ANALYSIS OF METEORITE SAMPLES

Project number	18-67805/02/93
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1. Introduction:

A number of samples of meteoritic material were supplied with a request to determine the composition of the crust materials and to confirm the origin of the other materials as meteoritic.

- 7 samples (designated H1 – H7) were slices about 5 mm thick and 10 to 50 cm in dimension.
- 18 samples of small meteorite fragments.
- 2 samples of meteorite dust (designated A & B).

Some of the 27 supplied meteorite samples were studied using an Optical microscope to select samples for examination in the Scanning Electron Microscopy (SEM) with attached Energy Dispersive X-ray Spectrometer (EDXS) which was used to determine the elemental composition of the metallic and crust phases. Slice H2 was ground and polished from one side and etched lightly with a dilute solution of nitric acid in alcohol.

Part of the oxidised scale from slice H2 was also cut and prepared for investigation using X-ray diffraction (XRD). Results of this examination were compared with XRD patterns taken from one of the small meteorite fragments and meteorite dust A (super fine grade).

Meteorite dust B (fine grade) was acid etched and also investigated using the SEM.

2. Results:

The **Widmannstatten pattern** developed on slice H2 positively identified this slice as from an iron-based meteorite. From studying the structure in this slice (Fig. A1) it was concluded that this meteorite belongs to the **medium octahedrite** where **kamacite** crystals (Fe - 6% Ni) 11 to 20 mm long and about 2 mm wide are separated by very thin **taenite** (Fe - 19% Ni) lamellae that cross each other in octahedral patterns. In some places however skeletal **schreibersite** $(Fe,Ni)_3P$

inclusions, with large kamacite areas enclosing them, disrupt the orderly octahedral pattern of the kamacite. Under the SEM **Neumann lines** are visible in the etched kamacite crystals (figure S1 & S2) which is characteristic of impact metamorphism in iron meteorites. From the petrological examination of slice H2 and other slices included in this assessment it is apparent that the meteorite is very heavily oxidised and was probably buried or partially buried in the ground for a very long time (thousands of years). This terrestrial weathering causes the formation of a thick brown and black oxide scale, which can be referred as the "**oxidite**" i.e. subsoil buried meteorite (page 78 Meteoritics Vol. 1, No. 1 1953). This oxidised scale in many places penetrates iron meteorites along the cracks between kamacite grains and the schreibersite inclusions. Some slices consist mainly of such weathering products of the iron meteorite and become in fact "oxidite" themselves. These areas of oxide can also include quartz and alumino-silicate clays.

EDXS analysis showed nickel content in kamacite rich areas of between 6 and 7.4 wt% Ni and in taenite rich phases up to 14wt% Ni. In the oxide scale nickel content drops to 2.6 wt% and the X-ray diffractograms show mostly **quartz** (SiO2), **goethite** (FeOOH) and **trevorite** (Fe,Ni oxide) with no traces of kamacite.

The sample taken from one of the small meteorite fragments has a similar X-ray diffraction pattern but consists mainly of goethite with some trevorite. EDXS analyses revealed the nickel content to be about 4wt% and it is likely that these fragments originate from oxidised iron-based meteorite scale and may be classified as **oxidites**. This diffraction pattern did not show the presence of kamacite.

EDXS analysis revealed that both meteorite dust samples contain 6-7 wt% of nickel which is consistent with values measured in the kamacite phase of sample H2. Phosphorus was also detected which may be associated with the meteorite mineral schreibersite .

The meteoritic iron mineral kamacite was also detected in the X-ray diffraction trace for the dust sample A and in the etched sample of coarse grade dust sample B.

EDXS elemental composition, X-ray diffraction and SEM structural analyses are consistent with the examined dust samples being of meteoritic origin.

Generally, the primary metal phase of the examined meteorite slice has a measured nickel content within the published range of poor octahedrite (in some places hexahedrites).The structure is built from kamacite crystals with small amounts of taenite and schreibersite inclusions.

Sincerely Yours
Dr. Marek Zbik

Figure A1 **Acid etched iron meteorite slice H2 showing the Widmannstatten pattern characteristic of medium octahedrite**

