台灣北橫公路之磁感率異向性研究

Study of Magnetic Susceptibility Anisotropy along the Northern Cross-Island Highway, Taiwan

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■ Introduction

Taiwan is located at the junction of oblique convergence between the Eurasian Plate and Philippine Sea Plate. Because the Philippine Sea Plate has moved toward northwest continuously, Taiwan mountain belt was developed and uplifted. By the arc- continental collision, different geologic structures were formed in different regions along the Taiwan orogen. According to the tectonic movement, the regional strain pattern recorded the structural history of Taiwan orogeny. The variation of finite strain pattern could be studied by analyzing the mineral deformation in strata. Anisotropy of magnetic susceptibility (AMS) is a convenient and fast method to study the strain pattern.

The temperature profile along the Northern Cross-Island Highway was reported by Chen et. al., (2011)〔Fig.1〕. They used vitrinite and Raman spectroscopy to measure maximum metamorphic temperature for understanding the temperature profile across the Hsuehshan Range. The maximum metamorphic temperature could be inferred by the graphitization degree of buried organic matter. Their results showed the maximum temperature increases from west to east, especially increases dramatically since where the cleavage emerges〔Fig.2〕. Is this temperature profile related to deformation or not? We will use AMS to solve this question.

■ Method & Results

Objects would get magnetization by giving a fixed intensity of magnetic field. The coefficient between them is the magnetic susceptibility. Magnetic susceptibility can be taken as an ellipsoid with three principle axes and values (K1, K2, and K3). Because minerals are deformed by external force, mineral grains may be stretched. The compression direction is usually perpendicular to K1. Flinn-diagram indicates deformation conditions of ellipsoid〔Fig.3〕. The y-axis is lineation and the x-axis is foliation. Degree of anisotropy is K1 over K3. The intensity is the distance to origin by the diagram.

There are twenty-two coring sites along the Northern Cross-Island Highway〔Fig.4〕. The stereonet plot of all samples shows that K1 is northeast-southwest direction. Because K1 is perpendicular to the compression direction, it can infer the compression direction is northwest-southeast, which is consistent with current compression direction in Taiwan〔Fig.5〕.

The anisotropy pattern is similar to the intensity pattern, they both increase from west to east, it is also

similar to previous temperature profile〔Fig.6〕. But some points are higher than others, like site2, site4, and site13. We found out that the higher values are located at the foot wall of thrust-faults〔Fig.7〕. It is believed that footwall sustained higher stress which caused higher intensities.

■ Discussion

The magnetic susceptibility can be affected by magnetic mineral type and mineral size. There are two ways to determine that whether the result is affect by them or not. The first experiment is temperature-function magnetic susceptibility. It indentifies the type of minerals. There are three typical patterns in results. During heating, one changes susceptibility around 300~400℃, another changes around 400~600℃, the other is no response〔Fig.8〕. Based on the Curie temperature, they are belonged to pyrrhotite, magnetite, and few ferromagnetic, respectively. Due to time limitation, we only run 10 samples for test. We can found out that the magnetic mineral type have no relationship with the intensity trend〔Fig.9〕. So it can infer that the types of magnetic mineral have little effect on the intensity trend.

The second experiment is hysteresis loop that can determine the mineral grain size. The grain is coarser when the lens shape is smaller, and finer with bigger lens shape〔Fig.10〕. According to hysteresis loop, ferromagnetic domain can classify as single-domain, pseudo- single-domain, and multi-domain. The particles of single-domain is smaller, and multi-domain is bigger. Ms is saturation magnetization and Mr is residual magnetization. By the ratio of Mr over Ms, the mineral grain size can be determined easily. The result tells us that the data there is no regularity〔Fig.11〕. Hence we know mineral grain size may not affect on the intensity trend.

■ Conclusion

To summarize all results and information, it is clearly that K1 orientation of magnetic ellipsoids indicates northwest-southeast compression, which is consistent with plate convergence direction. The trend of intensity is similar to the temperature profile, suggesting both deformation and temperature increase from west to east along the Northern Cross-Island Highway. We can infer that in the foot wall of thrust-fault, intensity is higher. Except the regional deformation, there is no other factors affect on intensity trend.

