa-2 30 Dec 85 17:35:49
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


MONTMORILLONITE. PACKED SURFACE. CALIFORNIA: CMS SCa-2 5 Jan 85 9:09:52
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


MONTMORILLONITE. < 2 UM SIFTED. CALIFORNIA: CMS SCa-2
5 Jan 85 8:40:26
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Montmorillonite (<2 um) (Na, Ca).33 $(Al, Mg)_2$ Si_4 $O_{10}(OH)_2$. nH_2O

Locality: Gonzales Co., Texas

Last donor: Hunt and Salisbury collection

Intermediate donor:

Ultimate donor: Clay Mineral Society Clay Mineral Repository

Catalog numbers, etc.: CMS STx-1

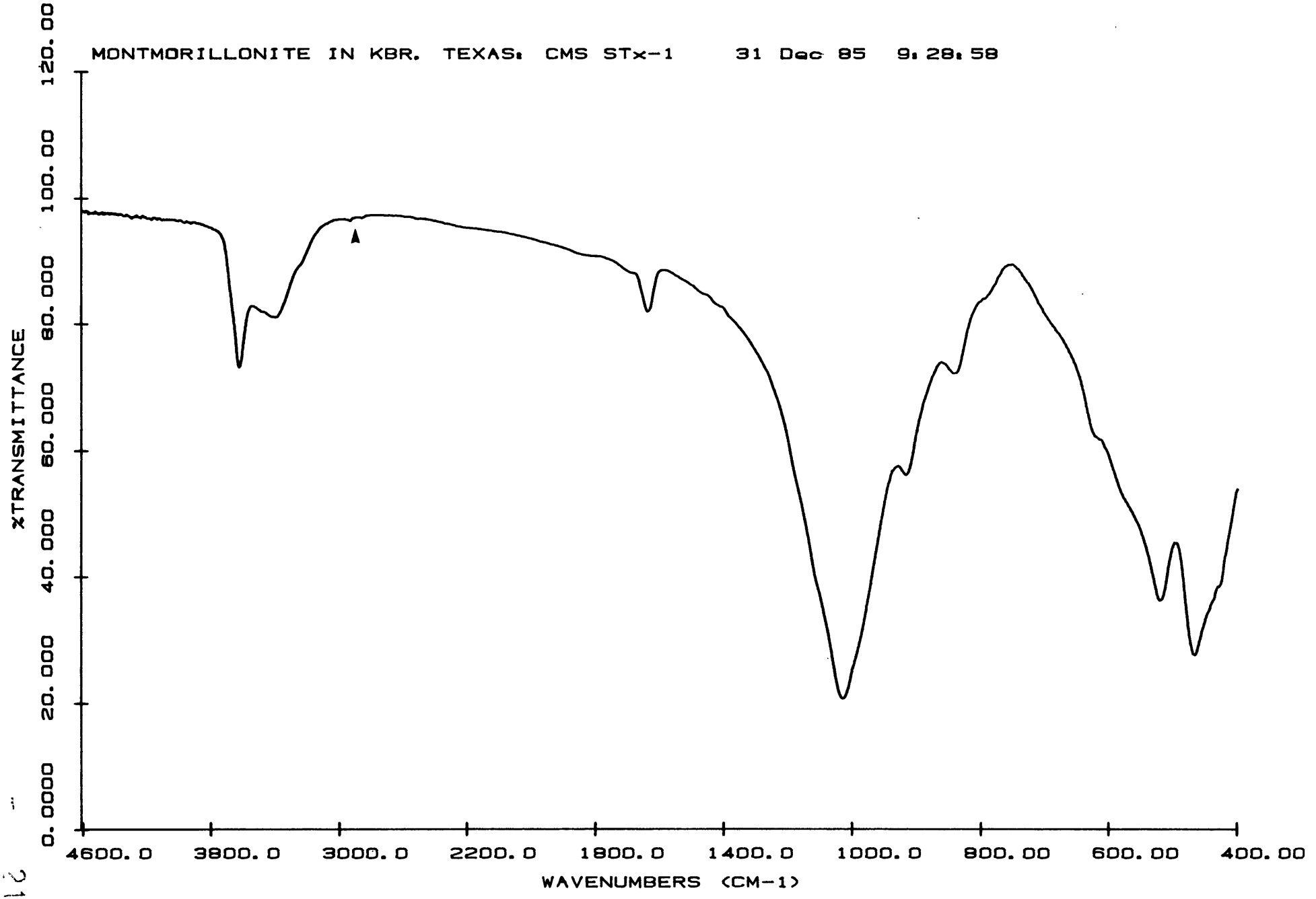
Results of petrographic examination: This is a white montmorillonite.

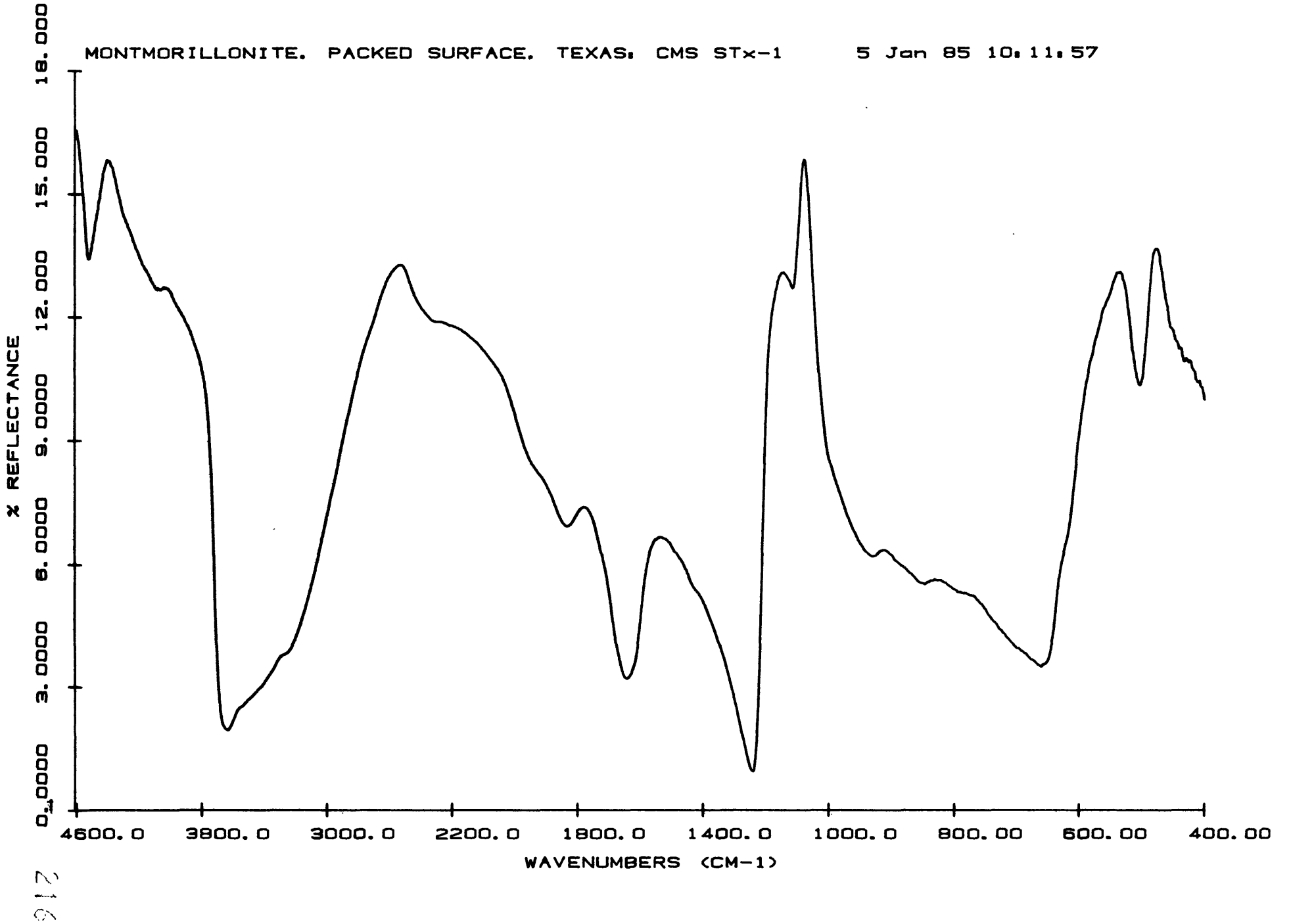
Results of XRD: Bulk sample contains calcite, but <2 um size fraction is pure montmorillonite.

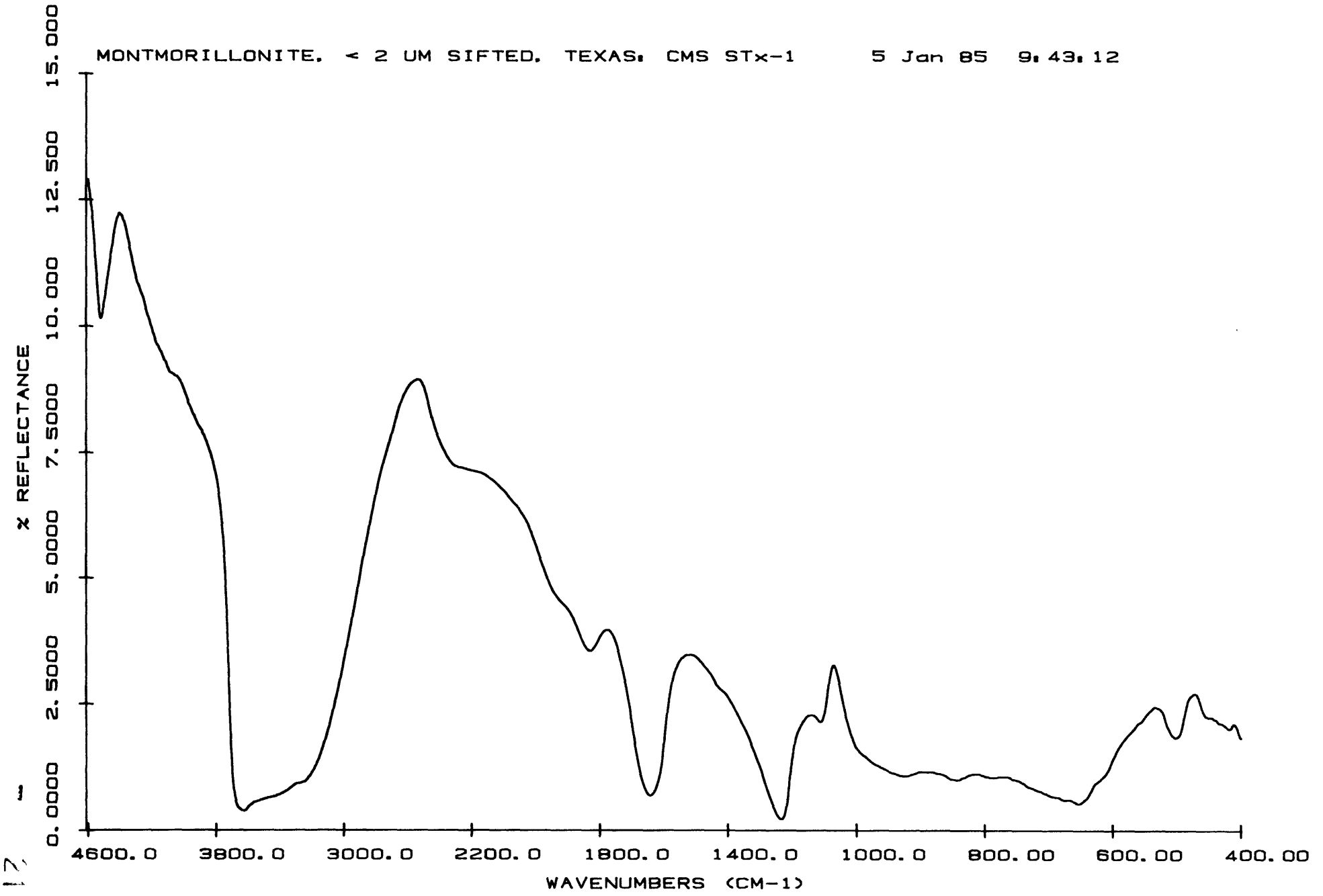
Results of XRF or other compositional analysis: None

Spectra of file:

Montmor.2 Transmittance spectrum of <2 um size fraction on disk #1.
Montmor.2 Reflectance spectrum of <2 um size fraction on 0-74 um disk #1.
Montmor.2 Reflectance spectrum of a packed surface of the <2 um size fraction on solid sample disk #1.


MONTMORILLONITE IN KBR. TEXAS: CMS STx-1 31 Dec 85 9:28:58
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


MONTMORILLONITE. PACKED SURFACE. TEXAS. CMS STx-1 5 Jan 85 10:11:57
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


MONTMORILLONITE. < 2 UM SIFTED. TEXAS: CMS STx-1 5 Jan 85 9:43:12
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Montmorillonite <2 um $(Na, Ca)_{0.33}$ $(Al, Mg)_2$ Si_4O_{10} $(OH)_3$. nH_2O

Locality: Apache Co, Arizona

Last donor: Roger Clark

Intermediate donor:

Ultimate donor: Clay Mineral Society Source Clay Mineral Repository

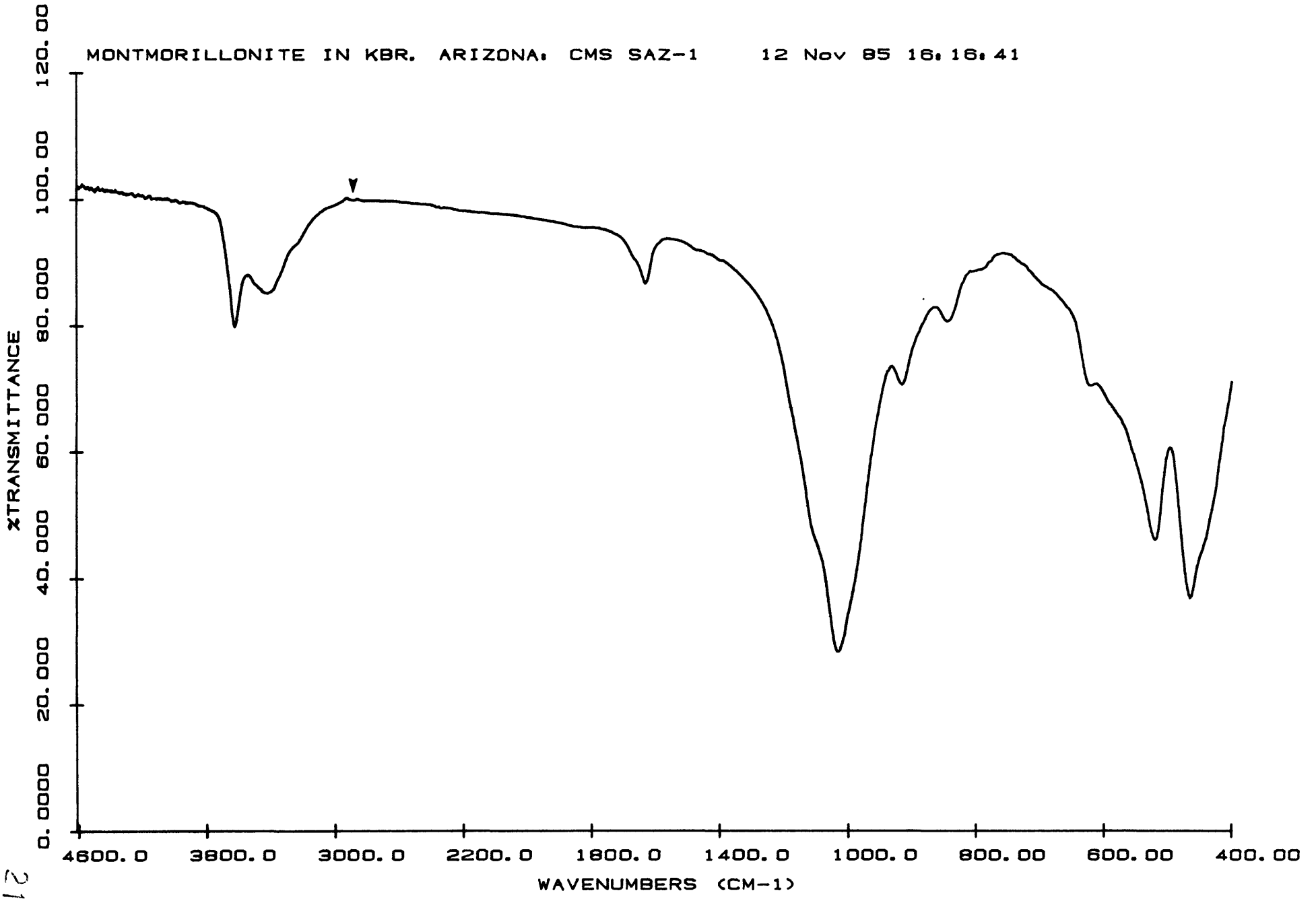
Catalog numbers, etc.: SAZ-1 (CMS)

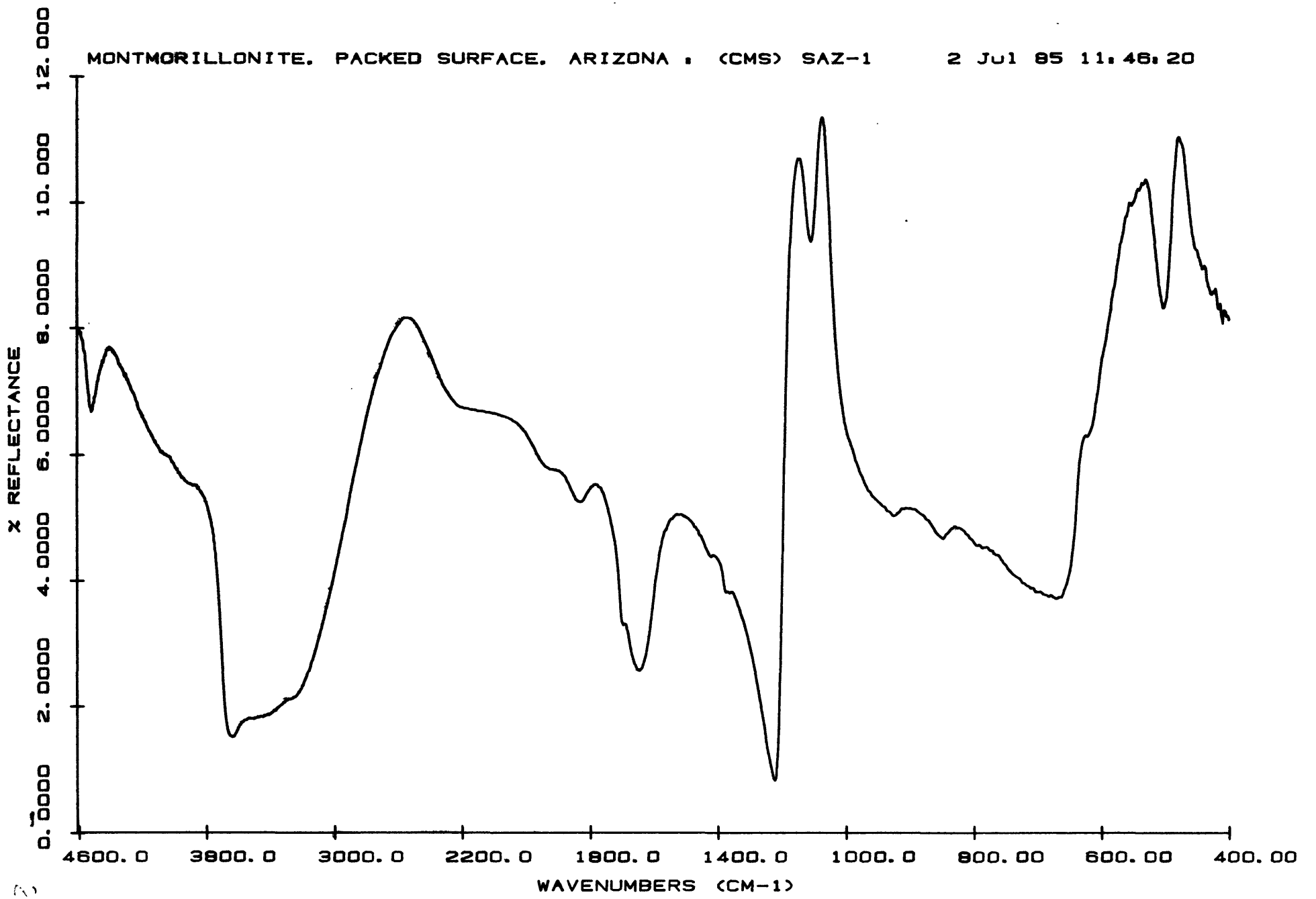
Results of petrographic examination: Hand sample is light brown.

Results of XRD: Both bulk sample and <2 um separate are pure montmorillonite.

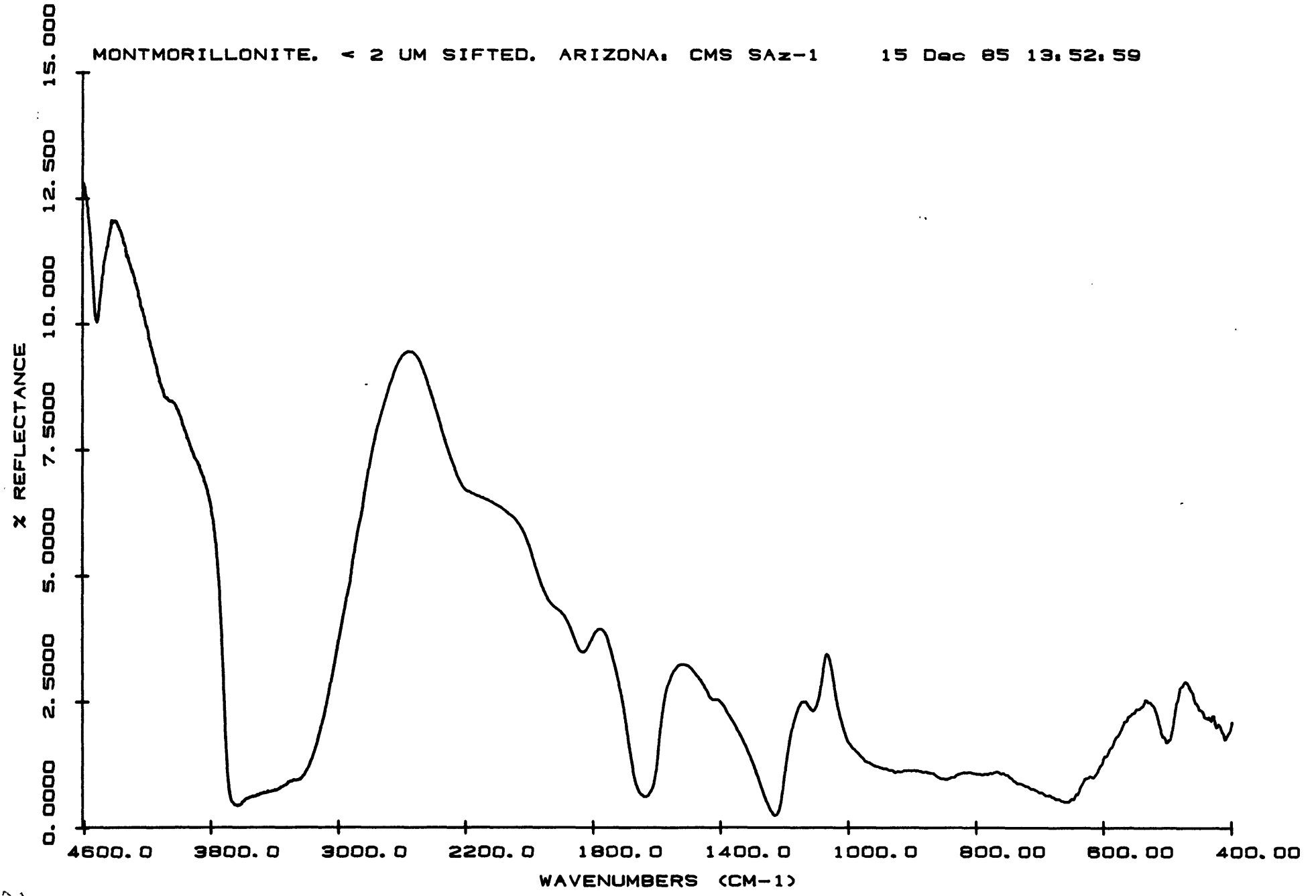
Results of XRF or other compositional analysis: None.

Spectra on file:
Montmor.3 Reflectance spectrum of packed sample on solid sample disk #1
Montmor.3 Reflectance spectrum of < 2 um sifted sample on 0-74 disk #1.
Montmor.3 Transmittance spectrum on disk #1.


MONTMORILLONITE IN KBR. ARIZONA: CMS SAZ-1 12 Nov 85 16:16:41
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


MONTMORILLONITE. PACKED SURFACE. ARIZONA . (CMS) SAZ-1 2 Jul 85 11:46:20
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

023


MONTMORILLONITE. < 2 UM SIFTED. ARIZONA: CMS SAz-1 15 Dec 85 13:52:59
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Muscovite $KAl_2(Si_3Al)O_{10}(OH,F)_2$

Locality: Methuen Township, Ontario, Canada

Last donor: Bruce Hemingway

Intermediate donor:

Ultimate donor: Prof. C.S. Hurlbut, Jr., Harvard Un.

Catalog numbers, etc.: None

Results of petrographic examination: Clear, tranparent pieces of muscovite which appear pure in hand sample. Microscope examination showed possible trace (<1%) of quartz present.

Results of XRD: Pure muscovite. Coarse fraction separated from fine fraction after light grinding by elutriation with acetone. This produced disorder in the fine fraction, which was avoided by edge-on filing to obtain fine fraction.

Results of XRF or other compositional analysis: See Robie, R.A. and Hemingway, B.S., 1976, Jour, Res. U.S. Geol. Survey, vol. 4, no. 6, p. 631-644. Part of same sample yields

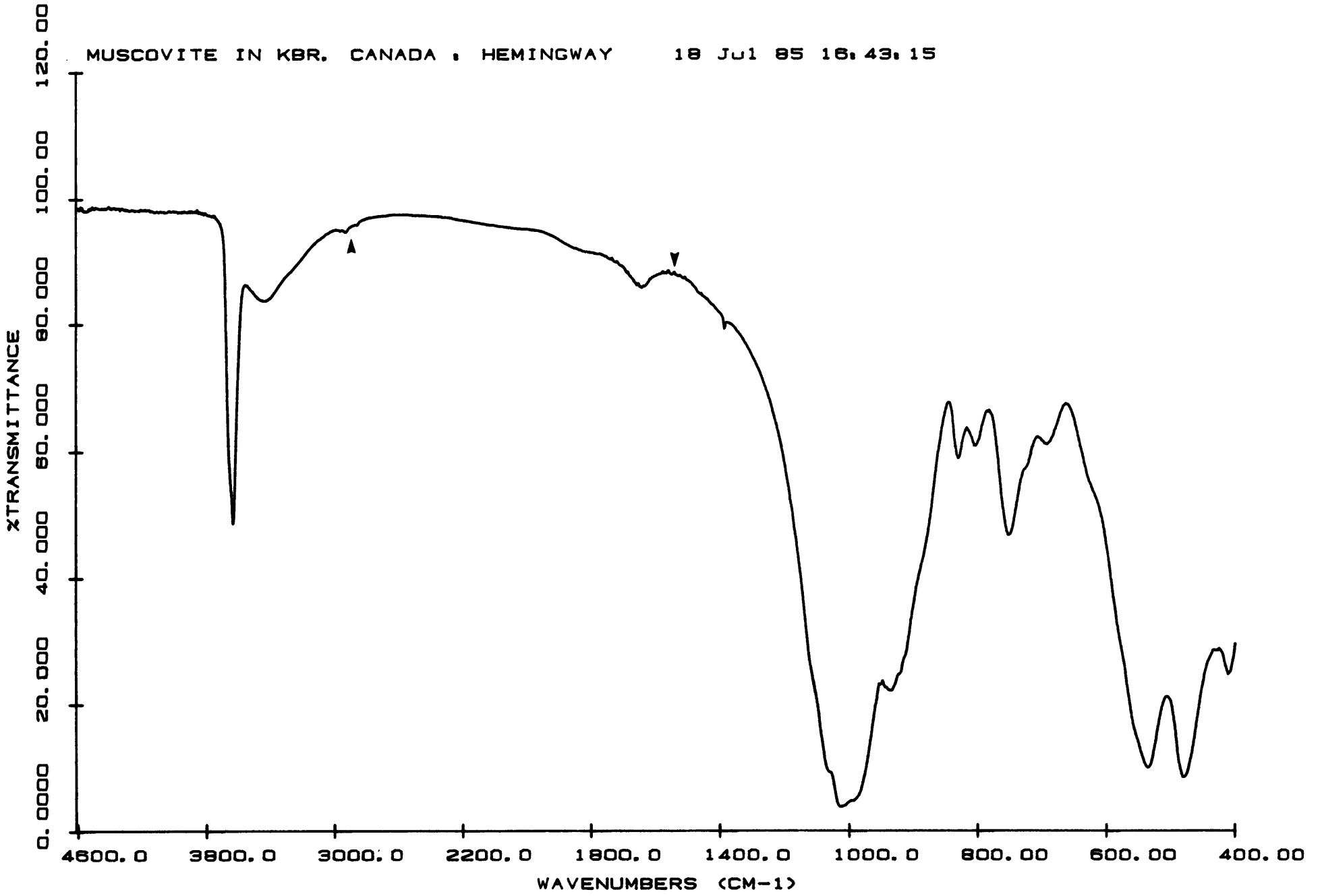
SiO_2	- 46.29
Al_2O_3	- 35.82
Fe_2O_3	-
FeO	- 2.27
MgO	- .65
CaO	-
Na_2O	- .45
K_2O	- 10.25
H_2O^+	-
H_2O^-	- 4.27

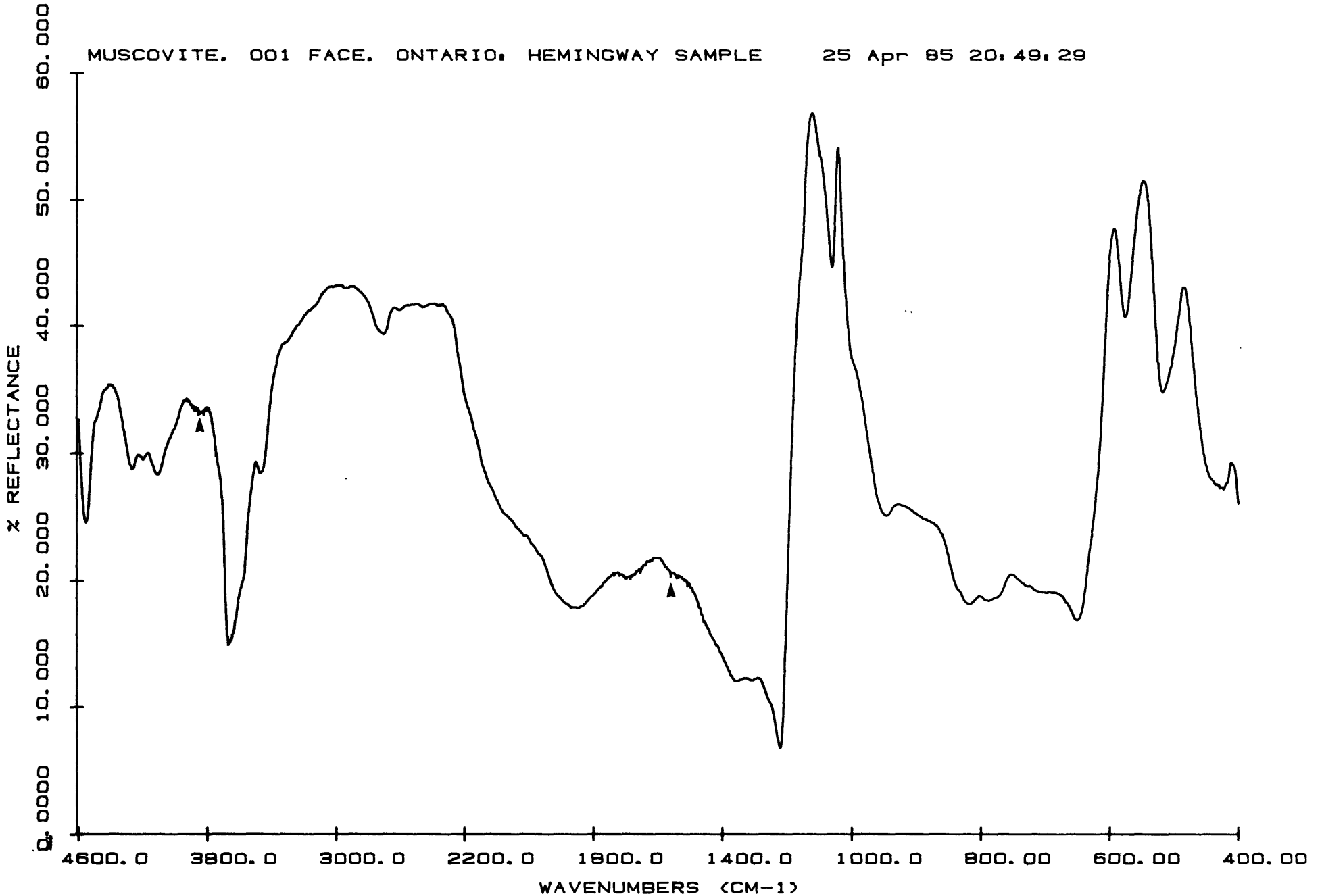
Microprobe analysis by L. Walter was only of a single grain from our sample due to difficulties in sample preparation. Analysis showed:

SiO_2	- 44.80
Al_2O_3	- 37.30
FeO	- 2.37
MgO	- 0.49
CaO	- 0.00
K_2O	- 10.31
Na_2O	- 0.45
TiO_2	- 0.19
MnO	- 0.11
Total	- 96.02

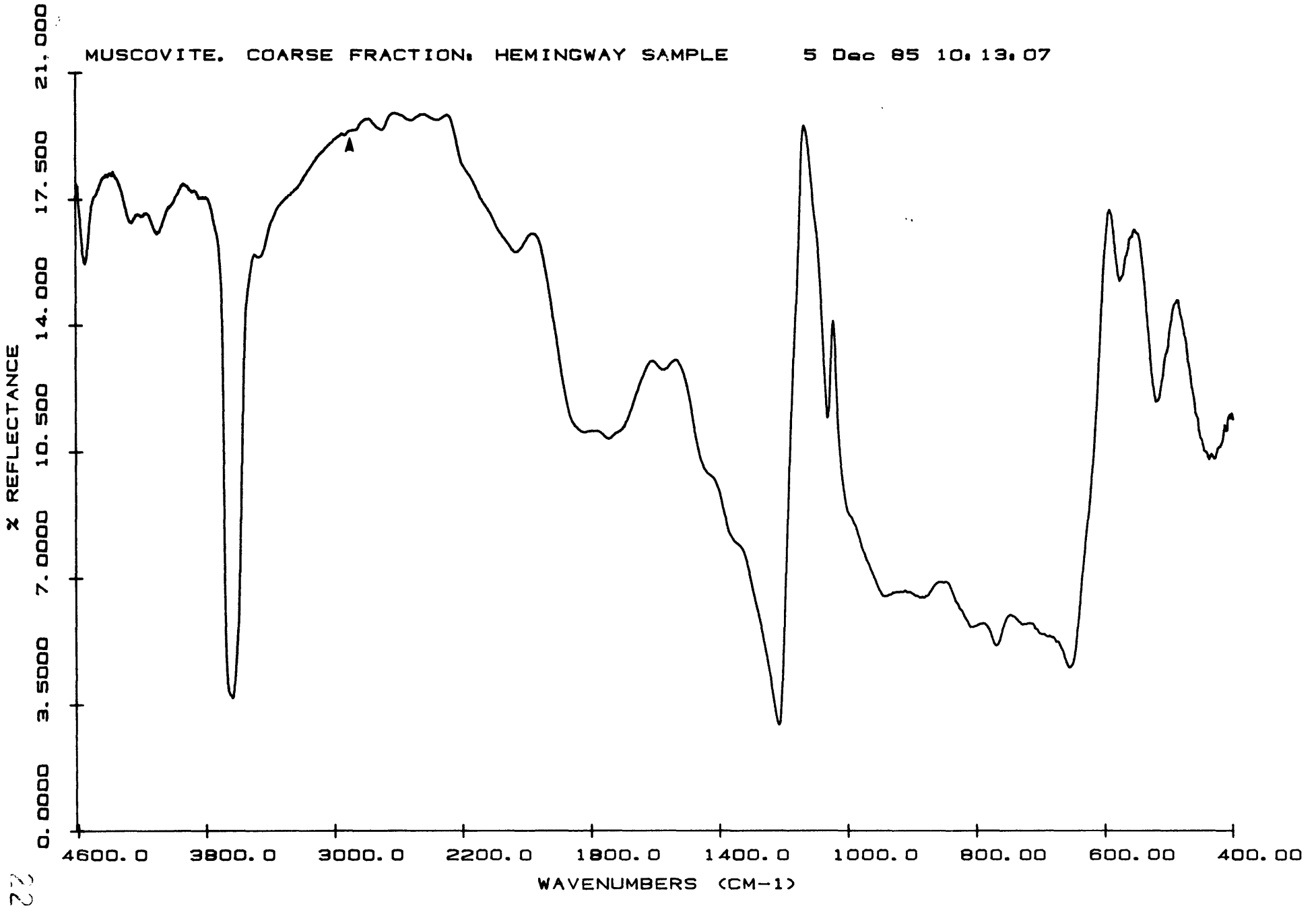
Spectra on file:

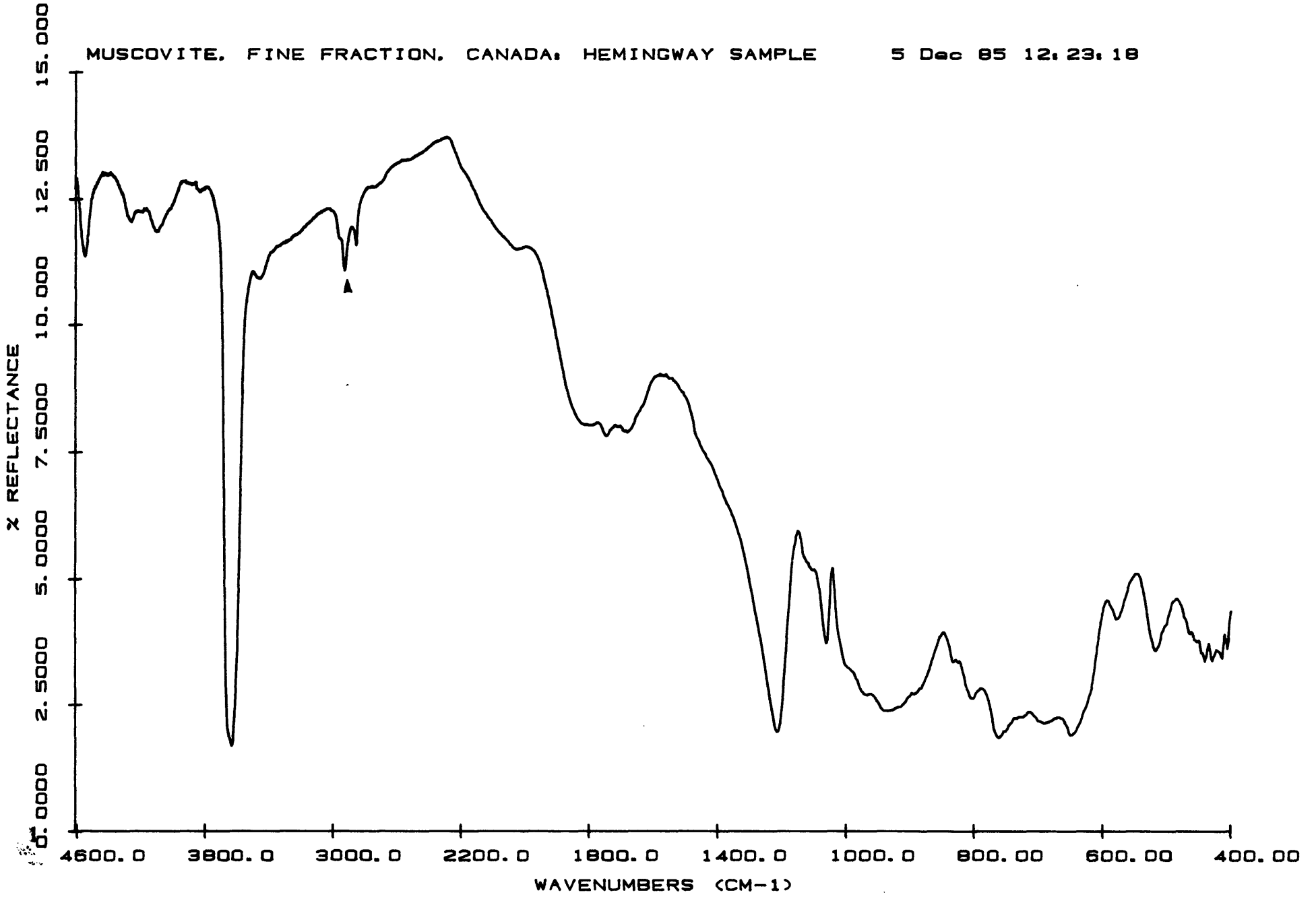
Muscovite.1	Reflection spectrum of 001 cleavage face on solid sample disk #1.
Muscovite.1	Reflectance spectrum of fine fraction on 0-74 um disk #1.
Muscovite.1	Reflectance spectrum of coarse fraction on 74-250 um disk #1.
Muscovite.1	Transmittance spectrum on disk #1.


MUSCOVITE IN KBR. CANADA : HEMINGWAY 18 Jul 85 16:43:15
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


MUSCOVITE. 001 FACE. ONTARIO: HEMINGWAY SAMPLE 25 Apr 85 20:49:29
% REFLECTANCE
60.000
50.000
40.000
30.000
20.000
10.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

224


MUSCOVITE. COARSE FRACTION: HEMINGWAY SAMPLE
5 Dec 85 10:13:07
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


MUSCOVITE. FINE FRACTION. CANADA. HEMINGWAY SAMPLE
5 Dec 85 12:23:18
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Nontronite $Na_{0.33}\ Fe_2^{+3}\ (Si,\ Al)_4\ O_{10}\ .\ 3H_2O$

Locality: Holen Hagen, Germany

Last donor: Hunt and Salisbury collection

Intermediate donor:

Ultimate donor: Clay Mineral Society Source Clay Mineral Repository.

Catalog numbers, etc.: CMS Ng-1

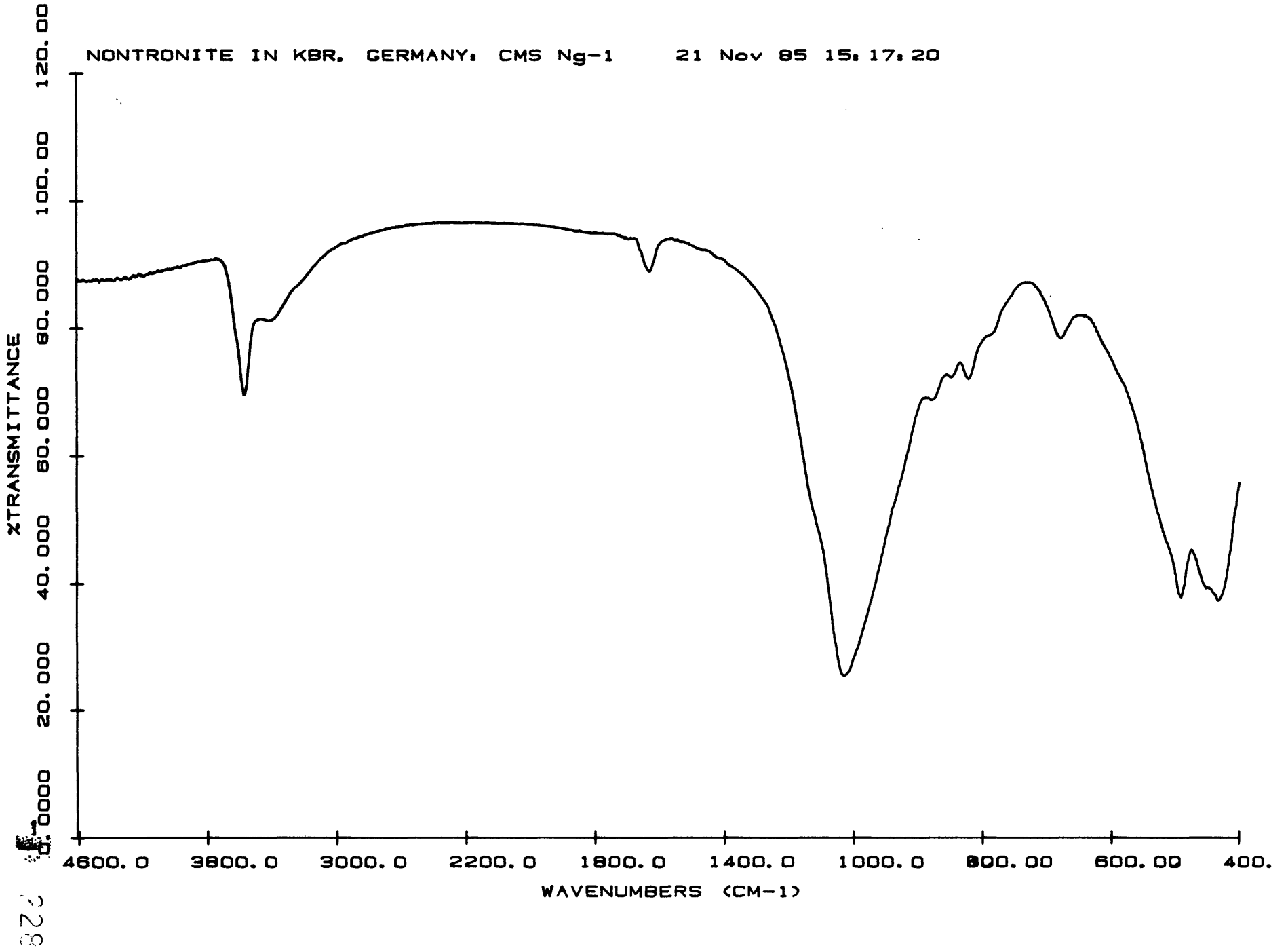
Results of petrographic examination: Brown color.

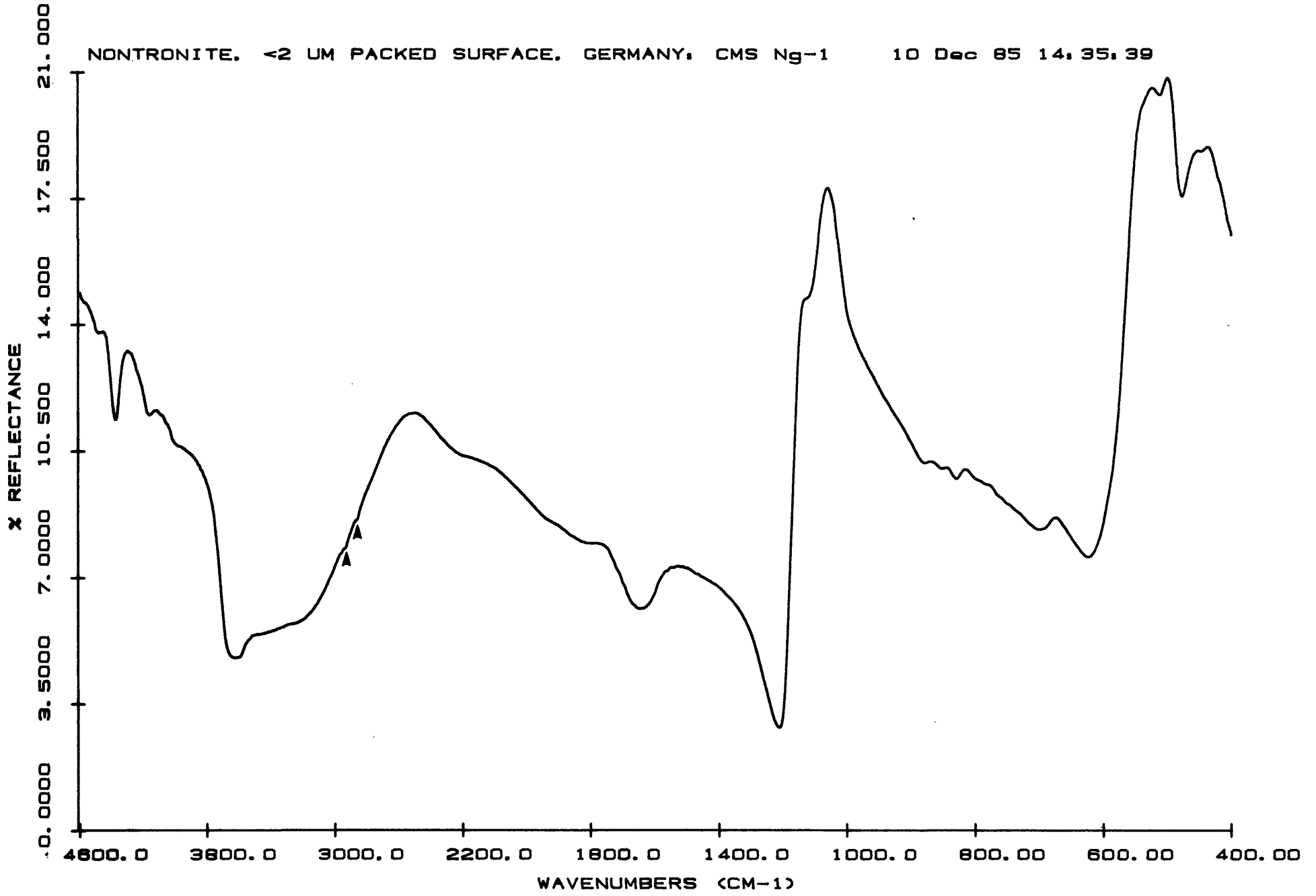
Results of XRD: Less than 2 um fraction is nontronite, plus a faint trace of quartz. Larger size fraction has abundant quartz. (Note: Quartz features do not show up in spectra of <2 um size fraction).

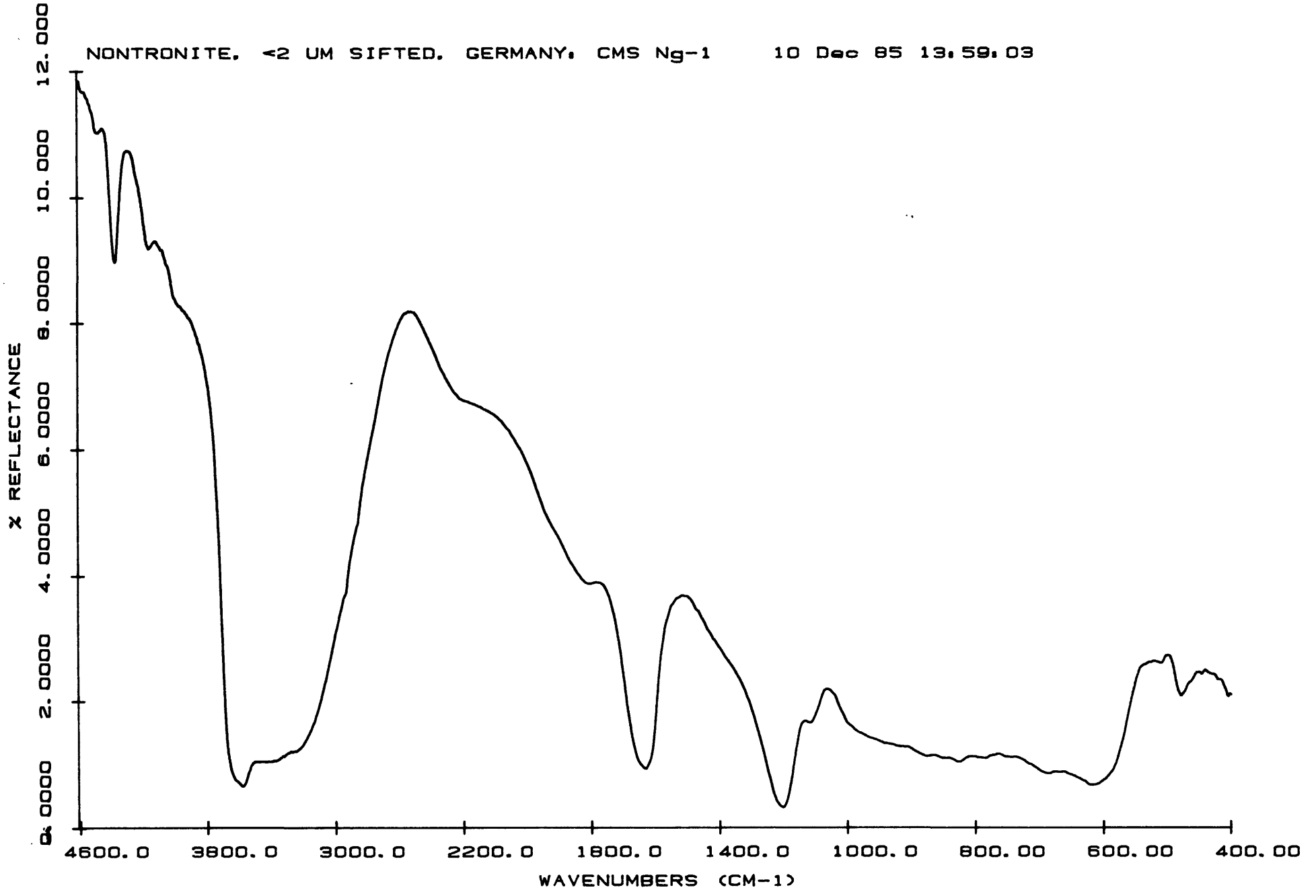
Results of XRF or other compositional analysis: None

Spectra of file:

Nontronite.1	Transmittance on disk #1.
Nontronite.1	Reflectance of <2 um size fraction sifted on 0-74 um disk #1.
Nontronite.1	Reflectance of <2 um size fraction packed on solid sample disk #1.


NONTRONITE IN KBR. GERMANY: CMS Ng-1 21 Nov 85 15:17:20
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.
WAVENUMBERS (CM-1)


NONTRONITE. <2 UM PACKED SURFACE. GERMANY: CMS Ng-1 10 Dec 85 14:35:39
% REFLECTANCE
21.000
17.500
14.000
10.500
7.0000
3.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


NONTRONITE. <2 UM SIFTED. GERMANY: CMS Ng-1 10 Dec 85 13:59:03
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Olivine (FO11)

Locality: Kiglapait intrusion, Labrador

Last donor: Trude King

Intermediate donor:

Ultimate donor: S.A. Morse, Un. of Mass., Amherst, Mass.

Catalog numbers, etc.: Trude King KI3005

Results of petrographic examination: Initial specimens contaminated with pyroxene, spinel (?) and ilmenite. Heavy liquid separation, followed by magnetic separation and hand picking, allowed olivines of different iron content to be obtained. Sample ground to <30 um and wet sieved with methanol. Sample preparation by Trude King, USGS, Denver.

Results of XRD: None

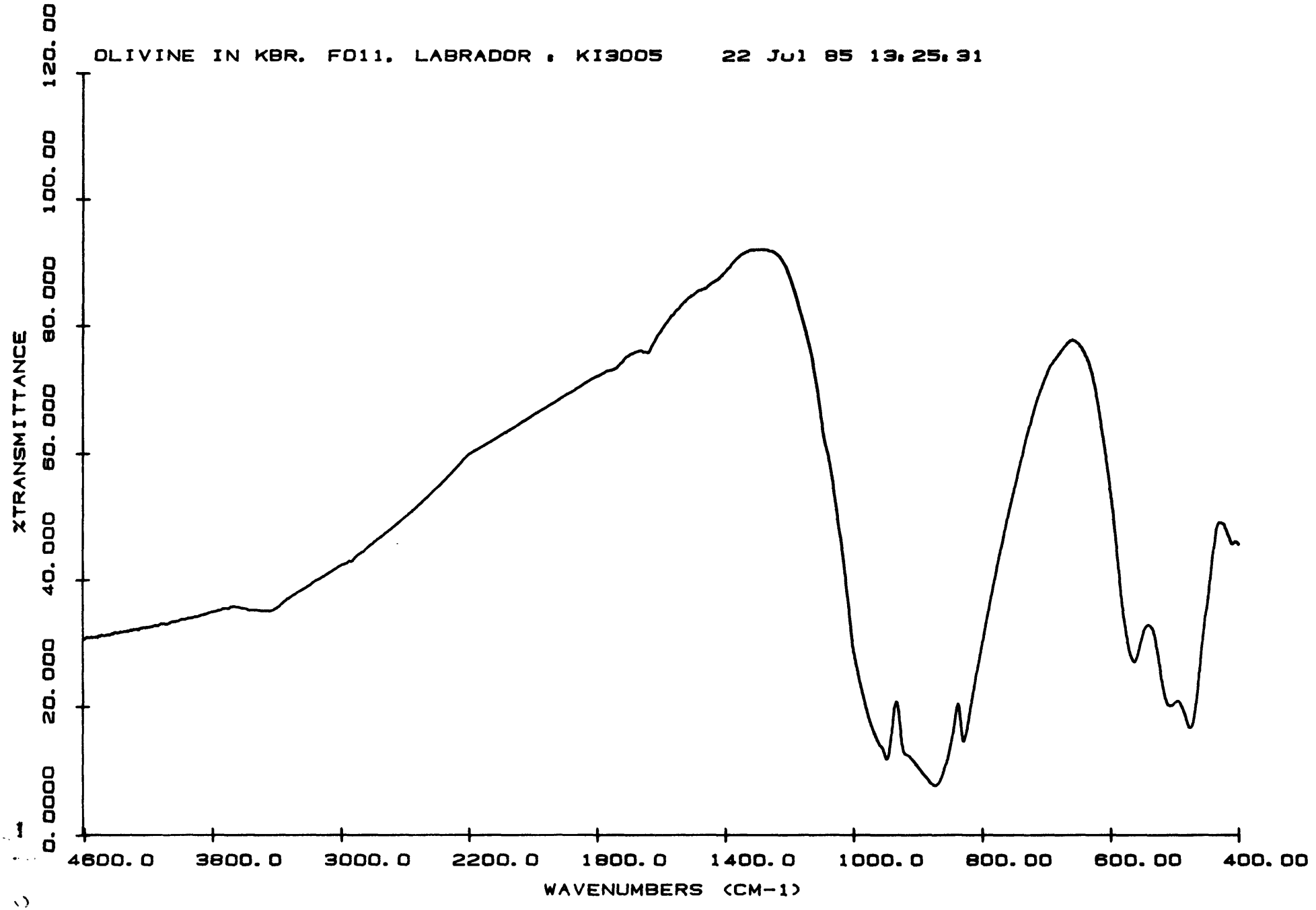
Results of XRF or other compositional analysis:

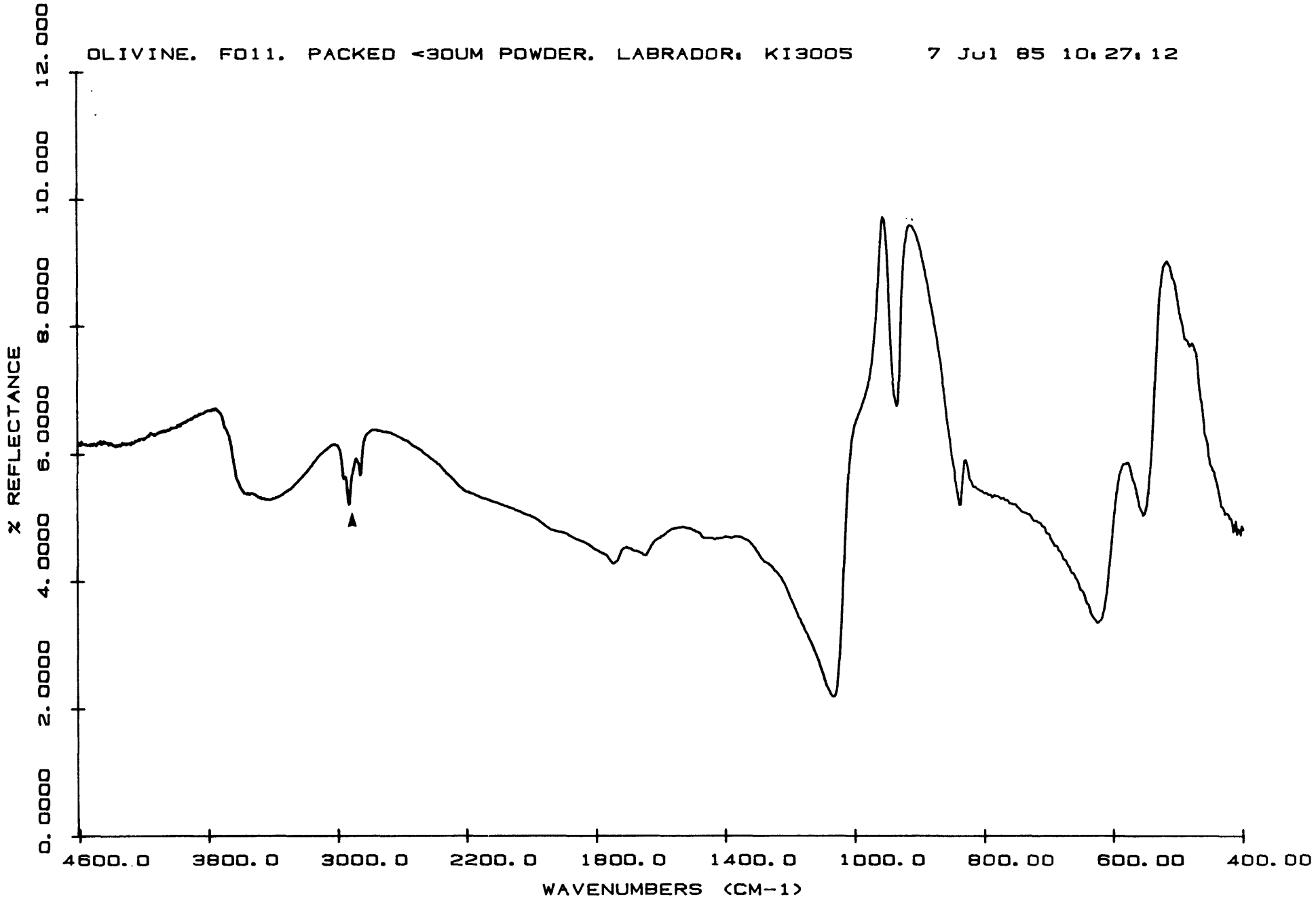
Microprobe analysis by W.I. Ridley, USGS:

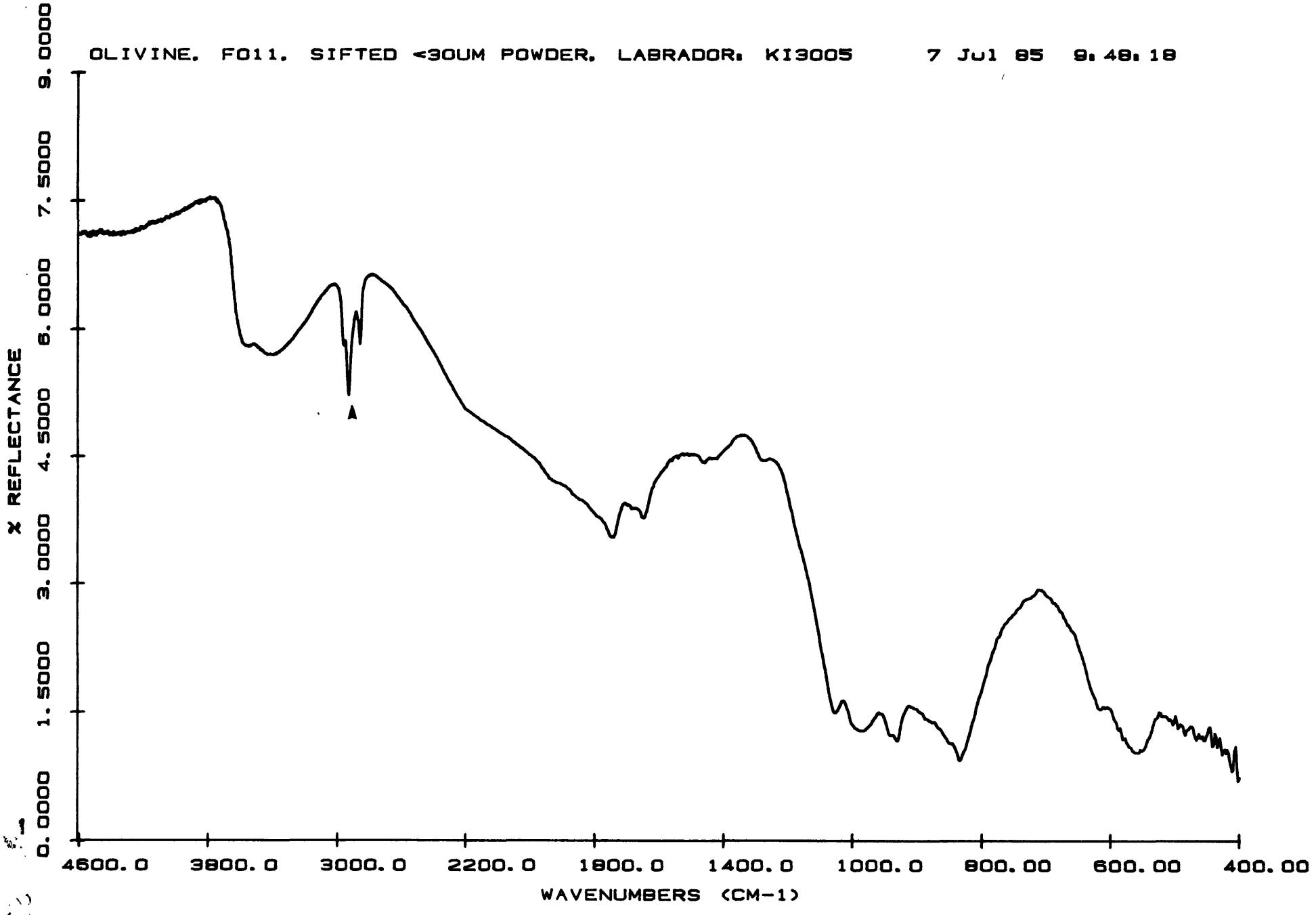
SiO_2	-	30.11
TiO_2	-	0.07
Al_2O_3	-	0.00
Cr_2O_3	-	0.06
MnO	-	1.55
NiO	-	0.12
FeO	-	62.82
MgO	-	4.42
CaO	-	0.14
		99.29

Spectra on file:

Olivine.1 Reflectance spectrum of sifted sample on 0-74 Disk #1
Olivine.1 Reflectance spectrum of packed sample on Solid Sample Disk #1.
Olivine.1 Transmittance spectrum on Disk #1.


OLIVINE IN KBR. FO11. LABRADOR : KI3005 22 Jul 85 13:25:31
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. FO11. PACKED <30UM POWDER. LABRADOR: KI3005 7 Jul 85 10:27:12
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. FO11. SIFTED <30UM POWDER. LABRADOR. KI3005 7 Jul 85 9:48:18
% REFLECTANCE
9.0000
7.5000
6.0000
4.5000
3.0000
1.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Olivine (FO18)

Locality: Kiglapait intrusion, Labrador

Last donor: Trude King

Intermediate donor:

Ultimate donor: S.A. Morse, Un. of Mass., Amherst, Mass.

Catalog numbers, etc.: Trude King KI3377

Results of petrographic examination: Initial specimens contaminated with pyroxene, spinel (?) and ilmenite. Heavy liquid separation, followed by magnetic separation and hand picking, allowed olivines of different iron content to be obtained. Sample ground to <60 um and wet sieved. Sample preparation by Trude King, USGS, Denver.

