Dynamic Computer Model for the Metallogenesis and Tectonics of the Circum-North Pacific

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INTRODUCTION

This document describes the digital files on this CD-ROM report that consists of a dynamic computer model of the metallogenesis and tectonics of the Circum-North Pacific, and background articles, figures, and maps. The CD-ROM report is for sale by U.S. Geological Survey, Information Services, ESIC Open-File Reports, PO Box 25286, Denver, CO 80225 (Telephone 888-ASK-USGS). The tectonic part of the dynamic computer model on this CD-ROM is derived from a major analysis of the tectonic evolution of the Circum-North Pacific (Nokleberg and others, 2001) which is also contained on this CD-ROM in directory \tectevol.

The dynamic computer model and associated materials on this CD-ROM are part of a project on the major mineral deposits, metallogenesis, and tectonics of the Russian Far East, Alaska, and the Canadian Cordillera. The project provides critical information on bedrock geology and geophysics, tectonics, major metalliferous mineral resources, metallogenic patterns, and crustal origin and evolution of mineralizing systems for this region. The major scientific goals and benefits of the project are to: (1) provide a comprehensive international data base on the mineral resources of the region that is the first, extensive knowledge available in English; (2) provide major new interpretations of the origin and crustal evolution of mineralizing systems and their host rocks, thereby enabling enhanced, broad-scale tectonic reconstructions and interpretations; and (3) promote trade and scientific and technical exchanges between North America and Eastern Asia.

QUICK START

For those already familiar with Windows Media Player and who have this program on their computer, go directly to the file withstops.avi in directory \dynamod. Double click on this file to start the start-stop version of the dynamic computer model for metallogenesis and tectonics, or double click on file nonstop.avi to start the continuous version of the computer model for tectonics.

For those already familiar with QuickTime Movie Player, and who have version 5 or higher on their computer, go directly to the file withstops.mov in directory \dynamod. Double click on this file to start the start-stop version of the dynamic computer model for metallogenesis and tectonics, or double click on file nonstop.mov to start the version of the continuous dynamic computer model for tectonics.

CONTENTS

At the root (base level) of this CD-ROM are the 1_README.TXT file and the documentation for this preliminary publication (OF 01-261.DOC and OF 01-261.PDF).

The dynamic computer model is in Windows Media Player format (*.avi) and Quicktime format (*.mov). Explanatory materials, including explanations, tables, and a companion article are in Word 6 format (*.doc) and Adobe Acrobat Reader format (*.pdf). Plane-text files are in ASCII (*.txt).

The directories on the CD-ROM, including the dynamic computer model, maps, tables, and articles, are stored in the following directories under the indicated file name. In alphabetical order, the files are described as follows

Directory \Acrobat - FILES FOR INSTALLING ADOBE ACROBAT READER

The directory \Acrobat contains installers for Adobe Acrobat Reader 5.0 for both Windows (PC directory) and Macintosh (Mac directory). The installers are provided on this CD, or can be downloaded as the latest version of Adobe Acrobat Reader, free, via the Internet from the Adobe homepage on the World-Wide Web at http://www.adobe.com/.

Directory \dynamod - DYNAMIC COMPUTER MODEL

The directory \dynamod contains the dynamic computer model in Windows Media Player format (*.avi) and Quicktime format (*.mov), and explanatory files in Word and Portable Document (*.PDF) Formats. With installation of the Adobe Acrobat Reader program, provided on the CD-ROM, the explanatory files in PDF format can be viewed or printed by double-clicking on the file names ending in .pdf. The various explanatory files are included to provide viewers with information on explanation of the graphic elements of the model, summary table of metallogenic belts, detailed table of metallogenic belts, and a description of the major metallogenic and tectonic events for the computer model.

