UNITED STATES DEPARTMENT OF INTERIOR GEOLOGICAL SURVEY

The isotopic composition of ore lead of the Creede mining district and vicinity, San Juan Mountains, Colorado:

Text of a talk presented at the San Juan Mountains Symposium to honor Thomas A. Steven

Rocky Mountain Section meeting of the Geological Society of America, May 2, 1987, Boulder, Colorado

by

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Abstract[1]

Galenas from the major Creede veins and their northern extensions are remarkably homogeneous in Pb-isotopic composition and are too radiogenic to have been derived from any magma comparable in composition to the principal volcanic rocks. This pattern was identified by Doe et al. in 1979 who proposed that the lead was derived from the Precambrian basement. The homogeneity of the ore leads, however, requires a uniform reservoir; an unlikely prospect for lead from the Precambrian basement. We report on 16 new analyses of geographically and paragenetically dispersed galenas from the Creede district and other areas as far as 11 km to the north. The lead values range from 18.972 to 19.060 for $^{206}Pb/^{204}Pb$, from 15.591 to 15.671 for $^{207}Pb/^{204}Pb$, and from 37.781 to 37.921 for $^{208}Pb/^{204}Pb$. These ranges overlap those previously reported for the main ore zone.

Recent work allows us to extend the results of Doe et al. and to consider alternative processes to explain the widespread homogeneity and radiogenic nature of the ore lead: 1) David Matty (pers. commun., 1986) has shown that some minor volcanic units in the area have unusually radiogneic lead values; magmas comparable in composition to the units are a possible, though improbable, source of the ore lead. 2) The uniformity of the isotopic values of galenas may have resulted from homogenization during an extensive potassium-metasomatic event that predated the ores; this possibility is being tested in an on-going study of feldspars from metasomatized and unmetasomatized rocks. 3) Recent regional studies suggest the possibility of a pre-volcanic, NNW-trending graben system filled by clastic sediments derived from the Precambrian basement, a process that would have an homogenizing effect on the lead isotopes. This interpretation implies importation, deep within the Creede hydrologic system, of fluids from remote sources. These alternatives show that the Pb-isotope systematics may have a profound impact on the interpretation of the Creede hydrothermal system, and that further study is warranted.

[1]Abstract published in Rocky Mountain section meeting, May 1-2, 1987, Geological Society of America, Program with Abstracts, v. 19, no. 5, p. 275.

Figure Captions

This is a list of slides used in the talk. The slides are reproduced as figures in this report. Slides 2, 5, and 16 are identical, as are slides 9 and 12.

1. General geologic map of the central San Juan Mountains caldera cluster (modified from Steven and Lipman, 1976) showing the locations of the La Garita, San Luis, Bachelor (B), and Creede calderas and the location of the graben extending between the San Luis and Creede calderas. The box outlines the general area of the Creede district (Figure 2), the Bondholder district is shown with a cross.

2. General geologic map of the Creede district showing the locations of major structures. The dots locate samples of galena analysed in this study and a previous study (Doe and others, 1979).

3. $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagram showing the lead isotopic composition of galenas from the Creede district analysed by Doe and others (1979). Samples from the Alpha - Corsair system are shown with closed squares, samples from the main mining district are shown with open squares. Maximun error at 2 sigma is shown by large cross.

4. Summary of the results of lead isotope study of the Creede district by Doe and others (1979).

5. General geologic map of the Creede district showing the locations of major vein structures. The dots locate samples of galena analysed in this study and a previous study (Doe and others, 1979).

6. $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagram with the results of new analyses of galena from the Creede district, the Equity mine area and the Bondholder district. Galenas from the Alpha-Corsair vein system are shown with diamonds, galenas from the Bulldog, OH and Amethyst vein systems are shown with squares and triangles, galena from the northern exploration area is shown with an X, and samples from the Bondholder district are shown with crosses.

7. General paragenetic sequences for the main mining district at Creede. Equivalent stages are shown for the Bulldog and OH vein systems.

8. $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagram showing the differences in lead isotopic compositon between different generations of galena and adularia. B = Stage II galena, D = Stage IV galena, A = Stage I adularia, * = no paragenetic information.

9. Possible explanations for the radiogenic and homogeneous nature of the ore leads.

10. $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagram comparing data for galenas with data on feldspars separated from igneous rocks in the area. Feldspars analysed by Doe and others (1979) are shown with crosses, feldspars analysed by Matty (1986) are shown with stippled field. Error bars are at 2-sigma level.

11. $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagram comparing data for galenas with data on feldspars separated from igneous rocks in the area. Feldspars analysed by Doe and others (1979) are shown with crosses, feldspars analysed by Matty (1986) are shown with stippled field. Error bars are at 2-sigma level.

12. Possible explanations of the radiogenic and homogeneous nature of the lead compositions.

13. Geologic map of Creede district. Areas of extreme potassium enrichment are shown with dots; Bachelor-age rocks are shown in shaded pattern.

14. $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagram showing initial results of feldspar study. Analysis of vein adularia is shown with solid square; all others symbols are analyses of galenas. Error bars are at 2-sigma level.

15. Geologic map from Baars and Stevenson (1984) showing distribution of Permian arkoses, shown in dashed, stippled, dotted, and circled patterns, derived from Precambrian basement.

16. General geologic map of the Creede district showing the locations of major structures. The dots locate samples of galena analysed in this study and a previous study (Doe and others, 1979).

Introduction

Today I am going to talk primarily about the lead isotopic composition of galena from the Creede mining district and nearby areas in the Bachelor and San Luis calderas of the central San Juan mountains.

I will start out by familiarizing you with a previous study of these areas because part of my talk draws on data from this earlier study. In 1979, Bruce Doe and others published the first regional study aimed at understanding the genesis of ore deposits of the entire San Juan volcanic field. Included in that study was a section on two mineral deposits associated with the central San Juan area - the Creede mining district and the Bondholder district.

The purpose of our study is to look more closely at different generations and occurrences of galena within the main mining district at Creede, and in the newly discovered northern exploration area, and to consider some processes that may explain the radiogenic and homogeneous nature of the ore leads.

I would like to start by reviewing tha data and results of Doe's study that relate specifically to these districts.

SLIDE 1: (General geologic map of the San Juan Mountains)

This slide shows the areas that Doe and his coworkers studied. They analysed samples from two main areas, the Bondholder district, which is located to the north in the San Luis caldera on this figure, and the Creede district which is outlined by the rectangle on this slide.
Next we'll look at a enlargement of the Creede mining district.

SLIDE 2: (Generalized geologic map of the Creede mining district)

For the Creede district, Doe and his coworkers analysed one or more galenas from the major vein systems - the Solomon-Holy Moses vein to the east, the Amethyst vein, the OH vein, the Bulldog vein, and the Alpha-Corsair vein system to the west.

The results of their study are shown with open squares on the next slide.

SLIDE 3: (Lead isotopic compositions of galenas from the Creede district from Doe et al., 1979)

This $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagram has the data of Doe and others plotted with open squares. Analyses for most veins of the main mining district and for the Bondholder district form a remarkably homogeneous population; they all plot between $^{206}Pb/^{204}Pb$ values of about 19.01 and 19.09 and $^{207}Pb/^{204}Pb$ values of 15.56 and 15.64. These lead values also proved to be

much more radiogenic than analyses of the enclosing volcanic rocks that were published in 1978 by Peter Lipman and others.

The three samples which plot away from the main group were all collected from mines along the Alpha-Corsair system. These galenas have isotopic compositions that are distinct from those of the main mining district and the Bondholder district.

