A combination of expertise, curiosity and luck brought small teaspoonful samples of moon dust from three moon walks to NRC's Atlantic Regional Laboratory (ARL) in Halifax. Here, a group of scientists with different specialties are pooling their expertise to help advance man's understanding of the geology and chemistry of the moon. Dr. C. R. Masson, the group leader, is a chemist and a specialist in the study of silicate melts and glass. Dr. Alex Volborth, a guest research worker at ARL, is a geology professor at Dalhousie University. Dr. W. D. Jamieson is a specialist in mass spectrometry and Dr. J. L. McLachlan, a phycologist, is an expert in photomicrography. A former Postdoctorate Fellow, Dr. J. J. Gotz, was a member of the original team but now has left and has been replaced by another chemist, Dr. I. B Smith.

The scientists of ARL's High Temperature Section have refined an analytical technique (trimethylsilylation) for determining the constitution of silicate glasses and have obtained excellent results with earth-bound glass. The method involves handcuffing the ions made up of silicon and oxygen, then separating and identifying them by means of gas-liquid chromatography. Side reactions and the laboriousness of a several-stage procedure hampered this method until the NRC scientists developed a direct method of analysis which also minimized complications due to side reactions.

The curiosity and luck which brought the moon dust to Halifax are Dr. Masson's. A chance glimpse of mention in a scientific article that the lunar dust samples were rich in glass spurred him into writing to the U.S. National Aeronautics and Space Administration. His letter pointed out what the ARL team has accomplished in the analysis of terrestrial glasses and offered to share its knowledge of experimental techniques with NASA scientists. NASA rewarded this impulsive gesture by offering to consider Dr. Masson's proposal if he would apply formally through his national space agency which, for these purposes, was none other than NRC! Shortly thereafter, two samples of Apollo 12 moon dust arrived in Halifax.

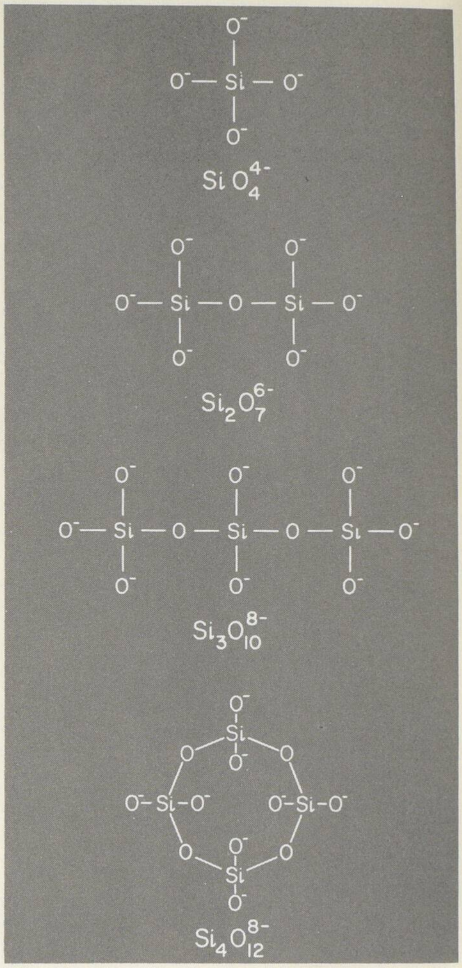
The first samples of lunar dust studied at ARL were a minute part of what the Apollo 12 crew gleaned from the Ocean of Storms. Grains ran in size from 130 millionths to less than one millionth of a metre across and the total sample weighed a mere four ten-thousandths of a gram. In 3,300 of the larger grains scientists counted pyroxenes (24 per cent by volume), olivine (10 per cent), plagioclose (nine per cent), opaque minerals (five per cent), aggregates (25 per cent) and glass (27 per cent).

"The grains of glass from this minute sample assumed a wide variety of shapes and colors," Dr. Masson says. "Dr. Volborth's mineralogical examination revealed all stages of formation in lunar glass, from transparent particles to lackluster crystals. We observed clear glass shards, perfect spheres, dumbell shaped beads, some with spherical cavities, and teardrops of combined glass and other minerals. They were mostly colored brownish, yellowish, rarely clear, or with distinct skeletal growths of ilmenite concentrated mostly in the center. Some of these teardrops were almost black, some were partially devitrified (crystallized), sometimes filled with fine-grained mineral aggregates. In addition, many mineral grains were rounded and covered by a crust of glass."

The Apollo 12 samples contained both glass and olivine. These minerals have different silicate structures. Whereas glass contains a wide variety of silicate ions, each a small fraction of the total, olivine contains only one kind in large abundance. When it came to the chemistry and chemical analysis of the ionic constituents in the sample, the NRC scientists found it difficult to assess the relative contributions of glass and olivine in the mixed material because the abundance of ions from olivine tended to obscure the contribution due to glass. NASA soon came to the rescue by furnishing a further sample, this time from the Sea of Tranquility, picked up by the Apollo 11 astronauts. This sample consisted of fine and coarse grains from which a single fragment of vesicular (blistered or pock-marked) glass was selected for further study.

What ions are present in moon glass? Is it similar in ionic content to terrestrial varieties? Careful trimethylsilylation analyses of the lunar fines from Apollo 11 and 12 and of the vesicular glass from Apollo 11 answered these questions. In so doing, they also confirmed precisely what Dr. Masson and his co-workers had predicted earlier from theoretical considerations on the anionic (negatively-charged groups of atoms) content of glass. According to their theory, silicate melts and glasses are polymeric materials with a wide variety of constituents, ranging from the "monomeric" ion or basic building block, made up of one silicon atom linked to four oxygen atoms and bearing four negative

lunar glass



Structures of the various silicate ions detected in extracts of lunar fines and glass: the tetrahedral "monomer," the dimer, the trimer and the unexpected cyclic ion (O = oxygen, Si = silicon).

Structures des ions des silicates détectés dans la poussière et le verre lunaires: le "monomère" en forme de tetraèdre, le dimère, le trimère et l'ion cyclique (O = oxygène, Si = silicum).

charges (SiO_4^{4-}), through the "dimer" containing two silicons ($Si_2O_7^{6-}$), trimer ($Si_3O_{10}^{8-}$) and so on up the ladder to complex ions of high molecular weight.

The monomer, dimer and trimer ions were precisely those which were identified as being most prevalent in glass from the moon's surface. Moreover, just as predicted from the theory, the SiO_4^{4-} ion was by far the most abundant distinct ionic species in all lunar glass samples.

Somewhat unexpectedly, one other ion was found in lunar glass. It was a cyclic ion containing a skeleton of four silicon atoms and four oxygen atoms in an eight-membered ring ($Si_4O_{12}^{8-}$).

Where did this tagalong cyclic ion