UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

# An expert system for mineral resource assessment in the Sherbrooke-Lewiston 1° x 2° quadrangles, Maine, New Hampshire and Vermont

by

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# INTRODUCTION

A prototype expert system has been developed to aid in the assessment of the mineral resources in the Sherbrooke-Lewiston 1° x 2° quadrangles, Maine, New Hampshire, and Vermont as part of the Conterminous United States Mineral Appraisal Program (CUSMAP). This system is comprised of deposit models constructed for the five major tectonostratigraphic terranes recognized within the quadrangles.

The deposit models are based upon recognition criteria developed by geologists most familiar with the general geologic setting of the deposit types considered. Each of the models consists of a rule-based method for evaluating the likelihood of occurrence of one or more deposits within an arbitrarily selected geographic area within the quadrangles. It should be noted that the evaluations are directed at assessing the mineral resources within the Sherbrooke-Lewiston quadrangles and not necessarily the mineral resources outside the quadrangles.

muPROSPECTOR II is a microcomputer-based expert system for evaluating the mineral resources within a given geographic area. The models are encoded in a form compatible with muPROSPECTOR II, a computer program patterned after SRI's PROSPECTOR program. An evaluation in muPROSPECTOR II consists of a probabilistic estimate of the likelihood of occurrence of the deposit type being considered coupled with the reasons upon which the evalution is based. Each evaluation takes into account the evidence judged favorable or unfavorable. Evidence for upgrading the likelihood of occurrence or downgrading the likelihood of occurrence of a deposit, therefore, is taken into consideration. Such evidence is important in planning surveys either in unexplored new areas or partially explored known areas.

The models are listed in Appendix A under the following tectonostratigraphic terranes:

- Metavolcanic terranes
- Metasedimentary terranes
- Ordovician to Carboniferous terranes
- Jurassic volcanic-plutonic terranes
- Surficial material terranes

Each model is described using the Backus-Naur Representation (BNR) in Appendix B. The current source listing of muPROSPECTOR II is given in Appendix C.