The samples studied by Doe and others clearly show the radiogenic and homogeneous nature of the lead isotopic compositions of galenas from the Creede district and the Bondholder district to the north.

The companion $^{208}Pb/^{204}Pb$ diagram shows the same general relationships among the samples analysed by Doe and others and emphasizes the fact that the Alpha-Corsair samples have distinctly lower values of $^{206}Pb/^{204}Pb$ and higher values of $^{208}Pb/^{204}Pb$ compared to the main mining district.

These data lead to the conclusions that are summarized on the next slide.

SLIDE 4: (Conclusions of Doe et al., 1979)

First, Doe and others proposed that the homogeneous lead compositions of the galenas suggested that the lead was derived from a large, well-mixed reservoir.

They also proposed that the radiogenic nature of the lead precluded the possibility that it was derived from alteration of volcanic wallrocks or from any magma comparable in composition to the exposed volcanic rocks in the area.

These observations led them to conclude that the lead was derived from the Precambrian basement by a deeply circulating hydrothermal system.

Lastly, the fact that galena from the Alpha-Corsair system is isotopically distinct from galena from the main mining district led them to suggest that there were probably separate hydrothermal cells for the Alpha-Corsair system and the Bulldog-OH-Amethyst systems.

SLIDE 5: (Sample locations for the lead isotope study)

In our study so far, we've concentrated primarily on the main mining district, and those samples are shown with solid dots on this map. Samples were also analysed from the northern exploration area, the general location of which is shown by the dot near the Equity fault, and from the other localities in the Bondholder district which are shown with dots-and-arrows and would plot off the map to the north. As you can see, samples of galena were taken from roughly along the strike of the main faults of the Creede mining district for a distance of over 11 kilometers.

New analyses of galenas from these sixteen localities are shown next.

SLIDE 6: (New analyses of galena from the Creede district and vicinity)

On this $^{207}Pb/^{204}Pb$ diagram I've plotted samples from each of the vein systems using different symbols. Before I discuss the individual points, I want to emphasize that the most notable thing that this plot shows is that galenas from each of the veins in the Creede area, with the exception of the Alpha-Corsair system, have compositions that cover almost the entire range of lead isotopic compositions shown on this diagram. They all have extremely uniform values of $^{206}Pb/^{204}Pb$, and the same general spread in $^{207}Pb/^{204}Pb$. Now let's look at the data for each vein.

The diamonds show galena analyses from the Alpha-Corsair system that I talked about earlier.

The isotopic compositions of galenas from the Bulldog, OH, and Amethyst veins of the main mining district are shown with open squares and triangles. The samples range from 18.972 to 19.049 for $^{206}Pb/^{204}Pb$ and from 15.618 to 15.671 for $^{207}Pb/^{204}Pb$.

Galenas from the northern exploration area are shown with an X, and samples from the Bondholder district are shown with crosses. These galenas show almost complete overlap with the ranges defined by values of galenas from the main mining district.

A $^{208}Pb/^{204}Pb$ plot of these data shows essentially the same relationships so I will skip that diagram and instead, in the next few slides, we will look at isotopic differences between different generations of galena.

SLIDE 7: (General paragenetic sequence for the main mining district at Creede)

This slide shows the general paragenetic sequence for the main mining district at Creede. It is divided into two parts, one that describes the paragenetic stages for the OH vein and the other describes the equivalent stages for the Bulldog system. All of Doe's samples were taken from D- or fourth-stage galena, but, as you can see from this slide, galena also occurs earlier in both veins, in the second or B-stage. In addition, adularia and galena occurs in the earliest or A-stage.

Analyses of galena and adularia from these earlier stages are shown next, in comparison to analyses from D-stage galenas.

SLIDE 8: (Analyses of different generations of galena)

This slide shows the results of looking at different generations of galena.

The two B's on this diagram represent samples of galena from the stage two or B of the Bulldog system. These can be compared with most of the data, identified with D's, which are from the fourth or D-stage. (The samples shown with asterisks are not correlated with paragenetic stage).

The A on this slide is an analysis of adularia thought to be from the earliest stage. It falls roughly at the extreme high end of the range of $^{206}Pb/^{204}Pb$ values for the field of D-stage galenas.

These apparent differences in lead isotopic composition among the stages are very minor, only slightly more than twice the analytical uncertainty. However, they do suggest that more thorough study of the different generations of galena may be useful in tracing the evolution of the lead isotopic composition of the ore fluid.

Some alternative processes to explain the unusually homogeneous and radiogenic compositions of the ore leads are shown on the next slide.

SLIDE 9: (Alternative explanations for radiogenic and homogeneous lead compositions)

We'll first consider the radiogenic nature of the ore leads. Doe and others initially proposed that the radiogneic lead was derived directly from the Precambrian basement. The recent work of Dave Matty on the lead systematics of volcanic units in the area, part of which he presented this morning, has shown that some volumetrically insignificant units have lead isotopic compositions that resemble those of galena and it's been suggested that these units or their hypabyssal equivalents might be a source of the lead.

SLIDE 10: (Lead isotope diagram showing compositions of feldspars from volcanic rocks and ore leads)

This $^{207}Pb/^{204}Pb$ diagram compares the galena data, in squares, with data on feldspars from igneous rocks from the area published by Lipman and others, 1978, in crosses, and the field represents common lead analyses by Dave Matty of volcanic rocks from the area. This field includes Dave's most radiogenic values which may reflect alteration. The curves on this diagram are average evolution curves of Doe and Zartman's 1979 plumbotectonic model; for reference the middle curve is the curve for the orogene.

In general, the galenas have more radiogenic values of $^{206}Pb/^{204}Pb$, but comparable values of $^{207}Pb/^{204}Pb$. However, the galenas trend toward lower values of $^{207}Pb/^{204}Pb$ with only a slight change in $^{206}Pb/^{204}Pb$.

There is some overlap with galenas from the main mining

district having the highest values of $^{207}Pb/^{204}Pb$ and the more radiogenic points of Dave Matty's data. Galenas from the Alpha-Corsair system are contained entirely within the field of Dave Matty's data.

These points raise the possibility that the lead in the ores and rocks may have had similar sources. However, the $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagram shown on the next slide clearly discounts the possibility that they may have had similar sources.

SLIDE 11: (Lead isotope diagram showing compositions of feldspars from volcanic rocks and ore leads)

The fields on this diagram are the same as on the previous slide.

This $^{208}Pb/^{204}Pb$ plot clearly shows that the galenas from the main mining district and the Alpha Corsair systems were probably derived from a source or sources having a different Th/U ratio that that of the volcanic rocks. This diagram also emphasizes the restricted ranges of the $^{206}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ that characterize the galenas.

The most likely process and source for the radiogenic lead remains, a direct derivation from Precambrian basement.

We will now consider two possible causes of the homogenization of the lead.

SLIDE 12: (Alternative explanations for radiogenic and homogeneous lead compositions)

In the first case, the uniformity of the lead isotopic composition may be a result of an extensive Bachelor-age K-metasomatic event that predated the ores. And secondly, recent regional studies by Baars and Stevenson suggest the possibility of a pre-volcanic, NNW-trending graben system which may have been filled by clastic sediments derived from the Precambrian.

These possible ways of deriving the homogeneous compositions of the ore leads are treated in the next three slides.

SLIDE 13: (Volcanic rocks showing extreme potassium enrichment)

This slide shows the Bachelor-age rocks in dark gray and the dots mark areas of extreme potassium enrichment. The K-enrichment is centered around the Bulldog, OH, and Amethyst vein systems which all have fairly similar lead isotopic compositions. The Alpha-Corsair, which has a lead isotopic composition that is distinctly different from that of the main mining district is in an area that does not show the extreme K-enrichment. These two observations suggest the possibility that the homogenization of the lead in the main mining district may have resulted from the same processes that caused the K-metasomatic event affecting some combination of igneous rock, Permian, and Precambrian leads.

