Nuclear India Nov. 1977

Geomagnetic Studies in India

At Gulmarg in Kashmir, the Bhabha Atomic Research Centre operates a High Altitude Research Laboratory. In September this year a magnetic observatory was set up next to the laboratory by the Indian Institute of Geomagnetism as Gulmarg offers some special conditions for studying the effect of magnetospheric processes on the ionospheric current systems, and for geomagnetic survey work. The observatory includes special non-magnetic structures (for housing magnetic instruments) constructed by the Civil Engineering Division of BARC.

by G. K. Rangarajan
Indian Instt. of Geomagnetism, Bombay

THE science of geomagnetism may be considered to have taken roots with the discovery, several centuries ago, of the "directive" property of lodestone – a naturally occurring magnetic material. That the earth behaves like a big magnet has been known for a long time but significant insight into the intricacies of geomagnetic field variations is of recent origin, *i.e.* of the post-satellite era. Through an ingenious method, the method of spherical harmonic analysis, applied to the then scanty geomagnetic data, the German mathematician and astronomer Karl Friedrich Gauss (1777-1855) showed that the bulk of the earth's magnetic field emanates from within. A small but potentially significant fraction (about 1 to 5 per cent) has its origin outside the earth, with the sun as its main source. As it became known that the vast space between the sun and the earth is one huge laboratory freely available for studies on plasmas, launching of satellites with magnetic and other payloads was the next logical step. Information received from these satellites has only underlined the fact that physical theories in themselves are inadequate to explain all the observed geophysical phenomena. To test the validity of several postulates, and to provide reliable ground-based data, a network of magnetic observatories was conceived. Since geomagnetic variations spanning the entire range of frequencies exhibit a latitudinal dependence, it is necessary to have as dense a network of magnetic stations as possible.

India began systematic observation and study of the surface magnetic field almost a century back; it has one of the oldest magnetic observatories of the world located at Bombay-Alibag. To quote a report of the International Association of Geomagnetism and Aeronomy (IAGA):

A view of the High Altitude Research Laboratory campus at Gulmarg showing the non-magnetic Absolute Room of the observatory.

"... the records of Colaba and Alibag were found to form a beautiful series beginning in 1871 and making up perhaps the most complete collection of records in the world, Their quality and, especially their regularity, were particularly impressive even in comparison with Kew and Melbourne records" (*P. N. Mayaud in Bull. No. 33 of the IAGA.*)

Indian Magnetic Observatories

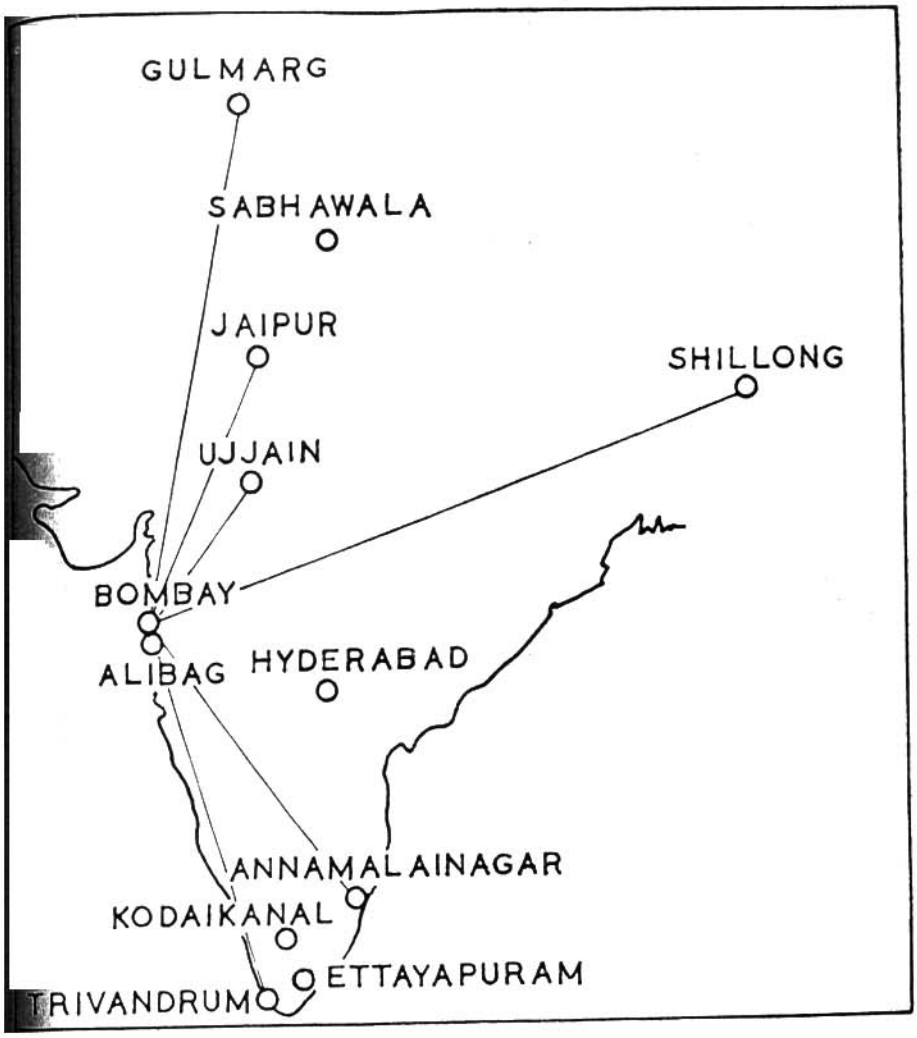
Starting with the establishment of the observatory at Colaba, Bombay in 1846, and ending with the commissioning of the Gulmarg observatory in 1977, there are now 11 magnetic stations, from Trivandrum in the south to Gulmarg in the north. A table showing the location of these observatories and other details is given on page 4.

