applied sciences

MDPI

Supplementary Materials

Portable Raman spectrometer for *in situ* analysis of asbestos and fibrous minerals.

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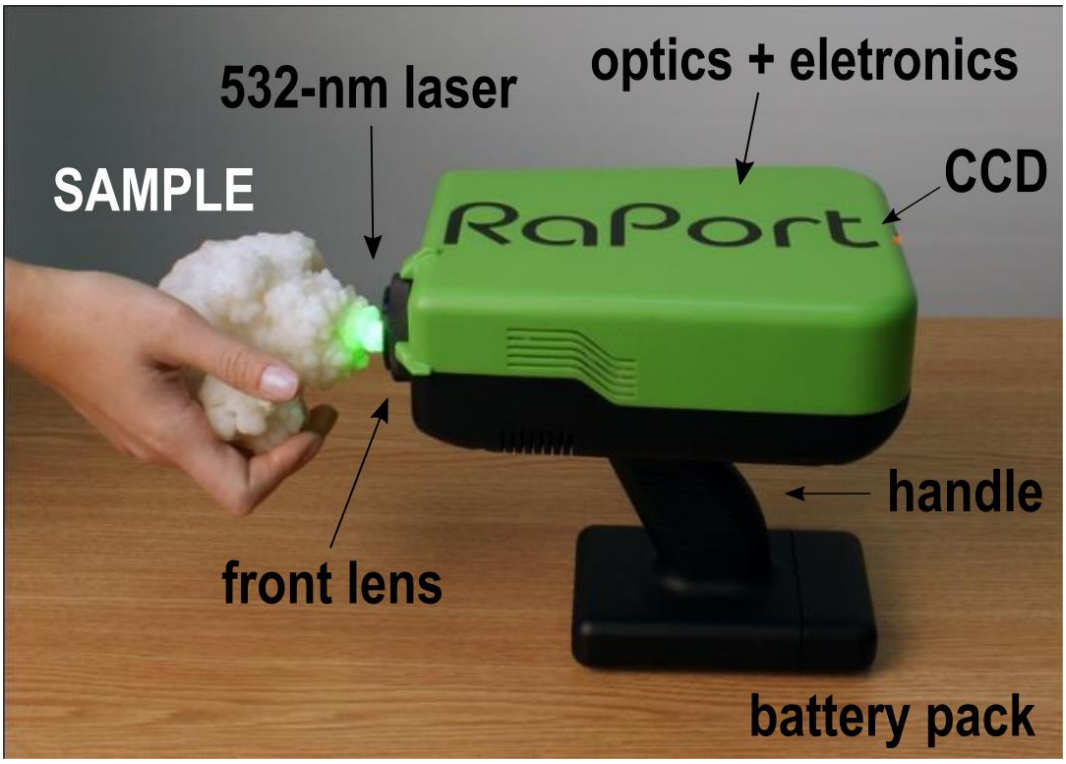
Summary

Scheme 1. Schematic for Portable Raman Instrument (pRS).