The lead samples from the northern exploration area and the Bondholder district are similar in lead isotopic composition to the main mining district, but they occur in areas that do not have K-metasomatized surface samples. However, K-enriched rocks may occur at depth.

The possibility that the uniform ore leads were generated in this way is being tested in an on-going study of feldspars from metasomatized and unmetasomatized rocks in the area; the next slide shows some initial results of that study.

SLIDE 14: (Initial results of feldspar lead study)

The solid square on this slide shows the results of a single analysis of vein adularia from stage 1 of the OH vein system that will be used to compare with rock feldspars. (This is the same analysis that was shown earlier as point A on slide 8). The rest of the symbols represent galena analyses. Vein adularia has a lead isotopic composition that falls at the extreme high end of the $^{206}Pb/^{204}Pb$ ratios of the galena.

Next, we'll consider the second possible explanation for homogenization of the feldspars.

SLIDE 15: (Geologic map showing distribution of Permian arkoses)

Baars and Stevenson, in 1984, raised the possibility that Permian arkoses, derived from Precambrian basement, may fill rifts produced by late Paleozoic block faulting. The distribution of these arkoses are shown in patterned areas on this map. Such a mechanical mixing of various units in the Precambrian basement coupled with widespread leaching of lead may have acted to produce a homogeneous and radiogenic lead reservoir. This idea implies that fluids were imported deep within the Creede hydrologic system from fairly remote sources.

All of these alternatives suggest complexities in the lead systematics that need to be more clearly defined and that may have a profound impact on the interpretation of the Creede hydrothermal system.

SLIDE 16: (General geologic map of the Creede district)

To conclude, we have shown that ore leads from the main mining district at Creede, the northern exploration area and the Bondholder district are remarkably homogeneous and radiogenic for over 11 kilometers along strike of the ore deposits. This character suggests that the hydrothermal system was fairly open to a uniform lead reservoir along it's entire length at least during the later stages of ore development. And, this character has important implications for the hydrology of the ore fluid.

In addition, we've shown that minor variations in the lead isotopic compositions for different generations of galenas may be

useful for tracing the evolution of the ore fluid, although the small magnitude of the changes will require a good paragenetic base and extremely detailed and careful analytical work.

References

Baars, D.L., and Stevenson, G.M., 1984, The San Luis uplift, Colorado and New Mexico - an enigma of the ancestral Rockies: The Mountain Geologist, v. 21, p. 51-67.

Doe, B.R., Steven, T.A., Delevaux, M.H., Stacey, J.S., Lipman, P.W., and Fisher, F.S., 1979, Genesis of ore deposits in the San Juan volcanic field, southwestern Colorado - lead isotope evidence: Econ. Geol., v. 74, p. 1-26.

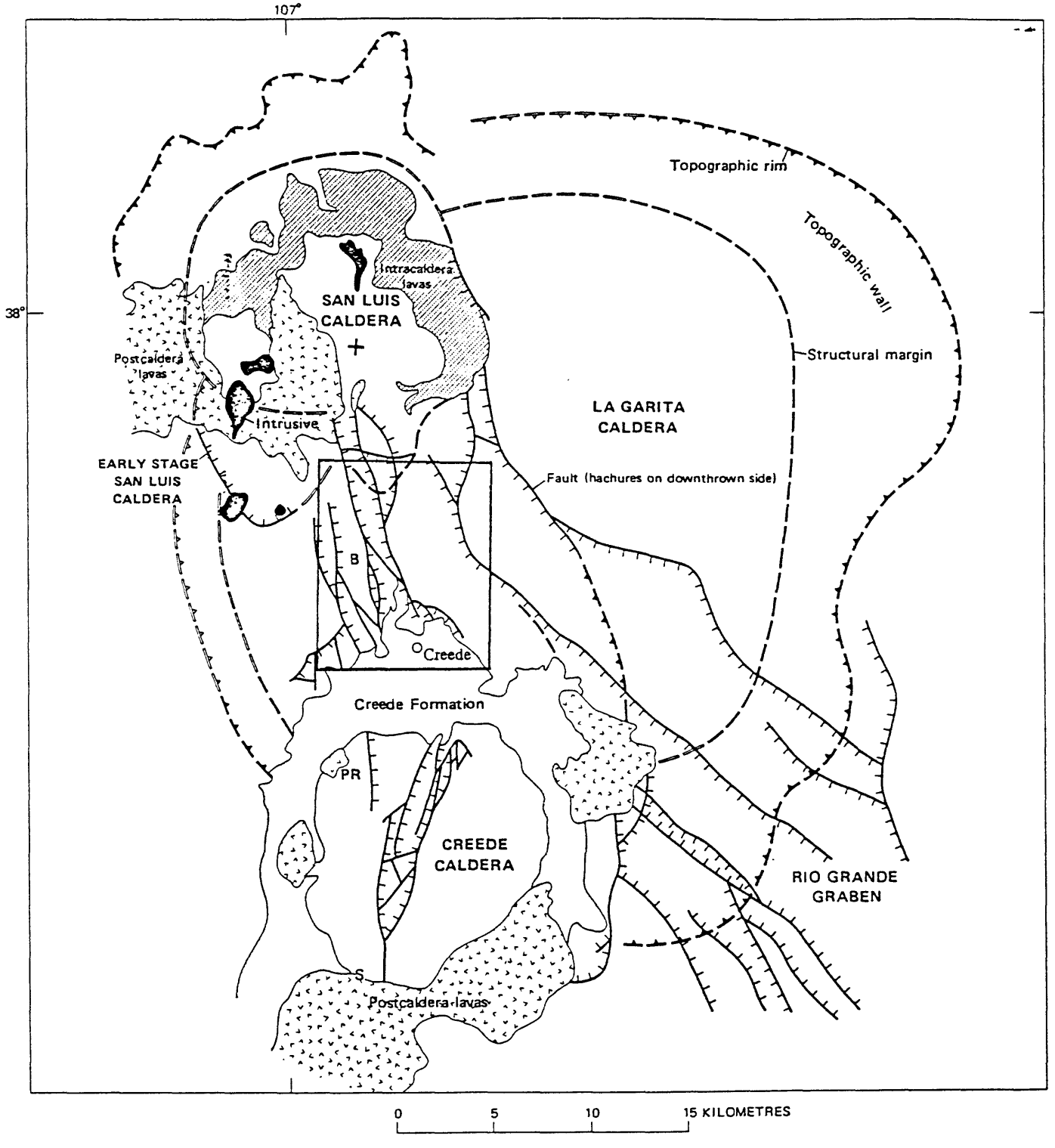
Doe, B.R., and Zartman, R.E., 1979, Plumbotectonics: The Phanerozoic, in Barnes, H.L., ed., Geochemistry of hydrothermal ore deposits: New York, Wiley Interscience, p. 22-70.

Lipman, P.W., Doe, B.R., Hodge, C.E., and Steven, T.A., 1978, Petrologic evolution of the San Juan volcanic field, southwestern Colorado - lead and strontium isotopic evidence: Geol. Soc. America Bull., v. 89, p. 59-82.

Matty, D.J., Lipman, P.W., and Stormer, J.C., 1987, Common-Pb isotopic characteristics of central San Juan ash-flow tuffs [abs]: Geol. Soc. Amer. Rocky Mtn. Sect., Abstacts with Programs, v. 19, no. 5, p. 319-320.

