MAPPING OF A THICK SEDIMENTARY COVER FOR MINERAL EXPLORATION AT THE SOUTHERN BENUE TROUGH OF NIGERIA FROM A SYNTHETIC BOUGUER GRAVITY DATA

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Abstract

Mapping of the basement relief in regions of a high geological importance is key to mineral prospecting. In this study, we estimate the sediment thickness within the Southern Benue Trough of Nigeria by using synthetic Bouguer gravity data alongside 113 logged borehole data to validate the gravimetric inversion and interpretation.A 3-D gravimetric inversion of the residual gravity data was carried out to determine the thickness of sedimentation after a regional-residual gravity separation. Our numerical results (ranging from 0.8 to 5.5 km) have almost no systematic bias (mean value = 0.045) when compared with the 113 measured sediment depths obtained from drilling profiles. The estimated sediment depths closely mimic the known geological structures and tectonic complexities of the highly rifted Southern Benue Trough of Nigeria. The synthetic Bouguer gravity map exhibits a spatial pattern that indicates possible magmatic movements, which could have led to shallow sediments over and along the Abakaliki Anticlinorium. This elevated crust (because of an upward magmatic movement) created crevices, faults, folds, ridges, or troughs that must have paved way for a thick sedimentary cover that possibly have matured overtime (because of a high temperature) into important habitats for mineral resources. We conclude that the very thick sedimentary cover at the southwestern portion of the study area may have been brought about by a compaction or compression of tectonic plates thereby generating adequate heat and pressure for the maturation of several mineral resources at the Southern Benue Trough of Nigeria.

Keyword: Bouguer gravity maps; gravity inversion; sediment thickness; Regional-residual gravity separation; mineral exploration

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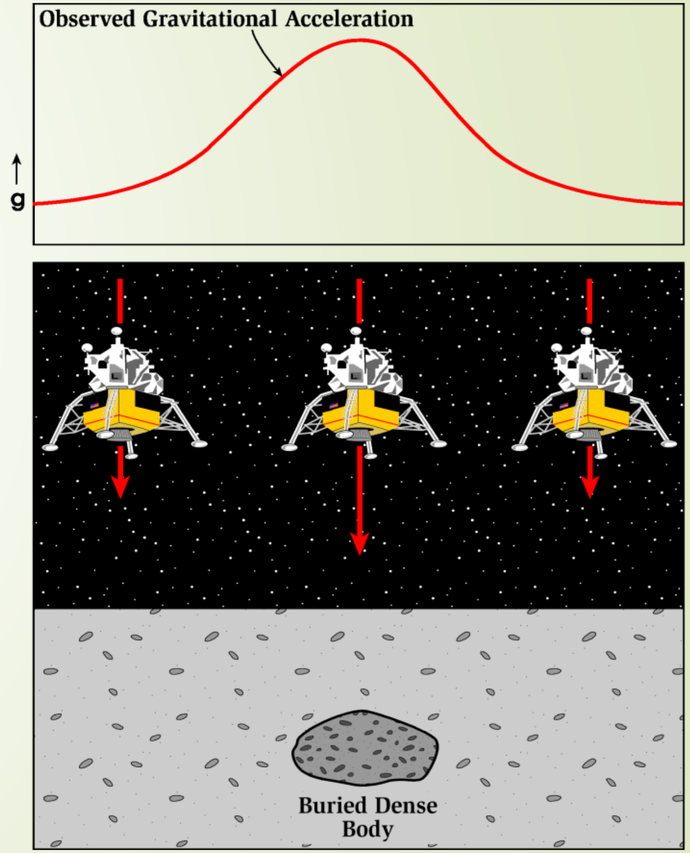
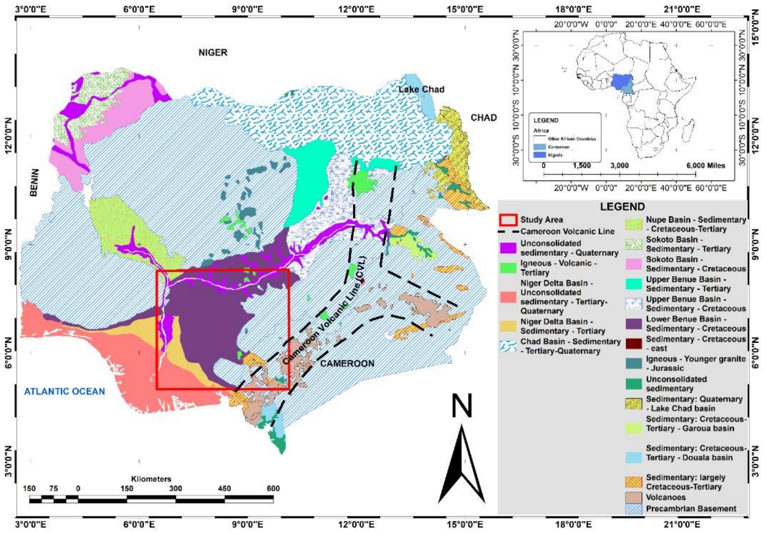
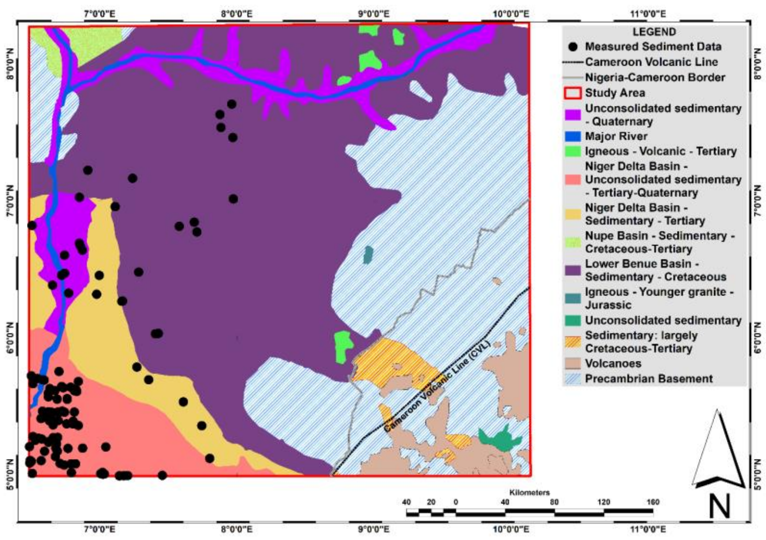


