Dissipative Structures of Rock- and Ore-forming Systems in Faults*

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Abstract

The dissipative structure is an ordered structure. When a system is far from reaching equilibrium in the condition of non-equilibrium and exchanges some energy and material with the surroundings, this structure will be formed and preserved. Starting with the analysis of practical data, we attempt to use this theory to discuss the tectono-geochemical problems of some rock and ore-forming systems in faults.

1. Ordered structure: Under the geological condition, due to the opening of a system in which energy and material are involved in geochemical action, the entropy tends to reduce gradually and substances evolve from non-ordered to ordered in structure. In the processes of formation of rocks and ores in faults, various layer-bands will be formed in rocks.

2. Functional action: The physico-chemical activities which include pressure-creeping and thermal-diffusion as well as liquid diffusion have been shown.

3. Fluctuating cycle: In the process of metamorphism, various changes in pressure, temperature and liquid are of fluctuation and periodicity. These may play an important role in the formation of rocks and minerals and the occurrence of ordered structures in fault zones.

A few examples of mineral deposits in the middle and lower Yangtze River Valley are presented here, and the dissipative activities of rock-forming minerals and mineral-forming elements have been preliminarily established.

The theory of dissipative structure was suggested and established by an outstanding Belgian scientist, Ilya Prigogine (1955, 1962, 1971, 1978), on the basis of the systematic work by W. Thomson (1854) and L. Onsager et al. (1931) on non-equilibrium thermodynamics. This new subject is rapidly expanding to other scientific fields such as physics, chemistry and biology. I. Prigogine pointed out in particular that the irreversible thermodynamics of an open system is very important for many other scientific fields, for example, geology.

The theories involved in geosciences are fundamentally derived from mathematics, physics and chemistry. It is clear that the leading thoughts have all been restricted to the conception of equilibrium state in the past hundred years or more since C. Lyell (1797 - 1895). In view of dissipative structure and non-equilibrium state, the authors try to deal with some problems concerning rock-and ore-forming systems in faults. Of course, on the basis of the characteristics of geology and physics themselves, the theory of dissipative structure is applied to geological problems only on the qualitative basis.

Since the term ——— fault structure was formally coined by J. Playfair in 1802, the description and study of fault structures has experienced a process from structural geometry, through structural mechanics and tectonophysics to tectonogeochemistry (J. G. Dennis, 1967; Guo Lingzhi et al., 1982; Sun Yan et al.,

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No doubt, it is a new approach of exploration to combine the study of fault structures with that of rock-and ore-forming systems, and of geological structures with dissipative structures. The authors try to deal with the problems mentioned above in the light of open system, ordered structure, functional action and fluctuating cycle.

**The Open System**

1. In the geological literature available, the compressive fault is regarded as a closed system and the shearing fault as a semi-closed system, but the tensile fault is regarded as an open system.

   According to the strict thermodynamic definition, a system involving neither energy exchange nor material exchange within the interior of it or with the outer environment is called an isolated system. A system involving only energy exchange is called a closed system. A system involving not only material exchange but also energy exchange is defined as an open system (Prigogine, 1962, 1971). In other words, the open system is a system which can interact with other systems. In thermodynamics a new function — entropy — is introduced, which is called the state function. The increment of entropy (\( ds \)) in the open system should be equal to the sum of the entropy current (\( des \)) for the outer environment relative to a system and the entropy (\( dis \)) source in the interior of the system:

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   ds = des + dis.
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   So far as the definition is concerned, the systems involved in the field of geology are, almost without exceptions, open systems. So, Prof. Zhang Wenyou once pointed out: "There is almost no absolutely isolated system in the crust". Therefore, in terms of the relations of the compressive, shearing and tensile faults with the atmosphere, they can be regarded as a closed-open system, a semi-closed-open system and a complete open system, respectively. This paper is mainly concerned with the first kind of systems.

2. Since there exists mutual influence between an open system and its outer environment, there must exist an energy difference between them. In the geological study of rock-and ore-forming conditions such as pressure, temperature and ore-forming solution, it is obvious that there exist differences in pressure, temperature and concentration between the open system and its outer environment, giving rise to a non-equilibrium system. In addition, because of the direction of time, the above system is also an irreversible system. It is shown that the entropy is equal to zero in the equilibrium (reversible) process.

   It should be pointed out that the fault system in which rocks and ores are formed is considered as an open system, but the open system referred to here does not restrict itself to the whole system under the influence of the environment. Sometimes, even a unified system, if it involves physical and chemical activities, geological factors, or the activity involved in some processes, could be regarded as an open system, and the other factors are considered to be related with the outer environment.

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