■ Reference

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2. 呂懿德 (1989)：台灣北部摺皺衝斷帶之古地磁研究暨其構造上意義。國立台灣大學地質學研究所博士論文, 共 226 頁。
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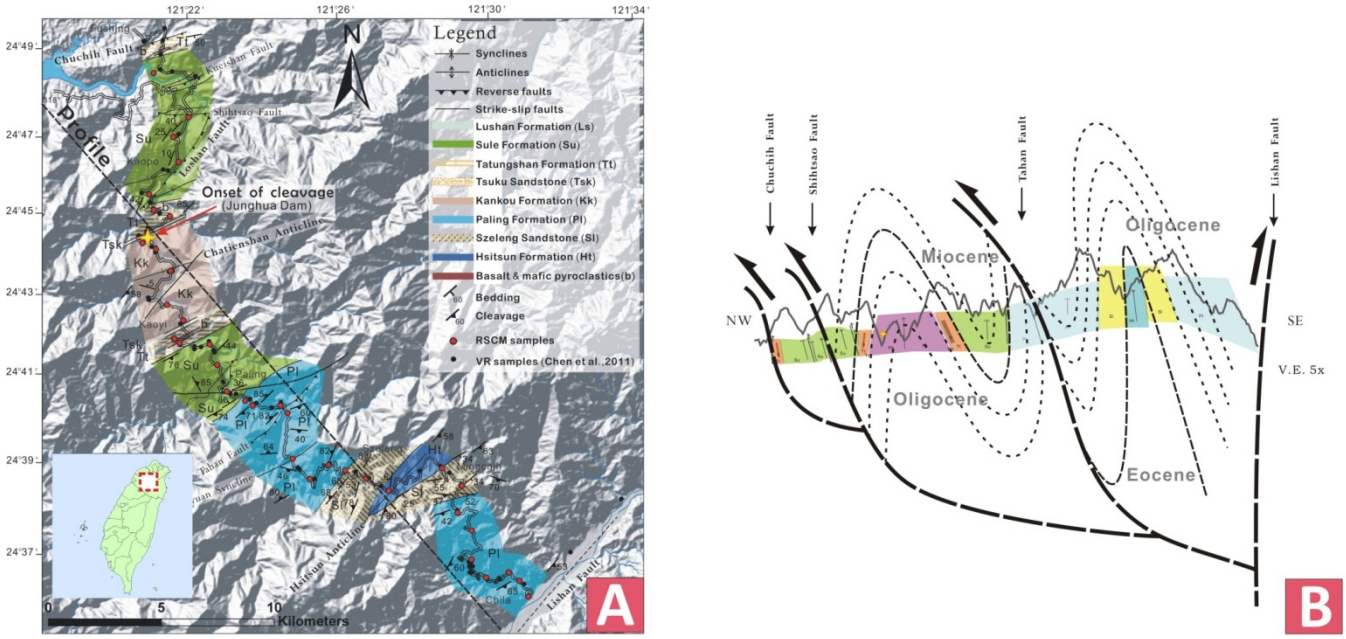
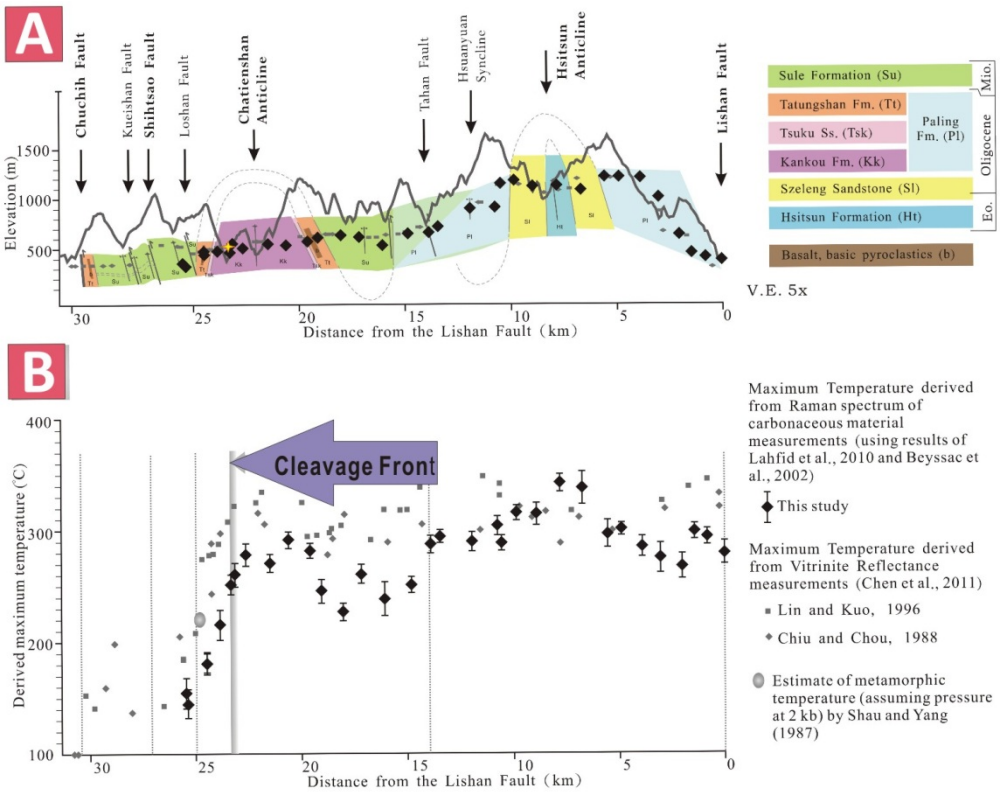
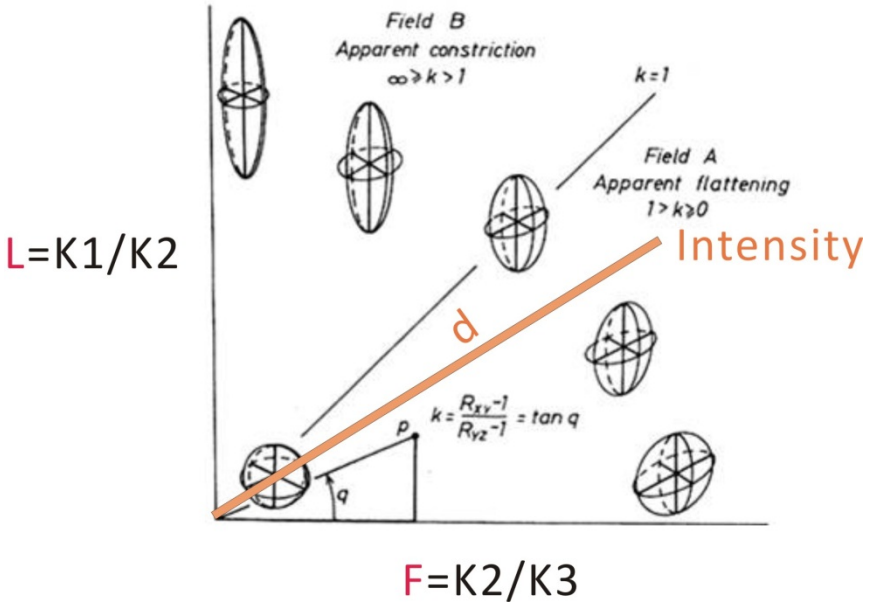


