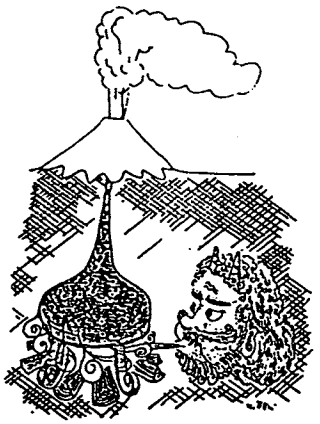


ASH FALL

Newsletter of the Volcanology Division
Geological Association of Canada

ASH FALL #29 OCTOBER, 1991

WOLFVILLE '92

Volcanology Division of the GAC
Presents

Volcanic Stratigraphy of the Greek Islands

May 9 - May 23, Maximum 36 persons

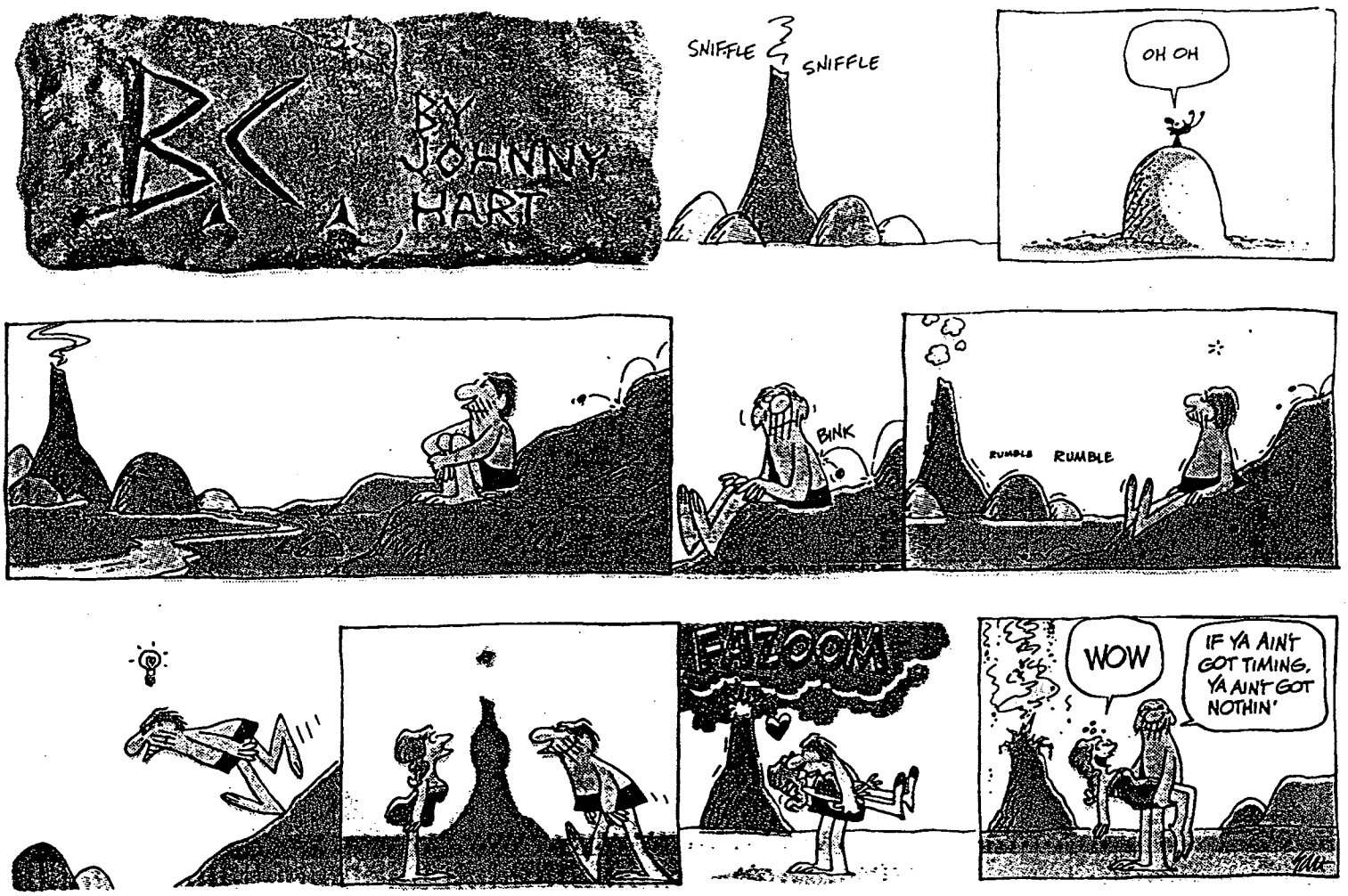
Leaders: Karen Stametelopoulou-Seymour, Edward W. Grove, and Greek geologists

