

Paleoproterozoic positive $\delta^{13}\text{C}_{\text{carb}}$ excursion in the Liaohe Group: Record of the Lomagundi event in the northeastern Sinokorea Craton

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The 2.33 ~ 2.06 Ga positive $\delta^{13}\text{C}_{\text{carb}}$ excursion, associated with an environmental catastrophe and the breakup of the Kenorland or Superia supercontinent, is called the Lomagundi or Jatulian Event or Great Oxidation Event, which has been reported in all Early Precambrian cratons except the Sinokorean craton. To check if the event occurred in Sinokorea craton, we have carried out a chemostratigraphic study of the Liaohe Group which developed in the northeast part of the Sinokorean Craton. The Liaohe was deposited in the time span of 2.3 ~ 1.85 Ga. The Guanmenshan Formation of the Liaohe Group occurs in northern Liao-Ji block. Its 42 samples of dolostones yield $\delta^{13}\text{C}_{\text{carb}}$ values ranging 3.5 ~ 5.9‰ (V-PDB), and $\delta^{18}\text{O}$ values ranging 15.4 ~ 24.8‰ (V-SMOW), showing clear positive $\delta^{13}\text{C}_{\text{carb}}$ excursions that characterize the Lomagundi Event. Thirty five of the 42 samples, which do not show obvious hydrothermal alteration, have higher $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$ values than the other 7 samples affected by fluid flow, confirming that fluid flow results in decrease in $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{18}\text{O}_{\text{carb}}$. Due to the most positive $\delta^{13}\text{C}_{\text{carb}}$ excursion appears in the period of 2.33 ~ 2.06 Ga in the earth's history, the obvious positive $\delta^{13}\text{C}_{\text{carb}}$ excursions of the Guanmenshan Formation validate its age ranging in the bracket of 2.33 ~ 2.06 Ga. The Dashiqiao Formation of the Liaohe Group is well known because it hosts a world-class magnesite deposit (Dashiqiao) in the Jiao-Liao-Ji belt. The thickness of the Dashiqiao Formation is about 1144 meters. Six dolomite samples from the host-rocks yield $\delta^{13}\text{C}_{\text{PDB}}$ values ranging 0.6 ~ 1.4‰ with average of 1.2‰ and $\delta^{18}\text{O}_{\text{SMOW}}$ ranging 16.4 ~ 19.5‰ with average of 18.2‰, respectively. The $\delta^{13}\text{C}_{\text{PDB}}$ values are higher than those of normal marine carbonate and show slight positive anomaly. Six samples of massive magnesite ores, however, yield $\delta^{13}\text{C}_{\text{PDB}}$ values 0.1 ~ 0.6‰ averaging 0.4‰ and $\delta^{18}\text{O}_{\text{SMOW}}$ 9.2 ~ 12.7‰ averaging 10.9‰, respectively, clearly lower than the ore-hosting dolomites. Devaluation of $\delta^{13}\text{C}_{\text{PDB}}$ and $\delta^{18}\text{O}_{\text{SMOW}}$ is interpreted to be the result of regional metamorphism-fluid flow. This interpretation can be furthered by a magnesite sample whose $\delta^{13}\text{C}_{\text{PDB}}$ and $\delta^{18}\text{O}_{\text{SMOW}}$ values are -2.7‰ and 16.2‰, respectively. The sample is characterized by postore stockworks mainly composed of fine-grained quartz or amorphous SiO_2 and other indistinguishable components, implying for a locally-occurred postore low-temperature fluid-rock interaction. The $\delta^{13}\text{C}_{\text{PDB}}$ and $\delta^{18}\text{O}_{\text{SMOW}}$ values of hanging-wall dolomite, which contains giant cylindrical talc crystals, are -2.6‰ and 14.1‰, respectively. The talc crystals must be originated from interaction between dolomite and siliceous fluid or high water/rock ratio metamorphism of argillite dolomite. In summary, the Liaohe Group shows positive $\delta^{13}\text{C}_{\text{carb}}$ excursion.

Geochemical constraints on tectonic affinity of eclogite and granulite protoliths in the Jiaodong terrane, the Sulu orogen

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The location of the Triassic suture for continental collision between the South China Block (SCB) and the North China Block (NCB) has been controversial. This is particularly so because zircon U-Pb ages of ~1.8 Ga have been dated for protolith of UHP eclogite at Rongcheng and granulite at Haiyangsuo in the Jiaodong terrane (the eastern part of the Sulu orogen). Because of crustal detachment and tectonic accretion during the Triassic continental collision, the occurrence of ~1.8 Ga protoliths in the interior of the UHP metamorphic zone could imply that these lithotectonic slices were derived from the continental margin of NCB, and either involved in the UHP metamorphism or juxtaposed as non-UHP units against the UHP rocks. However, most of the UHP metamorphic rocks in the Jiaodong terrane are characterized by the Neoproterozoic low $\delta^{18}\text{O}$ protoliths and the Triassic UHP metamorphism, similar to those elsewhere in the Sulu and Dabie orogens. Thus the Jiaodong terrane appears to differ from the Jiaobei terrane in protolith nature and metamorphic grade.

There are three faults within the triangle area of Yantai, Qingdao and Weihai, namely the Yantai, Muping and Mishan faults, respectively. Two samples of granitic gneiss located between the Yantai and Muping faults were dated to have Neoproterozoic ages of protolith (738±11 Ma and 730±120 Ma), indicating that the suture is located along the Yantai fault rather than the Muping fault or the Mishan fault. Triassic deformation did occur in the Jiaobei terrane (the southeastern edge of NCB), but no Triassic HP or UHP metamorphism has been observed in this terrane. Nevertheless, the Jiaobei terrane would behave like a microcontinent during the Triassic continental collision. By basal subduction erosion during the initial subduction of SCB beneath NCB, it is likely that the Paleoproterozoic protolith of UHP eclogite in the Jiaodong terrane would be derived from the NCB basement and tectonically emplaced into the suture zone and even the Jiaodong terrane. However, whole-rock and zircon of the eclogite display similar ^{18}O depletion to the hosting gneiss. This indicates that the eclogite protolith was once subjected to the Neoproterozoic high-T water-rock interaction and thus has the tectonic affinity to SCB. Therefore, that protolith of this eclogite was present as a Paleoproterozoic mafic complex at the northern margin of SCB.