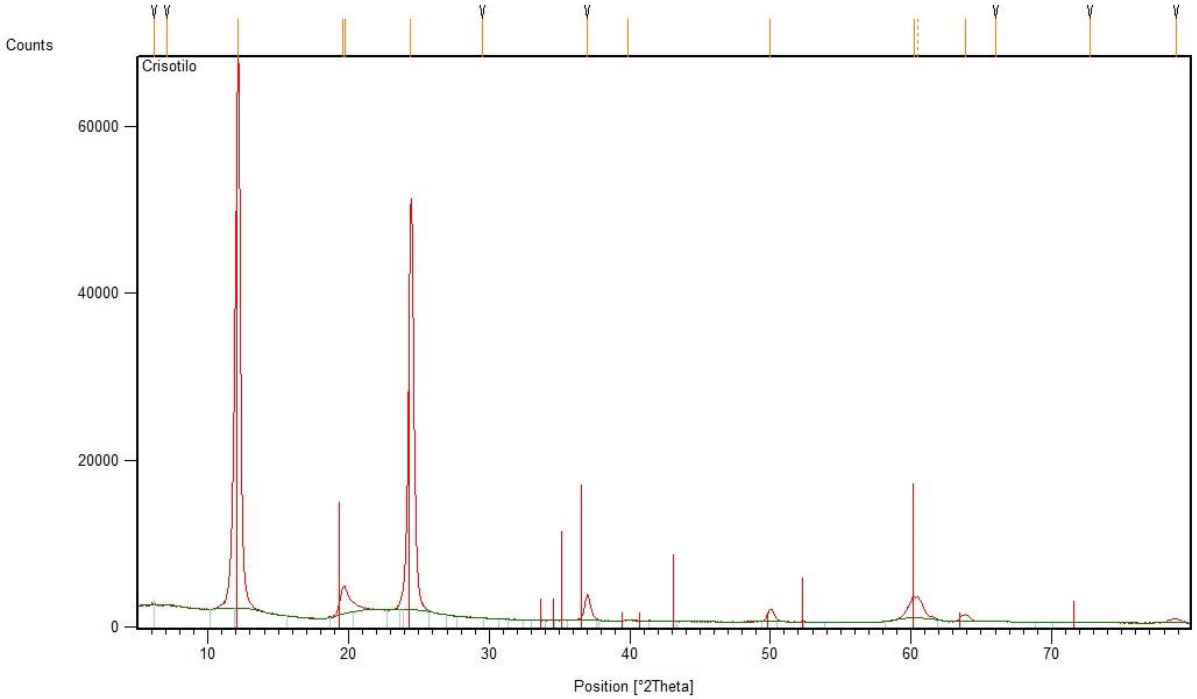
The portable Enspectr RaPort® Raman spectrometer (pRS) is a 'pistol-like' handheld instrument weighing 2.1 kg, equipped with a thermoelectrically cooled silicon CCD and a 532-nm laser at maximum output power of 30 mW, an integrated optic and electronics embedded in the body of the instrument. The laser spot is focussed by the front lens on the sample with a spatial resolution of nearly 0.5 mm.



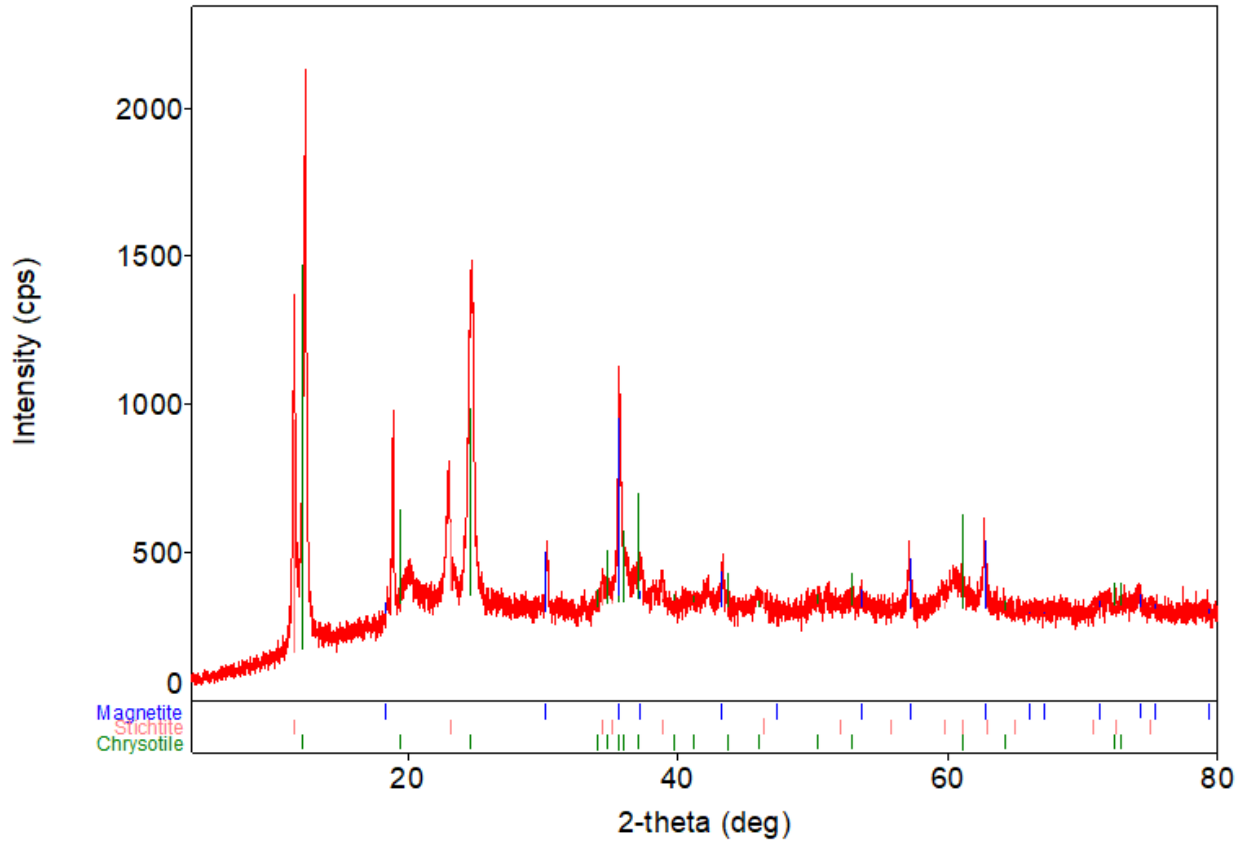
Adapted from http://enspectr.org/wp-content/uploads/2017/06/RaPort_mineralogy_EN_org.pdf

