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Drone-Based Magnetics Over Mechanised Diamond Mine In Panna District, Madhya Pradesh, India

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Abstracts:
A drone-based magnetic survey was conducted with a magnetic sensor for the first time in India over a mechanised diamond mine. The paper briefly describes the findings of the drone-based Magnetic surveys over the Majhgawan Diamond Mine in Panna District, Madhya Pradesh, India. The data was interpreted using the Geometrics interpretation software. The experiment showed a promising result in deciphering the lamproite pipe depicted by a magnetic high intruded into the Baghain sandstone of the Kaimur Group. From the total magnetic anomaly map, it can be observed that a high magnetic anomaly of about 27 nT in the central part of the pipe which forms a part of the near-circular anomalous zone, is associated with the diamond-bearing pipe and demarcates its boundary.

Keywords: Drone, Magnetics, Diamond Mine, Majhgawan, India

INTRODUCTION

Drone-based magnetic surveys have several advantages over traditional ground-based and manned aerial surveys using drones reduces the need for expensive manned aircraft or extensive ground crews, leading to significant cost savings in data acquisition, and fewer personnel are required to operate drones compared to traditional survey methods. This facilitates rapid deployment to survey areas, allowing for faster data collection as drones can cover large areas more rapidly than ground surveys, increasing the overall efficiency of the exploration process. In addition, drones can fly at lower altitudes than manned aircraft, allowing for higher-resolution magnetic data acquisition, the proximity to the ground ensures better resolution and more detailed magnetic anomaly detection and drones can easily navigate and survey areas that are challenging for ground-based teams or manned aircraft, such as steep slopes, dense forests, and remote regions. Drones can fly complex patterns and maintain consistent altitudes over varied terrain, ensuring comprehensive coverage (Yaoxin Zheng et al.,2021). Such surveys do not have an Environmental impact they have a smaller environmental footprint compared to ground surveys, which do not require cutting through vegetation or disturbing the landscape and are quieter than manned aircraft, reducing noise pollution in sensitive areas.

GEOLOGY

The Majhgawan diamond pipe is the largest diamond producer in India. It is a lamproite pipe intrusive into Proterozoic flat-lying quartz arenites. The pipe has a surface dimension of 500 × 320 m and is carrot-shaped, reminiscent of a typical kimberlite with minimal erosion (Figure 1). Diamond production at Majhgawan started before 1827. The mine operated by NMDC Limited a Central Public Sector Undertaking has a Capacity to produce 80,000 carats.

The Majhgawan pipe, along with the Hinota pipe, is intruded into the Baghain Sandstone- Kaimur Group of the Vindhyan basin. This is South Asia's only Mechanised Diamond mine situated in the Panna District, Madhya Pradesh. These pipes viz., Majhgawan and Hinota are emplaced into Baghain Sandstone, lying west of the Panna Diamond Belt.

PETROGRAPHY

The petrography of the Majhgawan diamond pipe rock provides detailed insights into its mineralogical composition, texture, and the processes that have influenced its formation. The Majhgawan pipe, being a kimberlite, exhibits typical features associated with this type of ultramafic rock. Several studies related to petrography, mineralogy and geochemistry were conducted by Paul (1991), Abhijeet Mukherjee et al., (1997), Ravi Shankar et al., (2001) and Chalapati Rao (2006)

The primary minerals include (a)Olivine: Olivine is the most abundant mineral in the Majhgawan lamproite, often occurring as large, rounded crystals known as phenocrysts. These olivines are typically rich in magnesium (forsteritic composition) and may show signs of serpentinization, where olivine is altered to serpentine minerals.(b)Phlogopite: This mica mineral is a common constituent of kimberlite and is present in the Majhgawan pipe. Phlogopite appears as brownish flakes and contributes to the rock's micaceous appearance. (c)Pyroxenes: Both clinopyroxene (diopside) and orthopyroxene may be present. These minerals are significant as they provide clues about the pressure and temperature conditions during formation(d)Garnet: Often found as small, red to pink crystals, garnet in the pipe is typical of the pyrope variety. It is an important indicator mineral in diamond exploration.

The accessory minerals consist of (a)Spinel: Which includes minerals like chromite and magnetite, which occur as small, black to brown grains (b)Perovskite: A titanium oxide mineral that appears as tiny, yellow to brown crystals (c) Ilmenite: An iron-titanium oxide that contributes to the magnetic properties of the kimberlite.

