Magnetic Prospecting Modeling of Seamount with COMSOL Multiphysics

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1. Introduction

In general, seamount magnetic modeling assumes uniform magnetization for the entire construct. The following geologic observations are often not considered:

1. **The internal structure composed of multiple volcanic layers.**
2. **Remanent magnetization gained during the magnetic polarity reversals.**

In this study, we build synthetic models based on these geological building processes of seamounts. We think that the observed magnetic data from seamount would be strongly affected by the magnetic information of the thickest and the closest volcanic layer from the surface. To verify this hypotheses, we compare 5-layered synthetic models with uniformly magnetized model and investigate which layer is the most influence to the observed data.

2. Methods

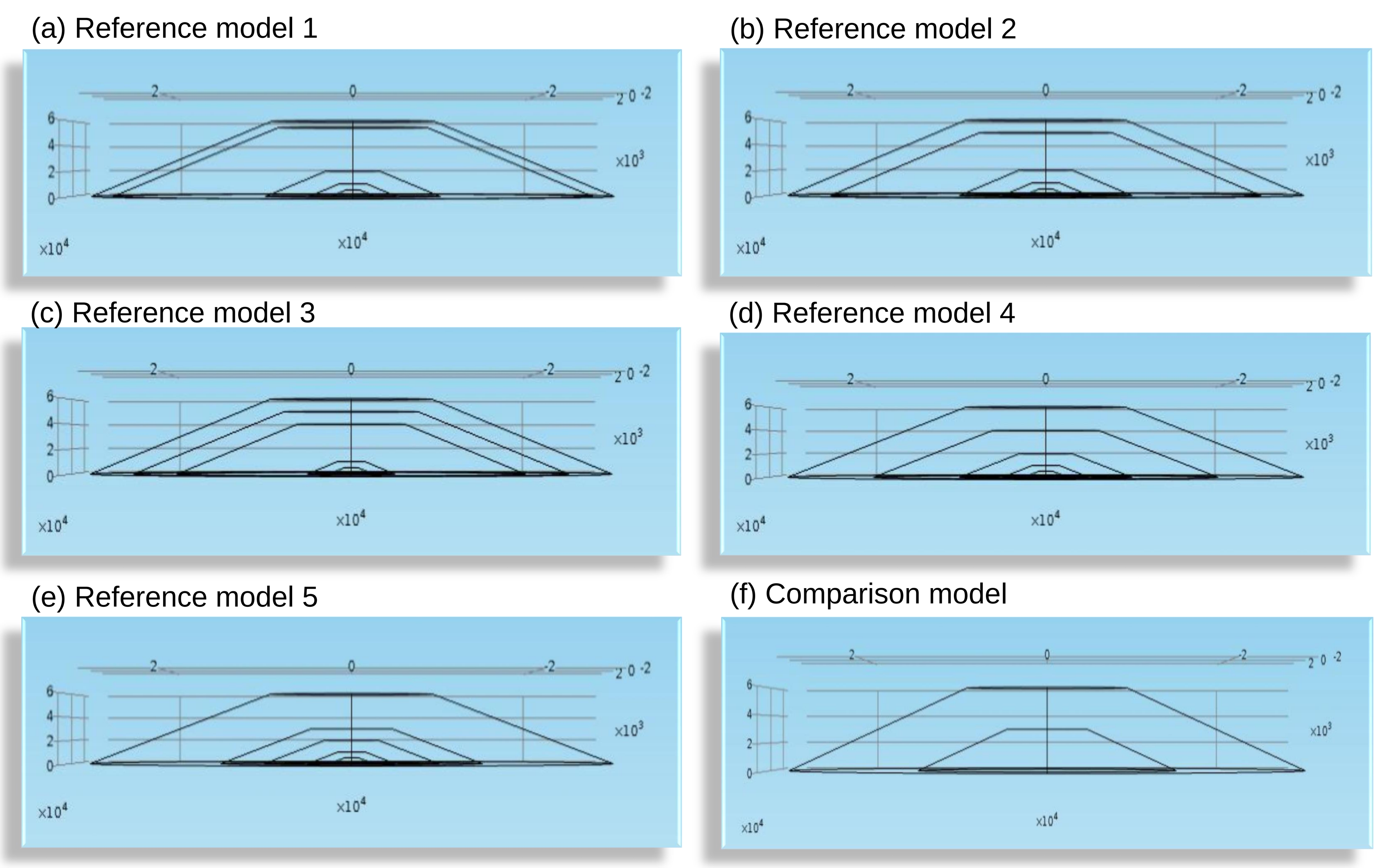

Figure 1. Geometry of reference models and comparison model. The seamount model has 6000 m height. **(a) ~ (e)** We build 5 different reference models by changing the thickness of the uppermost layer from 500 m to 3000 m, as shown in **[Table 2]**. Then, we assign magnetic field