IMPLICATIONS OF CARBON AND NITROGEN EVOLUTION AND SOURCES DEEP INSIDE THE EARTH FROM THE STUDY OF C AND N ISOTOPES AND N CONCENTRATIONS IN DIAMONDS FROM FUXIAN AND MENGYIN, China

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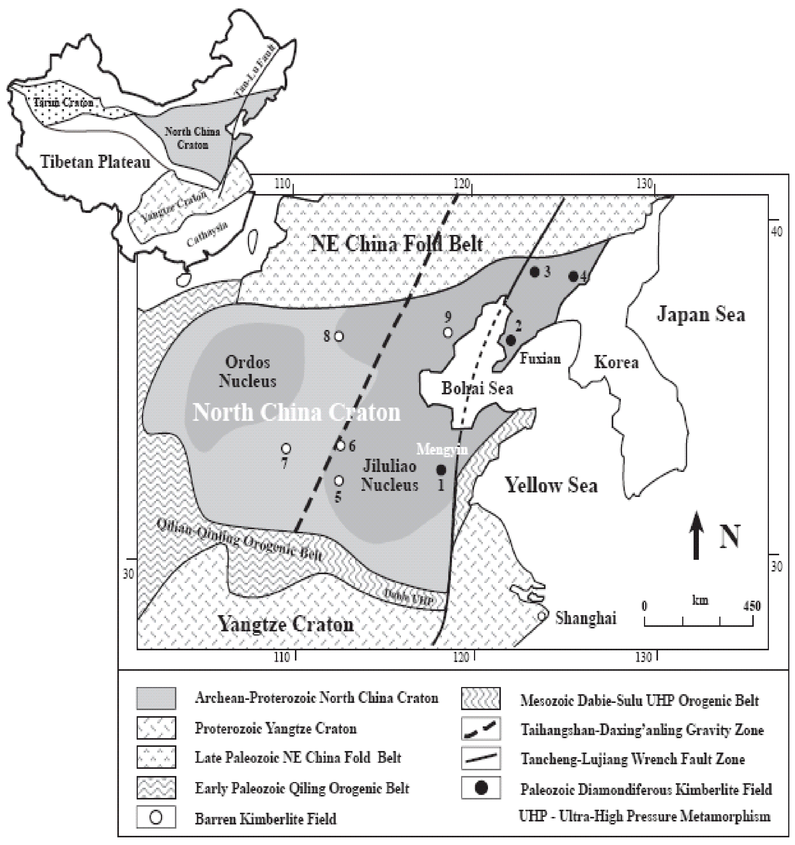
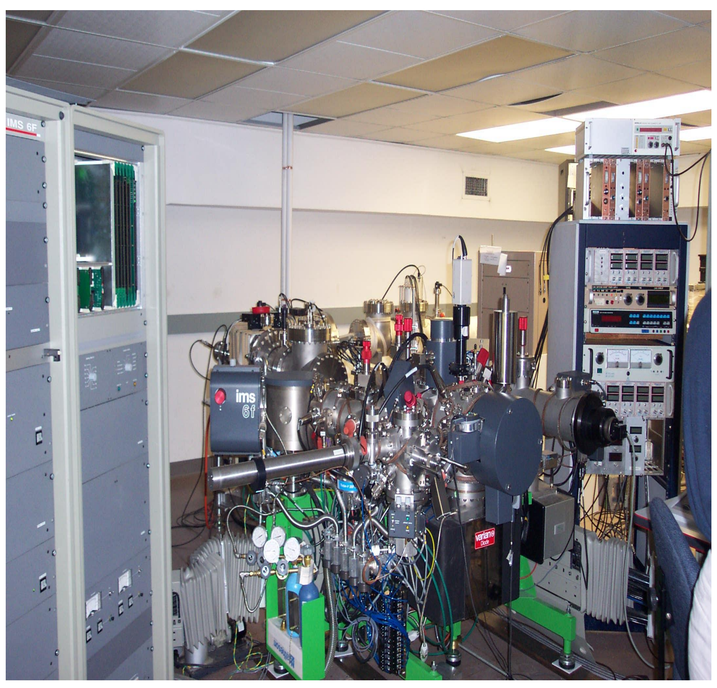
Introduction

