Oxford Laboratory Mixes Physics and Archeology

If an archeologist sat down to dinner with a physicist, their conversation might stir up ways to pursue the two sciences together. Such a meeting happened once at the University of Oxford and the resulting laboratory, established in 1955 by C. F. C. Hawkes and Viscount Cherwell, is now carrying on what is probably the world's most intense program of physics applied to archeology. The present director is E. T. Hall.

We visited the laboratory recently and talked with the deputy director, Martin J. Aitken, about some of its projects, particularly a program that can be called "magnetic dating," another in thermoluminescent dating and various methods for finding metal objects and magnetic anomalies.

Magnetic dating can be accomplished because the clay in a hearth freezes the local magnetic field. Heating of the clay causes the iron oxide in it to assume the field alignment and keep it when the clay cools. When Oxford archeological physicists find such a hearth, they pour plaster of paris around pieces of it, carefully mark the directions and take the pieces back to their laboratory for measurement. Moving the sample may superimpose an unstable, short-term magnetization on the residual one, but the experimenters can separate the two. Samples are stored in a field-free space until they are to be measured. Then each is rotated inside measurement coils. Phase and magnitude of the potential developed in the coils tell the magnetization of the sample.

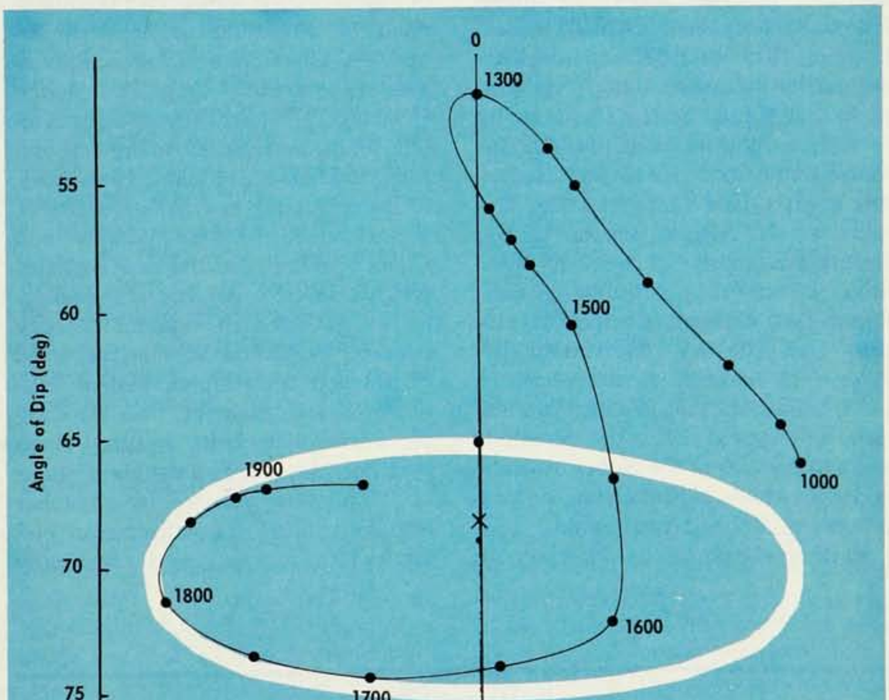
Results show that the magnetic field of the earth in England has followed an irregular pattern during the past millenium (see graph) and has not followed the ellipse in which geophysicists used to believe until about 60 years ago. Back in Roman times the field had a direction near the present one, but no measurements yet link that field with the start of the plotted curve at about 1000 A. D. When the circle of uncertainty is not too large, placing a field direction on the curve dates the hearth in which it is found.

Thermoluminescent dating uses the phenomenon that makes possible thermoluminescent dosimetry of ionizing radiation: In certain materials irradiation moves electrons into traps where they have higher-than-normal energy. When the material is heated, the stored energy is released as light.

Pottery fragments are the materials of interest at Oxford. When they were baked, heating released all trapped electrons. Subsequently irradiation by uranium, thorium and potassium in the clay produced trapped electrons. Measurement of the radioactivity present and the radiation dose registered by thermoluminescence enables the experimenters to tell how long ago the pottery was made.

To measure the dose, they heat a powdered sample quickly (500°C in 25 sec), record the light, then repeat. The difference between the amounts of light released in the two heatings is the thermoluminescence produced by long-term irradiation. Subsequently they expose the sample to a known dose of beta radiation and find its thermoluminescent susceptibility. They also spread it out on a zinc sulfide screen and record counting rate (typically 20 counts/hr with 1 count/hr background) to determine radioactivity.

The proton magnetometer is the laboratory's favorite tool for finding magnetic anomalies. A 3-sec current through a 2000-turn coil aligns the protons in a bottle of alcohol. When the current is suddenly removed, the protons precess in the local magnetic



GEOMAGNETIC FIELD VARIATIONS as found in England. Over the last millenium changes have not followed the ellipse formerly accepted.

field, and their frequency (read for the next half second) indicates its value. The Oxford group got the design as a windfall from Britain's Ministry of Supply. When the instrument was invented in the US, the ministry sought to develop it as a mine detector. The effort failed, but the development work was available when the Oxford archeophysicists wanted to survey an area in a hurry before a road was laid over it. Recently developed is a field model that weighs only 10 kg with batteries.

