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Figure 2 depicts a first attempt at constructing a general consequence tree for damage to a museum specimen or collection. Some of the branches indicate losses but others, such as careers, may be gains or losses depending on their relationship to the damage. Some, such as work hours and funds can be measured in financial terms while others such as the effect on international relations, arising perhaps as a consequence of the provenance and ownership of the specimen, cannot. Anguish, although depicted here as an expression of conservation only would, hopefully, be a more universal consequence of damage.

Conclusions

Damage arises as a consequence of access but it is not the only consequence. Assessments of risks help us to manage access and to prevent damage, but do not consider consequences at a useful level. A full consideration of the consequences which arise as a result of a failure event add to an appreciation of the risks and the management of the access from which they result.

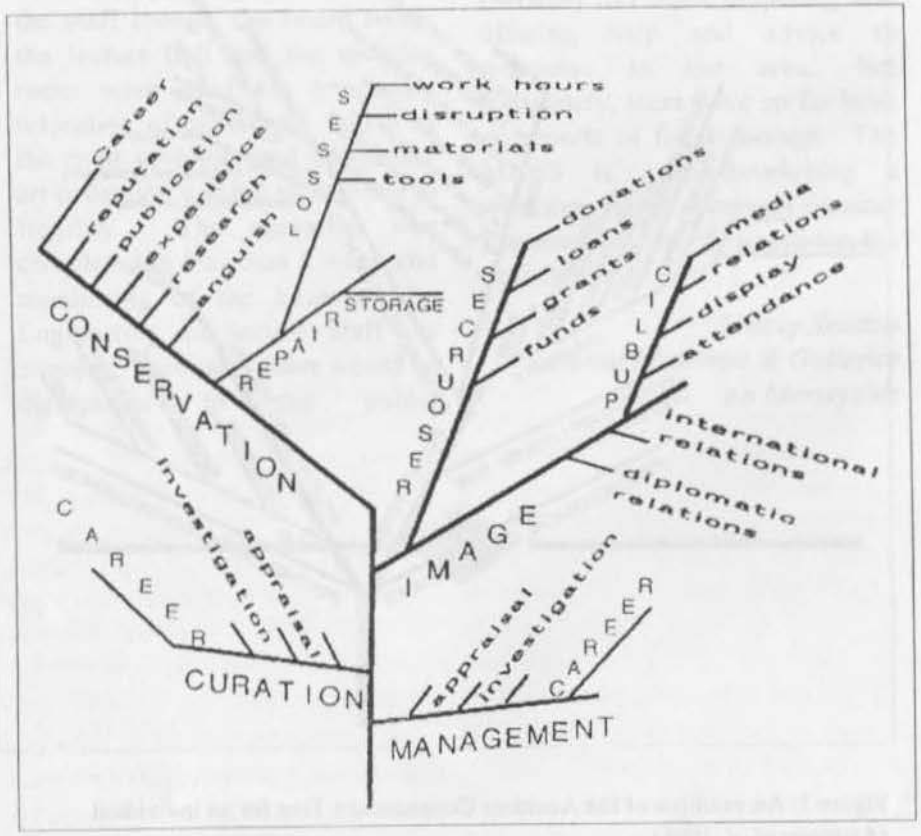

Figure 2. Consequences for the Institution

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Risk Assessment of Radiation and Radon Hazards Associated with the Mineral Collections of the National Museums and Galleries of Wales

Radioactive mineral specimens present twofold hazards to curators: radiation and radon gas. Uranium and thorium mineral species are always radioactive and a variety of other minerals are also commonly radioactive (Lambert 1994a). The action of radiation on the human body has biological effects and a health hazard may be caused by radioactive minerals (Brunton *et al* 1985, Dixon 1983, Hicks 1983, Howie 1987, King 1986, Lambert 1994b). Radiation effects, where the damage appears in the irradiated person, include skin burns and cataracts. These occur at high dose rates and cannot be caused by normal handling of geological specimens. Other effects are those where there is a probability relationship between exposure and effect, the main one being the induction of cancer. The genetic effect of radiation arises in the offspring of an irradiated person as a result of damage to their reproductive organs. Genetic effects may be dominant or recessive.

Radiation damage does not show immediately, after exposure there is a latent period before damage becomes evident, radiogenic cancer may not show for 10 to 20 years after the irradiation which is responsible for it.

There is moreover no lower limit of safety for radiation, even low levels carry some risk (NRPB 1988). The risk of lasting damage to the human body depends on which parts are irradiated, those organs most at risk are sites where rapid cell replacement is occurring, e.g. adult reproductive organs are radiosensitive. Children, as they are growing up, undergo rapid cell replacement and should not be exposed to any unnecessary radiation.

It is important to keep the risk from radiation in perspective, we are all exposed to background radiation from the environment. The risk from non-background radiation can be assessed from measurements of exposure to radiation, the dose equivalent, which is a guide to the likely biological effect (Martin and Harbison 1986). The risk to geological curators exposed to radioactive collections can be quantified for comparison to other risks in life by multiplying the measured exposure to radiation by a risk factor, for the working population the risk factor for the induction of a fatal cancer is 400 x 10^{-4} per Sievert (ICRP 1990). This factor means that for every million people receiving 1 mSv an extra 40 cancers would be expected to occur.

For example if a curator is exposed for a known period of time to radioactive specimens the risk can be calculated from measurements of the dose rate at the site of radiation exposure.

The calculation is as follows:

Dose = Dose rate(measured with meter) x Exposure time

Risk = Dose (in sieverts) x Risk factor (400 x 10^{-4})

Radioactive minerals should never be prepared, sawn, lapped or polished without extensive precautions being taken to prevent serious and dangerous internal contamination occurring. Exposure to radiation should be as low as reasonably achievable (ALARA). The mineral collection at the National Museum and Gallery Cardiff contains approximately 750 radioactive minerals which have been isolated in a separate radioactive mineral store. It is a controlled radiation area and has continuous extraction to purge radon (Lambert 1994a).

Radon poses a risk quite separate to that of direct radiation but the risk can be quantified in a similar way from measurements of the radon concentration and estimates of exposure time.

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Further information about radiological protection can also be found on the NRPB web site at http://www.nrpb.org.uk

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