

11. Pfeiffer, S. R., Dillon, P., Ragusa, S. and Hutson, J., Injection well clogging processes during aquifer storage and recovery (ASR) with reclaimed water. In *Management of Aquifer Recharge for Sustainability* (ed. Dillon, P. J.), Proceedings of the International Symposium on Artificial Recharge 4, Adelaide (22–26 September 2002), A. A. Balkema Publishers, Tokyo, 2002, pp. 189–194.
12. Malik, R. S., Jhorar, B. S., Jhorar, R. K. and Streck, T., Retrofittings in cavity type irrigation tubewells for artificial ground water recharge for sustaining rice ecosystem. Proceedings of National Workshop on Rainwater and Ground Water Management for Rice Ecosystem, Kharagpur, India, 2000, pp. 1–21.
13. Meigs, L. C. and Beauheim, R. L., Tracer tests in a fractured dolomite: 1 Experimental design and observed tracer recoveries. *Water Resour. Res.*, 2001, **37**(5), 1113–1127.
14. Boochs, P. W. and Barovic, G., Numerical model describing groundwater treatment by recharge of oxygenated water. *Water Resour. Res.*, 1981, **17**, 49–56.
15. Faust, S. D. and Vecchioli, J., Chemical problems associated with the injection of highly treated sewage into a deep sand aquifer. *J. Am. Water Works Assoc.*, 1974, **66**(6), 371–377.
16. Gerges, N. Z., Howles, S. R. and Dillon, P. J., Town water supply purification using aquifer storage and recovery in a saline aquifer. In *Management of Aquifer Recharge for Sustainability* (ed. Dillon, P. J.), Proceedings of the International Symposium on Artificial Recharge 4, Adelaide (22–26 September 2002), A. A. Balkema Publishers, Tokyo, 2002, pp. 459–464.
17. Pavelic, P., Dillon, P. J. and Simmons, C. T., Lumped parameter estimation of initial recovery efficiency during aquifer storage and recovery. In *Management of Aquifer Recharge for Sustainability* (ed. Dillon, P. J.), Proceedings of the International Symposium on Artificial Recharge 4, Adelaide (22–26 September 2002), A. A. Balkema Publishers, Tokyo, 2002, pp. 285–290.
18. Ragone, S. E. and Vecchioli, J., Chemical interaction during deep well recharge, Bay Park, New York. *Ground Water*, 1975, **13**, 17–24.
19. Troester, J. W. and Richards, R. T., Geochemical properties and saline-water intrusion in the valle de Yabucoa alluvial aquifer, Southeastern Puerto Rico. US Geological Survey Water-Resources Investigations Report 96-4188, 1996, p. 39.
20. Goyal, V. P., Goralpuri, V. N. and Singh, M., Distribution of clay minerals in the semi arid region soils of a part of southern Haryana. *Int. J. Trop. Agric.*, 1990, **8**(2), 154–165.
21. Duggal, S. L., *Water Resources of Haryana*, Publication Division, HAU, Hisar, India, 1977, pp. 1–64.
22. Walkley, A. and Black, L. A., An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Sci.*, 1934, **37**, 29–38.

**ACKNOWLEDGEMENTS.** We thank Volkswagen Foundation, Germany for providing ASR facilities under the Indo-German collaborative project 'Artificial recharge of groundwater through cumulative sand filter – recharge well technique' between the Chaudhary Charan Singh Haryana Agricultural University and the University of Hohenheim, Institute for Soil Science and Land Evaluation (Biogeophysics Section). We also thank German Academic Exchange Service (DAAD), Germany for providing financial assistance to carry out part of the research work at the University of Hohenheim, Institute for Soil Science and Land Evaluation (Biogeophysics Section), under Sandwich model of DAAD fellowship.