Steven, T.A., and Lipman, P.W., 1976, Calderas of the San Juan volcanic field, southwestern Colorado: U.S. Geol. Survey Prof. Paper 958, 35p.

Figure 1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Postcaldera lavas
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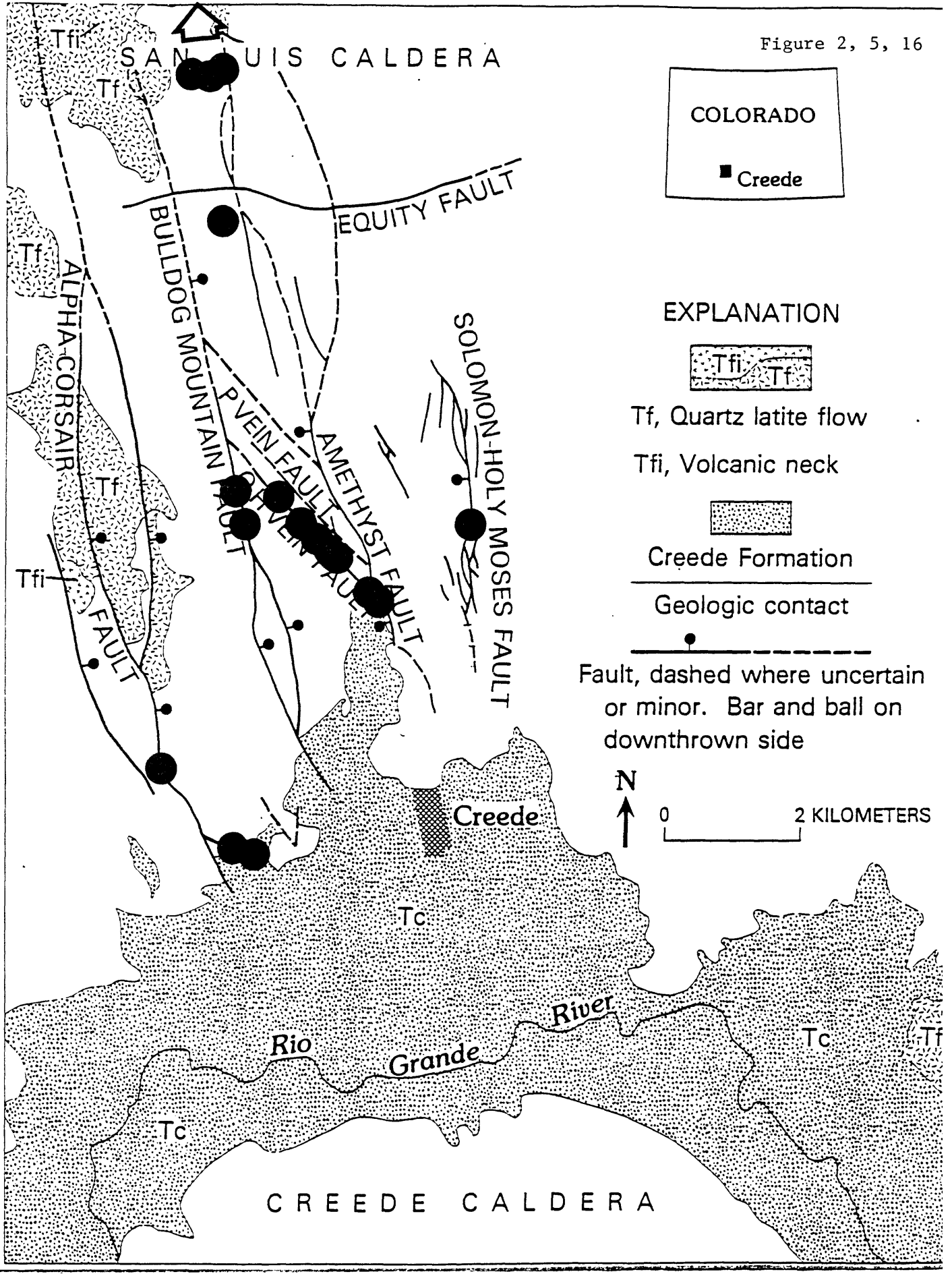
Figure 2, 5, 16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AMETHYST FAULT
SOLOMON-HOLY MOSES FAULT
ALPHA-CORSAIR FAULT
EXPLANATION
Tf, Quartz latite flow
Tfi, Volcanic neck
Creede Formation
Geologic contact
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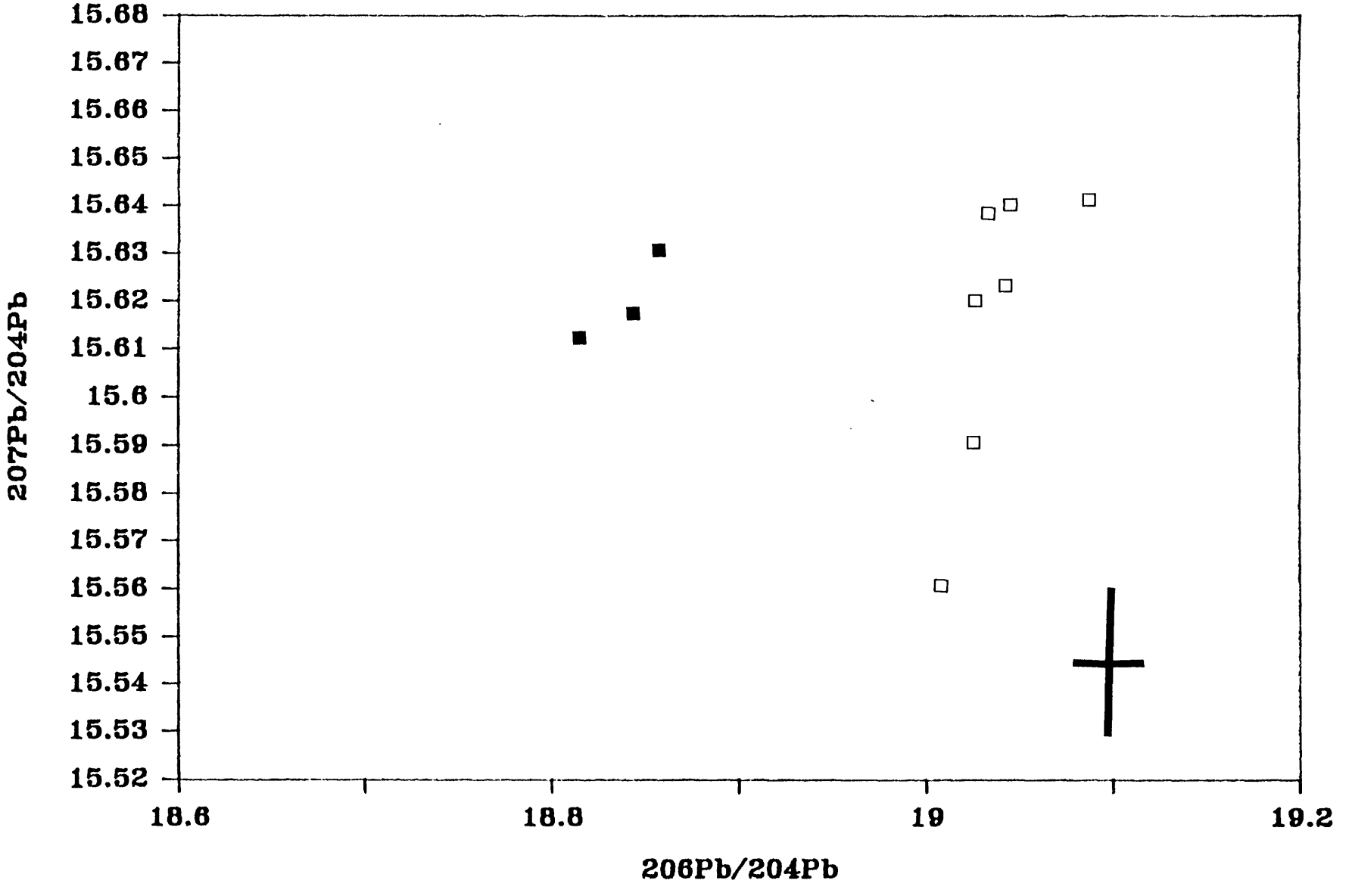
CREEDE CALDERA