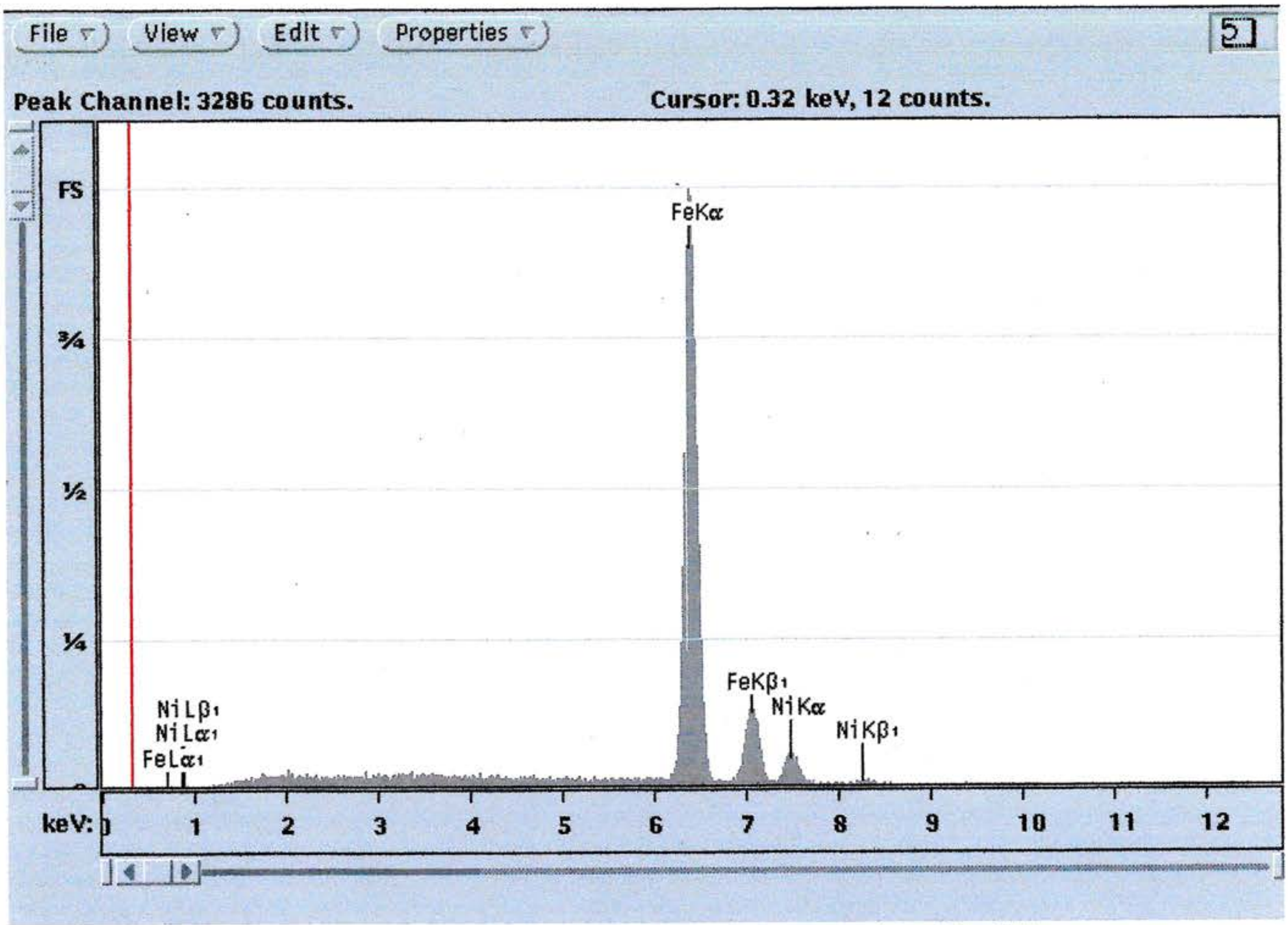

Figure E1 **EDXS spectrum from "kamacite" on meteorite slice H2**

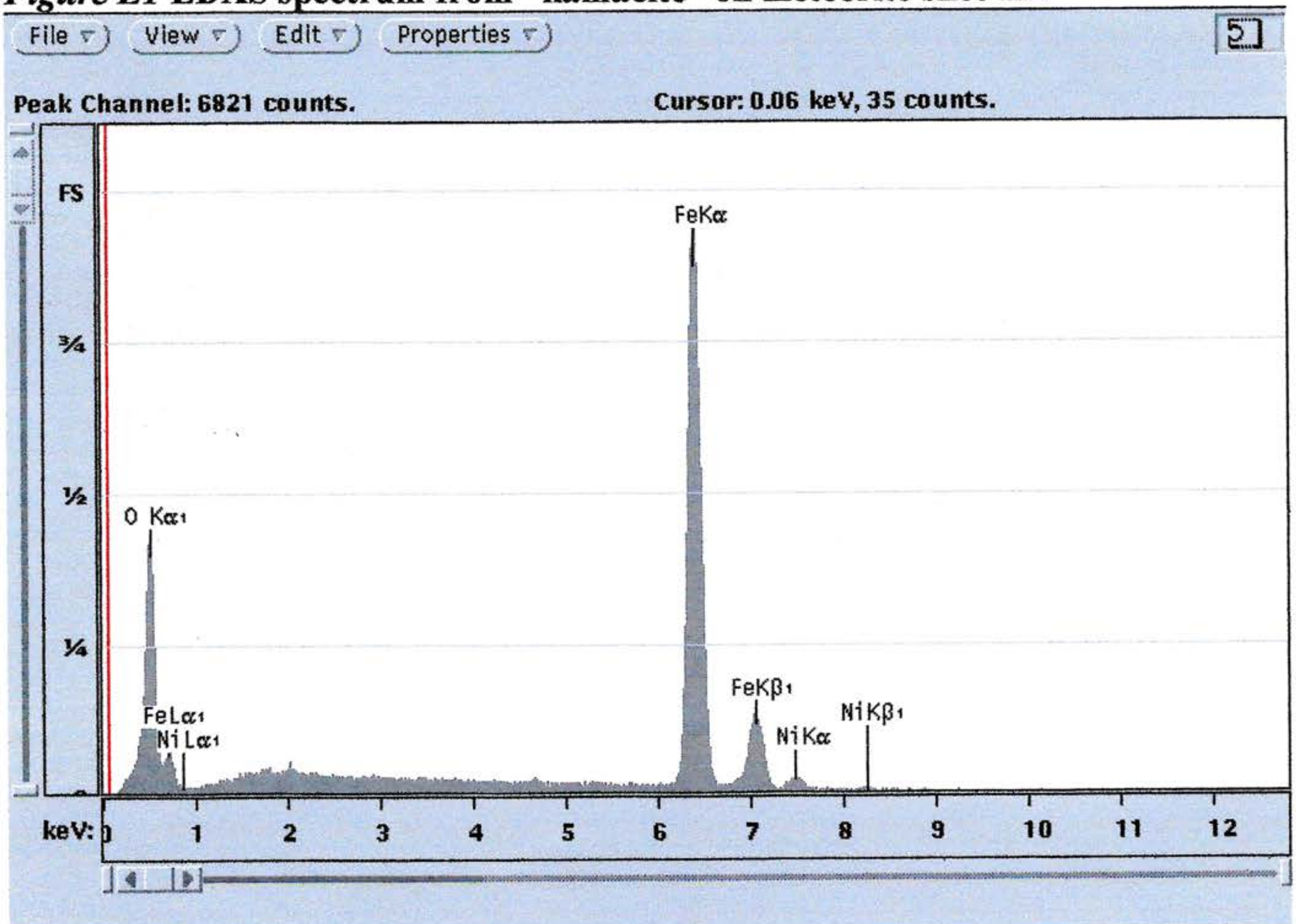

Figure E2 **EDXS spectrum from "oxidite"**

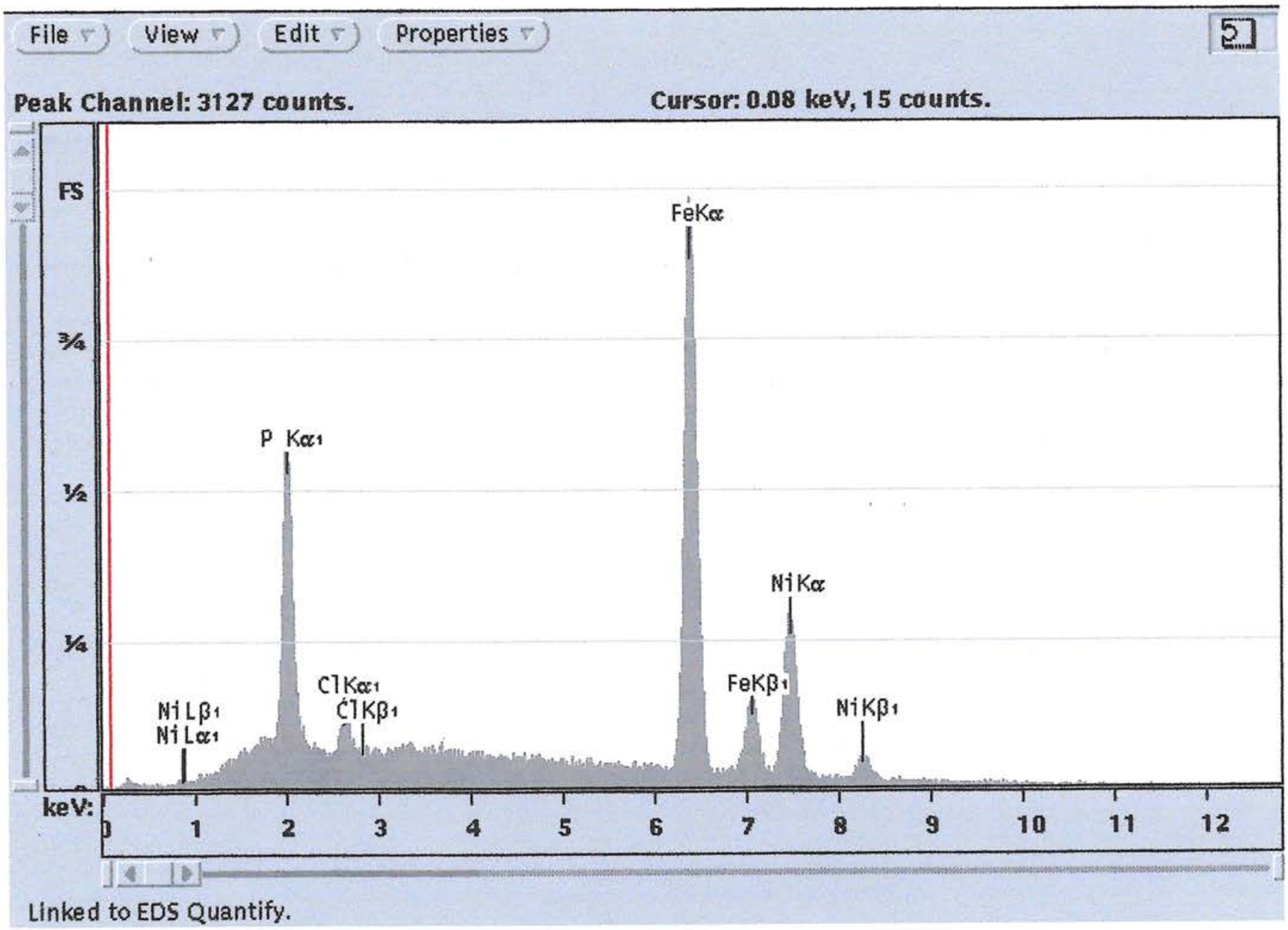

Figure E3 **EDXS spectrum from "schreibersite"**

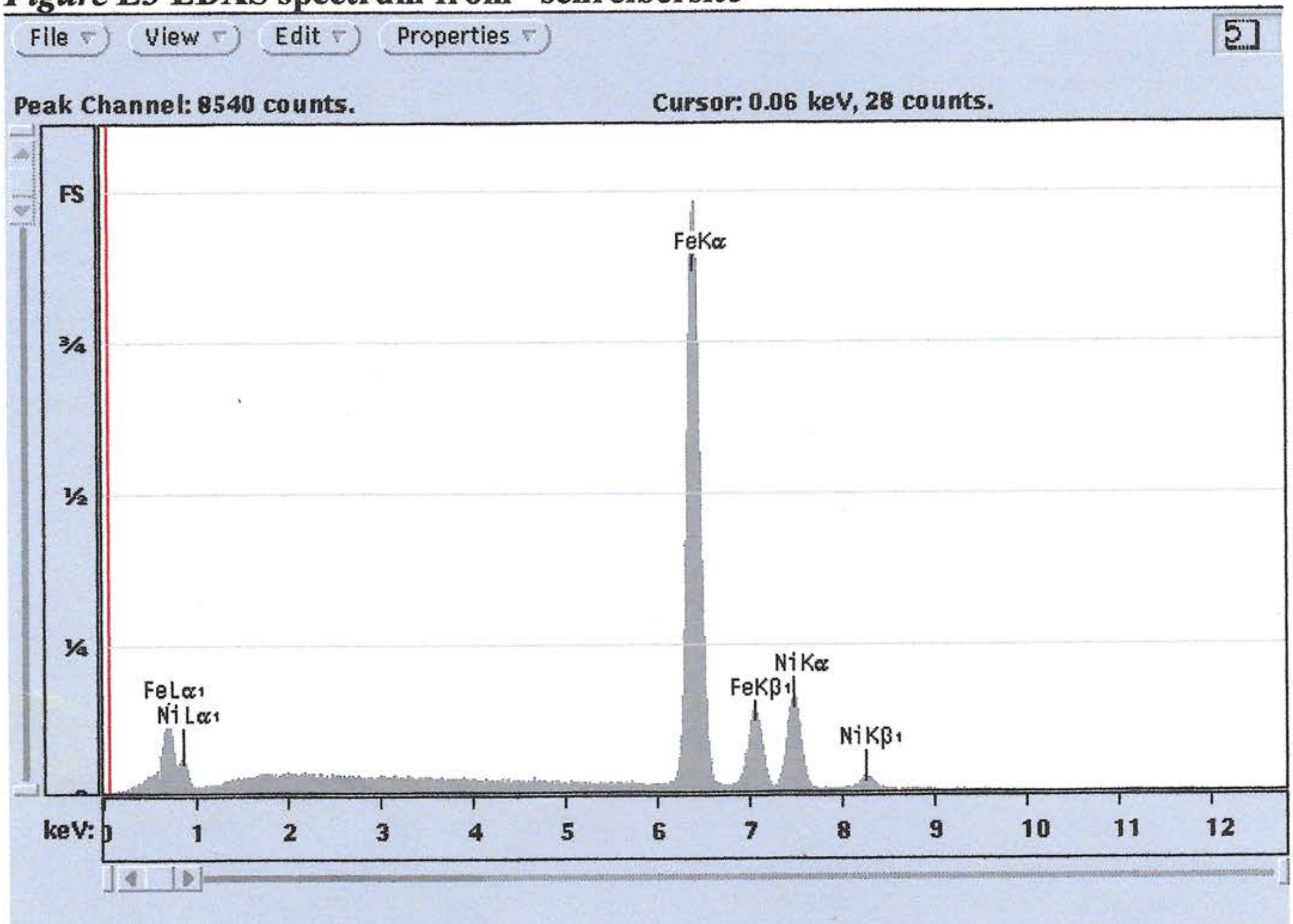

Figure E4 **EDXS spectrum from "taenite"**

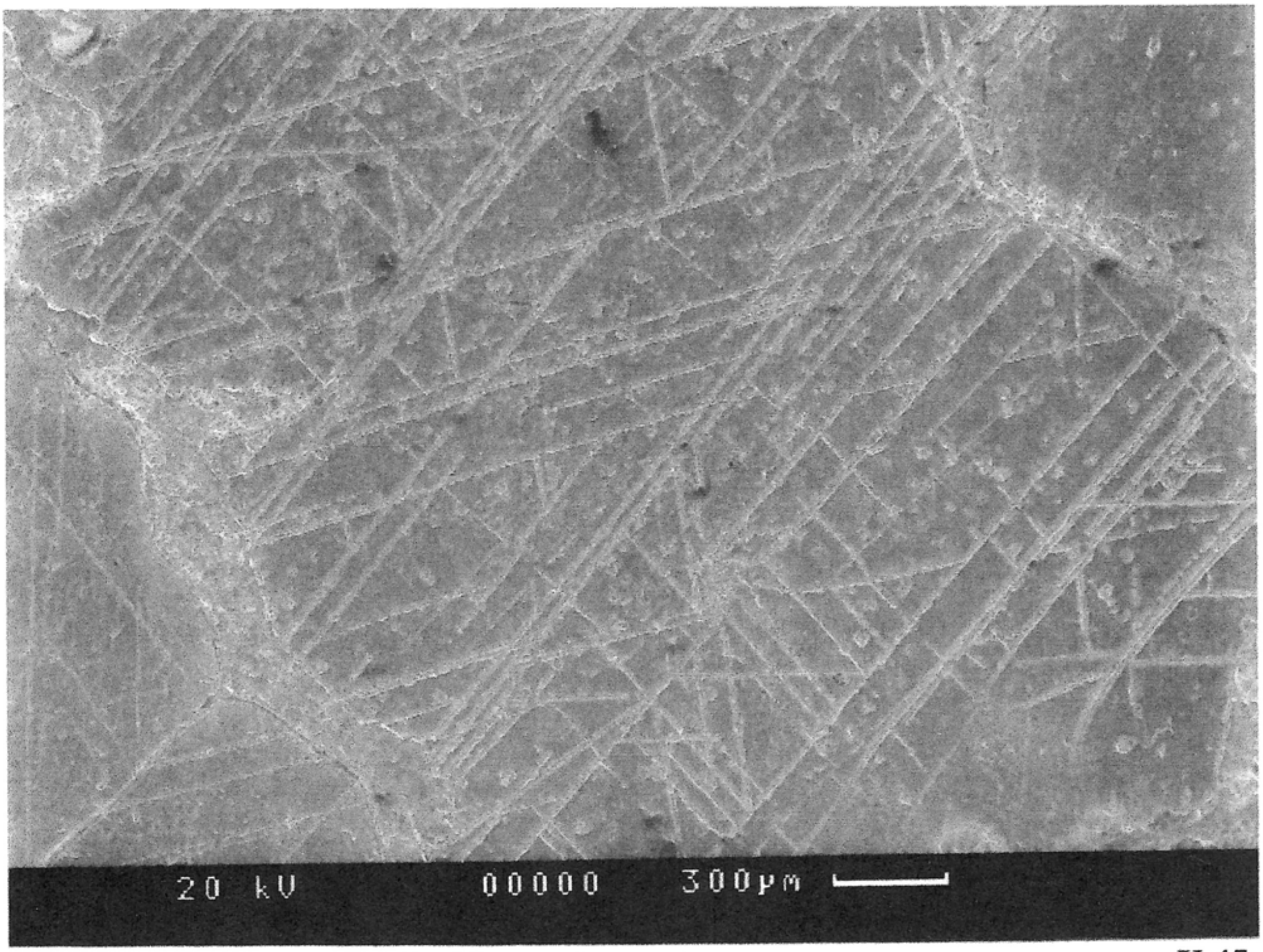