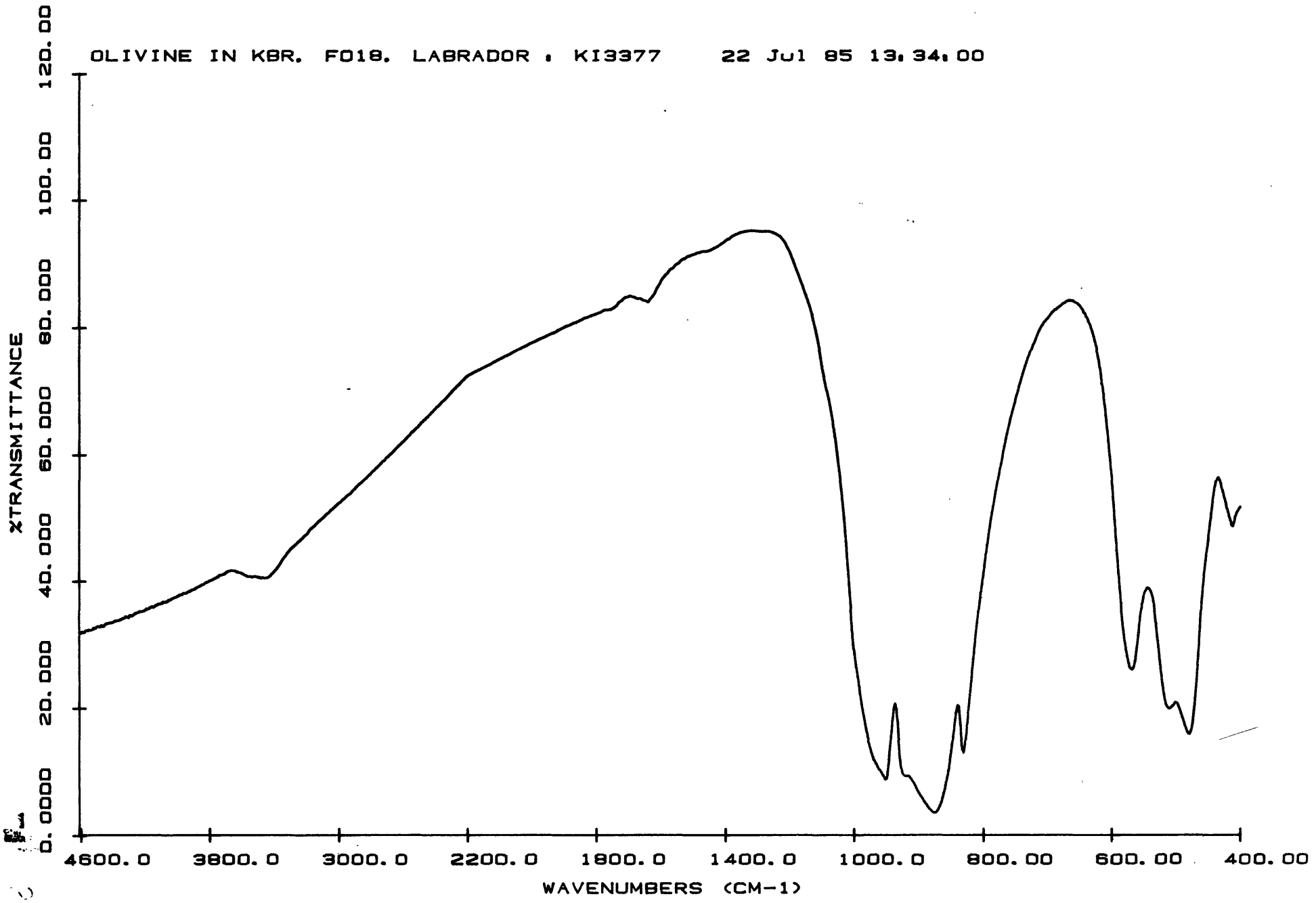
Results of XRD: None

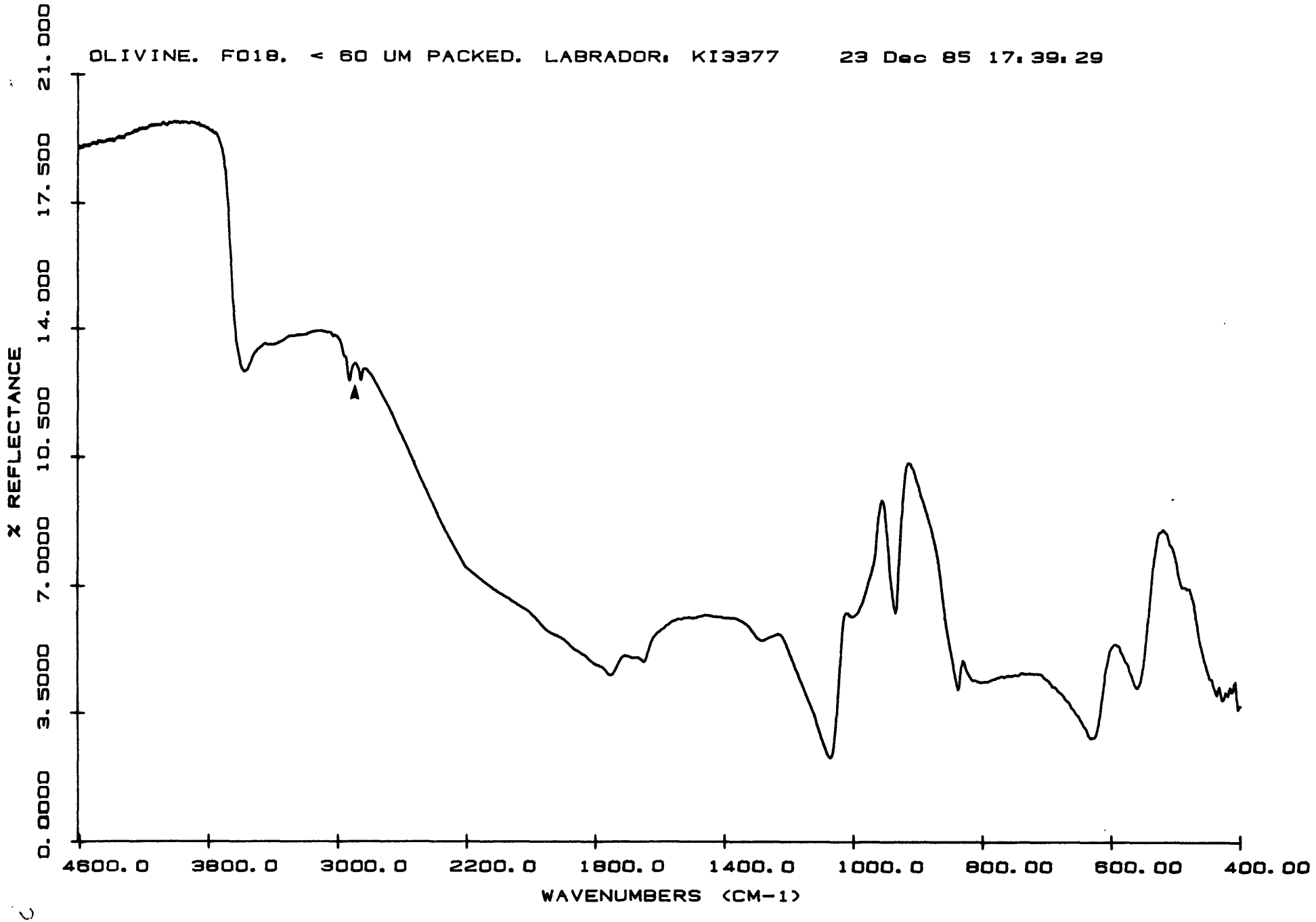
Results of XRF or other compositional analysis:

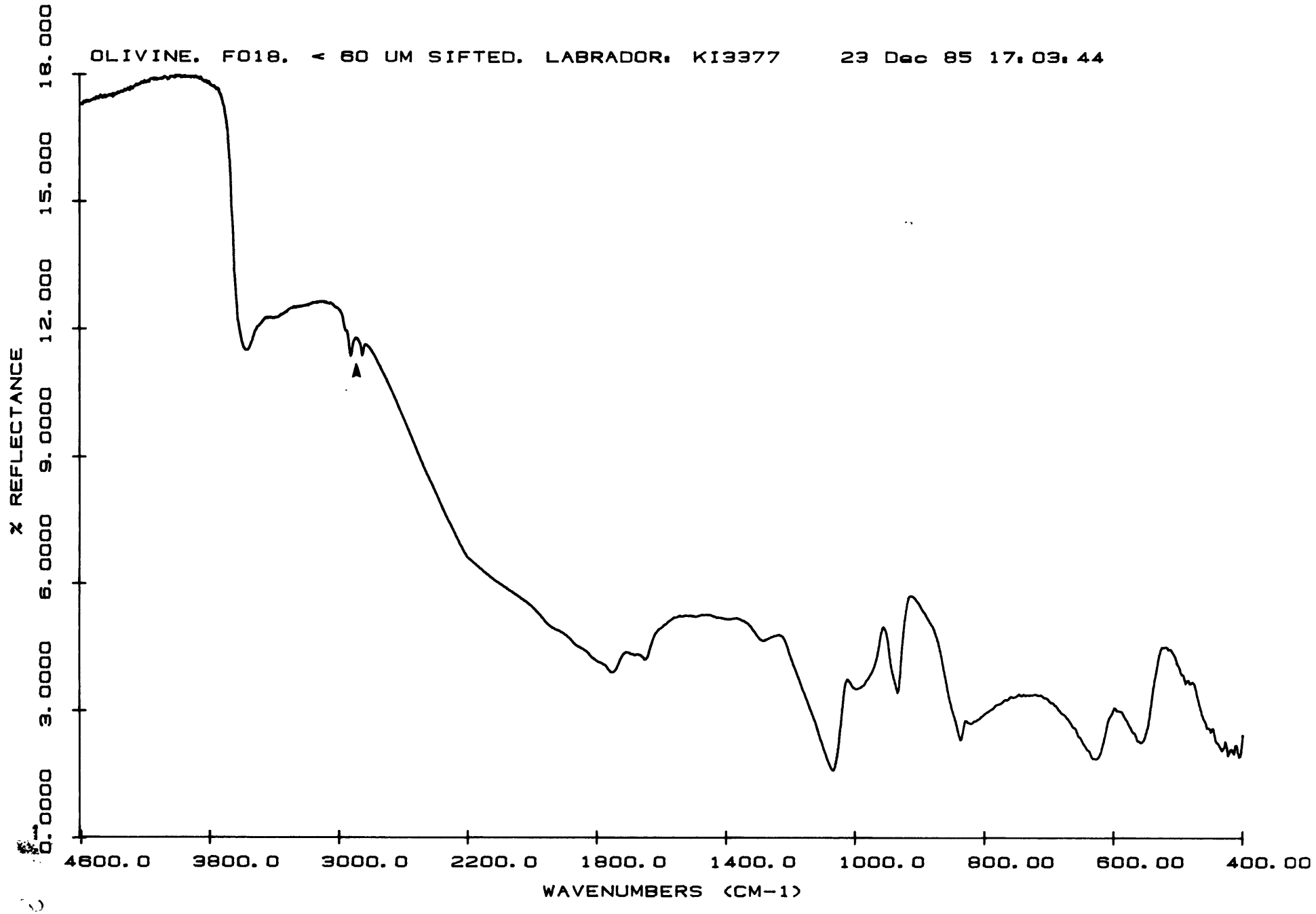
Microprobe analysis by W.I. Ridley, USGS:

SiO_2	- 31.11
TiO_2	- 0.06
Al_2O_3	- 0.00
Cr_2O_3	- 0.07
MnO	- 1.30
NiO	- 0.12
FeO	- 59.75
MgO	- 7.71
CaO	- 0.09
	100.21

Spectra on file:
Olivine.2 Diffuse reflectance of sifted sample on 0-74 um Disk #1.
Olivine.2 Diffuse reflectance of packed surface on solid sample Disk #1.
Olivine.2 Transmittance spectrum on Disk #1.


OLIVINE IN KBR. FO18. LABRADOR . KI3377 22 Jul 85 13:34:00
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F018. < 60 UM PACKED. LABRADOR: KI3377 23 Dec 85 17:39:29
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F018. < 60 UM SIFTED. LABRADOR: KI3377 23 Dec 85 17:03:44
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Olivine (FO29)

Locality: Kiglapait Intrusion, Labrador

Last donor: Trude King

Intermediate donor:

Ultimate donor: S.A. Morse, Un. of Mass., Amherst, Ma.

Catalog numbers, etc.: Trude King KI 3291

Results of petrographic examination: Initial specimens were contaminated with pyroxene, spinel ? and ilmenite. Heavy liquid separation, followed by magnetic separation and hand picking, allowed olivines of different iron content to be obtained. Sample ground to <60 um and wet sieved. Sample preparation by Trude King, USGS, Denver.

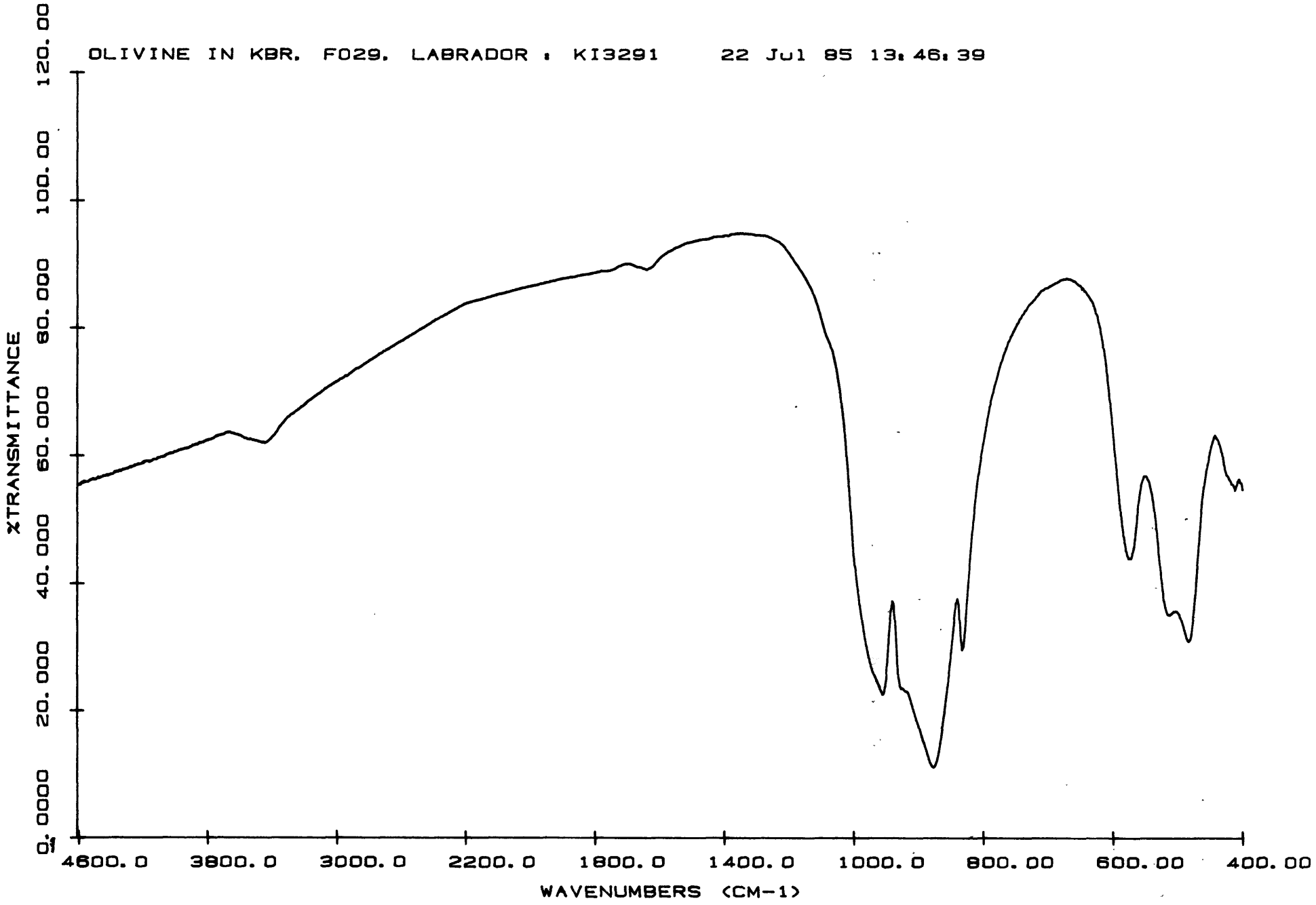
Results of XRD: None

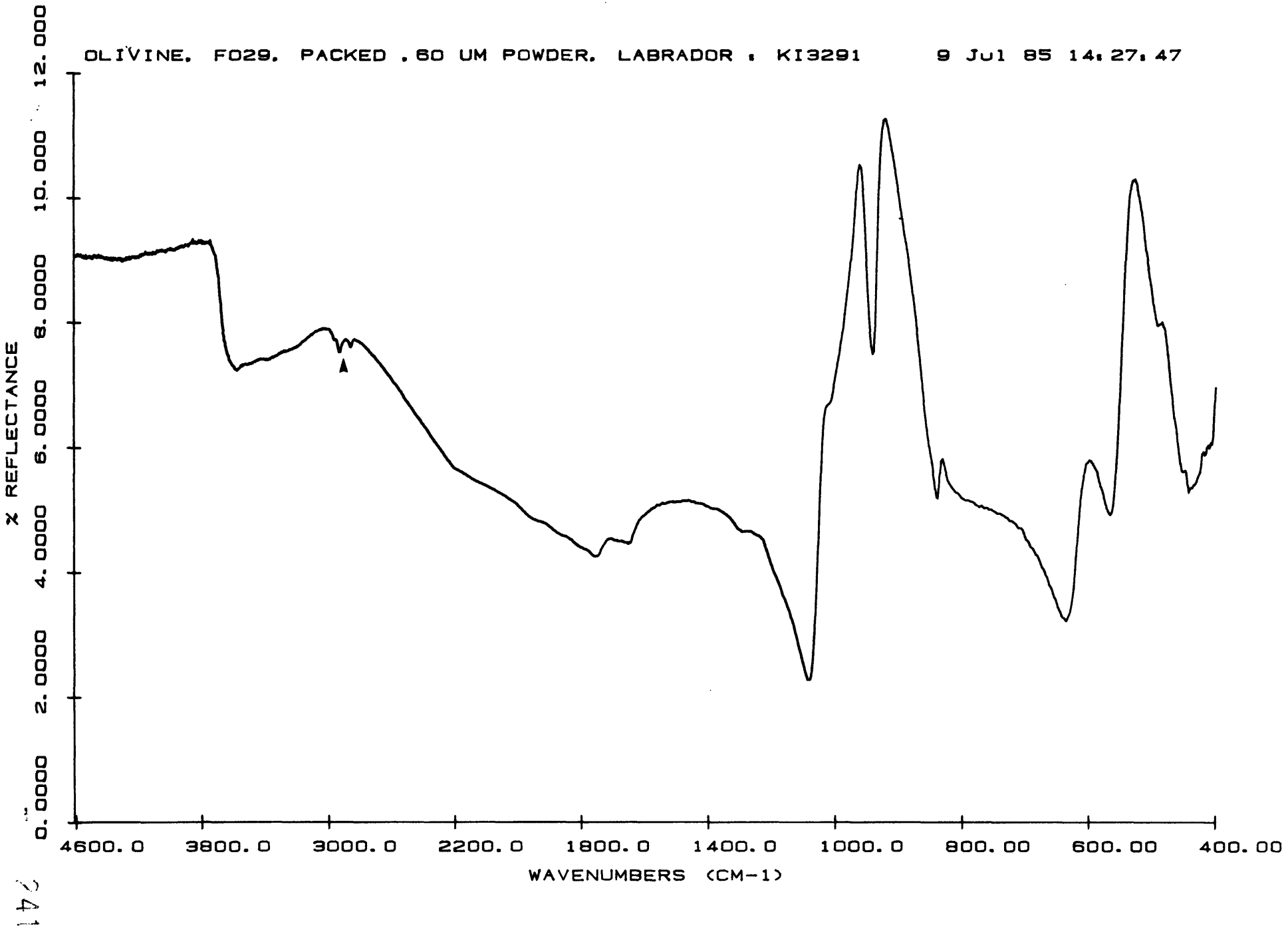
Results of XRF or other compositional analysis:

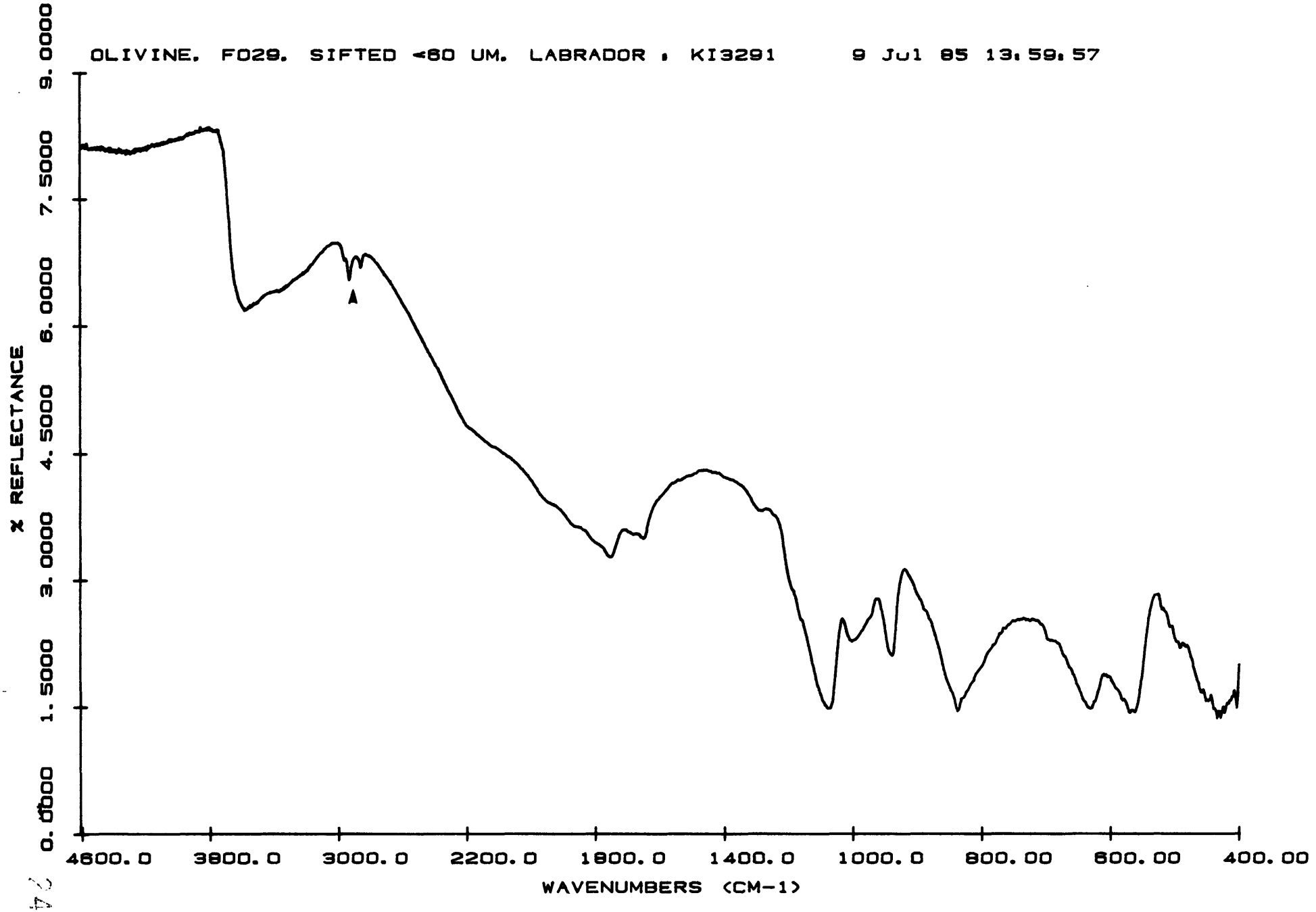
Microprobe analysis by W.I. Riley, USGS:

SiO_2	-	31.98
TiO_2	-	0.06
AlO_3	-	0.00
Cr_2O_3	-	0.05
MnO	-	1.23
NiO	-	0.11
FeO	-	53.65
MgO	-	12.61
CaO	-	0.35
		100.04

Spectra on file:
Olivine.3 Diffuse reflectance of sifted sample on 0-74 um disk #1.
Olivine.3 Diffuse reflectance of packed sample on solid sample disk #1.
Transmittance spectrum on disk #1.


OLIVINE IN KBR. F029. LABRADOR : KI3291 22 Jul 85 13:46:39
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F029. PACKED .60 UM POWDER. LABRADOR : KI3291 9 Jul 85 14:27:47
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F029. SIFTED <60 UM. LABRADOR : KI3291 9 Jul 85 13:59:57
% REFLECTANCE
9.0000
7.5000
6.0000
4.5000
3.0000
1.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Olivine (FO41)

Locality: Kiglapait Intrusion, Labrador

Last donor: Trude King

Intermediate donor:

Ultimate donor: S.A. Morse, Un. of Mass., Amherst, Ma.

Catalog numbers, etc.: Trude King KI4143

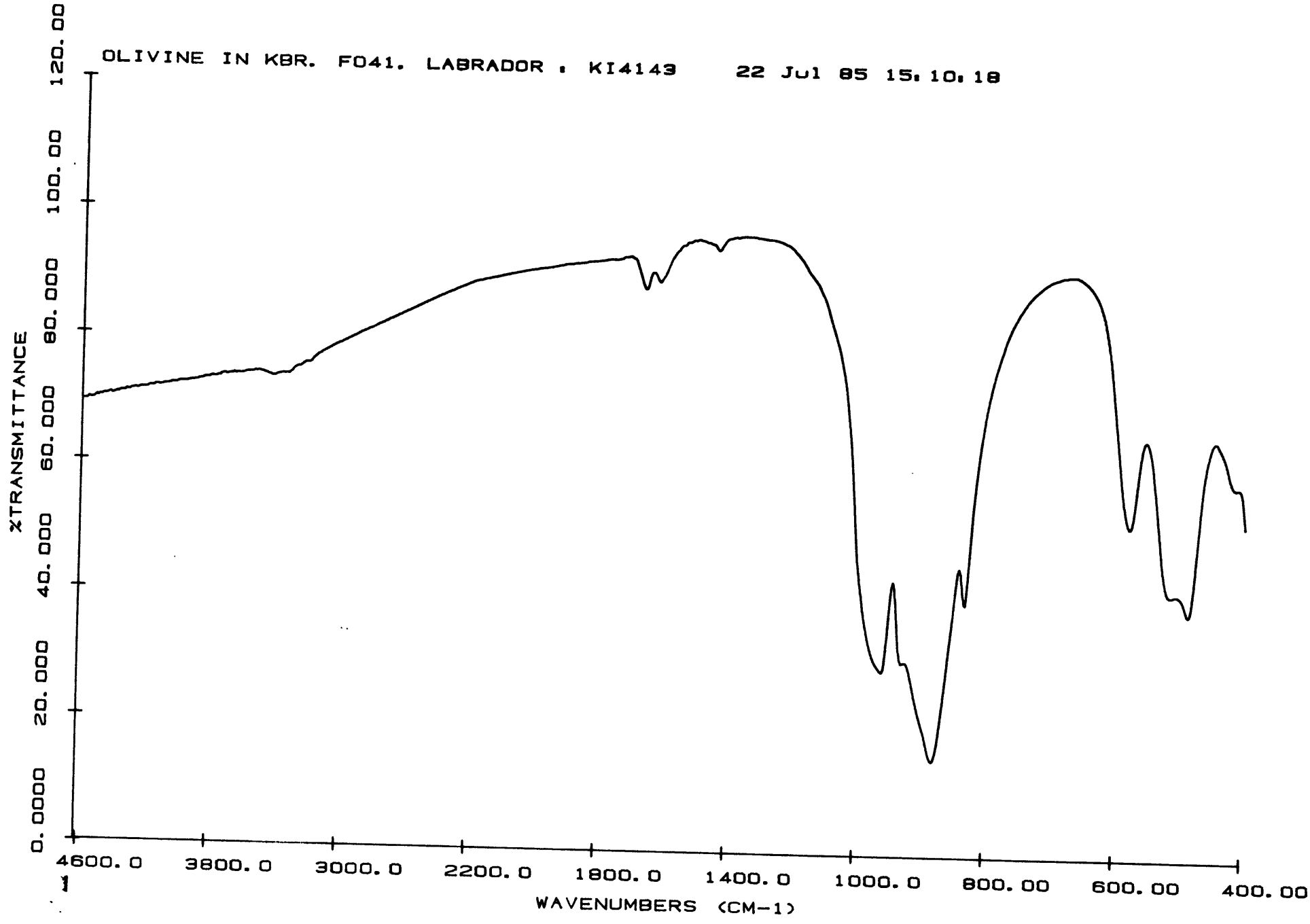
Results of petrographic examination: Initial specimens were contaminated with pyroxene, spinel (?) and ilmenite. Heavy liquid separation, followed by magnetic separation and hand picking, allowed olivines of different iron content to be isolated. Sample ground to <60 um and wet seived. Fine particles are missing from the sample, so average particle size is close to 60 um. Sample prep. by Trude King, USGS, Denver.

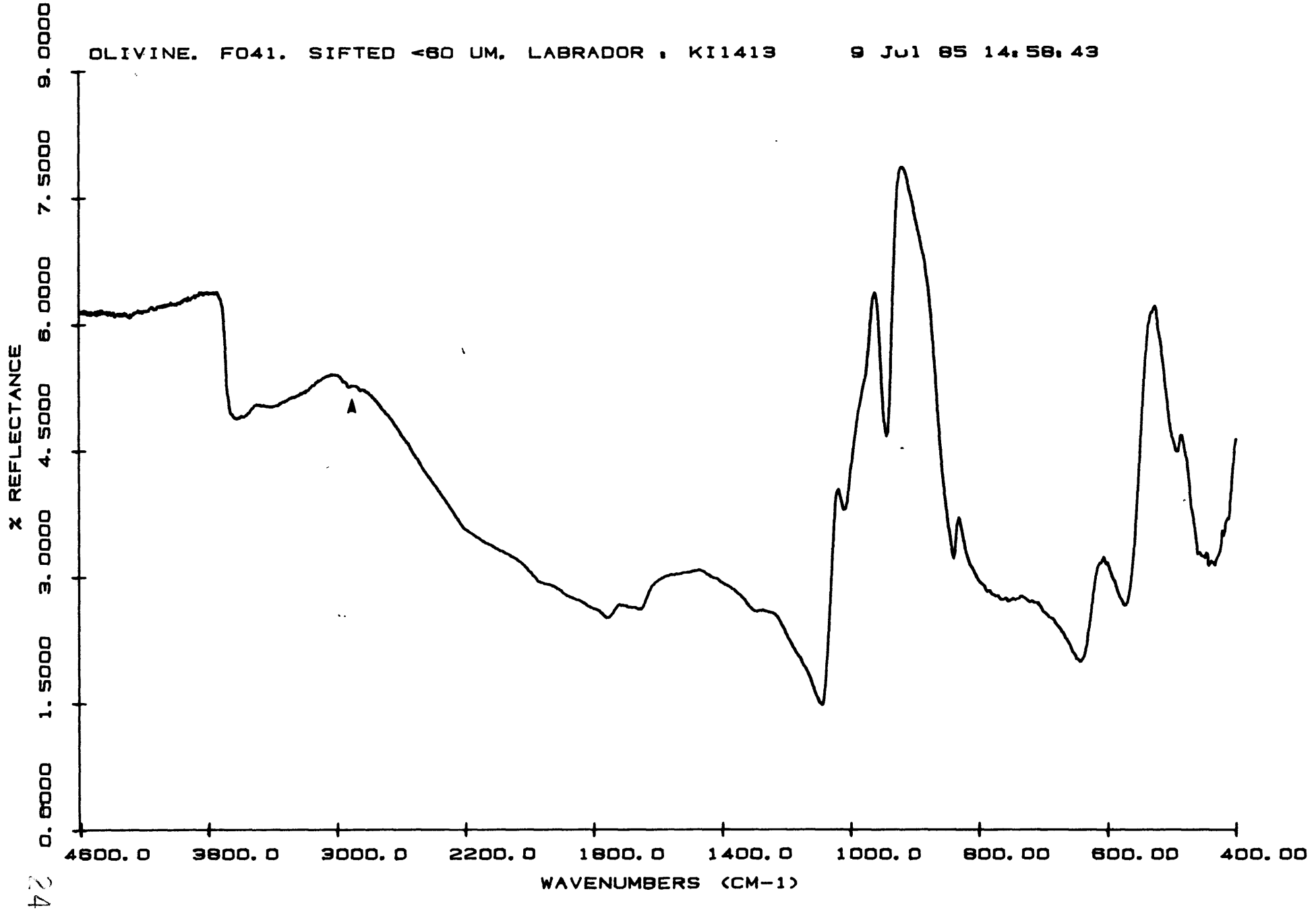
Results of XRD: None

Results of XRF or other compositional analysis:
Microprobe analysis by W.I. Ridley, USGS:

SiO_2	- 33.15
TiO_2	- 0.04
Al_2O_3	- 0.00
Cr_2O_3	- 0.04
MnO	- 0.90
NiO	- 0.10
FeO	- 47.65
MgO	- 18.43
CaO	- 0.20
	100.51

Spectra on file:
Olivine.4 Diffuse reflectance of sifted sample on 0-74 um Disk #1
Not enough to pack
Olivine.4 Transmittance spectrum on disk #1


OLIVINE IN KBR. F041. LABRADOR : KI4143 22 Jul 85 15:10:18
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F041. SIFTED <60 UM. LABRADOR : KI1413 9 Jul 85 14:58:43
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

242

Species name: Olivine (FO51)

Locality: Kiglapait Intrusion, Labrador

Last donor: Trude King

Intermediate donor:

Ultimate donor: S.A. Morse, Univ. of Mass, Amherst, MA

Catalog numbers, etc.: Trude King KI3188

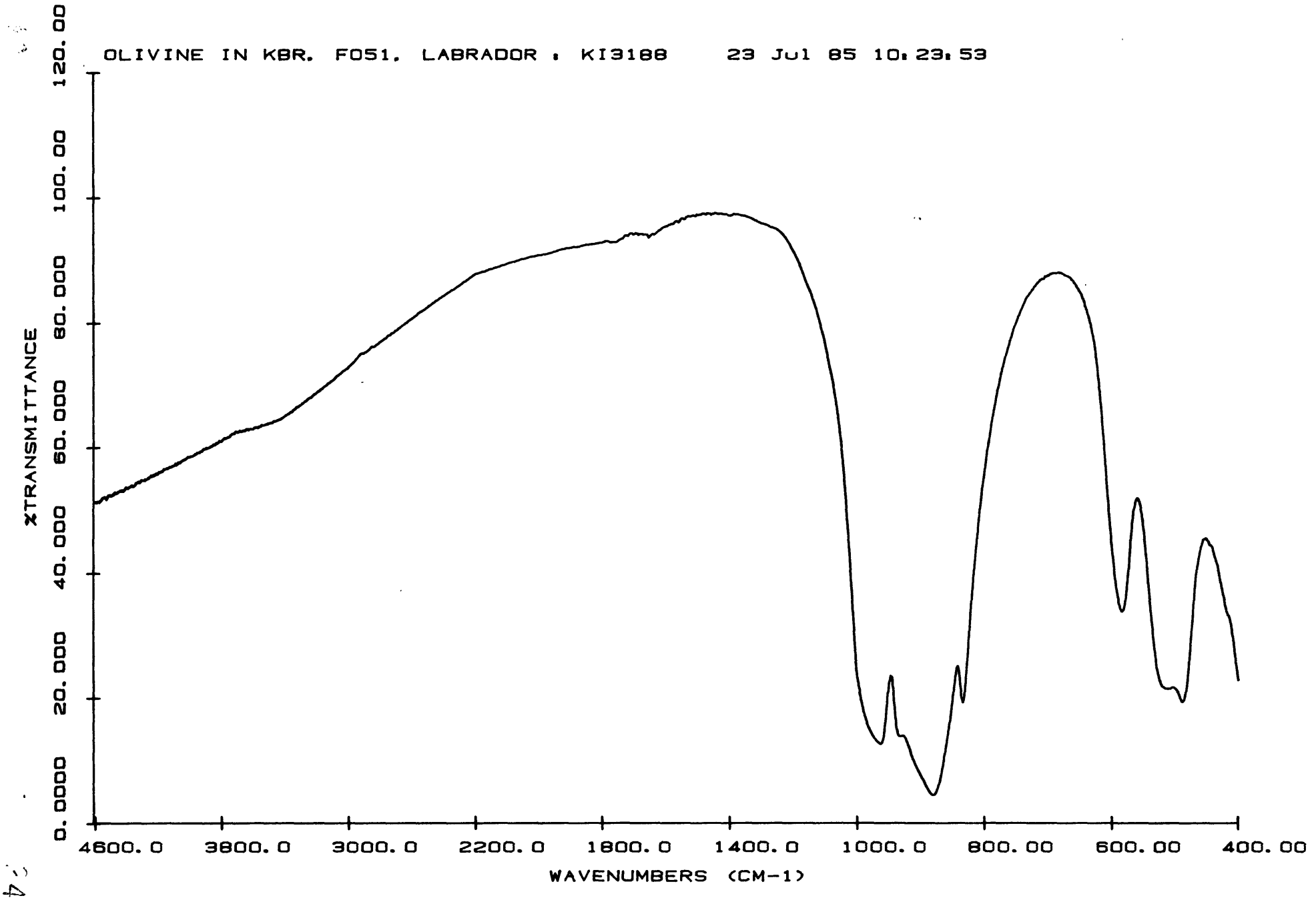
Results of petrographic examination: Initial specimens were contaminated with pyroxene, spinel (?) and ilmenite. Heavy liquid separtion, followed by magnetic separation and hand picking, allowed olivines of different iron content to be isolated sample ground to <60 um and wet seived. Sample prep. by Trude King USGS Denver.

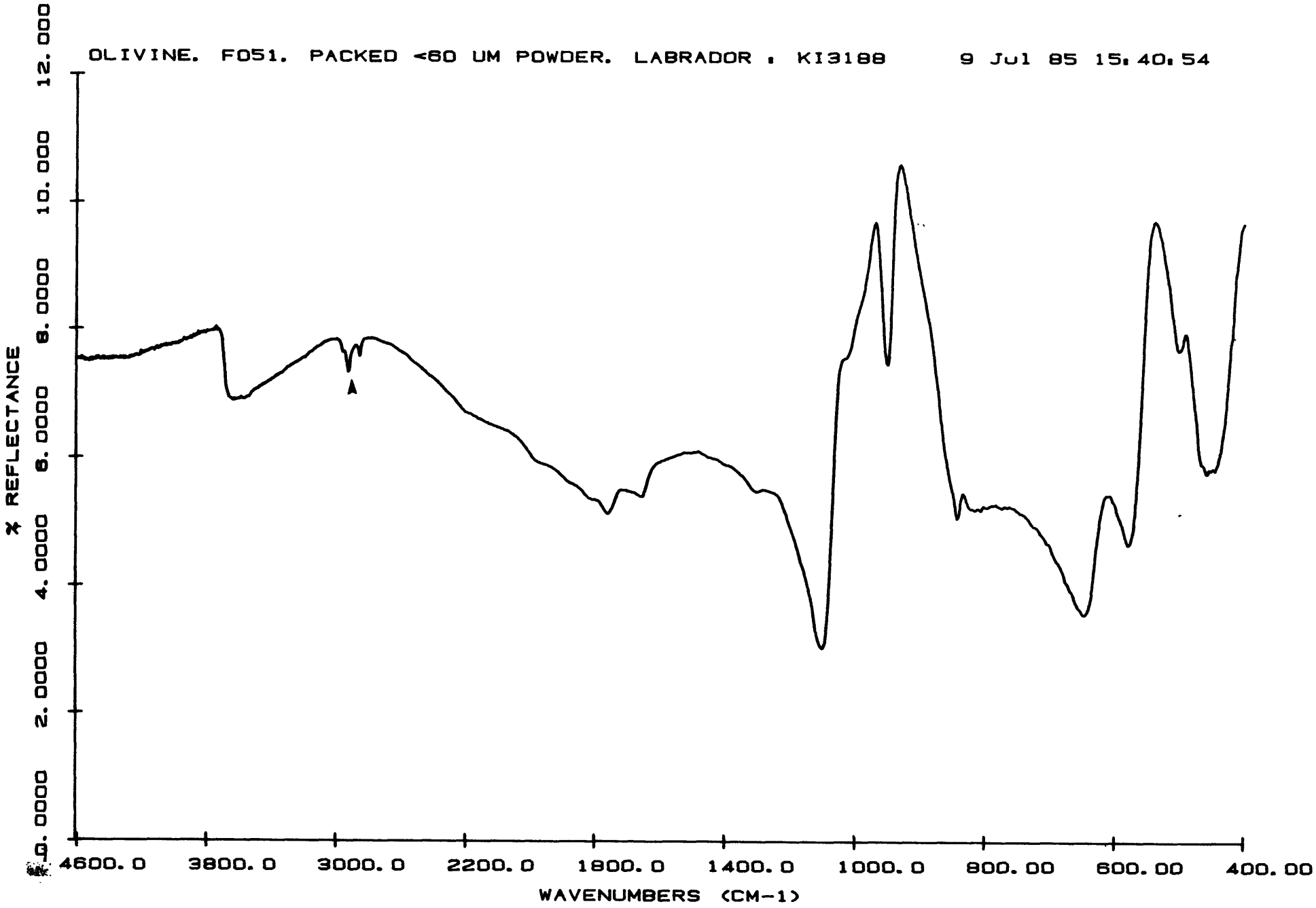
Results of XRD: None

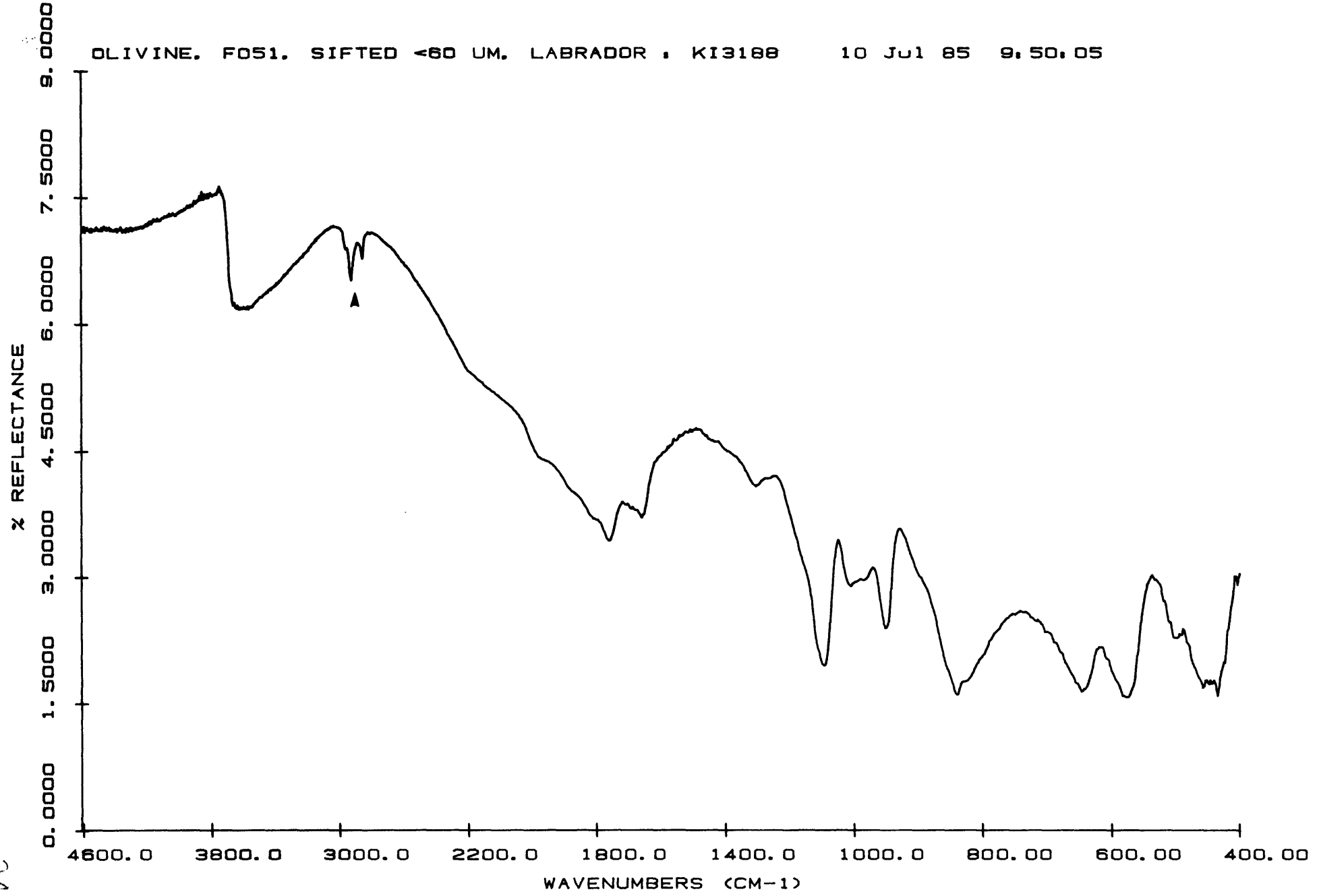
Results of XRF or other compositional analysis:
Microprobe analysis by W.I. Ridley, USGS:

SiO_2	- 34.34
TiO_2	- 0.04
Al_2O_3	- 0.00
Cr_2O_3	- 0.04
MnO	- 0.73
NiO	- 0.07
FeO	- 41.34
MgO	- 23.80
CaO	- 0.05
	103.41

Spectra on file:
Olivine.5 Diffuse reflectance of sifted sample on 0-74 um disk #1.
Olivine.5 Diffuse reflectance (SpectraTech attch) of packed sample on solid sample disk #1.
Olivine.5 Transmittance spectra on disk #1.


OLIVINE IN KBR. F051, LABRADOR : KI3188 23 Jul 85 10:23:53
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F051. PACKED <60 UM POWDER. LABRADOR : KI3188 9 Jul 85 15:40:54
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F051. SIFTED <60 UM. LABRADOR : KI3188 10 Jul 85 9:50:05
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Olivine (F060)

Locality: Kiglapait Intrusion, Labrador

Last donor: Trude King

Intermediate donor:

Ultimate donor: S.A. Morse, Univ. of Mass, Amherst, MA

Catalog numbers, etc.: Trude King KI3189

Results of petrographic examination: Initial specimens were contaminated with pyroxene, spinel (?), and ilmenite. Heavy liquid separation, followed by magnetic separation and hand picking, allowed olivines of different iron content to be isolated. Sample ground to <60 um and wet seived. Sample prep. by Trude King USGS Denver.

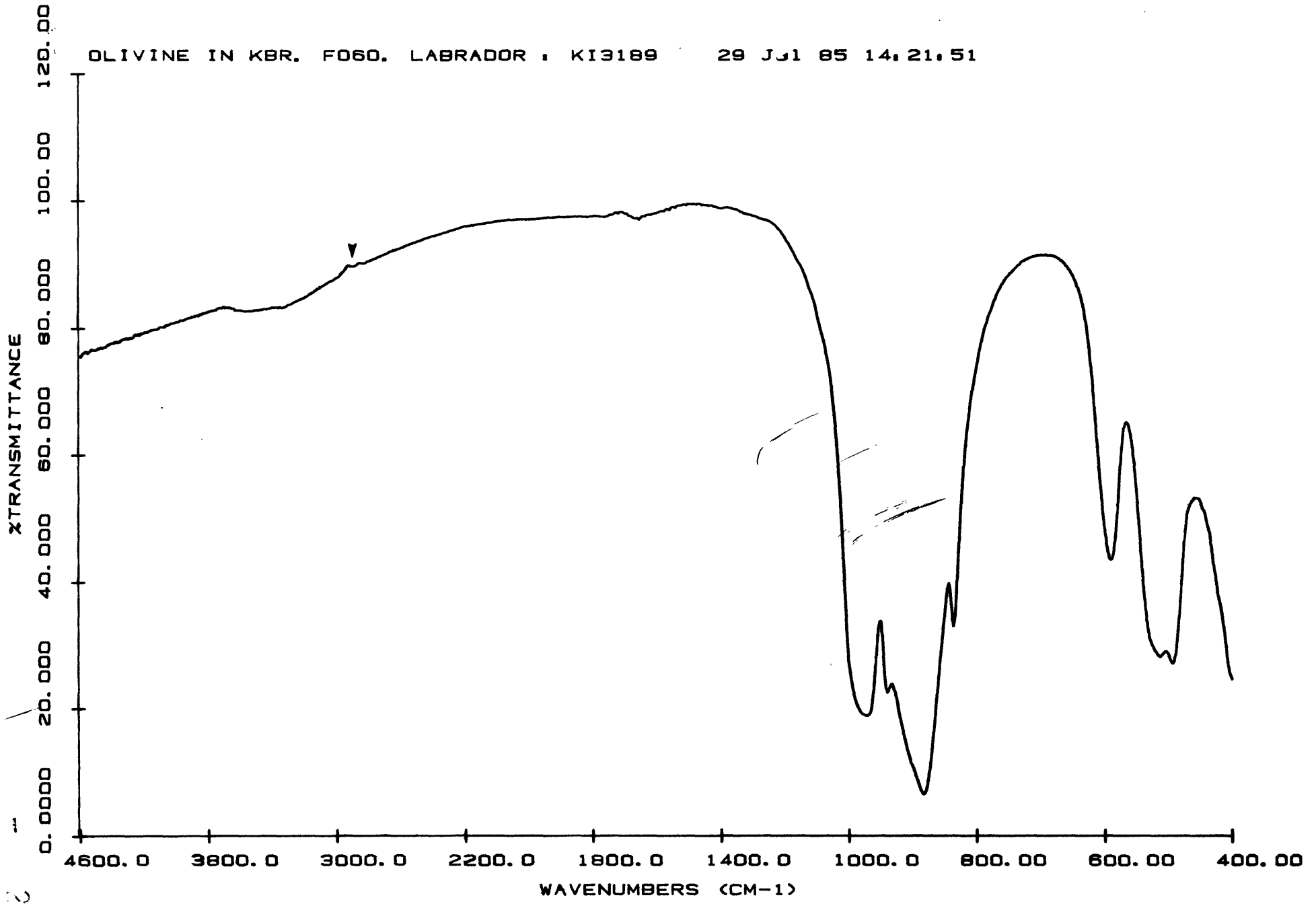
Results of XRD: None

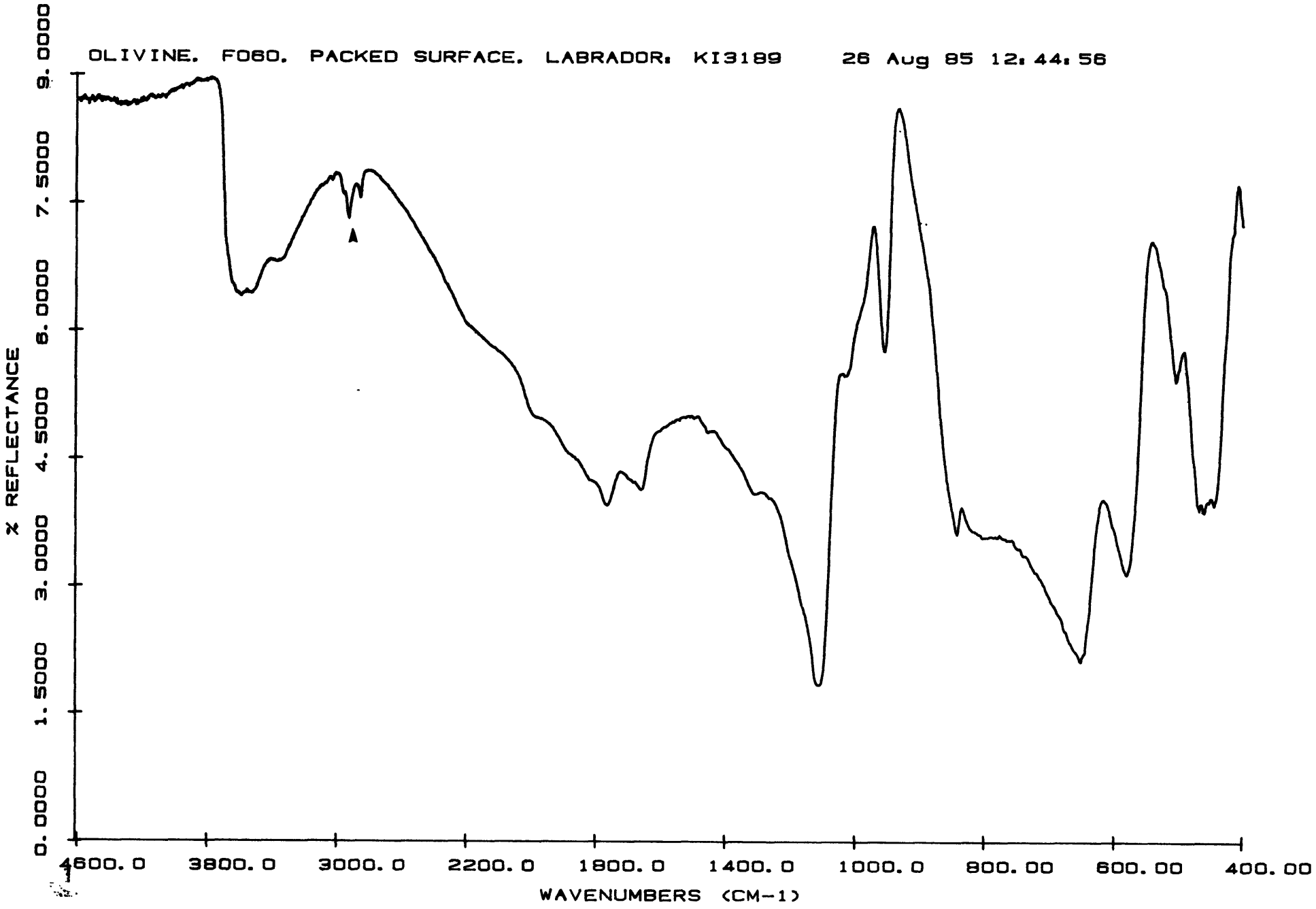
Results of XRF or other compositional analysis:

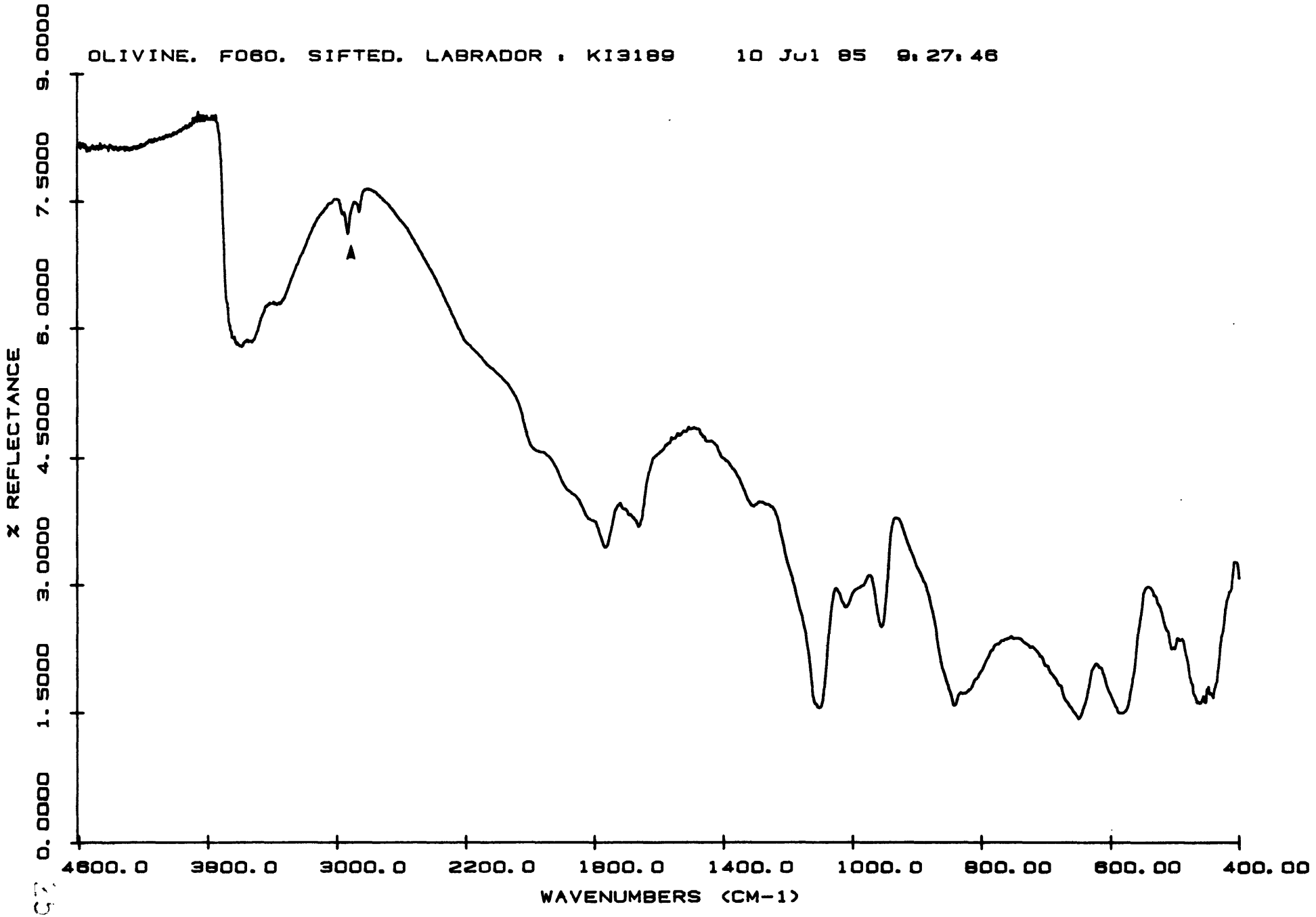
Microprobe analysis by W.I. Ridley, USGS:

SiO_2	35.47
TiO_2	0.03
Al_2O_3	0.00
Cr_2O_3	0.04
MnO	0.55
NiO	0.05
FeO	34.63
MgO	29.49
CaO	0.09
	100.35

Spectra on file:
Olivine.6 Difuse reflectance of sifted sample on 0-74 um disk #1.
Olivine.6A Diffuse reflectance of packed sample on solid sample disk #1.
Olivine.6 Transmittance spectra on disk #1.


OLIVINE IN KBR. F060. LABRADOR : KI3189 29 Jul 85 14:21:51
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. FO60. PACKED SURFACE. LABRADOR: KI3189 26 Aug 85 12:44:56
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. FO80. SIFTED. LABRADOR : KI3189 10 Jul 85 9:27:46
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Olivine (F066)

Locality: Kiglapait Intrusion, Labrador

Last donor: Trude King

Intermediate donor:

Ultimate donor: S.A. Morse, Univ. of Mass, Amherst, MA

Catalog numbers, etc.: Trude King KI3054

Results of petrographic examination: Initial speciments were contaminated with pyroxene, spinel (?), and ilmenite heavy liquid separation, followed by magnetic separation and hand picking, allowed olivines of different run content to be isolated. Sample ground to <60 um and wet seived. Sample prep. by Trude King USGS Denver.

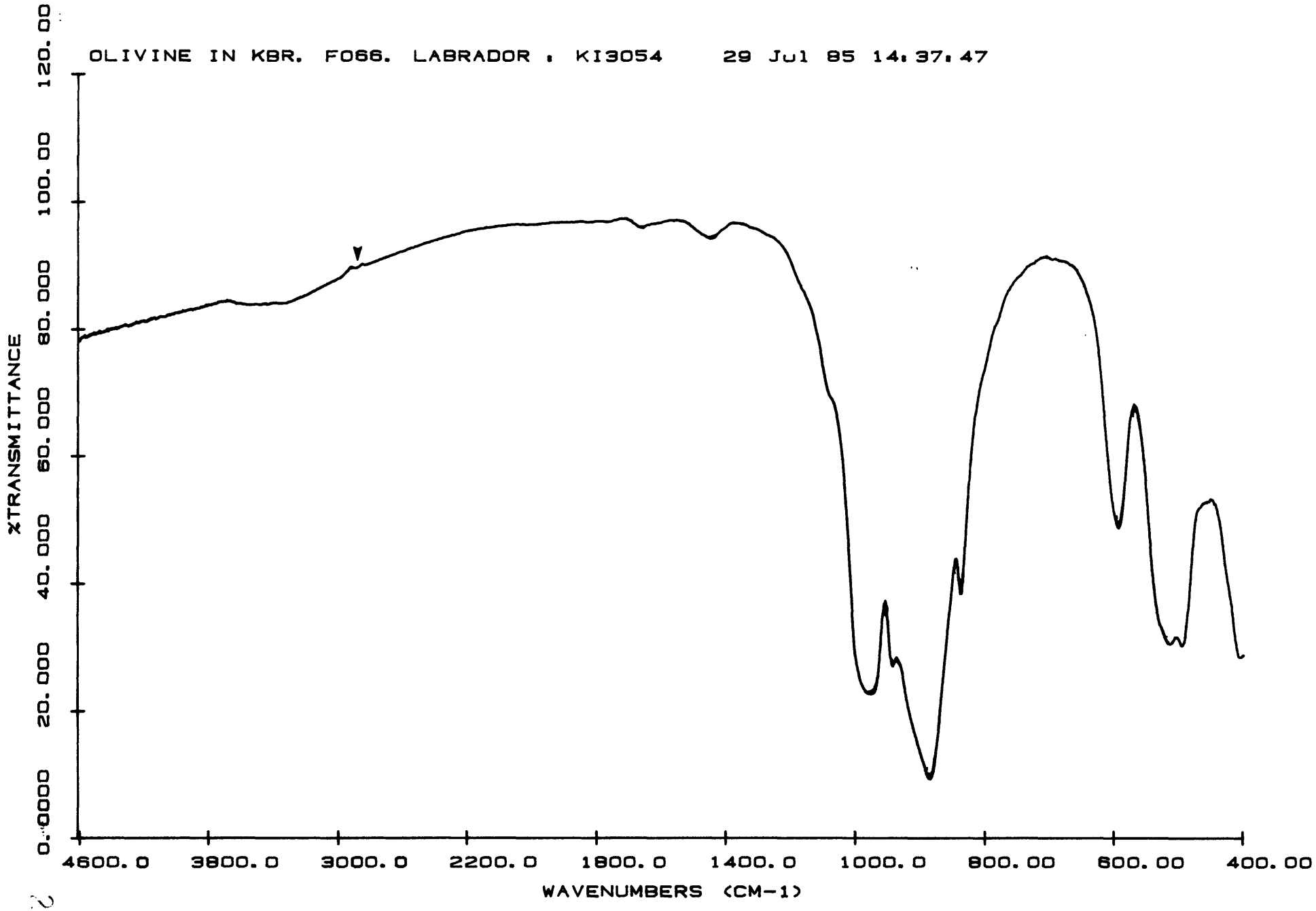
Results of XRD: None

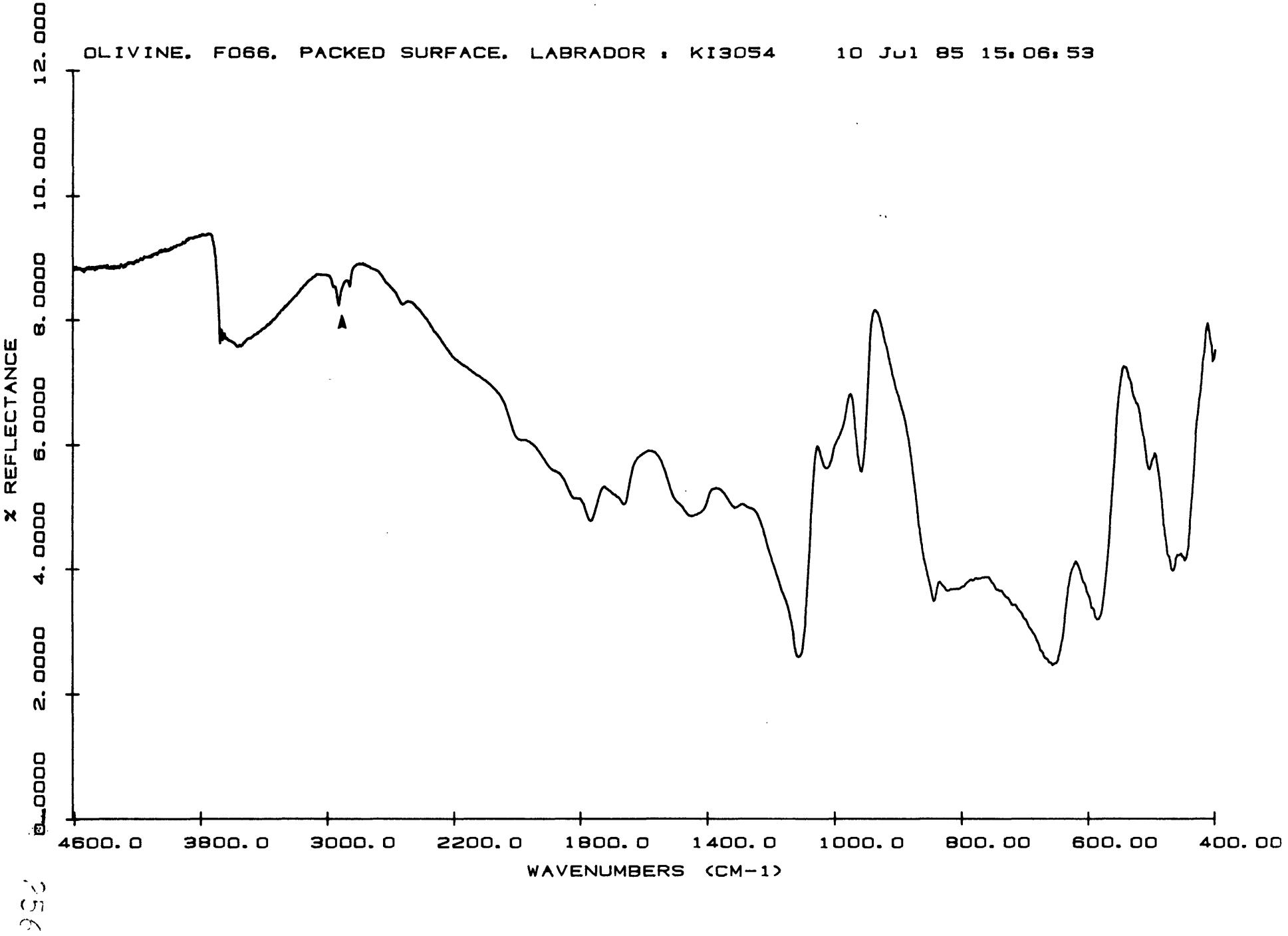
Results of XRF or other compositional analysis:

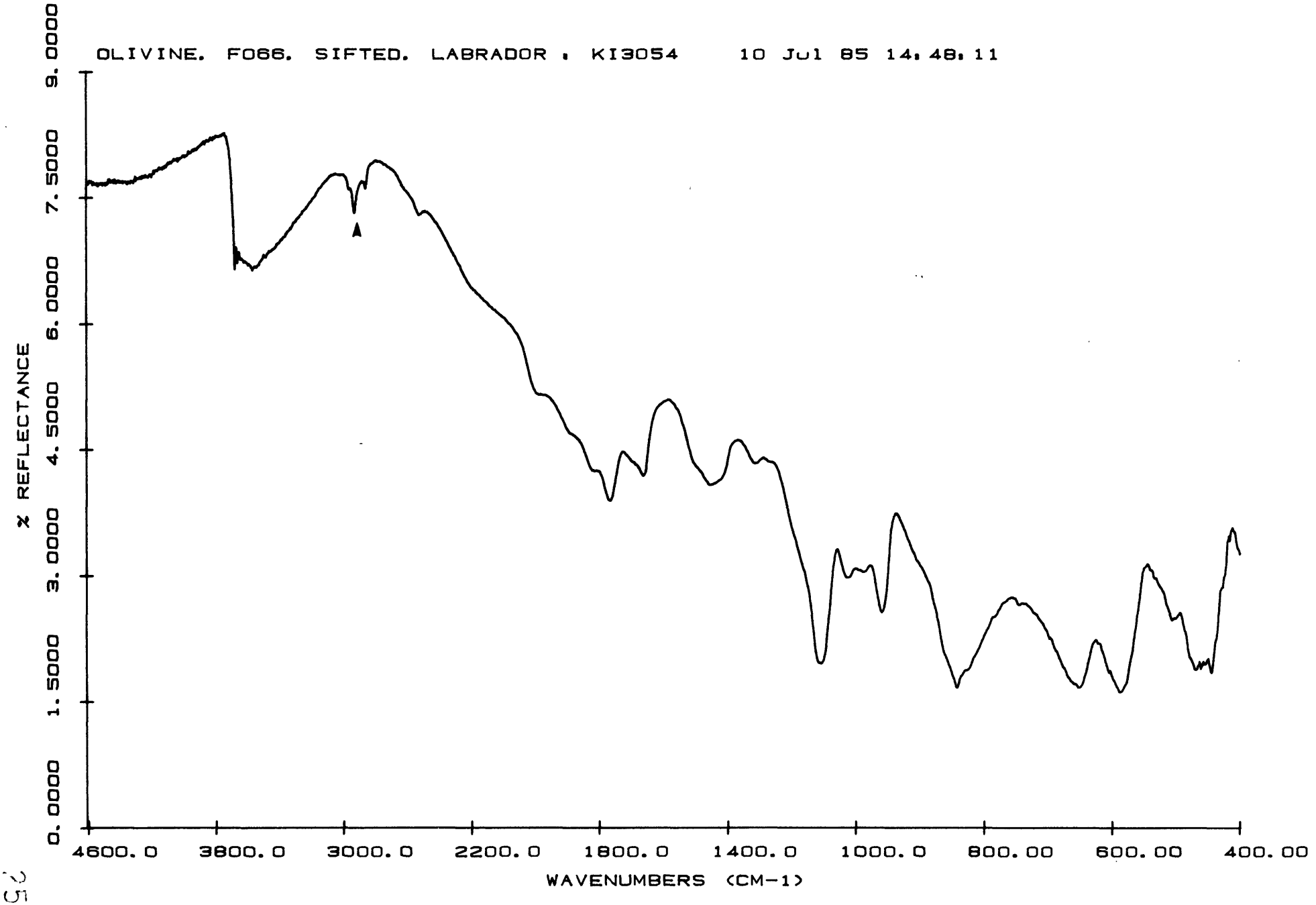
Microprobe analysis by W.I. Ridley, USGS:

SiO_2	- 36.30
TiO_2	- 0.03
Al_2O_3	- 0.00
Cr_2O_3	- 0.03
MnO	- 0.05
NiO	- 0.09
FeO	- 30.59
MgO	- 32.62
CaO	- 0.04
	99.75

Spectra on file:
Olivine.7 Diffuse reflectance of sifted sample on 0-74 um disk #1.
Olivine.7 Diffuse reflectance of packed sample on solid sample disk #1.
Olivine.7 Transmittance of disk #1.


OLIVINE IN KBR. F066. LABRADOR . KI3054 29 Jul 85 14:37:47
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F066. PACKED SURFACE. LABRADOR : KI3054 10 Jul 85 15:06:53
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F066. SIFTED. LABRADOR . KI3054 10 Jul 85 14:48:11
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Olivine (F088)

Locality: Brenham, Kanasas

Last donor: Trude King

Intermediate donor:

Ultimate donor: Center for Meteorite Studies, Arizona State University, Tempe, AZ

Catalog numbers, etc.: Trude King Brenh (Cent. for Meteorite Studies #10L)

Results of petrographic examination: Olivine obtained from the Breham meteorite was optically examined using a petrographic microscopic prior to spectral measurements to insure purity of the olivine. Olivine then hand ground and wet seived to less than 30 microns. Sample prep. by Trude King USGS Denver.