Received 14 July 2010; revised accepted 25 January 2011

## Carbon isotopic evidence for the origin of Himalayan graphite from Almora crystallines

Rajesh Sharma<sup>1,\*</sup>, Rakhi Rawat<sup>1</sup> and Randall Law<sup>2</sup>

<sup>1</sup>Wadia Institute of Himalayan Geology, Dehra Dun 248 001, India

<sup>2</sup>University of Wisconsin, Madison, USA

**Graphite is widely associated with the metasedimentary rocks of the Almora Group, predominantly in the Gumalikhet Formation, which were metamorphosed up to the upper amphibolite grade. This graphite occurs in the form of layers, bands, pockets and lenses, hosted within the garnetiferous mica schist and quartzite. The carbon isotope analyses of the representative samples of Almora graphite are presented here. The  $\delta^{13}\text{C}$  values range from  $-23.2\%$  to  $-31.7\%$ , however with mean value of  $-29.08\%$ , which attributes that graphite is crystallized from the biogenic carbon during the metamorphism of the host sediments.**

**Keywords:** Almora crystallines, carbon isotopes, graphite, origin of graphite.

ALMORA nappe, the largest among the detached thrust sheets of the crystalline rocks in the Lesser Himalaya, extends from the West of Nayar River to the East of Kali River in Indian Himalaya, and further to the Dandeldhura region in western Nepal. It comprises the allochthonous Precambrian crystalline rocks termed as Almora Group<sup>1–7</sup>, which from their root zone of the Munsiri Formation, are thrust over the Precambrian–Lower Palaeozoic autochthonous metasedimentary sequence of the Lesser Himalaya. The rocks of the Almora Group are bounded by Almora Thrust which in the North separates them from the underlying metasedimentaries, and in the South forms the contact with low grade rocks of the Ramgarh Group<sup>7</sup>. The extension of this thrust in the western Nepal is designated as Dandeldhura Thrust<sup>2</sup>. Some of the workers considered that the Almora nappe includes both the Ramgarh Group and the overlying Almora Group<sup>2–4</sup>. The Almora Group comprises granitic and pelitic gneisses, gneissose granite, augen gneisses, granite, mica schists, garnetiferous mica–quartz schists, quartzite and phyllites<sup>8,9</sup>. The Rb–Sr whole rock age assigned to the granitic gneiss of the Munsiri Formation is  $1830 \pm 200 \text{ Ma}$ <sup>10</sup>, and to the gneisses from a similar nappe in Lesser Himalaya is  $1865 \pm 50 \text{ Ma}$ . The granitic intrusions present in the nappe are about  $560 \pm 20 \text{ Ma}$ -old<sup>11</sup>. A number of workers have studied the geology, structure, petrology and metamorphism of the Almora Group<sup>3–9</sup>. Valdiya<sup>7</sup> classified rocks of the Almora Group into three formations, viz.

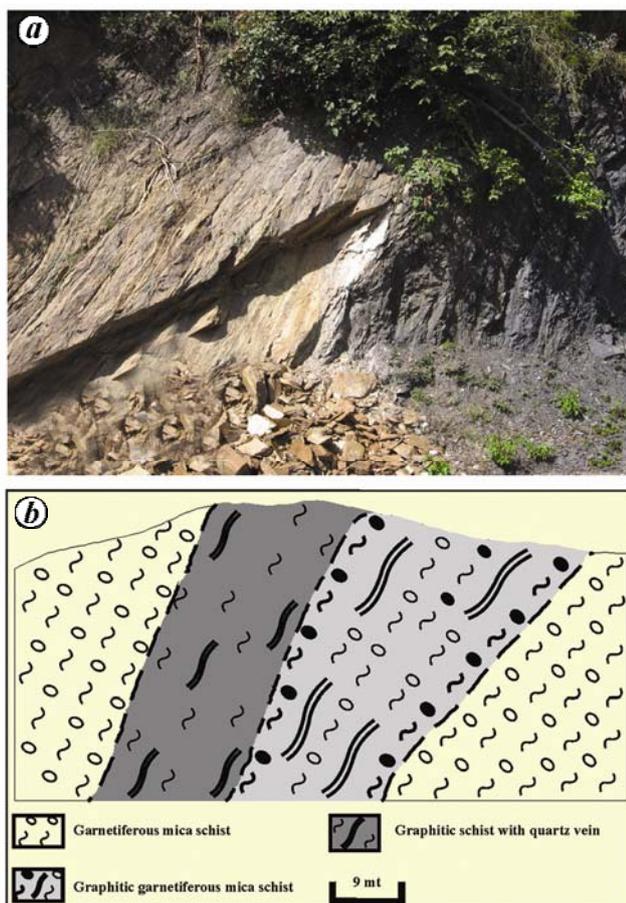
\*For correspondence. (e-mail: sharmarajesh@wihg.res.in)

Saryu Formation, Champawat Granodiorite and Gumalikhet Formation. Whereas a few other workers<sup>4</sup> consider two broad divisions for Almora Group, viz. the Saryu Formation largely consisting of the metamorphosed sediments and the Champawat Granodiorite. Recent studies have shown the records of metamorphism up to kyanite grade, and T–P varying from 450°C, 4 kb to 709°C, 7.9 kb in the rocks of the Almora Group<sup>4</sup>.