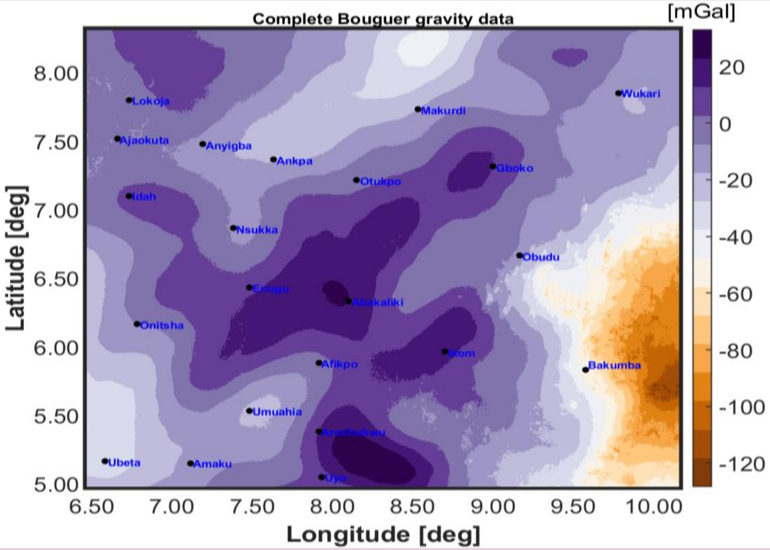
Aim: to estimate sediment thickness by employing a high-resolution synthetic gravity data and logged borehole data within a highly rifted continental plate.