Scheme 2. XRPD qualitative bulk analysis.

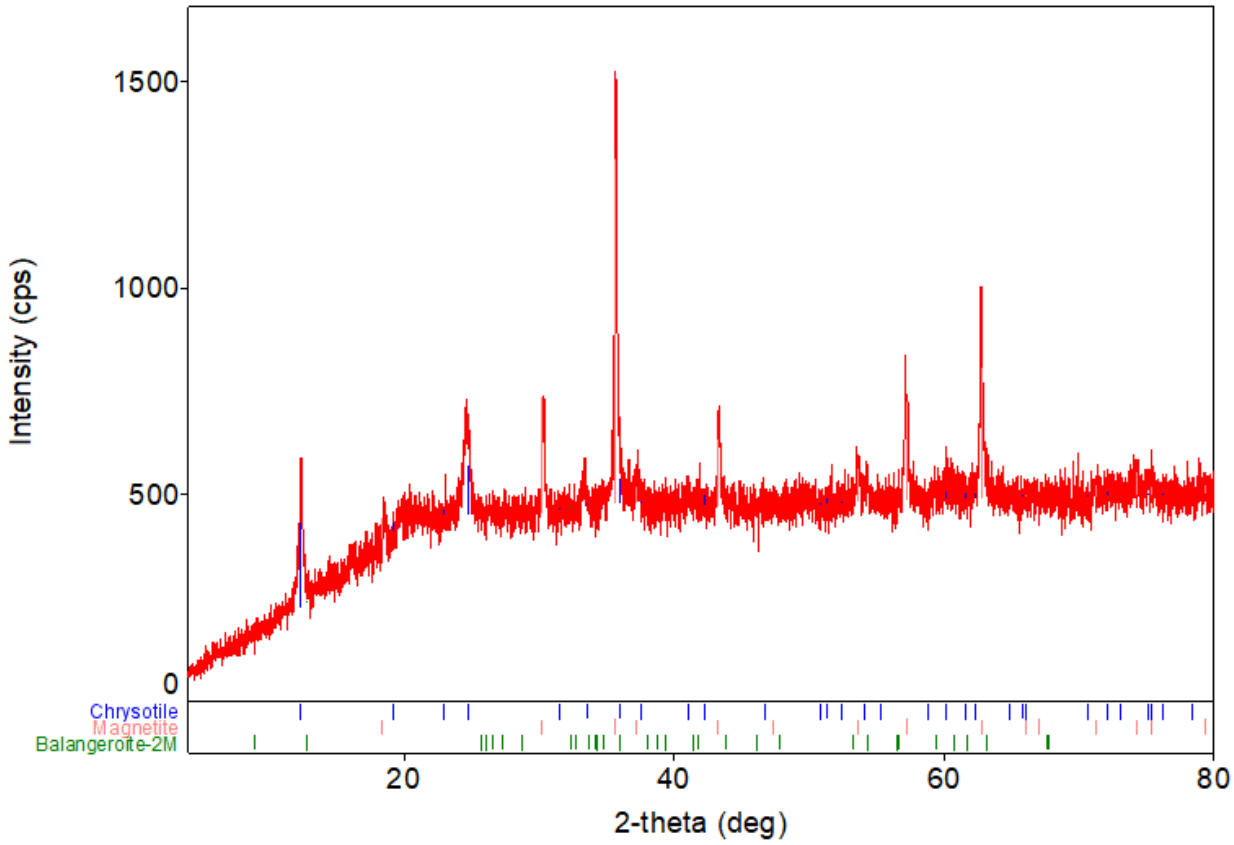
Scheme 2. 1. Valmalenco quarry. Vein of long-fibre chrysotile.



