Release of metals and dissolution of mineral fibres in THP1 macrophagic cell-line systems exposed to chrysotile asbestos

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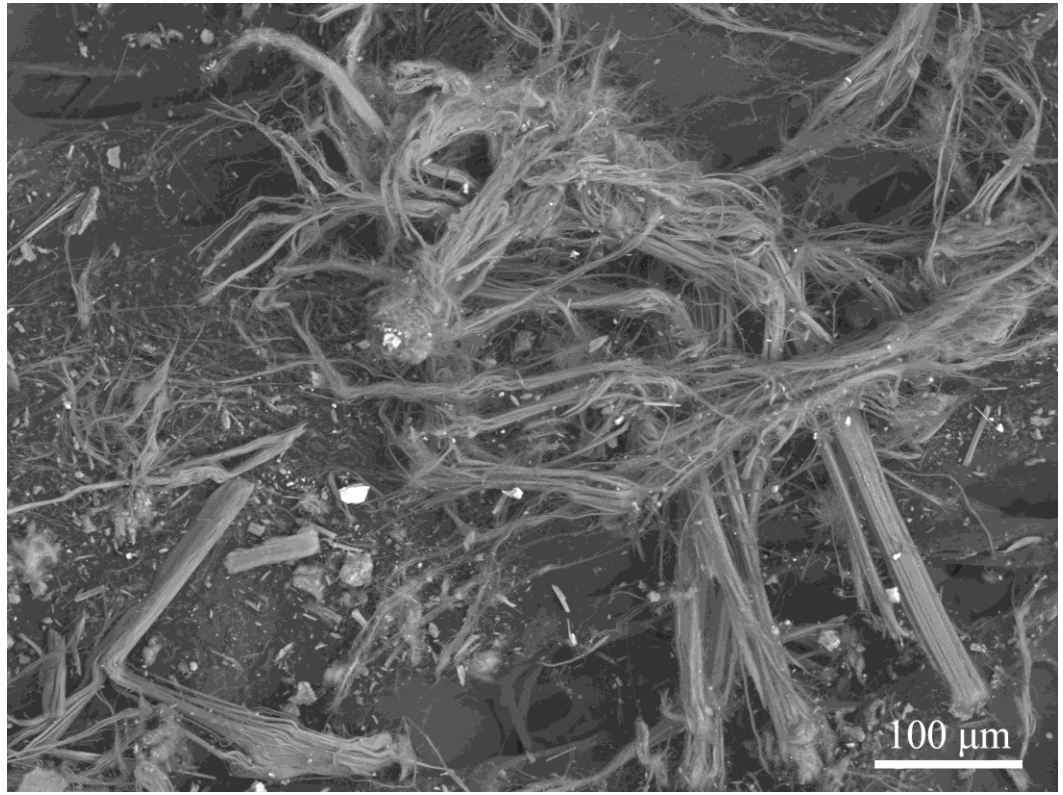
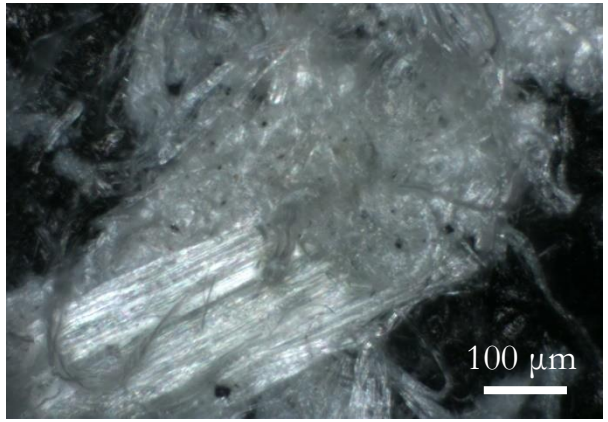
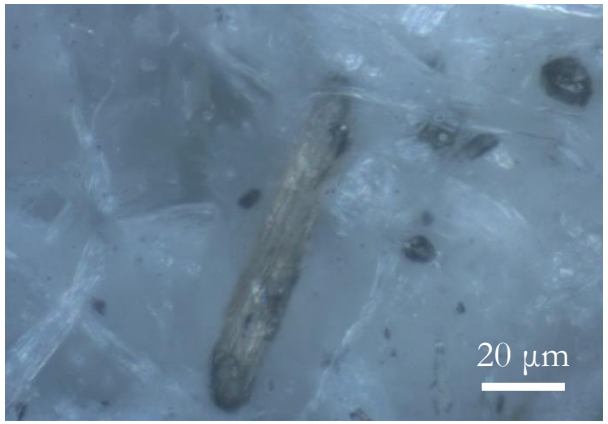
Outline