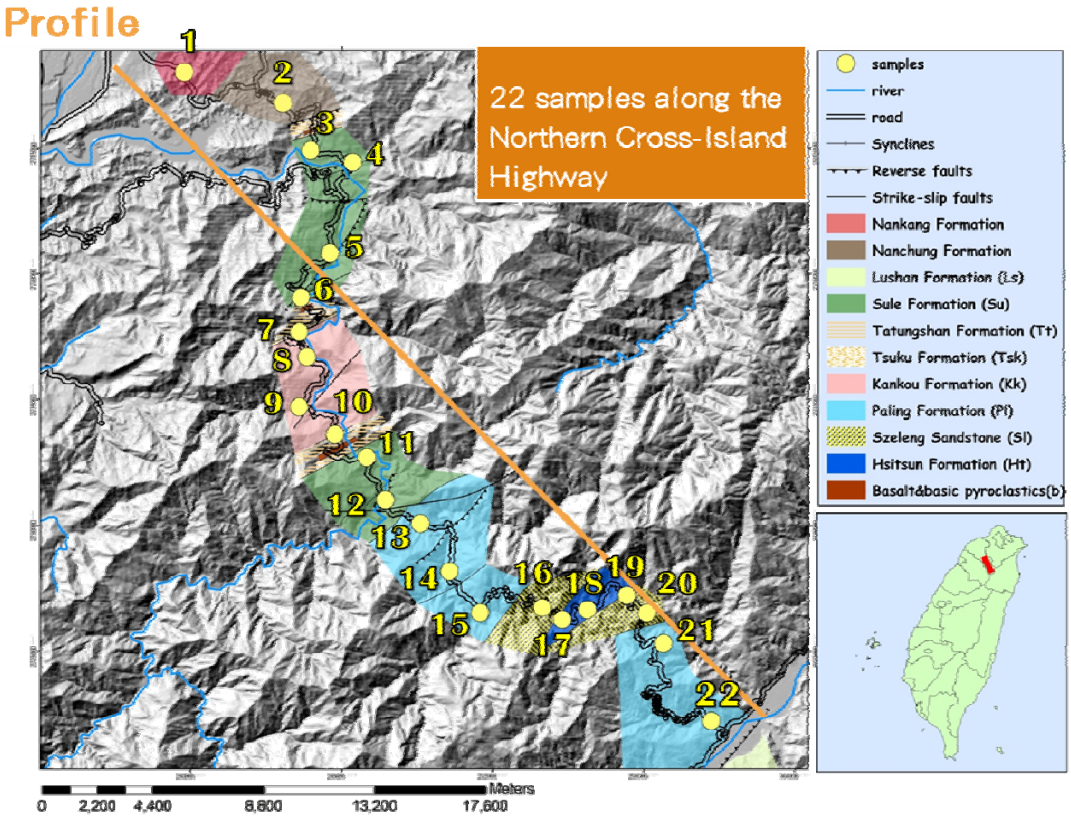
〔Figure 1〕(A) Geology map of the Northern Cross-Island Highway transect. (B) Detailed nappe structure Interpretation. There are some large thrust faults and anticlines. (Chen et al., 2011)



