percent In present as an impurity. The presence of this rare element in relatively high concentrations was so unusual that, out of common prudence, the work was repeated five times by two different methods. Each time, however, the same positive result for indium was obtained. We hazarded the suggestion that indium might prove a diagnostic impurity of tin produced from local ores in ancient times.

The next day at the Congress, Brush discussed a group of pre-Conquest metal artifacts found in coastal Guerrero, a group in which three bronze objects contained indium as an impurity (*2*). Brush also had had the tests repeated with the same positive result for indium. He concluded that it seemed highly probable that the ore from which the tin in our two specimens had been extracted and the ore that supplied the tin for his three indium-bearing bronzes came from the same locality.

Our efforts to obtain cassiterite samples from Guerrero at that time were unavailing. Eduardo Schmitter V of the Institute of Geology of the National Autonomous University of Mexico assured us that *gambusinos* (prospectors and small-scale miners) occasionally found "stream tin" in Guerrero, so we left a standing order for any samples that might turn up.

In July of this year William Spratling, the noted silversmith in Taxco, sent us a nodule with the information that it came from the Cerro el Atache in the mountains quite near the town of Taxco in Guerrero. It weighed 40.7 g, still had quartz crystals from the matrix adherent, and, on chemical analysis, proved to be impure, native stannic oxide. Its reported source and physical appearance indicated "wood tin" rather than "stream tin." The Battelle Memorial Institute made emission-spectrographic analyses. Indium was definitely present as an impurity, although the proportion was less (approximately 0.02 percent) than that in the two fragments of metallic tin from Teloloapán. The important fact is that it was present in a local ore. Furthermore, there is no reason to expect that the proportion of indium in the mineral should correspond exactly with that in tin extracted from it by primitive smelting methods.

"One swallow maketh not summer," but the analysis of this nodule establishes that indium-bearing cassiterite exists in Guerrero, and greatly increases the probability that the artifacts reported in 1962 by us and by Brush were made locally from metal extracted from local tin ore. Also it fully confirms the report Cortés sent to Charles the Fifth in 1524, in which he wrote of pre-Hispanic mining of tin ore in the mountains near Taxco and of his unsuccessful efforts to work those deposits (*3*).

That such deposits have been forgotten and are no longer worked, and that we encountered so much difficulty in securing a specimen of tin ore from Guerrero, should not surprise anyone. The ancient Mexican miners had neither roads nor beasts of burden. They traversed the worst sort of country on shanks' mare and recovered ore from surface outcrops wherever they found it. For example, Hendrichs' diligent and patient search, based in part on an ancient picture writing, showed that early copper mining and ore treatment in Guerrero took place in mountainous regions so inaccessible and remote from modern transport as to render it commercially unsound, if not virtually impossible, to work the ore bodies today (*4*).

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References and Notes

1. E. R. Caley and D. T. Easby, Jr., *Actas y Memorias, XXXV Congreso Internacional de Americanistas* (Mexico, 1964), vol. 1, pp. 507–517.
2. C. F. Brush, *Science* **138**, 1336 (1962).
3. H. Cortés, *Five Letters, 1519–26*, J. Bayard Morris, Transl. (McBride, New York, 1929), pp. 274–75.
4. P. R. Hendrichs, *Por Tierras Ignotas, Viajes y Observaciones en la Región del Río de las Balsas* (Instituto Panamericano de Geografia e Historia, Mexico, 1945), vol. 1, pp. 199–208, 233–34.

14 November 1966

Molluscan Faunal Changes around Bermuda

Abstract. *The recent appearance of large populations of certain adult marine mollusks in Bermuda shallows, unreported in previous surveys, suggests that an invasion is taking place, probably from Florida or the Bahamas, or from both. "Newcomers" grow to sizes larger than any known elsewhere, suggesting that the characteristically large sizes of some species in Bermuda reflect environmental rather than genetic causes.*

During the last 110 years the marine mollusks of Bermuda have been intensively collected and reported upon six times (*1, 2*). They have been collected incidentally almost annually by visiting scientists and amateur shell collectors who have deposited specimens in museums of natural history (*3*). One of us (R.T.A.) made collections in 1934, 1936, 1952, and 1964; the other collected every weekend from 1941 through 1944, and for 3 weeks during each summer from 1959 through 1966.

