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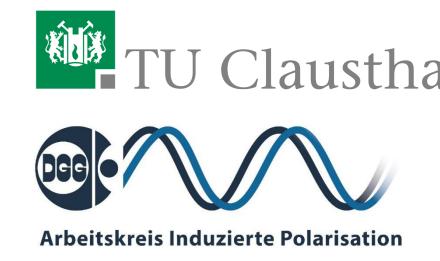
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Superposition of IP signals measured on pyrite-sand mixtures



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Introduction

- IP is a valuable tool in ore exploration to get insights into the material properties of ores, slags, and other processing residuals.
- Most studies have been focused on single fractions of metallic particles with varying grain size (Fig. 1) or varying volume percentage (VP).
- The chargeability has been accepted as a proxy for the metal content and the relaxation time for the particle size.
- We investigate whether mixtures with two fractions of different grain size and the same VP (Fig. 2) can be presented by an additive superposition of the spectra measured with single grain size fractions.
- The measured spectra are fitted to Peltonmodels and processed by a Debye decomposition to get the relaxation time distribution (RTD).
- We compare the resulting values of chargeability and the spectra of imaginary conductivity, phase shift, and RTD.

Material

- 11 unconsolidated **pyrite sand mixtures**, measured with SIP-ZEL (Tab. 1)
- 6 samples consisting of a single pyrite grain radius mixed with sand (E - samples) with a pyrite content of 2.75 VP
- 5 samples containing two different grain radii within the sand (Z samples) with a pyrite content of 5.5 VP
- Pyrite grain radius between 31 1000 μm,
 quartz sand grain radius ~100 μm

Sample	First pyrite grain radius [µm]	Second pyrite grain radius [µm]	Mean pyrite grain radius r _{gm} [μm]	Pyrite content p _v [VP]
E 01	31 - 56	•	42	2.75
E 02	56 - 100	1	75	2.75
E 03	100 - 177	1	133	2.75
E 04	177 - 315	1	236	2.75
E 05	315 - 500	•	397	2.75
E 06	500 - 1000	-	707	2.75
Z 01	31 - 56	500 - 1000	172	5.50
Z 02	56 - 100	500 - 1000	230	5.50
Z 03	100 - 177	500 - 1000	307	5.50
Z 04	177 - 315	500 - 1000	409	5.50
Z 05	315 - 500	500 - 1000	530	5.50

Tab. 1: Overview about the measured samples with a single pyrite grain radius (Esamples) and two different pyrite grain radii (Z-samples).

