Paleoproterozoic Leopard Dikes of the Wyoming Craton: A Dismembered Fragment of the 2.45 Ga Hearst-Matachewan Dike Swarm of the Superior Craton?

Stephen S. Harlan; George Mason University, sharlan@gmu.edu

Abstract

A unique Paleoproterozoic ENE-striking dike swarm is found in the northern Bighorn Mountains of Wyoming and Beartooth Mountains of northwestern Wyoming/Montana. The dikes are porphyritic diabase with dyke parallel plagioclase rich interior zones of zones. The plagioclase in these zones are subhedral to euhedral and up to 8 cm in diameter, consisting of up to 60% of the volume of the rock. The concentration of the white saussuritized plagioclase in these zones imparts a spotted appearance to the dikes, thus prompting the name "leopard dikes". The concentration of plagioclase into the central zones of the dikes is probably due to flow differentiation during a single episode of dike emplacement (Heimlich and Manzer, 1973).

Although there have been attempts to date the leopard dikes by Rb-Sr and K-Ar methods, their age has not been reliably determined but they are probably Paleoproterozoic in age. The overall appearance and characteristics of the dikes are similar to dikes of the 2.48-2.45 Ga Matachewan-Hearst dike swarm of the Superior craton.

Recently, Heaman (1997) suggested the Wyoming craton leopard dikes may have been emplaced during a major mafic magmatic that included emplacement of layered mafic complexes, giant radial dike swarms, and flood basalts within the Superior and Karelia cratons, which together were part of the Archean/early Paleoproterozoic supercontinent Kenorland.

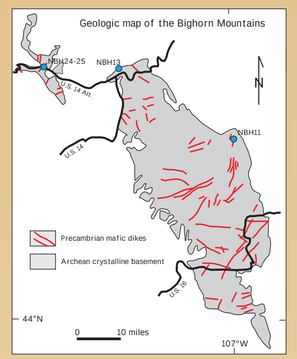
Recently published isotopic dates of ca. 2.48 Ga from the Blue Draw metagabbro form the Black Hills of the Wyoming craton (Dahl et al., 2003) may also be related to this event. Limited paleomagnetic data from the Wyoming craton have been argued to be consistent with this model (Heaman, 1997) but the data must be considered to be unreliable. However, recently published paleomagnetic and geochronologic data suggest that the Wyoming and Superior cratons were adjacent at about 2.2 Ga. A paleogeographic reconstruction following Harlan et al. (2003) is consistent with the idea that the Wyoming craton leopard dikes were part of the giant radial Matachewan-Hearst dike swarm and place the Blue Draw metagabbro near the plume center. Subsequent breakup and rifting at about 2.15 Ga has since dispersed these continents and the records of this mafic magmatic event. New paleomagnetic and geochronologic data from the Wyoming craton leopard dikes should allow test of such models and thus could prove valuable in assessing the viability of the Kenorland or other Paleoproterozoic plate reconstructions.

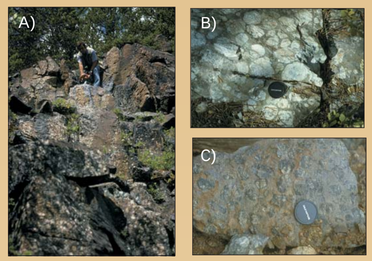
Goals of Project:

1) Characterize paleomagnetism of Northern Bighorn Dikes
2) Determine age of remanence acquisition
3) Test whether Bighorn and Beartooth Mtns. Leopard Dikes are part of the 2.48-2.45 Ga Matachewan-Hearst Dike swarm of the Superior Province

Lab Assistant ("Bayley')

Proterozoic Mafic Dikes in the Northern Bighorn Mountains, WY



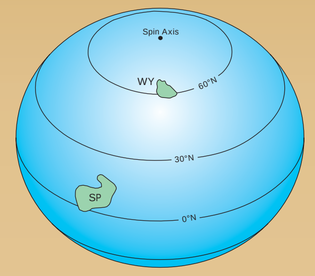


Photographs of Leopard dikes from the northern Bighorn and Beartooth Mountains. A) Typical exposure of Leopard dike in the northern Bighorn Mountains. B) Close up of typical Leopard dike sample from the Beartooth Mountains. C) Close up of unusual Leopard dike that does not show the cloudy white feldspars typical of the other dikes. This dike is exposed near Beartooth Butte in the Beartooth Mountains.

NE-striking diabase dike in the northern Bighorn Mountains, Wyoming. The dike intrudes pink Archean granite along the left side of the photograph. Paleomagnetic results from this dike are shown below (sites NBH24 and NBH25).

