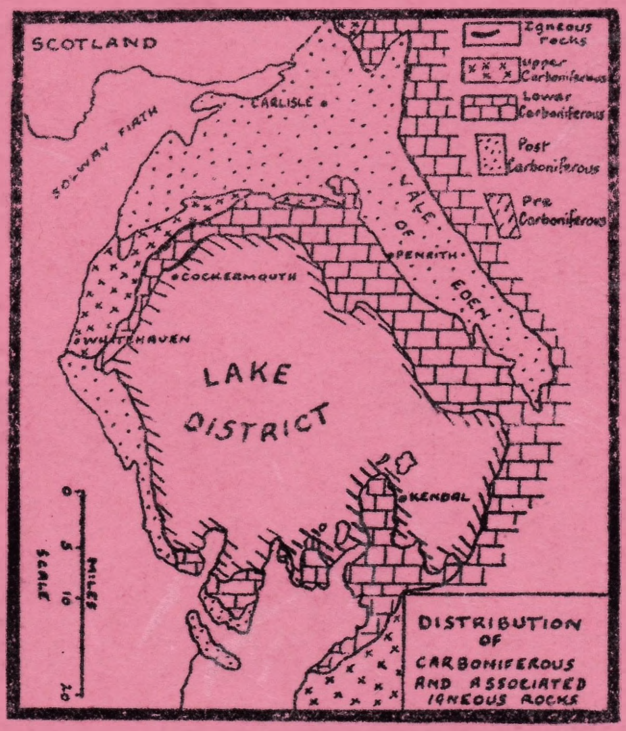
CUMBERLAND GEOLOGICAL SOCIETY



PROCEEDINGS

No. 2 1965

Two Shillings and Sixpence

THE CUMBERLAND GEOLOGICAL SOCIETY

President:

E. H. Shackleton, F.G.S.

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PROCEEDINGS 1965, Number 2.

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December, 1965.

GENERAL SECRETARY:

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[redacted]

LIST OF MEMBERS OF THE SOCIETY, 1965.

[redacted]

[redacted]

[redacted]

= EDITORIAL =

With the fourth year of the existence of the Cumberland Geological Society drawing to a close, I feel we can look back to a very satisfactory programme of events completed. Attendances at our last three monthly meetings, the Soiree in October, the Film Evening in November, and the lecture on Mining in the Alston District, just past, were particularly heartening, and it is very satisfying to know that there is so much support in this corner of England for a Geological Society such as ours.

It has been said on numerous occasions that we are unfortunate in not having a nearby University to sponsor our work and support our functions. Certainly the Council of the Society feels very keenly the lack of people willing to undertake lectures and excursion leadership. Might I add that where people have been persuaded to help, often protesting that they do not know enough geology, they have invariably made a very good job of the lecture or excursion undertaken. It takes some time, certainly, to prepare a lecture or to go over the ground for an excursion, but there is always advice available, and in the library we have a good selection of geological literature and maps which is all the better for being used. We do lack the resources of a University, resources which most, indeed I think all, other localised geological societies have. But there is nothing we can do about it until a University is established in Cumberland: we shall perforce continue as a largely "amateur" (in the best sense of the word) body. This is in no way a drawback. The Society, and individual Members, have had many requests for geological information. We have this year run two courses for the Cumberland Education Authority, one residential, and the other as a series of lectures at an Evening Centre. We have supplied speakers for Rotary Clubs and for the very successful and popular lecture programmes run at Keswick and Ambleside by the Lake District National Park and University of Newcastle Department of Extra-mural Studies. All this in addition to our normal programme.

The General Secretary has been making a scrapbook of newspaper cuttings of the activities of the Society, with photographs and colour slides taken during Society meetings. He tells me he would particularly welcome copies of photographs or slides which Members might care to donate.

This is the eighth issue of the Proceedings that I have prepared, and with the increasing size of the Society and the expansion of its programme over the past four years, the business of preparing accounts of the activities is becoming increasingly onerous. The Council has now sanctioned the setting up of an Editorial Board, comprising the General Secretary, the Librarian and myself. We would welcome the assistance of people willing to type, prepare stencils, check manuscripts, duplicate and assemble copies. My own attempts to improve the presentation and content of the Proceedings could be bettered, I feel, with more help available.

It is proposed to make the eight issues of 1962 - 1965 into Volume I of the Proceedings. The next issue will now be Part 1 of Volume II. It is further proposed to publish Proceedings once yearly, at about this time. This would result in economies in postage and materials; also it takes far less time to prepare one larger issue than it does for two smaller ones.

I trust Members will enjoy reading this issue, with pleasant memories of meetings attended, and useful information gleaned about those missed. We look forward to seeing you at meetings in 1966.

EXCURSION TO THE BLEA CRAG COMPLEX, LANGSTRATH

Sunday, 27th. June, 1965. Leader: M.F. Burton.

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Blea Crag is situated approximately 3 miles south-east of Stonethwaite, (Borrowdale) in the Langstrath valley.

It is the centre of a minor intrusion comprising a differentiated magma producing basic and acid type rocks and intermediate varieties of both.

Clifton Ward mapped Blea Crag as a small laccolite, but Walker in his paper on the Crag points out that if this is the case, it is of very irregular form; for on the west side of the valley the branches of the intrusion often run at right angles to the strike of the surrounding rocks. Ward also described the rock as a diabase with felsite veins; there seems, however, to be an almost infinite variety of rock, from a very fine-grained black, through a coarse porphyritic dark-green rock, to one containing quartz and pink felspar.

The country rock in the vicinity of the intrusion is comprised of fine grained ashes and tuffs of the Sty Head Garnetiferous Group of the Borrowdale Volcanic Series. This group, referred to in earlier works as "Garnet Bearing Streaky Rocks of the B.V.S." was accepted as lying between the lower Ullswater Basic Andesites and higher Scafell Ash and Breccias and formally named "The Sty Head Garnetiferous Group" by Dr. Marr in the Anniversary Address to the Geological Society in 1906.

The excursion party paused en route to the Crag for lunch at "Blea Rock", a large boulder similar to the Bowder Stone which lies perched just above the valley track. Several varieties of rock were seen here, the writer noting a light-coloured dense rock with a slightly glassy texture, probably a dacite. Some fair sized almandine-rich garnets were also found contained in the rocks at this spot.

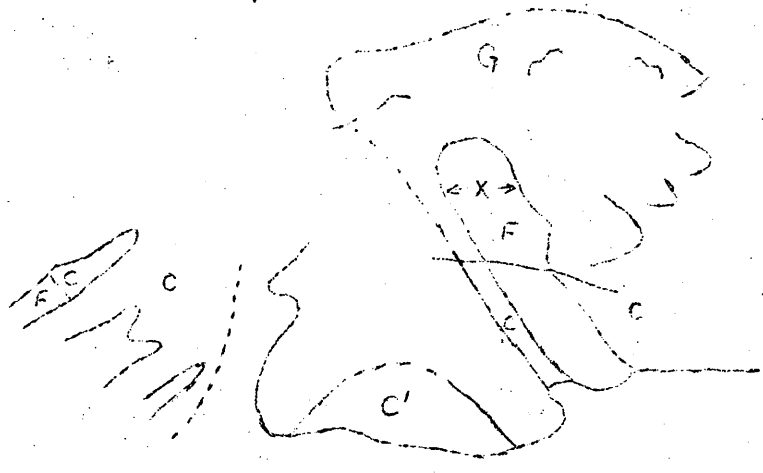
The summit of Blea Crag was visited by the party first, as it is here that the basic dark rock, the first type to be intruded is most easily discovered. This basic rock type is not altogether in appearance unlike the adjacent country rock, being a shade heavier and of a finer grain. Working round the base of the Crag from south to north, the party observed the various types of rock dividing its steep face in narrow bands, some being a matter of inches wide. The most acid type to be found and the final differentiate of the magma is a granophyre bearing a strong resemblance to the familiar Ennerdale-Buttermere mass. That the basic portion of the magma issued first, followed by the acid fraction, is borne out by the fact that good junctions are seen below Blea Crag where the fine-grained rock is plastered against the coarse, and is penetrated by veins of the latter. The interval between the two periods of intrusion must have been short for the two types to have intermixed to form an intermediate one.