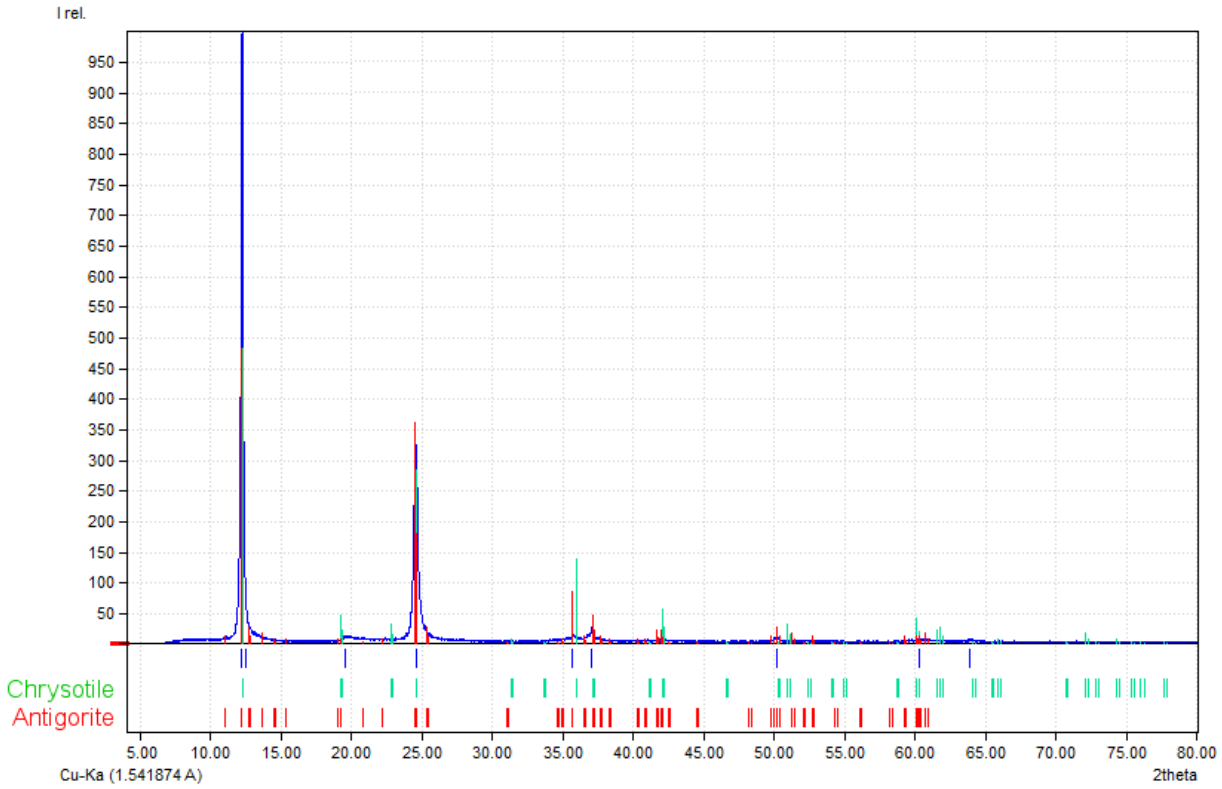
Scheme 2.2. Balangero mine. Vein of slip short-fibre chrysotile.



