TIRE DEBRIS IN THE ENVIRONMENT: PRELIMINARY RESULTS ABOUT CHARACTERIZATION, IDENTIFICATION AND PROCESS ANALYSIS

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PLAN

Motivation
Characterization
- morphological
  - fractal analysis
- microstructural
  - REV
- chemical
  - EDX
  - IR

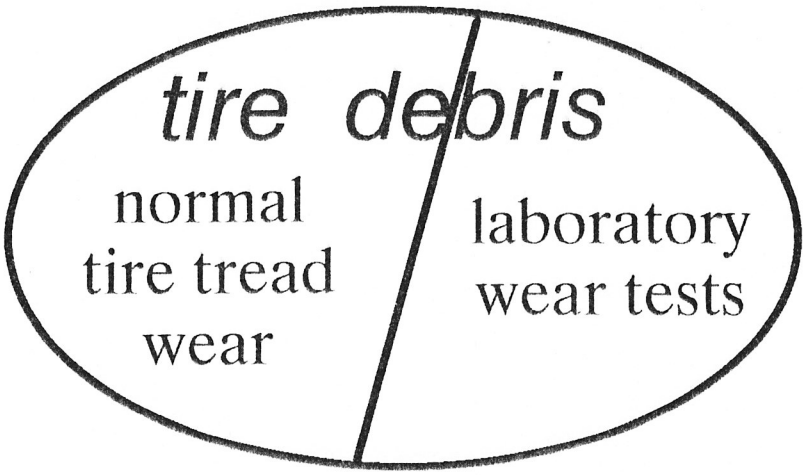
Identification
- { SEM + EDX; SEM X ray maps } ⇒
- ⇒ size histogram

Process analysis
- size histogram ⇒
- ⇒ tire debris advection – diffusion.

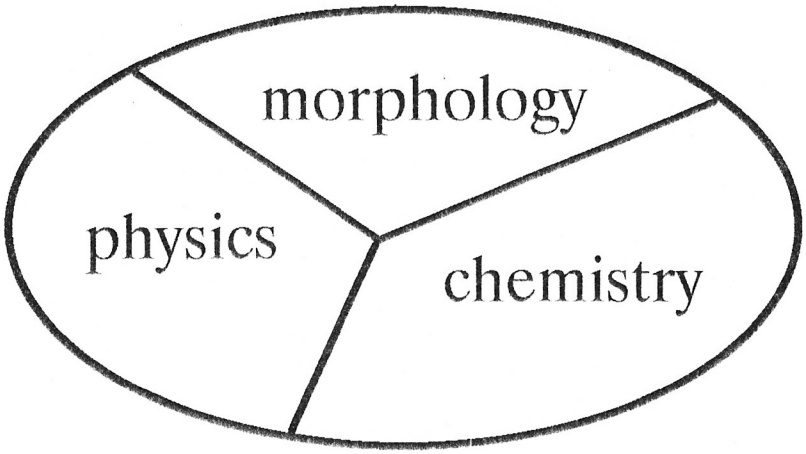
MOTIVATION

Tire debris.

Wherefrom ?



Which properties ?



Why ?

Dual Use of Results

environmental & health impact ⟵ ⟶ product quality control

MATERIALS

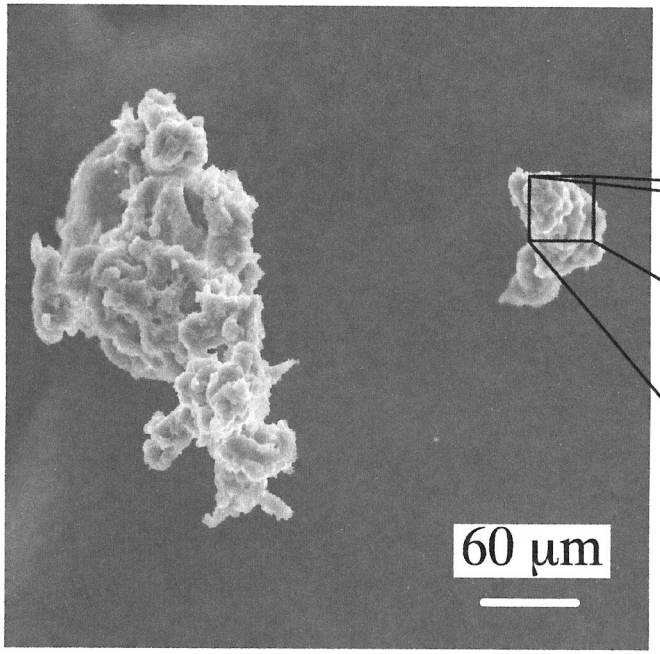
1 – Typical ingredients of tire treads.

