Discussion to Dr. D.H. Griffiths' Communication "The Remanent Magnetism of Varved Clays from Sweden"

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I should like to add some remarks to Dr. Griffiths' interesting communication, as I have collaborated with him, partly through my former assistant, Mr. L. Granar, in the collecting of samples of recent fluvial deposits near the mouth of the Ångerman-river ("Ångermanälven") in northern Sweden.

Dr. Griffiths is to be credited for having promoted the magnetic study of these sediments in collaboration with Swedish geologists and physicists; I think the original instigation came from P. M. S. Blackett. It is, *a priori*, a very suggestive idea to test the reliability of "paleomagnetic" measurements on sediments of known age from, say, the last two or three hundred years, when direct determinations of the earthfield allow a comparison to be made.

For this purpose, the geologist C. Caldenius recommended the sediments around the mouth of the Ångerman river as offering an almost unique possibility of obtaining dateable varves up to our time. The present mouth of the Ångerman river is situated at Nyland, where the river flows out into the Nyland-firth: "The river there forms a delta which, on account of the quick landupheaval and the considerable depth of the primordial firth-groove, has no time to build up above the watersurface. The streampaths on the delta-plane go down to a depth of 5 m, the banks reach up to a little below the watersurface. The delta-plane is outwards limited by a steep discharge-bank, outside of which depths above 20m very soon commence." (Quotation from a paper, in Swedish, by E. Fromm 1944).

Samples of the older fluvial sediments, mentioned by Dr. Griffiths, were dug out by him from the banks of the present river at Prästmon (about 8km above Nyland) and at Undrom; while the youngest sediment samples, having an age from 0 to about 700 years, were taken up (1952) with a Kullenberg piston core sampler, made of austenitic stainless steel, from the bottom of the Nyland-firth at a water-depth of 65-95m, about 3km from the delta-bank. Of the four cores taken up, Nrs I and III were sent to Dr. Griffiths in Birmingham, while Nrs II and IV have been investigated in Stockholm by L. Granar, who also took a number of samples from core I (the orientation of which was most accurately known) for the purpose of comparison.—Glacial varved clay from the same region has an age of about 9000 years.

The fluvial sediments in their properties markedly diverge from glacial varved clay; the varve-boundaries are much less distinct and also their magnetic properties are somewhat different. For instance, when measuring the magnetic characteristics

of a number of samples, Granar found the dispersion (mean error) to be greater; this was especially marked in the declination of the remanent magnetization, which showed a dispersion 2-3 times greater than in glacial clay. It seems as if the river deposits during sedimentation had been more influenced by disturbances, probably of hydrodynamic origin, than is as a rule the glacial sedimentation—at least at some distance from the mouth of the ancient glacier stream (“distal” sediments).

Concerning such (hydrodynamic) disturbances, I wish to underline Dr. Griffiths' words in the last section of his communication: “All the details of the sedimentation process are not yet fully understood”, and to emphasize the desirability of further experiments on artificial sedimentation, *e. g.* such as Dr. R.F. King has taken up in Birmingham. Of course, experiments ought to go hand in hand with some schematic theory of the sedimentation process in (slowly) streaming water, allowing quantitative calculations to be made. The simplest possible scheme considers the whole column of water, from the bottom to the surface, as sliding on its horizontal bed with a common velocity U , while the conveyed grains are sinking independently of U and of each other. This picture may, perhaps, allow a satisfactory calculation of the distribution of grain-sizes along the bottom of a deep and very slow current; but it is much too simplified for a general theoretic survey of the sedimentation process and the grain-orientation. Apart from the possibility of coagulation in concentrated suspensions, especially such of calciferous grains, also purely hydrodynamic disturbances ought to be faced. Mr. Granar, in his examination of natural sediments (to be published before long) has found distinct signs of stream-influence, especially on the magnetic anisotropy; and he has tried to improve the theoretic scheme by taking into account also the vertical velocity-gradient $\frac{dU}{dz}$ near the bottom of the stream.