Inchtuthil Roman Fort (Scotland)

Description: A rare but unquantified reference to pitting of iron artefacts comes from the excavation of Roman nails at Inchtuthil in Perthshire, Scotland, the site of the most northerly legionary fortress in the Roman Empire (Angus et al., 1962; Pitts and St. Joseph, 1985). The fortress was built near the River Tay but was abandoned by the Romans in 87 AD soon after construction. In a successful attempt to hide metal objects, which potentially could be fashioned into Pictish weapons, the Romans buried over one million nails in a 5 m deep pit and covered them with 3 m of compacted earth (see Figure 1). These nails remained buried until the 1950s, when the site of the fortress was excavated and the nails were unearthed.

Figure 1 Artist's impression of the scene when nearly a million nails were buried at the Roman legionary fortress at Inchtuthil, Scotland, in 87AD (courtesy of Nagra, in Miller et al., 2000).

After excavation, it was found that the nails on the outside of the hoard, particularly those on the top, were very badly corroded and had formed a solid iron oxide crust. However, nails inside the hoard showed only very minimal corrosion, limited to the formation of a thin passivating layer on the nail surfaces (see Figure 2).

Although all the nails were composed of iron, they were heterogeneous in composition, with regions of high and low carbon content. Nonetheless, neither the nail composition nor size showed any significant correlation with the degree of corrosion. The survival of the central nails was attributed to the redox buffering capacity of the outer nails which removed free oxygen from the infiltrating groundwater such that the water was chemically reducing and less corrosive by the time it came into contact with the nails in the centre.

The excavation at Inchtuthil was undertaken as an archaeological study, not as a natural analogue study. Consequently, no information is available on the chemistry of the soils or porewaters in the burial environment, which means that no quantitative information on corrosion rates or processes

can be derived from the nails. However, the fact that the central nails survived for over 1860 years in a river flood-plain provides good illustrative evidence for iron durability.

Figure 2 A photograph of one of the nails (c.35 cm long) from the central part of the hoard at Inchtuthil. There is an excellent state of preservation despite over 1860 years of burial (from Miller et al., 2000).

Relevance: This archaeological analogue of iron stability is of illustrative value. The Inchtuthil study is potentially useful for providing non-technical demonstrations of the durability of repository steel as used in canister fabrication, roof bolts and meshing, roadway and shaft supports, etc. The information also illustrates the redox buffering capacity of iron placed in the ground.

Position(s) in the matrix tables: The Inchtuthil study would occupy the Waste Package Steel/iron – Chemical Integrity box in the near-field matrix table.

Limitations: The iron nails have a composition different to the composition of modern steels. Therefore, the corrosion properties and rates are not directly comparable. The nails were hosted in shallow sedimentary deposits, not in deep rock.

Quantitative information: No particular quantitative information e.g. iron pitting rates, came from the study.

Uncertainties: The qualitative information is not fully supported by environmental data on the ground conditions relevant to the hoard.

Time-scale: The time-scale of the analogue is archaeological, the nails having remained buried for over 1,860 years.

PA/safety case applications: Previous uses of the analogue study in a PA or safety case are not known.

Communication applications: Previous uses of the analogue study in communication and dialogue are not known.

References:

Angus NS, Brown GT and Cleere HF (1962) The iron nails from the Roman legionary fortress at Inchtuthil, Perthshire. Journal of Iron and Steel Institute, 200, 956-968.

Miller WM, Alexander WR, Chapman NA, McKinley IG and Smellie JAT (2000) Geological disposal of radioactive wastes and natural analogues. Lessons from Nature and Archaeology. Waste Management Series, Volume 2. 2000 Pergamon. Elsevier Science Ltd., Oxford.

Pitts L and St Joseph A (1985) Inchtuthil Roman legionary fortress excavation 1952-1965. Allan Sutton.

Added value comments: Visual demonstrations of long-term survival of an iron nail from Inchtuthil are potentially valuable when presenting a safety case before a wide audience. By referring to materials, processes and time-scales in an archaeological context, the message may appear clearer to a public audience. Passing round actual specimens of the nails to members of an audience for hands-on inspection would help drive home the message.

Potential follow-up work: Nil.

Keywords: Iron, steel, corrosion, durability

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