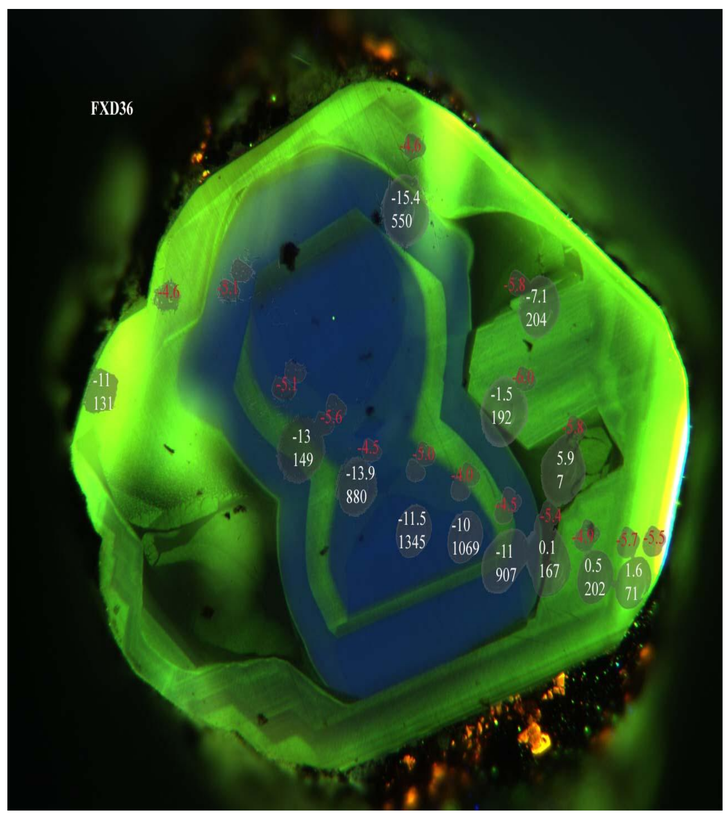
Previous studies of inclusions in diamonds indicate they are among the oldest minerals on Earth (3.5 Ga, Westerlund et al., 2006), but also formed over extended periods of time and at various depths in the Earth (as deep as lower mantle). Diamonds are among the best record keepers of physical and chemical conditions inside the Earth. Both Fuxian and Mengyin diamonds are from Paleozoic kimberlite pipes within the Archean Sino-Korean craton. Almost all inclusions in these diamonds are peridotitic (dominantly harzburgitic). Growth zonation in Fuxian and Mengyin diamonds are commonly observed in their cathodoluminescence (CL) images.