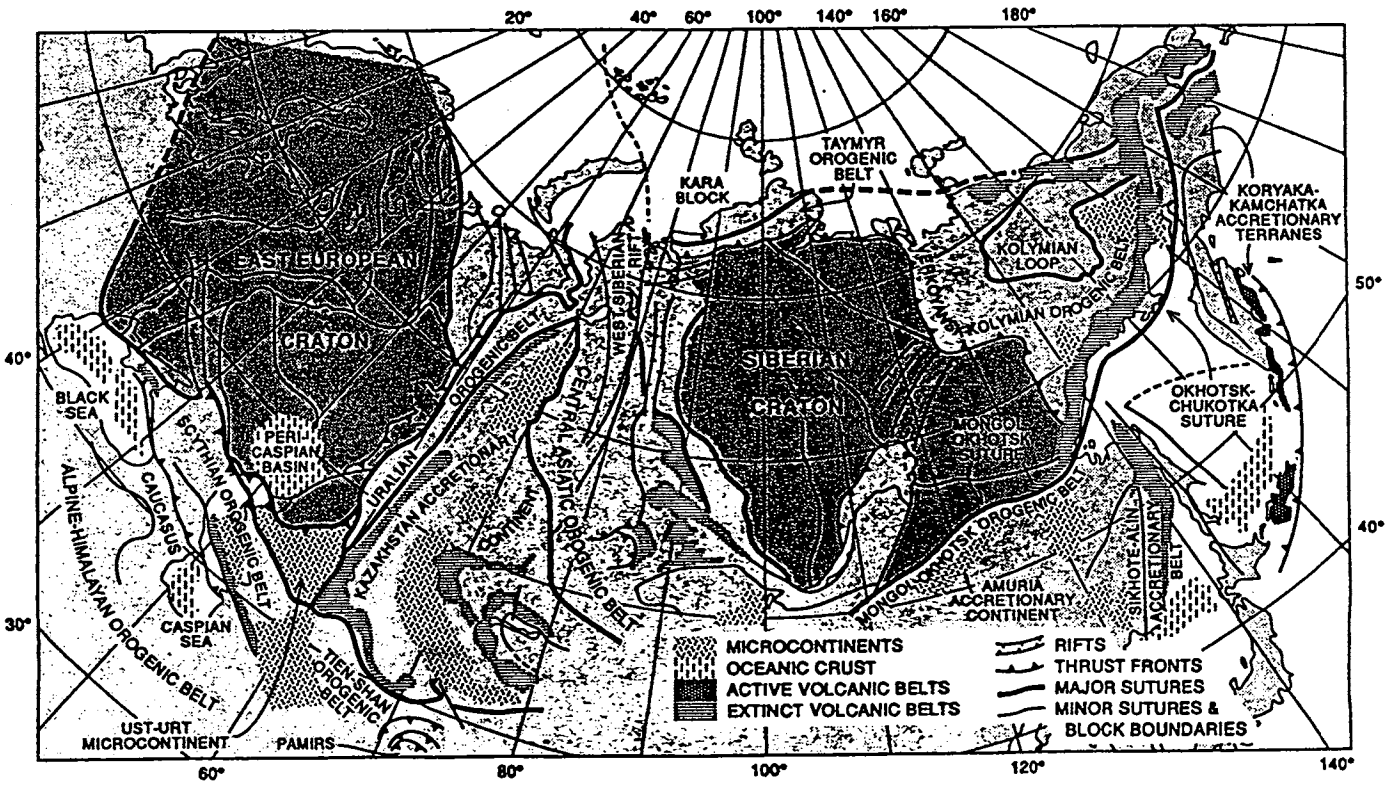
Participants will examine volcanoes, volcanic structure and stratigraphy on the Methana Peninsula near Athens, islands in the Aegean including the Cyclades and Dodecanese archipelagos and Lesbos. Participants will examine Fore and Back Arc settings, as well as a variety of places of classical interest near Athens, at Santorini and on Rhodes. Transportation will be by inter-island ferries, bus and aircraft. The deadline for confirming participation is November 15, 1991. There will be a waiting list for those who wish to subscribe in case of cancellations.

