nal evidence of malfunction. But, on the basis of an analysis of these results and experience with an equi-inclination machine, it seems that the two outstandingly poor sets of data are the result of an alignment problem peculiar to equi-inclination devices when mounting any triclinic crystal, or a monoclinic crystal to rotate about the *a* or *c* axes, as was the case here. This problem does not arise for monoclinic crystals mounted about the *b* axes or for any higher class of crystal.

The results of the individual structure refinements with these sets of data, however, are comforting. The poorer sets of data either failed to refine properly or else produced satisfactory coordinates. Indeed, the worst example which had shown 48 per cent average disagreement refined to a residual R of 4·7 per cent (R is the average disagreement between the observed and calculated structure factor amplitudes) which was the fourth best, with quite satisfactory coordinates. However, the anisotropic temperature factors (β_{ij}), which are related to the direction and magnitude of vibration of the atoms, were very poor indeed for the suspect data sets. For the worst set of data the value of $\beta 33$, which is directly related to the amplitude squared of vibration in the *c* axes direction, was about four times the most likely value. The divergence of the thermal parameters was otherwise greatest when absorption corrections had not been applied.

The first lesson for non-crystallographers is that the coordinates of any X-ray structure determination can safely be accepted, but the quoted internally derived standard deviations should be doubled, unless precautions have been taken to improve the accuracy, in which case a factor of $\sqrt{2}$ is more appropriate. The second lesson is that the thermal vibration parameters should be regarded with suspicion, especially if absorption corrections were not applied, and the quoted standard deviations multiplied by a factor of about 5. For any structure which shows one or two of the axial vibration components (β_{ii} and U_{ii}) to be consistently large or small for all atoms, the cross terms (β_{ij} or U_{ij} where $i \neq j$), which determine the angles between the thermal vibration ellipsoid axes and the crystal axes, are probably meaningless, though the other axial components may be acceptable.

MOON

Latest Report from Houston

by our Astronomy Correspondent

PRELIMINARY examination of the Apollo 12 samples at Houston is now complete, and it is clear that there are some significant differences from the Apollo 11 material (*Science*, **167**, 1325; 1970). The reason in most cases is that the Apollo 12 site in Oceanus Procellarum is younger than Mare Tranquillitatis, and the most interesting observation singled out from the Apollo 12 report by the preliminary examination team is the K–Ar age. Once again this indicates that the maria are very old, but that with crystallization occurring about $2 \cdot 3 \times 10^9$ years ago the material of Oceanus Procellarum is roughly 10^9 years younger than Mare Tranquillitatis.

Other facts also point to the Apollo 12 site being less mature than that of Apollo 11, indicating that maria formation lasted at least 10^9 years. The surface layer of fragmented material, for example, is thinner than at the Apollo 11 site, and craters as shallow as 3 metres seem to have penetrated to the harder rock below. And the lower content of gases from the solar wind in the Apollo 12 dust indicates that the material has not been exposed quite as long as the Apollo 11 material.

The landing site in Oceanus Procellarum is on one of the broad rays centred on Copernicus, and the astronauts reported several areas of dust which is lighter grey than normal. Whether the dust which troubled the Apollo 12 astronauts more than expected during landing was due to a difference in soil mechanics between the two maria, or to a difference in Sun angle or in descent path, is not known yet. But the most important clues to the history of the dust layer are the core samples. One tube reached a depth of 70 cm—compared with 15 cm for the Apollo 11 tubes, although a different bit probably helped—and contains ten identifiable layers representing presumably different ejecta blankets. This is backed up by a sample of what looks like volcanic ash taken from a 20 cm deep trench excavated by the astronauts. Coupled with the different distribution of particle types in the dust from Oceanus Procellarum, it is clear that the dust layer does not have a uniform composition from mare to mare.

Although the rocks are similar to the finds in Mare Tranquillitatis, there are some notable differences. Fewer breccias were picked up, thought to be due once again to the thinner surface layer so that excavated material is more likely to be bedrock than to be formed from the stressing and hardening of surface material into breccias. The chemical indications are indeed that the Apollo 12 breccias were formed from fine material with a lower content of solar wind gases than the present dust layer. It is odd that the Apollo 12 rocks have a wider range of texture and composition than expected from the Apollo 11 mission, but the preliminary examination team say that the rocks are consistent with a fractional crystallization sequence, so that they seem to come from a single intrusive sequence or from several similar sequences.

GALAXIES

Rotation of Andromeda Nebula

from our Observatories Correspondent

IN many respects it is easier to study the rotation of the Andromeda Nebula (M31) than that of the galaxy. The Sun's situation in the dust clouds of the Milky Way makes it impossible to take optical measurements of the Doppler shifts of distant stars. This is why the rotation of the galaxy has been studied most often through the Doppler shift of the 21 cm line of neutral hydrogen.

This approach has the advantage that the neutral hydrogen gas clouds might be expected to be moving in circular orbits about the centre of the galaxy. Its principal disadvantage is that it is only possible to make indirect inferences about the distance of a cloud having a given Doppler shift. For these reasons the rotation curve of the galaxy—the run of rotational velocity with radius—is imperfectly known for the galaxy. This is particularly true for the regions close to the galactic centre and outside the Sun's radius (about 10 kiloparsecs). The total mass of the galaxy depends