An adaptation of the proton magnetometer measures the difference between the magnetic field at the ground and that 10 ft in the air by bucking the signals from two detectors.

Metals underground are foumd with a new instrument. It consists of a transmitter coil, through which 10–20 A is sent for about a millisecond, and a receiver coil at the same position. In the absence of metal the magnetic flux falls as the transmitter current does. But when metals are present, eddy currents induced in them cause a slower falling off.

Several other instrumentation techniques are in use at the laboratory, notably x-ray fluorescence spectrometry, electron-beam analysis and neutron-activation analysis. What started at a dinner-table conversation has grown into a busy activity at Oxford labeled "Research Laboratory for Archeology and the History of Art." —RHE

Russians See Element 102, Call it Joliot-curium

A rose by any other name would smell as sweet, but would an element? Number 102, officially known as nobelium and occasionally called rutherfordium, has been renamed joliotcurium by a Russian group that suggests that it may be the first actually to observe the element. At the International Conference on Heavy-Ion Physics held at Dubna last October, G. N. Flerov, director of the Dubna Laboratory for Nuclear Reactions, reported that his group had produced five different isotopes of element 102. The new observations disagree with Berkeley measurements in 1958, 1959 and 1961, in which two isotopes of element 102 were reported, and experiments at the Nobel Institute in 1957, which indicated one or two isotopes of 102 had been found.

Earliest report of the discovery of element 102, made at the Nobel Institute by an Argonne, Harwell and Nobel collaboration, came from bombardment of a curium target with 90-MeV ^{13}C ions from a cyclotron. Experimenters reported they had found $^{253}102$ or $^{255}102$. They observed alpha emission with an energy of 8.5 MeV and half-life of about 10 minutes.

The following year Albert Ghiorso, T. Sikkeland, J. R. Walton and Glenn Seaborg used the new Berkeley HILAC (Heavy Ion Linear Accelerator) to produce ^{12}C ions at energies from 60 to 100 MeV. They reported $^{254}102$ had been found, with a half-life of 3 sec. Element 102, traveling on a conveyor belt, emitted alpha particles; the recoiling daughter atoms of $^{250}_{100}Fm$ were collected by a catcher foil. To confirm the existence of element 102, fermium was chemically identified. In 1959 the group found an isotope with a half-life of 3 sec and an alpha-particle energy of 8.2 MeV as well as spontaneous fissions with the same half-life. In 1961 the group reported a second isotope $^{255}102$, with an alpha-particle energy of 8.2 MeV and a half-life of 15 sec. The Berkeley group was unable to duplicate the results obtained at the Nobel Institute.

Ghiorso, commenting on the Dubna claim, says, "We do not agree that they have prior claim." His group has repeated its experiments with the HILAC, which now has greater intensity, and expects to publish new results shortly.

Dubna discovery. Flerov's large group used the two Dubna heavy-ion cyclotrons, 300-cm and 150-cm, to produce, over the last six months, five isotopes of element 102. The cyclotrons produced ions with 7 or 8 MeV/nucleon. To make element 102, either oxygen ions bombarded plutonium or nitrogen ions struck ^{243}Am. As in the Berkeley experiments, a conveyor belt and catcher foil were used to isolate daughter atoms. Reaction cross sections are an order of magnitude smaller than in the Berkeley work.

The Dubna group found isotopes of joliot-curium from 252 to 256, inclusive. Results appear in the table.

Flerov is currently searching for isotopes of element 105 by hitting americium targets with neon ions from the 300-cm cyclotron. He plans to increase ion energies from the 150-cm cyclotron to 15 or 20 MeV/nucleon and then search for $^{278}114$, which may be the most-stable very heavy nucleus, according to some heavy-ion experts. In 1964, Flerov's group reported the discovery of element 104, which has been named kurchatovium.

Another Soviet heavy-ion cyclotron is operating at the Physical Technical Institute in Leningrad, where I. C. Lemberg is doing coulomb-excitation studies with nitrogen, oxygen and carbon ions. And at the Kurchatov Atomic Energy Institute in Moscow, where A.A. Oglogblin is director of the cyclotron laboratory, there is a 150-cm cyclotron that accelerates helium, lithium, carbon and nitrogen ions. The lithium beam is regarded as the best now available anywhere for spectroscopic studies. —CBL

Decay Processes for Element 102

Isotope	*Alpha-decay energy (MeV)*	*Half-life (sec)*	*Branch for spontaneous fission (%)*
252	8.41	4.5	—
253	8.01	95	—
254	8.11	75	—
255	8.08	180	<0.01
256	8.41	8	<0.65