Clues Emerge to Rich Lodes of Diamonds
By WILLIAM J. BROAD
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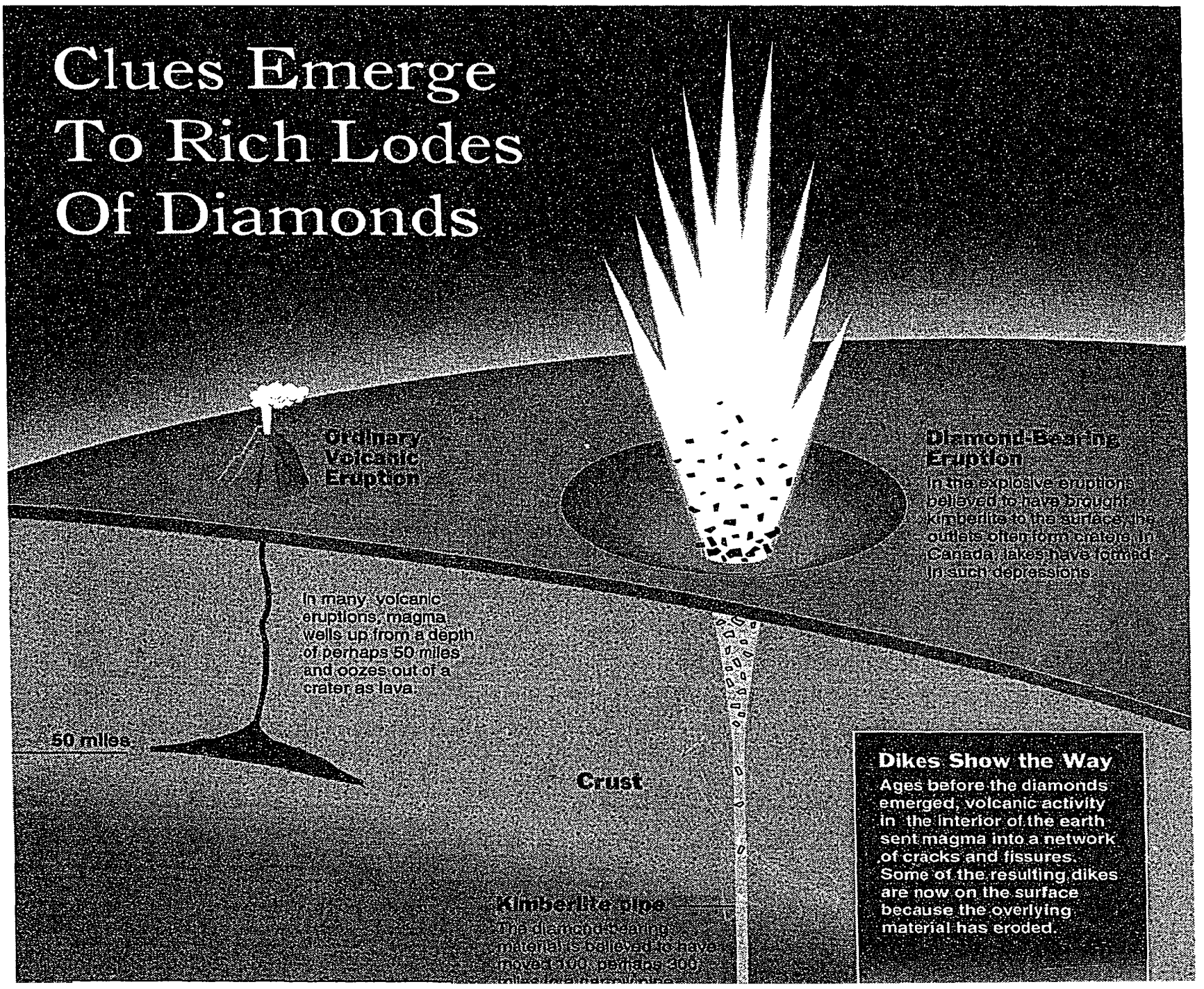

By WILLIAM J. BROAD

DIAMONDS are travelers from the earth's interior. How they form there is well known. Crushing pressures and blistering heats work in unison to squeeze ho-hum carbon into stones of unrivaled hardness that can be shaped into dazzling gems. But how diamonds make their journeys of a hundred miles or more to particular spots on the earth's surface, and not to others, has long been a mystery.

Now, clues to a possible explanation have emerged in the Canadian tundra amid a rush for diamond riches reminiscent of the Yukon gold days of a century ago. Braving a riot of claims, finds and swindles, geologists have been carefully examining the rocky ground and discovering what may prove to be new indicators of diamond-bearing ores. These signs, dikes of ancient lava that are often visible on the earth's surface, could make future prospecting for diamonds easier.