With the Windows Media Play program, or installation of the QuickTime Movie Player program, version 5.0.2, provided on the CD-ROM, the Windows Media Player files (*.avi) or QuickTime Move Player files (*.mov) can be viewed on both Windows and Macintosh computers. For easier manipulation of the computer model, the files can be copied onto a hard drive. Viewing from a hard drive will permit manual reversing of the computer model. Similar controls exists for the QuickTime Movie Player.

In Windows Media Player, the button with the two vertical bars, near the lower-left part of the window, can be used to stop the animation. To start the animation, click on the button to the left with the right-pointing arrow. Stopping the animation at each of the major times

will serve to show the major igneous-related metallogenic belts and lettering. If desired, under Options and View, the animation can be set to run forever, i.e., recycle.

In alphabetical order, the file names and purposes in the directory \dynamod are as follows.

beltsum.pdf. Summary table of metallogenic belts, major mineral deposit types, and tectonic environments for each of 14 time stages. This table is designed to be printed and placed to the side of the computer monitor for easy reference while viewing the computer model. This table is a summary version of dettab.pdf, described below.

descrip.pdf or descrip.doc. Description of major metallogenic and tectonic events for each of 14 time stages that were used to construct the dynamic computer model. This description is derived from the paper on the Phanerozoic tectonic evolution of the Circum-North Pacific (Nokleberg and others, 2001) and from dettab.pdf or dettab.doc, below, that is derived from a study of the metallogenesis of the Russian Far East, Alaska, and the Canadian Cordillera (Nokleberg and others, 2001, in press).

dettab.pdf or dettab.doc. Detailed table of metallogenic belts, mineral deposit types, environment, host unit, and tectonic event. This table is a detailed version of beltsum.pdf.

modexplan.pdf. Graphical explanation of symbols and colors in dynamic model. This file can be display on a computer monitor to the side of the dynamic model, each in separate windows.

nonstop.avi or nonstop.mov. Dynamic computer model for tectonics of the Circum-North Pacific. This computer model displays a continuous model for both metallogenesis and tectonics. The model is based on 14 separate time-stages, starting in the Devonian and ending in the Present. The model runs continuously, although can be stopped and resumed with the controls on the Windows Media Player or QuickTime Movie Player.

withstops.avi or withstops.mov. Dynamic computer model for metallogenesis and tectonics of the Circum-North Pacific. This computer model displays a continuous model for both metallogenesis and tectonics. The model is based on 14 separate time-stages, starting in the Devonian and ending in the Present. The model pauses for a few seconds for each time stage in order to display map units and metallogenic belt abbreviations. The model can be stopped and resumed with the controls on the Windows Media Player or QuickTime Movie Player.

DIRECTORY \Quicktime - FILES FOR INSTALLING QUICKTIME MOVIE PLAYER

The directory \Quicktime contains files for installing QuickTime Movie Player version 5.0.2 for both Windows and Macintosh. QuickTime Movie Player from Apple Computers will display *.avi files (Windows Media Player format files) for Mac OS and Windows.

DIRECTORY \tectevol - TECTONIC EVOLUTION ARTICLE

The directory \tectevol contains digital files for text and figures for the U.S. Geological Survey Professional Paper 1626 on the Phanerozoic Tectonic Evolution of the Circum-North Pacific (Nokleberg and others, 2001). This paper provides essential data and interpretations for the tectonic interpretations for the dynamic model. The paper is provided in Adobe Acrobat format (pp1626.pdf). The figures for the paper are provided in Adobe Acrobat (*.pdf), Corel Draw 9 (*.cdr), and Adobe Illustrator 7 (*.ai) formats.

With Word or Adobe Acrobat Reader installed, the files can be viewed and printed by double-clicking on the file name on the CD-ROM.

The file names and purposes are as follows.

FIG1.* through FIG20.* - Figures in various formats.

pp1626.pdf - Professional Paper in Adobe Acrobat format.