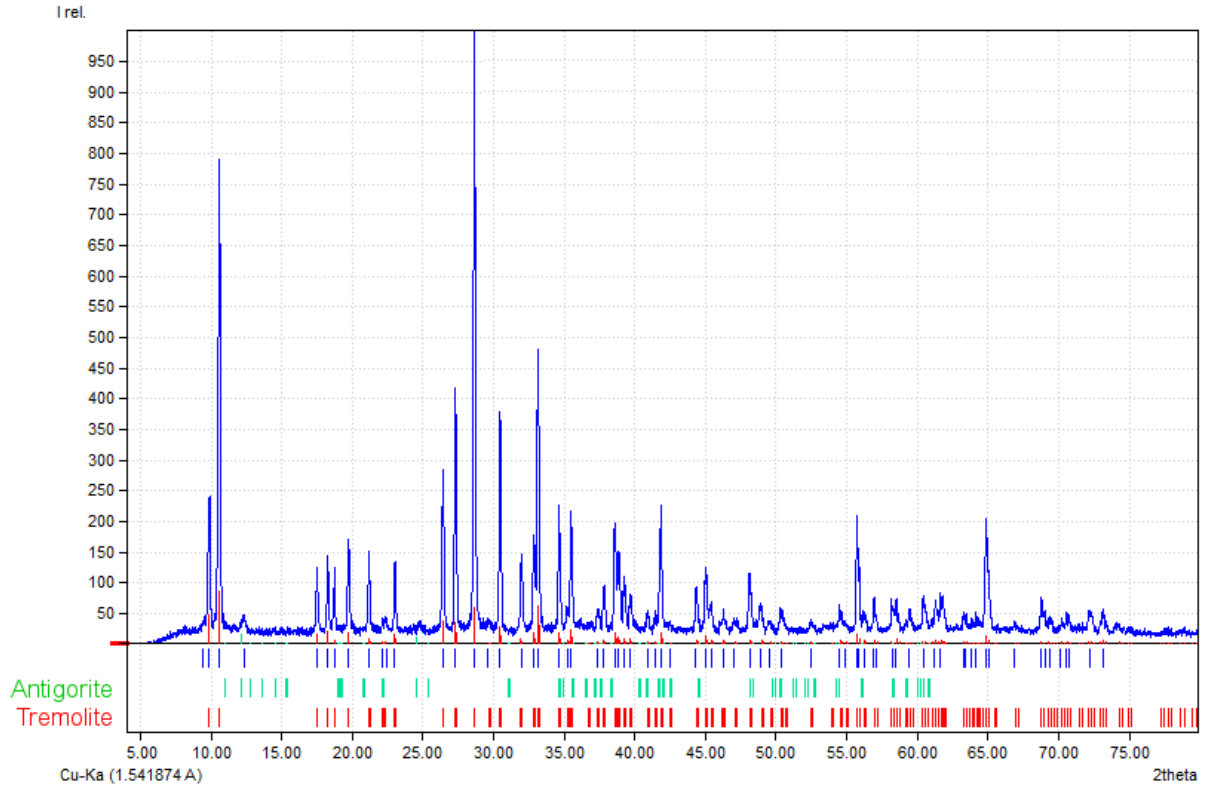
Scheme 2. 3. Balangero mine. Vein of long-fibre chrysotile with balangeroite.



