AstroNotes

Newsletter of the Ottawa Centre, RASC

An End of an Era - Discovery's Final Mission

Vol. 50 No. 2 March, 2011

Article submissions: email to: astronotes@ottawa-rasc.ca
Deadline for April 2011 Issue is March 24, 2011

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The Ottawa Centre is one of 29 centres of the Royal Astronomical Society of Canada – an organization dedicated to the advancement of astronomy and allied sciences.

The Ottawa Centre, formed in 1906, has approximately 400 members. Centre facilities include the Fred P. Lossing Observatory, near Almonte. The Centre also operates an astronomical book library and a telescope loan library. Membership in the Ottawa Centre is $70 per year for regular members (outside Canada, US $112) and $41 for junior members. Members receive the annual Observer's Handbook, the bimonthly electronic RASC Journal, the Canadian bimonthly magazine SkyNews, and 10 issues of the Ottawa Centre's newsletter, AstroNotes. The Centre can be contacted at P.O. Box 33012, 1363 Woodroffe Avenue, Ottawa ON K2C 3Y9; Internet at www.ottawa.rasc.ca

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An End of an Era

By Debra Ceravolo AstroNotes Editor

The space shuttle Discovery finally lifted off on its last mission to space, February 24, 2011 after almost four months of delays. Among other critical ISS components and supplies, Discovery also carried R2, the first humanoid robot in space to the International Space Station. This long running shuttle holds the record as the most traveled space craft in history with 143 million miles and 39 missions since its first launch in 1984. It has also carried up the Hubble Space Telescope in 1990 and John Glenn's return to orbit in 1998. Only two other shuttles remain in the program and have their final flights scheduled for this year: Endeavour will launch in April commanded by Mark Kelly, the husband of wounded Congresswoman Gabrielle Giffords and Atlantis will be the last to go in June, 2011. After that, astronauts will have to hitch a ride with the Russians. NASA is under presidential direction to retire the shuttle fleet by summer and let private companies take over trips to orbit and focus on getting astronauts to asteroids and Mars.

I personally have had the honour of watching one of Discovery's launches way back on January 22, 1992. It was a very special mission for Canadians as it was carrying Canada's first woman astronaut in space, Roberta Bondar. That was an experience I will never forget. I look forward to someday visiting Discovery in its new home at the Smithsonian Institution where it will be spending its well earned retirement.

In This Issue

Cover Photo: Space shuttle Discovery on its final mission, February 24, 2011.
Photo courtesy NASA

News around the Ottawa Centre

Free Stargazing

From the Helen Sawyer Hogg Observatory at the Canada Science and Technology Museum. Join the staff of the Museum for 90 minutes of fascinating fun. Dress warmly and events are weather permitting.
The upcoming dates are:

March 11, 2011	7:00 p.m.
March 26, 2011	8:00 p.m. - During Earth Hour!
April 1, 2011	8:00 p.m.
May 6, 2011	8:30 p.m.
July 8, 2011	9:00 p.m.

The Sky this Month - March 2011

Planets in March 2011:
* Jupiter is dissapearing in the sun's glow by mid month
* Saturn is the best planet to observe in the evenings
* Venus is nicely visible in the mirnings before sunrise
* Mars is not observable this month
* Mercury visible in evening twilight by mid month

March 4 - New Moon
March 19 - Full Moon-largest full moon this year
March 20- Spring Equinox
March 22 - Mercury's greatest elengation, best evening view this year
March 26 - Earth Hour, turn off power for 1 hour between 8-9 pm

Astro Quote of the Month

We shall not cease from exploration, and the end of all our exploring will be to arrive where we started and know the place for the first time.

Thomas Sterns Eliot
British poet
(1888-1965)

Position Statement of The Royal Astronomical Society of Canada On Green Laser Pointer Usage

The Royal Astronomical Society of Canada's (RASC) mission is to encourage improved understanding of astronomy for all, through education, outreach, research, publication, partnership, enjoyment, and community. The RASC advocates the safe and responsible use of green laser pointers (GLPs).