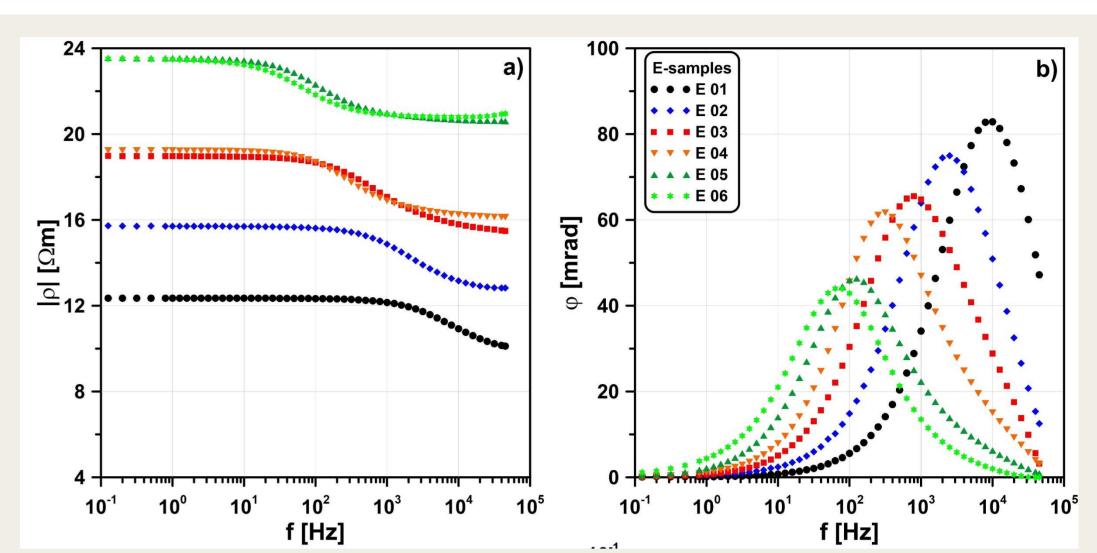


Fig. 1: Spectra of the E-samples with a single pyrite grain radius: a) resistivity amplitude, b) phase shift.

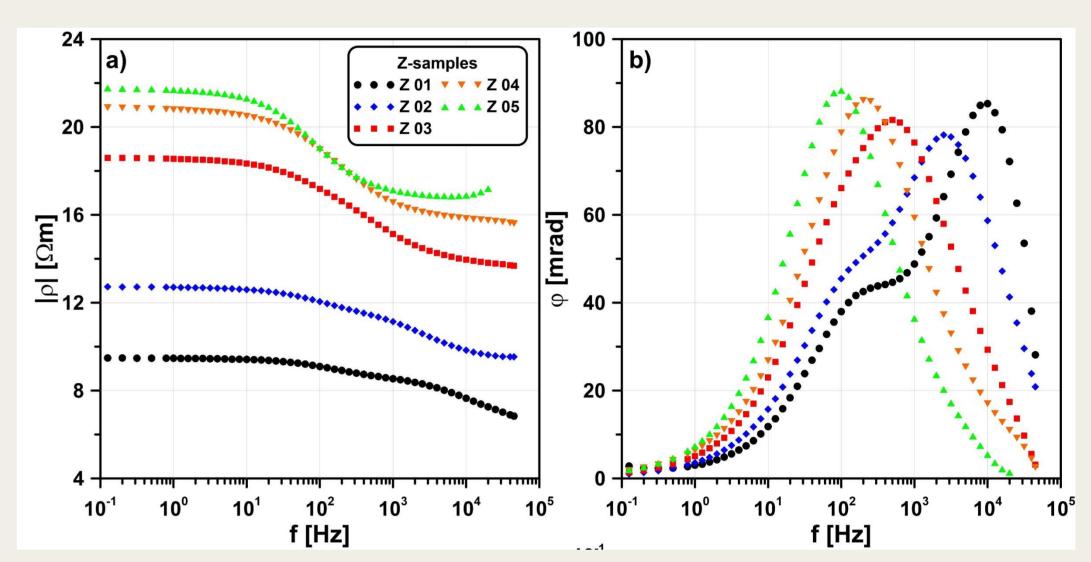


Fig. 2: Spectra of Z-samples with two pyrite grain radii: a) resistivity and b) phase shift.

