

the project in question. In light of the information thus gained, boreholes, test pits, or trenches, or other types of subsurface exploration may be planned most effectively. In detailed geologic mapping of sites for tunnels, aqueducts, dams, reservoirs and other types of engineering projects, faults, fractures, and other sources of weakness in the rock are of particular concern and aerial photos might direct attention to minor but important structures, which might otherwise be overlooked. Ancient landslide masses frequently constitute obstacles to the building of dams and other structures and their recognition is of considerable importance. The presence of old slides, furthermore, might suggest the possibility of repeated sliding and the desirability of suitable precautionary measures. In cases where highways, railways, canals, and dams are damaged or obstructed by active landslides, aerial photographs provide the quickest way of obtaining a complete picture of the situation and the

remedial measures to be taken. Aerial photos are very helpful in studying the effects of the silting of reservoirs and the control of erosion and deposition along rivers and harbours. They also are invaluable for the development of new surface and subsurface water-supplies, dam, reservoir and irrigation projects.

In conclusion the descriptions given above indicate in a brief way the advances that have been made in air-photo geology and their economic applications. The author cannot recommend too highly the widespread use of air-photos for geologic work. Not only are aerial surveys less costly than ground surveys, but they add to greater detail and accuracy. Air-photo geologic surveys likewise can be carried out in a fraction of the time of ground surveys; sometimes advancing the development of a mineral prospect by many years. In advanced civilizations, time is an important element and air-photo geology is an important new scientific tool.

ORTHO-PARA-CATALYSIS IN LIQUID-HYDROGEN PRODUCTION

FRESHLY liquefied hydrogen that has not been catalyzed consists of a 3-to-1 ortho-para-mixture. There is a slow but definite change in the mixture on standing, which complicates the problem of keeping the liquid for any great length of time. The exothermic heat of conversion of ortho- to para-hydrogen at 20° K. is about 254 calories per mole, whereas the endothermic heat of vaporization of liquid hydrogen is 216 calories per mole. As a result of this slow change, a thermally isolated tank of liquid hydrogen, prepared without conversion to the para form, will lose about 18% of its volume during the first day of storage. In the absence of this internal evolution of heat, the heat transfer to a well-insulated Dewar may result in a loss of less than 1% per day.

The obvious solution of the above difficulty is the conversion to the para form either in the gas phase before liquefaction or in the liquid phase immediately after liquefaction, but in any case before delivery to the storage Dewar.

Bonhoeffer and Harteck were the first to make use of heterogeneous catalysis to establish ortho-para-equilibrium. They used charcoal at liquid-air temperatures and were able to establish equilibrium quickly when normal hydrogen was passed over the catalyst. However, when para-hydrogen was passed over charcoal at room temperature, no conversion took place.

Taylor and collaborators studied the catalytic activity of the metallic oxides and found that the para-magnetic substances chromic oxide, cerium oxide, and neodymium oxide brought about rapid conversion, whereas zinc oxide, lanthanum oxide, and vanadium pentoxide, having low or negligible para-magnetism, showed low or negligible conversion efficiencies. They conclude that the magnetic character of the surface of the catalyst is a controlling factor and may account for their earlier success with metallic nickel, as well as for the results of Emmett and Harkness with Van der Waal's adsorption on iron synthetic ammonia catalysts.

A series of selected or specially prepared catalysts were studied for their ability to accelerate the ortho- to para-conversion of hydrogen. The results of this study are presented, and the performance of various catalysts are compared with that of chromic oxide on alumina pellets. An outstanding catalyst, unsupported hydrous ferric oxide granules, was selected for further study and used in the liquefiers of the National Bureau of Standards Cryogenic Engineering Laboratory. One and half litres of this catalyst has now been used to convert more than 100,000 litres of liquid hydrogen to 90-95% para at an average rate of about 235 litres of liquid per hour. There is to date no evidence of decrease in efficiency with continued use.