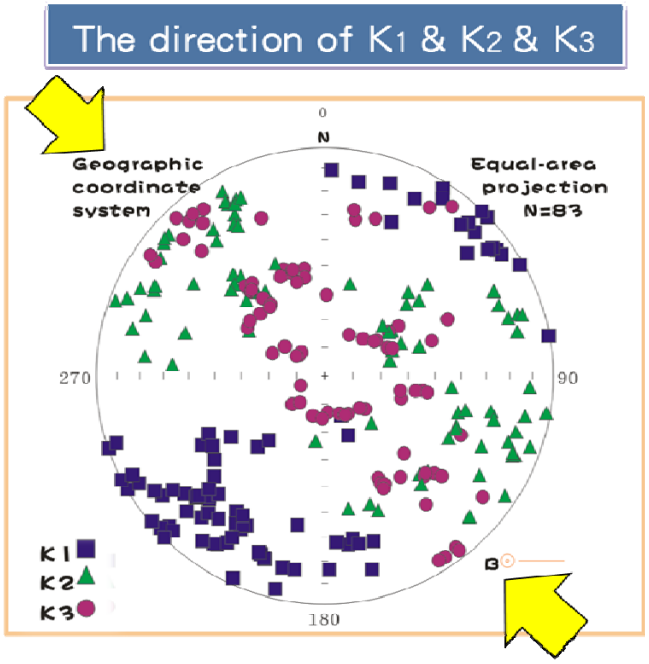
〔Figure 2〕(A) Sampling sites along the Northern Cross-Island Highway. (B) Derived maximum temperature profile of the transect. (Chen et al., 2011)