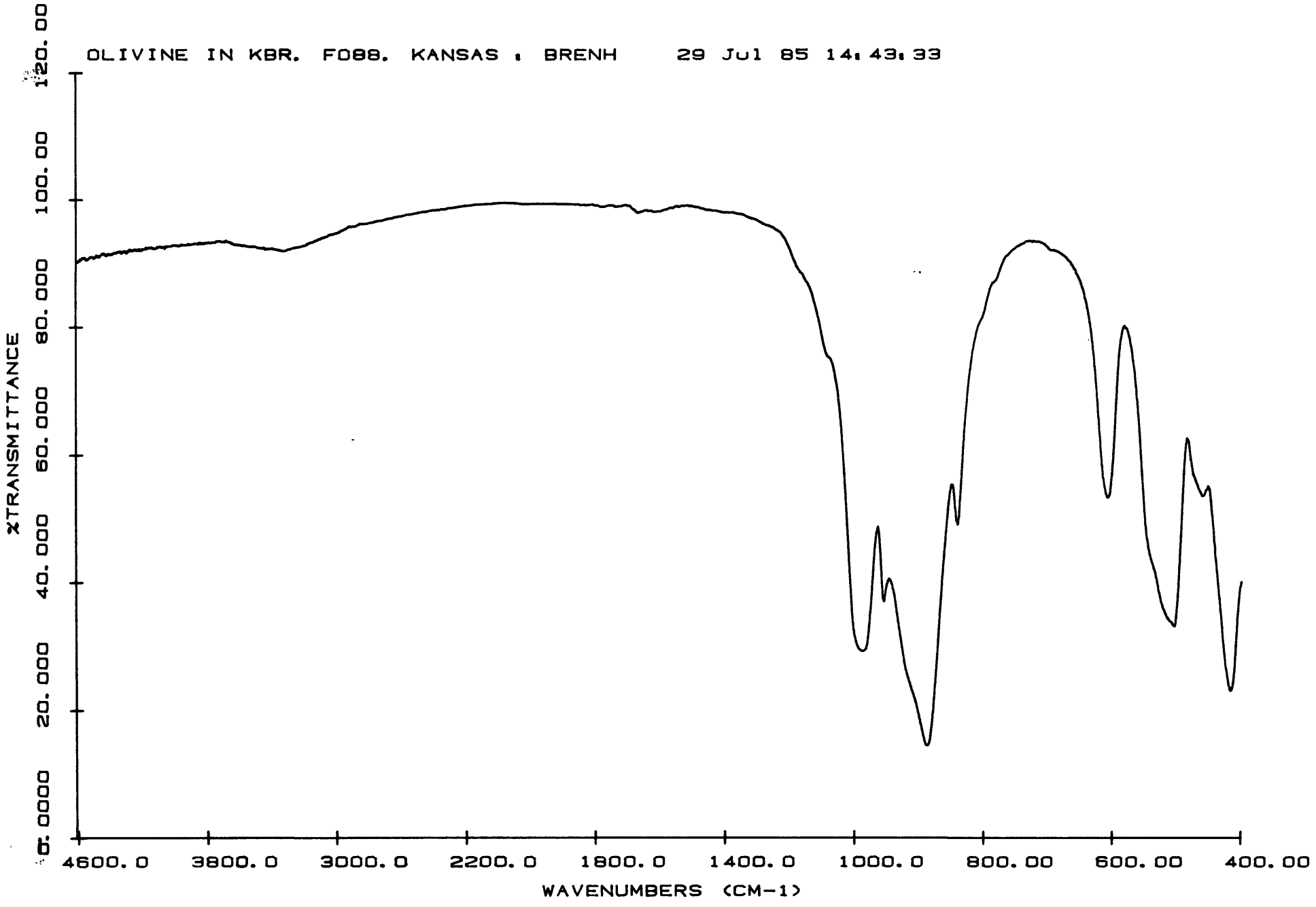
Results of XRD: None

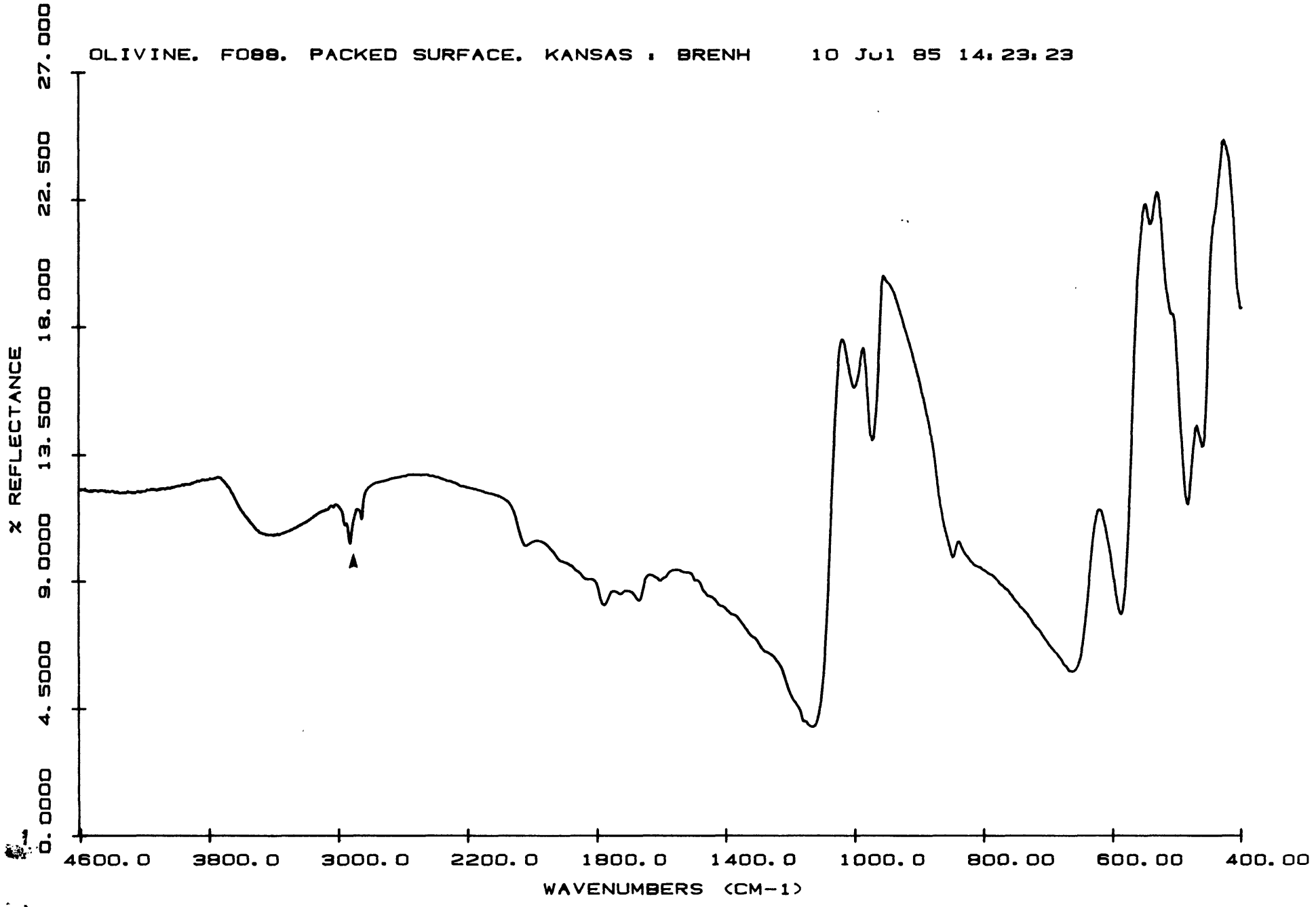
Results of XRF or other compositional analysis:

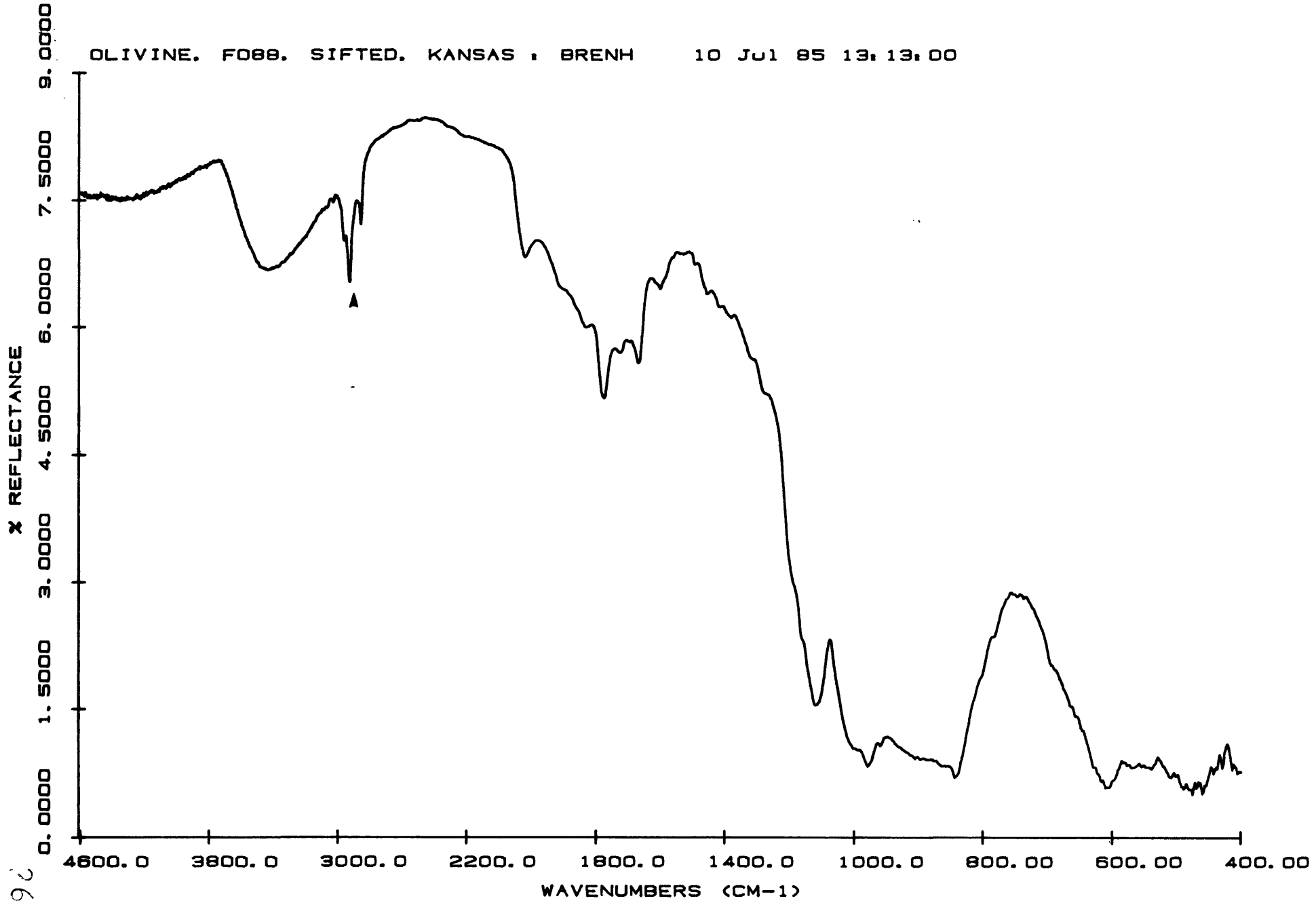
Microprobe analysis by W.I. Ridley, USGS:

SiO_2	- 40.10
TiO_2	- 0.002
Al_2O_3	- 0.007
Cr_2O_3	- 0.027
MnO	- 0.216
NiO	- 0.003
FeO	- 11.800
MgO	- 47.800
CaO	- 0.009
	99.964

Spectra on file:
Olivine.8 Diffuse reflectance spectrum of sifted sample on 0-74 um disk #1.
Olivine.8 Diffuse reflectance spectrum of packed surface on solid sample disk #1.
Olivine.8 Transmittance spectrum on disk #1.


OLIVINE IN KBR. FO88. KANSAS : BRENH 29 Jul 85 14:43:33
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F088. PACKED SURFACE. KANSAS : BRENH 10 Jul 85 14:23:23
% REFLECTANCE
27.000
22.500
18.000
13.500
9.0000
4.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. FO88. SIFTED. KANSAS : BRENH 10 Jul 85 13:13:00
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

196

Species name: Olivine (F088)

Locality: South Point, Hawaii

Last donor: Trude King

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: Trude King GSB

Results of petrographic examination: Samples of olivine from the green sand beach were optically examined using a petrographic microscope prior to spectral measurements to insure purity of the olivine. Sample >98% pure olivine. This sample was seived into <60 um size. Sample prep. by Trude King USGS Denver.

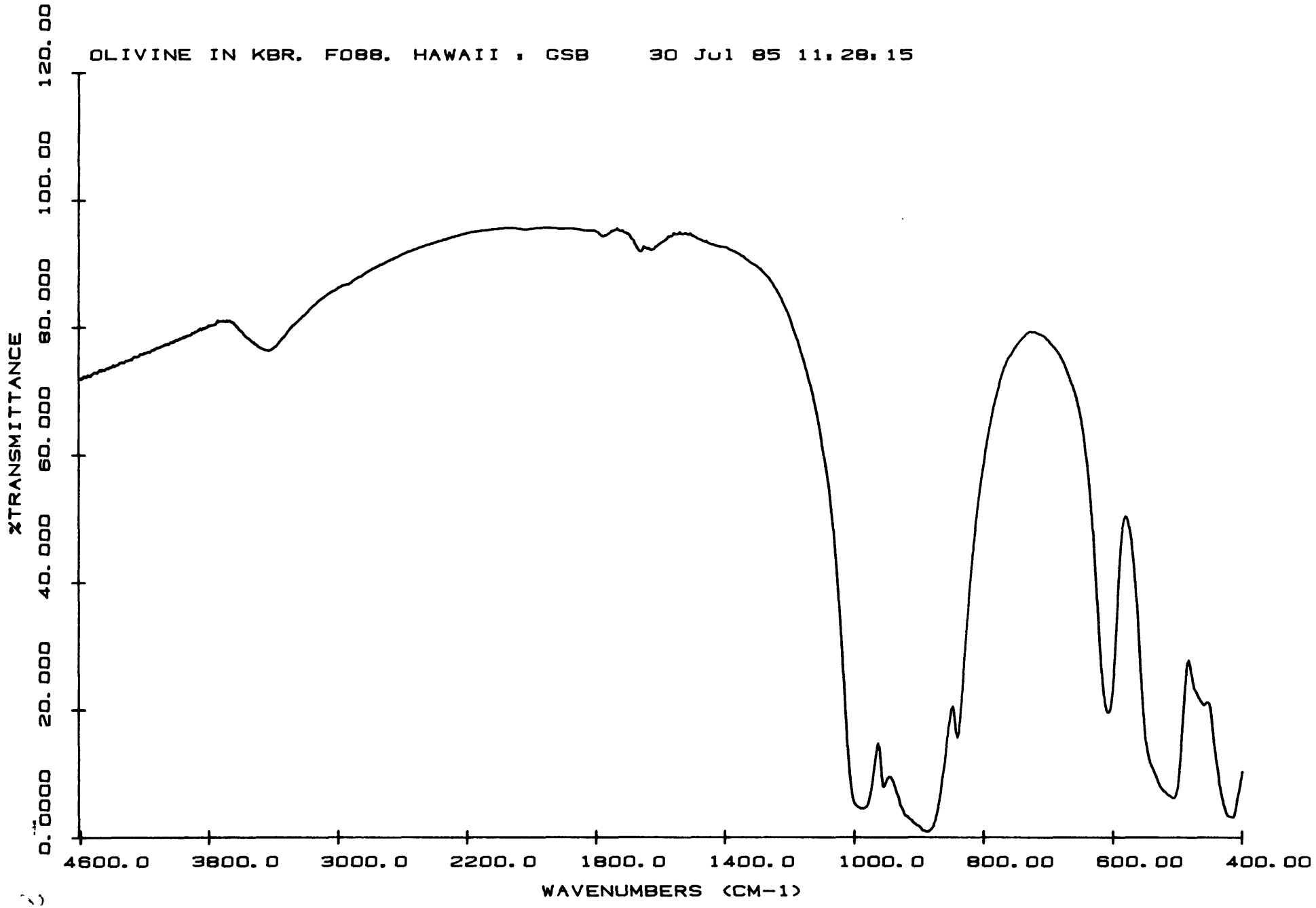
Results of XRD: None

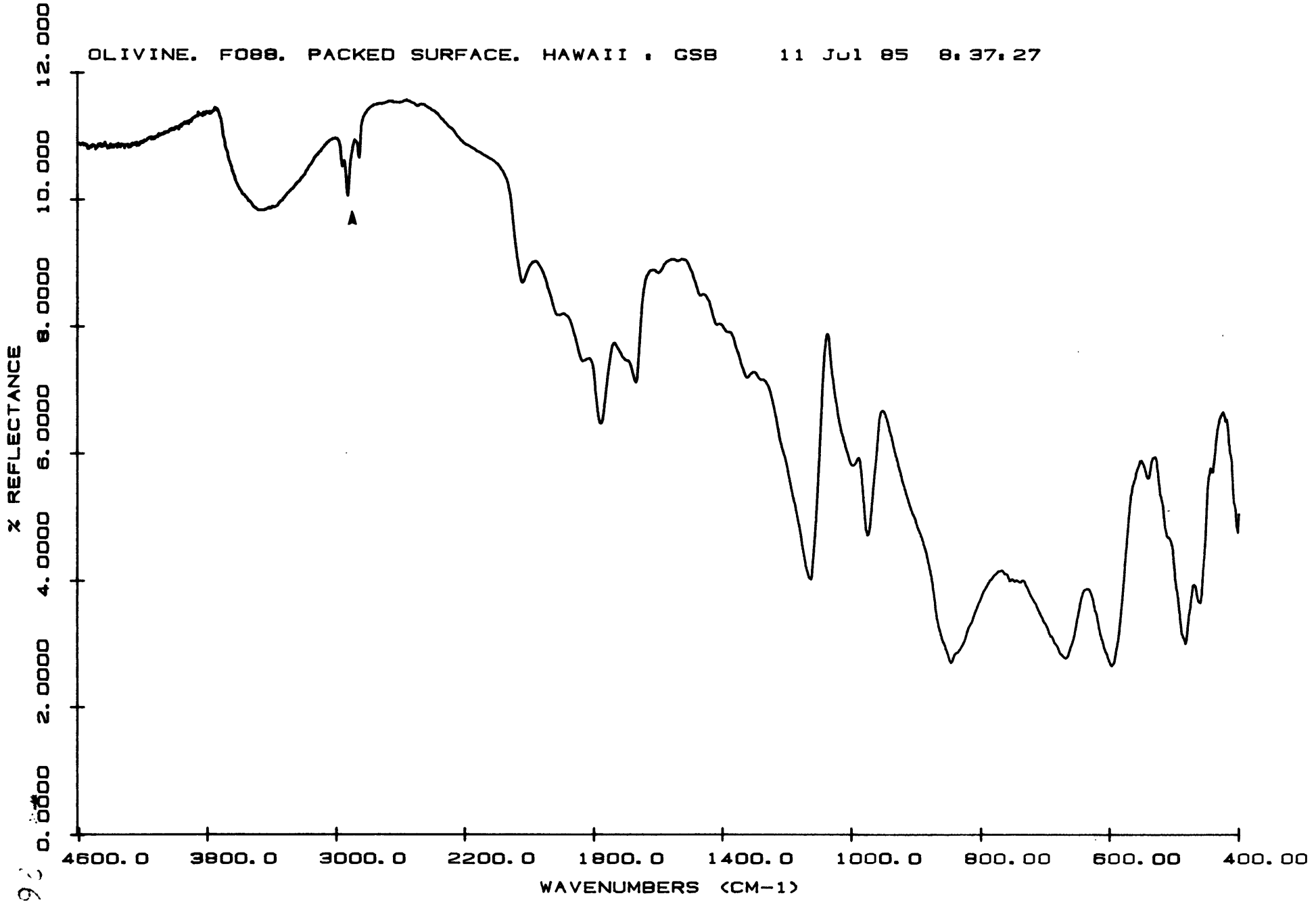
Results of XRF or other compositional analysis:

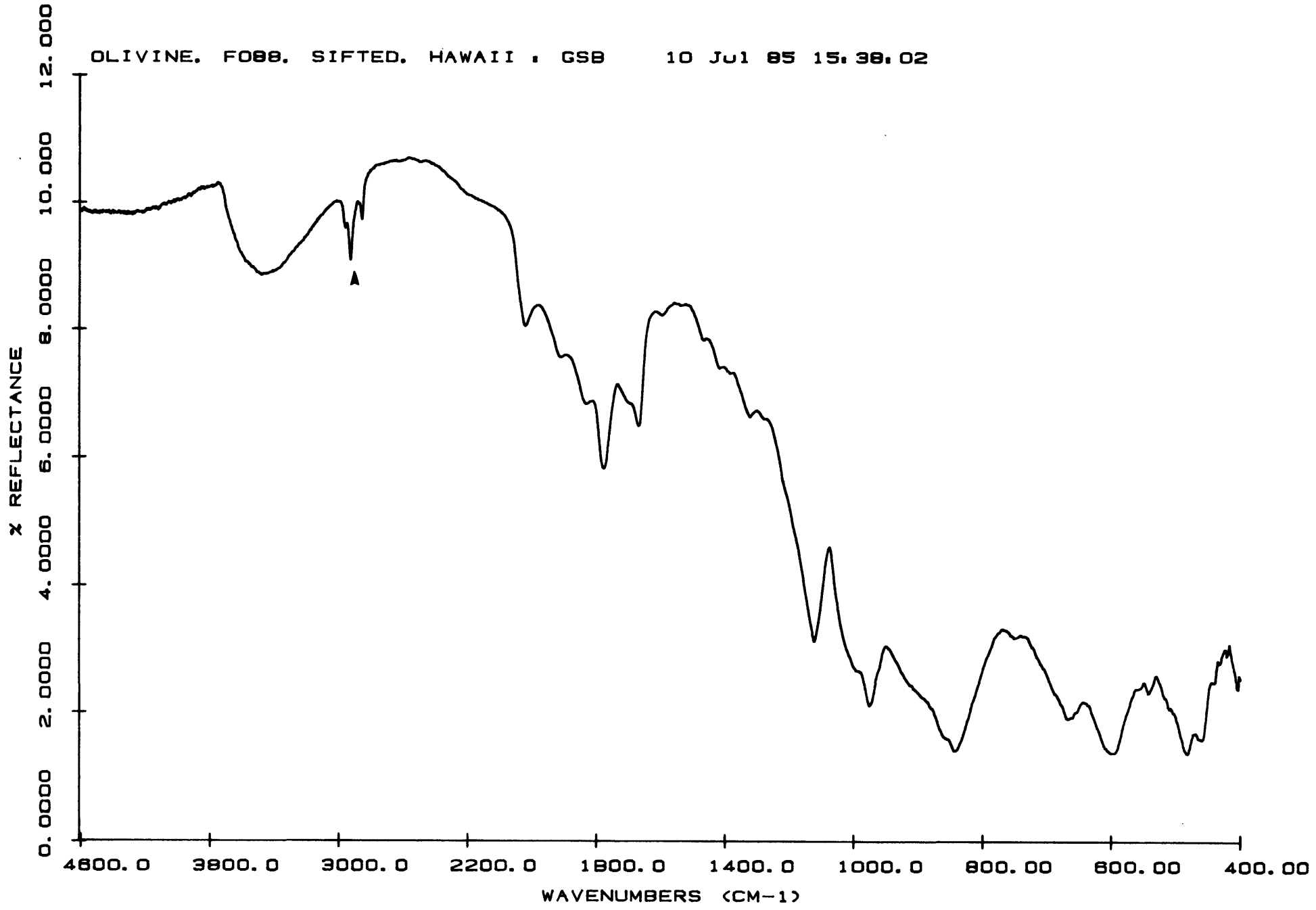
Microprobe analysis by W.I. Ridley, USGS:

SiO_2	- 41.09
TiO_2	- 0.01
Al_2O_3	- 0.00
Cr_2O_3	- 0.05
MnO	- 0.21
NiO	- 0.39
FeO	- 9.16
MgO	- 49.29
CaO	- 0.03
	100.23

Spectra on file:
Olivine.9 Diffuse reflectance of sifted sample on 0-74 um disk #1.
Olivine.9 Diffuse reflectance of packed sample on solid sample disk #1.
Olivine.9 Transmittance spectrum on disk #1.


OLIVINE IN KBR. F088. HAWAII : GSB 30 Jul 85 11:28:15
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F088. PACKED SURFACE. HAWAII : GSB 11 Jul 85 8:37:27
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. FO88. SIFTED. HAWAII : GSB 10 Jul 85 15:38:02
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Olivine (F091)

Locality: Twin Sisters Peak, Washington

Last donor: Trude King

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: Trude King TSD

Results of petrographic examination: Olivine was optically examined using a petrographic microscope prior to spectral measurements to insure purityof the olivine. Olivine >98% pure. Sample <60 microns. Sample prep. by Trude King USGS Denver.

Results of XRD: None

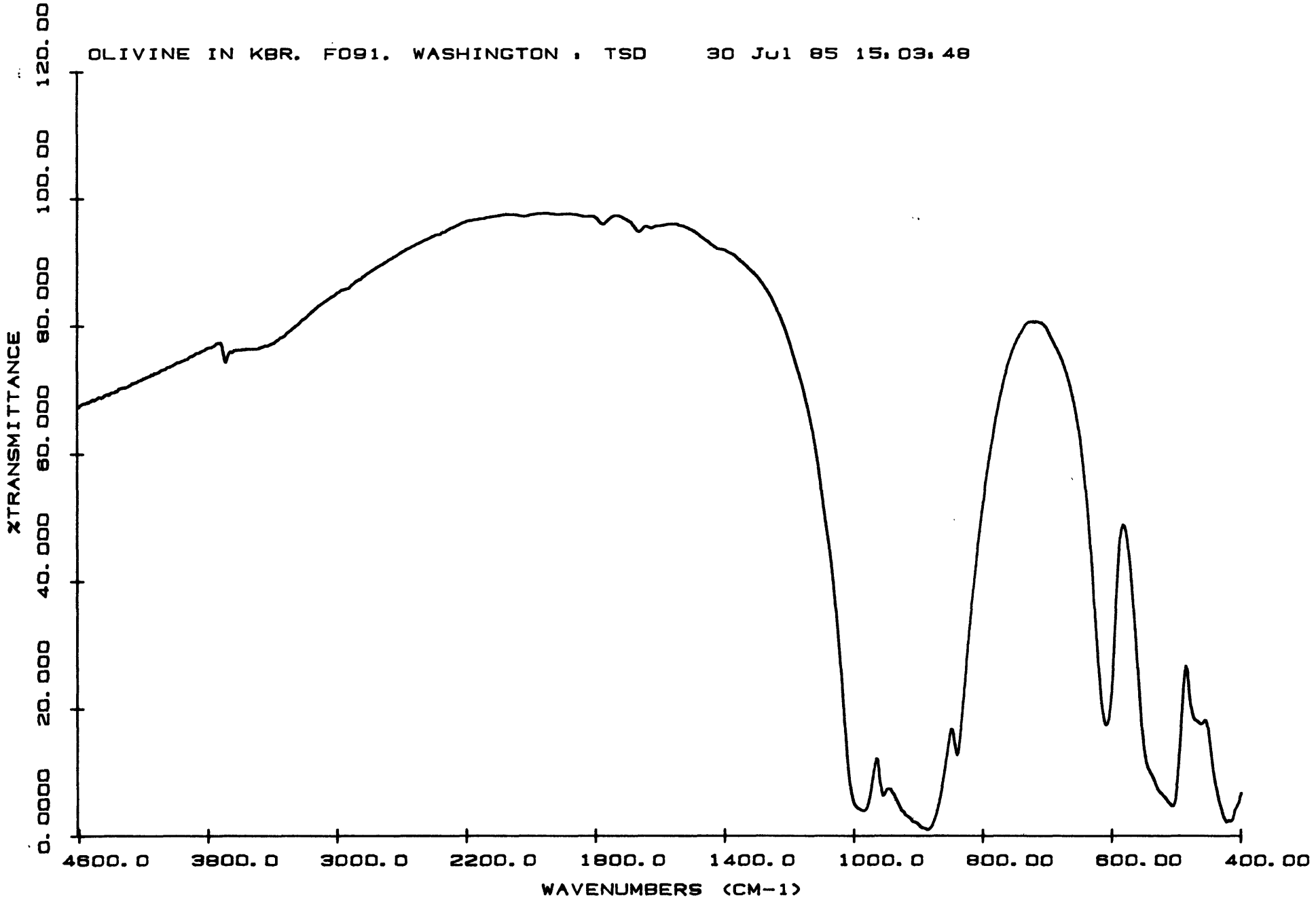
Results of XRF or other compositional analysis:

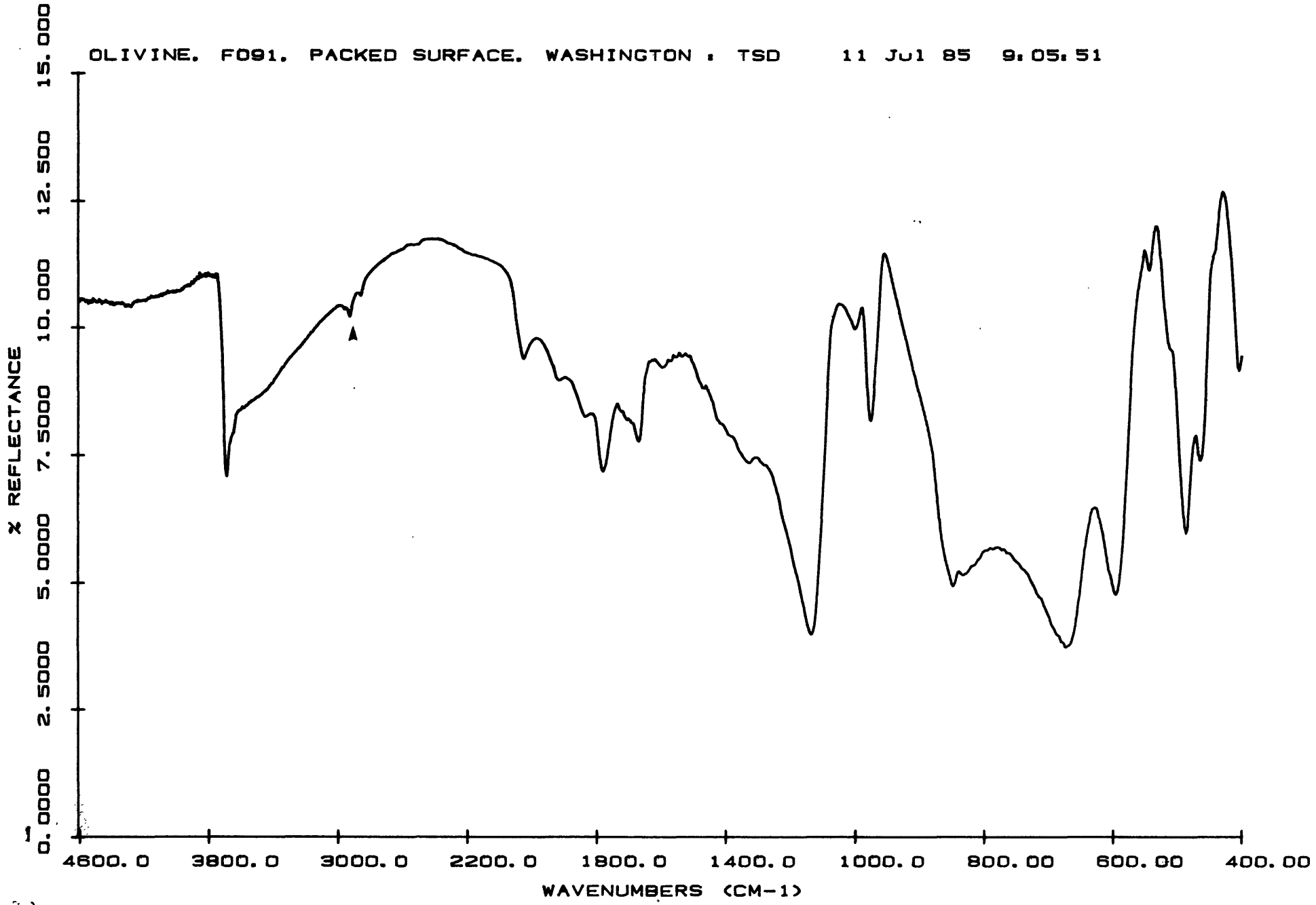
Microprobe analysis by W.I. Ridley, USGS:

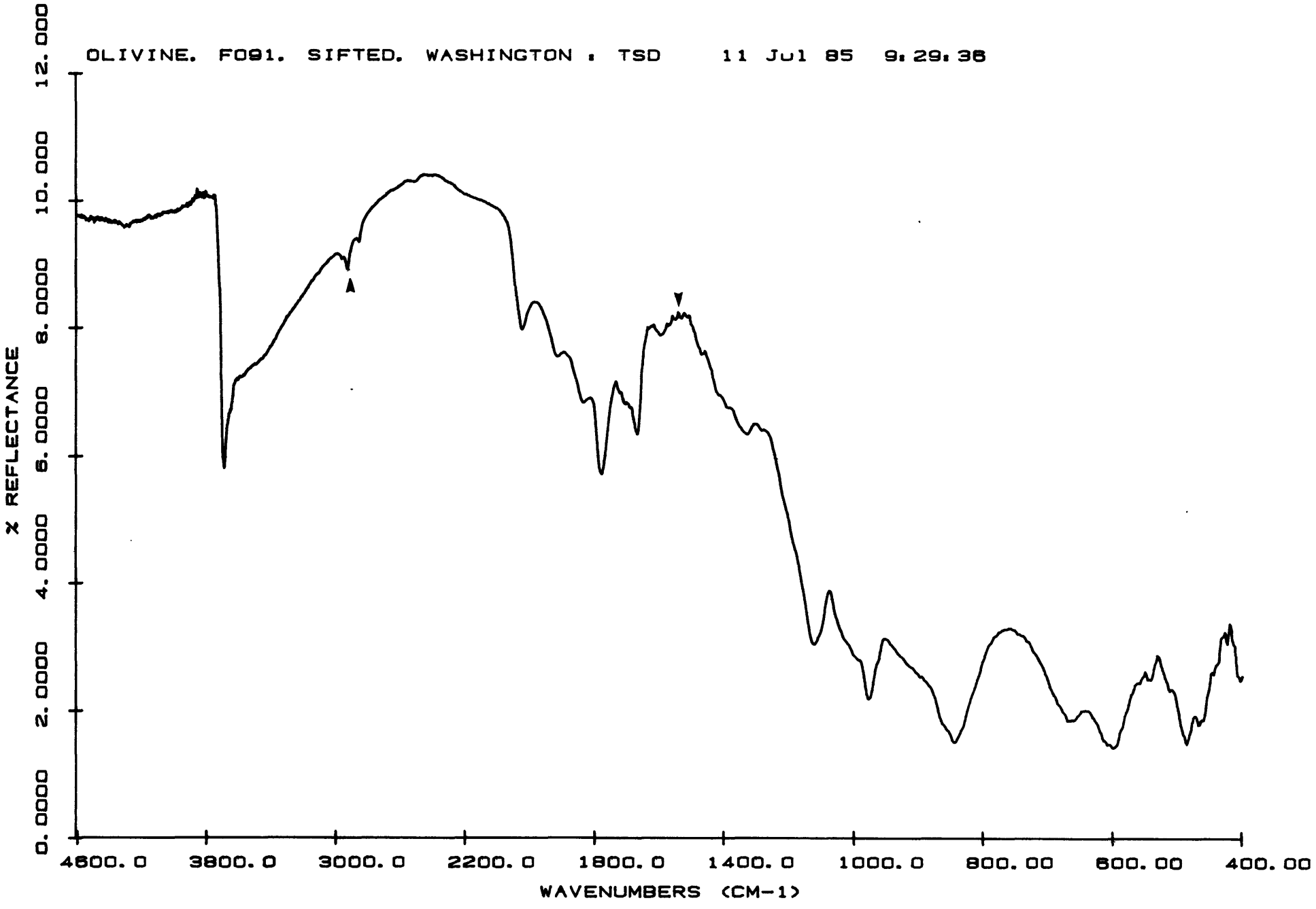
SiO_2	40.60
TiO_2	0.14
Al_2O_3	0.05
Cr_2O_3	0.06
MnO	0.12
NiO	0.28
FeO	7.93
MgO	50.70
CaO	0.06
TOTAL	99.94

Spectra on file:

Olivine.10 Diffuse reflectance of sifted sample on 0-74 um disk #1.
Olivine.10 Diffuse reflectance of packed surface on solid sample disk #1.
Olivine.10 Transmittance spectrum on disk #1.


OLIVINE IN KBR. F091. WASHINGTON : TSD 30 Jul 85 15:03:48
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F091. PACKED SURFACE. WASHINGTON : TSD 11 Jul 85 9:05:51
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE. F091. SIFTED. WASHINGTON : TSD 11 Jul 85 9:29:36
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

692

Species name: Olivine (FO92)

Locality: Chavira olivine-peridot mine, Kamargo (nr), Chihuahau, Mexico

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 137044

Results of petrographic examination: Sample consists of many .5 cm particles, grass green in color, appearing pure, plus one large fragment. The large one is 13 mm x 1 cm and seems to contain quite a bit of contamination. There is some bright green mineral, probably diopside, and areas which are very dark purplish to brownish unidentified. Also hematitic or limonitic staining (v. small amount).

Under petrographic microscope, hand-picked sample appears clean but one grain may be pyroxene.

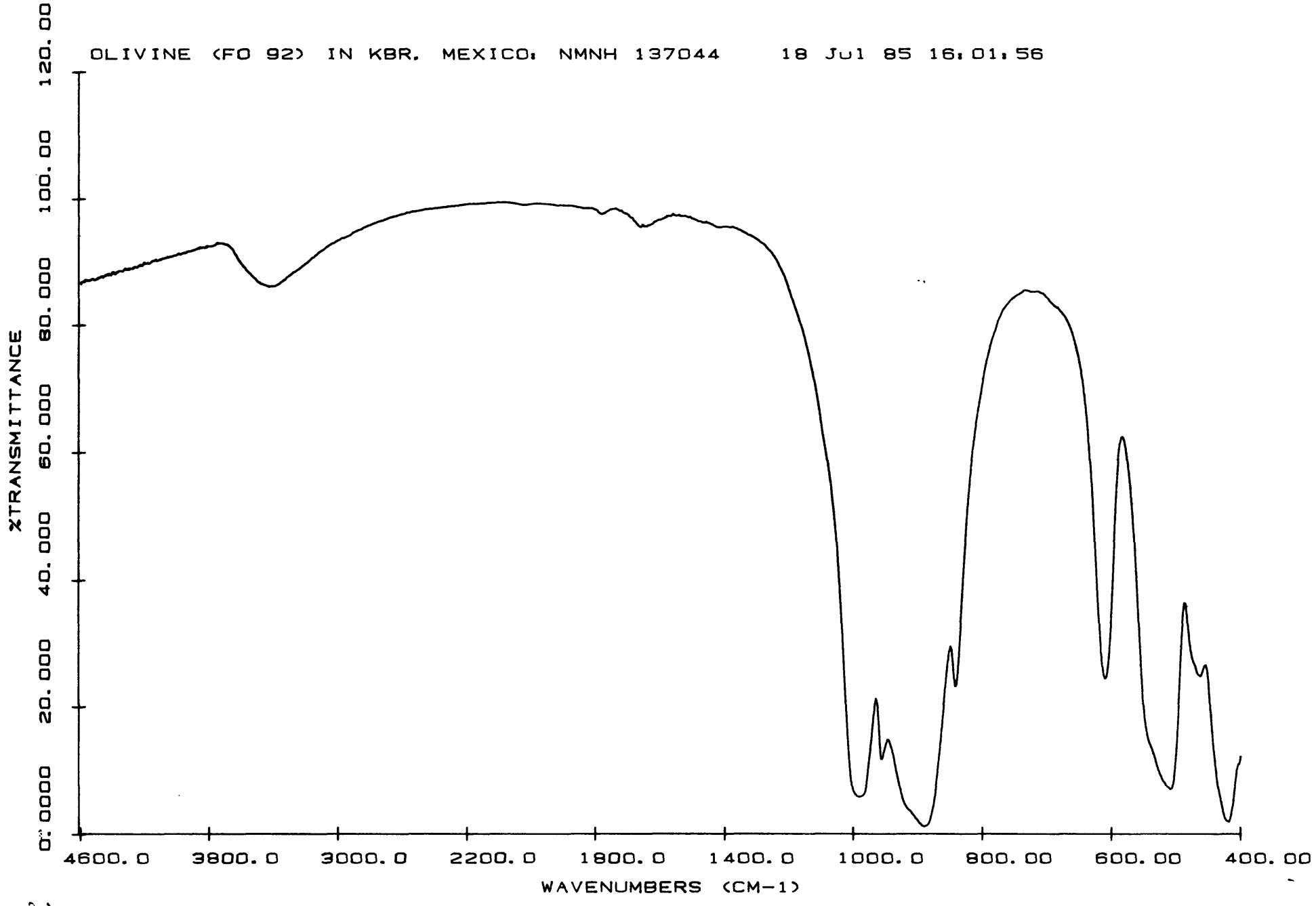
Results of XRD: Pure forsterite.

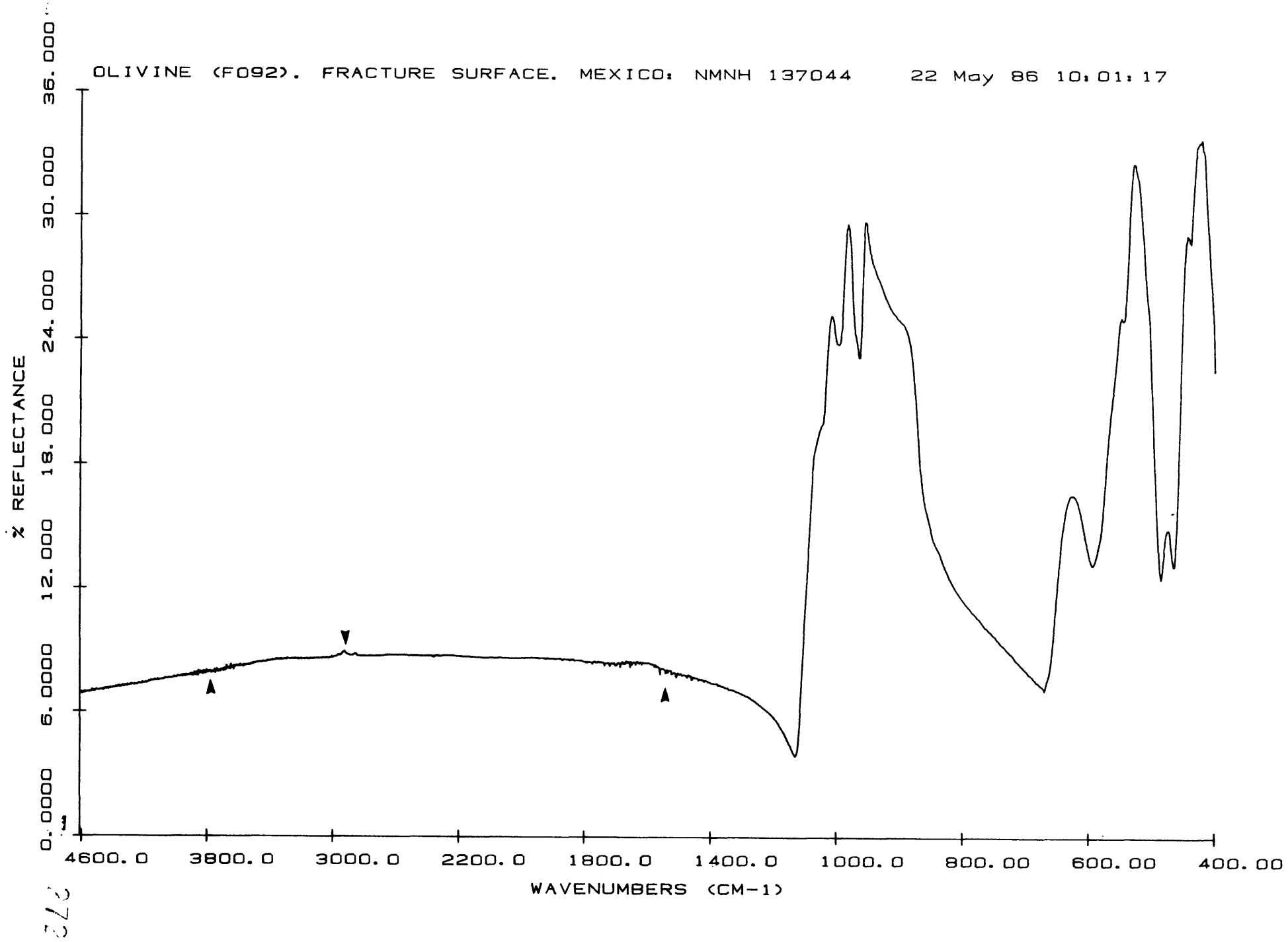
Results of XRF or other compositional analysis: Microprobe analysis of hand-picked grains showed the sample to be homogeneous within and between grains. Average of 10 analyses shows that the sum of the divalent cations is too high, but FO content is about 92 mole percent:

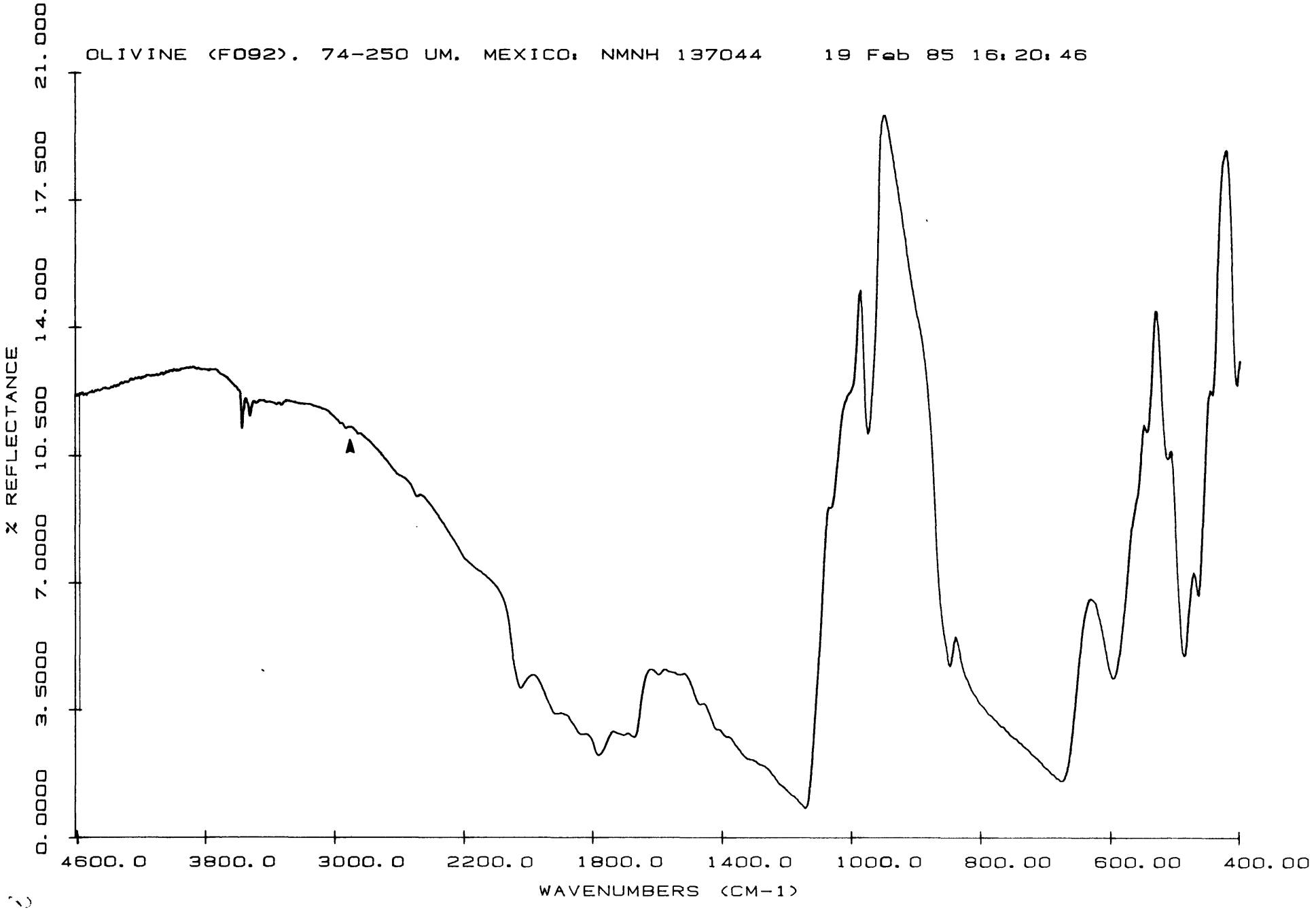
SiO_2	- 40.27
Al_2O_3	- 0.02
FeO	- 8.70
MgO	- 52.28
CaO	- 0.06
K_2O	- 0.01
Na_2O	- 0.02
TiO_2	- 0.01
MnO	- 0.15
Total	-101.52

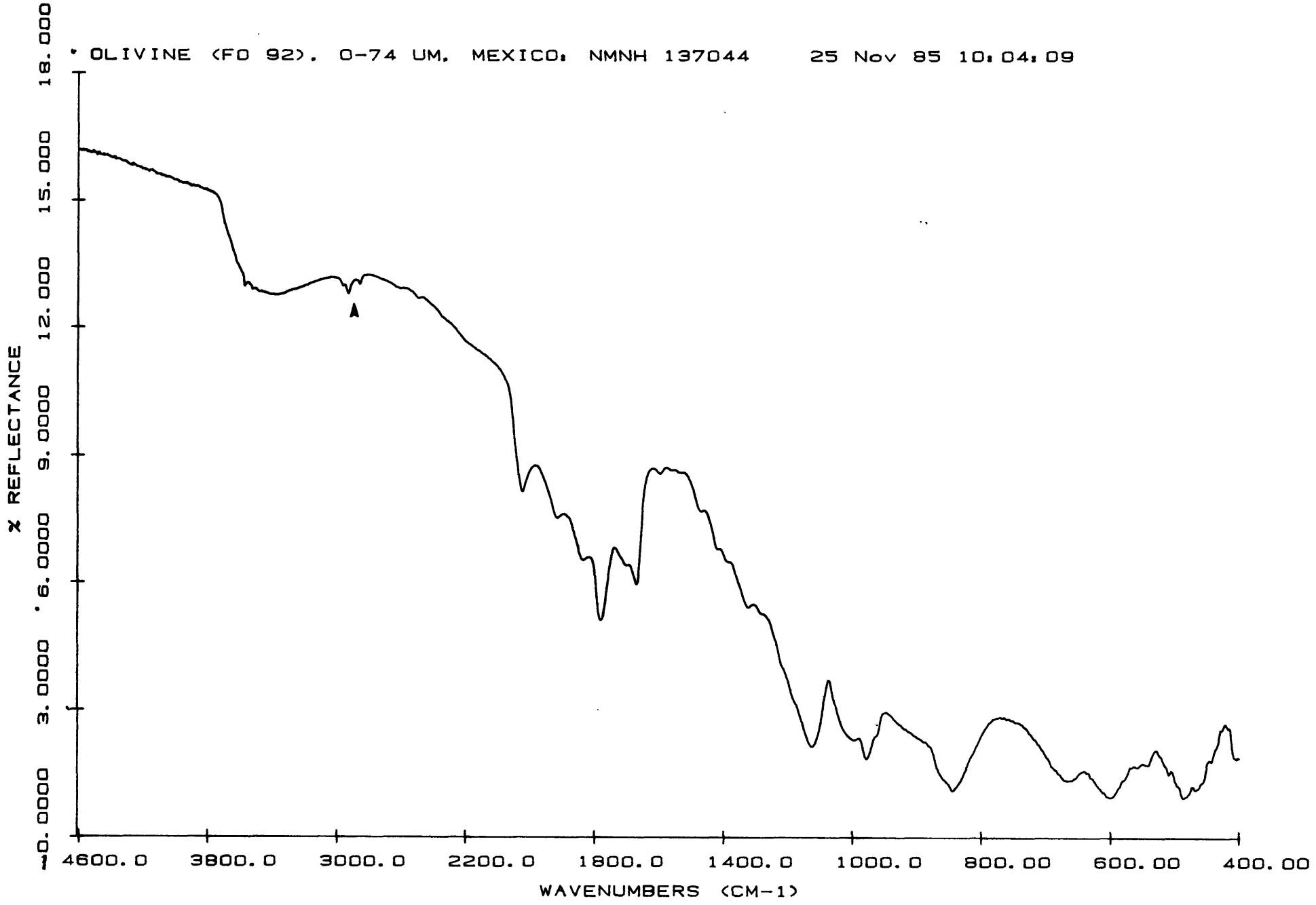
Spectra of file:

Olivine.11	Reflectance spectrum of fracture surface on solid sample disk #1.
Olivine.11	Reflectance spectrum of 0-74 um size range on disk #1.
Olivine.11	Reflectance spectrum of 74-250 um size range on disk #1.
Olivine.11	Transmittance spectrum on disk 1.
Olivine.11B	Reflectance of 0-74 um size range, packed, on solid sample disk #1.

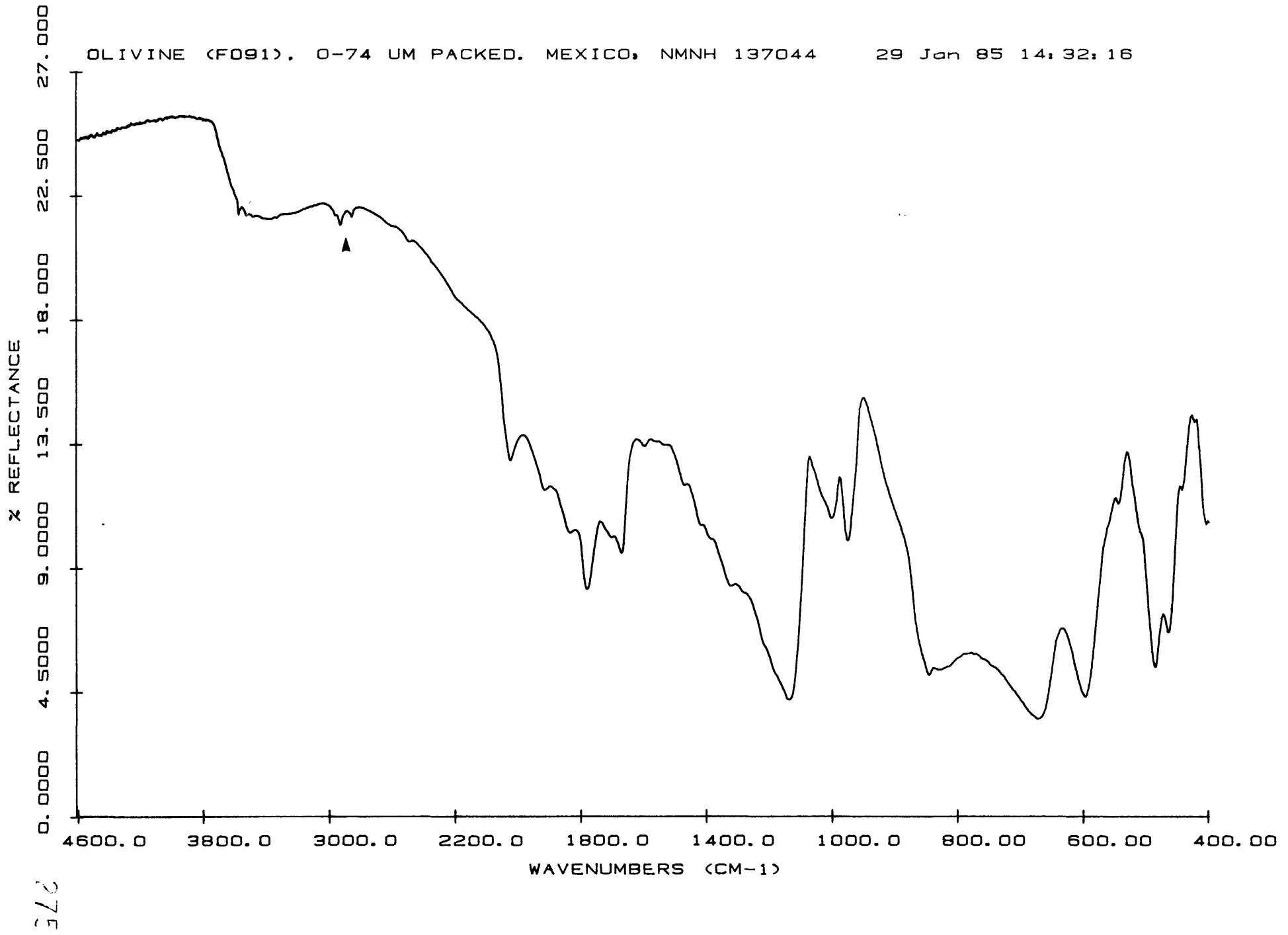

OLIVINE (FO 92) IN KBR. MEXICO: NMNH 137044 18 Jul 85 16:01:56
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE (F092). FRACTURE SURFACE. MEXICO: NMNH 137044 22 May 86 10:01:17
% REFLECTANCE
36.000
30.000
24.000
18.000
12.000
6.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


OLIVINE (F092). 74-250 UM. MEXICO: NMNH 137044 19 Feb 85 16:20:46
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


* OLIVINE (FO 92). 0-74 UM. MEXICO: NMNH 137044 25 Nov 85 10:04:09
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

274


OLIVINE (F091), 0-74 UM PACKED. MEXICO, NMNH 137044 29 Jan 85 14:32:16
% REFLECTANCE
0.0000
4.5000
9.0000
13.500
18.000
22.500
27.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Orthoclase (moonstone) $KAlSi_3O_8$

Locality: Harris farm mica mine, near Oliver, Goochland Co., Virginia

Last donor: Smithsonian

Intermediate donor:

Ultimate donor: Smithsonian

Catalog numbers, etc.: NMNH 113188

Results of petrographic examination: Hand sample is a single 11.97 g. piece of a single crystal. It is twinned, translucent, light beige in color and appears very pure.

Under the microscope, the sample is slightly altered to sericite, otherwise pure.

Results of XRD: Pure orthoclase.

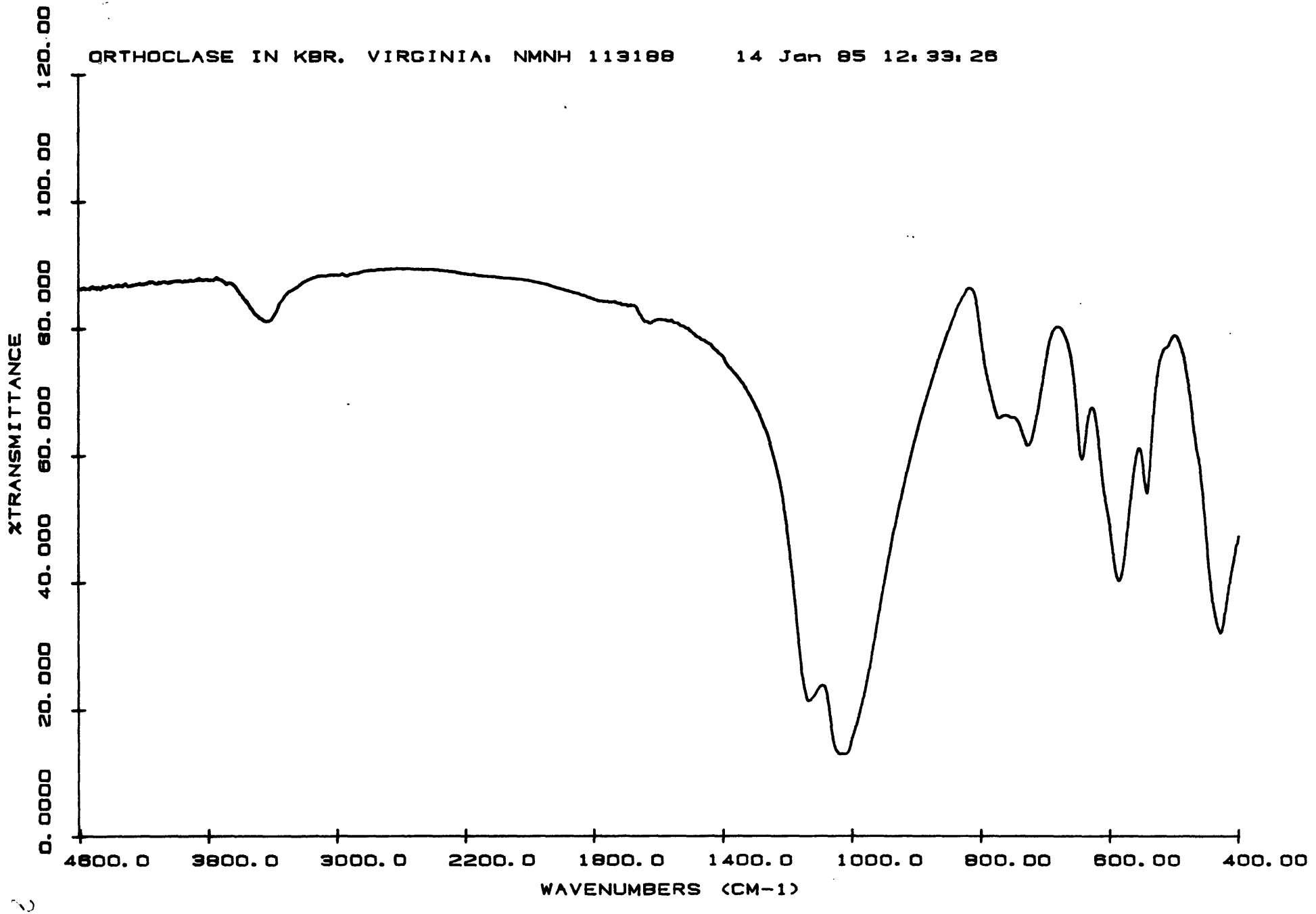
Results of XRF or other compositional analysis:

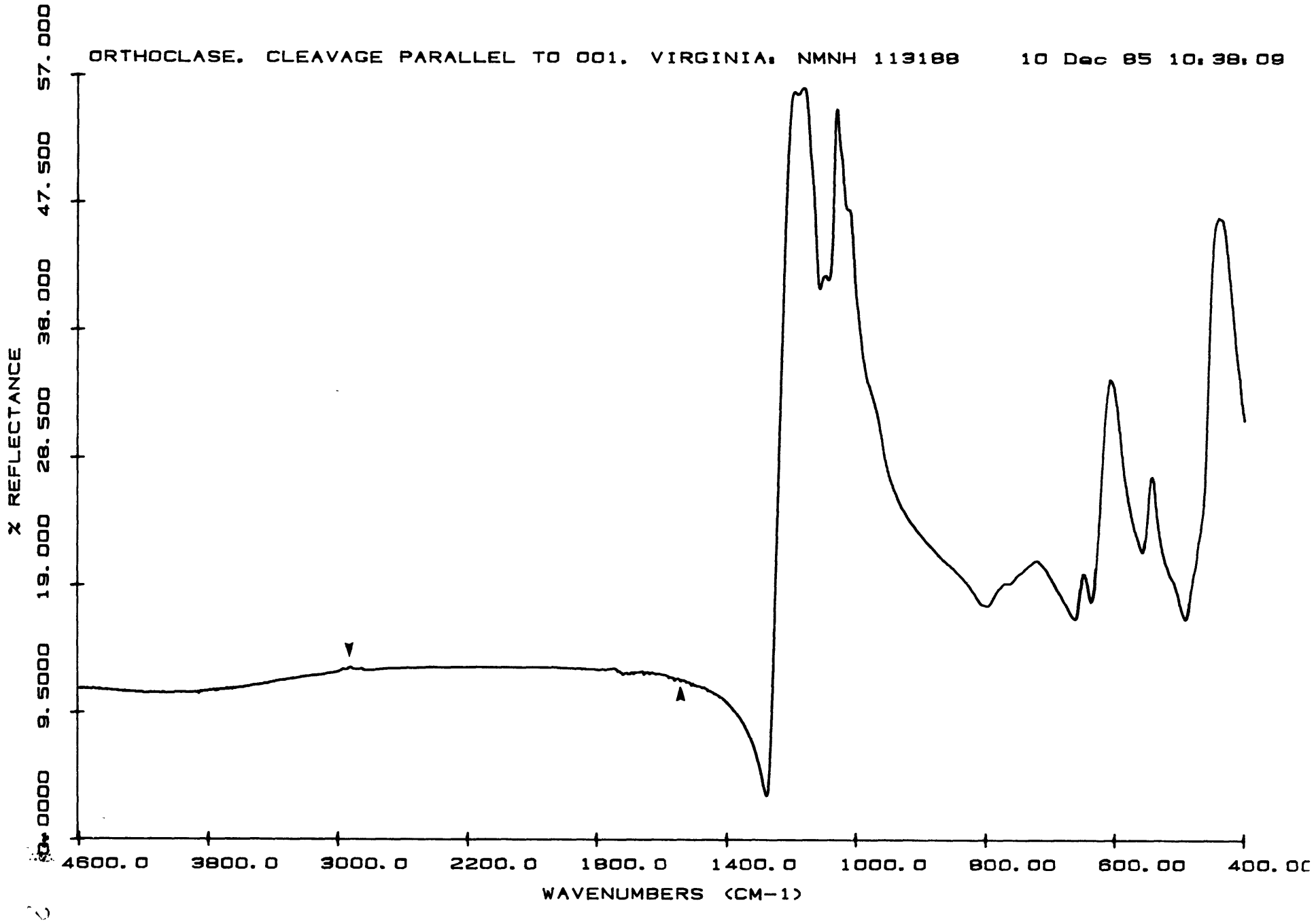
Microprobe analysis indicates typical orthoclase composition but there is a slight heterogeneity of the alkalies. Soda varies from 1.5 to 3.5%, while potash varies from 11 to 14%. Average of 14 analyses:

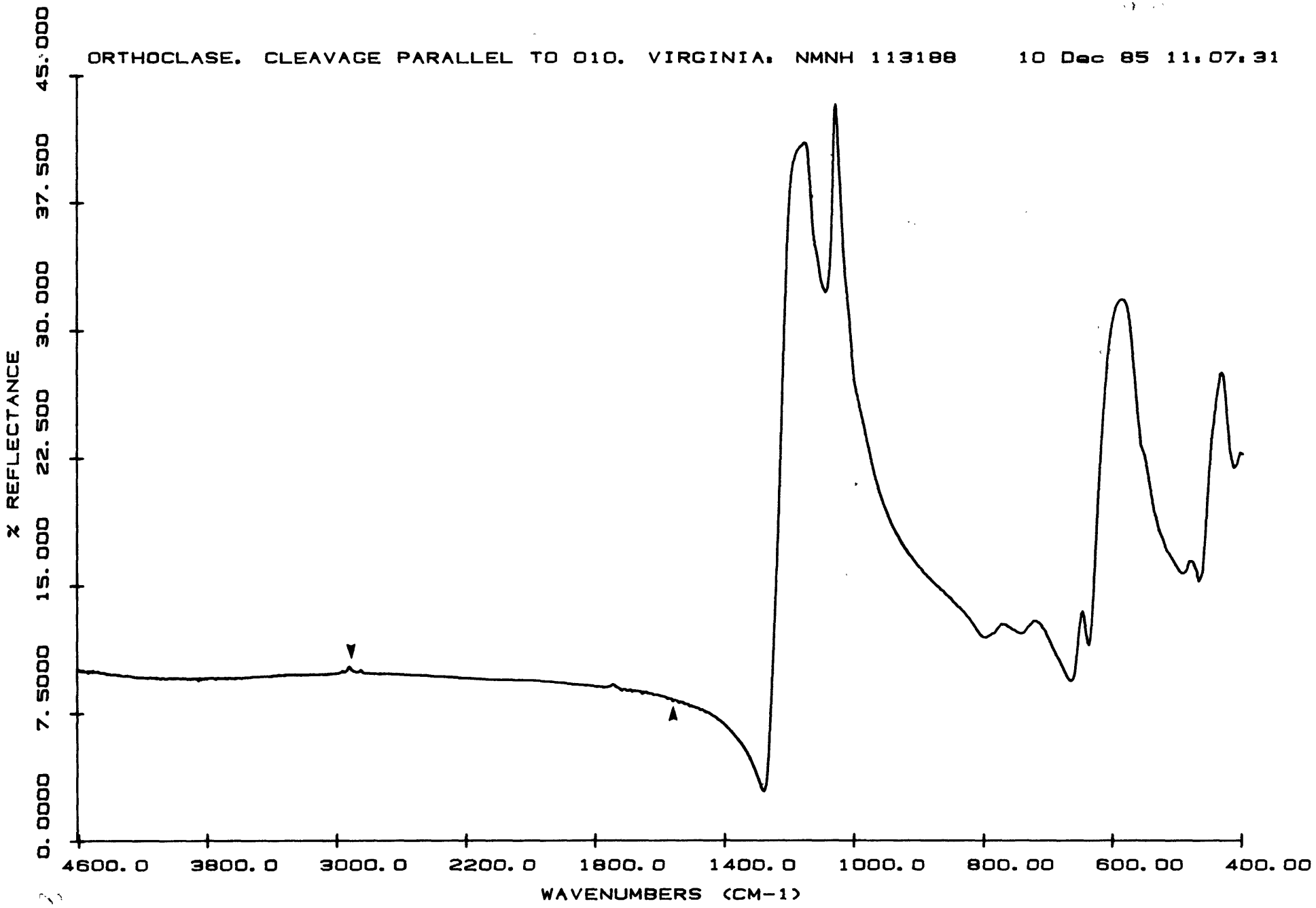
SiO_2	- 64.81
Al_2O_3	- 19.11
FeO	- 0.02
MgO	- 0.04
CaO	- 0.12
K_2O	- 13.51
Na_2O	- 1.69
TiO_2	- 0.02
MnO	- 0.03
Total	- 99.34

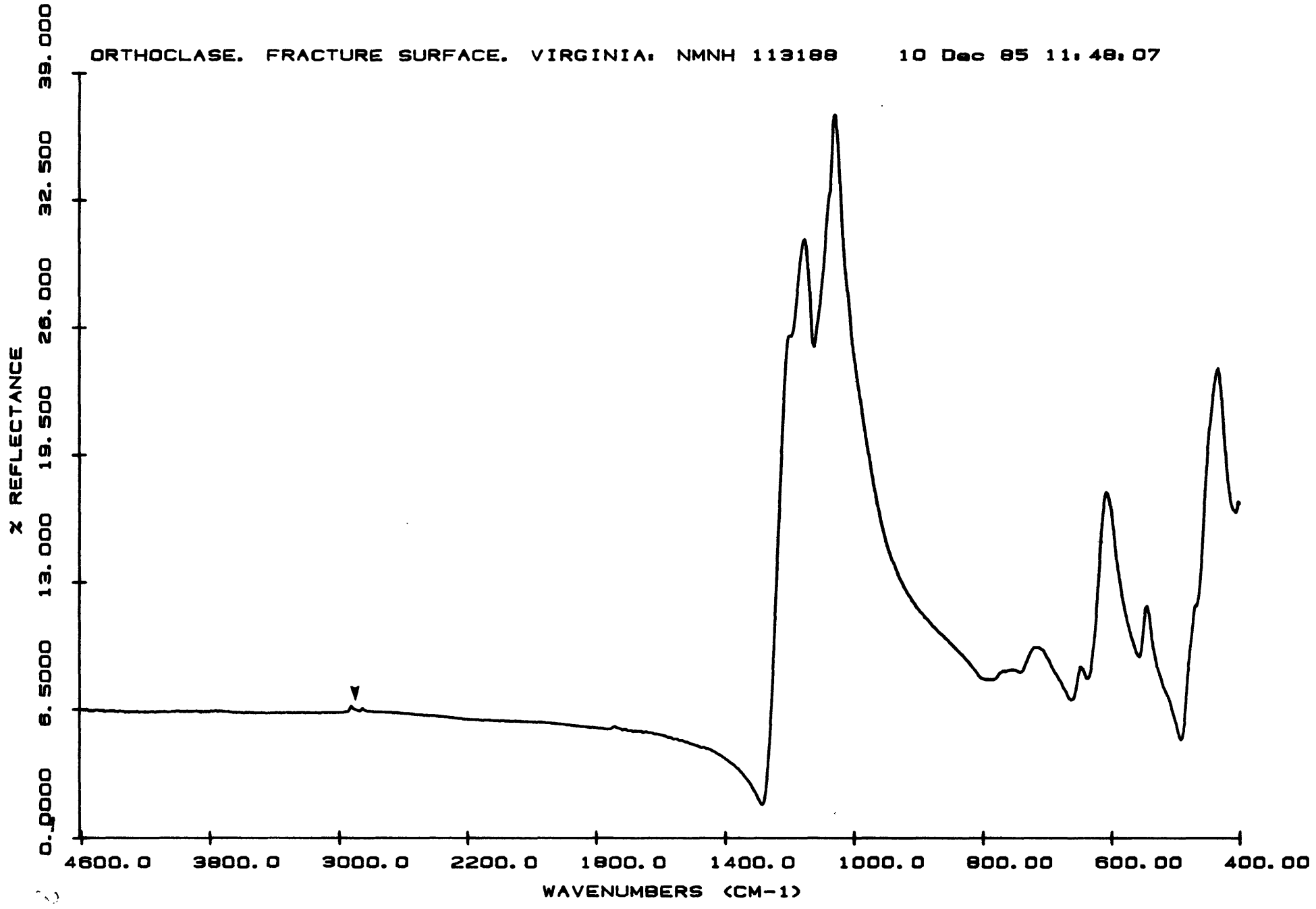
Spectra of file:

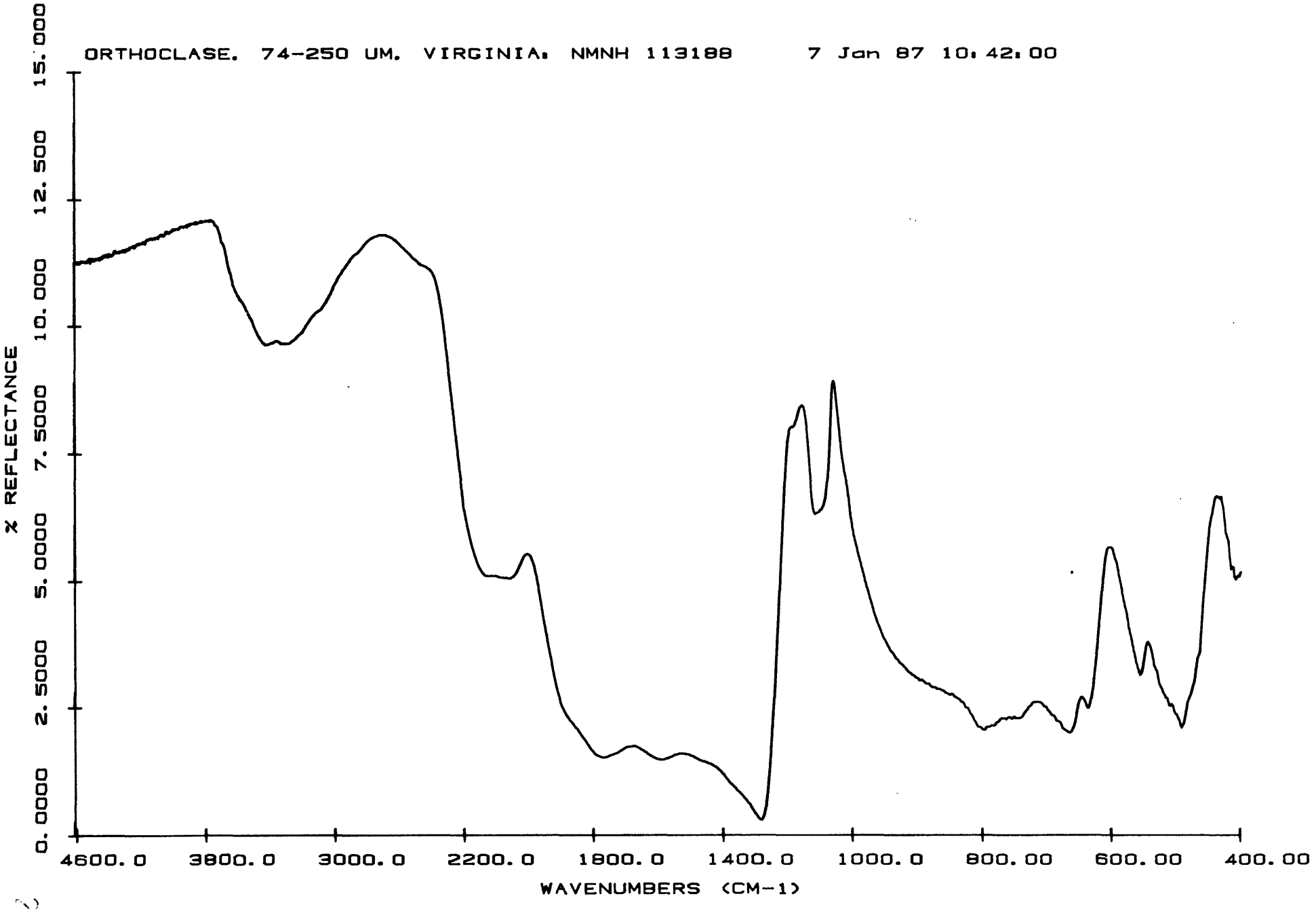
Orthoclase.3 Reflectance spectrum of face parallel to 001 on solid sample disk #1.
Orthoclase.3 Reflectance spectrum of face parallel to 010 on solid sample disk #1.
Orthoclase.3 Reflectance spectrum of fracture surface parallel to 100 on solid sample disk #1.
Orthoclase.3 Reflectance spectrum of 0-74 size range on disk #1.
Orthoclase.3 Reflectance spectrum of 74-250 um size range on disk #1.
Orthoclase.3 Transmittance spectrum on disk #1.