Figure S1 **SE image of etched kamacite grains** **magn X 45**

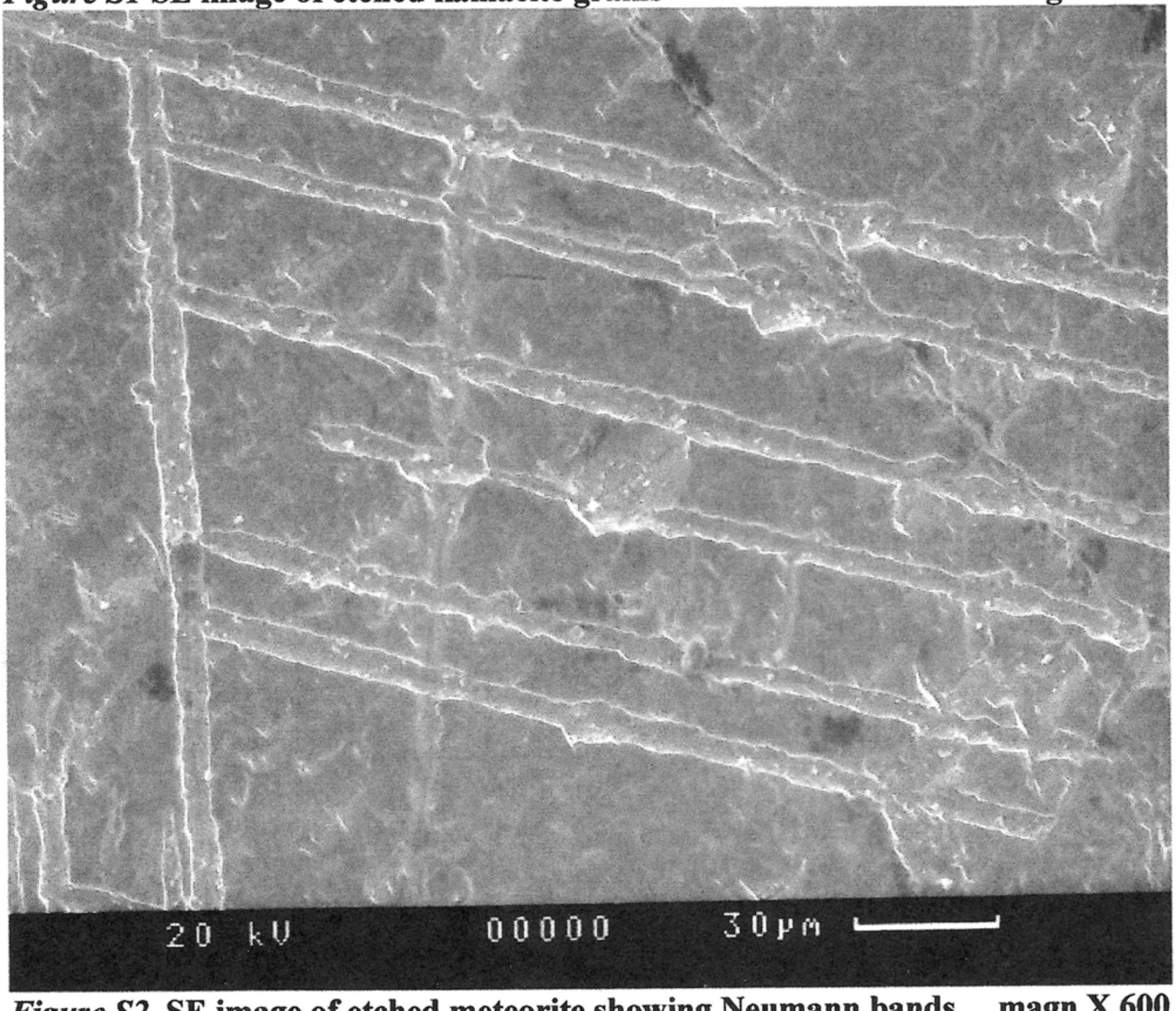

Figure S2 **SE image of etched meteorite showing Neumann bands** **magn X 600**

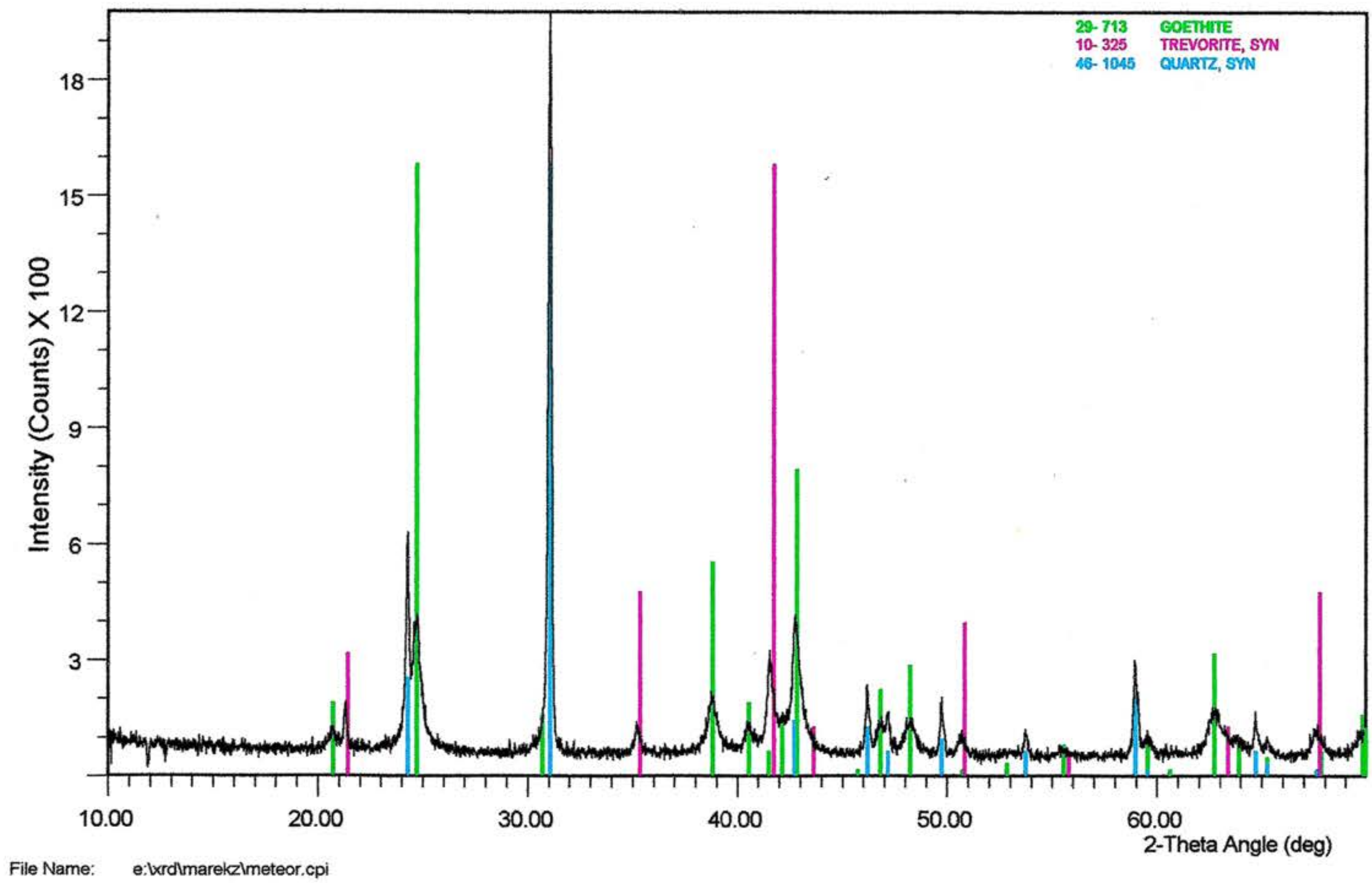

Figure X1 **XRD pattern from the oxide scale on the iron meteorite slice H2**

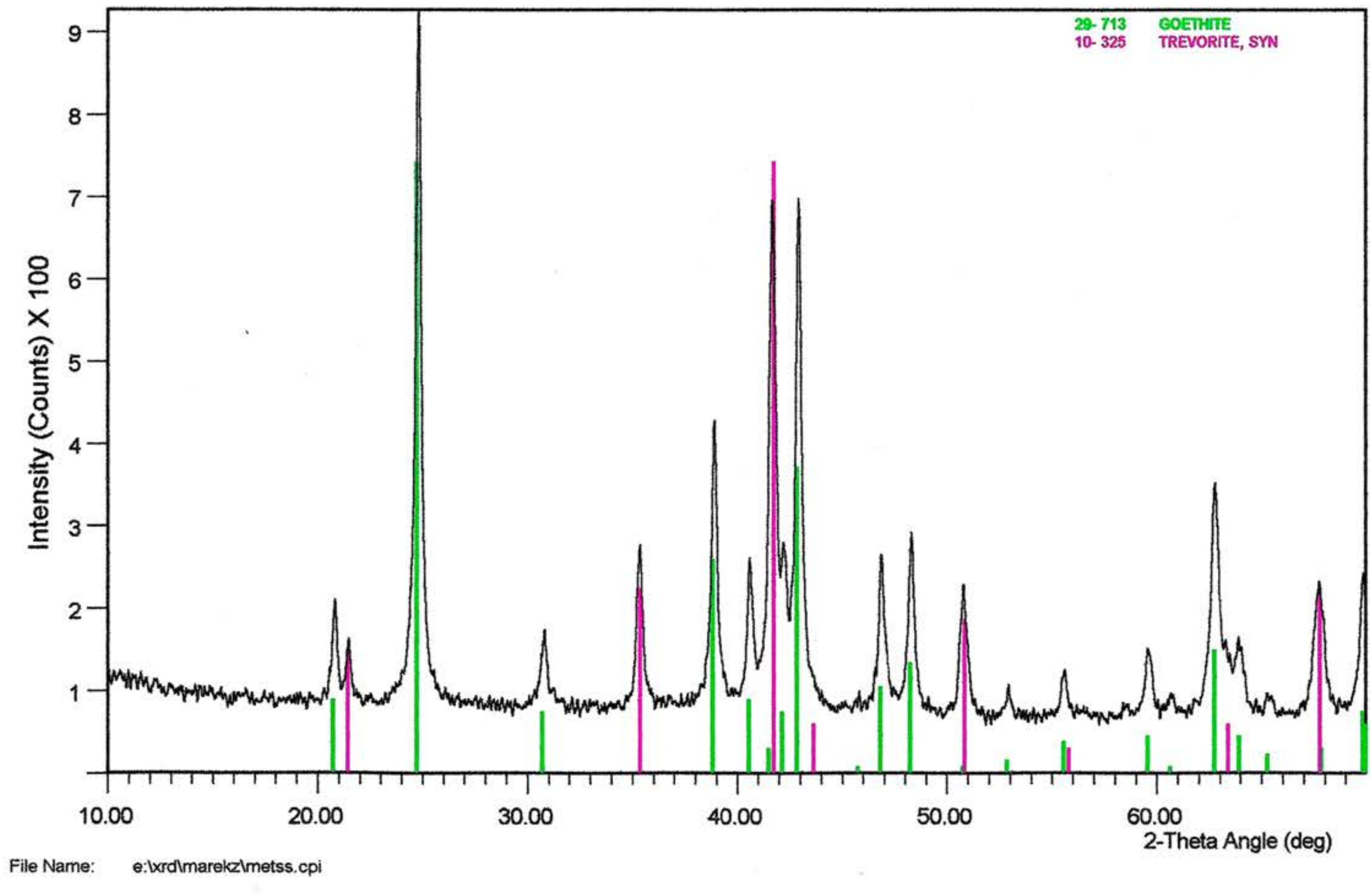

Figure X2 **XRD pattern of the small meteorite fragment**

