Abstract: - The present paper analyzed the major, trace elements, rare earth elements of these Cenozoic basalts and combined with Sr-Nd isotopic compositions to discuss the petrogenesis of these basalts and the tectonic setting of the study area. Based on major, trace elements and fractional crystallization model we suggest that the basaltic magma has experienced olivine, clinopyroxene and plagioclase fractionation during its evolution. Spidergrams and REE patterns reveal that Cenozoic basalts found in the Jiashan County, Anhui Province have geochemical characteristics similar to those of ocean island basalts (OIB) suggesting a derivation related to OIB-like mantle source. The slight positive Nb and Ti anomalies found in basaltic rocks of this study suggest the presence of Ti-bearing minerals in the mantle source and these Ti-bearing minerals had contributed to basaltic magma during partial melting, indicating a metasomatic event might have occurred before the partial melting. Based on 143Nd/144Nd vs. 87Sr/86Sr diagram we suggest that basalts of this study can be produced by MORB and EM-I components mixing and small degree of partial melting may be the major controlling factor during generation of basaltic magma. Some basaltic magma may be derived from partial melting of EM-I heated by the upwelling asthenospheric mantle. The basalts fall within the WPB field in the discriminant plot of 2Nb-Zr/4-Y indicate that the volcanic activities in this region may be closely related to deep continental rifting process.

Key-Words: - Geochemistry, Cenozoic basalts, Anhui Province, Petrogenesis, tectonic setting, Fractionation

1 Introduction
The basalts found in the Jiashan County, Anhui Province are situated in the boundary of Yangtze Craton and southeastern edge of Sino-Korean Craton, one of the oldest Archean continental nuclei in the world [1]-[4]. NE China can be divided into two main tectonic domains: the south Precambrian Sino-Korean Craton and the north Paleozoic Xing’an-Mongolian fold belt[5].The NCC, regarded as one of the world's oldest cratons, preserves continental crustal relics dating back to 3.8 Ga [6]. Tectonically, the NCC is bound to the north by the late Paleozoic to Mesozoic Central Asian Orogenic belt, to the west by the Qilian Orogenic belt, and to the south by the Qinling–Dabie–Sulu Orogenic belt [7].

Along the eastern Asian continental margin, Cenozoic extensional basins and associated
volcanic eruptions are developed, extending over 4000 km from Siberia to east China. Cenozoic basalts are widely distributed along the eastern China from north of Heilongjiang province to south of Hainan island, and South China Sea [8]. The Cenozoic volcanic rocks from Anhui-Jiangsu provinces are spread over an area of more than 2,000 km2 in eastern Anhui and western Jiangsu. The spatial distribution of volcanic rocks in this region is controlled by the NNE-trending Tan-Lu fault and its adjacent NW-trending basins and faults which can be divided into three periods [9]-[10].

The purpose of this paper is to analyze the major and trace elements (including rare-earth elements) of these basalts combined with Sr and Nd isotopic ratios (Chen et al., 1990)[11] in order to deduce the petrogenesis and magmatic evolution of these rocks and confer tectonic setting of the study area.

2 Analytical Methods

Nine Cenozoic basalts sampled found in the Jiashan County, Anhui Province (Fig. 1) were selected for bulk chemical analyses. The chemical analyses of the basalts in the present study have been carried out by colorimetry (Si, Al, Ti, P), atomic absorption (Fe, Mg, Ca, Na, K, Mn), inductively coupled plasma mass spectrometry (Ba, Co, Cr, Cs, Cu, Ga, Hf, Li, Nb, Ni, Pb, Rb, Sc, Sr, Ta, Th, U, V, Y, Zn, Zr and REEs) at the National Taiwan and Tsing-Hua Universities.

The calibration curves were constructed using USGS standard rocks BHVO-1, AGV-1, BCR-1, W-2, G2 and NBS standard rock basalt. The precision of the analyses in the present study is estimated to be around ±2% for colorimetric and atomic absorption methods and better than ±5% for all ICP-MS analyses.