Generalized geology of the study area



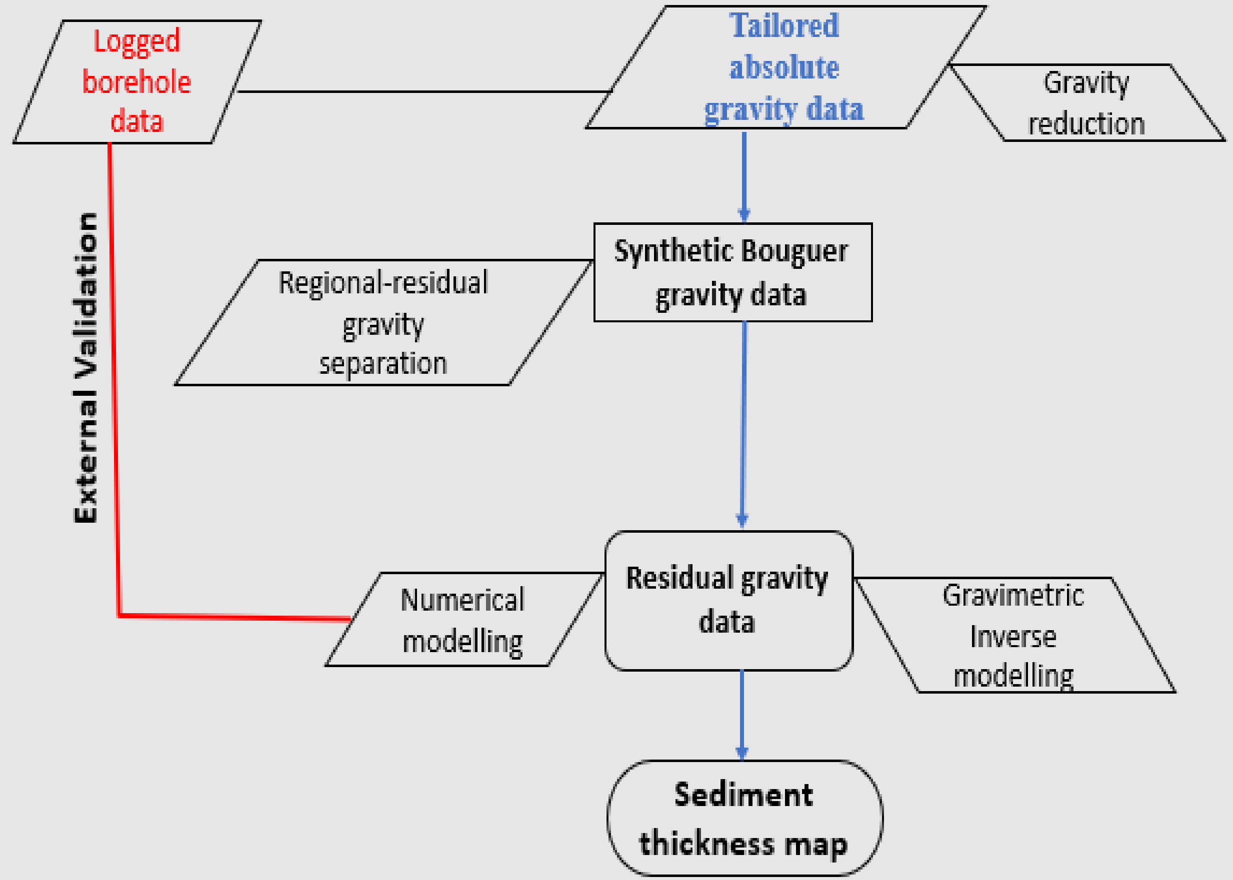
113 Logged Borehole data



High-resolution Bouguer gravity data

Apeh, O. I., Tenzer, R., Pham, L. T., & Ozuah, Z. H. (2023). Estimation of the sediment thickness beneath the Southern Benue Trough in Nigeria by using gravity and borehole data. *Earth Sciences Research Journal*, *27*(1), 47-57.

Methods: We computed a residual gravity data and utilized a numerical modelling procedure to ascertain optimal gravimetric inversion parameters for the entire study area