The Professional Paper is also available for free downloading on the World-Wide Web at http://geopubs.wr.usgs.gov/prof-paper/pp1626/

SYSTEM REQUIREMENTS

The data and text on this CD-ROM require either an IBM or compatible personal computer or a Macintosh or compatible computer. The PC should have a Pentium® II or higher processor (Pentium III recommended), Microsoft® Windows® 95 OSR 2.0, Windows 98 SE, Windows Millennium, Windows NT® 4.0 with Service Pack 5, or Windows 2000, 64 megabytes RAM (128 MB recommended). The Macintosh should have a PowerPC® processor running Mac OS software version 8.6, 9.0.4, 9.1, or OS X; some features of Acrobat 5.0 may not be available for OS 8.6 and OS X due to OS limitations.

Both platforms should have 64 or more megabytes of RAM (128 recommended), a monitor that can display 256 colors (16.7 million colors recommended), and a CD-ROM drive. On both platforms, Adobe Acrobat Reader 5.0 or higher (5.0 included on this disc for

Windows and Macintosh) or other software is needed that can translate PDF files, and a program that can display Windows Media Player (*.avi) files. Windows Media Player is part of Windows 98, 98, NT. In addition, QuickTime Movie Player 5.0.2 for Macintosh and Windows computers is included on this CD-ROM.

Because Windows Media Player and QuickTime Movie Player are not available for UNIX computers, the dynamic computer model on this CD-ROM cannot be displayed on these machines.

DISCLAIMERS

This Compact Disc-Read-Only-Memory (CD-ROM) publication was prepared by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed in this report, or represents that its use would not infringe privately owned rights. Reference therein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof..

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PRODUCTION OF DYNAMIC COMPUTER MODEL

The dynamic computer model was produced using the high-end computer morphing program, *Elastic Reality* from Avid Technologies. The morphing was done with 14 static, time-stage diagrams prepared in Corel Draw and Adobe Illustrator. Use of the *Elastic Reality* program produced about 1,500 intermediate diagrams, that, when played in rapid succession by a multimedia program, give the illusion of motion.

The animation was prepared 1999 through early 2001, and has been displayed at the June Cordilleran GSA 1999 meeting at U.C. Berkeley, at the May 2000 meeting of the Geological Society of Nevada, and at the May Cordilleran GSA 2000 meeting in Vancouver, Canada (Scotese and others, 1999a, b; 2000a, b; Nokleberg, 2000)

SUMMARY OF METALLOGENESIS AND TECTONICS OF CIRCUM-NORTH PACIFIC

The Phanerozoic metallogenic and tectonic evolution of the Circum-North Pacific (Russian Far East, Alaska, and the Canadian Cordillera) is recorded in the cratons, craton margins, and orogenic collages of the Circum-North Pacific mountain belts that separate the North Pacific from the eastern North Asian and western North American Cratons. The collages consist of tectonostratigraphic terranes and contained metallogenic belts that are composed of fragments of igneous arcs, accretionary-wedge and subduction-zone complexes, passive continental margins, and cratons; they are overlapped by continental-margin-arc and sedimentary-basin assemblages and contained metallogenic belts. The metallogenic and geologic history of terranes, overlap assemblages, cratons, and craton margins is highly complicated because of post-accretion dismemberment and translation during strike-slip faulting that occurred subparallel to continental margins.

Six processes overlapping in time were responsible for most of metallogenic and geologic complexities of the region. (1) In the Late Proterozoic, Late Devonian, and Early Carboniferous, major periods of rifting occurred along the ancestral margins of present-day Northeast Asia and northwestern North American. The rifting resulted in fragmentation of each continent, and formation of cratonal and passive continental-margin terranes that eventually migrated and accreted to other sites along the evolving margins of the original or adjacent continents. The rifting also resulted in formation of various massive-sulfide metallogenic belts. (2) From about the Late Triassic through the mid-Cretaceous, a succession of island arcs and contained igneous-arc-related metallogenic belts, and tectonically paired subduction zones formed near continental margins. (3) From about mainly the mid-Cretaceous through the present, a succession of igneous arcs and contained metallogenic belts, and tectonically paired subduction zones formed along the continental margins. (4) From about the Jurassic to the present, oblique convergence and rotations caused orogen-parallel sinistral, and then dextral displacements within the upper plate margins of cratons that have become Northeast Asia and the North America. The oblique convergences and rotations resulted in the fragmentation, displacement, and duplication of formerly more-continuous arcs, subduction zones, passive continental margins, and contained metallogenic belts. These fragments were subsequently accreted along the margins of the expanding continental margins. (5) From the Early Jurassic through Tertiary, movement of the upper continental plates toward subduction zones resulted in strong plate coupling and accretion of the former island arcs, subduction zones, and contained metallogenic belts to continental margins. Accretions