Recent reports indicate a rising trend in the illegal targeting of aircraft by people on the ground misusing consumer laser devices. This practice threatens the safety of aircrew, passengers, as well as people and personal property under flight paths. The RASC wishes to add its voice to those of the health-and-safety sector, aerospace industry associations, law-enforcement agencies, and government in calling for greater public awareness of the issue, for safe and responsible use of laser pointers.

Green Laser Pointers have established legitimate applications as effective teaching aids in astronomical education, observing, and public outreach, if used safely. The eye is very receptive to the wavelength of the green laser pointer, making it a very effective instrument for pointing out features in the night sky. People attending education sessions and star parties at science centres and observatories can experience the green laser beam apparently reaching out to the planets, stars, and nebulae.

The RASC, Canada's leading organization dedicated to astronomical education and public outreach, has developed a voluntary Green Laser Pointer best-practice policy to promote the safe and responsible use of GLPs for astronomy education and outreach. The RASC has established freely available guidelines for public education on the responsible use of laser pointers in astronomy. In keeping with the RASC's commitment to informative and safe education and public outreach, it encourages everyone to follow the guidelines at www.rasc.ca/education/other/glpuse.shtml.

Ottawa Centre meeting report - February 4, 2011

By Estelle Rother -Recorder

Bill Wagstaff welcomed everyone to the February meeting. He started with the Ottawa Skies presentation. Activity on the sun is continuing. Several coronal holes have appeared, including an instance of 2 holes opposite each other, one on either side of the sun. Coronal holes are darker, colder and have a lower density than the rest of the solar surface. They are associated with open magnetic field lines and this is where we see high velocity solar winds. If one of these holes is facing Earth, we will see increased auroral activity a few days later. Satellites in Earth orbit can also be affected. Their electronics could be damaged or their orbital dynamics could be changed. Bill showed images taken by the Solar Dynamics Observatory and a video.

The new moon occurred on February 3, the full moon would occur on February 18 and the next new moon would occur on March 4. Bill would like to meet with an avid lunar observer. The more reading he does, the more questions he has.

Gemini (The Twins) was Bill's constellation of the month. It can be seen straight up in the south after dark. The constellation has been recognized as two human figures since very early times. The two brightest stars, Castor and Pollux, are the heads of the twins. Bill described a few deep sky objects that could be seen in this part of the sky. Hubble's Variable Nebula, NGC 2261, is one of the few variable nebulas in the sky. Its variability is thought to be caused by opaque dusty filaments that sometimes block R Monocerotus, the star illuminating this reflection nebula. It is an older star, puffing off its outer layers as its nuclear fuel is exhausted. Like most planetaries, this one is relatively small, so visual observers using a small scope will not see details. You would need a Hubble telescope to see the details in the image Bill showed. The Christmas Tree open cluster, NGC 2264, is visually attractive and easy to see. The Cone Nebula is situated above it but you would need a large scope and good skies to see it visually. All of these objects were discovered by Herschel. NGC 2168, M35, is an open cluster that is about 2800 light years away and is about the size of the full moon. NGC 2158 is about 12,000 light years away.

Al Scott followed with a 10 minute astronomy news update. Al's first item asked why we are all left handed on a microscopic scale, in particular amino acids. A right and a left handed molecule have the same constituents and are chemically the same. But all life on Earth is made up of only left handed amino acids. No one knows why all biologically generated amino acids are left handed. Life based