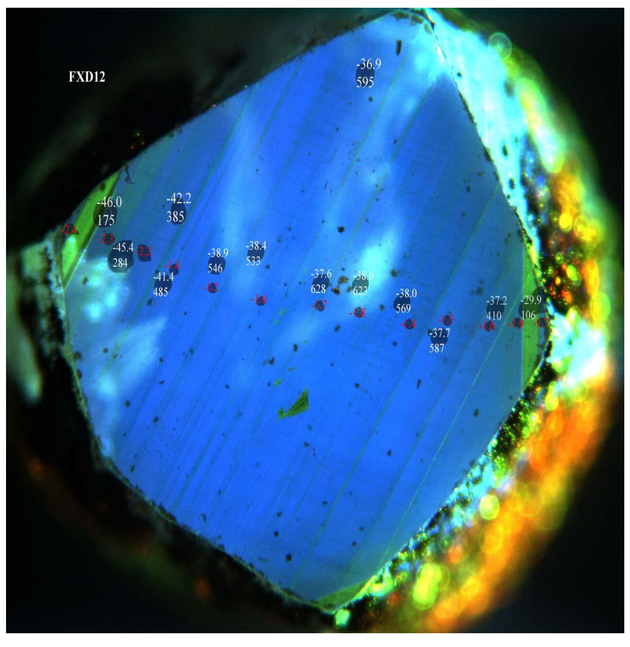
Method

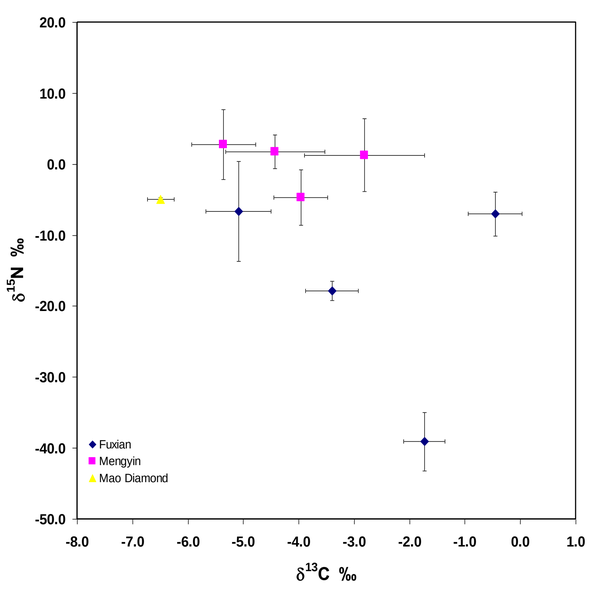
We measured C and N isotopes and N concentration profiles from 10 Fuxian and 12 Mengyin diamond plates using a Cameca 6f ion microprobe. For Fuxian, the average results are $\delta^{13}C$: −3.1 (−6.8 to 0.5) ‰; $\delta^{15}N$: −17 (−46 to 6) ‰; N concentrations: 398 (0 to 1226) ppm. For Mengyin, the results are $\delta^{13}C$: −4.3 (−6.1 to −1.0) ‰; $\delta^{15}N$: −5 (−14 to 4) ‰; N concentrations: 291 (1 to 1611) ppm. Carbon isotope compositions are almost identical to the result previously reported using conventional bulk analyses methods (Fuxian: −3.5±1.5‰, Cartigny et al., 1997 and Mengyin: −4.0±1.0‰, Zhang et al., 1999), within the range of worldwide peridotitic diamonds.

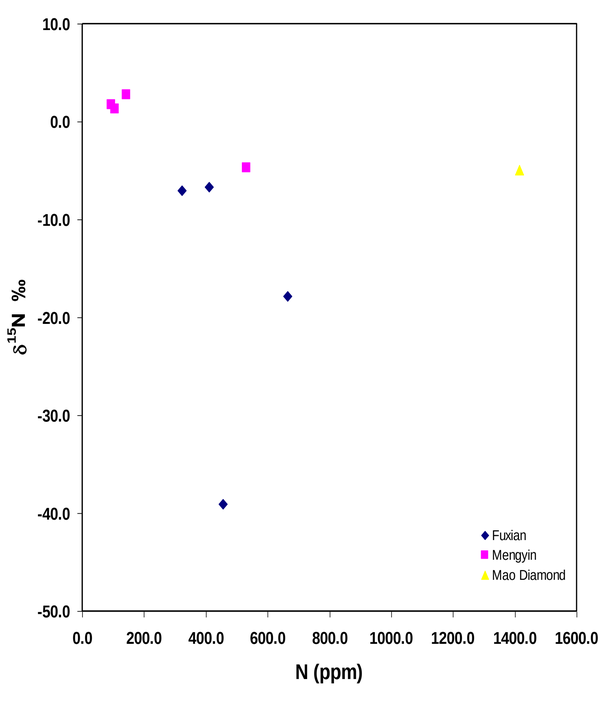












Most isotopic profiles show little zonation, and growth layers revealed by CL images are related to highly variable N concentrations in diamonds. $\delta^{15}N$ in terrestrial materials have rarely been found lower than −20 ‰. Cartigny et al. (1997) first reported −25 ‰ of $d^{15}N$ in a Fuxian diamond. We detected two Fuxian diamonds of extremely negative N isotopes (−18‰ and −37‰); these values are too light to have been derived from simple isotopic fractionation of upper mantle nitrogen (−5‰). Similarly negative N isotopes were measured in enstatite chondrites (−40‰ to −30‰, Kung and Clayton, 1978) and Allende chondrite (ca. −20‰, Thiemens and Clayton, 1981). These results will be verified with the further work on a NanoSIMS 50L using a new set of diamond standards. Our SIMS measurements provide further support that isotopically-light nitrogen lies deep within the Sino-Korean craton. Possible explanations include: (1) preservation of enstatite chondrite nitrogen accreted into the early Earth; (2) chemical evolution in a N-bearing fluid (perhaps containing ammonia) experiencing multi-stage open-system fractionation; and (3) recycling of ancient Achean crustal/atmospheric nitrogen depleted in ^{15}N (Beaumont and Robert, 1999).

References

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