Oceans on Mars: A Crater/Frequency Analysis by Elevation of the Northern Plains; Sahuaro High School Astronomical Research Classes of 1991, J. F. Lockwood (Sahuaro High School, Steward Observatory, Tucson, AZ)

Introduction: The fact that Mars once had water on its surface is evident to all who have studied its surface. Recent hypotheses propose the ancient presence of extensive oceans a kilometer or two deep and vast continental ice sheets covering the Northern Plains. To help in testing this theory, 46 members of two high school research classes have produced cumulative frequency graphs and R plots of most of the quads which are between 0 and 60 degrees N. These graphs used traditional square root two bins for crater diameter but were plotted for each 1 km elevation bin between -3 and +3 km. The USGS maps used in the study had a 1:2,000,000 scale so a lowest crater size resolution of 1.4 km was obtained, although only craters larger than 2 km were used in this study.

Observations: R plots were summed for MC quads 6, 7, 8, 13, 14, and 15 by the spring semester research class of 1991. The fall semester research class summed R plots for quads 2, 3, 4, 5, 11, and 12 then combined the R plots from both semesters to produce an R plot by elevation bin for the entire Northern Plains (see figure 1).

Then N>4 values were summed for each MC quad and placed on a contour map (USGS 2030) of the Plains. Pure crater counts for #>2 and #>4 were placed on the map as well.

Histograms were produced for N>2, >4, and >8 from -3000 to 0 contour lines and added for each MC quad then summed and plotted for the data compiled from both semesters producing N>2, >4, and >8 for the Northern Plains.

Results: The densities of craters larger than 8 km are highly variable in the Northern Plains, indicating varied terrain ages spanning the Hesperian era. These densities show a positive correlation with elevation suggesting possible long-term depositional/erosional activity being more concentrated at lower elevations.

R plots for the Northern Plains show a marked decrease in craters smaller than 8 kilometers in diameter for all contour intervals from -3000 to 0 meters. This result seems to show that some erosional or depositional forces have greatly affected the number of craters smaller than 8 kilometers in the Northern Plains.

The N>4 values and crater counts for #>2, >4 on the Northern Plains map agree with the supposition that there are fewer 8 kilometer and smaller diameter craters in the lower elevations as opposed to many small diameter craters in the higher elevations. The low numbers of small diameter craters and their location coincide with the proposed location of Oceanus Borealis quite well.

The histograms show (see figure 2) low and equivalent N>2 values for -3000 to -2000 and -2000 to -1000 elevation bins and a considerably higher value for the -1000 to 0 elevation bin. The N>2 value of 300 for the -3000 to -2000 and the -2000 to -1000 bin correlates with the a Lower Amazonian age. These data support the recent Lower Amazonian age of glacial modification determined by Kargel and Strom for certain sections of the Northern Plains. The equal amount of erosion and deposition occurring in the lower bins may be interpreted as indicating a shoreline near the -1000 meter contour. This correlates with the "middle-size" ocean model of Baker, et. al., 1991. This model is also supported by recent work which indicates that thumbprint terrain, a probable glacial-lacustrine moraine construct, is also distributed primarily between the -1 and -2 contour in the Northern Plains. However, the N>2 data must still be tested for observational completeness.

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Oceans on Mars: Sahuaro H.S. Research Class


Fig. 1a, b, c

Fig. 2a, b, c
NEW CHEMICAL MAPPING TECHNIQUE FOR ANALYSIS OF PYROXENES IN POLYMIC BRECCIAS AND APPLICATION TO SOME EUKRITES; K. Saiki, A. Yamaguchi, and H. Takeda; Mineralogical Institute, Faculty of Science, University of Tokyo, Hongo, Tokyo 113, Japan.

We developed a new chemical mapping system for characterizing pyroxenes in polymict eucrites and applied to some eucrites; Y82202, Stannern, and Y791439. This system enables us to identify the position of pyroxenes with a particular composition on the polished thin section (PTS) in the form of elemental distribution map. Exsolution textures and chemical zoning of pyroxene fragments in eucrites could be recognized on the colored map.

