Bjürbole meteorite: An inefficient recorder of extraterrestrial paleofields?

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Paleofield analysis of the Bjürbole meteorite

Olivine(($(Mg,Fe)_2SiO_4$)-rich (Fig. 2)- where is chondrules are believed to be formed in the Early Solar nebula, they contain proto-planetary dusts with refractory elements (iron, nickel, silicon, magnesium and sulphur), these dusts were heated, melted, and formed spherules. During the cooling, magnetic mineral grains could acquire magnetism, Thermal Remanent Magnetization (TRM), and the magnetic information could be preserved. Kletetschka et al., 2006 show that the lowest field that magnetic minerals, such as Fe, FeNi, a-Fe_3O_2, and Fe_4O_3, can record via TRM is near micro-Tesla. These measurements revealed the existence of an intrinsic remanent magnetization that appears unrelated to the field except when acquisition fields were larger than micro-Tesla. These intrinsic magnetizations can be viewed as "Background Magnetizations" (BM) characterizing specific multidomain. We attempt to test these preliminary ideas with Bjurbole chondrules.

Magnetization in Bjürbole meteorite

Magnetic record in the meteorite is difficult to characterize and interpret. There are mainly two reasons for that: the magnetic mineral phase such as Fe-Ni compounds (see phase diagram, Fig. 1) are poorly understood, and the meteorite might have experienced complex metamorphic histories. They also have been subject to impact events, entering Earth atmosphere, exposed Earth magnetic field, and so on. In addition to Fe-Ni compounds, meteorites may contain single or pseudo-single domain magnetic grains as inclusions in the olivine that may contribute NRM.

Complex Fe-Ni compounds transformation process

Fe-Ni Phase diagram is adopted from Yang et al (1997). a: a low-Ni bcc phase, g: high-Ni fcc phase, g1: a low-Ni paramagnetic fcc phase; g2: a high-Ni ferromagnetic fcc phase; g: ordered Ni3Fe; g": ordered FeNi; Ms: martensitic transformation starting temperature.

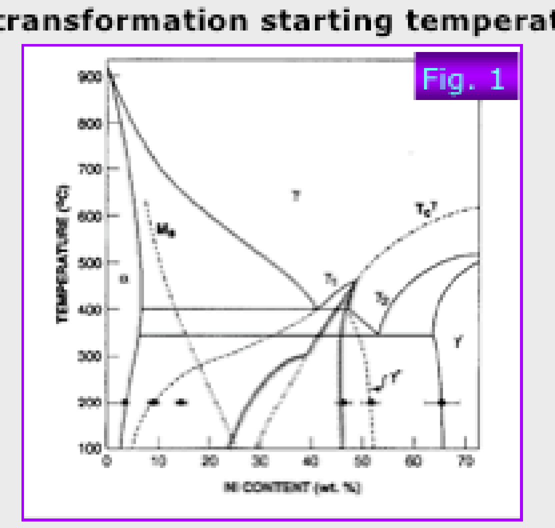


Fig. 1

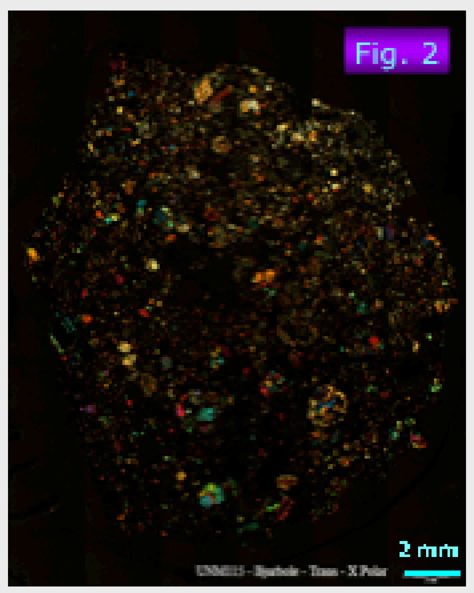


Fig. 2

Olivine and chondrule rich Bjurbole meteorite, photomicrograph of the petrographic thin section in X-polarised light (Fig. ?). The thin section was provided by University of New Mexico, NM