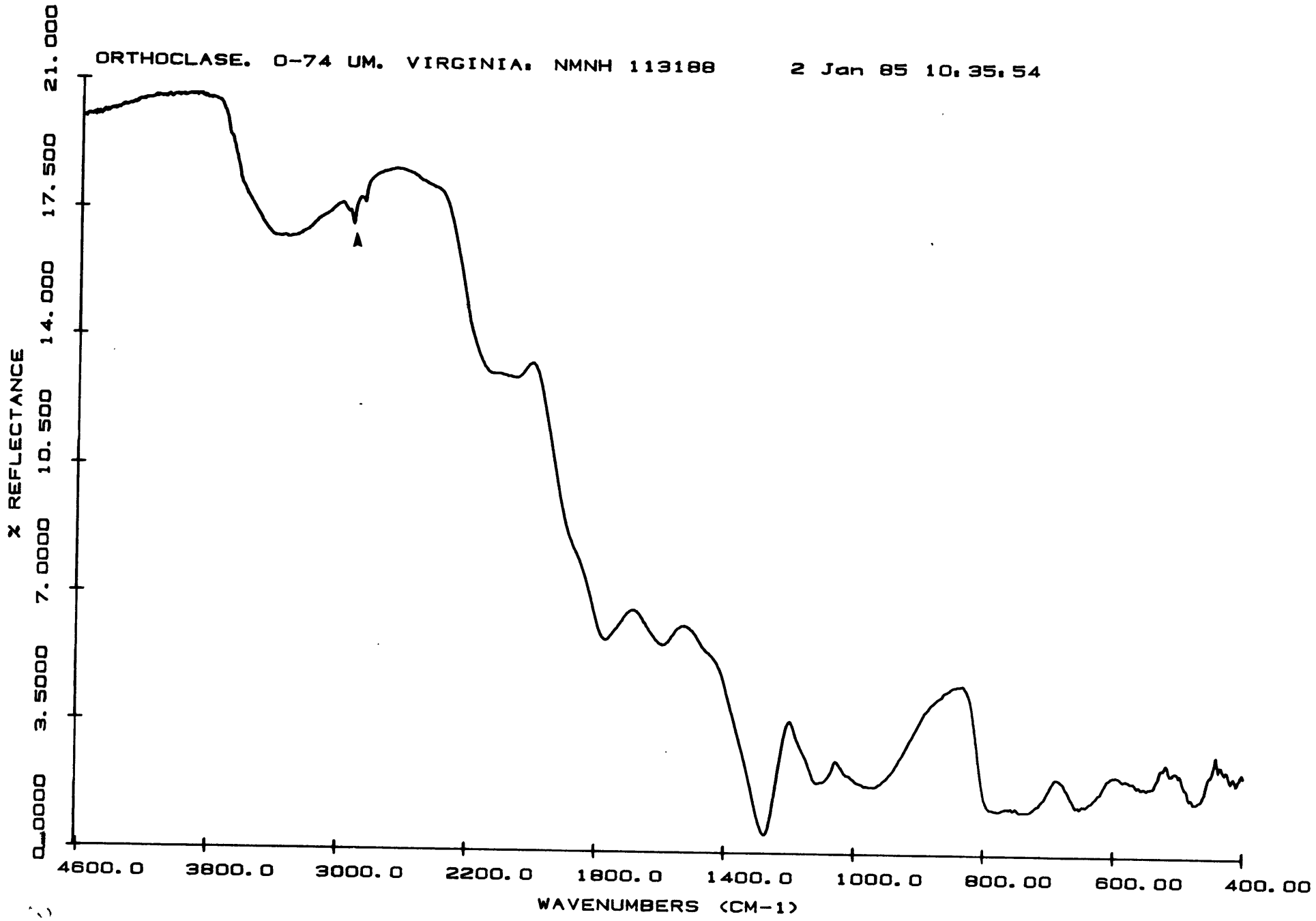

ORTHOCLASE IN KBR. VIRGINIA: NMNH 113188 14 Jan 85 12:33:26
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ORTHOCLASE. CLEAVAGE PARALLEL TO 001. VIRGINIA: NMNH 113188 10 Dec 85 10:38:09
% REFLECTANCE
0.0000
9.5000
19.000
28.500
38.000
47.500
57.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ORTHOCLASE. CLEAVAGE PARALLEL TO 010. VIRGINIA. NMNH 113188
10 Dec 85 11:07:31
% REFLECTANCE
45.000
37.500
30.000
22.500
15.000
7.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ORTHOCLASE. FRACTURE SURFACE. VIRGINIA: NMNH 113188 10 Dec 85 11:48:07
% REFLECTANCE
39.000
32.500
26.000
19.500
13.000
6.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ORTHOCLASE. 74-250 UM. VIRGINIA. NMNH 113188 7 Jan 87 10:42:00
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ORTHOCLASE. 0-74 UM. VIRGINIA. NMNH 113188
2 Jan 85 10:35:54
% REFLECTANCE
21.000
17.500
14.000
10.500
7.0000
3.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Pectolite $NaCa_2Si_3O_8$ (OH)

Locality: Thetford, Ontario, Canada

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 94865

Results of petrographic examination: Hand speciman consists of one small (1 mm x 1 cm) and one larger (5 mm x 6 mm x 1 cm) fragment. The larger one has a large area of albite (1/4 of sample). The rest is composed of pectolite needles. Under petrographic microscope, sample has 2% of an isotropic mineral. Fibrous nature of mineral precludes effective sieving. Fine fraction separated from coarse fraction by elutriation in acetone.

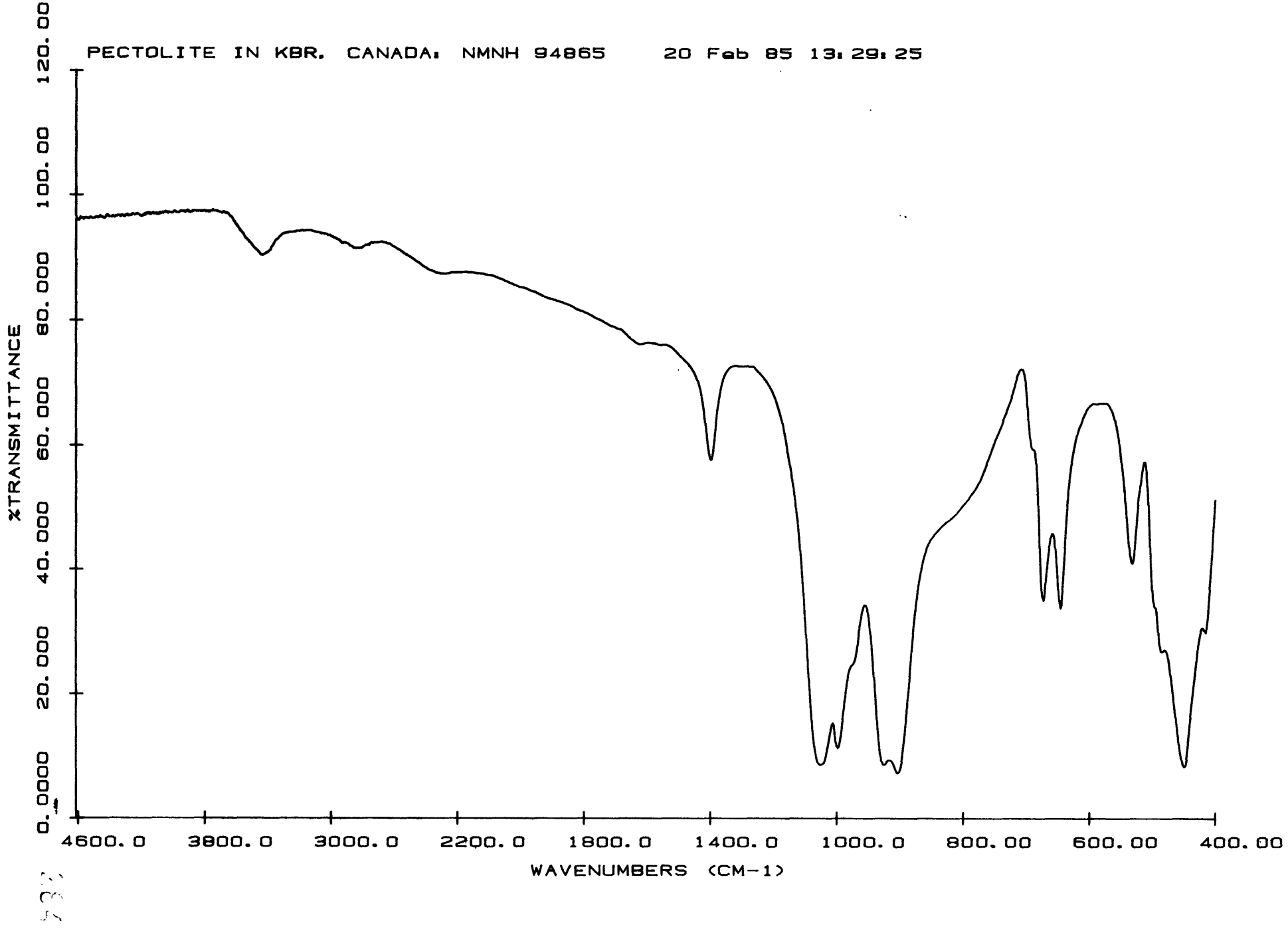
Results of XRD: Pure pectolite.

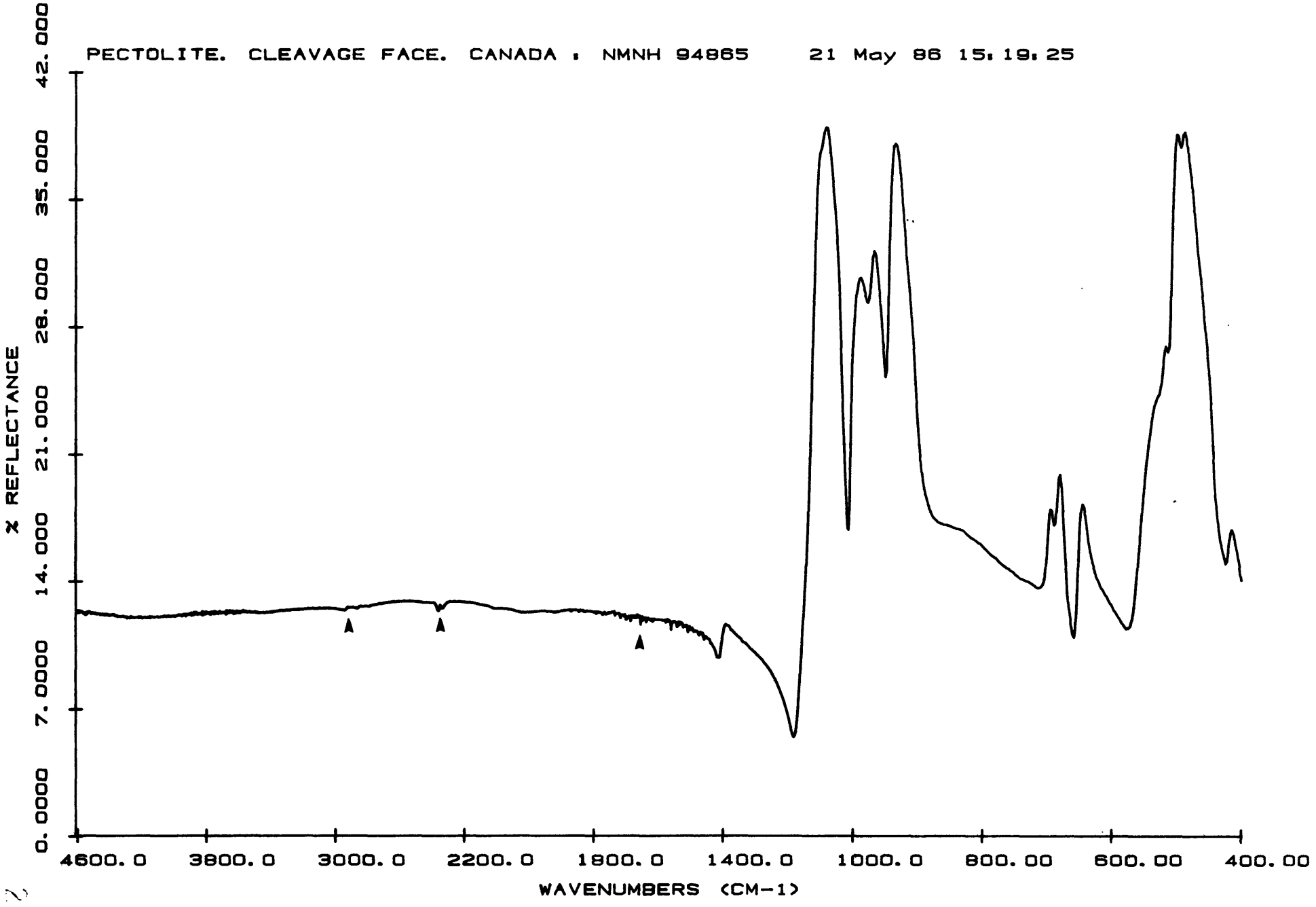
Results of XRF or other compositional analysis: Microprobe analysis found the sample homogeneous within and between grains of pectolite. An average of eight samples:

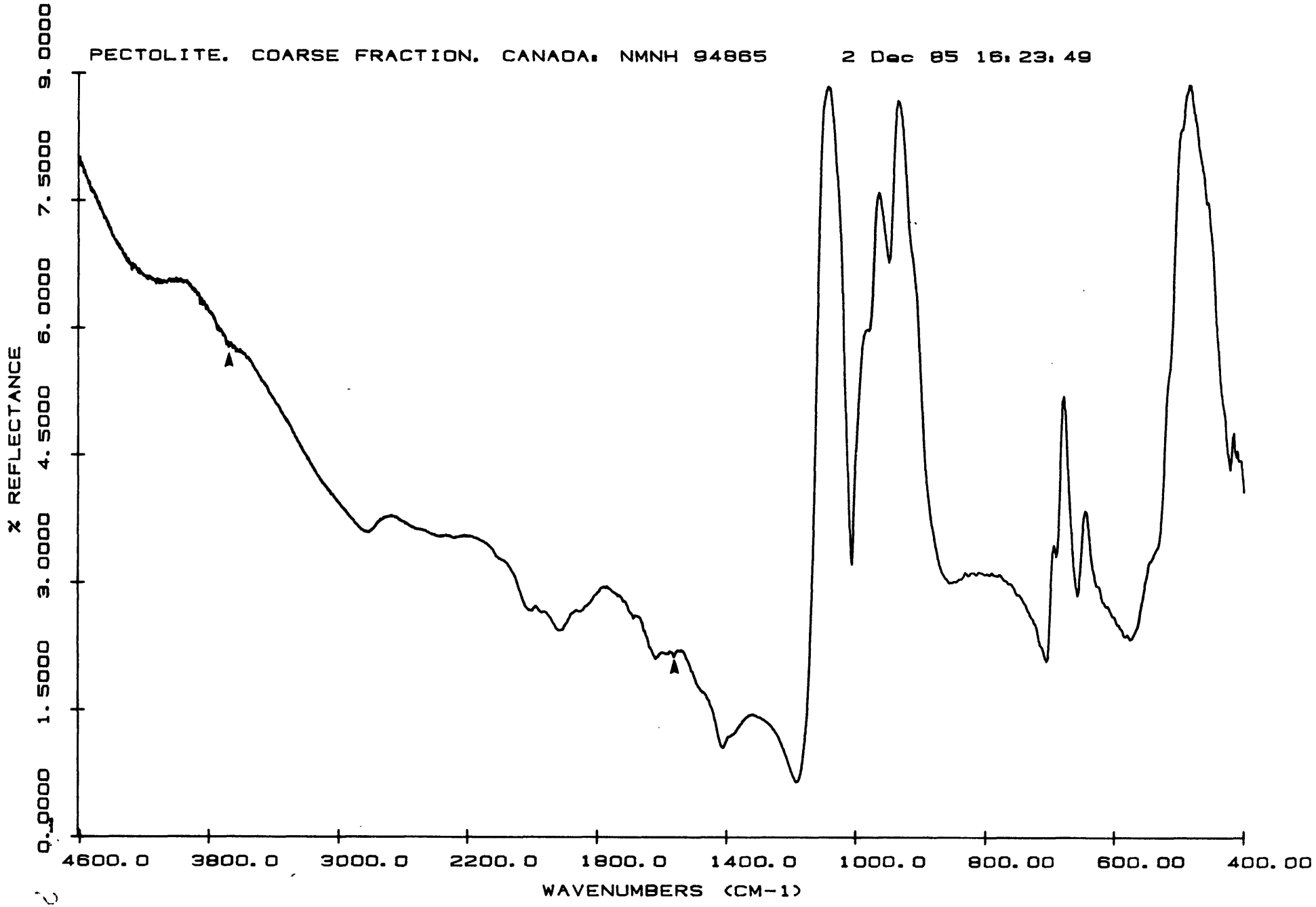
SiO_2	- 53.37
Al_2O_3	- 0.03
FeO	- 0.11
MgO	- 0.03
CaO	- 33.84
K_2O	- 0.01
Na_2O	- 9.61
TiO_2	- 0.01
MnO	- 0.03
Total	- 97.04

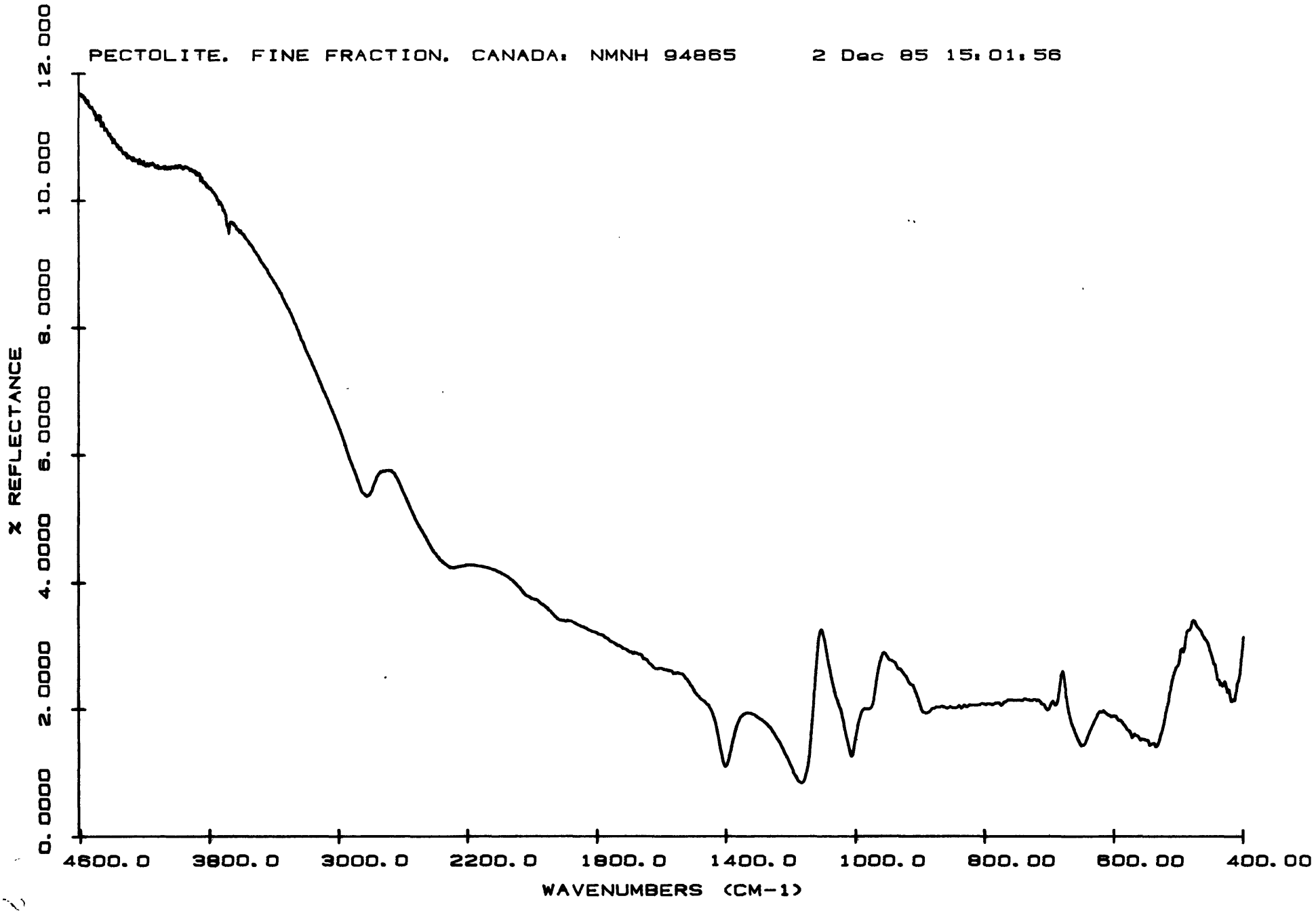
Spectra on file:

Pectolite.2 Reflectance spectrum of cleavage face on solid sample disk #1.
Pectolite.2 Reflectance spectrum of 0-74 um size range on disk #1.
Pectolite.2 Reflectance spectrum of 74-280 size range on disk #1.
Pectolite.2 Transmittance spectrum on disk #1.


PECTOLITE IN KBR. CANADA: NMNH 94865 20 Feb 85 13:29:25
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


PECTOLITE. CLEAVAGE FACE. CANADA : NMNH 94865 21 May 86 15:19:25
% REFLECTANCE
42.000
35.000
28.000
21.000
14.000
7.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


PECTOLITE. COARSE FRACTION. CANADA: NMNH 94865
2 Dec 85 16:23:49
% REFLECTANCE
9.0000
7.5000
6.0000
4.5000
3.0000
1.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


PECTOLITE. FINE FRACTION. CANADA: NMNH 94865 2 Dec 85 15:01:56
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Phlogopite $KMg_3Si_3AlO_{10}$ $(F, OH)_2$

Locality: Burgess, Ontario, Canada

Last donor: Bruce Hemingway

Ultimate donor: J.S. White, Smithsonian

Catalog numbers, etc.: NMNH 124158

Results of petrographic examination: Hand samples are cut rectangular sheets, copper colored and appear pure. Under petrographic microscope, sample also pure, clean.

Results of XRD: Pure phlogopite.

Results of XRF or other compositional analysis: See Robie, R.A. and Hemingway, B.S., 1984, Amer. Min., vol. 69, p. 858-868 Part of same sample:

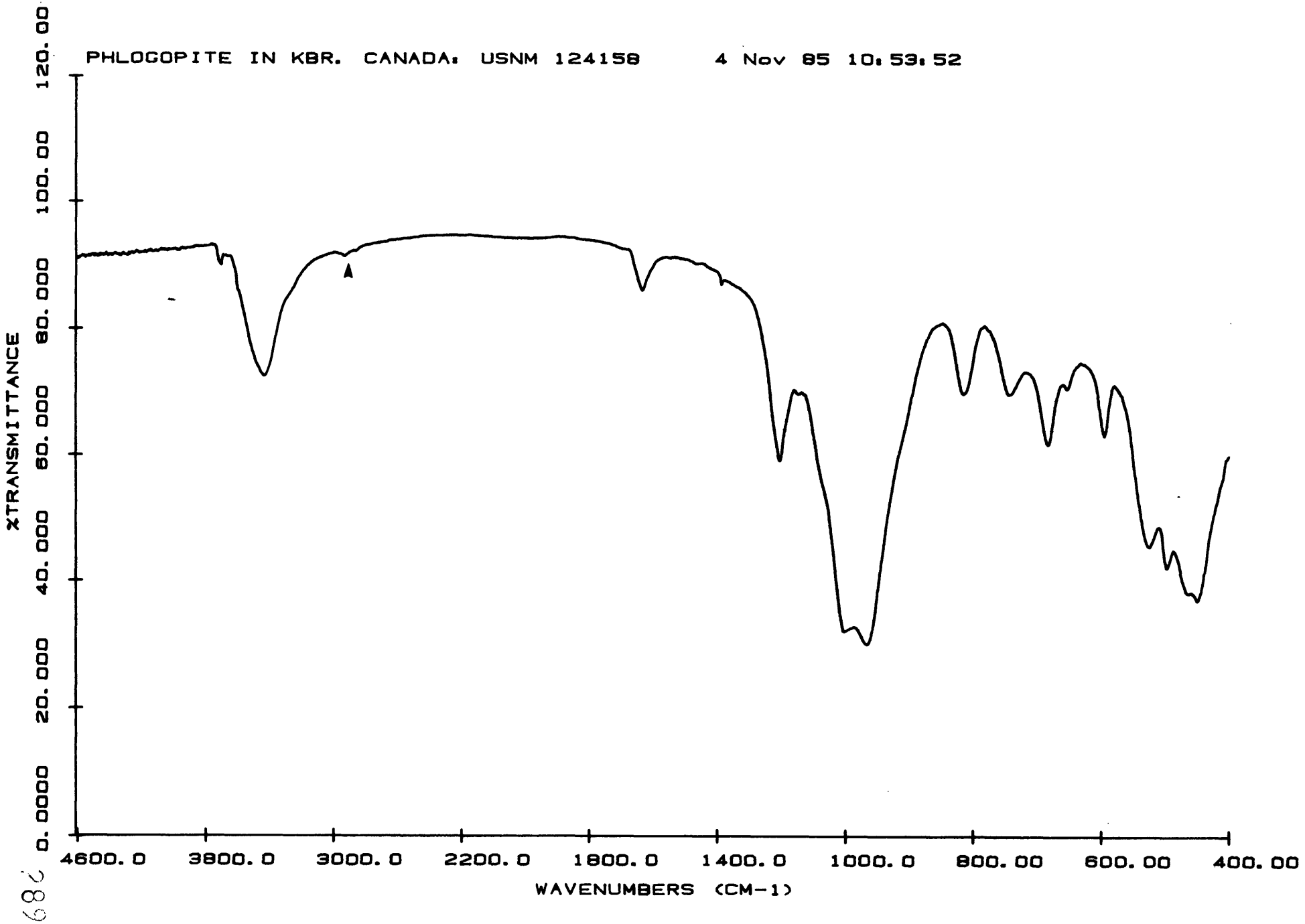
SiO_2 - 40.3
Al_2O_3 - 14.3
Fe_2O_3 - .63
FeO - 1.11
TiO_2 - 1.32
MnO - .03
MgO - 26.4
CaO - *.07
BaO - .16
Na_2O - .43
K_2O - 10.1
H_2O+ - 2.63
H_2O^- - .91
F - 3.2

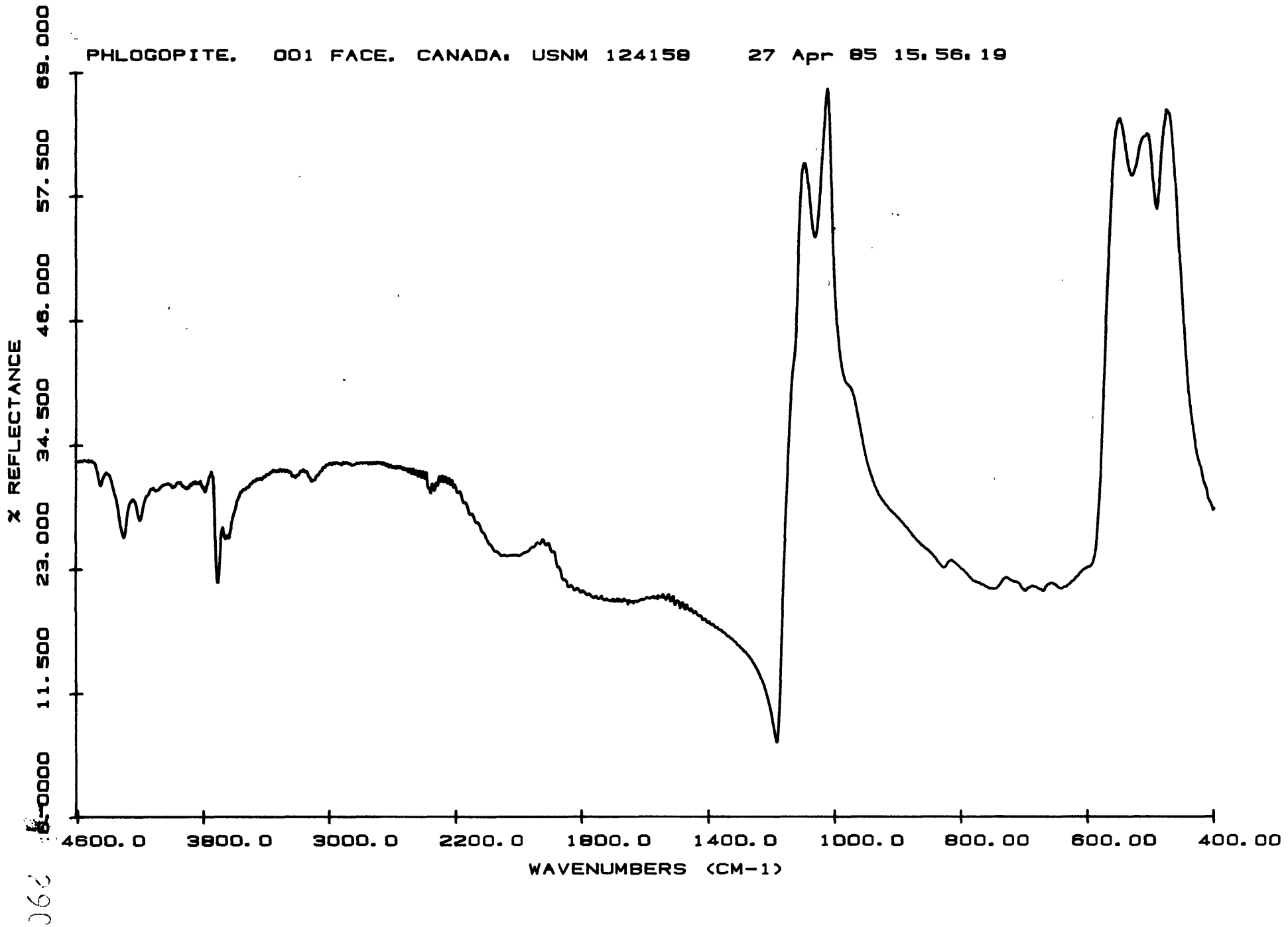
Microprobe analysis by L. Walter was on a single fragment because of sample preparation difficulties. Average of seven analyses:

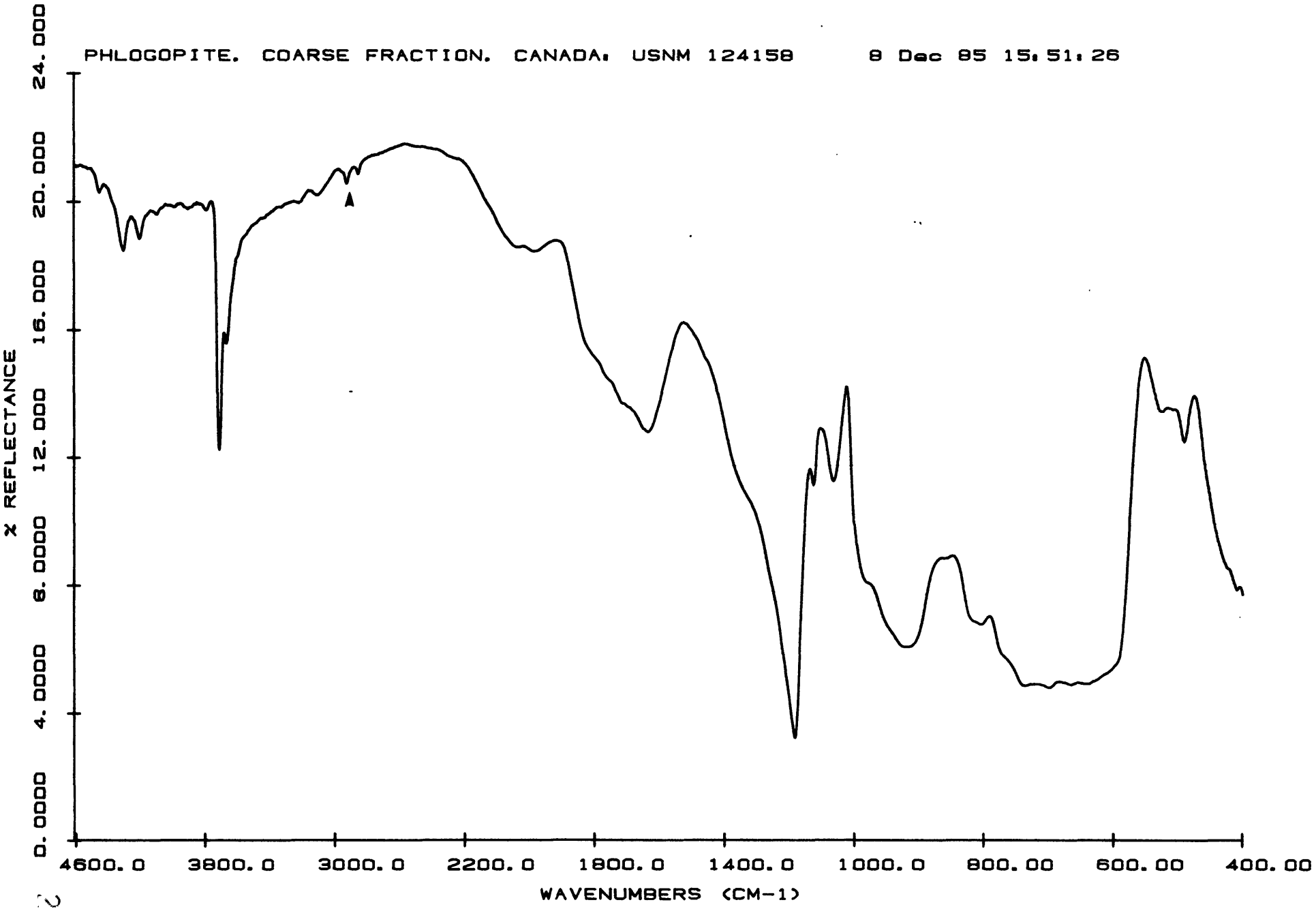
SiO_2 - 40.02
Al_2O_3 - 15.32
FeO - 1.97
MgO - 25.49
CaO - 0.01
K_2O - 10.26
Na_2O - 0.31
TiO_2 - 1.42
MnO - 0.04
Total - 94.84

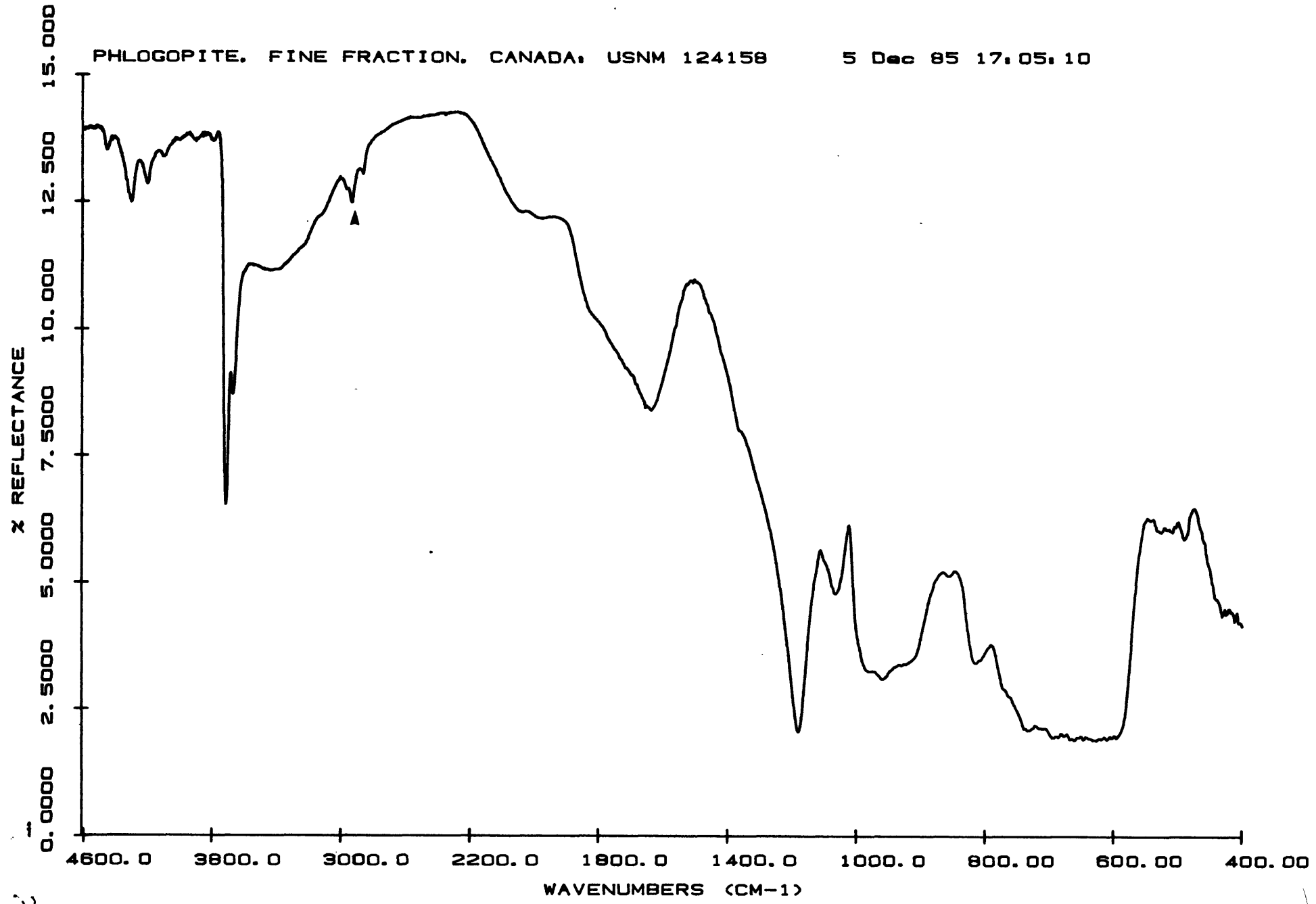
Spectra on file:

Phlogopite.1 Reflectance spectra from 001 face on solid sample disk #1.
Phlogopite.1 Reflectance spectra of 0-74 um size fraction on disk #1.
Phlogopite.1 Reflectance spectra of 74-250 um size fraction on disk #1.
Phlogopite.1 Transmittance spectrum on disk #1.


PHLOGOPITE IN KBR. CANADA: USNM 124158
4 Nov 85 10:53:52
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


PHLOGOPITE. 001 FACE. CANADA. USNM 124158 27 Apr 85 15:56:19
% REFLECTANCE
89.000
57.500
46.000
34.500
23.000
11.500
-0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


PHLOGOPITE. COARSE FRACTION. CANADA. USNM 124158
8 Dec 85 15:51:26
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


PHLOGOPITE. FINE FRACTION. CANADA: USNM 124158
5 Dec 85 17:05:10
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Pyrophyllite $Al_2Si_4O_{10}(OH)_2$

Locality: Staley, NC

Last donor: Bruce Hemingway

Intermediate donor:

Ultimate donor: E-an Zen, USGS

Catalog numbers, etc.: None

Results of petrographic examination: Hand samples are clusters of white radiating acicular crystals which appear pure. Under petrographic microscope, sample also pure, clean. Acicular crystals could not be effectively sifted and coarse fraction was separated from fine fraction by elutriation in acetone.

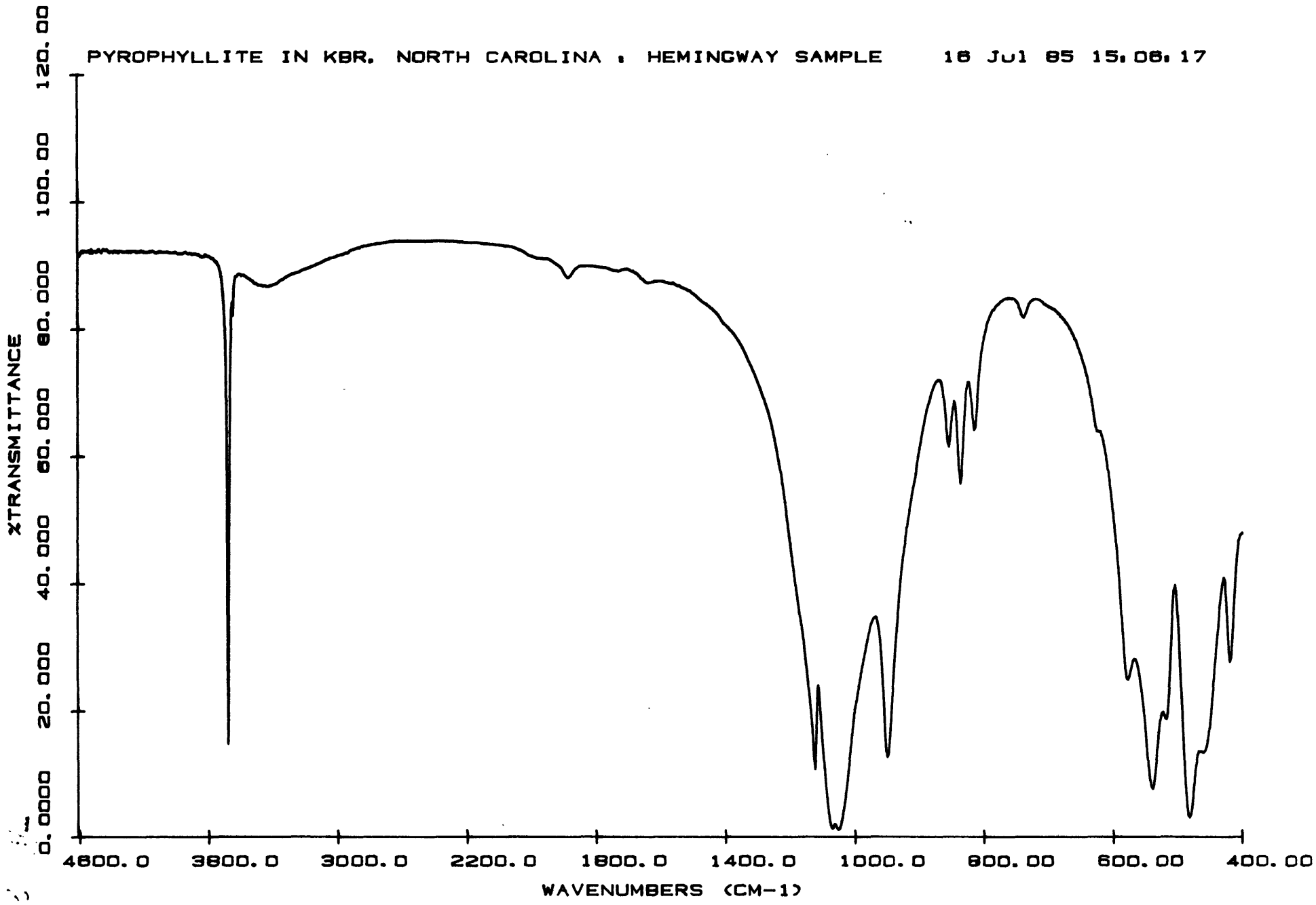
Results of XRD: Pure pyrophyllite.

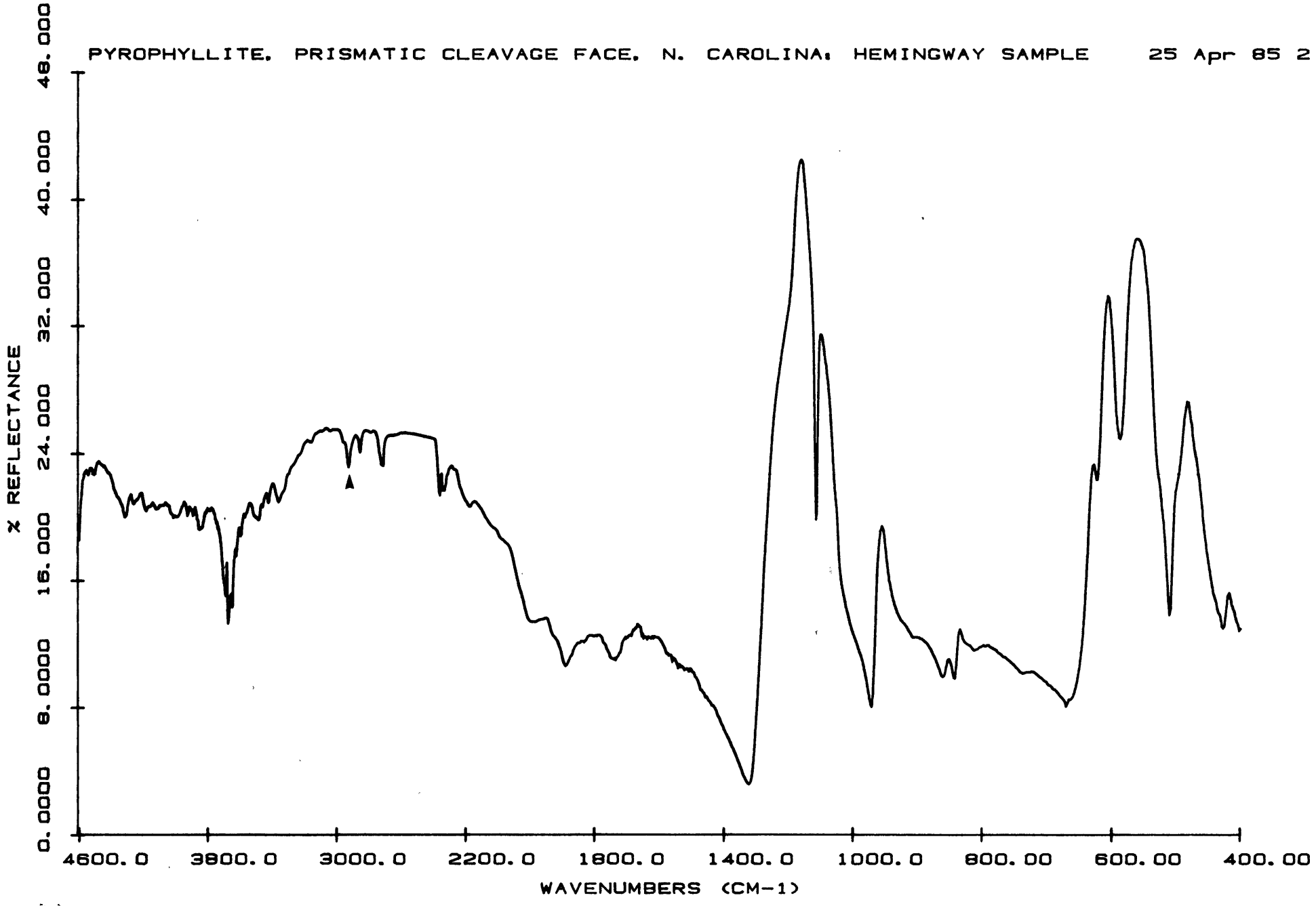
Results of XRF or other compositional analysis: See Robie, R.A. and Hemingway, B.S., 1976, Jour. Res. U.S. Geol. Durv., vol. 4, no. 6, p. 631-644. Part of same sample yielded: (note: a second rapid rock analysis also detected .01 P_2O_5, .01 CO_2 and .03 F).

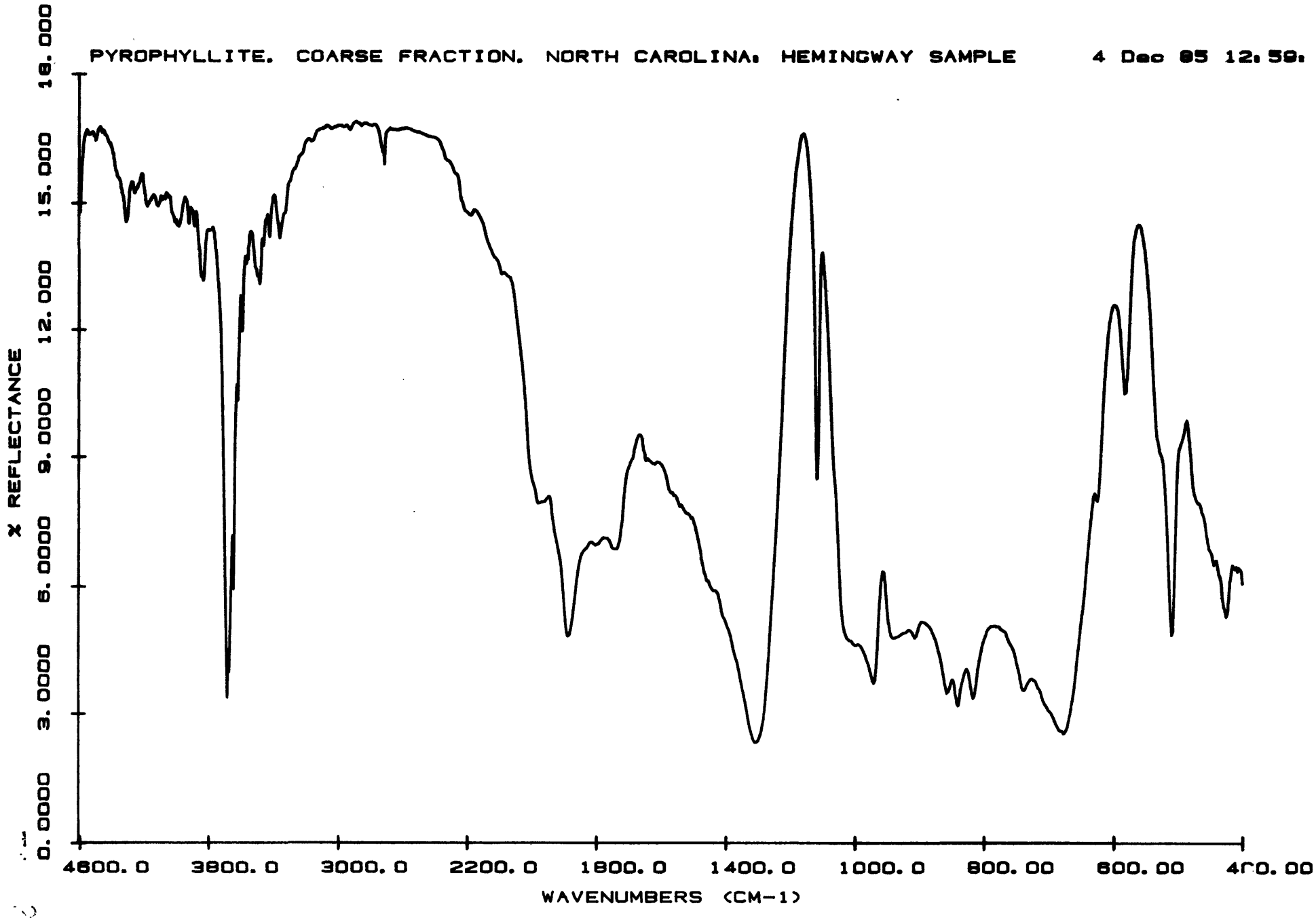
SiO_2	- 66.32
Al_2O_3	- 28.27
Fe_2O_3	- .32
FeO	- .03
MgO	- .07
CaO	-
Na_2O	- .05
K_2O	- .02
H_2O+	- 4.94
H_2O^-	-
TiO_2	- .01

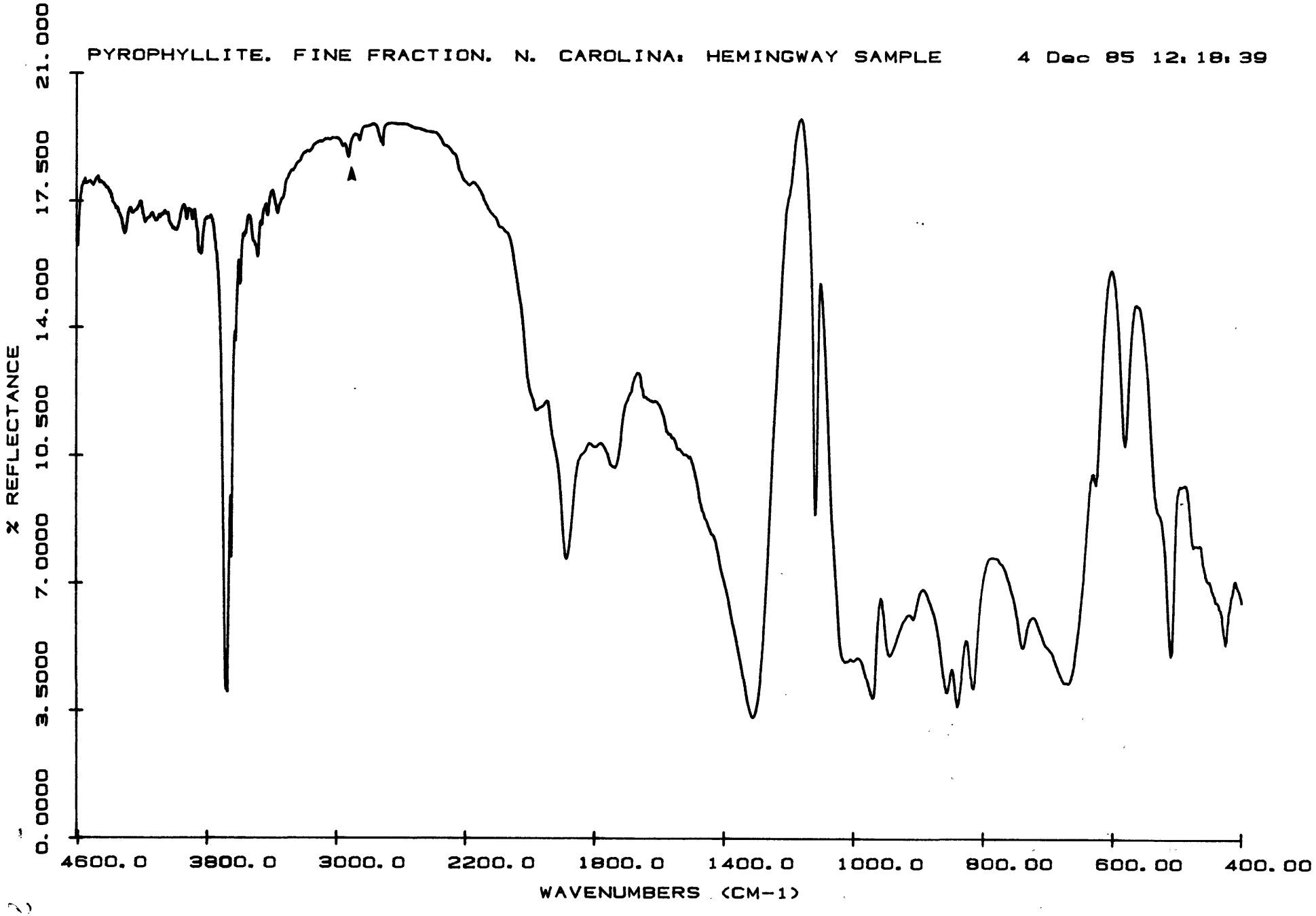
Spectra on file:

Pyrophyllite.1	Reflectance spectrum from the prismatic cleavage side of a cluster of radiating acicular crystals on solid sample disk #1.
Pyrophyllite.1	Reflectance spectrum of 0-74 um size range on disk #1.
Pyrophyllite.1	Reflectance spectrum of 74-250 um size range on disk #1.
Pyrophyllite.1	Transmittance spectrum on disk #1.


PYROPHYLLITE IN KBR. NORTH CAROLINA : HEMINGWAY SAMPLE 16 Jul 85 15:06:17
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


PYROPHYLLITE. PRISMATIC CLEAVAGE FACE. N. CAROLINA: HEMINGWAY SAMPLE 25 Apr 85 2
% REFLECTANCE
48.000
40.000
32.000
24.000
16.000
8.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


PYROPHYLLITE. COARSE FRACTION. NORTH CAROLINA: HEMINGWAY SAMPLE
4 Dec 85 12:59:
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


PYROPHYLLITE. FINE FRACTION. N. CAROLINA: HEMINGWAY SAMPLE
4 Dec 85 12:18:39
% REFLECTANCE
21.000
17.500
14.000
10.500
7.0000
3.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Quartz SiO_2

Locality: Brazil

Last donor: Bruce Hemingway

Intermediate donor:

Ultimate donor:

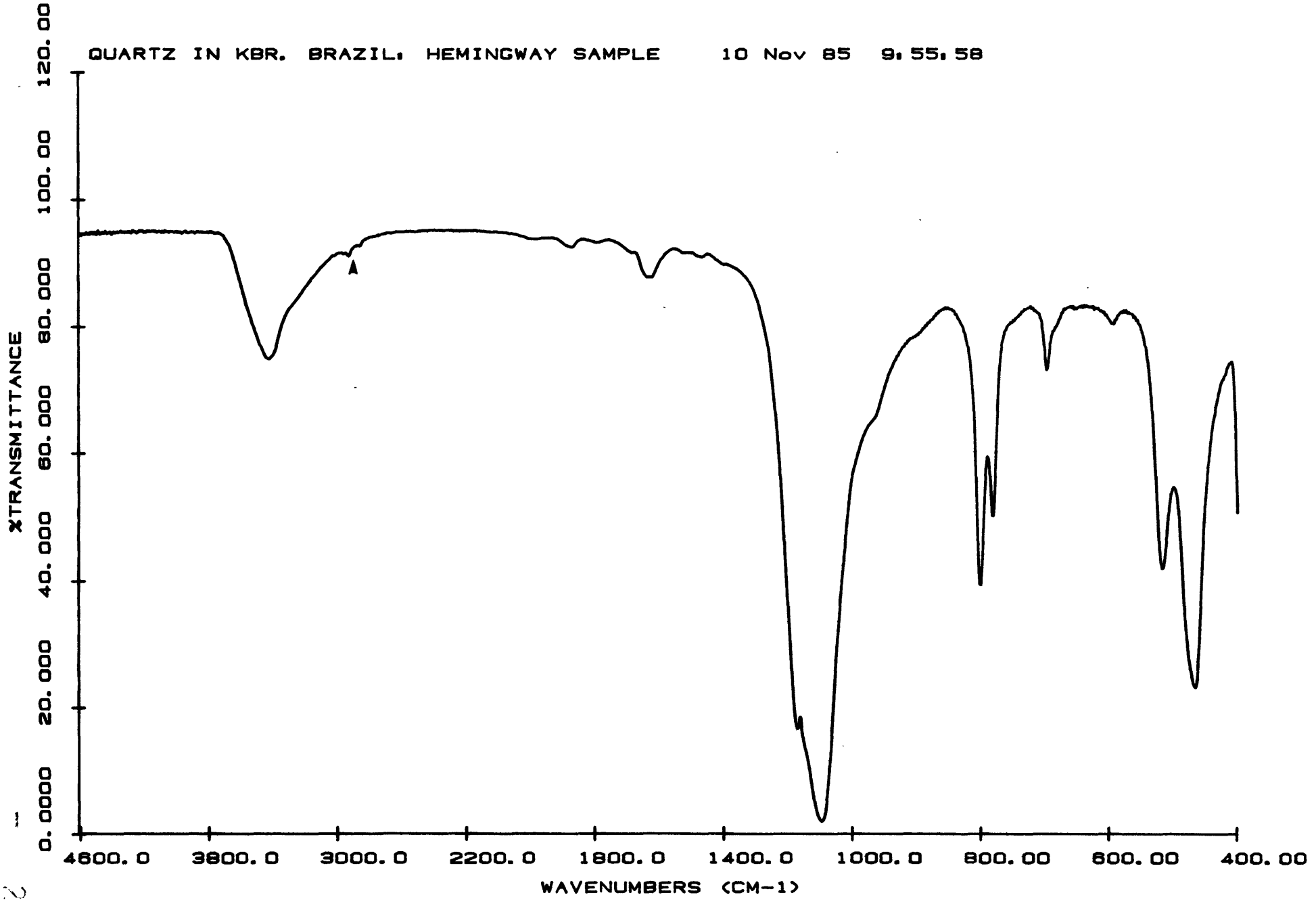
Catalog numbers, etc.: None

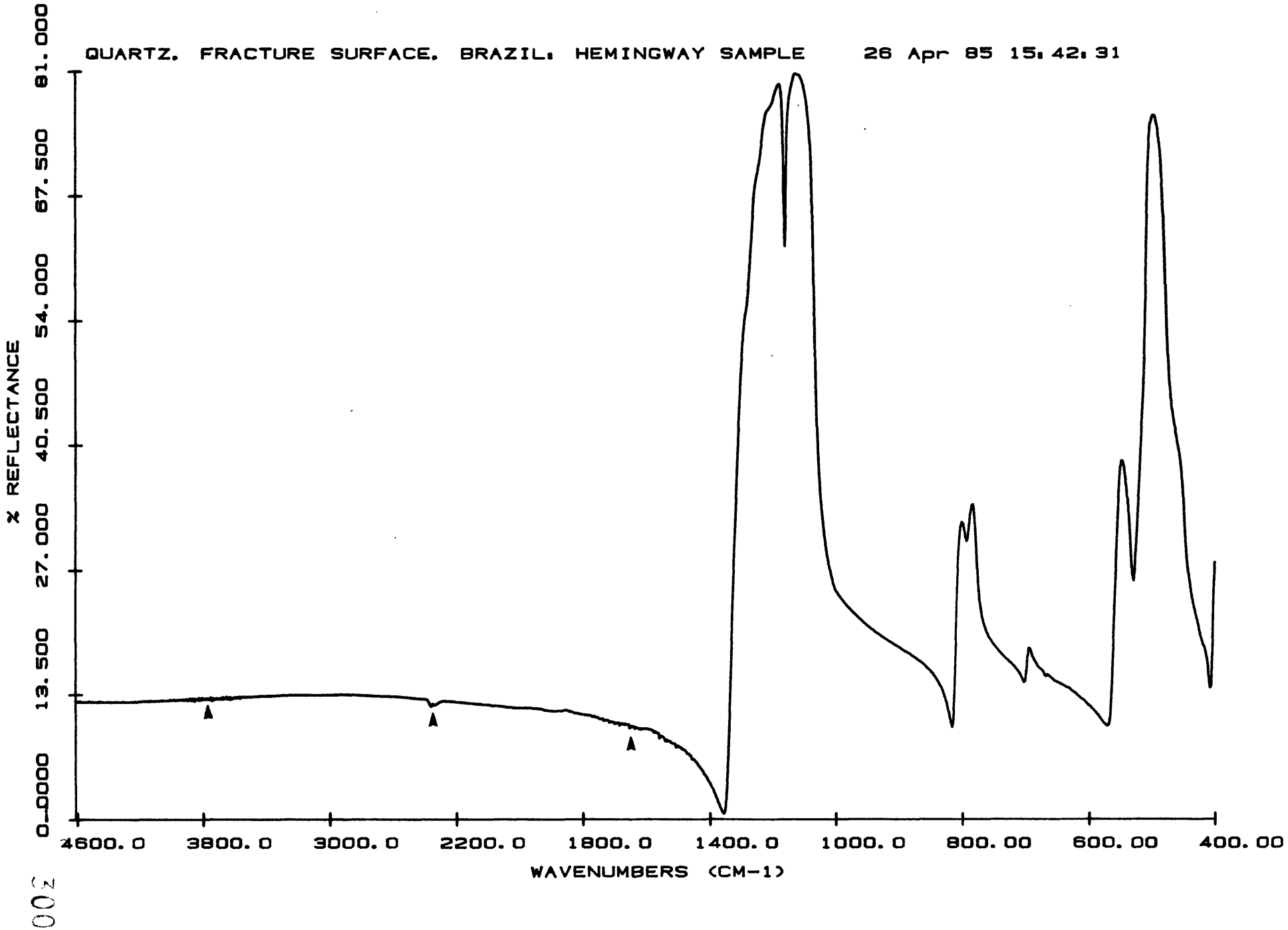
Results of petrographic examination: Hand sample appears entirely pure, being a clear and transparent fragment of a single crystal. Under petrographic microscope, sample also pure and clear.

