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# The Analysis of Resistivity Characteristics and Mineral Composition of Qinghai Meteorolite

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**Abstract.** Qinghai Province is the second largest meteorolites falling area in China. The samples are provided by Tianshi Cultural Development Co., Ltd., and are numbered HYLVS-1, THYS-2, HTYS-3 and SMDYS-4, and the results of density test is 7.57g / cm<sup>3</sup>, 3.60 / cm<sup>3</sup>, 3.80/cm<sup>3</sup> and 3.19 / cm<sup>3</sup> respectively. Major elements include Al, Ti, Ni, Mg, Ca, Fe, K, etc. Trace elements include Co, Ba, Te, Cd, Ce, Li, La, Nd, Sr, etc. The results of testing shows that the resistivity of HYLVS-1, HTYS-3 is low, which indicates that there are many metal minerals such as iron and nickel, and the resistivity of THYS-2, SMDYS-4 is high, which indicates that there are few metal minerals. From the analysis of the chemical elements of the samples, resistivity is positively correlated with the contents of nickel and iron, and has good fitting degree. The main factors that affect the resistivity of the samples include meteorite structure, moisture content, mineral crystal, ambient temperature, porosity and so on. To study the resistivity characteristics of Qinghai meteorolites is an effective means to obtain the key information about the physical characteristics, structure, chemical components, the state of occurrence of metallic elements, mineral crystals and its arrangement, etc.

## 1. Introduction

Rock and ore resistivity ( $\rho$ ) is one of the important parameters of electrical property. The resistivity is only related to the composition of rock and ore, closely related to the physical and chemical properties of the component, and independent of the geometry of the specimen. Mineral composition, structure and porosity are property of rock and ore, humidity is the property of surrounding fluid, and temperature and pressure are external environmental factors<sup>[1-2]</sup>. The resistivity is generally affected by the characteristics of the internal components of the rock and ore<sup>[3-4]</sup>. For conductive components, the resistivity increases with the increasing of temperature<sup>[5]</sup>. For semiconductors, the resistivity is negatively correlated with temperature. Because the different rock composition is the material basis of rock, therefore, different types of electrical parameters is corresponding to different types of stone. Similarly, the electrical parameters of same type of rock have obvious changes and differences with different factors<sup>[6]</sup>. The study area is located in the northeast of the Qinghai-Tibetan Plateau. The topography of Qinghai is a part of the Qinghai-Tibetan Plateau, which distributes between the basins, the mountains and the valleys, and the Qinghai-Tibetan Plateau has long been known as “the roof of the world”. As the second largest meteorolite falling area in China, it is mainly distributed in Huangzhong, Menyuan, Qilian and adjacent Tianzhu. Studying the resistivity characteristics of Qinghai meteorolite is an effective means for us to obtain some key information, which include physical characteristics, meteorite structure, chemical composition, state of occurrence of metal elements, mineral crystal and structure, etc. It is a difficult and scientific problem to explore the



relationship between physicochemical and resistivity characteristics of meteorolite and the influencing factors. Therefore, it is beneficial to the interdisciplinary knowledge of astronomy, petrology, electrochemistry, mineralogy, geochemistry and geophysics to study the resistivity characteristics of meteorolite and the influencing factors.

## 2. Mineral composition

A total of 4 samples were collected from Tianshi Cultural Development Co., Ltd. The weight and size of the samples meet the requirements of the test and analysis code (Figure. 1). The sampling sites are in the nearby Tianzhu area (HYLYS-1), Qilian area (THYS-2), Menyuan area (HTYS-3) and Huangzhong area (SMDYS-4). HYLYS-1 compounds include Fe-Ni metal minerals, magnesia-ferric spinel, ferric oxide, ferrous oxide, silica, alumina, etc. THYS-2 compounds include ibuterite, palliite, ferric olivine, pyroxene, ferric oxide, ferrous oxide, silica, alumina, calcium oxide, magnesium oxide, potassium oxide, sodium oxide, etc. HTYS-3 compounds include palliolite, olivine, pyroxene, ferric oxide, ferrous oxide, silica, alumina, calcium oxide, etc. SMDYS-4 compounds include nickel iron, olivine, iron oxide, ferrous oxide, silica, alumina, calcium oxide and magnesium oxide.



Figure 1. Samples external feature.  
(a. HYLYS-1; b. THYS-2; c. HTYS-3; d. SMDYS-4)

## 3. Physical and chemical characteristic

### 3.1. Samples preparation

In the early stage of test and analysis, the sample was treated preliminarily, including numbering, classifying, cutting, polishing, taking pictures under mirror, marking minerals, weighing and so on. The resistivity of the samples was measured directly by digital four-probe tester(ST2253), and the content of the metal conductive mineral in the samples could be preliminarily determined. The preparation of the samples were analyzed according to the requirements and regulations of DZ/T 0130.1-2006.

### 3.2. Results of test analysis

The results of resistivity measurements for HYLYS-1, THYS-2, HTYS-3, SMDYS-4 are shown in Table 1, Table 2, Table 3, Table 4. The curve graph of resistivity is shown in Figure 2. The samples

quality are obtained by AW (H)-15 Electronic Balance. Since the shape of meteorite samples is irregular, the volume was measured by measuring tube.