A few specimens were collected and analysed after Walker's visit to the Crag, and four of the published analyses are appended overleaf:

	A %	B %	C %	D %
SiO_2	57.91	60.02	61.63	64.40
TiO_2, Al_2O_3, Fe_2O_3	27.56	25.36	22.34	22.39
MnO	0.32	0.29	0.22	0.14
CaO	6.19	3.97	4.40	2.27
MgO	1.20	0.91	0.98	0.60
K_2O	1.82	2.55	4.04	5.79
Na_2O	1.64	2.62	2.51	2.51
Specific Gravity	2.856 @ 13.8°C	-	2.748 @ 13.4°C	2.722 @ 16.1°C

A = Fine grained black rock of Blea Crag summit.
B = Quartz-garnet-mica-porphyrite in stream above Blea Crag.
C = Quartz-garnet-mica-porphyrite in stream above Blea Crag.
D = Granophyre from Langstrath Beck, south of the Stake Pass.

Diagrammatic Sketch of an Exposure North-North-West of Blea Crag, Langstrath (after Walker)



F = Fine grained black rock.
C = Coarse pink rock
C' = The same, with pink felspars.
G = Dark green porphyritic rock, with greenish-white porphyritic felspars.

←X→ = 1½ yards.

At the base of the crag below the fallen scree the Vice President, Mr. Gowing, drew the attention of the party to a large angular boulder showing a well marked lava flow structure, and nearby a smaller stone containing both intermediate porphyritic and granophyritic rock types merging one in to the other.

A smaller intrusion (see Sketch) immediately N.N.W. of Blea Crag across two streams was finally visited by the last members of the party to leave the area. This exposure was specially visited in August 1900 by members of the Geologists' Association, and exhibits all the rock types in evidence on Blea Crag within a very small compass. It is possible, with plenty of time and patience to obtain from this intrusion hand specimens showing a gradual transition from the basic black rock through the dark-green porphyry to the pink granophyre. This being in addition to well marked junction specimens.

Various individual minerals were noted throughout the complex. Small crystals of pyrite were fairly common in all varieties of the rock. The occasional garnet was seen, sometimes in an altered condition.

With further reference to the Lake District garnets, opinions have oscillated over the last 60 years or so concerning their mode of occurrence. The strongest propositions are in favour of a pyrogenetic origin and only a few writers lean towards contact metamorphism as being the reason for their formation. R.L. Oliver (Geological Magazine 1956) is strongly in favour of the former and goes to considerable lengths in his paper to explain his views. He states in concluding "It is considered that the distribution of the Lake District garnets concerned precludes the possibility of all but a few having been formed as the result of contact metamorphism; and that a metamorphic paragenesis (either contact or regional) is unlikely also because there is no evidence that the containing rocks, in general, have been significantly affected by metamorphism. The possibility that the garnets have formed under hydrothermal or metasomatic conditions is also not favoured because temperatures normally prevailing in such an environment are thought to be substantially lower than the crystallization temperature of the garnets concerned."

The following is an analysis and formula of a garnet from the andesite of Stonethwaite, Borrowdale, after Oliver:

	%	Molecules per cent	
SiO_2	37.32	Almandine	67.27
Al_2O_3	20.89	Spessartite	4.22
TiO_2	trace	Pyrope	20.97
Fe_2O_3	0.30	Grossular	6.64
FeO	32.07	Andradite	0.90
MnO	2.00		
MgO	5.62		
CaO	2.49		
	100.69		

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References

Notes on the Garnet-bearing and Associated Rocks of the Borrowdale Volcanic Series. By E.E. Walker. Q.J.G.S., Vol. 60, February 1904.
The Origin of Garnets in the Borrowdale Volcanic Series and Associated Rocks, English Lake District. Br R.L. Oliver. Geol. Mag., Vol XCIII, No. 2, March-April 1956.
The Structure of the Eastern Part of the Lake District. By J.F.N. Green. Proc. Geol. Assoc., Vol. XXVI, Part 3, 1915.

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M.F. Burton.

AFTERNOON EXCURSION TO THE EXPLOSION BRECCIA OF CAPPLE CRAG

July 10th. 1965 Leader: R.E.O. Pearson.

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This excursion to the explosion breccia and associated rocks in the valley of the River Calder was held on a very wet Saturday afternoon. After meeting at Ennerdale Bridge the party proceeded by cars as far as the Wilton turning on the Cold Fell road between Ennerdale and Calder Bridge. Here the cars were parked, and dressed up as for a deep-sea fishing contest some twenty one members walked down the old packhorse track across Monks' Bridge to Capple Crag which may be seen from the road as a low outcrop of rock on the rising moors to the east.

The explosion breccia exposed at this "crag" is, it is thought, the result of submarine volcanic explosions bursting through newly consolidated Ordovician Latterbarrow Sandstone during the phase of volcanic activity that resulted in the Borrowdale Volcanic Series. The rock is composed of pieces of sandstone in a matrix of volcanic ash, the sizes of the fragments depending on their proximity to the seat of an explosion. Since some of the pieces of sandstone at Capple Crag are large, as much as a foot across, it is thought that the Crag is very near the centre of an explosive volcanic outburst.

After a good look at this very interesting outcrop, the party made its way across the moors, crossing Capple Beck and Latterbarrow Beck, where some interesting exposures of the Sandstone were observed. The River Calder was rejoined at a point where a useful "marker" dyke of dolerite divides the Skiddaw Slate from the overlying Latterbarrow Sandstone.

The River Calder rises on Black Pots behind Crag Fell to the south of Ennerdale, and is joined by Whoap Beck, Stinking Gill, and then Comb Beck at the ford below Lankrigg Moss. From this point downstream to the dyke it runs over Skiddaw Slates. At the bend of the river just upstream from the dyke the Slates are fossiliferous in so much that a trilobite was found in them on a previous Society excursion in 1960. The Slates are very much folded at this location, making the find all the more interesting.

The party was by now thoroughly wet, and the return journey downstream to Monks' Bridge was made easier by being able to wade the river as it meandered down the valley, in the realization that one just could not become any wetter.

The Latterbarrow Sandstone, traversed in this wet walk, is one of the Skiddaw Slate Series, occurring locally near the junction of the Slates with the Borrowdale Volcanic Series. In the bed of the Calder, the Sandstone gives way to Breccia, though here none of the fragments are nearly as large as those found on Capple Crag. Further downstream a sequence of ash and lava rocks of the Borrowdale Volcanic Series is encountered.

References

Memoir of the Geological Survey of England and Wales; The Geology of the Whitehaven and Workington area.

Ordnance Survey Map, Sheet NY 01, Scale 1:25,000.

Geological Survey 1" Map, Sheet 28 (Drift).

R.E.O. Pearson.

WEEKEND CAMPING EXCURSION TO THE SOUTHERN UPLANDS OF SCOTLAND

July 23rd. - 25th. 1965. Leaders: Messrs. Hewitt, James and Shackleton.

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Members gathered at the campsite, a field on the outskirts of Moffat, and after setting up tents and preparing and disposing of the evening meal, moved to the comfort of a hotel room where the Excursion Secretary outlined the programme for the following two days and the President enlarged upon the geology of the areas to be visited.

On the following morning, Saturday July 24th., members set out by car to visit the fossiliferous Silurian Shales in Dob's Linn, a famous locality about 15 miles from Moffat. We were particularly gratified to have the company of Mr. Eckford, a retired member of the Geological Survey who had done much of the routine fossil collecting in the area in his younger days. In spite of the wet and windy weather, and a day spent on near-vertical slopes of crumbling shale, much of interest was seen, and many specimens were collected for comparison with those of the same horizon in the Lake District, namely that seen at Skelgill near Ambleside.

