Study of the Compositional, Mechanical and Magnetic Properties of Saudi Meteorite

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Abstract

In the current study, the experimental results of the investigation on the compositional, mechanical and magnetic properties of Saudi meteorite were presented. Meteorite specimen was examined using techniques like scanning electron microscopy, EDAX, Backscattered electron imaging, XRD, hardness testing (Rockwell, Vicker, Brinell) and magnetic properties measurements. The composition analysis results of the meteorite reveal that it is essentially composed of an iron-Ni alloy with iron playing a dominant role. The hardness testing shows that the meteorite is formed of soft material with a Rockwell hardness of 22.5 HRC. Furthermore the magnetic measurement also supports the fact that the meteorite specimen is a soft ferromagnetic material. The saturation magnetization (M_s) of 0.701 emu/g was found for the saturation field of (H_s) = 5025 Oe. No trace of radioactivity is revealed when using a sensitive GM counter.

Keywords

EDAX • Backscattered electron imaging • XRD • Hardness testing (Rockwell, Vicker, Brinell) • Magnetic properties measurements

1 Introduction

The ancient specimens of meteorite are called remnants that were formed some 4.6 billion years ago in the solar system due to geologic processes. Most Meteorites come from the outer space to the Earth and provide information on the solar system relevant to the creation, growth and structure of the Earth. A lot of information about their celestial history can be unveiled from iron-bearing minerals which are classified as an important component of meteorites. These mainly consist of iron-nickel alloys commonly known as iron meteorites [1–5] which represent 5% of the total discovered meteorites. In this study the compositional, mechanical and magnetic properties of Saudi meteorite were investigated.

2 Materials and Methods

Field emission scanning electron microscope (SEM) JSM-7600F Jeol Japan was used to carry out the microscopic studies. The SEM equipped with energy dispersive X-ray (EDX) system for morphological and elemental compositional analysis. In order to characterize the specimen for its mechanical properties, its hardness was measured by the Zwick/Roel ZHU hardness tester capable of performing various types of hardness tests. The EZ7 Vibrating Sample Magnetometer (VSM) was used to measure the magnetic properties of the meteorite.

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3 Results and Discussion

A scanning electron microscope (SEM) JSM-7600F Jeol Japan was used as one of the tools to characterize the Saudi meteoroid specimen. The specimen was scanned in its initial form—i.e., as it reached the Earth—and also after being ground with silicon carbide papers of a grit size of 180, 300 and 600. The energy dispersive X-ray spectrum results of the ground region show that only iron and nickel are the major constituting elements of the Saudi meteoroid specimen as shown in Fig. 1.

The specimen was cut into small pieces and kept embedded firmly into a bakelite base in order to measure the surface hardness by three types of standard instruments (Rockwell, Vicker and Brunell). Table 1 summarizes the hardness test values from different tests.

With the major composition of the Fe, Ni and CO, the piece has shown good magnetic properties with a magnetic field strength of 3 gauss as measured by a Hall probe.

It was subjected to a magnetization and demagnetization cycle with a Lab VSM E27 to obtain a hysteresis loop as shown in Fig. 2 which gives a coercive field value of 152 oersted and the saturation magnetization (M_s) of 45.4 emu/g, remnant magnetization 154 emu/g and coercivity (H_c) is 9.66, all as determined from the hysteresis loop. All these values are indicative of ferromagnetic soft iron. The magnetic properties of stony achondrites are identical with FeNi alloys, usually by low Ni kamacite [6, 7].

