The Formation and Evolution on the Central Asian Orogenic Belt

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Geological Setting

The Central Asian Orogenic Belt (CAOB), one of the largest orogens on the Earth, has attracted numerous geologists and geochemists around the world[1]. It is surrounded by the Siberian craton in the north and by the North China and Tarim cratons in the south and extends from the Ural Mountains in the west to the Pacific coast in the east. The CAOB is considered as an accretion orogen through arc/backarc systems, ophiolites, and microcontinental fragments[2,3]. Although there are many achievements on geodynamic models, accretion rates, Precambrian microcontinents etc., general characters of the CAOB have not been summarized yet.

Methodology

Due to rapid development of SHRIMP and LA-(MC)-ICP-MS techniques, a lot of precise and accurate U-Pb dating and Hf isotopic data of zircons in the CAOB have been accumulated during recent 10 years. We compiled the comprehensive histograms and probability density curves of U-Pb ages and Hf model ages on zircons as well as Nd depleted mantle model ages of whole rocks on the basis of our results and published data.

Results and Conclusions

Although the Hf isotope of a zircon grain represents its composition in a micro-domain, averaged Hf model age (1.39Ga) is almost consistent with that (1.28Ga) of Nd model ages，which are much older than that (571Ma) of zircon U-Pb ages. Collectively, the most intensive magmatic and crustal growth event took place during the Early Palaeozoic and Neoproterozoic periods according to consistent peaks among U-Pb ages and Hf model ages of zircons and Nd model ages. The earliest history can be tracked to ~3.2Ga by U-Pb ages of zircons and Nd model ages, whereas the oldest Hf model age is ~4.3Ga, which indicates that the crustal components of older than 3.2Ga have only been recorded in some zircon grains. The zircons of older than 1.0Ga derived from reworked Precambrian basements of the CAOB, which account for <10% in populations of all zircon U-Pb ages, in contrast to cumulative probability of over 60% in those of Hf and Nd model ages. Therefore, the Mesoproterozoic juvenile crustal components constitute dominant part of CAOB's Precambrain basements, most of which have involved in subsequent intra-crustal magmatisms. The Neoproterozoic is a transition period initiating intensive magmatism in the CAOB. Magmatism arrived at the climax in Palaeozoic, whose cumulative probability possesses 76% in whole range of ages.

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Local spatial and scaling modelling for geochemical heterogeneity and anomaly detection

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Regional geochemical mapping with stream sediments provides information on weathering and transport processes and on the presence of contaminants and mineral deposits. Various quantitative methods have been developed in geochemical exploration to separate anomalies associated with mineralization from background reflecting regional geological processes. However, geochemical datasets often show strong heterogeneity in geomorphologically and geologically complex settings. Therefore, anomaly detection methods based on the assumption of homogeneity and stationary are inappropriate. A key change in separating anomalies from background has been from a focus on local singularities rather than the search for global regularities and production of local mappable statistics rather than global summaries. The local spatial and scaling model that combines local singularity analysis and spatial U-statistics introduced is a potential powerful method for geochemical heterogeneity and anomaly detection.

The study area is in the northern part of the Lanping basin, Yunnan province, China. A total of 1172 stream sediment samples were collected at 2 km intervals. Many Pb-Zn-Ag deposits including the Jinding super large Pb-Zn deposit exist in this area.

The scale-invariant property has been observed not only in many geochemical maps but has also proved useful for characterizing variability in maps. Local singularity analysis based on multifractal theory is a powerful tool for characterizing local structural properties of spatial patterns. It uses the local singularity index α to indicate background or anomaly, where $\alpha(x)$ close to 2 represents background with homogeneity, $\alpha(x) > 2$ corresponds to local depletion, and $\alpha(x) < 2$ to anomalous enrichment at the neighborhood $\Omega(x)$. Locally-adaptive detection of the geometrical properties of $\Omega(x)$ (size, shape, and orientation) will obtain better $\alpha(x)$ if patterns are heterogenous at the scale of measurement. A spatial U-statistic can be used not only for geochemical anomaly separation but also for searching anisotropic parameters at arbitrary sample location. Thus, it useful for anisotropic local singularity modelling.

The combined local singularity analysis and spatial U-statistics considers not only concentration values, frequency distributions and spatial correlation, but also geometrical properties of anomalies and scale independence characteristics, which are effective to reveal multi-scale anisotropy and heterogeneity in geochemical exploration data. It can be a useful tool to discover weak anomalies related to buried mineral deposits.

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