- μ-Raman identification of iron compounds in Chrysotile from Balangero. SEM-EDS analyses on mineral fibres and iron bearing crystals.
- Experiment at Elettra Sincrotrone Trieste. Beamline TwinMic. "Release of metals and dissolution of mineral fibres in THP1 macrophagic cell-line systems exposed to chrysotile asbestos". Proposal n° 20215552. 21-27/03/2022.
- Experiment at ESRF Synchrotron Grenoble. Beamline ID21. "Release of metals and dissolution of mineral fibres in THP1 macrophagic cell-line systems exposed to chrysotile asbestos". Proposal n° LS-3076. 14-20/06/2022.

Iron compounds in Chrysotile from Balangero: investigation with micro-Raman spectroscopy and SEM-EDS







Identification of iron compounds in chrysotile from the Balangero mine (Turin, Italy) by micro-Raman spectroscopy

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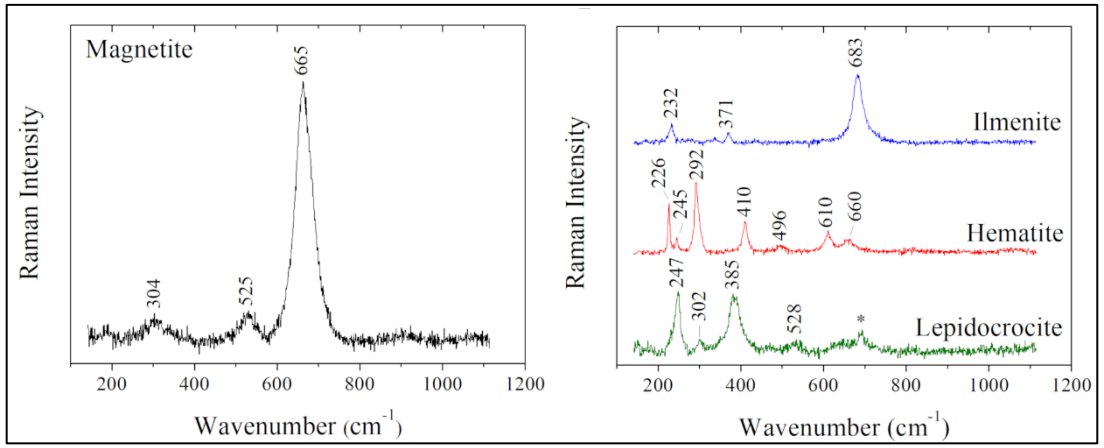
Research article submitted to Journal of Raman Spectroscopy under review

SEM-EDS analyses on mineral fibres and Fe-bearing compounds investigated by micro-Raman spectroscopy

Chrysotile from Balangero: chrysotile, antigorite and balangeroite

- Identification of chrysotile, antigorite and balangeroite from the Raman spectra
- Typical morphologies in flexible and curvilinear fibres with frayed ends (chrysotile), stocky lamellae (antigorite) and thin rigid fibres (balangeroite)
- Cr^{3+} luminescence between 680-710 nm (632.8 nm excitation)