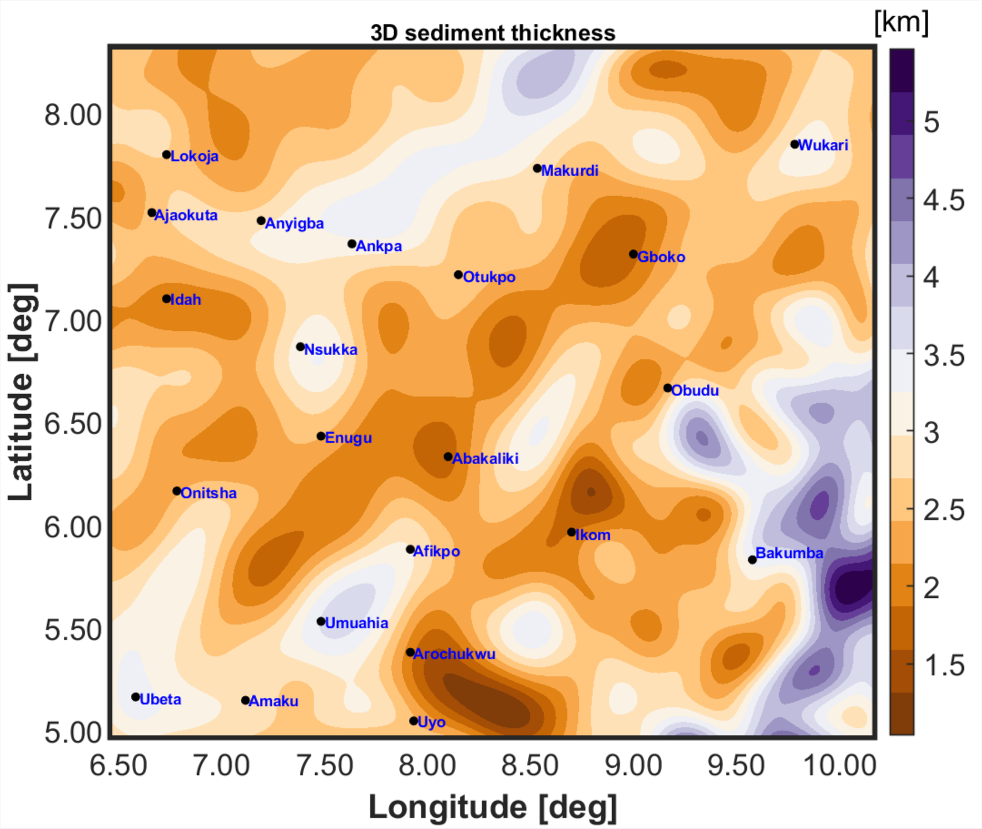


RMS of differences based on selected gravimetric inversion parameters

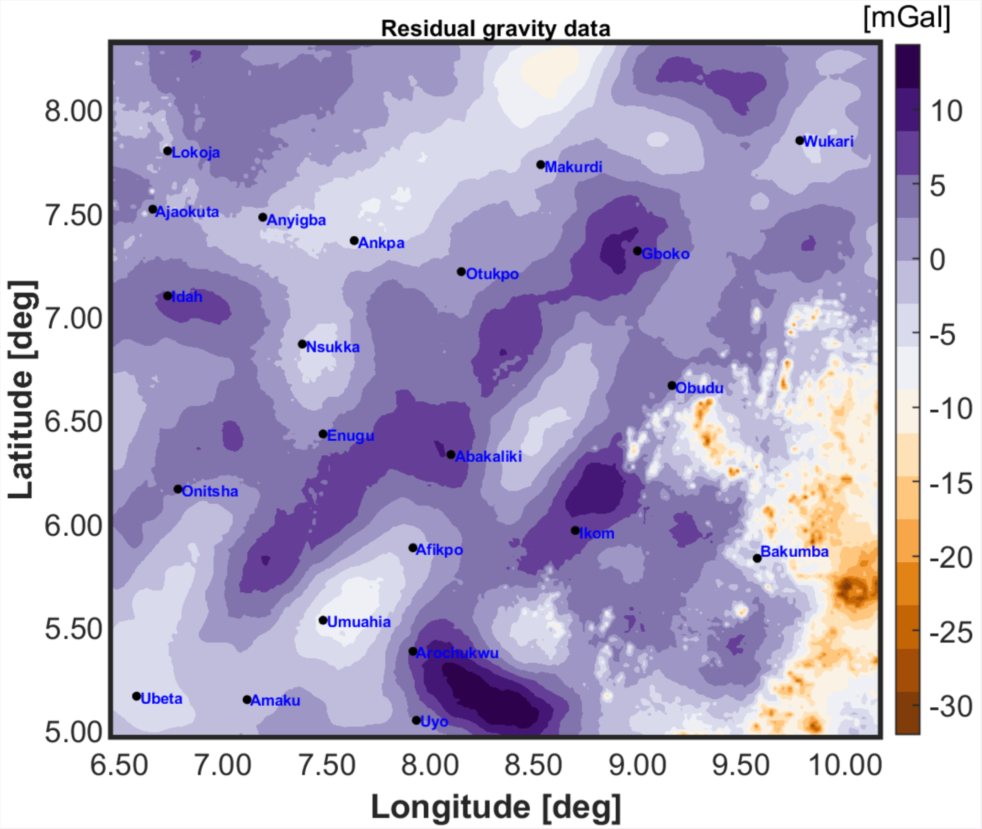
Mean sediment depths (km)	Density contrasts (gcm^{-3})													
	0.11	0.13	0.15	0.17	0.19	0.21	0.23	0.25	0.27	0.29	0.31	0.33	0.35	0.37
	RMS of residuals													
0.0	2.73	2.77	2.81	2.83	2.86	2.88	2.89	2.9	2.92	2.93	2.94	2.94	2.95	2.96
0.3	2.44	2.48	2.52	2.54	2.57	2.58	2.6	2.61	2.63	2.64	2.65	2.65	2.66	2.67
0.6	2.16	2.20	2.23	2.26	2.28	2.30	2.31	2.33	2.34	2.35	2.36	2.37	2.38	2.38
0.9	1.89	1.92	1.95	1.98	2.00	2.02	2.03	2.05	2.06	2.07	2.08	2.09	2.09	2.10
1.2	1.62	1.65	1.68	1.70	1.72	1.74	1.76	1.77	1.78	1.79	1.8	1.81	1.82	1.83
1.5	1.38	1.40	1.42	1.44	1.46	1.48	1.49	1.51	1.52	1.53	1.54	1.55	1.55	1.56
1.8	1.17	1.17	1.19	1.20	1.22	1.23	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.31
2.1	1.01	0.99	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.08	1.09
2.4	0.92	0.88	0.87	0.86	0.86	0.87	0.87	0.88	0.89	0.89	0.9	0.91	0.91	0.92
2.7	0.94	0.87	0.84	0.82	0.81	0.80	0.80	0.80	0.81	0.81	0.81	0.81	0.82	0.82
3.0	1.05	0.97	0.92	0.89	0.87	0.85	0.84	0.84	0.83	0.83	0.83	0.83	0.83	0.83
3.3	1.23	1.14	1.08	1.04	1.01	0.99	0.98	0.97	0.96	0.96	0.95	0.95	0.95	0.94
3.6	1.46	1.36	1.30	1.25	1.22	1.20	1.18	1.17	1.16	1.15	1.14	1.14	1.13	1.13

Pham, L. T., Oksum, E., & Dolmaz, M. N. (2021a). GRV_D_inv: A graphical user interface for 3D forward and inverse modeling of gravity data. *Geofizicheskiy Zhurnal*, *43*(1), 181-193.

Findings: Our sediment thickness map depicts a prevailing southwest trend of increasing sediment thicknesses, while decreasing eastward and also demonstrating the various tectonic events within the entire study area