Table 1. HYLYS-1 Resistivity test results

NUM	X (mm)	Y (mm)	Forward direction ( $\Omega\cdot\text{cm}$ )	Opposite direction ( $\Omega\cdot\text{cm}$ )	Average ( $\Omega\cdot\text{cm}$ )	Resistivity ( $\Omega\cdot\text{cm}$ )
1	13.5	0	59.53	59.65	59.59	59.65
2	13.5	0	59.59	59.65	59.62	59.65
3	13.5	0	59.71	59.77	59.74	59.77
4	13.5	0	59.71	59.83	59.77	59.83
5	13.5	0	59.77	59.83	59.80	59.83
6	13.5	0	59.71	59.77	59.74	59.77
7	13.5	0	59.83	59.89	59.86	59.89
8	13.5	0	59.89	59.95	59.92	59.95

Table 2. THYS-2 Resistivity test results

NUM	X (mm)	Y (mm)	Forward direction ( $\Omega\cdot\text{cm}$ )	Opposite direction ( $\Omega\cdot\text{cm}$ )	Average ( $\Omega\cdot\text{cm}$ )	Resistivity ( $\Omega\cdot\text{cm}$ )
1	10	0	154300	114300	134300	114300
2	10	0	154300	114300	134300	114300
3	10	0	154300	114300	134300	114300
4	10	0	154300	114300	134300	114300
5	10	0	154300	114300	134300	114300
6	10	0	154300	114300	134300	114300
7	10	0	154300	114300	134300	114300
8	10	0	154300	114300	134300	114300

Table 3. THYS-3 Resistivity test results

NUM	X (mm)	Y (mm)	Forward direction ( $\Omega\cdot\text{cm}$ )	Opposite direction ( $\Omega\cdot\text{cm}$ )	Average ( $\Omega\cdot\text{cm}$ )	Resistivity ( $\Omega\cdot\text{cm}$ )
1	13.5	0	26.64	26.87	26.755	26.87
2	13.5	0	26.64	26.87	26.755	26.87
3	13.5	0	26.70	26.87	26.785	26.87
4	13.5	0	26.70	26.87	26.785	26.87
5	13.5	0	26.70	26.7	26.700	26.70
6	13.5	0	26.70	26.87	26.785	26.87
7	13.5	0	26.70	26.87	26.785	26.87
8	13.5	0	26.76	26.93	26.845	26.93

Table 4. THYS-4 Resistivity test results

NUM	X (mm)	Y (mm)	Forward direction ( $\Omega\cdot\text{cm}$ )	Opposite direction ( $\Omega\cdot\text{cm}$ )	Average ( $\Omega\cdot\text{cm}$ )	Resistivity ( $\Omega\cdot\text{cm}$ )
1	0	16.5	93820	72720	83270	72720
2	0	16.5	113900	86060	99980	86060
3	0	16.5	128200	95530	111865	95530
4	0	16.5	138000	102000	120000	102000
5	0	16.5	145000	106700	125850	106700
6	0	16.5	150200	150200	150200	150200
7	0	16.5	153500	112500	133000	112500
8	0	16.5	155100	114100	134600	114100