Ingredient	Vehicle	
	car	truck
masterbatch elastomers	SBR 75% PB 10% NR 15%	10% 10% 80%
masterbatch	60 phr	50 phr
fillers	Example: Carbon Black 30 phr SiO_2 30 phr	$SiO_2 \leq 10$ phr
vulcanizers	3 ÷ 4 phr	3 ÷ 4 phr
accelerators	0.5 ÷ 2 phr	0.5 ÷ 2 phr
activators	ZnO 2 phr	ZnO 2 phr
antioxidants & protectors	phenylamines 1 phr	phenylamines 1 phr
extenders	high viscosity aromatic oil 20 phr	high viscosity aromatic oil 5 phr
weight loss before disposal	**0.8 kg**	**8 kg**

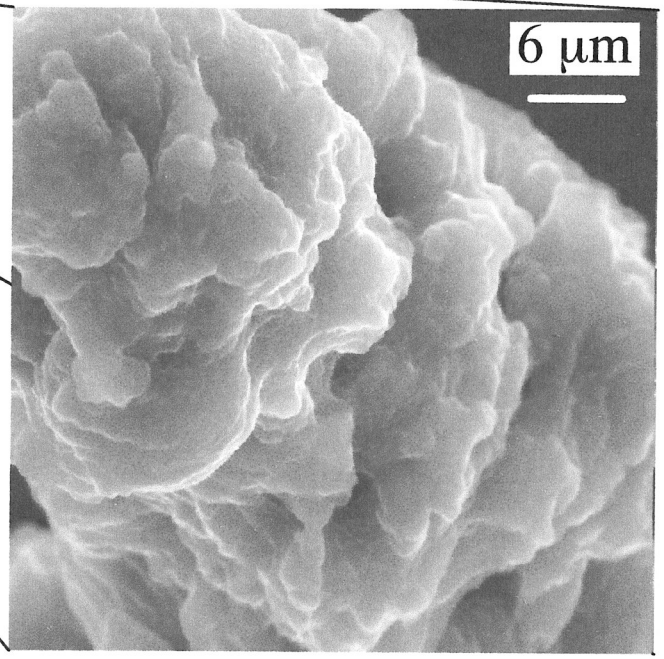
2 – Laboratory debris types

Label	Method	Abrader tool	Anti smear agent	Tire pressure	v_T	F_N
LS	low severity	3M 18N74	starch	N.A.	2 to 9 m/s	440 N + 3 Nm torque
HS	high severity	steel blade	talc	N.A.	80 mm/s	35 N
R	rasping	steel brush	NONE	0.25 MPa	25 km/h	?