The large calico clam, *Macrocallista maculata* (Linné, 1758), common from Brazil to North Carolina and the Bahamas, has never been reported alive from Bermuda (*4*), but has been recorded as a fossil (*1, 2*). The first live specimens were collected near The Aquarium, just within the entrance to Harrington Sound, by one of us (R.J.) in July 1961. By 1964 the clams abounded around Trunk, Cockroach, and Rabbit islands in Harrington Sound; by 1965 they were being used for bait and were appearing in the local food markets (*5*).

No one has reported the presence of the colorful, intertidal nerite *Puperita pupa* (Linné, 1767) in Bermuda (*1, 6*). One of us (R.J.) discovered a few specimens in upper-level tidepools in Devonshire Parish in 1964; by 1966 they had spread to other tidepools along a 16-km stretch of Bermuda's south shore.

Another common intertidal gastropod new to Bermuda is the false prickly winkle, *Echininus nodulosus* (Pfeiffer, 1839). Abbott (*7*) could not find this species in Bermuda after a careful search of collections (*3*) and of the literature. One of us (R.J.) found it not uncommon along the south shore from 1964 through 1966. Other species of Littorinidae, such as *Littorina mespillum* (Mühlfeld, 1824), *L. meleagris* (Potiez and Michaud, 1838), *L. nebulosa* (Lamarck, 1822), and *L. lineolata* (Orbigny, 1842), now occur along the south shore, but were not reported in Bequaert's extensive monograph (*8*) or in collections (*3*) existing prior to 1962. Jones (*9*) reported *L. ziczac* (Gmelin, 1791) to be uncommon in 1864; today it is one of Bermuda's most common mollusks. However, the

absence of certain species from early written records of Littorinidae may reflect misidentification or failure to distinguish between closely related species.

Many other species have been added by one of us (R.J.) to the list of living Bermuda mollusks within the last 5 years: such as *Cymatium poulsenii* (Mörch, 1877), *Cassis flammea* (Linné, 1758), *Phalium granulatum* (Born, 1778), and *Murex pomum* (Gmelin, 1791). Other species are too uncommon or too small to be positively claimed as recent arrivals. Dramatic increase in the numbers of individuals of certain species during the last 10 years seems certain. We have collected and observed many specimens of *Strombus costatus* (Gmelin, 1791) in 1.2 to 6 m of water in Great Sound; in 1864 Jones failed to mention this species (*9*). Heilprin in 1889 reported finding only gerontic specimens (*10*), and Clench and Abbott considered it extinct in 1941 (*11*). By 1946 it was becoming not infrequent (*2*), and by 1966 it was common enough to be taken for food. The history of the now moderately common *Conus bermudensis* (Clench, 1942) is very similar.

The causes, origins, and manner of these introductions or efflorescences are not easily explained in the absence of continuous and complete observations. That Bermuda is being bombarded with planktonic larval mollusks by the Gulf Stream has been demonstrated by Scheltema (*12*). But living adult gravid clams and snails are probably easily transported in bilges of leaky sailboats coming from Florida or the Bahamas. Moreover, one can never be certain but that many of these species may have been merely "holding on" in very limited, inaccessible areas for many years; subtle changes over the years in temperature, salinity, food availability, or enemies could have finally signaled the efflorescence.

The newly dominant mollusks in Bermuda are also abundant in the Bahamas, Cuba, and the lower Florida Keys. Bermuda specimens of *Macrocallista maculata* (Linné, 1758) most resemble in color pattern those from Florida and North Carolina. The fossil Pleistocene Bermuda *Strombus alatus* (Gmelin, 1791) (*2, 13*) is identical with that living from Florida to North Carolina, and is unlike the West Indian S. pugilis (Linné, 1758). The *Puperita pupa* (Linné, 1758) of Bermuda, however, most resembles Bahama specimens.

All the supposed newcomers grow unusually large in Bermuda, a characteristic of other long-familiar Bermuda species such as the 125-mm scallop *Pecten ziczac* (Linné, 1758); *M. maculata* (Linné, 1758) in Bermuda reaches a length of 94 mm, while the largest known specimen living elsewhere is 77 mm and the mean size of Florida specimens is 66 mm (*4*). Adult *Cymatium parthenopeum* (von Salis, 1793) from Bermuda are between 140 and 145 mm in length; elsewhere in the western Atlantic they are 80 to 96 mm (*14*). If these species are recently introduced, as they seem to be in several instances, their large sizes are probably attributable primarily to environmental rather than genetic factors.