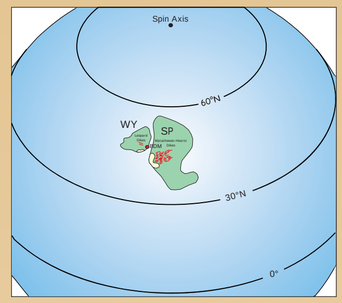
Preliminary Reconstruction Based On Paleomagnetic Data from Leopard Dikes

Paleogeographic reconstruction of the Wyoming and Superior cratons using the preliminary virtual geomagnetic pole from the northern Bighorn Mountains Leopard dike and the paleomagnetic pole from the Matachewan-Hearst dike swarm (Bates and Halls, 1990). Assuming that the Leopard dikes are the same age as the Matachewan dikes, then the preliminary data indicate that the Wyoming and Superior cratons were at signficantly different paleolatitudes. This result must be viewed with caution, however, as it is based on a very limited paleomagnetic data set from the Leopard dikes and the Leopard dikes have not been reliably dated. More data are need to fully evaluate this interpretation and further work is in progress.



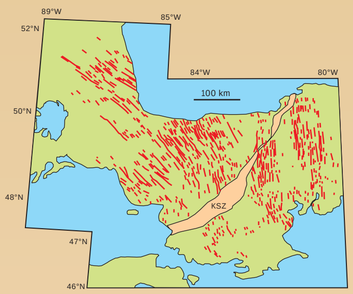
Alternative Reconstruction ca.2.2 Ga

Proposed paleogeographic reconstruction of Wyoming and Superior cratons based on paleomagnetism of a ca. 2.2 Ga quartz diorite in the southern Wind River Mountains (Harlan et al., 2003). The paleomagnetic data indicate that the two cratons could have been located close together at this time. The overlap of sedimentary successions of the Wyoming Craton Snowy Pass Supergroup and the Huronian Supergroup at this time was originally proposed by Roscoe and Card (1993). If this reconstruction is correct, then the Matachewa-Hearst and Wyoming Leopard dikes could have been part of a proposed radial dike swarm prior to rifting and breakup of the two cratons at about 2.1 Ga. The ca. 2.48 Blue Draw metagabbro (BDM) (Dahl et al., 2003) may have also been part of this event.



(Harlan et al. 2003)

2.48-2.45 Ga Matachewan Dike Swarm and Plume Hypothesis



Distribution of dikes associated with the Matachewan and Hearst dike swarms (Heaman, 1997). KSZ is the Kapuskasing Structural zone.

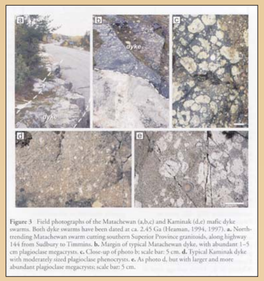


Figure 3 Field photographs of the Matachewan (a,b,c) and Kaminak (d,e) mafic dyke swarms. Both dyke swarms have been dated at ca. 2.45 Ga (Heaman, 1994, 1997). **a**, North-trending Matachewan swarm cutting southern Superior Province granitoids, along highway 144 from Sudbury to Timmins. **b**, Margin of typical Matachewan dike, with abundant 1–5 cm plagioclase megacrysts. **c**, Close-up of photo b; scale bar: 5 cm. **d**, Typical Kaminak dyke with moderately sized plagioclase phenocrysts. **e**, As photo d, but with larger and more abundant plagioclase megacrysts; scale bar: 5 cm.

Photographs of Matachewan Dikes of the Superior craton (Bleeker, 2004)

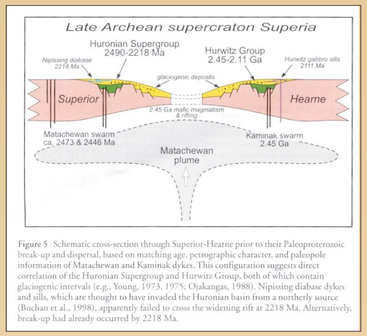
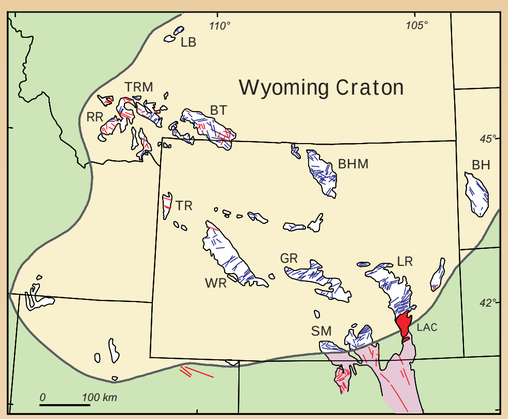


Figure 5 Schematic cross-section through Superior-Hearne prior to their Paleoproterozoic break-up and dispersal, based on matching age, petrographic character, and paleopole information of Matachewan and Kaminak dykes. This configuration suggests direct correlation of the Huronian Supergroup and Hurwitz Group, both of which contain glacigenic intervals (e.g., Young, 1973, 1975; Ojakangas, 1988). Nipissing diabase dykes and sills, which are thought to have invaded the Huronian basin from a northerly source (Buchan et al., 1998), apparently failed to cross the widening rift at 2218 Ma. Alternatively, break-up had already occurred by 2218 Ma.