Figure 3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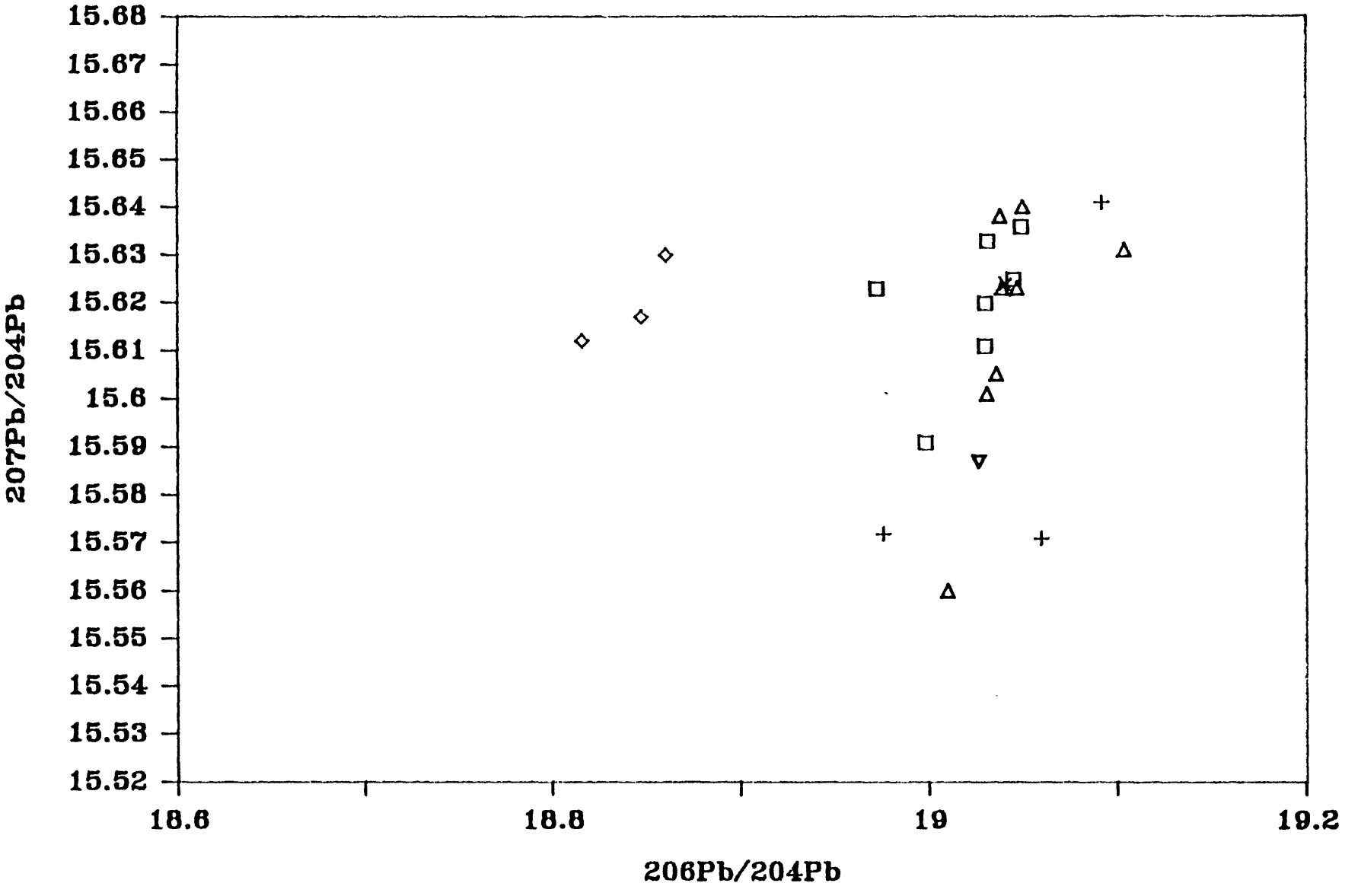
206Pb/204Pb

FIGURE 4

DOE AND OTHERS, 1979

1. LARGE, WELL-MIXED RESERVOIR
2. NOT AFFECTED BY VOLCANIC ROCK PATHWAYS
3. SOURCE OF LEAD FOR MAIN MINING DISTRICT - PRECAMBRIAN BASEMENT
4. SEPARATE CELL FOR ALPHA-CORSAIR SYSTEM

Figure 6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207Pb/204Pb
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206Pb/204Pb

Figure 7

OH VEIN

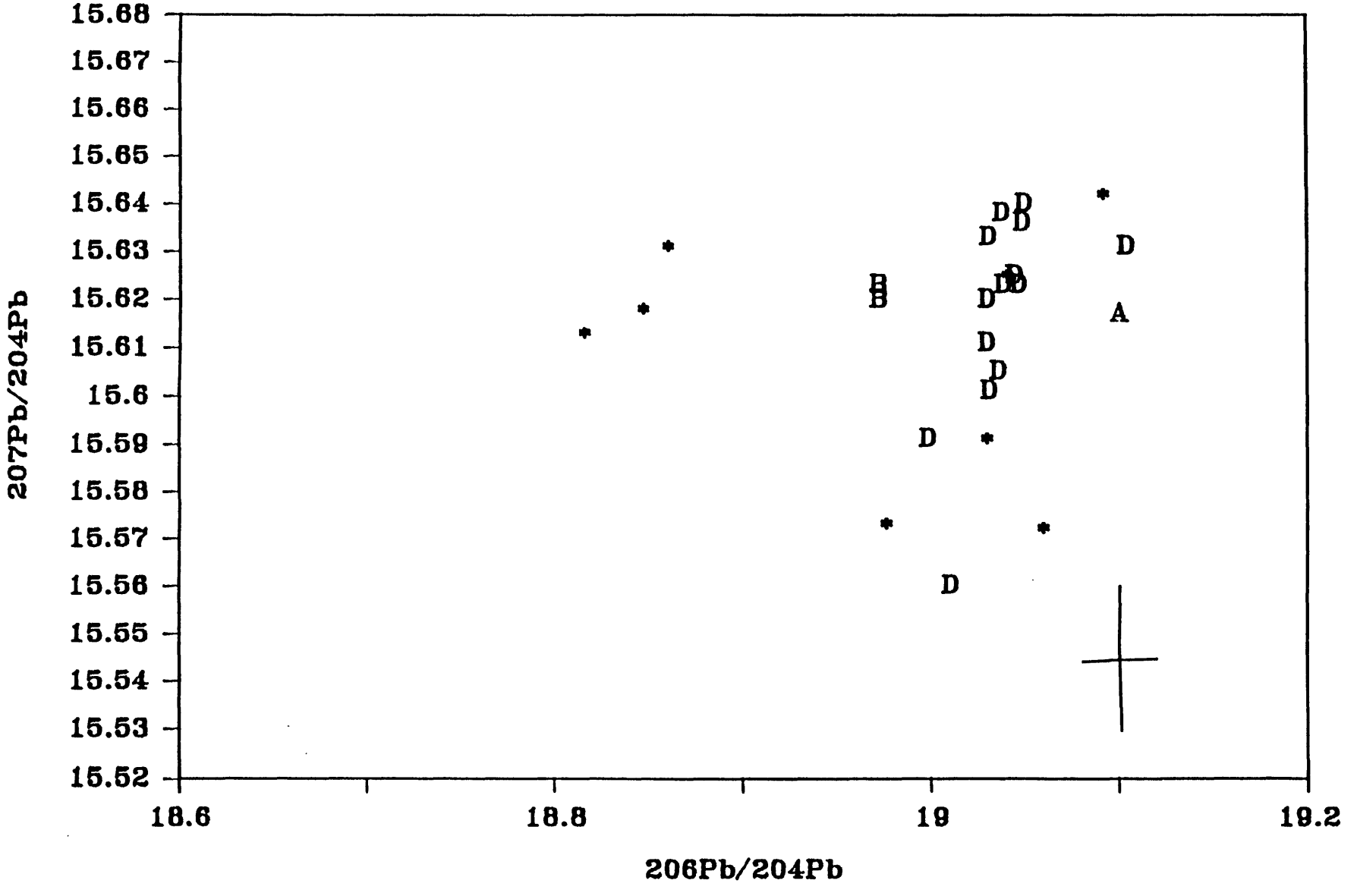
(similar to P vein)