directions alternating normal and reversed polarities to each layer. **(f)** Comparison model with uniform magnetization. In this calculation, we only consider the magnetization of the uppermost layer and assign the magnetic direction of the bottom layer to parallel to the background field direction. Then, we change the magnetization direction of the uppermost layer only and compute the predicted data by changing the magnetic inclination and declination of the upper layer.

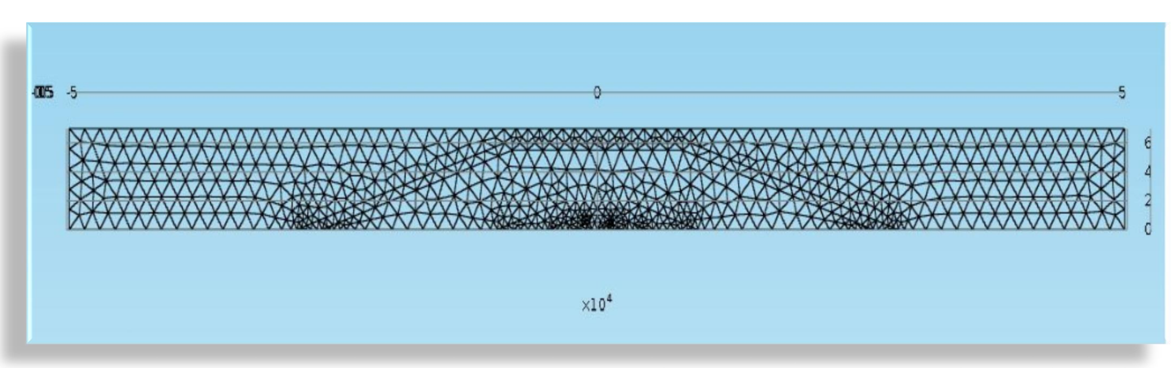

Figure 2. Mesh distribution of Model 1.

We compare with the predicted data of uniform magnetization model with the reference magnetic intensity data and determine the best magnetic parameters that minimize the RMS errors.

3. Results

	Case 1 (Hawaii)	Case 2 (Magellan seamount chain)
Normal polarity (Inclination/Declination)	40° / 4°	15° / 2°
Reversed polarity (Inclination/Declination)	220° / 4°	195° / 2°

Table 1. Geomagnetic field direction of each case. We choose two different regions where many seamounts are distributed. We assume the regional field vector is parallel to the present-day geomagnetic field given by the IGRF models. Reversed polarity is calculated from the regional field direction.

