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December 11, 1992

Dr. Norman Goldstein
Division of Engineering & Geosciences, ER-15
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874

Dear Norm:

This letter represents a progress report on DOE FG03-90ER14154, entitled "Fluid Flow, Element Migration, and Petrotectonic Evolution of the Early Mesozoic Central Klamath Island Arc, Northwesternmost California." The first two years of the award was funded at \$201,086 for the period 09/15/90 - 09/14/92. An additional 24 month extension was awarded for the period, 09/15/92 - 09/14/94, funded at a level of \$157,768. This provides the final scientific report of the activities of the first two years of support.

Summary

Investigations in the central Klamath Mountains have documented the presence of a polymetamorphosed suite of highly magnesian basaltic rocks, the Yellow Dog greenstones, in the Sawyers Bar terrane of the western Triassic and Paleozoic belt. These metavolcanics display apparent komatiitic chemical affinities. The metabasalts were initially thought to reflect the Permo-Triassic to Middle Jurassic overriding of an oceanic hot spot by the stable, non-subducted arc-capped North American lithospheric plate, but are now regarded as metamorphosed, mildly alkaline oceanic island lavas (OIBs) and surmounting immature arc basalts (IATs), possibly erupted following subduction of a spreading center. These igneous rocks are interlayered with, and are interpreted to largely overlie distal turbidites. The assemblage was laid down, altered and metasomatized during the hypothesized collapse of a Phillipine Sea-type back-arc basin which brought the westerly Sawyers Bar oceanic arc terrane into juxtaposition with the inboard, pre-existing Stuart Fork subduction complex, and more easterly Klamath terranes in an immature island arc setting.

Supporting research has concentrated on elucidating the areal extent and structural/stratigraphic relations of these mafic/ultramafic Yellow Dog metavolcanic units, and has documented the insignificant degree of crustal contamination of the melts by associated terrigenous metasediments. The physical conditions of metamorphism and of aqueous-fluid-rock interaction accompanying island-arc accretion have been determined as follows: Middle Jurassic regional metamorphism of the Sawyers Bar/Stuart Fork amalgamated terrane took place at 350-500°C and 2.5-4.0 kbar; contact aureoles peripheral to the mid-Jurassic calc-alkaline plutons reached maximum physical conditions of 500-600°C at 2.0-3.0 kbar. Intrusion of the post-collisional granitoids mobilized alkalis, silica, and especially oxygen isotopes in the sedimentary strata intimately interlayered with the Yellow Dog greenstones, overprinting the effects of an inferred earlier submarine alteration in the mafic volcanics. Several sets of temporally overlapping mafic dike/sill series have been intruded into the complex (Ernst, in press). The thermal structure and its evolution in the central Klamath Mountains evidently reflects surfaceward advective transport of magmatic energy derived from the partly fused downgoing oceanic slab, as

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well as hydrothermal fluid circulation. Clarification of the thermal evolution of this crust-constructional event in the immature basaltic island arc are the goals of the research now underway, employing both field and geochemical methods.

Continuing work by Hacker and Ernst is documenting the flow and P-T history of aqueous fluids through the evolving Klamath arc, utilizing electron microprobe and oxygen isotopic data. We have nearly finished a regional reconnaissance map showing the distribution of the OIB and the IAT lavas throughout the California part of the Klamath Mountains (Hacker, Ernst, and Donato, in press). Application of the terrane concept to the central Klamath Mountains has also been reevaluated in the light of regional petrotectonic relationships (Hacker, Ernst, and McWilliams, in press; Hacker and Ernst, in review). Investigations of the regional and contact metamorphism/metasomatism of the Sawyers Bar metasedimentary pile are in progress. Another work, a colored map of the Sawyers Bar area at a scale of 1:48,000, is approaching completion (Ernst, in preparation).

In an experimental study of metamorphic transformation rates, Hacker, Kirby, and Bohlen (1992) have investigated the calcite-aragonite reaction in polycrystalline marbles. Two copies of this paper are enclosed.

DOE-Supported Productivity

Hacker, B.R., Kirby, S.H., and Bohlen, S.R., 1992, Time and metamorphic petrology: calcite to aragonite experiments: *Science*, v. 258, p. 110-112 (see p. 112 for DOE acknowledgement).

Ernst, W.G., in press, Chemically distinct diabasic dike/sill sequences of contrasting ages, Sawyers Bar area, central Klamath Mountains, northern California: *Jour. Petrology*, v.

Hacker, B.R., Ernst, W.G., and McWilliams, M.O., in press, Genesis and evolution of a Permian-Jurassic magmatic arc/accretionary wedge, and a reevaluation of the terrane concept in the central Klamath Mountains, *Tectonics*, v.

Hacker, B.R., Ernst, W.G., and Donato, M.M., in preparation, Regional extent of chemically distinctive metabasaltic flow units and structure of the central WTrPz belt, northern Klamath Mountains, California.

Hacker, B.R., and Ernst, W.G., in review, Jurassic orogeny in the Klamath Mountains:

Ernst, W.G., in preparation, Areal geology of the Sawyers Bar region, central Klamath Mountains, northern California: scale 1:48,000.

Newly Initiated Research

Samples have been collected from the Yellowdog greenstones and the Pony Camp gabbro complex for shallow-level water-rock interaction studies, utilizing stable isotope fractionation. This project will be undertaken in cooperation with Yehoshua Kolodny (Hebrew University) and Mark Barton (University of Arizona).

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DOE-Supported Personnel

The P.I. is joined in this research project by doctoral student, D.E. Miller, and Research Associate, B.R. Hacker.

Let me take this opportunity to thank the Department of Energy for ongoing support of our investigations of a well-exposed Mesozoic volcanic/plutonic arc in the Klamath Mountains.

Best regards, Norm,

A handwritten signature in black ink, appearing to be 'W.G. Ernst', written in a cursive style.

W.G. Ernst
Dean

cc: Dr. W.C. Luth
Janet Wright
WGE:llm