**Introduction:** Tremolite is a member of the calcic amphibole group of silicate minerals with the chemical formula Ca$_2$Mg$_3$Si$_2$O$_{10}$(OH)$_2$ [1-6]. Calcic amphiboles possess similar crystal structures and basic chemical formula, although the various crystal forms have different physical properties [1].

In the literature, there are many studies on the identification and the characterization of tremolite mineral obtained from various parts of the world by means of XRD, EDXRF, FTIR and Raman spectroscopy. The aim of this study is to identify the major and minor phases and to characterize structurally Mihaliccik tremolite sample using complementary XRD, EDXRF, FTIR, and Raman spectroscopy.

**Experimental:** The natural tremolite sample used in this study was supplied from Tatarcik deposits of Mihaliccik region of Turkey (39.8788N; 31.3806E). The powdered sample examined by the powder method using a Rigaku DMAX diffractometer equipped with CuKα radiation in the region between 10$^\circ$ and 70$^\circ$. The Bruker IFS 66 v/S FTIR system is employed for recording the spectra. The chemical analysis of Mihaliccik tremolite sample was performed by using an energy dispersive X-ray spectrometer (EDXLINK ISIS 300). The Raman spectrum was obtained at room temperature with a Bruker Senterra Raman Spectrograph.

**Results and Discussion:** The Mihaliccik tremolite sample used in this study contains mainly 54.41% SiO$_2$, 22.81% MgO, 15.04% CaO, and 1.45% Al$_2$O$_3$. 1.42% Na$_2$O, 0.18% FeO, and 4.69% others & H$_2$O.

Fig. 1 displays the X-ray diffraction pattern (XRD) of the Mihaliccik tremolite sample. The sample was not pure as shown in Fig. 1. It consists of tremolite with minor amount of calcite. In this pattern, the some characteristic diffraction peaks are appeared at 2$\Theta$= 28.6$^\circ$, 10.54$^\circ$, 27.24$^\circ$ for tremolite, at 29.38$^\circ$, 22.98$^\circ$, 48.72$^\circ$ for calcite.

The infrared spectrum is one of the most useful physical methods of investigation in identifying functional groups. With the help of this method, the molecular structure and identification of mineral can be determined. In this paper, the FTIR spectrum of the Mihaliccik tremolite in the range between 4000 and 350 cm$^{-1}$ at room temperature was plotted in Fig. 2. The main absorption band system is found in the spectral range between 1100 and 900 cm$^{-1}$, consisting of partly overlapping bands at 1105, 1063, 1020, 997, 952, and 919 cm$^{-1}$. The band at 919 cm$^{-1}$ can be attributed to the symmetrical stretching vibration of Si-O-Si [7]. The other bands belong to Si-O-Si asymmetric stretching vibrations [3]. The two sharp bands observed at 687 and 757 cm$^{-1}$ are assigned to the symmetrical stretching of Si-O-Si bending [3, 7]. The sharp bands at 457, 507, and 548 cm$^{-1}$ are attributed to Si-O-Si bending vibrations. The three weak bands at 387, 399, 420, and 445 cm$^{-1}$ are assigned to the M-O (metal-oxygen) stretching vibrations [3, 8]. Identification of calcite is easy by FTIR spectroscopy since there are sharp characteristic absorption bands that might be recognized in the complex pattern of mineral mixture. In the sample spectrum, the bands at 875, and 713 cm$^{-1}$ are characteristic for calcite mineral [3, 9]. They are attributed to Ca-O bending vibrations.

The region of spectrum around 3660 cm$^{-1}$ contains a complex feature composed of two major bands and several minor bands and shoulders. In this region, the sharpest band observed at 3669 cm$^{-1}$ and other bands are attributed to the presence of Mg$^{2+}$/Fe$^{3+}$ in the M1 and M3 sites and OH stretching vibrations [8, 10, 11]. In this spectrum, the calcite in the sample is shows by the absorption bands at 2881, 2644, 2497, 1794, and 1417 cm$^{-1}$. The band at 1417 cm$^{-1}$ is assigned to Ca-O asymmetric stretching vibration. The other bands in this spectrum are assigned to the combination bands (bending + asymmetric stretching) [12].

![Fig. 1. XRD patterns of the Mihaliccik tremolite used in the present investigation](image1)

![Fig. 2. FTIR spectrum of the Mihaliccik tremolite used in the present investigation (in the 350-1200 cm$^{-1}$ and 1300 and 4000 cm$^{-1}$ range).](image2)
Figure 3 presents the Raman spectra of the Mihaliccik tremolite in the ranges 70–1150, and 3500–3700 cm\(^{-1}\) at room temperature. They are complex and contain the characteristic bands of tremolite and calcite, in accordance with XRD result. The characteristic bands of calcite are normal because our Mihaliccik tremolite sample is associated with calcite [13, 14].

![Raman spectrum of Mihaliccik tremolite](image)

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