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Review paper

MINERALS FROM MACEDONIA. COMPLEMENTARY USE OF VIBRATIONAL SPECTROSCOPY AND POWDER X-RAY DIFFRACTION FOR IDENTIFICATION AND DETECTION PURPOSES

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A b s t r a c t: A review of the results of complementary use of vibrational spectroscopy (infrared and Raman) and powder X-ray diffraction in the process of identification and detection of some carbonate, sulfide, oxide and silicate minerals originating from the Republic of Macedonia is presented. Studied are the following minerals: calcite, $CaCO_3$; aragonite, $CaCO_3$; siderite, $FeCO_3$; magnesite, $MgCO_3$; dolomite, $CaMg(CO_3)_2$; kutnahorite, $CaMn(CO_3)_2$; galena, PbS; sphalerite/wurtzite, (Zn,Fe)S; hematite, Fe_2O_3; magnetite, Fe_3O_4; limonite, FeOOH; goethite, α-FeOOH; corundum, Al_2O_3; rutile, TiO_2; chromite, $FeCr_2O_4$; almandine, $Fe_3Al_2(SiO_4)_3$; spessartine, $Mn_3Al_2(SiO_4)_3$; zircon, $ZrSiO_4$; titanite, $CaTiSiO_5$; olivine, $(Mg,Fe)_2SiO_4$; forsterite, Mg_2SiO_4; staurolite, $Fe_2Al_9O_6(SiO_4)_4(OH)_2$; kyanite, Al_2SiO_5.

Key words: minerals; vibrational spectroscopy; powder X-ray diffraction

1. INTRODUCTION

The Republic of Macedonia is very rich in minerals. It lies in the Alpine–Balkan–Carpathian–Dinaride collision belt and a large number of carbonate, sulfide, oxide, silicate and other types of ore deposits are present in Macedonia. For instance, there is a unique ore deposit at Alšar (near Kavadarci) where 44 mineral species have been identified up to now.

In spite of these very rich ore deposits in a relatively small area, the total number of minerals present in Macedonia is not yet fully established. There

are a few incomplete mineral collections, but no complete literature data con cerning their systematizaton and characterization are available. In order to pre pare the *Atlas of Minerals from Macedonia* (a task presently in hand), the sys tematic process of collection, separation, identification and systematization a well as spectroscopic and structural characterization of minerals originatin from Macedonia was undertaken.

The acquisition of all the available minerals is almost completed an the *Mineral Collection* at the Institute of Chemistry in Skopje is set up. Th minerals are studied mainly by Fourier transform infrared and Raman vibra tional spectroscopy and by powder X-ray diffraction [1–23]. In order to deter mine the presence and content of trace elements in the minerals, atomic absorp tion spectrometry and inductively coupled plasma – atomic emission spectro metry are also used and analytical methods for discrimination between som mineral species are developed [e.g. 24–39]. It should be noted here that variou instrumental techniques and procedures for mineral detection, identificatio discrimination and quantitative determination have been developed during th last few decades. The most frequently used among them are X-ray diffractio [40], vibrational infrared [41] and Raman [42] spectroscopy, thermal analysi [43] and optical diffuse reflectance [44] (only a selection of the relevant refer ences is given above).

Here a review of the results of the complementary use of vibrationa spectroscopy (infrared and Raman) and powder X-ray diffraction in the proces of identification and detection of some carbonate, sulfide, oxide and silicat minerals originating from the Republic of Macedonia is presented. The identi fication is based on the comparison of the results of our study with the corre sponding literature data for the analogous mineral species originating fro other localities in the world. It is worth mentioning that, in general, the com parison of the data is often accompanied by difficulties, the most importan among them being related to the temperature at which the experiment was per formed; the instrument resolution; the vibrational spectral region and/or 2θ re gion of the registered powder X-ray patterns; the specimen quantity used in th experiment; the sample preparation, particle size and shape; the locality wher the specimen was collected from, etc.

2. EXPERIMENTAL

The studied minerals were collected from various localities (Fig. 1) After that, from the collected ore samples single crystals were carefully picke up under a microscope and then powdered.