A provenance study of the Maverick Shale of central Arizona

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INTRODUCTION

The main purpose of this study is to use sedimentological analysis to infer the provenance and tectonic setting of the Maverick Shale, and to contrast these inferences to previously published studies of the Mazatzal Peak Quartzite and Dead Man Quartzite (Trevena, 1979; Wilson, 1939; Bayne and Middleton, 1996; Cox and Lowe, 1996).

The Maverick Shale was named by Wilson (1939) who identified the type section in the Maverick Basin, central Arizona (fig 1). Although deformation makes thickness of the unit difficult to determine, a minimum thickness is estimated at 115 meters (Doe and Karlstrom, 1991), with a possible maximum thickness of 208 meters (Trevena 1979). The Maverick Shale consists of alternating shale, siltstone and quartzose sandstone. The unit generally coarsens upward. Mudstone and siltstone form the lower portions of the unit (Trevena, 1979). Sandstone beds are absent in the lowest parts of the unit but become predominant towards the upper part of the unit (Trevena 1979).

The study area was located in the Mazatzal Mountains, with fieldwork restricted to Barnhardt Canyon, Shake Tree Canyon and outcrops along the North Peak trail. Because of the shaley nature of the lower half of the Maverick Shale, most samples in this study were collected from the upper half of the unit, where quartzite beds are more prevalent. Because of the deformation of the Maverick Shale in Barnhardt Canyon, the exact position of samples within the overall stratigraphic sequence uncertain. Samples collected from the Shake Tree Canyon sectioncan be precisely located.

METHODS

Thirteen samples intentionally biased towards fine sand-size or coarser(to optimize provenance indicators) were point counted (333 counts per sample) using the standard Dickinson-Gazzi method in order to minimize variation in sandstone framework minerals due to grain size. Grains with crystals smaller than the minimum sand framework size (0.0625 mm) are counted as lithic fragments (Ingersoll et al., 1984). Any crystals larger than this size are counted as mineral grains, even if they are clasts within a matrix or polycrystalline fragment (ibid.). This technique allows standardized compositional fields to be used to determine provenance (ibid.).

Graphs to determine provisional provenance of the samples were plotted using the graphing program Ternary. Boundaries for the provenance zones within ternary diagrams were taken from Dickinson (1985), and added to the graphs using Canvas. Other ternary plots with provenance zones (figs. 3b and 4b) are also from Dickinson (1985).

One possible source of error in this study is the effect that the matrix composition will have when evaluating provenance. Cox and Lowe (1996) suggest that a whole rock chemical analysis will remove most of the effects caused by fine-grained matrix in determining provenance.

RESULTS:

The vast majority of the framework grains are monocrystalline quartz. These clasts range in size from fine sand (0.0625 mm) to very coarse sand (1-2 mm). In general, framework diameter in each sample show little variation, although, a few samples contain framework grains ranging from fine sand (0.0625 mm) to granule (up to 4 mm).

The most common lithic fragment is chert. Some clasts counted as detrital chert may be detrital clasts of quartzose material recrystallized or mechanically altered. Other clasts, though not very common, include K-feldspar and plagioclase. Plagioclase grains are relatively unaltered, with only occasional kinks developing across the twining. K-feldspar grains are highly degraded. Most other lithic fragments are mudstones and siltstones which are extremely rare.

The matrix material, predominately mud to silt sized grains, composes a significant portion of the samples viewed in thin section. The percentage of matrix material ranges from approximately 17% to approximately 50%. Sandstone of the Maverick Shale are mainly quartz wacke, with a few lithic wackes (Dott, 1964; See Table 1).

Data Table 1

Sample #	Qm	Qp	Qt	Ls	Lv	Lt	P	K	Ft
1	174	42	216	35	0	77	0	0	0
2	179	13	192	9	0	22	0	0	0
3	167	28	195	11	0	39	1	2	3
4	219	30	249	0	0	30	0	1	1
5	171	21	192	0	0	21	4	6	10
6	125	25	150	0	0	25	0	9	9
7	189	55	244	7	0	62	0	0	0
8	169	83	252	12	0	95	0	1	1
9	190	47	237	0	0	47	0	2	2
10	181	21	202	0	0	21	0	0	0
11	195	29	224	0	0	29	0	4	4
12	252	19	271	0	0	19	0	1	1
13	231	43	247	0	0	43	0	0	0
Average:	187.85	35.08	220.85	5.69	0	40.77	0.38	2	2.38

Table 1: Number of point counts for each type of grain found for quartzite samples of the Maverick Shale.