## Appendix A

## muPROSPECTOR DEPOSIT MODELS

The following disk files represent the deposit models developed to aid in the mineral resource assessment of the Sherbrooke-Lewiston 1° x 2° quadrangles, Maine, New Hampshire, and Vermont. Each file is represented according to the Backus-Naur Representation (BNR).

```
TITLE /* "***" NEW ENGLAND MINERAL RESOURCE APPRAISAL PROGRAM "***" */
---
HELLO  /* I am here to assist you in appraising the potential
for metallic deposits in New England "." */
---
PURPOSE /* This is a program to assist in the evaluation of
environments favorable for the occurrence of metallic deposits
in New England "." It is based on the occurrence models used by
Moench "," Boudette "," McCammon "," Cameron "," Cox and others
in their assessment of the potential mineral resources in the
Sherbrooke-Lewiston two-degree sheets "."  */
---
FILENAMES /* METAVOLC METASED OCPLUT JVLPL SURF */
---
TERRLST /* Metavolcanic Metasedimentary
"Ordovician to Carboniferous plutonic"
"Jurassic volcanic-plutonic" "Surficial material"  */

STOP
```

```
model metavolc
          topspace  EST
---
space EST desc /* Estimable thickness of metavolcanic sequence */
          ques /* CAN YOU ESTIMATE THE THICKNESS OF THE VOLCANIC SEQUENCE
 LOCALLY */          expl /* I am trying to determine if the sequence can
 be considered a thick volcanic pile  */
 announce /* The following is intended to aid in the evaluation of
 the Potential Mineral Resources in metavolcanic rocks in New England
  */   yes THK  no MXD1
---
space THK ques /* DOES THE THICKNESS EXCEED 500 METERS */
          desc /* Thickness exceeds 500 meters locally */
          expl /* Thicknesses of volcanic piles less than this are
 not generally considered favorable for massive sulfide deposits
 */    yes  MXD   no MXD1
---
space MXD desc /* Differentiated volcanic rocks  */
          ques /* DOES THE SEQUENCE CONTAIN BOTH MAFIC AND
 INTERMEDIATE-TO-FELSIC LAYERS  */
          expl /* I am trying to determine if the pile is composed
of differentiated volcanics  */  yes PYRO  no PYRO1
---
space PYRO          desc /* Evidence of pyroclastic activity  */
          ques /* DO YOU OBSERVE THE PRESENCE OF PYROCLASTICS IN
 THE VOLCANIC SEQUENCE */
          expl /* I am trying to establish evidence of pyroclastic
 activity, especially involving silicic elements "." Pyroclastic
 activity is indicated by the presence of tuffs, tuff-breccias
 and agglomerates, or fragmental felsic domes as represented by
 quartz-eye prophyries  */    yes CHEM  no CHEM1
---
space CHEM          desc /* Evidence of chemical sedimentation */
          announce /* Congratulations! You have identified a
 favorable geologic setting for volcanogenic massive sulfide
 deposits of the Kuroko type "." The
 following questions are intended to aid in evaluating this
 possiblility more fully  */
          ques /* IS THERE ANY CHERT, BANDED TUFFITE, COTICULES,
 IRONSTONE OR TOURMALINITES PRESENT */
          expl /* I am trying to determine if the volcanics can
 be considered to be the result of subaqueous volcanism and
 possbily deposited proximal to felsic volcanic centers */
          yes ALT  no ALT1
---
space ALT desc /* Evidence of hydrothermally altered rocks */
          ques /* IS THERE ANY EVIDENCE THAT SUGGESTS HYDROTHERMAL
 ALTERATION */          expl /* Hydrothermal alteration is indicated by
 the presence of such rocks as chlorite or talc schists, sericite
 or plagioclase or kyanite or sillimanite rich rocks or strong
 bleaching of mafic rocks and so forth  */
```

```
          yes IND  no  IND1
---
space IND desc /* Presence of distinctive indicator minerals */
          expl /* I am trying to determine the presence of minerals
 associated often with massive sulfide deposits */
          ques /* IS THERE ANY GAHNITE, SPESSARTINE, TOURMALINE,
 BARITE, MAGNETITE, OR APATITE PRESENT */
          yes ORE  no ORE1
---
space ORE desc /* Presence of ore minerals */
          ques /* IS THERE A SIGNIFICANT AMOUNT OF PYRITE OR
PYRRHOTITE AND LESSER AMOUNTS OF CHALCOPYRITE, SPHALERITE, OR GALENA
PRESENT */     expl  /* These are the dominant sulfide minerals
in massive sulfide deposits  */
          yes  DEF   no PROB
---
space DEF desc /* Definite Potential Resource for
 Copper-Zinc-Lead */
          inf /* Definite Potential Resource for Copper-Zinc-Lead
 in From JFisher.Help 09/18/84  1332.4 edt Tue: You have mail.
Volcanogenic Massive Sulfide Deposit */
---
space PROB          desc /* Probable Potential Resource for
 Copper-Zinc-Lead  */
          inf /* Probable Potential Resource for Copper-Zinc-Lead
 in Volcanogenic Massive Sulfide Deposit  */
---
space POSS          desc /* Possible Potential Resource for
 Copper-Zinc-Lead  */
          inf /* Possible Potential Resource for Copper-Zinc-Lead
 in Volcanogenic Massive Sulfide Deposit  */
---
space SPEC          desc /* Speculative Resource for Copper-Zinc-Lead
  */      inf /* Speculative Potential Resource for
 Copper-Zinc-Lead in Volcanogenic Massive Sulfide Deposit */
---
space NONE          desc /* Insufficient Evidence for Potential
 Copper-Zinc-Lead Resource */
          inf  /* Insufficient evidence at present that indicates
 a Potential Resource for Copper-Zinc-Lead in metavolcanics */
---
space MXD1          ques  MXD  desc MXD   expl MXD
          yes PYRO1  no PYRO2
---
space PYRO1   ques  PYRO  desc PYRO   expl PYRO
          yes CHEM1   no NONE
---
space PYRO2         ques  PYRO  desc PYRO         expl PYRO
          yes CHEM2 no NONE
---
space CHEM1         ques  CHEM  desc CHEM         expl CHEM
          yes ALT2  no ALT3
---
space CHEM2         ques  CHEM  desc CHEM         expl CHEM
```

```
          yes ALT3  no NONE
---
space ALT1          ques  ALT  desc ALT expl ALT
          yes IND1  no IND2
---
space ALT2          ques  ALT  desc ALT expl ALT
          yes IND2  no IND3
---
space ALT3          ques  ALT  desc ALT expl ALT
          yes IND3  no IND4
---
space IND1          ques  IND  desc IND expl IND
          yes ORE1  no PROB
---
space IND2          ques  IND  desc IND expl IND
          yes POSS  no ORE3
---
space IND3          ques  IND  desc IND expl IND
          yes ORE3  no ORE4
---
space IND4          ques  IND  desc IND expl IND
          yes ORE4  no NONE
---
space ORE1          ques  ORE  desc ORE expl ORE
          yes DEF   no PROB
---
space ORE2          ques  ORE  desc ORE expl ORE
          yes PROB  no POSS
---
space ORE3          ques  ORE  desc ORE expl ORE
          yes POSS  no SPEC
---
space ORE4          ques  ORE  desc ORE expl ORE
          yes SPEC  no NONE

STOP
```

```
model metased
        topspace RX
---
space RX  desc /* Presence of siliciclastic rocks */
        ques /* DO YOU OBSERVE SILICICLASTIC ROCKS "," PARTICULARLY
 PELITES OR CARBONAEOUS PHYLLITES IN THE SEQUENCE */
        expl /* I am trying to determine the presence of a
 favorable host rock for massive sulfide Pb-Zn type deposits */
        announce /* To date "," there is little that is known
 about the occurrence of sediment-hosted massive sulfide Pb-Zn
 deposits in New England "." The following questions are intended
 to aid in evaluating the potential for this type of deposit in
 metasedimentary rocks */
        yes SETTING  no NOPOT
---
space SETTING       desc /* Favorable regional setting  */
        ques /* WITHIN THE SEQUENCE "," DO YOU OBSERVE BEDS
 OF VARIABLE THICKNESS OR BEDS THAT CONTAIN ALLOCHTHONOUS
 COMPONENTS SUCH AS COARSE-GRAINED OR VOLCANOCLASTIC OR
 BRECCIATED FRAGMENTS OR ELSE LIMESTONE OR DOLOMITE BRECCIA */
        expl /* I am trying to determine if there is evidence
 of tectonism that was contemporaneous either during or shortly
 after the time that the original sediments were deposited */
        yes  STRUCT  no ALT1
---
space STRUCT        desc /* Favorable structures */
        ques /* DO YOU OBSERVE ANY DOWNFAULTED BLOCKS IN THE
 SEQUENCE OR IS THERE EVIDENCE OF SYNDEPOSITIONAL FAULTING
 SUCH AS GROWTH FAULTS "," SLUMP BRECCIAS "," OR LOCAL ZONES
 OF FOLDING AND FAULTING OF GREATER INTENSITY RELATIVE TO THE
 REGIONAL DEFORMATION */
        expl /* Penecontemporaneous local vertical tectonism
 that could have led to the formation of smaller basins and
 rises could result in favorable sites for accumulation of
 sulfides derived from exhalative processes */
        yes ALT  no ALT1
---
space ALT desc /* Presence of alteration */
        ques /* DO YOU OBSERVE ANY SIGNS OF ALTERATION SUCH AS
 THE PRESENCE OF WHITE MICA "," SILICIFICATION CROSS-CUTTING
 THE SEQUENCE "," CHLORITIZATION "," OR TOURMALINIZATION IN
 THE ROCKS */
        expl /* I am looking for signs of hyrdrothermal alteration
 that would signal the presence of any ore-bearing fluids that
 may have been introduced from below */
        yes GEOCHEM   no GEOCHEM1
---
space GEOCHEM       desc /* Favorable geochemistry  */
        ques /* DO YOU OBSERVE EITHER IN THE ROCKS OR IN THE
 STREAM SEDIMENTS DERIVED FROM SUCH ROCKS ANOMALOUS CONCENTRATIONS
 OF Ag "," Ba "," Pb "," OR Zn */
