Response to reviewers

We sincerely thank the reviewers for their time and effort in evaluating our revised manuscript. We deeply appreciate the encouraging feedback regarding the strength of our analysis and the significance of utilizing these geophysical datasets for geological interpretation. The reviewers' constructive criticism, particularly regarding the magnetic modeling terminology and the chronological clarification of the survey equipment, has been instrumental in improving the accuracy and clarity of our work. Below, we address each concern sequentially.

Reviewer 1

Overall this is a clear and interesting analysis of potential field geophysical data from Bangladesh, which provides some valuable analysis of the subsurface geology in that area. My comments are some technical suggestions to clarify the analysis of the magnetic anomalies:

1) In general, there are no magnetic data or assumed values for the susceptibility (or ranges of this value) of the different geological units. It seems these should be available for at least the drill-core samples? A better understanding of these would be valuable as these relate to the produced anomaly models.

Authors' Response: We appreciate the reviewer's insightful observation regarding the magnetic susceptibility data. We agree that incorporating measured susceptibility values, particularly from drill-core samples, would ideally constrain the models and improve the robustness of the interpretation. However, we were unable to include this data in the current analysis for the following reasons:

<u>1. Data Availability and Reliability</u>

Access to well data was limited, with magnetic susceptibility logs available for only one drill core. Furthermore, the values published in the Geological Survey of Bangladesh report for this core appeared anomalously high and physically improbable for the described lithologies. For instance, the report cites susceptibility values of 2–3 SI at depths of 400 m, and values exceeding 10 SI below 600 m. Given the questionable reliability of these specific measurements, we deemed it necessary to exclude them to maintain the integrity of our analysis.

<u>2. Modeling Approach and Relative Contrast</u>

The primary objective of this study was not to determine absolute petrophysical properties, but rather to resolve the geometry of the magnetic source body based on lateral susceptibility contrasts. To achieve this, we utilized a simplified forward modeling approach where the sedimentary cover and granitic crust were treated as a non-magnetic background (0 SI). The susceptibility of the basaltic unit was then adjusted relative to this baseline to reproduce the observed magnetic anomalies. We have updated the revised manuscript to explicitly describe this approximation and the rationale behind the assumed background values.

3. Non-Uniqueness and Future Work

Finally, given the lack of independent ground constraints for the granitic and sedimentary units, assigning them varying non-zero susceptibility values would severely exacerbate the non-uniqueness of the problem. This would result in an excessive number of potential models capable of fitting the observed data. We determined that a complex inversion strategy to resolve these specific ranges was outside the scope of this 2-D structural analysis. We intend to address this in future work by developing a 3-D model constrained by seismic refraction tomography, which will allow for a more accurate assignment of non-zero susceptibility values to the background units.

2) From the manuscript and figures (notably Fig 5 and Fig 6, and S2), the magnetic susceptibility of all the units except for the presumed gabbro are assumed to be negligible (S=0 in these figures). Clastic sediments, such as the Siwalik, can have high magnetic susceptibility (1x10-2 or -3 SI vol units), and in places their lateral extent, thickness, and shallow depth (compared to bedrock units) can produce a significant contribution to measured a magnetic anomaly. Likewise, felsic intrusives can have high susceptibility and significant remanence. For all of these materials, the S values used seem to be 0. This may be due to the S value used being the difference relative to that assumed for the gabbros- but that is not clear in the manuscript. So a related question can be how using non-zero S for the sediments in the basin can produce a better anomaly fit (as in Figure 6) that may agree better with the geological model constrained by the boreholes and seismic profiles?

Authors' Response: We completely agree with the reviewer on this review. We acknowledge that these units can exhibit non-negligible susceptibility values (e.g., 10^{-2} to 10^{-3} SI) and that ignoring them is a simplification. However, as noted in our response to Comment 1, reliable in-situ susceptibility constraints (such as well logs) are unavailable for the sedimentary cover and granitic basement in this study area. Consequently, we treated these units as a non-magnetic background to avoid introducing unconstrained variables. This approach focuses the modeling on the contrast provided by the primary target (the gabbro).

We have revised the manuscript to explicitly state this assumption and its utility in constraining the model. In Section 3.2 (Methods), we added the following text:

"Due to the absence of reliable magnetic susceptibility logs for the sedimentary cover and granitic basement, we treat these lithologies as a non-magnetic background (0 SI). This approximation reduces the non-uniqueness of the potential field problem, ensuring that the modeled response is driven primarily by the lateral susceptibility contrast of the target magnetic unit."

3) As I understand this, the preferred model has the gabbros being reversely-magnetized, with the magnetic susceptibility of all the surrounding units being negligible (S=0). Referring to the S for the gabbros as being negative is not the best use of magnetic properties and terminology- negative susceptibility results from diamagnetism, and is only produced by relatively pure carbonates, marbles, or more rarely quartzites. The preferred model should be stated as having a reverse-polarity remanent magnetization (this is correctly labelled as J in Figure 6). This leads to another question- the remanent vector you are using is antipodal to the present-day field. The gabbros, though, are significantly older (Proterozoic ?)- and so their magnetization direction may be (and is likely to be) significantly different than the present-day geomagnetic field direction. I am not aware of any paleomagnetic studies of these rocks. However, an analysis such as shown in Fig 6 should mention that the J vector can be significantly different than the present-day field direction, or even its reverse-polarity counterpart. Using different J vector directions may yield an improved model that can closely fit the observed magnetic field anomaly whilst agreeing better with the geology of the area.