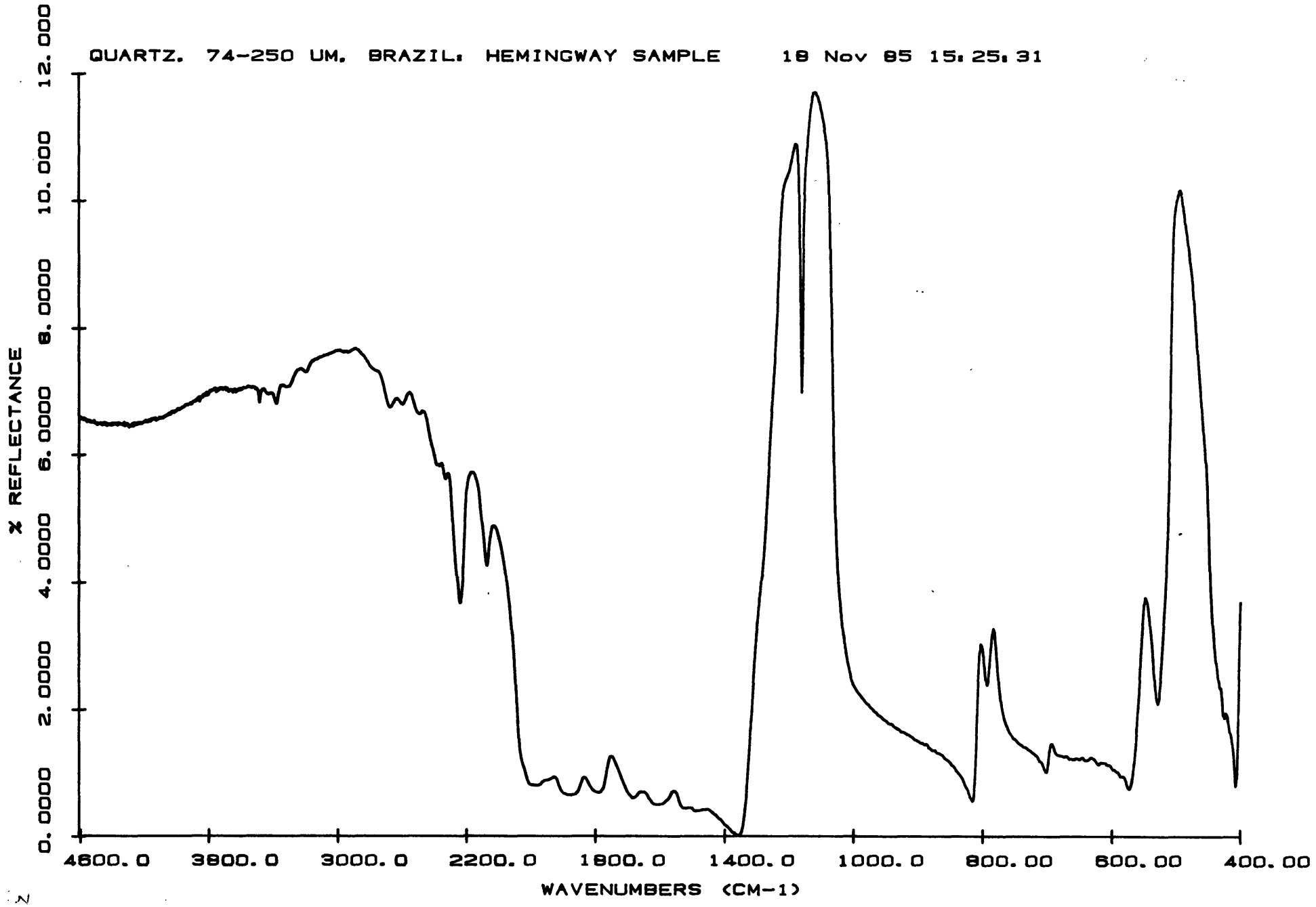
Results of XRD: Pure quartz.

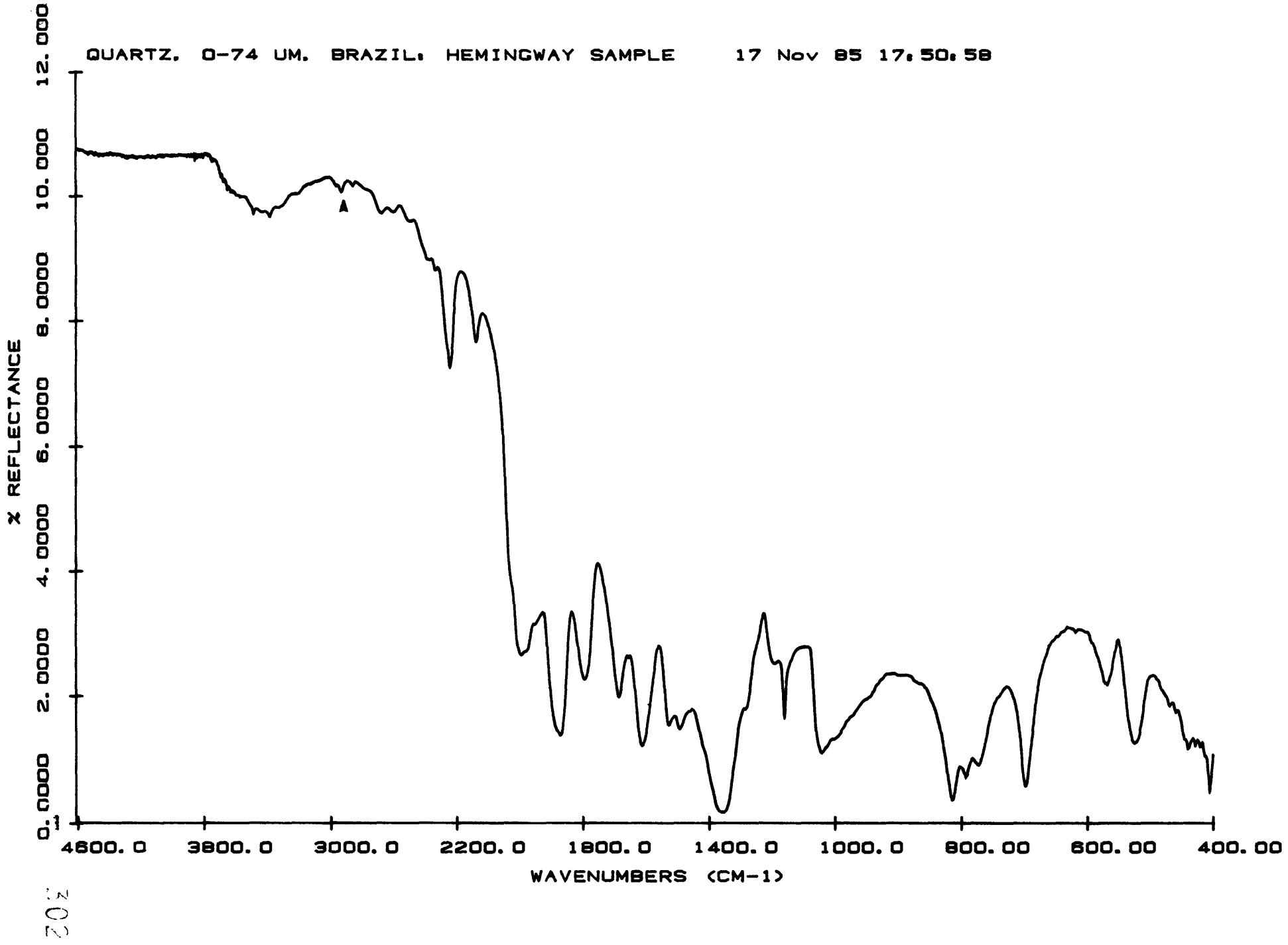
Results of XRF or other compositional analysis: Essentially pure SiO_2 within the limits of microprobe error.

Spectra on file:
Quartz.1 Reflectance spectrum of random fracture surface on disk #1.
Quartz.1 Reflectance spectrum of 0-74 um size range on disk #1.
Quartz.1 Reflectance spectrum of 74-250 um size range on disk #1.
Quartz.1 Transmittance on disk #1.


QUARTZ IN KBR. BRAZIL. HEMINGWAY SAMPLE 10 Nov 85 9:55:58
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


QUARTZ. FRACTURE SURFACE. BRAZIL: HEMINGWAY SAMPLE 26 Apr 85 15:42:31
% REFLECTANCE
81.000
67.500
54.000
40.500
27.000
13.500
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


QUARTZ. 74-250 UM. BRAZIL: HEMINGWAY SAMPLE 18 Nov 85 15:25:31
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


QUARTZ. 0-74 UM. BRAZIL. HEMINGWAY SAMPLE 17 Nov 85 17:50:58
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Quartz SiO_2

Locality: Rock Springs, Arkansas

Last donor: Hunt and Salisbury

Intermediate donor:

Ultimate donor: Ward's Scientific

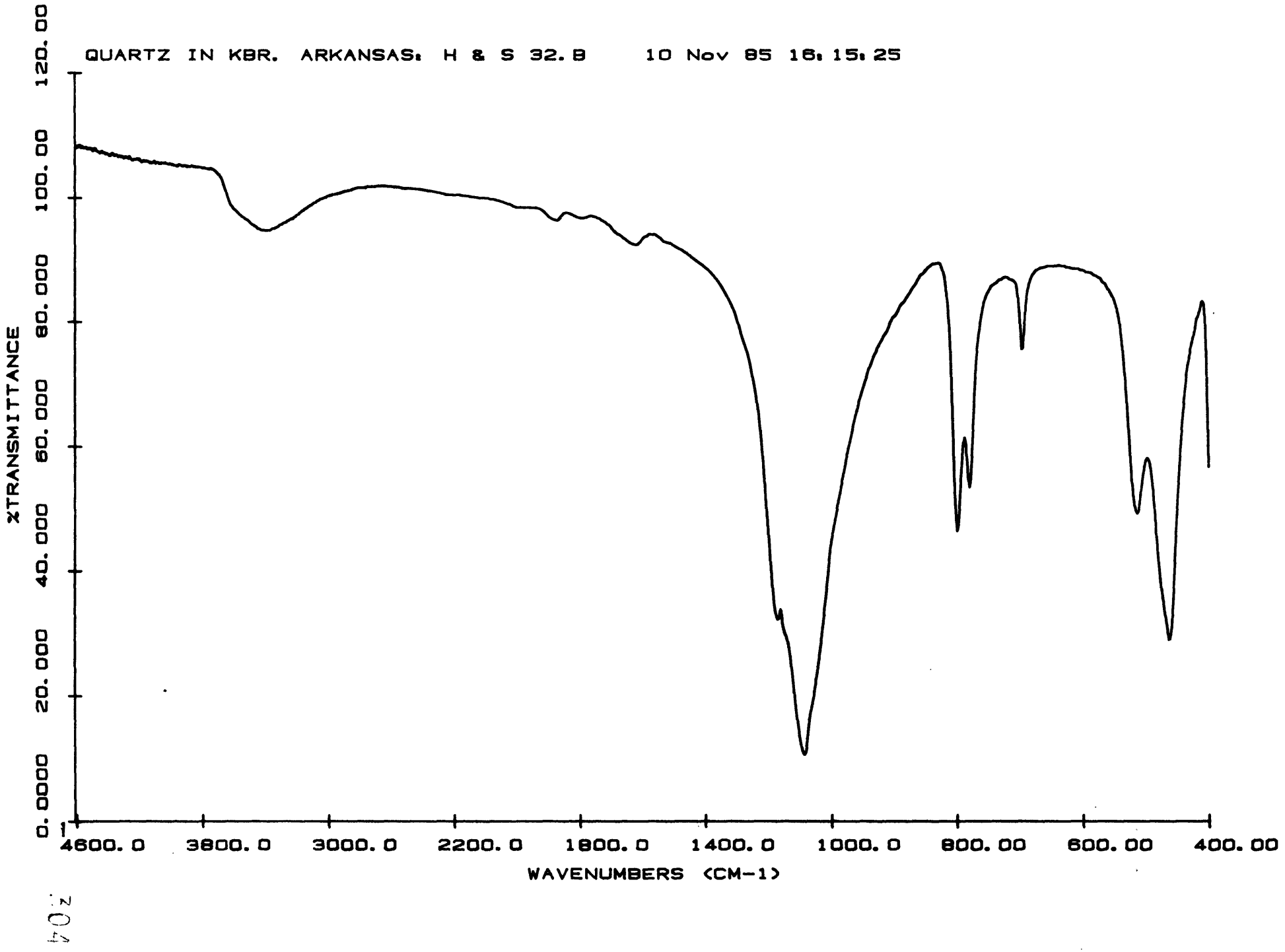
Catalog numbers, etc.: H and S 32B

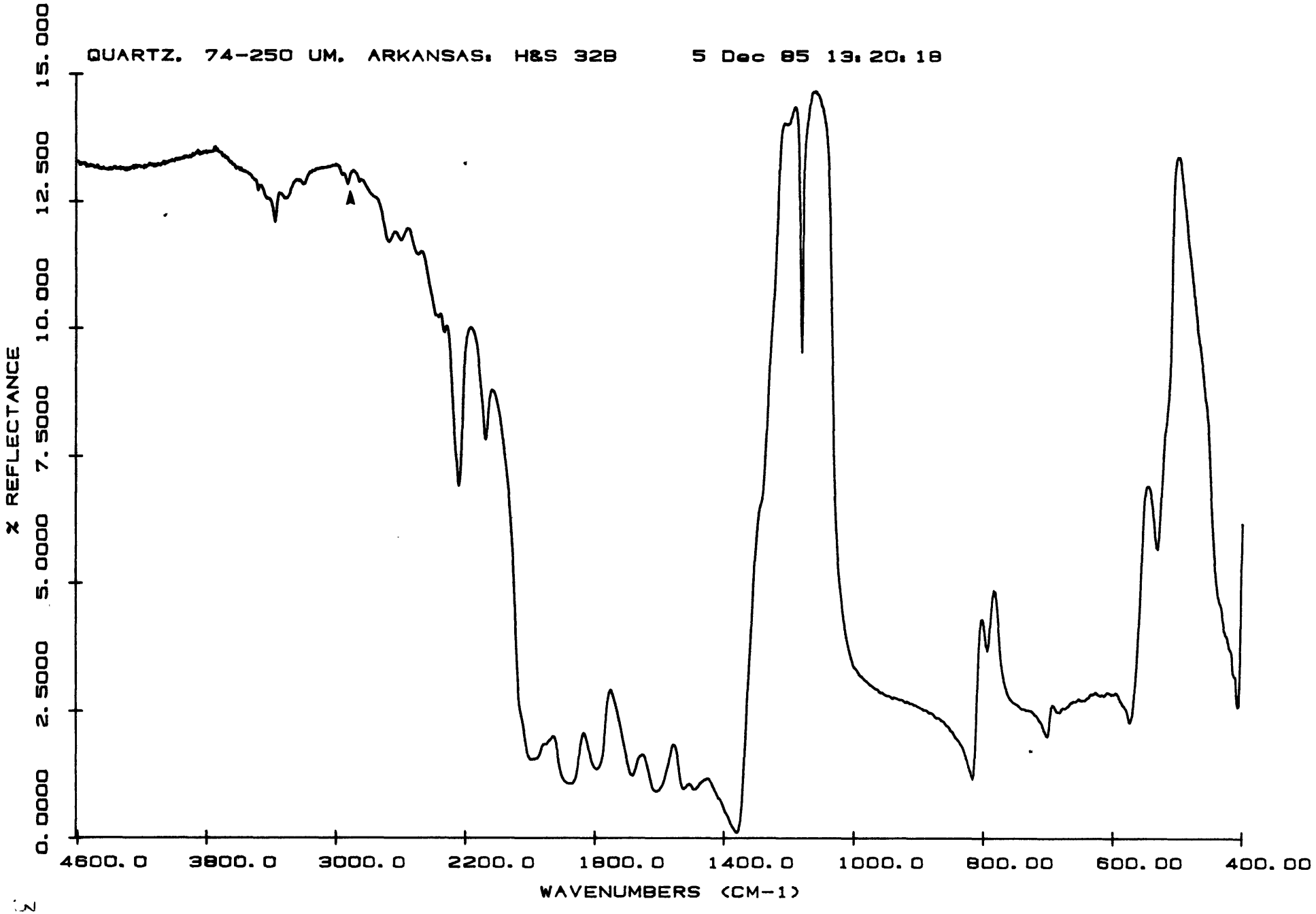
Results of petrographic examination: Crystal clear quartz.

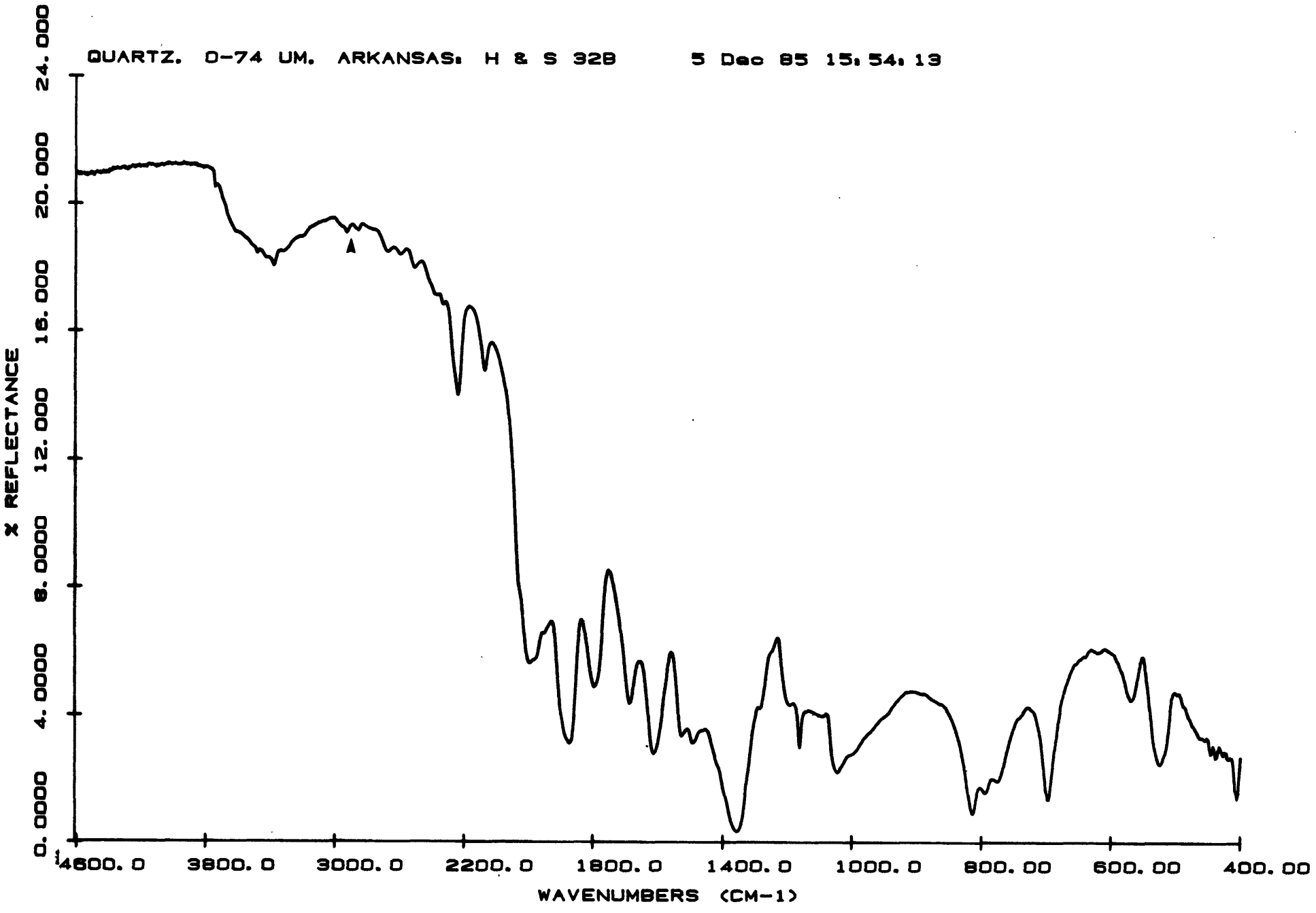
Results of XRD: Pure quartz.

Results of XRF or other compositional analysis: Essentially pure SiO_2 within the limit of microprobe error.

Spectra on file:
Quartz.2 Reflectance spectrum of 0-74 um size range on disk #1.
Quartz.2 Reflectance spectrum of 74-250 um size range on disk #1.
Quartz.2 Transmittance spectrum on disk #1.


QUARTZ IN KBR. ARKANSAS: H & S 32.8 10 Nov 85 16:15:25
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


QUARTZ. 74-250 UM. ARKANSAS: H&S 328
5 Dec 85 13:20:18
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


QUARTZ. 0-74 UM. ARKANSAS: H & S 328
5 Dec 85 15:54:13
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Rhodonite (Mn^{+2}, Fe^{+2}, Mg, Ca) SiO_3

Locality: Franklin, New Jersey

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH C6148

Results of petrographic examination: Hand sample is composed of two fragments, each about 2 cm x 2 cm x 1 cm. About one third of each is host rock on which the rhodonite crystals grow. This was removed by sawing to free pure rhodonite. Under petrographic microscope, many of the grains show a small degree of alteration (not identified).

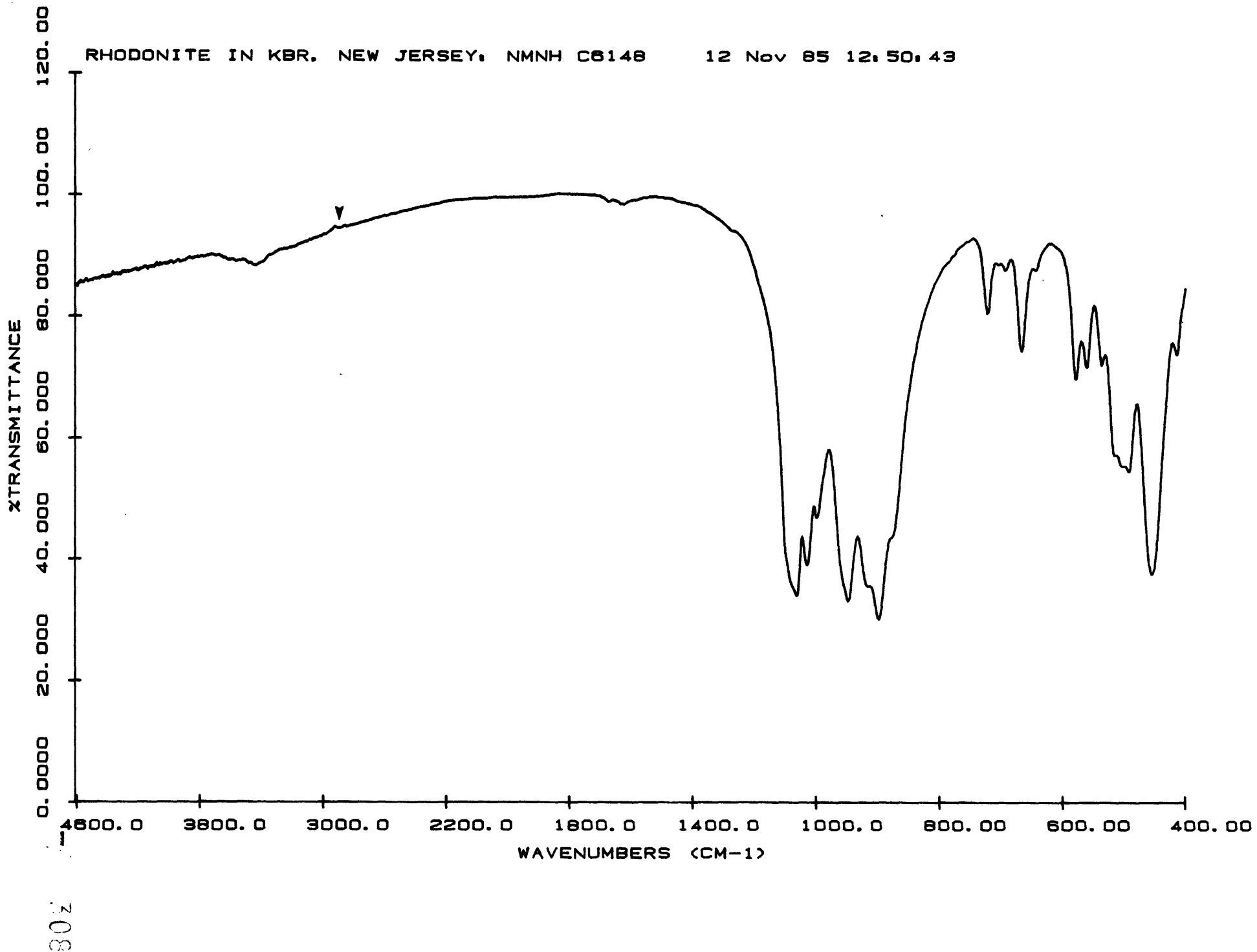
Results of XRD: Pure rhodonite.

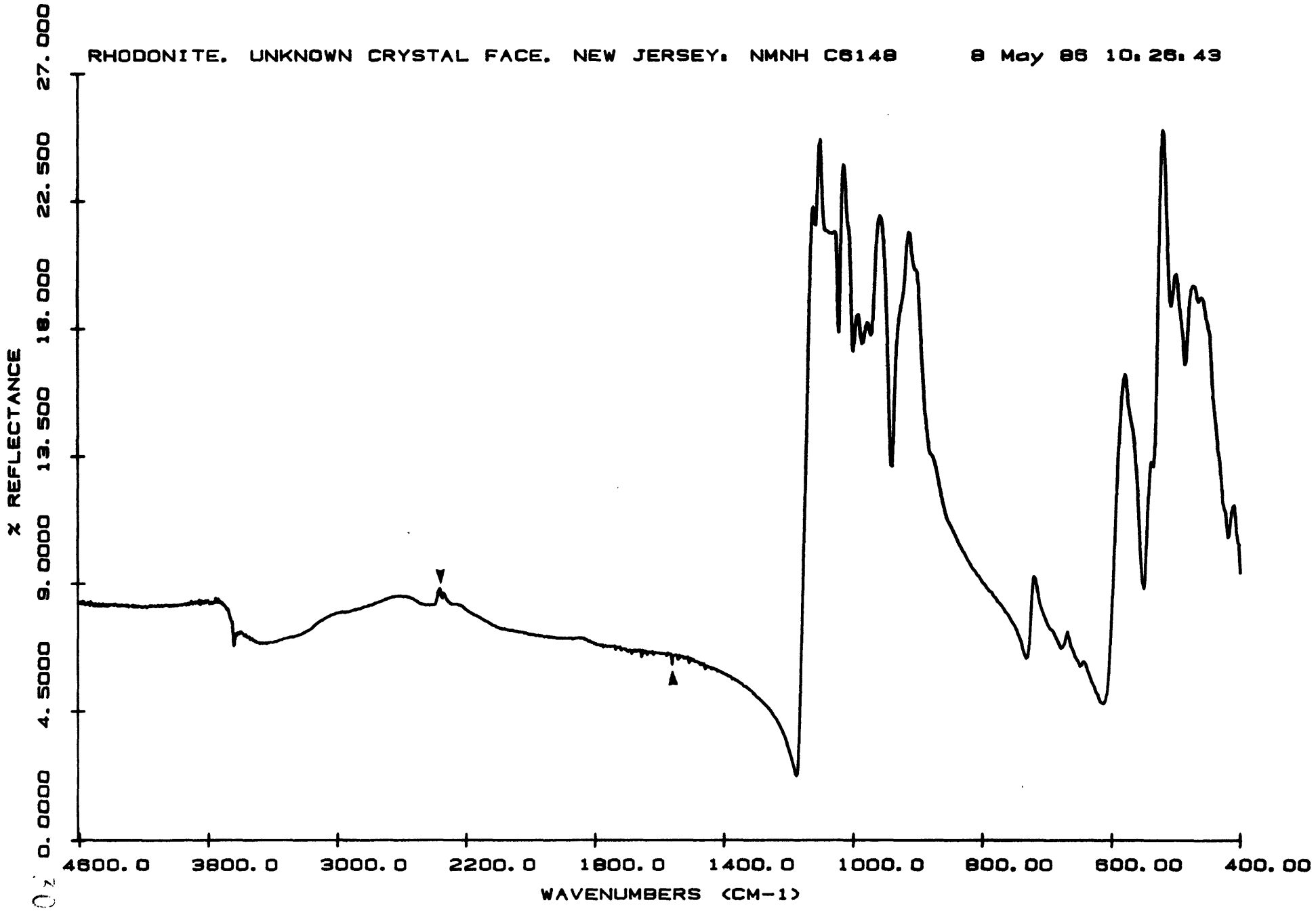
Results of XRF or other compositional analysis: Microprobe analysis shows samples is homogeneous between and within grains. Average of six analyses:

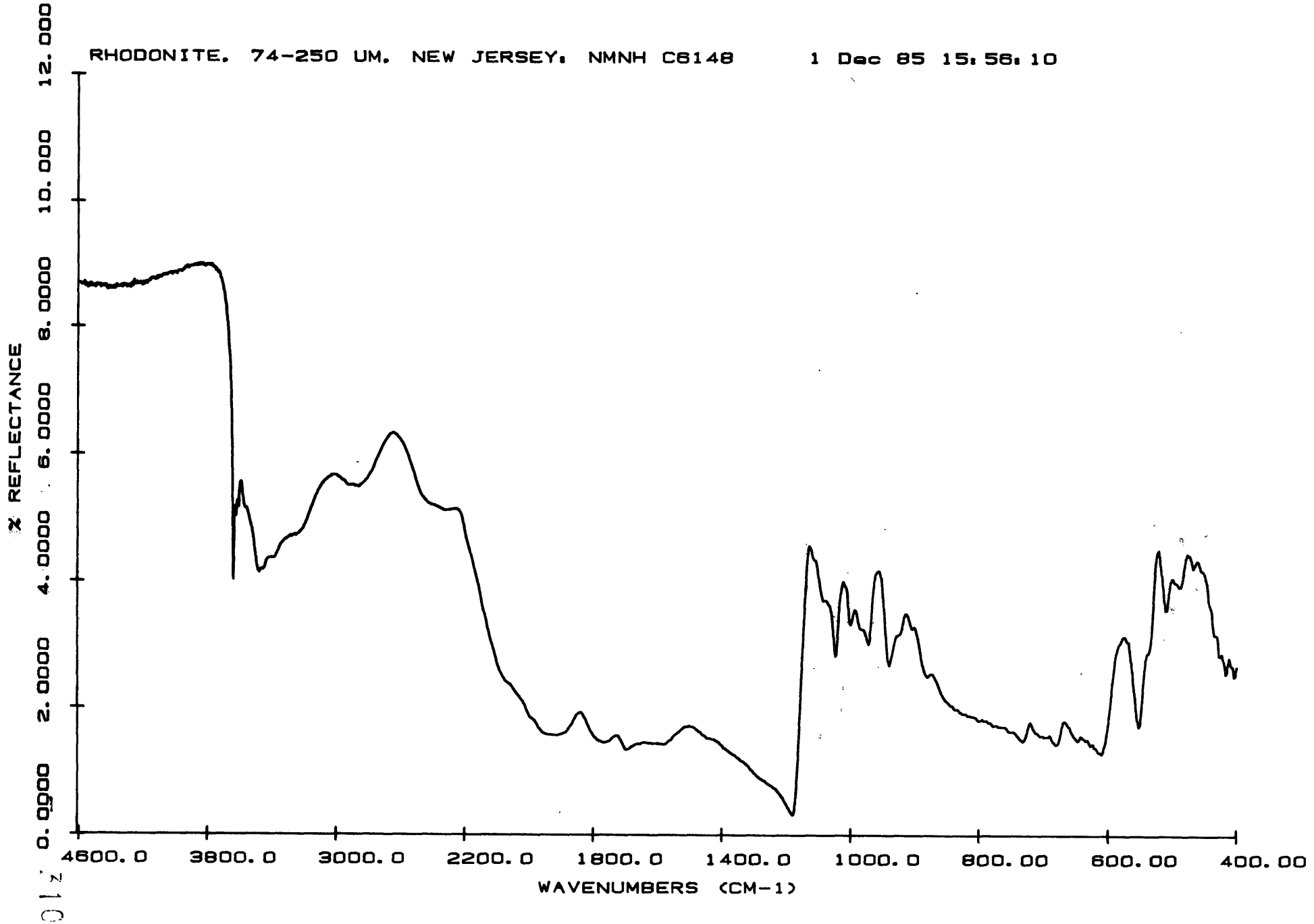
SiO_2	- 46.30
Al_2O_3	- 0.05
FeO	- 0.50
MgO	- 0.41
CaO	- 8.27
K_2O	- 0.04
Na_2O	- 0.28
TiO_2	- 0.07
MnO	- 40.17
Total	- 96.09

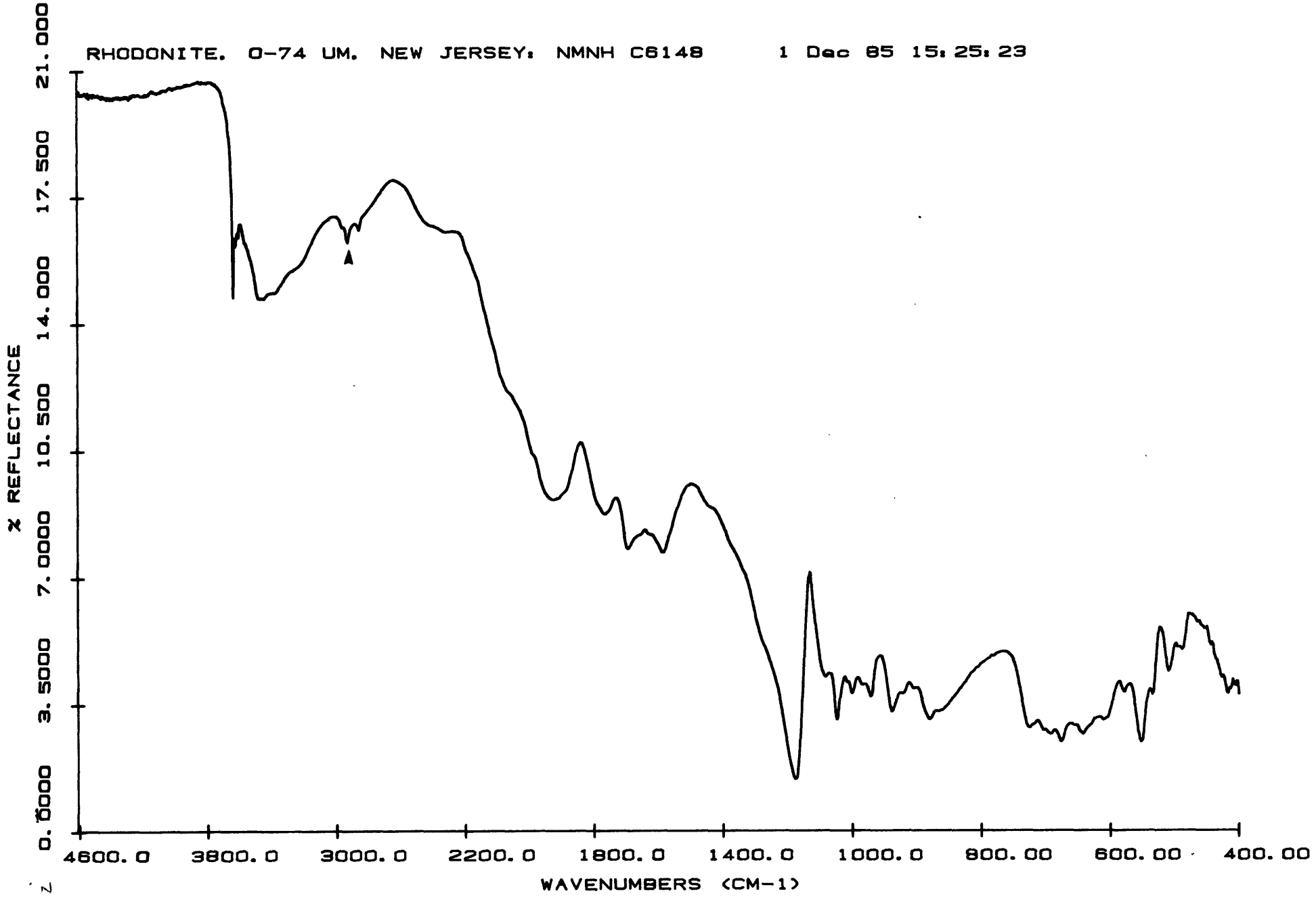
Spectra on file:

Rhodonite.1 Reflectance spectrum of crystal mass on solid sample disk #1.
Rhodonite.1 Reflectance of 74-250 um size fraction on disk #1.
Rhodonite.1 Reflectance of 0-74 um size range on disk #1.
Rhodonite.1 Transmittance spectrum on disk #1.


RHODONITE IN KBR. NEW JERSEY. NMNH C6148 12 Nov 85 12:50:43
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


RHODONITE. UNKNOWN CRYSTAL FACE. NEW JERSEY: NMNH C6148
8 May 86 10:26:43
% REFLECTANCE
27.000
22.500
18.000
13.500
9.0000
4.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


RHODONITE. 74-250 UM. NEW JERSEY: NMNH C6148
1 Dec 85 15:58:10
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


RHODONITE. 0-74 UM. NEW JERSEY: NMNH C6148 1 Dec 85 15:25:23
% REFLECTANCE
21.000
17.500
14.000
10.500
7.0000
3.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Richterite $Na_2Ca(Mg,Fe^{+2})_5Si_8O_{22}(OH)_2$

Locality: Wilberforce, Ontario, Canada

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 150800

Results of petrographic examination: Two large (6.49 and 6.45 g) pieces and 2 fragments (4.18 g), black in color. Parts of single crystals. One fragment has large white (calcite) contamination. Crystals also have generally small blotchy inclusions of calcite. Crushed sampled treated with HCl.

Under the microscope, individual crystals before treatment appear clean and pure except for about 1% calcite impurities.

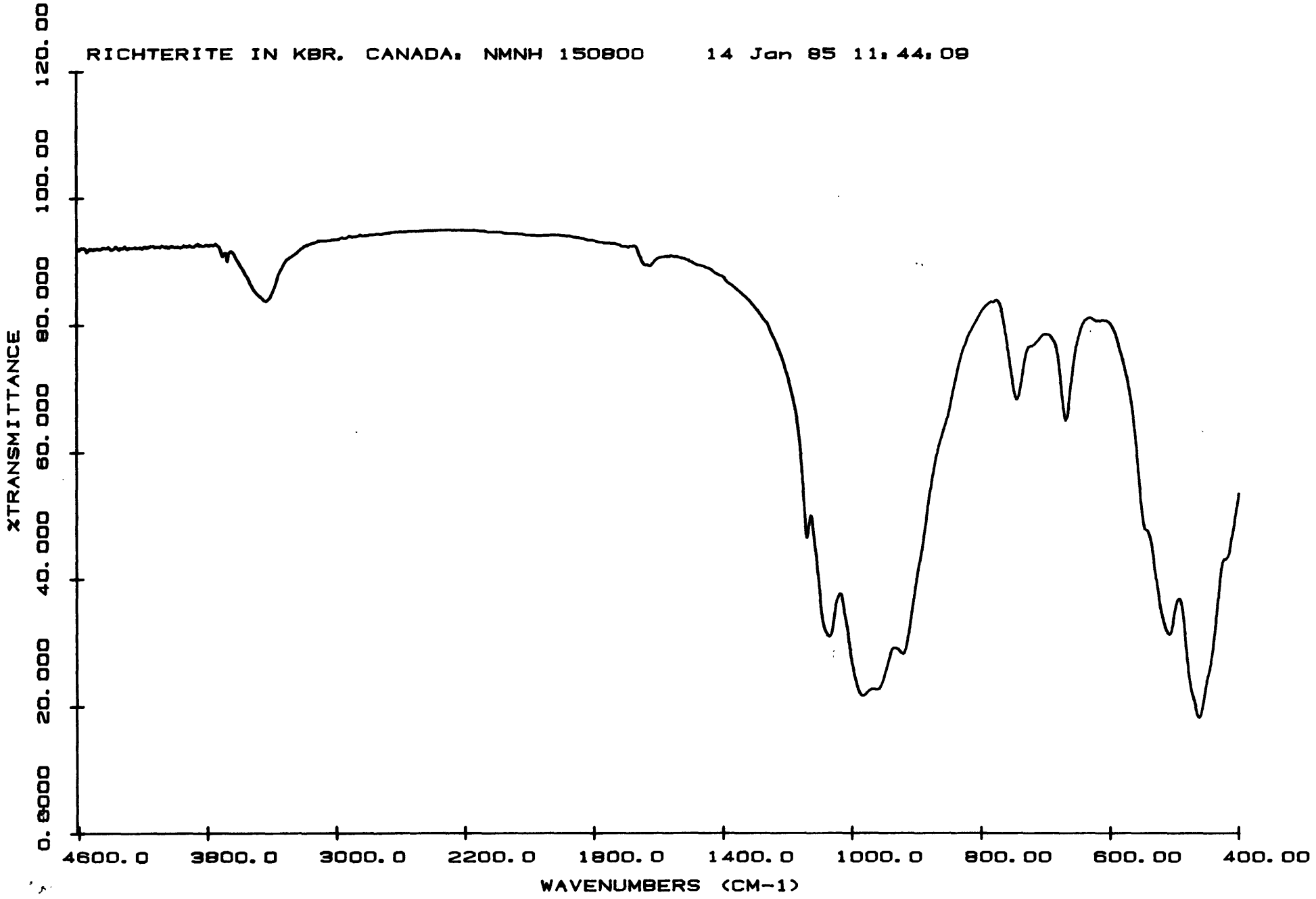
Results of XRD: Richterite plus a trace of mica. Infrared spectra do not show a mica hydroxyl band.

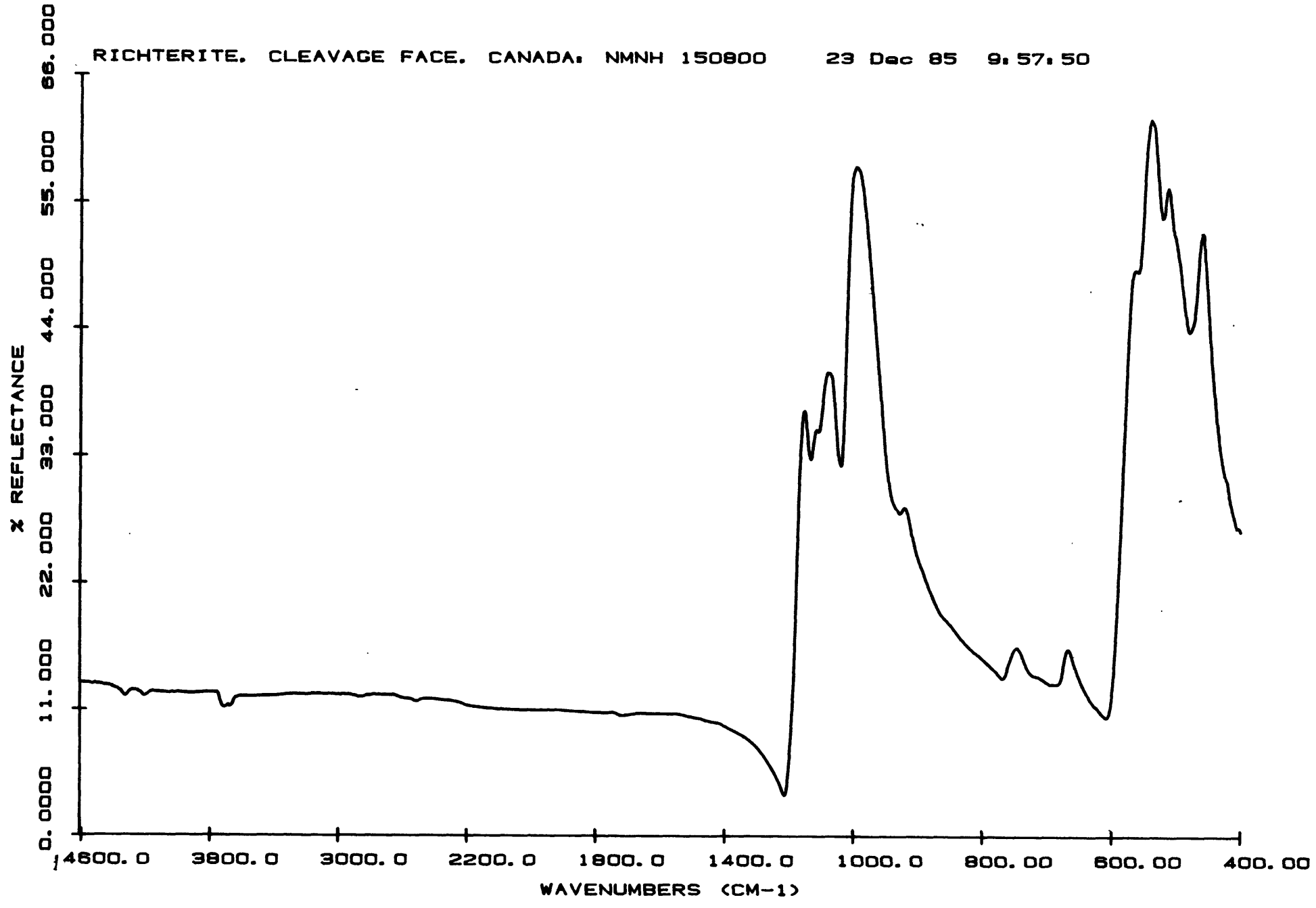
Results of XRF or other compositional analysis:

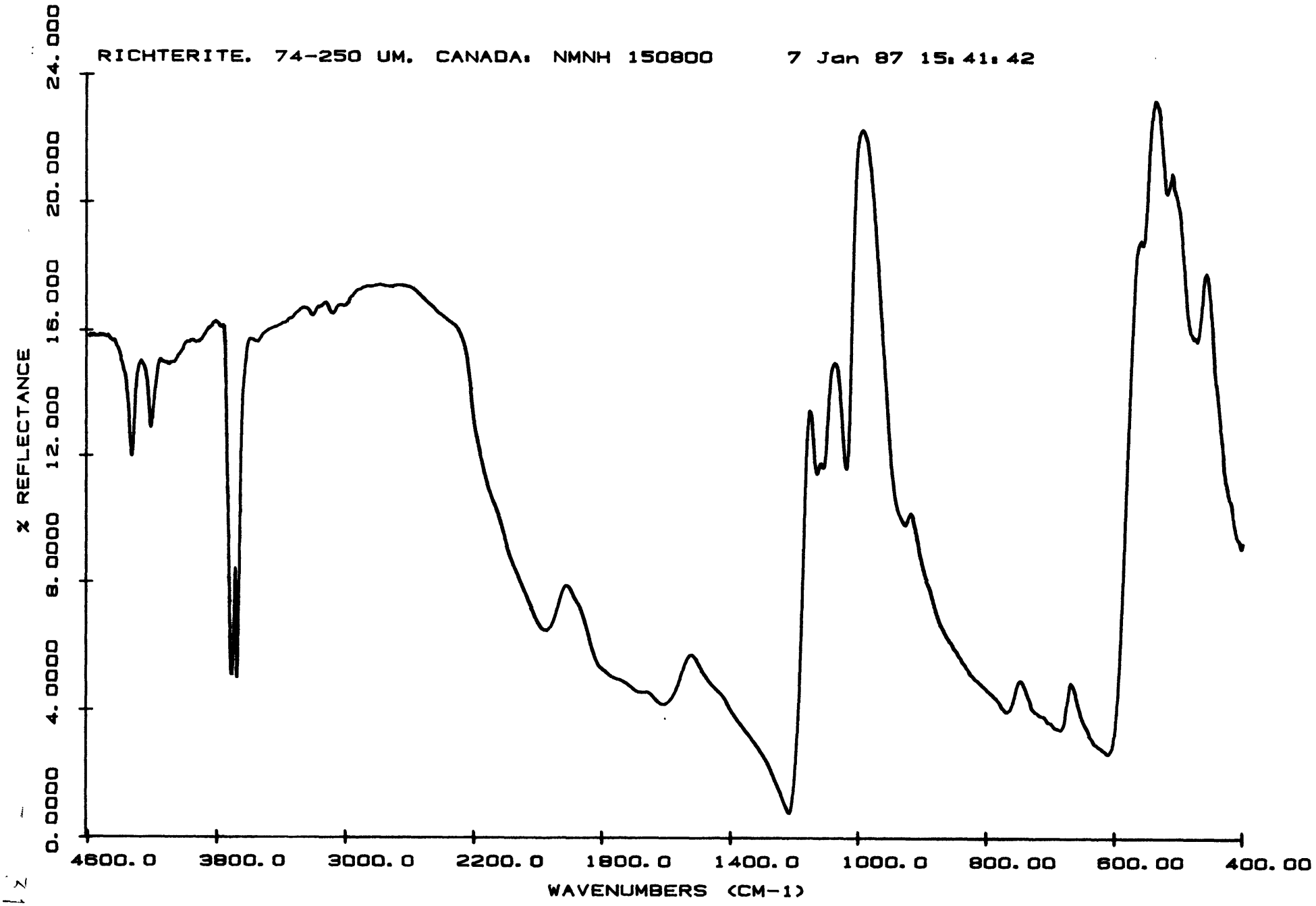
Microprobe analysis by L. Walter shows sample to be homogeneous within and between grains, with a composition typical of richterite. Average of 9 analyses:

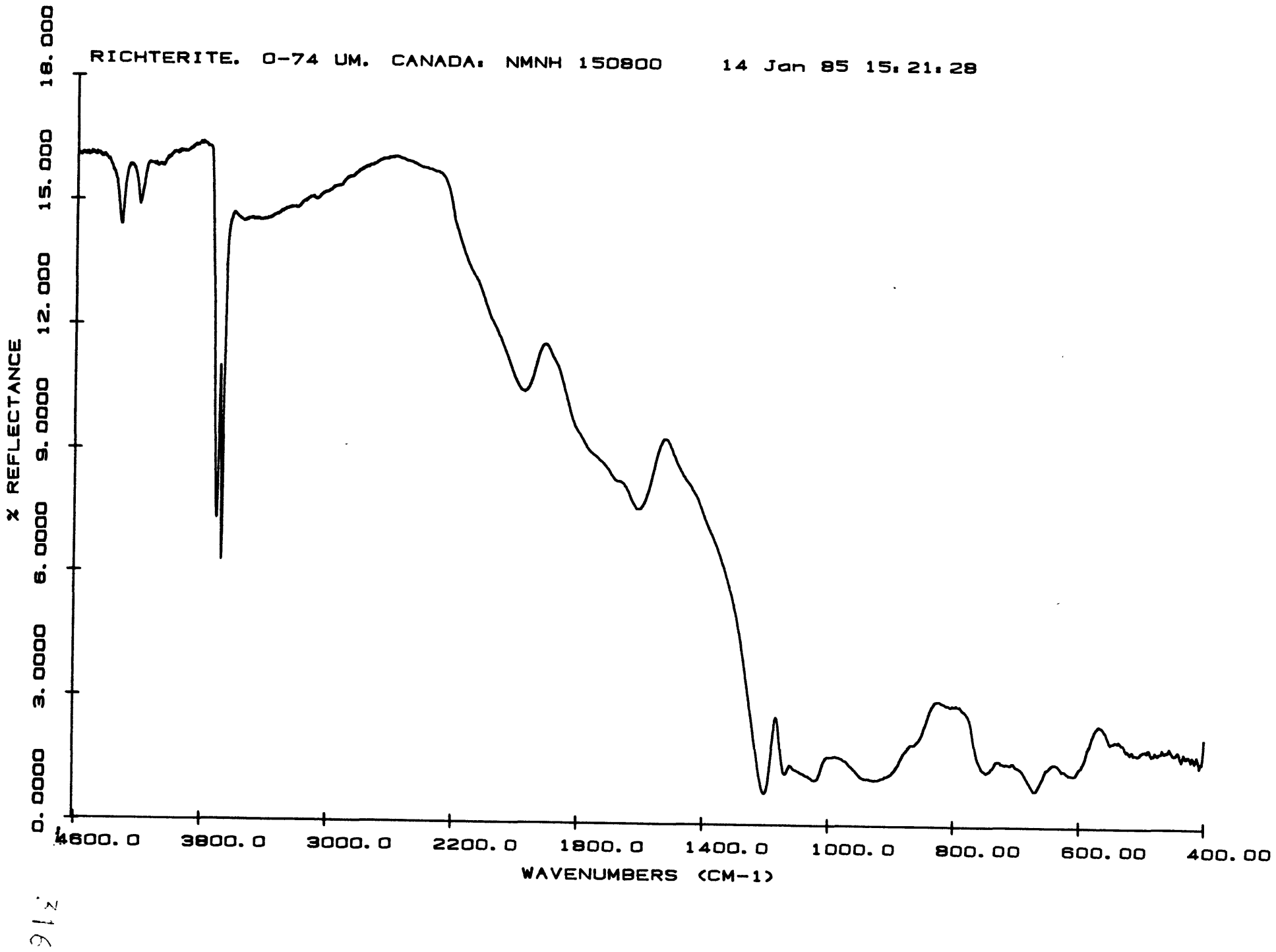
SiO_2	- 54.87
Al_2O_3	- 1.97
FeO	- 2.40
MgO	- 22.92
CaO	- 9.09
K_2O	- 1.48
Na_2O	- 4.32
TiO_2	- 0.39
MnO	- 0.20
Total	- 97.65

Spectra of file:
Richterite.1 Reflectance spectrum of cleavage face on solid sample disk 1.
Richterite.1 Reflectance spectrum of 74-250 um size range on disk #1.
Richterite.1 Transmittance spectrum on disk 1.
Richterite.1 Reflectance spectrum of 0-74 um size range on disk #1.


RICHTERITE IN KBR. CANADA. NMNH 150800 14 Jan 85 11:44:09
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


RICHTERITE. CLEAVAGE FACE. CANADA: NMNH 150800 23 Dec 85 9:57:50
% REFLECTANCE
66.000
55.000
44.000
33.000
22.000
11.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


RICHTERITE. 74-250 UM. CANADA: NMNH 150800
7 Jan 87 15:41:42
% REFLECTANCE
0.0000
4.0000
8.0000
12.000
16.000
20.000
24.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


RICHTERITE. 0-74 UM. CANADA: NMNH 150800 14 Jan 85 15:21:28
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

216

Species name: Riebeckite $Na_2(Fe^{+2},Mg)_3Fe_2^{+3}Si_8O_{22}(OH)_2$

Locality: Hurricane Mtn., Conway, New Hamphsire

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 122689

Results of petrographic examination: One 11.54 g. piece, black; part of single crystal. Small amount of limonite staining - seems to be entirely surficial. May be brushed off. Very small amount of internal contamination by a white mineral (quartz). May be possible to avoid the grains. (Lou Walter).

Individual grains of riebeckite appear very pure under the microscope (<1% impurities).

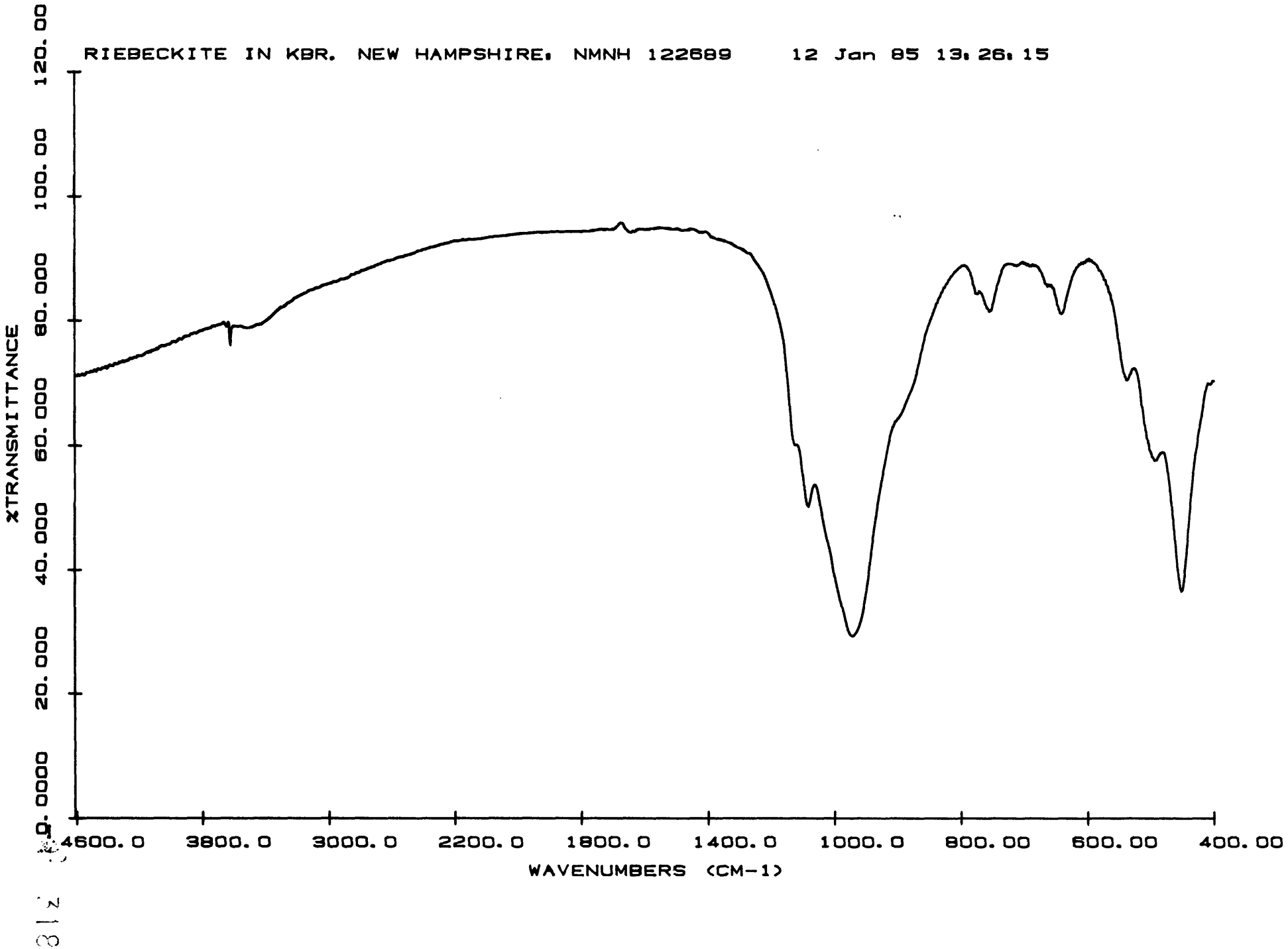
Results of XRD: Pure riebeckite.

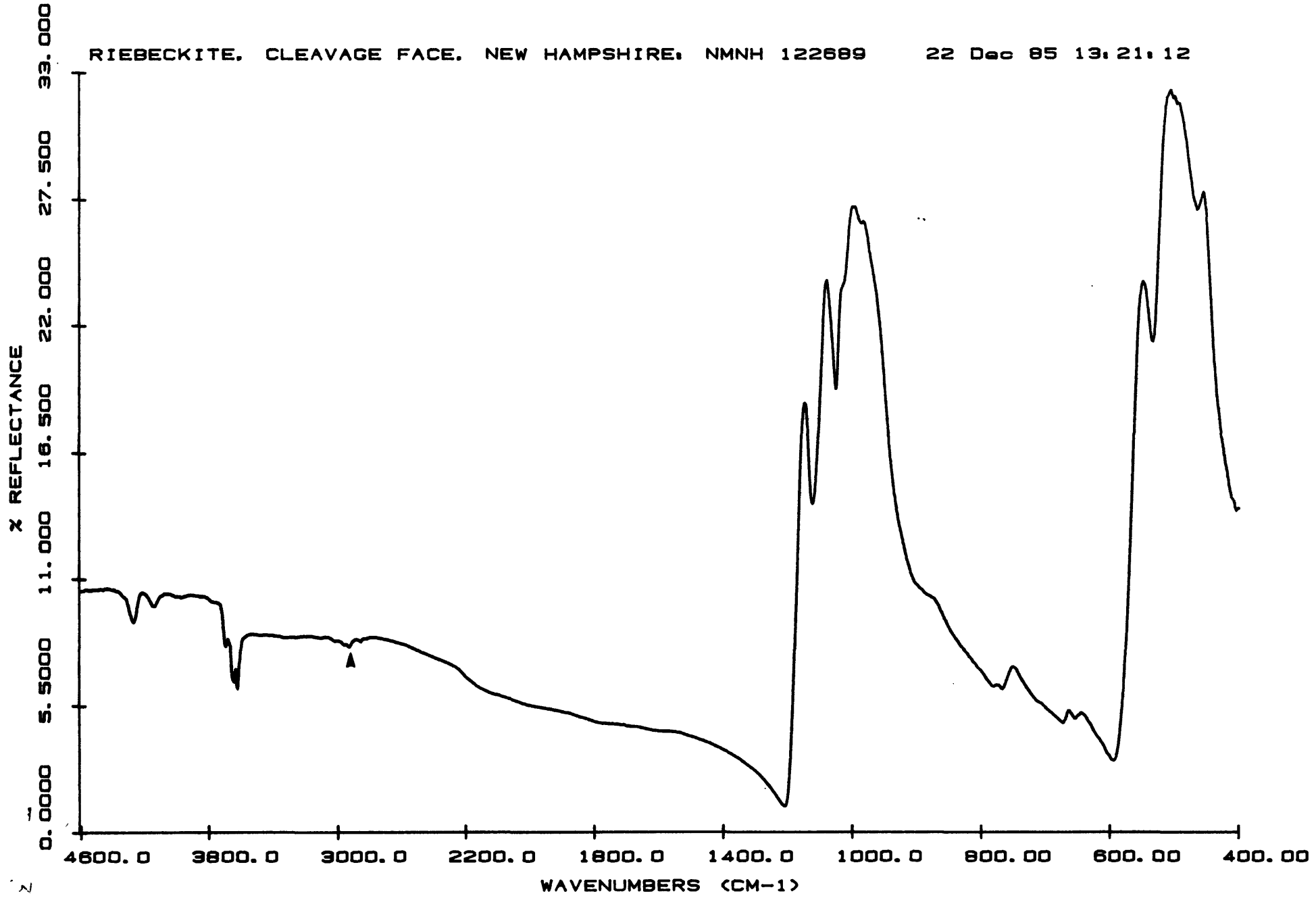
Results of XRF or other compositional analysis:

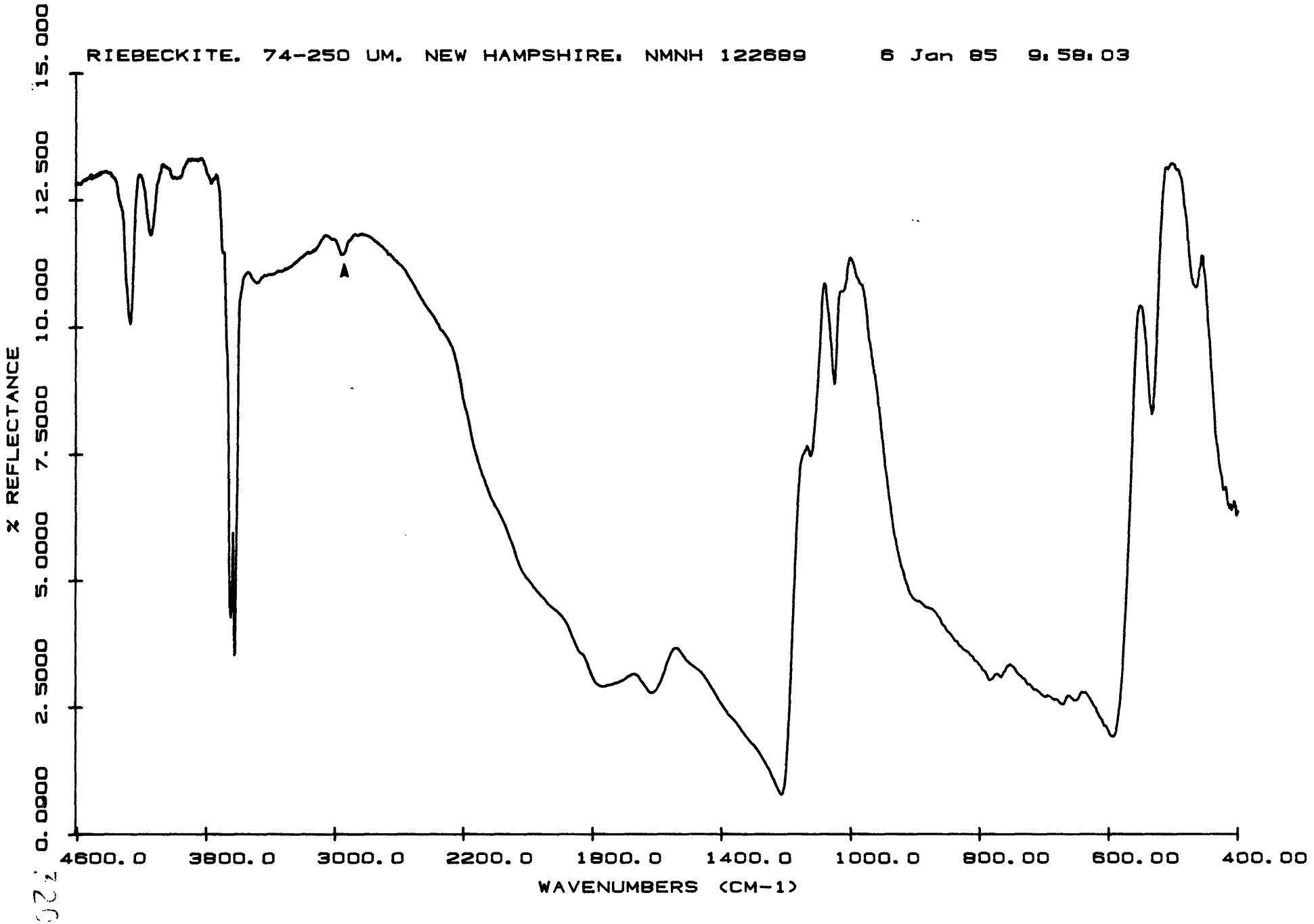
Microprobe analysis of hand-picked sample shows it to be homogeneous within and between grains, with typical riebeckite composition. Average of 10 analyses:

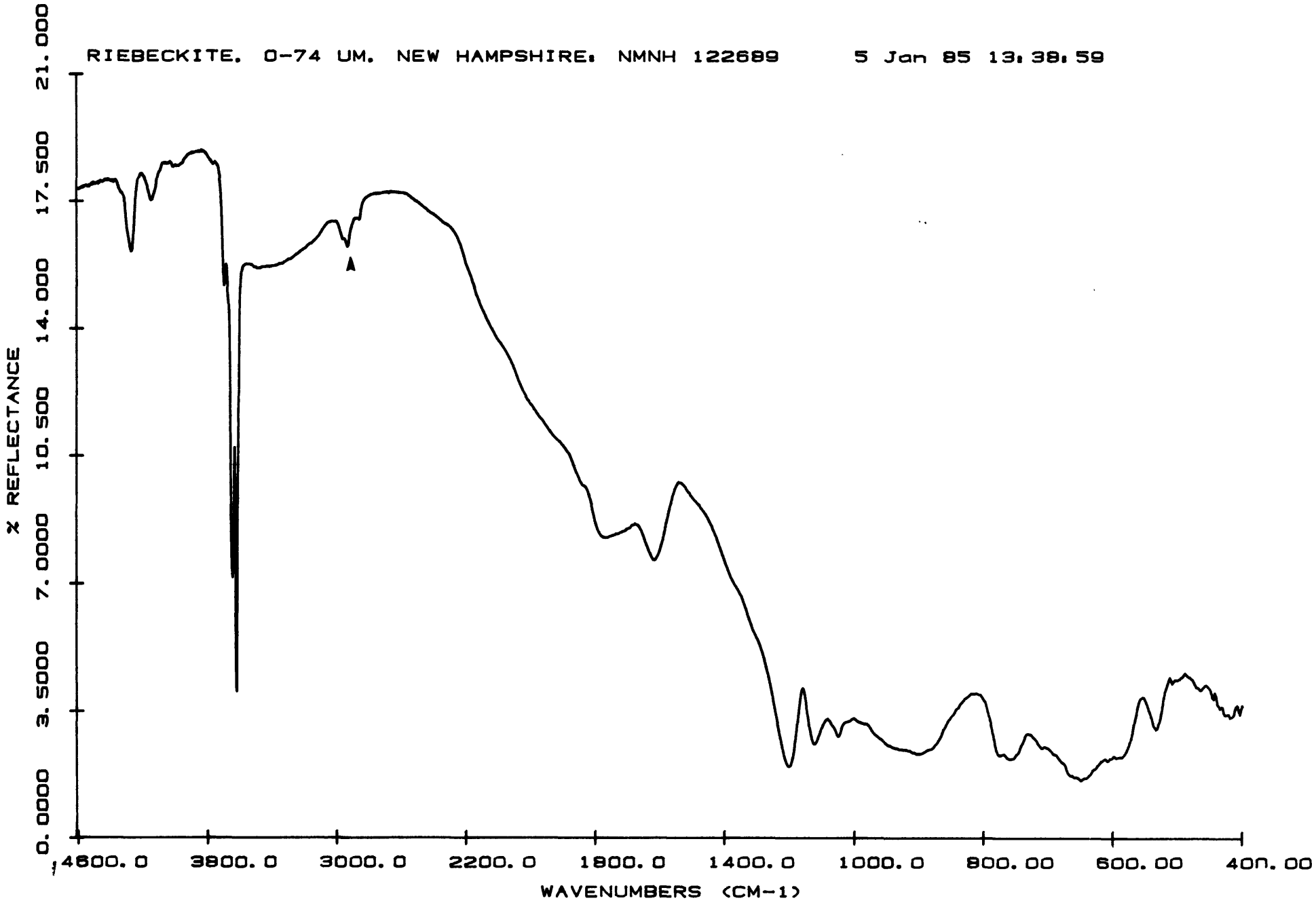
SiO_2	- 50.32
Al_2O_3	- 0.86
FeO	- 35.27
MgO	- 0.07
CaO	- 0.08
K_2O	- 1.41
Na_2O	- 7.95
TiO_2	- 0.53
MnO	- 1.12
Total	- 97.61

Spectra of file:
Riebeckite.1 Reflectance spectrum of cleavage face on solid sample disk #1.
Riebeckite.1 Reflectance spectrum of 0-74 um size range on disk #1.
Riebeckite.1 Reflectance spectrum of 74-350 um size range on disk #1.
Riebeckite.1 Transmittance spectrum on disk #1.