Hysteresis

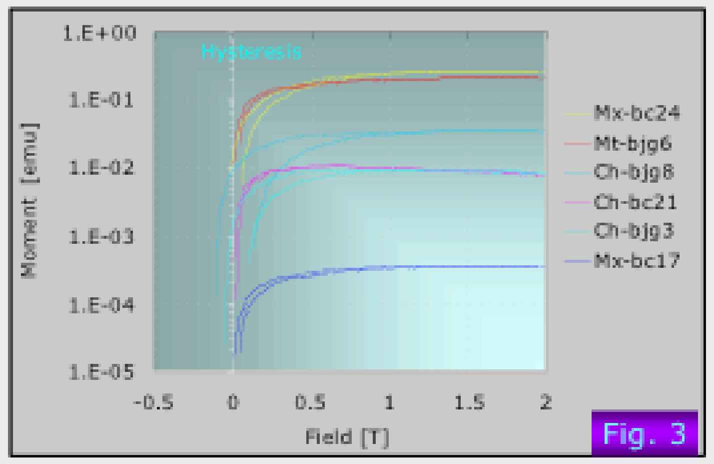


Fig. 3

Fig. 3 shows the measured hysteresis loop of a part from 0 to 2 T. The marix and metal grains show the large coercivities, and the three chondrules show the similar coercivities. The results indicate the presence of tetrataenite (Wasilewski, 1988). Wasilewski described that the magnetism of Bjurbole is due to these Fe-Ni compounds, primary a-kamacite (<7% Ni), g-taenite (>7% Ni), and g"-tetrataenite (re-52% Ni). The Fig. 4 is adopted from Wasilewski (1988) show temperature history during the cooling of a meteorite containing tetrataenite.

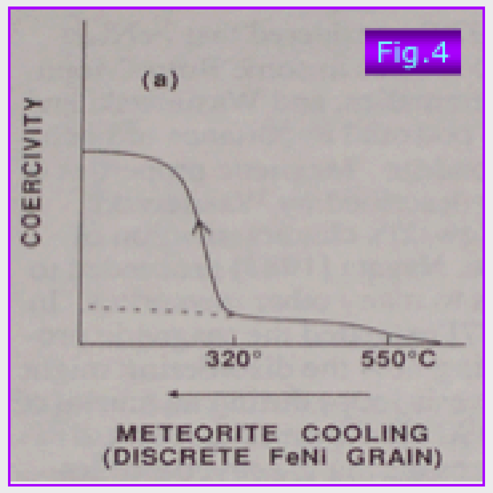


Fig.4

NRM and SIRM results

Natural Remanent Magnetization (NRM) of chondrules, metal grains, and matrix were measured and demagnetized by alternating field (AF) ranging between 2 and 240 mT (Fig. 5). A decay of NRM values, due to AF demagnetization, stopped at around 10 mT, and continued to fluctuate until the highest demagnetization field of 240 mT. The initial moment demagnetized by 10 mT was most likely by Viscous Remanent Magnetization (VRM). Whereas the saturation isothermal remanent magnetization, SIRM show smooth decay (Fig. 6). We propose that NRM fluctuation is a critical signature and recognized as "Background Magnetization". The remaining component could be interpreted that the NRM decay reached the intrinsic BM that could not be further demagnetized. This would suggest that the Bjurbole meteorite would not have preserved paleofield information. This however, requires much more work as the magnetic mineralogy such as tetrataenite etc was not considered. This is a working hypothesis in progress.