"Diamond exploration is probably the hardest exploration to do in the mineral industry," said Tom E. McCandless, a geochemist at the University of Arizona who studies diamond ores and advises prospectors. "People are eager for anything that helps."

The rush of prospecting centers on the Northwest Territories of Canada just south of the Arctic Circle, a rocky area of tundra dotted with frozen lakes and populated by wolves, caribou, arctic foxes and grizzly bears. Since 1991, when diamonds were first discovered there, more than 200 companies have staked out claims over nearly 75,000 square miles, an area larger than the state of Wisconsin. It is the biggest mineral rush in Canadian history. The outback is alive with new roads, camps, airstrips and fuel dumps.

While some diamond experts are confidently predicting that Canada will be the next South Africa, whose mines have produced a large share of the world's diamonds, most of the activity so far has been exploratory. There are no mines, only pilot rigs drilling into icy rock for samples. To date, the big beneficiaries of the diamond euphoria have been outfitters, bush pilots, stockbrokers and scientists.

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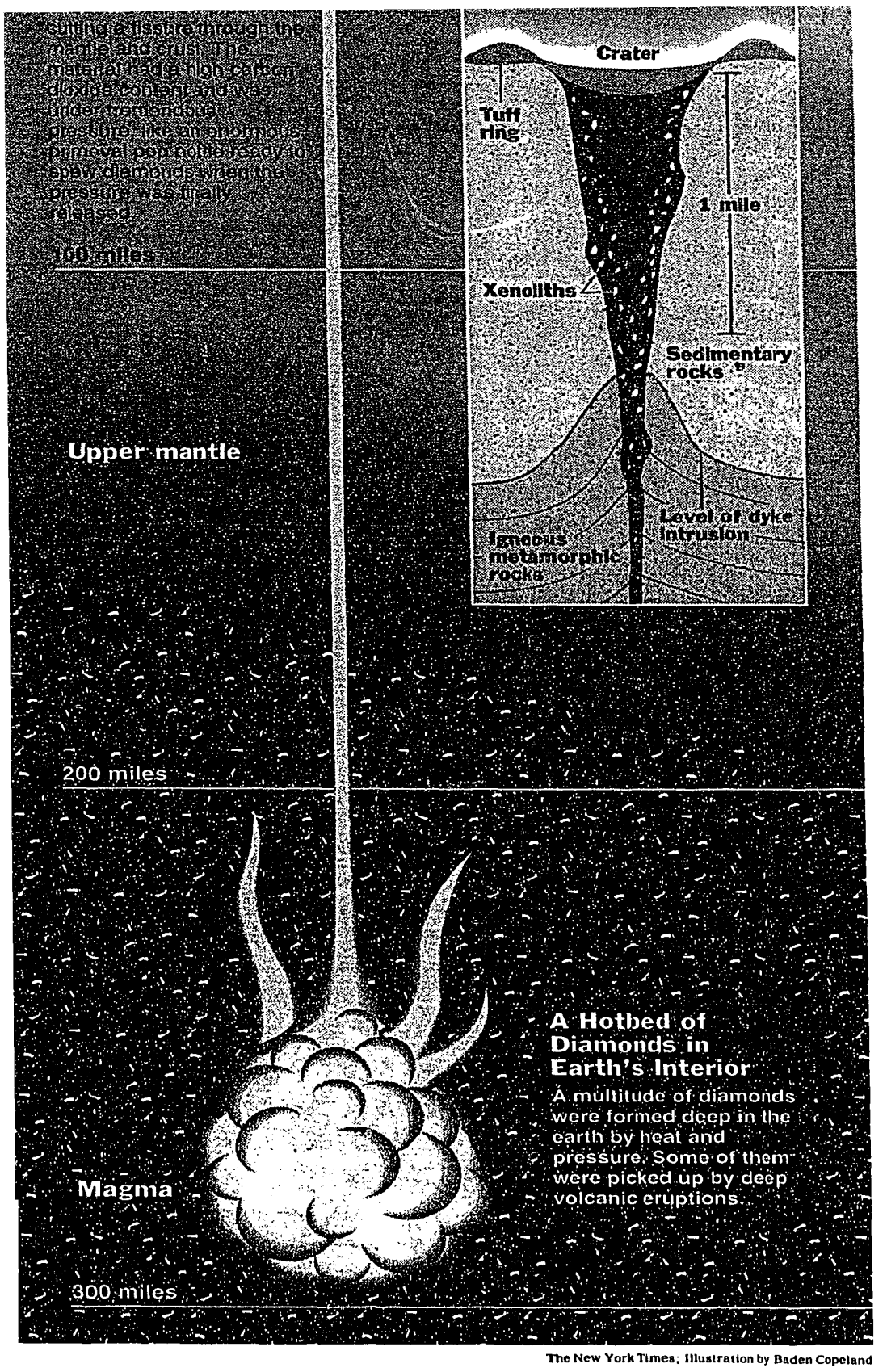

