

A computational investigation of the thermal environment of the *caldarium* in a replica Roman bath

Taylor Oetelaar, Lisa A. Hughes, John W. Humphrey,
Clifton R. Johnston and David H. Wood

In 2003, F. Yegül and T. Couch published in this journal an article on a replica Roman bath built for the American television show NOVA¹ (henceforth the “NOVA baths”). Being among the smallest of Roman baths, the dimensions of its floor plan and other detailed information available made it ideal as a case-study for investigating the thermal environment of a Roman bath using an engineering methodology called computational fluid dynamics (CFD: see explanation below). Unlike mathematical techniques used previously,² CFD can paint a more precise and complete picture of the environment. This article provides a full overview, by introducing CFD and explaining how its application can help further research on baths through this particular case-study. The NOVA baths were not a theoretical model studied solely on paper but a built model where a team led by Yegül and Couch studied, measured and experienced the thermal properties. Through the application of CFD to the NOVA baths, two new considerations are possible: first is the idea that the temperature break between rooms may be gradual and not well-defined; second is the potential impact of cloth doors on the thermal environment — a cloth door, though permeable, could block a large amount of the heat from escaping the hottest room.

First, an understanding of two key aspects of Roman baths is necessary: the layout of the rooms (particularly those of the NOVA baths) and their heating systems (hypocausts). The NOVA baths (figs. 1a-1b) consist of three rooms that make up the major bathing sections of a Roman bath: *frigidarium*, *tepidarium*, and *caldarium*. The *frigidarium* housed the unheated baths, whose water would be at ambient temperature; the *tepidarium*, the warm baths; and the *caldarium*, the hot pools. In the NOVA baths, however, it is important to note that the *tepidarium* does not have a pool and, in this instance, is a warm room. As a result, our study focuses on the *caldarium* and the interplay of the *tepidarium* with it. The NOVA building itself is relatively small. The air volume of the *caldarium* is just over 42 m³. The E wall of the *caldarium* has an open doorway that connects to the *tepidarium*. The S wall has an alcove for a hot pool. The N, W and E walls (up to just below the springing of the vault)

1 F. K. Yegül and T. Couch, “Building a Roman bath for the cameras,” *JRA* 16 (2003) 153-77.

2 For previous studies on the thermal environment and hypocaust, see F. Kretschmer, “Hypocausten,” *Saaljb* 12 (1953) 7-41; E. Thatcher, “The open rooms of the Terme del Foro at Ostia,” *MAAR* 24 (1956) 167-264; T. Rook, “The development and operation of Roman hypocausted baths,” *JArchSci* 5 (1978) 269-82; A. Jorio, “Sistema di riscaldamento nelle antiche terme pompeiane,” *BullCom* 86 (1978-79) 167-89; H. Hüser, “Wärmetechnische Messungen an einer Hypokaustenheizung in der Saalburg,” *Saaljb* 36 (1979) 12-30; D. Baatz, “Heizversuch an einer Rekonstruierten Kanalheizung,” *Saaljb* 36 (1979) 31-44; J. W. Ring, “Windows, baths, and solar energy in the Roman empire,” *AJA* 100 (1996) 717-24; T. Basaran and Z. Ilken, “Thermal analysis of the heating system of the small bath in ancient Phaselis,” *Energy and Buildings* 27 (1998) 1-11; T. Basaran, A. Ereğ, G. Uluans and A. Ersoy, “Energy analysis of the Roman bath in Metropolis” (paper delivered at 2nd Int. Exergy, Energy and Environment Symposium, Kos, July 2005); and T. Basaran, “The heating system of the Roman baths,” *ASHRAE* [American Society of Heating, Refrigerating and Air Conditioning Engineers] *Transactions* 113 (2007) 199-205.