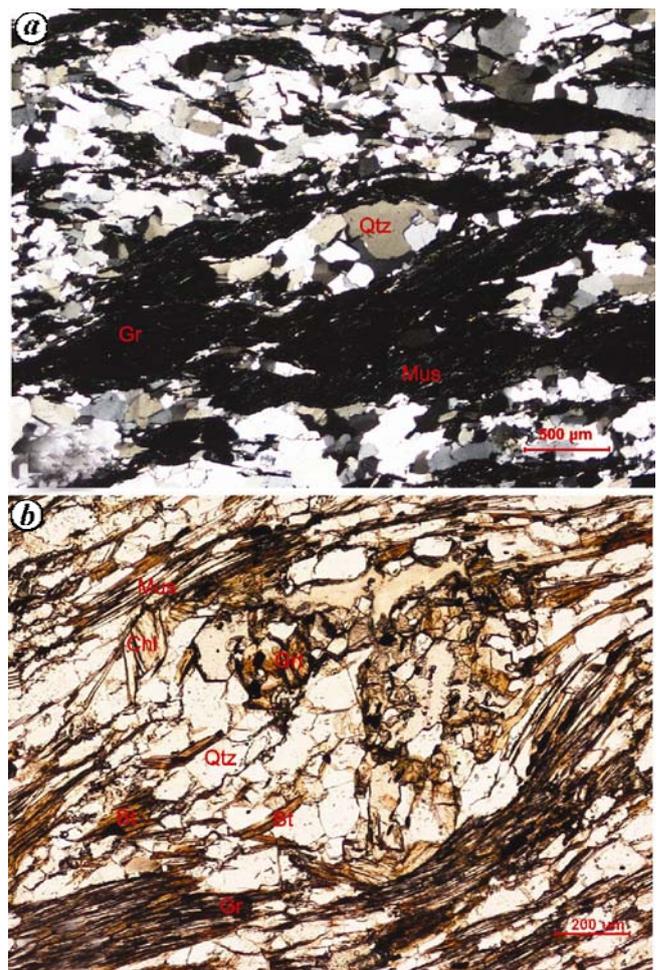
The graphite is common in the schists and gneisses of the Lesser and Higher Himalaya, and is particularly widespread in the Kumaun Himalaya. Earlier work<sup>12</sup> (Bhattacharji, T. K., 1965, unpublished report) carried out on this graphite reports the deposits of graphite schist near Persal, Sirar and Kalimat areas in the Kumaun Himalaya, wherein the reserves of Sirar and Kalimat area are estimated about 8–10 m tonne each. The occurrences of the graphite are also reported in the Munsiri Formation proposing that this was formed by the metamorphism of the organic material<sup>7</sup>. Conclusive evidence for the origin of widely scattered graphite in Lesser Himalaya has been largely awaited. We present here the carbon isotope data of the representative graphite from the Almora Group as

evidence to delineate the origin of the Lesser Himalayan graphite. Graphite is found as small occurrences to the sizable deposits in the Almora Group of rocks, wherein it is either present as graphitic schist or quartzitic graphite. It occurs in the forms of layers, nodules, lenses and pockets (Figure 1). The host rocks for this graphite are garnetiferous mica schist and micaceous flaggy quartzite of the Gumalikhet Formation (Figure 2). The minerals associated with graphite are quartz, biotite, muscovite, chlorite, garnet, feldspar, tourmaline and apatite. Specks of the opaque minerals such as pyrite, illmenite and uncommon chalcopyrite are also seen though not ubiquitous. These sulphide minerals are often altered to goethite, limonite and malachite. Under the reflected light microscopy Almora graphite is strongly pleochroic and anisotropic. The grains and the laths of this graphite are anhedral to subhedral in shape. They are disseminated in the host rock, and usually aligned along the foliation enveloping quartz and garnet grains.

