SPHERICAL HEMATITE CONCRETIONS IN MERIDIANI PLANUM, MARS, AND MONTERDE, NORTHEAST SPAIN: AN ANALOGUE AQUEOUS ORIGIN

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Hematite-enriched spherules are the most conspicuous diagenetic features observed in the Meridiani Planum region to date by MER-1 Opportunity. Their almost perfect spherical shape and close similarity in color and size point to a similar origin and history. After observations based on textural, compositional and mineralogical analyses, they have been hypothesized to have formed during early burial diagenesis in an aqueous-influenced sedimentary sequence, when groundwater carrying dissolved minerals flowed through the rocks and precipitated a grain that typically growed into a secondary hematite-cemented sphere [1]. Alternative origins related to impact glass [2] or volcanic lapilli [3] have also been suggested. Terrestrial analogues have been proposed for the Meridiani concretions, such as those formed by groundwater infiltrating the Jurassic Navajo Sandstone of southern Utah [4,5], and those formed by aqueous alteration of basaltic tephra under acid-sulfate conditions on Mauna Kea volcano of Havaii [6].

Here we present a previously undescribed terrestrial locality in Northeast Spain, Monterde (Fig. 1A,B), where similar concretions appear dispersed across several tens of km^2. We have selected two specific sites for collecting concretions (Fig. 1B-F). The spatial distribution of the spherules in Monterde is similarly uniform to those found in Meridiani, and their preservational state indicates a greater resistance to weathering with respect to the surrounding rock. Compared to those observed in Meridiani, Monterde spherules have narrower sizes (Fig. 1G), as well as an inner massive structure coated by concentric banding (Fig. 1G), in contrast to the general lack of internal structure observed in the martian counterparts. In addition, Mössbauer-based analysis of the Meridiani spherules indicate a nearly pure hematite composition, whereas our XRD-based analysis of the Monterde concretions indicate a mostly sandstone composition cemented by kandite (caolinite) and goethite, with hematite comprising up to a few percent to one-quarter of the rock (Fig. 1H).

Monterde spherules (concretions) formed during the Cretaceous period, involving subsurface and/or surface water transport and precipitation of iron in an ocean/land transitional environment (likely deltaic). We infer that the context for the formation of hematite concretions on Mars may have also involved both shallow surface and subsurface water, giving credence to the hypothesis that Meridiani was the site of a coastal dune and interdune playa-like platform margin of a former lake or ocean [7].