Plume hypothesis for Matachewan Dikes (Bleeker, 2004)

Proterozoic Mafic Dikes of the Wyoming Craton



Modified from Snyder et al. (1988)

Proterozoic mafic dikes are common in the basement-cored uplifts of the Laramide foreland province of Wyoming and Montana. Apparent ages, determined by a variety of means range from ca. 2.7 to 0.78 Ma. Unfortunately, much of the isotopic dating is potentially unreliable and new modern geochronologic dating efforts are needed. Dikes in blue are Paleoproterozoic or possible Archean; dikes in red are Mesoproterozoic or Neoproterozoic. LB = Little Belt Mountains; TRM = Tobacco Root Mountains; RR = Ruby Range; BT = Beartooth Mountains; TR = Teton Range; BHM = Bighorn Mountains; WR = Wind River Range; GR = Granite Mountains; LR = Laramie Range; SM = Sierra Madre Mountains; LAC = Laramie anorthosite complex.

Proposed ca. 2.45 Ga Plate Reconstruction Based on Matachewan Dikes (Heaman, 1997)

A proposed 2.45 Ga plate reconstruction by Heaman (1997) showing the paleogeographic position of the Superior, Wyoming, and Karilia cratons based on paleomagnetism. A problem with this plate reconstruction is that the paleomagnetic data from the Wyoming craton (Larson et al., 1973) must be considered suspect, because it is not clear which paleomagnetic poles are being used in this reconstruction nor are the age of the dikes or the age of remanence acquisition well constrained. From a review of the literature, it is unclear and perhaps unlikely that the Matachewan-like Leopard dikes of the Wyoming craton were sampled by Larson et al. (1973).

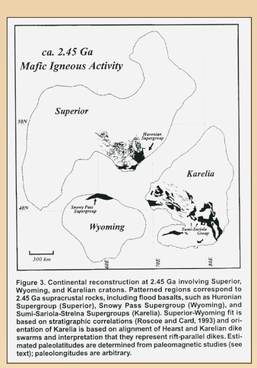
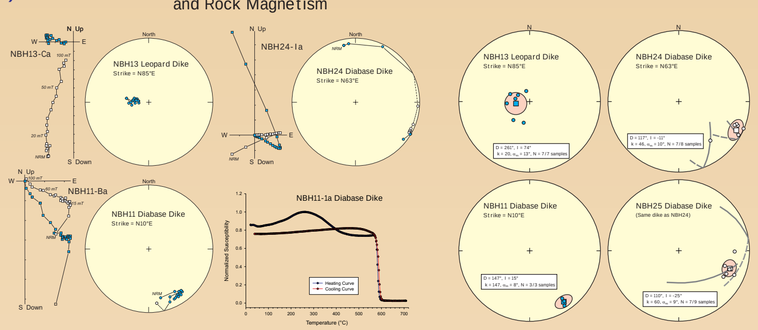


Figure 3. Continental reconstruction at 2.45 Ga involving Superior, Wyoming, and Karelian cratons. Patterned regions correspond to 2.45 Ga supracrustal rocks, including flood basalts, such as Huronian Supergroup (Superior), Snowy Pass Supergroup (Wyoming), and Sumi-Sariola-Strelna Supergroups (Karelia). Superior-Wyoming fit is based on stratigraphic correlations (Roscoe and Card, 1993) and orientation of Karelia is based on alignment of Hearst and Karelian dike swarms and interpretation that they represent rift-parallel dikes. Estimated paleolatitudes are determined from paleomagnetic studies (see text); paleolongitudes are arbitrary.

Preliminary Paleomagnetic Results

Demagnetization Behavior and Rock Magnetism

Sample- and Site-mean Directions



Preliminary paleomagnetic data from four sites in three dikes from the northern Bighorn Mountains, Wyoming. Paleomagnetic data from only one Leopard Dike is available at this time.

Conclusions

1) Preliminary paleomagnetic data from four sites from dikes with three different orientations/characteristics yield interpretable paleomagnetic data. The data are distinct from present-day or Recent field directions and are thus interpreted to be ancient remanent magnetizations. Additional work is needed to establish whether these are primary magnetizations associated with dike emplacement.

2) A ca. 2.45 Ga reconstruction based on paleomagnetic data from the one Leopard dike yields distinctly different paleolatitudes for the Superior and Wyoming cratons. This suggests that the Matechewan and Leopard dikes are unrelated. However, further work is needed to establish the age of the dikes, the age of dike remanence, and to produce a more robust paleomagnetic data set.

3) A more robust data set, based on paleomagnetic data from a ca. 2.2 Ga tonalite elsewhere in Wyoming, suggests that the Superior and Wyoming cratons were in close proximity at that time. It is thus possible that Superior and Wyoming were linked at ca. 2.45 Ga and that the Matachewan and Leopard dikes are part of the same magmatic event. Additionally, the ca. 2.48 Ga Blue Draw metagabbro in the Black Hills (Dahl et al., 2003) may also be part of this event.

4) Better geochronologic control, using high precision U-Pb techniques, is needed to better understand the age and distribution of mafic dikes in the Wyoming craton in order to provide possible markers or piercing points for Precambrian plate reconstructions.

References

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