Source: Gemological Institute of America

The New York Times; Illustration by Baden Copeland

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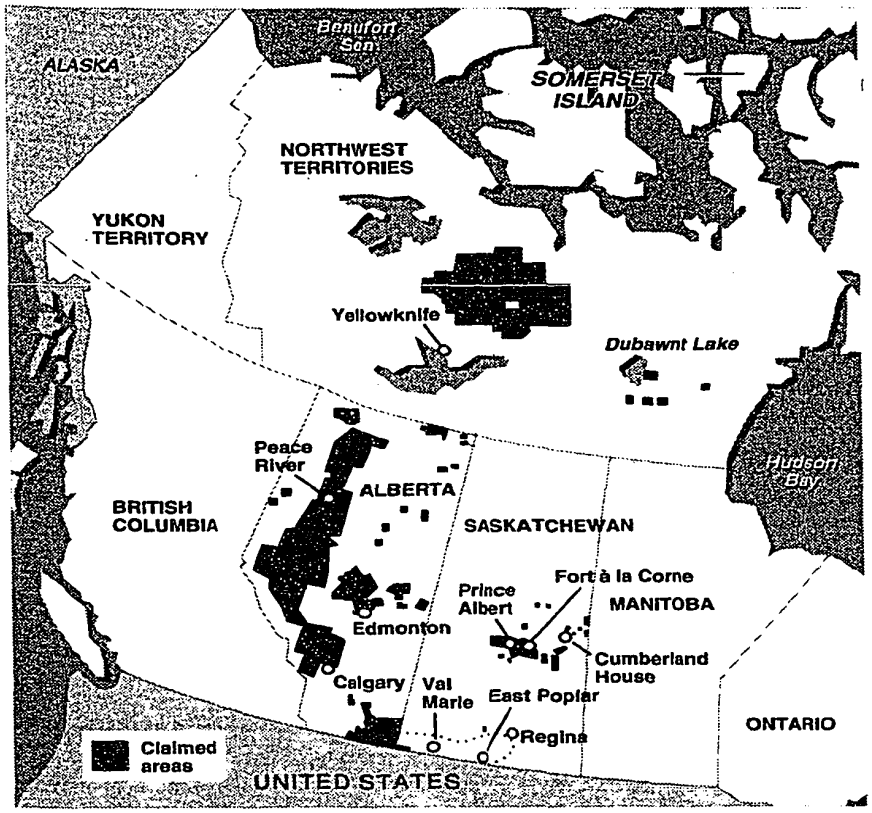

The New York Times

Locations of 50 million acres staked for diamond exploration as of mid-December 1992; most of the exploration is looking for kimberlites.

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Dr. Bruce Kjarsgaard, a geologist with the Canadian Geological Survey in Ottawa who heads a project that is mapping bedrock in the area, said it was a natural laboratory for discovering the location of diamond-bearing ores.

"What's happening in the Northwest is very exciting," he said in a telephone interview. "There's a lot of good science to be done. We're trying to understand what controls the spatial distribution."

Dr. McCandless said that behind the hustles, hype and feverish speculation of the current craze was a body of evidence suggesting a major find. Rich ores and diamonds have already been found, he said, along with indications that the productive zone may extend over an ample part of the Canadian hinterland. "In the end," he said, "it will be the next major diamond-producing area on the planet."

Natural diamonds are formed deep in the earth's interior, roughly at depths of 100 miles and perhaps as far down as 300 miles. Heats and pressures there are great enough to transform carbon into the hardest substance known to man and the raw material for sparkling jewels. Some of the carbon may be elemental graphite, the same greasy-feeling, black stuff used in "lead" pencils. Another source may be carbonate rocks like limestone, which are driven into the earth's interior by the slow, continuous motion of the Earth's tectonic plates.

Most diamonds are believed to be very old, forming up to 3.3 billion years ago. This makes them among the oldest minerals on earth, truly relics of earth's infancy.

Diamonds are driven to the earth's surface by a very unusual, super-long kind of volcanic shaft, often known as a pipe. While the pipe of a conventional volcano may extend down 50 miles or so, the volcanic pipes that pick up diamonds along the way must go very much deeper, perhaps as much as 300 miles. And they are very narrow, a few yards across in some places. In general, the material in the diamond pipes is from depths far greater than any other known volcanic rock.