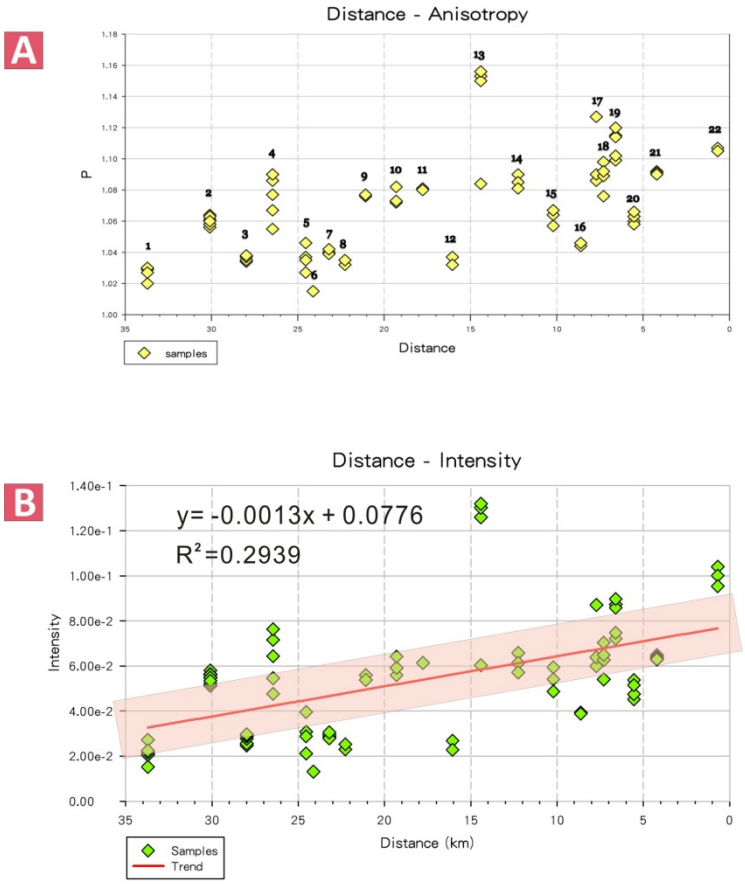
〔Figure 3〕This is Flinn-diagram that indicates deformation condition of ellipsoid. The y-axis is lineation and the x-axis is foliation. Degree of anisotropy is K1 over K3. The intensity is the distance to origin by the diagram. (Flinn, 1962)



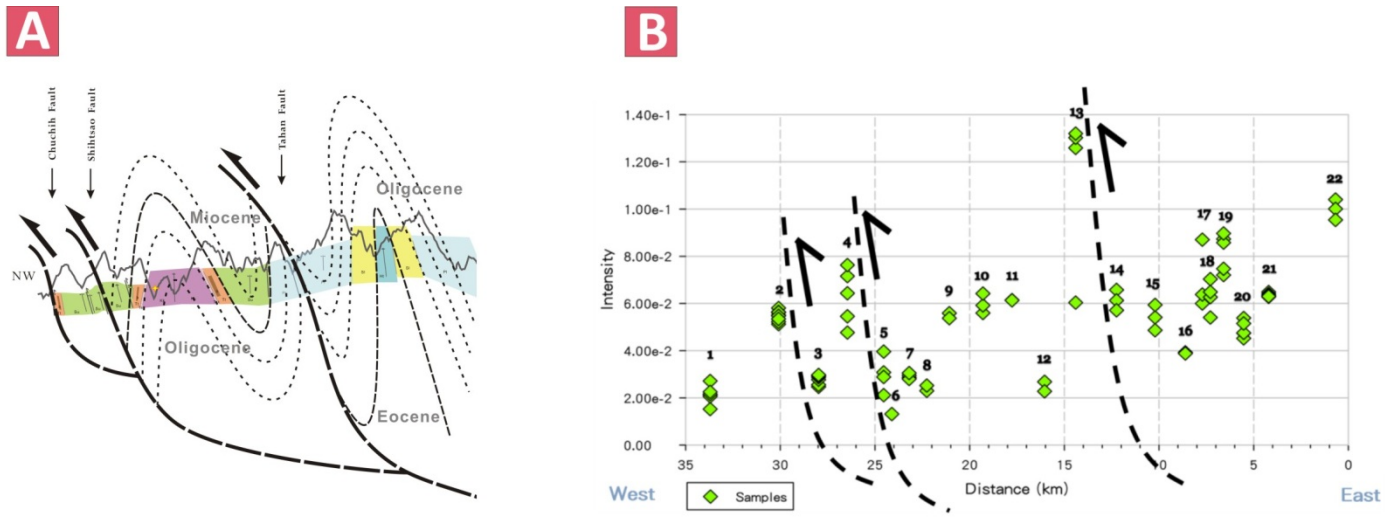
〔Figure 4〕Sample location map. There are twenty-two samples sites along the Northern Cross-Island Highway. From west to east is 1 to 22.