were accompanied and followed by crustal thickening, anatexis, metamorphism, formation of collision-related metallogenic belts, and uplift. The accretions resulted in the substantial growth of the North Asian and North American continents. (6) In the middle and late Cenozoic, oblique to orthogonal convergence of the Pacific Plate with present-day Alaska and Northeast Asia resulted in formation of the modern-day ring of volcanoes and contained metallogenic belts around the Circum-North Pacific. Oblique convergence between the Pacific Plate and Alaska also resulted in major dextral-slip faulting in interior and Southern Alaska and along the western part of the Aleutian-Wrangell arc. Associated with dextral-slip faulting was crustal extrusion of terranes from Western Alaska into the Bering Sea.

ASSOCIATED PROJECT

The dynamic computer model and associated materials on this CD-ROM are part of a project on the major mineral deposits, metallogenesis, and tectonics of the Russian Far East, Alaska, and the Canadian Cordillera. The project provides critical information for collaborators and customers on bedrock geology and geophysics, tectonics, major metalliferous mineral resources, metallogenic patterns, and crustal origin and evolution of mineralizing systems for the Russian Far East, Alaska, and the Canadian Cordillera.

The major scientific goals and benefits of the project are to: (1) provide a comprehensive international data base on the mineral resources of the region that is the first, extensive knowledge available in English; (2) provide major new interpretations of the origin and crustal evolution of mineralizing systems and their host rocks, thereby enabling enhanced, broad-scale tectonic reconstructions and interpretations; and (3) promote trade and scientific and technical exchanges between North America and Eastern Asia. Products from the project are providing sound scientific data and interpretations for commercial firms, governmental agencies, universities, and individuals that are developing new ventures and studies in the project area, and for land-use planning studies that deal with mineral resource issues. The Russian Far East part of the project (as well as Alaska and the Canadian Cordillera) has vast potential for known and undiscovered mineral deposits.

Published major companion studies for the project are: (1) a report on the metallogenesis of mainland Alaska and the Russian Northeast (Nokleberg and others, 1993); (2) a tectono-stratigraphic terrane map of the Circum-North Pacific at 1:5 million scale with a detailed explanation of map units and stratigraphic columns (Nokleberg and others, 1994a); (3) a tectono-stratigraphic terrane map of Alaska at 1:2.5 million scale (Nokleberg and others, 1994b); (4) a summary tectonostratigraphic terrane map of the Circum-North Pacific at 1:10 million scale (Nokleberg and others, 1997b); (5) detailed tables of mineral deposits and placer districts for the Russian Far East, Alaska, and the Canadian Cordillera in paper format (Nokleberg and others, 1996a) and in CD-ROM format (Nokleberg and others, 1996b); (6) a GIS presentation of a summary terrane map, mineral deposit maps, and metallogenic belt maps of the Russian Far East, Alaska, and the Canadian Cordillera (Nokleberg and others, 1998); (7) a study of the Phanerozoic tectonic evolution of the Circum-North Pacific (Nokleberg and others, 2001); and (8) a GIS compilation of geophysical, geologic, and tectonic data for the Circum-North Pacific (Greninger and others, 1999).

A project description is available on the Internet/Web at http://geopubs.wr.usgs.gov/open-file/of96-513-b/

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