The graphite may be found associated with genetically diverse rock types such as magmatic, chemical precipitated calcareous rocks or the metamorphosed pelites, and



**Figure 1.** *a*, Field photograph of a typical graphite enriched zone in Almora crystallines. *b*, Schematic diagram of the geological cross-section of graphite mineralized zone in garnetiferous mica schist.



**Figure 2.** *a*, Photomicrograph of the graphitic quartzite. *b*, Photomicrograph of the garnetiferous mica schist with graphite flakes.

the source of carbon in graphite can be biogenic or abiogenic<sup>13-17</sup>. The organic material present within the sediments can be converted to graphite or carbon may be abiogenic directly precipitated from the C–O–H fluids in the reducing environment. The devolatilization and decarbonation reactions during metamorphism particularly in the presence of carbonate minerals can produce carbon through the released CO<sub>2</sub> (ref. 17). The amorphous carbon can be converted to graphite or even diamond when subjected to the suitably high pressure and temperature conditions<sup>18,19</sup>. Overall, the graphite disseminated in the host rocks is considered to have crystallized from the carbonaceous material. Whereas, the carbon for the graphite occurring as veins and along the shear zones is deemed to have derived from magmatic/metamorphic fluids. In view of such diversity in graphite formation, the source of carbon is vital in understanding the graphite origin. The carbon isotopic ratio (<sup>13</sup>C/<sup>12</sup>C) in graphite has potential for discriminating its various origins<sup>20</sup>. This is supported by a number of studies carried out on the carbon isotopic composition of graphite<sup>13,14,16,21,22</sup>. These studies have established that the graphite formed through the participation of biogenic carbon is enriched in the <sup>12</sup>C, whereas the graphite formed from the abiogenic carbon has high <sup>13</sup>C. The ratio of these isotopes of carbon is represented by δ<sup>13</sup>C‰, which can typically characterize the source of carbon involved in graphite crystallization. The δ<sup>13</sup>C‰ can be expressed through the formula: δ<sup>13</sup>C‰ = [(<sup>13</sup>C/<sup>12</sup>C) graphite sample / (<sup>13</sup>C/<sup>12</sup>C) standard] – 1] × 1000, wherein the standard is carbon isotopes in belemnite of the Pee Dee Formation (PDB) of Chicago.

The carbon isotope analyses of six numbers of the selected graphite samples were carried out at the Environmental Isotope Laboratory, Department of Geosciences, University of Arizona. The selected samples represent different bands of graphite occurring in Lohaghat, Sirar, Makraon and the Banlekh areas. All these locations are within the Almora nappe, and comprise Almora Group of rocks. Five samples represent typical graphite found within the Gumalikhhet Formation, whereas one sample (RR-2) from the Banlekh area represent minor graphite occurrence within the Champawat Granodiorite. Overall, four samples from the graphite schists and two from the graphitic quartzite have been analysed. The δ<sup>13</sup>C of graphite were measured on a continuous-flow gas-ratio mass spectrometer, Finnigan Delta PlusXL coupled to an elemental analyser. The samples were combusted in the elemental analyser. Standardization for δ<sup>13</sup>C is based on acetanilide for elemental concentration, NBS-22 and USGS-24. Precision based on repeated internal standards is better than ± 0.09‰ for δ<sup>13</sup>C.

The obtained values of δ<sup>13</sup>C for Almora graphite are shown in Table 1. It is evident that δ<sup>13</sup>C values for the studied graphite vary from –23.2‰ to –31.7‰, with a mean value of –29.08‰. However, the value of –23.2 is obtained only for one sample (RR-2) collected from near