Contact Edward W. Grove, 4581 Boulderwood Drive, Victoria, B.C., V8Y 3A5; (604) 658-2366 or FAX (604) 658-5289.

Estimated Cost $2,800. This amount includes transportation in Greece and return airfare from Toronto, double-room occupancy, continental breakfast, dinner for three nights, taxes, and tips.

Costs are subject to change because of currency fluctuations and changes in transportation costs.





Main structural elements of the U.S.S.R., reflecting by their variety and distribution the accretionary processes that created the continent.

EOS Vol. 72, No. 29, 7/16/91

Pinatubo Cloud Measured

FROM EOS Vol 27, No 29, July 16/91

Satellite observations of the aerosol cloud produced by the eruption of Mount Pinatubo in the Philippines on June 15 indicate that, in terms of sulfur dioxide emissions, the eruption may be as much as two times larger than the El Chichon eruption in Mexico in April 1982, making Pinatubo possibly the largest eruption of the century. Ten days after the initial eruption, the aerosol cloud formed a nearly continuous band that stretched 11,000 km from Indonesia to Central Africa. Timely evacuations saved many lives on Luzon Island, but the combined effects of the eruption and a typhoon killed more than 300 people.

The following report on the eruption and its atmospheric effects was provided by the Smithsonian Institution's Global Volcanism Network. All times are local (= UT + 8 hours).

"After more than two months of increasing seismicity, deformation, and emission of small plumes, a series of strong explosions culminated in one of the largest eruptions of this century. The June 15–16 climactic phase lasted more than 15 hours, sending tephra to 30 km altitude, generating voluminous pyroclastic flows, and leaving a small caldera in the former summit region.

"The initial strong explosions began on June 12 when a tephra column rose to about 20 km as an explosive episode at 0851 signalled the start of a major pyroclastic phase. Prevailing winds carried the eruption plume west-southwest, depositing ash more than 30 km away.

"Weather satellite images showed that the eruption plume had separated from the volcano by 1330, after reaching about 330 km length. By 1830, winds had sheared the plume into three different layers; material at 15–18 km altitude traveled west-southwest at 100 km/hr; at 11–14 km altitude, west at 55 km/hr; and at 6–9 km altitude, west-northwest at 35 km/hr. The tropopause above the Philippines is at about 15 km elevation.

"The Nimbus-7 satellite's TOMS instrument detected a significant amount of sulfur dioxide during its pass over the area about two and a half hours after the onset of the explosion. Aviation authorities warned aircraft to avoid the plumes and closed several air routes west of the volcano.

"Another large explosive pulse occurred between 2250 and 2305 on June 12, producing an eruption column that briefly rose to 25 km altitude before declining to a sustained elevation of about 20 km. After an eruptive lull of about 28 hours, explosions resumed at 1309 on June 14, ejecting tephra to 25 km altitude. Another explosion at 1853 sent ash to 24 km altitude and additional pyroclastic flows to the northwest. Strong rains during several of the explosive pulses generated mudflows.

"An explosion at 0555 on June 15 fed a 20–22-km ash column and generated pyroclastic flows, marking the onset of strong sustained activity that included the climactic explosions and lasted until early June 16. Much of the summit region was removed by explosions or collapse, leaving a caldera 2.5 km in diameter centered slightly north of the former summit.

"Comparison of satellite-derived eruption column temperatures with atmospheric temperature profiles from nearby radiosondes yielded an altitude of 25–30 km as the cloud spread west-southwest toward mainland Asia, and elevations of 35–40 km for the eruption column over the volcano. A plume's maximum altitude can be underestimated by this technique if it has not fully equilibrated thermally with the surrounding air, or if more diffuse material extends above the plume's densest region. Satellite data suggest that more than 95% of the stratospheric cloud was produced by this 12-hour eruptive phase.