Sunday was devoted to an ambitious general survey of the old mining area of Leadhills and Wanlockhead, directed by R.H. Hewitt and D.C. James.

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EXCURSION TO THE LEADHILLS-WANLOCKHEAD DISTRICT

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Outline of the Geology

The Leadhills-Wanlockhead district is geologically interesting because it contains the largest worked lead-zinc deposit in Scotland, and also includes part of one of the belts of inliers of Arenig rocks in Upper Ordovician strata extending right across the Southern Uplands.(reference 1) The mining district lies in a series of Ordovician greywackes and mudstones which are generally assigned to the Caradoc and Ashgill Series and are given the local name of the Lowther Group (2). A recent interpretation of these has been given by Pringle (3) as:

Ashgillian Stage..Lower shales with conglomerates and greywackes

Caradocian Stage..Black shale passing into greywackes, shales and conglomerates.
Greywackes, shales, grits, etc.

Unconformity

Arenigian Stage...Radiolarian cherts.
Volcanic and intrusive rocks.

Greywacke dominates the country in which the veins lie. These are stratigraphically above the series of black shales and cherts, but are tectonically below them. Many felsite dykes cut these rocks. The numerous faults in the area generally form two distinct sets, N.W.-S.E. and N.-S. These main faults are also occupied by veins. An important feature of the district is a low angle reverse fault or zone of movement dipping N.W. at an angle of 30-40°. The faulting and fracturing of the mine area may be summarized as follows:

(a) Intense shearing, which has locally converted greywacke to a soft, shale-like rock.

(b) Low angle faults, displacing (a) but generally displaced by (c).

(c) Barren quartz veins, often with no movement along their planes.

(d) Steep faults, usually of small magnitude.

(e) Mineralized veins, many of which have considerable movement on the plane of the vein.

(f) Post-mineral faulting.

Although it is generally believed that the Romans mined lead in this part of Scotland, the first lead production in the district is recorded in 1263. In the sixteenth century the district was worked for gold and at that time lead was imported for refining purposes. Total production for 1842-1935 is quoted as lead ore 266,591 tons, zinc blende 13,796 tons. The mine was flooded from 1934 until 1954, when it was pumped out. A mill erected in 1957 produced 200 tons of ore per day but low lead prices caused suspension of production in 1958. The mining district is divided into two separate areas with separate adits, mills and offices. There was no connection, physical or managerial, between the Leadhills and Wanlockhead districts.

There are only two primary minerals which have been worked in the district, galena and sphalerite, the latter being localised. The galena occurs frequently as massive coarse and crystalline aggregates, but is sometimes disseminated and is sometimes intermixed with sphalerite, pyrite and chalcopyrite. The sphalerite is normally dark brown in colour and occurs in a similar fashion to the galena. In part it is very dark - a typical "Black Jack".

Chalcopyrite and pyrite are frequently found in the veins, and pyrite often occurs in the country rock, particularly in felsite dykes, and the shaly parts of the greywackes.

The main gangue minerals are quartz, calcite and dolomite, with barytes being important in individual veins. Hematite and limonite are also common.

The field has the usual oxidation minerals of lead, zinc and copper in the upper parts of the veins. In addition to the above, various minerals occur which are interesting to the collector. These include leadhillite, lanarkite and caledonite, all sulphates of lead or of lead and copper, which are named after this locality. Vanadinite and jamesonite (a sulph-antimonide of lead) have also been reported.

Description of the field meeting.

The sequence of exposures visited and described as follows is based on that given by G.W. Borthwick in reference 1. The camp at Moffat was struck on Sunday morning and the party proceeded via Leadhills to Clowgill Dod where the red-stained cherts were examined. Following the course of Bell-gill Burn for several hundred yards, good exposures of chert and shale were observed in the bed and banks of the burn.

The party then drove to the second exposure at Big Wool Gill which provides a good section through the vein-bearing greywackes. On the north bank of the stream is an old mine shaft. The dump around this shaft was

examined and found to be mainly of sheared black shale. From the bed of Big Wool Gill fairly good specimens of manganite, pyrrhotite and pyrite were obtained as well as small specimens of chalcopyrite, malachite and azurite. Three small specimens of granular orange-yellow wulfenite were also found.

The group moved south through Leadhills to Wanlockhead where an old beam pumping engine was examined and photographed. This was driven by water passing from a high level via the underground pump to an adit from which it flowed to the surface lower down the valley. Lunch was then taken near the ruins of an old smelt mill which was afterwards examined. Brick flues were seen to have connected the mill ruins with buildings used for the recovery of zinc. From these, remains of old wooden flues could be seen branching up the fellside and it appeared that zinc could be recovered from these flues by washing with water down to the settling ponds. After these items of Industrial Archaeology, the mine dumps round Glencrieff Shaft were picked over and some very good specimens of pyrrhotite, anglesite, chalcopyrite, galena, malachite, pyromorphite, sphalerite, azurite, minium and zincite were obtained. These dumps are rich in highly disseminated galena which is now being recovered by a flotation process. This is profitable since there is now no longer any penalty clause excluding the presence of zinc.

Glencrieff mine dumps proved so fruitful that by the time the last part of the excursion was reached at Whyte's Cleugh it was late in the afternoon and several members had already left the party. The whole of the valley floor was filled with broken vein material, and specimens were found of the same minerals as at Glencrieff, the secondary minerals being better.

Thanks are due to Mr. Jamieson of the Glencrieff Mining Company for permission to visit the dumps.

D.C. James.

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1. Edinburgh Geology - An Excursion Guide. Edited by G.H. Mitchell, E.K. Walton and D. Grant. Oliver & Boyd, 1960.

2. Mackay, R.A., 1959. The Leadhills-Wanlockhead Mining District. Symposium on the future of Non-ferrous Mining in Great Britain and Ireland. The Institute of Mining and Metallurgy.

3. Pringle, J. The South of Scotland, 2nd. ed. British Regional Geology, 1948.

THE SOIREE

October 12th., 1965. Whitehaven College of Further Education.

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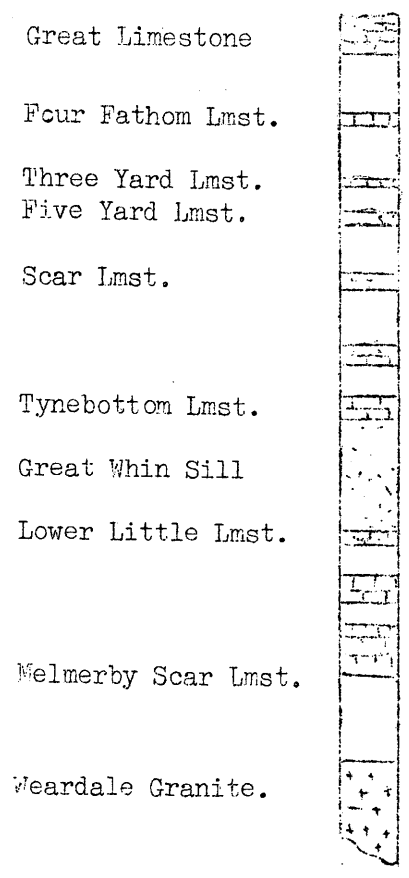
A good number of Members and friends met for this the first meeting of the Winter Programme. By convention, the meeting was very informal; some Members showed selections of colour slides, whilst several brought specimens, of which the outstanding one was a specimen of Weardale Granite, displayed and explained by our Vice-President, Mr. G.S. Gowing. The story of the Weardale Granite started in 1934 when Professor Dunham pointed out that the various minerals found in the Northern Pennine Ore-field had been deposited in very roughly concentric zones about a centre in the neighbourhood of Rookhope, north of Weardale. He suggested that this was similar to the zoning of minerals around the Cornish Granite and that therefore there was a good possibility that a granite mass existed deep down below Weardale

In the 1950's Martin Bott and his co-workers carried out detailed gravity surveys over the whole of the Northern Pennines and found a very marked gravity "low" under Weardale. This work also suggested the existence of a large mass of granite, which is a light rock, and Bott's final measurements pointed to the top of the granite being at a depth of 1,000 to 2,000 feet below the surface.