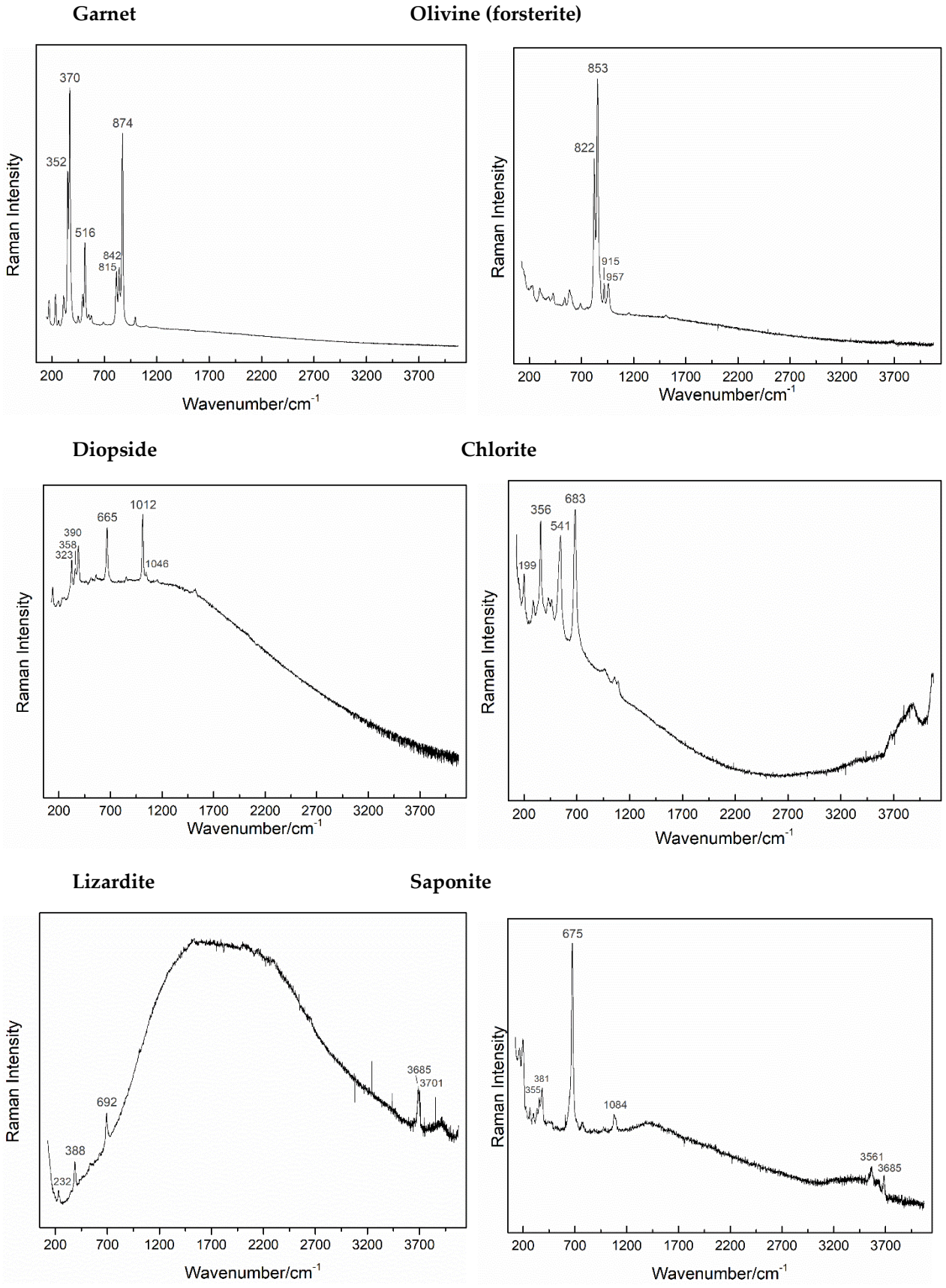
Scheme 2. 4. Tontouta mine. Vein of chrysotile and fibrous antigorite.



Scheme 2. 5. Tontouta mine. Tremolite vein.



Scheme 3. Representative Raman spectra of non-asbestos phases collected with portable Raman Spectrometer (pRS).



Scheme 4. Assignment of peaks in the Raman spectra at low- and high-wavenumber regions of investigated asbestos and asbestos-like minerals.