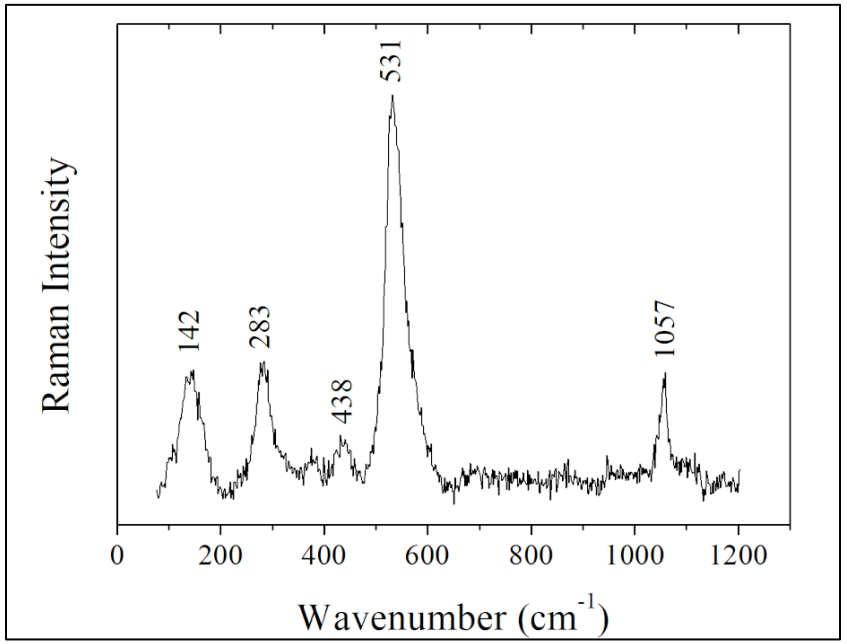
Iron compounds in Chrysotile from Balangero: oxides and oxyhydroxides

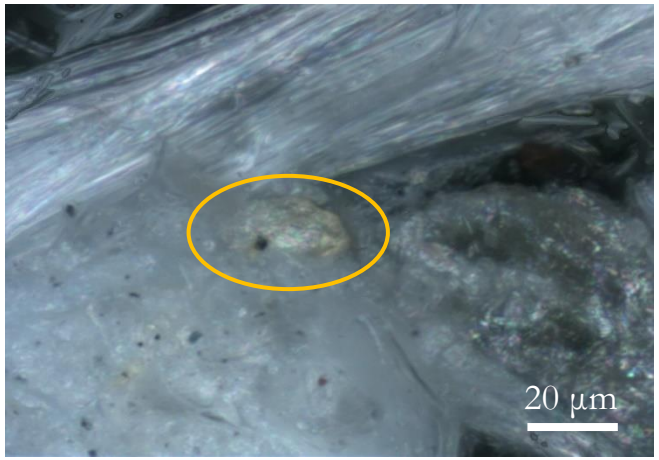


- Micrometric crystals from few micrometers up to ~40 micrometer with blackish colours
- Crystals both isolated and attached to the fibres
- Identification of iron oxides as magnetite (the most abundant), ilmenite and hematite (rare) and iron oxyhydroxides as lepidocrocite (rare)

[Omitted Data – under review for publication]

Iron compounds in Chrysotile from Balangero: carbonates





- Micrometric yellow-reddish crystals
- Carbonates containing Fe and Mg, as detected by SEM-EDS
- Not identified as a univocal carbonate phase, pure Fe carbonate excluded (siderite), carbonate similar to pyroaurite ($Mg_6Fe^{3+}_2(OH)_{16}[CO_3] \cdot 4H_2O$) suggested

Iron compounds in Chrysotile from Balangero: sulphides

- Micrometric crystals with blackish colour of irregular shape
- Crystals both isolated and attached to the fibres
- Identification of iron sulphides as mackinawite and Fe-Ni sulphides (rare): S, Fe and Ni detected by SEM-EDS
- Mackinawite in different forms as nanocrystalline mackinawite and partially oxidized mackinawite