	Thickness of each layer (m)				
	Model 1	Model 2	Model 3	Model 4	Model 5
1st layer (uppermost)	500	1000	1000	**2000**	**3000**
2nd layer	**3500**	**3000**	1000	**2000**	1000
3rd layer	1000	1000	**3000**	1000	1000
4th layer	500	500	500	500	500
5th layer (innermost)	500	500	500	500	500
RMS minimum point of Case 1	**240°/4°**	**260°/4°**	**70°/4°**	**70°/4°**	**40°/4°**
RMS minimum point of Case 2	**230°/2°**	**100°/2°**	**60°/2°**	**60°/2°**	**20°/2°**

Table 2. The results of each model run. Each number represent the thickness of the layer. Blue bold numbers represent the thickest layer of each model. Gray shaded layers represent that reversed polarity is assigned. We use normal and reversed polarity in **[Table 1]** for both cases.

Model 1 & Model 5 In both models, RMS best fit is close to the magnetic direction of the thickest layer. It indicates that the magnetic data from model 1 and model 5 are dominantly affected by the magnetic information of the thickest layer.

Model 2 : In the case 2, although the thickest layer is the 2nd layer with reversed polarity, the result appears to be affected by the 1st layer. For the better comparison, we compare the magnetic intensity patterns on the surface between the reference model (Figure 4) and the comparison models (Figure 3). As a result, the magnetic intensity pattern obtained from the 2nd layer's field direction is most similar to the pattern of the reference model. It indicates that the magnetic data from model 2 are dominantly affected by the magnetic information of the thickest layer.

Model 3 & Model 4 : The results show that the magnetic data from model 3 and model 4 are dominantly affected by the magnetic information of the closest layer.

