MAGNETIC PALEOPOLE ASSOCIATED WITH APOLLINARIS PATERA, MARS, AND POLAR WANDER. B. Langlais[1], G. Tobie[1], Y. Quesnel[2], and G. Robuchon[1], [1]Laboratoire de Planétologie et Géodynamique, CNRS UMR 6112, Université de Nantes, France (Benoit.Langlais_AT_univ-nantes.fr), [2]GeoForschungsZentrum, Potsdam, Germany.

Introduction: The magnetic field of Mars as measured today by Mars Global Surveyor is very likely due the combination of (i) magnetization processes (primary, while a dynamo was active on Mars, or secondary), and (ii) demagnetization processes (thermal reheating, shock effects, tectonics). Modeling and interpreting magnetic measurements is thus a key step to better understand Mars' early evolution.

In this paper we focus on magnetization directions. These can indeed by used to infer magnetic paleopole locations, and paleo rotation axis, assuming the magnetic field was axial and dipolar. We identify a magnetic anomaly associated with a volcano. Such a correlation between a tectonic feature and a magnetic anomaly greatly reduces the uncertainty related to the location and to the direction of the magnetic anomaly. We first present data and modeling approach. We then introduce the volcano, and discuss the results in terms of paleopole location and polar wander.

Magnetic field measurements and magnetization directions: MGS has provided a global coverage of the Martian magnetic field at a quasi-constant altitude of ~400 km [1]. Prior to these Mapping Orbit (MO) cycles, MGS sampled the magnetic field of Mars at altitudes as low as 90 km, between Sept. 1997 and March 1999. MGS measured the three components of the magnetic field, with accuracy lower than 1 nT on each component [2] (spacecraft generated magnetic fields and attitude errors).

Magnetic field measurements can be used to infer the magnetic properties of the sources. This can be done using the forward approach, based on simple geometry magnetized bodies [3-6]. Source parameters are adjusted so that the predicted magnetic signal is close to the actual measurements. However, this approach relies on isolated magnetic anomalies, as it is difficult to take into account adjacent sources. More complex anomalies can be investigated through local inverse methods, in which the problem is first approximated via a priori information on the magnetic sources (direct approach [7], or surface signatures [8]). Finally, more global approach, such as the equivalent source dipole scheme, may be used [9,10]. But it relies on a homogeneous distribution of sources, which limits the accuracy of the magnetization directions. Source location and magnetization direction can be used to infer the location of the magnetic paleopole, assuming the magnetic field that did magnetize the unit was dipolar.

Magnetic paleopoles: There have been many studies dealing magnetic anomalies, magnetization directions and magnetic paleopole. Most of these studies were based on forward approaches, applied on relatively isolated magnetic anomalies, in order to minimize the uncertainty linked to adjacent sources. However, source location and magnetization directions are correlated, which limits the accuracy of the results. We list in Table 1 some of the previous studies.

Ref	Data	Studied area	Method	Paleopoles
[4]	4 low-altitude orbits	Terra Sirenum et Terra Cimmeria	Alterning polarity magnetic stripes	Lon (90,360), Lat (-10,10)
[5]	Spherical Harmonics model	10 isolated anomalies	Vertical cylinders	Cluster of 7 paleopoles within 30° of (25N, 230E)
[6]	Low altitude	2 isolated anomalies, north pole	Prisms	(38N, 141E) and (61N, 136E)
[11]	Low and high altitude	9 isolated anomalies	Vertical cylinders	2 clusters, near (30N, 170E) and (15N, 270E)
[12]	High altitude	9 dipolar anomalies	Surface disks and 3D prisms.	No cluster

Table 1 – Summary of previous magnetic paleopole studies.

Apollinaris Patera is a shield volcano located in (9.3°S, 174.4°E), slightly North of the crustal dichotomy. It extends over near 200 km, and has a 75-km wide caldera. Recent crater counts showed that the edifice was completed 3.74 Gy ago [13]. Its oldest visible surface is 3.98 Gy old. It is very likely that the volcano is actually older.