In 1960 Professor Dunham obtained from the Department of Scientific and Industrial Research a grant of money sufficient to put down a borehole, if necessary to 5,000 feet, to prove the granite. In February 1961, the borehole entered granite at a depth of 1,281 feet.

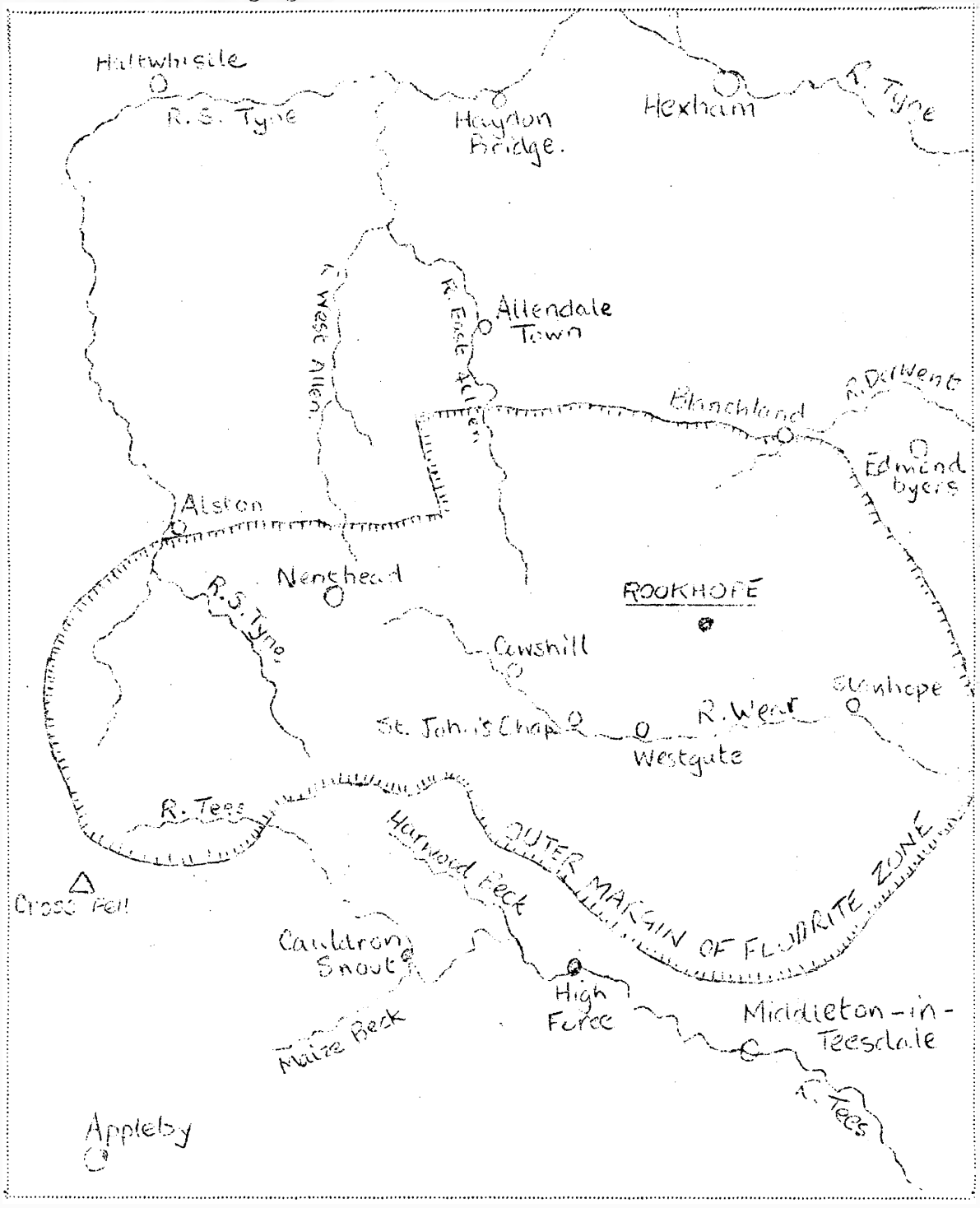
The discovery of this granite is a spectacular proof of the accuracy of gravity survey methods. It turned out, however, not to be the source of all of the minerals as the veins continued into the granite, showing that they had come from an even deeper source. Radiometric dating also showed that the granite is of Devonian age, while the mineralisation is much later, probably late Carboniferous. Professor Dunham's original theory is, however, probably not entirely wrong, as no doubt the Weardale Granite formed a channel up which the minerals rose to the surface from their deeper source.

The specimen of granite on display was cut from a core taken at a depth of 2,240 feet. It showed quartz, felspar, biotite and muscovite. Mr. Gowing also showed vertical sections of the



strata in many of the mines and boreholes in Weardale and Teesdale, and pointed out that the granite only appears within the Rookhope borehole, proving that the sides of the intrusion are steep as predicted by gravity measurements.

The map shows part of the Northern Pennine Area, indicating the limit of fluorspar as a gangue mineral in the galena deposits; outside this line, barytes forms the gangue.



FILM EVENING AT WYNDHAM CENTRE, EGREMONT.

November 9th. 1965.

DRILLING FOR OIL AND GAS IN THE NORTH SEA

The subject was introduced by Mr. G.S. Gowing, the Vice-President of the Society, who outlined by means of maps and slides the reasons for the sudden interest in the area and the manner in which the oil companies concerned are tackling the job.

Three main reasons can be put forward for the sudden burst of activity in exploring for oil and gas under the North Sea. These are:-

1. The discovery of important deposits of gas in Holland.
2. The conclusion of international agreements over the right to drill on the Continental Shelf.
3. Advances in the technique of undersea drilling to the point where the difficulties of the North Sea can be overcome.

In considering the first of the above, we must realize that drilling in the sea-bed is inevitably more expensive than drilling on land and that, in consequence, an oil company requires to be more certain of finding oil or gas under the sea than it does on land. Now although it has been known for some time that a small quantity of gas exists near Edinburgh and some more near Whitby, while a small oil-field has been worked since the war near Eakring in Nottinghamshire, this is all that has been found on the British side of the North Sea, while on the other side only small occurrences had been found in Belgium, Holland and Germany until 1959, when the gas-field near Groningen in Holland was discovered. This has turned out to be the second largest individual gas-field in the world (the Panhandle-Hugoton field in Texas is the largest) and its discovery immediately enhanced enormously the chances of oil or gas existing under the North Sea.

The question of who owns the rights for drilling in the North Sea is obviously of prime importance in an area surrounded by half a dozen or more independant countries, and it was not until the United Nations set to work to reach an agreement that any real steps could be taken. This was in 1958 and it is only quite recently that general agreement has been reached and only in the last few months that final terms have been settled between individual pairs of countries.

Finally, there is the question of technique. The North Sea, although of no great size and under a temperate climate, is much more subject to prolonged bad weather, to storms and fogs, than other parts of the world where undersea drilling has been tried, and it was not until the drilling outfits and their ancillary equipment had reached considerable development that the drilling companies were prepared to tackle the problem.

Thus the three main factors affecting undersea drilling in the North Sea all reached a favourable stage in the early 1960's and this accounts for the flurry of activity at the present time.

A number of companies carried out seismic and other methods of surveying from 1961 to 1964, and in this latter year the British Government

divided up its portion of the area into 100 square mile blocks for leasing to the various applicants. The licence fee for each block was £6,250, and on top of this the Government will get a share of over 60% in any profits made by successful wells. In July this year applications for further licences were invited in areas around the Orkney and Shetland Islands and in the northern part of the Irish Sea.