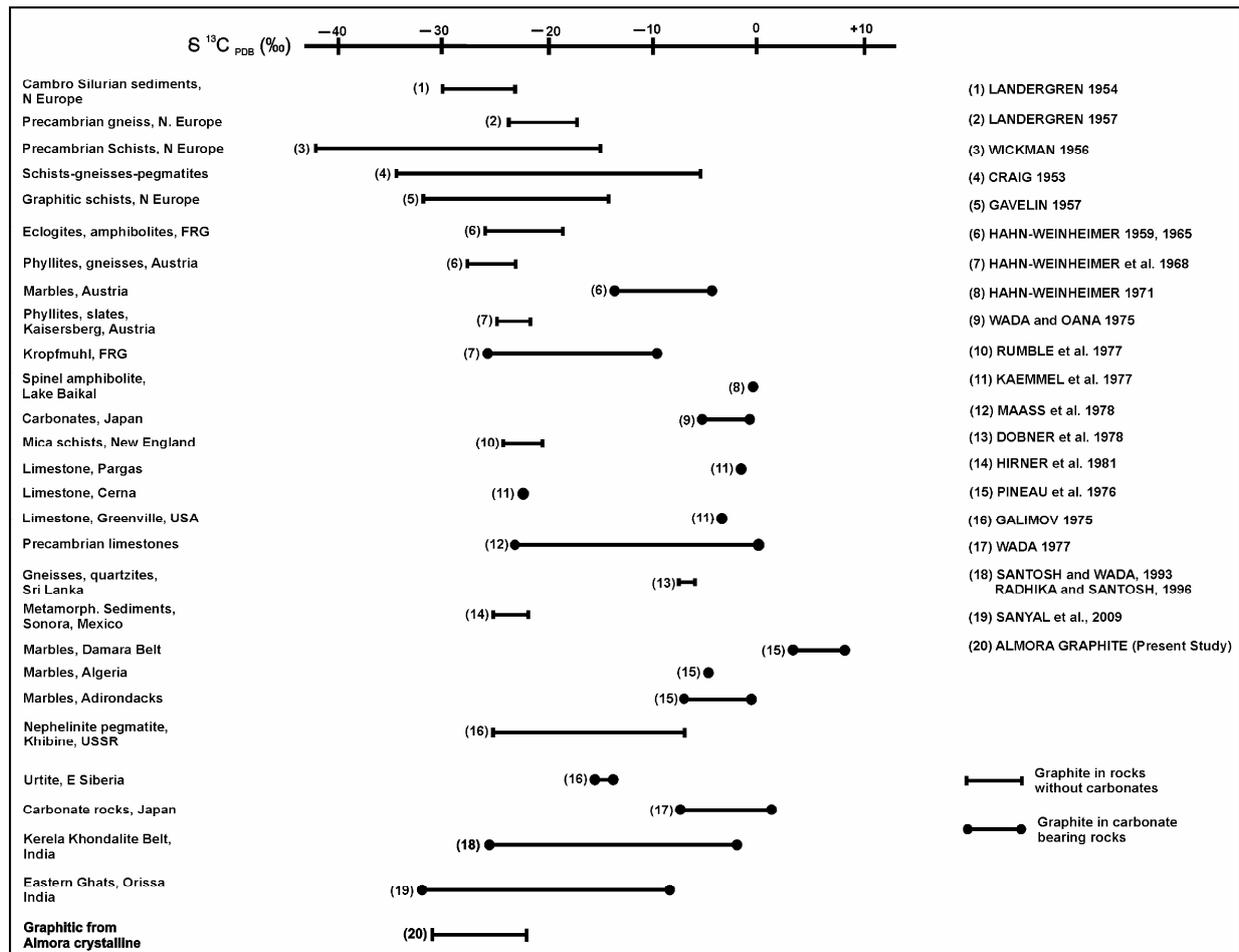
Banlekh, close to the southern border of Almora nappe. This sample is from the uncommon thin graphite bands hosted within the schists that are part of the Champawat Granodiorite Formation. The δ<sup>13</sup>C values for other samples vary between –29.4 and –31.7, and those obtained for graphite schists and the quartzitic graphite are matching. There is also no difference between δ<sup>13</sup>C obtained for the graphite from different locations within the Gumalikhhet Formation of Almora Group, such as for the Sirar deposit and for the graphite bands from the Makraoun area.