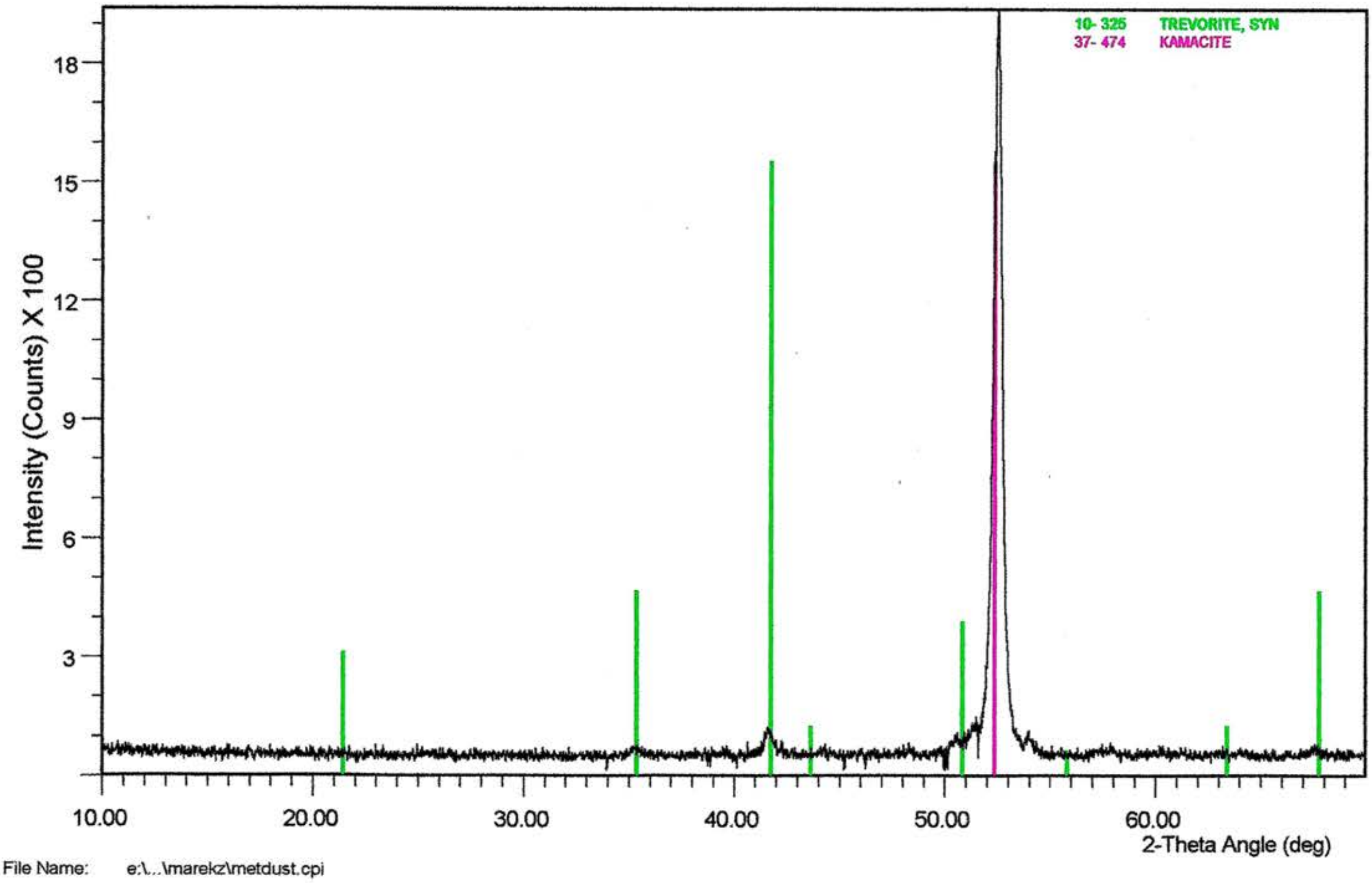

Figure X3 **XRD pattern from meteorite dust A**

APPENDIX - A

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Dr Marek Zbik has training and expertise in geology, hydrogeology, and mineralogy with specialization and experience in soil science (also **lunar soil**), mineralogy and petrography, **space geology and meteoritics**.