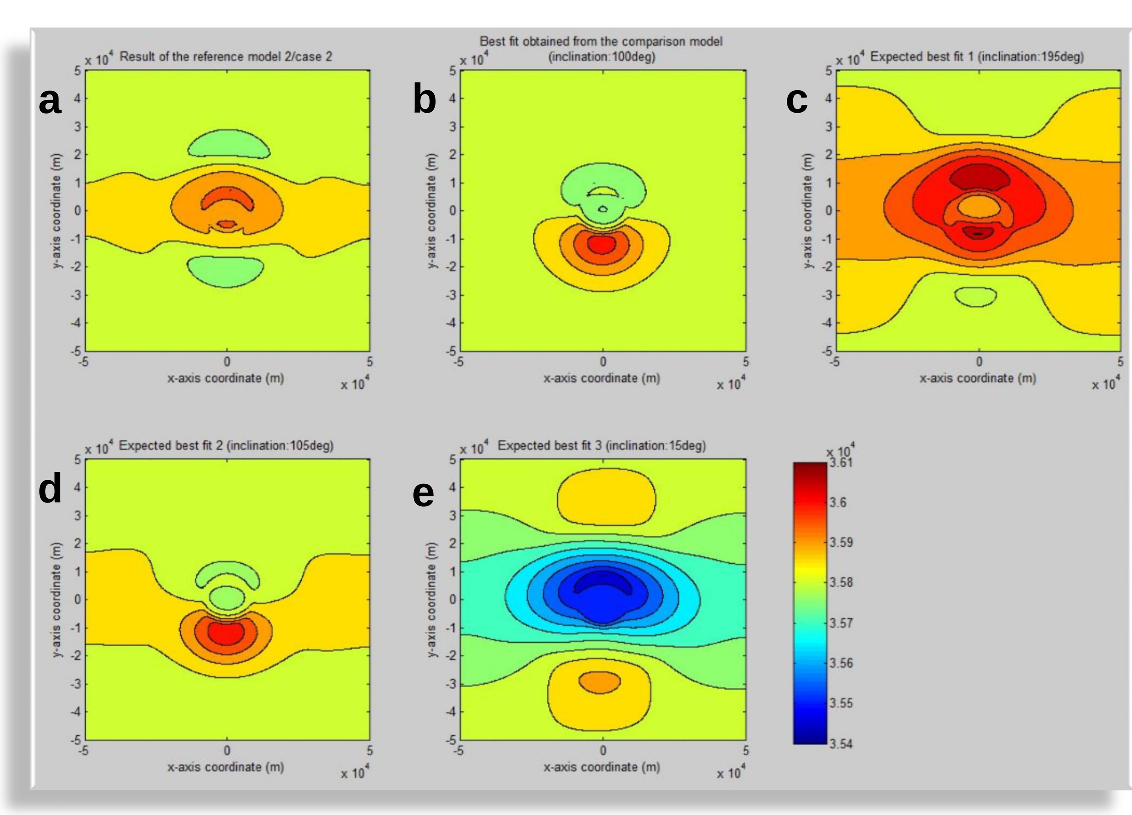

Figure 3. Magnetic flux density patterns obtained from the reference model (a) and the comparison models (b~e). **(a)** Magnetic flux density pattern obtained from the reference model 2/case 2. Magnetic flux density pattern obtained from the comparison model using **(b)** RMS best fit direction, **(c)** 2nd layer's field direction, **(d)** average direction of 1st and 2nd layer, **(e)**1st layer's direction.

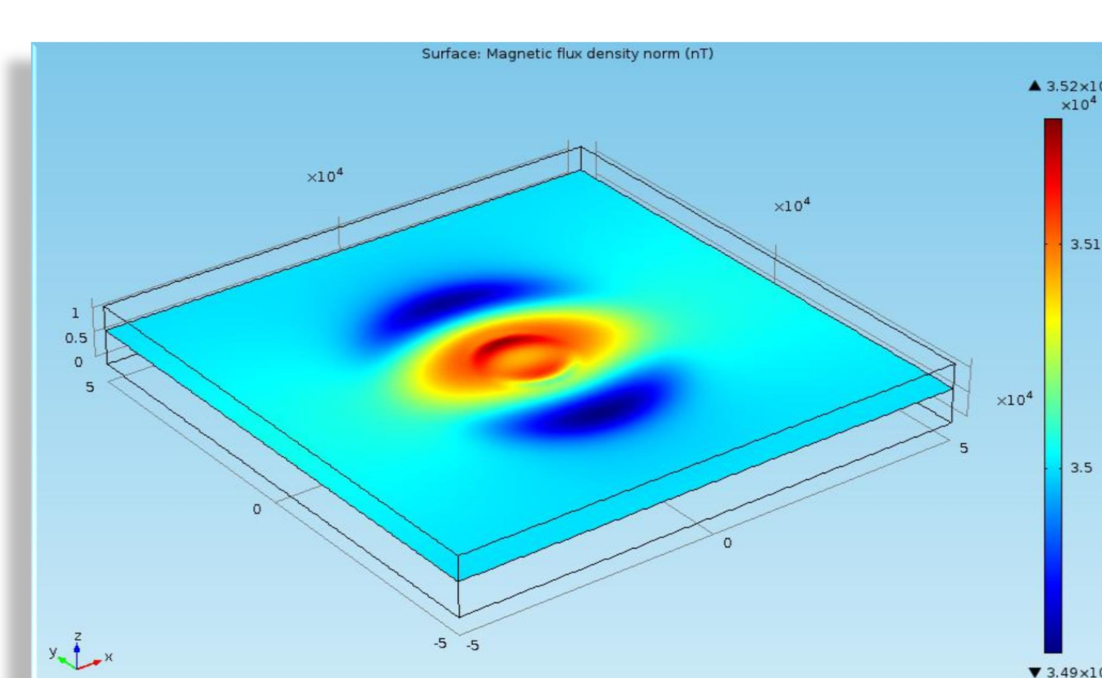

Figure 4. Magnetic flux density of the model 2 at the surface.

4. Conclusions

- Magnetic data from the synthetic models are dominantly affected by the magnetic information of the thickest and the closest layer from the surface.
- If the thickness of each layer are the same, the observed data will be dominantly affected by the information of the uppermost layer.
- If the magnetic inclination of normal polarity assigned to reference model is small or the intensity of the uppermost layer in reference model is large, the observed data is affected by the information of much thinner uppermost layer.

5. References

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