A PTS of Stannern (1058-1) was supplied by the American Museum of Natural History (AMNH). PTS's of Y791439,51 and Y82202,51-1 were supplied by the National Institute of Polar Research (NIPR) in Japan. These samples were investigated by SEM (JEOL840A) equipped with the Keveks Super 8000 EDS system, which is capable of EDS X-ray elemental distribution map (EDX-Map) analysis. Backscattered Electron Images (BEI) and fluorescent X-ray intensity maps of up to 15 elements obtained by digital electron beam controller were converted into digital images and processed by graphics software "Keveks Advanced Imaging". X-ray intensities are expressed by grey scale on each pixel. This system was connected with a personal computer (SHARP X68000) by RS232C cable. We transferred EDX-Map intensity data from Keveks system to the computer and processed them for chemically classifying pyroxenes of polymict eucrite by "Elemental Distribution Map for Pyroxene Quadrilateral (EDMPQ)" software.

EDMPQ System: EDMPQ software is an EDX-Map processor we developed for characterizing pyroxenes from different source rocks speedily and easily. On this software, Mg-Si-Ca-Fe intensities are processed for quantitative analysis using modified Bence and Albee method (1). It calculates rough chemical compositions, identifies pyroxenes, and plots on a map image and a quadrilateral simultaneously. Color palette, showing chemical composition, are assigned for each point displayed on the map image and the quadrilateral. Ca, Mg, and Fe mol% are expressed as Red, Blue, and Green% on each pixel. The accuracy of data on a quadrilateral is not so good because dwell time per one point is 1 sec. The accuracy, however, is sufficient enough for rough classification of pyroxenes. EDMPQ software also provides us with modal analysis tool for pyroxenes.

Application to Eucrites: Y82202 is an unequilibrated monomict eucrite. Its pyroxenes are extensively zoned. There is no exsolution lamella resolvable by microprobe (2). Its EDMPQ image (Fig.1) displays pyroxene zoning trend and their distribution clearly.

Stannern is a partly equilibrated monomict eucrite. Its pyroxenes are originally zoned, as those of Y82202, but the original Mg-Fe zonation was homogenized by a later thermal event (3). Its EDMPQ image (Fig.2) displays strong Ca zonation. The Ca-rich rim of a pyroxene crystal is composed of densely arranged thin augite lamellae less than 1µm in scale. The resolution of EDMPQ image is not sufficient for such submicron texture, but slightly better than that of EPMA (WDS).

Y791439 may best be classified as a polymict cumulate eucrite with small diogenitic and rare ordinary eucrite components (4). We investigated entire surface of the PTS. Accumulated images suggest that Y791439's pyroxene chemical compositions are divided into four types; JU(Juvinas)-type, MC(Moore County)-type, BD(Binda)-type, D(Diogenite)-type in the order from Fe-rich to Mg-rich (5). One of the EDMPQ image (Fig.3) covers three kinds of pyroxene;
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JV-type, BD-type, and D-type. The image displays characteristics of each type of pyroxene clearly. In other part of the PTS, the JV-type pyroxenes are severely brecciated to small pieces, so original texture is not clear. One pyroxene on this image, however, retained original shape and has an augite lamella. The BD-type pyroxenes are most abundant. One pyroxene on this image has augite blebs typical in Binda, and another has coarse augite lamellae similar to those of Moore County. The D-type pyroxenes are most magnesian ones. There is no lamella observed. On some D-type pyroxenes of other images, however, thin augite lamellae are detected as dotted lines. The width of lamellae observed by BEI is less than 1 μm. On the D-type pyroxene of this image, there is no lamella detected even by BEI.

These examples demonstrate that EDMPQ method is very useful for extracting characteristics of pyroxenes and presentation for publication. EDMPQ system would become more accurate and speedy if it is connected with EPMA (WDS) and stage control device.

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Fig.1, fig.2, and fig.3
EDMPQ images of Y82202, Stannern, and Y791439. Width is 1.3 mm.