Discussion

The sandstone framework minerals of the of the Maverick Shale indicate a mixed provenance: a continental block (interior craton) and recycled orogenic material. Directional indicators in both the Maverick Quartzite and the Maverick Shale suggest that this is not a lacustrine deposit, as proposed by Trevena (1979). Bayne and Middleton's (1996) suggestion of a braided deposit may be a more accurate interpretation.

The QmFtLt plot (fig. 2) shows relative proportions of monocrystalline quartz (Qm), total feldspar (Ft) and total lithic fragments (Lt). The Maverick Shale samples stratle the "cratonic interior" and "quartzose recycled" fields. This suggests that the source area may have included cratonic sedimentary sequences as well as quartz-rich sedimentary terranes within uplifted orogens.

Cox and Lowe (1996) suggest that the average value for a suite of samples is a more accurate indication of source because it removes the bias of individual samples. The mean values from table 1 are also shown on the ternary diagrams.

The QtFL plot (fig. 3) shows relative percentages of total quartz (Qt, monocrystalline quartz and chert) total feldspar (Ft) and other lithic fragments (L), i.e. sedimentary and volcanic materials. These also indicate sources ranging from "cratonic interior" and "quartzose recycled" source areas.

The QmPK diagram (fig. 3) shows relative percentages of monocrystalline quartz (Qm), plagioclase (P) and potassium feldspar (K). All samples contain more than 90 percent quartz relative to the plagioclase and potassium feldspar. These samples in the Dickinson classification (fig. 3) plot as highly mature and stable sandstones, typical of detritus eroded from continental blocks.

The QpLvLs diagram (fig. 4) plots relative percentages of polycrystalline quartz (Qp), volcanic lithic fragments (Lv) and sedimentary lithic fragments (Ls). Because many of the samples contain no lithic grains of sedimentary origin, the single point at the Qp end member represents 8 of the 13 samples plotted. None of the samples contain volcanic clasts. Three samples plot within the "collision suture/ fold and thrust belt" provenance field (fig. 4). The other ten samples do not occur within a defined field on the Dickinson classification.

Conclusions

The general conclusions of the overall provenance study indicate a source material of mixed cratonic rocks and quartz-rich sedimentary rocks, weathering to highly stable and mature sediment. The implied tectonic environment is one of a collision suture/fold and thrust belt. No volcanic material in the samples indicates that either volcanic activity within the source area or volcanic material was not a contributing source during the time of deposition.

References

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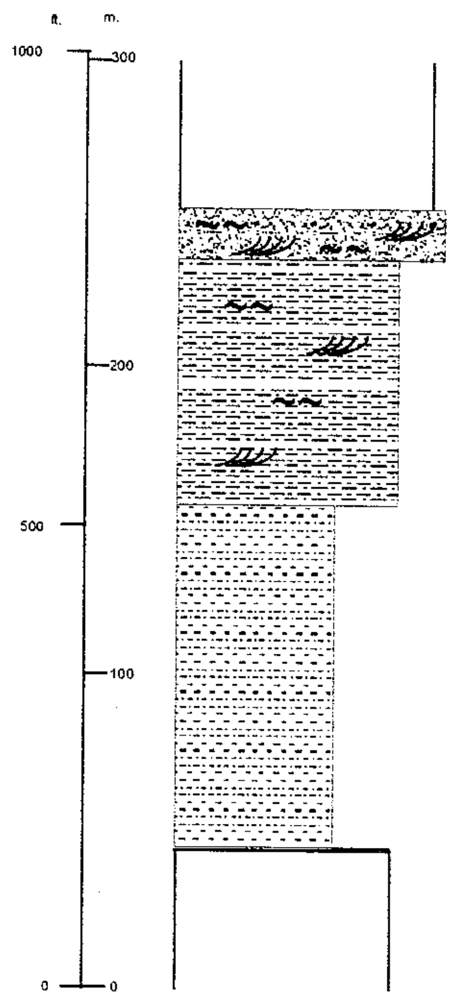

Quartzite (~60%), siltstone (~40%), granule conglomerate (~1%). Upper few centimeters at contact with Mazatzal Quartzite are dark gray to black mudstone. Many cross-strata and symetrical ripples throughout.

Quartzite (~20%), siltstone and minor mudstone (~80%). Thinly laminated brown to gray siltstone interbeded with gray to white quartzite. Quartzite predominately fine grained. Small scale cross-strata and scour/fill structures. Surfaces of many quartzite beds preserve symetrical ripples.

