Electron Back-Scattered Diffraction Studies of the Barbacena Meteorite

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EBSD STUDIES AT THE BARBACENA METEORITE

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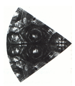
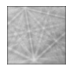
The relatively new technique of EBSD (Electron Back-Scattered Diffraction), the essential features of which are its unique capabilities of diffraction and imaging in real time with spatial resolution of 0.1 m, may be combined with the regular capabilities of SEM (Scanning Electron Microscope), such as chemical analysis and simple specimen preparation [1]. In addition, it makes possible to perform Orientation Imaging Microscopy (OIM) [1], providing the means for obtaining overall crystallographic orientation distribution and misorientation distribution from a set of individual crystal orientation measurements of bulk samples.

ELECTRON BACKSCATTERING DIFFRACTION

Electron back-scattered diffraction patterns (EBSD) are formed when an electron bean hits a crystalline sample tilted at an angle of 70 degrees to the electron beam..

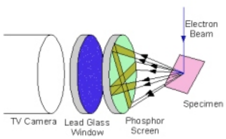


Kikuchi patterns on TEM



Kikuhi patteern at SEM

EBSD consists of symmetrically arranged bands (kikuchi bands) of slight higher intensity with respect to the background. The electrons diffracted according to the Bragg condition, lie on the surface of a cone whose axis is normal to the diffracted plane.

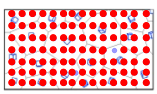


Camera - Sample geometry

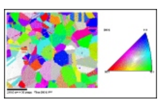
Those cones intercept with the phosphor screen and give rise to the pattern, which is monitored by an integrating low light TV (ccd) camera.

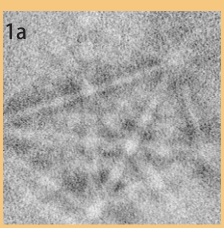
Software provides a compreensive support for collecting and analyzing EBSPs, For example crystal orientations can be found in less than one second. Microtexture measurements are easily made by identifying points of interest on the sample collecting EBSP and displaying the orientations as direct or inverse pole

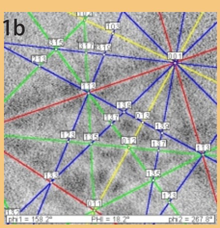
To acquire the spatial distribution of crystallographic phases the automatic indexing procedure is repeated at points distributed in a regular network over the sample surface.



It is possible to construct OIM (orientation imaging maps), where each color is related with a crystallographic orientation comparing with inverse pole figure



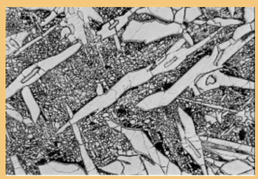




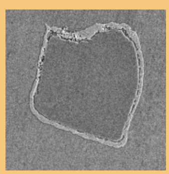
Example of Electron back scatter diffraction pattern (EBSD), the pattern consists of a series of Kikuchi bands. Right, from the recognized patterns the orientation of the crystal can be determined.

Barbacena Iron

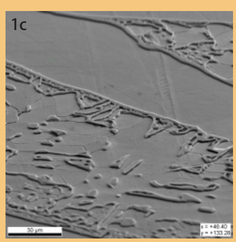
At the present work we have investigated the Barbacena iron meteorite which microstructure exhibits a widmanstätten structure displaying an irregular network of kamacite bands sometimes spindles varying from 100m m to 400m m wide and some cm long and numerous plessite fields with features of both groups IVA and IIC. The chemical analysis performed by instrumental neutron activation analysis (INAA) (Fe, 10.5%Ni, 0.5%Co, 12.6ppm Ga, 2.98 ppm Ir and 1.9ppm Au) allowed Wasson to classify this

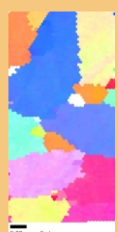


The kamacite is limpid, shows fainted Neumann bands and very soft HV=155 10, corresponding to an well-annealed material. The taenite appear as discontinuous rim separating kamacite lamellae. Plessite fields exhibit a clear and rather homogeneous taenite rim without cloud edges but followed by a transitional zone of small-elongated kamacite

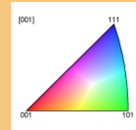


Phosphides segregates were frequently observed at center of kamacite lamellae. Many of these phosphides are enveloped in a discontinuous rim of 1-4 mm wide particles. It appears that this last one was formed during annealing, when nickel-rich schreibersite seems to have decreased its nickel content according to the equilibrium phase diagram [3].

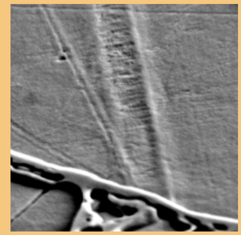


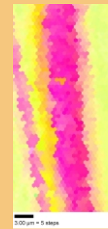


SE image of a kamacite lamellae between two typical plessite fields. At the center, the orientation imaging microscopy (OIM)micrography from the same field with colors related to the crystal orientation as shown at the reference map. At the right , an OIM micrography from plessite field.

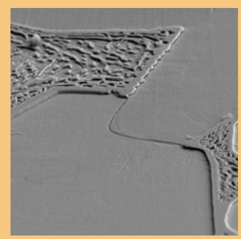


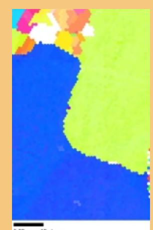
Inverse polo figure reference map





Although this meteorite clearly shows signs of cosmic annealing process, the recrystalization didn't take place, as we could verify by OIM. Figure I-a shows a Kikuchi pattern obtained from the kamacite phase, which is properly indexed in I-b. The SEM micrography at I-c shows a field fainted Neumann bands crossing a kamacite lamellae between two typical plessite fields. The orientation maps, I-d, showed detailed pattern quality maps of the perfectly oriented kamacite lamellae with smoothed Neumann bands.





The lattice remains distorted inside these bands. The evidences observed indicate mild shocks smaller than 130 kbars and posterior mild and long time annealing, which permitted changes of the taenite and phosphides by diffusion but only the recovery of the kamacite

It is also interesting to notice that the difference in orientation between the kamacite lamellae and the Neumann bands was about 20 degrees, indicating that perhaps those are not really twins but in fact slip bands.

References

[1] Randle, V. (1992), Microtexture Determination and its Applications, Inst. Materials, London
[2] Kracher et al. (1980), GCA, 44,773-787
[3] Buchwald, F.V. (1966), Acta Polytechnica Scandinava, 51