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References and Notes

1. A. J. Peile, *Proc. Malacol. Soc. London* **17**, 71 (1926).
2. H. B. Moore and D. M. Moore, *Bull. Geol. Soc. Amer.* **57**, 207 (1946).
3. The main repositories for thousands of samples of Bermuda mollusks are the Museum of Comparative Zoology (Harvard College), the Academy of Natural Sciences of Philadelphia, the U.S. National Museum, and the Bermuda Museum (Haycock Collection).
4. W. J. Clench, *Johnsonia* **1**(3), 6 (1942).
5. Anon., "A treat from Colony's deep for our table," *Mid-Ocean News*, 24 July 1965.
6. H. D. Russell, *Bull. Museum Comp. Zool. Harvard Coll.* **88**, 369 (1941).
7. R. T. Abbott, *Proc. U.S. Nat. Museum* **103**, 458 (1954).
8. J. C. Bequaert, *Johnsonia* **1**(7), 11 (1943).
9. J. M. Jones, *Trans. Nova Scotia Inst. Nat. Sci.* **2**, 1 (1864).
10. A. Heilprin, *The Bermuda Islands* (Philadelphia, 1889), p. 170.
11. W. J. Clench and R. T. Abbott, *Johnsonia* **1**(1), 10 (1941).
12. R. S. Scheltema, *Deep-Sea Res.* **13**, 83 (1966).
13. The *Strombus pugilis* Linné reported by Moore and Moore (*2*) prove to be *S. alatus* Gmelin.
14. W. J. Clench and R. D. Turner, *Johnsonia* **3**(36), 230 (1957).

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Fission-Fragment Synthesis of a New Nitrogen-Fluorine Compound

Abstract. *Fission-fragment radiolysis of a mixture of NF_3 and F_2 at room temperature has resulted in the formation of a new, unidentified nitrogen-fluorine compound that is stable at room temperature.*

The discoveries of such interesting compounds as F_3NO (*1*) and ClF_5 (*2*) following closely the discovery of noble-gas compounds should encourage the search for other interesting molecules and perhaps a fresh approach to the theory of bonding [for example, that suggested by Searcy (*3*)]. We report here evidence for the formation of a new N-F compound, in the hope of stimulating further work in this area. The compound is stable at room temperature in perfluorinated, all-monel containers.

In six separate experiments, mixtures of NF_3 and F_2 in all-monel capsules, maintained at room temperature, were bombarded with fission fragments produced by neutron irradiation of fully enriched UF_4 within the sample capsules. Total pressures ranged from 80 to 94 atm with equal amounts of NF_3 and F_2. The total number of fissions per experiment ranged from 7.5×10^{12} to 3×10^{15}. Fission-fragment radiolysis has been used to produce NF_3 from the elements, and hydrazine from ammonia (*4*). Gas-chromatographic analysis of samples taken from each of the six capsules several days after irradiation indicated the presence of a new material in addition to the two reactants. Only the two reactants were found in samples taken from the capsules before irradiation and in unirradiated control capsules. The all-monel gas chromatograph, for which a temperature-programed separation column is used, is capable of detecting such reactive materials as FNO and FNO_2 in quantities as small as 1 ppm without causing decomposition.

Only 1 to 10 micromoles of the new compound have been synthesized, so that identification is difficult. The suggestion, by gas-chromatographic evidence, that it has a normal boiling point near −50°C eliminates such other candidate N-F compounds as N_2F_4 *cis*-N_2F_2, and *trans*-N_2F_2 (which elute near their normal boiling points). Results from mass spectrometry indicate a peak at $m/e = 90$ (mass/charge), suggesting the ion NF_4^+, possibly a fragment of NF_5 or F_3NNF_3.

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References and Notes

1. W. B. Fox, J. S. MacKenzie, N. Vanderooi, B. Sukornich, C. A. Wamser, J. R. Holmes, R. E. Eibeck, B. B. Stewart, *J. Amer. Chem. Soc.* **88**, 2604 (1966).
2. D. F. Smith, *Science* **141**, 1039 (1963).
3. A. W. Searcy, *J. Chem. Phys.* **28**, 1237 (1958).
4. E. R. White, *Int. J. Appl. Rad. Isotopes* **16**, 419 (1965); C. P. Fritsch, M. R. Gustavson, J. H. Cusack, R. I. Miller, *Chem. Eng. Progr.* **57**(3), 37 (1961).

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