PY, stib	E	V	PY, stib, pyrarg
SP, GN, cpy, hem, qtz	D	IV	SP, GN, cpy, td, pearc, ac
QTZ (amy, wh), fl, Mn-sid	C	III	QTZ (amy, wh), fl, Mn-sid
SP, GN, chl, hem, td, qtz, [bar]	B	II	SP, GN, BAR, td
QTZ, ad	A	I	RC, sp, gn, ad

BULLDOG MTN VEIN SYSTEM

(similar to so. Amy. vein)

Figure 8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RADIOGENIC LEAD COMPOSITION:

1. DIRECTLY FROM PRECAMBRIAN BASEMENT
2. RADIOGENIC VOLCANIC UNITS (MATTY, 1986)

HOMOGENEOUS LEAD COMPOSITION:

1. HOMOGENIZATION BY K–METASOMATISM
2. HOMOGENIZATION IN REGIONAL PRE–VOLCANIC GRABEN

Figure 10

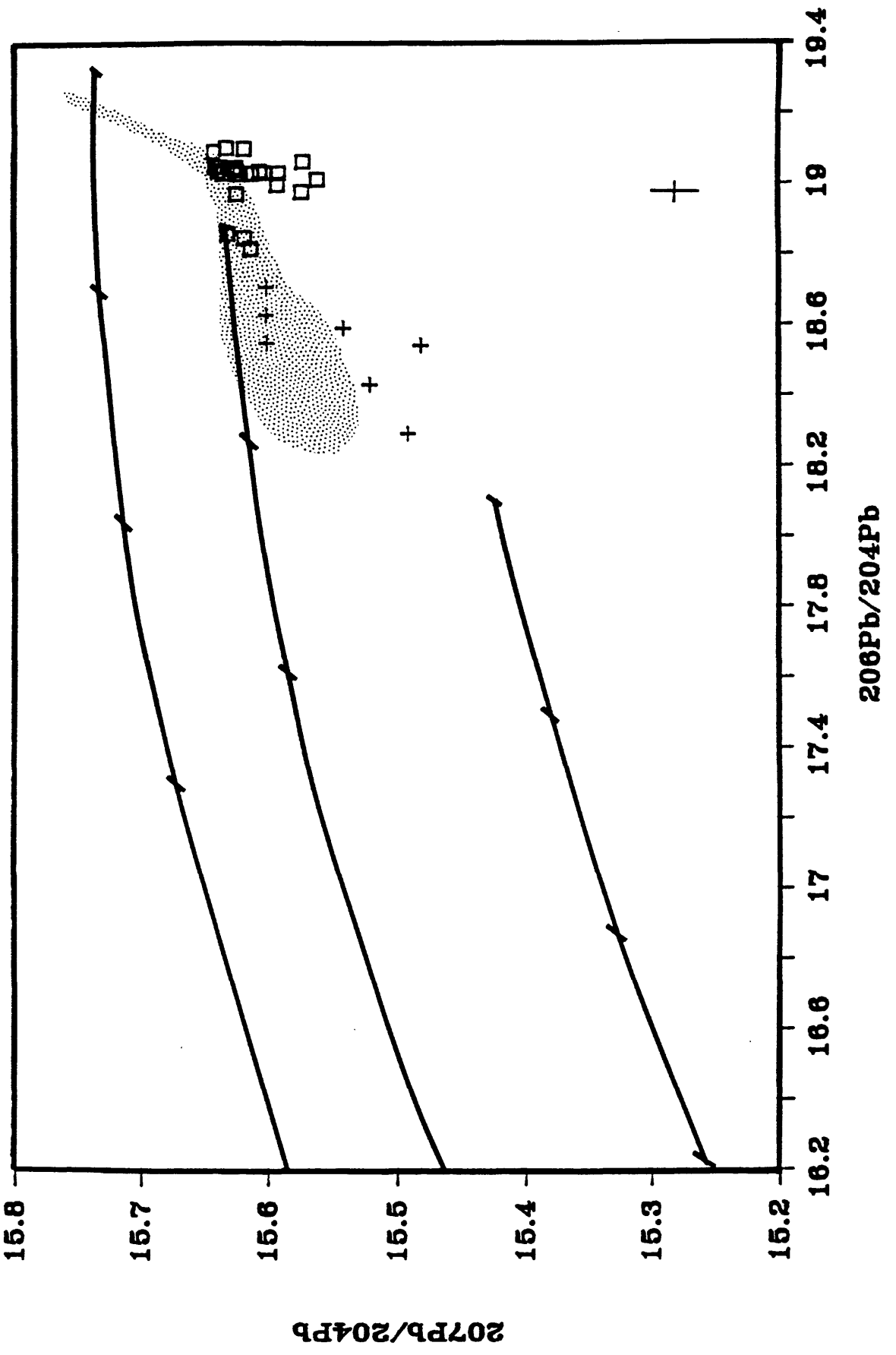
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Figure 11