```

```
         expl /* These elements are direct indicators of concealed
 Pb-Zn deposits */
         yes SPEC  no NOGEOCH
---
space SPEC          desc /* Speculative Potential for sediment-hosted
 massive sulfide Pb-Zn type deposit */
         inf /* Speculative Potential for sediment-hosted massive
 sulfide Pb-Zn deposit */
---
space NOGEOCH       desc /* Favorable geologic setting for
 sediment-hosted massive sulfide Pb-Zn deposit */
         inf /* Although you lack any direct evidence for a
 sediment-hosted massive sulfide Pb-Zn deposit "," there is
 sufficient evidence that suggests a favorable geologic setting
 for such a deposit */
---
space NOALT         desc /* Presence of anomalous base-metal
 concentrations within a generally favorable geologic setting
 for a sediment-hosted massive sulfide Pb-Zn deposit */
         inf /* The presence of anomalous base-metal concentrations
 within a generally favorable geologic setting for a sediment-hosted
 massive sulfide Pb-Zn deposit bears closer examination  */
---
space NOPOT         desc /* Insufficient evidence for a metallic
 resource */
         inf /* There is insufficient evidence to suggest the
 presence of a metallic resource */
---
space GEOSPEC       desc /* Presence of anomalous base-metals */
         inf /* The presence of anomalous base-metal concentrations
 suggests the possibility somewhere of a sediment-hosted
 massive sulfide Pb-Zn deposit "." More detailed sampling is
 indicated */
---
space GEOCHEM1      desc GEOCHEM  ques GEOCHEM  expl GEOCHEM
         yes NOALT  no NOPOT
---
space GEOCHEM2 desc GEOCHEM ques GEOCHEM  expl GEOCHEM
         yes GEOSPEC  no NOPOT
---
space ALT1          desc ALT  ques ALT  expl ALT
         yes GEOCHEM  no GEOCHEM2

STOP
```

```
model ocplut
        topspace AGE
---
space AGE desc /* Age of intrusive */
        announce /* The following is intended to aid in evaluating
 the Potential Mineral Resources in Ordovician to Carboniferous
 plutonic terranes in New England */
        choices /* RX RX1 RX2 RX3 */
---
space RX  desc /* Favorable porphyry type intrusive */
        noun-phrase /* Age of intrusive is Ordovician to
 Carboniferous "(500-290 m.y.)" */
        ques /* CAN THE ROCK BE CLASSIFIED ESSENTIALLY AS BEING OF
 QUARTZ-BEARING INTERMEDIATE COMPOSITION "," THAT IS ","
 GRANODIORITE "," TONALITE OR ADAMELLITE "," AND IF VISIBLE "," BEING
 COMPOSED OF CLOSELY SPACED PHENOCRYSTS IN A MICROGRANULAR APHANITIC
 QUARTZ-FELDSPAR GROUNDMASS WITH A TEXTURE SIMILAR TO FINE APLITE
 "(" A WET SUGAR APPEARANCE UNDER A HAND LENS ")" */
        expl /* Most of the known porphyry deposits are associated
 with intrusives with this composition and texture "." Quartz-poor
 diorite or gabbro are unlikely to be hosts for this type of
 deposit  */
        yes ASSOC  no RX2
---
space ASSOC         desc /* Favorable associated rock types */
        ques /* DO YOU OBSERVE CONTACTS WITH VOLCANIC ROCKS ","
 BRECCIA FRAGMENTS OF THE COUNTRY ROCK ", AND/OR" NUMEROUS
 DIKES AND APOPHYSES IN THE VICINITY */
        expl /* Ore-related intrusions are always passive "."
 That is "," their contacts show stoping "," intrusion brecciation
 "," and veining "." It is also evidence of a sub-volcanic
 environment */
        yes FRAC  no FRAC1
---
space FRAC          desc /* Evidence of fracturing */
        ques /* DO YOU OBSERVE ABUNDANT QUARTZ-VEIN FILLED
 FRACTURES "," OR MORE SIGNIFICANT "," ABUNDANT PYRITE
 IN CLOSELY SPACE VEINLETS IN THE ROCK */
        expl /* These are two strong indicators that are best
 developed in zones peripheral to a porphyry deposit */
        yes PYLL  no PYLL1
---
space PYLL          desc /* Evidence of propylitic alteration */
        ques /* ARE THERE SIGNS OF ALTERATION INDICATED BY THE
 PRESENCE OF CHLORITE "," EPIDOTE "," ACTINOLITE "," CALCITE ","
 PYRITE "," OR HEMATITE */
        expl /* Propylitic alteration forms an outer zone
 surrounding but not including known deposits thus providing a
 larger target for exploration  */
        yes ARG  no ARG1
---
```

```
space ARG desc /* Evidence of argillic alteration */
          ques /* IS THERE EVIDENCE OF CLAY REPLACMENT OF PLAGIOCLASE
 AND OTHER MAFIC MINERALS OR Al-RICH MINERALS SUCH AS PYROPHYLLITE
 OR ANDALUSITE PRESENT */
          expl /* Argillic alteration may be present and is due
 mainly to supergene processes  */
          yes GCHEM  no GCHEM1
---
space GCHEM          desc /* Geochemical data available */
          ques /* DO YOU HAVE GEOCHEMICAL DATA EITHER FROM STREAM
 SEDIMENTS OR PAN CONCENTRATES */
          expl /* Information on the geochemical expression of
 porphyry deposits is becoming increasingly more
 important as the search for such deposits requires the
 interpretation of more subtle clues in the data */
          yes CUPBZN  no SPEC
---
space CUPBZN         desc /* Presence of base metal anomalies */
          ques /* DO YOU OBSERVE AMOUNTS OF Cu "," Pb "," AND
 Zn IN EXCESS OF 100 ppm IN STREAM SEDIMENTS AND AMOUNTS OF Ba
 IN EXCESS OF 3000 ppm AND Sr IN EXCESS OF 1000 ppm IN HEAVY
 MINERAL CONCENTRATES AT ONE LOCATION OR A GROUP OF RELATED
 LOCATIONS */
          expl /* Although the geochemical expression of porphyry
 metal deposits is highly variable "," the concentrations of
 the above elements have been found extending out to 10 km
 from known deposits */
          yes ELEM  no SPEC
---
space ELEM           desc /* Evidence for type of porphyry */
          choices /* POSPORPH MO AU AG */
---
space POSPORPH       desc /* Possible Potential for Porphyry Copper */
 noun-phrase /* No data */
          inf /* Possible Potential Resource for Copper in
 Porphyry Copper Deposit  */
---
space MO  desc /* Porphyry copper - molybdenum rich grade
 material */  noun-phrase /* Data on Molybdenum in the rock */
          ques /* DO THE DATA SUGGEST THAT MOLYBDENUM
 IS PRESENT IN AMOUNTS OVER 300 ppm OVER A CONSIDERABLE VOLUME
 OF THE INTRUSIVE ROCK */
          expl /* I am considering the possibility of a copper
 porphyry molybdenum-rich type deposit */
          yes PORPHMO  no PROBPORPH
---
space AU  desc /* Porphyry copper - gold rich grade material */
          noun-phrase /* Data on Gold in the rock */
          ques /* DO THE DATA SUGGEST THAT GOLD IS
 PRESENT IN AMOUNTS OVER "0.1 g/t" OVER A CONSIDERABLE VOLUME
 OF THE INTRUSIVE ROCK */
          expl /* I am considering the possibility of a copper
 porphyry - gold rich type deposit */
          yes PORPHAU  no PROBPORPH
```

```
---
space AG  desc /* Porphyry copper grade material */
          noun-phrase /* Data on Copper and Silver */
          ques /* DO YOU HAVE DATA THAT SUGGEST THAT COPPER IS
 PRESENT IN AMOUNTS OVER 3000 ppm AND SILVER IN AMOUNTS OVER
 "1.0 g/t" OVER A CONSIDERABLE VOLUME OF THE INTRUSIVE AND
 COUNTRY ROCK */
          expl /* I am considering the possibility of copper
 porphyry type deposit */
          yes PORPHCU  no PROBPORPH
---
space PROBPORPH     desc /* Probable Potential for Porphyry Copper */
          noun-phrase /* No data */
          inf /* Probable Potential Resource for Copper in Porphyry
 Copper Deposit  */
---
space PORPHMO       desc /* Definite Potential for Porphyry Copper
 - Molybdenum Rich Deposit */
          inf /* Definite Potential Resource for Cu-Mo in
 Porphyry Copper - Molydenum Rich Deposit */
---
space PORPHAU  desc /* Definite Potential for Porphyry Copper
 - Gold Rich Deposit */
          inf /* Definite Potential Resource for Cu-Au in
 Porphyry Copper - Gold Rich Deposit */
---
space PORPHCU       desc /* Definite Potential for Cu in Porphyry
 Copper Deposit */
          inf /* Definite Potential Resource for Copper in Porphyry
 Copper Deposit */
---
space SPEC          desc /* Speculative Potential for Porphyry
 Copper */      noun-phrase /* No data */
          inf /* Speculative Potential Resource for Copper in
 Porphyry Copper Deposit  */
---
space NOPOT         desc /* Insufficient Evidence for Potential for
 Porphyry Copper */   inf /* Insufficient evidence at present that
 indicates a Potential Resource for Copper in a Porphyry Copper deposit  */
---
space FRAC1         desc FRAC  ques FRAC  expl FRAC
          yes PYLL1  no PYLL2
---
space PYLL1         desc PYLL ques PYLL expl PYLL
          yes ARG2   no  ARG3
---
space PYLL2         desc PYLL ques PYLL  expl PYLL
          yes ARG2  no ARG3
---
space ARG1          desc ARG  ques ARG  expl ARG
          yes GCHEM1  no GCHEM2
---
space ARG2          desc ARG  ques ARG  expl ARG
          yes GCHEM2  no GCHEM3
```

```
---
space ARG3          desc ARG  ques ARG  expl ARG
          yes GCHEM3   no  NOPOT
---
space GCHEM1        desc GCHEM  ques GCHEM  expl GCHEM
          yes CUPBZN  no SPEC
---
space GCHEM2   desc GCHEM  ques GCHEM  expl GCHEM
          yes CUPBZN1  no SPEC
---
space GCHEM3   desc GCHEM  ques GCHEM  expl GCHEM
          yes CUPBZN1  no SPEC
---
space CUPBZN1       desc CUPBZN  ques CUPBZN  expl CUPBZN
          yes ELEM1  no SPEC
---
space ELEM1         desc ELEM
