TOMOGRAPHYC AND DIFFRACTION STUDY OF HED METEORITES: A STRUCTURAL CHARACTERIZATION. N. Calisi[1], V. Luzin[2], F. Salvemini[2], S. Caporali[1], M. Morelli[3], D. Faggi[3], G. Pratesi[4], J. T. Mitchell[5], A. G. Tomkins[5], S. Piazolo[6], [1]Dipartimento Ingegneria Industriale, Università degli Studi di Firenze, Via S. Marta 3, 50139 Firenze, Italy, e-mail: nicola.calisi@unifi.it, [2]Australian Centre for Neutron Scattering, Australian Nuclear Science and Technology Organisation (ANSTO), Lucas Height, NSW 2234, Australia, [3] Fondazione Parsec - Museo di Scienze Planetarie, Via Galcianese, 20H, 59100 Prato Italy, [4] IAPS-INAF, Via del Fosso del Cavaliere, 100, 00133 Roma, Italy. [5]School of Earth, Atmosphere and Environment, Monash University, Clayton, Victoria, Australia, [6]School of Earth and Environment, University of Leeds, Leeds, UK.

Introduction: Neutron Diffraction Texture (NDT) and Neutron Computed Tomography (NCT) analyses have been demonstrated to be the most suitable tools to qualitatively, and quantitatively, determine compositional, textural and structural properties of materials [1]. Furthermore, these neutron-based techniques, can be coupled to traditional X-ray based ones exploiting the advantages of both types of probes. Infact, respect to traditional X-rays, thermal neutrons are characterized by high penetration capability and extreme sensitivity to the presence and distribution of hydrogen, i.e., water or OH^-, with its implications for aqueous alteration processes in planetary materials. Therefore, the use of NCT and NDT to investigate planetary materials is continuously growing [2-7] Here, we present a preliminary investigation of HED-group meteorites carried out by a synergic use of X-ray and neutron techniques to evidence their structural differences and providing a glimpse into their origin and petrological evolution.

Method and samples: The different attenuation capability of the elements constituting the samples, allows discerning different phases present within the sample interior from its computationally reconstructed 3D structure. X-ray attenuation is mainly dependent upon the density of the material [8] while the probability of interaction of neutrons of a given energy varies widely with the isotope on which they are incident.

NCT images were obtained at the Australian Nuclear Science and Technology Organisation (ANSTO, Lucas Heights Australia) with their Neutron Imaging Facility (DINGO beamline [9]).

Complementarily, NDT measurements were also performed at ANSTO with the Neutron Diffractometer KOWARI beamline [10]. NDT can determine crystallographic relationship between major phases in a meteorite body.

Micro-CT data were collected using a Skyscan 1172 high-resolution MicroCT system at the University of Florence (CRIST). This system has a sealed, microfocus tungsten X-ray tube with a 5 µm focal spot size operating at 100 kV, 100 µA, and a 11 Mpixel detector panel with a 16 bit pixel depth. The total acquisition time was approximately 30 min. Spatial resolution of the single tomogram was kept in a range of 5–10 µm in terms of pixel size, giving a corresponding voxel resolution range between 125 and 1000 μm^3.

Table 1 summarizes the data of the investigated samples that were analyzed, as received.

Table 1. Summary of the analyzed meteorites. MCT stands for Museo del Cielo e della Terra (Bologna, Italy), MSP stands for Museo Scienze Planetarie (Prato, Italy).

Meteorite Name	Classification	sample N°
Dhofar 700	Diogenite	MCT437
NWA 1877	Diogenite	MCT852
Yurtuk	Howardite	MCT790
NWA 7977	Diogenite	MCT871
NWA 3211	Eucrite	MSP5034
NWA 6686	Howardite	MSP5152
NWA 6690	Diogenite	MSP5156

Results and discussion: Our preliminary results show some of the possible application of NCT in analyzing HED meteorites. Figure 1 depicts NCT volume rendering and reconstructed slices of a Diogenite (Dhofar 700). Figure 2 depicts the X-ray volume rendering and the isosurface images highlighting the orthopyroxene phase present inside the NWA 6686 meteorite.

The neutron diffraction texture analysis is still under progress and an example of typical result is demonstrated in figures 3 and 4 relatively to orthopyroxene phase.