"The stratospheric cloud expanded rapidly west-southwest, and by 1030 the next day its leading edge had reached the Bangkok area, more than 2000 km away. Preliminary Nimbus-7 satellite data showed very high concentrations of sulfur dioxide over a broad area, with a total mass that appeared to be approximately double that of the 1982 injection from El Chichon. Light ashfalls were reported in southern Vietnam (from Da Nang to the Mekong Delta, 1400 km west to 1800 km west-southwest), northern Borneo (Sabah and Sarawak, 1000–2000 km south)."

Information Contacts

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Super Plume Connection to Cretaceous Warming

A global warming event that took pace during the Cretaceous period may have been caused in part by a "super plume" from the Earth's interior that released massive amounts of carbon dioxide into the atmosphere, according to a paper published in the June issue of *Geophysical Research Letters*.

Ken Caldeira and Michael Rampino of New York University used global biogeochemical carbon-cycle models to calculate the climatic effects of a large injection of CO_2 into the atmosphere/ocean system. The primary sources of CO_2 that they studied included mantle degassing at mid-ocean ridges and metamorphic decarbonation of sediments at subduction zones.

In the paper, super plumes are assumed to be plumes of extraordinary size and power that have profound effects on the topography and chemistry of the planet.

Caldeira and Rampino suggest that a super plume of material originating near the core/mantle boundary of the Earth about 120 million years ago rose through the mantle and erupted beneath the mid-Cretaceous Pacific Basin. This may have been the cause of a major pulse of ocean-crust formation and volcanism. The timing of this proposed super plume corresponds to a known increase in global temperatures during the Cretaceous.

It was previously estimated that the average global surface temperature during the mid-Cretaceous was 6–14°C higher than at present. The paleogeographic factors that were previously examined could explain about 4.8° of this temperature change. That

GREECE 1992

FROM SCIENCE, Vol. 253, p. 176

Rapid Eruption of the Siberian Traps Flood Basalts at the Permo-Triassic Boundary

PAUL R. RENNE AND ASISH R. BASU

The Siberian Traps represent one of the most voluminous flood basalt provinces on Earth. Laser-heating $^{40}Ar/^{39}Ar$ data indicate that the bulk of these basalts was erupted over an extremely short time interval (900,000 ± 800,000 years) beginning at about 248 million years ago at mean eruption rates of greater than 1.3 cubic kilometers per year. Such rates are consistent with a mantle plume origin. Magmatism was not associated with significant lithospheric rifting; thus, mantle decompression resulting from rifting was probably not the primary cause of widespread melting. Inception of Siberian Traps volcanism coincided (within uncertainty) with a profound faunal mass extinction at the Permo-Triassic boundary 249 ± 4 million years ago; these data thus leave open the question of a genetic relation between the two events.

Deadly gas building again in Cameroon, team warns

N.Y. Times News Service

NEW YORK — Scientists are warning that another disaster is possible at a lake in Cameroon that suddenly released huge amounts of carbon dioxide in 1986, killing 1,700 people, as well as cattle, birds and other animals.

The deadly gas came from the bottom of Lake Nyos, and an international team has concluded that about 300 million cubic metres of the gas have again accumulated under the lake, making it "very dangerous" to those who have resettled there.

The group estimated that three million cubic metres are being added annually.

The gas is assumed to be of volcanic origin, accumulating in water at the bottom of the lake until turbuluence or some other factor releases it. The lake is in a volcanic region of Cameroon, in west Africa.

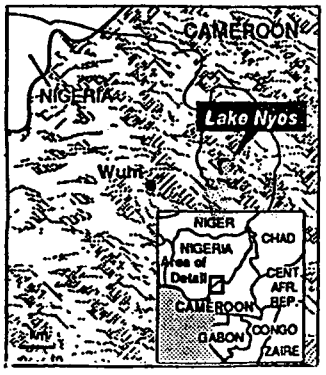
"Another gas disaster could occur at any time, "so the carbon dioxide in Lake Nyos should be reduced as a matter of urgency," the group reported in a recent letter to the journal Nature.

It suggested that gas-laden water be pumped from the bottom of the lake through a series of pipes.