India is one of the few countries where such a distribution in latitude of land is available. This aspect enables the study, in depth, of several interesting features associated with geomagnetic field variations at low and equatorial latitudes.

Equatorial Electrojet

In the early part of this century a startling discovery was made: geomagnetic field variations in horizontal intensity were found to exhibit an anomalously large range over a small latitude zone centred on the dip equator. This was later known to be associated with the intense band of current flowing from west to east in the ionospheric E-layer called "The Equatorial Electrojet"; analogous to the "jet stream" in meteorology.

A look at the dip 'I' values listed in the Table shows that peninsular India is most favourably situated for a study of this phenomenon and its complexi-



Map showing the location of all permanent magnetic observatories in India, with lines joining those run by the Indian Institute of Geomagnetism.

lies. The magnetic data of the four Indian stations — Trivandrum, Ettayapuram, Kodaikanal and Annamalainagar, together with that of Alibag and Hyderabad have proved most useful in studies relating to:

(i) The nature and magnitude of the equatorial electrojet in the Indian region.

(ii) The question whether the electrojet current is a superposition over the world-wide Sq. currents, or a separate current system.

(iii) The cause and nature of the counter-electrojet phenomenon during periods of which the field at equatorial latitudes shows a depression instead of an enhancement.

(iv) The day-to-day variability and seasonal changes of the electrojet strength and its axis.

(v) The relation between the world-wide Sq. current, and the electrojet current.

(vi) The relation between the strength and direction of the electrojet and the interplanetary magnetic field.

Electromagnetic Induction Within the Earth, and Coastal Effects

The magnetic observatories at Alibag, Trivandrum and Annamalainagar are located close to the coast. Together with the corresponding inland stations at Hyderabad, Ettayapuram or Kodaikanal, significant insight into the problems related to the modulation, by the ocean, of the surface daily variation in geomagnetic field, especially in the vertical component, can be obtained. These and other related studies enable scientists to construct models approximating the snb-surface conductivity distribution in the vicinity of the magnetic observatories, and provide valuable clues to geologists and geo-physicists in the exploitation of natural resources. The magnetic stations at Shillong and Sabhawala would likewise provide data for studies on the distribution of electrical conductivity and depth, to the mantle in the lesser Himalayan regions.

Low-latitude transient variations, bayse, magnetic pulsations and other periodic oscillations

The latitudinal distribution of Indian magnetic stations provides valuable data in unravelling the complex behaviour of transient variations with periods ranging from about a year to a few seconds. Most of these variations have causative mechanisms located above the earth, preferentially in the ionosphere and the magnetosphere. The transformation processes that take place far above the earth, at distances of the order of a few earth radii can be surmised from the records of the magnetic field variation at low latitudes, and those close to the dip equator.