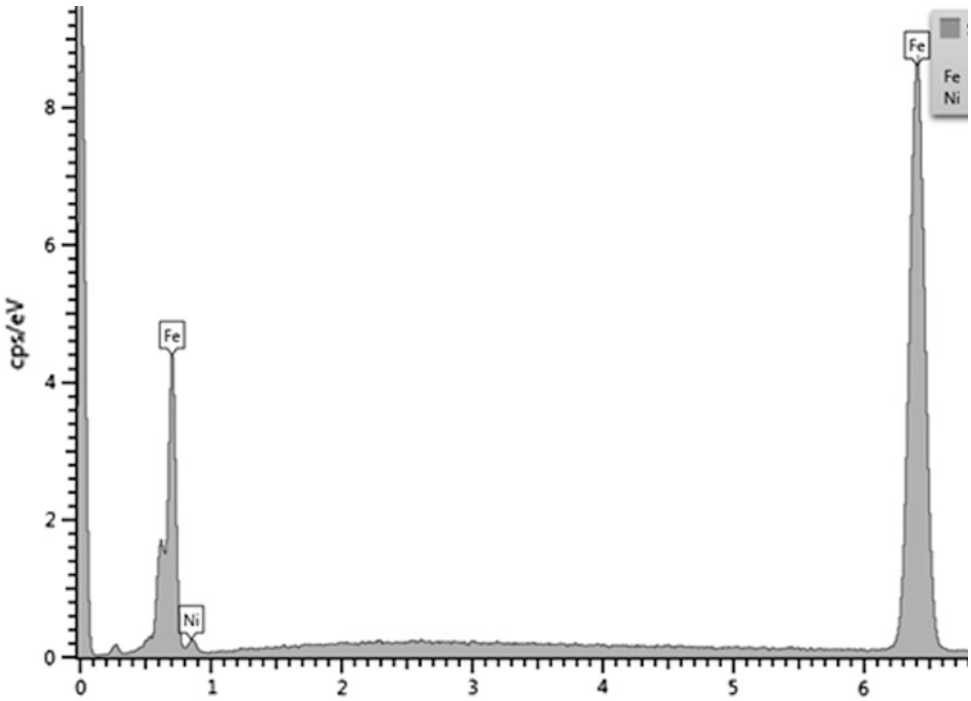

Fig. 1 Shows the energy dispersive X-ray spectrum results of the ground region

Table 1 Hardness tests results

Test#	Test type	Load used (KG)	Hardness value
1	Rockwell hardness (HRA)	60	60.5
2	Rockwell hardness (HRC)	150	22.5
3	Vicker hardness (HV)	30	181.7
4	Brinell hardness (HB)	62.5	184.15

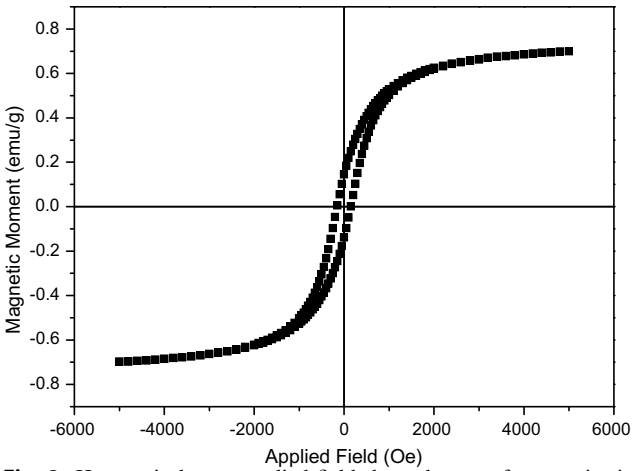

Fig. 2 Hysteresis loops; applied-field dependences of magnetization recorded at room temperature

4 Conclusion

This paper gave new insights of the biggest meteorite of the Kingdom of Saudi Arabia. The meteorite composition analysis disclosed that it is iron nickel alloy and iron-Ni alloy with iron playing a dominant role. The experimental results of hardness show that it is a soft material. Furthermore the magnetic properties of the meteorite specimen confirmed that it was a soft ferromagnetic material.

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References

1. Corrigan, C.M., Chabot, N.L., McCoy, T.J., McDonough, W.F., Watson, H.C., Saslow, S.A., Ash, R.D.: The iron–nickel–phosphorus system: effects on the distribution of trace elements during the evolution of iron meteorites. Geochim. Cosmochim. Acta **73**, 2674–2691 (2009)
2. Garcia-Guinea, J., Tormo, L., Ordoñez, A.R., Garcia-Moreno, O.: Non-destructive analyses on a meteorite fragment that fell in the Madrid city centre in 1896. Talanta. **114**, 152–159 (2013)
3. Goldstein, J.I., Scott, E.R.D., Chabot, N.L.: Iron meteorites: crystallization, thermal history, parent bodies, and origin. Chem. Erde. **69**, 293–325 (2009)
4. Hafner, S., Kalvius, M.: The Mössbauer resonance of Fe^{57} in troilite (FeS) and pyrrhotite ($Fe_{0.88}S$). Z. Kristal. **123**, 443–458 (1966)
5. Kruse, O., Ericsson, T.: A Mössbauer investigation of natural troilite from the Agpalilik meteorite. Phys. Chem. Miner. **15**, 509–513 (1988)
6. Nagata, T.: Meteorite magnetism and the early solar system magnetic fields. Phys. Earth Planet. Inter. **20**, 324–341 (1979)
7. Sugiura, N., Strangway, D.W.: Magnetic studies of meteorites. In: Kerridge, J.F., Matthews, M.S. (eds.) Meteorites and the Early solar system, pp. 595–615. University of Arizona Press, Tucson, USA, 1269 pp (1988)