[Omitted Data – under review for publication]

Iron sulphides: thermal effects

- Thermal effects investigated (strong red laser absorption by Fe-based sulphides) on a partially oxidized mackinawite crystal
- Changes induced by the increase of laser power (P1<P2<P3): 0.08, 0.32, 0.80 mW: broadening and shift of Raman peaks
- Irreversible transformation after "threshold" power: similar Raman spectra at P3 and P2* lowering the laser power

[Omitted Data – under review for publication]

Iron compounds: potential source of metal release?

- Potential contribution to toxicity if Fe-bearing compounds dissolve in the macrophage acidic environment.
- **Iron oxides and oxyhydroxides**: scarcely soluble, except at extreme pH values. No or low toxicity for Fe_3O_4 and Fe_2O_3 observed by *in vitro* studies [1,2].
- **Iron sulphides**: observation of the dissolution of mackinawite in acidic environment (pH 4.9) in literature [3]. Release of Fe(II) into the solution without being oxidized.
- "Trojan horse effect" to be taken into account if toxic metals are released. Correlation between the release of metals and acute inflammatory effects to be accounted.

Release of metals and dissolution of mineral fibres:
2 proposals at synchrotron radiation facilities accepted

Elettra Sincrotrone Trieste

ESRF
The European Synchrotron

Ref:
1. S. M. Hussain, K. L. Hess, J. M. Gearhart, K. T. Geiss, J. J. Schlager, *Toxicol. Vitr.* **2005**, *19*, 975.
2. H. L. Karlsson, P. Cronholm, J. Gustafsson, L. Möller, *Chem. Res. Toxicol.* **2008**, *21*, 1726.
3. H. Y. Jeong, Y. S. Han, S. W. Park, K. F. Hayes, *Geochim. Cosmochim. Acta* **2010**, *74*, 3182.

#20215552 – TwinMic, Elettra 21/03-27/03/2022

#20215552 – TwinMic, Elettra 29/04-01/05/2022

Elettra Sincrotrone Trieste

Samples:

- THP-1 M0 control
- Chrysotile control
- THP-1 M0 Chrysotile 8h
- THP-1 M0 Chrysotile 24h
- THP-1 M0 Chrysotile 96h

- THP-1 M0 Crocidolite 8h
- THP-1 M0 Crocidolite 24h
- THP-1 M0 Crocidolite 96h

- THP-1 M1 control
- THP-1 M1 Chrysotile 8h
- THP-1 M1 Chrysotile 24h
- THP-1 M1 Chrysotile 96h

Areas of interest:

- Fibres with/into cells
- Clusters

XRF mapping:

C_K, O_K, Na_K, Mg_K,Fe_L

ISTITUTO OFFICINA DEI MATERIALI

AFM and Micro-Raman on some areas of interest

#LS-3076- ID21, ESRF
14/06 - 20/06/2022

DOI:10.15151/ESRF-ES-744175308

- THP-1 M0 control
- THP-1 M1 control
- Chrysotile control
- Crocidolite control
- Erionite control

- THP-1 M0 Chrysotile 8h
- THP-1 M0 Chrysotile 24h
- THP-1 M0 Chrysotile 96h
- THP-1 M0 Crocidolite 8h
- THP-1 M0 Crocidolite 24h
- THP-1 M0 Crocidolite 96h

- THP-1 M1 Chrysotile 8h
- THP-1 M1 Chrysotile 24h
- THP-1 M1 Chrysotile 96h
- THP-1 M1 Crocidolite 8h
- THP-1 M1 Crocidolite 24h
- THP-1 M1 Crocidolite 96h
- THP-1 M1 Erionite 8h
- THP-1 M1 Erionite 24h
- THP-1 M1 Erionite 96h

Areas of interest:

