Naturally Occurring Carbon Nanotubes from Graphite Ore Deposit

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Abstract: Carbon nanotubes represent an impressive kind of materials with diverse unexpected properties. A new type of natural carbon nanotubes found in the Sujiquan graphite ore deposit, Xinjiang, China is presented and observed with high resolution transmission electron microscopy (HRTEM). This finding shows that all allotropic carbon forms known up to date can be produced in nature, and high temperature, pressure, catalysts particles seem to play an important role in producing carbon nanotubes. The forming conditions such as temperature and pressure of carbon nanotubes in graphitizing granite have been calculated. It has very important significance for scientist to design the condition of CNTs synthesis and utilize the ore deposit.

Key words: mineral structure; carbon nanotubes; high resolution electronic microscopy; ore genesis
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Since their discovery in 1991, carbon nanotubes (CNTs) have become an important nano-material. Some authors suggest the possibility of finding carbon nanotubes produced by a number of natural processes. Recently, fullerenes were reported in Permian-Triassic boundary sediments[1].

1 Sample and experimental

The sample was obtained from Sujiquan graphite deposit, Xinjiang, China. The ore genesis is thought to be asmagmatic gas-liquid hydrothermal, the quasi nanometer needle graph-ite was found in 2004[2].

The HRTEM is Philips Tecnai F_{30} field emission electron microscope mp (LaB6 filament, accelerating voltage 300 kV, symmetry lighting, object lens diaphragm D=50μm).

2 Results and discussion

2.1 Results

Fig. 1 shows the topography image of one typical carbon nanotube found in Sujiquan graphite deposit, whose length is 293.22 nm and width 8.05 nm. Its two sides are symmetrical with 11 layers, and on the lower, the width became narrow and bended. It has more layers than that of CNTs reported. Fig. 2 is the local high resolution image of the CNTs. The widths of CNTs are 3.88 nm and 3.82 nm on the upper and on the lower respectively. The lattice fringe distance of the crystal plane is 0.35 nm. The result of X-ray energy dispersive spectroscopy (XEDS) of the carbon nanotubes shows that it is composed of carbon. The selected area electron diffraction (SAED) pattern shows spots consistent with (002) plane and (004) plane of 2H graphite having d=0.338 nm and d=0.169 nm which indicate the existence of a graphite-like atomic arrangement[3] and were observed consistent with the results of Kawasaki[4].

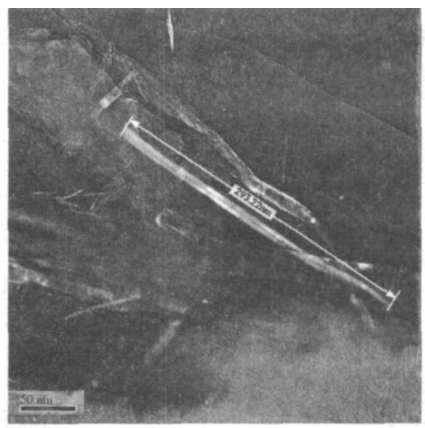

Fig. 1 HRTEM image of the CNTs

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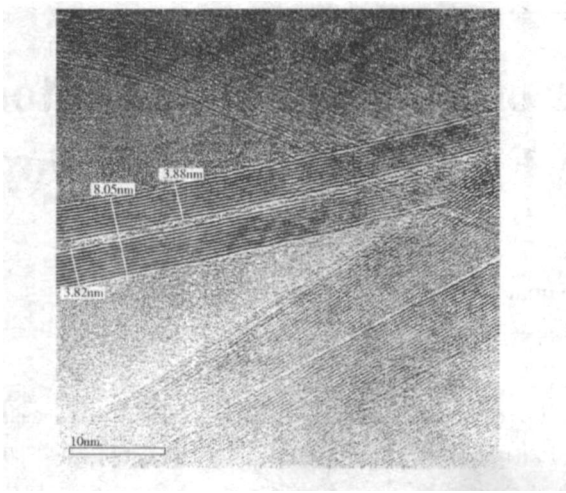

Fig. 2　HRTEM lattice fringe image of the CNTs

2.2　Discussion

Based on the chemical composition of alkali feldspar and plage feldspar by electron microprobe, the forming temperature and pressure has been calculated according to the method provided by Green[5]. The temperature was 626.79 ~ 927.03 ℃ and pressure at 9165.97×10^5 ~ 20652.07×10^5 Pa. The forming model of carbon nanotubes in the Sujiquan graphite ore deposit can be summarized as follows: at the early stage, the Sujiquan granite body intruded along Qingshui-Sujiquan large fault during middle period of Hercynian and assimilated the high carbon-bearing rock in the process of intruding. In the process of the formation of magmatic assimilation, Xinjiang Sujiquan graphitized granite which mainly including hornblende graphite granite, graphite-bearing biotite granite and granite formed. Finally, a large number of spherical ores and carbon nanotubes had been formed in the conditions of boiling and rolling of magma.

3　Conclusions

The present results indicate that natural processes can indeed produce all the different allotropic carbon forms known to date. The variations in the graphitization degree are likely dependent on different variables (temperature, pressure, metal catalysts) that occur in nature, particularly in the Earth's crust which influence the crystalline structure of the natural materials. Based on the chemical composition of alkali feldspar and plage feldspar by electron microprobe, the forming temperature and pressure has been calculated according to the method provided by Green[5]. The temperature was 626.79 ~ 927.03 ℃ and pressure at 9165.97×10^5 ~ 20652.07×10^5 Pa. This kind of CNTs occurring in the graphite ore deposit has excellent mechanic properties and high elasticity. Furthermore, it has very important theoretical and practical significance to study the genesis, structure, properties and purification process and can guide researchers to design the better methods on synthesis.

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石墨矿床中产出的天然纳米碳管

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摘　要：纳米碳管因其特有的性质已成为一种引人注目的材料。本文报道了产于新疆苏吉泉石墨矿床中的天然纳米碳管，并对其进行了高分辨电子显微镜研究。该发现表明迄今为止所有碳的同素异形体均可产于自然界，并且高温、压力、催化剂颗粒在产生纳米碳管的过程中起到了非常重要的作用。计算了石墨化花岗岩的形成温度和压力等条件。该发现对指导科学家合成纳米碳管和利用该矿床具有十分重要的意义。

关键词：矿物结构；纳米碳管；高分辨电子显微镜；矿床成因

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