on right handed amino acids should work just as well. So if you find a life form based on right handed amino acids, you have discovered alien life. In March 2009 researchers at NASA Goddard Spaceflight Center discovered traces of amino acids in carbonaceous meteorites and found a 1% excess of left handed forms. It is possible early life on Earth was seeded by organic molecules from carbonaceous meteorites. This left-right asymmetry was then amplified. This month new research announced that this 1% asymmetry was present in all the meteorites that were examined. This is the first asymmetry discovered other than in life. In some of the studied meteorites this asymmetry was enhanced by a factor of 1000. These are the meteorites where there is evidence that liquid water has altered some of their minerals. It seems that some process has selectively destroyed the right handed molecules. Light has a polarization. Photons have electric fields that oscillate back and forth. The fields can oscillate in any direction as the light travels. In the lab, shining circularly polarized light at carbonaceous materials results in an excess of 1% in the handedness of the amino acids that are produced. Light can become circularly polarized in extremely bright stars in star forming regions by passing through dust grains that have been aligned by the star's magnetic field. Our solar system likely formed in a nebula with a very bright nearby star with a strong magnetic field and surrounded by a lot of dust. The star system formed in a lobe with preferentially circular polarization. Carbonaceous meteorites that formed here created left handed amino acids. Other stars in this system could have formed in a right handed zone. This is the first natural explanation for the observed handedness.

Occam's Razor has potentially sliced a planet. This is a rule of thumb used by scientists. All things being equal, the explanation for something that has the least number of parameters necessary to describe it, is more likely to be correct. In September there was a news release by a group observing the M-class red dwarf star Gliese 581. They have been measuring radial velocity shifts of the star to detect planets orbiting it. Based on the known temperature of the star, they know where the habitable zone around that star is located. They concluded there are six planets orbiting Gliese 581. There were orbital periods of 3.16 days, 5.36 days, 12.9 days and 67 days, known from earlier data. Two more planets were discovered with orbital periods of 34 days and 395 days. The 34 day planet has 3 Earth masses and is orbiting in the habitable zone. The scientists believe there is less than a 1% chance that this is a false detection. This month a Canadian astronomer at UBC has done an analysis and believes the data is more likely to

be caused by an additional unidentified source of noise in the measurements or a systematic error that has not been accounted for.

Al then donned his Centre President's hat to call for a SmartScope observing coordinator. SmartScope was supposed to be a millennium project but several difficulties delayed the project. These have now been resolved and SmartScope should be ready in a month or so. Al is looking for someone to implement training, monitor status and find a way of doing outreach. Talk to Al if you are interested.

Mike James considers himself to be an armchair amateur astronomer. He has a small scope but his back yard is full of trees. He does look at the moon and has seen a bright spot in Tranquilitatis. He looked at a map courtesy of the NASA web site but could not see the bright spot. He identified other features and was able to get an approximate latitude and longitude. NASA pictures are sorted by latitude and longitude and after searching, Mike found the bright spot in an image taken by Apollo 10. The 5 kilometer diameter crater is identified as Censorinus. Mike concluded that if you see something puzzling, you can get a lot of information from NASA.

Last month Eric Kujala presented a lunar challenge to find a photograph of the Earth during a lunar eclipse. Thanks to Google, Eric found a photo taken on May 18, 2009 by Kaguya, the Japanese spacecraft orbiting the moon. This is one of only a few photos of Earth taken during a lunar eclipse. This photo was of a penumbral eclipse. During a lunar eclipse there is a unique set of conditions under which you can observe the Earth. Eric thinks a station on the moon, where the equator and the meridian intersect, would be a good place to put a small telescope to photograph Earth during lunar eclipses. Two eclipses occur every year. Each one presents an opportunity to study Earth from that perspective.

Eric then showed an excerpt from the dinner meeting video when Dr. Luc Simard talked about applications for the 30 meter telescope being built in Hawaii. It will help us understand planets around other stars and to look for traces of life. It will be possible to measure the spectra of the atmospheres of these planets. Oxygen exists in our atmosphere only because of life on Earth, so finding a significant amount of oxygen in the atmosphere of an extrasolar planet could be a strong indicator of life there.

Eric has produced a DVD of each meeting for the past three years and has not missed a meeting. There is a copy in the Centre library and he has a copy for each presenter. It is his way of saying thank you to the speakers for doing their presentations.