Authors' Response: We thank the reviewer for this crucial correction regarding magnetic terminology. We agree that referring to the anomaly source as having "negative susceptibility" was physically incorrect. We have revised the manuscript to correctly attribute the negative anomaly to reverse-polarity remanent magnetization rather than negative susceptibility.

We also acknowledge that the gabbros are likely Proterozoic, and therefore their paleomagnetic vector direction may differ significantly from the present-day field. While varying the declination and inclination of the *J* vector might yield a closer fit to the observed anomaly, we lack the specific paleomagnetic data to constrain this unique direction.

Reviewer 2

This research offers valuable insights, and the author's effort to reinterpret such historical data is commendable. The combination of geological and geophysical datasets to tackle challenges in mineral resource exploration is significant. The maps produced through various data processing techniques also provide users with guidance on managing diverse datasets. However, I have concerns regarding the reliability of the information presented, as it appears simplistic yet raises questions about other aspects discussed in the paper. In particular, the manuscript claims that equipment not in use at that time, like GPS and CG-5 Aurograv, was employed in this project. If this astonishing claim is indeed accurate, I would have no objections to the publication of this manuscript, provided they can substantiate this assertion.

As I stated in my previous comment, the application of potential methods for regional geological mapping and exploration is a common practice and in that context, the manuscript's purpose, its relevance, and significance of the findings is undeniable. Furthermore, the authors deserve recognition for addressing each of my comments, including specifics on data acquisition, enhancements to the gravity-magnetic modeling results, and the incorporation of borehole locations in the model, allowing for comparative analysis and information extraction from drilling data. In the revised manuscript (with tracked changes), the authors noted that the gravity survey was conducted in the 1970s (line 215). "Observation points were positioned 1–1.5 km apart, with elevation measurements taken using digital leveling referenced to benchmarks from the Survey of Bangladesh. Two gravimeters were utilized, the analog Sodin Worden and the digital CG-5 AutoGrav with integrated GPS, undergoing frequent cross-verification to ensure data accuracy" (section 3.1). However, I am a bit concerned that from what I know, the Scintrex CG-5 Autograv was first released in the early 2000s (around 2002), making it impossible for this gravimeter (CG-5) to have been employed prior to that time. This incorrect information raises a serious issue regarding the accuracy of the original details and responses, potentially compromising the authors' credibility. I suspect they employed the Sodin Worden, and perhaps the LaCoste & Romberg, which were quite common during those years, but not the CG-5. Therefore, I urge the authors to clarify this matter and provide a truthful answer to ensure that the readers of this work are not misled. The same issue applies to the GPS system used in conjunction with the gravity survey for positioning. Which GPS system was utilized? Here again, I have doubts regarding the use of GPS in the late 1970s; to my understanding, GPS became available for public use only after 1993. Thus, a solid justification for these points is required. Either the survey was conducted later, or GPS and the CG-5 Autograv could not have been utilized in the late 1970s.

Authors' response: We sincerely thank the reviewer for pointing out the chronological inconsistency regarding the equipment used. We fully agree that the Scintrex CG-5 AutoGrav and GPS technology were not available during the initial surveys in the 1970s. The confusion arose because our previous revision inadvertently compressed the timeline.

The gravity dataset presented in this manuscript is the result of continuous, multi-decadal acquisition campaigns. While the initiative began in the late 1970s using analog instruments (Sodin Worden) and optical leveling, the data collection has continued annually during dry seasons. Modern equipment, including the CG-5 AutoGrav and GPS units, was only introduced in later phases (specifically post-2007) to refine previous data and expand the survey coverage.

We have revised Section 3.1 to clearly distinguish between the historical and modern phases of data acquisition. We now explicitly state that the dataset is cumulative and specify which instruments were used during the different time periods. We believe this clarifies the methodology and restores the credibility of the data presentation.

"The gravity data presented in this paper represent a cumulative dataset acquired through successive land-based surveys initiated in the late 1970s and continuing to the present day. These surveys were primarily conducted during the dry season (November–April) to ensure accessibility, gradually covering approximately 8,000 km^2 in northwestern Bangladesh. Data acquisition methodology evolved over the decades to incorporate technological

advancements. During the earlier campaigns (starting in the 1970s), gravity measurements were taken using an analog Sodin Worden gravimeter (Model WS 410), while surveys conducted after 2007 also deployed the digital Scintrex CG-5 AutoGrav. Cross-verification between the analog and digital instruments was performed regularly in later phases to ensure consistency across the historical dataset. Similarly, positioning methods were modernized over time; while earlier observation points relied on standard benchmarks from the Survey of Bangladesh, later campaigns utilized handheld GPS receivers and the CG-5's integrated GPS for precise coordinate determination.

Throughout the survey history, observation points were generally spaced 1–1.5 km apart. Elevations were determined using digital leveling referenced to benchmarks from the Survey of Bangladesh, maintaining high vertical accuracy crucial for gravity corrections. The Sylhet Gravity Base Station, connected to the IGSN 71 network, served as the primary national reference, with local sub-bases established to correct for instrument drift. Standard geophysical corrections—including those for instrumental drift, tidal and latitude variations, and elevation differences—were applied to the entire dataset. Bouguer corrections were calculated using a crustal density of 2.0 g/cm^3."