There are three main types of drilling outfits that have been employed for undersea drilling. These are:-

1. A platform on piles, with a rig erected on it.
2. A platform which floats and can be towed into position, when legs can be put down to the sea-bed and the platform jacked up out of reach of the waves.
3. A completely floating platform held in position by a number of anchors This type can be divided into:
   (a) A more or less normal barge-like vessel, and,
   (b) a semi-submersed type with most of its bulk underwater so as to be only slightly affected by wave action.

Of these, the first is obviously more expensive in the long run owing to the necessity of dismantling and re-erection when it is required to move it to another site. The second type is used regularly in depths up to about 150 feet of water, the newer ones being designed to go to 250 feet or more, while the third type can work in the deepest water. Actually, though the North Sea can well be covered by outfits of the second type, several of the third type are being used, as well as at least one of the first type.

In addition to the rigs there will be servicing vessels to bring out stores, and helicopters for bringing out personnel, and these of course involve considerable shore installations. When one remembers that one of the above drilling outfits can cost between two and three million pounds in capital and five or six thousand pounds a day to run, some idea will be gained of what is being spent today in the North Sea. And since much of this money is being spent in Britain, it will be seen that this country will benefit greatly even before any oil or gas is found.

Following this preamble by Mr. Gowing, the British Petroleum film

"THE CALCULATED RISK"

was shown, telling the story of drilling offshore and the subsequent development of an oilfield at sea.

MINES AND MINING IN THE ALSTON AREA

Report of a lecture given by G.S. Gowing, M.A., F.G.S. to the Society in the Workington College of Further Education on December 7th. 1965.

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The Meeting, which was attended by about 40 Members, was opened by the President.

In his opening remarks, the lecturer briefly surveyed the mining activities that have taken place in the Lake District and its immediate neighbourhood. One tends to think of the Coal and Iron Ore in the West, and of the Lead and Copper of the Keswick and Coniston areas but there is also a tendency to overlook the mines in the North-east corner of the County, mines which were very important in their day, perhaps the most important in Europe. The mines of the Alston area form part of the much greater Pennine Orefield, the other important major mining centres being in Derbyshire, Grassington, Wensleydale, Swaledale and Weardale. The ore in these areas occurs in more or less vertical veins and it is noteworthy that it is found principally in the hard beds, sandstones and limestones, and is nearly always pinched out and often displaced in shale bands. This fact provoked some discussion at the end of the lecture. It is evident from the structure that minerals in aqueous solution came up from the depths and filled cracks in the rocks. The principal metalliferous mineral is galena, whilst there is a little zinc and a very little copper. The gangue is fluorspar and barytes.

In outlining the history of mining in the area, Mr. Gowing stated that there was no evident Roman or Pre-Roman working found on Alston Moor, but a Roman pouring ladle and stamped pigs of lead had been found in Weardale. There was considerable activity in Mediaeval times; coins of William Rufus had been found at Garrigill near Alston, and there was a treatise on the desilvering of lead written by the Dean of Durham in the 12th, century. However, the real expansion of mining came after the Dissolution of the Monasteries. It is recorded that Alston Moor, property and mineral rights, was bought in 1629 for £2,500, while a little later, the Earl of Derwentwater was making £3,000 per annum profit before he was beheaded after the rebellion of 1715. The property reverted to the Crown and was handed over to Greenwich Hospital, but the profits by now were down to only £200 p.a. The leases were taken for a while by a Col. Liddell of Newcastle, whose optimism exceeded his mining sense. He made nothing of the contract, so the mines reverted to the Greenwich Hospital, and were then taken over by the London Lead Company, a Quaker company which was to develop the mines and initiate far-reaching social reforms in the Alston area for nearly 200 years. The Company made its headquarters at Nenthead, a few miles east of Alston, where a model village was built, with school and reading room. The Company provided a schoolmaster (£100 p.a.), and a doctor (£150 p.a.), and in view of these social amenities, it is hardly surprising that people in the area remember the "good old days" with the L.L.C.

The price of lead falling from £20 per ton in the 1860's to £10 per ton at the end of the century caused the Company to pack up in 1905. The mines were sold to a Belgian concern. There was a slight revival of mining during the First World War, and in the Second World War the dumps at Nenthead were re-worked for lead and zinc. Now all activity in the area has ceased.

Mr. Gowing concluded his lecture by answering questions put by the audience.

THE IDENTIFICATION OF MINERALS BY X-RAYS

W.D. Smith, A.R.I.C.

The chemical analysis of minerals is in many instances a long and tedious process, since many minerals resist attempts at dissolution, the first step in standard chemical analytical procedure.

Optical spectroscopy can indicate the elements present, but not their state of combination. Also by this technique no information about structure is given.

X-ray fluorescence will identify a large number of elements, but it has the same disadvantage as optical spectroscopy with regard to structure determination.

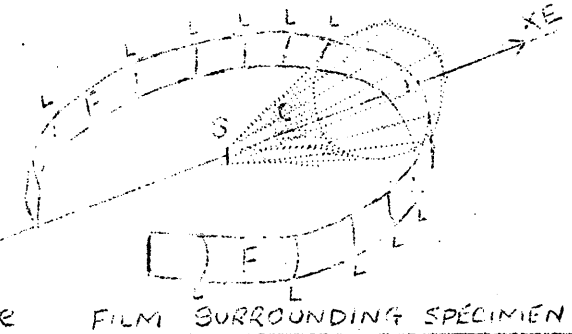
Minerals are frequently identified by determination of physical properties such as hardness and specific gravity, optical properties, and a few relatively simple chemical tests. This method is fairly satisfactory when a fair sized specimen of the mineral can be obtained, but is not often reliable when only microscopic amounts are available. In the latter case, examination of the mineral or of the rock containing it requires the preparation of a thin section, which is a time-consuming process.

The X-ray powder photography technique will not only identify small samples of minerals (about 1 mg.) but will also give enough information to assign each mineral to one of the 32 crystal classes, and in many cases will allow the unit cell dimensions to be determined.

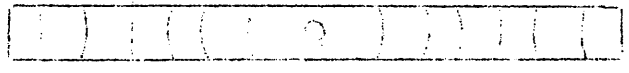
Principles of X-ray Powder Photography

When a narrow monochromatic beam of X-rays passes through a small specimen of a powdered crystalline solid, in which the crystal fragments are oriented at random, numerous cones of diffracted beams emerge from the specimen and they can be recorded as arcs on a strip of film encircling the specimen.

XI - incident X-ray beam.
XE = emergent X-ray beam.
S = mineral specimen.
C = cone of diffracted X-rays (only one shewn).
F = film surrounding specimen.
L = diffraction lines where cones cut the film.



