GAMMA IRRADIATION EFFECTS IN MARS ANALOGUES. A.W.Needham[1], C.L. Smith[1], K.T. Howard[1], M.A.Sephton[2], Z.Martins[2], N.J. Foster[3], I.A.Franchi[4], S.S.Russell[1], [1]IARC, Department of Mineralogy, The Natural History Museum, London, SW7 5BD, UK (A.W.Needham@open.ac.uk). [2]IARC, Department of Earth Science and Engineering, Imperial College, London, UK. [3]Centre for Astrophysics and Planetary Sciences, School of Physical Sciences, Ingram Building, University of Kent, Canterbury, Kent, CT2 7NH, UK.[4]PSSRI, The Open University, Milton Keynes, MK7 6AA, UK

Introduction: The search for life on Mars is a primary focus of sample return missions planned for the coming decades. Although the chance of finding extant life in returned samples is small, it is non-zero, and suitable precautions must be taken. Mars sample return (MSR) missions will be designated COSPAR category IV_{b-c}[1], and sterilisation of Martian material will be essential prior to removing samples from biocontainment. Previous studies indicate that gamma irradiation with doses exceeding 30 Mrad may provide a suitable method of biological sterilisation due to the limited alteration it produces in the host sample [2,3]. The present study provides further information regarding gamma irradiation effects on petrological, chemical, isotopic, and organic properties in a range of Martian analogue material.

Methods: A ^{60}Co radiation source was used to expose the samples to ≥30Mrad. A broad range of analytical techniques have been employed to analyse irradiated and unirradiated samples; these include electron, optical and IR microscopy, XRD, Raman spectroscopy, ICP-MS, light stable isotope analyses (C, N, O), and analyses of organic compounds.

Samples: Previous studies have demonstrated several effects of gamma irradiation [2,3]. Various rocks and minerals were demonstrated to respond differently to intense gamma irradiation. The range of minerals and rocks analysed in the current study include basalt, JSC Mars soil stimulant, halite, illite, jarosite, gypsum, Kimmeridge Clay, and the Murchison meteorite. This sample set includes a diverse range of physical and chemical properties, including different crystal lattice structures, single and complex mineral associations, and highly variable concentrations of organic compounds and lattice-bound water (potentially critical if radiolysis occurs during irradiation).

Aliquots of several of these rock/mineral samples were also synthetically doped with organic compounds, and other aliquots were irradiated in the presence of ultra-pure water.

Results: XRD results demonstrate that gamma irradiation has no obvious systematic effects on crystal structure (Fig.1).

Optical properties of most minerals are unaffected, though halite is a significant exception. The unirradiated sample was colourless, while the irradiated sample was very dark brown. The reasons for this were discussed in detail by [2].

Preliminary electron microscopy investigation (secondary electron imaging) suggests no significant surface alteration effects. Further electron microscope investigations will be carried out using higher resolution imaging (Field Emission SEM). Polished sections have been prepared for more detailed study, and these images will be presented at the conference. Major and trace element data, as well as results from stable isotope, organic, and Raman spectroscopy analyses will similarly be presented at the conference.

Implications for MSR: It is clear from the results to date that the effects of gamma irradiation are limited, but significant unknowns remain. The effects of such irradiation do not significantly alter mineral structure, and alteration of chemistry is small at a whole-rock scale. However, reliable identification of martian biosignatures will not be at a whole-rock scale. It is at the nm scale that evidence for life will most likely be found, and it is at this level that the effects of gamma irradiation (radiolysis, decompositions of organic compounds) will be apparent. Further investigation of the effects of gamma irradiation, both on organic compounds and petrologically/chemically/isotopically at the finest scale is essential.

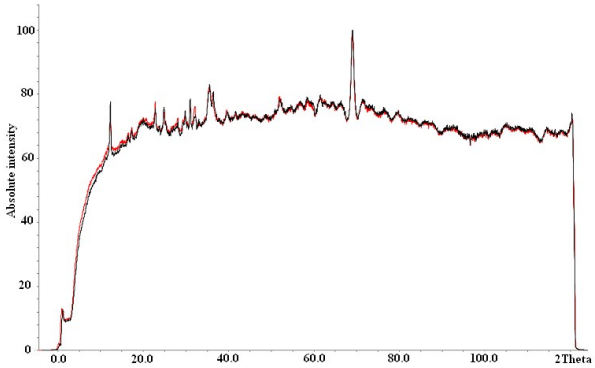

Figure 1 - The XRD plot above shows the irradiated (red line) and unirradiated (black line) samples of the CM2 chondrite, Murchison. It is clear from these results that gamma irradiation has had no significant effect on the crystal structures present in the rock.

References: [1] Rummel et al. (2002), *Report of the COSPAR/IAU Workshop on Planetary Protection* [2] C.C.Allen et al. (1999) *Journal of geophysical research, vol. 104* [3] A.W.Needham et al. (2008) *Meteoritics & Planet. Sci., 43, A5279*