Serpentine minerals

Chrysotile	Antigorite	Lizardite	Attribution
232	229	230	M-O
345-	-	349	M-O
388	377	386	ν_5 SiO_4
-	520	532	Perpendicular Mg-O/Si-O bend
622	631	621	OH-Mg-OH translation
691	687	689	ν_s Si-O_b-Si
-	1045	-	ν_{as} Si-O_b-Si
3651	-	3660	ν_s outer OH
3691	3665	3683	ν_s outer OH
3698	3695	3703	ν_s inner OH

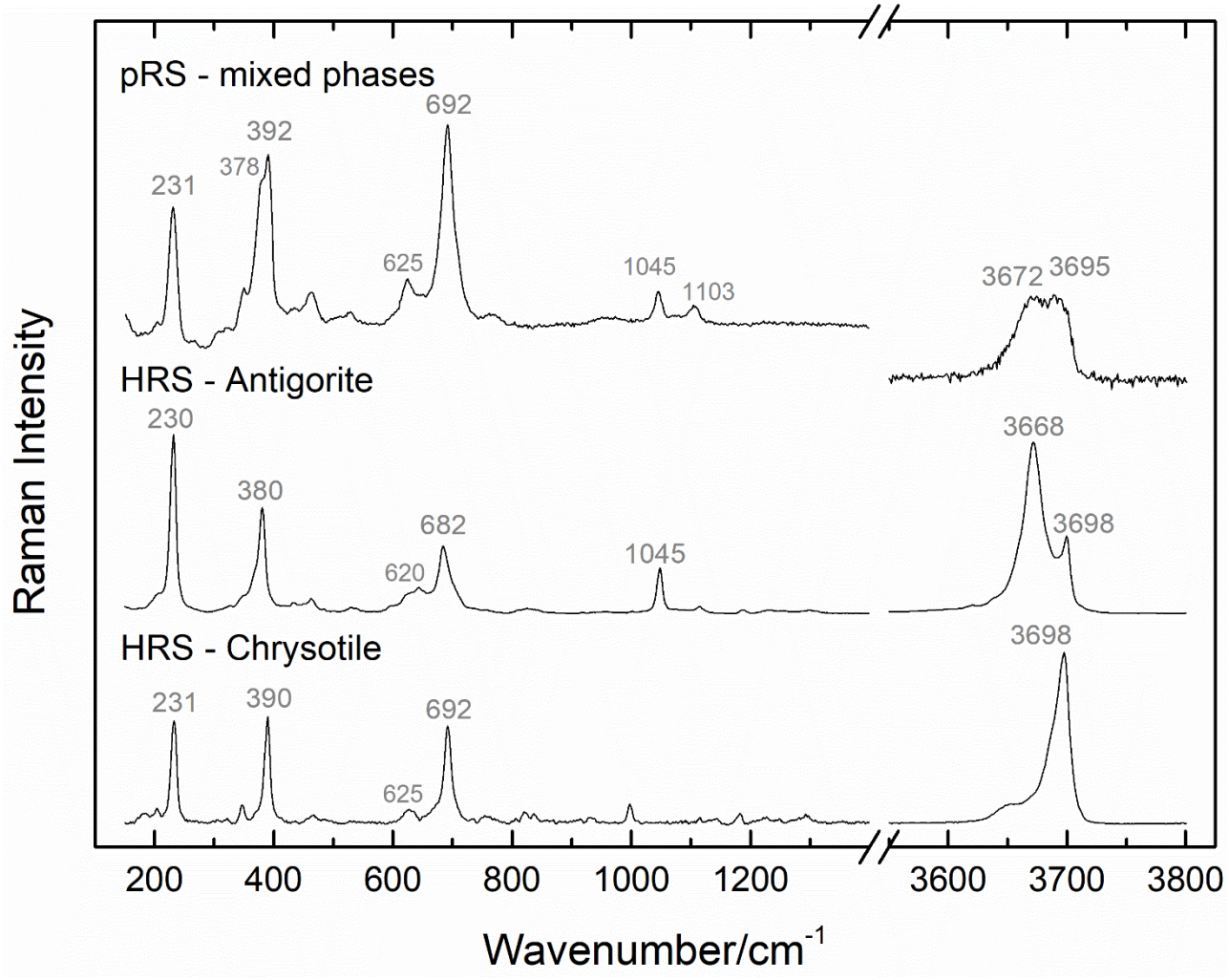
The band wavenumber is reported in cm^{-1}.