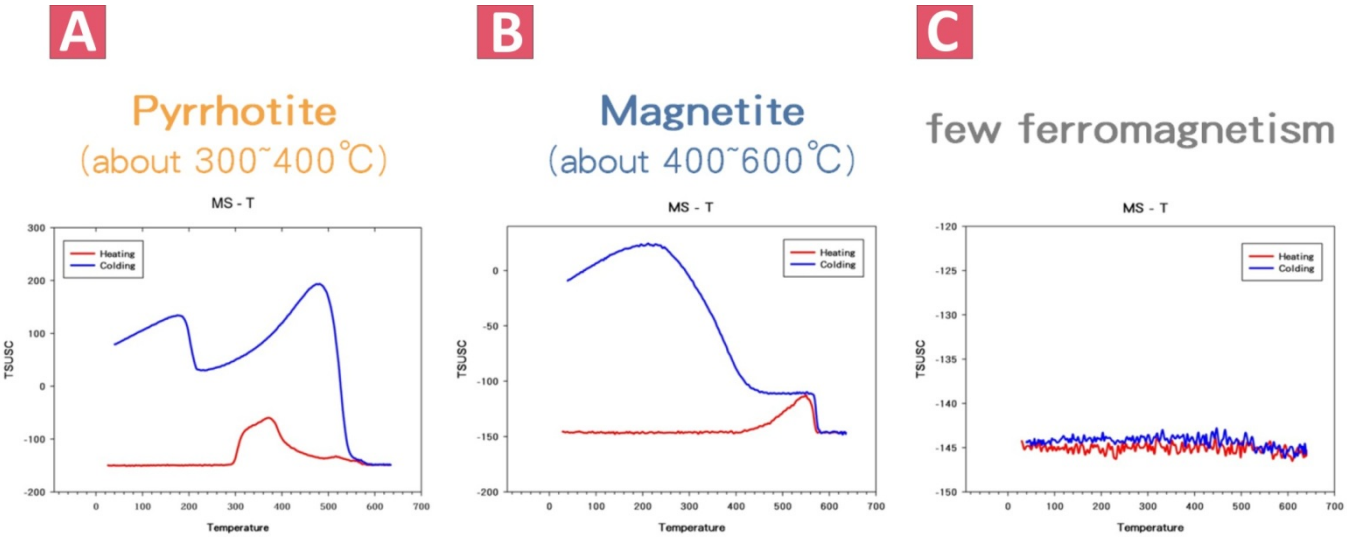
〔Figure 5〕Stereonet plot of principal axes of susceptibility ellipsoid. The blue square is K1, the green triangle is K2, and the pink circle is K3. K1 is perpendicular to the compression direction, so it can infer the compression direction is northwest-southeast, the yellow arrow.



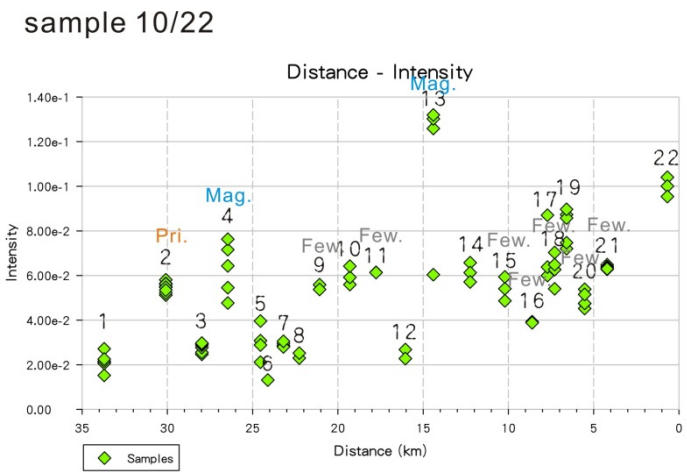
〔Figure 6〕(A) The cross-plot of distance and anisotropy. (B) The distance and intensity plot. The red line is linear regression. Both of them show an increase from west to east.



