Characterization of Fuel Debris (28’A)
(5) Phase and microstructure of large scale MCCI test product

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Under a collaborative agreement with the Commissariat à l'énergie atomique et aux énergies alternatives (CEA), the phases and microstructures of large-scale MCCI test products from PLINIUS/VULCANO experiments have been analyzed. The phases and microstructures vary at different sampling locations, each of which is representative of a product to be generated under severe accident conditions and which is considered to be close to that of 1F1.

Keywords: MCCI, Phase, Microstructure

1. Introduction: In case of failure of the RPV during severe accident progression, there will be an interaction between molten corium and the concrete in containment vessel, presumably as in the case of Fukushima Daiichi NPP unit 1 (1F1). In this situation, a specific liquid will be produced and solidify with a partial effect by the local elemental composition and cooling conditions. Scaling effect plays a role in the concrete ablation phenomena caused by the molten pool, and the concrete ablation concentrates concrete components in the molten pool, the so-called Molten Core Concrete Interaction (MCCI). For these reasons, large scale MCCI VULCANO experiments [1] are able to be representative of reactor case conditions especially for oxidic and metallic corium mixtures. Material samples of VULCANO VBS-U4 test have been chosen to have a better understanding of the characteristics of the solid materials with post-test analysis. These characteristics will be very useful to estimate severe accident progression and to develop decommissioning technologies such as fuel debris removal and storage.

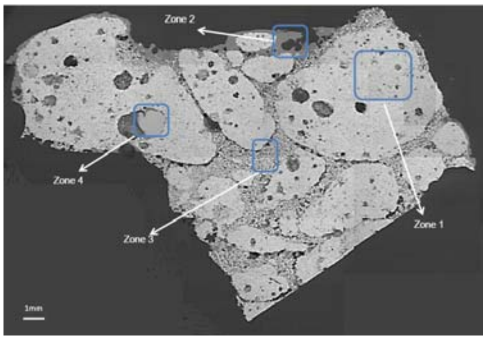

Figure 1 Cross section of molten pool sample

2. Experiment The phases and microstructures of five samples obtained from different locations of VBS-U4 test product: upper crust, molten pool, boundary with lateral concrete wall, metallic layer and bottom crust, were analyzed by scanning electron microscopy couple with energy dispersion spectroscopy and x-ray diffraction [2].

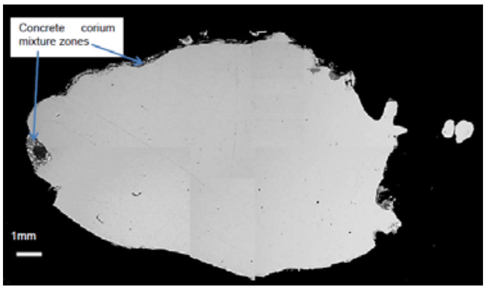

Figure 2 Cross section of metallic sample

3. Results Upper crust is composed of a metallic part and the massive oxides which contain concrete rich and corium rich zones. In the molten pool sample, round-edged corium rich oxides which diameters are 1-10 mm are surrounded by concrete rich oxides as shown in Figure 1. The sample in contact with vertical concrete walls is similar to the molten pool sample. The sample of metallic layer is a homogeneous Fe-Cr-Ni alloy as shown in Figure 2. The major part of the sample obtained from bottom crust is a large oxide corium rich zone and the concrete zones are located at the edges of the sample as shown in Figure 3. It contains remnants of aggregates and the many bubbles produced by concrete decomposition gas which diameters are a few millimeters.

Main phases are SiO_2 forming a variety of crystal structures, $(U,Zr)O_2$ in varying proportions, α-Fe, Fe_3O_4, Cr_2O_3, and $ZrSiO_4$ which includes small amounts of U which is detected only in the bottom crust. These phases form heterogeneous microstructures in the samples except for the metallic layer. The local proportion of Fe-Cr-Ni is different from the initial stainless steel composition and depends on the local oxidation process during MCCI phenomena.

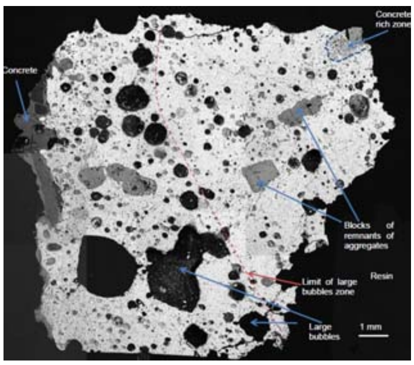

Figure 3 Cross section of bottom crust sample

References [1] C.Journeau et al., Nucl. Eng. Tech., 44, 3, 261 (2012).
[2] K.Yano et al, 2015 Fall Meeting of AESJ, G38.

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