FILM SURROUNDING SPECIMEN OF MINERAL



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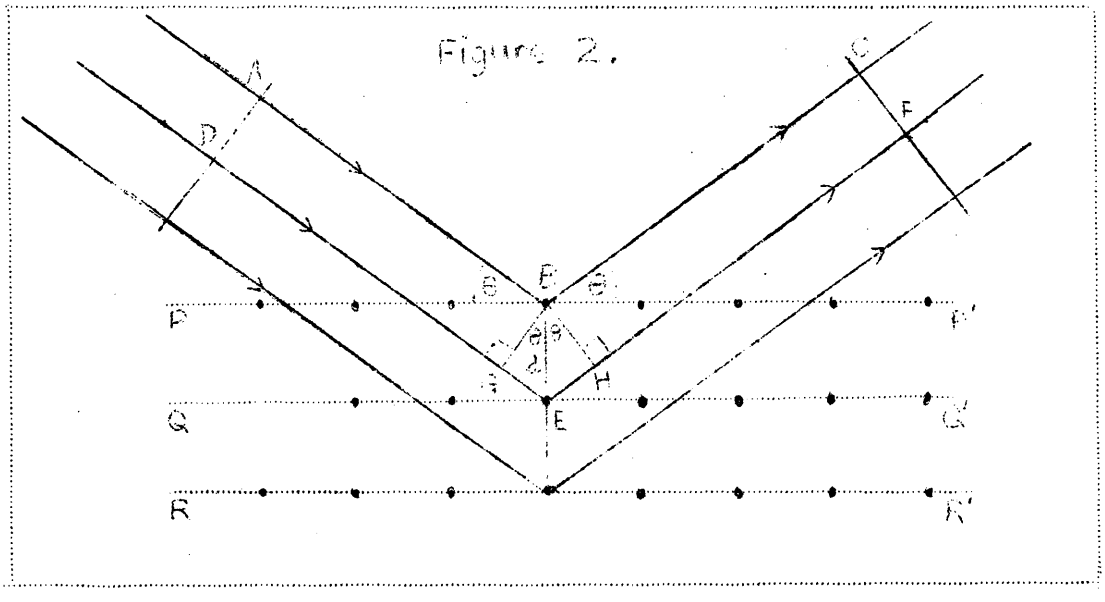
Figure 1.

Each cone consists of a large number of small diffracted beams, each from a small crystal. All the diffracted beams in any one cone are reflections by one particular type of crystal plane. Any particular crystal plane can reflect monochromatic X-rays only when it is at a definite angle θ to the primary beam, and all the crystal fragments which happen to lie with this plane at the correct angle θ to the primary beam will give a reflection. The angle of reflection is equal to the angle of incidence, hence the reflected beam makes an angle 2θ with the primary beam. The reflected beams from all the little crystals which are suitably oriented therefore form a cone of semi-vertical angle 2θ, having the primary beam as its axis. Each different type of crystal plane requires a different angle of incidence, and therefore gives a reflected beam at a different angle to the primary beam. Thus numerous cones of reflected beams are produced at specific angles, each cone coming from a different crystal plane. By simple geometry, knowing the diameter of the camera and after measuring the distance between corresponding lines of the diffraction pattern, the angle θ can be accurately determined.

What is the relationship between "d", the interplanar distance which we require to know for each set of planes in a crystal in order to identify it, and θ? When X-rays strike a regular array of points in a plane, reflection takes place in a similar manner to reflection of light, the angle of reflection being equal to the angle of incidence. However, there is one vital difference between reflection of light from a surface and reflection of X-rays from a crystal which behaves as a regular three dimensional point array. If the incident X-rays are to produce a diffracted beam, the diffracted waves from a series of points in one crystal plane must be in phase with waves from the other planes, that is, the differences in path lengths of waves diffracted from adjacent crystal planes must be a whole number of wavelengths.

Consider figure 2. PP', QQ', and RR' are adjacent planes of points seen edge-on. If plane PP' were alone it would reflect the primary beam AB as BC. This would happen whatever the angle of incidence θ. Likewise with the other planes taken in isolation.

Figure 2.



The path length DEF, however, is longer than ABC and if the two sets of waves are to be in phase, then the difference in path length must be an integral number of wavelengths. The difference in path length is GE + EH where BG is perpendicular to DE and BH to EF. BE is perpendicular to PP' and QQ' so that its length is d, the spacing between the planes.

Therefore GE and EH are each equal to $d.\sin\theta$, but for a diffracted beam to occur, GE + EH must equal a whole number of wavelengths, or,

$2d.\sin\theta = nL$ (where L is the wavelength of the incident beam).

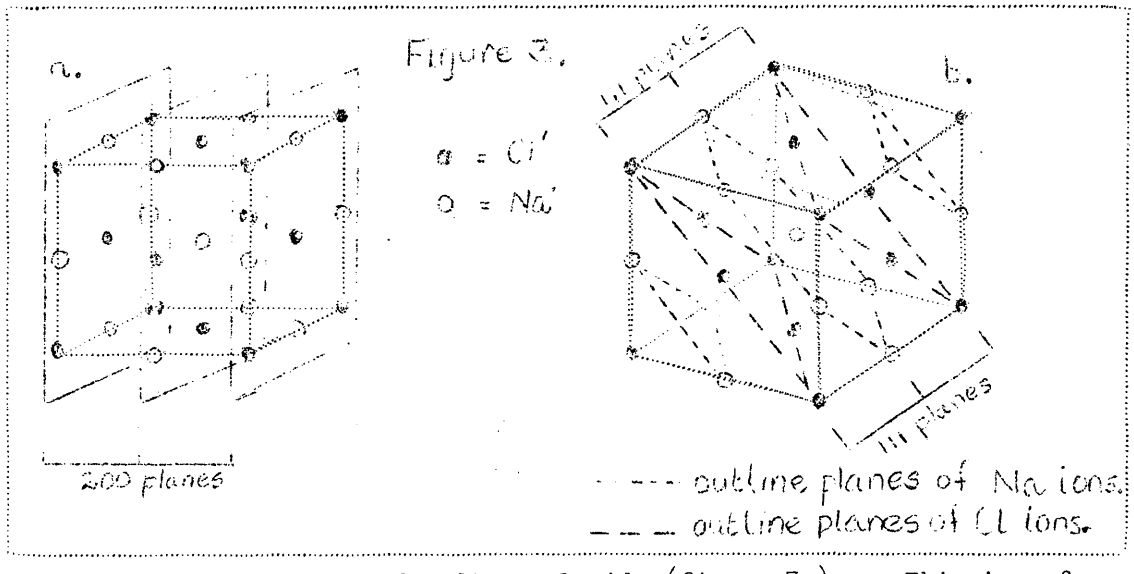
This equation, which must be satisfied for a diffracted beam to occur, is known as Bragg's Law, first demonstrated by Sir William Bragg in 1915.

Thus if L is known and θ determined, d, the interplanar spacing corresponding to each diffraction cone, can easily be calculated. The series of values of d obtained for each crystalline substance is specific.

Apart from d, there is another variable to be measured, and that is the intensity of the diffraction lines relative to the strongest.

Each arc on an X-ray diffraction photograph may be regarded as the reflection of X-rays by a particular set of parallel crystal planes. The intensity is controlled by several factors, the diffracting powers of the atoms, the arrangement of the atoms with regard to the crystal planes, the Bragg angle at which reflection occurs, the number of crystallographically equivalent sets of planes contributing towards the total intensity, and the amplitude of the thermal vibrations of the atoms.

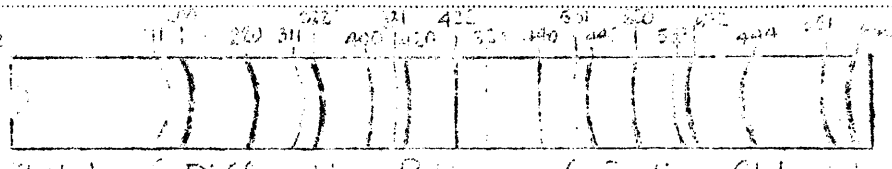
An illustration of the most important factor determining intensity, the arrangement of the atoms with regard to the crystal planes, is the following:



Consider the unit cell of sodium chloride (figure 3a). This is a face-centred cubic lattice. There are chlorine ions at each corner and at the centre of each face. In addition, there are sodium ions halfway along each edge and in the centre of the cube: these form another "interleaving" face-centred cubic lattice.

Now it is due to the different diffracting powers of different ions that this type of variation in intensity occurs, and incidentally, it appears that the diffracting power is proportional to the number of electrons in the ion. In figure 3b the 111 planes are shown by broken lines, and here waves from the sheets of chlorine ions are in phase with each other, but since there are sheets of sodium ions midway in between those of chlorine ions, waves reflected from the sodium ions partly cancel those from the chlorine ions and thus weaken their reflection, the diffracting power of sodium being half that of chlorine. On the other hand, figure 3a shows that both types of ions occur in 200 planes, and all the reflected waves co-operate to give a strong reflection. For such reasons, all reflections from crystallographic planes with odd indices are weak, whilst those with even indices give strong reflections. This is shown in the diffraction pattern of sodium chloride.

