

古地磁気強度と古地磁気方位の時系列スペクトルの比較：核進化の観測に向けて Comparison between the temporal spectrums of geomagnetic paleointensity and paleo-magnetic direction: A case study

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地磁気スペクトルは外核のダイナミクスを反映していると考えられるため、核の進化を捉える観測量となるかもしれない。地磁気の長期時系列スペクトルは堆積物の相対古地磁気強度記録から推定されることが多い。しかし、地質学的過去について同様な相対古地磁気強度記録を得ることは極めて難しい。一方、古地磁気方位は地質試料からも比較的高精度に得ることができる。古地磁気方位のスペクトルは主に80年代以前に 10^{-2} [1/kyr]程度の周波数まで検討され、最近の研究で報告されている古地磁気強度スペクトルと基本的に類似するものが報告されている。地磁気方位スペクトルの実際上の有用性を検討するために、深海堆積物データについて古地磁気強度と古地磁気方位の時系列スペクトルの比較を行った。堆積速度の遅いサイトのデータから計算された古地磁気強度と古地磁気方位の時系列スペクトルは、 10^{-3} から 10^{-1} [1/kyr]の周波数範囲でよく一致し、グローバルな古地磁気強度スタック(SINT-2000)に見られるコーナー周波数も観察される。また、堆積速度の早いサイト(ODP Leg 162など)のデータから計算された古地磁気強度と古地磁気方位の時系列スペクトルも、 10^{-1} [1/kyr]以下の周波数範囲ではよく一致した。しかし、それ以上の周波数では、高周波に行くにつれ古地磁気方位のパワーが古地磁気強度に比べ相対的に低くなっていく傾向があった。この原因は、双極子磁場と非双極子磁場の時間変動が高周波数帯で異なることや、古地磁気方位データがスタッキング後の古地磁気強度データより精度が低いこと、サイト特有の古地磁気方位バイアスが存在すること、などが考えられる。いずれにせよ、今回の結果は少なくとも 10^{-1} [1/kyr]以下の周波数範囲では単一サイトの古地磁気方位データから地磁気スペクトルが推定できる可能性を示す。スペクトル推定のためには、従来の古地磁気研究に比べ、はるかに高精度な年代層序決定と大量のサンプル処理が必要となる。発表では、その課題に向けた連続熱消磁装置の試作についても述べる。

キーワード: 古地磁気, スペクトル解析, 核, 古地磁気強度

Keywords: paleomagnetism, spectral analysis, core, paleointensity

高圧下における合金融体の音速・密度測定

Sound velocity and density measurement of alloy liquid under pressure

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Sound velocity and density of liquid alloys under high pressure are important physical properties for understanding the light element(s) in the terrestrial molten outer core by comparing with the seismological data. We have developed the system for sound velocity (V_P) and density () measurements combined with X-ray computed micro-tomography (CT) at high pressure and high temperature. V_P of Fe-S liquid has been recently reported up to 5.4 GPa (Nishida et al., 2013). The terrestrial core is likely to contain 5-10 wt% of Ni. In order to clarify the Ni alloying effect on the V_P and , we have measured the V_P and of Ni-S liquid at high pressure and temperature. V_P was measured using ultrasonic pulse-echo overlap method and was measured using X-ray absorption method.

High pressure experiment was performed using 80-ton uni-axial press (Urakawa et al. 2010) installed at X-ray CT beamline (BL20B2), SPring-8. High pressure was generated using opposed cupped anvils. The Ni-S with an eutectic composition was enclosed in hBN capsule and single crystal sapphire rods were placed at top and bottom of the sample for ultrasonic measurement. P-wave signals with frequencies of 37 MHz were generated by LiNbO₃ transducer. The echo signals from the sample were detected using high-resolution digital oscilloscope. CT measurement was carried out by rotating the press from 0 to 180 degree with 0.2-0.3 degree steps. Monochromatized X-ray of 51 keV was used. X-ray absorption profile was obtained from the X-ray radiograph and the sample thickness in X-ray direction was directly measured from the CT slice image.

Sound velocity and density measurements at room temperature was performed up to 1.4 GPa and those at high temperature was carried out up to 0.4 GPa and 1673 K. P-wave signal was clearly observed at the present conditions. V_P of Ni-S suddenly dropped after melting of the sample. The V_P of liquid Ni-S decreases slightly with increasing temperature in the range of 1273-1673 K. Density of Ni-S decreased slightly after melting. The present measurement can provide the relationship between V_P and for alloys under pressure.

キーワード: 音速, 密度, 液体, 核

Keywords: Sound velocity, Density, Liquid, Core

高温高圧下における Fe-Ni-S 系の相関係 Phase relationships of the Fe-Ni-S system at 15GPa

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The melting relations of the iron and light elements system are fundamental information to understand the formation and evolution of the planetary liquid core. Here we report the results of high-pressure experiments on the phase relationships of the Fe-Ni-S system. We have studied the entire field of the Fe-Ni-S system at 15 GPa based on the textural observation and chemical analysis of the quenched samples. The melting relation of the Fe-Ni-S system is a pseudo-binary eutectic system between the Fe-Ni alloy and (Fe, Ni)S monosulfide. The eutectic trough divides the liquidus surface into the metallic field and the sulfide field. Eutectic temperature shows a minimum point at Ni/(Ni+Fe)=0.75, and sulfur content of the eutectic point is about 30 at%. We revealed the stability fields of (Fe,Ni)₃S₂ and (Fe,Ni)₃S phases, intermediate phases which affect the melting relations of the Fe-Ni-S system. (Fe,Ni)₃S₂ makes a complete solid solution between Fe₃S₂ and Ni₃S₂, which melts incongruently into (Fe, Ni)S and liquid. On the other hand, (Fe,Ni)₃S is stable at Ni-rich side and melts incongruently into Fe-Ni alloy and liquid. We also study the subsolidus stability of (Fe,Ni)₃S₂ by synchrotron-based in situ X-ray observation, and those results will be discussed.

キーワード: 核, 融解, 高圧, 硫化鉄

Keywords: core, melting, high pressure, iron sulfide