Mudstone (50%) and siltstone (50%). Mudstone more prevalent towards bottom of section. Few thin Quartzite beds in upper part of section. Beds gray to light brown in Shake Tree Canyon. In Barnhardt Canyon this section is dark green and Highly silicified and cleavage nearly destroys bedding. Some cross-strata noted in quartzite beds, predominately in upper portion of the section.

Figure 1. A generalized stratigraphic section of the Maverick Shale. Adapted from Trevena (1979)

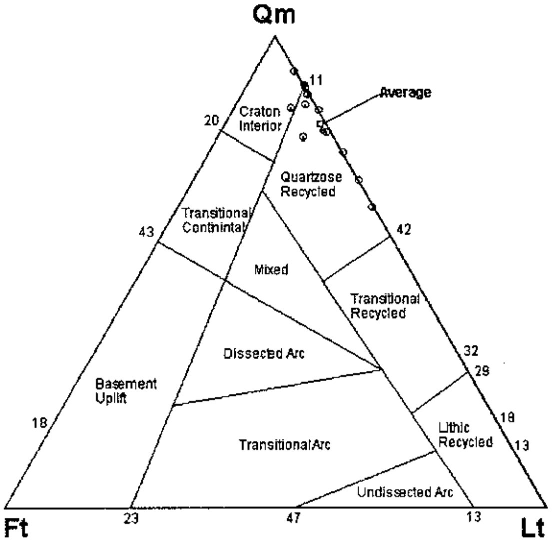

Figure 2. QmFtLt ternary diagram. Provenance fields from Dickinson (1985).

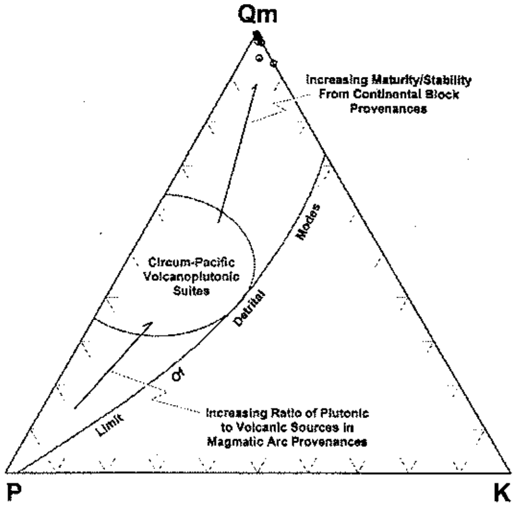

Figure 4. QmPK ternary diagram. Provenance fields from Dickinson (1985).

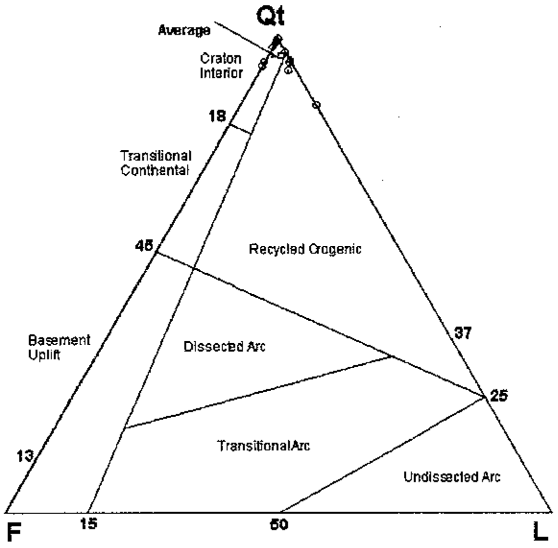

Figure 3. QtFL ternary Diagram. Provenance fields from Dickinson (1985).

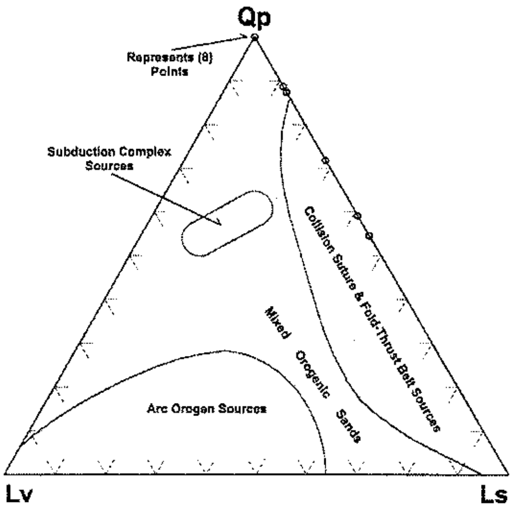

Figure 5. QpFtLt ternary diagram. Provenance fields from Dickinson (1985).