          choices /* SPEC  MO1  AU1  AG1 */
---
space MO1 desc MO noun-phrase MO ques MO  expl MO
          yes POSPORPHMO  no POSPORPH
---
space AU1 desc AU noun-phrase AU ques AU  expl AU
          yes POSPORPHAU   no POSPORPH
---
space AG1 desc AG noun-phrase AG  ques AG  expl AG
          yes POSPORPHCU  no POSPORPH
---
space POSPORPHMO    desc /* Possible Potential for
 Porphyry Copper - Molybdenum Rich Deposit */
          inf /* Possible Potential Resource for Cu-Mo in
 Porphyry Copper - Molybdenum Rich Deposit */
---
space POSPORPHAU    desc /* Possible Potential for
 Porphyry Copper - Gold Rich Deposit */
          inf /* Possible Potential Resource for Cu-Au in
 Porphyry Copper - Gold Rich Deposit */
---
space POSPORPHCU    desc /* Possible Potential for
 Porphyry Copper */
          inf /* Possible Potential Resource for Copper in Porphyry
 Copper Deposit */
---
space RX1 desc RX   ques RX  expl RX
          noun-phrase /* Age of intrusive is Ordovician to Silurian
"(500-410 m.y.)" */
          yes ASSOC  no NOPOT
---
space RX3 desc RX   ques RX  expl RX
          noun-phrase /* Age of intrusive is Carboniferous
 "(360-290 m.y.)" */
          yes ASSOC  no NOPOT
---
space RX2 desc /* Favorable uranium source rock */
```

```
         noun-phrase /* Age of intrusive is Devonian
 "(410-360 m.y.)"  */
         ques /* CAN THE INTRUSIVE BEST BE DESCRIBED AS A PINK TO
 GRAY "," VARIABLY PORPHYRITIC "," PEGMATITIC OR TWO-MICA GRANITE */
         expl /* I am considering the possibility of a vein
 uranium type deposit */
         yes FRACT no NOPOTU
---
space FRACT          desc /* Evidence of fractures */
         ques /* DO YOU OBSERVE MAJOR FAULTS IN THE VICINITY OR IS
 THE INTRUSIVE HIGHLY FRACTURED */
         expl /* Extensive faulting and fracturing of the source
 rock for uranium is considered favorable for localized uranium
 concentrations */
         yes POTASH   no  POTASH1
---
space POTASH         desc /* Presence of potash-enriched zone */
         ques /* CAN YOU IDENTIFY POTASH-ENRICHED ZONES WITHIN
 THE INTRUSIVE */
         expl /* Localized potash-enriched zones within a potential
 source rock for uranium are a strong indicator of localized uranium
 concentration  */
         yes POSU  no SPECU
---
space POSU           desc /* Possible Potential for Vein Uranium
 deposit */          inf /* Possible Potential Resource for Uranium
 in Vein deposit */

space SPECU          desc /* Speculative Potential for Vein Uranium
 deposit  */         inf /* Speculative Potential Resource for Uranium
 in Vein Deposit */
---
space POTASH1        desc POTASH  ques POTASH   expl  POTASH
         yes POSU  no SPECU
---
space NOPOTU         desc /* Insufficient Evidence for Potential for
 Vein Uranium Deposit  */
         inf /* Insufficient Evidence for Potential Resource for
 Uranium in Vein Uranium Deposit  */


STOP
```

```
model jvlpl
        topspace RX
---
space  RX desc /* Presence of granitic pluton */
        ques /* ARE THE ROCKS PART OF OR OVERLYING A GRANITIC
 PLUTON */
        expl /* Granitoid rocks are the presumed source of tin */
        announce /* The following is intended to aid in evaluating
 the Potential Mineral Resources in Jurassic volcanic-plutonic
 terranes in New England */
        yes POS  no OTHR
---
space OTHR          desc  /* Other models than for Tin are under
 development */ inf  /* Models being developed for other than
 Tin in Jurassic volcanic-plutonic rocks */
---
space POS desc /* Favorable position in pluton  */
        ques /* ARE YOU AT A RELATIVELY HIGH LEVEL WITHIN THE PLUTON
 AS EVIDENCED BY FIELD RELATIONS "(" i"."e"." CONTACTS WITH VOLCANIC
 AND HOST ROCK ")" "," INTERNAL FABRIC "(" MIAROLITIC CAVITIES ","
 PEGMATITES "," VARIED TEXTURE - COMMONLY PORPHYRITIC ")" ","
 OR MINERALOGICAL P-T INDICATORS */
        expl /* I am trying to determine if you are at a relatively
 high level of the pluton "," the apical region and peripheral
 margins of which are considered as being most favorable with
 respect to the occurrence of tin-bearing deposits provided that
 these regions have survived erosion  */
        yes ALTQ   no  MIN3
---
space ALTQ          desc /* Evidence of greisenized granite  */
        ques /* DO YOU OBSERVE INTENSE ALBITIZATION ","
 HEMATIZATION "," OR DISSEMINATED ALTERED OR METALLIC MINERALS
 SUCH AS PYRITE "," COLUMBITE "," MOLYBDENITE "," OR
 CASSITERITE IN THE GRANITE
 HOST OR AN EQUIVALENT ALTERATION OF THE ADJACENT HOST ROCKS */
        expl /* I am trying to determine signs of greisenized
 granite or relative closeness to greisen lode systems or cusps
 at depth  */
        announce /* Please note ! The following question asks
 you about evidence for greisenized granite "." If you do not
 observe such evidence but do observe other types of alteration
 there is an alternative alteration question further along
 in the model */
        yes  STRUCT   no  ALTS
---
```

```
space STRUCT        desc /* Favorable structure  */
         ques  /* ARE THERE ANY MAJOR FAULTS OR ZONES OF FRACTURE
 OR DIKES OR LINEAMENTS OBSERVABLE  */
         expl /* Either regional or local zones of fracturing would
 have permitted the flow of fluids from a cooling magma and possibly
 would have resulted in post-magmatic tin-mineralization or
 served as sites for later replacement veins */
         yes  QTZ   no  QTZ
---
space QTZ desc /* Presence of quartz-cassiterite mineral
 assemblage */  noun-phrase  /* quartz-cassiterite mineral
 assemblage */  ques /* DO YOU OBSERVE CHALCOPYRITE
 "," MOLYBDENITE "," ARSENOPYRITE "," OR TOPAZ */
         expl /* These are minerals that are associated with
 quartz-cassiterite type mineralization  */
         yes PROBQTZ  no  CHEMQ
---
space PROBQTZ       desc /* Probable Potential for Tin in
 greisens or quartz-cassiterite veins or stockworks */
         inf /* Probable Potential Resource for Tin in Greisens
 of Quartz-cassiterite veins or stockworks  */
---
space POSQTZ        desc /* Possible Potential for Tin in
 greisens or quartz-cassiterite veins or stockworks */
         inf /* Possible Potential Resource for Tin in Greisens
 of Quartz-cassiterite veins or stockworks  */
---
space ALTS          desc /* Favorable localized alteration */
         ques /* DO YOU OBSERVE ALTERATION OF THE PRIMARY MINERALS
 IN THE GRANITE HOST TO CHLORITE "," SERICITE "," EPIDOTE "," OR
 CLAY MINERALS ALONG FRACTURES FILLED EITHER WITH QUARTZ AND/OR
 MINERALS SUCH AS FLUORITE "," CARBONATES "," OR SULFIDES */
         expl /* Localization of alteration and mineralization
 along fractures suggests formerly percolating aqueous fluids */
         yes STRUCT1   no MIN2
---
space STRUCT1       desc STRUCT  ques STRUCT  expl STRUCT
         yes MIN   no MIN1
---
space MIN desc /* Type of mineralization  */
         choices /* CHEMQS SULF QTZ1 */
---
space SULF          desc /* Presence of Pb-Zn sulfide minerals */
         noun-phrase /* Pb-Zn sulfide minerals */
         ques /* DO YOU OBSERVE ANY SULFIDES SUCH AS GALENA OR
 SPHLALERITE EITHER DISSEMINATED IN THE HOST ROCK OR IN VEINS */
         expl /* The presence of sulfides may be indicative of
 nearby sulfide-cassiterite concentrations */
         yes PROBSULF  no CHEMS
---
space PROBSULF      desc /* Probable potential resource for tin in
 sulfide-cassiterite deposits */
         inf /* Probable Potential Resource for Tin in
 Sulfide-cassiterite type deposits  */
```

```
---
space SPEC          desc /* Speculative potential resource for tin */
          noun-phrase  /* No evidence of mineralization */
          inf /* Speculative Potential Resource for Tin either
 within or in rocks intruded by Tin-enriched Granites */
---
space POSSULF       desc /* Possible potential resource for tin in
 sulfide-cassiterite deposits */
          noun-phrase /* No evidence of mineralization */
          inf /* Possible Potential Resource for Tin in
 Sulfide-cassiterite type deposits */
---
space POSQTZSULF    desc /* Possible potential resource for
 tin in either quartz-cassiterite or sulfide-cassiterite
 deposits */  inf /* Possible Potential Resource for Tin in
 either Quartz-cassiterite or Sulfide-cassiterite type deposits */
---
space MIN1          desc MIN  choices /* CHEMQS SULF2 QTZ2 */
---
space QTZ1          desc QTZ   ques QTZ  expl QTZ noun-phrase QTZ
          yes PROBQTZ  no CHEMQ1
---
space QTZ2          desc QTZ  ques QTZ  expl QTZ noun-phrase QTZ
          yes PROBQTZ  no CHEMQ2
---
space SULF1         desc SULF  ques SULF  expl SULF noun-phrase SULF
          yes PROBSULF   no CHEMS1
---
space MIN2          desc MIN  choices /* SPEC SULF2  QTZ3 */
---
space SULF2         desc SULF  ques SULF  expl SULF noun-phrase SULF
          yes POSULF  no CHEMS2
---
space MIN3          desc MIN  choices /* SPEC ALTMINS  ALTMINQ */
---
space ALTMINS       desc /* Presence of sulfide-cassiterite
 mineralization */
          noun-phrase /* alteration with sulfide-cassiterite
 minerals */
          ques ALTS  expl /* I am now considering the possiblility