RIEBECKITE IN KBR. NEW HAMPSHIRE: NMNH 122689 12 Jan 85 13:26:15
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


RIEBECKITE. CLEAVAGE FACE. NEW HAMPSHIRE: NMNH 122689 22 Dec 85 13:21:12
% REFLECTANCE
33.000
27.500
22.000
16.500
11.000
5.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


RIEBECKITE. 74-250 UM. NEW HAMPSHIRE: NMNH 122689 6 Jan 85 9:58:03
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


RIEBECKITE. 0-74 UM. NEW HAMPSHIRE: NMNH 122689
5 Jan 85 13:38:59
% REFLECTANCE
21.000
17.500
14.000
10.500
7.0000
3.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Sanidine

Locality: Volkesfeld bei kempenick, Eifel, Rheinland, Germany

Last donor: Dave Stewart, USGS

Intermediate donor:

Ultimate donor: Dr. F. Krantz, Bonn, W. Germany

Catalog numbers, etc.: None

Results of petrographic examination: Hand sample is large (56.16 g) fragment of what appears to be a badly fractured single crystal. Small fragments are transparent, but "smoky". Shows no significant contamination under the microscope.

Results of XRD: Pure sanidine.

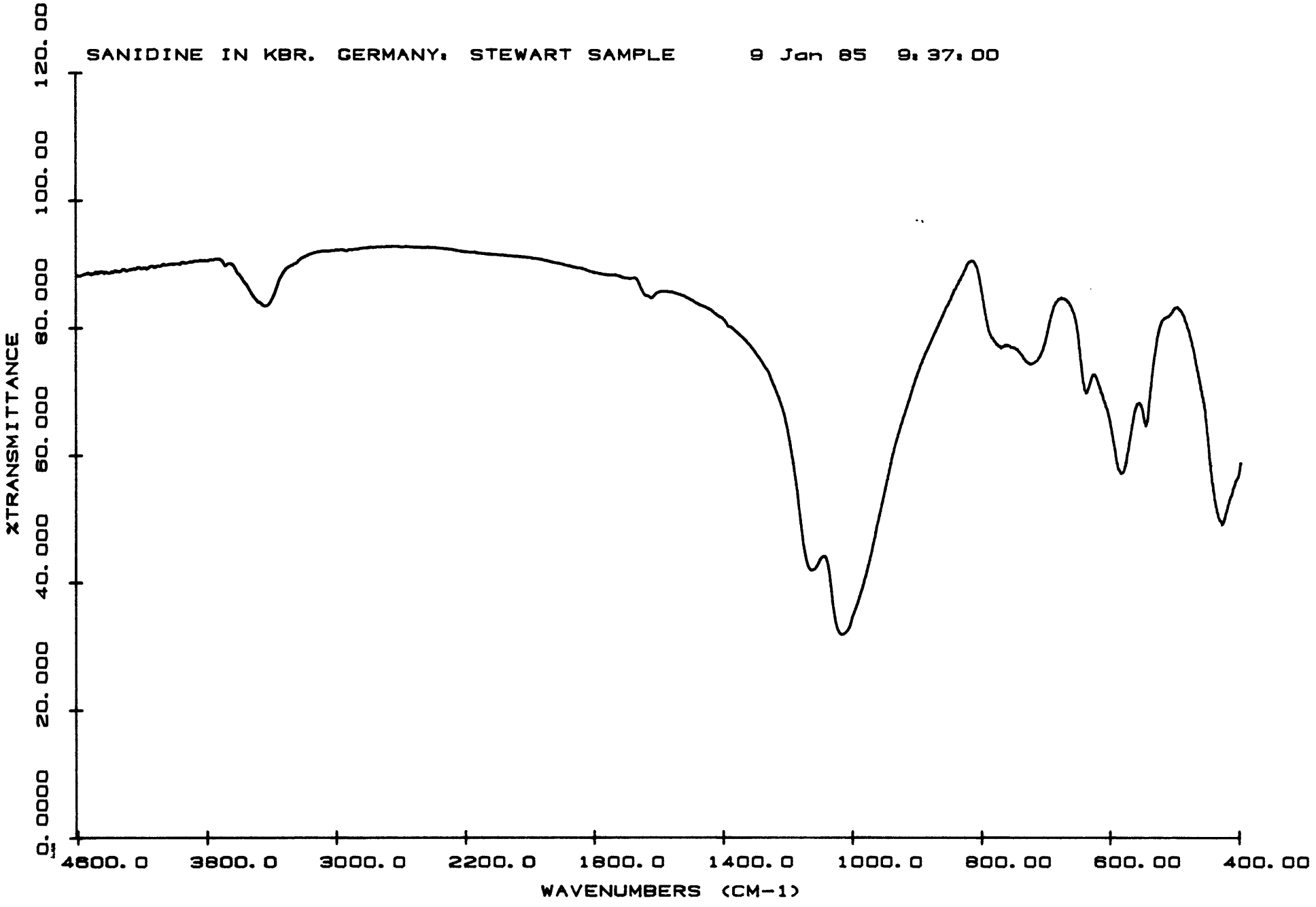
Results of XRF or other compositional analysis:

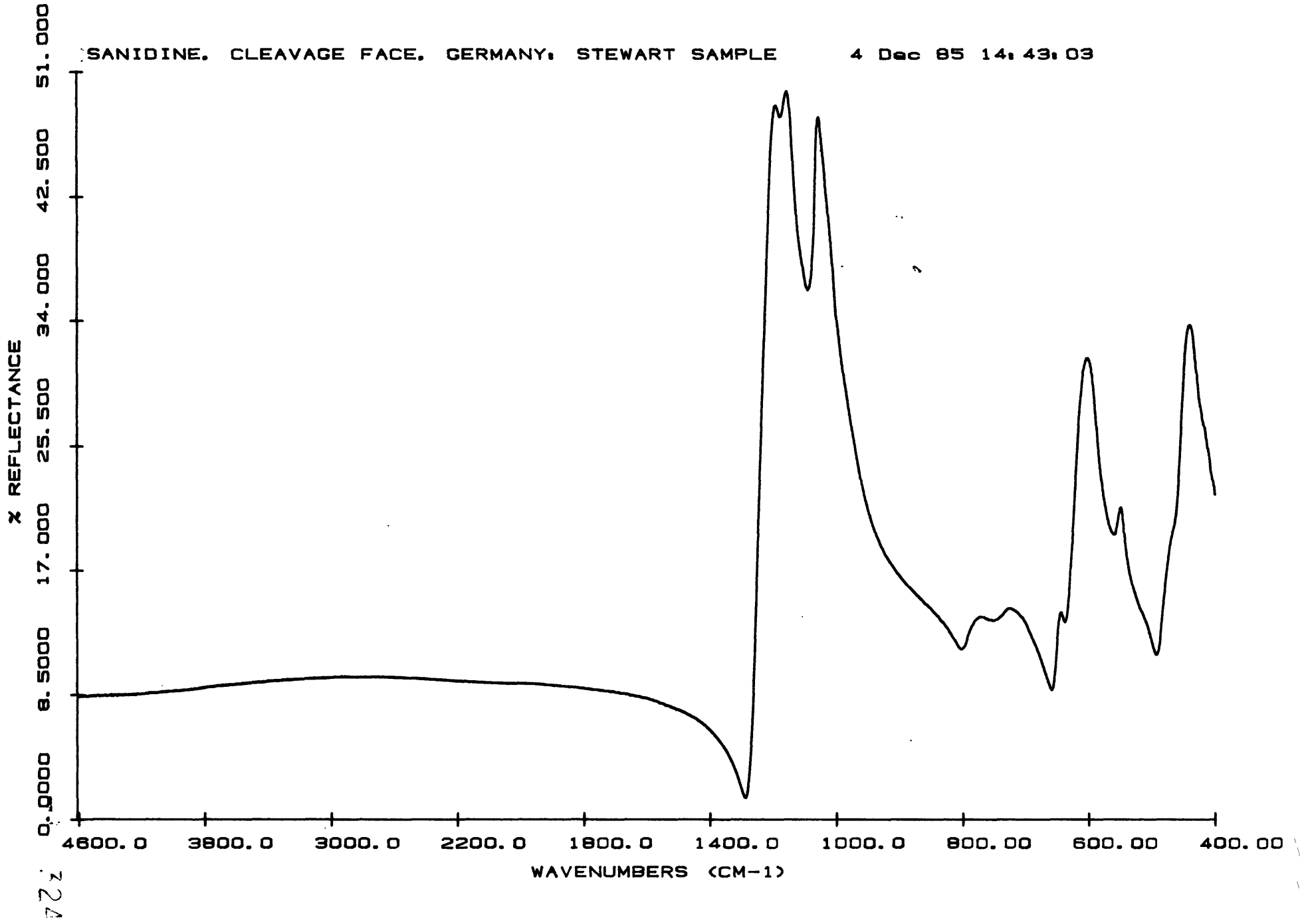
Microprobe analysis showed sample to be homogeneous within and between grains, and to be of typical sanidine composition except for the unusually low albite content. Average of 10 analyses:

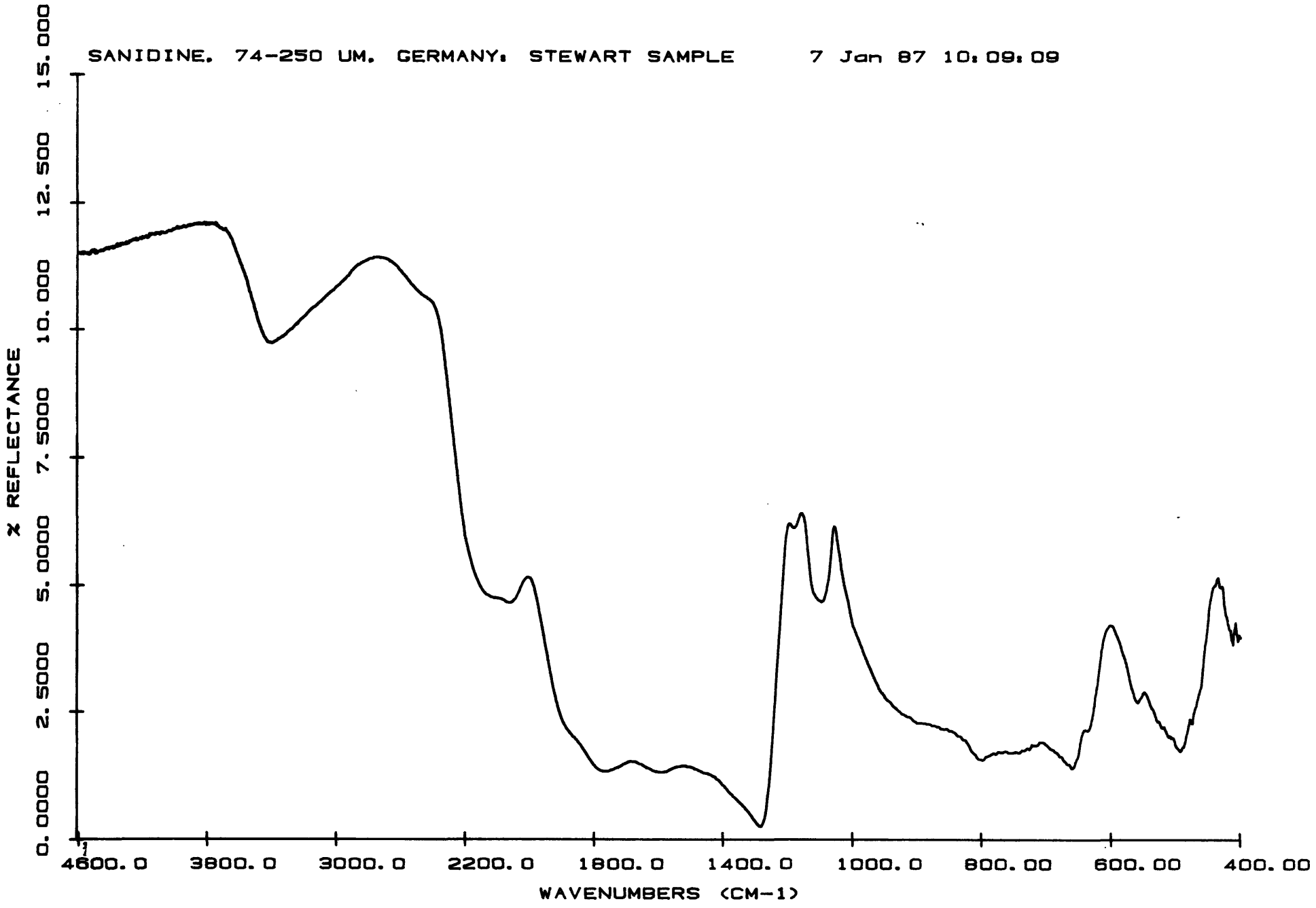
SiO_2	- 64.53
Al_2O_3	- 18.76
FeO	- 0.17
MgO	- 0.04
CaO	- 0.02
K_2O	- 13.96
Na_2O	- 1.30
TiO_2	- 0.03
MnO	- 0.04
Total	- 98.86

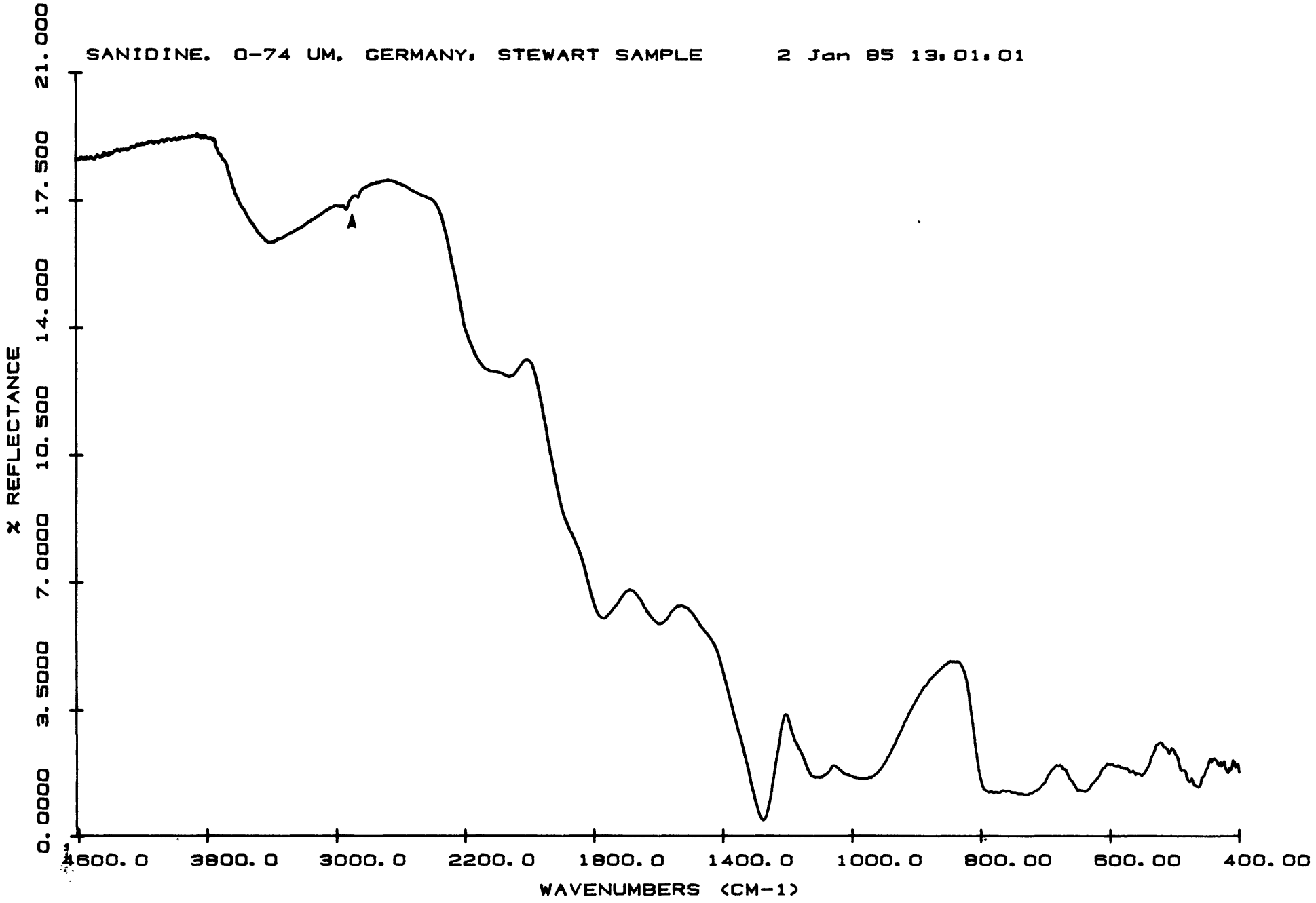
Spectra of file:

Sanidine.1	Reflectance spectrum of a cleavage face on solid sample disk #1.
Sanidine.1	Reflectance spectrum of 0-74 um size range on 0-74 um disk #1.
Sanidine.1	Transmittance on disk #1.
Sanidine.1	Reflectance spectrum of 74-250 um size range on disk #1.


SANIDINE IN KBR. GERMANY: STEWART SAMPLE 9 Jan 85 9:37:00
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SANIDINE. CLEAVAGE FACE. GERMANY: STEWART SAMPLE
4 Dec 85 14:43:03
% REFLECTANCE
51.000
42.500
34.000
25.500
17.000
8.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SANIDINE. 74-250 UM. GERMANY: STEWART SAMPLE 7 Jan 87 10:09:09
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SANIDINE. 0-74 UM. GERMANY; STEWART SAMPLE 2 Jan 85 13:01:01
% REFLECTANCE
21.000
17.500
14.000
10.500
7.0000
3.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

22

Species name: Sanidine

Locality: Higasinuiro-gun, Taiji, Wakayama, Japan

Last donor: Smithsonian

Intermediate donor:

Ultimate donor: Smithsonian

Catalog numbers, etc.: NMNH 103200

Results of petrographic examination: Many small (0.5 cm) euhedral crystals totaling 6.49 g. almost all have some adhering clay/limonite, to be removed by brushing or ultrasonic cleaning.

Under the microscope, a very, very few acicular inclusions (rutile?) can be seen. Otherwise very pure.

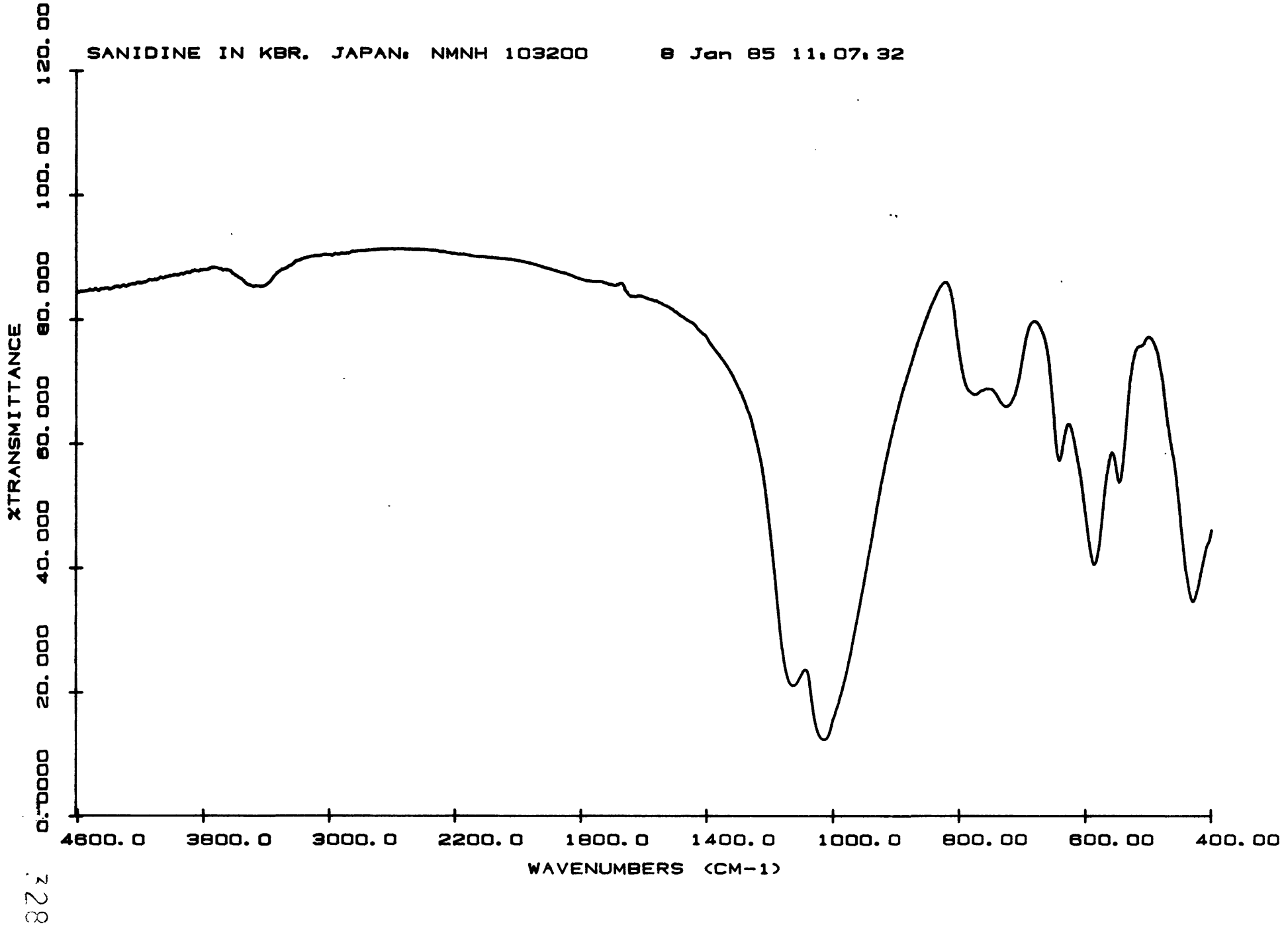
Results of XRD: Sanidine plus a moderate amount of albite.

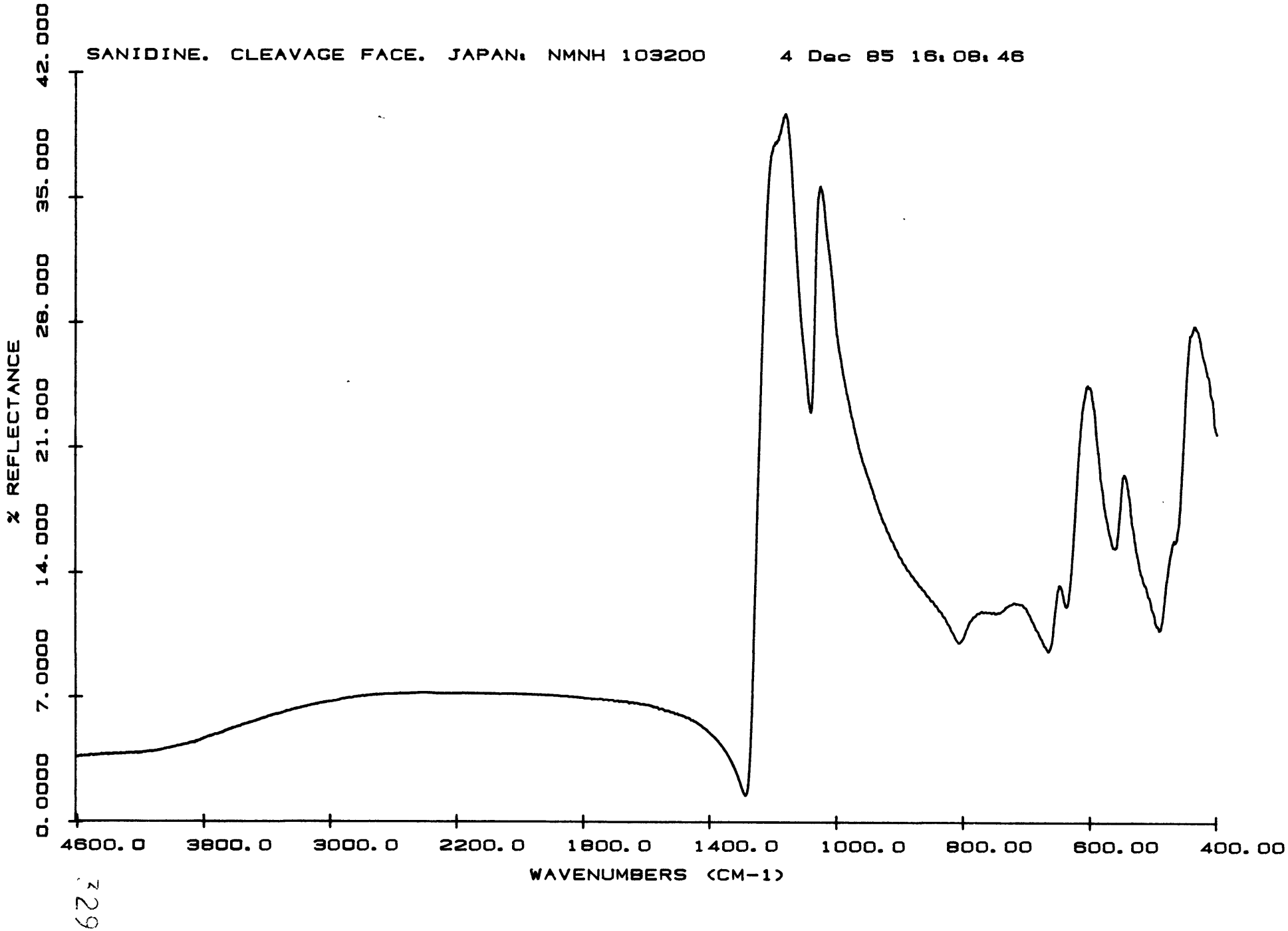
Results of XRF or other compositional analysis:

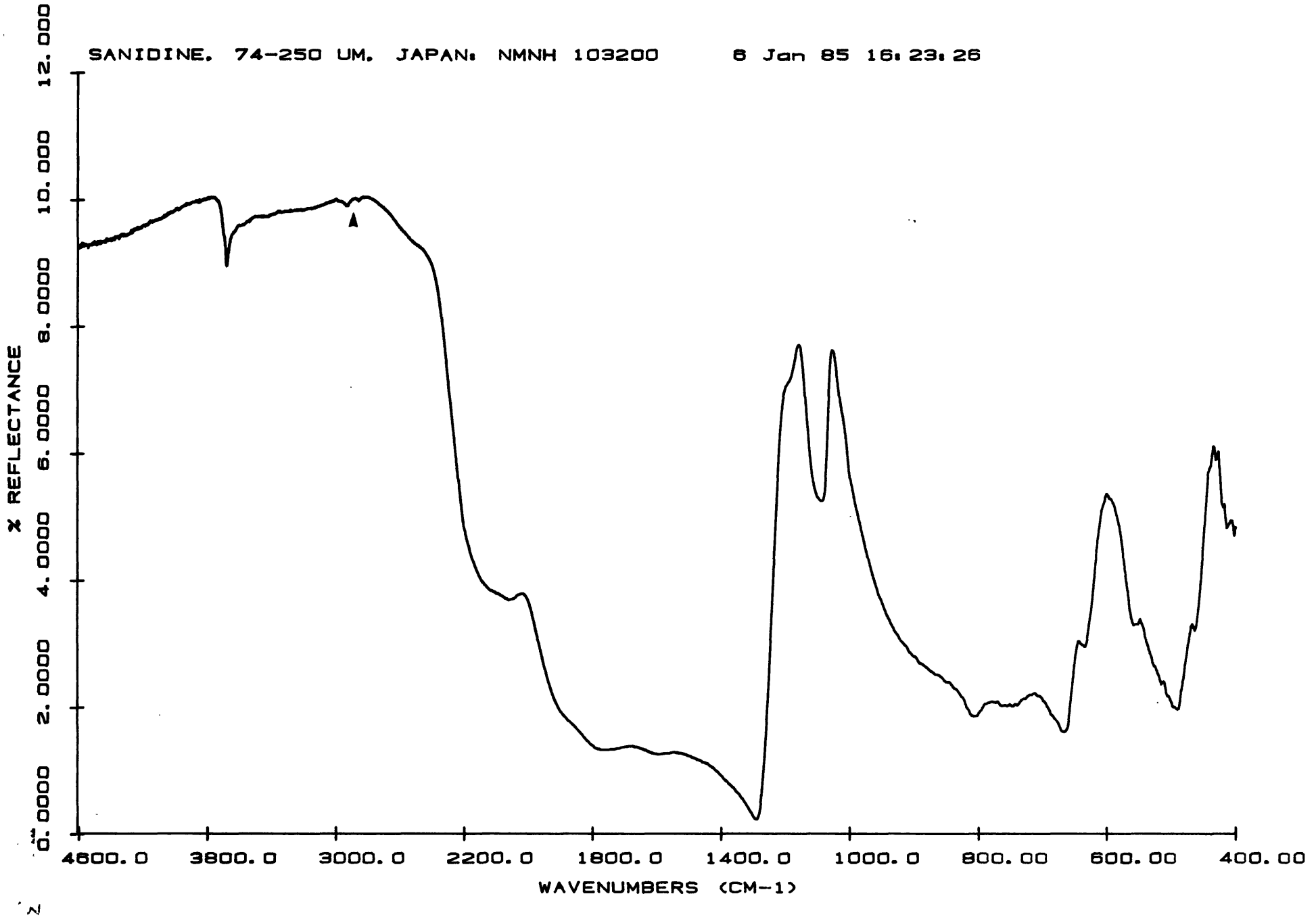
Microprobe analysis shows homogeneity within and between grains. This is typical sanidine with about as much soda as potash, but the albite present is cryptoperthic. Average of 10 analyses:

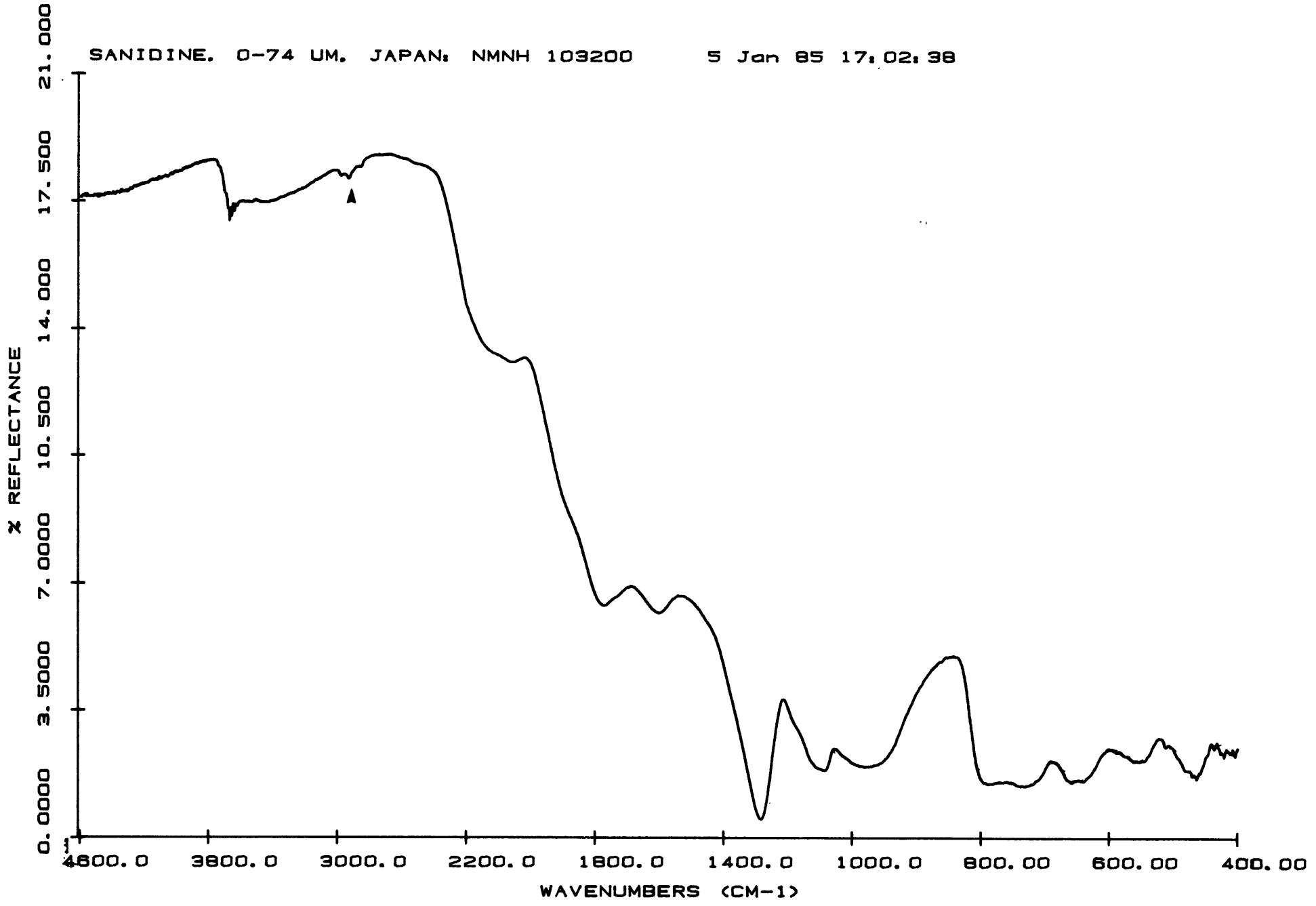
SiO_2	- 67.43
Al_2O_3	- 18.65
FeO	- 0.59
MgO	- 0.03
CaO	- 0.02
K_2O	- 7.38
Na_2O	- 5.38
TiO_2	- 0.03
MnO	- 0.02
Total	- 99.97

Spectra of file:
Sanidine.3 Reflectance spectrum of cleavage face on solid sample disk #1.
Sanidine.3 Reflectance spectrum of 0-74 um size range on disk #1.
Sanidine.3 Transmittance on disk #1.
Sanidine.3 Reflectance spectrum of 74-250 um size range on disk #1.


SANIDINE IN KBR. JAPAN: NMNH 103200 8 Jan 85 11:07:32
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.70000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SANIDINE. CLEAVAGE FACE. JAPAN: NMNH 103200 4 Dec 85 16:08:46
% REFLECTANCE
0.0000
7.0000
14.000
21.000
28.000
35.000
42.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SANIDINE. 74-250 UM. JAPAN: NMNH 103200 6 Jan 85 16:23:26
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SANIDINE. 0-74 UM. JAPAN: NMNH 103200 5 Jan 85 17:02:38
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Saponite

Locality: Ballarat, Cal.

Last donor: Hunt and Salisbury collection

Intermediate donor:

Ultimate donor: Clay Mineral Society Source Clay Mineral Repository

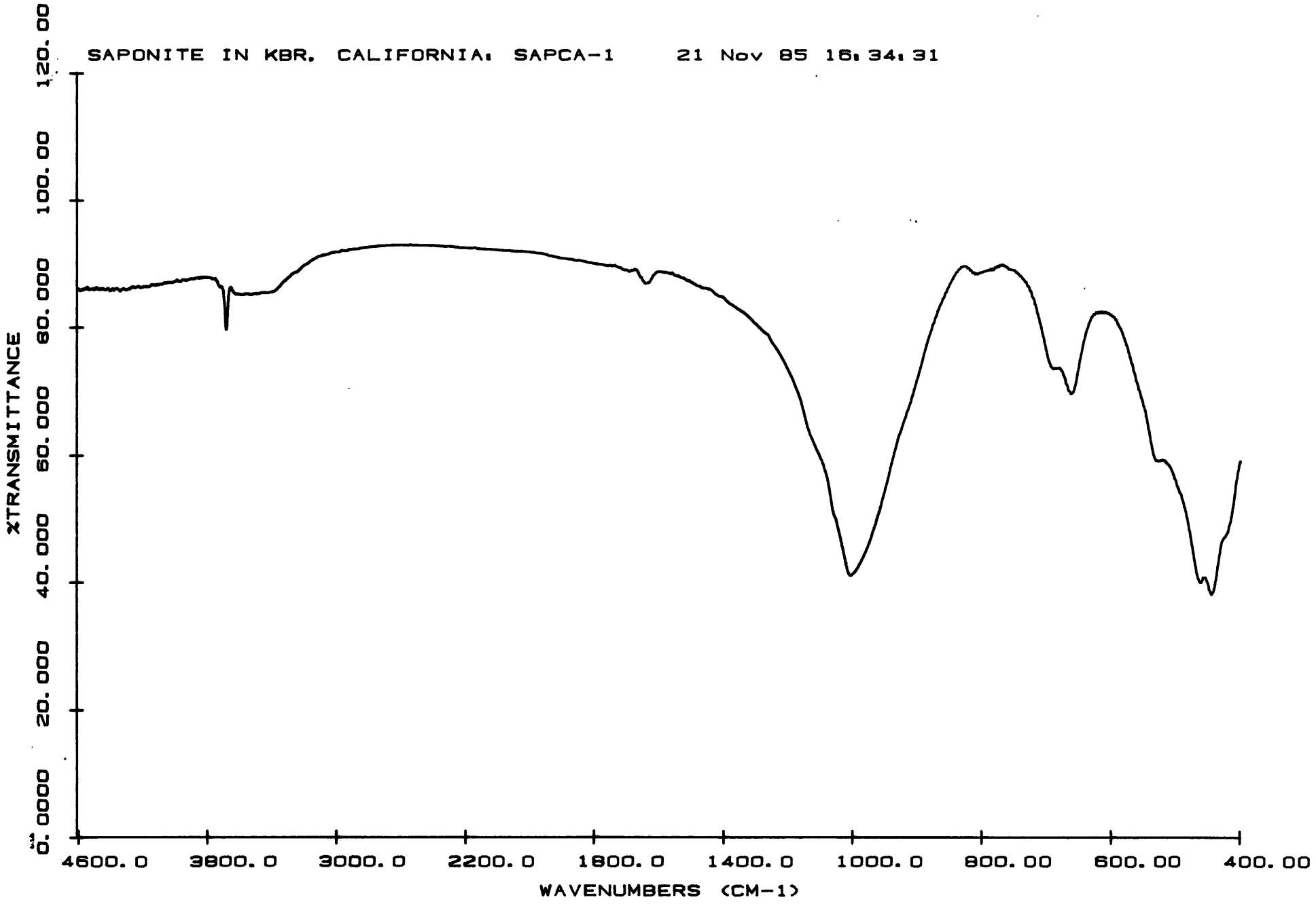
Catalog numbers, etc.: CMS SapCa-1

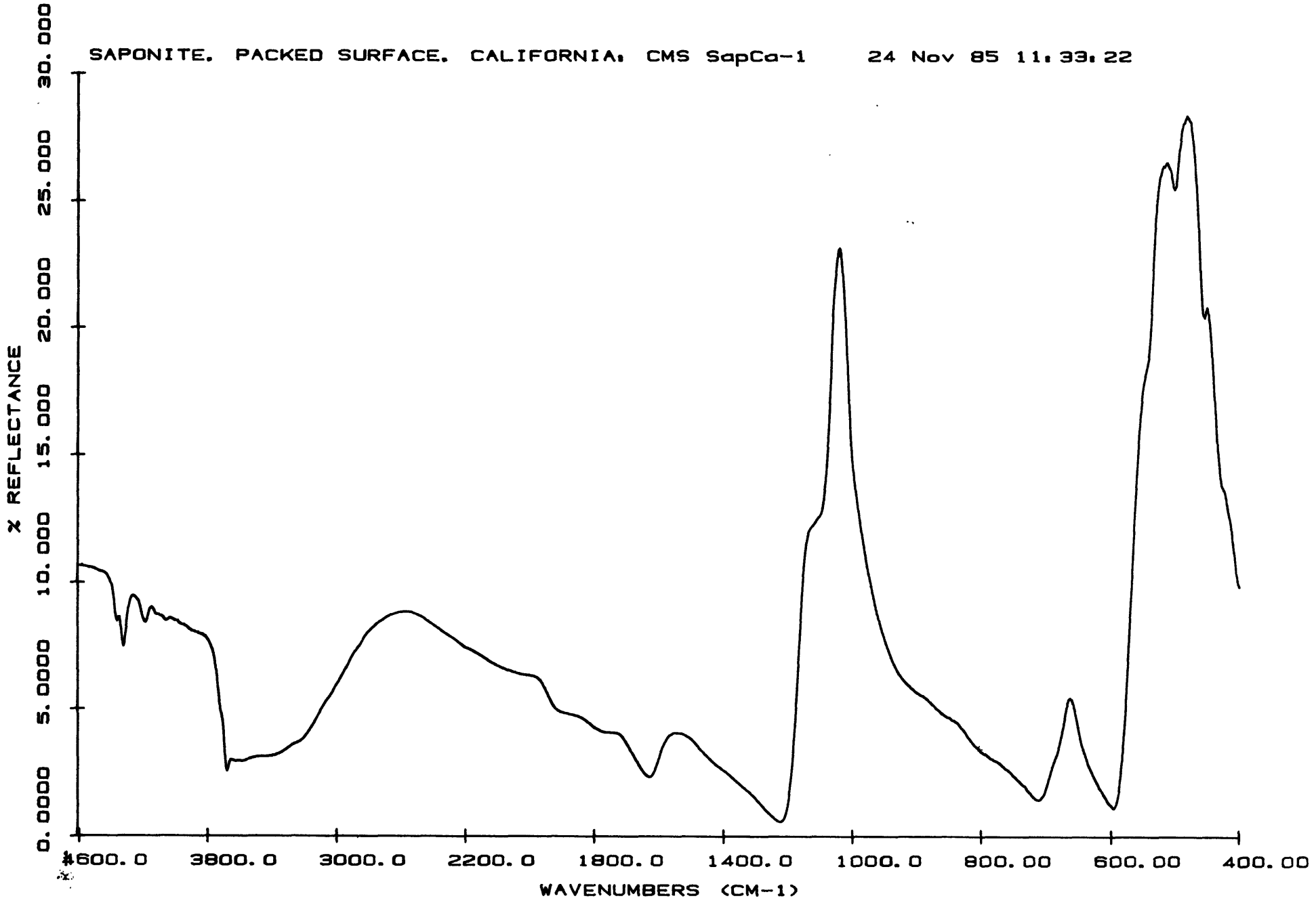
Results of petrographic examination: Sample is cream colored.

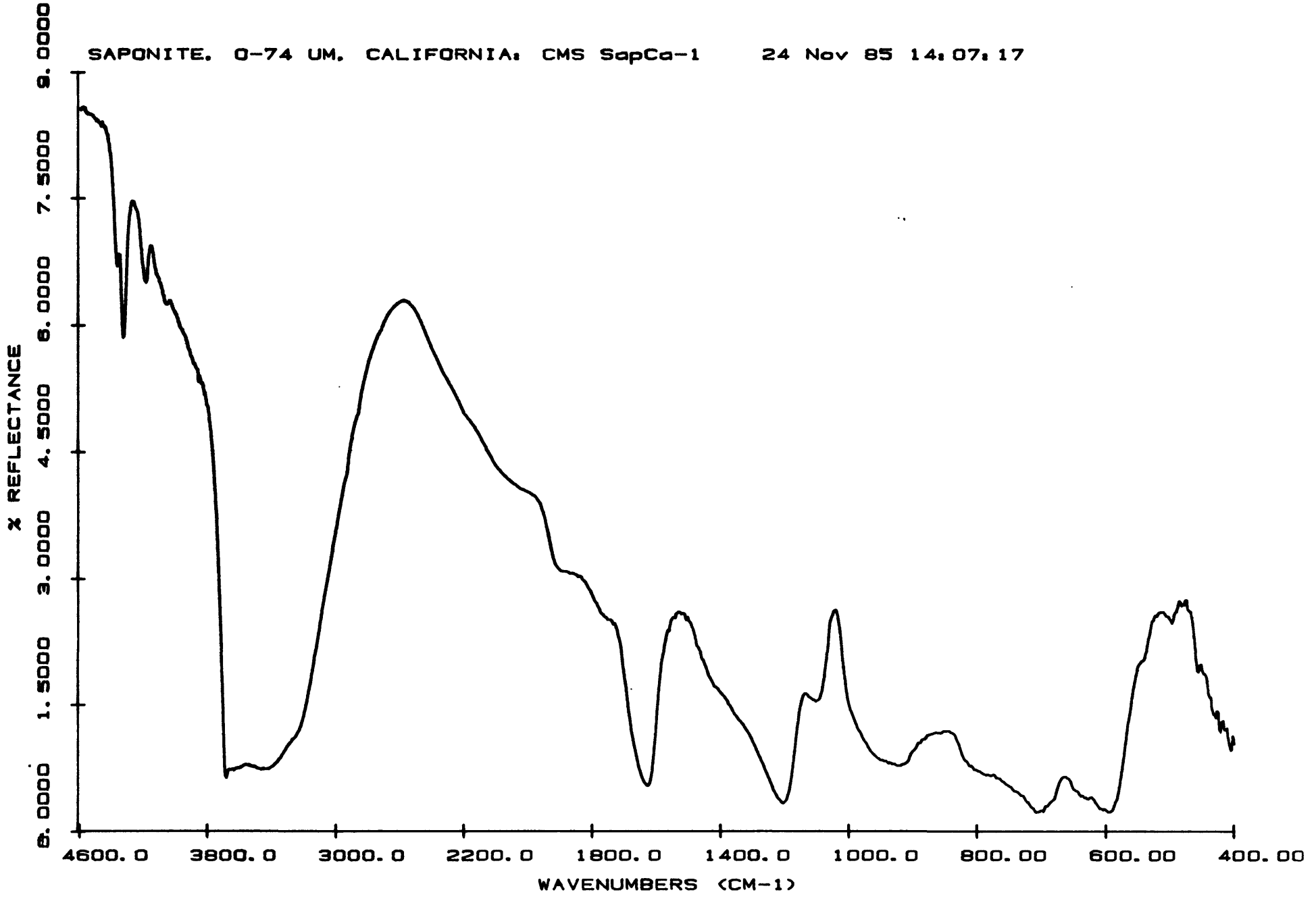
Results of XRD: Less than 2 um size fraction is saponite with a trace of unknown material with x-ray peaks at 8.6, 3.26 and 3.14 angstroms. Coarser fraction contains quartz.

Results of XRF or other compositional analysis: None

Spectra of file:
Saponite.1 Transmittance disk #1.
Saponite.1 Packed sample reflectance on solid sample disk #1.
Saponite.1 Reflectance spectrum of sifted <2 um sample on 0-74 um on disk #1.


SAPONITE IN KBR. CALIFORNIA: SAPCA-1 21 Nov 85 16:34:31
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SAPONITE. PACKED SURFACE. CALIFORNIA: CMS SapCa-1 24 Nov 85 11:33:22
% REFLECTANCE
30.000
25.000
20.000
15.000
10.000
5.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SAPONITE. 0-74 UM. CALIFORNIA: CMS SapCa-1 24 Nov 85 14:07:17
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Sepiolite $Mg_4Si_6O_{15}(OH)_2\ 6H_2O$

Locality: Two Crows, Nevada

Last donor: Hunt and Salisbury collection

Intermediate donor:

Ultimate donor: Clay Mineral Society Source Clay Mineral Repository

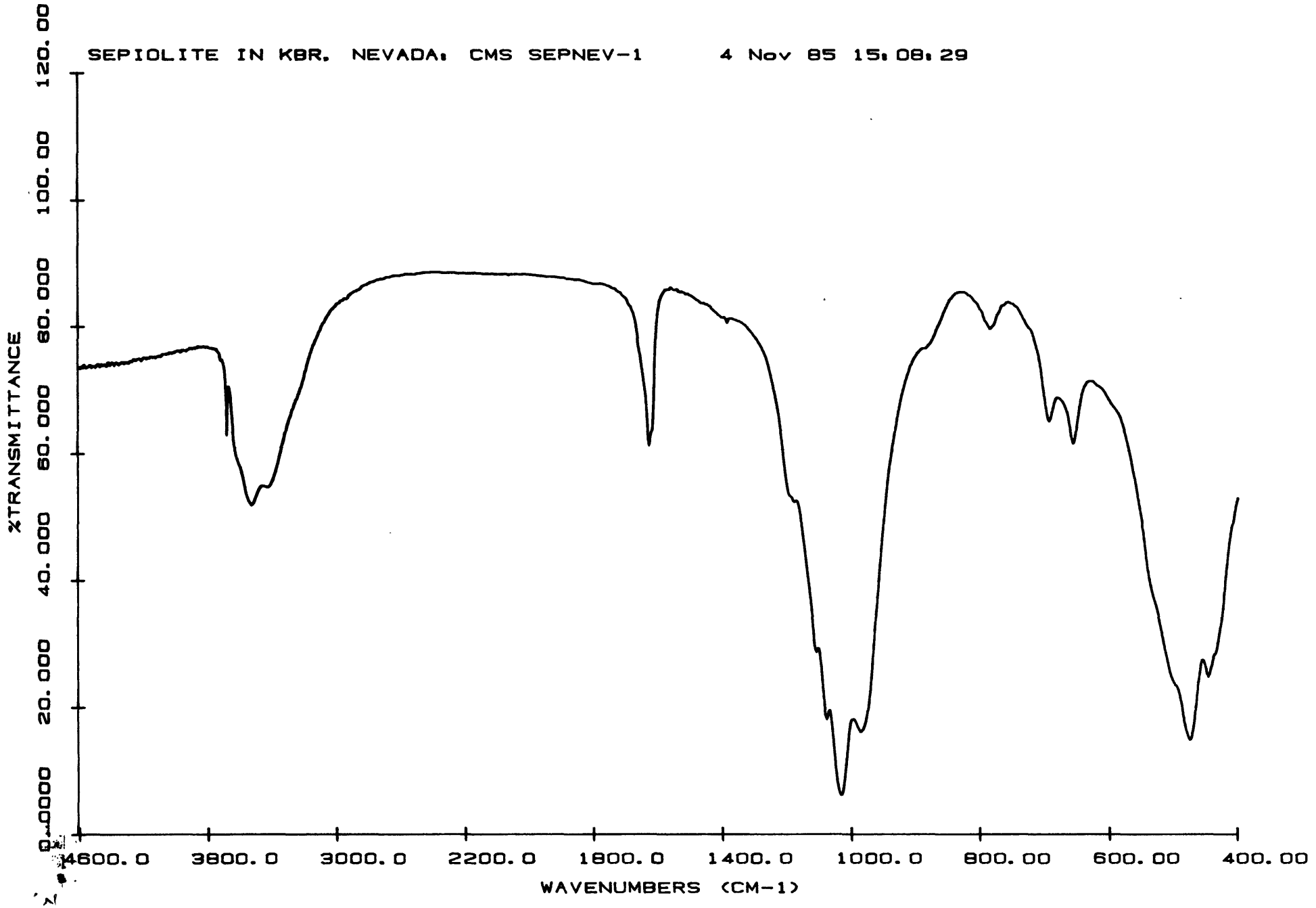
Catalog numbers, etc.: CMS SEPNEV-1

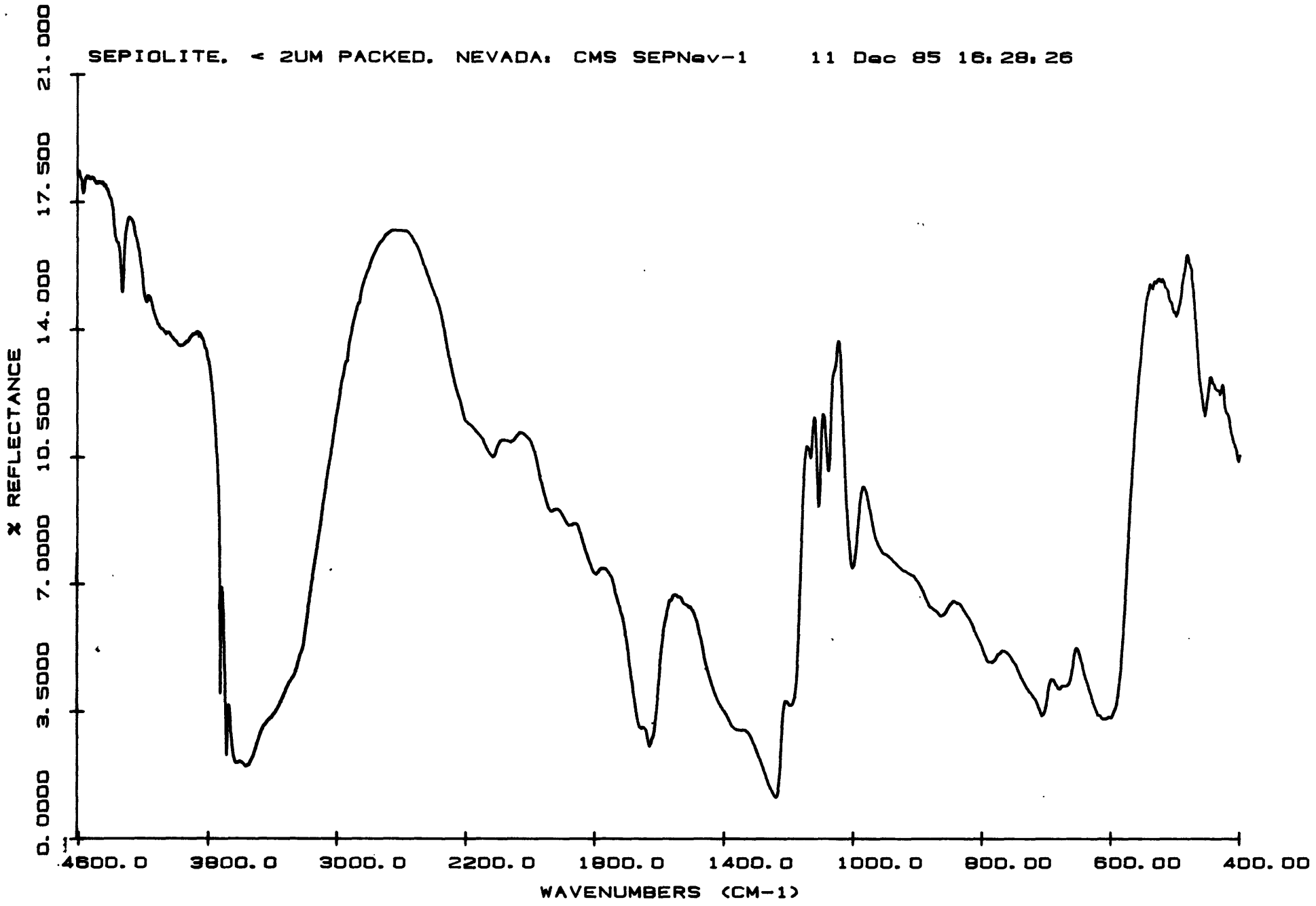
Results of petrographic examination: White in color.

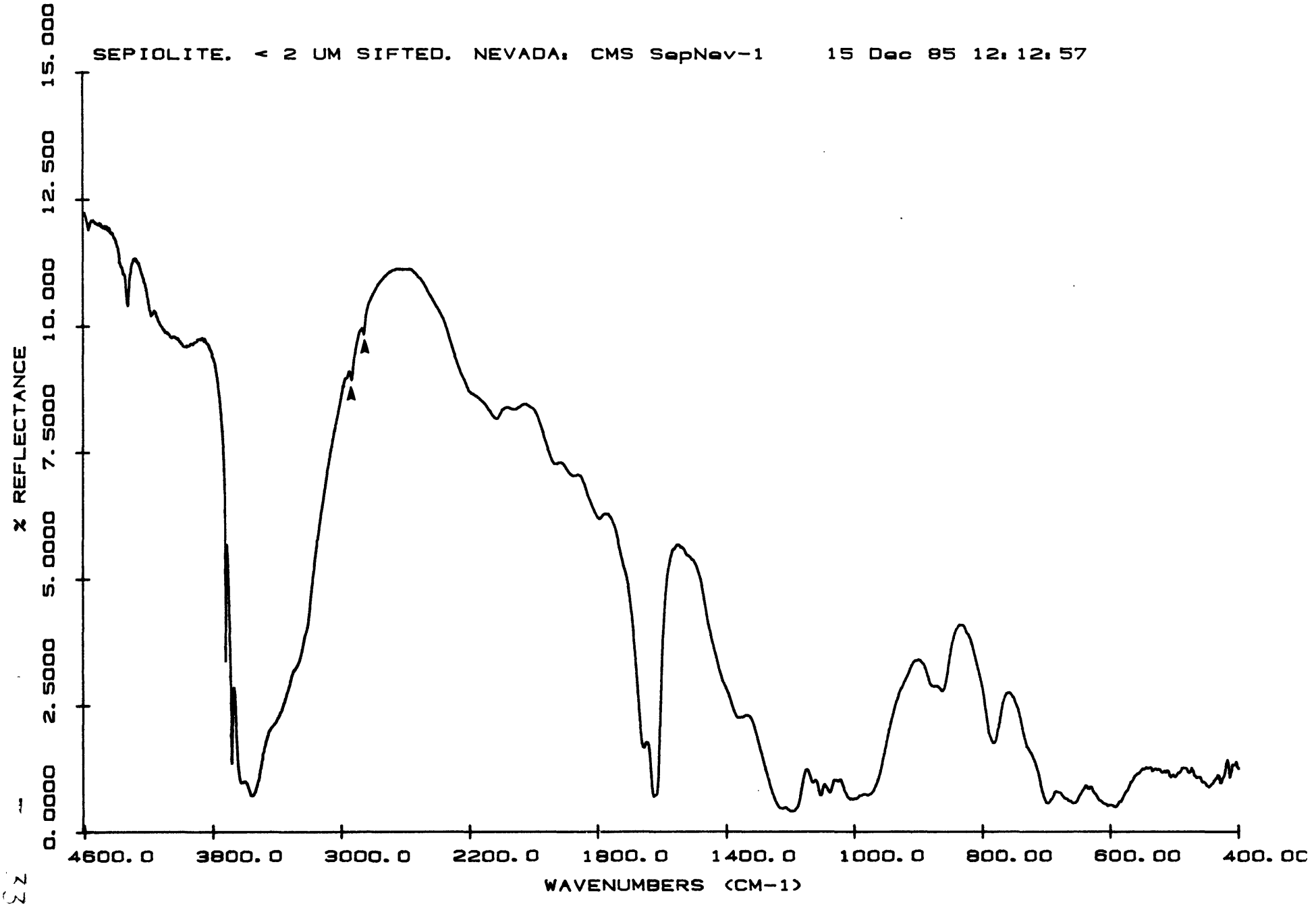
Results of XRD: Sepiolite plus a small amount of dolomite. Sample was treated with HCl to remove dolomite.

Results of XRF or other compositional analysis: None

Spectra on file:
Sepiolite.1 Reflectance spectrum of sifted <2 um separate on 0-74 um disk #1.
Sepiolite.1 Reflectance spectrum of packed sample on solid sample disk #1.
Sepiolite.1 Transmittance spectrum on disk #1.


SEPIOLITE IN KBR. NEVADA: CMS SEPNEV-1 4 Nov 85 15:08:29
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SEPIOLITE, < 2UM PACKED, NEVADA: CMS SEPNev-1 11 Dec 85 16:28:26
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SEPIOLITE. < 2 UM SIFTED. NEVADA: CMS SepNev-1 15 Dec 85 12:12:57
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Smectite

Locality: Grant Co., Washington

Last donor:

Intermediate donor:

Ultimate donor: Clay Mineral Society Source Clay Mineral Repository

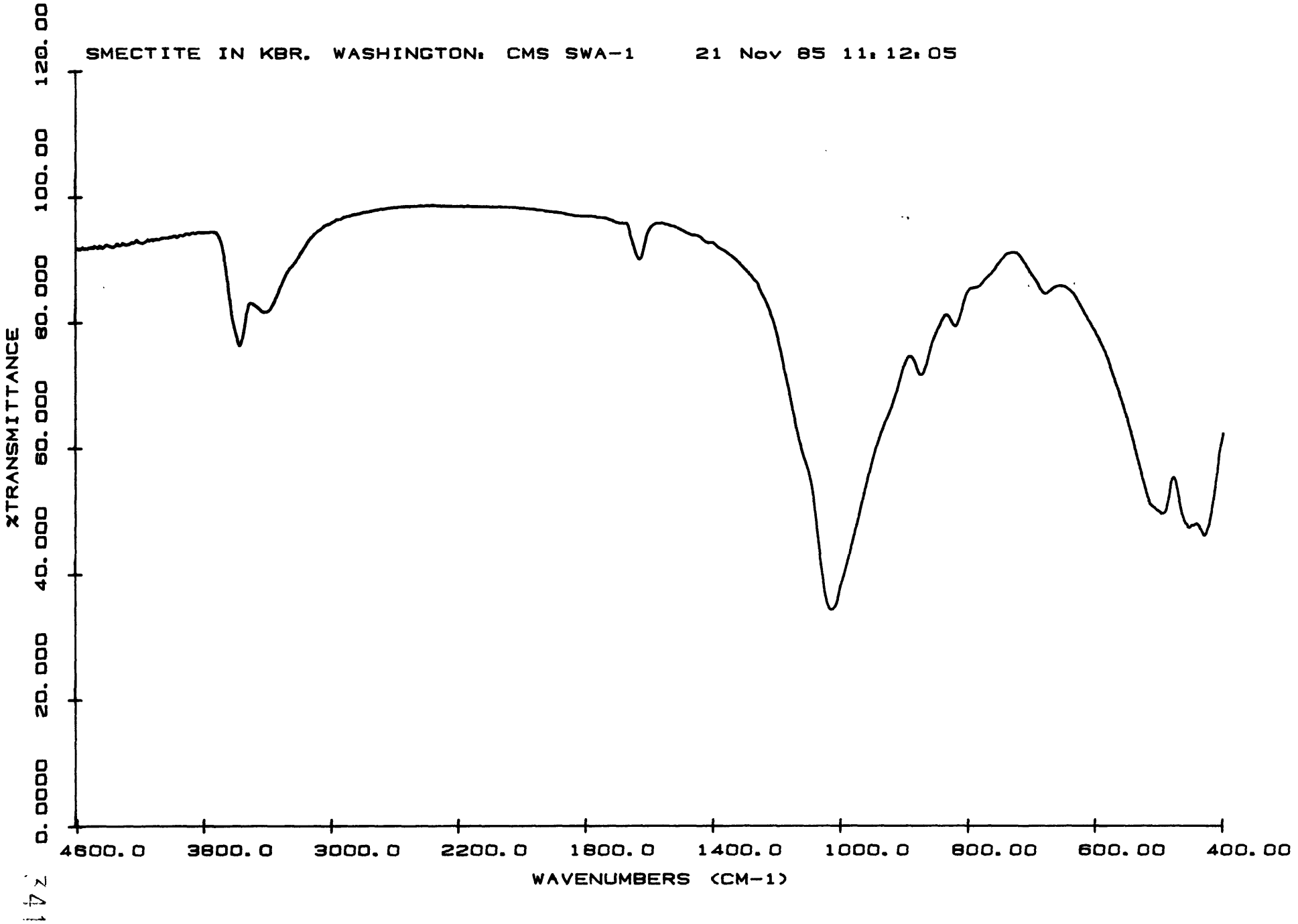
Catalog numbers, etc.: CMS SWa-1

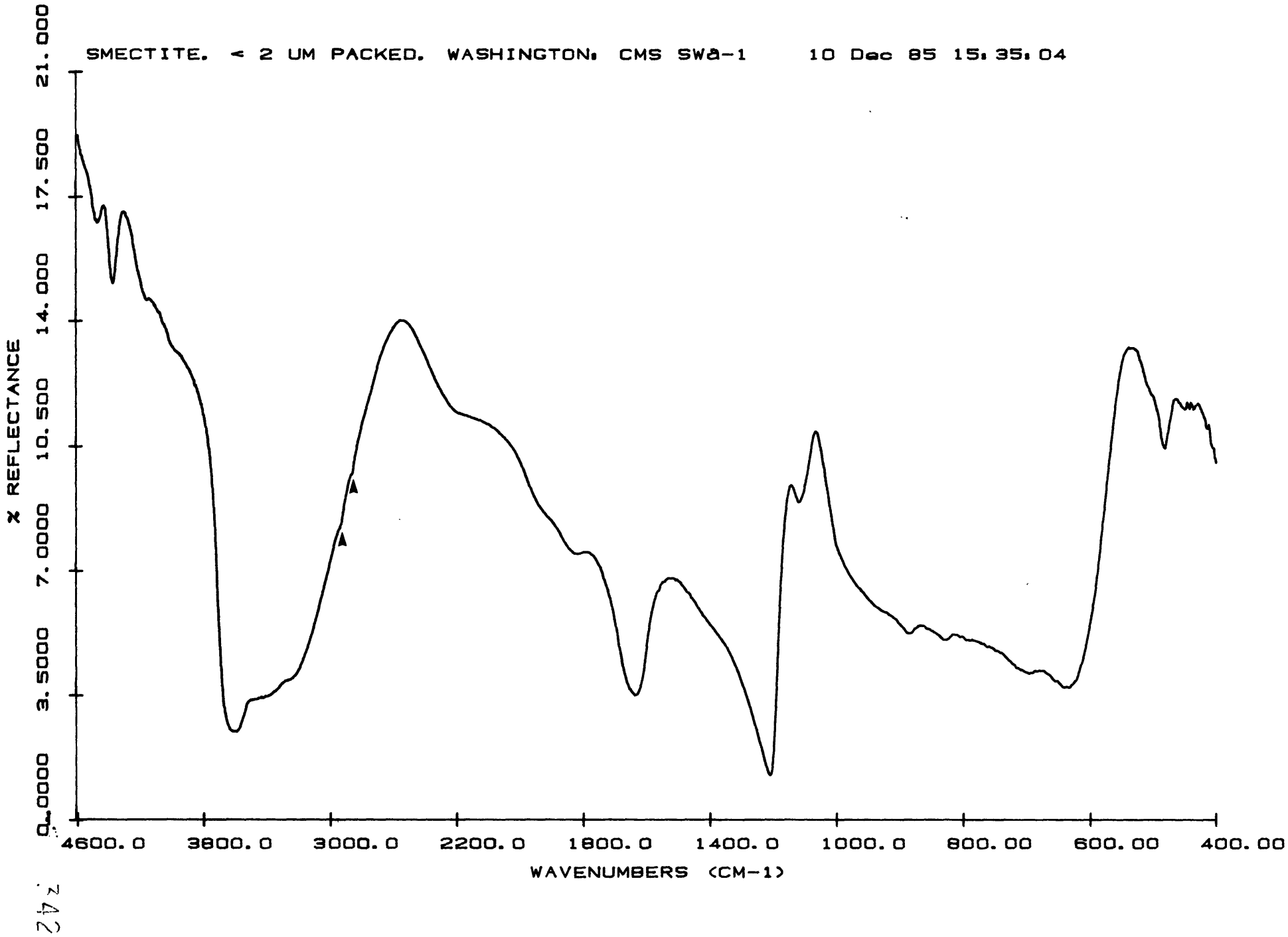
Results of petrographic examination: Described by CMS as a ferroginous smectite, the sample is brown in color.