Sediment thickness map of the entire study area

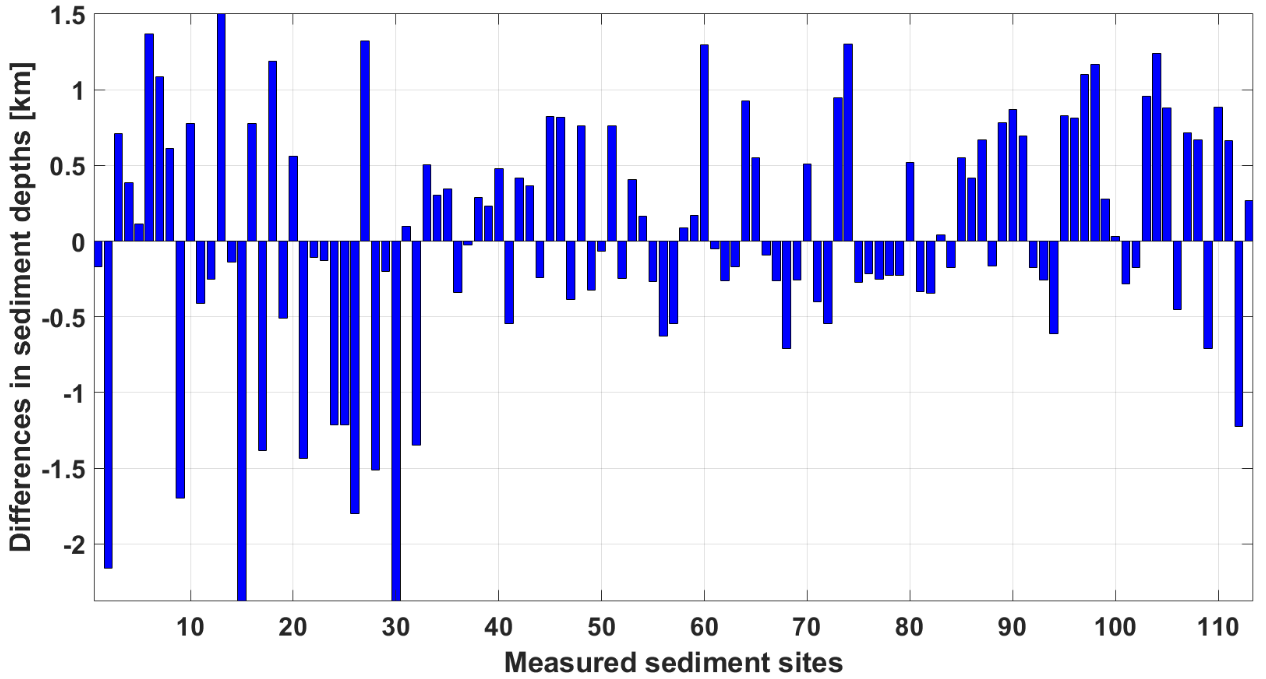


Structure of the crust from our residual gravity map

Apeh, O. I., Tenzer, R., Pham, L. T., & Ozuah, Z. H. (2023). Estimation of the sediment thickness beneath the Southern Benue Trough in Nigeria by using gravity and borehole data. *Earth Sciences Research Journal*, *27*(1), 47-57.

Findings: Our estimated sediment thickness map is consistent with the available logged borehole data and other localized estimates from previous studies

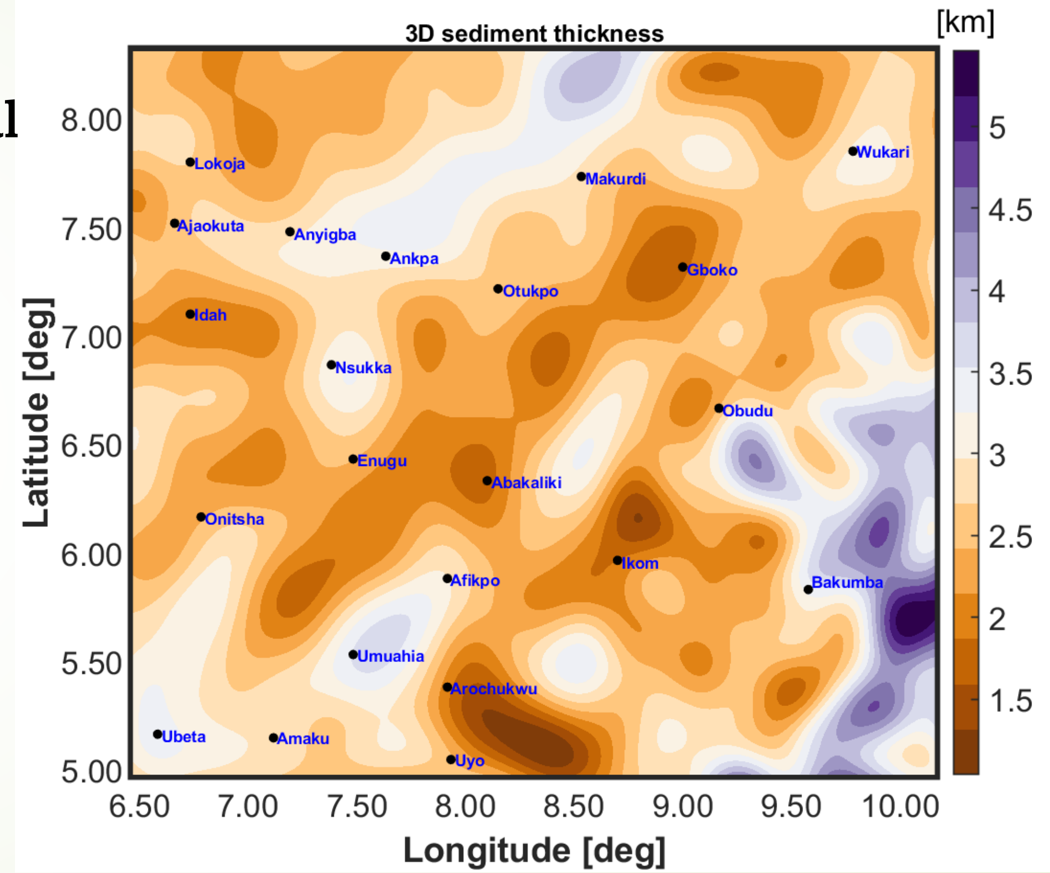
Data for the analysis	Results	Authors
Borehole and gravity data	Maximum of 4.5-5km	Adighije (1976; 1979; 1981a; 1981b)
Surface geology	3.3km for the Albian shales	Kogbe (1976)
Aeromagnetic data	1.3-2.5km within the Anticlinorium	Ofoegbu and Onuoha (1991)
Aeromagnetic data	1.0-4.0km	Obi et al. (2010)
Aeromagnetic data	Maximum of 4.4-4.9km	Oha et al. (2016)