In general, the carbon isotope ratios in graphite vary from +10‰ to –45‰ as compared to the standard PDB‰. The graphite formed by the carbon generated through the decomposition reactions possible in the carbonate lithology shows δ<sup>13</sup>C values between about +10‰ and –5‰. Whereas the δ<sup>13</sup>C values for the magmatic carbon range from –7‰ to –15‰. The δ<sup>13</sup>C values of graphite derived from the organic carbon vary from –17‰ to as low as –40‰. The mean δ<sup>13</sup>C values given by Galimov<sup>23</sup> are characteristics for the carbon derived from different sources, viz. it is 0‰ in carbon from the carbonates and –7‰ for the magmatic source. The lowest value (cf. –24‰) is for the organic carbon.

The work carried out on a wide variety of graphite also shows that distinctive values of δ<sup>13</sup>C are obtained for graphite crystallized from carbon of diverse origin (Figure 3). Even within a deposit of graphite, the δ<sup>13</sup>C may show variation with respect to carbon source and thereby the origin of graphite. Such results are evident in graphite present in the Kerala Khondalite Belt wherein the range of δ<sup>13</sup>C from –8.2‰ to –12.4‰ is measured for the shear-hosted graphite, and from –10.1‰ to –15.1‰ are for the pegmatite-hosted graphite. Herein, further contemplation is available from the graphite disseminated in the country rock showing enrichment of lighter carbon with δ<sup>13</sup>C from –17.5‰ to –31.1‰, which attribute biogenic carbon<sup>21,22,24</sup>. The study on the single graphite crystal suggested that a variation in the carbon isotope is possible during the overgrowth depending on the carbon source<sup>25</sup>. The δ<sup>13</sup>C of vein deposited graphite from Bogala Mine, Srilanka shows a mean value of –7.76‰, and its range is interpreted as it is fluid-deposited graphite with carbon source from the mantle<sup>26</sup>. The wide range of δ<sup>13</sup>C for graphite from Eastern Ghats is about –2.4‰ to –26.6‰, which points to the graphite origin from the carbon of different sources, i.e. by the metamorphism of

**Table 1.** Carbon isotope data for the graphite in Almora crystallines

Sample No.	δ <sup>13</sup> C (‰)		
RR-2	–23.2	SD	0.09
RR-43	–31.3	True value	–29.48
RR-44	–31.7	Offset	–0.41
RR-173	–29.4	Mean	–29.08
RR-451	–31.3		
RR-452	–31.3		



**Figure 3.** Diagram showing the range of  $\delta^{13}\text{C}$  values in Almora graphite together with known graphite deposits of the world. (Modified after Dis-sanayake<sup>16</sup>.) For the references cited in the figure, the readers are referred to Dis-sanayake<sup>16</sup>, and Hahn-Weinheimer and Hirner<sup>20</sup>.

organic material, through the carbonates sources and/or mantle derived<sup>27</sup>.

The  $\delta^{13}\text{C}$  obtained for the Almora graphite is  $-23.2\text{‰}$  to  $-31.7\text{‰}$  with an average of  $-29.08\text{‰}$ , but most samples show narrow range of  $-29.4$  to  $-31.7\text{‰}$ . These measured values suggest that the Almora graphite is formed through the metamorphism of the organic carbon. This organic carbon was possibly derived from the carbonaceous material distributed in the sediments during their deposition<sup>28</sup>. The graphite associated with the Almora crystalline rocks is scattered within the schists and the quartzites, and the carbonate lithology is also not significant in the host rocks. The  $\delta^{13}\text{C}$  range rules out the possibility of the fluid deposited graphite, which is also substantiated by the disseminated nature of this graphite, presence of graphite nodules and its widely scattered nature. A comparison of the  $\delta^{13}\text{C}$  values obtained for Almora graphite with the globally known major graphite deposits (Figure 3) also attributes that our data match well with the  $\delta^{13}\text{C}$  values presented earlier for the graphite crystallized from organic carbon during metamorphism of host sediments.