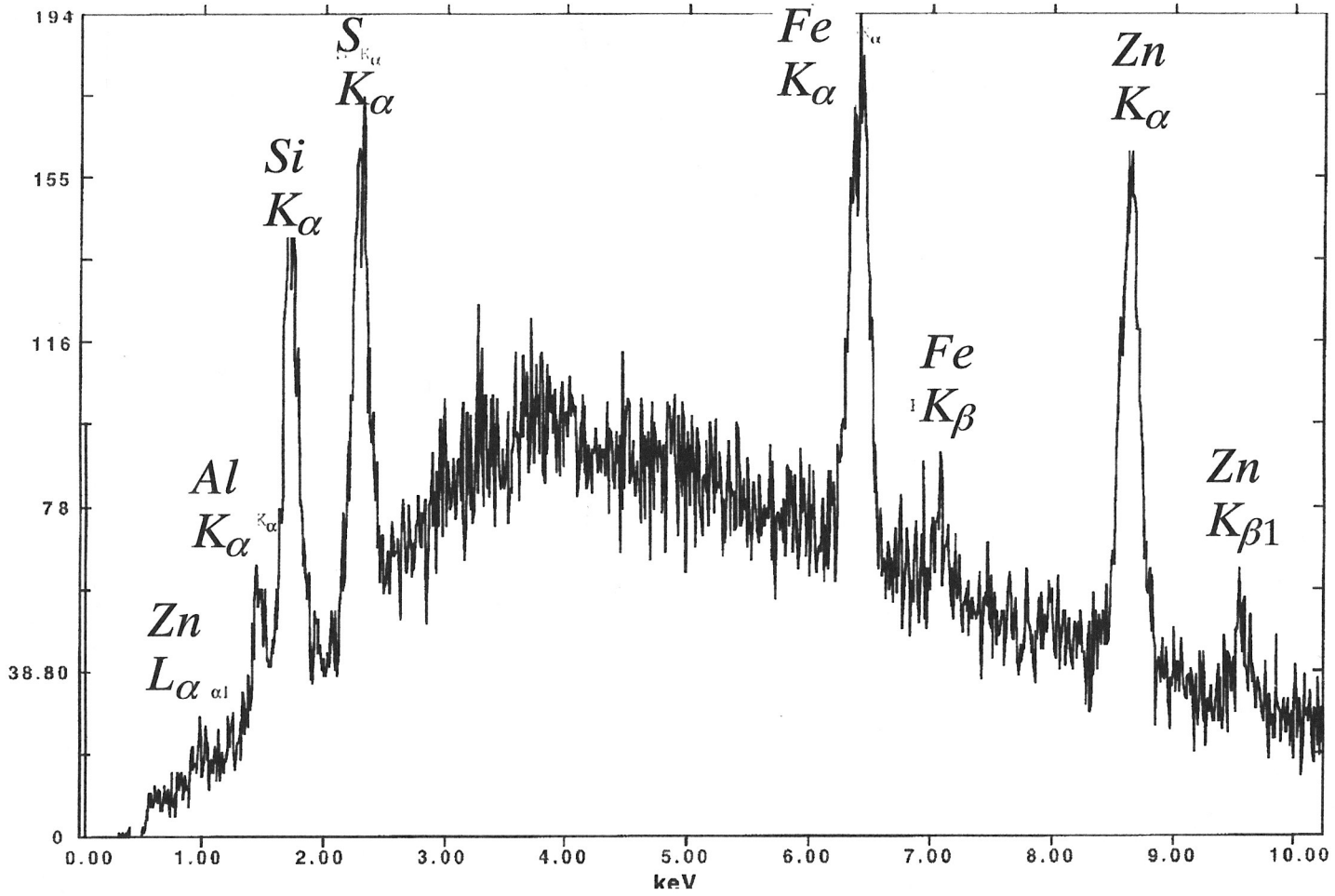
CHARACTERIZATION BY SEM IMAGING + EDX



S117x500.tif



S119x5k.tif


194
155
116
78
38.80
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
keV
Zn
Lα
Al
Kα
Si
Kα
S
Kα
Fe
Kα
Fe
Kβ
Zn
Kα
Zn
Kβ1