Figure 4



Sketch of Diffraction Pattern of Sodium Chloride

Reflections from planes with odd Miller Indices are weak, while those from planes with even Indices are strong.

The case of potassium chloride is interesting. Since the diffracting power of the potassium ion is almost exactly equal to that of the chlorine ion, both ions containing the same number of electrons, the 111 and other reflections from odd indices are completely absent. The diffraction pattern of potassium chloride is thus deceptive, not appearing like a face-centred cubic pattern, but rather like a simple cubic pattern.

The study of intensity variations therefore provides information about the arrangement of the various ions in the crystal lattice. The intensities of diffraction lines for known ions in a known type of lattice can be calculated from theoretical principles, so that a proposed structure may be confirmed or otherwise by comparison of theoretical values of the intensities of the lines with those observed.

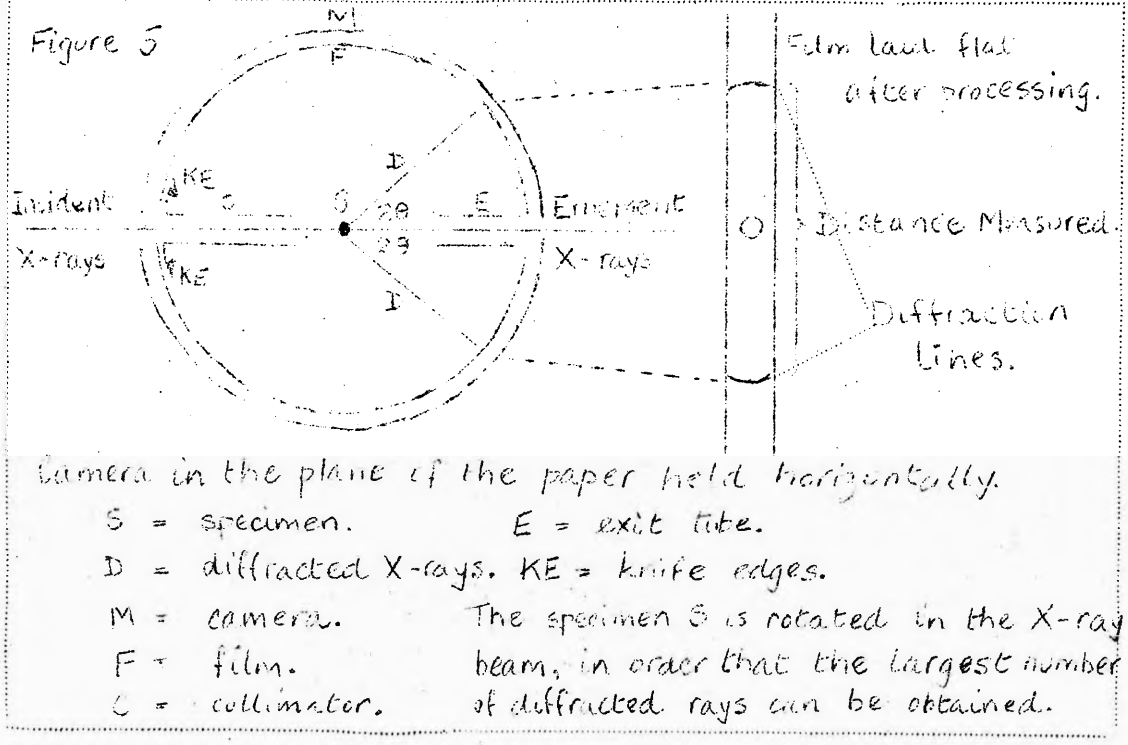
The Experimental Technique

The sample of the mineral is powdered, mixed with a small amount of Canada Balsam softened with xylene and moulded into a small rod about 1 cm. long and 0.5 mm. diameter. It is then accurately placed in the optical centre of a circular camera about 19 cm. in diameter (figure 5), an X-ray film having previously been mounted around the circumference.

The sample is slowly rotated by a small electric motor in order that the crystal planes are presented to the X-ray beam at as large a number of angles as possible. The X-ray beam enters between the ends of the film and leaves through a hole in the centre. When the film is laid out flat after processing, it looks like the sketch on the right of figure 5. If ϕ_k is one quarter of the angle subtended by the knife edges at the centre of the camera, then the Bragg Angle θ for any pair of corresponding lines is connected with the distance S between them by the relation:

$$\theta = \phi_k \cdot \frac{S^S}{S_k}$$

where S_k is the distance on the film between the shadows of the knife edges.



Having thus determined the Bragg angle θ, and wavelength L being known, then using the Bragg Equation, d is derived for each pair of lines on the film. The intensities of the lines relative to the strongest may, after some experience, be estimated visually.

By reference to an index of diffraction patterns published by the American Society for testing and Materials, which gives a list of 2,000 minerals indexed in order of the three strongest lines, with further reference to a card index giving the d values and relative intensities of all the other reflections, the identities of individual minerals may be found. This method not only serves to identify crystalline materials, but also, since there is a relationship between the Miller Indices (h,k,l) and d, the interplanar distance corresponding to them, and the unit cell dimensions, the latter can be determined in many cases. Analysis of the relative intensities of reflected lines gives information about the arrangement of the atoms in the crystal lattice.

X-ray powder photography, with a very small sample, and without the need for elaborate preparation or chemical techniques, will allow the identity of a mineral to be determined in a few hours. For example, a mineral found on Carrock Fell recently was thought to be pharmacosiderite. This was verified in about five hours, the bulk of this time being taken by photographic exposure, as the diffracted X-rays are weak.

For a detailed treatment of this subject, the reader is recommended to consult "X-ray Powder Photography in Inorganic Chemistry" by R.W.M. D'Eye and E. Wait. (Published by Butterworth).

GROW YOUR OWN CRYSTALS

S.H. Gate, B.Sc.,M.Sc.,A.R.I.C.

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Members have probably by now cleaned, labelled and arranged their hard-won mineral specimens of last summer. This is the time of year to obtain, with a little patience and ingenuity, some further examples of crystal shape as pleasing to the eye as many mineral crystals.

Let us recall the simple principles of solubility. A fixed volume of water will dissolve only a fixed weight of a soluble substance at a certain temperature. Thus, if to half a pint of water in a jar we keep adding common salt and shaking it, there comes a stage when no more salt dissolves and a saturated solution is obtained. In the case of salt, the solubility varies hardly at all with temperature. Supposing, however, some of the water evaporates. Now the smaller volume of water can contain only a proportionally lower weight of salt. The "balance" crystallises out.

Crystals of Common Salt

To make salt crystals we need a saturated solution of salt, made by shaking a mixture of salt and water at intervals over about an hour, then decanting the solution from the small surplus of solid. In addition, a "seed" crystal is required, and several of these are obtained by leaving some saturated solution to evaporate slowly in a cup. A piece of blotting paper over the top keeps dust out. Meanwhile, the bulk of the saturated solution is kept tightly stoppered. The seed needs only to be a single crystal of reasonable cube shape and large enough to catch in the slip-knot in a piece of thread.

It is wise to flush the seed crystal briefly with water, dry it with blotting paper and ensure you are not contaminating it with salt dust from your hands. Suspend it by the thread in the saturated solution, the top of the jar being covered with blotting paper to keep out dust. Crystal growing by evaporation is slower than the next method to be described, but it is the only practicable one for salt, so the salt crystalliser needs to be left for a few weeks to get a sizeable crystal.

Crystals of Other Salts

The other method is for substances whose solubilities increase as the temperature is raised. If a saturated solution of one of these materials is made in hot water, then on cooling, only a smaller amount of material should be capable of remaining dissolved in the same volume of water. In many instances, however, the balance if not too large will not crystallise immediately. At this stage we have a supersaturated solution, and this balance of dissolved solid can be used for rapid crystal growth on a seed crystal.