 of being above a hidden lower pluton
 as indicated by this type of alteration "." Recurring plutonism
 has occurred over a range of depth and time leaving the
 possibility of hidden cupolas */
          yes STRUCT3  no ALTCHEMS
---
space ALTMINQ   desc /* Presence of quartz-cassiterite
 mineralization  */
          noun-phrase /* alteration with quartz-cassiterite minerals */
          ques ALTQ  expl  ALTMINS
          yes STRUCT2  no ALTCHEMQ
---
space STRUCT3  desc STRUCT ques STRUCT  expl STRUCT
          yes POSHSULF  no SPEC
```

```
---
space STRUCT2  desc STRUCT ques STRUCT  expl STRUCT
          yes POSHQTZ  no SPEC
---
space POSHSULF       desc /* Possible Potential Resource for tin in
 deposits related to a hidden lower pluton */
          inf /* Possible Potential Resource for tin in
 Sulfide-cassiterite type Deposits in Hidden lower Pluton */
---
space POSHQTZ desc POSHSULF
          inf /* Possible Potential Resource for Tin in Greisen
 or Quartz-cassiterite veins or stockworks in Hidden Lower
 Pluton  */
space QTZ3           desc QTZ  ques QTZ expl QTZ  noun-phrase QTZ
          yes POSQTZ  no CHEMQ3
---
space CHEMQ          desc /* Favorable chemistry  */
          ques /* DO THE DATA INDICATE ANOMALOUS VALUES FOR
 As "," Cu "," Mo "," OR Sn */
          expl /* These elements are associated with quartz-cassiterite
 mineral assemblages */
          yes PROBQTZ  no POSQTZ
---
space CHEMQS         desc /* Favorable chemistry */
          ques /* DO THE DATA INDICATE ANOMALOUS VALUES FOR
 Ag "," As "," Cu "," Mo "," Pb "," Sn "," OR Zn */
          expl /* These elements are associated with either
 quartz-cassiterite or sulfide-cassiterite mineral assemblages */
          noun-phrase /* No evidence of mineralization  */
          yes POSQTZSULF  no SPEC
---
space CHEMQ1         desc CHEMQ  ques CHEMQ expl CHEMQ
          yes PROBQTZ  no SPEC
---
space CHEMQ2         desc CHEMQ ques CHEMQ expl CHEMQ
          yes PROBQTZ  no SPEC
---
space CHEMQ3         desc CHEMQ   ques CHEMQ  expl CHEMQ
          yes PROBQTZ   no SPEC
---
space CHEMS          desc /* Favorable chemistry */
          ques /* DO THE DATA INDICATE ANOMALOUS VALUES FOR
          Ag "," Pb "," OR Zn */
          expl /* These elements are associated with sulfide-cassiterite
 mineral assemblages */
          yes PROBQTZ  no SPEC
---
space CHEMS1         desc CHEMS  ques CHEMS  expl CHEMS
          yes PROBSULF  no SPEC
---
space CHEMS2         desc CHEMS  ques CHEMS   expl CHEMS
          yes PROBSULF  no SPEC
---
space ALTCHEMQ       desc CHEMQ   expl CHEMQ   ques CHEMQ
```

```
          yes STRUCT2   no SPEC
---
space ALTCHEMS   desc CHEMS  expl CHEMS  ques CHEMS
          yes STRUCT3   no SPEC


STOP
```

```
model surf
        topspace ORG
---
space  ORG          desc /* Presence of organic material */
        ques /* DOES THE MATERIAL CONTAIN VISIBLE AMOUNTS
 OF ORGANIC MATTER */
        expl /* Texture is not critical */
        announce /* The following is intended to aid in the
 evaluation of the Potential Mineral Resources in surficial
 materials in New England */
        yes TMG  no ALLUV
---
space TMG desc /* Favorable bedrock composition */
        ques /* DOES THE MATERIAL OVERLIE TWO-MICA
 GRANITE OR PEGMATITIC GRANITE OR PEGMATITE */
        expl /* Such rocks may range from Ordovician to
 Devonian in age */
        announce /* Uranium and other trace metals are known
        to occur in organic matter "." The following questions
        are intended to aid in evaluating this possibility */
        yes VALLEY  no PROX
---
space PROX          desc /* Proximity to two-mica granite with
 fractures  */   ques /* IS THE MATERIAL SITUATED NEAR TWO-MICA
 GRANITES THAT EXHIBIT FRACTURES  */
        expl /* Proximity to such rocks with fractures could
 indicate a favorable setting for Uranium deposition */
        yes VALLEY   no NONE
---
space VALLEY        desc /* Favorable topographic setting */
        ques /* IS THE MATERIAL SITUATED IN EITHER A VALLEY
 OR BASIN SETTING  */
        expl /* I am trying to establish if the setting
 is favorable for accumulation of organic matter */
        yes HMS      no NONE
---
space HMS   desc /* Presence of heath, marsh or swamp
 environment */  ques /* IS THE VEGETATION INDICATIVE OF
 A HEATH, SWAMP, OR MARSH ENVIRONMENT  */
        expl /* The geomorphic development of the present
 wetland must be determined in order to locate layers of
 organic deposits that may have accumulated */
        yes GRDWTR1  no GRDWTR2
---
space GRDWTR1  desc /* Evidence of water movement */
        ques /* IS THERE EVIDENCE EITHER OF GROUNDWATER OR
 SURFACE WATER MOVEMENT */
        expl /* In bedrock, look for zones of fracture ";"
 in surficial deposits, look for permeable horizons";" in swamps,
 marshes, and heaths, look for vertical sequences of former
 swamp, marsh, and heath environments  */
```

```
         yes SAMP  no U2
---
space GRDWTR2 desc /* Evidence of water movement */
         ques GRDWTR1  expl GRDWTR1
         yes U2  no SPEC
---
space SAMP  desc /* Have sampled sites of possible Uranium
 concentration */
    ques /* HAVE YOU SAMPLED SITES WHERE URANIUM IS LIKELY
 TO BE CONCENTRATED AND PRESERVED  */
         announce /* Congratulations! You have identified a
 favorable geologic setting for Uranium  */
         expl /* Such localities are stratigraphic horizons below
 ponds, underneath heaths or within swamps */
         yes U1  no PROB
---
space U1   desc  /* Presence of Uranium */
         ques /* IS THE URANIUM CONTENT OF THE MATERIAL
 100 PPM OR GREATER */
         expl /* This is the minimum concentration in order
 that the material be considered a potential resource for
 Uranium */
         yes DEF  no PROB
---
space DEF  desc /* Definite Potential Uranium Resource */
         inf /* Definite Potential Resource for Uranium in
 Holocene Organic Materials */
---
space PROB   desc /* Probable Potential Uranium Resource */
         inf /* Probable Potential Resource for Uranium in
 Holocene Organic Materials */
---
space U2  desc U1
         ques U1   expl U1
         yes PROB  no POSS
---
space POSS          desc /* Possible Potential Uranium Resource  */
         inf /* Possible Potential Resource for Uranium in
 Holocene Organic Materials */
---
space SPEC   desc /* Speculative Potential Uranium Resource  */
         inf /* Speculative Potential Resource for Uranium in
 Holocene Organic Materials  */
---
space NONE          desc /* Insufficient Evidence for Potential Uranium Resource  */
         inf /* Insufficent evidence at present that indicates
 a Potential Resource for Uranium in Holocene Organic Materials */
---
space ALLUV         desc /* Presence of alluvial material */
         ques /* CAN THE MATERIAL BE CONSIDERED AS ALLUVIAL IN
 ORIGIN */
         expl /* I am considering the possibility of placer type
 deposits  */
         yes GRAN_SCR   no RESID
```

```
---
space GRAN_SCR      desc /* Presence of granitic source rocks */
         ques /* IS THE SEDIMENT DERIVED FROM GRANITIC SOURCE
 ROCKS  */   expl /* I am trying to determine the favorability
 for an alluvial tin placer */
         yes  GRAN_CP  no  METARX
---
space SN_PLCR       desc /* Speculative Potential Tin Resource */
         inf  /* Speculative Potential Resource for Tin in
 placer deposits */
---
space METARX        desc /* Favorable gold-bearing source rocks */
         ques /* IS THE SEDIMENT DERIVED FROM EITHER METAVOLCANIC
 OR METASEDIMENTARY ROCKS  */
         expl /* I am trying to determine the favorability for an
 alluvial gold placer  */
         yes  AU_PLCR  no NOPOT
---
space AU_PLCR       desc /* Speculative Potential Gold Resource */
         inf /* Speculative Potential Resource for Gold in
 placer deposits  */
---
space RESID         desc /* Presence of residual accumulation */
         ques /* IS THE MATERIAL THE RESULT OF RESIDUAL
 ACCUMULATION */  expl /* Residual placers are of economic
 interest */
         yes GRAN_PLT   no NOPOT
---
space GRAN_PLT      desc  GRAN_SCR  ques  GRAN_SCR
         expl /* I am trying to determine the favorability for
 a residual tin placer deposit  */
         yes GRAN_CP  no NOPOT
---
space NOPOT desc /* Insufficient Evidence for Potential Resource */
         inf /* Insufficient evidence at present that indicates
 a Potential Resource in Surficial Sediments */
space GRAN_CP       desc /* Favorable Tin-bearing composition */
         ques /* DOES THE MATERIAL OR THE ROCK FROM WHICH THE
 MATERIAL WAS DERIVED CONTAIN TOPAZ "," CASSITERITE "," FLUORITE
 "," OR BERYLLIUM-BEARING MINERALS */
         expl /* Tin-specialized granitic rocks have relatively
 high concentrations of gaseous constituents such as H2O ","
 P "," Cl "," F "," and S as well as large-ion lithophile and
 other elements such as Li "," Be "," Zr "," Nb "," Mo "," Sn ","
 Ta "," W "," Th "," U "," and some REE "," all or some of which
 would be reflected in the mineralogy  */
         yes SN_PLCR   no  NOPOT

STOP
```

