This work was carried out under the sponsorship of the United Kingdom Atomic Energy Authority. I thank Dr. E. Schneider for his advice.

GERHARD HEILMANN

Department of Physics,
University of Newcastle upon Tyne.

* Present address: Universität des Saarlandes, Institut für Experimentalphysik, 66 Saarbrücken, 15.

[1] Heilmann, G., *Z. angew. Physik*. **17**, 482 (1964).
[2] Heilmann, G., *Applied Optics*, **4**, 1201 (1965).
[3] Leontovitsch, M., and Mandelstam, jun., S., *Physik. Z. Sowjetunion*, **1**. 317 (1932).
[4] Taurel, L., and Humphreys-Owen, S. P. F., *Proc. Phys. Soc.* (London). **75**, 473 (1960).

GEOLOGY

Corona Structures in the Basic Igneous Masses of East Aberdeenshire

THE presence of corona structures in the east Aberdeenshire intrusions is well known. Read[1] described and figured such reaction relations from olivine-gabbros of the Huntly mass. Stewart[2] noted in the Belhelvie mass common reaction rims surrounding the olivines of the troctolites, the inner being colourless orthopyroxene, the outer amphibole. Sadashivaiah[3] described from ultrabasic rocks of the Bourtie area of the Insch mass "Very beautiful double coronas . . . are developed around the olivines at the contacts with feldspar; the narrow inner rim is usually of orthopyroxene and the broader outer rim of fibrous amphibole . . .". Read, Sadashivaiah and Haq[4] recorded from olivine-gabbros of the Insch mass "intergrowths of various kinds and reaction-associations are beautifully developed. . . . The discontinuous reaction series involved in the reaction association consists of the following members: olivine, hypersthene, augite, hornblende and biotite." In my investigation of the southern end of the Huntly mass I have observed in troctolites double coronas of enstatite and hornblende, and in olivine-gabbros and olivine-norites double coronas of hypersthene and hornblende.

These facts are of considerable importance in the light of recent investigations into the effects of pressure on the melting of enstatite by Boyd, England and Davis[5]. From the results presented, they suggest that ". . . rocks which show textural evidence of an olivine-liquid reaction relation have developed this relation at relatively shallow depth, probably less than about 9 km".

Stewart[2] stated that the most reasonable explanation of the form and banded nature of the Belhelvie mass is "that of gravitative differentiation in place, and subsequent tilting to an almost vertical position". Blundell and Read[6], from palaeomagnetic evidence, state "There is no significant difference between the magnetism of any of the basic masses, and it is therefore suggested that they have remained relatively undisturbed since their formation". Stewart and Johnson[7] ". . . feel that the evidence in favour of differentiation in place and subsequent folding, provided by the primary igneous structures, is strong". Read *et al.*[4] advanced a provisional conclusion for the Insch mass that crystal-fractionation of gabbro magma occurred in place.

From the results obtained by Boyd, England and Davis[5], it would appear that the basic intrusives of east Aberdeenshire are high-level types, and do not represent a large Bushveld type' layered intrusive broken up at depth. The presence of perfect corona and other reaction structures in each of these masses suggests a common factor in their crystallization history; perhaps as one fractionation sequence, for example, Read *et al.*[4] ". . . the exposed basic masses of north-east Scottish Province might make one huge sheet"; perhaps as individual bodies of magma crystallizing under similar conditions of depth and metamorphism. Stewart and Johnson[7] suggest that the 'older' rocks near the western margin of the Huntly mass south of Knock Hill are in reality 'younger'. If this is correct, and indeed if the Port Soy ultrabasics are also 'younger' and hence correlate with the southern end of the Huntly mass, crystallization of these rocks must have occurred before some, at least, of the regional metamorphism. In contrast, the thermal aureole surrounding part of the Insch mass shows it to be younger than the MacDuff Slates.

In the symposium: "Depth and Tectonics as Factors in Regional Metamorphism", it was suggested by Chinner[8] that: "On the load pressure assumption, kyanite-sillimanite sequences appear to require not only low geothermal gradients . . . but also depths of burial of the order of 30 kilometres". Any depth burial approaching this figure is at odds with the evidence of the presence of corona and reaction structures in the Aberdeenshire basic masses, which suggest late-tectonic, high-level crystallization.

Variation in regional metamorphism in the country rocks surrounding each of these masses, coupled with investigation of the variation of contact aureoles and the nature of the reaction structures present in each mass, will be necessary before the general history of these masses is elucidated.

D. S. WEEDON

Department of Geology,
University of Glasgow.

[1] Read, H. H., *Mem. Geol. Surv. U.K.* (1923).
[2] Stewart, F. H., *Quart. J. Geol. Soc. Lond.*, **102**, 465 (1947).
[3] Sadashivaiah, M. S., *Geol. Mag.*, **91**, 137 (1954).
[4] Read, H. H., Sadashivaiah, M. S., and Haq, B. T., *Proc. Geol. Assoc. Lond.*, **72**, 391 (1961).
[5] Boyd, F. R., England, J. L., and Davis, B. T. C., *Geophys. Res.*, **69**, 2101 (1964).
[6] Blundell, D. J., and Read, H. H., *Proc. Geol. Assoc. Lond.*, **69**, 191 (1958).
[7] Stewart, F. H., and Johnson, M. R. W., *Trans. Edin. Geol. Soc.*, **18**, 104 (1960).
[8] Chinner, G. A., *Proc. Geol. Soc. Lond.*, **15**, 1594 (1962).

Oligocene in California ?

RECENTLY, Eames, Banner, Blow and Clarke[1] stated that strata of Oligocene age are missing in most of America. To support their conclusions, they noted that the Relizian Stage of California was Aquitanian in age and correlated it with the Chickasawhay Formation of the Gulf Coast region. They also noted that the Tumey Formation of California, formerly considered as Oligocene, contains Eocene *Discocyclina clarki*. By ignoring the strata between the Tumey Formation and rocks of the Relizian Stage in the context of a "Brief Review of Significant Faunas from Important Parts of the Central American Region", they created the impression that California also lacks strata of Oligocene age. Indeed, for America they "conclude that in the whole region we have considered (and even as far north as the state of Washington), there are no published records of stratigraphical sections of fossiliferous marine beds which can be dated as Oligocene". Kleinpell long ago suggested that his 'Miocene' stages below the Relizian were equivalent to the Oligocene of Europe[2]. Later, Kleinpell and Weaver[3] discussed 'Oligocene' molluscs and benthonic foraminifera from part of California, but stated that their local sequence did not necessarily coincide in age with that of the typical European Oligocene.

Planktonic foraminifera, indicative of the Oligocene *Globigerina oligocaenica* Zone (= *G. selli* Zone) of Eames *et al.*, have been found in rocks assigned previously to the Zemorrian Stage of the California 'Miocene'. These strata occur immediately below the type section of the overlying Saucesian Stage and above the Vaqueros Formation in Los Sauces Creek, Ventura County, California. The benthonic fauna has been documented