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Lithofacies palaeogeography and sedimentology

Quantitative lithofacies palaeogeography

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Abstract Quantitative lithofacies palaeogeography is an important discipline of palaeogeography. It is developed on the foundation of traditional lithofacies palaeogeography and palaeogeography, the core of which is the quantitative lithofacies palaeogeographic map. Quantity means that in the palaeogeographic map, the division and identification of each palaeogeographic unit are supported by quantitative data and quantitative fundamental maps. Our lithofacies palaeogeographic maps are quantitative or mainly quantitative. A great number of quantitative lithofacies palaeogeographic maps have been published, and articles and monographs of quantitative lithofacies palaeogeography have been published successively, thus the quantitative lithofacies palaeogeography was formed and established. It is an important development in lithofacies palaeogeography. In composing quantitative lithofacies palaeogeographic maps, the key measure is the single factor analysis and multifactor comprehensive mapping method — methodology of quantitative lithofacies palaeogeography. In this paper, the authors utilize two case studies, one from the Early Ordovician of South China and the other from the Early Ordovician of Ordos, North China, to explain how to use this methodology to compose the quantitative lithofacies palaeogeographic maps, and to discuss the palaeogeographic units in these maps. Finally, three characteristics, *i.e.*, quantification, multiple orders and multiple types, of quantitative lithofacies palaeogeographic maps are conclusively discussed.

Key words quantitative lithofacies palaeogeography, single factor analysis, multifactor comprehensive mapping, Early Ordovician, three characteristics

1 Introduction

According to the traditional definition, palaeogeography is a science that studies physical geographical characteristics and their evolution in geological history periods (Feng, 1999a, 1999b).

However, in December 2002, during the 197th Symposium of Xiangshan Science Conference supported by the Chinese Academy of Sciences, as the chairman of this symposium, the first author significantly modified the definition of palaeogeography, *i.e.*, palaeogeography is a science that studies the characteristics and their evolution of physical geography in the geologi-

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cal history periods and in the human history periods (Feng, 2003). The major modification is that the definition includes physical geographical characteristics and their evolution in the human history periods. Both geological history periods and human history periods are "palaeo". Both physical geographical characteristics and their evolution in geological history and human history periods belong to the research subjects of palaeogeography. The characteristics and distributions of each physical geographic unit on the surface of the present Earth, such as the characteristics and distributions of lands and seas and their sub-units, are the evolutional results of them during the geological history periods and human history periods. This is the historical relationship between the "palaeo" geography and the "present" geography (Feng, 2003, 2009; Feng and Bao, 2012；Feng *et al.*, 2012).

Quantitative lithofacies palaeogeography is developed on the foundation of traditional palaeogeography. The most important monographs are the following: Grabau, 1924−1928; Huang, 1945; Hsieh, 1948; Liu, 1955; Wang, 1956, 1985; Mineralogy and Petrology Section of Beijing Petroleum Institute, 1961; Lu *et al.*, 1965; Lu, 1979; Mineralogy and Petrology Section of East China Petroleum Institute, 1982; Guan *et al.*, 1984; Liu, 1986; Yin, 1988; Wang *et al.*, 1990; Liu *et al.*, 1993; Liu and Xu, 1994; Zhou and Lin, 1995; Zeng *et al.*, 1996; Yin *et al.*, 1999; Ma *et al.*, 2009; Zheng and Hu, 2010.

The core of quantitative palaeogeography is quantitative palaeogeographic map. Quantity means that on the palaeogeographic map, the division and identification of each palaeogeographic unit are supported by the quantitative data and quantitative fundamental maps.

Our lithofacies palaeogeographic maps are quantitative or mainly quantitative. A great number of quantitative lithofacies palaeogeographic maps have been published one after another, and the articles and monographs of quantitative lithofacies palaeogeography have been published successively. Thus, quantitative lithofacies palaeogeography was formed and established gradually.

In quantitative lithofacies palaeogeography, the key measure is the single factor analysis and multifactor comprehensive mapping method — the methodology of quantitative lithofacies palaeogeography.

The following is a brief discussion of this methodology and the quantitative lithofacies palaeogeographic maps made by this methodology.

2 Single factor analysis and multifactor comprehensive mapping method — methodology of quantitative lithofacies palaeogeography

2.1 Introduction

The proverb says "squares and circles can not be drawn without compasses and rulers".

Without the new quantitative methodology that is compatible with the new theory of quantitative lithofacies palaeogeography, it is difficult to make the new quantitative lithofacies palaeogeographic maps and the lithofacies palaeogeography will not evolve into a new quantitative stage. Thus, the new quantitative methodology for lithofacies palaeogeography, *i.e.*, the single factor analysis and multifactor comprehensive mapping method is in urgent need.

In the early days, the senior author used to call this methodology "single factor mapping methodology" (Feng, 1977, 1979; Feng *et al.*, 1983; Feng, 1987). Later on, this method was called "single factor analysis and comprehensive mapping method" (Feng, 1989, 1992, 1993, 1994). Recently, this methodology was termed "Single factor analysis and multifactor comprehensive mapping method" (Feng, 2004). Although these names are slightly different, they are virtually expressing the same idea. The latest name, "single factor analysis and multifactor comprehensive mapping method", seems more closely matched to reality and is more adequate.

Single factors are those that can independently reflect some characteristics of a sedimentary environment of a certain stratigraphical unit in a certain area. The thickness, rock types, textural components, mineral composition, chemical composition, fossils and their assemblages, and colours of the stratigraphical unit, can all independently reflect certain characteristics of the sedimentary environment of the stratigraphical unit in this area, such as the nature of the sedimentary area, the depth of water, the dynamic energy of water, *etc.*, and can to be used as single factors.

The single factor analysis and multifactor comprehensive mapping method includes three steps. First, an in-depth petrological study of each section, especially a fundamental section, should be undertaken in order to obtain various firsthand qualitative and quantitative data, especially quantitative data, and to understand the characteristics of the sedimentary environment of each bed and