After a short break and the draw for door prizes, the meeting continued. Are you interested in astronomy on your iPhone or iPad? There are apps for that. Chris Teron introduced us to what is available. The Apple iTunes store has 367 iPhone apps and 111 iPad apps related to astronomy. Chris picked those he thought would interest us. Three components on these devices make the applications possible. A built-in GPS gives your current location and the correct time. A digital compass the direction you are holding the device. and an accelerometer tells the angle the device is held. Combining all this information lets the program know what you are looking at in the sky. All these components are only available on the iPhone 3. The GPS does not exist in the iPad. The biggest difference between the iPhone and the iPad is size. The iPad is much larger. Initially images on the iPad were the same size as on the smaller iPhone. Programs are now written specifically for each platform.

Chris then described several planetarium apps. All the programs have built-in catalogs. Star Walk is visually rich but lacks depth. It would be more useful for non-amateur astronomers. Go Sky Watch is similar and it gives good control of what is displayed on the screen. Both programs will show you which direction to move to see your chosen object. If Chris had given this talk last month, Star Map would have been his preferred program. It is not as visually attractive but it has deeper features. It contains catalogs and highlites what is visible. There are menus that let you turn on Telrad settings and input your scope information. There is also a log book function and built-in telescope controls that operate most modern GoTo telescopes. This program also has built-in databases of comets and asteroids. Both can be updated. Star Map HD is the iPad version. Sky Safari is now at the top of the list for Chris. It combines visual attractiveness with most of the features of Star Map. It has more catalogs than any of the other programs and more information on the objects. It does the moon well; the other programs do not do the moon at all. Telescope control is supported and this program has the best screen control. There is nothing for the Blackberry. Many apps are free of charge. Apps are obtained from the iTunes store. To be continued next month with satellite and observing apps.

Members' observation reports followed. Paul Comision showed images of NGC 0436, NGC 0581 (M103) and NGC 0673. All of these open clusters in Cassiopeia are younger than Earth. Tony Peterson began with a n image of the Horsehead Nebula (Barnard 33, IC 434). He also showed images of M31 and M33, a galaxy in Triangulum. Paul Klauninger's first image was the lunar crater Cassendi. He then showed the Helix Nebula, a planetary in Aquarius; M8, the Lagoon Nebula; M45, the Pleiades, with many O class stars and at a distance of 440 light years from Earth; and the Heart Nebula, 7000 light years away and located near Cassiopeia. Gordon Webster showed a drawing of M33. He followed this with Billy on the Moon from the Astronomy Sketch of the Day web site. He has renovated an old observatory for winter use. He takes it down in summer. The roof folds open from both sides and the table is now frozen in place. Bob Olson is now somewhere a little warmer. He sent images of Orion and a nice sunset. Rolf Meier showed images of a sunset and of the zodiacal light.

'The Mystery of the Missing Antimatter' was the Stan Mott library pick of the month. If you have not already done so, please return library books so others can enjoy them.

Thanks to Ann and Art Fraser for the after meeting refreshments.

President's Review of 1990 - by Rolf Meier

As the year began, plans were being made for the year's main event- the hosting of the 1990 General Assembly of the RASC. The organizing committee, chaired by Rob McCallum, was busy finding locations for the various paper sessions, banquets and tours that we were to enjoy. During the next six months, the plans fell into place. The committee's work paid off with an excellent General Assembly during the weekend from June 28 to July 3. Rob McCallum is to be congratulated for an enthusiastic approach to the GA and terrific results. Doug George wrote an article summarizing the event of the GA in the September issue of AstroNotes.

In preparation for the GA, an IRO improvement of major proportions was undertaken. Thanks go to Robin Molson and the Observatory Committee for their hard work on this, the Centre's main asset. Work was completed on a new roof for the clubhouse, which also added some much needed storage. Thanks also to Rob Haughton for the donation of an 8 foot dome. This will house the 10 inch newtonian, which is having its clock drive improved by Doug George.

