Viking's experiments and hypothesis that Fe(VI) is a possible candidate as Martian oxidant.

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The note submitted by Dr. Gil Levin was to be expected - one always wants a forum for arguing for one's ideas. In suggesting that Fe(VI) in some form might be part of the explanation for the Viking LR experiment, we hoped to open a dialogue with those who seek to understand the past and plan for the future.

Dr. Levin's interpretation of our report is that we want to explain all of the Viking results via Fe(VI) oxidative chemistry. While this might be an outcome (we personally believe it is unlikely to be the sole explanation), nothing of the sort was or is on our minds. We sought to report the oxidative properties of a few Fe(VI) adducts, to show that qualitatively they mimicked some of the Viking results, and to suggest that if they are on the surface of Mars, they will be easy to identify by any of several different techniques specifically by the Moessbauer spectrometer to be carried by the '03 MER rovers.

Our paper does not deal with the question is (or was) life on Mars. Our paper was written simply to point out that there are potential oxidants that may be not have been previously considered, and that these can be easily measured *in situ*. Why not to do it? As we pointed out in our paper what we really need are more data, and some experiments with controls. These will be forthcoming, and if real evidences to support the presence of life, oxidants or both come forward, we will welcome all.

Oxidizing nature of Martian soil, and contribution of active oxygen forms such as peroxides and superoxides to these oxidizing properties is a widespread belief. In a recent publication (A. S. Yen et al., 2000; see also rebuttal by G. Levin, 2001) some additional chemical simulation and spectral data have been presented in favor of the formation of superoxide radical ions in Martian soil at UV irradiation. Thus, both superoxide and iron(III) may be there. Lack of IR evidence for the presence of hydrogen peroxide in the atmosphere of Mars (Krasnopolsky, V. et al., 1997) has little to do with the composition of Martian soil. Further question is what is the fate of this active oxygen. It may stay as, say, potassium superoxide, or other metal superoxide, or transform into some other chemical forms. We explored one of such opportunities: formation of higher oxidation state iron, ferrate(VI).

There is an important point to be gathered here, one that perhaps deserves some discussion. The Viking experiments were remarkable achievements of technology, especially for their time. The fact that they remain to be explained some 25 years later is testament to the complexity of the situation. If life had been abundant and obvious, it would have been unambiguously seen. Could these experiments be a combination of chemistry and biology, could they be chemistry, or could they be biology? It is our goal and our duty to ask such questions. On Earth we can design possible mimics and test

them, which we have done with the Fe(VI). That the match was not perfect was acknowledged when biology experiments are repeated, even in the lab, they are seldom perfect matches. In our opinion, if the explanation for Viking is chemistry, then it will likely be a complex mixture of different oxidants acting together in ways that no single one could mimic. We are rather comforted by a qualitative agreement with some of the LR and GEx results.

As for the explanations of these results being due to biological activity by contaminating microbes, it was an oversight on our part to not include details of sterility and cleanliness that were taken. In fact, Fe(VI) is such a strong oxidant that it is now used for sterilization by our laboratory, and for the removal of contaminating nucleic acids, which are oxidized to CO_2 (Tsapin A. et al., 2000). While we acknowledge that this may be no excuse for leaving out the detailed sterilization procedure, we can only say emphatically, despite of page calculations presented by Dr. G. Levin, it is not the case. No biological activity accounted for our results.

In a final point, Dr. Levin states that "none of the thirty non-biological explanations offered to date has been completely convincing" and infers that his conclusion that "the LR detected living microorganisms in the soil of Mars" must thus be correct. We note here that the LR experiment was also extremely controversial and joins the non-biological explanations as being less than completely convincing. The excitement of searching for life on Mars and elsewhere lives on, but we urge Dr. Levin to not dismiss other hypotheses, especially when they are eminently and rather easily testable.

1. A. S. Yen, S. S. Kim, M. H. Hecht, M. S. Frant, and B. Murray 2000, Evidence That the Reactivity of the Martian Soil Is Due to Superoxide Ions **289**, 1909-1912.

2. G. V. Levin, 2001, O_2^- Ions and the Mars Labeled Release Response, Science, **291, 2041a.**

3. V. A. Krasnopolsky, G. L. Bjoraker, M. J. Mumma, and D. E. Jennings 1997, High-resolution spectroscopy of Mars at 3.7 and 8 mm: A sensitive search for H2O2, H2CO, HCl, and CH4, and detection of HDO. J. Geophys. Res. **102**, 6525-6534.

4. A.I. Tsapin, M.G. Goldfeld, K.H.Nealson, K.M.Kemner, B. Moskowitz 2000, Self-Sterilizing properties of Martian Soil: Possible Nature and Implications, 30th International Conference on Environmental Systems, Toulose, France.

Abstract

In this rebuttal to G. Levin critic of our previous publication we claim again, that iron (VI) is a very good candidate as Martian oxidant. Our experiments could not be explained as a result of microbial activities, as we showed that Fe(VI) could be used as a sterilizing agent for destroying microorganisms, nucleic acids, and proteins.