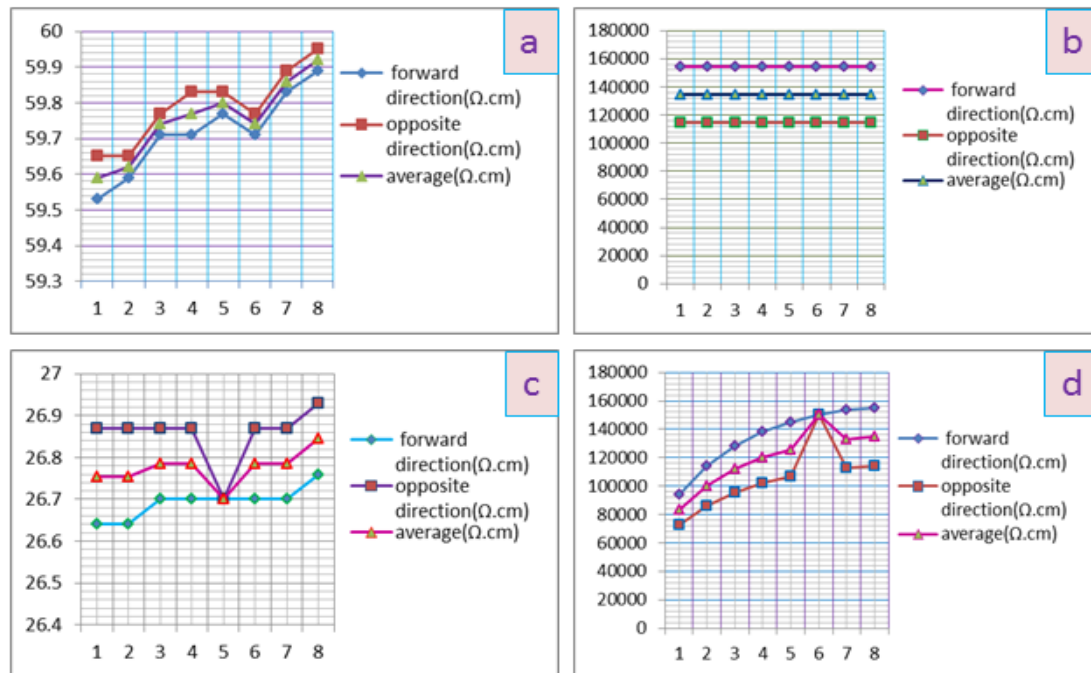


Figure 2. The curve graph resistivity  
(a. HYLVS-1; b. THYS-2; c. HTYS-3; d. SMDYS-4)

### 3.3. Physical and chemical characteristics

The density test results of HYLVS-1, THYS-2, HTYS-3 and SMDYS-4 are  $7.57 \text{ g/cm}^3$ ,  $3.60 \text{ g/cm}^3$ ,  $3.80 \text{ g/cm}^3$  and  $3.19 \text{ g/cm}^3$  respectively. The major elements include Al, Ti, Ni, Mg, Ca, Fe, K, etc. The trace elements include Co, Ba, Te, Cd, Ce, Li, La, Nd, Sr, et al. The results of resistivity test shows that the resistivity of HYLVS-1, HTYS-3 is low, which indicates that there are many metal minerals such as iron and nickel, and the resistivity of sample THYS-2, SMDYS-4 is high, which indicates that there are few metal minerals. In Fe-Ni alloys, Co is positively correlated with iron, and negatively correlated with nickel. According to the characteristics of the samples, the resistivity is positively correlated with the contents of nickel, iron, magnesium and so on, and has good fitting degree and positive correlation.

### 3.4. Analysis of influencing factors

In terms of conducting mechanism, solid minerals can be classified into three types: metallic conductors, semiconductors and solid electrolytes, metal conductors and semiconductors belong to electronic conductors, and solid electrolytes are ionic conductors. Natural metals are metal conductors, most metal minerals are semiconductors, and most rock-forming minerals are solid electrolytes. The samples are sampled at different locations, environments and times, and minerals exhibit different dielectric and conductance properties<sup>[7-8]</sup>. The main influencing factors involved are material composition, structural structure, pore size and its connectivity, humidity, mixing of other impurities, ambient temperature and pressure, etc. In most cases, the smaller the porosity is, the greater the resistivity is. The larger the water content is, the smaller the resistivity is, the better the pore connectivity is, the smaller the resistivity is, and there is the nonlinear variation of resistivity among temperature, pressure and rock<sup>[9-11]</sup>. Under the condition of constant water content, porosity and other disturbance factors of the same type meteorite specimen under normal temperature and pressure, the difference of resistivity can be caused only by the difference of rock and ore composition. The water content and dielectric constant of the samples is positively correlated with its electrical conductivity, and the partial weathering degree is a little serious, which will affect the resistivity of the samples. The degree of crystallization, arrangement, ambient temperature, porosity and so on are the influencing factors of the resistivity parameters of the samples, and the resistivity of the samples is related to these factors. The change of the microscopic composition of minerals in the samples is also sensitive to the resistivity response, so the factors affecting the resistivity of meteorolites are quite complex, and it have a wide range of influence.

## 4. Discussions and conclusions

### 4.1. Discussions

The factors that affect the resistivity of the samples are mainly chemical composition, structure, water content, mineral crystal, ambient temperature, porosity, etc. the resistivity of the sample is related to these factors. Because of the different sampling sites, environment and time, the minerals have different resistivity. In a certain range of temperature, the resistivity of all metals almost changes linearly with temperature, and the logarithmic normal distribution can basically explain resistivity distribution curve of rock and ore. However, in recent years, it has been found that some electrical parameters of rock and ore are not applicable to Ohm's law, it is called nonlinear phenomenon. With the increasing of the volume of conductive minerals, the resistivity becomes smaller obviously. Mineral resistivity can be used to study the structure of minerals, electron and ion migration processes and other physical properties. If environment humidity of the metal mineral surface and surrounding is high, its conductivity moves according to electron and ion. Meteorite is mixture of multi-material materials, the resistivity characteristics of different types of meteorite vary widely and have anisotropy.

### 4.2. Conclusions

(1) The resistivity test results show that the resistivity of Sample HYLYS-1, HTYS-3 is low, which indicates that there are many metal minerals such as iron and nickel, and the resistivity of Sample THYS-2, SMDYS-4 is high, which indicates that there are few metal minerals such as iron and nickel.

(2) Meteorolite is mixture of multi-material materials. The resistivity characteristics of different meteorolites vary greatly, the resistivity is positively correlated with the contents of nickel, iron, magnesium, etc, and it has good fitting degree and positive correlation.

(3) The factors that affect the resistivity of the samples are mainly chemical composition, structure, water content, mineral crystal, ambient temperature, porosity, etc, and the resistivity of the samples is related to these factors.

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