- Fibres with/into cells
- Clusters
- Areas arleady scanned at TwinMic

XRF mapping:

From Na to Cr

XANES:

At **Fe**, **Mn** and **Cr-edge**

Future activities

X R F

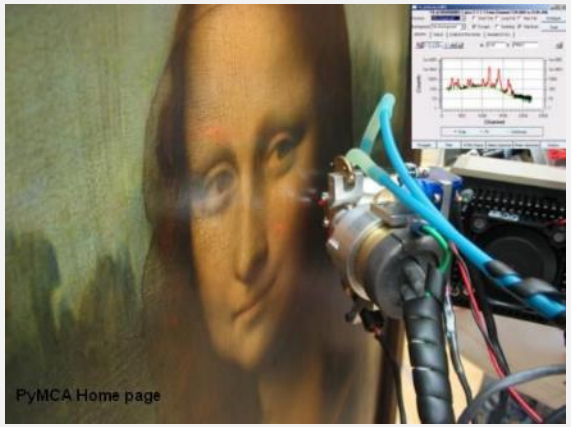
F I T

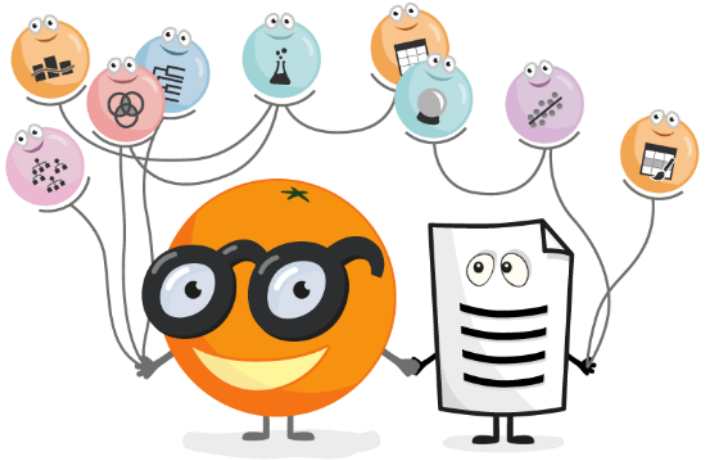
V I S

- Process all data get at TwinMic

- Process all data get at ID21

Chemical maps and PCA&LDA on XANES spectra





Partecipation to Conferences

- *EGU General Assembly 2022*, 23-27 maggio, Vienna. Session NH8.3. Mineral particles and fibres: bridging minero-chemistry to occupational and environmental strategies for health hazard control. Danilo Bersani, Laura Fornasini, Simona Raneri, Luciana Mantovani, Valentina Scognamiglio, Dario Di Giuseppe, Alessandro F. Gualtieri. Micro-Raman investigation on Fe-bearing impurities in chrysotile fibres

- *Geosciences for a sustainable future, SGI-SIMP Joint Congress 2022*, 19-21 settembre, Torino. Session S22. Naturally Occurring Asbestos (NOA): hazard identification, assessment and mitigation. Conveners: Dario Di Giuseppe, Jasmine Rita Petriglieri, Laura Fornasini, Michele Mattioli

- *Geosciences for a sustainable future, SGI-SIMP Joint Congress*, 19-21 settembre, Torino. Session S22. Naturally Occurring Asbestos (NOA): hazard identification, assessment and mitigation. Simona Raneri, Laura Fornasini, Alessandra Gianoncelli, Eduardo Villalobos, Dario Di Giuseppe, Valentina Scognamiglio, Serena Mirata, Vanessa Almonti, Valentin Bonanni, Pietro Parisse, Danilo Bersani, Anna Maria Bassi, Barbara Marengo, Sonia Scarfì, Alessandro F. Gualtieri: Release of metals and dissolution of mineral fibres in THP1 macrophagic cell-line systems exposed to chrysotile asbestos. A synchrotron-based study

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Thank you for the attention