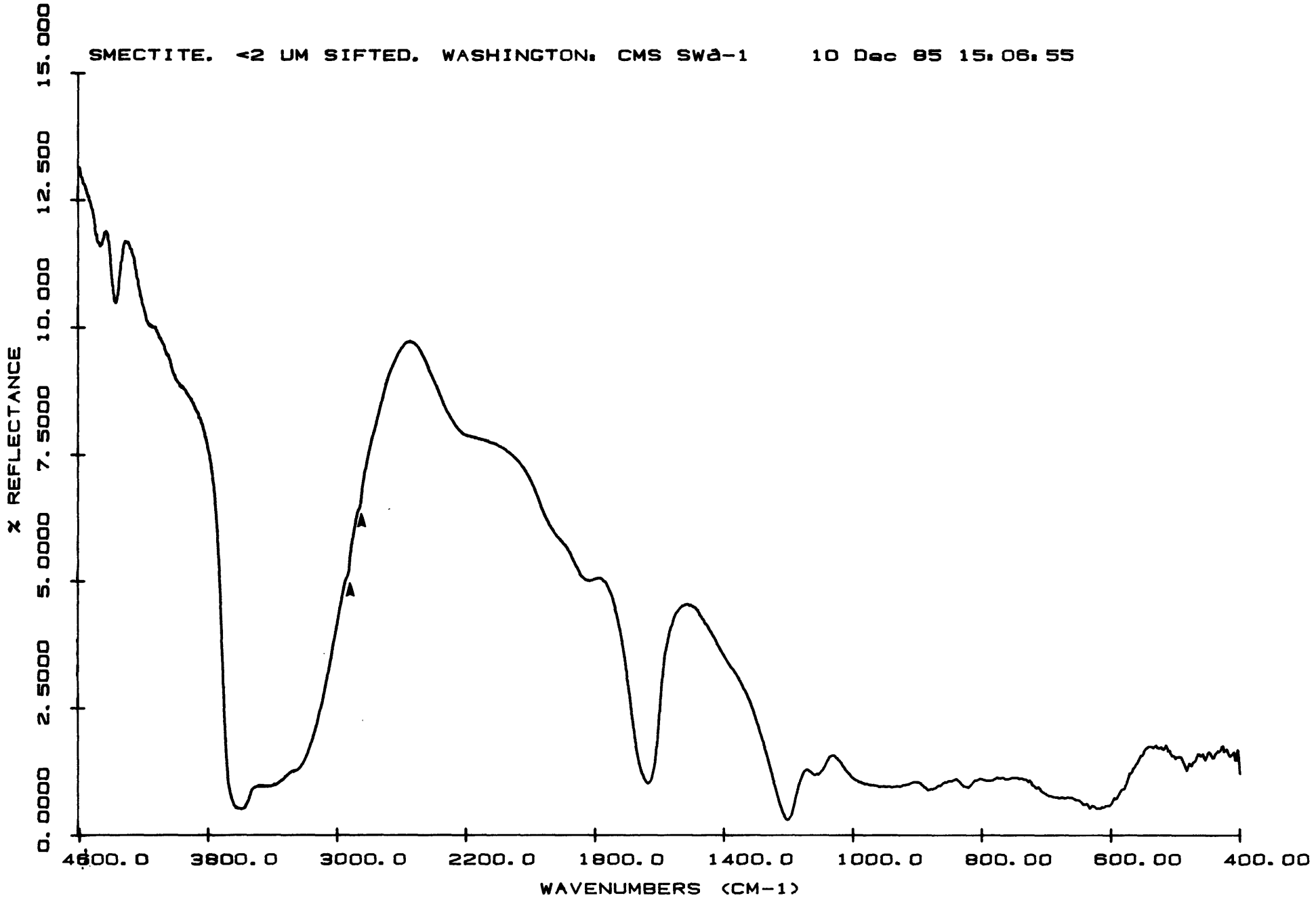
Results of XRD: Less than 2 um fraction is pure Fe-smectite (probably nontronite). Larger size fraction contains a small amount of quartz.

Results of XRF or other compositional analysis: None.

Spectra of file:
Smectite.1 Transmittance of <2 um size fraction on disk #1.
Smectite.1 Reflectance of <2 um sifted on 0-74 disk #1.
Smectite.1 Reflectance of <2 um size packed on solid sample disk #1.


SMECTITE IN KBR. WASHINGTON: CMS SWA-1 21 Nov 85 11:12:05
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SMECTITE. < 2 UM PACKED. WASHINGTON. CMS SWA-1 10 Dec 85 15:35:04
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SMECTITE. <2 UM SIFTED. WASHINGTON: CMS SWâ-1 10 Dec 85 15:06:55
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Spessartine $Mn_3Al_2(SiO_4)_3$

Locality: Rutherford #2 mine, Amelia, Amelia Co., Virginia

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 114143

Results of petrographic examination: A group of 3 mm and smaller diameter reddish crystals. Seem to be a few clear crystals adhering to the grains that were picked off; otherwise appears pure. Under petrographic microscope, sample appears pure.

Results of XRD: Pure spessartine.

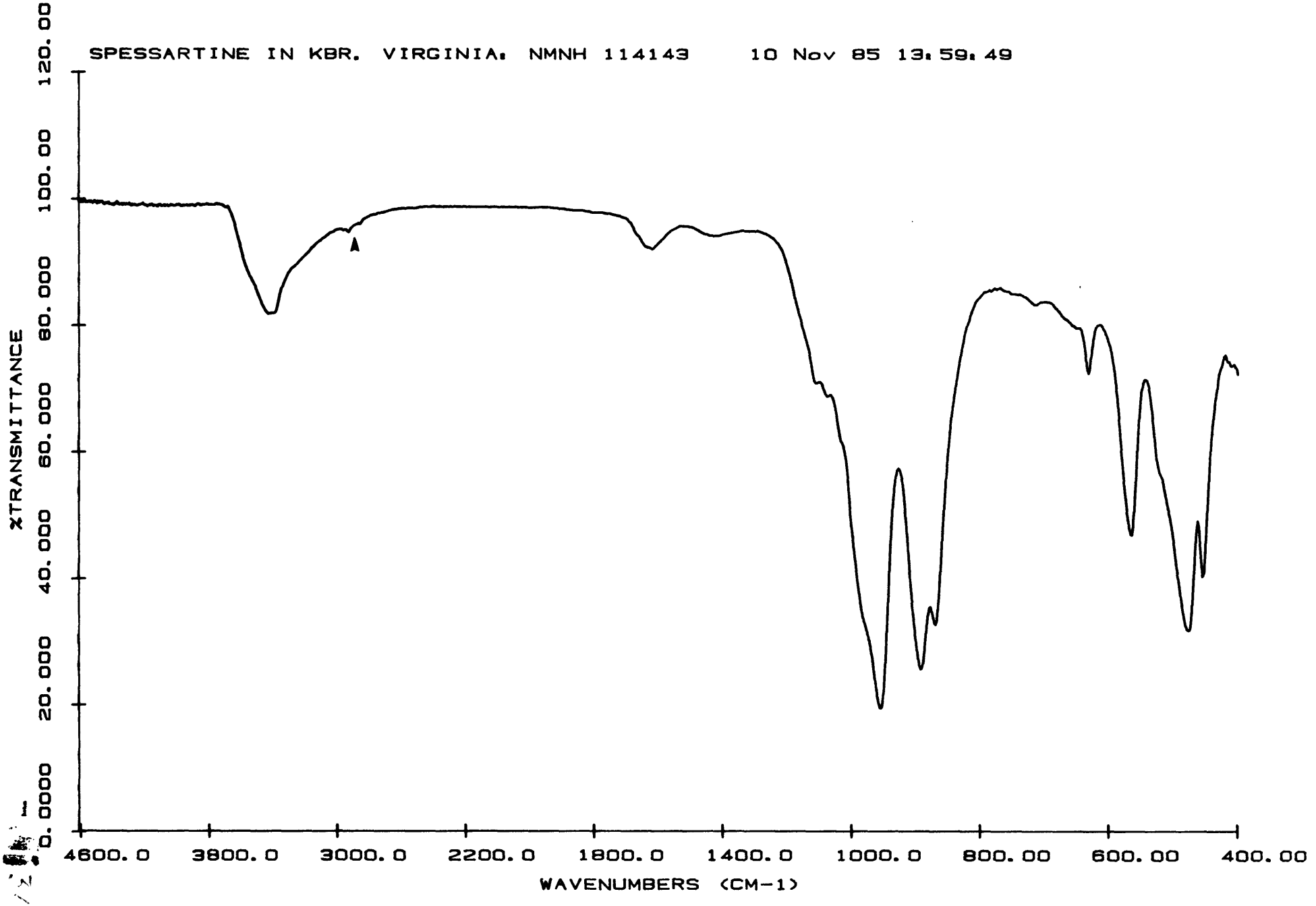
Results of XRF or other compositional analysis: Microprobe analysis found one heterogeneous area where all oxides, including silica, summed to only 27 wt %. Otherwise, FeO varies from 7.5 to 12%, with inverse variation in MnO. Average of 10 analyses (other than anomalous point)

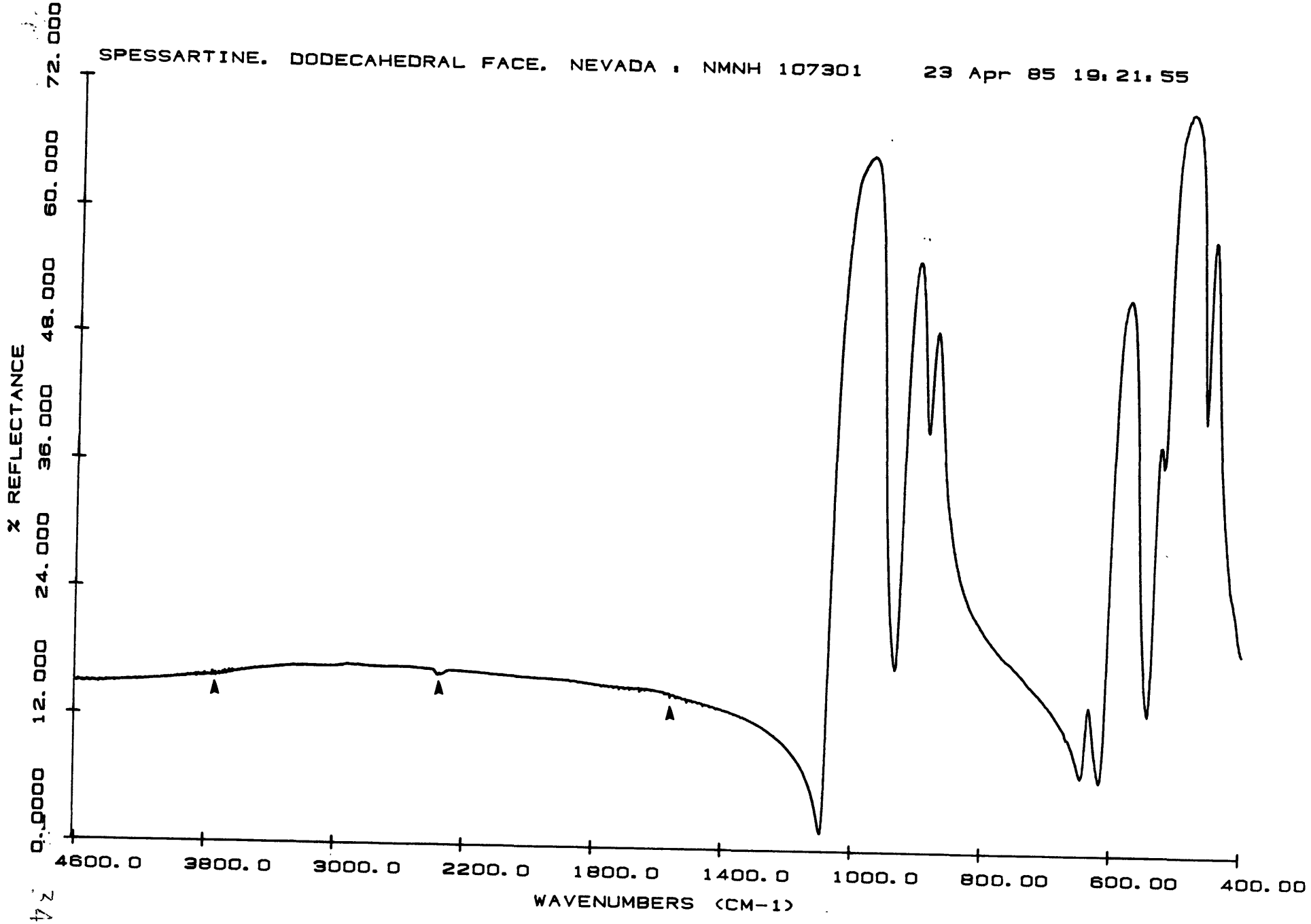
SiO_2	- 35.02
Al_2O_3	- 20.74
FeO	- 10.40
MgO	- 0.04
CaO	- 1.61
K_2O	- 0.03
Na_2O	- 0.09
TiO_2	- 0.07
MnO	- 30.82
Total	- 98.81

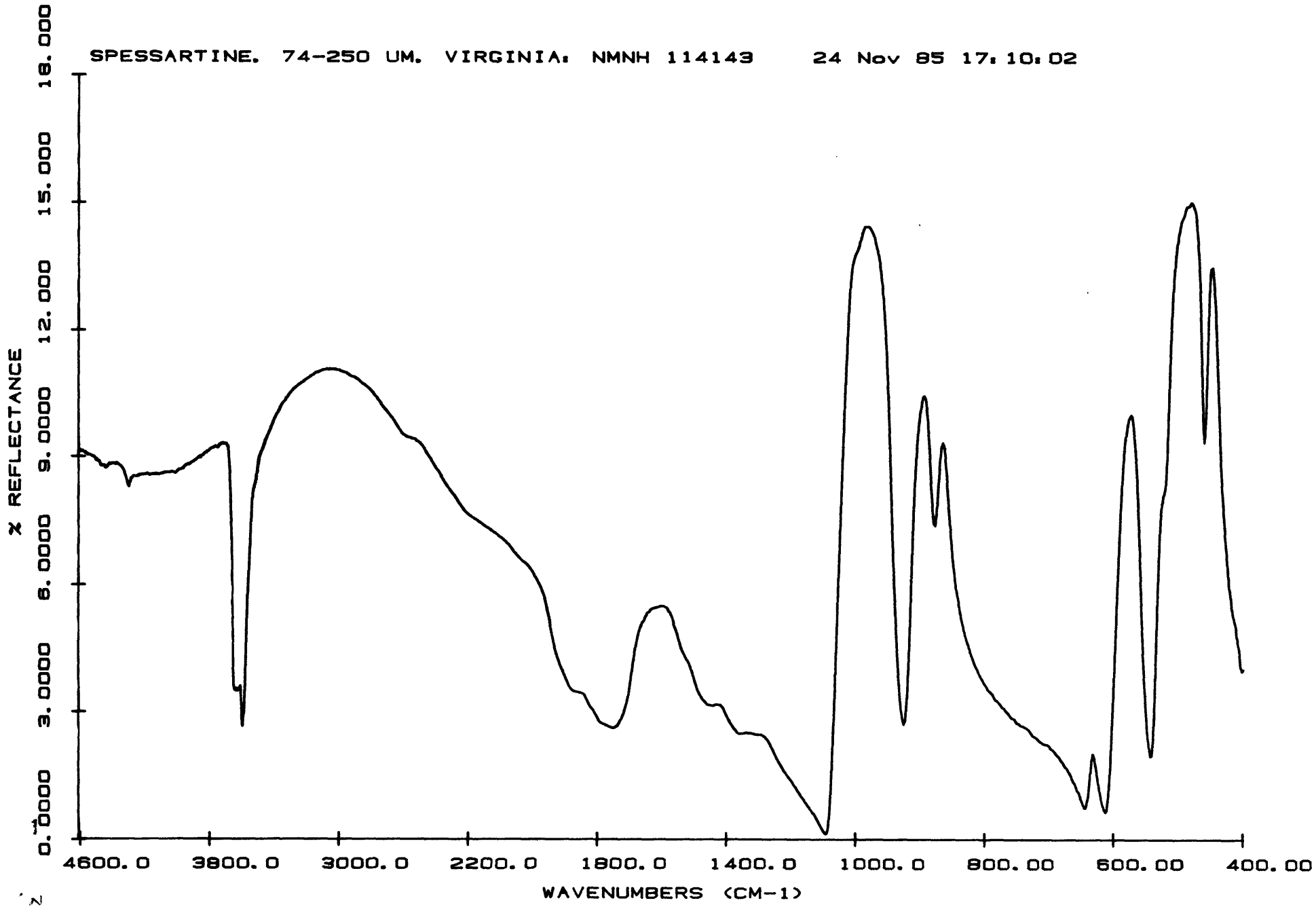
Spectra on file:

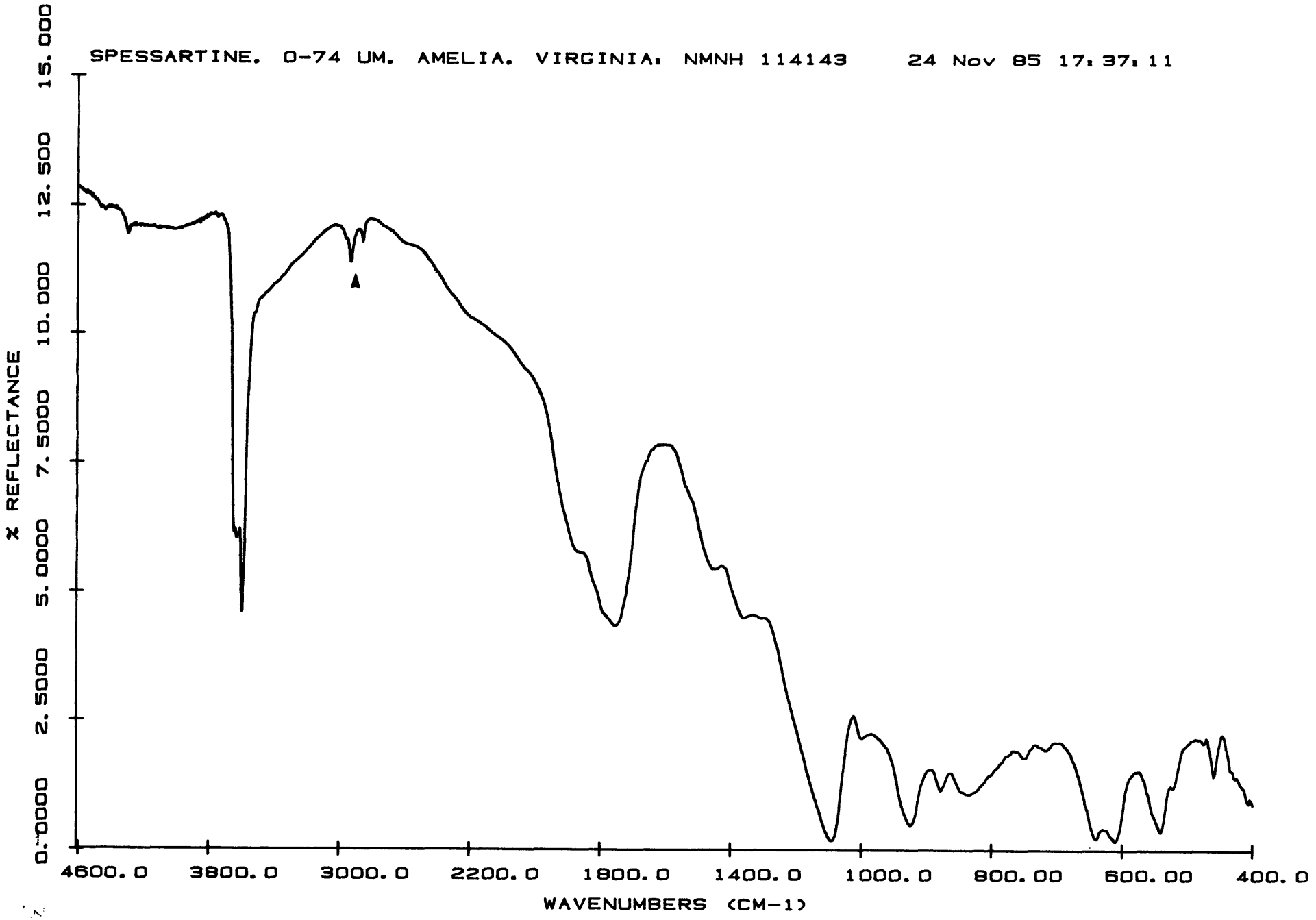
Spessartine.2 Reflectance spectrum of 74-250 size range on disk #1.
Spessartine.2 Reflectance spectrum of 0-74 um size range on disk #1.
Spessartine.2 *Reflectance spectrum of dodecahedral crystal face on solid sample disk #1.*
Spessartine.2 Transmittance spectrum on disk #1.

*This reflectance spectrum is from another mineral specimen, which was ultimately rejected because of contamination of the powdered sample by interstitial quartz. However, spectra of the spessartine crystals were identical for both specimens. The solid sample spectrum from NMNH 114143 was inadvertantly lost and is replaced by NMNH 107301.


SPESSARTINE IN KBR. VIRGINIA: NMNH 114143 10 Nov 85 13:59:49
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SPESSARTINE. DODECAHEDRAL FACE. NEVADA : NMNH 107301
23 Apr 85 19:21:55
% REFLECTANCE
72.000
60.000
48.000
36.000
24.000
12.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SPESSARTINE. 74-250 UM. VIRGINIA: NMNH 114143 24 Nov 85 17:10:02
% REFLECTANCE
18.000
15.000
12.000
9.0000
6.0000
3.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SPESSARTINE. 0-74 UM. AMELIA. VIRGINIA: NMNH 114143 24 Nov 85 17:37:11
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.70000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.0
WAVENUMBERS (CM-1)

Species name: Spodumene $LiAlSi_2O_6$

Locality: Anita Mine, Pala Chief Hill, Pala, San Diego Co., Cal.

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 12430-1

Results of petrographic examination: Hand sample is 3 cm long x 1 cm wide, transparent with small amount of iron staining. Under petrographic microscope no foreign material noted.

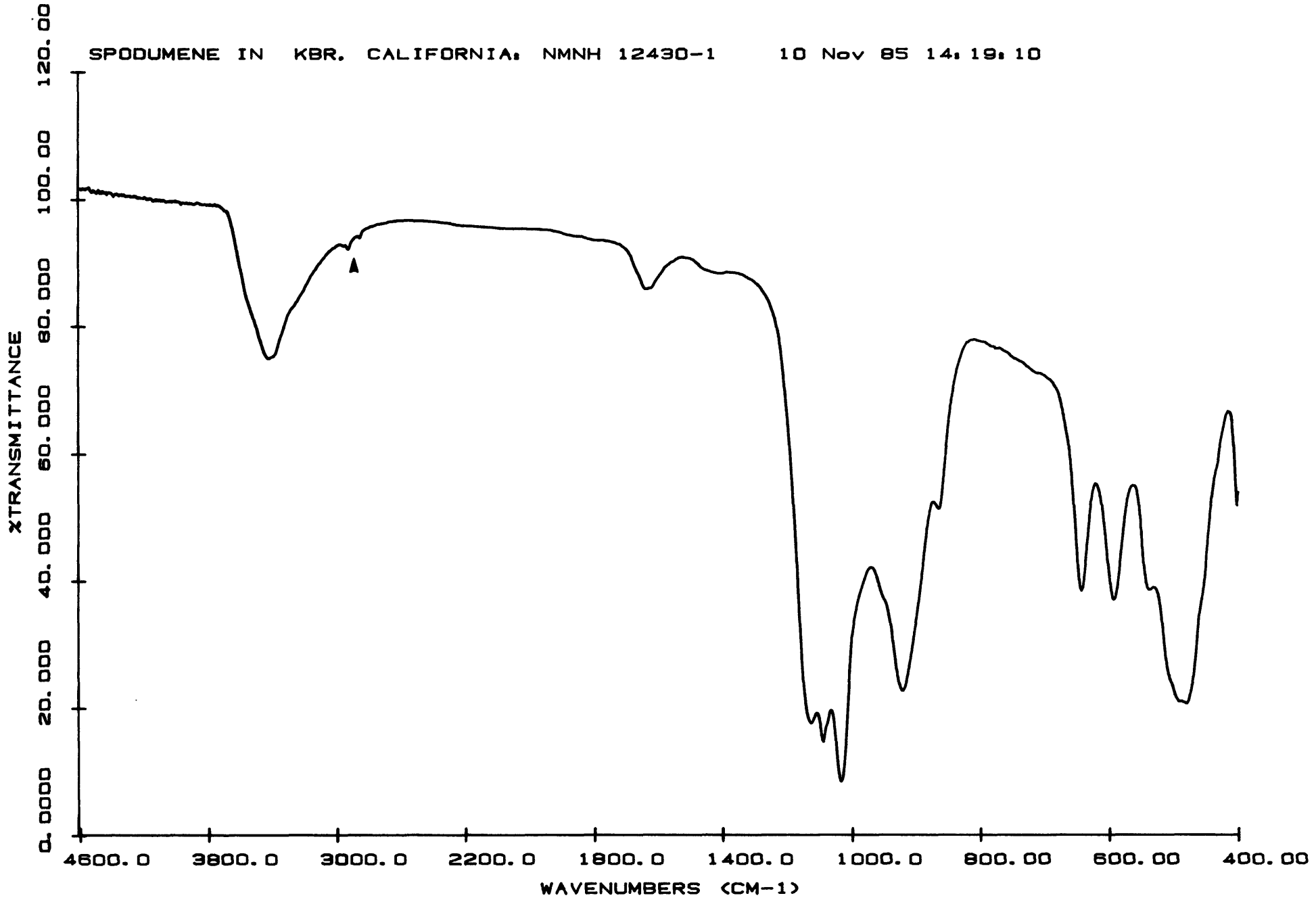
Results of XRD: Sample contains spodumene with extra, small peaks at 4.44 A and 1.847 A due to unknown.

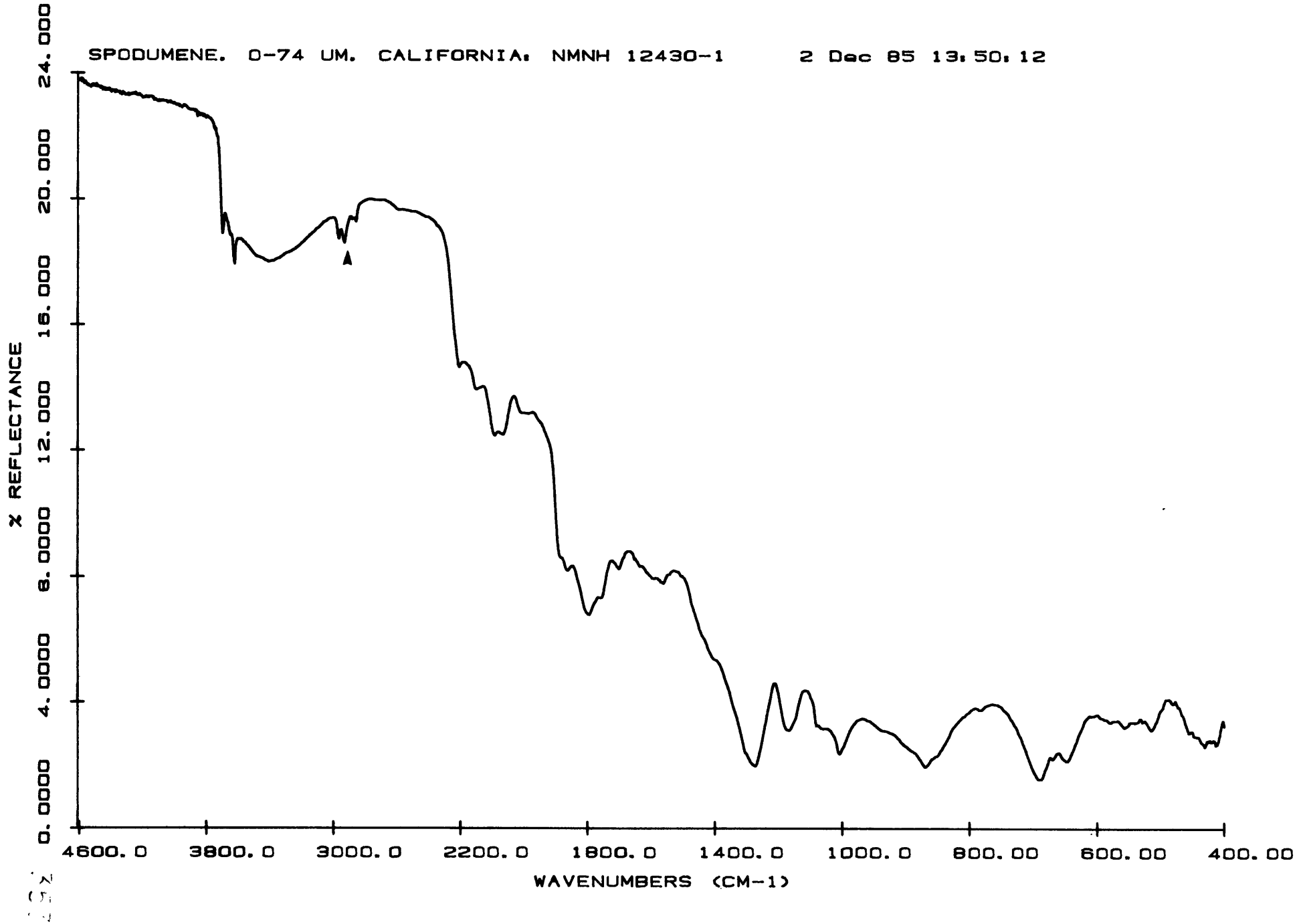
Results of XRF or other compositional analysis: Microprobe analysis showed the sample to be homogeneous within and between grains. Average of 9 analyses which did not include lithium:

SiO_2	- 63.97
Al_2O_3	- 26.88
FeO	- 0.01
MgO	- 0.01
CaO	- 0.01
K_2O	- 0.01
Na_2O	- 0.22
TiO_2	- 0.02
MnO	- 0.10
Total	- 91.23

Spectra on file:

Spodumene.1	Reflectance spectrum of prismatic cleavage face on solid sample disk #1.
Spodumene.1	Reflectance spectrum of 0-74 um size range on disk #1.
Spodumene.1	Reflectance spectrum of 74-250 um size range on disk #1.
Spodumene.1	Transmittance spectrum on disk #1.


SPODUMENE IN KBR. CALIFORNIA: NMNH 12430-1 10 Nov 85 14:19:10
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


SPODUMENE. 0-74 UM. CALIFORNIA: NMNH 12430-1
2 Dec 85 13:50:12
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Talc, $Mg_3Si_4O_{10}(OH)_2$

Locality: Feiser Mine, Ruby Mountains, Montana

Last donor:

Intermediate donor:

Ultimate donor: Jim Crowley

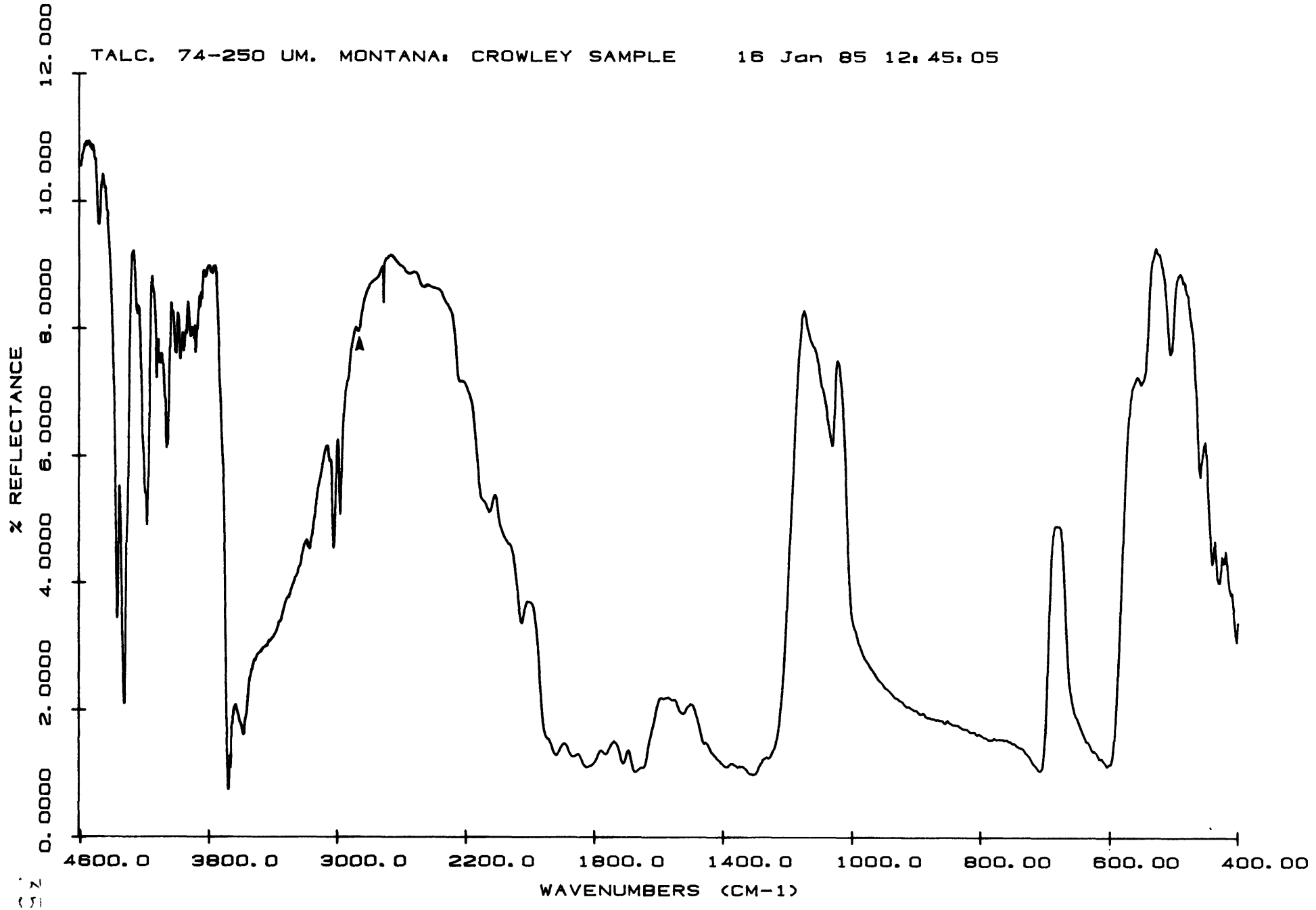
Catalog numbers, etc.: Crowley sample

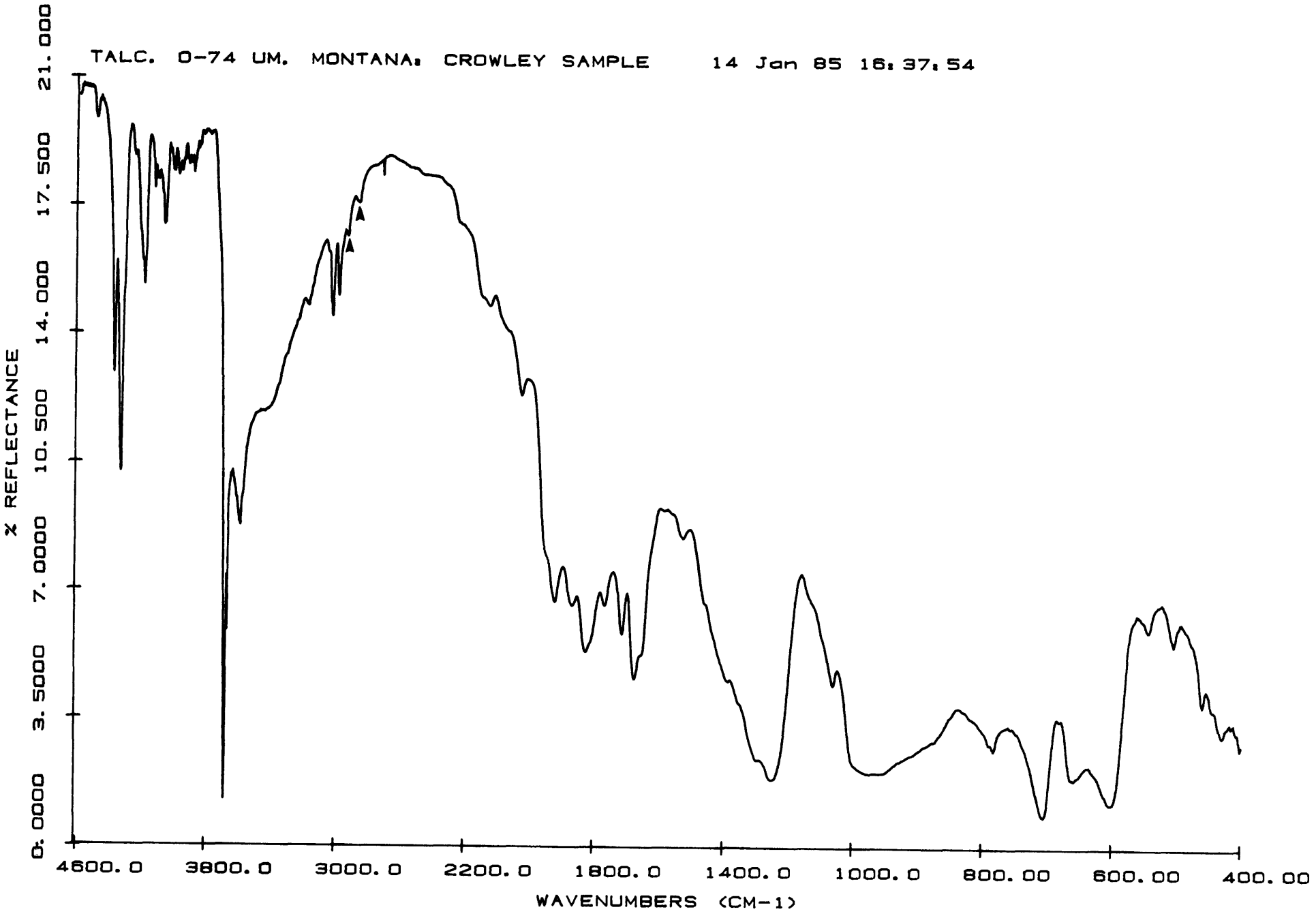
Results of petrographic examination: Hand sample is massive, fine-grained and slightly greenish in color. Under the microscope, sample is cryptocrystalline.

Results of XRD: Pure talc (Jim Crowley).

Results of XRF or other compositional analysis: To be determined.

Spectra of file:
Talc.1 Transmittance spectrum on disk #1.
Talc.1 Reflectance spectrum of 0-74 um size range on disk #1.
Talc.1 Reflectance spectrum of 74-250 um size range on disk #1.
Talc.1 Reflectance spectrum of fracture surface on solid sample disk #1.


TALC. 74-250 UM. MONTANA: CROWLEY SAMPLE 16 Jan 85 12:45:05
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


TALC. 0-74 UM. MONTANA: CROWLEY SAMPLE 14 Jan 85 16:37:54
% REFLECTANCE
0.0000
3.5000
7.0000
10.500
14.000
17.500
21.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Tourmaline (Elbaite) $Na(Li, Al)_3 Al_6 (BO_3)_3 Si_6O_{18}(OH)_4$

Locality: Sao Jose De Brejuada, Minas Gerais, Brazil

Last donor: Smithsonian Museum of Natural History

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 94217-1

Results of petrographic examination: A purple sudhedral crystal, transparent with some green coloration to one end. Sample is ~ 5 mm x 2 cm x 2 cm. Under petrographic microscope, sample appears pure, clear.

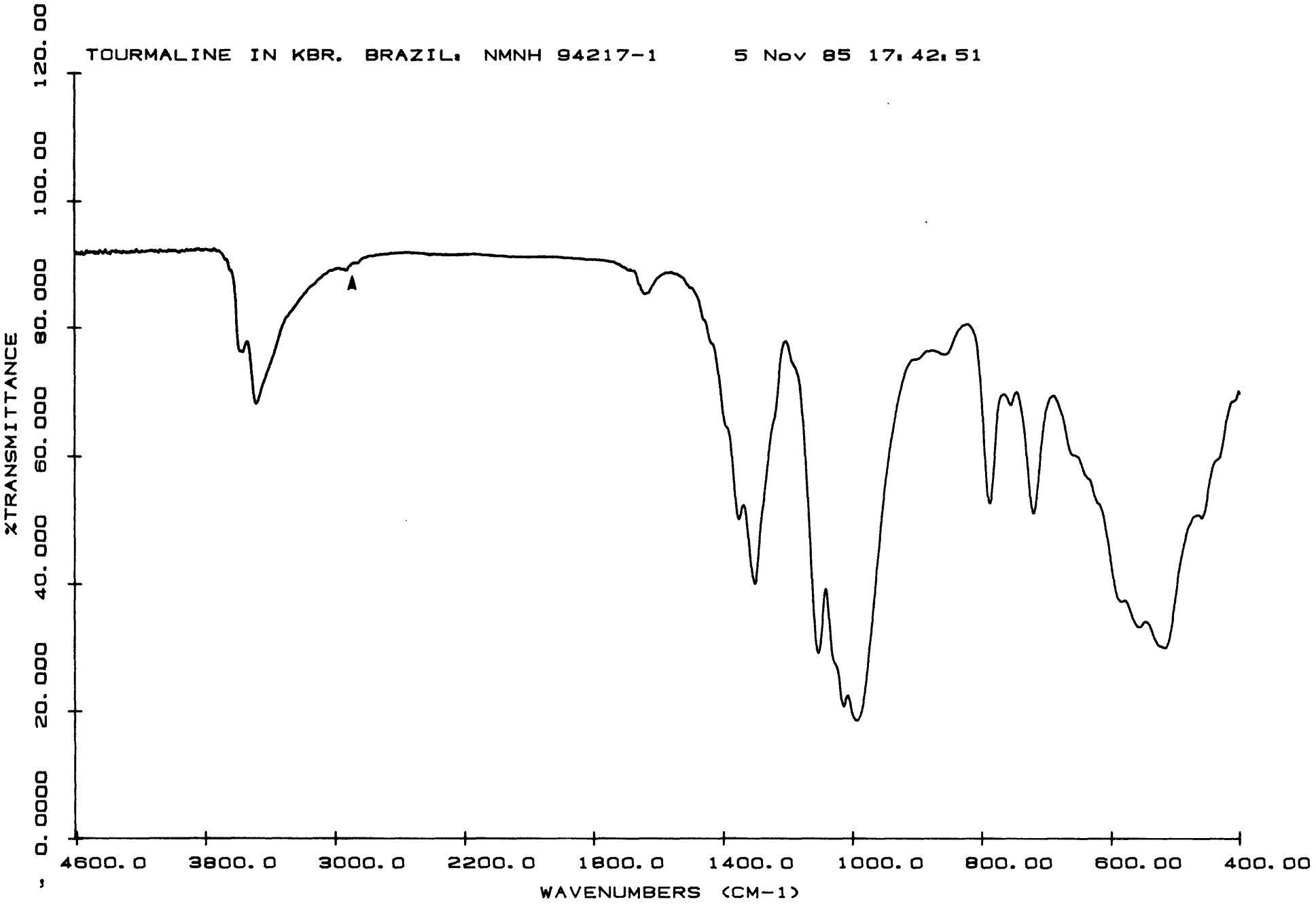
Results of XRD: Pure tourmaline.

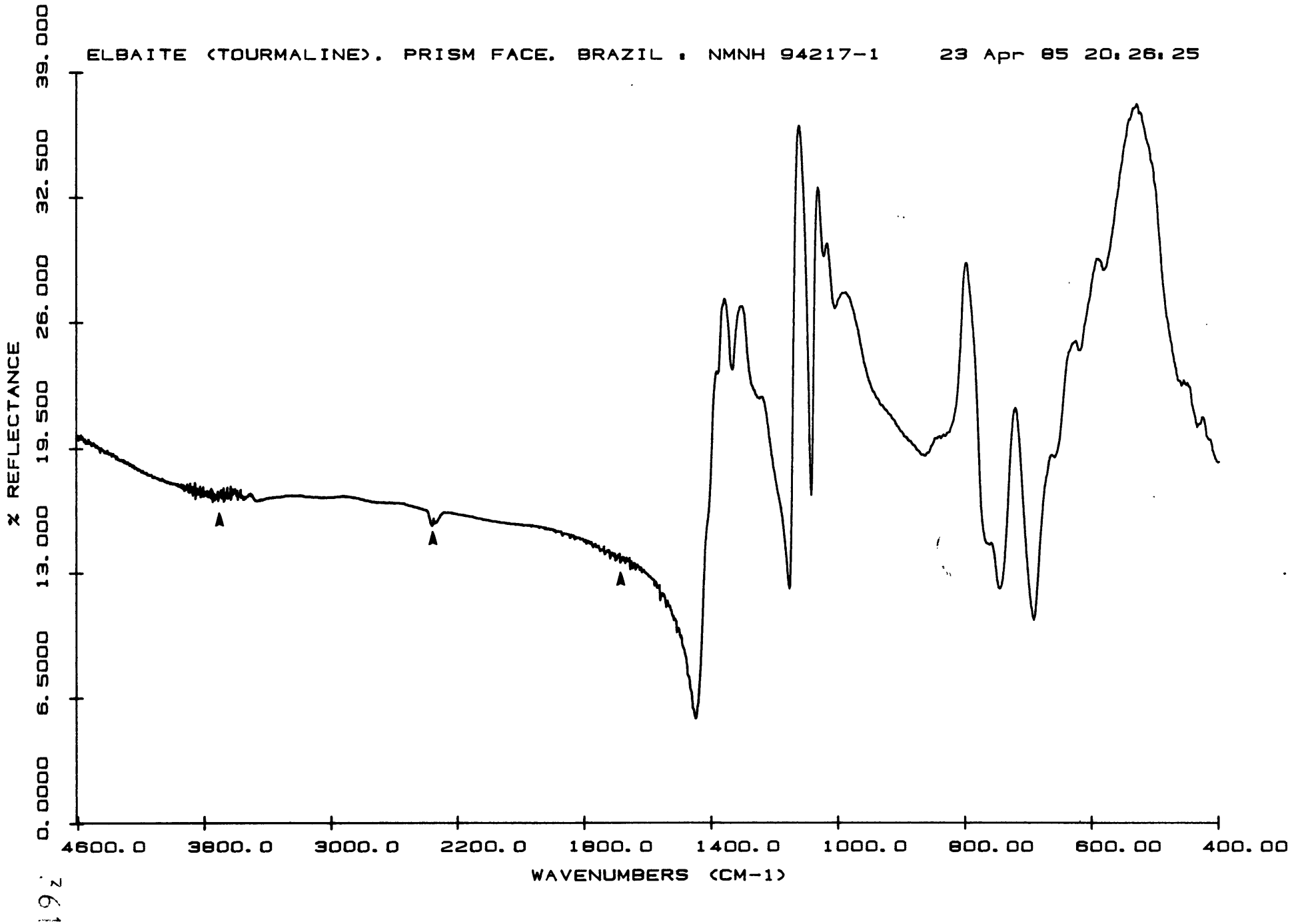
Results of XRF or other compositional analysis: Microprobe analysis showed the sample to be homogeneous within and between grains. Average of seven analyses does not include lithium, boron or water, but demonstrates the presence of sufficient manganese to indicate that this is not end member elbaite:

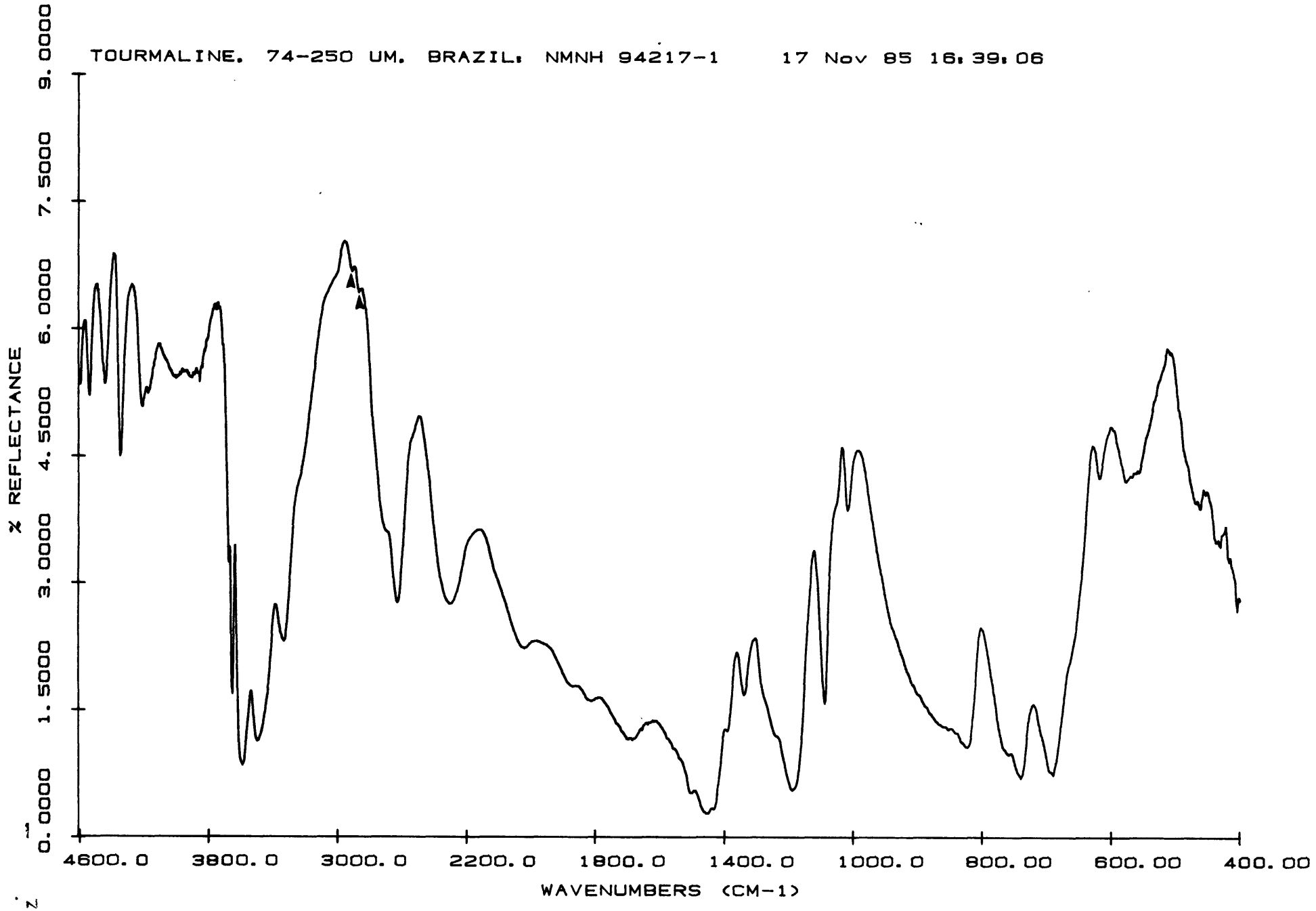
SiO_2	- 36.83
Al_2O_3	- 40.56
FeO	- 0.12
MgO	- 0.03
CaO	- 0.13
K_2O	- 0.01
Na_2O	- 2.37
TiO_2	- 0.04
MnO	- 4.40
Total	- 84.49

Spectra on file:

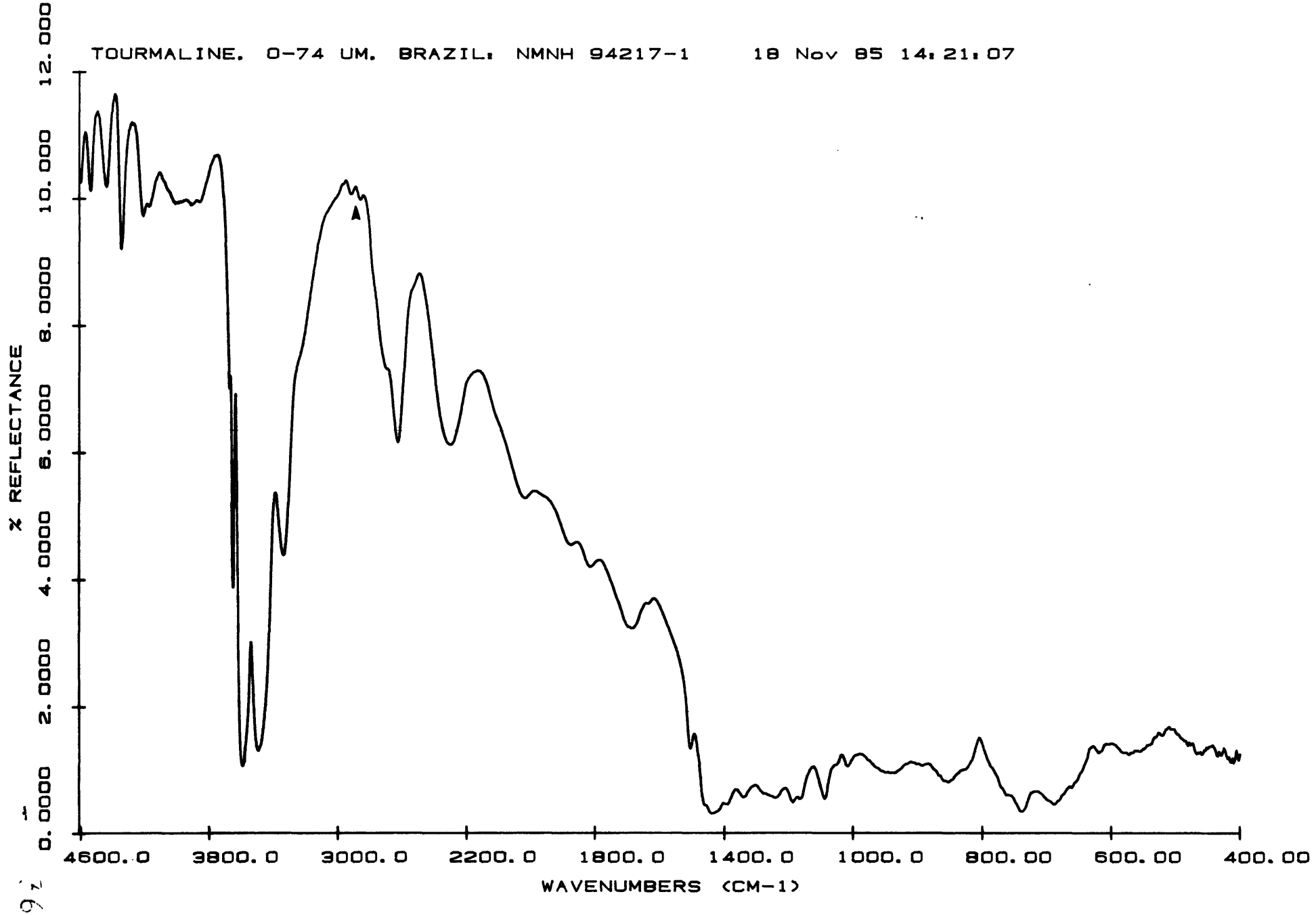
Tourmaline.1 Reflectance from prism face on solid sample disk #1.
Tourmaline.1 Reflectance spectrum of 0-74 um size range on disk #1.
Tourmaline.1 Reflectance spectrum of 74-250 um size range on disk #1.
Tourmaline.1 Transmittance spectrum on disk #1.


TOURMALINE IN KBR. BRAZIL: NMNH 94217-1 5 Nov 85 17:42:51
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


ELBAITE (TOURMALINE). PRISM FACE. BRAZIL . NMNH 94217-1 23 Apr 85 20:26:25
% REFLECTANCE
39.000
32.500
26.000
19.500
13.000
6.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


TOURMALINE. 74-250 UM. BRAZIL: NMNH 94217-1 17 Nov 85 16:39:06
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

29z


TOURMALINE. 0-74 UM. BRAZIL: NMNH 94217-1 18 Nov 85 14:21:07
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Tourmaline $NaFe_3^{+2}Al_6(BO_3)_3Si_6O_{18}(OH)_4$

Locality: Minas Geras, Brazil

Last donor: Hunt and Salisbury

Intermediate donor:

Ultimate donor: Ward's Scientific

Catalog numbers, etc.: H & S 120B

Results of petrographic examination: Under petrographic microscope, no contamination noticed. Color (blue) indicates it possibly is closer to schorl.

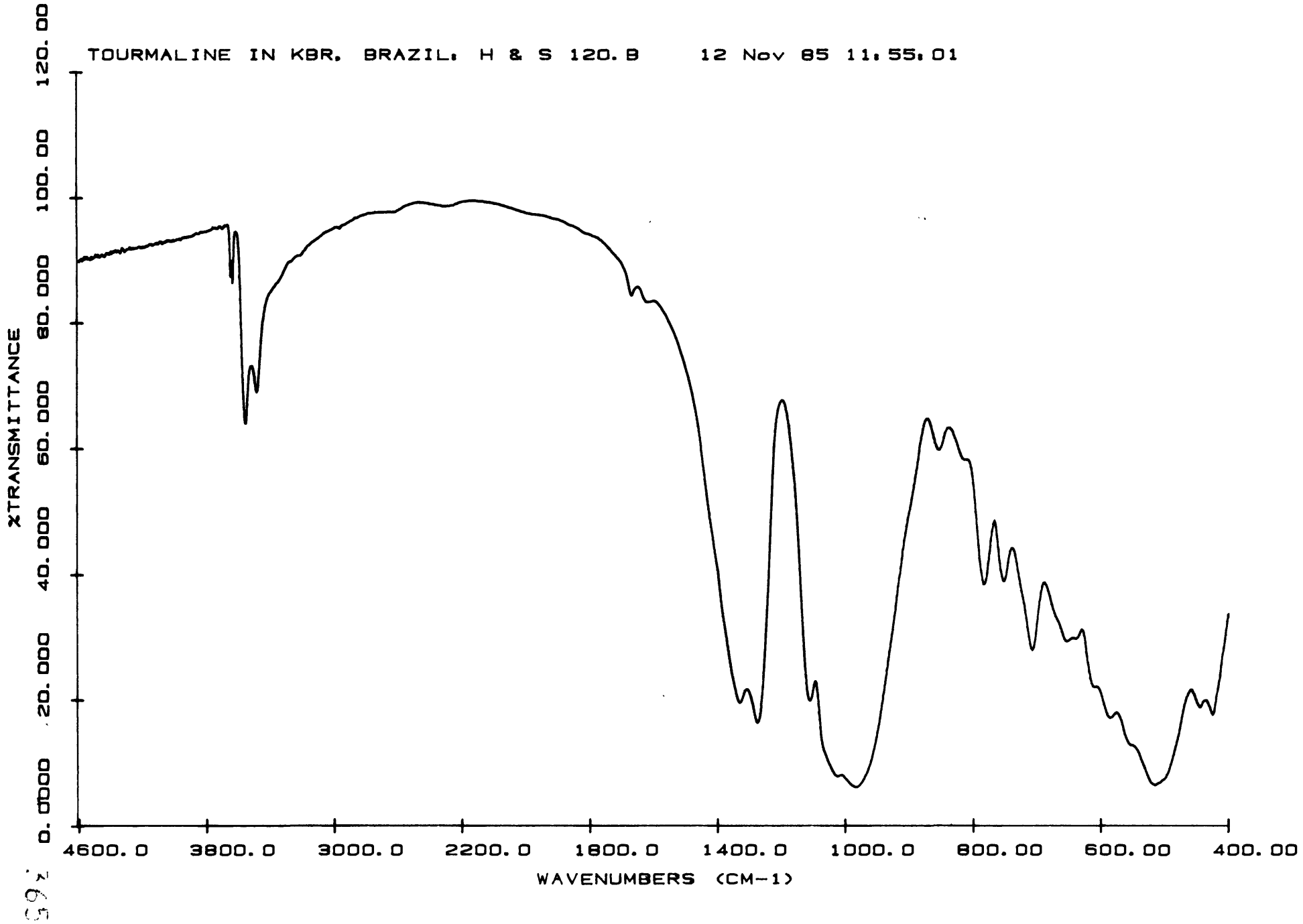
Results of XRD: Pure tourmaline.

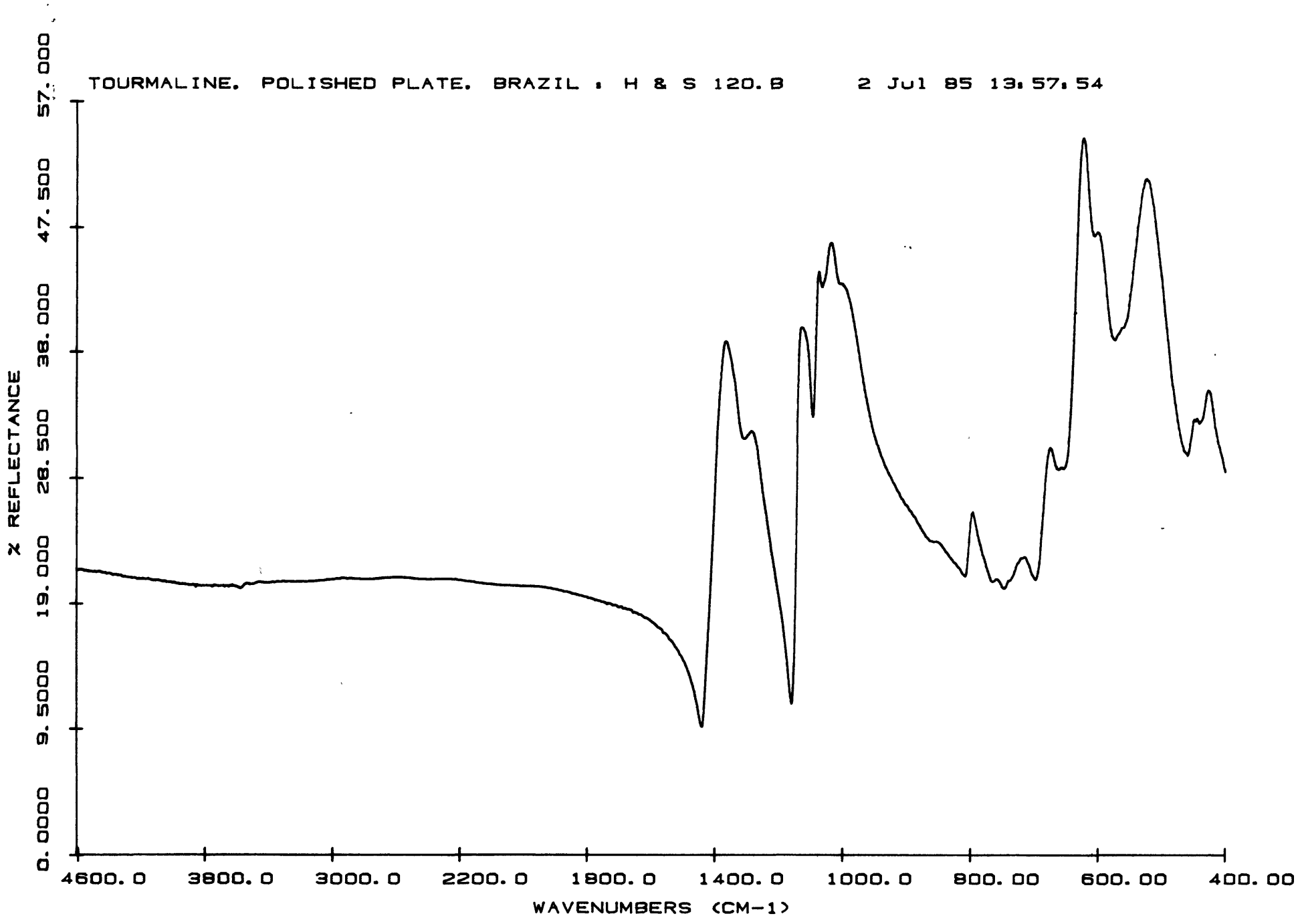
Results of XRF or other compositional analysis: Microprobe analysis shows that sample is homogeneous between and within grains. Average of 10 analysis lacks information on boron and water, but shows sufficient iron present to confirm schorl composition.

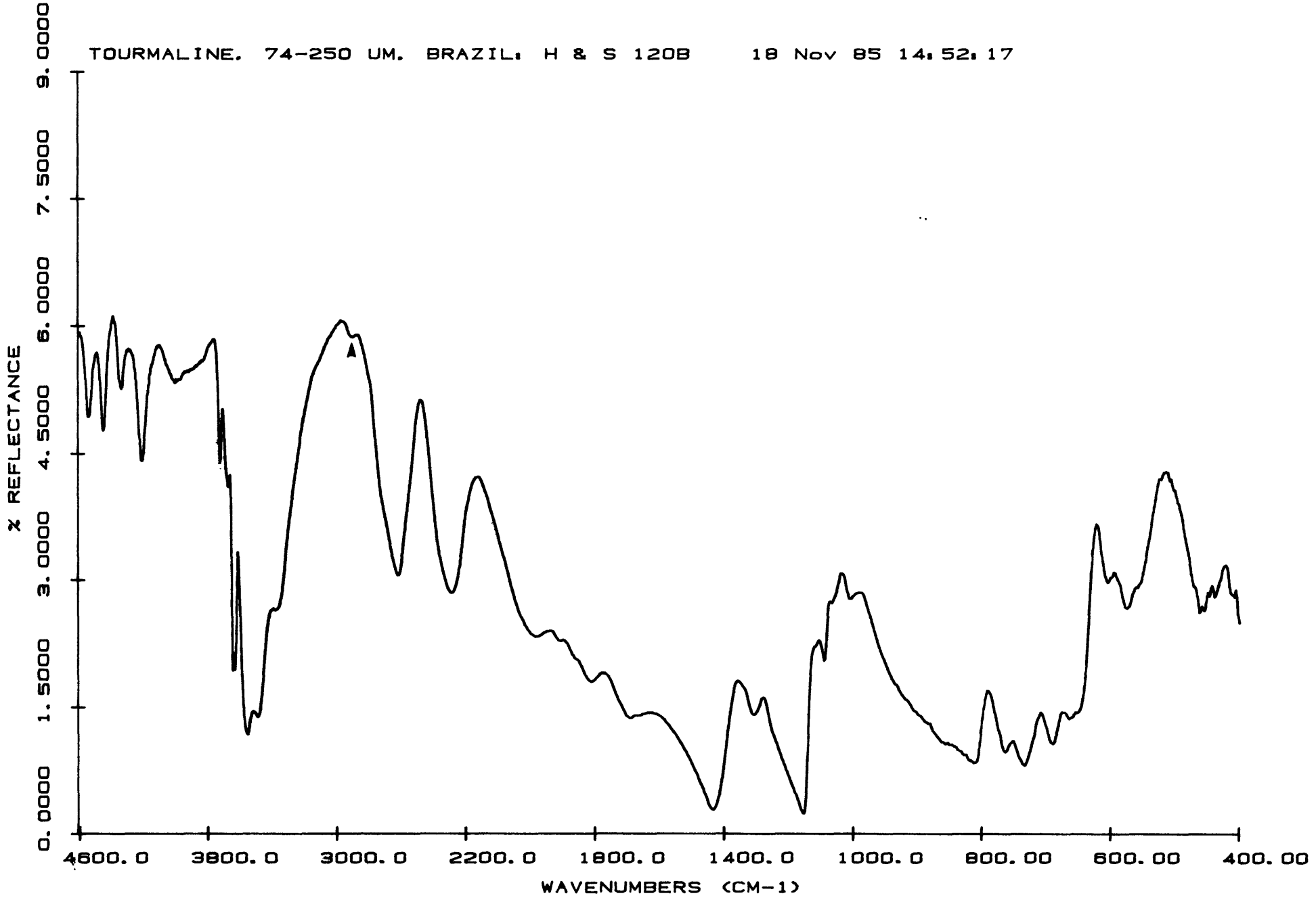
SiO_2	- 35.11
Al_2O_3	- 34.52
FeO	- 11.98
MgO	- 1.02
CaO	- 0.07
K_2O	- 0.04
Na_2O	- 1.38
TiO_2	- 0.05
MnO	- 0.27
Total	- 84.44

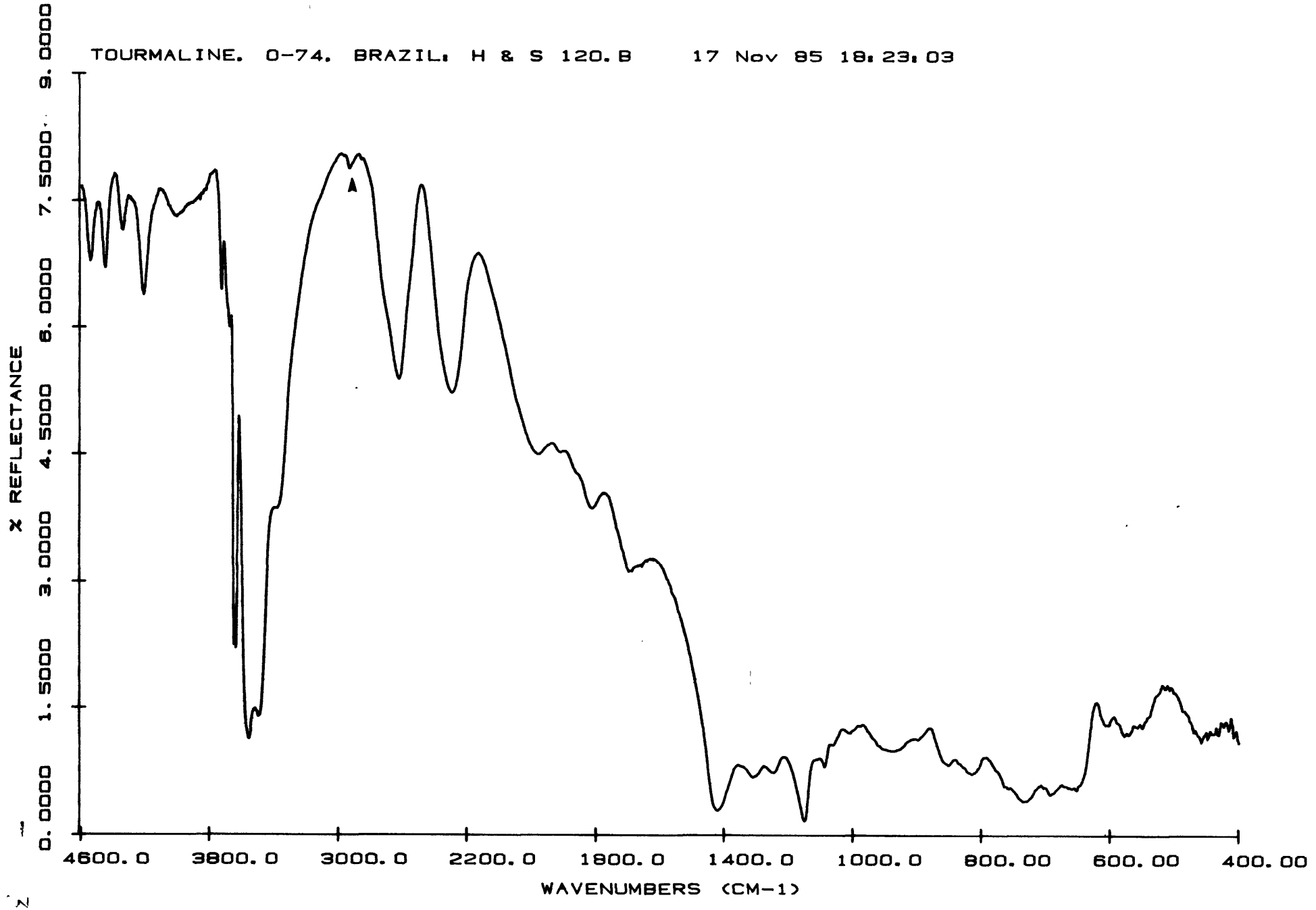
Spectra on file:

Tourmaline.2 Diffuse reflectance spectrum of 74-250 um size range on disk #1.
Tourmaline.2 Diffuse reflectance spectrum of 0-74 um size range on disk #1.
Tourmaline.2 Transmittance spectrum on disk #1
Tourmaline.2 Diffuse relfectance spectrum of polished plate surface on solid sample disk #1.