Amphibole asbestos minerals

Actinolite	Amosite	Anthophyllite	Crocidolite	Tremolite	Attribution
147	154	112	143	124	M-O
216				223	M-O
382	349	382		395	M-O
	528	429	534		Perpendicular Mg-O/Si-O bend
668	660	674	664	674	Mg-O / Si-O- bend or stretch
	968		964	930	ν_{as} Si-O_{nb}
1023				1028	ν_{as} Si-O_b-Si
1048	1020	1044	1082	1060	ν_{as} Si-O_b-Si
3624	3618				OH-stretch
3643	3637				OH-stretch
3660					OH-stretch
3674				3675	OH-stretch

The band wavenumber is reported in cm^{-1}.

Scheme 5. Raman spectra of bundle of intermixed chrysotile and fibrous antigorite collected with portable Raman (pRS) and micro-Raman spectrometer (HRS).



High-resolution micro-Raman (HRS) analysis performed on this mixed-phases sample resolved both antigorite and chrysotile phases, confirming the peak attribution assigned for spectra acquired with pRS.

Main references

1. Apopei, A.I.; Buzgar, N. The Raman study of amphiboles. Analele Stiint. Univ. AI Cuza din Iasi. Sect. 2, Geol. 2010, 56, 57.

2. Auzende, A.-L.; Daniel, I.; Reynard, B.; Lemaire, C.; Guyot, F. High-pressure behaviour of serpentine minerals: a Raman spectroscopic study. *Phys. Chem. Miner.* **2004**, *31*, 269–277, doi:10.1007/s00269-004-0384-0.

3. Bersani, D.; Andò, S.; Scrocco, L.; Gentile, P.; Salvioli-Mariani, E.; Fornasini, L.; Lottici, P.P.; Andò; Mariani, S.- Composition of Amphiboles in the Tremolite–Ferro–Actinolite Series by Raman Spectroscopy. *Miner.* **2019**, *9*, 491, doi:10.3390/min9080491.

4. Groppo, C.; Rinaudo, C.; Cairo, S.; Gastaldi, D.; Compagnoni, R. Micro-Raman spectroscopy for a quick and reliable identification of serpentine minerals from ultramafics. *Eur. J. Miner.* **2006**, *18*, 319–329, doi:10.1127/0935-1221/2006/0018-0319.

5. Kloprogge, J.T.; Frost, R.L.; Rintoul, L. Single crystal Raman microscopic study of the asbestos mineral chrysotile. *Phys. Chem. Chem. Phys.* **1999**, *1*, 2559–2564, doi:10.1039/a809238i.

6. Petriglieri, J.R.; Salvioli-Mariani, E.; Mantovani, L.; Tribaudino, M.; Lottici, P.P.; Laporte-Magoni, C.; Bersani, D. Micro-Raman mapping of the polymorphs of serpentine. *J. Raman Spectrosc.* **2015**, *46*, 953–958, doi:10.1002/jrs.4695.

7. Rinaudo, C.; Gastaldi, D.; Belluso, E. CHARACTERIZATION OF CHRYSOTILE, ANTIGORITE AND LIZARDITE BY FT-RAMAN SPECTROSCOPY. *Can. Miner.* **2003**, *41*, 883–890, doi:10.2113/gscanmin.41.4.883.

8. Rinaudo, C.; Belluso, E.; Gastaldi, D. Assessment of the use of Raman spectroscopy for the determination of amphibole asbestos. *Miner. Mag.* **2004**, *68*, 455–465, doi:10.1180/0026461046830197.

9. Rinaudo, C.; Croce, A. Micro-Raman Spectroscopy, a Powerful Technique Allowing Sure Identification and Complete Characterization of Asbestiform Minerals. *Appl. Sci.* **2019**, *9*, 3092, doi:10.3390/app9153092.

10. Wang, A.; Freeman, J.J.; Jolliff, B.L. Understanding the Raman spectral features of phyllosilicates. *J. Raman Spectrosc.* **2015**, *46*, 829–845, doi:10.1002/jrs.4680.