The Secondary Minerals observed are (a)Serpentine: Formed by the alteration of olivine, serpentine minerals give the rock a greenish hue and a fibrous texture (b)Carbonates: Such as calcite and dolomite, which often fill veins and cavities within the lamproite (c) Monticellite: A calcium magnesium silicate that can occur in altered lamproites.

TEXTURE

The Majhgawan pipe rock typically exhibits a porphyritic texture, characterized by large, well-formed phenocrysts of olivine set in a finer-grained groundmass. The groundmass of the Majhgawan lamproite is fine-grained and consists of a mixture of micaceous minerals (like phlogopite), carbonates, serpentine, and smaller crystals of primary minerals such as pyroxenes and spinels.

XENOLITHS AND XENOCRYSTS

Kimberlites and lamproites often contain xenoliths (fragments of foreign rocks) and xenocrysts (foreign

crystals). In Majhgawan, mantle-derived xenoliths of peridotite and eclogite are common, along with crustal xenoliths from the surrounding country rock. Diamond xenocrysts are the most significant economically and are found as isolated crystals within the kimberlite matrix.

ALTERATION AND WEATHERING

The alteration of olivine to serpentine is a prominent feature, resulting in a softer and more weathered appearance of the rock. The introduction of carbonate minerals into the rock, often seen as veins and cavity fillings, indicating fluid interactions post-emplacement.

EMPLACEMENT FEATURES

Brecciated Zones and Volcaniclastic textures could be observed in the core samples and in the mine. The Majhgawan lamproite may show evidence of brecciation, where fragments of rock are cemented by a finer matrix, indicating explosive volcanic activity during emplacement. Pyroclastic features, such as tuffaceous layers and lapilli, can be present, reflecting the volcanic nature of the pipe.

SPECIFICATIONS OF THE UNMANNED AERIAL VEHICLE (OCTACOPTER DRONE) AND MAGNETOMETER

The customised Octacopter Drone had major specifications like payload capacity of 8kgs, endurance of 15-20 minutes, range of 1km LOS, altitude of 1km LOS, position accuracy of less than 2m, stability at a location of less than 0.5m (as measured in altitude hold mode). The frame & propeller of carbon frame material thus does not influence the magnetic observations. The magnetometer used for the survey was Geometrics-Magarrow with an operating principle of Laser-pumped caesium vapour (Cs133 non-radioactive). The specifications of the Magarrow magnetometer weighs about 950 grams have an operating range of 20,000 to 1,00,000 n T, gradient tolerance of 10,000 n T, noise /sensitivity 0.005 n T/√Hzrms, sample rate of 1000 Hz synchronised to GPS1PPS, GPS commercial grade with typical 1m accuracy and heading range/error of +/- 5 n T over the entire 360^0 equatorial and polar spins, and a bandwidth of 400Hz.

FLIGHT PLANNING AND PROCESSING OF DRONE BASED -MAGNETIC DATA

Before flying the Drone for magnetic data acquisition the site topography, access roads and launch stations, weather conditions, flight line spacings, flight height, area coverage, geology and mineralization zone and survey duration were planned. The flight lines are kept approximately in the N-S direction The flight height was 30m AGL (above ground level) with spacing of 50m. The drone-based flight planning was carried out using Mission Planner Software (Figure 2).

RESULTS AND DISCUSSION

The total magnetic field anomaly map of the Majhgawan Diamond Mine area, Panna District along with the flight lines of the drone, survey is shown in Figure 2. From the map, it can be observed that the pipe has a high magnetic anomaly of about 27 nT in the south-western region to the central part of the map/pipe, which forms a part of the near-circular anomalous zone and this high is associated with the diamond-bearing pipe and demarcates its boundary (Figure 2). The magnetic anomaly between 10 to 20 nT surrounding the higher magnetic anomaly is also a part of the kimberlite pipe in the area, which has been weathered and hence the relative magnetic anomaly has decreased.

The drone-based magnetic surveys have successfully demarcated the boundary of the kimberlite pipe at

the Majhgawan Diamond Mine, Panna District. The survey was done in the allocated area. More lines could have brought much more clarity to the anomaly.