It warned, however, that the rate of removal should not exceed inflow, lest the lake level be lowered, reducing pressure on the bottom that confines the heavy gaseous water there. The removed water should be discharged outside the surrounding valley.

It also recommended that the method first be tested on Lake Monous, 95 kilometres to the southeast, where 37 people were killed by a similar disaster in 1984.

That lake is only half as deep as Lake Nyos and "potentially far less dangerous," the group said. During the degassing, the scientists added, preparations should be made for a medical emergency, in case something goes wrong.



Tiny glass globules may prove meteorite wiped out dinosaurs with climate change

Reuter

NARRAGANSETT, R.I. — The "crime" is the death of the dinosaurs 65 million years ago.

The "suspect" is a 10-kilometre-wide meteor which, some scientific detectives believe, crashed into Earth with a force that would have been far greater than the explosion of all the world's nuclear bombs at once.

Such an impact, sclentists believe, would have thrown an enormous amount of dust and debris into the atmosphere and contributed to the climatic changes that led to the extinction of the dinosaurs.

Now scientists at the University of Rhode Island believe they have discovered a "smoking gun" pointing to a meteor impact as the primary culprit.

Their evidence: tiny globules of glass locked in a layer of rock created when half of all life on Earth, including the dinosaurs, disappeared.

A meteor impact can create glassy globs such as those found by Haraldur Sigurdsson of URI's Graduate School of Oceanography. Volcanic eruptions, the other chief suspect in this mystery, cannot.

"Not only does it provide definitive evidence of an impact in that age for people who didn't believe in one, (but) we can use the composition of the glass to predict which type of rock was struck by the impact," says Steven D'Hondt, a co-author of the study.

The reason behind the dinosaurs' demise was a major mystery until a decade ago, when a team led by Nobel Prize-winning physicist Luis Alvarez and his son, Walter, suggested that the remains of an asteroid or a comet sparked the extinctions by slamming into the Earth.

Their evidence was a thin layer of the element Iridium locked in rocks created at the end of the dinosaur era, known to geologists as the Cretaceous period. Iridium is rarely found on Earth's surface. It is common in meteorites.

The theory gained support as other scientists discovered iridium layers in 65-million-year-old rocks from other parts of the world.

Critics of the meteor theory argue that the iridium found in the prehistoric rocks could have come from deep underground, ejected into the atmosphere during volcanic eruptions. Once in the air, the iridium could have spread around the globe before settling down to earth.

A meteor impact became the prime suspect when scientists discovered grains of 65-million-year-old quartz similar to grains found only at the sites of meteor impacts or nuclear tests. Yet critics say volcanoes could have created grains of shocked quartz as well.

The new evidence, reported recently in the scientlfic journal *Nature*, comes from rock taken from Haiti for a different reason.

"We weren't looking for glass," said D'Hondt. But when the glassy particles appeared in the sample, their composition told the researchers that the source was a meteor impact.

$^{40}Ar/^{39}Ar$ Age of Cretaceous-Tertiary Boundary Tektites from Haiti

Sci: Vol. 252, p. 1539

G. A. IZETT, G. B. DALRYMPLE, L. W. SNEE

$^{40}Ar/^{39}Ar$ dating of tektites discovered recently in Cretaceous-Tertiary (K-T) boundary marine sedimentary rocks on Haiti indicates that the K-T boundary and impact event are coeval at 64.5 ± 0.1 million years ago. Sanidine from a bentonite that lies directly above the K-T boundary in continental, coal-bearing, sedimentary rocks of Montana was also dated and has a $^{40}Ar/^{39}Ar$ age of 64.6 ± 0.2 million years ago, which is indistinguishable statistically from the age of the tektites.

Magellan finds more 'spider' bulges on Venus

Pictures taken by the Magellan spacecraft show spider-shaped volcanic bulges on Venus, providing more evidence rising underground blobs of molten rock help shape the planet, NASA said Wednesday.

The features are called "arachnoids" because of their resemblance to spiders, which fall under the biological class known as arachnids. They were discovered by Soviet spacecraft in 1983 and 1984 but Magellan's much more detailed radar pictures led scientists to theorize about how they were formed, said Ellen Stofan, a Magellan geologist.

Huge blobs of molten rock deep inside Venus probably slowly rose upward, creating cracks, bulges and volcanic dikes and lava flows on the surface, she said.