1. Heim, A. and Gansser, A., Central Himalaya – geological observations of Swiss Expedition 1936. *Mem. Soc. Helv. Sci. Nat.*, 1939, **73**, 1–245.
2. DeCelles, P. G., Robinson, D. M., Quade, J., Ojha, T. P., Garzicione, C. N., Copeland, P. and Upreti, B. N., Stratigraphy, structure and tectonic evolution of the Himalayan fold-thrust belt in western Nepal. *Tectonics*, 2001, **20**(4), 487–509.
3. Joshi, M., Evolution of the Basal Shear Zone of the Almora Nappe, Kumaun Himalaya. *Mem. Gond. Res. Gr. Mem.*, 1999, **6**, 69–80.
4. Joshi, M. and Tiwari, A. N., Structural events and metamorphic consequences in Almora Nappe, during Himalayan collision tectonics. *J. Asian Earth Sci.*, 2009, **34**, 326–335.
5. Misra, R. C. and Sharma, R. P., Structure of the Almora crystallines, Lesser Himalaya: an interpretation. *Himalayan Geol.*, 1972, **2**, 330–341.
6. Misra, R. C., Sharma, R. P. and Sinha, A. K., Petrochemistry of the Almora crystallines, Kumaun Himalaya. *Himalayan Geol.*, 1973, **3**, 411–435.
7. Valdiya, K. S., *Geology of Kumaun Lesser Himalaya*, Wadia Institute of Himalayan Geology, Dehradun, 1980, p. 291.
8. Agarwal, K. K., Tectonic evolution of the Almora crystalline zone, Kumaun Lesser Himalaya: a reinterpretation. *J. Geol. Soc. India*, 1994, **43**, 5–14.
9. Chakraborty, S. K. and Malaviya, A., Geology of the Almora group of Kumaun Lesser Himalaya. *Geol. Surv. India Spl. Pub.*, 1996, **21**(1), 39–45.

10. Bhanot, V. B., Singh, V. P., Kansal, A. K. and Thakur, V. C., Early Proterozoic Rb–Sr whole-rock ages for Central Crystalline Gneiss of Higher Himalaya, Kumaun. *J. Geol. Soc. India*, 1977, **18**, 90–91.
11. Trivedi, J. R., Gopalan, K. and Valdiya, K. S., Rb–Sr ages of granitic rocks within the Lesser Himalayan Nappes, Kumaun, India. *J. Geol. Soc. India*, 1984, **25**, 641–654.
12. Krishnamurthy, M. and Krishnaswamy, V. S., Status of mineral exploration and reserves in northwest Himalaya. In Seminar on Himalayan Geology, New Delhi preprint. *Geol. Surv. India Misc. Publ.*, 1976, **41**(VI), 291–352.
13. Dissanayake, C. B., The origin of graphite of Sri Lanka. *Org. Geochem.*, 1981, **3**, 1–7.
14. Weis, P. L., Friedman, I. and Gleason, J. P., The origin of epigenetic graphite: evidence from isotopes. *Geochim. Cosmochim. Acta*, 1981, **45**, 2325–2332.
15. Katz, M. B., Graphite deposits of Sri Lanka: a consequence of granulite facies metamorphism. *Mineral Deposit*, 1987, **22**, 18–25.
16. Dissanayake, C. B., Origin of vein graphite in high-grade metamorphic terrains. *Mineral Deposit*, 1994, **29**, 57–67.
17. Hapuarachchi, D. J. A. C., Decarbonation reactions and the origin of vein-graphite in Sri Lanka. *J. Nt. Sci. Council*, 1977, **5**, 29–32.
18. Landis, C. A., Graphitization of dispersed carbonaceous material in metamorphic rocks. *Contrib. Mineral. Petrol.*, 1971, **30**, 34–45.
19. Buseck, P. R. and Bo-Jun, H., Conversion of carbonaceous material to graphite during metamorphism. *Geochim. Cosmochim. Acta*, 1985, **49**, 2003–2016.
20. Hahn-Weinheimer, P. and Hirner, A., Isotopic evidences for the origin of graphite. *Geochem. J.*, 1981, **15**, 9–15.
21. Santosh, M. and Wada, H., A carbon isotopes study of graphites from the Kerala Khondalite Belt, Southern India: evidences for CO<sub>2</sub> infiltration in granulites. *J. Geol.*, 1993, **101**, 643–651.
22. Radhika, U. P. and Santosh, M., Shear-zone hosted graphite in southern Kerala, India: implications for CO<sub>2</sub> infiltration. *J. South-east Asian Earth Sci.*, 1996, **14**, 265–273.
23. Galimov, E. M., *Carbon Isotopes in Oil and Gas Geology*, NASA Translation-TTF, Washington, 1975.
24. Eichman, R. and Schidlowsky, M., Isotopic fractionation between coexisting organic carbon–carbonate pairs in Precambrian sediments. *Geochim. Cosmochim. Acta*, 1975, **39**, 589–595.
25. Santosh, M., Wada, H., Satish-Kumar, M. and Binu-Lal, S. S., Carbon-isotope ‘Stratigraphy’ in a single graphite crystal: implications for the crystal growth mechanism of fluid-deposited graphite. *Am. Mineral.*, 2003, **88**, 1689–1696.
26. Dobner, A., Graf, W., Hahn-Weinheimer, P. and Hirner, A., Stable carbon isotopes of graphite from Bogala Mine, Sri Lanka. *Lithos*, 1978, **11**, 251–255.
27. Sanyal, P., Acharya, B. C., Bhattacharya, S. K., Sarkar, A., Agrawal, S. and Bera, M. K., Origin of graphite, and temperature of metamorphism in Precambrian Eastern Ghats Mobile Belt, Orissa, India: a carbon isotope approach. *J. Asian Earth Sci.*, 2009, **36**, 252–260.
28. Rawat, R. and Sharma, R., Features and characterization of graphite in Almora crystallines and their implication for the graphite formation in Lesser Himalaya, India. *J. Asian Earth Sci.*, 2011 (in press).