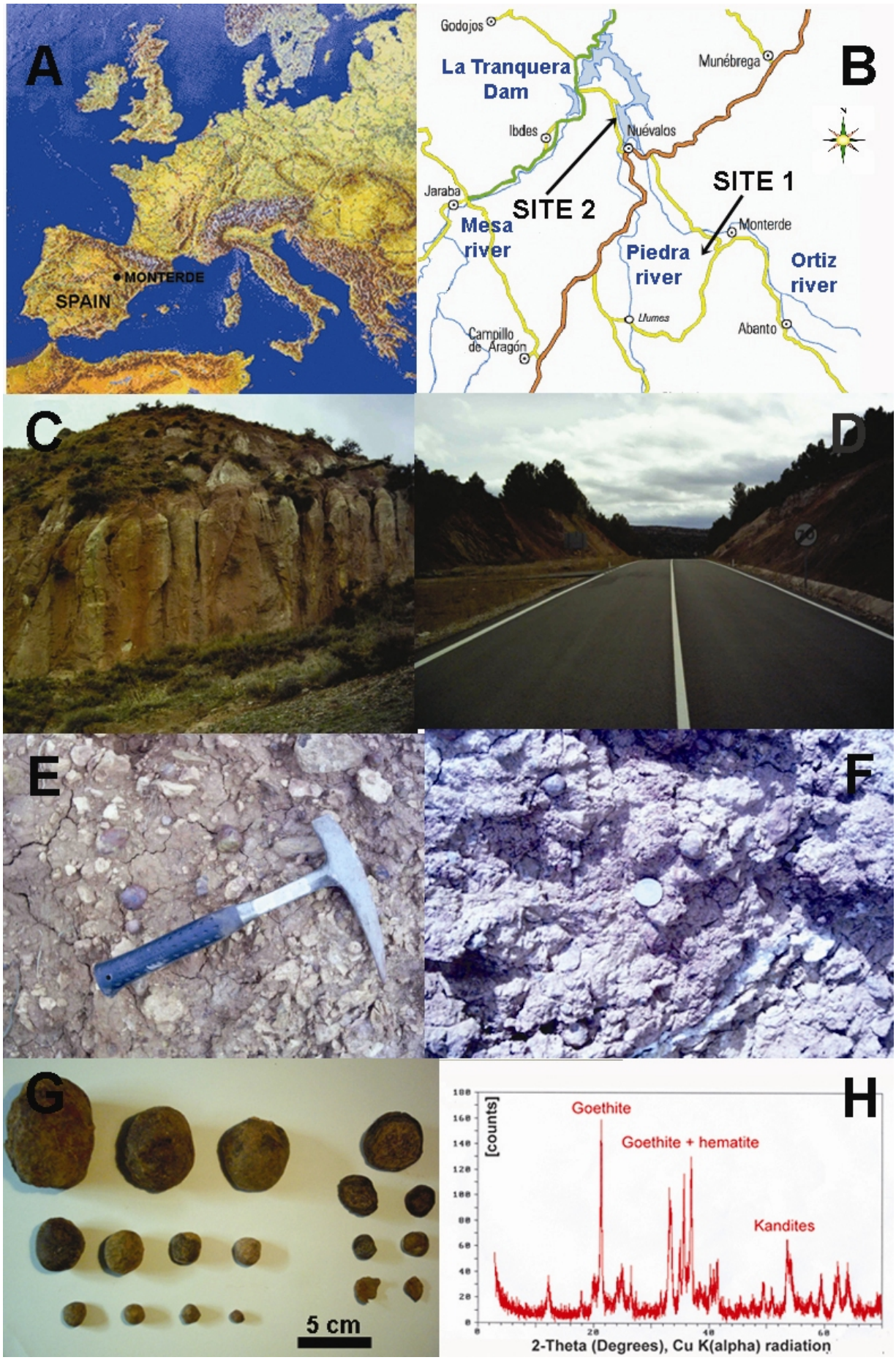
Our work in progress will include additional scientific scrutiny on where and how the Monterde concretions formed, in the aim of shedding further light on the formational mechanisms of the Meridiani spherules. Also, we plan to analyze whether there is evidence for past microbial activity in the Monterde concretions, since microorganisms can act as catalysts for a more rapid formation of concretions [8], and thus may bear on the search for evidence of life on Mars.

References:

[1] Squyres, *et al. Science* 306, 1709-1714 (2004). [2] McCollom & Hynek, *Nature* 438, 1129-1132 (2005). [3] Knauth, *et al. Nature* 438, 1123-1128 (2005). [4] Ormö, *et al. Icarus* 171, 295-316 (2004). [5] Chan, *et al. Nature* 429, 731-734 (2004). [6] Morris, *et al. Earth Planet. Sci. Lett.* 240, 168-178 (2005). [7] Fairén, *et al. Icarus* 165, 53-67 (2003). [8] Coleman *et al. Nature* 361, 436-438 (1993).

Figure 1:

A: Geographic setting of Monterde. B: Locations of sample collection Sites 1 and 2. C,D: General views of Sites 1 and 2, respectively. E,F: Rock outcrops comprising concretions in both Sites 1 and 2, respectively (note hammer and 1-€ coin for scale). G: Size ranges and outer coatings of concretions. H: XRD results for Monterde spherules collected at Sites 1 and 2.


A
MONTERDE
SPAIN
B
Godojos
La Tranquera Dam
Munébrega
Ibdes
Nuévalos
SITE 1
SITE 2
Jaraba
Mesa river
Monterde
Piedra river
Ortiz river
Llumes
Abanto
Campillo de Aragón
C
D
E
F
G
5 cm
H
[counts]
Goethite
Goethite + hematite
Kandites
2-Theta (Degrees), Cu K(alpha) radiation