TOURMALINE IN KBR. BRAZIL. H & S 120.B 12 Nov 85 11:55:01
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


TOURMALINE. POLISHED PLATE. BRAZIL : H & S 120.B 2 Jul 85 13:57:54
% REFLECTANCE
57.000
47.500
38.000
28.500
19.000
9.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


TOURMALINE. 74-250 UM. BRAZIL: H & S 120B 18 Nov 85 14:52:17
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


TOURMALINE. O-74. BRAZIL: H & S 120.B 17 Nov 85 18:23:03
% REFLECTANCE
0.0000
1.5000
3.0000
4.5000
6.0000
7.5000
9.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Tremolite $Ca_2(Mg, Fe^{+2})_5Si_8O_{22}(OH)_2$

Locality: Balmat, NY

Last donor: Bruce Hemingway

Intermediate donor:

Ultimate donor: Burminco, 128 S. Encinitas Ave. Monrovia, CA.

Catalog numbers, etc.: None

Results of petrographic examination: Sample consists of 2-3 cm long x 1-2 cm wide mass of tremolite crystals, white in color, appearing pure. Under petrographic microscope, sample pure.

Results of XRD: Pure tremolite.

Results of XRF or other compositional analysis: Analysis by Ed Olsen, natural History Museum, Chicago on sample from the same location (not same sample):

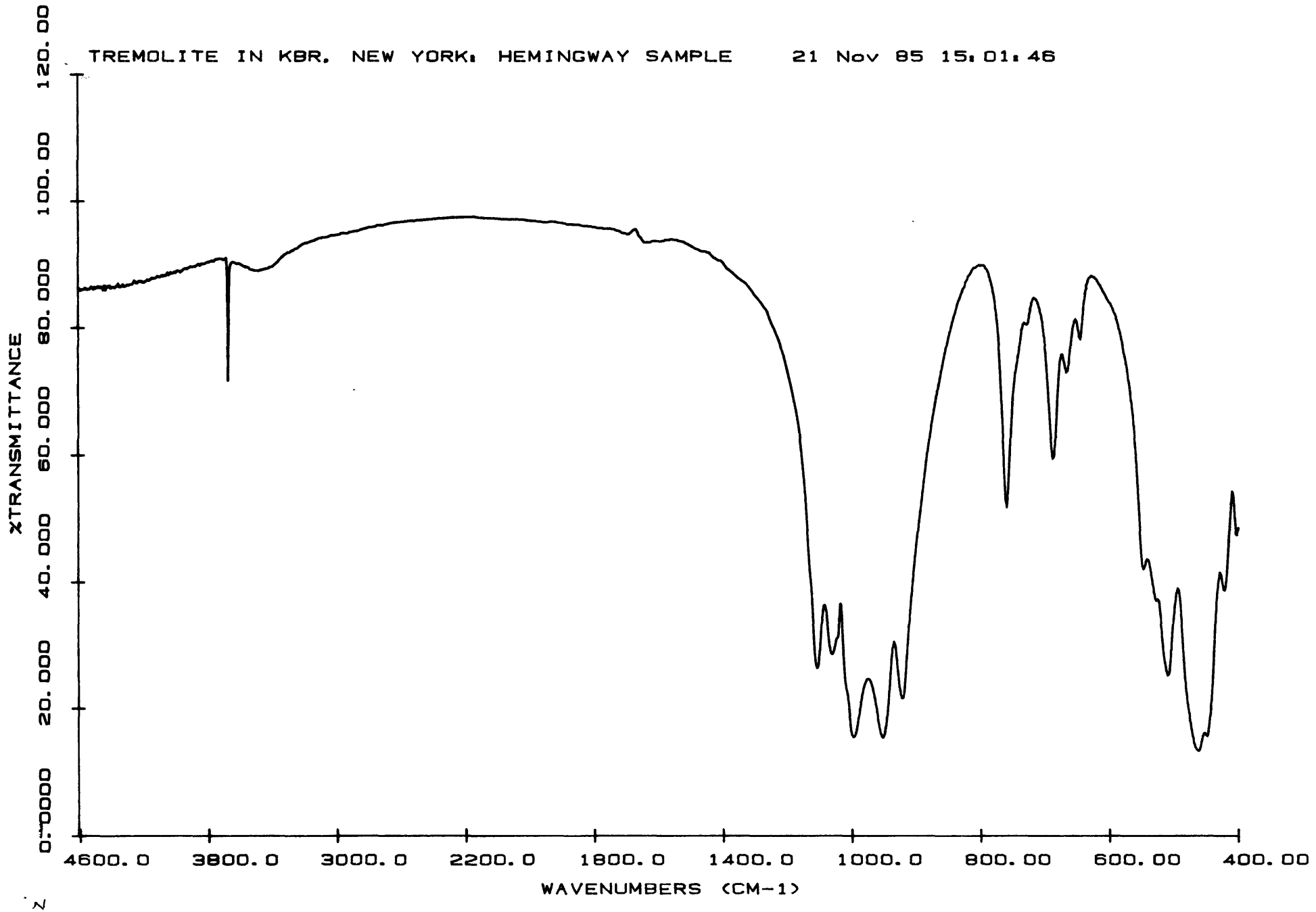
SiO_2	- 59.45
Al_2O_3	- 0.49
FeO	- 0.07
MnO	- 0.38
MgO	- 25.19
CaO	- 11.88
H_2O^+	- 2.27

Microprobe analysis by L. Walter shows sample is homogeneous between and within grains. Average of 9 analyses:

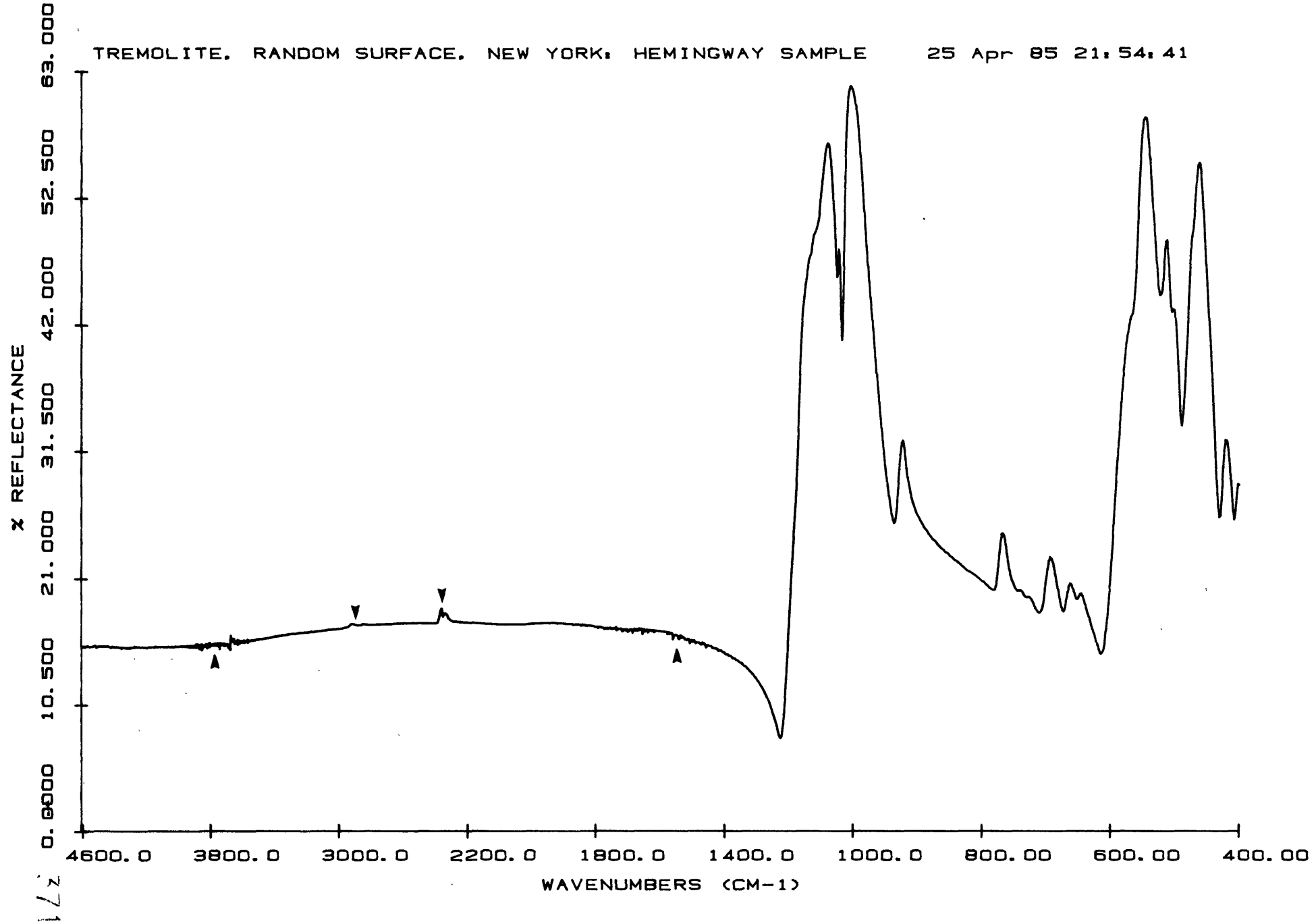
SiO_2	- 57.97
Al_2O_3	- 0.09
FeO	- 0.08
MgO	- 24.51
CaO	- 13.02
K_2O	- 0.13
Na_2O	- 0.17
TiO_2	- 0.02
MnO	- 0.63
Total	- 96.62

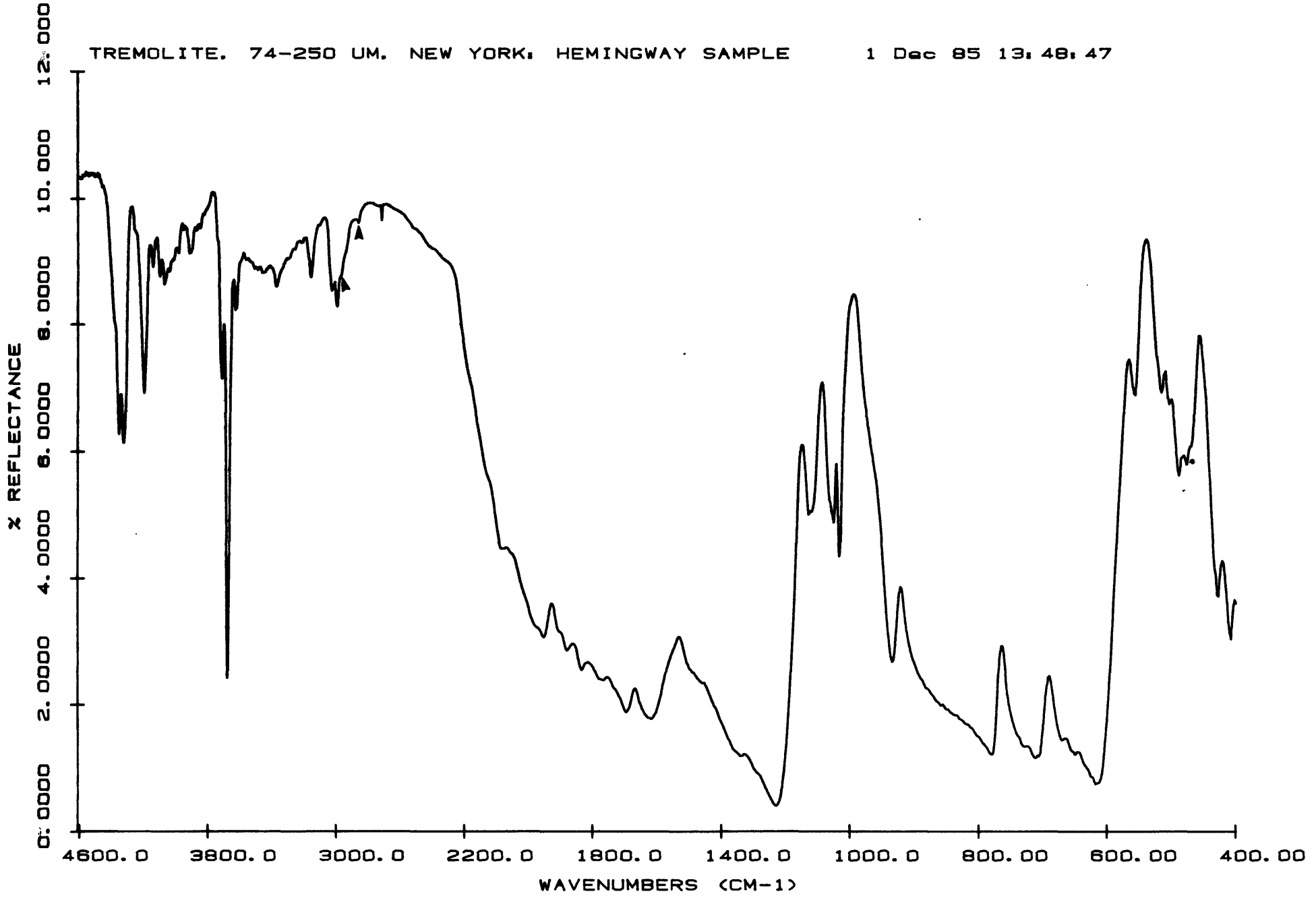
Spectra on file:

Tremolite.1 Reflectance spectrum from a sawn surface of crystal cluster on solid sample disk #1.
Tremolite.1 Reflectance spectrum of 0-74 um size range on disk #1.
Tremolite.1 Reflectance spectrum of 74-250 um size range on disk #1.
Tremolite.1 Transmittance spectrum on disk #1.

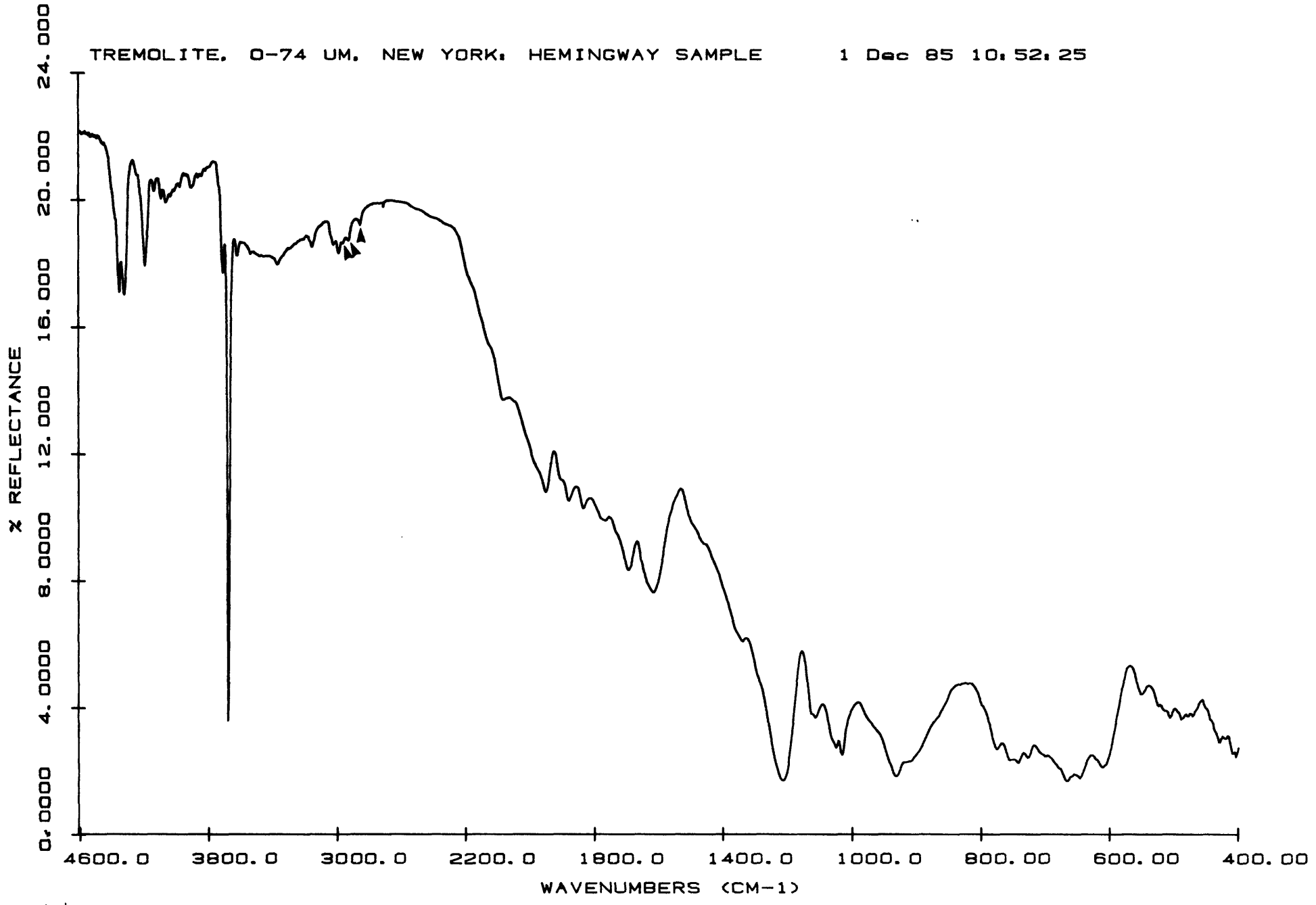

TREMOLITE IN KBR. NEW YORK: HEMINGWAY SAMPLE 21 Nov 85 15:01:46
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.00000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

270


TREMOLITE. RANDOM SURFACE. NEW YORK: HEMINGWAY SAMPLE 25 Apr 85 21:54:41
% REFLECTANCE
63.000
52.500
42.000
31.500
21.000
10.500
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


TREMOLITE. 74-250 UM. NEW YORK: HEMINGWAY SAMPLE
1 Dec 85 13:48:47
% REFLECTANCE
0.0000
2.0000
4.0000
6.0000
8.0000
10.000
12.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

272


TREMOLITE, 0-74 UM, NEW YORK: HEMINGWAY SAMPLE 1 Dec 85 10:52:25
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

27

Species name: Tremolite $Ca_2(Mg,Fe^{+2})_5Si_8O_{22}(OH)_2$

Locality: Canada

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 117611

Results of petrographic examination: One 21.41 g. piece, deep brown, and translucent. Part of a single crystal with euhedral faces. Very, very small amount of calcite contamination. Wash with HCl.

Under the microscope, appears to be virtually all pure, clean tremolite with a very small amount (<1%) of low refractive index impurity. Refractive index indicates very little iron.

Results of XRD: Tremolite plus a trace of mica.

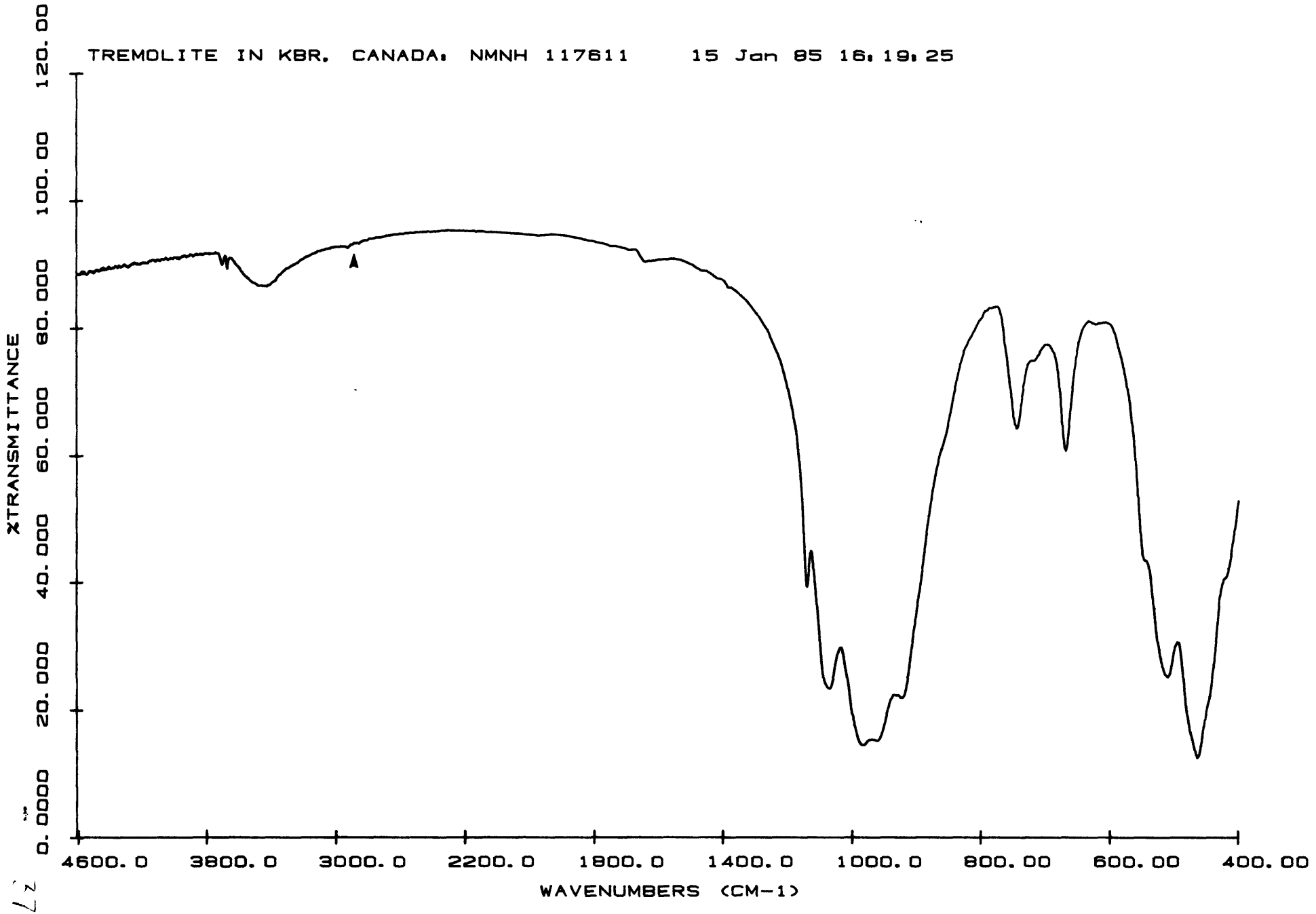
Results of XRF or other compositional analysis:

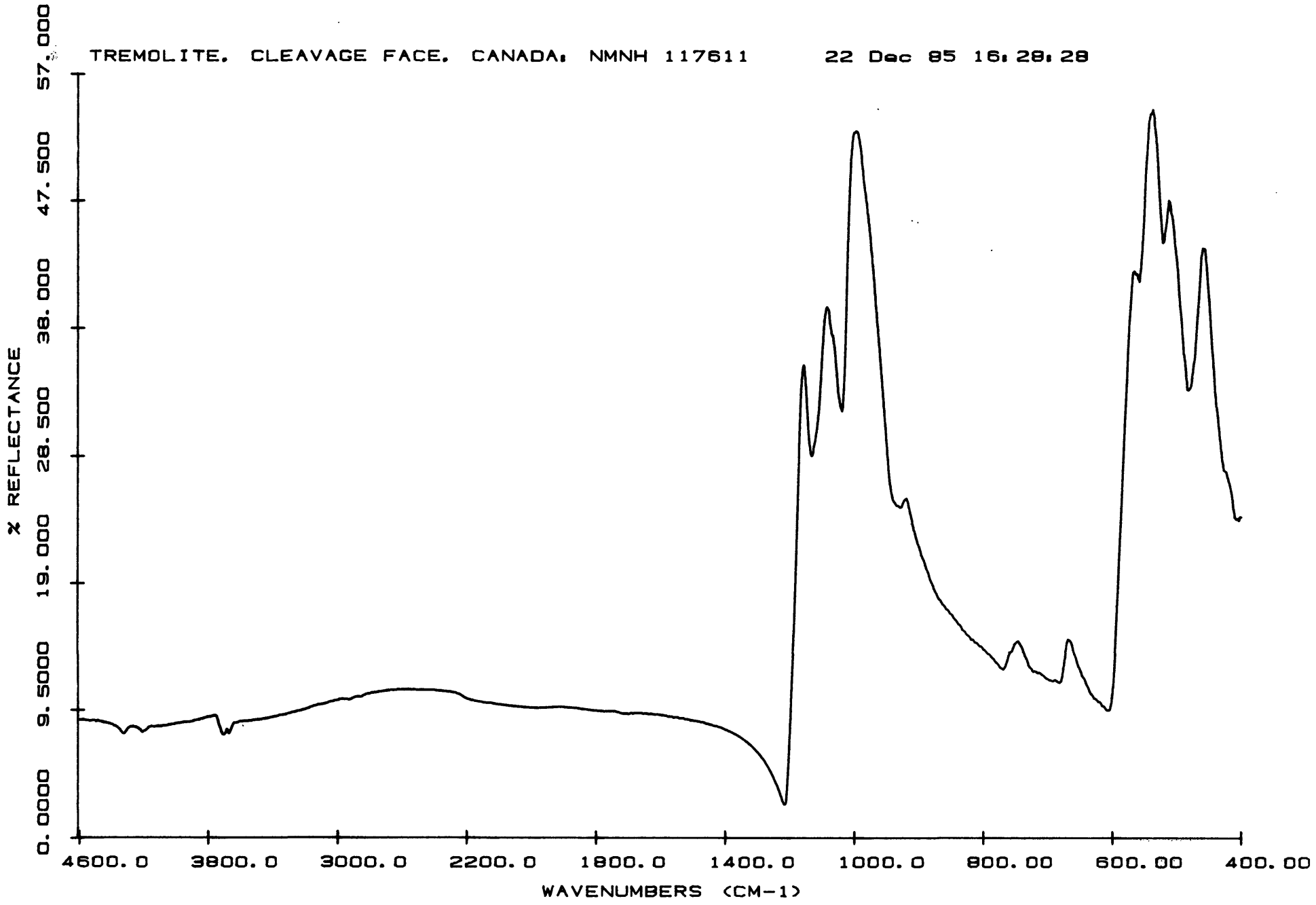
Microprobe analysis shows sample to be homogeneous within and between grains. It has extremely high soda and potash. Thus chemically it is more towards richterite than tremolite. Average of 10 analyses:

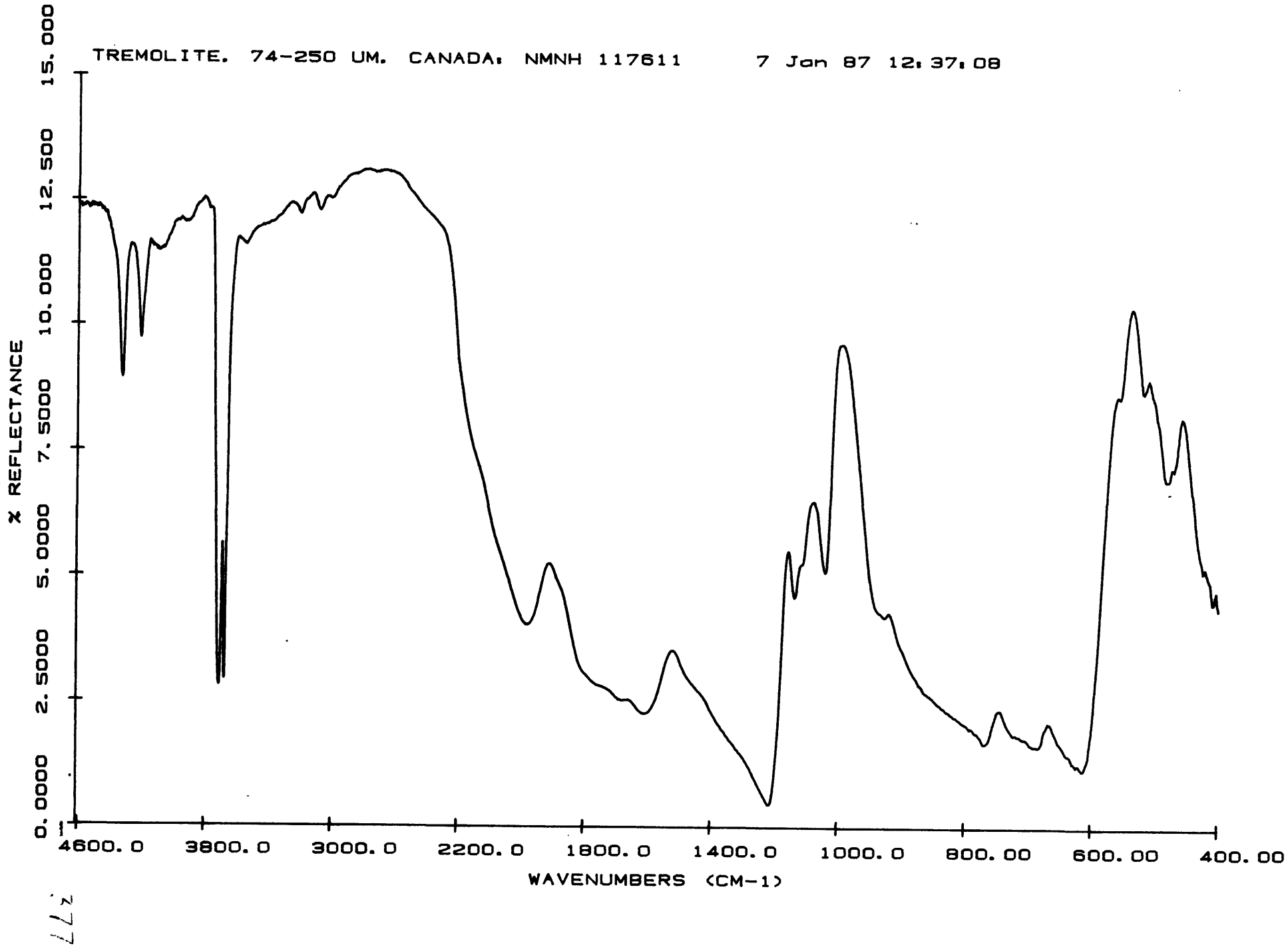
SiO_2	- 54.60
Al_2O_3	- 1.88
FeO	- 2.25
MgO	- 23.13
CaO	- 8.82
K_2O	- 1.42
Na_2O	- 5.54
TiO_2	- 0.41
MnO	- 0.19
Total	- 98.23

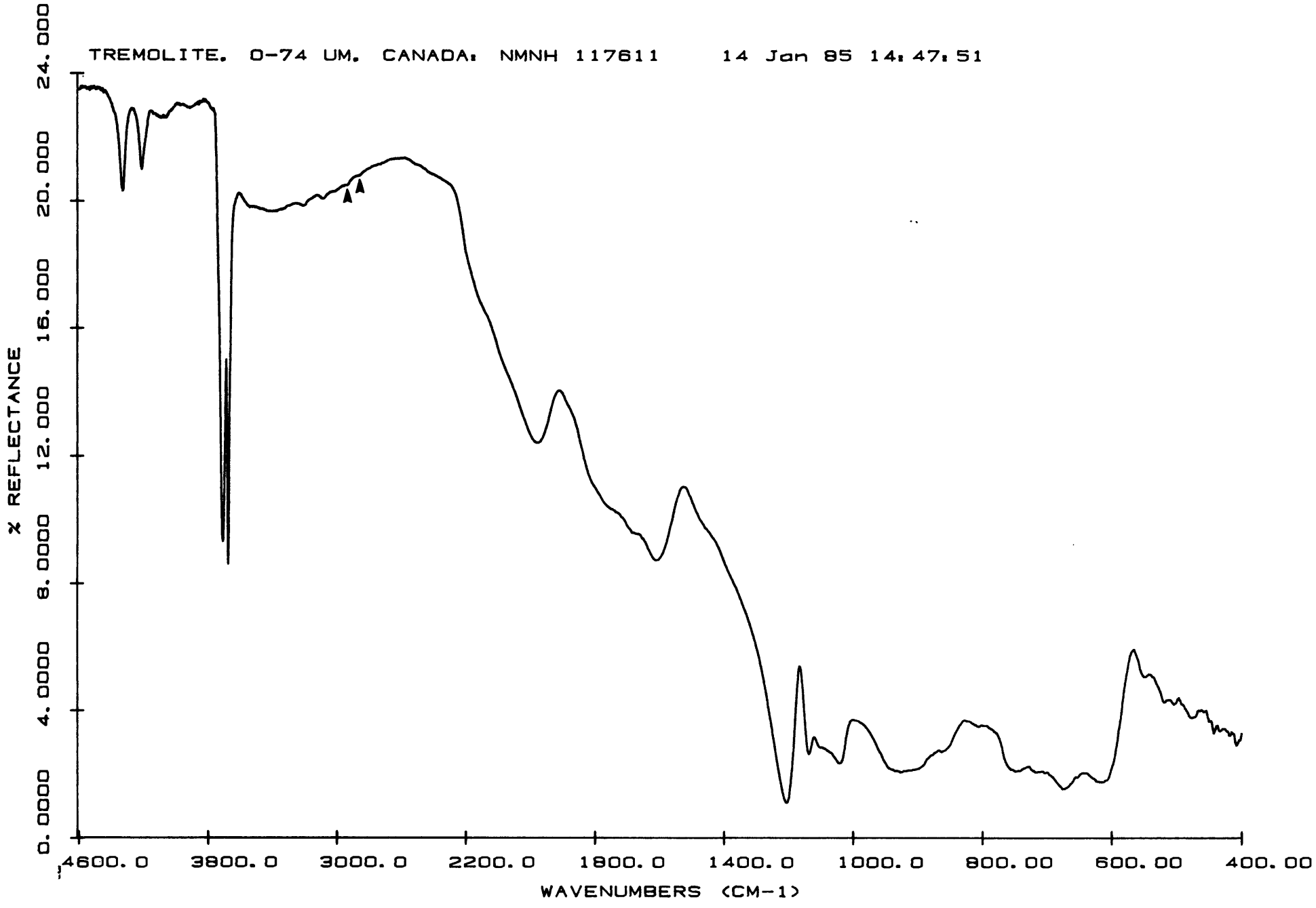
Spectra of file:

Tremolite.2	Reflectance spectra of cleavage face on solid sample disk 1.
Tremolite.2	Reflectance spectrum of 74-250 um size range on disk #1.
Tremolite.2	Reflectance spectrum of 0-74 um size range on disk #1.
Tremolite.2	Transmittance spectrum on disk #1.


TREMOLITE IN KBR. CANADA: NMNH 117611 15 Jan 85 16:19:25
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


TREMOLITE. CLEAVAGE FACE. CANADA: NMNH 117611
22 Dec 85 16:28:28
% REFLECTANCE
0.0000
9.5000
19.000
28.500
38.000
47.500
57.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


TREMOLITE. 74-250 UM. CANADA: NMNH 117611
7 Jan 87 12:37:08
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


TREMOLITE. 0-74 UM. CANADA: NMNH 117611 14 Jan 85 14:47:51
% REFLECTANCE
24.000
20.000
16.000
12.000
8.0000
4.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

278

Species name: Vermiculite

Locality: Llano, Texas

Last donor: Norma Vergo

Intermediate donor:

Ultimate donor: Clay Mineral Society Source Clay Mineral Repository

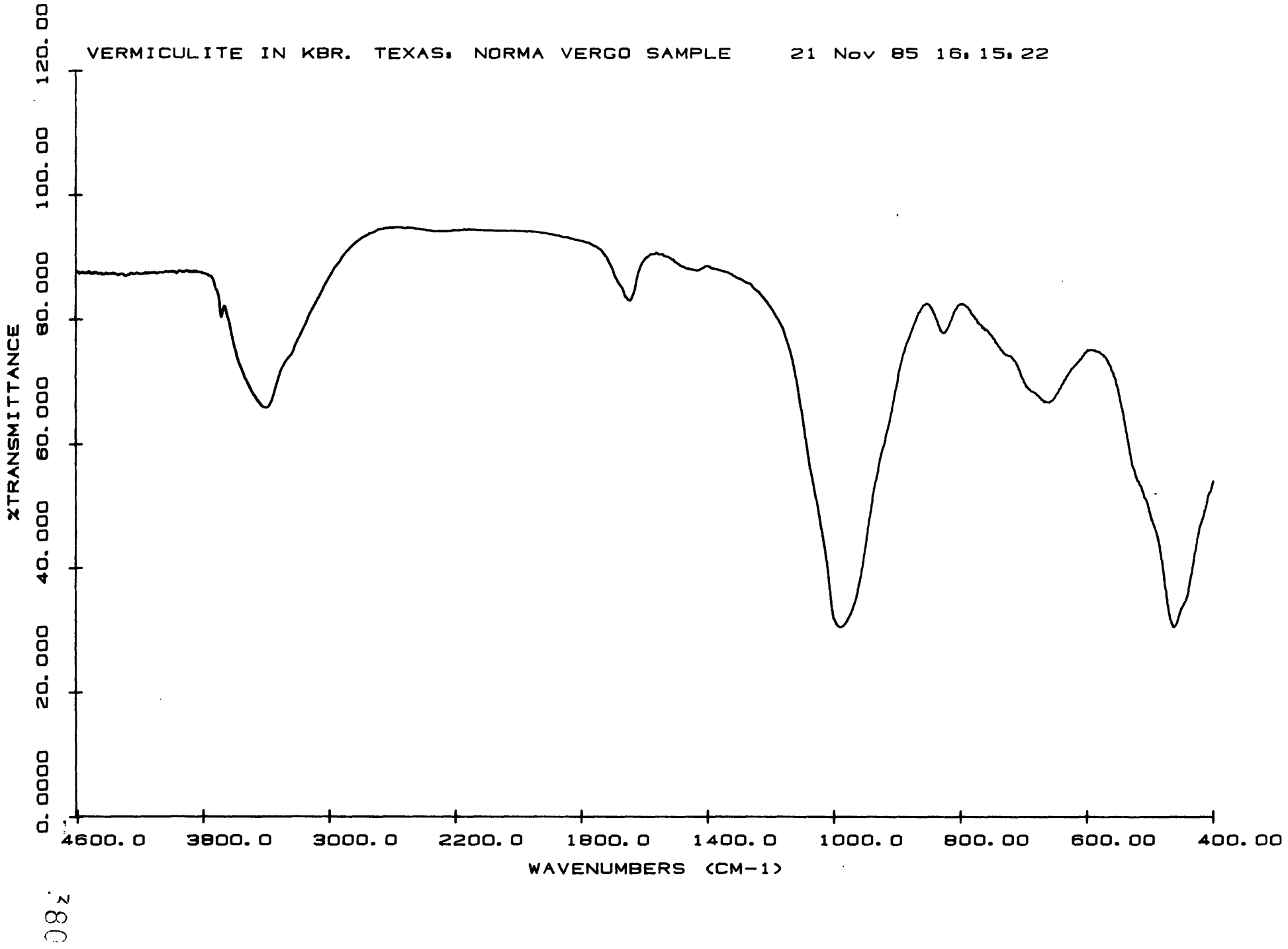
Catalog numbers, etc.: VTx-1 (CMS)

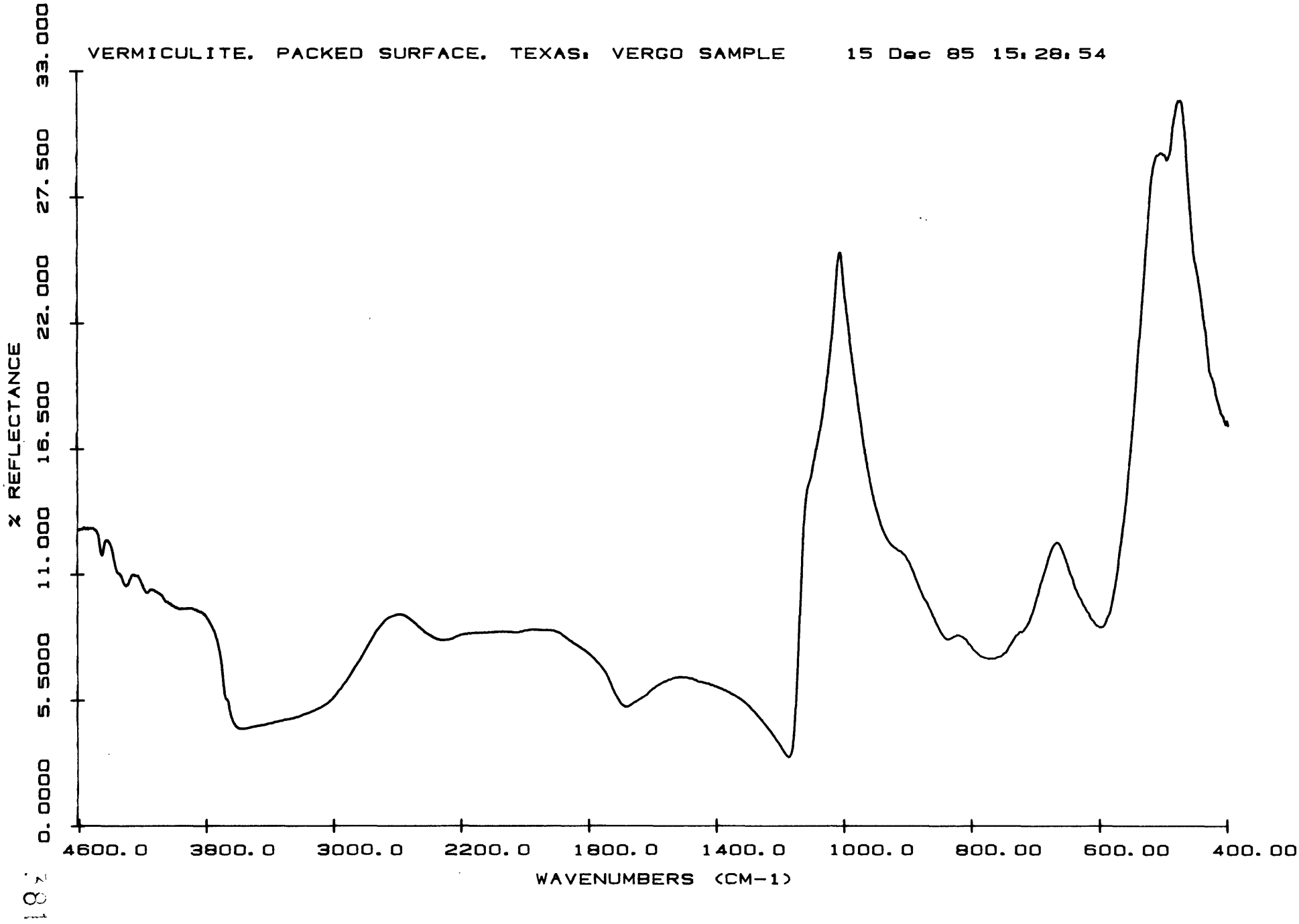
Results of petrographic examination: White color.

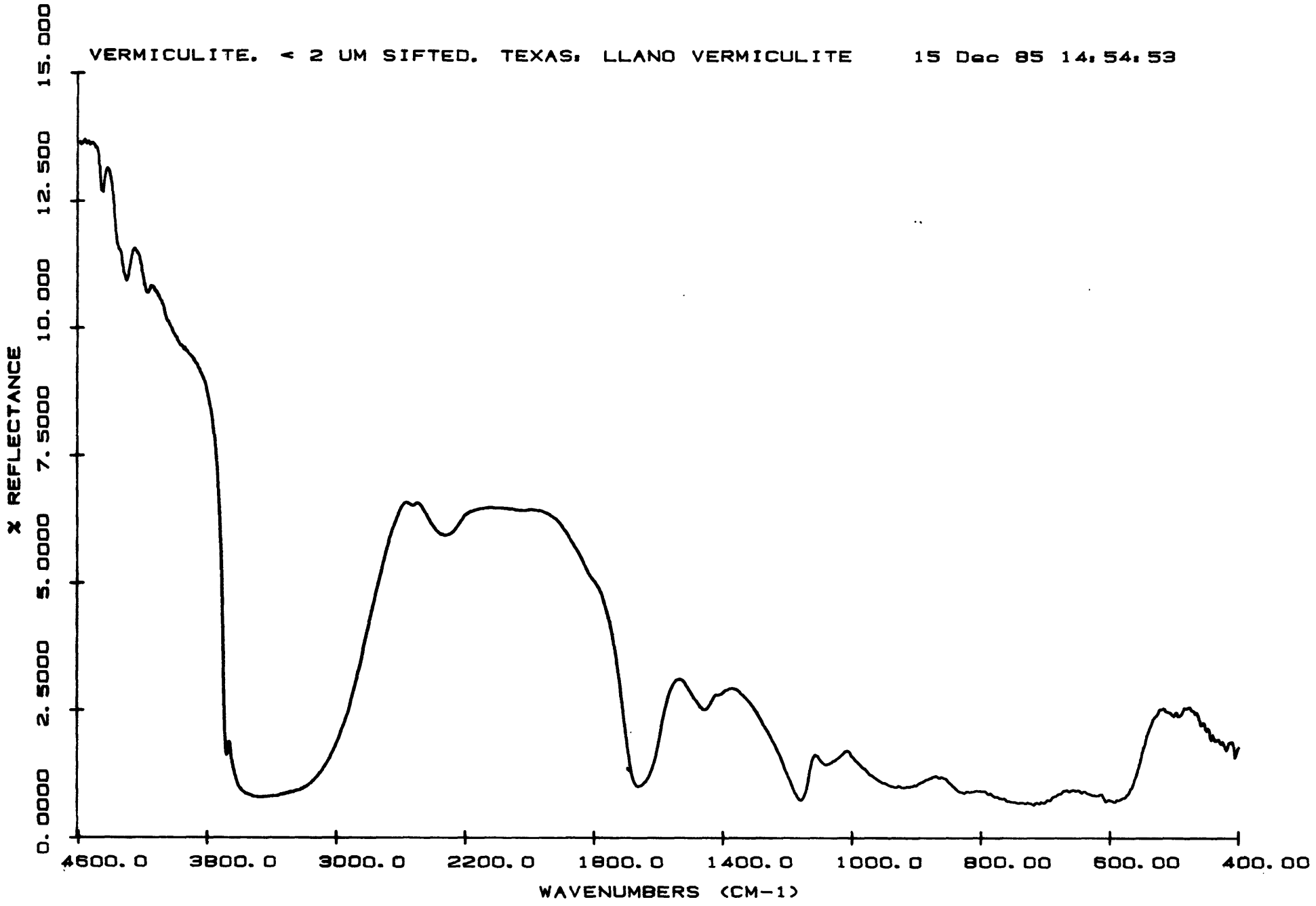
Results of XRD: Pure vermiculite.

Results of XRF or other compositional analysis: None

Spectra of file:
Vermiculite.1 Transmittance on disk #1.
Vermiculite.1 Reflectance of <2 um size range on 0-74 um disk #1.
Vermiculite.1 Reflectance of packed sample on solid sample disk #1.


VERMICULITE IN KBR. TEXAS. NORMA VERGO SAMPLE 21 Nov 85 16:15:22
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


VERMICULITE. PACKED SURFACE. TEXAS: VERGO SAMPLE 15 Dec 85 15:28:54
% REFLECTANCE
0.0000
5.5000
11.000
16.500
22.000
27.500
33.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


VERMICULITE. < 2 UM SIFTED. TEXAS: LLANO VERMICULITE 15 Dec 85 14:54:53
% REFLECTANCE
15.000
12.500
10.000
7.5000
5.0000
2.5000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

Species name: Wollastonite $CaSiO_3$

Locality: Santa Fe Mine, Pichucalco, Chiapas, Mexico

Last donor: Smithsonian

Intermediate donor:

Ultimate donor:

Catalog numbers, etc.: NMNH 131913

Results of petrographic examination: Single crystal 2 x 0.5 x 1 cm and one large piece 4 x 0.5 x 1 cm. One dirty surface and sulfide inclusions which were separated by crushing and hand picking. Under petrographic microscope, some grains show a little alteration and inclusions or voids along cleavage directions - possibly exsolved pyroxene?

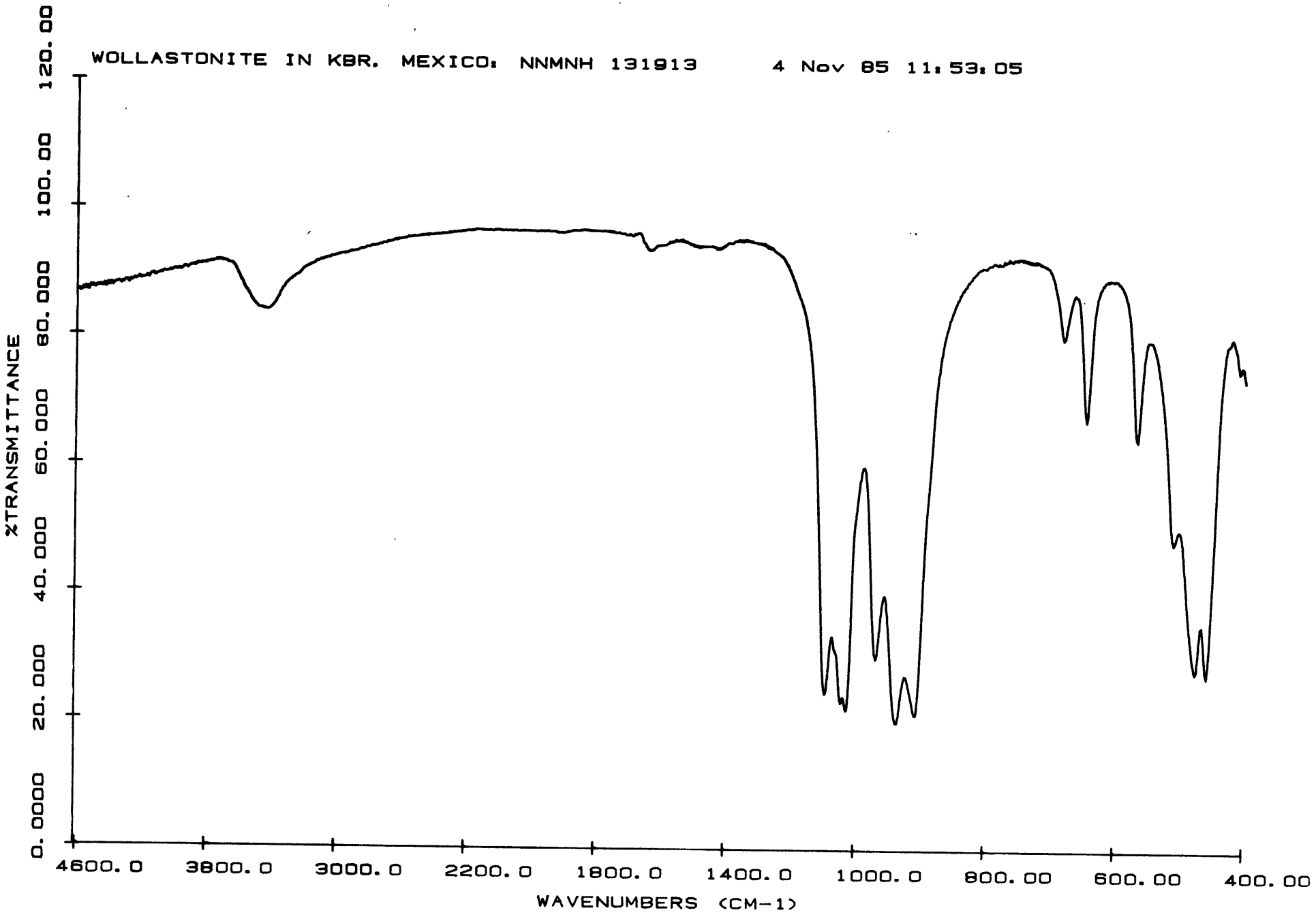
Results of XRD: X-ray analysis indicates sample is pure.

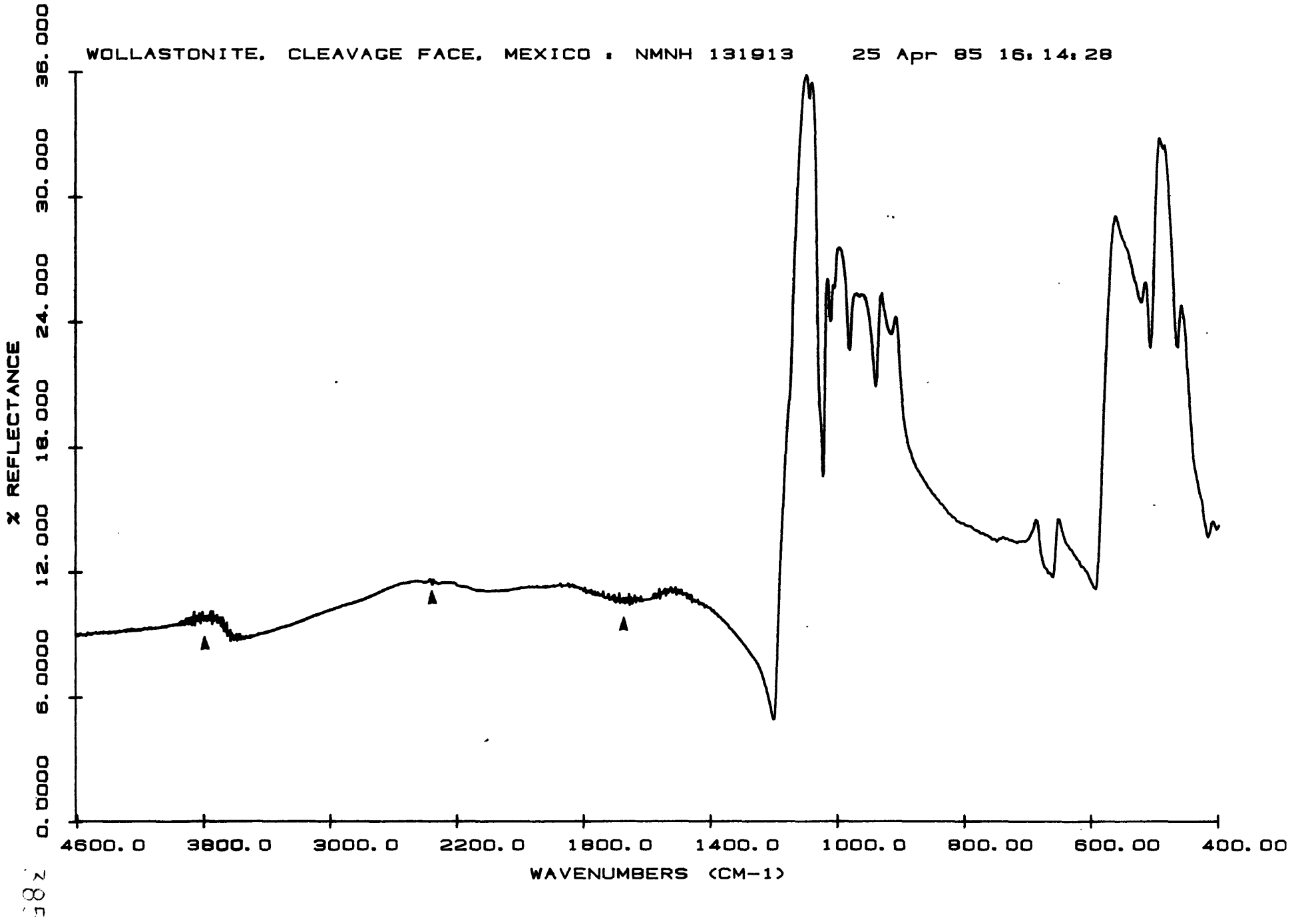
Results of XRF or other compositional analysis: Microprobe analysis shows that sample is homogeneous between and within grains. Average of 7 analyses:

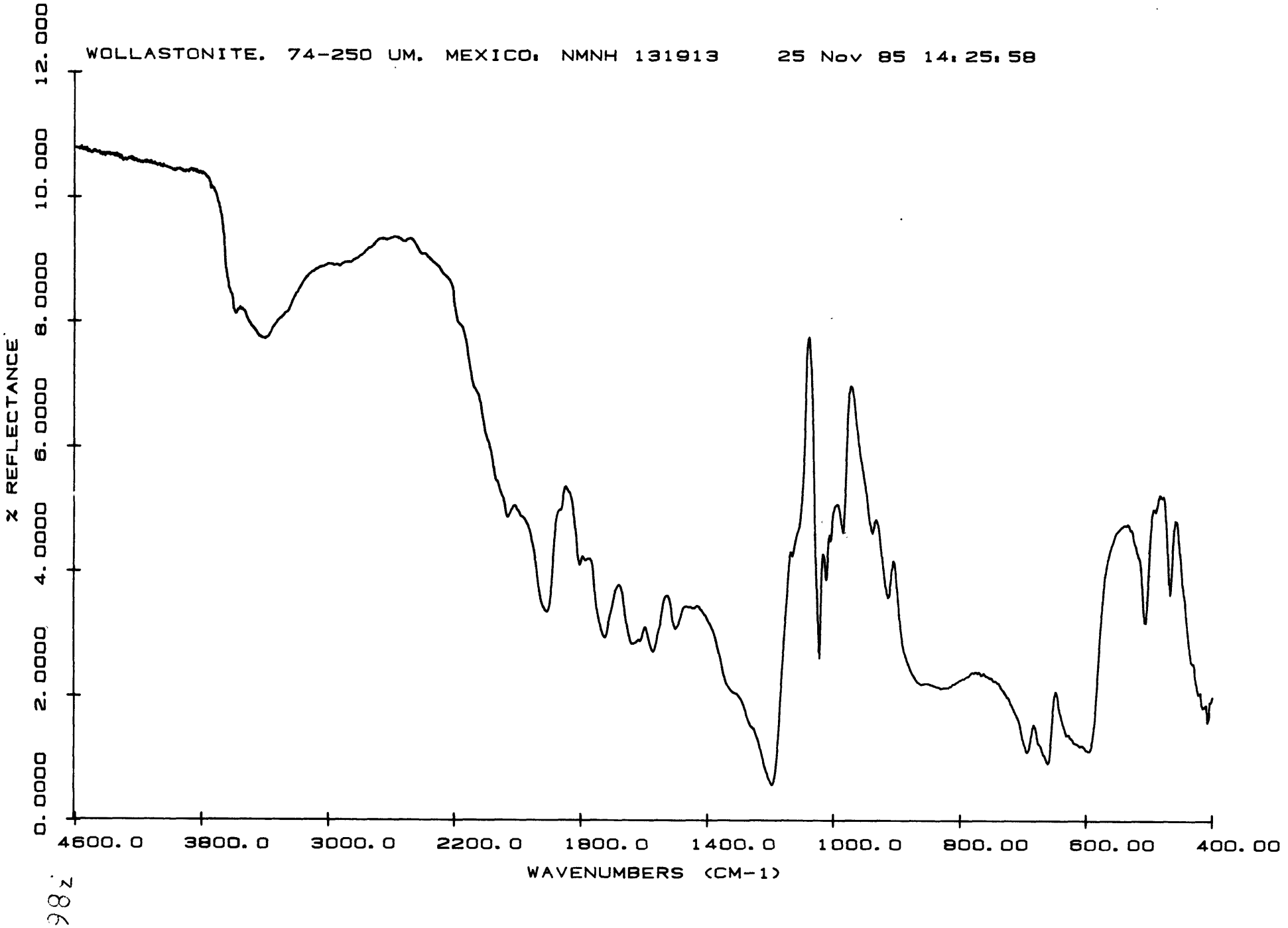
SiO_2	- 50.84
Al_2O_3	- 0.05
FeO	- 0.18
MgO	- 0.08
CaO	- 47.62
K_2O	- 0.03
Na_2O	- 0.01
TiO_2	- 0.01
MnO	- 0.75
Total	- 99.57

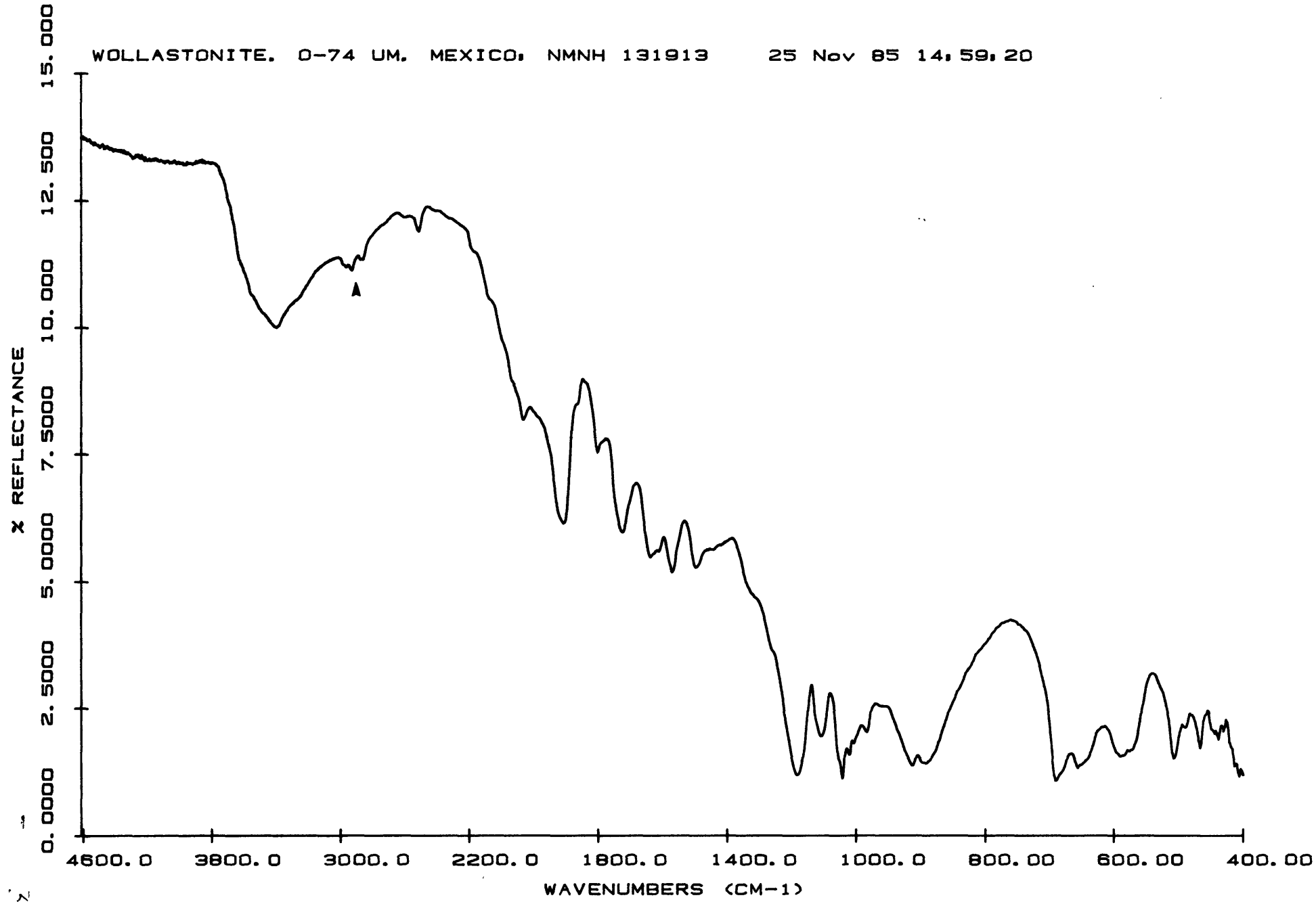
Spectra on file:

Wollastonite.1	Reflectance spectrum of cleavage face on solid sample disk #1.
Wollastonite.1	Reflectance spectrum of 74-250 um size range on disk #1
Wollastonite.1	Reflectance of 0-74 um size range on disk #1.
Wollastonite.1	Transmittance spectrum on disk #1.


WOLLASTONITE IN KBR. MEXICO: NNMNH 131913
4 Nov 85 11:53:05
%TRANSMITTANCE
120.00
100.00
80.000
60.000
40.000
20.000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


WOLLASTONITE. CLEAVAGE FACE. MEXICO : NMNH 131913 25 Apr 85 16:14:28
% REFLECTANCE
36.000
30.000
24.000
18.000
12.000
6.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


WOLLASTONITE. 74-250 UM. MEXICO: NMNH 131913 25 Nov 85 14:25:58
% REFLECTANCE
12.000
10.000
8.0000
6.0000
4.0000
2.0000
0.0000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)


WOLLASTONITE. 0-74 UM. MEXICO: NMNH 131913 25 Nov 85 14:59:20
% REFLECTANCE
0.0000
2.5000
5.0000
7.5000
10.000
12.500
15.000
4600.0
3800.0
3000.0
2200.0
1800.0
1400.0
1000.0
800.00
600.00
400.00
WAVENUMBERS (CM-1)

7.0 Appendix 2

Making a KBr Pellet

There are several different ways to make a KBr pellet. We have developed a technique which is described in some detail here to help a user of this library make comparable pellets for more useful spectral comparisons.

First, 0.7 mg of sample is weighed out. This is considerably less sample than some others have used, but generally provides good results when processed as described below. Minerals with very strong molecular vibration bands (quartz) require less sample (0.6 mg) for full scale display of the most intense band, while those with weak bands (labradorite) require more (0.8 mg). Trial and error is sometimes required to obtain the desired band intensity.

We start with the 0-74 um particle size range of most samples, except for the clay minerals which have been centrifuged to <2 um. The 0-74 um size range must be ground to <2 um to assure that the particle size is less than the wavelength throughout the spectral range. This avoids excessive scattering, which can be detected as a monotonic decrease in transmittance as the 2 um wavelength is approached from the longer wavelength side. (Some iron-rich minerals will display a similar fall-off in transmittance that is due to absorption, not scattering). It is also necessary to grind the sample to a fine particle size for the spectra to show fine detail, instead of simply broad features. Too much sample in a pellet will also broaden spectral features and destroy fine detail. The most intense absorption band ideally should show between 10 and 30% transmittance.

The 0-74 um samples are ground (and the <2 um samples disaggregated) in an agate mortar with a fresh, shiny surface. Initial sample grinding was performed in a sintered sapphire mortar, which has the advantage of being very hard. However, like porcelain mortars, a sapphire mortar is porous. Porosity, whether original to the mortar type or produced on agate by scratching, will steal sample, so that 0.7 mg will not be enough to produce strong absorption bands. Worse, despite careful cleaning, stolen sample from previous grinding will contaminate later samples; thus the need for a fresh, shiny agate mortar. A mortar as small as 35 mm in diameter may be used to keep the cost of new mortars low.

The mortar is first wiped clean with a fresh paper wiper and then about 200 mg of clean KBr is ground vigorously in the mortar to act as a "getter" for any sample left over from the previous run. Then the mortar is cleaned with water, wiped dry, rinsed with alcohol, wiped dry, and stored in a 100^{o}C oven while the sample is weighed.

The sample is ground in the mortar under a few drops of alcohol to <2 um (experience shows the feel of grit under the pestle disappears). Then the mortar is tilted and rotated to spread the evaporating alcohol (and hence the sample) over the bottom of the mortar.

KBr (300 mg) is added to the mortar and mixed with the sample. This is accomplished with a grinding motion of the pestle. However, little downward pressure is applied so that the grains of KBr are not ground to finer particle size, which would increase the surface area exposed to atmospheric water vapor.

The proper pestle pressure will allow the operator to feel the grains of KBr rolling under the pestle, rather than crushing. The rolling grains will pick up the sample from the bottom of the mortar.

The motion of the pestle will cause the KBr to climb the walls of the mortar, from whence it can be dislodged and brought to the center of the mortar by tapping the latter on a hard surface. About ten cycles of mixing and tapping are required to distribute the sample evenly through the KBr.

This mixture is transferred to a pellet die, held under vacuum for 5 minutes and then pressed at 10,000 kg/cm^2 under vacuum for a further 2 minutes. Note that each surface of the die in contact with an O-ring, as well as the O-ring itself, should be wiped clean between each use. This avoids air leakage and insures that a proper vacuum (<2 cm Hg) is maintained.

* U.S. GOVERNMENT PRINTING OFFICE:1987-181-407:40107