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Basement Geophysical Interpretation of the National Petroleum Reserve Alaska (NPRA), Northern Alaska – supplementary text

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TEXT TO ACCOMPANY BOXES ON PANEL 3 – Part III, the Magnetic Story

Project flowchart

This box contains a pictorial representation of the data, maps, modeling, and interpretation for this part of the project. The rectangles depict data and maps. Arrows show the flow of information. Italicized text shows actions at each step. The eyeglasses highlight a list of things we looked at after completing the magnetic modeling.

We started the project by assembling data from 5 separate aeromagnetic surveys as shown by the small pink boxes. Data specifications for these surveys are in the data table beneath the Location Map in the bottom left of the poster. We did a potential field inversion (Phillips, 1997) to calculate the magnetization of the basement required to produce the observed aeromagnetic anomalies. The geometry of the basement surface was defined by the Tetra Tech (1982) seismic data. We looked at the resulting magnetizations and asked ourselves if they were reasonable values given typical ranges for crustal rocks. Regions of the model where magnetization is greater than 5 A/m, equivalent to a susceptibility of about 100×10^{-3} SI of the basement rocks, were regarded as too great to be plausible. Instead, we prefer a model where these values are indicative of zones in which the magnetic sources are likely shallower than basement and of lower magnetization than modeled.

Rock guide

The right column summarizes our knowledge and assumptions about magnetic susceptibility for rocks beneath NPRA. We have measured susceptibilities on core samples from many portions of the basin stratigraphy. All measurements have yielded susceptibilities less than 2×10^{-3} SI. Basalts encountered in the Tunalik drill core (the Tunalik well is in westernmost NPRA) had maximum susceptibilities of 0.5×10^{-3} SI. We do not have any measurements of basement rock susceptibility. Our magnetization model yields susceptibilities less than about 20×10^{-3} SI in the weakly magnetic basement domain and up to 100×10^{-3} SI in the strongly magnetic domain. Where our basement magnetization model suggests rocks with greater magnetic susceptibility than 100×10^{-3} SI (equivalent to a magnetic intensity of about 5 A/m) we infer that there may be shallower magnetic rocks – labeled “strongly magnetic intrusions?” – within the basin above seismic basement.

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Aeromagnetic map

This map shows the residual total field aeromagnetic field for NPRA and the surrounding region. The map was assembled using data from 5 individual aeromagnetic surveys as listed in the data table and plotted on the Location Map. Most of NPRA is covered by the 1945-46 aeromagnetic survey – the earliest regional survey ever flown over land. The map is dominated by the broad, high-amplitude North Slope deep magnetic high (Saltus and others, 1999) and the flanking lows related to the high. The North Slope deep magnetic high is a fundamental crustal feature, persisting even after 10 km upward continuation of the data (Saltus and others, 1999).

Basement Magnetization Map

This map shows the magnetization required for basement rocks to produce the observed aeromagnetic anomalies. We have divided the basement into two domains based on these data. The northern domain consists of weakly magnetic (magnetization less than 1 A/m) rocks. The southern domain consists of strongly magnetic (magnetizations greater than 1 A/m) rocks. The southern domain includes localized areas with inferred magnetization greater than 5 A/m (equivalent to magnetic susceptibilities greater than 110 x 10^{-3} SI). We regard these magnetizations as being unreasonably high and postulate that magnetic sources are shallower than basement in these areas.

Seismic line with "disturbed zone" = magnetic intrusions?

This poster box displays a depth-migrated view of seismic line R-8, a north-south regional seismic line located in eastern NPRA (shown on Location Map at lower left of poster panel 3). The magenta ovals outline features identified by Rockwell (1978) as possible igneous intrusions based on interpretation of the seismic data.

Noatak region – surface analog?

This box presents several figures that outline our work on interpretation of gravity and aeromagnetic anomalies in the Noatak region, just to the southwest of NPRA. Mafic and ultramafic rocks of the Copter Peak and Misheguk Mountain allochthons correlate spatially with, and are the most obvious source for, the geophysical anomalies. Based on measurement of susceptibility and density on rocks from the area as well as extensive geophysical modeling, we have concluded that the mafic and ultramafic rocks of the Noatak region must be at least 8 km thick and rooted in the crust (Saltus and others, 2001). This interpretation is at odds with the prevailing geologic view of these rocks as parts of thin, far-traveled klippen. If these rocks are not far-traveled, but instead originally emplaced within the sedimentary section and deformed along with it, they may be analogs to the deep magnetic sources of the North Slope deep magnetic high.

Conclusions/References – Poster panel 3

Our geophysical modeling indicates that there is substantial variability in the apparent magnetization of basement rocks beneath the NPRA. In general the northern domain has a weakly magnetic basement and the southern domain a strongly magnetic basement. Portions of the strongly magnetic domain have inferred magnetizations that are too high to be reasonable. Where this occurs, we postulate that there are magnetic sources within the deeper (Ellesmerian) portions of the sedimentary section above the basement, consistent with some features seen on deep seismic lines, but never proven by drilling. The coincidence of these deep basinal magnetic sources in the region of pervasive strongly magnetic basement leads us to postulate that the two sources may be related. They may be the results of mafic magmatism related to extension and the formation of the Ellesmerian basins. Alternatively, some or all of the geophysical variation observed in the basement may be older and unrelated to the possible magnetic sources in the Ellesmerian part of the sedimentary section.

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