Volcanology: 1987-1990, IAVCEI/CNC-IUGG, T.S.Hamilton

Introduction:

Canada's span for age and distribution of volcanic deposits is perhaps the largest of any country. This includes:

1.) Archean through Proterozoic greenstone belts of the shield
2.) Paleozoic through Mesozoic assemblages of the Appalachians
3.) Proterozoic through Recent formations of the Cordillera
4.) Submarine volcanism of the Juan de Fuca/Explorer Ridges.

With the diversity of magmas, tectonic settings and physical processes this list implies, and several billion dollars of production annually from mines in volcanogenic massive sulfide and epithermal deposits, opportunity and justification for volcanological research is ample. Volumes 40-42 of The Canadian Geophysical Bulletin (Volcanology) provide annual bibliographies and report on about 75 projects by 50 researchers. The majority of federal and provincial government research is mission oriented and applied to understanding the distribution, setting and genesis of specific volcanic formations or volcanic dominated map areas as a key to their geological development or to their economic potential. Most projects are multifaceted efforts of 1 to 3 years duration that examine: field relations, stratigraphy, facies, petrography, petrochemistry, mineralogy, age and isotopes of a particular formation. Several descriptive works and papers on observation-based models are published each year.

The Geological Association of Canada meeting also provides an annual overview of volcanological contributions. A topical volcanology component is also found in multidisciplinary megaprojects and geotraverses both in Canada and abroad and in Canadian participation in international programs (Cyprus Crustal Studies Project and the Ocean Drilling Program).

Meetings and Field Trips

At the 1989 Geological Association of Canada meeting in Montreal, 90 papers had volcanology-petrology-geochemistry content. At the Vancouver '90 GAC, a special symposium commemorated the 10th anniversary of Mt. St. Helens' eruption (Geoscience Canada 13:3). Also of more general petrologic interest were short course #8 on petrogenetic hypothesis testing with Pearce Element Ratios and the "Greenwood Symposium on Quantitative Methods in Petrology". Short course #9 on "Nonlinear Dynamics, Chaos and Fractals With Applications to Geological Systems" had examples of petrologic relevance including: thermochemical evolution of magmas, eruptive cycles and convection. The GAC also sponsored volcanological field trips: Ottawa'86 - to the Trans-Mexican Volcanic Belt, and Montreal'89 - to active volcanoes in Italy, Sicily, the Aeolian Islands. For Wolfville'92 a trip is planned to the Greek Islands. The 1989 IAVCEI meeting on Continental Magmatism in Santa Fe, was attended by 40 Canadians. "The Friends of the Igneous Rocks" have held informal gatherings since 1986 to provide a sounding board for controversial petrologic research. Don Francis will host the 1992 meeting in Montreal. In 1993 Mavis Stout and Jim Nicholls (University of Calgary) will lead the "Friends" to Craters of the Moon, Idaho.

Precambrian Applications

Detailed mapping and geochronology in the Canadian Shield's Superior province by Ontario Geological Survey and Royal Ontario Museum researchers revise the understanding of tectonics and metallogeny in greenstone belts. Halls and Fahrig (1988) Mafic Dyke Swarms is a landmark. The advent of precise U-Pb ages on single-crystals constrains complexities within and differences between formerly correlated belts. Several different volcanic environments are now widely accepted including: island arc, mafic plain (ocean ridge), epicontinental platform, and pull-apart basins, with speculation for the existence of "Pacific-style" marginal basins. Stratigraphy, chronology and structure of volcanic belts imply terrane transport and accretion. The GSC's project on the Cape Smith Belt (St-Onge et al., 1989; and others in the same volume) document the world's oldest known (1998 +/- 2 Ma) ophiolite. In this imbricate allochthonous belt, younger epicontinental rift and transitional oceanic basalts underlie the ophiolite. Trace elements and isotopes (Hegner and Bevier, 1989) demonstrate a composite origin for the ophiolite, including units

derived from depleted MORB- and enriched OIB-like mantle sources.

In the Western Churchill province, Tony Peterson and colleagues (GSC) found ultrapotassic mafic flows, dykes and pyroclastics preserved in a series of ENE basins between Baker and Dubawnt Lakes, forming one of the most extensive lamproite-minette provinces known. These ol-phlog-cpx bearing volcanics formed at 1.84 Ga, just after the collision of the Churchill and Superior provinces and the cessation of Proterozoic subduction.