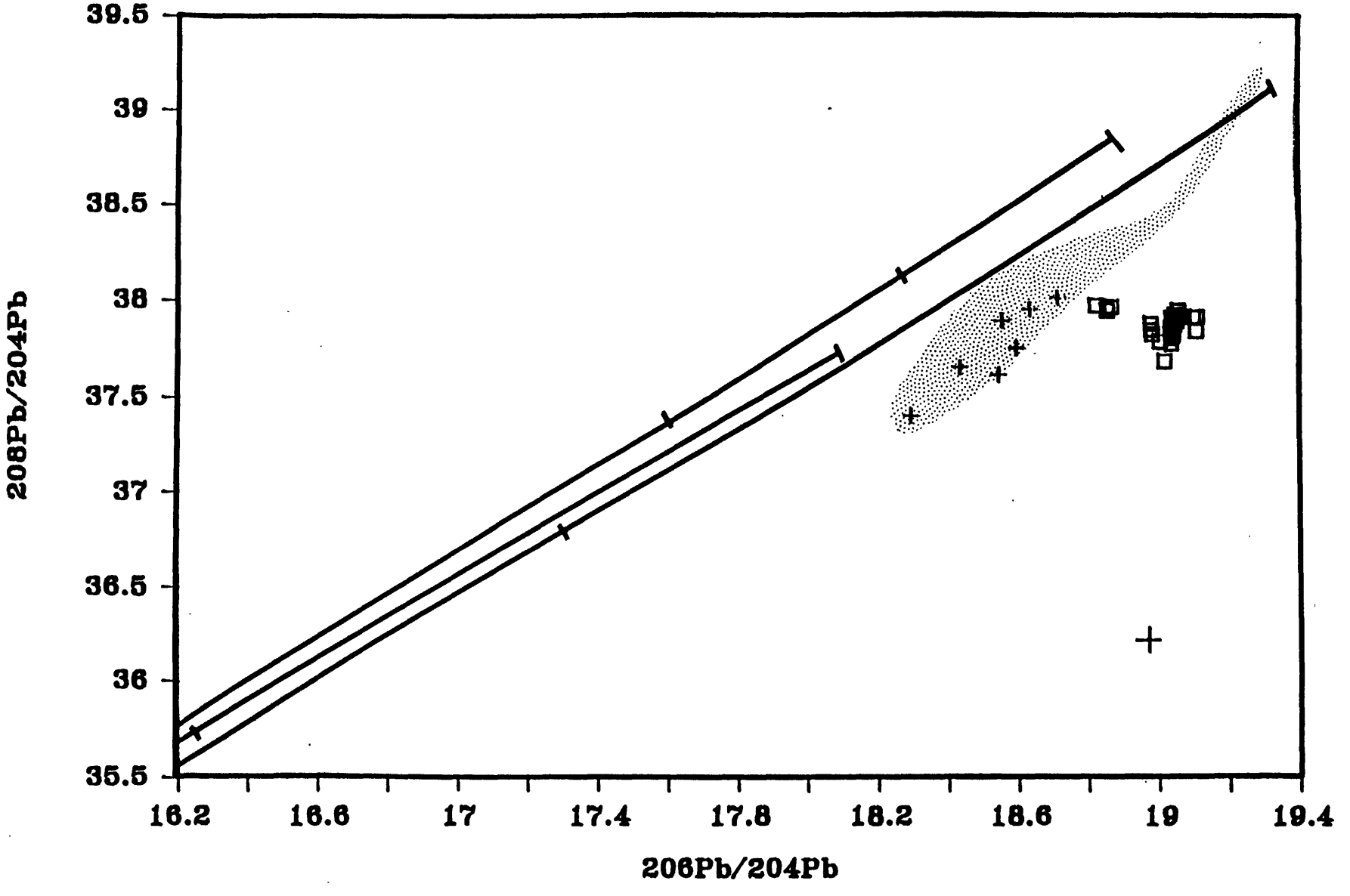
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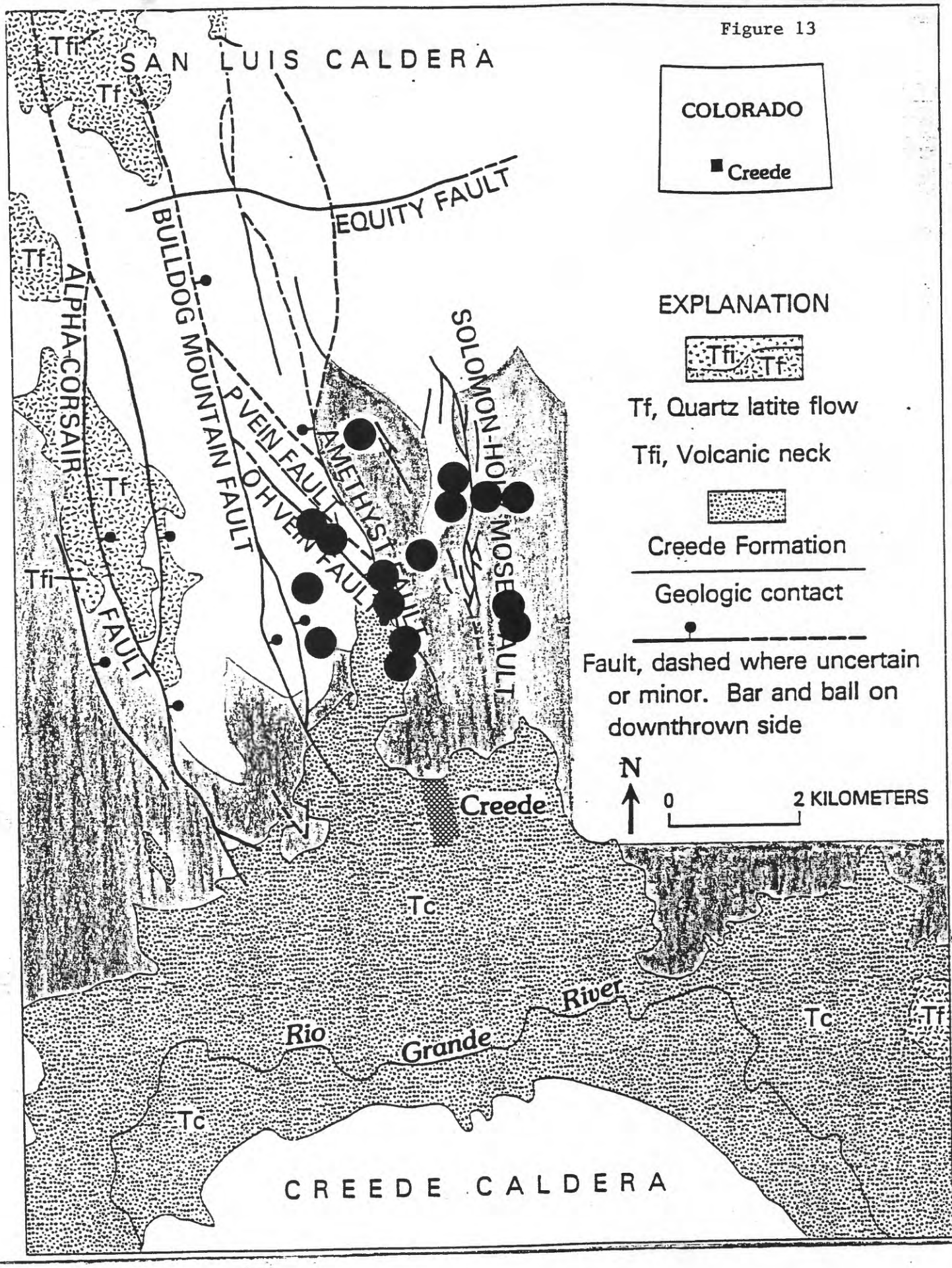
Figure 13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OHVEIN FAULT
AMETHYST FAULT
SOLOMON-HOSMER FAULT
EXPLANATION
Tf, Quartz latite flow
Tfi, Volcanic neck
Creede Formation
Geologic contact
Fault, dashed where uncertain or minor. Bar and ball on downthrown side
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Creede
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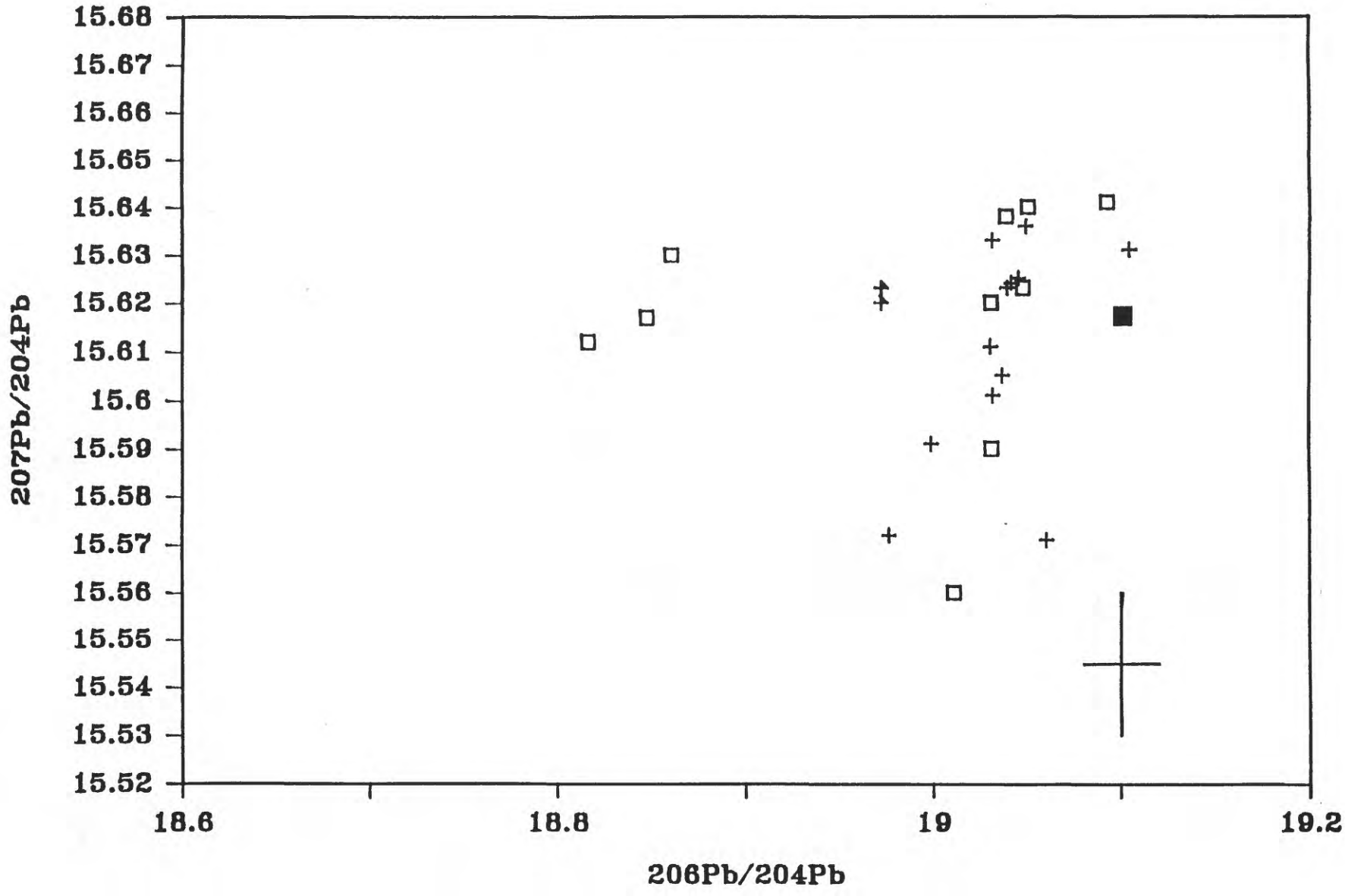
Rio Grande River
CREEDE CALDERA