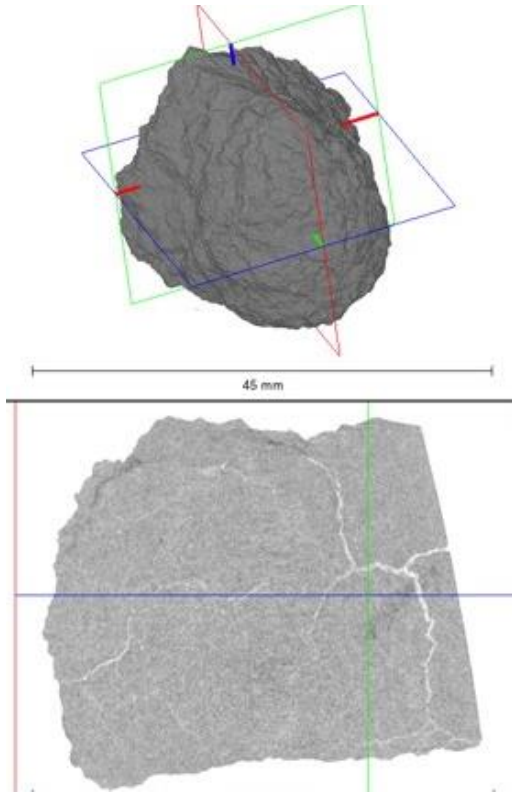

Figure 1. From top to down: NCT volume rendered image and a CT slices through the Dhofar 700 meteorite sample.

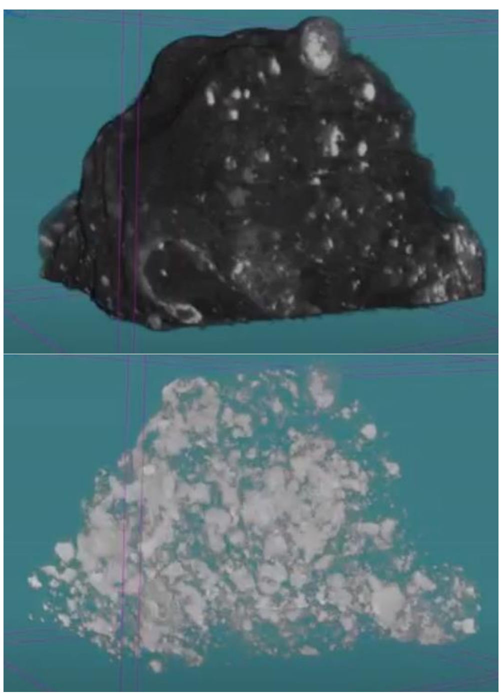

Figure 2. From top to down: volume rendered NCT image and on the right, the isosurface images highlight orthopyroxene phase present inside the NWA 6686 meteorite.

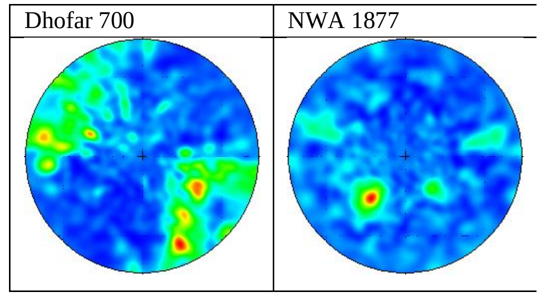

Figure 3. Pole figures showing crystallographic relationship between orthopyroxene (040) in two diogenite samples (Dhofar 700 and NWA 1877).

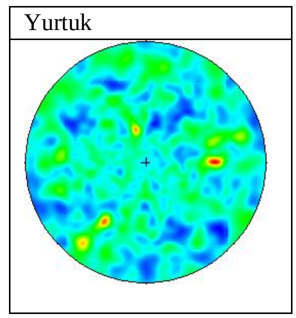

Figure 4. Pole figure showing crystallographic relationship between orthopyroxene (040) in an howardite sample (Yurtuk).

Acknowledgments: This work is supported by Regione Toscana under, POR FSE 2014-2020 programme, trought the project "ASSIEME-Structural and 3d analysis of metallic meteorites and multimedial database realization". We also wish to thank Museo del Cielo e della Terra, San Giovanni in Persiceto, Italy, and Fondazione Parsec - Museo di Scienze Planetarie, Prato Italy, for providing the samples studied.

References:

[1] Cheetham A.K. and Wilkinson A.P. (1992) *Angewandte Chemie*, 31, 12, 1557-1570. [2] Sears D.W. et al. (2016) *MPS* 51, 833- 838. [3] Grazzi F. et al. (2018) *Minerals*, 8(1), 19 [4] Caporali S. et al. (2016) *Minerals*, 6(1), 14. [5] Treiman A.H. (2018) LPSC XXXIX, Abstr. #1993. [6] Zolensky M. et al. (2010) *MPS* 45, 1618–1637 [7] Salvemini F. et al. (2018) *J. Archaeological Science: Reports* 20, 748-755. [8] Stock S.R. (1999) *Int. Mat. Rev.* 44, 4, 141-164. [9] Garbe U. et al. (2015) *Physics Procedia*, 69, 27-32. [10] Brule A. and Kirstein O. (2006) *Physica B* 385-386, 1040-1042.