This volcano is associated with a strong magnetic anomaly (Fig 1). In particular, there is a correlation between the high- and low-altitude measurements: the radial components changes its polarity above the volcano while the horizontal North-South one is maximum. This signature is commonly associated with horizontally magnetized bodies.

Results: Source parameters are estimated using an inverse scheme, based on a local array of equivalent sources. Several tests are performed, using either one or more sources, and by imposing homogeneous magnetization or without a priori constraints on magnetization directions.

Magnetization directions are very stable over the volcanic edifice. The mean inclination is close to 0°, with a declination close to 180°. We use the seven closest sources from the volcano to infer a mean paleopole location. It is located at (88°S, 99°E), with an associated α_{95} equal to 18°. This paleopole is actually very close to the rotation axis [14].

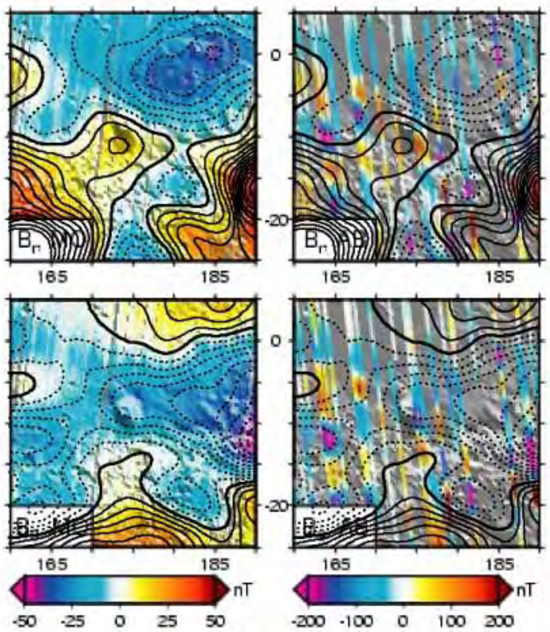

Figure 2 – Radial and north-south magnetic field components measured over Apollinaris Patera during the AeroBraking (right panel) and the Mapping Orbits (left panel). Isocontours of the MO data (5 nT interval) are superposed onto AB data.

Discussion and polar wander: This new result is based on the correlation between a geologic structure and a magnetic anomaly, and can thus be considered as reliable. We show on Fig. 2 paleopole locations estimated using different approaches. These and our result implies a major polar wander, from a near Tharsis bulge location to its present day location. Such a polar wander would have occurred prior to the dynamo shutdown.

The migration of Tharsis toward the equator has already been advocated by several authors [18-20]. The new results reported here provide fundamental constraints on the timing of Tharsis' apparent motion. As the migration rate is controlled by the rotational bulge readjustment, it gives key information on the viscosity of the Martian mantle at the time of Tharsis emplacement and subsequent motions. However, accurate timing of terrainsassociated with the different computed magnetic (and rotation) paleopoles is required in order to assess the time and the duration of this major polar wander event.

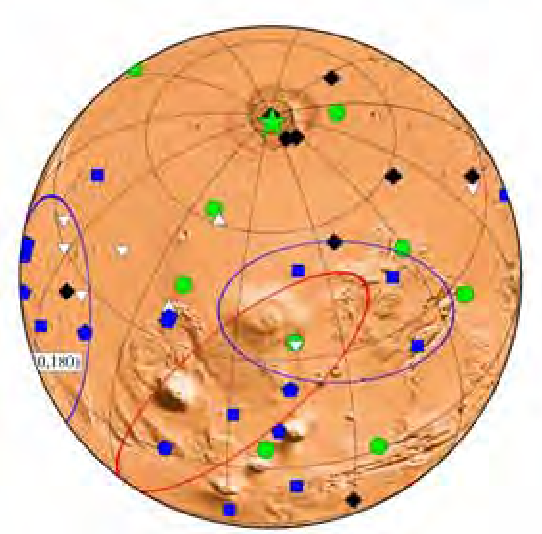

Figure 2 – Location of magnetic paleopoles as computed in several studies: ⬟ [5]; △ [6]; ● [7]; ■ [11]; ♦ [12]; ★ [14]; ▽ [15]; ***0*** [16]; ***0*** [17].

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