

RYUSEITO: THE JAPANESE SWORDS MADE FROM SHIRAHAGI IRON METEORITE.

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Introduction: Meteorites are not only scientifically important, but they also give us information about the history of interaction of people with extraterrestrial objects. Many cultures have considered the arrival of meteorites as celestial omens: meteorites were, and occasionally still are considered to be intricately linked to gods, and treated as objects of religious devotion. In addition, recent studies of meteorite artifacts revealed the use of meteor metal such as beads and knife [1,2], and the ancient trade network in North America [3].

Ryuseito, the Meteor Swords, are the Japanese swords made from iron meteorite in 1898. They were manufactured by Japanese notable swordsmith Okayoshi Kunimune by the order of Viscount Enomoto Takeaki in Meiji period. Enomoto stayed in Russia as a special envoy to conduct negotiation with Russia, where he was fascinated by the Russian meteor sword *Sowerby's Sword* for the Czar Alexander I [4, 5].

Ryuseito are made from Shirahagi iron meteorite (IVA). Shirahagi meteorite, weighing 22.7 kg, was reported in 1890 to have been found in the bed of the Kamiichigawa river, Toyama prefecture, Japan, and then was purchased by Enomoto in 1895. Enomoto reported the chemical analysis of the Shirahagi iron meteorite, and described the processes of producing meteor swords in *Ryuseito Kiji* (The Meteor Swords Report)[6], which is one of the first science paper about the iron meteorite in Japan. According to his report, about 4 kg of Shirahagi iron meteorite was consumed to produce the total of five swords including two long swords and three short swords. One of the long sword was donated to the crown prince who later became the Taisho Emperor. In this study, we have investigated the historical background of making the meteor swords and non-destructive observation of the *Ryuseito* itself.

Methods: We have investigated the short sword which is the one of the five *Ryuseito* swords, the one now owned by Toyama Science Museum. We performed a research on historical background of making *Ryuseito*, and non-destructive surface observation on *Ryuseito* itself.

Results and Discussion: The short sword investigated in this study is ~30 cm long in size, and the blade length is ~21 cm. The words “Sei Tetsu (Star Iron)” and “Meiji 31 nen 3 gatsu jitsu (March 1898)” are carved on the front and the back side of the tang of the sword, respectively. The blade of the sword shows a tree ring-like pattern on their surface (Fig.1). It is likely the pattern is the same one that *Ryuseito Kiji* described, in which it is explained that the pattern is the characteristics of the meteor swords, and the long sword showing a fine tree ring-like pattern was donated to the crown prince [6].

One of the most characteristics of manufacturing Japanese sword is the forging process, where the swords are made by repeatedly heating, hammering and holding the iron sand metal. Enomoto described that the swordsmith had a difficulty in making swords from meteorite, but finally found a reasonable forging conditions to produce meteor swords [6]. Later study on the examination of manufacturing meteorite sword concluded that impurities play an important affect for forging process -- the amount of impurities such as S and P increases the difficulty in heat-forging [7]. These impurities are attributed to FeS and schreibersite, and the cracks during heat-forging are caused by these crystals. We find the surface of the studied sword is quite homogeneous, showing no evidence of these crystals or cracks.

In conclusion, *Ryuseito* are the meteorite artifacts with the full record of the identification as a meteorite, chemical analysis, and the manufacturing process of meteor sword [4-6], which holds both scientifically and historically valuable information.

References: [1] Rehren T. et al. (2013) *Jour. of Archaeological Sci.* 40:4785-4792. [2] Comelli D. et al. (2016) *MaPS* 51:1301-1309. [3] McCoy T. J. et al. (2017) *Jour. of Archaeological Sci.* 81:13-22. [4] Enomoto T. (2003) *Jour. of Geography* 112:453-457. [5] Murayama S. (1953) *Meteoritics* 1:99-102. [6] Enomoto T. (1898, abr in 1902) *Jour. of Geography*,14:33-35. [7] Taguchi I. (1991) *Bull. of the National Museum of Japanese History* 35:355-372.



Fig.1. Photograph of *Ryuseito*. A tree-like pattern is observed on the surface of the blade. The full length of the sword is ~30cm.