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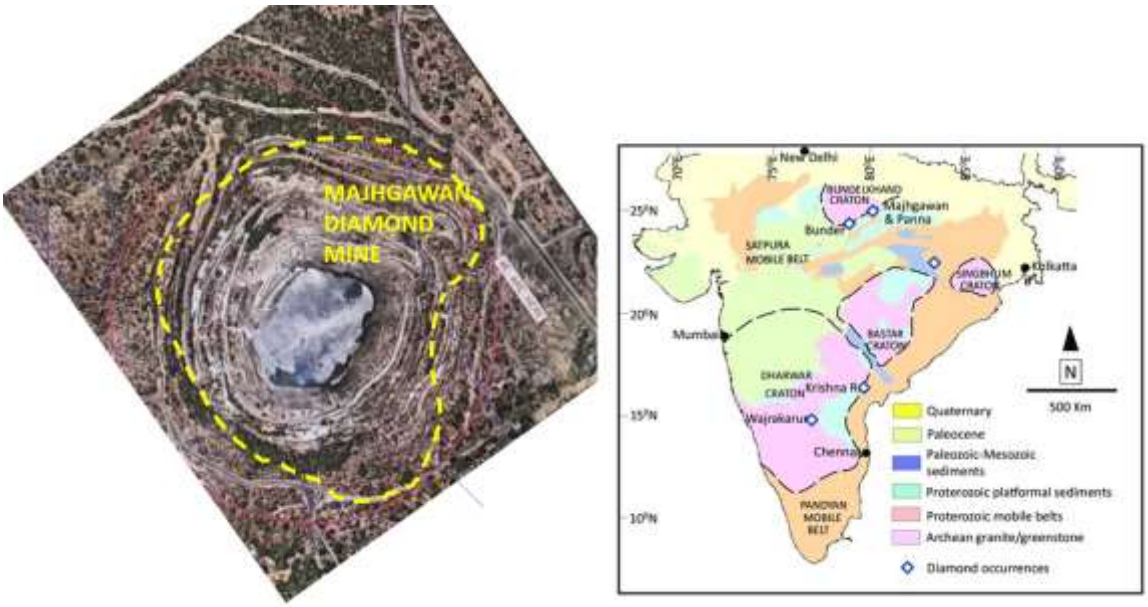

Figure 1 Geological Map showing the location of Majhgawan Diamond Mine, Panna District (Map modified after Smith et al., 2018).

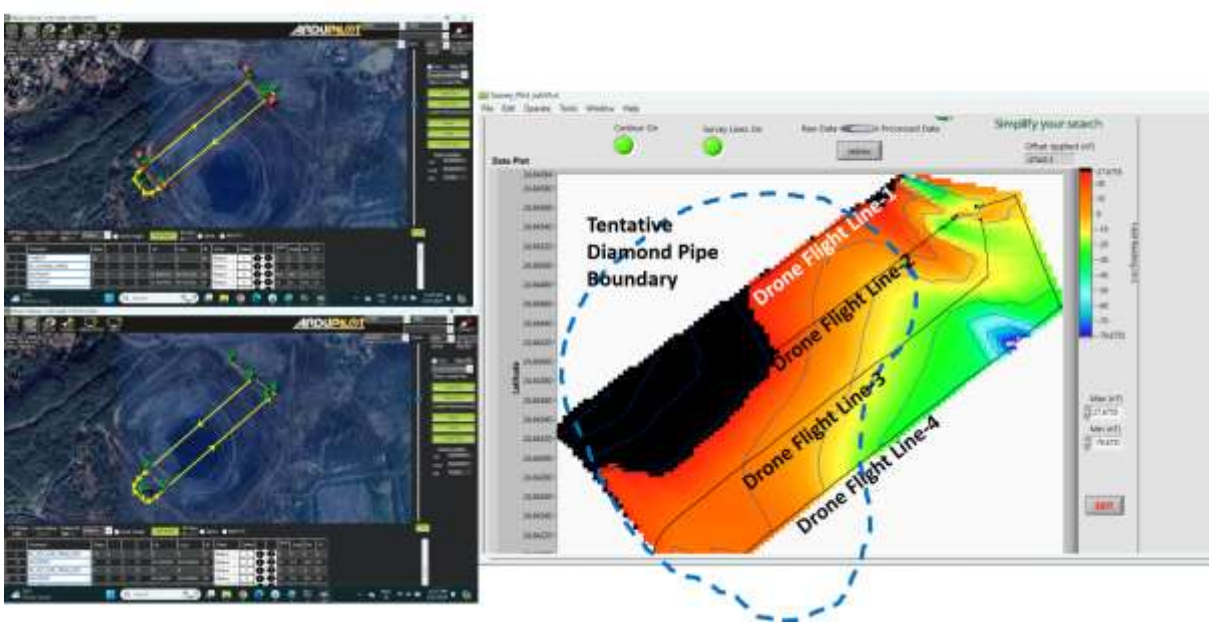

Figure 2 Magnetic Field anomaly map of part Majhgawan Diamond Mine, Panna District (based on Drone Magnetic survey at 30 mAGL)