## Appendix B

## BNF DESCRIPTION OF THE FORMAL LANGUAGE FOR EXTERNAL REPRESENTATION OF MUPROSPECTOR MODLELS

This appendix contains a modified Backus-Naur Form description of the syntax of muPROSPECTOR's knowledge representation language, which is used for representing models in external files. The syntax described here is the one accepted by muPROSPECTOR's parser.

The following conventions apply:

- Terminal symbols are written in uppercase.
- Nonterminal symbols are either written in upper case and enclosed in angled brackets or implicitly defined by a phrase written within double quotes.
- Alternate choices are enclosed in parentheses.
- Optional items are enclosed in square brackets.
- Items repeated at least once are enclosed in curly brackets.
- Unless stated otherwise, terminals must be separated by a <delimiter> (defined below).

<model definition> ::= MODEL <model name>
  TOPSPACE <space name> [<space definition>] <stop>

<model name> ::= <character string>

<character string> ::= "a sequence of characters except a <delimiter character>"

<delimiter> ::= [<delimiter character>]

<delimiter character> ::= ("space" "tab" "carriage return" "line feed"
  "comma" "period")

<space name> ::= <character string>

<text> ::= /* <text body> */

<text body> ::= "a sequence of arbitrary characters, except the sequence
'*/'"

<space definition> ::= space <space name> <text section> [(<optional section>)]

<text section> ::= [<text entry>]

<text entry> ::= (<description entry> [<announce entry>] [<explanation entry>])

<description entry> ::= DESC ( <space name> <text> )

<announce entry> ::= ANNOUNCE ( <space name> <text> )

<explanation entry> ::= EXPL ( <space name> <text> )

<inference entry> ::= INF ( <space name> <text> )

<choices entry> ::= CHOICES [ <space name> ]

<noun-phrase entry> ::= NOUN-PHRASE ( <space name> <text> )

<question entry> ::= QUES ( <space name> <text> )

<yes entry> ::= YES <space name>

<no entry> ::= NO <space name>

<default entry> ::= ( DEF <space name> <no entry> )