Figure 14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207Pb/204Pb
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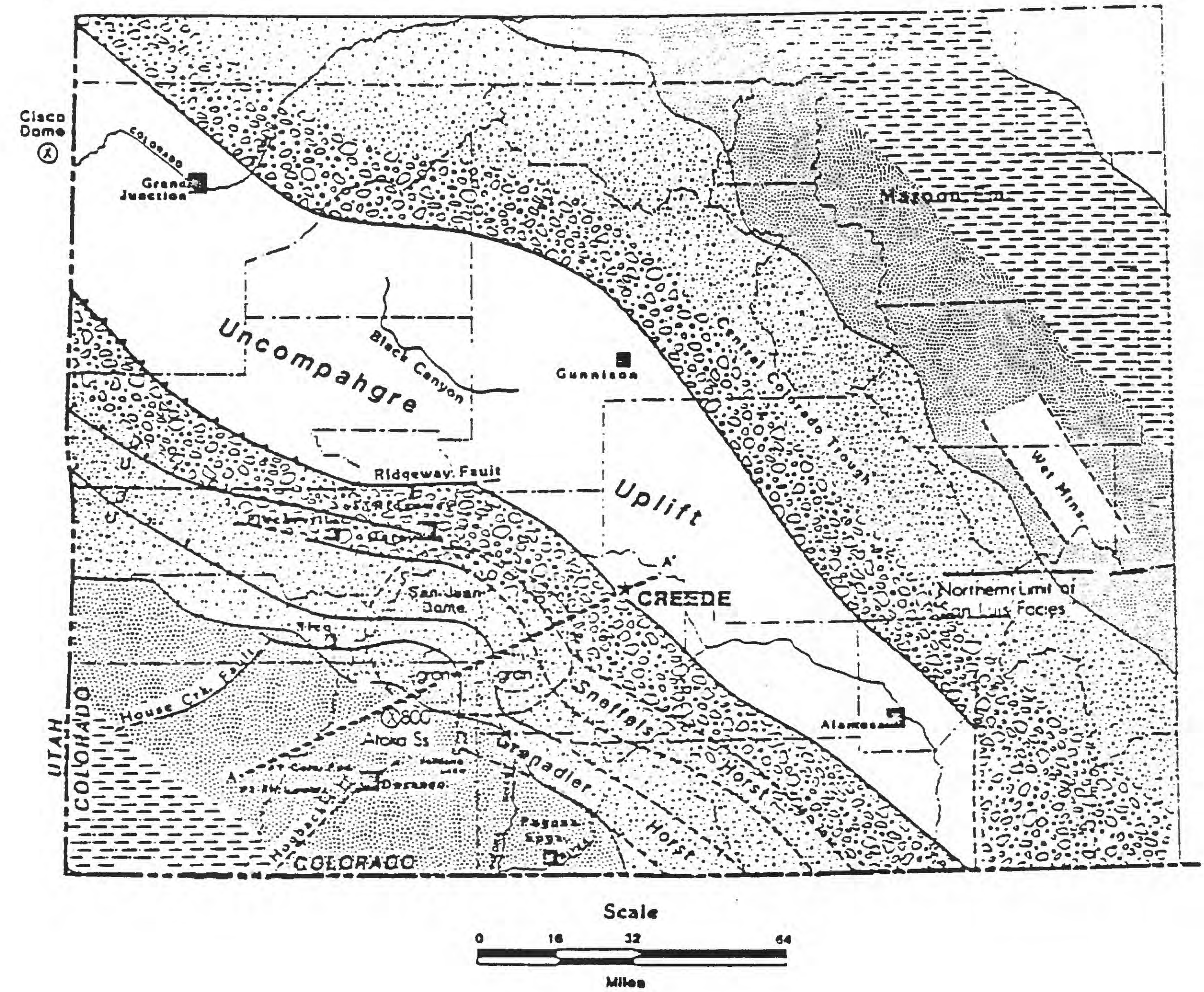
206Pb/204Pb

Figure 15


Cisco Dome
Grand Junction
Uncompahgre
Black Canyon
Gunnison
Central Colorado Trough
Maroon Fm.
Wet Mtns.
Ridgeway Fault
Uplift
A'
CREEDE
Northern Limit of San Luis Facies
San Juan Dome
House Crk. Fault
Sneffels Horst
Granadier Horst
Atoka Ss
Durango
Pagosa Spgs.
Alamosa
UTAH
COLORADO
A
Scale
0
16
32
64
Miles