Precise U-Pb geochronology proves a 4-6 Ma duration for both the 1.27 Ga Coppermine River flood basalt-Muskox intrusion-Mackenzie dyke swarm (3000 X 2500 km extent) and the 1.1 Ga midcontinent rift (up to 25 km thick). Both of these voluminous Proterozoic suites are interpreted to be caused by mantle plumes leading to continental rifting (LeCheminant and Heaman, 1989). Recognizing distinct volcanic products and settings, assesses borrowed models from Cenozoic plate tectonics. This volcanological insight is also central to documenting the nature of Precambrian crust-mantle processes and continental growth. Tests for these Precambrian volcanological and volcanic belt structural models will come from their application to the exploration of other map areas and targets, from seismic reflection profiling and from proposed deep continental drilling.

Laboratory studies: NFLIM AND Nomarski DIC:

The group at Queen's laser lab pioneered 2 techniques providing insight into the dynamic details of magma evolution. Narrow Fringe Laser Interference Microscopy (NFLIM) uses a monochromatic Argon Ion laser (514.5 nm) to generate an interferogram that provides detailed compositional gradients across individual crystals in thin section. Nomarski Differential Interference Contrast microscopy, a reflected light technique for etched polished sections, enhances texture and structure within single crystals (Fig.1). Originally used for ore minerals, this technique for primary volcanic silicates is crucial to understanding magma evolution (Pearce, 1987). These novel tools and observations address processes like mixing, polybaric fractionation, and crystallization with thermal feedback with a level of rigor that has hitherto been impossible.

Studies of Recent Volcanism in the Canadian Cordillera

Over the past few years, media sensitivity to eruptions elsewhere have focussed attention on diverse phenomena from fires to unusual clouds, but at present, Canada has no active vent. More than 100 volcanic vents have been active since deglaciation. This is evident in Cathie Hickson's compilation of Pliocene to Recent vents and volcanic fields and the 34 pages on Canadian volcanoes in Wood and Kienle (1990). The majority of these are within-plate, small volume, isolated flows and monogenetic cones of alkaline mafic lava and situated more than 150 km east of the Queen Charlotte-Fairweather transform fault. An example is the 3 phase Nazko Cone, midway between Quesnel and Bella Coola, whose last known activity was a basanite tephra at 7100 BP (Souther et al., 1987). Activity of this type has also occurred within the last few hundred years further to the NW at the Tseax River Cone and Aiyansh on the S. Nass River, and as shown in the photos and captions for Lava Fork and Eve Cone (Figs.2 & 3). The Garibaldi Belt, Canada's extension of the Cascades Arc, has a number of volcanoes with post-glacial eruptions. Opal Cone and the Ring Creek flow on the south flank of Mount Garibaldi post date the retreat of Fraser Ice at about 6,670 BP (Green, 1990). The Bridge River rhyodacite tephra (2350 BP) issued from a vent on the NE side of Plinth Peak on Mount Meagher (Read, 1990), which like Mount Cayley, has volcanic related hot springs. Despite the intermittency of this volcanism, where even the longlived centres are quiescent for hundreds to thousands of years, the potential hazards ranging from tephra to debris avalanches (Evans, 1990) make this a topic for continued study and concern. Any magma emplacement into the crust would cause harmonic tremor or a swarm of events. With a detection limit of about 2, the Western Canada Telemetered Seismic Network should provide ample warning of renewed volcanism.

High Pressure Experimental Petrology

Canada's premier high pressure facility at the University of Alberta has a multiple anvil press that operates to 25 GPa and 3000°C. Experiments on peridotite phase petrology challenge concepts of melt generation, convection, and mantle evolution, while pressure-induced coordination changes for silicon (Xue et al., 1989) provide the first evidence for 5 and 6-fold coordinated Si in silicate melts.

The Juan de Fuca Ridge and ODP

While mining industry's preoccupation is with gold mineralization associated with structures and metamorphic fluids, much research still focusses on volcanogenic massive sulfide deposits both on land and offshore. With 2 or more cruises annually by scientists from the GSC, universities, and abroad, the Juan de Fuca can claim to be the best studied ridge. ODP Leg 139 under Earl Davis will be drilling into the sedimented zero-age crust of Middle Valley to examine volcanically driven hydrothermal systems and the stratigraphic record of ridge processes.