Fig. 1 A sketch map showing the simplified tectonic framework of eastern China and the location of the studied area (modified after Xu and Bodinier, 2004).[12]

3 Results and discussions

CIPW normative data suggest that alkali olivine basalt is the major rock type in the Jiashan County, Anhui Province. The SiO2 contents of the alkali olivine basalts ranges from 44.57% to 53.56%. The SiO2 contents show negative correlation with MgO, ∑FeO, CaO, Na2O, K2O, MnO which indicate the possibility of fractional crystallization of olivine, clinopyroxene and plagioclase in magmatic evolution. The Ba, Co, Cr, Nb, Ni, Sr, Th contents are positively correlated with SiO2 contents and the fractional crystallization model proposed by Brooks and Nielsen (1982)[13](Fig 2), suggesting fractional crystallization of olivine, clinopyroxene and plagioclase may have occurred during magmatic evolution.

Fig. 2 The MgO vs. 100FeO/(MgO+FeO) plots for basaltic rocks found in the Jiashan County, Anhui Province. Fractionation model modified from Brooks and Nielsen(1982)[13].

Fig. 3 shows that The Primitive mantle-normalized incompatible element diagrams of basalts found in the Jiashan County, Anhui Province and OIB, E-MORB as well as N-MORB. The spidergrams of basalts of this study are similar to that of OIB (oceanic island basalt; [14]), indicating an enriched mantle source beneath the study area. The spidergrams do not have obvious depletions in Nb, indicating crustal contamination can be excluded during magma generation [15]-[20]. The slight Nb and Ti positive anomaly observed in the basalts support the suggestion that the basaltic magma may have derived from a rutile-bearing mantle source and rutile has involved in the partial melting process [21]-[23].

Fig. 3 Primitive mantle normalized incompatible element patterns for average basaltic rocks of this study. OIB,N-MORB,
E-MORB and primitive mantle data are from Sun and McDonough (1989)[14].

Fig. 4 shows the chondrite-normalized REE patterns of basaltic rocks in the present study as compared with the patterns of the OIB, E-MORB and N-MORB. The patterns of basaltic rocks of this study are similar to those of OIB. The negative heavy REE (Yb and Lu) anomalies in the basaltic rocks studied may be attributed to the presence of garnet peridotite in the upper mantle which can hold back HREE (Yb and Lu).

On the 143Nd/144Nd vs. 87Sr/86Sr diagram (Fig. 5), all basaltic rocks fall between MORB and EM-I defined by Zindler and Hart (1986)[24], and most of samples are closely related to the mantle array, indicating that basalts of this study can be produced by MORB and EM-I [24] components mixing and small degree of partial melting may be the major controlling factor during generation of basaltic magma. The volcanic activities in this region may be closely related to deep continental rifting process[25]. The basalts fall within the WPB field in the discriminant plot of 2Nb-Zr/4-Y (Fig. 6).

4 Conclusion

CIPW normative data suggest that alkali basalt is the major rock type in the Jiashan County, Anhui Province. Based on major, trace elements and fractional crystallization model we suggest that the basaltic magma has experienced olivine, clinopyroxene and plagioclase fractionation during its evolution. Spidergrams and REE patterns reveal that Cenozoic basalts found in the Jiashan County, Anhui Province have geochemical characteristics similar to those of ocean island basalts(OIB) suggesting a derivation related to OIB-like mantle source. Based on 143Nd/144Nd vs. 87Sr/86Sr diagram we suggest that basalts of this study can be produced by MORB and EM-I components mixing and small degree of partial melting may be the major controlling factor during generation of basaltic magma. Some basaltic magma may be derived from partial melting of EM-I heated by the upwelling asthenospheric mantle. The basalts fall within the WPB field in the discriminant plot of 2Nb-Zr/4-Y indicate that the volcanic activities in this region may be closely related to deep continental rifting process.

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