Surplus killings of gulls by foxes.

is not clear whether, on balance, surplus killing is a good thing or a bad thing for the animal doing it. In the case of the foxes killing gulls, Kruuk argues that it might in fact wipe out the whole population in a particular area, to the detriment of the foxes themselves. It is, however, a relatively rare phenomenon and may simply reflect upset of otherwise efficient hunting and killing behaviour.

SELENOLOGY

Surface Structure

from our Geomagnetism Correspondent

In addition to the so-called Passive Seismic Experiment (PSE) instituted by earlier Apollo missions, the Apollo 14 astronauts took the first steps in carrying out an Active Seismic Experiment (ASE). The difference between the PSE and the ASE is simply that, whereas the first made use principally of natural sources such as meteorite impacts (although it has also utilized lunar module descents and ascents), the second incorporates its own artificial explosive sources and an array of geophones. There are two such sources—a "thumper" device operated by the astronauts during their presence on the Moon and a package containing four grenades which may be launched by rocket following an instruction from Earth. The grenades have not yet been released because of the dangers to other lunar experiments not yet complete; but the Apollo 14 astronauts operated the thumper thirteen times out of a possible twenty-one.

The purpose of the ASE, the first results of which have now been reported by Watkins (J.) and Kovach (*Science*, **175**, 1244 ; 1972), was to determine the surface structure of the Moon down to a depth of about 460 m; and this aim has been achieved within the limits of interpretation imposed by the basic data. The explosive seismic refraction data thus indicate that the immediate surface layer (layer A) of the Moon is 8.5 m thick beneath the geophone array at the Apollo 14 site and has a compressional wave velocity of 104 m s^{-1}. Because this velocity is typical of a porous and highly brecciated rock material, Watkins and Kovach conclude that layer A is the lunar regolith which, in this region, probably comprises chiefly overlapping ejecta sheets from post-Fra Mauro craters.

Layer B, which lies below layer A but which is distinct from the material below (layer C), has a compressional wave velocity of 299 m s^{-1} although its thickness cannot be determined precisely from the ASE because the velocity of compressional waves in layer C is unknown. But limits may be set for the thickness of layer B. If, on th hand, the velocity in layer C is t be infinite, calculations show tha maximum thickness of layer B must be 76 m. On the other hand, if it is assumed that the critical distance for the arrival of the head wave travelling through layer C is that to the end of the geophone line (100 m), the minimum velocity of compressional waves in layer C is 370 m s^{-1} and the minimum thickness of layer B turns out to be 16 m.

The fact that layer B is a seismically distinct layer with well defined boundaries suggests that it is also physically distinct from the layers above and below it; but its precise nature is not clear. There seem to be two principal possibilities—that layer B is what Offield (US Geologic Survey Map ORB-III-S-23(25); 1970) identified as smooth terrain material "similar to nearby plains material of presumed volcanic origin" or the Fra Mauro Formation which comprises "material of ejecta blanket surrounding the Imbrium basin".

In an attempt to decide between these alternatives, Watkins and Kovach have tried to estimate the thickness of the overlapping ejecta sheets from post-Fra Mauro craters (that is, craters younger than the Fra Mauro Formation) which are thought to form the lunar regolith in the Apollo site region. The regolith thickness thus calculated turns out to be 3.9 to 7.2 m, which must be seen in the light of a previous estimate of the thickness of the Fra Mauro Formation of 5.5 to 15.6 m (Hu and Watkins, *Trans. Amer. Geophys. Union*, **52**, 273 ; 1971). The maximum thickness obtained from these calculations thus compares well with, respectively, the thickness of layer A and the minimum thickness of layer B derived from the ASE.

This would seem to suggest that layer B is, in fact, the Fra Mauro Formation except that the volcanic interpretation cannot so easily be rejected. For example, Watkins and Kovach estimate the porosity of layer B to be 35–55 per cent, a range which includes various terrestrial analogues of the possible nature of layer B. Thus although the ejecta sheet from Meteor Crater has a porosity of 40 per cent, rhyolite ash and lapilli from the Mono Craters in California have a porosity of 46 per cent and the S.P. andesitic lava flow of Arizona has a porosity of 56 per cent. In short, volcanics as well as ejecta sheets have porosities comparable with those of layer B—a similarity which also extends to compressional wave velocities.

Even so, Watkins and Kovach conclude that, on balance, layer B is more likely to be the Fra Mauro Formation. For one thing, although several young craters in the Apollo 14 site region have penetrated layer B, the Apollo 14 astronauts found very few igneous rocks in the vicinity—a fact which militates against a volcanic nature for layer B.

More Variations from Sco X-1

Sco X-1 has now been seen to vary at X-ray frequencies on a time scale of ~1 min. In next Monday's *Nature Physical Science* (April 17) R. E. Griffiths and B. A. Cooke report an analysis of observations which were made with proportional detectors on the same two rocket flights that carried the counters designed to detect the FeXXV line, suspected of being present in the spectrum of Sco X-1 (*Nature Physical Science*, **229**, 175; and **231**, 136; 1971).

The essence of this analysis is that during the first flight the intensity of the source at 4 to 14 keV was constant for 140 s and then fell by about 2 per cent over 80 s. On the second flight, the energy in the range 2 to 14 keV was steady for about 3 min, then rose by 5 per cent before beginning to fall again, all within the last minute of observation (see figure).

Griffiths and Cooke point out that these time scales are far greater than the expected cooling time of the plasma in which the X-rays originate (a few tenths of a second); they conclude that the presence of these ~1 min fluctuations supports the idea that mass motions or vibrations of the emitting plasma are responsible for the optical and X-ray flickering.