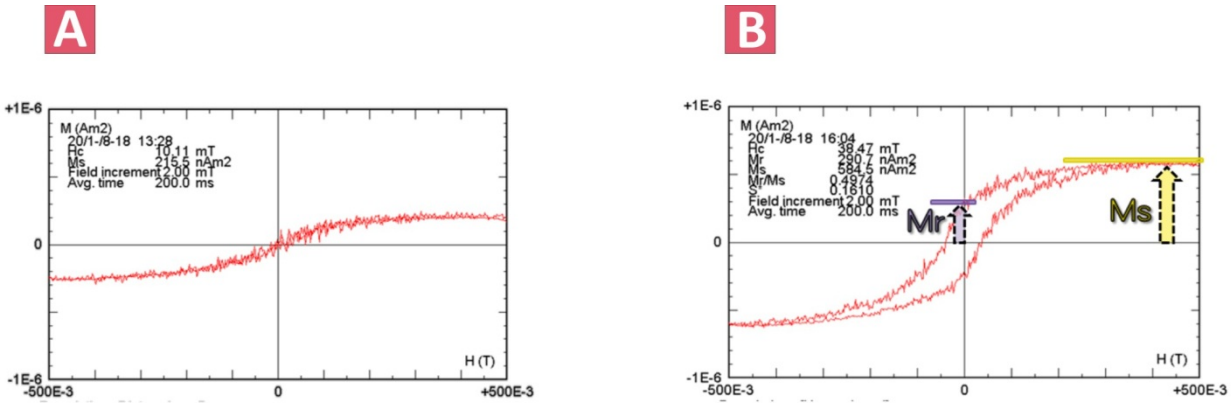
〔Figure 7〕(A) The detailed nappe structure interpreted by Chen (Chen et al.,2011). (B) Compared with (A), the higher values, sample2, 4, and 13, are located in the foot wall of thrust-faults.



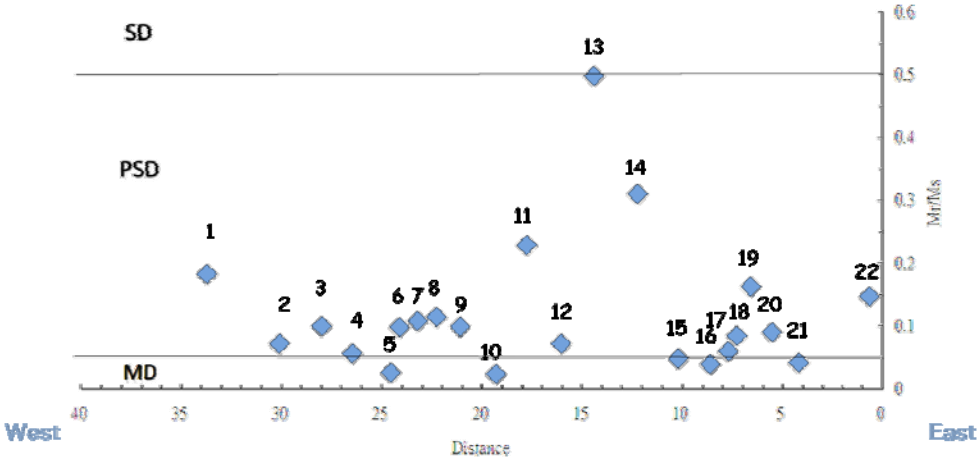
〔Figure 8〕Three typical results of temperature-function magnetic susceptibility. (A), (B), and (C) represent pyrrhotite, magnetite, and few ferromagnetism ,respectively. The red line is heating process, while the blue is cooling.



〔Figure 9〕The distribution of magnetic minerals. Due to time limitation, we only run 10 samples for test.



〔Figure 10〕Result of hysteresis loop. (A) The smaller lens implies larger grain size. (B) Grain size is finer with bigger lens.



〔Figure 11〕The ratio of Mr over Ms. The data seem to have no clear trend.