Ottawa Centre members should be reminded that they have an excellent facility at IRO. I encourage more members to come out at star nights and see what's available. Or, get to know some of the keyholders and make arrangements to go out some other time. Actually, I am surprised that the number of cars often equals the number of observers and that number is often low. Why don't keyholders and non-keyholders drive out together to save some gas?

Before becoming a keyholder, it is wise to become familiar with observing techniques and the usage of telescopes. To help in that regard, we have a telescope loan library which is due to increase in size this year. If you would like to borrow a telescope up to 8 inches in diameter, contact Anthony Dore. I highly recommend it to beginners without telescopes.

Beginners and experts alike continue to enjoy the Observers Group meeting and the Regular Centre meetings.

Hilderic Browne and Patrick Laffey put together an excellent set of Observers Group meetings. Attendance was high, and the speakers were informative. I urge members to support the Chairman and Vice-Chairman with proposals to give talks. Especially interesting are reports of observations, including slides. Don't think that the coordinators are the only ones allowed to give talks. Also, I know that the coordinators will appreciate any input such as observations which they can compile with the data from other observers.

Sandy Ferguson helped out enormously last year with the organizing of many excellent Regular meetings. January began the year with our own Centre members describing Atmospheric Phenomena. For February, Dr. Ian Halliday spoke on the Voyager missions to the outer planets. Complimenting this talk, the March meeting featured Dr. Peter Millman, describing the surface features revealed by the

AstroNotes of the Past - Remembering 1990

Voyagers on the satellites of the outer planets. Unfortunately, that was Dr. Millman's last talk to the Ottawa Centre. In April, Dr. Lloyd Higgs described how a modern radio telescope works, with reference to the Penticton, BC facility. This was Dr. Higgs last talk as outgoing President of the RASC. In May, there was an address by Dr. David Malin of the Anglo-Australian Observatory with some spectacular deep sky photographs. In June, July, and August there were no Regular meetings, as is our custom. In September, member Tom Harris spoke on the new probes now being launched to explore the solar system. In October, member Ronald Rodgers lectured on the observational differences between historical European and Oriental astronomers. November was the Annual Dinner meeting, featuring Davy Levy, discoverer of eight comets. Finally, December was the annual film night. I would also like to thank Estelle Rother for including summaries of the Centre meeting in AstroNotes.

It is, of course, AstroNotes that brings all Centre members together. Doug George has again produced an excellent volume of ten issues for 1990. A new cover was introduced, giving a distinctive look to the new generation of newsletter - word processors, computer graphics, E-mail, and scanner halftones now enhance the appearance of AstroNotes and make Doug's production work much easier than the hunt-and-peck technique of past editors.

AstroNotes began as an Observer's Group publication, but now speaks for the entire Centre. It is very important for keeping members informed of upcoming events. And if members cannot attend certain events, the coverage in AstroNotes will keep them informed of what they missed. I also encourage members to make reports of observations or instrumentation. You don't have to be a member of any executive or committee of Council in order to contribute an article.

Comets were a big story for members last year. Doug George discovered his first (I expect there will be others) comet in late 1989, and members were happy to observe it in 1990. Comet Skorichenko-George also helped Doug to win the Observer-of-the-Year Award for 1990. I wonder if the other fellow won anything.

In early 1990, there were high hopes for Comet Austin, which unfortunately did not attain great brightness. However, the best show of the year was put on by Comet Levy, 1990c, which was a nice naked eye comet for members in late summer.

During the summer, many members attended Starfest in Southern Ontario, with several members participating in the events. Doug George and I joined David Levy in a panel discussion on comet hunting (well, actually, comet finding) in a hot tent on Saturday afternoon. Peter Ceravolo showed much dedication by testing the optical quality of attendees' telescopes late into the night.

