THREE AGES FOR THE MARTIAN LITHOSPHERE.

Alberto G. Fairén, Miguel A. de Pablo, Gabriel Castilla, Javier Ruiz, Jorge Anguita, Álvaro Hácar, Elisa Toloba, Antonio García, Sergio Rodríguez. Seminar on Planetary Sciences, Universidad Complutense, 28040 Madrid, Spain. Fairen.ag@terra.es

INTRODUCTION.

The magnetic lineations detected in Mars were originally explained as a sea-floor spreading effect [1]. Here we argue instead that the lineations could have been formed at a convergent plate margin, through both the accretion of terranes and back-arc spreading. This would imply a differential process in the origin of the Martian lithosphere, which would determine the formation of three extended areas in different times.

SCIENTIFIC BACKGROUND.

The discovery of large expanses of Martian crust with remanent magnetism [2] required an in-depth revision of the previous ideas on Martian dynamics. As Connerney *et al.* (1999) put it [1], "Plausible alternatives to this interpretation [the Mars highlands as remnants of an early "oceanic" crust] are few". They call to intrusives, folding, and hydrochemical alteration. Since the Earth's oceanic crust is created by sheet dike intrusions, the first one is not really different from sea floor spreading. The folding alternative would only explain the lineations geometry, but would pose an almost impossible geologic problem in exchange. On the contrary, the chemical magnetization would be at odds to explain a linear geometry.

Barring the ultimate alternative (namely, that a physical or chemical process unknown on Earth is the responsible of a feature which would only apparently resemble Earth's magnetic lineations), we propose that the Martian magnetic bands could be related to a past period of plate tectonics, but to a process of lithospheric destruction instead of generation. If the Martian boundary is, as proposed by Sleep (1994) [3], a former convergent plate border, the area southwards of it would be a zone where fragments of crust would accrete, the geometry of which would be defined, as in Earth, by the angle of collision between the two plates. The five clearly linear bands of Terra Sirenum-Terra Cimmeria (110º-200ºW, 40º-80ºS, Fig. 1) would thus be sheared terranes, and their transition to more round-shaped magnetic features (110º-220ºW, 10ºN-40ºS) would indicate face-on collision conditions.

An earthly parallel with the process proposed can be seen in the aeromagnetic map of Alaska (Fig. 2) published by Saltus *et al.* (1999) [4], where the southern linear anomalies, with similar sizes (~100 km) and geometry as the Martian lineations, are interpreted as sheared terranes. There is a debate between the continental [5, 6] or oceanic [7] interpretations of the interior region, a broad expanse of neutral magnetic character. In what concerns the Martian magnetism, the interesting point is that this neutral zone steps laterally into a magnetic high, just the same geometry we see at Terra Cimmeria (200ºW, 80ºS; Fig. 1) and Terra Sirenum (120ºW, 45ºS; Fig. 1). Mars magnetized crust could thus be interpreted as the Earth's: a jigsaw of continental and oceanic pieces. Alternatively, some of the magnetic highs could be mafic intrusions (related or not to rift episodes), as in the interpretation of the deep magnetic high in Alaska northern region.

THE AGE OF THE MARTIAN CRUST.

Following the previous ideas, the magnetized Martian highlands would be the same age as the Martian paleomagnetic field [8][9]. And the northern lowlands would have the same sea-floor spreading origin the highlands have, instead some time after; in fact, the lowlands seems to be a landscape derivated from the own ocean presence [10]. So, it seems that the magnetization process would have affected them in the same way. Nevertheless, no significant anomalies have been detected on the Martian lowlands and, in any case, no linear bands have been described. It is likely that this area has never presented magnetic anomalies, because the possible plate tectonics would have called for a melted nucleus to operate; and the inner self-induced dynamo would have required, furthermore, this nucleus to be in convection to generate a magnetic field.

Once more, the Earth provides support for this proposal. A planetary dynamo needs a great energetic contribution, as high as $6x10^{22}$ J for the terrestrial magnetic field; whereas the absolute superficial geothermic flux energy emission is only $7,5x10^{20}$ J for the Earth. Following these data, we can imagine an evolutive scenario where the Martian core would have had progressively dissipated its energy (faster than Earth's, due to the smaller size of the planet and its high relation surface/volume), driving the magnetic field to cease its activity before the litosphere dynamism did. This delay would have been long enough for plate tectonics to generate new, unmagnetized crust in the lowlands, until the disappearance of the sea floor spreading effect on its own. As this process would have been gradual, the weaker and localized anomalies detected in some areas in the younger crust of the lowlands [11], as the ones at Arabia Terra are, could be taken as the final stages of the magnetic field activity.

In this model, the area between ~60º S and *Chasma Australe*, which also lacks magnetic lineations, would be the only remainder of the Mars' primitive crust, constituted even before the nucleus formation and the inner dynamo began to operate.

References.

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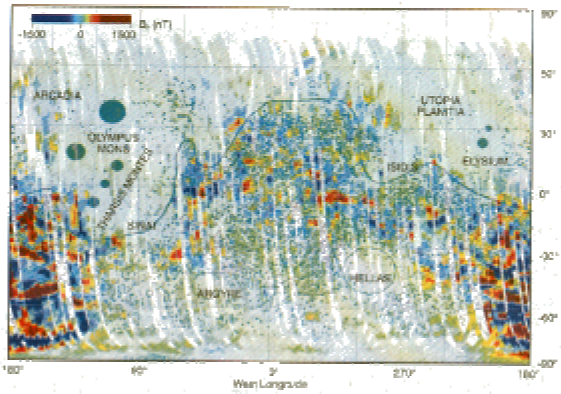

Fig. 1: Map of the Martian magnetic anomalies (from ref [2]).

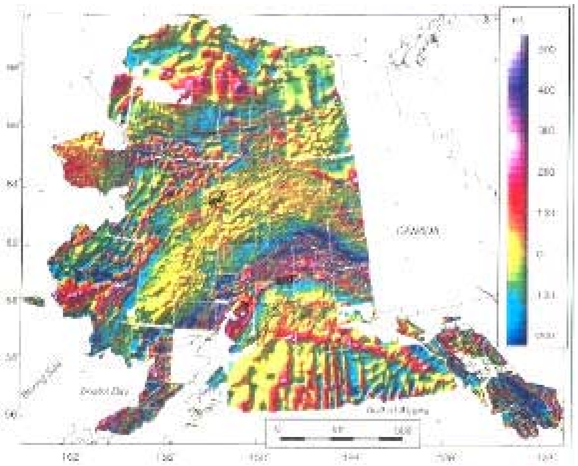

Fig. 2: Aeromagnetic map of Alaska, after ref [4].