## Appendix C

## PROGRAM LISTING OF muPROSPECTOR II

The following is the current source listing of muPROSPECTOR. muPROSPECTOR is written in the muLISP programming language.

```
; File: MUPROSPECTOR.LIB          9/21/84          Richard B. McCammon

(PUTD 'DEFUN '(NLAMBDA (NAM$ EXP$) (PUTD NAM$ EXP$) NAM$))

(DEFUN SETQQ (NLAMBDA (NAM$ EXP$)
  (SET NAM$ EXP$)
  NAM$ ))


(LOOP (PRINl '*) (EVAL (READ)) ((NULL RDS)))

(DEFUN ADDl (LAMBDA (NUM$)
  (PLUS NUM$ 1) ))

(DEFUN CENTER (LAMBDA (MSG)
  (SPACES (QUOTIENT (DIFFERENCE (LINELENGTH) (LENGTH MSG)) 2))
  (PRINT MSG) ))

(DEFUN DO-CHOICES (LAMBDA (CHOICES LST)
  (PUSH CHOICES LST)
  (LOOP
    ((NULL CHOICES)
      (LIST (REVERSE LST)) )
    (PUSH (DO-SPACE (NTH (DIFFERENCE (POP CHOICES) 1) (GET-LIST SPACE
        'choices))) LST) ) ))

(DEFUN DO-SPACE (LAMBDA (SPACE ANSWR)
  ((EQ (CAR (FLAGP SPACE 'inf)) 'inf)
    (SETQ *RESULTS* (CONS (CONS SPACE 'I) *RESULTS*))
    (SETQ *EVSP* (APPEND (LIST SPACE) *EVSP*))
    NIL )
  ((GET SPACE 'choices)
    (DO-CHOICES (GET-CHOICES SPACE)) )
  (SETQ ANSWR (GET-YESNO SPACE ANSWR))
  (CONS ANSWR (DO-SPACE (GET-SPACE SPACE ANSWR))) ))

(DEFUN EQLIST (LAMBDA (LSTl LST2)
  ((NULL LSTl)
    (NULL LST2) )
  ((NULL LST2) NIL)
  ((NOT (EQ (CAR LSTl) (CAR LST2))) NIL)
  (EQLIST (CDR LSTl) (CDR LST2)) ))

(DEFUN EVALUATE (LAMBDA (RESULT SP STR ANS EV EVSP EST UNC)
  ((NULL RESULT)
    (PRTSENT '(No results yet) 2) )
  (SETQ STR RESULT)
  ( ((EQ SP *TOP*)
      (CLRSCRN)
      (SEPARATOR)
      (PRTSENT (APPEND '(Based on your answers) (LIST *NAME*) '("," my
          evaluation of the potential for undiscovered mineral deposits
          occurring in the area you are considering is as follows:)) 2)
```

```
      (LOOP
        (SETQ ANS (POP STR))
        ((NULL ANS)
          (SETQ EV (REMOVE-DUPLISTS EV))
          (LOOP
            ((NULL EV))
            (PRTSENT (POP EV) 1) ) )
        ( ((AND
             (EQ (CDR ANS) 'I)
             (NULL (MEMBER (CAR ANS) EVSP)) )
           (PUSH (GET-LIST (CAR ANS) 'inf) EV)
           (PUSH (CAR ANS) EVSP) ) ) ) ) )
  (LOOP
    (SETQ ANS (POP RESULT))
    ((NULL ANS)
      (TERPRI)
      (SETQ EST (REMOVE-DUPLISTS EST))
      (PRTSENT '(You have established:) 2)
      (LOOP
        ((NULL EST))
        (SPACES 5)
        (PRTSENT (POP EST) 1) )
      ((NOT (NULL UNC))
        (TERPRI)
        (SETQ UNC (REMOVE-DUPLISTS UNC))
        (PRTSENT '(You were uncertain about:) 2)
        (LOOP
          ((NULL UNC))
          (SPACES 5)
          (PRTSENT (POP UNC) 1) ) ) )
    (LOOP
      ((EQ (CDR ANS) 'D)
        (PUSH (GET-LIST (CAR ANS) 'desc) UNC) )
      ((EQ (CDR ANS) 'Y)
        (PUSH (GET-LIST (CAR ANS) 'desc) EST) )
      ((EQ (CDR ANS) 'N)
        (PUSH (NO-ANSWER (GET-LIST (CAR ANS) 'desc)) EST) )
      ((EQ (CDR ANS) 'I)) ) )
  ((NOT (EQ SP *TOP*))
    (SETQ *LST* *EVSP*)
    (GET-DEPTH SP)
    (SETQ *LST* (REVERSE (PRUNE-LIST *LST*)))
    (TERPRI)
    (PRTSENT '("Presently," I would favor the following:) 2)
    (LOOP
      ((NULL *LST*)
        (TERPRI)
        (RETURN)
        (TERPRI) )
      (SPACES 5)
      (PRTSENT (GET-LIST (POP *LST*) 'inf) 1) ) ) ))

(DEFUN EVAL-CHOICES (LAMBDA (CHOICES)
  (LOOP
```

```
    ((NULL CHOICES))
    (GET-DEPTH (POP CHOICES)) ) ))

(DEFUN FIND-LENGTH (LAMBDA (MSG)
  (SETQ N 0)
  (LOOP
    ((NULL MSG) N)
    (SETQ N (PLUS N (LENGTH (POP MSG)))) ) ))

(DEFUN FLUSH (LAMBDA NIL
  (LOOP
    ((EQ (READCH) CR)) ) ))

(DEFUN GET-CHOICE (LAMBDA (LST CHAR RDS READCH READ)
  (LOOP
    (SETQ READCH 'NIL)
    (SETQ CHAR (READCH))
    (SETQ READCH 'T)
    (PRINT CHAR)
    (SETQ READCH 'NIL)
    (TERPRI)
    ((EQ CHAR 'Q)
      (SYSTEM) )
    (SETQ NAM (CADR (ASSOC CHAR FILENAMES)))
    ((AND
        (MEMBER CHAR LST)
        (NOT (EQ NAM 'NONE)) ) NAM)
    (SETQ READCH 'T)
    ( ((EQ NAM 'NONE)
        (PRTSENT '(The models for this terrane are not yet completed ".") 2)
          ) )
    (PRTSENT '(please re - enter ".") 1)
    (SETQ READCH 'NIL) ) ))

(DEFUN GET-CHOICES (LAMBDA (SPACE LST N)
  ( ((NOT (EQ (GET SPACE 'announce) NIL))
      (PRTSENT (GET-LIST SPACE 'announce) 2) ) )
  (PRTSENT '(For which of the following do you have any information :) 2)
  (SETQ LST (GET-LIST SPACE 'choices))
  (SETQ N 0)
  (LOOP
    ((NULL LST))
    (SETQ N (PLUS N 1))
    (PRTSENT (APPEND (LIST N) '(")") (GET-LIST (POP LST) 'noun-phrase)) 1) )
  (TERPRI)
  (LOOP
    (SETQ LST NIL)
    (PRTSENT '(Please enter one or more of the preceding numbers) 1)
    (SPACES 5)
    (PRTSENT '("(separated" by blanks and terminating with a <CR>))
    (CHARTYPE CR 2)
    (LOOP
      (SETQ CHAR (RATOM))
      ((EQ CHAR CR)
```

```
        (TERPRI) )
      ( ((MEMBER CHAR LST))
        (PUSH CHAR LST) ) )
    (CHARTYPE CR 1)
    ((TEST-LST LST N)
      (REVERSE LST) )
    (PRTSENT '(please re - enter ".") 1) ) ))

(DEFUN GET-DEFAULT (LAMBDA (SP KEY LST)
  (SETQ LST (GET-LIST SP KEY LST))
  ( ((NOT (EQ LST NIL) LST)
      (SETQ LST 'N) ) ) ))

(DEFUN GET-DEPTH (LAMBDA (SP)
  (LOOP
    ((EQ (CAR (FLAGP SP 'inf)) 'inf)
      (SETQ *LST* (APPEND (LIST SP) *LST*)) )
    ((GET SP 'choices)
      (EVAL-CHOICES (GET-LIST SP 'choices)) )
    (SETQ SP (GET-SPACE SP 'no)) ) ))

(DEFUN GET-FILENAMES (LAMBDA (FILNAM LST)
  (LOOP
    ((NULL FILNAM)
      (REVERSE LST) )
    (PUSH (CAR (POP FILNAM)) LST) ) ))

(DEFUN GET-LIST (LAMBDA (SP KEY LST FIRST)
  (SETQ POINT (GET SP KEY))
  ((EQ POINT NIL)
    (SETQ LST '(No further explanation available at this time)) )
  (RDS *FILNAM* 'MDL)
  (READPTR POINT)
  (RATOM)
  (RATOM)
  (LOOP
    (SETQ NEXT (RATOM))
    ((AND
        (EQ NEXT '*)
        (EQ (READCH T) '/) )
      (PROG1
        (REVERSE LST)
        (RDS) ) )
    (SETQ LST (CONS NEXT LST)) ) ))

(DEFUN GET-RESPONSE (LAMBDA (LST HLP CHAR READ READCH RDS)
  (LOOP
    (SETQ READCH 'T)
    (PRTSENT LST)
    (SETQ READCH 'NIL)
    (SETQ CHAR (READCH))
    (SETQ READCH 'T)
    (PRINT CHAR)
    (SETQ READCH 'NIL)
```

```
    (TERPRI)
    ((EQ CHAR ESC)
      (SYSTEM) )
    ((EQ CHAR 'Y)
      'Y )
    ((EQ CHAR 'N)
      'N )
    ((EQ CHAR 'D)
      'D )
    ((EQ CHAR 'S)
      'S )
    ( ((EQ CHAR '?)
       (SETQ READCH 'T)
       (PRTSENT HLP 2)
       (SETQ READCH 'NIL) )
      (SETQ READCH 'T)
      (PRTSENT '(I don't understand "," please re - enter ".") 1)
      (SETQ READCH 'NIL) ) ) ))

(DEFUN GET-SPACE (LAMBDA (SP ANS)
  (RDS *FILNAM* 'MDL)
  (SETQ KEY (CADR (ASSOC ANS RESPONSE)))
  (SETQ POINT (GET SP KEY))
  ( ((EQ POINT NIL)
     (READPTR (GET SP 'no)) )
    (READPTR POINT) )
  (RATOM) ))

(DEFUN GET-TERRANE (LAMBDA (LST1 LST2 NUM)
  (RDS)
  (TERPRI)
  (CLRSCRN)
  (CENTER "m u P R O S P E C T O R   I I")
  (TERPRI)
  (CENTER "T E R R A N E   C L A S S I F I C A T I O N")
  (TERPRI 2)
  (SPACES (QUOTIENT (DIFFERENCE (LINELENGTH) 46) 2))
  (PRINT "Number              Terrane")
  (TERPRI)
  (SETQ LST1 TERRLST)
  (SETQ LST2)
  (SETQ NUM 1)
  (LOOP
    ((EQ LST1))
    (SPACES (QUOTIENT (DIFFERENCE (LINELENGTH) 43) 2))
    (PUSH (PRIN1 NUM) LST2)
    (SETQ NUM (PLUS NUM 1))
    (SPACES 1)
    ( ((LESSP (LINELENGTH) 50))
      (SPACES 3) )
    (PRINT (POP LST1)) )
  (TERPRI 2)
  (PRTMSG '(Enter number or Q to quit the terrane you think most closely
     matches the area you have in mind:))
```

```
  (GET-CHOICE (GET-FILENAMES FILENAMES)) ))

(DEFUN GET-YESNO (LAMBDA (SPACE)
  ((GET (GET SPACE 'PQUES) 'ASKED)
    (SETQ *RESULTS* (CONS (CONS SPACE (GET (GET SPACE 'PQUES) 'ANS))
        *RESULTS*))
    ANS )
  ( ((NOT (EQ (GET SPACE 'announce) NIL))
      (PRTSENT (GET-LIST SPACE 'announce) 2) ) )
  (LOOP
    (SETQ ANS (GET-RESPONSE (APPEND (LIST (PLUS QUESTN 1) '--) (GET-LIST
        SPACE 'ques) '("(Y/N/D/S/?) :")) (GET-LIST SPACE 'expl)))
    ((NOT (EQ ANS 'S))
      (SETQ *RESULTS* (CONS (CONS SPACE ANS) *RESULTS*))
      (PUT (GET SPACE 'PQUES) 'ASKED 'T)
      (PUT (GET SPACE 'PQUES) 'ANS ANS)
      (SETQ QUESTN (PLUS QUESTN 1))
      ANS )
    (EVALUATE *RESULTS* SPACE) ) ))

(DEFUN HEADER (LAMBDA (RDS)
  (REGISTER 0 10752)
  (INTERRUPT 33)
  (SETQ YEAR (DIFFERENCE (REGISTER 2) 1900))
  (SETQ MONTH-DAY (DIVIDE (REGISTER 3) 256))
  (REGISTER 0 11264)
  (INTERRUPT 33)
  (SETQ HOUR-MINUTES (DIVIDE (REGISTER 2) 256))
  (SETQ SECONDS (DIVIDE (REGISTER 3) 256))
  (SETQ MINUTES (CDR (DIVIDE (REGISTER 2) 256)))
  (SETQ SECONDS (CAR SECONDS))
  ((LESSP MINUTES 10)