On a sadder note, several members of the Centre passed away in 1990. Dr. Peter Millman will be remembered as a long-time supporter and friend of the Ottawa Centre. Phil Park had been very active in the past, having served as the President of the Centre. And Walter Peshke was still active last year, having discovered his astronomical interest only recently after retirement.

AstroNotes of the Past - Remembering 1990

With the General Assembly behind us, and the Indian River Observatory in stable condition, a new challenge awaits us in 1991.

With the gvernment cutbacks has come a consolidation of various NRC activities, among them that of the Herzberg Institute of Astrophysics. This has been our main link with the professional astronomical community for the past 15 years. (Prior to that, it was the old Dominion Observatory, which was also, sadly, closed to cutbacks). The NRC provided assistance in nearly all of our activities, such as the observatory, AstroNotes, library, and meeting rooms. Gradually, this assistance has been reduced as government spending has come under closer scrutiny.While this may help with out tax bill, non-profit organizations such as ours will suffer. Whatever scientific and educational activities the RASC provides will now have to stand on their own without government assistance.

The number of professionals from NRC who are also Ottawa Centre members has gradually diminished, as older members retire and others move to British Columbia, which will be the focus of the HIA in the future. As a result, the internal NRC support has all but vanished. The most recent effect of NRC's changing policy is the elimination of the availability of NRC's auditorium facilities for the meeting of outside groups. It has become increasingly difficult in the past few years to book the meeting rooms. It is a service that NRC does not really want to support. Security and safety are certainly issues. This is one reason why we changed to the auditorium from room 3001. The elimination of the audio-visual facilities caused us to buy our own projectors. And now, the final blow has come with the decision to disallow ALL outside meetings for 1991, and probably beyond 1991 when the policy becomes entrenched. The reason? NRC wants to reserve the rights to its meeting rooms for 1991 because it is having a 75th birthday party for the year (at whose expense, I wonder?) and doesn't know right now when it might need the auditorium.

The result is that we now must look for another meeting location. The problem is that we cannot afford to pay very much for meetings. Also, we have to find a place for our library, which is currently permitted to be on NRC premises; we don't know for how much longer.

A committee of Council has been formed to consider the problem. If any members have suggestions for a meeting location, contact Rob McCallum or me.

The problem of location aside, I look forward to another year of interesting meetings, as well as star nights, AstroNotes and observing.

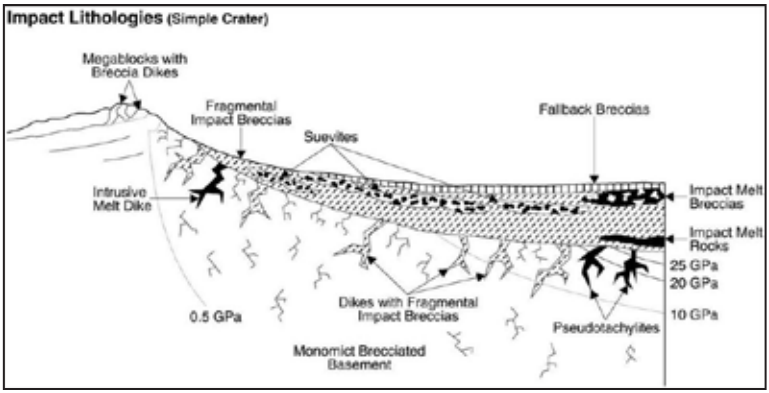
The big observing event of the year is the total solar eclipse of July 11. A number of members will be travelling to Mexico or Hawaii for this phenomenon. If weather permits, I know we will be seeing some tremendous pictures when the observers return.

Identifying Impact Structures - Part VII(a)

By Chuck O'Dale

INTRODUCTION

An obvious craterform is an excellent indicator of a possible impact origin; particularly if it is a circular geologic structure, as illustrated in Part II of this series. But as noted, such features are rare and short-lived in the terrestrial environment. The burden of proof for an impact origin generally lies with the documentation of the occurrence of shock-metamorphic effects. Impacts produce distinctive "shock-metamorphic" effects that are found in situ within the crater and allow impact sites to be distinctively identified. Such shock-metamorphic effects, in addition to the shatter cones (documented in Parts V & VI of this series), include brecciated rocks, suevites, impact melts and pseudotachylites. They attest to the destructive power of the impact event.