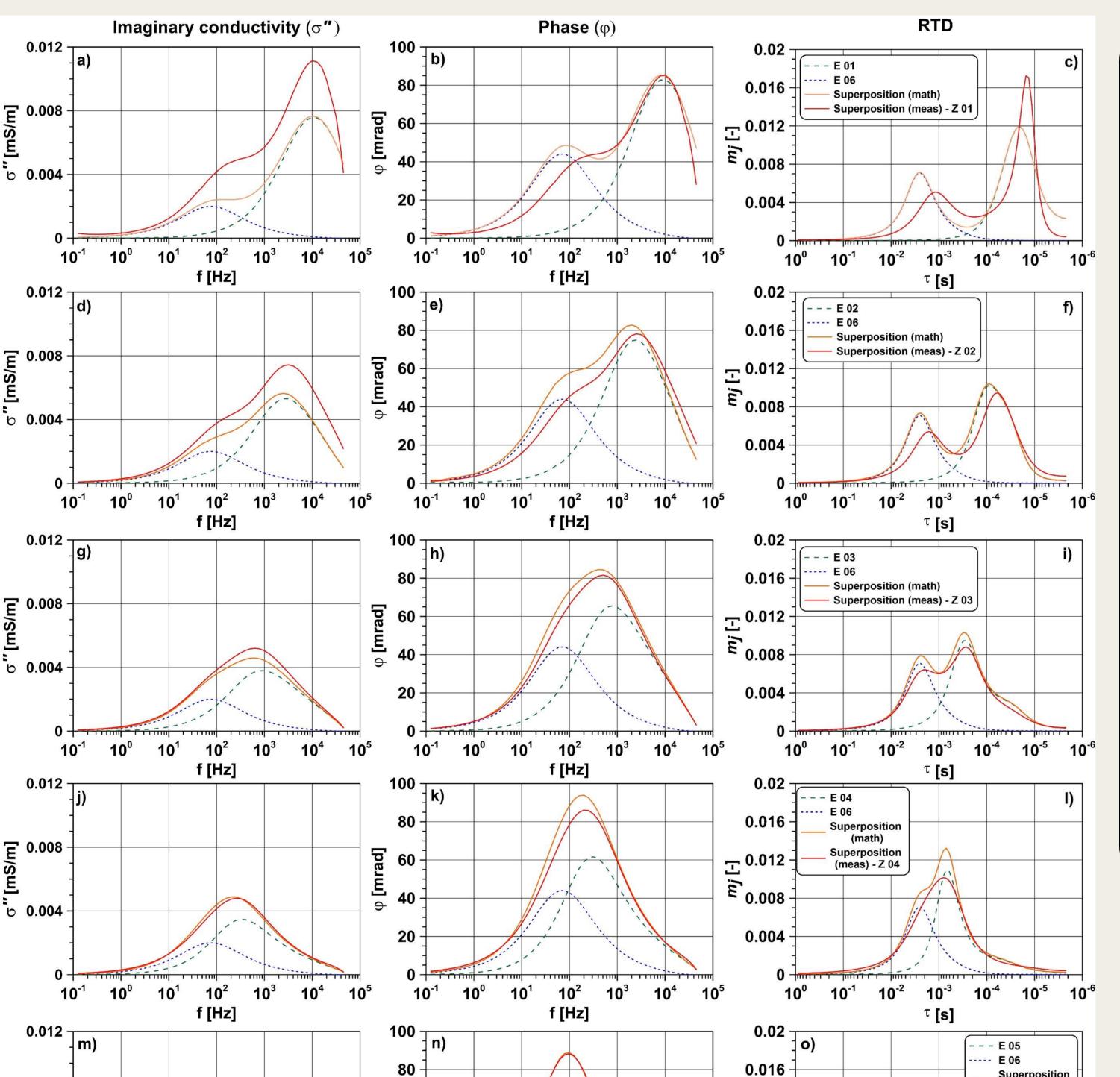


Fig. 3: Superposition of spectra of samples with different pyrite grain radii for the imaginary conductivity, phase shift, and the RTD from Debye decomposition. Consider that the τ -axis is scaled in inverse direction (from larger to lower values).

立 0.012 -

E 0.008

0.004

 ϕ [mrad]

Results

- E-samples (Fig. 1): An increase in resistivity (ρ) , a decrease in chargeability (m), and a decrease in the peak frequency (f_{peak}) is observed with increasing pyrite grain radius.
- Although equal in VP, the fraction with the lowest grain size indicates the strongest IP effect.
- Z-samples (Fig. 2): An increase in ρ , a decrease in m and a decrease in f_{peak} is observed with increasing radius of the **fraction of smaller pyrite grains**. The spectra become wider for an increasing radii difference between the two pyrite grain fractions.
- Phase spectra indicates a good agreement between the measured (red line) and mathematically predicted (orange line) additive superposition (Fig. 3, middle column).
- The mathematical superposition underestimates the measured superposition of **spectra of imaginary conductivity** (Fig. 3, left column).
- The agreement becomes better for fractions with similar grain size (see sample Z 05, lowermost row in Fig. 3).
- Although equal in VP, **chargeabilities** m_a , m_p , and m_t decrease with increasing grain size (Figs. 4, 5). Mathematical superposition overestimate the values determined from the measured spectra.