Ground-based monitoring of magnetic pulsations in the range of 2 to about 600 secs. gives extensive information useful in the diagnosis of both the day-side and night-side magnetosphere. The magnetic observatories at Ujjain and Jaipur were specially commissioned with a view to providing a uniform latitudinal distribution of magnetic stations, as a part of a multinational project — Project Geomagnetic Meridian. They are continuing to aid another major international venture, 'The International Magnetospheric Study', during which a comprehensive and unified picture of the outer environment of the earth is likely to emerge.

Lunar magnetic variations

In comparison with the magnitude of the daily variation of the magnetic field associated with the Sun, the amplitudes of oscillations associated with the tidal effect of the moon are much smaller, but they can still be detected by statistical analysis. Such studies, carried out at the Institute, have provided valuable information regarding the

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Special Non-magnetic Lab Room at Gulmarg

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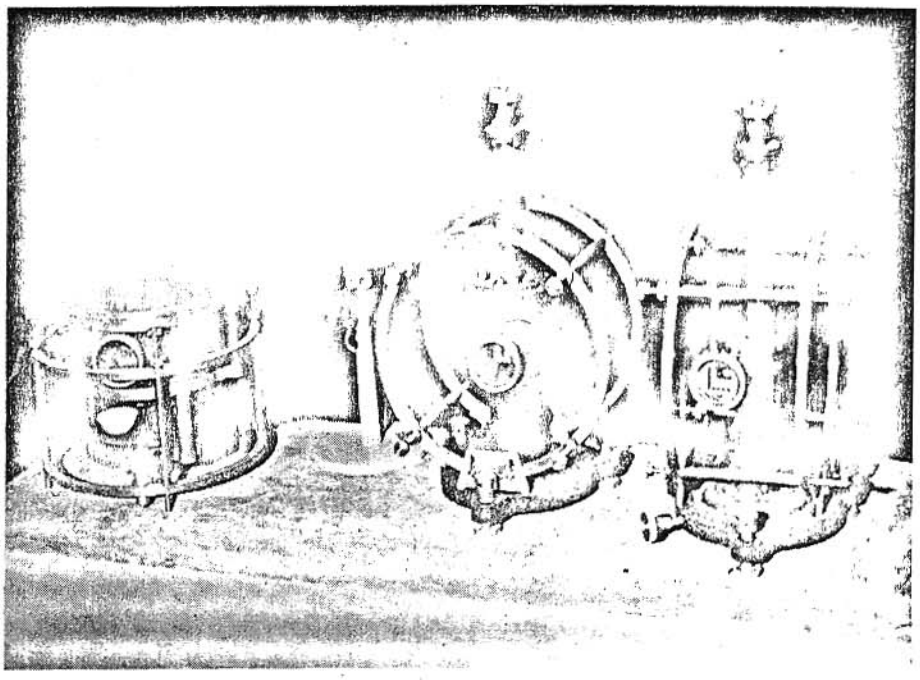
seasonal changes, the dependence of the magnitude of the lunar daily variation on magnetic activity, solar activity, and the distance of the moon from the earth. The observed total variations can also be separated into a part attributed to the ocean currents and another to the ionospheric currents.

Influence of Interplanetary Magnetic Field at Low Latitudes

The strong magnetic field on the Sun's photosphere is stretched out by the streaming plasma; this field, extending past the orbit of the earth, is known to provide the vital link in the energy transfer processes between the interplanetary medium and the magnetosphere. Magnetic data from the Indian chain of observatories have been extensively used in studies related to the influence of the direction, in the ecliptic plane of the Inter-planetary Magnetic Field (IMF), defining the sector structure of the field. Significant correlation between the passage of the boundaries of the sector structure and low latitude geomagnetic field, indices of magnetic activity, and occurrence of magnetic pulsations in different frequency ranges have been established. Association between lunar daily variation and the sector structure of IMF has also been indicated in some studies.



The 3 La Cour variometers installed at Gulmarg to record variations in H, Z and D.