Schematic radial cross-section through one-half of a simple impact structure, showing locations of different impact-produced lithologies. Curved lines show isobars of shock pressures (in GPa) produced in the basement rocks by the impact.

The rocks at the target site are melted, shattered, and mixed during the impact explosion. When the site finally settles and cools, a new composite rock, impact breccia in bodies tens to hundreds of meters in size, is the result. Lithologies showing these unique diagnostic shock effects, formed at pressures ?10 GPa, tend to be restricted to two locations: (1) crater-fill materials (suevites, melt breccias, and fragmental impact breccias) deposited in the crater; and (2) brecciated basement rocks, often containing shatter cones, near the center of the structure. The magnitudes of the impact shock relative to the point of impact that form the shock metamorphic effects were quantified for reference in Part V. This article is a continuation of Part VII of this series. In it I will further document the impact shock metamorphic effects that I found within the Sudbury, Charlevoix and Skelton Lake structures I have explored.

DEFINITIONS

BRECCIA - (from a Latin word meaning "broken") is a rock that is composed of angular fragments of other rocks surrounded by a fine-grained "matrix" that may be of a similar or a different material. Breccias are extremely common in the central uplift, in crater-fill deposits, and in the ejecta blanket of meteorite impact craters.

IMPACT MELT - rock that has been made temporarily molten as a result of the energy released by the impact of a large colliding body. Impact melts include small particles, known as impact melt spherules, that are splashed out of the impact crater, and larger pools and sheets of melt that coalesce in low areas within the crater. They are composed predominantly of the target rocks, but can contain a small but measurable amount of the impactor

PSEUDOTACHYLITE - is a fault rock that has the appearance of the basaltic glass, tachylyte. It is dark in color and has a glassy appearance. However, the glass has normally been completely devitrified into very fine-grained material with radial and concentric clusters of crystals. It may contain clasts of the country rock and occasionally crystals with quench textures that began to crystallize from the melt.

SUEVITE - a rock consisting partly of melted material, typically forming a breccia containing glass and crystal or lithic fragments, formed during an impact event. It forms part of a group of rock types and structures that are known as impactites.

SUDBURY - breccia, pseudotachylite

The Sudbury Structure comprises a 200-250 km multi ring impact basin formed at 1.85 Ga. The core of the structure is elliptical, 60 x 30 km, containing a layered 2.5 km thick impact melt sheet, referred to as the Sudbury Igneous Complex (SIC). The SIC was formed by differentiation of the impact melt pool at the probable main contact point of the impactor.

Immediately interfacing the upper SIC is the grey Whitewater breccia that contains many large angular rock fragments floating in a glass like amorphous rock. These fragments are the fallback particles from the surrounding Huronion supergroup country rock that were deposited immediately after the impact. These rock

fragments were ejected ballistically hundreds of km into the atmosphere and then minutes to hours later "plopped" into this still molten rock. Note the large fragment in the lower right of the image that is hydrothermally altered and surrounded by a "chilled margin" (a mineralized area around the fragment caused by a hydrothermal vent). The size of the Sudbury structure implies that the hydrothermal venting continued for thousands of years after the impact. (a mineralized area around the fragment caused by a hydrothermal vent). The size of the Sudbury structure implies that the hydrothermal venting continued for thousands of years after the impact.

Further into the structure is the darker Whitewater breccia containing smaller rock fall-back fragments originating from the igneous quarts granite north range footwall. Here the breccia indicates the introduction of carbon. A biogenic origin of the carbonaceous material (soot) found in the black Whitewater Group is theoretically caused by the evaporation/condensation from the hot impact fireball and/or from a later global cloud. The colour of the rock is not uniform indicating that the carbon is not uniformly distributed. Bucky balls (soccer-ball-shaped molecules of 60 carbon atoms) possibly of extraterrestrial origin and with traces of helium and argon gas trapped inside were found in this breccia.