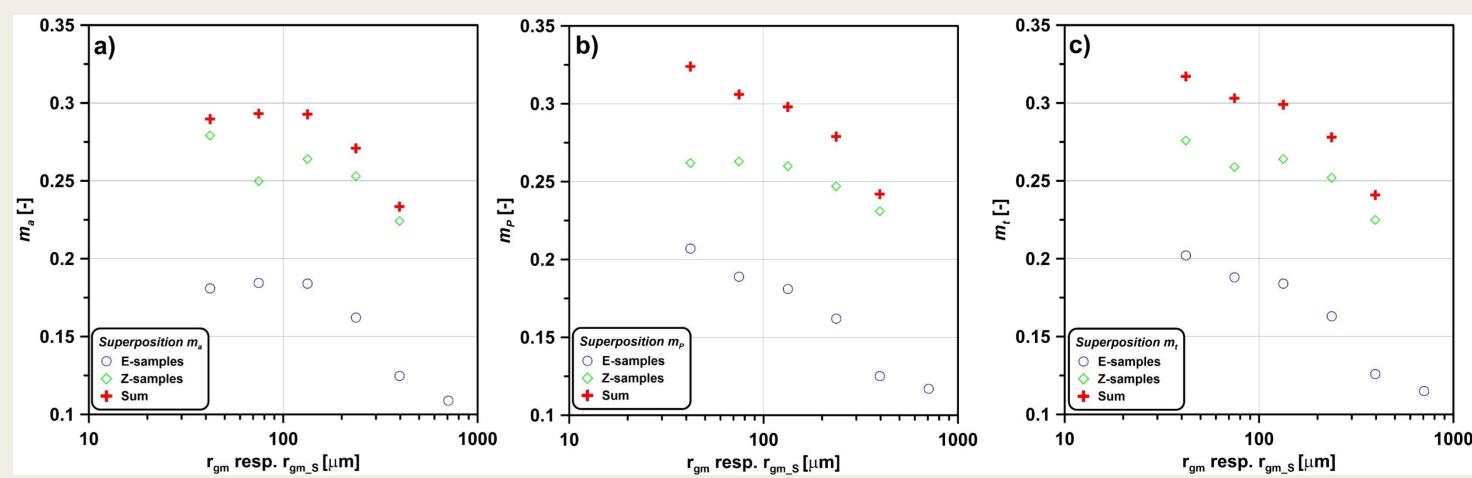


Fig 4: Superposition of different chargeabilities (m_a , m_p , and m_t) versus grain size $r_{\rm gm}$ (E-samples) or for the smallest grain size fraction $r_{\rm gm_s}$ (Z-samples). Sum (red crosses) corresponds to the mathematical superposition via addition. (a) Approximate chargeability m_a , (b) chargeability of the Pelton model m_p and (c) total chargeability resulting from the Debye decomposition m_t .

Fig 5: Chargeability versus grain size for E- and Z-samples. The solid lines are the calculated chargeability values for VP according to Gurin et al. 2015 (2.75 VP - blue, resp. 5.5 VP - orange).

Conclusions

- Mathematical superposition of spectra of σ' , phase shift, and RTD provides a useful approximation.
- Although equal in VP, chargeability and RTD-amplitude decrease with increasing grain size.
- RTD amplitude does not reflect the VP of a certain grain radius.
- Chargeability is not a suitable proxy for the volumetric metal content (for particles $r_{\rm gm}$ < 500 μ m).

<u>Reference:</u> Gurin, G., Titov, K., Ilyin, Y. & Tarasov, A., 2015. Induced polarization of disseminated electronically conductive minerals: a semi-empirical model, Geophys. J. Int., 200(3), 1555–1565.

(meas) - Z 05