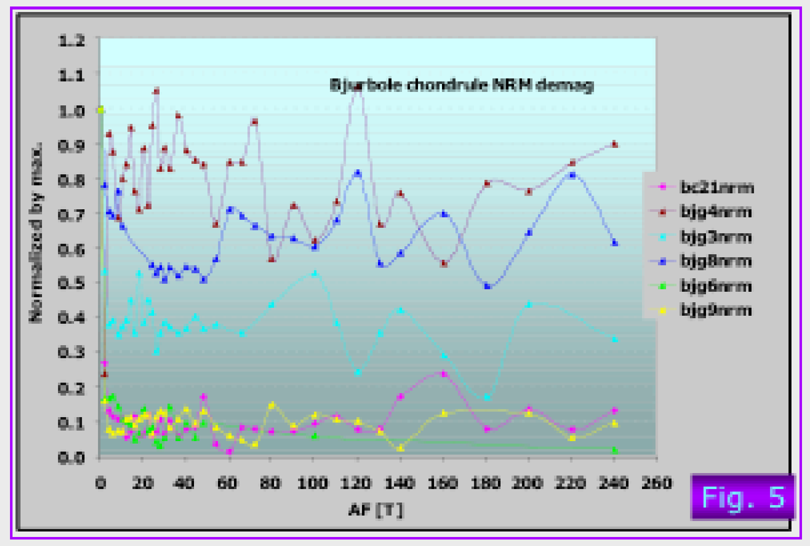


Fig. 5

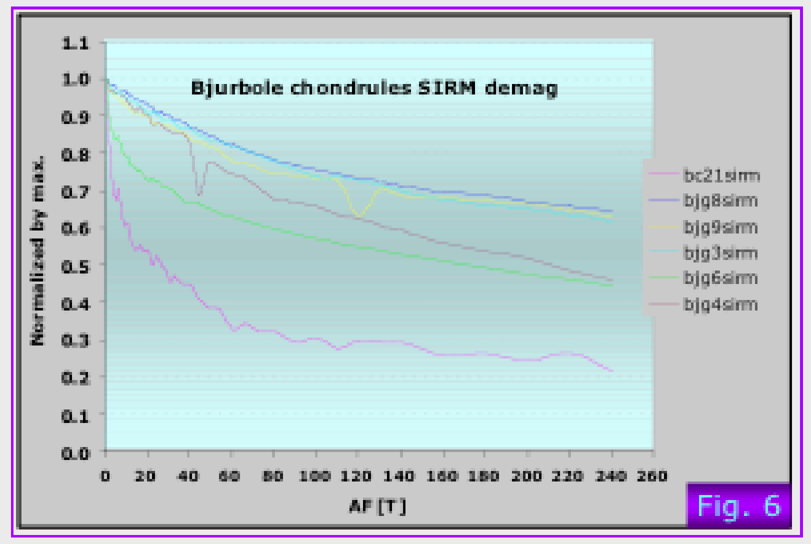


Fig. 6

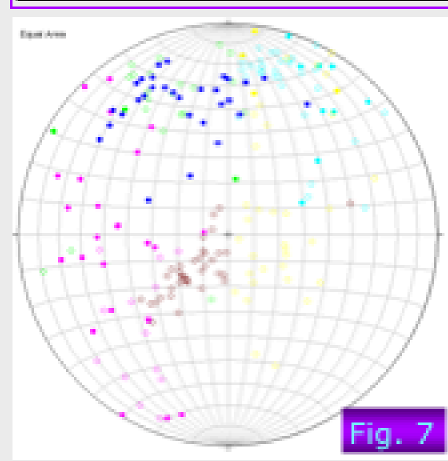


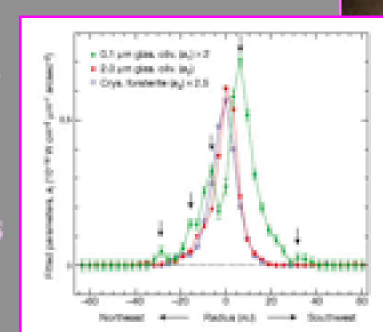
Fig. 7

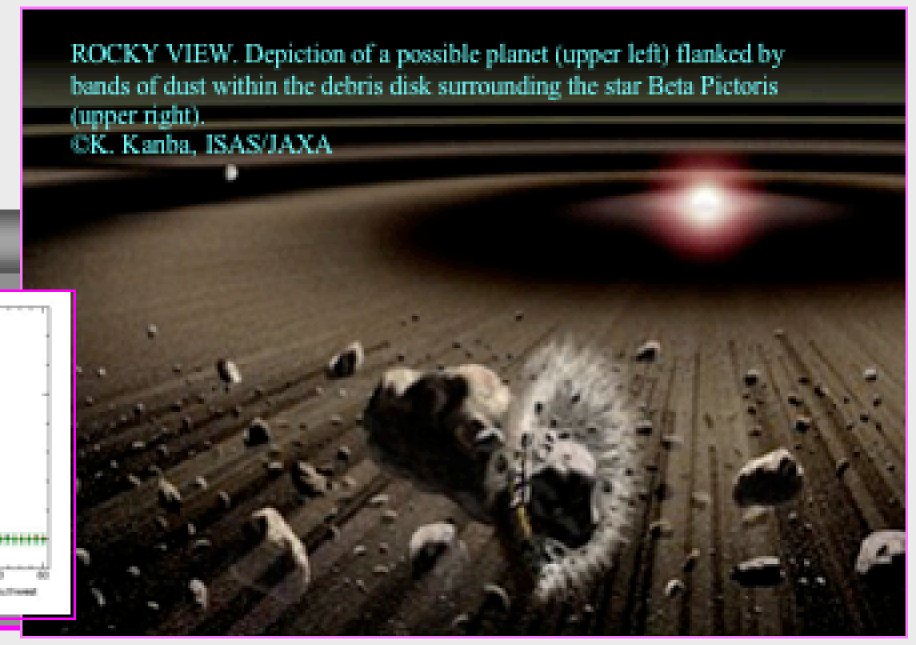
Fig. 7; Stereonet projection of NRM directions. The color representation corresponds to the Fig. 5.

- bc21
- bjg4
- bjg3
- bjg8
- bjg6
- bjg9

Olivine-rich proto-planetary disc has been revealed

Okamoto et al (2004) suggested that the b pictoris, a main-sequence star with an edge-on dust disk that might represent a state of the Early Solar System. The Beta Pictoris disk of the inner part, within a few AU of the star, has a different composition from material that lies farther out. The crystal form of the mineral olivine is more concentrated near the star, as are silicate grains with diameters greater than a few micrometers.





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