Elemental composition analysis of stony meteorites discovered in Phitsanulok, Thailand

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Abstract. A meteorite is a fragment of pure stone, iron or the mixture of stony–iron. The falling of meteorites into Earth’s surface is part of Earth’s accretion process from dust and rocks in our solar system. When these fragments come close enough to the Earth to be attracted by its gravity, they may fall into the Earth. Following the detection of objects that fall from the sky onto a home in Phitsanulok in June 27, the meteorites were analyzed by scanning electron microscopy coupled with energy dispersive X-ray spectroscopy (SEM/EDS) instruments. The results from SEM/EDS analysis show that the meteorites are mainly composed of Fe-Ni and Fe-s. The meteorite is Achondrite, a class of meteorite which does not contain Chondrule. The meteorites in this work are thought to be part of a large asteroid.

1. Introduction
The Meteorites are rocks, normally containing a great deal of iron, which was once a fragment of moons, planets or large asteroids. Some may even be from the moon and Mars. When these fragments come close enough to the Earth to be attracted by its gravity, they may fall into the Earth. The scientists have divided these meteorites into three main types including stone, iron, and stony-iron, as shown in Figure 1. In each type, there are many sub-groups. Characteristic of each sub group includes the appearance of the skin which is a fusion crust, different steel or stone parts. Most meteorites are not porous. The evolution of life on the Earth has been affected by the impact of these space objects. These impacts could affect the Earth in the future as well.

Figure 1. shows types of meteorites; (a) stony meteorite, (b) iron meteorite, and (c) stony-iron meteorite.

Stony Meteorites contain minerals which are mostly silicates and oxygen. They possibly composed of some metal nickels and irons. There are two types of stony chondrites and achondrites. Chondrites
develop from dust and small objects that formed as asteroids in the early solar system. Achondrites, without chondrules, are very rare, making up about 3 percent of all known meteorites on Earth. Achondrites, formed from outer layer of an asteroid, has the compositions similar to Earth’s crust or crust layers of other planets.

**Achondrites** are mainly composed of iron and nickel, which survive during the harsh plummet through Earth’s atmosphere without breaking into smaller pieces. **Stony-Iron Meteorites** consist of a mixture of stony silicate, iron and nickel

For the method to recover the meteorites, when a large object impacts the surface of the Earth, the surface rock at the impact site is deformed and ejected into the atmosphere to fall back to the surface. This results in a bowl shape depression with raised rim, which is called an impact crater. Astronomers discovered the impact crater to be an evidence of impact and use to find meteorite fragments. Some time we can collect those fragments and information about the trajectory of meteorite from eyewitnesses. From this information, we may confirm the directions of fireballs and burning tails of the meteorites.

### 2. Meteorite Testing Procedure

The first procedure is direct discovery. The stone should be very heavy, with a concave feature or fusion crust. Meteorites will be checked for magnetism with the magnet. If the rock is attached to the magnet, it can be a meteorite. Next, a streak test involves scratching a sample. The powder produced by grinding most meteorites will be brown. In addition, most meteors consist of iron and nickel. Natural stones on earth do not have nickel. This test must be checked in the laboratory.

Following the detection of objects that fall from the sky onto a home in Phitsanulok on June 27, our team went to the impact site to correct the meteorite fragments. The 65-year-old witness, Mrs. Bualom Chalomprai, found the meteorite of 300 g main mass and many rock fragments fell through her roof after an explosion in the sky was heard. Two small pieces of meteorite were given for the analysis. With a scanning electron microscope at National Metal and Materials Technology Center, the meteorological analysis is shown in Figure 2.

![Figure 2](image)

**Figure 2.** A sample which is expected to be a meteorite, with (a) 300 g main mass. (b) The main mass and 4 fragments under the meteorological analysis.

Meteorological analysis allows scientists to learn about the elemental composition in meteorites. The analysed result is the percentage of each element. The results can be divided into two portions; the pure element which yields percentages of base elements and compound element which gives the percentages of oxide elements. In this study, pure element analysis was performed.