    (SETQ MINUTES (PACK (LIST '0 MINUTES))) )
  ((LESSP SECONDS 10)
    (SETQ SECONDS (PACK (LIST '0 SECONDS))) )
  (SETQ DATE-LINE (LIST (CDR MONTH-DAY) '- (CDR (ASSOC (CAR MONTH-DAY)
      MONTHS)) '- YEAR "    " (CAR HOUR-MINUTES) ': MINUTES ': SECONDS))
  (PRINT "muPROSPECTOR --- Version II")
  (PRINT "U.S. Geological Survey")
  (PRINT (PACK DATE-LINE)) ))

(DEFUN INSTRUCTIONS (LAMBDA (RDS)
  ((NOT (EQ *NAME* '*NAME*)))
  (PRTSENT (APPEND HELLO '(First I need to know your name "." Please type in
      your first name and then press the RETURN key ".")) 2)
  (SPACES 10)
  (PRTSENT '(Your first NAME :))
  (SETQ *NAME* (RATOM))
  (TERPRI)
  (PRTSENT (CONS 'Thanks (CONS *NAME* (CONS '"," PURPOSE))) 1)
  (PRTSENT '(In using the program you will be asked to answer questions about
      the existence of various kinds of evidence "." Answers to questions can
      be """Y""" "," """N""" "," or if you dont know "," """D""" "." In
      addition to supplying answers "," you can request information at any
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      time with the following commands:) 2)
  (SPACES 10)
  (PRTSENT '("? -- Print" a rephrased version of the question) 1)
  (SPACES 10)
  (PRTSENT '("S -- Prints" a summary at this point in the consultation) 2)
  (RETURN) ))

(DEFUN LOAD-MODEL (LAMBDA (FILNAM ECHO RDS)
  (RDS FILNAM 'MDL)
  (SETQ SPLIST NIL)
  (LOOP
    (SETQ EXPN (RATOM))
    ((EQ EXPN 'STOP)
      (RDS) )
    ( ((EQ EXPN 'model)
       (SETQ *MODEL* (RATOM)) ) )
    ( ((EQ EXPN 'topspace)
       (SETQ *TOP* (RATOM)) ) )
    ( ((EQ EXPN 'space)
       (SETQ SPACE (RATOM))
       (PUT SPACE 'PQUES SPACE)
       (PUSH SPACE SPLIST) ) )
    ( ((MEMBER EXPN PLIST)
       (SETQ PROP EXPN)
       ( ((EQ PROP 'inf)
          (FLAG SPACE PROP) ) )
       (SETQ POINT (READPTR))
       (SETQ EXPN (RATOM))
       (SETQ PFLG (MEMBER EXPN SPLIST))
       ( ((NOT (EQ PFLG NIL))
          (SETQ POINT (GET (CAR PFLG) PROP))
          ( ((EQ PROP 'ques)
             (PUT SPACE 'PQUES (CAR PFLG)) ) ) ) )
       (PUT SPACE PROP POINT)
       ( ((AND
            (EQ EXPN '/)
            (EQ (RATOM) '*) )
          (PASS-EXPN) ) ) ) )
    ( ((MEMBER EXPN PTRLST)
       (PUT SPACE EXPN (READPTR)) ) ) ) ))

(DEFUN MUPROSPECTOR (LAMBDA NIL
  (RDS)
  (WRS)
  (CLRSCRN)
  (HEADER)
  (WAIT 1000)
  (READ-HDRFILE)
  (SETQ FILENAMES (SEQ-FILENAMES FILENAMES))
  (CLRSCRN)
  (TERPRI 2)
  (SPACES (QUOTIENT (DIFFERENCE (LINELENGTH) (FIND-LENGTH TITLE)) 2))
  (PRTSENT TITLE 2)
  (SETQ ESC (ASCII 27))
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  (SETQ CR (ASCII 13))
  (SETQ *FILNAM* '*FILNAM*)
  (CHARTYPE - 0)
  (INSTRUCTIONS)
  (TERPRI)
  (FLUSH)
  (LOOP
    ((LOOP
        (SETQ FILNAM (GET-TERRANE))
        ((RDS FILNAM 'MDL)
          (RDS) )
        (PRTSENT '(File NOT found) 2)
        (RETURN) ))
    ( ((NOT (EQ FILNAM *FILNAM*))
        (LOAD-MODEL FILNAM)
        (SETQ SPLIST (REVERSE SPLIST)) ) )
    (SETQ *FILNAM* FILNAM)
    (CLRSCRN)
    (SETQ QUESTN 0)
    (SETQ *RESULTS* NIL)
    (SETQ *EVSP* NIL)
    (UNDO SPLIST)
    (DO-SPACE *TOP*)
    (EVALUATE *RESULTS* *TOP*)
    (RDS)
    (TERPRI)
    (RETURN)
    (TERPRI)
    ((NOT (QUERY '(Do you wish to consider another terrane or another area
        "(Y/N/?):") '(You may wish to reconsider the same area)))  )
  (PRTSENT (APPEND '(Have a nice day) (LIST *NAME*) '("," and do come back
      !)) 2)
  T ))

(DEFUN NO-ANSWER (LAMBDA (LST FIX)
  (SETQ FIX (CADR (ASSOC (CAR LST) POSNEG)))
  ((NOT (EQ FIX NIL))
    (CONS FIX (CDR LST)) )
  (CONS 'No LST) ))

(DEFUN PASS-EXPN (LAMBDA NIL
  (LOOP
    ((AND
        (EQ (RATOM) '*)
        (EQ (READCH T) '/) )) ) ))

(DEFUN PRETERPRI (LAMBDA (NUM)
  ((GREATERP (PLUS (SPACES) NUM) (LINELENGTH))
    (TERPRI) ) ))

(DEFUN PRTMSG (LAMBDA (LST)
  (LOOP
    (PRIN1 (POP LST))
    ((NULL LST))
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    ( ((LESSP (SPACES) (LINELENGTH))
       (SPACES 1) ) ) ) ))

(DEFUN PRTSENT (LAMBDA (LST NUM)
  (LOOP
    ((NULL LST))
    ((NULL (CDR LST))
      (PRIN1 (CAR LST)) )
    ( ((OR
         (MEMBER (CADR LST) TRMLIS)
         (MEMBER (CADR LST) PCTLIS) )
       (PRETERPRI (ADD1 (LENGTH (CAR LST))))
       (PRIN1 (POP LST)) )
      ((MEMBER (CADR LST) SEPLIS)
        ((NULL (CDDR LST))
          (PRETERPRI (ADD1 (LENGTH (CAR LST))))
          (PRIN1 (POP LST)) )
        (PRETERPRI (PLUS (ADD1 (LENGTH (CAR LST))) (LENGTH (CADDR LST))))
        (PRIN1 (POP LST))
        (PRIN1 (POP LST)) ) )
    (PRIN1 (CAR LST))
    ((NULL (CDR LST)))
    ( ((MEMBER (POP LST) TRMLIS)
        ((EQ (ADD1 (SPACES)) (LINELENGTH))
          (TERPRI) )
        (SPACES 2) )
      ((EQ (SPACES) (LINELENGTH))
        (TERPRI) )
      (SPACES 1) ) )
  ((PLUSP NUM)
    (TERPRI NUM) )
  ((EQ (ADD1 (SPACES)) (LINELENGTH))
    (TERPRI) )
  (SPACES 2) ))

(DEFUN PRUNE-LIST (LAMBDA (LST)
  (SETQ LST1 NIL)
  (LOOP
    ((NULL LST) LST1)
    ( ((MEMBER (CAR LST) (CDR LST)) NIL)
      (PUSH (CAR LST) LST1) )
    (SETQ LST (CDR LST)) ) ))

(DEFUN READ-HDRFILE (LAMBDA NIL
  ((RDS 'MUPROSPECTOR 'HDR)
    (LOOP
      (SETQ EXPN (RATOM))
      ((EQ EXPN 'STOP)
        (RDS) )
      ( ((MEMBER EXPN HDRLST)
          (SET (CAR (MEMBER EXPN HDRLST)) (READ-LIST)) ) ) ) )
  (PRTSENT '(File NOT found) 2)
  (SYSTEM) ))
```

```
(DEFUN READ-LIST (LAMBDA (NEXT LST)
  (RATOM)
  (RATOM)
  (LOOP
    (SETQ NEXT (RATOM))
    ((AND
        (EQ NEXT '*)
        (EQ (READCH T) '/) )
      (REVERSE LST) )
    (SETQ LST (CONS NEXT LST)) ) ))

(DEFUN REMOVE (LAMBDA (LST1 LST2)
  ((NULL LST2) NIL)
  ((EQLIST LST1 (CAR LST2))
    (REMOVE LST1 (CDR LST2)) )
  (CONS (CAR LST2) (REMOVE LST1 (CDR LST2))) ))

(DEFUN REMOVE-DUPLISTS (LAMBDA (LST LST1)
  ((NULL (CADR LST)) LST)
  (LOOP
    ((NULL LST)
      (REVERSE LST1) )
    (SETQ LST1 (CONS (CAR LST) LST1))
    (SETQ LST (REMOVE (CAR LST) (CDR LST))) ) ))

(DEFUN RETURN (LAMBDA (RDS)
  (PRTSENT '(Press RETURN to continue "..."))
  (FLUSH) ))

(DEFUN REV (LAMBDA (X)
  (COND
    ((NULL X) NIL)
    (T (APPEND (REV (CDR X)) (REV2 (CAR X)))) ) ))

(DEFUN REV2 (LAMBDA (Y)
  (COND
    ((ATOM Y)
      (LIST Y) )
    ((ATOM (CAR Y))
      (LIST (REV Y)) )
    (T (LIST (APPEND (REV (CDR Y)) (REV2 (CAR Y))))) ) ))

(DEFUN QUERY (LAMBDA (LST HLP CHAR READ READCH RDS)
  (LOOP
    (SETQ READCH 'T)
    (PRTSENT LST)
    (SETQ READCH 'NIL)
    (SETQ CHAR (READCH))
    (SETQ READCH 'T)
    (PRINT CHAR)
    (SETQ READCH 'NIL)
    (TERPRI)
    ((EQ CHAR ESC)
      (SYSTEM) )
```

```
    ((EQ CHAR 'Y))
    ((EQ CHAR 'N) NIL)
    ( ((EQ CHAR '?)
        (SETQ READCH 'T)
        (PRTSENT HLP 2)
        (SETQ READCH 'NIL) )
      (SETQ READCH 'T)
      (PRTSENT '(I don't understand "," please re - enter ".") 1)
      (SETQ READCH 'NIL) ) ) ))

(DEFUN SEPARATOR (LAMBDA NIL
  (TERPRI)
  (PRTSENT '(----------) 1) ))

(DEFUN SEQ-FILENAMES (LAMBDA (LST LST1 N)
  (SETQ N 0)
  (LOOP
    ((NULL LST)
      (REVERSE LST1) )
    (PUSH (CONS (ADD1 N) (POP LST)) LST1)
    (SETQ N (ADD1 N)) ) ))

(DEFUN TEST-LST (LAMBDA (LST N OBJ)
  ((NULL LST) NIL)
  (LOOP
    ((NULL LST) T)
    (SETQ OBJ (POP LST))
    ((OR
        (NOT (PLUSP OBJ))
        (GREATERP OBJ N) ) NIL) ) ))

(DEFUN UNDO (LAMBDA (LST)
  (LOOP
    ((NULL LST))
    (PUT (POP LST) 'ASKED NIL) ) ))

(DEFUN WAIT (LAMBDA (LEN)
  (LOOP
    ((EQ LEN 1))
    (SETQ LEN (DIFFERENCE LEN 1)) ) ))

(SETQQ FILENAMES ("No FILENAMES"))

(SETQQ HDRLST (HELLO PURPOSE TITLE FILENAMES TERRLST))

(SETQQ HELLO (You have no HELLO))

(SETQQ MONTHS ((1 . Jan)
  (2 . Feb)
  (3 . Mar)
  (4 . Apr)
  (5 . May)
  (6 . Jun)
  (7 . Jul)
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  (8 . Aug)
  (9 . Sept)
  (10 . Oct)
  (11 . Nov)
  (12 . Dec) ))

(SETQQ PCTLIS ("," ";" ")" "(" :))

(SETQQ PLIST (desc ques expl inf noun-phrase announce))

(SETQQ POSNEG ((Evidence . "Lack of evidence")
  (Adequate . Inadequate)
  (Presence . Absence)
  (Favorable . Unfavorable)
  (Indication . "No indication")
  (Identified . Unidentified)
  (Have . "Have not")
  (Differentiated . Undifferentiated)
  (Estimable . Inestimable) ))

(SETQQ PTRLST (yes no def choices))

(SETQQ PURPOSE (You have no PURPOSE))

(SETQQ RESPONSE ((Y . yes)
  (N . no)
  (D . def) ))

(SETQQ SEPLIS ("'" -))

(SETQQ TERMINATOR (?))

(SETQQ TERRLST ("No TERRLST"))

(SETQQ TITLE (You have no TITLE))

(SETQQ TRMLIS ("." ! ?))

(RDS)
```