Differences between computed and logged borehole sediment data

Implications of the sediment thickness map to mineral exploration

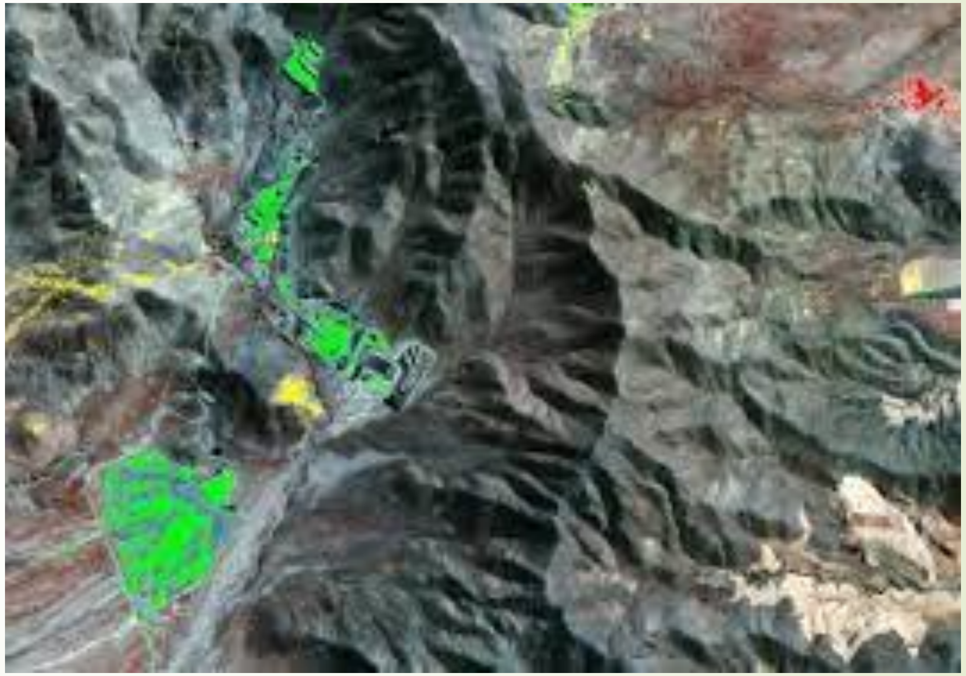
- Thick sedimentary covers within the study area may have been so compacted or compressed to generate adequate heat and pressure for the maturation of several mineral resources in this region.
- Presence of synclines and anticlines indicate compressional and extensional tectonic regimes which could pave way for hydrothermal fluid migration
- Areas with shallow sediments may be good habitats for ore bodies uplifted as a result of magmatism
- There is the likelihood of sediments been entrapped within and under the uplifted crust, which may have matured (because of high temperatures) overtime into mineralization hotspots.



Sediment thickness map

Summary: *the newly compiled sediment thickness map is a good resource for mineral exploration activities

*our methodology could be beneficial for developing countries and regions with insufficient coverage of borehole or seismic data.



THANK YOU