Table

Station	Geographic		Dipole		Functioning from	Organisation*	Approximate values of			
	Lat.	Long.	Lat.	Long.			D	I	H	Z
									nT	nT
Gulmarg	34°03′ N	74°24′ E	24°.5 N	147°.2	1977	IIG	1°30′ E	51°.0	31000	40050@
Sabhawala	30°22′ N	77°48′ E	20°.8 N	149°.8	1964	SOI	0°22′ E	45°.0	34050	34400
Jaipur	26°55′ N	75°48′ E	17°.3 N	147°.4	1975	IIG	0°50′ W	40°.0	36000	29600
Shillong	25°34′ N	91°53′ E	14°.6 N	162°.4	1975	IIG	0°42′ W	35°.0	37700	27200
Ujjain	23°11′ N	75°47′ E	13°.5 N	147°.0	1975	IIG	0°32′ W	33°.0	37300	24250
Alibag	18°38′ N	72°52′ E	9°.5 N	143°.6	1904	IIG	0°50′ W	24°.0	38500	17400
Hyderabad	17°25′ N	78°33′ E	7°.6 N	148°.9	1965	NGRI	1°38′ W	20°.0	39900	14900
Annamalainagar	11°22′ N	79°41′ E	1°.4 N	149°.4	1957	IIG	2°40′ W	5°.5	40500	3900
Kodaikanal	10°14′ N	77°28′ E	0°.6 N	147°.1	1949	IIA	2°25′ W	3°.0	39350	2150
Ettayapuram	9°10′ N	78°01′ E	0°.6 S	147°.5	1975	NGRI	2°54′ W	0°.5	40300	300@
Trivandrum	8°29′ N	76°57′ E	1°.2 S	146°.4	1957	IIG	2°45′ W	—1°.0	39950	—600

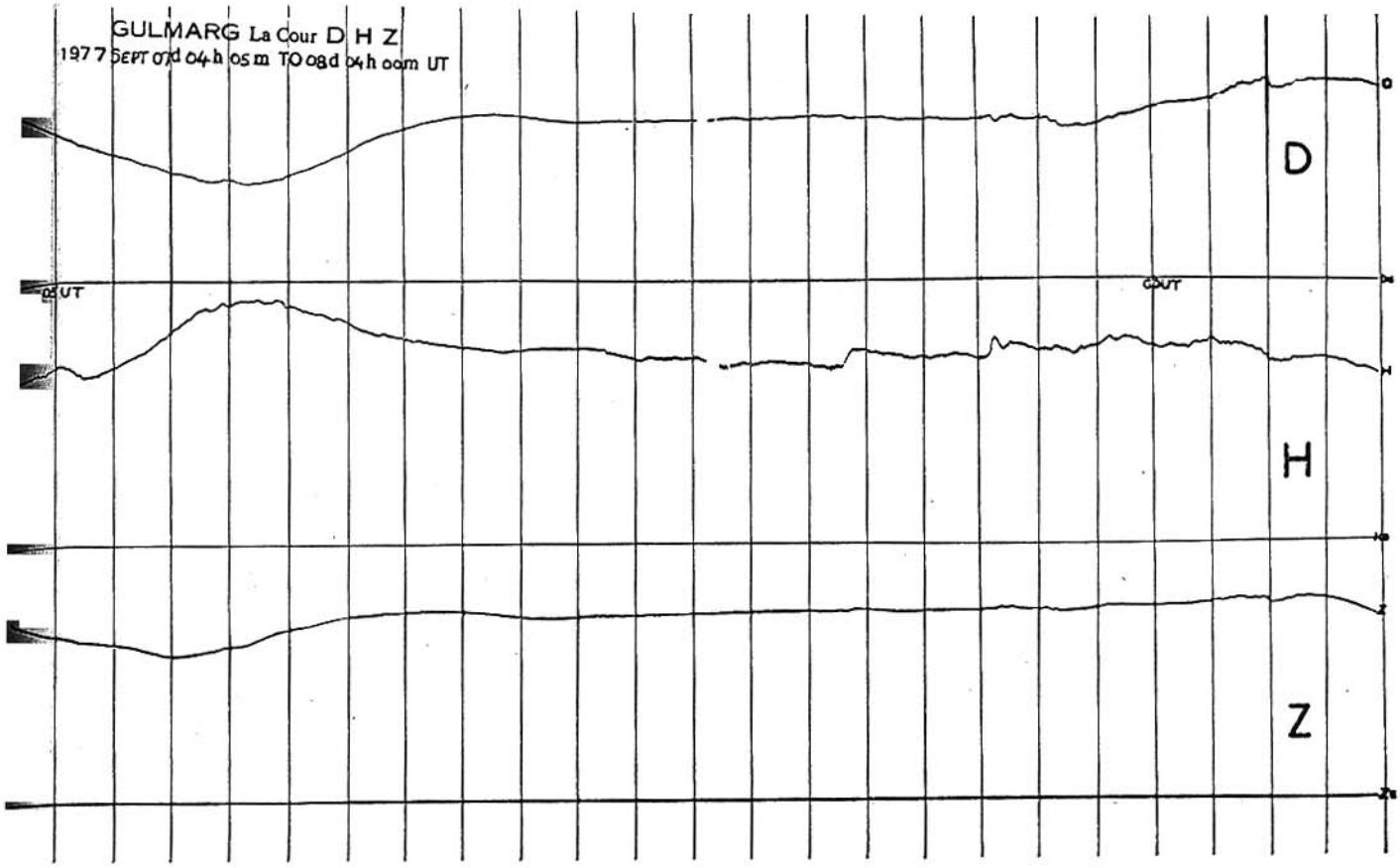
*IIG : Indian Institute of Geomagnetism, Colaba, Bombay.