The impact probably occurred in a shallow sea as there is evidence of water flow-back in the top layers of the Whitewater Group. The quantity of "breccia fall-back" specifies that the fall-back segment of the impact lasted a substantial amount of time (perhaps hours) before the appearance of the returning tsunami.

In this image the Pseudotachylite Sudbury Breccia (SB), the black pulverized (by the impact) country rock injected into the pink gneiss, was formed when the high pressure from the meteorite impact was applied to these rocks and then abruptly released. This caused the rock along and within these dykes to partly melt. The dykes containing the pseudotachylite were welded shut as soon as the motion created by the impact stopped. Subsequent stress was supported by the fault as though it had never been active. The entire period of activity of a fault filled with pseudotachylite may be measured in minutes. (e.g., Pseudotachylite is a rock type formed by friction-induced melting, during very rapid deformation) (Philpotts 1964; Maddock 1983).

SB pseudotachylite dikes range from veins less than 1 mm thick to massive zones measuring up to 1 km thick and extending for approximately 45 km. Formations of SB are found up to 100 km north of the SIC.

CHARLEVOIX - impact melt

The Charlevoix Meteorite Crater is a multi ringed impact basin with a central uplift. It is located in southern Quebec on the north shore of the St. Lawrence River, 105 km NE of Quebec City. One feature that supports an impact origin of a structure is impact melt rock. This expamle of impact melt rock was extracted from within the Charlevoix impact structure. At pressures in excess of about 60 GPa, rocks undergo complete (bulk) melting to form impact melts. The melts can reach very high temperatures due to the passage of shock waves that generate

temperatures far beyond those commonly encountered in normal crustal processes or in volcanic eruptions. Each mineral grain is instantaneously raised to a post-shock temperature that depends on the shock-wave pressure and on the density and compressibility of the mineral itself. If the postshock temperature produced in a mineral exceeds its normal melting temperature, each grain of that mineral in the rock will melt, immediately and independently, after the shock wave has passed. The melt will have approximately the same composition as the original mineral before any flow or mixing takes place, and the melt regions will initially be distributed through the rock in the same pattern as the original mineral grains. Note the country rock fragment in the inclusion.

SKELTON LAKE - breccia

Skeleton Lake is a generally circular lake provisionally classified as a simple meteorite crater. It is located in the Muskoka District of Ontario on the Canadian Shield slightly east of Georgian Bay. It is the largest open body of water within the Muskoka Lakes.

These images illustrate a breccia deposit on Opal Island situated in the area of the crater rim. This breccia may have been formed as the result of a hypervelocity impact.

"These are the breccia samples I had recovered from Opal Island within the Skelton Lake structure. The breccia deposit on Opal Island stands in stark contrast to the surrounding target rock in the Central Gneiss Belt. The country rocks comprise of parautochthonous gneisses overlain by northwest-transported allochthonous terraines originating from the pre-Grenvillian Laurentian margin or from farther outboard as inferred for the Parry Sound allochthon.

As of this date (Feb. 2011), firm evidence of an impact has not been found in the Skelton Lake structure.

Conclusion

In this article, the breccia and pseudotachylite that I documented at the "outskirts" of impact structures is NOT firm evidence of an impact. Separately, each of these shock metamorphic features could be explained by naturalistic means (tectonic, volcanic, sedimentary - other than impact), but taken together they strongly suggest evidence for an impact. But these findings would suggest that further investigation to gather evidence of in impact may be warranted. Therefore, crater identification cannot rely soly on the discovery of breccias, there must be other impact evidence (IE shatter cones and/or planar deformation features) before the structure is identified as impact related.

In Part VII(b) of my "Identifying Impact Structures" series, I will document the geological features of other impact sites that I have explored.

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