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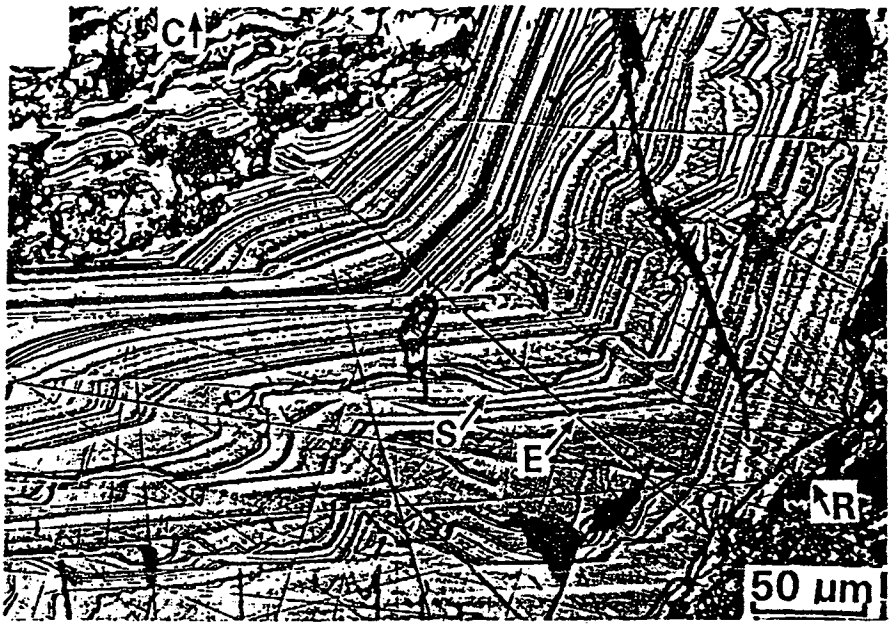
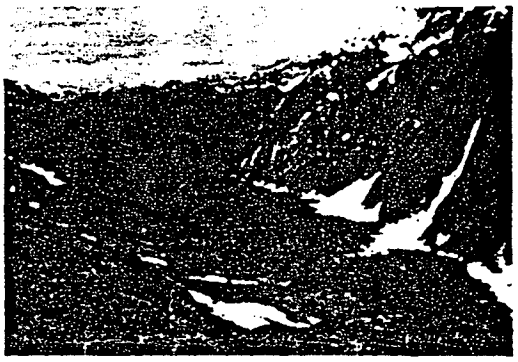
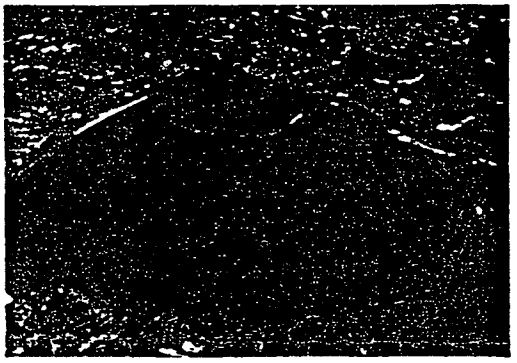


Nomarski DIC image of plagioclase from an amphibole bearing 2-pyroxene andesite. Inclusion-rich core (C) is in the upper left, rim (R) is in the lower right. This image, provided by Angela Kolisnik, reveals a complex history of alternating euhedral growth and dissolution whereas ordinary petrography shows only uniform sweeping extinction of normal zonation.



Intermittently between the late 17th century and 1904, alkali olivine basalt erupted from fractures in granitic bedrock and the Lehua Glacier infilling the glacial valley at Lava Fork, B.C. and damming a series of lakes. The flow surface in the picture dates from the 1850s. This view is to the SSW towards Blue River, Alaska.



Satellitic vents of basaltic pyroclastics like Eve Cone on the north flank of Mt. Edziza typify post glacial volcanism in the Stikine region of northern B.C. Both photographs of Recent volcanics were taken by E.W.Grove.

CONTRIBUTIONS

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