IIA : Indian Institute of Astrophysics, Kodaikanal.

NGRI : National Geophysical Research Institute, Hyderabad.

SOI : Geodetic & Research Branch, Survey of India, Dehra Dun, U.P.

@ Values derived from model global field.



A typical magnetogram showing 24 hours' geomagnetic variations at Gulmarg.

Gulmarg Magnetic Observatory

To analyse the problem related to day-to-day variability of the geomagnetic field variations, and to determine the association between the Sq. current and the equatorial electrojet currents, it is essential that a magnetic station be maintained in the vicinity of the focal latitude, and in the same longitude zone as other stations above and below. The magnetic station at Sabhawala has been serving this purpose, but the latitudinal gap between Sabhawala and the next higher latitude station, Tashkent in the USSR, is quite appreciable and the focal latitude is found to be located between the two in this longitude belt. A station located close to the latitude of the focus can also be used to study the effect of magnetospheric processes on the ionospheric current systems. Also, for geomagnetic survey work in the country, a suitably located base station in relation to which the field data can be reduced is essential.

In view of these long felt needs, the Indian Institute of Geomagnetism decided to establish a permanent magnetic observatory in Jammu and Kashmir region and availed of the offer of land and facilities made by the Bhabha Atomic Research Centre at its High Altitude Research Laboratory in Gulmarg. Two structures, entirely non-magnetic in nature and specially constructed to house the magnetic instruments, were built by the Civil Engineering Division of BARC. The Gulmarg Magnetic Observatory became operational in September 1977.

The present set-up at the Magnetic Station at Gulmarg consists of:

1. A La-Cour three-component variometer system with a photographic recorder, registering variations in the three components, H, Z and D of the earth's magnetic field at a uniform char-speed of 20 mm/hour. This uniform speed is achieved through a synchronous motor (230 V AC/50 Hz), for which power is derived from a 12V DC source, and an inverter.

2. A system for time marking on the magnetogram to indicate exactly the beginning of each UT hour. This is recorded by flooding the cylindrical lens in front of the recorder for a duration of about 5 seconds by a light source which is switched on at each UT hour. The timer used is a high precision digital clock. Accurate time is derived from a 1 MHz quartz crystal, and a frequency count-down chain using divider counter ICs, which divides this frequency to 1 second and 1 hour timed output.

3. Calibration systems for the variometers, which are Helmholtz coils with single turn of wire, with the magnets of the three different systems at the appropriate centres of the coils through which known current can be passed, creating a given magnetic field at coil centre.

4. A Quartz Horizontal Magnetometer (Q.H.M. No. 734), which is used for measuring the absolute value of the horizontal component daily, and the absolute value of Declination once a week.

5. A Balance Magnetometer Zero (B.M.Z. No. 304), which is used for

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Neutrons Against Cancer

THE Cancer Therapy Facility at Fermilab treated its first patient a year ago (7 September 1976). Since then a total of 86 patients have completed the prescribed course of radiation and, overall, the results have been very satisfactory.

