iodide showed very fast quenching with virtually no phosphorescence, whereas potassium bromide gave excellent response but long-lasting phosphorescence. The deterioration of luminescence efficiency was almost exponential in potassium chloride and rather slow in sodium chloride, showing that quenching centres are produced in potassium chloride faster than in sodium chloride.

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[1] Przibram, K., *Irradiation Colours and Luminescence* (Pergamon Press, London, 1956).

GEOLOGY

Occurrence of Graywacke in the Lower Siwaliks, Simla Hills

We would like to direct the attention of scientists regarding the occurrence of graywacke in the Nahan Series near Kalka, Simla Hills, Panjab, which has remained unnoticed in Indian geology.

During the course of a traverse near Kalka, while studying the terraces of Kaushallia and Jhajjar Rivers, we came across a grey to greenish micaceous 'sandstone' type of rock which in hand specimens appeared to be graywacke. This was confirmed in thin sections of the rocks, which revealed the presence of angular grains of quartz (approximately 50 per cent) embedded in a matrix composed of fragments of slate, schist, quartzite, chert, felspar, chlorite and authigenic sericite. The rock grades imperceptibly into the underlying red clays.

This graywacke is considered to be a part of the lower Siwaliks known as Nahan Series of the area. All the existing text-books on the geology of India state that these deposits are of fresh-water origin. They are considered to be made up of sandstones, grits, conglomerates, clays, and silts having the characters of fluviatile deposits of torrential streams and floods in shallow water basins.

It is interesting to note that as early as 1937, Krynine had referred to the presence of graywacke from the Siwalik formations of north-west India. However, it has failed to direct the attention of the Indian geologists and hence remained out of the present-day Indian geological literature. We would like to state that the present findings were made independently of Krynine's observation.

Although very diverse types of graywacke having variable mineral composition have been described from different parts of the world, it is generally accepted that the graywackes are characteristic of the geotectonic belts. The presence of this rock in the Himalayan foothills is therefore noteworthy as it will throw light on the sedimentation history of the Siwaliks and other adjoining formations at least of this area. It is therefore probable that the notion that the Siwaliks are entirely of fresh-water origin may no longer be true at least in this part of the sub-Himalayan region.

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RADIATION CHEMISTRY

Behaviour of Neutron-irradiated Ammonium Sulphate on Thermal Annealing

The behaviour of a neutron-irradiated substance in thermal annealing is known to depend on the temperature and on the period of heating. Normally, the retention reaches a saturation value after a few hours of heating. Very recently, experimental evidence was obtained which indicates that the ammonium group in a compound can influence the course of thermal and radiation annealing[1]. Potassium and ammonium dichromate were irradiated with thermal neutrons under the same conditions and their behaviour in thermal annealing was compared. Retention of potassium salt for various temperatures was as expected, while the retention of ammonium salt passed through a maximum above 170° C. This suggests that a reduction process is taking place at the same time as thermal annealing. Similar results have been obtained for the radiation annealing process.

Experiments with ammonium sulphate were carried out in order to see if this anomaly is also common to other ammonium compounds. The sample of 'Analar' grade ammonium sulphates was irradiated in a polythene tube in the thermal column of the *Bepo* reactor at Harwell for four weeks at a neutron flux of 10^{10} n./cm.^{2}/sec. (pile factor 0·1). The temperature during the irradiation was below 50° C. Together with sulphur-35 formed by the nuclear reaction $^{34}S(n,\gamma)^{35}S$, $^{32}P[^{32}S(n,p)^{32}P]$ and $^{33}P[^{33}S(n,p)^{33}P]$ were also produced. Phosphorus-32 and -33 were subjected to separate investigations.

Under the conditions of irradiation used in these experiments sulphur-35 is distributed into several fragments because of recoil. It was found that about 60 per cent of the total sulphur activity was in the form of sulphate, the rest being present as sulphite. It is possible that other fragments of sulphur could be formed as intermediates which, however, are readily transformed into sulphate and sulphite under the conditions of analysis. The samples were dissolved in oxygen-free, boiling, diluted hydrochloric acid together with sulphate and sulphite carrier and phosphate hold-back carrier. Thereby sulphite and other volatile sulphur compounds were immediately separated as gases. These were removed by a stream of nitrogen and absorbed under oxidation in strongly alkaline hydrogen peroxide solution. This part of the sulphur activity as well as the remaining sulphate activity were precipitated as barium sulphate and measured with a suitable end-window Geiger counter. All the necessary corrections have been made.

The thermal annealing of the irradiated ammonium sulphate was carried out in an oven at various temperatures and various heating periods in the presence of air. The heated samples were analysed as stated here. The retention at 100° ± 0·5° C. was plotted against heating time and found to follow a typical annealing process curve. However, at temperatures above 150° C., the curve passed through a maximum. This anomaly was most conspicuous at 180° ± 0·5° C., as shown in Fig. 1. A certain radiation annealing is assumed to occur also during the pile radiation.

It is supposed that free radicals are formed in the target under the influence of the γ-radiation in the pile, probably in a relatively large 'steady-state'