Tomographic investigation of a complete iron meteorite

Background

On May 30th 2017 a meteorite was found near Lieksa. This was the 14th meteorite finding and the 1st iron meteorite [1] finding in Finnish history. The meteorite weighs 238.30 g and has a density of (6988 ±2) kg/m^3. It was sent as a possible meteorite specimen to K. A. Kinnunen at Geological Survey of Finland for identification. It has now been submitted for registration under the name “Lieksa”.

Other analysis methods

One corner of the meteorite was polished and etched for determination of mineralogy and geochemistry. Petrophysical properties were also determined. The Fe-Ni phase consisted of kamacite and taenite, with troilite inclusions. The silicate phase consisted mostly of olivine. The contents of the main components for each mineral in the Fe-Ni phase, as well as bulk composition of the Fe-Ni phase, are shown in Table 1. Petrophysical properties of the meteorite are shown in Table 2.

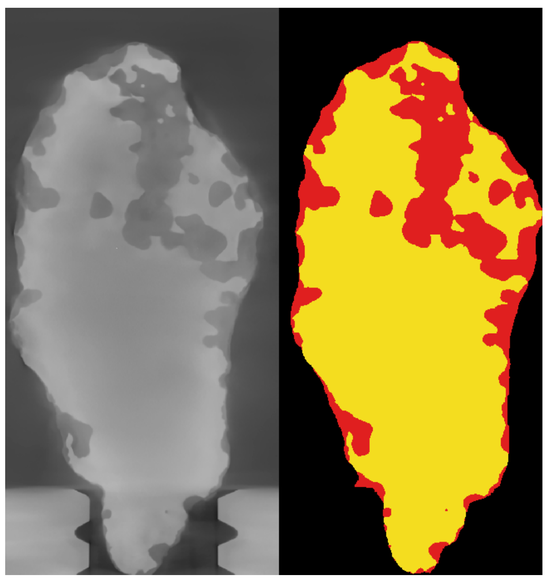

Figure 1: Left panel: One cross-section from a tomographic reconstruction of the Lieksa meteorite, showing the silicate phase in a darker shade and the metal phase in a lighter shade, with the sample holder also visible. Right panel: The same cross-section with the mineral phases segmented.

Computed x-ray tomography

The meteorite was scanned with a GE phoenix v|tome|x s tomography device, using a 220 kV acceleration voltage and a 220 µA current. 1.0 mm of Cu and 0.5 mm of Al were used to filter the beam. Voxel size in the final image was 49.9 µm. The metal and silicate phases were segmented with watershed segmentation using FEI PerGeos software and their volume fractions were determined. The segmenation is shown in Fig. 1 and a three dimensional rendering of the meteorite, along with a photograph, are shown in Fig. 2. **The meteorite was found to contain roughly 20% silicates and 80% metal, by volume.**

Table 1: Composition of the Lieksa meteorite determined with EPMA.

Component	S	Fe	Co	Ni
Fe-Ni phase	0,00%	88,03%	0,63%	10,78%
Kamacite	0,00%	91,38%	0,74%	6,06%
Taenite	0,00%	63,58%	0,16%	34,66%
Troilite	35,52%	62,28%	0,00%	0,10%

Table 2: Petrophysical properties of the Lieksa meteorite.

Mass g	Volume cm^3	Density kg/m^3	Susceptibility 10^{-6} (SI)	Remanence mA/m	Resistivity Ωm
230.94 ±0,01	33.05 ±0.04	6988 ±2	> 5000000	194000 ±2000	2E-7 ±2E-8

Discussion

This is the first complete iron meteorite to be scanned with x-ray tomography. With this method we were able to confirm the classification of the meteorite by determining the metal content to be over 50%. The images also provided valuable insight to the morphology of the silicate phase within the iron meteorite, unattainable by other methods.

Acknowledgments

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References

[1] V.F. Buchwald, Handbook of Iron Meteorites. Their History, Distribution, Composition and Structure (University of California Press, Berkeley, CA, 1975)

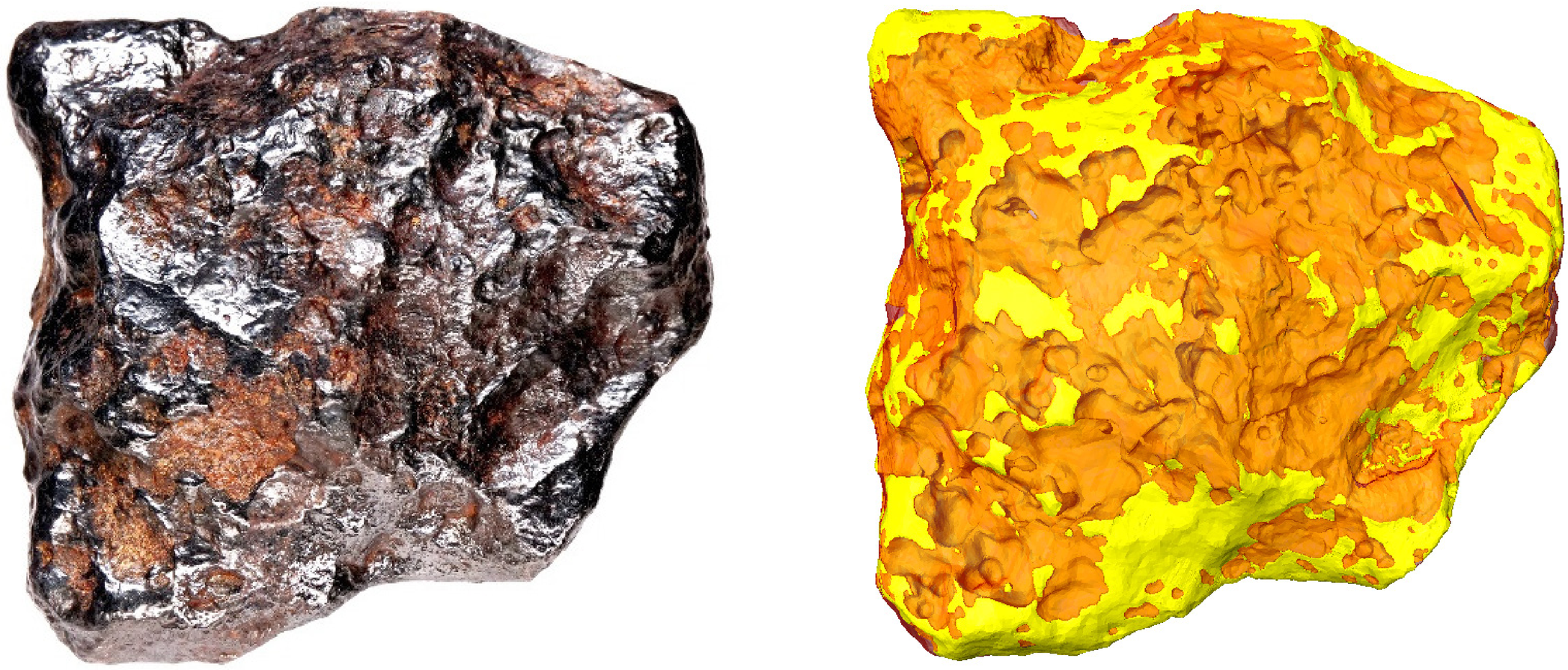

Figure 2: Left panel: Photograph of the Lieksa meteorite. Kari A. Kinnunen. Right panel: Three dimensional visualization of the Lieksa meteorite, showing the silicate phase in transparent orange and the metal phase in yellow.

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