The Facility draws a neutron beam from a beryllium target bombarded by 66 MeV protons from the linac of the 500 GeV synchrotron. It has been used for biomedical experiments, as well as for cancer treatment, mainly aiming to determine parameters of neutron radiation which are important for therapy and for comparisons with other forms of radiation.

With the patients treated so far, the use of neutron beams as the sole method of treatment was very successful in controlling radiation resistant tumours. Side effects have been mild.

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THE Medical Research Council Cyclotron Unit at Western General Hospital, Edinburgh was officially opened on 27 September. It houses a cyclotron for the production of neutron beams for cancer treatment.

Two neutron beams are produced by the cyclotron and a special feature is that one of them is steerable. The compact cyclotron, manufactured by the Cyclotron Corporation, provides 100 μA of deuterons at 15 MeV. A switching magnet enables the output beam to be directed onto a fixed target or an isocentric target to give the manoeuvrable beam.

The considerable clinical experience in the use of neutron beams for cancer therapy at the Hammersmith Hospital, London, was of great value in the design of the new unit. The first patients were treated in March of this year and some 70 patients have now completed their treatment. All have received neutrons from the fixed beam up to now and the steerable beam is scheduled to be in operation in a few months' time.

A TEAM of biologists (Frank Ngo, Antun Han, Hiroshi Utsumi and Mortimer Elkind) from the Biological and Medical Research Division at Argonne are carrying out a detailed study of the relative effects of neutron irradiation and conventional X-ray and cobalt-60 gamma rays on cancerous cells.

They have access to three neutron sources in the Chicago area, each covering a different energy spectrum. These are—the JANUS reactor at Argonne, the cyclotron at the Franklin McLean Institute of Chicago University and the Cancer Therapy Facility at Fermilab.

The results so far show that smaller doses of neutrons than X-rays are needed to kill equal numbers of cells. As the neutron energy increases (from reactor energies to CTF energies) the dose needed increases. Neutrons are more effective in killing the oxygen starved, radiation resistant cells often found in tumours. Also, the cells are less able to repair damage after neutron irradiation. (*CERN Courier, Oct. 77*)

Decommissioning of Nuclear Facilities

A COMMITTEE of technical experts from 10 countries and two international organisations met in Vienna in October to review the decontamination and decommissioning of nuclear facilities for their safe disposition after their operational lives. The meeting was convened by the International Atomic Energy Agency (IAEA).

The purpose of the meeting was to initiate the development of a code of practice and guidelines to the code for the decommissioning of nuclear reactors. Among the topics reviewed by the technical committee were the radiological, mechanical and administrative aspects of decommissioning. The committee endorsed the conclusions of its prior meeting in 1975 on the same subject that there were no insurmountable technical problems to decommissioning of nuclear reactors after their operating lives. In addition, the committee discussed the decontamination requirements of facilities to be decommissioned.

The technical committee also discussed the subjects to be covered at the International Symposium on the Decommissioning of Nuclear Facilities which is to be held in Vienna from 13 to 17 November 1978. The Symposium is being sponsored by the IAEA and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development. ●

Gulmarg Station

(*Continued from page 5*)

determining the absolute value of the vertical component of the earth's field. A proton vector magnetometer for precise determination of horizontal component and derivation of the vertical component from the value of the total field will be commissioned shortly.

While the variometers are set up in a thermally insulated double-walled, light-proof structure, the absolute measurements are carried out in an adjacent non-magnetic room. The photographic paper registering the field variation is changed every day and developed. The calibration experiments are carried out once a week, and the magnetograms and other data are sent to the Indian Institute of Geomagnetism at Colaba, Bombay in weekly batches for further processing.

In view of the importance of the location of the Gulmarg magnetic station, the data and records obtained will prove to be of immense use to scientists everywhere. Collaborative research programmes between scientists at the Nuclear Research Laboratory at Srinagar and at the IIG are also on the anvil.

The role played by BARC in assisting IIG in establishing this magnetic station cannot be over-emphasised. A word of thanks is also due to the Survey of India for quickly evaluating the azimuth of the datum mark used in computation of the absolute value of Declination. ●

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