Dr Marek Zbik is internationally recognised as a meteor and planetary expert. He carried out scientific investigations on **extraterrestrial matter** (meteorites Lunar & Martian soil and cosmic dust particles) in large multidisciplinary, scientific teams at Warsaw University, Tokyo University, Space Research Centre of the Polish Academy of Science, Moscow University, Academy of Sciences USSR, Adelaide University, and recently at the University of South Australia and has significant number of scientific publications in this area.

Since his arrival to Australia in 1992 he cooperate with Dr. Allan Pring from the Mineralogy Department of the South Australian Museum in **classifying new South Australian meteorites**. This work, as well as his personal extended **research into meteorites and impactites** (with Prof. V. Gostin from the Adelaide University) in the Flinders Ranges, resulted in publications in national and international journals, as well as papers read at **international meteoritic conferences** in Tokyo, Houston, Prague and Berlin.

Meteorites have become his passion and he has good personal and scientific relations with mineral and meteorite curators from South and Western Australian Museum (Dr's A. Pring and A. Bevan), Dr Marilyn Lindstrom from NASA Johnston Space Center, Dr Hideyasu Kojima from National Institute of Polar Research and Dr. Alexander Basilevskij from Russian Academy of Science.

List of Marek's publications regarded to extraterrestrial study

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2. **ZBIK M.** 1984 From Milky Way dust. *Pub. Nasza Ksiegarnia* Warsaw p. 126
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