ACKNOWLEDGEMENTS. We thank the Director, Wadia Institute of Himalayan Geology, Dehra Dun for the encouragement and permission to publish this work. The carbon isotope analyses were done by Chris Eastoe of the Department of Geosciences, University of Arizona.

Received 17 June 2010; accepted 12 January 2011

## Development of non-radioactive probes for specific detection of *Dasheen mosaic virus* infecting *Amorphophallus paeoniifolius*

Binoy Babu, Vinayaka Hegde\*, T. Makesh Kumar and M. L. Jeeva

Division of Crop Protection, Central Tuber Crops Research Institute, Thiruvananthapuram 695 017, India

**A cDNA fragment ca. 1.2 kb encoding the coat protein and the 3′ untranslated region (UTR) of *Dasheen mosaic virus* (DsMV) infecting *Amorphophallus paeoniifolius* was successfully amplified from infected plant tissues using specific degenerate primers. Reverse transcription-polymerase chain reaction products were sequenced and found to be derived from the expected virus. Two specific probes, cDNA probe and riboprobe were generated from the amplicon, comprising the coat protein gene and the 3′ UTR. The probes were then successfully used for the diagnosis of the DsMV infecting *A. paeoniifolius* through nucleic acid spot hybridization. The probes detected only the DsMV infecting *A. paeoniifolius*, while they did not detect the DsMV from *Colocasia esculenta* or *Xanthosoma*.**

**Keywords:** *Amorphophallus paeoniifolius*, *Dasheen mosaic virus*, elephant foot yam, *Potyvirus*, riboprobe.

ELEPHANT foot yam (*Amorphophallus paeoniifolius*, family Araceae) is an important edible tropical tuber crop of South-east Asian origin and grown widely in Philippines, Malaysia, Indonesia and Southeastern Asian countries. Due to its high production potential (50–60 t/ha), nutritional and medicinal values and good economic returns<sup>1</sup>, it has achieved the status of a cash crop. The tubers are popularly used as vegetables in various delicious cuisines and in the preparation of indigenous ayurvedic medicines<sup>2</sup>. Among diseases of *A. paeoniifolius*, the mosaic disease caused by *Dasheen mosaic virus* (DsMV) belonging to the genus *Potyvirus* of Potyviridae family is the most destructive. Infection by DsMV causes the leaves of *A. paeoniifolius* to exhibit mosaic, leaf puckering and even shoestring-like symptoms. A major concern of the viral infection is the reduction in the tuber yield, due to perpetuation of the virus through infected planting materials.

In India, 24–88% mosaic incidence with a maximum yield loss up to 38% was reported from *Amorphophallus* growing areas in Uttar Pradesh<sup>3</sup>. In our survey also, viral disease incidence of 5–10% was observed in other major *A. paeoniifolius* growing states of India, viz. Kerala,

\*For correspondence. (e-mail: vhegde18@yahoo.com)