### 3. Meteorite discovery and elemental analysis

Retrieving the evidence in Phitsanulok's muang district, we confirm the type of meteorite and gave two fragments of the meteorite from Mrs. Bualom Chalomprai for meteorite testing at the laboratory. The colour of explosion observed by eyewitnesses can identify the fragments as stony meteorites. The samples respond to a magnet. They have melted coating, which is called “Fusion Crust”, which may survive from burning in the atmosphere. The initial procedures are shown in Figure 3.
Figure 3. shows initial procedures in Phitsanulok’s muang district; (a) the locations of the impact site, (b) the meteorite on the roof, and (c) the samples given by Mrs. Bualom Chalomprai.

Meteorite fragments were tested to determine the elemental composition at the National Metal and Materials Technology Center. They were analyzed by scanning electron microscopy coupled with energy dispersive X-ray spectroscopy (SEM/EDS) instruments. The type of meteorite and percentage of elements were determined as shown in Figure 4.

Figure 4. shows the process of meteorite testing by Scanning Electron Microscope (SEM). The sample (a) was analyzed by scanning electron microscopy coupled with energy dispersive X-ray spectroscopy (SEM/EDS) (b).

The results from SEM/EDS instrument show mineral phases in ordinary achondritic meteorite. The analyzed results confirmed that the sample is a meteorite, and mainly composed of iron, nickel and sulfur. They were not found to contain any dangerous chemicals. The percentage of elements and compound elements in X-ray mapping are shown Figure 5.

Figure 5. shows a mapping phase on the sample, analysed by SEM/EDS

After mapping on the sample, we analysed the percentage of elements and compound elements with SEM/EDS. The results are shown in Table 1.

Table 1. Analysed percentages of all elements by weight.
### Spectrum

|            | C    | O    | Na   | Mg   | Al   | Si   | S    | K    | Ca   | Cr   | Fe   | Ni   | Total (%) |
|------------|------|------|------|------|------|------|------|------|------|------|------|------|----------|
| Map Sum Spectrum | 12.7 | 8    | 41.99 | 1.04 | 7.54 | 10.91 | 4.32 | 0.33 | 18.00 | 2.00 | 100.00 |     |          |
| Fe Ni phase1    | 95.34 | 4.66 | 100.00 |      |      |      |      |      |      |      |      |      |          |
| Fe Ni phase2    | 64.83 | 35.17 | 100.00 |      |      |      |      |      |      |      |      |      |          |
| Fe S phase1     | 50.79 | 49.21 | 100.00 |      |      |      |      |      |      |      |      |      |          |
| Fe S phase2     | 49.17 | 50.83 | 100.00 |      |      |      |      |      |      |      |      |      |          |
| Matrix Al rich phase | 7.34 | 56.58 | 6.81 | 8.00 | 20.29 | 0.32 | 0.67 |      |      |      |      |      | 100.00 |
| Fe Ni phase3    | 95.17 | 4.83 | 100.00 |      |      |      |      |      |      |      |      |      |          |
| Matrix phase1   | 6.42 | 61.88 | 13.44 | 15.55 | 0.18 | 2.54 |      |      |      |      |      |      | 100.00 |
| Matrix Ca rich phase | 8.40 | 61.39 | 0.71 | 7.57 | 0.42 | 15.58 | 4.56 | 0.20 | 1.16 |      |      |      | 100.00 |
| Fe Ni phase4    | 50.02 | 49.98 | 100.00 |      |      |      |      |      |      |      |      |      |          |
| Matrix phase2   | 6.10 | 58.24 | 0.50 | 13.23 | 17.79 | 0.31 | 3.83 |      |      |      |      |      | 100.00 |

### 4. Conclusions

Following the detection of objects that fall from the sky onto a home in Phitsanulok on June 27, we analysed and identified the type of meteorite and the percentage of elements, by SEM/EDS instrument. The meteorite is a chondrite, a class of meteorite which does not contain chondrule. It is mainly composed of Fe, Ni, and S. The high amount of (Fe-Ni), (Fe-S) ratios were found in all phases based on the measurement by SEM/EDS instruments. It has the main features of stony meteorites. These samples can be used further investigation.

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