It must be remembered that supersaturated solutions are unstable and sensitive to dust, especially to crystal dust, to sudden temperature fluctuations, and even to sudden disturbances. Therefore ensure that your crystallisation jars and your hands are scrupulously clean when you reach the final setting-up stage, and stand the jars in a large container of cold water where they will not be disturbed for a few days.

How is the correct small excess arrived at? The simplest way is first

to make a solution which is just saturated at room temperature in the following manner. Keep adding the solid in counted spoonfuls to hot water (8 fluid oz. is suggested) until a little remains undissolved. Cool the solution to room temperature, and remove any small individual crystals deposited which may be suitable for seed crystals. Pour the solution away from the crystals into a clean vessel which can be heated. A clean, empty can will do provided that the solution does not react with it; to make sure test it with a small quantity first. Estimate how much material is still dissolved in your solution by the number of spoonfuls added minus the quantity of crystals left on cooling, and then add about 15% more (30% in the case of alums), reheating the solution to dissolve it. Let the resulting solution cool down slowly in a screw-top jar of about 12 fl. oz. capacity.

With the seed crystal attached to thread as in the other method, and with the same precautions to prevent seed or solution of salt being contaminated by dust or crystal fragments, stick the other end of the thread to the inside of the screw top with waterproof adhesive. Arrange this so that the crystal is halfway down in the solution. Do keep the crystal on clean blotting paper while setting-up. Do not immerse it until you are sure the solution has cooled completely, or the seed may dissolve. If at any stage you have to remove the crystal from the solution, wash it and dry it with blotting paper before returning it to the solution. Having seeded the solution, it is a good plan to stand the apparatus in a larger container of water to even out the effect of fluctuations in room temperature.

The crystal will grow quickly and will usually have used the excess material in three or four days. Inspect it twice daily during growth.

Materials to Try

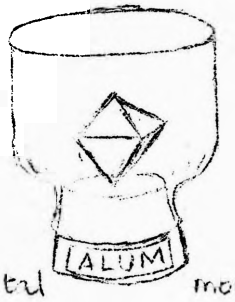
(Weights quoted here are what you need to buy starting with 8 fl. oz., about 230 c.c. of water.)

Rochelle salt	colourless	12 oz.
Potash alum	colourless	3 oz.
Chrome alum	purple (for colouring)	1 oz.
Tartaric acid	colourless	1 lb.
Sodium thiosulphate (hypo)	colourless	1 lb.
Copper sulphate (blue vitriol)	blue	8 ox.
Nickel sulphate	blue-green	9 oz.

and, of course, common salt, but do not waste your time on sugar.

The Finished Product

Remember that all of your crystals will be soluble, so handle them carefully. Cut off the thread and store each in a stoppered bottle. A display method is shown.



Crystal mounted by clear waterproof adhesive to white card fixed to cork.

"Two-tone" Crystals

Potash alum itself is colourless, but by recharging the potash alum solution with a little purple chrome alum, it is possible to grow a purple layer on the crystal.

Other Hints

1. If you require a larger crystal, remove it from the solution, dissolve more solid in the

heated solution, cool, and replace the crystal (with due precautions). Bear in mind that it will be more difficult to obtain well shaped large crystals of many substances.
2. If a solution remains supersaturated when you require a saturated solution, throw in some crystal dust of the same material.
3. Should the crystal develop side growths, it should be removed from the solution for trimming. Wash the trimmed crystal with water, dry with blotting paper and replace. Prompt action here will avoid disappointment.
4. Save your solutions after use. They can be recharged and re-used with relatively little additional material.
5. It is a good plan to keep a record of quantities used.

The Impatient and others will be rewarded by smearing saturated solution on a piece of glass and examining it under a microscope or with a powerful hand lens.*

A good book on crystals for the beginner

"Crystals and Crystal Growing" by Holden and Singer.
Heinemann's Science Study Series, about 12/6.

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* The Editor has obtained good results by placing saturated solutions on pieces of glass 2" x 2" and using these in a slide projector. Enormous magnification can be obtained. He has also watched the crystallisation of molten sulphur by the same means, having smeared the sulphur on a heated glass slide.

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SECTION AT THE BASE OF THE CARBONIFEROUS AT GHYLL WOOD, BLINDCRAKE.

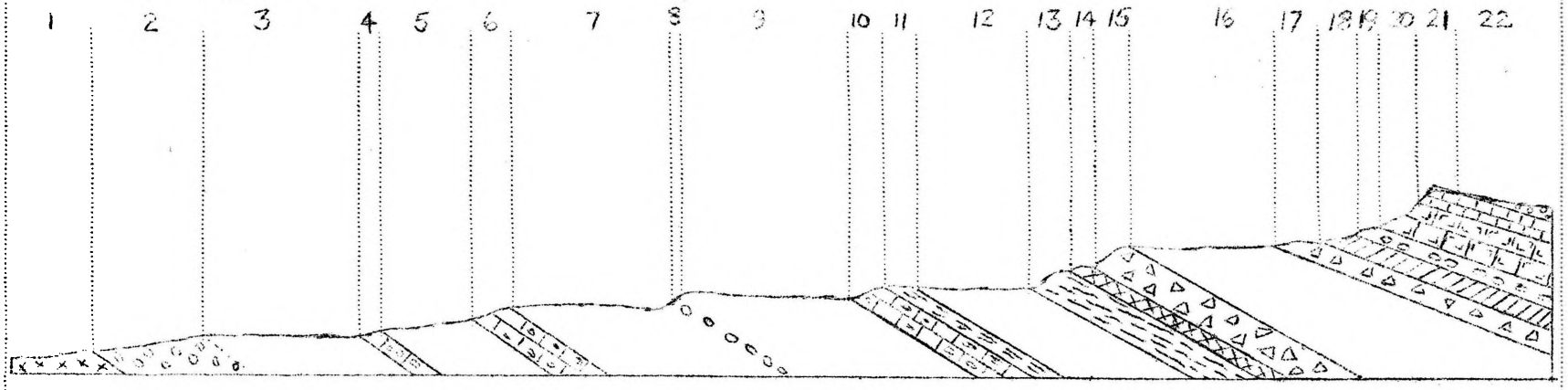
			FOSSILS
NORTH	22.	Drift	
	21.	7th. Limestone	
	20.	4 ft. dolomite mudstone passing into 7th. Limestone	
	19.	Shales with limy concretions & pyrites	
	18.	Productid band	Ostracods, Bryozoa
	17.	Green breccia	
	16.	6 ft. mudstones and shales	Pectens, Ostracods, Orthoceras, Fish scales
	15.	4 ft. breccia, sharp pale green limestones with angular quartz grains in calcite cement. Chert fragments.	
	14.	"Landscape" calcite with comminuted quartz towards top.	
	13.	10 inch purple-green shale	
	12.	4 ft. mudstone	N.F.F.
	11.	3 inch band of black shale	Modiola & Ostracods
	10.	9 inch calcite mudstone. Conchoidal fract.	Modiola & Ostracods.
	9.	6 ft. mudstone	N.F.F.
	8.	Band of ironstone mudstone	
	7.	6 ft. mudstone	N.F.F.
	6.	8 inch calcite mudstone with dicey fracture	Modiola & Ostracods.
	5.	1 ft. grey mudstone	N.F.F.
	4.	2 inch arenaceous mudstone. Ripple marked, with fine scattering of quartz pebbles.	
	3.	6 ft. thick bedded grey mudstone	N.F.F.
	2.	12 ft. Drift	
SOUTH	1.	Top of Cockermouth Lavas.	

(N.F.F. = no fossils found.)

SECTION IN STREAM COURSE

GHYLL WOOD, BLINDCRAKE

Index on page 24, facing.



J. Moon, F.G.S.