MICROSTRUCTURAL CHARACTERIZATION: TEM IMAGING, DIFFRACTION, EDXS

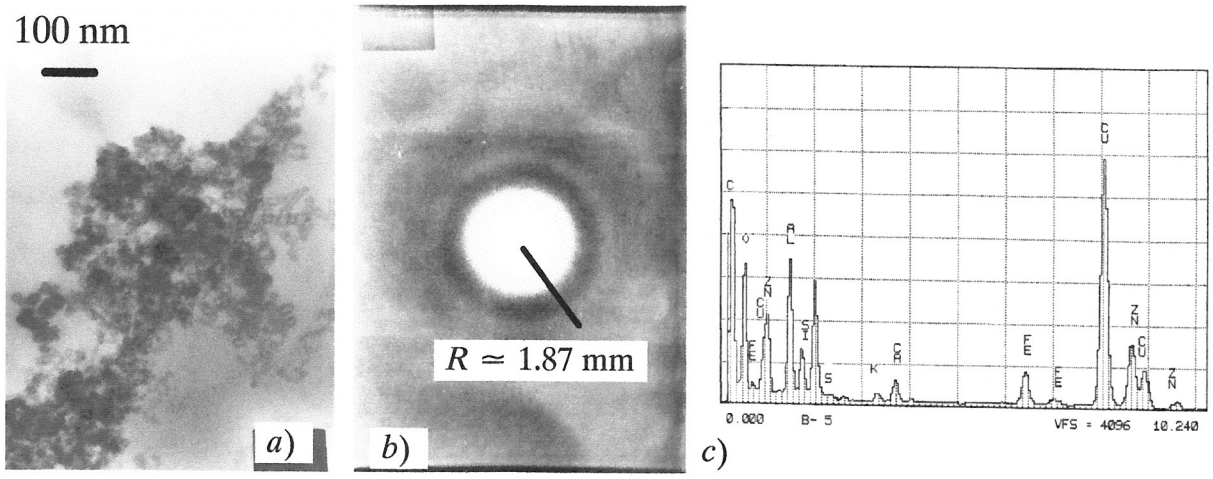
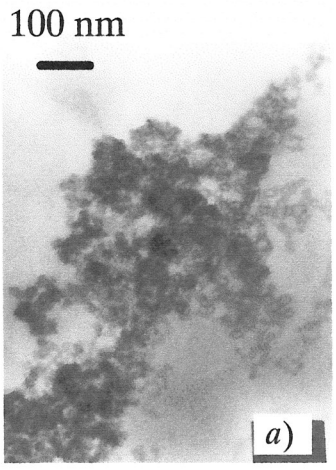


FIGURE 3.*a*: TEM image of type–*a* debris, which suggests a REV of $\simeq 10^{-1}$ μm^3.
FIGURE 3.*b*: typical SADP of a *tdp* with halos; no microcrystalline structure is expected.
FIGURE 3.*c*: typical EDX spectrum, where the *Zn* K_α and *Zn L* peaks are visible; elements other than *C*, *O*, *Si* are impurities due to the abrader and to the environment.

ESTIMATING THE *REV* FROM A TEM IMAGE



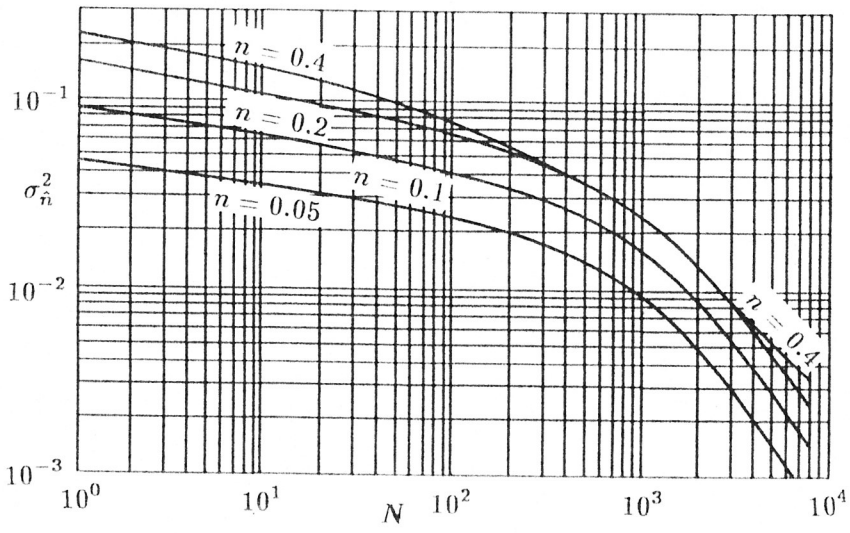


Figure 1.2.1: Variance of the estimate, $\hat{n}$, of porosity as a function of the number, N, of elementary subdomains.

$$REV = N \cdot \text{meas}[\Omega]$$

$$\left.\begin{array}{l} \text{meas}[\Omega] \simeq 8 \cdot 10^{-27}\text{m}^3 \\ \sigma^2_{\hat{n}_V} \simeq 3 \cdot 10^{-3} \\ 0.05 < n_V < 0.4 \end{array}\right\} \Rightarrow 3 \cdot 10^3 < N < 8 \cdot 10^3 \left.\begin{array}{l} \\ \\ \end{array}\right\} \Rightarrow REV \simeq 8 \cdot 10^{-23}\text{m}^3$$