The volcanic ore is often called kimberlite, after the material first found and identified in 1871 at Kimberley, South Africa. This discovery led to fabled mines that have yielded a stupendous treasure of diamonds.

Although not as old as most diamonds, volcanic pipes that cough up the stones are definitely elderly. The youngest ones are aged 45 million years, and the oldest ones go back some 2.6 billion years. No human has ever witnessed a diamond eruption. Still, evidence suggests that the process is explosive and nothing like the gentle gurgling of some contemporary volcanoes. The tops of many diamond pipes are craters rather than cones.

Experts believe that the overall journey from the earth's interior takes hours, not days or months. The erupted material is cool by the time of the surface explosion, perhaps because its volume is relatively small and it has given up heat to the surrounding rocks on the way up. No evidence has ever been found for a flow of molten lava.

For reasons that elude modern science, diamond pipes are found exclusively in ancient areas of the continents known as cratons, which are generally more than 1.5 billion years old. The youngish pipes cut through the cratons, which are often hard granite and very enduring. Diamond pipes are never found in oceanic environments or young mountains.

Prospectors generally find diamond pipes the old-fashioned way: panning rivers and checking for diamonds or indicator minerals from pipes like garnets, pyrope and chromium diopside. A trail of clues is then painstakingly tracked back to the source.

The pipes often contain diamonds, but not always of sufficient quantity or quality for profitable mining. In southern Africa, there are more than 3,000 pipes but only 50 or 60 have ever been worked. The spring 1991 issue of Gems and Gemology, published by the Gemological Institute of America, based in Santa Monica, Calif., says that in South Africa five tons of ore typically produces about one carat of rough diamond.

The Canadian discovery occurred in the usual way. In an area of ancient rock in the Northwest Territories, Charles Fipke, a field geologist, followed a trail of mineral clues for more than nine years and in the late 1980's quietly began staking claims. By 1991 he had scores of diamonds from sample drilling at test sites, and the stampede was on.

Dr. Kjarsgaard of the Canadian Geological Survey and his team have now spent two seasons in the region, in 1992 and 1993, and are now preparing to go back for a third expedition. He says the area shows geological signs that may significantly aid future prospecting.

The bedrock of the region is at least 2.5 billion years old, he said. Significantly, it is cut by swarms of lava dikes, which on the surface look like long low hills. The dikes can radiate over dozens of miles and are evidence of garden-variety volcanism that cut up the interior of the craton ages ago, riddling its hard granite with volcanic rocks and networks of cracks and fissures. The dikes of lava are clearly younger than the bedrock, Dr. Kjarsgaard said, dated at 2.2 billion and 1.2 billion years. Younger still are the diamond-bearing pipes, which have been dated to about 50 million years.

Taken together, he said, the evidence suggested that old cratonic rock over the ages had been sufficiently weakened by volcanic action to allow the explosive intrusion of thin diamond-bearing pipes. These eruptions would speed upward from the depths of the earth through the roots of old volcanic activity.

"Based on what information we have," Dr. Kjarsgaard said, "there seems to be a spatial relationship between pipes and dikes." He added, however, that the relationship was hard to pin down since prospectors tended to be extremely secretive about the exact location of pipes. This is expected to get easier as prospecting ends and mining begins.

"People have been talking about diking for 20 years" as a clue to diamond prospecting, he said. "But nobody proved the hypothesis one way or another. I think the potential is pretty high to prove it once and for all. It's a big deal."

So far more than 100 diamond pipes have been found in the Northwest Territories and the quality of the ore appears to be good.

"Preliminary bulk samples are very encouraging," Dr. Kjarsgaard said, adding that "three of largest mining companies in world are out there." These include Monopros Ltd., the Canadian subsidiary of De Beers, the South African gold and diamond giant.

Dr. Kjarsgaard suggested that the Canadian area had the potential to hold a host of pipes. "You've got to remember that in South Africa they've been trying to find them for more than 100 years," he said. "They had a headstart. For sure the potential exists to find thousands of pipes in Canada, or at least hundreds."

Dr. McCandless, who in the 1980's did chemical analysis for Mr. Fipke, the discoverer of the Canadian field, said the technique of following dikes by airplane or helicopter might prove to be a regional aid in finding diamond pipes. But he added that hitting pay dirt would still take a tremendous amount of hard work on the ground.

"In the end you still have to take samples and find those indicator minerals," he said. "In the Northwest Territories it's hard. Most of the pipes are under lakes, and there's a lot of them up there. If you have 1,000 lakes on your claim, that comes down to a lot of field work."